The Relationship Between Fungiform Papillae Density, PTC Supertasting, Food Preferences, and Eating Behaviors in College Students

Erin Berger

Wittenberg University

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Abstract

Perceived taste sensitivity is important because it significantly influences food preferences, and it may help predict dietary habits and other eating behaviors that influence body weight. Because supertasters are more sensitive to bitter taste, they may have a reduced preference for bitter, but beneficial, phytonutrients that are common in fruits and vegetables. The present study examined taster status, BMI, food preferences and eating behaviors for 63 Wittenberg University students. Results from this study have shown that taster status, indicated by PTC intensity scores and fungiform papillae densities, explains heightened taste sensitivity and therefore influences food preferences. This relationship between taste anatomy and food choice provides important evidence that individuals may be biologically prone to liking and therefore consuming specific foods.

The Relationship Between Fungiform Papillae Density, PTC Supertasting, Food Preferences, and Eating Behaviors in College Students

Weight management has been on the public health agenda for decades, addressing malnourished, overweight and obese individuals. The World Health Organization estimated 800 million people are undernourished, a statistic overshadowed by the 1.2 billion people that are overweight, and 300 million that are diagnosed obese ("WHO | Obesity," n.d.). Obesity is classified as a medical condition where there is an abnormal accumulation of excess body fat, often determined by having a body mass index (BMI) of greater than or equal to 30. With sedentary behaviors becoming increasingly prevalent in response to a growing reliance on convenience as a priority, body weight—treatment, maintenance, as well as prevention—is becoming a focused area of interest for many professionals (Bouchard, 2007). While reflecting on human evolution, it is remarkable to see that the discovery of processing and manufacturing food coincided with a dramatic change in dietary habits (Krebs, 2009). In the past, humans have adapted to times of feast and famine through accommodating appetites and metabolic changes. However, with the development of processed foods came an increased reliance on sweeter, fattier, foods high in caloric density and a reduced protein and nutrient-rich intake (Krebs, 2009). The increased susceptibility to obesity is a combined result of genetics, lifestyle factors, and personal behaviors that have developed through societal influences as well as individual families.

Perceived taste sensitivity is important because it significantly influences food preferences, and it may help predict dietary habits and other eating behaviors that influence body weight. Genomic DNA studies have isolated alleles of the TAS2R38 gene—a ‘taste’ receptor gene that is related to sensitivity of bitter taste through 6-n-Propylthiouracil (PROP) and Phenylthiocarbamide (PTC) chemical compounds (Mennella, Pepino, & Reed, 2005; Duffy et al., 2004). PTC/PROP testing is used to classify subjects based on these genotype differences: supertasters, medium tasters, and non-tasters (Bartoshuk, Duffy, & Miller, 1994). Supertasters, which account for about 25% of Caucasians and are mostly female, find the bitter taste of the chemical compounds to be extremely intense and unpleasant. Likewise, medium tasters can mildly identify the bitterness, whereas non-tasters do not perceive any sensation from the compounds (Bartoshuk, Duffy, & Miller, 1994). Because of this connection, PTC/PROP bitterness taste testing is often used in the hopes of finding a link to genetics and consumption based on individual differences in taste intensity. Most studies have utilized PTC/PROP supra-threshold taste intensity scaling: preparing solutions varying in chemical concentration to determine the individual's bitterness sensitivity. However, other studies use PTC/PROP saturated papers to detect sensitivity measures (Bartoshuk, Duffy, & Miller, 1994; Chang, Chung, Kim, Chung, & Kho, 2006; Drewnowski, Henderson, & Shore, 1997; Duffy et al., 2004; Hayes, Bartoshuk, Kidd, & Duffy, 2008; Ju-Hee Hong et al., 2005; Yackinous & Guinard, 2002).

Most studies examining the effects of taster status have investigated this genetic component in relation to food choice. According to Bartoshuk, Duffy, and Miller (1994), the TAS2R38 gene has Mendellian tendencies: people with 2 recessive alleles may be nontasters, people with one dominant allele may be medium tasters, and people with 2 dominant alleles may be supertasters. In a study of bitterness perception and sweet preferences, it was found that heterozygous bitter-insensitive and homozygous bitter-sensitive children responded to the lowest concentration of PROP and showed heightened preferences for sweet tasting foods, indicating that the TAS2R38 gene controls food preferences and aversions for children (Mennella, Pepino, & Reed, 2005). Another study determined that PROP taster status, alcohol sensation and alcohol intake were predicted by the TAS2R38 gene, indicating that genotype does in fact relate to sensation as well as intake (Duffy et al., 2004). From this and other studies, it is suggested that supertasters and those most sensitive to PROP experience more intense sensations from virtually all taste substances (Snyder & Bartoshuk, 2009).

Fungiform Papillae and Taste

More recent studies have analyzed this further by bringing in the element of taste anatomy and orosensory systems. Fungiform papillae are the structures that hold taste buds on the anterior of the tongue (Hayes, Bartoshuk, Kidd, & Duffy, 2008; Snyder & Bartoshuk, 2009). In order for an individual to experience taste, the stimuli must be in a liquid solution in order to flow through the taste pore to the taste receptor. Taste buds are then innervated by three cranial nerves: VII (facial nerve), IX (glossopharyngeal nerve), X (vagus nerve). From there the sensation travels to the cortex where the taste is processed and intensity is cognitively recognized (Bartoshuk et al., 2006). Because fungiform papillae mediate taste and tactile sensations, this provides another measure of oral stimulation that helps investigate dietary habits.

