INQUIRY & INVESTIGATION

Why Do We Choose Certain Foods?

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Abstract

Research into human eating behavior is complex. Innate preferences for sweet and aversions to bitter tastes may explain why we choose certain foods. Some segments of the population, called "supertasters," are more sensitive to bitter-tasting foods because of a genetic polymorphism. These individuals may reject bitter vegetables like broccoli, potentially putting them at risk for obesity and chronic disease. However, learned associations with food, including rewards, social experiences, and modeling, have also been shown to explain food choice. The respective roles of taste and learning in food choice are explored here in a classroom investigation designed for undergraduates.

Key Words: *Taste; genetics; nutrition; public health.*

○ Introduction

Human eating behavior has long been the subject of scientific inquiry. Determining why we eat certain foods and not others has been the objective of many disciplines, ranging from anthropology to psychology. Nutritionists and public health practitioners have recently led the charge to understand this process, concerned about the shifting dietary patterns that are to blame for rises in obesity and noncommunicable diseases (Malik et al., 2013). Promoting health would be easier, it is argued, if we knew what leads some to choose nutrient-dense foods like broccoli instead of cupcakes.

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Human food choice is influenced by a range of biological, social, and environmental factors. Two, in particular, have been implicated as predisposing individuals to dietary patterns that promote obesity: inborn biological taste preferences and associative taste learning (Mennella, 2014). This complex interplay can be simplified through the "nature versus nurture" paradigm, but this is of little use for educators who strive to emphasize the subtle nuances that make inquiry of this sort interesting and applicable to society (Falk, 2014).

Here, I provide a basic overview of the biology and genetics of taste and discuss the potential for taste learning early in life; this information can be provided to students as prerequisite knowledge. I further describe the social and ethical implications of taste and food choice and provide a case study and classroom-based laboratory activity designed to help students think through the respective roles of taste, genetics, and flavor learning.

○ The Biological Basis of Taste

As early as 1825, taste was noted as a driver of eating behavior, purported to function principally as the mechanism by which humans "repair the continual losses which we suffer by the action of life" and allow us to "select, among the various substances Nature presents to us those which are alimentary" (Brillat-Savarin, 1825). Today, taste is cited as the most important reason for food purchases in consumer surveys (International Food Information Council, 2013). *Taste* is defined as one of the basic qualities of a food (sweet, salty, bitter, sour, and umami) that can be perceived by the human body. Specifically, taste is a sensation perceived by the fungiform papillae, or taste buds, on the anterior of the tongue (Drewnowski & Monsivais, 2012). This is different from the other sensory properties that a food offers, including its mouth feel, sound, smell, and appearance, which, when combined with taste, are more properly called *flavor*.

Several lines of research have converged on the conclusion that preferences for sweet and aversions to bitter tastes originate innately (Steiner, 1979; Mennella, 2014). Studies of early infants' facial expressions help elucidate responses to taste and, therefore, the presence of taste receptors (Forestell & Mennella, 2007). Such studies have helped to determine that bitter-tasting compounds are detected at very low thresholds and trigger an innate aversion (Feeny et al., 2011), that the preference for sweetness is universal, and that children prefer

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sweetness in greater concentrations than adults (Drewnowski, 1997). Evolutionary biologists have described the preference for sweet and aversion to bitter as biological adaptations designed to signal the presence of energy-providing carbohydrates and to protect against potentially toxic substances from plants, respectively. However, in the current food environment, the mechanisms through which humans recognize and choose foods may be co-opted and lead to overconsumption.

There is growing recognition that humans live in different taste worlds. Despite evidence of a universal perception of and distaste for bitter, the degree to which humans can perceive this taste varies across the population (Hayes et al., 2008). Genetic polymorphisms have been identified that result in differential expression of the class of bitter taste receptors, TAS2R (Mennella, 2014). Those who display a dominant phenotype, called *supertasters*, are more likely to detect bitter-tasting compounds in smaller concentrations. Further, supertasters may exhibit greater density of fungiform papillae, the structures found on the tongue that house taste receptors (Hayes et al., 2008).

