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Taste Assessment in Normal Weight and Overweight Individuals with Co-Occurring Binge Eating Disorder

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Abstract

Background—Taste perception influences food choice, and may contribute to both weight status and disordered eating. Relatively little work has attempted to disentangle contributions of weight status and Binge Eating Disorder (BED) to human taste perception. We predicted weight status and BED would interact, showing difference in taste perception from non-eating disorder matched groups.

Methods—The four study groups included: normal weight BED (NW BED), normal weight healthy controls (NW HC), overweight BED (OW BED), and overweight healthy controls (OW HC) ($N = 60$). Groups were matched for age (± 5 years), ethnicity, and weight status. Participants were assessed using the Structured Clinical Interview for DSM-IV Axis I Disorders, the Eating Disorder Examination Version 16.0, and the NIH Toolbox Gustatory Assessment with additional taste solutions and taste stimulus delivered with edible taste strips.

Results—Interactions were found between weight status and diagnosis on measures of regional taste intensity for quinine hydrochloride (CI 95% [44.61, 56.31], $p = .018$), sucrose (CI 95% [46.79, 56.45], $p = .003$), and 6-*n*-propylthiouracil (CI 95% [25.557, 39.269], $p = .015$). OW BED participants perceived these taste stimuli significantly less intensely than OW HC and NW BED. Whole mouth taste intensity tests at suprathreshold amounts did not reveal group differences. All four groups reported similar hedonic response to taste stimuli. Edible taste strips had medium to large significant correlations with NIH Gustatory Assessment taste stimuli.

Conclusions—There were significant differences in the taste perception of OW BED relative to the other three groups. These findings may provide partial explanation as to why previous studies correlating taste and weight status have mixed results. Replication in larger samples assessed longitudinally is needed to extend this work.

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Conflict of Interest:

Eunice Y. Chen, Ph.D. discloses annual royalties from Guilford Press, and has consulted to Shire Pharmaceuticals in the last three years. All other authors declare no potential conflict of interest with the current work.

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Keywords

Binge Eating Disorder; Obesity; Taste Sensitivity; NIH Gustatory Assessment

Introduction

Taste intensity, taste quality, and hedonic response play an important role in food selection, and influence food intake patterns (Drewnowski, 1997). The bitter taste stimuli, 6-*n*-propylthiouracil (PROP) and quinine hydrochloride (HCI) encourage aversion, and the sweet taste stimulus, sucrose, encourage approach. These are the most researched tastes in weight and eating disorders, however gaps remain in our characterizations of taste perception, specifically in Binge Eating Disorder (BED).

BED is marked by aberrant eating patterns, including frequent binges, where objectively large amounts of food are consumed rapidly in a finite time period. Binge foods typically have high sugar, high salt, high fat, and low protein content (Yanovski et al., 1992). BED co-occurs with obesity, with approximately 23–55% of overweight individuals seeking weight loss treatment also meeting BED criteria (Linde et al., 2004). Though taste perception contributes to food selection and intake, taste has not yet been studied in BED nor have differences in taste perception been disentangled from the effect of weight status. Given that individuals with BED appear to have a distinct preference for sweet and salty taste stimuli during bingeing, any differences in taste perception specific to BED are important to identify to better understand the etiology of the disorder and inform therapeutic interventions (Yanovski et al., 1992).

Sensitivity to bitter tastes is regarded as representative of overall taste functioning (Coldwell et al., 2013). Associations between bitter taste stimuli and weight have produced mixed results. Perception of quinine HCI bitterness is relatively universal, and sensitivity to quinine HCI is associated with consuming plant products (Coldwell et al., 2013), whereas PROP perception is partly determined by fungiform papillae density and the *TAS2R38* receptor genotype (Calò et al., 2011; Hayes, Bartoshuk, Kidd, & Duffy, 2008). Taste blindness to PROP is associated with preference for high calorie foods (Duffy & Bartoshuk, 2000; Hayes & Duffy, 2007; Tepper, Neilland, Ullrich, Koelliker, & Belzer, 2011; Tepper & Nurse, 1998). Some studies show an inverse correlation between PROP perception and Body Mass Index (BMI) (Goldstein, Daun, & Tepper, 2005; Tepper, 1999, 2008; Tepper et al., 2008; Tepper & Ullrich, 2002), while others show that very low weight restrictive eating disorders are associated with reduced sensitivity to PROP (Barbosa et al., 2015; Mitchell & Crow, 2006; Polivy, 1996). Additional examinations of BMI and PROP have revealed no association (Drewnowski, Henderson, & Cockroft, 2007; Kaminski, Henderson, & Drewnowski, 2000; Yackinous & Guinard, 2001, 2002). Importantly, obesity is highly heterogeneous and there are likely multiple endophenotypes within a given obese sample (Sacks et al., 2009). As such, there is a need to examine biological and psychological variations within samples of the same weight status to differentiate these endophenotypes. Differentiating endophenotypes within obesity may subsequently allow for more efficacious interventions. Some have hypothesized that BED is a specific endophenotype of obesity (Hudson et al.,