Although taster status has traditionally been defined through PROP/PTC bitterness testing, a study conducted by Hayes, Bartoshuk and Duffy (2008), examined the connection between bitterness perception and the number of fungiform papillae. Oral sensory phenotype was assessed by counting the number of fungiform papillae in a circular area 6-mm in diameter on the anterior blue-stained tongue surface. By using a general Labeled Magnitude Scale to report the intensity of sensation of different PROP concentrations, the taste threshold for PROP was determined (Hayes, Bartoshuk & Duffy, 2008). All subjects' TAS2R38 genotype was collected. From the threshold ratings, 24% of the 198 subjects were nontasters, 54% were tasters, and 22% were supertasters. Consequently, the number of fungiform papillae correlated with heightened PROP bitterness sensitivity in homozygotes, but not in heterozygotes (Hayes, Bartoshuk &

Duffy, 2008). This study supports the claim that supertasters who are sensitive to and avoid bitter-tasting foods also have an increased number of fungiform papillae.

Taste and Food Intake

Although it has been established that there are multiple causes contributing to the rise of this health concern, we are still far from identifying all of the triggers that lead to fatness. In addition to other factors such as socioeconomic status and race, how palatable a food is perceived by an individual is a major determinant of caloric intake. Because supertasters are more sensitive to bitter taste, they may have a reduced preference for bitter, but beneficial, phytonutrients that are common in fruits and vegetables. PROP/PTC supertasters have reported strong aversions for green tea, grapefruit juice, green beans, cooked turnips, watercress, coffee, spinach, cabbage, cruciferous vegetables, as well as other foods that contain antioxidants. However, no study has demonstrated a statistically significant link between PTC/PROP sensitivity and actual consumption of the aforementioned foods and beverages (Drewnowski, Henderson & Shore, 1997; Yackinous & Guinard, 2002).

Similar to various fruits and vegetables in terms of their micronutrient content, are spices. Spices have nutritional benefits as they are thought to be antioxidants with the power to reduce oxidative damage to cells (Krebs, 2009). Previous work has shown that supertasters are more sensitive to strongly spiced food. Spices are also believed to be natural antimicrobial compounds derived from plants—particularly inhibiting bacterial growth in meat dishes (Krebs 2009). How taste sensitivity and spices are related to various health risks has not yet been studied, but similar antioxidants in our diet such as plant-based phenols, flavonoids, isolflavones and glucosinolates are known to have anticarcinogenic effects (Drewnowski et al., 2000).

Research on breast cancer patients examined taster status and eating preferences within a population where dietary strategies are often the first line of defense to control tumor growth and carcinogenic effects. Results showed that of the 35 women in the study who reported dislike for cruciferous and raw vegetables, 34 were PROP taster or supertasters (Drewnowski et al., 2000). These findings suggest a pattern of food preferences—avoidance and selection—that are associated with inherited traits that could genetically explain and predict eating behavior.

Consistent with previous studies, the supertasters in the Drewnowski et al. (2003) study, had significantly higher average counts of fungiform papillae that both tasters and non-tasters. Yackinous and Guinard (2002) found significant evidence suggesting that taster and supertaster women consumed more calories from fat and fat-containing foods than non-tasters; however, when relating taster status to BMI and caloric intake, there were no significant findings. It is possible that supertasters have an increased palatability for fattier, creamier foods and therefore consume more; or, alternately they could prefer to ingest less because their heightened sensitivity to fattier foods gives them the same sense of satisfaction at lower concentrations. Although in Yackinous and Guinard’s (2002) study taster status was not significantly related to BMI, another study of 81 low-income, preschool-aged children found that PROP supertasters (*N* = 63) were more likely to be overweight and report lower hedonic ratings for vegetables and healthier foods (Lumeng, Cardinal, Sitto, & Kannan, 2008). These results have yet to be replicated with significance.

In a similar study, Hayes and Duffy (2008) examined fungiform papillae density and levels of liking for sugars and fat. Participants tasted 15 mixtures that provided varying degrees of fat and sugar. After rating the items, measuring fungiform papillae, and using PTC/PROP supra-threshold taste intensity scaling, results supported previous findings that creaminess and sweetness rating increased with fungiform papillae number. Additionally, those who perceived more creaminess needed less fat to achieve maximal liking—a behavior exhibited by normal weight women as opposed to obese women, who require higher levels of fat to reach maximal liking (Hayes & Duffy, 2008). They suggest through these findings that tasters' heightened sensitivity to fattier foods is similar to their heightened response to bitter foods. Furthermore, their aversion to bitter foods is comparable to their reduced desire to intake creamier foods, which could explain the tendency for tasters to be thinner (Hayes & Duffy, 2008). Although these results contradict previous studies by Yackinous and Guinard (2002) and Lumeng, Cardinal, Sitto, and Kannan (2008), which suggest that tasters consumed more calories from fatty foods because of their palatability, these findings support the overall trend that supertasters and tasters achieve optimal liking of high-fat foods with reduced levels of intake.

