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Examining relationships of taste sensitivity and body fat percentage using body adiposity index

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Examining relationships of taste sensitivity and body fat percentage using body adiposity index

by

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Dedication

I dedicate my thesis work to my husband, Tom. Thank you for being there for me through all my ups and downs, ins and outs, and every which way in between. I must also mention a very special feeling of gratitude to my parents, Renee and Steven, for their love and support throughout, not just work on this project, but my entire life. Thank you so much for lending a listening ear when I need it the most.

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Abstract

Body fat and taste sensitivity have been explored with mixed results. Generally, studies have used Body Mass Index (BMI) as an indicator of obesity. This research study explores the relations between body fat percentage using a fairly new measure, Body Adiposity Index (BAI; Bergman et al., 2011), BMI, and the three types of taste sensitivities: non-, medium, and supertasters. Taste sensitivity was assessed using two methods: the blue food dye exam (Miller & Reedy, 1990) and the filter paper method (Zhao, Kirkmeyer, & Tepper, 2003) using the general Labeled Magnitude Scale (Bartoshuk et al., 2004) among student participants (n = 75). It was hypothesized that supertasters would have a lower BAI than non-tasters and medium tasters, and BAI would explain more of the variance among taster groups than BMI. Neither hypothesis was supported by the data. Limitations, implications, and suggestions for future research were discussed.

Keywords: taste sensitivities, body adiposity index, body mass index, supertasters

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Introduction

In 1931, a chemist named Arthur Fox was working in his lab with a colleague. They were working with the compound phenylthiocarbamide, commonly known as PTC. As Fox was putting a small amount of PTC into a bottle, his colleague commented on the bitter taste in the air. Fox did not taste anything. Perplexed, he ventured upon a quest to test 2,500 participants on their reaction to PTC. He found that while 28% of participants did not taste the PTC, 65.5% indicated that it tasted bitter. His research was published in 1932. Along with the article, the editor included a small piece of paper laced with PTC, so readers themselves could report on the taste quality (Bartoshuk, 2000). From that published piece, the field of taste sensation exploded.

The word *taste* is used to indicate the quality of food, labeling it as sweet, salty, bitter, sour or umami. What most people commonly think of as taste is actually flavor. Flavor, however, is a combination of taste and smell (Bartoshuk, 1991a). It is nearly impossible to taste without using the sense of smell as well. Flavor is generated once tastes and odorants are detected (Dominguez, 2011). Many people include the food's temperature, texture, and consistency in the term *flavor* as well (Blake & Sekuler, 2006). In terms of odors, the possibilities are almost limitless, since humans can detect and discriminate between around a half of million different odors (Dominquez, 2011). While taste qualities have the five classifications (sweet, salty, bitter, sour, and umami, a savory taste), olfactory qualities are much more numerous. When it does come to naming odors, we use very concrete words like smoky, vanilla, or minty (Bartoshuk, 1991a), and most terms for the quality of smell are derived from the object that omits the odor. Generally, classification of odors is collective. Taste, however, is unique to every individual. Everyone has some thoughts on what someone else may taste when eating a familiar food, but tastes are so distinctive and matchless and can have high context effects. The

amount of sweet, salty, sour, bitter or umami of a certain food is divergent, which is why taste is a special sensation and so much research has been devoted to it.

Our sense of taste produces an affective response that is present at birth. We can learn to pair specific tastes with fond memories and positive emotions, thereby enhancing their appeal (Yamamoto, 2008). Affective response to taste can be seen in several studies of newborns (Jacobs, Smutz, & DuBose, 1977; Rosenstein & Oster, 1988; Steiner, 1977). Most research has focused on sweet and bitter responses. By placing a small amount of sugar on a newborn's tongue, a look of satisfaction (shown through smile or similar facial expression) is observed. By placing a small amount of quinine on the tongue, the upper lip becomes elevated and some newborns will even spit or gag, indicating a bad taste. This probably is the result of evolution. For example, the sugars in milk hide the bitter taste of calcium, enhancing the likelihood that the infant will want to drink it, and thereby aiding in survival (Capaldi & Privitera, 2008).

Taste detection through development is another well studied aspect of taste. We know that our sense of taste develops before birth, but it does change with age. There has been some attention to this area of taste in research, but the conclusions are conflicting. Some studies report that children have similar taste thresholds to adults (Anliker, Bartoshuk, Ferris, & Hooks, 1991), while some report striking differences. James, Laing and Oram (1997) explored the taste detection thresholds of 8 to 9-year-olds and compared their thresholds to adults. They found 8 to 9-year-old boys' mean threshold for taste detection was significantly higher than that of adult men and women. This could indicate that boys of this age may not be fully matured in their taste detection. Females ages 8 to 9 years old had similar thresholds to adults, and there were no gender differences between the adult participants. Taste detectors can change not only with age,

but with level of hunger (Zverev, 2004), hormonal status (Alberti-Fidanza, Fruttini, & Servili, 1998), temperature (Ross & Weller, 2008) and in the context of other tastes.

The academic literature on taste sensations began to evolve into a more sophisticated area of research in the 1990s, pioneered by Linda Bartoshuk. Bartoshuk studied food preference and taste sensations, and in 1991, she noticed that some participants were more sensitive than others, having a much lower threshold for specific tastes. This study was the first to detect and label hypersensitive tasters, and Bartoshuk coined the term "supertasters" to describe them (Bartoshuk, 1991b). Supertasters are defined as those who have hypersensitivity to specific tastes, mostly bitterness. Supertasters can also be sensitive to or experience other flavors differently (Lim, Urban, & Green, 2008). Individuals sensitive to bitter have been labeled as pST or PROP (6-n-propylthiouracil) tasters, while general enhanced taste intensity supertasters are labeled as gST or general supertasters (Reed, 2008). Supertasters are the opposite of non-tasters (aguesiacs), also called blind tasters. The introduction of and scientific support for the supertaster has led to several new studies and new literature in understanding taste sensations.

In addition to taste sensitivity, supertasters also perceive greater pain or irritation from ingestible irritants like capsaicin (which makes peppers hot; Tepper & Nurse, 1997), piperine (black pepper), and ethanol (drinking alcohol; Karrer, 1991). Supertasters can also experience intense sensations from substances found in food that provide tactile stimulation. Specifically, they can have strong reactions to food ingredients such as fat from salad dressing (Tepper & Nurse, 1997), canola oil, and guar gum, which is a substance often used as a thickener in foods (Prutkin, Fast, Lucchina, Snyder, & Bartoshuk, 1999).

Gender differences have also been detected. Females are more likely than males to be supertasters (Bartoshuk, Duffy, & Miller, 1994). It has also been well documented that PROP

tasting and liking of sweet and high fat foods has a negative relationship, which appears to be strongest in women (Bartoshuk, 2000). However some PROP tasters have exceptionally strong preference for foods high in fat and sweetness (Duffy & Bartoshuk, 1996 as cited by Bartoshuk, 2000). There also have been positive correlations between PROP intensity and intense ratings of sweet (sucrose), salty (sodium chloride), and sour (citric acid; Lim, Urban, & Green, 2008). PROP should be used with caution in studies that look across the four tastes, as it may have the ability to alter intensities of other taste qualities (Bartoshuk, 2000).

Measurement of Sensitivity to Taste

Blue food dye test. So, how can one tell whether a person is a supertaster? There is a fairly easy, however limited, test to determine supertaster, medium taster or non-taster status that was developed by Miller and Reedy (1990). Miller and Reedy were the first to discover anatomical difference on the tongue when comparing the three different types of tasters. Using dyes (specifically, blue food coloring) to stain the tongue, the deep color will soak into the taste pores on the tongue and no color will remain on the fungiform papillae. (The papillae are mushroom shaped, and the taste buds are inside). To count fungiform papillae and pores, a reinforcement ring for hole-punched paper is placed on the tongue around the dye. Next, one simply counts how many papillae (i.e., the dots surrounded by the dye) are within the circle (Figure 1). Commonly, a flashlight and magnifying glass are used for accuracy. It was found that super tasters, specifically those sensitive to PROP, had more papillae on their tongues than others (Reedy et al., 1993). On average, non-tasters will have 1-15 papillae, medium tasters will have 15-29 papillae visible, and supertasters will have 30 or more (Bartoshuk, Duffy, & Miller, 1994). While a high density of fungiform papillae and PROP intensity have been found to be positively correlated (Bartoshuk, Duffy, & Mills, 1994; Hayes, Bartoshuk, Kidd, & Duffy,

2008), this method cannot fully predict supertaster status. The reason is that "taste bud density, taste damage, morphological differences in fungiform papillae, differences in central processing and variable taste gene expression may also contribute to supertasting" (Baake, 2010, p. 7).