2006). Taste perception may be one way to differentiate a BED-specific endophenotype. Those with co-occurring BED may perceive taste differently, and this finding could account for the mixed results in taste perception and weight status research.

The link between sweet taste perception and obesity is unclear. While some studies have revealed a positive association between BMI and hedonic response to sucrose, others have found an inverse relationship, and others have found no association (Drewnowski, Brunzell, Sande, Iverius, & Greenwood, 1985; Drewnowski, Kurth, Holden-Wiltse, & Saari, 1992; Frijters & Rasmussen-Conrad, 1982; Grinker, 1978; Malcolm, O'Neil, Hirsch, Currey, & Moskowitz, 1979; Salbe, DelParigi, Pratley, Drewnowski, & Tataranni, 2004). Undetected eating disorder pathology may muddle these results. For example, while there is a correlation between self-reported hedonic response and neural response to sucrose in normal weight healthy individuals, there is no correlation between these responses in normal weight individuals with a history of very low weight, restrictive eating disorders (Wagner et al., 2008). In contrast, normal weight women with Bulimia Nervosa relative to normal weight women without eating disorders, report greater hedonic liking of sweet taste stimuli (Franko, Wolfe, & Jimerson, 1994). Eating disorders including BED may influence taste perception relative to individuals without eating disorders. To our knowledge, there are currently no studies examining sucrose taste perception in BED.

The current study examines taste intensity and hedonic response in four groups matched for age, ethnicity, and weight status; normal weight BED (NW BED), normal weight women without BED (NW HC), overweight BED (OW BED), and overweight HC. Women have been shown to have more fungiform papillae, the taste buds that respond to sweet, sour, bitter, and salty tastes, than men (Bartoshuk, Duffy, & Miller, 1994; Miller & Reedy, 1990). There is evidence for differential neural responses to sweet taste stimuli in men compared with women (Cornier et al., 2015). To avoid confounds introduced by sex difference, only women were included in this sample. The modified NIH Toolbox Gustatory Assessment and edible taste strips containing one of two different taste stimuli were used to examine taste perception with the objective of clarifying the role of weight status and BED (Coldwell et al., 2013; Smutzer, Desai, Coldwell, & Griffith, 2013; Smutzer et al., 2008). We predicted that eating disorder status and weight status would interact, showing differences in OW BED and NW BED relative to HC groups. We also predicted an additional interaction between eating disorder status and weight status, where OW BED and NW BED would report different hedonic response from sucrose taste compared with HC groups on NIH Gustatory Assessment measures. Finally, we predicted ratings on PROP and sucrose-containing edible taste strips ratings would correspond to ratings on these same measures within NIH Gustatory Assessment in this clinical sample.

Methods and Materials

Participants

This study was conducted at a northeastern United States university and was approved by the university's Internal Review Board. All participants provided written consent before beginning the study. Participants included 60 women between the ages of 18 and 57 years

($M = 27.82$, $SD = \pm 10.11$) recruited through paper and online advertisements from the local community as a part of a larger study.

Measures

Eating Disorder Examination Version 16.0—The EDE (Fairburn, Wilson, & Schleimer) is an assessor-driven, semi-structured interview that assesses behavioral features and cognitions associated with eating disorders. The EDE has both good inter-rater and test-retest reliability for BED (Grilo, Masheb, Lozano-Blanco, & Barry, 2004). The assessor rates items by degree of severity from 0 (no or minimal symptom) to 6 (extremely severe symptom). Individuals in the BED group met criteria as outlined in the Diagnostic and Statistical Manual (DSM) 5 (American Psychiatric Association, 2013).