Hypothesis and Predictions

The conflicting and insignificant results of studies assessing BMI in relation to PTC/PROP tester status and food preferences beg for further investigation. Because there is little research connecting the eating behaviors of college students to taster status, the aim of this study is to find a relationship between PTC taster status, fungiform papillae density, BMI, food preferences and eating behaviors. I predict that fungiform papillae density will correlate positively with PTC taster status, indicating that both are effective measures of taster status. Additionally, I hypothesize that, due to the expected sensitivity of supertasters, they will indicate lower scores of overall food liking, which should be reflected by lower BMI levels. I also hope to find results confirming the correlation between cognitive restraint and disinhibition, as well as finding patterns of eating behaviors that can be correlated with taster status.

Method

Participants

Sixty-three students (17 male) voluntarily participated in this experiment. They were recruited through fliers located in Zimmerman Hall, the psychology departmental building of Wittenberg University. Professors encouraged their students to participate in exchange for extra credit for select introductory psychology courses. The Institutional Review Board approved all procedures, and written consent was obtained from each participant upon entry into the study. Height and body weight data were collected at the start of the experiment, using a digital floor scale and standard tape measure in order to accurately calculate BMI.

Identification of PTC Taster Status

Participants were given a strip of paper saturated with PTC and were asked to place it on his/her tongue for at least 5 seconds. They were asked to indicate how strong the taste was on a Likert scale ranging from ‘absolutely no taste’ (0) to ‘strongest taste’ (10). The perception of taste was clarified in terms of ‘no sensation’ to ‘most intense sensation’ and words indicating flavor were omitted from the explanation.

Determination of Fungiform Papillae Density

After identifying taster status, measurements of fungiform papillae were taken from each participant. The methods of collecting and determining fungiform papillae density were modeled from earlier studies conducted by Essick, Chorpa, Guest, and McGlone (2003). The anterior dorsal surface of the tongue was swabbed with blue food coloring (McCormick & Co., Inc, Hunt Valley, MD) using a sterile cotton tip applicator. The staining dyed filiform papillae, allowing the easy identification of the contrasted, unstained fungiform papillae. Tongues were swabbed with sterile cotton squares prior to and following application of food coloring in order to remove excess saliva. Participants rested their chin on an ophthalmologic head rest which had a ruler (cm) mounted below the chin. Multiple photographs were taken of the outstretched tongue with a 10-megapixel Nikon camera placed on a tripod.

The photographs were analyzed using a method adapted from Essick, Chorpa, Guest, and McGlone (2003). The density of fungiform papillae was determined by counting within a 6-mm diameter circle. For each photograph, three samples were taken from both the left and right anterior of the tongue and the mean number of fungiform papillae was reported. Because not all photographs were clear enough to accurately display the number of fungiform papillae, data for this measure was only collected for 30 participants.

Food Familiarity and Liking

Each participant completed an adaptation of a 60-item Food Familiarity and Liking Questionnaire (FFLQ) used in previous studies of food neophobia and food preferences during weight reduction sessions (Rigal et al., 2006; Monneuse et al., 2008). Because the FFLQ was initially designed for French populations, 16 food items were not culturally appropriate and were therefore replaced with more relevant items (see Appendix A for original and substituted FFLQ items). The 60 food items were allotted into the following seven food categories: fruits and vegetables, never-served foods, spices, breakfast foods, animal products, relatively high-density foods, and calorie-reduced foods. Food familiarity for each item was initially assessed by a binary response (Yes/No) to the question, ‘Have you already tasted this food?’ In the case of an affirmative answer, the participant was then asked to indicate their liking for the food on a nine-point Likert scale labeled from ‘I don’t like it at all’ (1) to ‘I like it a lot’ (9).

Three different scores were taken from the FFLQ: (1) the total number of unknown foods (‘No’ responses), (2) mean food liking response for all foods that have been previously tasted, and (3) mean food liking response for each of the seven food categories. Higher scores indicated higher likings (Rigal et al., 2006; Monneuse et al., 2008). All 63 participants completed all 60 items of the survey.

Three-Factor Eating

Each participant completed a second survey, adapted from Stunkard and Meeick’s 1985 Three-Factor Eating Questionnaire (TFEQ). This 51-item survey was developed to examine the three emerging dimensions of eating behavior: (I) cognitive restraint of eating, (II) disinhibition or lack of eating behavior restraint, and (III) susceptibility to hunger (Stunkard & Messick, 1985). From examining these three factors, psychologists can address various treatment options based on the behavioral tendencies of the individual. Those who have high scores for factor I, cognitive restraint of eating, may be more responsive to nutritional and caloric balance information that controls cognitive triggers. High scorers for factor II, disinhibition, may succeed with specific behavioral intervention plans that manage eating and minimize disinhibition, whereas high scorers of factor III, susceptibility to hunger, could benefit from techniques aimed at control hunger or even appetite suppressants (Stunckard & Messick, 1985).

Part One of the TEFQ presents 36 statements that could apply to the participant’s eating behavior and require a binary response (‘True’ or ‘False’). Part Two asks 15 questions and requires the participant to indicate their response on the labeled Likert scales (see Appendix B for both parts of TEFQ). Consistent with each survey, all three factors are randomly placed within the two parts, with 21 items measuring cognitive restraint of eating, 16 measuring disinhibition, and 14 measuring hunger. The scoring of the TFEQ was adapted from Stunkard and Messick (1985), with higher scores indicating strong tendencies towards that given dimension of eating behavior.

