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Evaluating dietary quality and taste preferences with a simple liking survey: Application to studying individuals with morbid obesity

Marina L. Zoghbi
University of Connecticut, marina.zoghbi@gmail.com

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ABSTRACT*

Feasible ways are needed to screen for dietary behaviors and taste preferences in clinical settings. We examined the internal validity and reliability of a brief survey to assess food preferences and dietary behaviors among morbidly obese individuals considering bariatric surgery. Survey-reported liking is a proxy for dietary intake, correlating with reported food intake and biomarkers of nutritional status (Sharafi et al, 2015) and linking taste genetics with diet and health (Pallister et al, 2015). Methods –Enrolled were 138 morbidly obese patients awaiting bariatric surgery, who completed a 100-item liking survey of foods/beverages, physical/sedentary activities, and pleasurable/unpleasurable experiences. They were oriented to the survey with examples of activities that could be liked (winning the lottery, succeeding), neutral (doing a routine chore), and disliked (running out of money, paper cut) on a bi-directional, horizontal scale labeled at either end with strongest disliking/liking of any kid and mid-point of neither like/dislike. The survey took <10 minutes to complete. Survey items were averaged into nutritional, sensory (bitter, sour, spicy), and activity groups. The nutritional groups were formed into a dietary quality index (Sharafi et al, 2015) and, with activities, into a behavior index. The indexes had internal reliability (alpha>0.65) and were normally distributed. The most liked items were fruit, pleasurable activities, high fat proteins, and sweet foods (listed from highest); least liked were unpleasurable activities, alcoholic beverages, adventurous foods, and physical activities (listed from disliked to barely liked). In exploratory principal component analyses, >50% of variability in either index was explained by 2 factors—less healthy (sweets, fats, salty, television) and more healthy (vegetables, fruits, fiber, physical activities) behaviors. Patients who reported greater liking for bitter beverages and spicy items had significantly higher dietary quality. Summary: A simple liking survey is a feasible and relatively valid/reliable tool for assessing dietary and taste-related behaviors in a clinical setting.

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INTRODUCTION:

Greater than one-third, or 78.6 million of adults in the U.S. are obese (CDC, 2015). According to these population statistics, obesity is defined by the body mass index (BMI) (weight in kilograms (kg) divided by height in meters squared) equal or above 30 (NIH, 2012). Although obesity is observed across all demographics, it is most prevalent among non-Hispanic blacks, at an incidence of 47.8%, compared to 32.6% of non-Hispanic whites. Middle-aged adults (40-59 years old) are more obese than both young adults (20-39 years old) and the elderly (older than 60 years). While higher socioeconomic status is positively correlated with the rate of obesity among non-Hispanic blacks and Mexican-American men, there is a negative correlation between socioeconomic status and prevalence of obesity among women (CDC, 2015). Obesity increases the risk of many conditions such as heart disease, stroke, type 2 diabetes mellitus, and some cancers. Type 2 diabetes mellitus is a disease characterized by insulin resistance; sugar is unable to enter fat, liver, and muscles cells and accumulates in the blood (American Diabetes Association, 2014). Left untreated, type 2 diabetes can result in blindness, sores and infections resulting in loss of a limb, heart attack, stroke, nerve damage, and kidney damage. There is no cure for diabetes, although weight loss and a healthy diet can help to support healthy blood sugar levels. The conditions accompanying obesity reduce not only the quality of life, but also the quantity; they are among the top sources of preventable death in our country. The prevalence of obesity has elevated national medical costs. In 2008, approximately $147 billion was spent on obesity-related care and the medical expenses of obese individuals were $1,429 greater than those of average body weight (CDC, 2015).

