ARTICLE IN PRESS

Food Quality and Preference xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Food Quality and Preference

journal homepage: www.elsevier.com/locate/foodqual

Sweet liker status in children and adults: Consequences for beverage intake in adults

Nicole L. Garneau[a], Tiffany M. Nuessle[a], Barbara J. Mendelsberg[a], Stephanie Shepard[a], Robin M. Tucker[b,*]

[a] Denver Museum of Nature & Science, 2001 Colorado Blvd, Denver, CO 80205 United States

[b] Department of Food Science and Human Nutrition, 2110 S. Anthony Hall, 474 S. Shaw Ln, Michigan State University, East Lansing, MI 48824, United States

ARTICLE INFO

Keywords:
Sweet taste
Sweetness
Sweet preference
Beverages
Sugar-sweetened beverages
Children
Adults

ABSTRACT

Different patterns of sweet liking exist. For some, liking increases as concentration increases up to a point at which it typically plateaus. These individuals are referred to as sweet likers. How sweet likers' beverage intake, especially sugar sweetened beverage intake, differs from sweet dislikers' beverage intake is not well characterized. A total of 953 visitors (650 adults; 62.0% women; 303 children; 58.7% girls) to the Denver Museum of Nature & Science rated the taste intensity and liking of 5 sucrose solutions that spanned concentrations typically encountered in sugar-sweetened beverages (0.0–13.7% w/v) using visual analog scales. Beverage intake by adults was quantified using the validated BEVQ-15 questionnaire. Among adults, hierarchical cluster analysis identified three clusters of liking patterns (likers, dislikers, and neutrals). Among children, two clusters of liking patterns were identified (likers and dislikers). For both adults and children, BMI, percent body fat, age, and sex did not differ between clusters. Concentration by cluster interaction effects were observed for both adults and children. Adult sweet likers consumed more energy from all beverages, more sweetened juice and tea, and less water than those in other clusters. Sweet liker status may be a useful predictor of increased energy intake from beverages, but prospective trials are necessary to confirm this utility.

1. Introduction

While humans are born with an innate appreciation for sweetness (Steiner, 1979), the degree of liking can differ from one person to the next. Psychophysical studies testing sucrose or other sweet solutions have established individual variation in sweet liking (Asao et al., 2015; Drewnowski, Henderson, Shore, & Barratt-Fornell, 1997; Kim, Prescott, & Kim, 2014, 2017; Looy, Callaghan, & Weingarten, 1992; Looy & Weingarten, 1991, 1992; Methven, Xiao, Cai, & Prescott, 2016; Pangborn, 1970; Stone & Pangborn, 1990; Thompson, Moskowitz, & Campbell, 1976; Witherly, Pangborn, & Stern, 1980; Yeomans, Tepper, Rietzschel, & Prescott, 2007). For some individuals, as sweetness intensity increases, liking increases, with an eventual plateau for liking if the concentration is sufficiently high enough; for others, as intensity increases, liking may decrease, remain relatively neutral across all tested concentrations, or follow an inverted U-shaped pattern where liking increases up to a point and then decreases (Drewnowski et al., 1997; Kim et al., 2014, 2017; Looy & Weingarten, 1991; Looy et al., 1992; Methven et al., 2016; Pangborn, 1970; Stone & Pangborn, 1990; Witherly et al., 1980; Yeomans et al., 2007). In these studies, the first class of people have been referred to as sweet "likers" while those whose liking decreases as concentration increases are typically classified as sweet "dislikers". Participants who follow an inverted U-shaped pattern are sometimes categorized as dislikers (e.g. Yeomans et al., 2007), as their own category, (e.g., Stone & Pangborn, 1990), or removed from analysis (e.g., Looy et al., 1992). These sweet liking patterns are observed across a variety of cultures (Holt, Cobiac, Beaumont-Smith, Easton, & Best, 2000; Moskowitz, Kumaraiah, Sharma, Jacobs, & Sharma, 1975; Prescott et al., 1992), suggesting that sweet liker/disliker phenotypes are fairly robust. There is also some data to suggest that sweet liker status determined by sucrose liking also holds for liking of other sweet substances, like stevia (Oleson, 2014). Thus, it could be the case that sweet liker status could be a useful predictor of intake of nutritive and non-nutritive sweeteners across cultures.