Procedure

Immediately upon completing the consent form, all participants indicated their intensity score of the PTC saturated paper strip. Next, each individual was called by his or her assigned identification number to have their tongue photographed. The participants then individually filed into a separate room where their height and weight were recorded to calculate the BMI measure. As each individual completed the sequence, they returned to the initial room where they were given a packet of surveys in the following order: FFLQ, TFEQ Part One, and then TFEQ Part Two. They were instructed to take their time filling out the surveys with no necessary breaks in between each separate questionnaire. Participants were debriefed and thanked for their time as they handed in their completed questionnaire packets.

Statistical Analyses

Using SPSS software, correlation analyses were conducted to detect significant relationships between the following variables: fungiform papillae density, sex, BMI, PTC score, cognitive restraint, disinhibition, susceptibility to hunger, the number of unknown foods reported from the FFLQ, mean liking score of all foods, mean liking score of fruits and vegetables, mean liking score of foods rarely served, mean liking score of spices, mean liking score of breakfast foods, mean liking score of animal products, mean liking score of high-density foods, and mean liking score of calorie-reduced foods. Next, independent samples *t*-tests were run to detect significant gender differences as well as significant differences between tasters and non-tasters. Additionally, 2x2 (gender by taster status) analyses of variance (ANOVA) were run to detect main effects as well as interactions.

Results

Correlations

A Pearson *r* correlational analysis showed a significant positive correlation between PTC score and fungiform papillae density, indicating that those with higher PTC scores also had higher fungiform papillae density, $r(30) = .72$, $p < .01$. A significant positive correlation was found for cognitive restraint and disinhibition, indicating that individuals showing high cognitive restraint, also display high disinhibition, $r(63) = .28$, $p < .05$. Additionally, a significant positive correlation was found between BMI and mean liking score of high-density foods, indicating that individuals with higher BMI levels tend to like foods of high caloric density, $r(63) = .36$, $p < .01$. Also, a significant negative correlation between PTC score and mean liking score of all foods was detected, suggesting that non-tasters, or individuals who reported lower PTC scores, displayed a higher liking for all foods than tasters, $r(63) = -.30$, $p < .05$. A significant negative correlation was also found between PTC score and mean liking score of spices, indicating that non-tasters displayed a higher liking for spices than tasters, $r(63) = -.28$, $p < .05$. Additionally, a negative trend was reported between BMI and fungiform papillae density, indicating that those with higher BMI levels displayed lower fungiform papillae density and were therefore more likely to be non-tasters, $r(30) = -.33$, $p < .75$.

Gender Differences

Table 1 shows means and standard deviations for selected physiological and psychological measures for both males and females. A *t*-test analyses indicated no significant differences between males and females in BMI, $t(61) = 1.08$, *ns*, fungiform papillae density, $t(28) = -.19$, *ns*, PTC score, $t(61) = -1.61$, *ns*, and susceptibility to hunger, $t(61) = -1.10$, *ns*. However, a significant difference was found between males and females for cognitive restraint, indicating that females demonstrate more cognitive restraint than males, $t(61) = -3.75$, $p < .001$. Also, a significant gender difference was found for disinhibition, suggesting that women show higher levels of disinhibition than males, $t(61) = -3.95$, $p < .001$.

Similarly, a *t*-test analysis was run to explore gender difference for food preferences as reported from the FFLQ, with means and standard deviations reported in Table 2. Although no significant differences between males and females were found for the number of unknown foods reported from the FFLQ, mean liking score of all foods, mean liking score of foods rarely served, mean liking score of spices, mean liking score of breakfast foods, mean liking score of animal products, and mean liking score of calorie-reduced foods, a significant gender difference was detected for the mean liking score for fruits and vegetables, indicating that women like fruits and vegetables more than males do, $t(61) = -2.10$, $p <.05$.

Taster Status Differences

An independent samples *t*-test was conducted to explore differences between tasters and non-tasters as classified by fungiform papillae density. Table 3 reports the mean and standard deviations of TFEQ and FFLQ measures for tasters and non-tasters. No significant differences were found in either eating behaviors or food preferences using fungiform papillae density as the measure assessing taster status.

Similarly, an independent samples *t*-test was conducted to explore differences between tasters and non-tasters as classified by PTC score. Table 4 reports the mean and standard deviations of TFEQ and FFLQ measures for tasters and non-tasters. A statistically significant difference between tasters and non-tasters was detected for overall mean liking scores of all foods, indicating that tasters are pickier eaters whereas non-tasters display overall higher liking for all foods, $t(61) = -3.00$, $p < .005$. Also, a statistically significant difference between tasters and non-tasters was found for mean liking score of spices, suggesting that non-tasters enjoy spices for than tasters, $t(61) = -2.25$, $p < .05$. Additionally, a significant difference between tasters and non-tasters was detected for mean liking scores of breakfast foods, indicating that non-tasters enjoy more breakfast foods than tasters, $t(61) = -2.10$, $p < .05$. A significant difference between tasters and non-tasters was found for mean liking scores of high-density foods, suggesting that non-tasters enjoy foods of high caloric density, $t(61) = -2.65$, $p < .01$. No significant differences were found for any other reported measures.