Many solutions are available to promote weight loss and reduce risk of type 2 diabetes such as healthy dietary plans, increasing physical activity, and FDA approved weight-loss medications (NIH, 2012). Obese individuals may also have the opportunity to receive bariatric surgery to aide in weight loss and alleviate conditions associated with obesity. About 113,000 patients have received bariatric surgery each year since 2003 (Livingston, 2010). Bariatric surgery is a viable treatment option for individuals that are severely obese (with a BMI greater than 35) accompanied by serious health conditions such as sleep apnea, cardiomyopathy, and type 2 diabetes (NIH, 2012). Some of the more common procedures include the adjustable gastric band, Roux-en-Y Gastric Bypass and Vertical Sleeve Gastrectomy (NIDDK, 2011). The

adjustable gastric band (AGB) limits food intake by confining the size of the opening from the esophagus to the stomach. Roux-en-Y Gastric Bypass (RYGB) aids in weight loss by limiting food consumption through a small pouch, as well as decreasing absorption of nutrients by routing the digestive tract to avoid contact with the stomach, duodenum and upper intestines. The Vertical Sleeve Gastrectomy procedure removes a large portion of the stomach, which limits food consumption and also may decrease the production of the appetite hormone ghrelin, therefore decreasing hunger. Bariatric surgery is a substantial commitment both in money and time. The average bariatric procedure costs $20,000 to $25,000, and may or may not be covered by health insurance (NIDDK, 2011). A typical bariatric patient can expect to invest a considerable amount of time into the process, which includes initial consultations, nutrition sessions, psychiatric evaluations, surgery, recovery, regular follow-up visits, and learning to adopt a different diet post-surgery.

Bariatric surgery has been shown to significantly reduce long-term remission of type 2 diabetes. Arterburn et al (2016) conducted a three-year randomized clinical trial where 61 obese patients were assigned to either an intensive weight loss intervention for one year and a subsequent low-level lifestyle intervention for two years, or a bariatric surgery (Roux-en-Y gastric bypass or laparoscopic adjustable gastric banding) and low-level lifestyle intervention years 2 and 3 after surgery. At year 3, partial or complete type 2 diabetes remission was observed in 40% of the Roux-en-Y gastric bypass patients and 29% of the laparoscopic adjustable gastric banding patients. However, none of the patients who underwent lifestyle intervention alone achieved remission. A similar pattern was observed in medication use; 65% of RYGB patients and 33% of AGB patients ceased taking diabetes medication while none of the lifestyle intervention patients were able to stop taking medication.

Unfortunately, not all bariatric surgery patients are successful at weight loss. A systematic review of fifty-one bariatric surgery studies found that the most common definition of failure of bariatric surgery is <50 % excess weight loss at 18 months (Mann et al, 2015). Weight loss success depends on a multitude of factors. Limited research suggests that changes in levels of hormones involved in hunger and satiety, such as decreases in ghrelin and leptin, may correlate with greater weight loss (Pedersen, 2013). Who is successful with this surgery depends on their ability to change their tastes and preferences and intake of energy dense foods and to follow a higher quality diet and enjoyable physical activity to maintain the weight loss. Practical

measures that assess preference for foods as well as provide a measure of dietary quality that have relevance for taste and smell functioning are needed for clinically-based studies.

Background:

This section will introduce common methods of assessing food preference, including survey reported. We will present the U.S. Department of Agriculture's Healthy Eating Index (HEI) and how a similar Dietary Quality Index can be created from a food preference survey. Finally, we will discuss the criteria for assessing whether an index demonstrates construct validity and reliability.

Assessing Food Preference

Drewnowski (1997) conducted an annual review on taste preferences and food intake. Food preferences are influenced by the sensory perception of foods (taste, odor, texture), as well as how pleasurable it is. Taste responses are dependent on genetic, physiological, and metabolic factors while food intake in influenced by sex, age, obesity and eating disorders. In addition, social and economic conditions play a role in preference and consumption. Food preferences have been evaluated with solutions, food, and survey methods. Taste factors consider taste perception, olfaction perception, texture profile, and hedonic preference. Aqueous solutions are used in measuring taste perception via acuity and sensitivity; acuity is measured by detection and recognition thresholds while sensitivity is measured by intensity scaling. Olfaction perception considers acuity, sensitivity, and recognition, all of which can be tested with odorants (as well as food in the case of recognition). Texture profile is analyzed with food, while hedonic preference can be measured with solutions, odorants, foods, or even model foods. Food preference can be evaluated via sensory evaluation and acceptability ratings of foods, or with a checklist and preference ratings of food names. Food intakes consider selection and consumption which are analyzed with variety and diversity scores, and dietary intake measures, respectively. Both these methods utilize foods and food groups.