These subtle differences in taste perception have led investigators to wonder how they may influence food choice. It has been hypothesized that supertasters would likely reject and avoid the most bitter of foods, especially leafy greens and cruciferous vegetables. While laboratory studies confirm that supertasters have a lower threshold for bitter compounds and rate bitter substances as less palatable, there is little agreement on the extent to which this status may alter choices. Some observational studies have shown that supertasters have lower intakes of vegetables, while others have shown no relationship (Baranowski et al., 2011; Feeny et al., 2011).

A complex chain of events links basic biology to food choice, including learned associations such as social and contextual factors. In infancy, flavors in the amniotic fluid and the mother's milk may prime the infant to accept the taste of bitter foods that the mother usually eats (Mennella, 2014). In childhood, parental modeling, rewards, social experiences, and repeated exposure can help promote the consumption of bitter vegetables (Addessi et al., 2005). Experimental studies of children have shown that alterations to bitter foods, such as the addition of dips or sauces, can reduce the bitter taste and induce a preference (Fisher et al., 2012; Sharafi et al., 2013). In adulthood, it is thought that aversion to some widely consumed bitter foods like coffee, tea, and beer is overcome by the learned effect of accompanying chemical compounds like caffeine and alcohol and their physiological effects (Drewnowski & Monsivais, 2012).

○ Implications for Public Health

Overall, the role of bitter taste sensitivity and food choice is inconclusive but has interesting implications for public health practitioners. Supertasters demonstrate a wide range of behaviors that are associated with weight status – for example, they may reject bitter foods, namely cruciferous vegetables like kale, broccoli, Brussels sprouts, and cabbage, possibly putting them at risk for obesity and chronic diseases like cancer (Feeny et al., 2011). On the other hand, some behaviors exhibited by supertasters may be protective of health. Presumably because of their greater density of taste buds, supertasters are more likely to reject alcohol (Pelchat & Danowski, 1992) and high-fat foods like cheeses and creamy dressings (Feeny et al., 2011).

Current estimates suggest that Americans largely do not meet public health recommendations for fruits and vegetables and exceed recommended limits for sugars (Krebs-Smith et al., 2010a). Simultaneously, the U.S. food supply is unhealthy and oversupplies added sugar in foods (Krebs-Smith et al., 2010b). Although bitter taste sensitivity has no relationship to sweet taste sensitivity, children are more sensitive to bitter and prefer sweet solutions in a greater concentration than adults (Drewnowski et al., 2012).

The complexity of food choice, a mixture of both biology and learning, makes it difficult to conceive appropriate interventions to promote healthful diets. Although universal, the preference for sweet and distaste for bitter are also subject to learned associations. Biology is not destiny, at least for food choice; the roles and quantities of sweets and bitter-tasting vegetables in the diet can be learned. Public health strategies to improve diet may be necessary, such as social marketing campaigns that attempt to educate families about the importance of fruits and vegetables or restrictions on advertising of sweet foods during children's television programming.

○ A Classroom Investigation

Materials

- Phenylthiocarbamide (PTC) strips
- Visual analog scales (VAS)
- Preference and food frequency questionnaires (FFQs)
- *Optional:* Broccoli (or similarly bitter-tasting vegetable) and strawberries (or similar sweet-tasting fruit)

Methods

The preceding discussion of taste and food choice was integrated into a laboratory activity for an undergraduate-level introductory science course for nonmajors, mostly consisting of freshmen and sophomores. The activity described below can take place in a general classroom and does not require specific equipment beyond the aforementioned materials.

Students are first divided into groups of three to five and presented a video and a *New York Times* article describing President George Bush's comments about broccoli as a case study (Dowd, 1990). They are asked to hypothesize possible reasons for his distaste for the vegetable and are encouraged to think scientifically about how to gather more evidence to support this hypothesis. Although answers are varied, students inevitably mention taste as a possible reason.