NIH Toolbox Gustatory Assessment—The NIH Toolbox for Assessment of Neurological and Behavior Function offers a gustatory assessment, along with directions for assessing whole mouth and regional taste sensitivity of sweet, salty, and bitter (Coldwell et al., 2013). Four taste stimuli were presented following the procedures described by Coldwell et al. (2013); bitter (quinine HCl), salty (sodium chloride), sweet (sucrose), and bitter (PROP). Two measures of bitter taste perception were included because, while quinine HCl is detectable to most, some individuals show taste blindness to PROP (Bartoshuk, 1979).

Edible Taste Strips—Edible taste strips were prepared using a pullulan base with the polymer hydroxypropyl methylcellulose (HPMC) at a 11.5:1 wt. ratio of pullulan to HPMC, as in Smutzer et al. (2008). Two taste stimuli were prepared; sucrose and PROP. Sucrose strips contained between 2.5% to 5% wt/vol of taste stimulus, and PROP strips contained 0.11% wt/vol of taste stimulus. These levels are considerably above the established suprathreshold for each respective taste and have been validated previously as a highly sensitive tool for assessing human taste perception (Smutzer et al., 2013; Smutzer et al., 2008).

Weight Status

Participants' heights and weights were measured using a Health-o-Meter 500KL Professional Digital Scale and stadiometer to calculate Body Mass Index (BMI). BMI classifications from the World Health Organization (2011) were used. Normal weight was defined as a BMI between 18.50 and 24.99. Overweight was defined as a BMI ≥ 25.00 .

Procedure

All participants underwent a clinical diagnostic interview using the Eating Disorder Examination (EDE) Version 16.0 and the Structured Clinical Interview for DSM Disorders-IV (SCID-1) (Fairburn et al., 1993; First, Spitzer, Gibbon, & Williams, 1997). HC participants were matched to BED participants by age (± 5 years), ethnicity, and weight status, forming the four study groups.

During administration of the NIH Gustatory Assessment, participants were presented with each taste stimulus separately and regional taste intensity was assessed first. Participants were asked to saturate a Q-tip in the taste stimulus, spread the taste stimulus across the

anterior of the tongue, and then use the general Labeled Magnitude Scale (gLMS) to rate taste intensity (i.e. “no sensation” = 0 to “strongest imaginable sensation of any kind” = 100) and liking of the taste (i.e. “Disliked” = 0 to “Liked” = 100) (Bartoshuk et al., 2004). Participants were trained in the use of the gLMS. Between each administration, participants were asked to rinse their mouths with 10 ml of water. Participants were then assessed for whole mouth sensitivity by taking a sip of the taste stimulus and completing the same rating procedure. Once again, between each administration, participants were asked to rinse their mouths with water. During administration of edible taste strips, participants were given each strip individually to place on the tongue, allowing the strip to dissolve, and then asked to identify the taste and use the gLMS to rate taste intensity. Between each administration, participants were asked to rinse their mouths with water.

Data Analytic Plan

Weight status and BED group were coded as two binary variables, where 0=NW and 1=OW, and 0=HC and 1=BED. Ethnicity status was coded as 0=Caucasian and 1=African-American, Hispanic/Latina, Asian or multiracial. Participant groups differed significantly on age and ethnicity, therefore these two variables were used as covariates in all subsequent analyses. The main analysis examined whether intensity and hedonic liking differed (1) between weight statuses, (2) between BED diagnosis groups or (3) if there was an interaction between weight status and BED diagnosis group for each NIH Gustatory Assessment taste stimulus (quinine HCl, sodium chloride, sucrose, and PROP). For this analysis we used a 2 (Weight status: NW or OW) x 2 (BED diagnosis: BED or HC) multivariate analysis of covariance (MANCOVA) with the dependent variable as the taste stimulus. Significant interaction effects were further examined using simple contrasts. Cut-off conventions from Cohen (1988) were used to define partial η^2 effect sizes as small (0.01), medium (0.06) and large (0.14). Given the small sample size of this study and its exploratory nature, the p values are presented uncorrected (Gelman, Hill, & Yajima, 2012; Nakagawa, 2004).