Food preference checklists have demonstrated a correlation between preference for fat and body weight. Obese men and women have been found to have different preferences for sources of fat (Drewnowski, 1997). Men preferred foods high in fat, protein and salt such as steaks, hamburgers, and pizza, while women preferred foods high in sugar and fat such as bread,

cake, cookies and desserts. Bartoshuk et al (2006) were able to demonstrate that obese individuals have a stronger hedonic response to foods than do non-obese individuals using the method of magnitude matching, a technique used by psychophysicists in which individuals make cross-modality matches. In measuring preference, this could include surveys with foods and non-foods as representing different modalities of preference. They found that as BMI increases, perceived sweetness decreases; therefore, liking for sweet must be calibrated based on perceived sweetness. This lower perceived sweetness was related to an increased difference between liking of fat foods and sweet foods among obese individuals. Their work suggested that conventional scales based on uniform perceived intensities cannot accurately assess food preference in obese populations; rather, unrelated sensory and hedonic experiences should be used to make between group comparisons.

Food preference measures generated from survey and sampling correlate

In a laboratory-based investigation, food preferences measured by sampling and survey are significantly correlated. Hayes et al (2010) investigated the relationship among these methods by having participants sample multiple concentrations of propylthiouracil (PROP) and NaCl solutions and then rate the intensity and level of liking/disliking using the general Labeled Magnitude Scale (gLMS), taste salty foods and then rate with the gLMS, and complete a food liking survey, a food frequency survey, and a food diary. It was concluded that the diversity among subjects in taste sensation of salt solutions and foods accounted for variation in reported liking of high-sodium foods and consequently sodium consumption (Hayes et al, 2010). Survey reported liking of salty foods correlates well with sampled salty foods.

Survey Food preference – a proxy for food intake?

Affective ratings of liking and pleasantness of foods have been shown to associate with consumption (Tuorila et al, 2008). A large sample of consumers were instructed to rate ten familiar and unfamiliar foods on scales of pleasantness, liking, reported use frequencies, and likelihood of buying. Liking and pleasantness had a linear relationship for highly liked and familiar foods, but demonstrated a curvilinear relationship for disliked or unfamiliar foods. Affective responses to food and consumption were best explained by a curvilinear model, with

liking being a better predictor of consumption that pleasantness. These findings suggest that affective scales can be used to accurately predict consumer behaviors.

Survey reported liking has been shown to correlate with reported food intake and nutritional biomarkers (Sharafi et al, 2015). Parents/caregivers of 416 preschoolers (41% overweight/obese) completed an 18-item food liking survey, a food frequency survey, and were measured for skin carotenoid status. Indexes of dietary quality were constructed from the liking survey (Healthy Eating Preference Index) and frequency survey (Healthy Eating Index). The liking-based index, Healthy Eating Preference Index, did as well or better at explaining variability in skin carotenoid status (a biomarker of fruit and vegetable consumption) than did the frequency-based index, Healthy Eating Index (Sharafi et al, 2015).

Survey liking correlates with metabolites of tastes and dietary consumption according to a twin study examining the genetics of taste preference, especially considering fruit and vegetables, distinctive tastes, sweet and high carbohydrate and meat (Pallister et al, 2015). In a UK twin study, subjects completed a food and lifestyle preference survey and had their blood analyzed for metabolite levels. Reported liking correlated with metabolites of distinctive tastes, sweet and high carbohydrate, and meat significantly suggesting that a liking survey is a good indicator of dietary intake.