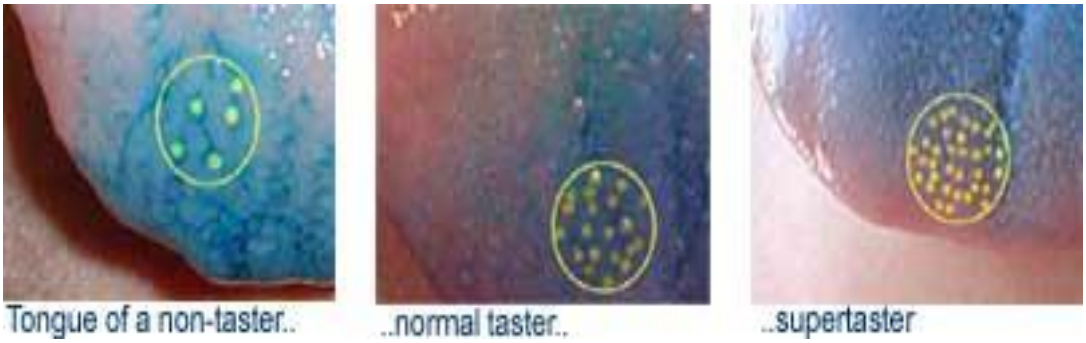

Figure 1. Blue food dye test results (retrieved from http://www.bbc.co.uk/science/humanbody/body/articles/senses/tongue_experiment.shtml).

Filter paper method. This method, developed by Zhao, Kirkmeyer and Tepper (2003) has been shown to be a quick and reliable screening tool for determining one's level of taste sensation (super-, medium- or non-taster). The method involves paper disks that have been impregnated with either 0.25mg PROP or NaCl. Participants are asked to rinse their mouths with distilled water and then asked to briefly place the paper disk on their tongue and mark on the LMS the intensity of the taste. Between samples, participants are instructed to rinse their mouths again with distilled water. NaCl disks are always administered first in the method as to minimize bitter carryover for the super-tasters. Those who rated PROP to be >67mm on the LMS were classified as supertasters. Those who rates PROP intensity to be ≤15mm we classified as non-tasters and those who rated between 16mm and 67mm were classified as medium tasters. These classifications will change based on the amount of PROP solution impregnated on the disks. NaCl ratings, although not a function of taste status when using the general Labeled Magnitude Scale (gLMS; more about that scale below), they are used as reference for data

obtained. Studies have shown that supertasters rate PROP as higher intensity than NaCl, medium tasters rate them similar and non-tasters rate NaCl lower than PROP (Zhao, Kirkmeyer, & Tepper, 2003; Tepper & Nurse, 1997).

Detection and Discrimination Scales

When using methods of comparison for measuring taste sensations, a valid and reliable detection or discrimination scale is essential. Several scales have been developed, mostly without real foods, but pure extracts are better predictors of true detection. For example, Marks and Bartoshuk (1979) used pure extracts of hydrogen chloride (HCl) for sour, sucrose for sweet and quinine hydrochloride (QHCl) for bitter. There are several chemical agents used to test hypersensitivity to bitter; the two most common are 6-*n*-propylthiouracil (PROP) and phenylthiocarbamide (PTC; Reed, 2008). The benefits of PROP are that, unlike PTC, it is odorless (PTC smells of sulfur) and PROP is considered less toxic than PTC in large quantities (Bartoshuk, 2000). When asking participants to compare different tastes, we can identify relationships between hypersensitivity in taste sensations. For example, positive correlations have been found between PROP intensity and intense ratings of sweet (sucrose), salty (sodium chloride), sour (citric acid; Lim et al., 2008).

Magnitude matching. When examining differences between groups, magnitude matching has been called the "gold standard" measurement of taste (Bartoshuk et al., 2004, p. 112). The most common form of magnitude matching for taste is with decibel levels of a tone (Marks et al., 1988). When using magnitude matching, participants are given taste stimuli (multiple and different concentrations of PROP, NaCl, QHCL, sucrose, etc.) which are presented at room temperature. Participants are always asked to rinse their mouth between sips to rinse any trace of a prior substance. Sound stimuli are also presented with different burst of a 1000-

Hx tone through headphones (again, multiple and different decibels). Participants are instructed to assign numbers in proportion to the intensity, so that both sound and taste are judged on the same scale (Marks et al., 1988, p. 65). The point is to have the intensity of a sound match the intensity of a taste. This datum works well, because non-tasters and supertasters alike have the same psychophysical function for loudness, thereby allowing researchers to readily find PROP tasters. The problem with magnitude estimates is that they do not provide information about absolute perceived intensities (Bartoshuk, Duffy, & Miller, 1994). Problems with comparisons could be solved if all participants had the same perceived intensity compared to a standard that was agreed upon; however, this is practically unattainable. The solution to the problem of a shared standard is to transfer the standard to unrelated stimuli. Through cross-modality matching, researchers are able to create a more reliable method of magnitude matching for taste.

Labeled magnitude scale (LMS) and the general labeled magnitude scale (gLMS). Another measurement for taste is by using labeled or matching scales. Marks and Bartoshuk (1979) asked participants to taste a standard concentration of sucrose (0.1M) with a small amount of QHCl added. Participants were asked to judge which component was strongest: sweet or bitter. Participants sipped and spit the solution, followed by a room temperature water rinse. If sweet was detected, the researchers added more bitter, and if bitter was detected, less QHCl was added. This was repeated until equal amounts of sweet and bitter were detected by the participants. This solution then became the standard for that participant's matching scale. The problem with labeled scales or matching scales is that they are not always a reliable method due to ceiling effects. The most intense taste in a scale, the ceiling of the scale, may be different from one taster to another; therefore, comparing other intensity sensations would not be consistent or valid across participants.

In 1993, Green and his students took a cue from other psychophysical scales and developed the Labeled Magnitude Scale (LMS; Bartoshuk, 2000). The LMS was different in its design from prior scales, because it did not concern taste. Rather it was designed for a ratio the intensities of the oral sensations. The scale originally had participants identify the "strongest imaginable" taste sensation. Recognizing the limitations of labeled scales, Bartoshuk and colleagues (2004) adapted the standard LMS to the gLMS. The "strongest imaginable" top of the scale was changed to have participants identify "the strongest imaginable sensation of any kind" (see Appendix A). The phrase "any kind" was added to allow evaluation of the complete oral sensation, including any oral pain associated with the flavor. The strongest sensation identifier is not the same for each individual. Each person differs in the perception of an intense sensation, but the "key is to select labels that are not related to the sensation of interest" (p. 112). The gLMS has been tested against magnitude matching in taste sensation testing and has been shown to produce similar results; therefore, it is a worthwhile alternative. One popular LMS is the "filter paper method".

One limitation to the LMS becomes evident with the difference threshold (detecting changes in a stimulus or differences between stimuli). It is unlikely that all participants will interpret the adjectives "strongest" and "barely detectable" the same way. This decreases the reliability and validity of the LMS. If we wanted to detect differences among tasters, a scale without a ceiling effect should be used instead. This is why the gLMS was developed, it is ceiling-less with the term "strongest imaginable."

Correlates of PROP and PTC

Why is all of this important? PROP and PTC sensitivity may be a genetic marker for eating habits (Bartoshuk, 1993). Generally, heightened sensitivities are associated with

decreased preference for trigger foods, such as bitter, sweet, or sour foods, creamy dairy-rich foods, foods containing chili pepper and alcohol. The converse is true for non-tasters; non-tasters are less sensitive to these foods and, therefore, are more likely to prefer them. Food preference can then guide food choices that can be a determinant of dietary health.

Body Fat Percentage

Body Mass Index. Correlational designs examining taste sensitivity and body mass index (BMI) have been academically popular in the last three decades. BMI was developed in the 19th century and has been the most widely used measure for classifying people into weight categories (underweight, normal weight, overweight, and obese; Bergman et al., 2011). However, BMI does have limitations. The greatest is the "inability to discriminate between fat and lean mass" (Romero-Corral et al., 2008, p. 960) when only using BMI. BMI assessments are typically not reliable or valid if weight and height are not directly measured (Bergman et al., 2011, p. 1084) but merely reported by participants. When using BMI, "another more direct estimation of body fat" (Moreno et al., 2005, p. 74) must also be obtained to increase the validity of the measurement. The greatest limitation of BMI is how to classify individuals based upon the data provided. More specifically, BMI is a result of a mathematical computation, and therefore clearly objective in one sense. However, there is variability in how this index is used, and what the results of this calculation actually mean. A variety of different benchmarks must be used to categorize weight class. Each set of benchmarks is based on gender differences and age. This can be problematic, however. Romero-Corral and colleagues (2008) found that the validity of BMI diminished as age increased. Many also question the validity of BMI when cultural or ethnic differences exist (Deurenberg, Yap, & Van Staveren, 1998; Guricci, Hartriyanti, Deurenberg, & Hautvast, 1996; Norgan, 1994).