2x2 Analyses of Variance

Because the participant's PTC score was a more robust measure of taster status (as indicated in the previous paragraph), this classification was used in further analyses with a 2x2 (gender x taster status) ANOVA. The dependent variables used were chosen based on their significant findings in the independent samples *t*-tests outlined in the previous paragraph. For liking scores of all foods, taster status had a significant main effect, $F(1, 59) = 8.82$, $p < .005$. However, no significant main effect for gender, $F(1, 59) = 1.90$, *ns*, and no interaction between taster status and gender, $F(1, 59) = 0.01$, *ns,* were found. For liking scores of high-density foods, taster status had a significant main effect, $F(1, 59) = 4.60$, $p < .05$. However, no significant main effect for gender, $F(1, 59) = 1.17$, *ns*, and no interaction between taster status and gender, $F(1, 59) = .02$, *ns,* were found. When looking at the three different factors of eating, a significant main effect was found for gender on cognitive restraint, $F(1, 59) = 12.37$, $p < .001$. However, no significant main effect of taster status and no interaction between gender and taster status were detected. No other main effects or interactions were found when analyzing the other two factors (disinhibition and susceptibility to hunger) as dependent variables in a 2x2 ANOVAs.

Discussion

Taste responsiveness, determined by both PTC intensity ratings as well as fungiform papillae density, appears to play a role in the mediation of food preferences. Tasters, those with higher PTC scores as well as greater fungiform papillae density, express lower overall liking from their food and dislike spices. Similarly, tasters tend to be thinner than non-tasters; a possible physiological response to their dissatisfaction with food. These findings were consistent with correlations reported in previous studies (Drewnowski et al., 2003; Duffy & Hayes, 2008; Yackinous & Guinard, 2002). However, there were no findings that supported specific behavioral eating patterns and their connection to taster status, despite their inherent significance in weight maintenance.

Although PTC score correlated with fungiform papillae density, the results of this study suggest that PTC score was a better measure of taster status because it was correlated with more food-related variables. Tasters were identified as those individuals with fungiform papillae density greater than 25 cm^2, and PTC scores greater than 4 (Essick, Chorpa, Guest, & McGlone, 2003; Golding et al., 2009). Taster status was originally divided into non-tasters, tasters, and supertasters; however, because there was an insignificant number of supertasters, the classification of taster was modified to incorporate the data from supertasters as well.

Because it was determined that PTC intensity rating was a more robust measure of taster status, PTC scores were the primary measure used to find differences in taster status. Although no specific eating behaviors outlined in the TFEQ were found to significantly differ between tasters and non-tasters, preference and liking scores for spices, breakfast foods and foods of high caloric density were significantly higher for non-tasters. When looking at the foods included in breakfast foods, most are carbohydrates that are also high in caloric density. Given the implications of eating high-density foods and refined-sugary carbohydrates, the relationship between taster status, food preferences, as well as BMI is consistent with the biological processes.

Although gender differences were not the primary focus of this investigation, evidence was found supporting previous results that women show higher levels of cognitive restraint and disinhibition than males (Stunkard & Messick, 1985). Women—the majority of dieters—have been found to have higher susceptibility to outside factors that diminish their control over eating, as well as having heightened awareness of cognitive restraint. Although food preferences and liking scores largely did not differ between gender, evidence was found supporting that women like fruits and vegetables more so than men. It is likely that women choose to eat these healthier foods because of their sharpened awareness/knowledge of a well-balanced diet that often accompanies individuals with high cognitive restraint.

To identify the variables associated with fungiform taste receptors, a factor analysis was conducted. A varimax rotation converged in seven iterations to produce six factors with Eigenvalues over 1.0 (see Table 5). Of the 6 factors, notable patterns emerged with relevance to the present study. The first factor, which accounted for 25.4% of the variance, consisted of females who had high disinhibition, and high liking for food. Another factor, accounting for 10.2% of the variance, included the tasters, who displayed both high PTC scores as well as high density of fungiform papillae. A third factor, which accounted for 7.69% of the variance, was associated with high BMI, liking of all foods and in particular displayed liking for foods of high caloric density. These patterns are consistent with previous research as well as the other significance tests of the present study (Hayes, Bartoshuk & Duffy, 2008; Drewnowski et al., 2003; Yackinous & Guinard, 2002).

Because the study overemphasized the topic of eating behaviors through the collection of taste sensitivity, examination of the tongue, height and weight data, as well as questionnaires concerning eating, participants' overexposure to the topic relating to food choice could have desensitized their self-report measures. Although the physiological measures were most likely not influenced through this lack of deception, it is possible that the participants responded in a biased manner because the purpose of the experiment appeared more transparent. Because weight is a socially engrained struggle for virtually everyone, people are often subjected to the effects of social desirability. Participants could have felt pressured to respond to both the FFLQ and TEFQ in a manner they believed justified their recorded weight—to themselves and to anyone who could potentially see their responses. Likewise, although the study was conducted in a controlled setting, participants completed the surveys at their leisure in a group setting, and could have been distracted by the proximity and pace of their peers.

In some of the photographs, it was difficult to count fungiform papillae because the tongues appeared too dark. Because there was over-staining by the food coloring, photographs of only 30 tongues were clear enough to permit me to accurately count the number of papillae. In the future, tongues should be swabbed with minimal food coloring so that the fungiform papillae are not stained along with the filiform papillae. Additionally, participants were not notified to abstain from eating or drinking prior to and during the study, which could have affected their sensitivity response to the PTC paper. In one instance a participant entered the study having just used mouthwash, which could have potentially explained the difficulty they expressed in determining a PTC score.