Dietary Quality Index and Dietary Behavior Index

The Center for Nutrition Policy and Promotion first created the Healthy Eating Index (HEI) in 1995 as a measure of diet quality that assesses correspondence to the Dietary Guidelines for Americans (USDA, 2016). The HEI assesses diet quality based on adequacy of healthy foods such as vegetables, fruits, whole grains, and low-fat dairy and moderation of unhealthy foods such as refined grains, saturated fatty acids, and added sugars (Guenther et al, 2013). Higher HEI scores correspond to better conformance to dietary guidelines.

Healthy Eating Preference Indexes generated from food preference surveys have demonstrated sufficient reliability, construct validity, and even predictability of risk of future cardiovascular disease (Sharafi et al, 2016). In one longitudinal study of cardiovascular risk in prematurely born adults, a Healthy Eating Preference Index (HEPI) was generated from a liking survey of 47 food/beverages and 19 non-food items. Food items were categorized by nutritional groups and a healthy "variety" score was found based on the number of nutrient-dense items that

rated ≥35 on the ±100 scale. Scores were averaged into nutritional groups which were then allotted conceptual weights based established dietary indices. HEPI scores were normally distributed and lower scores were associated with increased cardiovascular disease risk. In a separate study of preschool children, a HEPI was created from an 18-item preschool adapted liking survey (Sharafi et al, 2015). Again, food items were categorized by nutritional groups and a healthy "variety" score was found. Each group was assigned a weight based on 2010 Dietary Guidelines and were averaged to produce a HEPI score. The index had an absolute range of -250 to 250, with ≥25 considered ideal. HEPI scores were found to be in agreement with adiposity levels and carotenoid status of the preschoolers.

Framework for assessing an index - types of validity and reliability

The criteria developed by Guenther et al (2014) in their assessment of the validity and reliability of the 2010 Healthy Eating Index were utilized to assess the Diet Quality Index and the Dietary Behavior Index in this study. Construct validity is the extent to which a test measures the theoretical construct that it is intended to measure (Brown, 2000). Construct validity should be assessed with multiple statistical analyses to exhibit sufficient evidence. To evaluate construct validity, the following questions were considered as shown in Table 1:

Table 1. Framework of testing construct validity and reliability of a dietary quality index (Guenther et al, 2014) generated from a liking survey

Construct Validity	Does the index give maximum scores to dietary patterns that follow Dietary Guidelines?
	Does the index allow for sufficient variation in scores among individuals?
	Does the index distinguish between groups with known differences in diet quality (i.e., concurrent criterion validity)?
	Does the index measure diet quality independent of diet quantity?
	What is the underlying structure of the index (i.e., >1 dimension)?
Reliability	How internally consistent is the total score?
	What are the relationships among the index components?

	Which components have the most influence on the total score?

To determine whether the index gives maximum scores to menus developed by nutrition experts to illustrate high diet quality, Guenther et al (2014) computed scores for sample menus for USDA Food Patterns, DASH Eating Plan, Harvard Medical School Guide to Healthy Eating, and AHAH No-Fad Diet. To test whether the index allows for sufficient variation in scores among individuals, they estimated percentiles of component and total scores. To verify that the index distinguishes between groups with known differences in diet quality (demonstrates concurrent criterion validity), they compared mean scores of men and women, younger and older adults, and smokers and nonsmokers. To analyze whether the index measures diet quality independent of diet quantity, they estimated Pearson correlations between component scores and energy intake. To determine the underlying structure of the index (does it have >1 dimension?), they used principal component analysis. To evaluate how internally consistent the total score is, they found Cronbach's coefficient alpha. To analyze the relations among the index components, they estimated Pearson correlations between component scores. To discover which components have the most influence of the total score, they estimated correlations between each component and the sum of all other. Similar strategies were used to analyze the Dietary Quality Index and the Dietary Behavior Index for construct validity and reliability.