Scientific studies examining taste relationships and BMI have had varied results. Some investigators have found no relationship exists between PROP sensitivity and BMI (Bajec & Pickering, 2010; Drewnowski, Ahlstron-Henerson, & Cockroft, 2007; Drewnowski, Kristal, & Cohen, 2001; Villarino, Fernandez, Alday, & Cubelo, 2008), while other investigators have found negative correlations (Dabrila, Bartoshuk, & Duffy, 1995; Goldstein, Daun, & Tepper, 2007; Keller & Tepper, 2004; Tepper & Nurse, 1998). So, when measuring body fat, is BMI the best measurement?

DXA and underwater weighing. The "gold standard" of body fat measurement has been Dual-energy X-ray absorption (DXA). It is the most accurate, reliable and valid measurement specifically for body fat (Jensky-Squires et al., 2008). Another popular measurement method is hydrodensitometry (or underwater) weighing. This method assesses density, which researchers then convert to a body fat percentage. The largest limitation of these two methods of measurement, however, is the cost; both methods require materials that can be very expensive. Because of this, there has been a great push for researchers to develop a body fat measurement that is as accurate as DXA and underwater weighing, yet not as expensive or impractical. For example, underwater weighing takes time and for the person being weighed requires additional time to change clothes and afterwards to get dried, dressed, and so on.

Body Adiposity Index. The recently introduced Body Adiposity Index (BAI; Bergman et al., 2011), has already been shown to be a reliable and valid measurement, strongly correlated with DXA ratings (Bergman et al., 2011; Elisha, Rabasa-Lhoret, Messier, Abdulnour, & Karelis, 2011). The major difference with BAI, compared to indices of body fat, is that BAI does not use body weight; nor are there any age or gender differences. The final result of this calculation is percentage of body adiposity or body fat. BAI is calculated with the equations

$$BAI = (\text{Hip circumference in centimeters} / \text{Height in meters}^{1.5}) - 18$$

or

$$BAI = (\text{Hip circumference} / \text{Height} (\sqrt{\text{Height}})) - 18$$

Since its release into the academic community, BAI has been re-examined with mixed results, particularly when compared to BMI. For example, Barreira, Harrington, Staiano, Heymsfield and Katzmarzyk (2011) found similar results with both BMI and BAI in predicting body fat. López and colleagues (2012) found a correlation between BAI and percent of body fat higher than the one between BMI and percent of fat. Elisha, Rabasa-Lhoret, Messier, Abdulnour and Kareelis (2011) concluded BAI can well detect changes in body fat percentage of women after a weight loss intervention (compared to findings with DXA). On the other hand, Schulze and colleagues (2012) found BMI was a stronger correlate of percent of body fat than was BAI; they found waist circumference for men and hip circumference for women to be the best predictor of body fat. Appelhans and colleagues (2012) also concluded BAI as a less accurate measurement of body fat percentage than BMI.

Studies on BAI continue to mention one major limitation of the original study published by Bergman and colleagues: their sample. Using U.S. populations of only African-Americans and Mexican-Americans, Bergman failed to examine BAI in a Caucasian population. In a strictly Caucasian population, BAI has been shown as not being a universally valid measurement as Bergman claimed it to be (Suchancek et al., 2012). However, it has been shown to be a better indicator of adiposity in European American adults than BMI is (Johnson, Chumlea, Czerwinski, & Demerath, 2012).

Problem Statement

The purpose of this study was to try to identify the relationship between taste sensation (super-, medium-, and non-taster) and body adiposity. The topic of taste sensitivity and obesity has been explored before using Body Mass Index, as previously discussed; however, inconsistencies within these results have been reported. PROP sensitivity and body weight, specifically, has also been explored with mixed results. Keller and Tepper (2004) found gender differences in correlational patterns among 4 and 5-year old children. They found non-taster boys to have a higher weight to height percentile than supertaster boys. However, non-taster girls had a lower weight to height percentile than supertaster girls. Goldsetin, Daun and Tepper (2007) found that PROP status was not a predictor was body weight in children. Tepper (1999) found that, for adults, PROP taster status may well influence body weight, particularly in men, but not as much in women. What is not known is if this is due to a higher incidence of restrained eating habits in women.

This study is the first of its kind known to the researcher to examine the relation using Body Adiposity Index, a relatively recent, valid, and reliable measurement of adiposity that is strongly correlated to Dual-energy X-ray Absorptiometry, the gold standard of adiposity measurement.

Purpose

The purpose of this research was to further explore and examine the relationship between body adiposity and taste sensation using a new method of measurement, BAI. The information obtained in this research could be beneficial for doctors and nutritionists, because knowing what kind of taster a patient is could be a predictor of certain eating habits and/or obesity. More about the implications of this study can be found below.

Hypotheses

Hypothesis A: it was hypothesized that supertasters would have a lower BAI than non-tasters and medium taster and, in turn, medium tasters would have a lower BAI than non-tasters. This hypothesis drew upon reports that PROP sensitivity is correlated with lesser food consumption (Drewnowski, 1997), and PROP tasting is negative correlated with a liking of sweet and high fat foods (Bartoshuk, 2000); therefore, supertasters would consume few calories, and this could result in less body fat than the other taster status groups.

Hypothesis B: it was hypothesized that BAI would explain more variance in taster status than BMI.

Method

Participants

Participants (N=75) were students from Eastern Michigan University (EMU), with ages ranging from 18-50. Both genders were represented (62 females and 13 males). EMU was an ideal location for the current study due to the highly ethnically diverse campus. In fact, EMU has been recognized as the most ethnically diverse campus in Michigan (Mullens, 2010), with a population breakdown of 65% White; 21% Black; 2% International; 2.5% Asian-American; 2% Hispanic, 0.5% Native-American, and 7% who elected not to respond to this inquiry (Institutional profile, 2010). With the ethnic breakdown of this population, the researcher expected a range in ethnic background in the 75 participants that participated in this study, which would thereby overcome the previous problems with BAI's limited data within diverse ethnic backgrounds. The ethnic background breakdowns from these participants were 64% White/Caucasian, 24% Black or African American, 6.7% Asian/Pacific Islander, 1.3% Hispanic, 1.3% Middle Eastern, 1.3% West Indian, and 1.3% bi-racial.

Participants were recruited from psychology classes through announcements, presentations in classes, and through flyers hung in areas of public announcements in three buildings on campus. The researcher also discussed the possibility of extra credit with professors of these classes to encourage participation. The researcher let students know that participation in each segments of the study (online pre-screen and in the laboratory) would result in their name being entered into a raffle for a gift card. A grand prize winner received a gift card valued at $80. Two second place winners received a gift card valued at $40, and two third place winners, a gift card valued at $20.

Prescreening. Participants were pre-screened following recruitment to try to achieve a healthy normal population (Appendix B). First, demographic questions (gender, age, and race) were asked. The purpose of screening was to exclude individuals with dietary restrictions or past dietary hardship. Individuals with dietary restrictions may have a different pattern of caloric intake than those without restrictions; therefore precautious were taken (through specific pre-screening questions) to exclude those individuals. Individuals with known past dietary hardship (pre- or postnatal) were also not included in the sample. Roseboom and colleagues (2001) reviewed the health of adults born during and after the Dutch famine of 1944. They found that "maternal malnutrition during gestation may permanently affect adult health" (p. 97). Risk factors for impaired glucose tolerance, hypercholesterolemia, elevated blood pressure, and, most important to this study, obesity were found to have their origins in-utero. For these reasons, candidates for this study were asked the following questions: "To your knowledge, did your biological mother receive the proper nutrition and have a healthy diet while pregnant with you?", and "Have you ever been or are you currently nutritionally deprived (meaning you are not

getting a proper quantity or quality of food to sustain a sufficient diet)?" Those who answered "no" to the first question and yes to the second question were excluded.

In addition, the pre-screening process also excluded others to help maximize the potential for a healthy normal study sample. First, because a stable BAI was needed for this study, individuals who could, either intentionally or unintentionally, alter their weight were excluded. Second, a true measurement of taste sensitivity was needed, and therefore any individuals who endorsed a loss of taste or smell were also excluded. Furthermore, individuals who were athletes, currently on a diet with food restrictions, pregnant or lactating, had a medical condition with dietary limitations (such as diabetes), ever had bariatric surgery, were currently on medication that altered appetite, were current or past heavy cigarette smokers (defined as having smoked one cigarette in the last month or over 100 cigarettes in a lifetime), or who currently had a cold were excluded from the sample. The reasoning behind these exclusions was as follows: Athletes, especially those who engage in sports with weight classifications like wrestling or boxing, may alter their caloric intake by binging or purging to meet specific criteria. Limiting or altering caloric intake is also true for those individuals who are currently on a diet. Pregnant and currently lactating women were excluded because the fetus expands hip measurements, therefore not giving an accurate BAI measurement; pregnant and lactating women are also more likely to act on food cravings due to hormonal changes. Individuals who may eat more or less because of a medical condition (e.g., hyperactive thyroid) or are on medications that alter appetite (e.g. long term steroid use) were excluded. Those who had undergone bariatric surgery were excluded for two reasons. First, obtaining a true BAI measurement would be difficult due to the nature of the surgery (weight loss and ultimate decreased body circumference) and second, surgery itself results in alterations in taste preferences (Miras & le Roux, 2001). Participants who were

currently or who had a history of heavy smoking were excluded for two reasons. First, cigarette smoking may have lead to a loss of taste or smell (Fischer, Griffin, & Kaplan, 1963). Second, cigarette smoking influences metabolism and, therefore, weight. Lastly, any participant who had the "common cold" was excluded because of the potential for decreased taste sensitivity or sense of smell. Taste sensitivity is a requirement for this study (with filter paper disks) and sense of smell is a necessity because it is nearly impossible to taste without using the sense of smell (Dominguez, 2011). Recruitment lead participants to an experiment management system EMU uses called SONA. This system lists and tracks students' participation and time spent in on-campus and online studies. This system allows students to identify the professor(s) who should receive notification of their time spent participating in research for classroom credit. The pre-screening process was conducted by Survey Monkey and was preceded by an electronic informed consent (Appendix C).