First-order partial correlations controlling for age and ethnicity were conducted to examine the relationship between the NIH Gustatory Assessment measures of sucrose and PROP, and edible taste strips containing sucrose or PROP. Cut-off conventions from Cohen (1988) were used to define r effect sizes as small (0.10), medium (0.30), and large (0.50).

Results

Participant Characteristics

Table 1 lists the demographic characteristics of the sample population. The normal weight groups were younger [$F(58) = 38.64, p < .001$] and had a greater proportion of Caucasian participants [$X^2(1, N = 60) = 13.03, p < .001$] than the overweight weight groups. There were no significant differences in education level or household income. Participant groups differed significantly on ethnicity [$X^2(3) = 13.30, p = .003$] and age [$F(3, 56) = 9.07, p < .001$]. Groups were significantly different on Global EDE scores [$F(3, 53) = 17.82, p < .001$]. Post-hoc test confirmed that NW BED groups scored significantly higher than NW HC ($p < .001$) and OW HC ($p = .046$) groups, and that OW BED scored significantly higher than NW

HC ($p < .001$) and OW HC ($p < .001$) groups. Among BED participants, 7 (23%) met diagnostic criteria for a lifetime history of mood disorder, and 4 (13%) met diagnostic criteria for a lifetime history of anxiety disorder.

NIH Gustatory Assessment

The MANCOVA examining regional taste intensity revealed a significant large overall effect of group, $F(4, 51) = 3.96, p = .007, \eta_p^2 = .24$. Subsequent univariate analyses revealed a significant interaction of group on intensity measures of quinine HCI [$F(1, 54) = 5.96, p = .018, \eta_p^2 = .10$ CI 95% [44.61, 56.31]], sucrose [$F(1, 54) = 9.74, p = .003, \eta_p^2 = .15$ CI 95% [46.79, 56.45]], and PROP [$F(1, 54) = 6.27, p = .015, \eta_p^2 = .10$ CI 95% [25.557, 39.269]].

Simple main effects analyses were performed for each of the three significant taste stimuli: quinine HCI, sucrose and PROP. OW BED reported significantly less intense taste of quinine HCI compared with NW HC [$t(28) = 2.44, p = .021$], NW BED [$t(28) = 2.92, p = .019$], and OW HC [$t(28) = 2.86, p = .008$]. For sucrose, OW BED reported significantly less intense taste compared with OW HC [$t(28) = 2.80, p = .004$] and NW BED [$t(28) = 2.40, p = .029$]. Finally, OW BED reported significantly less intense perception of PROP compared to OW HC [$t(28) = 2.69, p = .012$] and NW BED [$t(28) = 2.50, p = .019$]. Figure 1 displays these results.

The MANCOVA examining regional taste liking showed no significant overall effect of group, $F(4, 49) = 1.67, p = .172, \eta_p^2 = .12$. Both analyses for whole mouth intensity [$F(4, 51) = 1.01, p = .172, \eta_p^2 = .07$] and whole mouth hedonic liking [$F(4, 49) = 0.37, p = .826, \eta_p^2 = .03$] revealed no significant group effects. Table 2 lists these results.

Edible Taste Strips

Whole mouth and regional taste intensity measures were significantly positively correlated with taste intensity measures with edible taste strips for both sucrose and PROP, and these effect sizes were medium to large. On measures of subjective liking of sucrose taste perception, regional taste liking was significantly positively correlated with sucrose taste strips with a medium effect size, $r(53) = .32, p = .018$. For PROP, whole mouth liking was significantly positively correlated with PROP taste strips with a medium to large effect size, $r(50) = .44, p = .001$. Table 3 lists all correlations.

Discussion

The current study examined taste perception in individuals with and without BED, and of normal weight and overweight status. We observed interactions between BED and weight status in regional taste intensity measures of bitter and sweet tastes using the NIH Gustatory Assessment, and controlling for age and ethnicity. Significant differences were found consistently between OW BED and OW HC on taste intensity experience of quinine HCI, sucrose, and PROP. These findings may provide partial explanation as to why previous studies attempting to correlate taste perception and weight status have had mixed results.