Objective

Traditional measures of dietary behaviors, such as food records and frequency surveys, are time and resource heavy, with high levels of inaccuracy due to participant misreporting. Simply asking food likes and dislikes takes little time and is easy to score into a measure of dietary quality. Liking surveys are a novel method of assessing dietary intake that is based on the assumption that individuals tend to eat foods they like and refrain from eating foods that they do not like.

The objective of this study was to utilize the strategies used to evaluate the HEI-2010 (Guenther et al, 2014) to test the construct validity and reliability of a liking survey-generated index to screen for lifestyle behaviors related to obesity risk in pre-bariatric surgery patients in clinical settings (Table 1).

MATERIALS AND METHODS:

Subjects:

A convenience sample of 138 morbidly obese adults, between the ages of 20 and 73 y (mean age = 43.28 ± 22.71), interested in bariatric surgery, was recruited from one bariatric surgery program in Glastonbury, CT. Most were female (82%) with a mean height of 65.02 ± 3.70 inches and a mean pre-op weight of 275.48 ± 57.59 pounds. The mean pre-op BMI was 45.76 ± 7.29 kg/m^2. All procedures were approved by the IRB. Participants provided informed and written consent for participation.

Liking Survey:

Participants completed a validated, 100-item liking survey comprised of foods, beverages, physical activities, sedentary activities, pleasurable experiences, and unpleasurable experiences (Duffy et al, 2007; Pallister et al, 2015, see APPENDIX A). They were oriented to the liking scale with examples of activities that are highly likeable (winning the lottery, succeeding), an activity that is reasonably neutral (doing a routine chore), and an activity that is highly dislikable (running out of money, getting a paper cut). The left end of the continuous bidirectional scale represented the "strongest disliking of any kind," while the right end of the continuous scale represented the "strongest liking of any kind" and the center of the scale was "neither like nor dislike" (Figure 1). The values that corresponded to liking were 0=neutral and 100 strongest of any kind applied to either liking (+) or disliking (-). The items were formed into eighteen groups: nutritional (alcohol, desserts, fruits, vegetables, low-fat protein, high-fat protein, sugary beverages, fats, carbohydrates, whole grains, salty), additional sensory groups (bitter, sour, adventurous), physical activities, pleasurable experiences, unpleasurable experiences, and TV. The survey took an average of 5 to 10 minutes to complete.

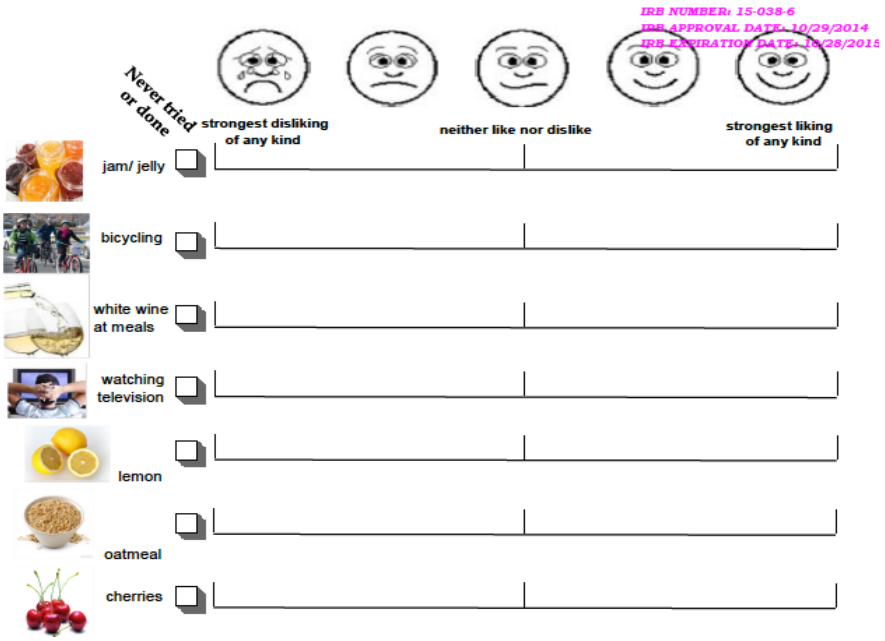

Figure 1: The Liking Survey.