Performance during psychophysical testing does not always predict behaviors towards food or intake; yet, sweet liker status has been associated with both liking of other sweet foods and intake of sugars (Holt et al., 2000; Kim et al., 2014). Classification of Korean women based on sweet liker or disliker status produced differences in liking ratings of

* Corresponding author.
E-mail addresses: Nicole.garneau@dmns.org (N.L. Garneau), tiffany.nuessle@dmns.org (T.M. Nuessle), tucker98@msu.edu (R.M. Tucker).

http://dx.doi.org/10.1016/j.foodqual.2017.10.005
Received 14 July 2017; Received in revised form 18 September 2017; Accepted 10 October 2017

some, but not all, sweet foods (Kim et al., 2014). In that study, the "disliker" group followed an inverted U-shape pattern of liking and rated the donut, chocolate milk, and non-nutritively sweetened coffee stimuli as less liked, but significant differences in liking were not observed for other foods with similar chemosensory or nutritional profiles like cookies, coffee with sugar, or milkshakes. Findings from studies assessing sweet liker status and dietary intake of sugars have been mixed, with one study observing higher refined sugar intake among sweet likers (Holt et al., 2000) while another found no differences in intake (Methven et al., 2016). Explanations for these differences may include differences in genetics and/or habitual diet as participants in the Holt study were Australian and Malaysian, while participants in the Methven study were Korean. An examination of relationships between sweet liker classification and beverage intake has not been reported previously, and differences between sweet likers and dislikers may be more apparent due to the greater similarity between taste stimuli tested and beverages.

Sugar added to foods often enhances palatability but provides little in the way of nutrition besides energy. For this reason, the 2015 US Dietary Guidelines Committee (Dietary Guidelines Advisory, 2015) recommended reducing added sugar intake to no more than 10% of total calories. Compared to foods sweetened with sugar, sugar-sweetened beverages appear to pose a greater risk for weight gain, as beverages possess lower satiety properties and elicit weaker dietary compensation (Tucker & Mattes, 2013). If sweet liker status influences intake of sweet beverages, then sweet likers could be at increased risk for health problems, including obesity.

Given the correlations between sweet liker status and liking of sweet foods, we sought to determine if there were associations between sweet liker status and beverage intake among adults. We hypothesized that sweet likers would consume more sugar-sweetened beverages. We also examined if there were associations between sweet liker status and body weight, given that some studies find differences in sweet preference between lean and non-lean individuals, e.g., (Bartoshuk, Duffy, Hayes, Moskowitz, & Snyder, 2006; Drewnowski, Brunzell, Sande, Iverius, & Greenwood, 1985) while others do not (Cox, Hendrie, & Carty, 2015). As these studies did not take sweet liker status into account, failing to classify participants by sweet liker status could be contributing to the variability observed. Because children typically demonstrate increased preference for sweetness compared to adults (De Graaf & Zandstra, 1999; Desor, Greene, & Maller, 1975; Drewnowski, 1997; Liem & de Graaf, 2004), we were curious to see if any relationships observed among adults in our study population regarding sweet liker status would also be noted in children. Data on beverage intake among children was not collected for this study.

2. Materials and methods

2.1. Participants

Participants ages 8 and older were recruited from guests to the Denver Museum of Nature & Science (the Museum), between November 2015 and August 2016. Participants provided informed assent or consent for participation in the Sweet Tasting Study in the Genetics of Taste Lab. The only exclusion criterion was age – children under the ages of 8 were not eligible. Individuals with implanted medical devices did not participate in weight, height, and %BF measures. The study was approved by The Bowling Green State University Human Subjects Review Board (approval # 796133).

