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Research report

Relationship between food preferences and PROP taster status of college students

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ABSTRACT

How food tastes plays a key role in our food choices and eating behavior, with important implications for health and nutrition. The negative relationship of genetically predisposed sensitivity to 6-n-propylthiouracil (PROP) and food preferences for bitter, creamy, and spicy foods, and alcohol is often reported in both scholarly and popular literature. Our review of research indicates the empirical results are far from conclusive. We conducted a questionnaire-based study to examine enjoyment ratings for 12 foods and beverages often reported to be disliked by PROP supertasters. We measured PROP ratings on the modified gLMS scale and administered a questionnaire to assess food preferences of a sample of 139 college undergraduates. Analysis of variance showed no significant group differences between supertasters, medium tasters, and nontasters in ratings of how much they liked brussels sprouts, raw broccoli, cabbage, spinach, black coffee, dark chocolate, crushed red pepper, jalapenos, chili peppers, red wine, beer, creamy salad dressing, or mayonnaise. Preferences for only two foods out of twelve, dark chocolate and chili peppers, had a significant correlation with PROP sensitivity in the predicted negative direction. While statistically significant, these correlations were low and of little practical significance. The role of culture in shaping attitudes toward food is proposed as a more powerful influence than the genetic factors that relate to PROP sensitivity.

Introduction

There is no denying that our individual pattern of preferences and aversions for various foods make us unique. Each of us loves foods that someone else loathes, and vice versa. These differences in food preferences have important implications for our health and well being. We are encouraged to eat fewer refined sugars and saturated fats and more fresh vegetables, especially green and cruciferous vegetables. Heart disease, stroke, cancer, hypertension, and obesity are but a few of the diseases linked to unhealthy eating habits. What is involved shaping in our individual tendency to enjoy certain foods and our strong aversion to others?

The taste of food is certainly a key component of preference. Consumers report that their food preferences are guided primarily by how the food tastes (Glanz, Basi, Maibach, Goldberg, & Snyder, 1998). Universally, foods that are high in sugar and fat are preferred over foods that are bitter (Drewnowski, 1997). This tendency is particularly strong during childhood (Mennella, Pepino, & Reed, 2005). However, there is ample evidence that when two individuals sample the same food they may have very different taste experiences. How do genetics and culture shape our perceptions of flavor? Research and theory examining these influences will be reviewed, and an empirical study aimed at understanding the relative contributions of genetics and culture will be presented.

Genetic aspects of taste perception

Bradbury (2004) defines taste as the sense by which the chemical qualities of food in the mouth are distinguished by the brain, based on information provided by the taste buds. The five taste qualities that humans perceive are salty, sweet, sour, bitter, and umami (savory flavors found in foods such as meaty broths, soy sauce, seaweed, Vegemite, bacon, aged parmesan cheese, monosodium glutamate). The ability to detect each flavor has an evolutionary purpose key to our species' survival. We need salt, or sodium chloride, a mineral necessary for almost all aspects of metabolism and neurological functioning. We crave sweet flavors, which help us obtain needed caloric energy from sugars and carbohydrates. Sour flavors, signaling acidity, are a cue that food has spoiled, or is unripe. Bitter flavors serve as a warning about poisonous foods and plants. Umami stimulates glutamate receptors and helps detect foods high in protein and amino acids (Bradbury, 2004).

Taste buds, housed primarily in fungiform papillae on the tongue, contain between 50 and 100 taste cells specialized to detect food flavors and textures. These cells have microvilli that poke

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through the taste pore on the top of the taste bud. Contact between the taste cell and food molecules stimulate neurotransmission along facial nerves, to the thalamus, and then to the somatosensory cortex where flavor is perceived. The widely popular textbook "tongue map" indicating that each part of the tongue is specialized to detect a flavor, for example sweet at the tip of the tongue, is incorrect. A mistranslation of an early research study led to the tongue map's dissemination for years in spite of evidence to the contrary; taste receptors for the various flavors are not regionalized (Smith & Margolskee, 2001). Aroma is also a major influence on how flavors are perceived in the brain, however this paper will focus on research regarding oral taste sensations as has most of the literature to date.

The importance of taste perception in helping early humans to identify and seek out important nutrients and avoid potentially poisonous compounds was critical to survival of our ancestors, subsistence hunters and gatherers for whom obtaining sufficient calories was a challenge. From birth we are hard-wired to crave sweet and salty flavors and reject bitter foods (Desor, Maller, & Andrews, 1975). However, this does not explain the tremendous variation in food preferences within the human population.