Dietary Quality Index and Dietary Behavior Index

Ten of the nutritional groups were considered for the Dietary Quality Index. The items of the groups were average and then weighted based on healthiness following Dietary Guidelines 2015 (http://health.gov/dietaryguidelines/2015/guidelines/): sweet drinks (-3), sweet foods (-3), fruits (+2), vegetables (+3), refined carbohydrates (-1), fats (-2), low-fat proteins (+3), high-fat proteins (-3), salty foods (-2), and whole grains (+2). The Healthy Behavior Index included all of the groups in the Dietary Quality Index, with the addition of a physical activity group, which was given a weight of +3. As healthy foods/behaviors were given a positive weight, while unhealthy foods/behaviors were given a negative weight, higher scores on the liking-based diet quality and dietary behavior indexes indicated being more healthy.

	Diet Quality (α=0.61)		Healthy Behavior (α=0.65)	
Groups	***Group Multipliers***		***Group Multipliers***	
Sweet Drinks	-3		-3	
Sweets	-3		-3	
Fruits		2		2
Vegetables		3		3

Refined CHO	-1		-1	
Fat	-2		-2	
Low-Fat Protein		3		3
Salty Foods	-2		-2	
High-Fat Protein	-3		-3	
Whole Grains		2		2
Physical Activity				3

Table 2: Groups generated from a liking survey that were averaged and multiplied by components listed in the table into dietary quality and dietary behavior indexes

Statistical methods:

The following table (Table 3), adapted from the evaluation of the Center for Nutrition Policy and Promotion's Healthy Eating Index by Guenther et al (2014), shows the statistical test associated with each indicator of construct validity and reliability. Excel and SPSS were used to perform the statistical procedures.

Construct validity	**Question**	**Statistic**
	Does the index give maximum scores to dietary patterns that follow Dietary Guidelines 2015?	Descriptive
	Does the index allow for sufficient variation in scores among individual?	Descriptive - Histogram, skew, kurtosis, normality tests
	Doe the index distinguish between groups with known differences in diet quality (i.e., concurrent criterion validity)?	Descriptive, t-tests, ANOVA
	What is the underlying structure of the index (i.e., > 1 dimension)?	Principal component analysis and plot; derived factors to explain >50% of variance
Reliability		
	How internally consistent is the total score?	Cronbach's Alpha

	What are the relationships among the index components	Spearman rho
	Which components have the most influence on the total score?	Spearman rho

Table 3: Statistical analysis completed to assess the construct validity and reliability of a dietary quality index generated from a liking survey.

To determine whether the index gives maximum scores to dietary patterns that follow Dietary Guidelines, we computed Healthy Behavior Index scores for all individuals using Excel. To test whether the index allows for sufficient variation in scores among individuals, we estimated percentiles of individuals and their liking for each category. We considered histograms, skew, kurtosis, and normality tests. To verify that the index distinguishes between groups with known differences in diet quality (demonstrates concurrent criterion validity), we compared mean Dietary Quality Index scores of pre-bariatric surgery patients and post-bariatric surgery patients using descriptive statistics, t-tests and ANOVA. To determine the underlying structure of the index (does it have >1 dimension?), we used principal component analysis and component plot. To evaluate how internally consistent the total score is, we calculated Cronbach's coefficient alpha for the groups and the overall index. To analyze the relations among the index groups, we estimated Pearson correlations between group scores. To discover which groups have the most influence of the total HBI score, we estimated correlations between each component and the sum of all other using Spearman rho.

RESULTS:

Construct Validity:

Does the index give maximum scores to dietary patterns that follow Dietary Guidelines?