Future studies could also explore other measures of eating behavior such as eating style and speed, rather than the diet behaviors which are the focus of the TFEQ. Although liking is a good indicator of food preference, satiety and food intake would be interesting options for further investigations. Potential observation of actual food consumption could provide a better assessment of eating behaviors than a self-report questionnaire. Also, it would be helpful to add different categories of foods or to include caloric beverages on the FFLQ in order to get a more comprehensive view of liking and food preference. Because the FFLQ used in the present study contained many food items that overlapped categories, it could be beneficial to include items that provide measures for only one given category so as not to overemphasize a certain type of food. Similarly, including a measure of intake frequency of the listed food item could also be helpful in determining a more accurate representation of food choice.

Studies have not deeply investigated the direct relationship between taster status and the healthy foods containing phytochemicals, so it could be helpful to narrow the focus of items to solely examine foods with clinically proven health benefits, or contrastingly, focus solely on fattier, creamier foods. Similarly, although BMI is a good measure of healthful weight, perhaps a more comprehensive assessment of healthiness could be examined. This could provide a better indication as to whether individuals benefit from the relationship between taste sensitivity and food aversions or rather if they are eliminating nutrients (such as phytochemicals found in fruits and vegetables or antimicrobial properties of spices) that are important to a healthy lifestyle—an implication that BMI does not necessarily detect. Additionally, investigating specific populations, such as obese individuals and those with eating disorders, could draw interesting results connecting taster status to anatomy of their orosensory systems. Because there were only six participants with BMI's associated with obesity and four participants with BMI's considered underweight, no conclusive results can be generalized to either of these populations.

Results from this study have shown than taster status, indicated by PTC intensity scores and fungiform papillae densities, explains heightened taste sensitivity and therefore influences food preferences. This relationship between taste anatomy and food intake provides important evidence that individuals may be biologically prone to liking and therefore consuming specific foods. Tasters, who report heightened sensitivity, do not enjoy foods as much as non-tasters. The present study's findings are unique in that tasters displayed lower liking for all foods, not just bitter items. Their overall lower liking could result in a tendency to not overeat, and therefore account for their thinness. The implications of these findings can be applied to the various weight management problems our society struggles with today. As previously suggested for future research, by understanding the taste anatomy of various target populations, we could expand our knowledge behind the causes of disordered eating behaviors and potentially focus intervention programs on these physiological tendencies.

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Table 1

Means and Standard Deviations for Selected Measures of Physiological and Pyschological Measures for Males and Females

	Male	Female
	M (SD)	*M (SD)*
BMI	25.51 (4.73)	24.04 (4.84)
Fungiform Papillae Density	16.38 (8.52)	16.95 (7.04)
PTC Score	4.24 (3.19)	5.80 (3.53)
Cognitive Restraint	5.59* (4.53)	11.02* (5.30)
Disinhibition	5.18* (2.04)	8.48* (3.21)
Suceptibility to Hunger	6.59 (3.64)	7.65 (3.32)

*$p < .001$, two-tailed.

Table 2

Means and Standard Deviations for Food Preferences for Males and Females

	Male	Female
	M (SD)	*M (SD)*
Number of Foods Not Tasted	10.18 (6.96)	11.00 (8.12)
Mean Liking Score:		
All Foods	5.76 (0.97)	5.90 (0.78)
Fruits and Vegetables	5.06* (1.12)	5.61* (0.86)
Foods Rarely Served	6.26 (1.39)	6.09 (1.19)
Spices	5.39 (1.19)	5.47 (1.34)
Breakfast Foods	6.32 (1.15)	6.60 (1.07)
Animal Products	6.16 (1.41)	6.12 (1.65)
Foods of High Caloric Density	6.47 (1.08)	5.82 (1.50)
Reduced Calorie Foods	5.22 (1.64)	5.76 (1.44)

*p < .05, two-tailed.

Table 3

Mean Responses (Standard Deviations) of Tasters and Non-Tasters as Classified by Density of Fungiform Papillae

	Taster	Non-Taster
	M (SD)	*M (SD)*
BMI	23.47 (4.91)	26.09 (6.12)
Cognitive Restraint	11.45 (6.44)	9.74 (5.29)
Disinhibition	6.82 (4.12)	7.42 (2.87)
Susceptibility to Hunger	6.64 (4.11)	6.68 (3.09)
Number of Foods Not Tasted	10.73 (8.31)	11.16 (9.44)
Mean Liking Score:		
All Foods	5.60 (0.71)	5.88 (0.66)
Fruits and Vegetables	5.30 (1.20)	5.58 (0.75)
Foods Rarely Served	5.75 (1.28)	5.88 (1.16)
Spices	4.97 (1.35)	5.63 (1.15)
Breakfast Foods	6.36 (1.28)	6.46 (1.19)
Animal Products	6.24 (1.65)	5.95 (1.12)
Foods of High Caloric Density	5.57 (1.08)	5.93 (1.20)
Reduced Calorie Foods	5.53 (1.59)	5.45 (1.38)

Table 4

Mean Responses (Standard Deviations) of Tasters and Non-Tasters as Classified by PTC Score

	Taster	Non-Taster
	M (SD)	*M (SD)*
BMI	23.50 (3.70)	25.88 (5.95)
Cognitive Restraint	9.89 (5.55)	9.04 (5.81)
Disinhibition	7.42 (3.33)	7.84 (3.25)
Susceptibility to Hunger	7.55 (3.69)	7.08 (2.99)
Number of Foods Not Tasted	9.84 (7.28)	12.20 (8.44)
Mean Liking Score:		
All Foods	5.63*** (0.83)	6.23*** (0.71)
Fruits and Vegetables	5.44 (0.10)	5.50 (0.91)
Foods Rarely Served	5.97 (1.39)	6.39 (0.95)
Spices	5.16* (1.12)	5.89* (1.44)
Breakfast Foods	6.30* (1.06)	6.87* (1.06)
Animal Products	5.92 (1.81)	6.46 (1.09)
Foods of High Caloric Density	5.63** (1.49)	6.55** (1.10)
Reduced Calorie Foods	5.35 (1.65)	6.02 (1.16)

* $p < .05$, two-tailed. ** $p < .01$, two-tailed. ***$p < .005$, two-tailed.