2.2. Study design

2.2.1. Taste measures

Sweet taste intensity and liking measures were conducted in a randomized, double-blind manner. Participants sampled five concentrations of sucrose dissolved in deionized (DI) water (0.0% (blank), 2.4% (low), 4.3% (medium), 7.7% (high), 13.7% (highest) w/v) by swishing and spitting 5 mL of each. These concentrations were selected as they: 1) are suprathreshold for most participants (Stevens, Cruz, Hoffman, & Patterson, 1995); 2) span a range of sweetness typically encountered in commercially available beverages (e.g., while products differ, sports drinks contain approximately 5.9% sucrose while sucrose-sweetened sodas contain approximately 11.3% sucrose); and 3) are evenly separated by a quarter-log step. Sweet taste intensity and liking for each solution was performed using 100 mm visual analog scales (VAS) with the anchors: 'extremely weak,' and 'extremely strong' and 'dislike extremely' and 'like extremely', respectively. Nose clips were worn during taste testing, and participants rinsed with bottled water between each sample.

2.2.2. Beverage intake

Participants aged 21 and older were asked to complete the BEVQ-15, a validated beverage food frequency questionnaire (Hedrick et al., 2012). The BEVQ-15 asks how much (ounces) and how often (times per day) various common beverages are consumed. Broad categories of the BEVQ-15 include: water; 100% juice; sweetened juice drinks; whole milk; reduced fat milk; low-fat/fat-free milk and milk alternatives; regular soft drinks; diet drinks; sweetened tea; tea and coffee with cream and/or sugar; tea and coffee black; beer and wine coolers; hard liquor; wine; and energy drinks. Energy intake was estimated following the BEVQ-15 protocol (Hedrick, Comber, Estabrooks, Savla, & Davy, 2010). Energy intake from all beverages was summed to determine total energy intake from beverages. Energy intake from sugar-sweetened beverages was determined from the sum of sweetened juice, sweetened tea, regular soft drinks, tea and coffee with cream and/or sugar, and energy drinks. Given that many people consume coffee with cream but not sugar, and because energy drinks come in both sugar-containing and sugar-free varieties, we analyzed sugar sweetened beverage intake without these variables as well.

2.3. Anthropometric measurements

Height, weight, and percent body fat (%BF) were measured using a freestanding stadiometer and bioelectrical impedance analyzer (Tanita TBF-215, Tanita, Tokyo, Japan). Body mass index (BMI) was calculated in both children and adults, with children's BMI converted to z-scores to normalize across age, sex, and height (Flegal & Ogden, 2011). Children were designated as lean, overweight, or obese based on the z-score classification of the World Health Organization (de Onis et al., 2007).

2.4. Data analysis

Data analysis was completed using IBM SPSS Statistics version 24.0 (Chicago, IL). Results are presented as means ± standard deviations. Hierarchical cluster analysis (HCA) was used to group participants by sweet liker status. HCA was selected because it is a powerful tool for examining the underlying structure of seemingly homogeneous data and does not require *a priori* decisions regarding number of clusters (Rani & Rohil, 2013; Yim & Ramdeen, 2015). Clusters were determined based on the liking ratings of all five solutions. Appropriate cut-offs for children and adults were based on numerical (agglomeration schedule) and visual (dendrogram) output. Chi-square tests were used to test for differences in cluster composition by demographic or anthropometric measures. Two-way mixed ANOVA analysis was conducted to examine the effects of concentration, cluster, and interaction effects on liking and intensity. Differences in intensity and liking scores by cluster were assessed using one-way Anova and Games-Howell post hoc tests (Ruxton & Beauchamp, 2008; Shingala & Rajyaguru, 2015). Results were considered significant when $p < .05$. Trends ($p < .08$) are also noted.