Much research on the topic of taste has explored how individual differences in the ability to detect bitterness and other food attributes relate to our food preferences. The ability to detect bitter flavors is a genetic trait encoded through specific genes in the T2R family, such as TAS2R38 (Bufe et al., 2005; Kim & Drayna, 2005). Which form of this gene and related genes an individual inherits determines his or her threshold for detection of bitter compounds (Mennella et al., 2005). The genetics of taste perception have been studied since the early 1930s, when researcher A. Fox made the serendipitous finding that a chemical called phenylthiocarbamide (PTC) tasted very bitter to some individuals but not at all bitter to others (Blakeslee & Fox, 1932). Research on PTC and its chemical cousin 6-n-propylthiouracil (PROP) has found that about 75% of the human population experiences these substances as intensely bitter, but 25–30% experience no bitterness whatsoever (Kim & Drayna, 2005). The degree of sensation experienced, and the associated genetic variant, has been reported to be correlated with the number and density of taste buds on the tongue. Those who detect no bitterness are reported to have significantly fewer fungiform papillae, structures on the tongue that contain taste buds, compared to those who find these substances highly bitter (Bartoshuk, Duffy, & Miller, 1994). However more research is needed to determine the relationship of genotype and taste bud density (Feeney, 2011). What is clear is that there are significant individual differences in the sensations elicited by stimulation of taste receptors at a basic sensory level.

Why would roughly 25% of the human population inherit a trait that renders them unable to detect bitterness, particularly if detecting bitterness was an advantage for our genetic ancestors' survival? It may be that under certain conditions, not detecting bitterness conveyed a genetic advantage. Ironically, many healthy foods do contain bitter-tasting compounds. Green and cruciferous vegetables such as kale, collard and mustard greens, Brussels sprouts, and broccoli are nutrient-rich foods that many perceive as bitter. Similar foods in our ancestor's environment would likely have been avoided by those who readily detected bitterness, but eaten by those who lacked the gene for bitterness detection. If this genetic trait provided an advantage in some situations but a disadvantage at other times, the variant forms of this gene would continue to be passed down in a proportion of the population. This would explain why about 25% of the human population is "taste blind" to bitterness. It is possible that their genetic ancestors ate healthy plants and somehow escaped succumbing to poisonous ones.

Assessing "Taster Status"

Linda Bartoshuk (1991) coined the terms "nontaster," "taster," and "supertaster" to categorize individuals according to their sensitivity to bitterness, or "taster status." The approximately 25% of the human population that does not detect bitterness in response to PROP are nontasters. Of the 75% that do detect bitterness, the 25% who detect the most intense, aversive sensation are categorized as supertasters. The remaining 50% are considered medium tasters who perceive PROP as bitter, but not as intensely bitter as the supertasters report. Medium tasters and supertasters may be referred to as "tasters".

Stuckey (2012) suggests the term "nontaster" should be replaced with "tolerant taster" and supertasters be called "hypertasters", as the original terms are misleading. The term "supertaster" connotes a gourmand adventurer who relishes flavor, however supertasters are reported to prefer blander foods that do not overwhelm their sensitive sense of taste. Nontasters do in fact taste flavors but have a much higher threshold for detecting bitterness and sweetness. Nontasters are reported to be more adventurous, less picky eaters who like more highly seasoned and stronger flavored foods. While we agree that the original terms are somewhat misleading, we will use them for consistency with the taste literature.

Most researchers assess taste sensitivity through the "PROP test". The participant places a small paper soaked in a liquid PROP (or PTC) solution on the tongue and rates the intensity of sensation experienced, from 0 to 100, on the modified general Labeled Magnitude Scale (Bartoshuk et al., 2004). Participants who perceive little to no sensation from the PROP are nontasters, those who perceive extremely powerful sensations are supertasters, and those in the middle are medium tasters. Another method of assessing taster status is to stain the tongue with blue food coloring which allows the number of fungiform papillae that house taste buds in a given area to be counted (Miller and Reedy, 1990). The results of this more time-consuming process correlate with the PROP measure (Tepper, 2008).

The individual's nontaster, medium taster, or supertaster status is purported to play a key role in the foods we prefer and those we dislike. The next section will review briefly review research that has found that medium and supertasters perceive more intense bitterness and other taste sensations, than do nontasters. Supertasters, and to a lesser extent medium tasters, are reported to dislike foods that are bitter, spicy, and strong tasting. Nontasters are said to have the opposite preference, in favor of bitter and strong tasting foods. However, the results of research are not clear cut. Many studies have found that taster status, measured through the standard PROP or PTC method, did not predict food preferences or consumption. Our informal observations while administering PROP at various seminars and demonstrations have been that food preferences and PROP response often do not fit the paradigm reported by most research on supertasters and their presumed food aversions. We will provide a brief review of the research literature and then report an original empirical study where we examined the correlation of PROP response with food preferences for a wide range of foods reported to be disliked by those who are sensitive to PROP.

Previous research on taste preferences and taster status

Bitter foods

Glanville and Kaplan (1965) found early evidence that PROP tasters disliked black coffee, grapefruit juice, lemon juice, and preferred mild over sharp foods. Those who reacted strongly to the PROP tended to dislike more foods, while those who could not taste the PROP reported preferences for strongly flavored foods. Other