We then cover three commonly used measurement methods in nutrition research. The first is a method to measure taste sensitivity. Taste sensitivity has been explored in the laboratory using the

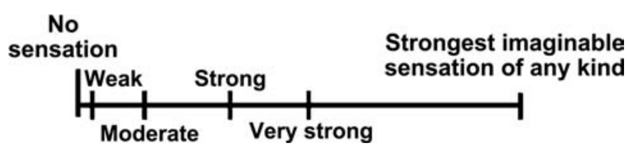

Figure 1. A version of the visual analog scale used in the classroom investigation.

Table 1. Questionnaire items used to assess the preference for selected foods in relation to taster status.

	Don't like at all	Dislike somewhat	Neutral	Somewhat like	Like a lot
Broccoli	1	2	3	4	5
Brussels sprouts	1	2	3	4	5
Cabbage	1	2	3	4	5
Radish	1	2	3	4	5
Kale	1	2	3	4	5
Arugula	1	2	3	4	5
Coffee	1	2	3	4	5
Tea	1	2	3	4	5
Grapefruit	1	2	3	4	5
Strawberries	1	2	3	4	5
Carrots	1	2	3	4	5
Apples	1	2	3	4	5
Sweets and candies	1	2	3	4	5
Potatoes	1	2	3	4	5

Table 2. Questionnaire items used to assess the frequency of consumption of selected foods related to taster status.

	Less than once per week	About once per week	A few times per week	Almost every day	Two or more times per day
Broccoli	1	2	3	4	5
Brussels sprouts	1	2	3	4	5
Cabbage	1	2	3	4	5
Radish	1	2	3	4	5
Kale	1	2	3	4	5
Arugula	1	2	3	4	5
Coffee	1	2	3	4	5
Tea	1	2	3	4	5
Grapefruit	1	2	3	4	5
Strawberries	1	2	3	4	5
Carrots	1	2	3	4	5
Apples	1	2	3	4	5
Sweets and candies	1	2	3	4	5
Potatoes	1	2	3	4	5

bitter-tasting compounds phenylthiocarbamide (PTC) and n-6-propylthiouracil (PROP), which, when administered to the tongue, are perceived by some as bitter. Strips impregnated with either of these compounds are easily obtained (Fisher Scientific). Biology teachers have previously used the PTC chemical to teach genetics because it is illustrative of a simple, heritable Mendelian trait (Overath, 2014). Here, the PTC strip is used to inform discussion of taste, learning, and food choice within the "nature versus nurture" paradigm.

Students are introduced to the visual analog scale (VAS; Figure 1), which allows for the quantification of taste experiences (Kalva et al., 2014). The scale is labeled, and participants are first instructed to think about a food or drink that has no sensation (labeled "0") and a food or drink that has the strongest imaginable sensation (labeled "100"). Then any food or drink can be presented to them, and they are instructed to enumerate it on the scale. Often the food or drink of interest is paired with a control that has no taste, and participants are asked to rinse with water between tests.

Prior to this class session, students are asked to complete a preference and food-frequency questionnaire (FFQ) for selected bitter foods (Tables 1 and 2). FFQs are often used in nutrition research and are an accepted method to quantify eating behaviors and food-choice preferences (Willett, 2013). This step must be completed in a session prior to discussion about bitter foods, so as not to bias students on the basis of their taster status. Although other FFQs are more expansive and attempt to capture all foods and drinks eaten in a given period, this questionnaire is specific to the frequency and preference for consumption of selected bitter, sweet, or control foods that are postulated to be related to taster status.