Proposed models of obesity and BED suggest that individuals who are more vulnerable to these conditions have higher reward sensitivity to anticipated consumption of highly

palatable foods relative to lean individuals, and this sensitivity may be even more pronounced in BED (Schag, Schönleber, Teufel, Zipfel, & Giel, 2013; Val-Laillet et al., 2015). This reward sensitivity may increase motivation to consume or over consume high fat, high sugar foods. Conversely, preclinical evidence demonstrates that patterns of food bingeing over time reduce sensitivity to the rewarding properties of food, and some evidence suggests that longer-term, individuals who are obese experience reduced reward during palatable food consumption (Avena, 2010; Val-Laillet et al., 2015). Thus, OW BED individuals may have increased reward sensitivity to anticipating consuming highly palatable foods, but dampened reward experience during actual consumption. This may lead to overeating and bingeing in an attempt to match the anticipated reward. The observed decreased sensitivity to both aversive and pleasant tastes found in the current study fits coherently in this model. In addition, decreased taste sensitivity may further predispose an individual to bingeing on high calorie content foods, as tastes experienced less intensely may fail to deliver an expected component of the reward, leading to further bingeing in an attempt to compensate. Further examination of anticipated and actual receipt of sweet and bitter tastes in OW BED is needed to support this conclusion. Additionally, given that taste perception is determined by genetic, biological, and psychological factors, these findings suggest taste perception may be a potential candidate for further endophenotype research in OW individuals with and without BED.

We did not observe differences in NW BED relative to HC groups, though this group differed from OW BED on quinine HCI, sucrose, and PROP taste intensity measures. It is difficult to theorize about the pattern of results for NW BED as very little has been published about this population, and this is the first examination of taste conducted in this group. It is plausible that years of bingeing behavior and overeating alter taste sensitivity in individuals who develop OW BED. Thus decreased taste intensity may not be a risk factor for BED but a consequence of binge eating, chronic overeating, and weight gain. It is also plausible that NW BED represents a distinct trajectory from OW BED. Recent literature suggests NW BED may be more similar to Bulimia-Nervosa (Carrard, Linden, & Golay, 2012). Individuals with NW BED may engage in smaller objective binges, less frequent binges, more dietary restriction between binges, or some combination of these behaviors over time, thereby protecting them from weight gain. Unlike observations of OW BED individuals, NW BED may also not engage in chronic overeating in addition to binge behavior (Masheb & Grilo, 2006). If NW BED is more similar to Bulimia-Nervosa, then previous work suggests there may not be strong observed differences between this group and HC groups (Rodin, Bartoshuk, Peterson, & Schank, 1990). However, our conclusions must be limited by the cross-sectional nature of this study, therefore longitudinal work on the trajectory of weight gain and BED is needed.

Additionally, no significant differences were observed in salt taste intensity or hedonic response in the NIH Gustatory Assessment. Previous literature suggests that while there may be differences in perception thresholds of salt taste for obese individual compared with non-obese, these differences are often not statistically significant (Ekmekcioglu et al., 2016; Pepino et al., 2014). Our results support this finding, and extend this finding to NW BED and OW BED. Other work suggests differences in intensity and liking of salty tastes

between weight statuses may appear when salt taste is presented with fat (Deglaire et al., 2015; Nasser, 2001).

We did not find differences in whole mouth measures of the NIH Gustatory Assessment. While regional taste intensity measures assessed the area where the highest concentration of taste buds are located on the tongue, whole mouth measures generally assess all taste buds on the tongue. Lack of difference may be due to the small sample size, or a difference in taste bud concentration at the tip of the tongue between groups.

We further validated the use of edible taste strips as a viable addition or alternative to the NIH Gustatory Assessment for taste perception evaluation in clinical and non-clinical populations. Both the PROP and sucrose taste strip intensity ratings significantly and positively correlated with the NIH Gustatory Assessment intensity ratings. Though there were significant associations between these two instruments on taste intensity experiences, not all of the subjective liking measures from the NIH Gustatory Assessment correlated with edible taste strips. This may be due to sample size, or this may be related to the difference in ‘mouthfeel’ between the two instruments. While the NIH Gustatory Assessment uses liquid taste stimuli, taste strips are made of rapidly dissolving edible polymers that cause virtually no tactile response. This highlights that multiple factors within taste experience influence hedonic response, and consideration should be taken in selecting and reporting on different taste assessment instruments.