Materials

To assess taste sensation the filter paper method was used (as discussed above) with PROP and NaCl concentrations based on pilot data and research data collected by Zhao, Kirkmeyer and Tepper (2003). Whatman #3 paper disks were impregnated with PROP and NaCl. To impregnate disks with PROP, PROP powder (50 mmol/L) was dissolved in 100º boiling spring water. Cotton thread was then threaded through each disk (with a sterilized sewing needle), separated by small lengths of silicone tubing for spacing. The disks were put in the solution of boiling water for approximately 30 seconds. Once removed, excess solution was shaken from the disks, and the disks were placed in an aluminum foil lined pan and oven dried for 1 hour at 121ºC. To impregnate disks with NaCl, disks were soaked in a 1.0mol/L NaCl solution at room temperature and dried. To ensure that the proper amount of PROP had been

absorbed onto the disks, a quantifying method from Zhao, Kirkmeyer and Tepper (2003, p. 627) was used. First, six disks were randomly selected and tested using a 1 centimeter cuvette in an absorbance spectrometer (accessed in the Chemistry Department of Eastern Michigan University). Each of the six disks were incubated in a 20-mL aliquot of methanol for 12 hours at 22ºC and then measured at peak wavelength of 214.04nm using the extinction coefficient (Ɛ) for PROP. The following formula was used

$$\text{PROP mass} = A * \text{MW} / Ɛ * V$$

Where *A* is absorbance (results from the spectrometer), MW is molecular weight of 6-n-propylthiouracil, which is 170.233 g/mol, Ɛ is the extinction coefficient constant, which at an absorption of 214.04nm is 15.6 mol/(L*cm), and *V* is volume of methanol which was 20m/l. Figure 2 shows the results of the absorbance in each of the six samples. On average, the six samples were quantified at 0.34mg of PROP mass per disk.

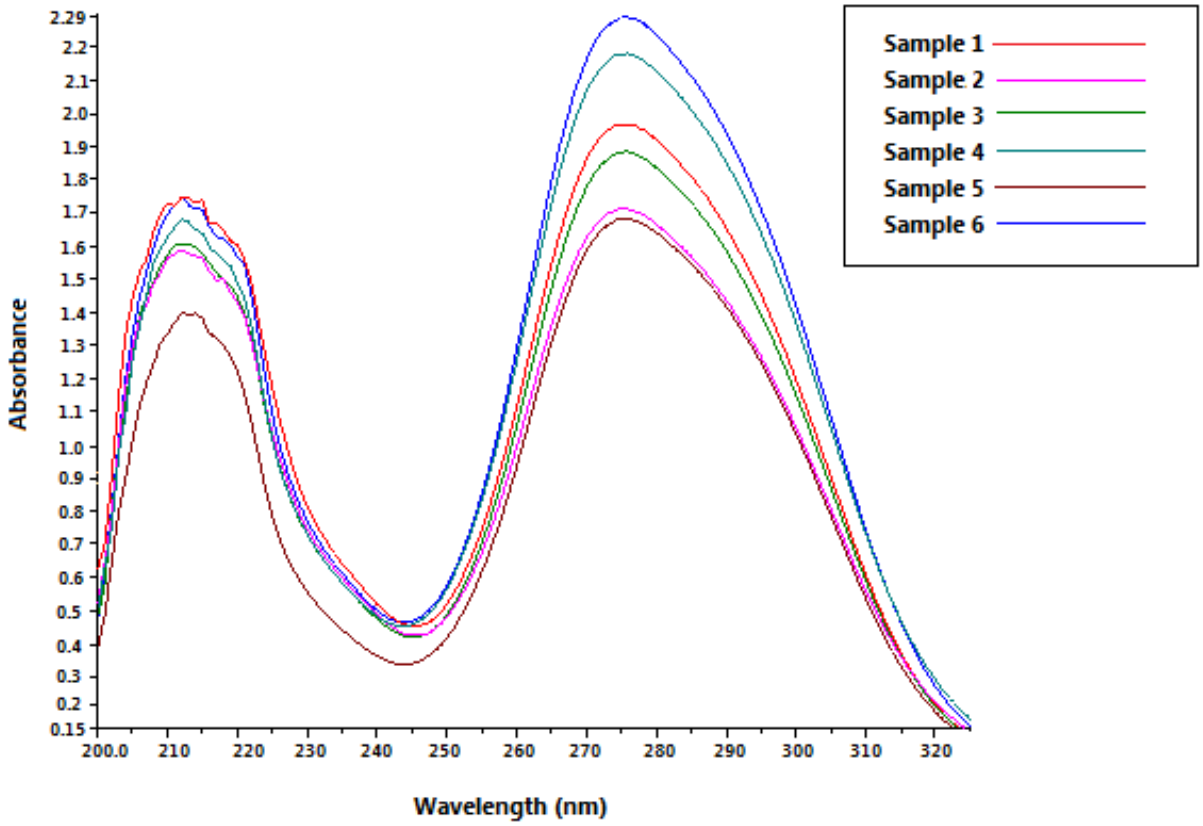

Figure 2. Absorption of PROP at 214.04nm

After the randomly selected disks were quantified, all remaining disks were stored at room temperature, individually sealed in plastic bags until they were ready to be used (as suggested by Zhao, Kirkmeyer, & Tepper, 2003, p. 627).

To assess body adiposity, BAI was used. Because it is a relatively new measurement of adiposity, its limitations are not concrete. Exact measurement procedures can be found below. Additionally, as noted above, there were several participant exclusion criteria. These exclusion criteria were used to minimize problems found previously with BMI. This study used BAI as a quantitative measure in order to determine how it is related to taster status; therefore classifications were not necessary within this study.

In order to assess BAI, participants' height and hip circumference are needed. A standard stadiometer was used to assess height and a cloth ruler was used to assess hip circumference. In addition to the height and hip circumference measurements taken for the adiposity calculation, a brief weight calculation using a standard physician's scale was also recorded. The scale was calibrated at the beginning of each day's data collection. Weight was recorded to calculate BMI.

Procedure

Preceding the pre-screening process, participants were asked to electronically sign an Informed Consent (Appendix C). Online pre-screening as outlined above occurred only if the participant consented. During pre-screening, participants were asked to provide a participant code by which they would be identified if selected for the second phase of the study. The participant code was the first four letters of the participant's last name and a four digit representation of their birth month and day. For example, if the participant's name was John Smith, born on February 12, the participant code would be Smit0212. This participant code was set in place to insure confidentiality. Immediately after pre-screening, participants were asked if they agreed to be contacted via email, and if so, if they could provide a working email address. This was done so participants could be told if they were an eligible or ineligible to participate in the main study. Eligible participants were emailed and given a list of days, times, and a location to come to for the second phase of the experiment. They were instructed to wear loose fitting, comfortable clothing for the experiment. Ineligible participants were emailed and told that they did not meet the necessary requirements and thanked for their time. All email addresses were destroyed at the conclusion of the study.

In the lab, when participants arrived, they were first given two copies of the experiment's Informed Consent forms (Appendix D). One was for the experimenter and the other for the

participant. The Informed Consent alerted each participant of the specific aims of the study, and they were told that they could waive participation at any time. After Informed Consent was obtained from each participant, the researcher began with the taste sensitivity test using the filter paper method and the general Labeled Magnitude Scale (gLMS).