Table 5

Factor Analysis

	Component					
	1	2	3	4	5	6
Fungiform Papillae Density				0.831		
0 = Male, 1 = Female	0.548	0.52				
BMI					0.844	
PTC Score				0.938		
Cognitive Restraint			0.744			
Disinhibition	0.650					0.408
Susceptibility to Hunger						0.931
Number of Foods Not Tasted			-0.740			
Mean Liking Score:						
All Foods	0.496	0.728			0.352	
Fruits and Vegetables		0.891				
Foods Rarely Served		0.659				
Spices			0.775	-0.363		
Breakfast Foods	0.716					
Animal Products	0.818					
Foods of High Caloric Density					0.856	
Reduced Calorie Foods	0.753					

Note. Varimax rotation converged in 7 iterations.

Appendix A

Food Familiarity Liking Questionnaire

Table A1

Rigal et al. (2006) Original 60-Item FFLQ

Fruits and Vegetables (20)	Kiwi	Breakfast Foods (7)	Cereals
	Lemon		Coffee
	Pear		Semi-skimmed milk
	Pineapple		Plain Yoghurt
	Aubergine		Rusk
	Broccoli		White Cheese 20% Fat
	Cauliflower		Yoghurt with Fruit
	Celery in Puree	Animal Products (6)	Boiled Egg
	Cooked Endive		Fresh Fish
	Cooked Beetroot		Guinea Fowl
	Courgette		Liver
	Green Beans		Shrimps
	Flageolet		Turkey
	Leeks	High-density Foods (9)	Black Chocolate
	Peas		Bon Bon
	Radish		Camembert
	Raw Cabbage		Coca-Cola
	Raw Endive		Fresh Cream
	Spinach		Mayonnaise
	Turnips		Raw Milk
Never Served Foods (6)	Blood Sausage		Sugar
	Cress		White Cheese 40% Fat
	Salted Groundnuts	Reduced Calorie Foods (8)	Creamed Milk
	Saucisson		White Cheese 0% Fat
	Sparkling Water		Light Butter
	Sweetened Baby Food		Light Coca-Cola
Spices (4)	Aromatic Plants		Light Mayonnaise
	Hot Spices		Light White Cheese
	Mustard		Mineral Water
	Salt		Sweetner

Table A2

Modified 60-Item FFLQ

Fruits and Vegetables (20)	Kiwi	Breakfast Foods (7)	Cereals
	Lemon		Coffee
	Pear		Skim Milk
	Pineapple		Plain Yogurt
	Eggplant		Biscotti
	Broccoli		Cream Cheese, Regular
	Cauliflower		Yogurt with Fruit
	Celery	Animal Products (6)	Hard Boiled Egg
	Cooked Collard Greens		Fresh Fish
	Beets		Cornish Game Hen
	Zucchini		Liver
	Green Beans		Shrimps
	Lima Beans		Turkey
	Green Onions	High-density Foods (9)	Black Chocolate
	Peas		Chocolate Glazed Donut
	Radish		Bleu Cheese
	Raw Cabbage		Coca-Cola
	Raw Collard Greens		Whipped Cream
	Spinach		Mayonnaise
	Turnips		Whole Milk
Never Served Foods (6)	Sausage		Sugar
	Water Cress		Cheddar Cheese, Regular
	Salted Nuts	Reduced Calorie Foods (8)	Half and Half Creamer
	Chitlins		Cottage Cheese, Fat Free
	Sparkling Water		Margarine
	Sweetened Baby Food		Diet Coca-Cola
Spices (4)	Basil		Light Mayonnaise
	Pepper		Cheddar Cheese, Fat Free
	Mustard		Mineral Water
	Salt		No Calorie Sweetner

Appendix B

Three Factor Eating Questionnaire (TFEQ)

For Part One, the correct answer is underlined and beside it is the number of the factor that it measures. For each item answered correctly in Part One, one point is given to the factor it measures. For Part Two, the correct options are bold face and italicized, and beside it is the number of the factor it measures. For each item answered using any of the correct options in Part Two, one point is given to the factor it measures.