Strengths and Limitations

A major strength of this study is that, to our knowledge, this is the first examination of taste perception in these four groups. There is a paucity of taste research that disentangles weight status and eating behavior. The BED groups in the current study were matched with HC groups by weight status, age, and ethnicity, allowing for examination of the contributions of both the presence of an eating disorder and weight status independently and together. An additional strength of the current study is the inclusion of the NW BED group. BED is characterized by regular food binges that may result in overconsumption of calories, and lead to weight gain. This makes the recruitment and study of NW BED individuals particularly challenging. This study contributes to the small body of literature on NW BED individuals.

The current study is limited by sample size, and it is possible that increasing the number of study participants would result in statistically significant differences in whole mouth gustatory measures. Additionally, this is a cross-sectional study, thus the cause of the observed differences cannot be determined. Future work should seek to address these limitations with longitudinal studies.

Conclusion

Our findings fill a gap in the literature on distinctions in taste perception between weight disorders and BED. While taste is one component in a large system of psychological and biological processes that determine food selection, differences in taste perception may have cumulative consequences. Densely caloric foods which are engineered to be hyper palatable

are easily available, and regular consumption of these foods has exponentially increased. In seeking to understand why certain individuals over-consume or binge on these foods, an understanding of associations between weight gain, disordered eating, and taste differences may provide an additional piece of the puzzle.

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Figure 1. Regional Taste Intensity Mean ratings for quinine hydrochloride (HCl), sucrose, and 6-*n*-propylthiouracil (PROP); gLMS = general Labeled Magnitude Scale, HC = Healthy Control, BED = Binge Eating Disorder

Table 1

Demographics in a sample of 60 women, 18–57 years old by diagnostic group and weight status

	NW HC	NW BED	OW HC	OW BED
Age Mean (SD) *** ^a	21.38 (3.12)	21.69 (3.18)	35.27 (11.46)	35.27 (11.46)
BMI Mean (SD)	21.62 (1.56)	22.29 (1.88)	30.74 (3.26)	33.06 (3.39)
EDE Mean (SD) *** ^b	0.46 (0.60)	1.90 (1.04)	1.21 (0.87)	2.70 (0.96)
Race N (%)				
White	12 (80%)	12 (80%)	5 (33%)	5 (33%)
Black/African American	0 (0%)	1 (7%)	9 (60%)	8 (53%)
Asian	2 (13%)	2 (13%)	0 (0%)	0 (0%)
Hispanic	1 (7%)	0 (0%)	1 (7%)	1 (7%)
Other	0 (0%)	0 (0%)	0 (0%)	1 (7%)
Education N (%)				
Some College	14 (93%)	13 (87%)	14 (93%)	11 (73%)
No College	1 (7%)	2 (13%)	1 (7%)	4 (27%)
Income Household N (%)				
\$0 – \$24,999	10 (67%)	12 (80%)	6 (40%)	10 (67%)
\$25,000 – \$49,999	5 (33%)	1 (7%)	7 (47%)	3 (20%)
>\$50,000	0 (0%)	2 (13%)	2 (13%)	2 (13%)

Note: NW = Normal Weight; OW = Overweight; HC = Healthy Control; BED = Binge-Eating Disorder; BMI = Body Mass Index;

*
p < .05**
p < .01***
p < .001;^a NW OW,^b NW HC NW BED & OW BED, OW HC OW BED

MANCOVA results for NIH Toolbox Gustatory Assessment by diagnostic group and weight status, controlling for age and ethnicity