For measurement of taste sensitivity, as outlined by Green and colleagues (1993), participants were given specific instructions (Appendix E). First, participants were asked to list their participant code at the top of the gLMS scale. Participants were provided two cups, one full of distilled water to sip, one empty to spit. Then they were asked to rinse their mouths with distilled water. Next they were asked to briefly place the disk in the bag labeled #1 (NaCl paper disk) on their tongue and rate the intensity of the taste on the gLMS using a dash on the scale with the number "1" written next to it (see Appendix A; Bartoshuk, 1994). After participants marked their first rating, they were instructed to rinse their mouths again with distilled water and spit. Next they were asked to repeat this procedure with the disk labeled #2 (the PROP disc) and rate it using a dash on the scale with "2" listed next to it. After both scores were recorded by the participant, they were asked to discard the materials (used disks, bags, and cups) but keep their scale with participant code noted.

The blue food dye test was done next. Participants were reminded of the test (which they already read about in the Informed Consent document) and told that the researcher would be placing a small amount of blue food dye on their tongues. They were asked to briefly close their mouths to distribute the dye, and then open again with their tongue out. The researcher used a small piece of plain white paper with a standard hole-punch punched out of it to assess the papillae density. The paper was placed over the dye, and then the researcher counted how many pappilae were observed within the circle and recorded the data. Occasionally a flash light was

needed to assess the papillae. After data were recorded, participants were offered another drink of water.

BAI was assessed by the researcher only. Participants were instructed to remove their shoes before their height was measured to ensure an accurate height, which was measured to the nearest 0.25cm. Weight, used for BMI, was measured in pounds and later converted to kilogram in Excel using the equation (weight in lbs. * 0.453592). For hip circumference, the researcher (single observer) used a cloth measuring tape (fabric tape), and this measurement was taken over participants' clothing. The researcher stood to the side of the participant and asked participants, with special instruction first, to place the tape around their hips, below their hip bone. Instructions included telling the participant of a true hip measurement, which has been described as "maximum extension of the buttocks posteriorly in a horizontal plane" (Bergman et al, 2011). This was explained to female participants as the place where their buttocks protrude farthest behind them. Male participants were instructed to place the tape approximately 2-4 inches below their navel. Participants were asked to stand straight, with their feet together and hands hanging freely at their side, palms facing inward. The researcher asked for permission to touch the tape, and with that handled the tape only near the participant's hip. The researcher checked the tape for a horizontal position and asked the participant to exhale gently and naturally while the measurement was read, rounded to the nearest 0.25cm. Data were entered into Excel and the proper mathematical equation was used to calculate BAI.

BMI was calculated in the lab using the participant's height, without shoes, recorded in centimeters, rounded to the nearest 0.25cm and weight recorded in pounds, rounded to the nearest 0.25lb and later converted in Excel to kilograms.

Upon completion of each of these measures, participants were allowed to ask any questions they had, instructed on how to obtain the SONA credit option if they had interest or necessity for class. Although no harm or repercussions were foreseen, participants were also instructed on the benefits of Snow Health Center (campus medical building) with an accompanying pamphlet, if they felt any physical discomfort from the PROP or NaCl on the filter paper disks, and then allowed to leave.

Results

There was very little data preparation or cleaning needed prior to data analysis. Data were exported from the Survey Monkey data collection website to an Excel file and transferred to SPSS version 22.0.0.0. For each participant there were two indices for body mass and two for taster status. The two indices for body fat were: BAI (percentage of body fat) and BMI (relationship between height and weight). The taster status of each participant as non-, medium-, or supertaster was determined by the gLMS results and the fungiform papillae density exam. To ready the data for analysis, the researcher investigated whether there were outliers in BAI or BMI, and there were none. (See Table 1.)

Of 339 initial participants who completed the pre-screening process, only 41% (n = 140) were eligible for the study based upon the criteria (see Table 2). Of these 140 individuals, 53.5% (n = 75) completed the second portion of the study. In addition, it is unknown whether the 65 people who were eligible for the study but did not participate differed from those who did participate in any way.

Table 1

Participant Demographics and Three Primary Variables

Demographics	*n*	Mean BAI	Mean BMI	% Non-Taster	% Medium Taster	% Supertaster
Ethnicity						
White/Caucasian	48	30.9	26.5	37.5	27.1	35.4
Black	18	28.8	23.3	22.2	27.8	50.0
Asian/Pacific Islander	5	26.6	22.8	60.0	0.0	40.0
Hispanic	1	29.6	21.3	0.0	0.0	100.0
Middle Eastern	1	30.0	24.7	100.0	0.0	0.0
West Indian	1	30.1	22.9	0.0	100.0	0.0
Bi-Racial	1	27.5	21.8	100.0	0.0	0.0
Age						
18-20	52	30.0	25.5	34.6	28.9	36.5
21-30	19	29.4	24.1	42.1	21.1	36.8
31-40	3	33.2	28.9	0.0	0.0	100.0
41-50	1	34.0	28.3	100.0	0.0	0.00
Gender						
Female	62	30.5	25.5	37.1	22.6	40.3
Male	13	27.9	24.2	30.8	38.5	30.8

Table 2

Percentage of Participants Excluded, and Reasons for Exclusions

Reason for Exclusion	*n*	Percentage of overall *n* (N=339)
Age	8	2.3%
Economic Status Growing Up	16	4.7%
Current Economic Status	23	6.8%
Improper Pre-Natal Care	27	8.0%
Previously or Currently Nutritionally Deprived	36	10.7%
Current Collegiate Athlete	33	9.7%
Currently Pregnant or Lactating	4	1.2%
Medical Condition with Dietary Restrictions	19	5.6%
Bariatric Surgery	5	1.5%
Taking Medication that Alter Appetite	37	10.9%
Have Loss of Taste or Smell	10	2.9%
Cigarette Smoker	51	15.0%
Currently have Cold or Flu	21	6.2%
Requested Not to be Contacted for Follow Up	51	15.0%

Recall Hypothesis A which stated that supertasters would have a lower BAI than non-tasters and medium tasters and, in turn, medium tasters would have a lower BAI than non-tasters. To test this hypothesis, a univariate analysis of variance (ANOVA) with taster status group as the

independent variable and BAI as the dependent variable was conducted. Results were not as hypothesized; BAI did not differ by taster status group ($F(2, 72) = 1.112$, $p = .334$). In other words, there were no significant differences among non-, medium, and super tasters on BAI. Respective means for the taster groups were as follows: non taster group $M = 29.090$, medium taster group $M = 31.702$, and super taster group $M = 29.821$. Hypothesis A was not supported. An additional analysis was conducted outside of the planned hypothesis to test whether BMI differed across taster status groups. Results showed BMI did not differ across groups ($F(2,72) = 1.003$, $p = .372$).

For the purposes of these analyses, taster status group was identified using the filter paper method and the general Labeled Magnitude Scale (gLMS). This study had n =27 (36%) non-tasters, n =19 (25%) medium tasters, and n =29 (39%) supertasters. Also used, was the blue food dye test in order to approximate participant taster status group. It should be noted that the blue food dye test only corresponded with the filter paper method and gLMS method for identifying taster status 42.67% of the time (77.78% of the time for non-tasters, 26.32% of the time for medium tasters, and 20.69% of the time for super tasters). Using Cohen's Kappa, a 3x3 analysis was done to show agreement between the two methods for identifying taster status. Results showed the agreement between the two methods was not satisfactory ($\kappa = 0.136$, $se(\kappa) = 0.073$). It should be noted that the mean papillae count across each taster status group was as follows: 8.67 papillae per non-taster (which falls with the appropriate range), 10 papillae per medium taster (does not fall within the appropriate range), and 14.48 papillae per super (again, does not fall within the appropriate range). Even so, Pearson's *r* was computed to assess the relation between papillae count and BAI. There was no significant correlation between the two variables ($r = .058$, $p = .619$). Additionally, Pearson's *r* was used to assess the relation between papillae

and BMI. Again, no significant correlation was found between the two variables (r =.033, p = .776).

Hypothesis B was that BAI would explain more variance in taster status than BMI. To test this, Spearman's rank correlation coefficient, or Spearman's *rho* (ρ) was used instead of the more commonly used Pearson *r*. Spearman's ρ is a nonparametric correlation, calculated among lab results of BMI, BAI and Taster Status group (non, medium, super). The Pearson *r* correlation coefficient requires continuous variables that are normally distributed; however, taster status is a ranked variable on an ordinal scale. In other words, non-tasters have less sensitivities (particularly to bitter) than do medium tasters, and medium tasters have less than super tasters. Because of this, the nonparametric Spearman's ρ is warranted. The magnitude of Spearman's ρ is interpreted similarly to Pearson's *r*.

When these correlations were calculated, results were not as hypothesized. The correlation between BAI and Taster Status group was ρ = .075, p = .521. The correlation between BMI and Taster Status group was ρ = -.033, p = .777. Neither of these correlations was statistically significant, and they were not significantly different from one another (z = -0.65, p = 0.258).