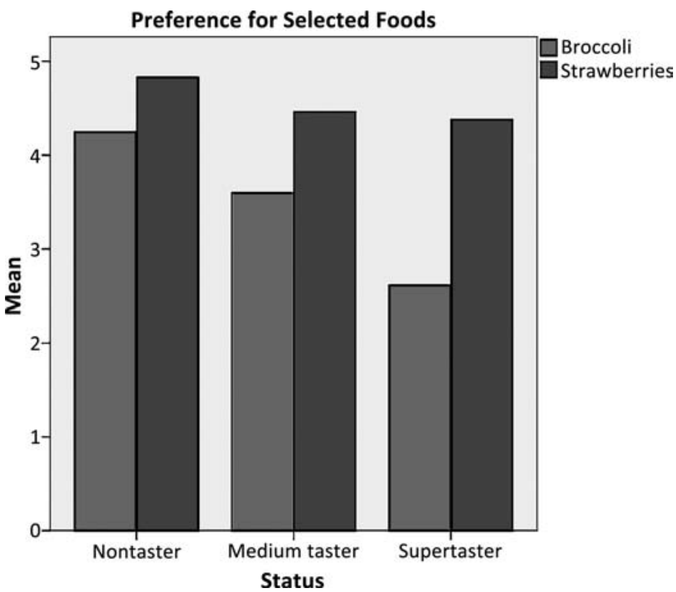

Figure 2. Example of data analysis of food frequency questionnaire and taster status.

To begin the experiment, students are presented with PTC strips and asked to rate the intensity of the taste on the VAS, following previous recommendations (for details, see Baranowski et al., 2011). Students are categorized as supertasters or nontasters, based on their intensity rating of the strip. Ratings <50 are defined as "nontaster," ratings >70 as "supertaster," and ratings in between as "medium taster." The experiment is best conducted in courses with ≥60 students; previous authors have estimated that the distribution of medium tasters, supertasters, and nontasters is about 20%, 50%, and 30%, respectively (Feeny et al., 2011).

The students' FFQs are then analyzed by taster status, comparing supertasters, medium tasters, and nontasters (see Figure 2). Answers to the FFQ can be collected electronically using online survey software to facilitate comparison (and can save class time if administered as homework). Students can create their own comparisons in groups and share with the class. Students should calculate average preference and frequency of consumption for various foods and compare groups by taster status (e.g., through bar graphs). It is hypothesized that supertasters will have lower preference for and frequency of consumption of bitter foods, namely broccoli, coffee, and tea. Depending on the size of the class and the spread of taster types, the results may or may not be consistent with these hypotheses. If this happens, the instructor should prompt the students to consider why some may grow to like certain bitter foods despite their genetic predisposition (for a list of questions for discussion, see Table 3).

To expand upon the investigation, food taste tests can be incorporated into the investigation, similar to those explained by Smutzer et al. (2006). For example, vegetables and fruits would also make ideal taste-testing material and might help students increase their

Table 3. Questions to prompt discussion during the laboratory activity.

1.	What are some reasons that the president might dislike broccoli?
2.	Do comments like these undermine the work of nutritionists who hope to ensure that the population eats healthy?
3.	What are some other bitter foods that humans consume?
4.	Is there a genetic basis for taste? How could we test this?
5.	Were there members of your group (or class) who avoided bitter foods but really preferred sweet ones? Vice versa?
6.	Are your findings consistent with the original hypothesis that those with the genetic predisposition to avoid bitter eat fewer bitter foods? How do you know?
7.	Based on our findings, what can we say about the genetics of taste? How representative is our class of other populations and settings?
8.	How can we design a follow-up experiment to confirm our findings?
9.	How might you learn to like a food that you initially found bitter and unpleasant?
10.	Knowing that certain dark-green and leafy vegetables are good for health, but also bitter and unpleasant, should future presidents pretend to like bitter-tasting vegetables to ensure that citizens eat them?

consumption of these foods while learning about the reasons they may avoid them. Broccoli and strawberries, for example, easily illustrate the difference between sweet and bitter foods (a neutral-tasting food, such as a jicama, can be included as a placebo test).

○ Conclusion

While the science of food choice is robust, and the reasons why we choose certain foods cannot yet be fully explained, bitter taste remains an area of exploration. In this case study of bitter taste, students are afforded three different measurement methods in nutrition research that can be used in the classroom to study the "bitter taste hypothesis." Results from the study inform a classroom discussion of the "nature versus nurture" of human eating behavior, from biological taste mechanisms to learned experiences with food.

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