Table 2

	NW HC (n = 15)	NW BED (n = 15)	OW HC (n = 15)	OW BED (n = 15)	Weight Status		BED Diagnosis		Weight Status*BED				
					F(df = 1, 54)	p	η^2	F(df = 1, 54)	p	η^2	F(df = 1, 54)	p	η^2
Regional Taste Strength Mean (SD)													
QHCl ^a	54.99 (21.90)	58.00 (18.18)	57.17 (17.41)	31.68 (29.78)	1.44	.24	0.03	3.70	.06	0.06	5.96	.018	0.10
NaCl	68.53 (14.73)	68.83 (15.04)	63.47 (12.19)	58.45 (15.43)	0.02	.89	0.00	0.27	.61	0.01	0.56	.46	0.01
Sucrose ^b	48.91 (17.75)	58.37 (14.88)	59.89 (9.11)	39.31 (26.93)	0.23	.63	0.00	1.27	.26	0.02	9.74	.003	0.15
PROP ^b	29.60 (28.79)	38.83 (25.61)	43.15 (30.47)	18.08 (19.45)	0.01	.94	0.00	1.40	.24	0.03	6.27	.015	0.10
Regional Taste Liking Mean (SD)													
QHCl	20.59 (15.61)	20.05 (15.67)	23.26 (13.94)	31.57 (20.02)	0.47	.50	0.01	0.69	.41	0.01	1.10	.30	0.02
NaCl	49.97 (28.78)	44.37 (24.38)	43.14 (28.46)	43.63 (27.81)	0.71	.40	0.01	0.07	.79	0.00	0.14	.71	0.00
Sucrose	61.15 (23.78)	68.96 (20.59)	70.69 (17.07)	61.28 (25.18)	0.98	.33	0.02	0.00	.99	0.00	2.30	.14	0.04
PROP	33.17 (19.02)	27.84 (14.93)	29.60 (18.33)	39.47 (17.92)	0.16	.69	0.00	0.22	.64	0.00	2.56	.12	0.05
Whole Mouth Taste Strength Mean (SD)													
QHCl	82.67 (10.03)	83.57 (10.69)	80.00 (10.08)	84.05 (12.72)	0.03	.86	0.00	0.94	.34	0.02	0.30	.59	0.01
NaCl	81.39 (9.68)	80.88 (8.92)	77.65 (12.04)	81.28 (9.12)	0.05	.83	0.00	0.35	.56	0.01	0.62	.43	0.01
Sucrose	63.63 (12.69)	70.40 (11.33)	70.08 (9.41)	69.17 (11.68)	0.17	.68	0.00	1.12	.30	0.02	1.76	.19	0.03
PROP	57.71 (27.72)	56.11 (28.62)	57.71 (26.90)	64.16 (28.57)	0.50	.48	0.01	0.06	.81	0.00	0.33	.57	0.01
Whole Mouth Taste Liking Mean (SD)													
QHCl	9.71 (10.71)	11.31 (9.10)	8.97 (4.92)	17.33 (24.41)	0.04	.85	0.00	0.81	.37	0.02	0.13	.72	0.00
NaCl	20.75 (23.61)	25.49 (15.91)	20.29 (18.62)	26.74 (28.81)	0.60	.44	0.01	0.69	.41	0.01	0.02	.89	0.00
Sucrose	68.21 (29.94)	70.16 (24.26)	66.80 (30.26)	65.12 (37.51)	0.03	.86	0.00	0.00	.97	0.00	0.06	.81	0.00
PROP	17.55 (14.07)	20.67 (17.86)	22.77 (19.90)	16.27 (15.66)	0.05	.83	0.00	0.14	.71	0.00	1.04	.31	0.02

Note: Scale of Magnitude is 0–100; NW = Normal Weight; OW = Overweight; HC = Healthy Control; BED = Binge-Eating Disorder; QHCl = Quinine Hydrochloride, NaCl = Sodium Chloride; PROP = 6-n-propylthiouracil; Post-hoc tests reveal

^aOW BED < NW HC & NW BED & OW HC,

HC
OW BED > NW BED
 q

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Table 3

Exploratory edible taste strips partial correlation controlling for age and ethnicity

Sucrose Intensity			
	Taste Strip	Regional	Whole Mouth
Taste Strip	1	0.34 *	0.45 **
Regional		1	0.31 *
Whole Mouth			1
Sucrose Hedonic Response			
	Taste Strip	Regional	Whole Mouth
Taste Strip	1	0.32 *	0.23
Regional		1	0.55 ***
Whole Mouth			1
PROP Intensity			
	Taste Strip	Regional	Whole Mouth
Taste Strip	1	0.34 *	0.62 ***
Regional		1	0.29 *
Whole Mouth			1
PROP Hedonic Response			
	Taste Strip	Regional	Whole Mouth
Taste Strip	1	0.19	0.44 ***
Regional		1	0.27
Whole Mouth			1

Note: PROP = 6-n-Propylthiouracil;

*
p < .05**
p < .01***
p < .001