Discussion

The purpose of this research was to gain a better understanding of the relations between taste sensitivities and body fat percentage, using body adiposity index (BAI) and body mass index (BMI). To address the hypotheses of this study, prescreened participants' BAI and BMI were measured in a lab setting. Taster status was assessed in two ways: the blue food dye papillae density count and the filter paper method, using a Labeled Magnitude Scale. The relation between taster status and BAI was miniscule, which was not as hypothesized. In

addition, the blue food dye test only correctly predicted taster status obtained from the filter paper method for 42.67% of the participants. Also contrary to hypotheses, BAI did not significantly explain more variance in taster status than BMI. However, as this is the first research of this kind using the fairly new measurement of BAI, instead of the traditional body fat indicator, BMI, further research may be able to detect correlational patterns if several limitations that plagued the current study could be overcome.

Limitations

In previous research BAI has been calculated and correlated with other body fat percentage measures (e.g., DXA, underwater weighing), but only in specific ethnic groups, namely African- and Mexican-Americans (Bergman et al., 2011). However, Suchancek and colleagues (2012) found that in a strictly Caucasian population, BAI was not a universally valid measurement, but BAI has been shown to be a better indicator of adiposity in European American adults than BMI (Johnson, Chumlea, Czerwinski, & Demerath, 2012). This research did not limit its population to a specific racial or ethnic group. Within this sample, the majority of the participants (67%) were Caucasian, which may mirror the Suchancek et. al. (2012) research and be why no relations among BAI and taster status were found. Also, when obtaining a hip circumference (more regarding its specific limitations to follow), it is possible that difference ethnic groups develop muscle and fat in localized areas of the body, specifically in the back and around the buttocks. While it is unknown if the variability in this could have influenced the body fat percentage from BAI, it is worth mentioning as a limitation.

In Bergman and colleagues' original study, height and hip circumference were obtained from two previous studies performed by some of the co-authors. They noted that, in gathering the data on hip circumference, measurements were taken by a single observer, over

nonrestrictive underwear or loose shorts. Three measurements were taken and then averaged. During the current study, a single observer was still used; however, only one measurement was taken. Additionally, participants were not asked to unclothe to underwear, but rather were instructed to come wearing "loose, comfortable clothing" and told a hip measurement would be taken. If this study is replicated, it is suggested that the researcher take additional recordings to create an average, preferably with a small time lapse between each recording.

Participants in the current study were heavily pre-screened. More specifically, participants were disqualified from participation if they were over the age of 51, if they did not receive proper prenatal care, if they had been previously or were currently nutritionally deprived, if they were a collegiate athlete, pregnant or lactating, currently on a diet, had bariatric surgery, smoked at least one cigarette in the last month or more than 100 in their lifetime, were on any medications that altered or suppressed appetite, currently had a loss of taste or smell, or currently had a cold or flu virus. As stated, of 339 initial participants, only 41% (n = 140) were eligible for the study and of these individuals, only 53.5% (n=75) completed the study. Regardless, it is quite possible that this rigorous prescreening could have been detrimental to the outcome of the study by causing limited variability within the data (specifically taster status proportions, which were not parallel to past research). In other words, if this extensive prescreening had not been used, perhaps it a more variable sample would have been obtained. It is unclear how being more inclusive may have affected the final outcomes of the study. It is also difficult to narrow down exactly which specific prescreening criteria would be excluded if the study were to be conducted again. This is because it is difficult to compare this prescreening procedure to what has been used in past research. Previous studies correlating taster status with other variables stated that pre-screening is a necessity, but rarely stated specifics regarding selection criteria. It would have

been beneficial to contact prior researchers in this field to gather their pre-screening questionnaire to find out exactly who was excluded (both in BAI research and taster status research).

Fifty-one participants (15% of the overall N=339 who completed the pre-screening) did not wish to give an email address to be contacted; this accounts for a relatively large portion of participants who did not participate, but could have been eligible to do so. If this study is replicated in the future, a more secure manner to inform participants of their eligibility would be beneficial. Although it is not known if security was the true reason for these participants not wanting to participate further, it could have been a contributing factor.

The blue food dye exam may also have had its limitations. As stated previously, this method did not always fully predict taster status, especially in the case of supertasters. Damage, density or the variability in structure of the papillae may be contributing factors to the lack of reliability of this measure. Although there was variability in the researcher's use of a flashlight to read the tongue, and introducing this variable to only certain participants could have made a difference. As previously noted, this was only done to clarify some readings. When papillae were difficult to see, the flashlight was used, but when they were prominent, the flashlight was not necessary. This variability in the need for a flashlight was simply due to individual genetic differences.

A larger sample size that was more representative of the typical breakdown in taster status may have also been beneficial. As noted prior, this study had 36% non-tasters, 25% medium tasters, and 39% supertasters. According to Zhao and Tepper (2007), the "estimated proportion of non-tasters, medium tasters, and super-tasters in the Caucasian population is 30%, 45%, and 25%, respectively" (p. 532). According to this reference point, this sample was a bit

uncharacteristic of the traditional breakdown in taster status. Additionally, the overall N that was used (n =75) corresponded to the average N from other taster status studies; however, a larger sample size may have provided more statistical power to detect small effects.

Lastly, and again in reference to the sample size, some difficulty was found in compliance from participants from the online portion of the study (the pre-screening) to the in-house lab portion (body fat and taster status data collection). As mentioned, 140 individuals were eligible based on their responses to the pre-screening; however, only 75 participants completed the study. Therefore, it is unknown whether the 65 people who were eligible for the study but did not participate differed from those who did participate in any way. In addition, the exact reason for the lack of compliance is unknown. However, it can be postulated that the lack of compliance may have to do with the location of the laboratory, which was located on the 3rd floor of the campus' Science Complex and houses the psychology department. If the location was more accessible or prominent to participants and placed in a well-traveled area of campus, it may have increased compliance rates of those eligible for the second portion of the study.

Implications

Although the results of this study were non-significant, there are still several important implications. As stated previously, PROP sensitivity may be a genetic marker for eating habits (Bartoshuk, 1993). Generally, because of heightened sensitivities, supertasters have a decreased preference for trigger foods, such as bitter, sweet, or sour foods, creamy dairy rich foods, foods containing chili pepper and alcohol. The converse is true for non-tasters; non-tasters are less sensitive to these foods. Therefore, non-tasters are more likely to prefer these trigger foods. Food preference can then guide food choices, which can be a determinant of dietary or overall health. For example, if a non-taster is less sensitive to a food containing a considerable amount

of chili pepper, it may lead to a higher probability of stomach ulcers or related digestive conditions such as Irritable Bowel Syndrome. Or, if a non-taster is more likely to prefer alcohol, this may lead to higher incidence of alcoholism or alcohol poisoning. More central to this study, even overall caloric intake could be affected by taster status. For example, if supertasters have a decreased preference for creamy dairy rich foods, which generally have a higher caloric count and fat content, and non-tasters do not have this preference, non-tasters may have a higher risk for obesity. In addition to the genetic factors (pre-disposition) and environmental factors (food readily available at lost cost and a decrease in daily physical activity) which influence obesity, taster status could also be a predictor

As stated previously, the blue food dye exam has its limitations due to damage or variability in fungiform papillae structure, which can be the result of a natural genetic occurrence. This could have been why the taster status results of this method and the taster status results of the filter paper method and gLMS did not correspond. It is quite possible that the blue food dye method may not be measuring taster status at all, as previously indicated. Since the papillae on the tongue also anatomically have taste buds in them, which one can conclude leads to specific brain signals for the five taste sensations, it is possible that papillae density has more to do with the gustatory system and the sense of taste rather than specific flavor sensitivity.

If the results of this study had been as hypothesized and taster status did have a relation to either measure of body fat percentage, physicians would be able to determine which patients may have a higher risk of obesity based on their sensitivity to bitter tastes, particularly 6-n-propylthiuracil. Therefore, greater precautions could be taken for that particular patient. In turn, obesity rates could potentially decline nationwide.

Further Research

There are many suggestions for future research in this area. First, replicating this study in its entirety without such strict pre-screening exclusions would be recommended. Again, this may allow for more variability and the possibility of a less restricted range of datum for at least some of the measured variables within the study. Also, for reasons noted above, analyzing the correlations among BAI, BMI, and taster status as a function of ethnic group would be an interesting approach in the future, as prior research has demonstrated that BAI may only correlate with other indices of body fat for individuals with certain ethnic identities. Furthermore, analyzing the correlations among BAI, BMI, and taster status as a function of age may show some interesting results. As people age, cultural variables may dictate food intake. Metabolism slows, more social activities involve food intake, and people may care less about appearance as they age. It could be possible that Hypothesis A could have been confirmed more for those participants in their 20s and 30s.