Part One

			Factor Number
1. When I smell a sizzling steak or see a juicy piece of meat, I find it very difficult to keep myself from eating, even if I have just finished a meal.	T	F	2
2. I usually eat too much at social occasions, like parties and picnics.	T	F	2
3. I am usually so hungry that I eat more than three times a day.	T	F	3
4. When I have eaten my quota of calories, I am usually good about not eating anymore.	T	F	1
5. Dieting is so hard for me because I just get too hungry.	T	F	3
6. I deliberately take small helpings as a means of controlling my weight.	T	F	1
7. Sometimes things just taste so good that I keep on eating even when I am no longer hungry.	T	F	2
8. Since I am often hungry, I sometimes wish that while I am eating, an expert would tell me that I have had enough or that I can have something more to eat.	T	F	3
9. When I feel anxious, I find myself eating.	T	F	2
10. Life is too short to worry about dieting.	T	F	1
11. Since my weight goes up and down, I have gone on reducing diets more than once.	T	F	2
12. I often feel so hungry that I just have to eat something.	T	F	3
13. When I am with someone who is overeating, I usually overeat too.	T	F	2
14. I have a pretty good idea of the number of calories in common food.	T	F	1
15. Sometimes when I start eating, I just can’t seem to stop.	T	F	2
16. It is not difficult for me to leave something on my plate.	T	F	2
17. At certain times of the day, I get hungry because I have gotten used to eating then.	T	F	3
18. While on a diet, if I eat food that is not allowed, I consciously eat less for a period of time to make up for it.	T	F	1
19. Being with someone who is eating often makes me hungry enough to eat also.	T	F	3
20. When I feel blue, I often overeat.	T	F	2

21. I enjoy eating too much to spoil it by counting calories or watching my weight.	T	<u>F</u>	1
22. When I see a real Delicacy, I often get so hungry that I have to eat it right away.	<u>T</u>	F	3
23. I often stop eating when I am not really full as a conscious means of limiting the amount that I eat.	<u>T</u>	F	1
24. I get so hungry that my stomach often seems like a bottomless pit.	<u>T</u>	F	3
25. My weight has hardly changed at all in the last ten years.	T	<u>F</u>	2
26. I am always hungry so it is hard for me to stop eating before I finish the food on my plate.	<u>T</u>	F	3
27. When I feel lonely, I console myself by eating.	<u>T</u>	F	2
28. I consciously hold back at meals in order not to gain weight.	<u>T</u>	F	1
29. I sometimes get very hungry late in the evening or at night.	<u>T</u>	F	3
30. I eat anything I want, any time I want.	T	<u>F</u>	1
31. Without even thinking about it, I take a long time to eat.	T	<u>F</u>	2
32. I count calories as a conscious means of controlling my weight	<u>T</u>	F	1
33. I do not eat some foods because they make me fat.	<u>T</u>	F	1
34. I am always hungry enough to eat at any time.	<u>T</u>	F	3
35. I pay a great deal of attention to changes in my figure.	<u>T</u>	F	1
36. While on a diet, if I eat a food that is not allowed, I often splurge and eat other high calorie foods.	<u>T</u>	F	2

Part Two

1. How often are you dieting in a conscious effort to control your weight?

1	2	***3***	***4***	
Rarely	Sometimes	***Usually***	***Always***	1

2. Would a weight fluctuation of 5 lbs affect the way you live your life?

1	2	***3***	***4***	
Not at all	Slightly	***Moderately***	***Very much***	1

3. How often do you feel hungry?

1	2	***3***	***4***	
Only at mealtimes	Sometimes between meals	***Often between meals***	***Almost always***	3

4. Do your feelings of guilt about overeating help you to control your food intake?

1	2	***3***	***4***	
Never	Rarely	***Often***	***Always***	1

5. How difficult would it be for you to stop eating halfway through dinner and not eat for the next four hours?

1	2	***3***	***4***	
Easy	Slightly difficult	***Moderately difficult***	***Very difficult***	3

6. How conscious are you of what you are eating?

1	2	***3***	***4***	
Not at all	Slightly	***Moderately***	***Very***	1

7. How frequently do you avoid ‘stocking up’ on tempting foods?

1	2	***3***	***4***	
Almost never	Seldom	***Usually***	***Almost always***	1

8. How likely are you to shop for low calorie foods?

1	2	***3***	***4***	
Unlikely	Slightly unlikely	***Moderately unlikely***	***Very likely***	1

9. Do you eat sensibly in front of others and splurge alone?

1	2	***3***	***4***	
Never	Rarely	***Often***	***Always***	2

10. How likely are you to consciously eat slowly in order to cut down on how much you eat?

1	2	***3***	***4***	
Unlikely	Slightly likely	***Moderately likely***	***Very likely***	1

11. How frequently do you skip dessert because you are no longer hungry?

1	***2***	3	4	
Almost never	***Seldom***	At least once a week	Almost everyday	3

12. How likely are you to consciously eat less than you want?

1	2	***3***	***4***	
Unlikely	Slightly likely	***Moderately likely***	***Very likely***	1

13. Do you go on eating binges though you are not hungry?

1	2	***3***	***4***	
Never	Rarely	***Sometimes***	***At least once a week***	2

14. On a scale of 0 to 5, where 0 means no restraint in eating (eating whatever you want, whenever you want it) and 5 means total restraint (constantly limiting food intake and never 'giving in'), what number would you give yourself?

0- Eat whatever you want, whenever you want it
1- Usually eat whatever you want, whenever you want it
2- Often eat whatever you want, whenever you want it
3- Often limit food intake, but often 'give in'
4- Usually limit food intake, rarely 'give in'
5- Constantly limiting food intake, never 'giving in' 1

15. To what extent does this statement describe your eating behavior? "I start dieting in the morning, but because of any number of things that happen during the day, by evening I have given up and eat what I want, promising myself to start dieting again tomorrow."

1	2	***3***	***4***	
Not like me	Little like me	***Pretty good description of me***	***Describes me perfectly***	2