Adding a measurement of food preference would also be an interesting approach to these research questions. This researcher hypothesized that supertasters would have a lower body fat percentage than non-tasters. This drew upon conclusions that PROP sensitivity is correlated with lesser food consumption, but how much? Using a 24 hour food inventory or using interactive and easy to access food planners and trackers, on smart phones for example, would be a few examples of how to obtain such data. Using an interactive and always accessible method for the participant to input dietary intake would ensure a more accurate account of actual food consumption than a 24-hour recall. One possible way to most efficiently collect food intake information electronically may be through a text messaging system. Text messaging is a quick way to transfer information from one place to another, and a smart-phone is not a necessity for

an application to be downloaded. If participants sent a text message of what they ate to a designated telephone number each time they consumed food (regardless of quantity), preference patterns could possibly begin to emerge in consumption of certain food types. It could be that non-tasters, in general, consume less of one type of food, or food that falls into one category (of the food pyramid, for example). By consuming less of that type or category of food, they may then compensate with another category or type of food which may result in no net difference in body fat percentage. Conversely, the food that they choose to compensate may be higher in calories or fat and that could be the reason for a difference in body fat percentage. Patterns in food intake within taster status group would be interesting to investigate further.

Further analyses can also be conducted on the current data in an attempt to contribute to future research in this area. One benefit to the extensive pre-screening was that there was an extensive amount of data obtained from participants who were not eligible for this particular study. Some of the data obtained could allow us to investigate whether there are gender differences in self-report of height and weight as compared to actual height and weight. This information would be useful in examining body image. It could lead to further explanations regarding whether and why one gender may over- or under-exaggerate self-reported height and weight. For example, if males overestimate height, as previous research suggests, do they also overestimate their weight so as not to appear too thin for their height? Or, do males worry about appearing overweight so they provide a fairly accurate estimate of weight? In addition, it would be interesting to know whether certain gender(s) realize they are falsely reporting their heights and weights. Is this inaccurate reporting purposeful or do these inaccurate estimates become part of what individuals believe to be truth about themselves?

The current data could also be used to investigate whether being currently nutritionally deprived is related to being nutritionally deprived in the past and/or not having proper pre-natal care. It would also be interesting to know whether perceptions of being nutritionally deprived vary by taster status. Do supertasters perceive that they are nutritionally deprived because of the myriad of foods they chose to avoid? Lastly, the current data could also build upon past research examining gender differences in taster status groups (past research shows females are more likely to be supertasters, but why?) or gender differences in fungiform papillae density as well.

Conclusion

From a bitter taste in the air in 1931, Arthur Fox could never have imagined how extensive and important taste research would become. What began as a simple observation from his colleague regarding the air tasting bitter has spawned into research about food preferences, taste sensitivities, taste bud, and papillae density, taster status groups, and many more diverse research topics within this field. As noted above, finding a relation among body fat and taster status would be an innovative approach to treating obesity for physicians, nurses, dieticians, and other medical professionals. More specifically, if individuals could have a high risk of obesity based on their sensitivity to bitter tastes, particularly 6-n-propylthiuracil, greater precautions could be taken and rates of obesity could potentially decline nationwide. However, at this point, further research is necessary to realize these possibilities.

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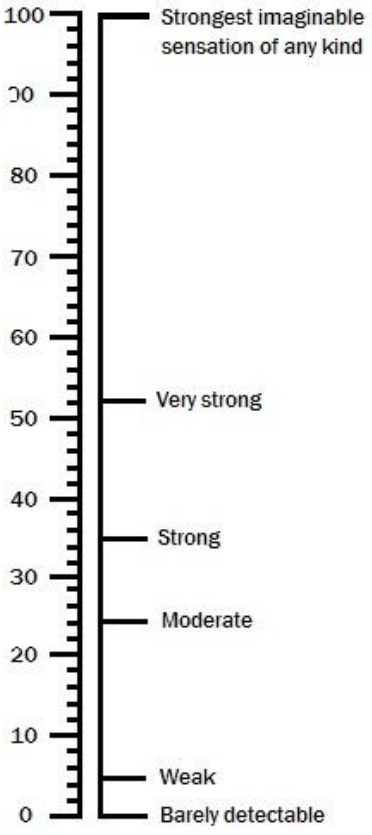
APPENDICES

Appendix A: general Labeled Magnitude Scale



The general Labeled Magnitude Scale devised by Green et al. (1993) and later adapted by Bartoshuk et al. (1994).

Appendix B: Pre-screening Questions via SONA/Survey Monkey

Pre-screening questionnaire: Taste sensitivity and body adiposity

1. What is your gender?

- Female
- Male

2. Which category below includes your age?

- 17 or younger
- 18-20
- 21-30
- 31-40
- 41 or older

3. Which race/ethnicity best describes you? (Please choose only one.)

- American Indian or Alaskan Native
- Asian / Pacific Islander
- Black or African American
- Hispanic American
- White / Caucasian
- Other (please specify): _____

4. How would you describe the economic situation of your family as you were growing up? We had:

- Almost enough to get by
- Enough go get by, but no more
- Definitely enough of everything
- Plenty of extras, but no luxuries
- Plenty of luxuries

5. How would you describe your economic situation now?

- Almost enough to get by
- Enough go get by, but no more
- Definitely enough of everything
- Plenty of extras, but no luxuries
- Plenty of luxuries

6. What is your current height: _____ ft. _____ in.

7. What is your current weight: _____ lbs.

8. To your knowledge, did your biological mother receive the proper nutrition and have a healthy diet while pregnant with you?

- Yes
- No

9. Have you ever been or are you currently nutritionally deprived (meaning you are not getting a proper quantity or quality of food to sustain a sufficient diet)?

- Yes

No

10. Are you currently a collegiate athlete?

Yes

No

11. Are you currently pregnant or lactating (if applicable)?

Yes

No

12. Do you currently have/are being treated for a diagnosed medical condition that has dietary restrictions?

Yes

No

13. Have you ever had bariatric surgery?

Yes

No

14. Are you currently taking any medications (prescribed or over the counter) that alter your appetite?

Yes

No

15. Do you currently have any loss of taste or smell?

Yes

No

16. Have you smoked a cigarette in the last month? Or smoked over 100 cigarettes in your lifetime?

- Yes
- No

17. Do you currently have a cold or have the flu?

- Yes
- No

Appendix C: Informed Consent for Research Screening

INFORMED CONSENT FOR RESEARCH SCREENING
Examining relationships of taste sensitivity and body fat percentage using body adiposity index: Main Study
Amanda J. Lemaster – Principal Investigator
Natalie Dove, Ph.D., Professor of Psychology – Co-investigator

1. Purpose of Study and How Long It Will Last: The purpose of this screening is to determine whether you are eligible to participate in an experimental study on taste sensitivities and body fat based on set inclusion and exclusion criteria. We cannot tell you in advance what the eligibility criteria are, but it is anticipated that many students will be eligible. This screening will be completed online and should only take approximately fifteen minutes to complete.

2. Participation Withdrawal or Refusal to Participate: Participation in this study is completely voluntary; you may choose to quit the research project at any time without any penalty. If you do decide to participate, you can change your mind at any time and withdraw from the study without negative consequences or loss of benefit. Because this section of the study is web-based, in order to withdraw, you can simply close the browser window at any time during the study.

3. Description of Study Procedures: For this study, you will be asked to fill out one online survey that will take approximately 15 minutes to complete. Following this consent form you will be lead to a 17 question questionnaire through Survey Monkey. You will be asked questions about your current activity and health, past medical conditions and some brief history. At the conclusion of the study, you will be given an algorithm to provide a participant code. This code is unique to you; please do not share it with anyone. If you are an eligible participant for the second step of the study, you will be identified only through your participant code. Additionally, at the conclusion of the survey, you will be asked to provide your primary email address. This will not be used for any identifying purposes. By providing an email address, you can then be contacted with the determination of eligibility. If you are deemed as an eligible participant for the study's conditions, you will be sent a list of days and times to continue the second phase of the study.

4. Confidentiality of Information Obtained: All responses and personally identifiable information will be kept confidential within the confines of Survey Monkey's privacy policy. Your personal responses will only be released to the principal investigator, who will download all the responses off the internet at the end of the study and delete the information off of the internet. At this point, any identifying information will be separated from your survey responses. During the second step of the study you will only be identified by your participant code, which you provided to protect your confidentiality. Information from this study may be reported or published in aggregated form, but your anonymity will be maintained in any publications or presentations.

5. Expected Risks of the Study: There are no known or anticipated risks for participating in the survey. If, however, you experience any reactions that are difficult for you to manage, you can

contact the principal investigator for referral information or you can contact Snow Health Center. Their services are free of charge to EMU students. 313 Snow Health Center, 734.487.1118.

6. Expected Benefits of the Study/Compensation for Participation: Your participation in this study will hopefully give the researchers a better understanding of the relationship between taste sensitivity and body fat percentage. You will have the benefit of learning a bit about how psychologists conduct research. If you are an EMU psychology student, it is possible that you may receive extra course credit in accordance with the guidelines established by your psychology-course instructor. In such cases, we will provide your instructor with your name and verification of participation so that this extra-credit can be awarded to you per your instructor's course policy. Extra credit may be granted proportionally more credit if participation in both phases are completed. In addition, completing both phases of the study will also result in your name being entered into a raffle. One grand prize will be a gift card in the amount of $80. Two second prizes could also be won, a gift card in the amount of $40. Lastly, two third prize gift cards will be awarded in the amount of $20. Upon completion of the raffle all names and contact information will be destroyed.

7. Use of Research Results: Findings from this study may be published in psychological journals and may also be presented at professional conferences. In addition, the data being collected are for the Principal Investigator's thesis, and, as such, may appear in that published document. As a participant, you are entitled to meet with the Principal Investigator to obtain the results of the study at any time and for any other questions or concerns.

8. Future Questions: If, at any time, you have questions about study procedures or your participation in the study, please contact the principal investigator, Mrs. Amanda Lemaster *(Phone: 248-736-8945; Email: aburnell@emich.edu)* or her Co-Investigator, Dr. Natalie Dove *(Phone: 734-487- 3782; Email: ndove@emich.edu).*

9. Human Subjects Review Board: This research protocol and informed consent document have been reviewed and approved by the Eastern Michigan University Human Subjects Review Committee for use from 1/30/13 to 1/29/14. If you have questions about the approval process, please contact Dr. Deb de Laski-Smith (734.486.0042, Interim Dean of the Graduate School and Administrative Co-chair of UHSCR, human.subjects@emich.edu).

CONSENT TO PARTICIPATE: I understand my rights as a research participant and I voluntarily consent to participate in this study and follow its requirements. I additionally understand the purpose, intent, and necessity of the present study. If I wish to, I can print a copy of this consent form for my future reference.

If you have read all of the above and would like to take part in this study, click the "next" button below. By doing so, you are giving informed consent for us to use your responses in this study.

If you do not wish to take part in this study, please close this browser window now.

Appendix D: Informed Consent for Participation in Research

INFORMED CONSENT FOR PARTICIPATION IN RESEARCH
Examining relationships of taste sensitivity and body fat percentage using body adiposity index: Main Study
Amanda J. Lemaster – Principal Investigator
Natalie Dove, Ph.D., Professor of Psychology – Co-investigator

1. Purpose of Study and How Long It Will Last: The purpose of this research study is to gain a better understanding of the relationships between taste sensitivities and body fat percentage, using body adiposity index (BAI) score. Total participation time will be approximately one half hour, divided among one experimental taste session, one taste bud density exam, and one BAI data collection session.

2. Participation Withdrawal or Refusal to Participate: Participation in this study is completely voluntary; you may choose to quit the research project at any time without any penalty. If you do decide to participate, you can change your mind at any time and withdraw from the study without negative consequences or loss of benefit. However, you will only be eligible for a raffle drawing if you complete all phases of the study.

3. Description of Study Procedures: The researcher will explain the study to you, answer any questions you may have, and witness your signature to this consent form. A duplicate copy of this informed consent will be provided, which includes follow-up contact information, if necessary. The experimental design consists of three components. One component will consist of testing for taste sensitivity. You will be instructed to rinse your mouth with distilled water and then you will be given a paper disk to place on your tongue. You will be instructed to give a rating on how intense the taste is. These steps will then be repeated. The second component of the experiment will entail a research assistant placing a small amount of blue food coloring on your tongue and then examining you taste buds. In the third component of the experiment your height, weight and your hip circumference will be measured and recorded by the researcher. After all components are complete, you will be debriefed and allowed to leave. It is estimated that you will be at the laboratory for approximately one half hour total. Throughout the study, the researchers ask that you DO NOT put your name on any of the study materials, so that your anonymity can be preserved but do put your participant code, which you will have created in the pre-screening process. If at any time you forget your participant code, the researcher will provide you with an algorithm to figure it out.

4. Confidentiality of Information Obtained: All responses and personally identifiable information will be kept confidential. You will choose a participant code which you will use throughout the study to protect your confidentiality. Information from this study may be reported or published in aggregated form, but your anonymity will be maintained in any publications or presentations.

5. Expected Risks of the Study: 6-*n*-propylthiouracil (PROP) will be used in the taste sensitivity experiment. PROP is used for thyroid treatment. Normal treatment calls for three or four 50mg tablets per day. The level of PROP on the disk you will be placing in your mouth is

approximately 0.34mg. Standard blue food dye (GFS brand) will be used in the taste bud density exam. If you experience any reactions that are difficult for you to manage, you can contact the principal investigator for referral information or you can contact Snow Health Center. Their services are free of charge to EMU students. 313 Snow Health Center, 734.487.1118, Counseling.Services@emich.edu.

6. Expected Benefits of the Study/Compensation for Participation: Your participation in this study will hopefully give the researchers a better understanding of the relationship between taste sensitivity and obesity. Through the filter paper method results and the taste bud density results, you will gain the knowledge of what category of taster you are (blind, medium or supertaster) which could explain eating habits and preferences. By learning your own personal BAI (body fat percentage) this information has the potential to encourage a healthy or healthier lifestyle. You will have the benefit of learning a bit about how psychologists conduct research. If you are an EMU psychology student, it is possible that you may receive extra course credit in accordance with the guidelines established by your psychology-course instructor. In such cases, we will provide your instructor with your name and verification of participation so that this extra-credit can be awarded to you per your instructor's course policy. Extra credit may be granted proportionally more credit if participation in both phases are completed. In addition, completing both phases of the study will also result in your name being entered into a raffle. One grand prize will be a gift card in the amount of $80. Two second prizes could also be won, a gift card in the amount of $40. Lastly, two third prize gift cards will be awarded in the amount of $20. Upon completion of the raffle all names and contact information will be destroyed. If you are interested in participating, a ticket can be completed following debriefing.

7. Use of Research Results: Findings from this study may be published in psychological journals and may also be presented at professional conferences. In addition, the data being collected are for the Principal Investigator's thesis, and, as such, may appear in that published document. As a participant, you are entitled to meet with the Principal Investigator to obtain the results of the study at any time and for any other questions or concerns.

8. Future Questions: If, at any time, you have questions about study procedures or your participation in the study, please contact the principal investigator, Mrs. Amanda Lemaster *(Phone: 248-736-8945; Email: aburnell@emich.edu)* or her Co-Investigator, Dr. Natalie Dove *(Phone: 734-487- 3782; Email: ndove@emich.edu).*

9. Human Subjects Review Board: This research protocol and informed consent document have been reviewed and approved by the Eastern Michigan University Human Subjects Review Committee for use from 1/30/13 to 1/29/14. If you have questions about the approval process, please contact Dr. Deb de Laski-Smith (734.486.0042, Interim Dean of the Graduate School and Administrative Co-chair of UHSCR, human.subjects@emich.edu).

CONSENT TO PARTICIPATE: I understand my rights as a research participant and I voluntarily consent to participate in this study and follow its requirements. I additionally understand the purpose, intent, and necessity of the present study. I will receive a copy of this consent form for my future reference.

_____ _____

Participant Signature *Date*

_____

Participant Name (Print)

Appendix E: Researcher Instructions for the Filter Paper Method and general Labeled Magnitude Scale

Instructions for filter paper method using the general Labeled Magnitude Scale based on instructions found in *Evaluating the 'Labeled Magnitude Scale' for measuring sensations of taste and smell* (Green et al., 1993).

"This portion of the experiment will determine your taster status through the filter paper method that you read about in the informed consent. Please mark your participant code on the top of the scale and then listen to all of the instructions before beginning anything further.

"In front of you, you will find two cups, one filled with simple distilled water and another empty, two bags with filter paper in them, a writing utensil and a scale to make your judgments. You will begin the experiment by taking a sip from the cup filled with water, swishing it around in your mouth, and spitting into the empty cup. (Please make sure you're remembering which is the sip and which is the spit cup). This is to completely rinse your pallet before we begin. You will also be asked to do this between and after tasting.

"Next, grab the paper disk out of the bag labeled #1. Place the disk on your tongue. You can place it anywhere, for as long as necessary. You can also leave your mouth open, or close it, which ever you prefer. You will hold this disk in your mouth until you think you understand the intensity of the taste. Once you do, you can take the disk out of your mouth (there are double bagged garbage cans on each side on the testing station). You will then rate the taste intensity on the scale provided by making a mark on the scale, followed by the disk number (for example, #1). This is a continuous scale, so feel free to mark anywhere you see fit on the vertical axis of the scale. The marks with labels such as "barely detectable" or "very strong" are just there as a

reference point to you. You do not need to mark exactly on those labels. In making your judgments of taste, you should rate the disk relative to other tastes of all kinds that you have experienced. Thus, ‘strongest imaginable' refers to the most intense sensation of taste that you can ever imagine experiencing. Note that by 'taste' we do not mean the pain produced by a physical trauma like biting or burning your tongue (this is not to be anticipated). Simply rate the samples relative to tastes that you experience in daily life.

“After you have completed your intensity rating, you will be asked to sip, swish and spit and repeat the procedure with the second disk.

“You may begin now.”