The HBI scores ranged from -93 to 136, with higher scores indicated better adherence to Dietary Guidelines 2015. Table 3 shows these two extremes in scores. The adult with the lowest score reported highest preference for sweets and fats yet lowest preference for vegetables and physical activity. Conversely, the adult with the highest score reported highest preference for fruits, vegetables, and physical activity yet lowest preference for sweet drinks, refined carbohydrates, high-fat proteins, and salty foods. Individuals with low and high health behavior indexes had group subscores that aligned with the Dietary Guidelines (i.e., High HBI) or did not follow these Guidelines (i.e., Low HBI) (Table 4).

Table 4: Examples of Individuals who received low and high HBI scores, and their respective group averages.

	Low HBI†	High HBI†
Sweet Drinks	20	-81
Sweets	75	-39
Fruits	49	89
Vegetables	-81	87
Refined CHO	55	-77
Fat	71	28
Low-Fat Protein	-13	3
Salty Foods	41	-72
High-Fat Protein	40	-74
Whole Grains	-3	28
Physical Activity	-50	80
HBI Score	**-93**	**136**

†Average group scores on gLMS hedonic scale, where 0=neutral, ±6 weakly, ±17 moderately, ±35 strongly, ±53 v. strongly ±100 strongest of any kind applied to liking/disliking.

Does the index allow for sufficient variation in scores among individuals?

The Dietary Quality Index scores and the Healthy Behavior Index scores showed variability across the sample. Dietary Quality Index scores ranged from -87 to 125 while Healthy Behavior Index scores ranged from -93 to 136. The maximum possible scores for the Dietary Quality Index and the Healthy Behavior Index were 240 and 250, respectively. The minimum possible scores for the Dietary Quality Index and the Healthy Behavior Index were -240 and -250, respectively. Both the Diet Quality Index and the Healthy Behavior Index had a normal distribution of scores (Figure 2) as shown by the non-significant Komogorov-Smirnov statistics of 0.035 ($p=0.20$) and 0.038 ($p=0.20$), respectively.

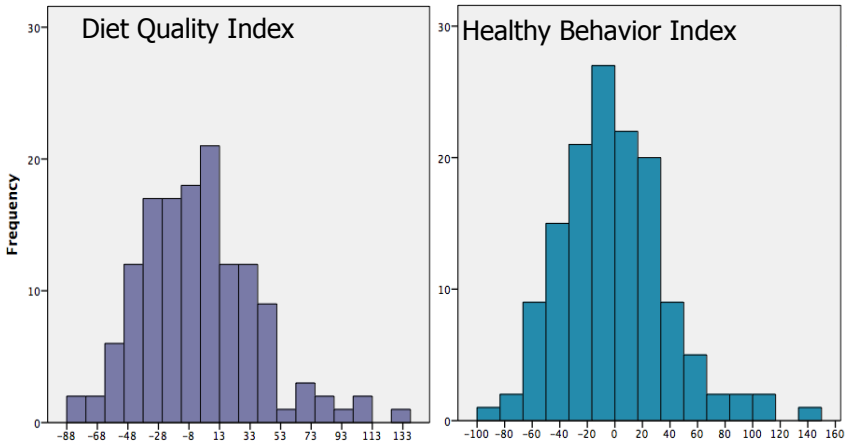

Figure 2: Both the Dietary Quality Index and Healthy Behavior index showed significant variation and were normally distributed.

Figure 3 supports that patients used the liking scale appropriately. Calculated are the percent of patients who fell into liking/disliking of each group based on categories from the gLMS hedonic scale of 0=neutral, ±6 weakly, ±17 moderately, ±35 strongly, ±53 v. strongly ±100 strongest of any kind applied to liking/disliking. The most liked items were fruit, pleasurable activities, high fat proteins, and sweet foods (listed from highest); least liked were unpleasurable activities, alcoholic beverages, adventurous foods, and physical activities (listed from disliked to barely liked).

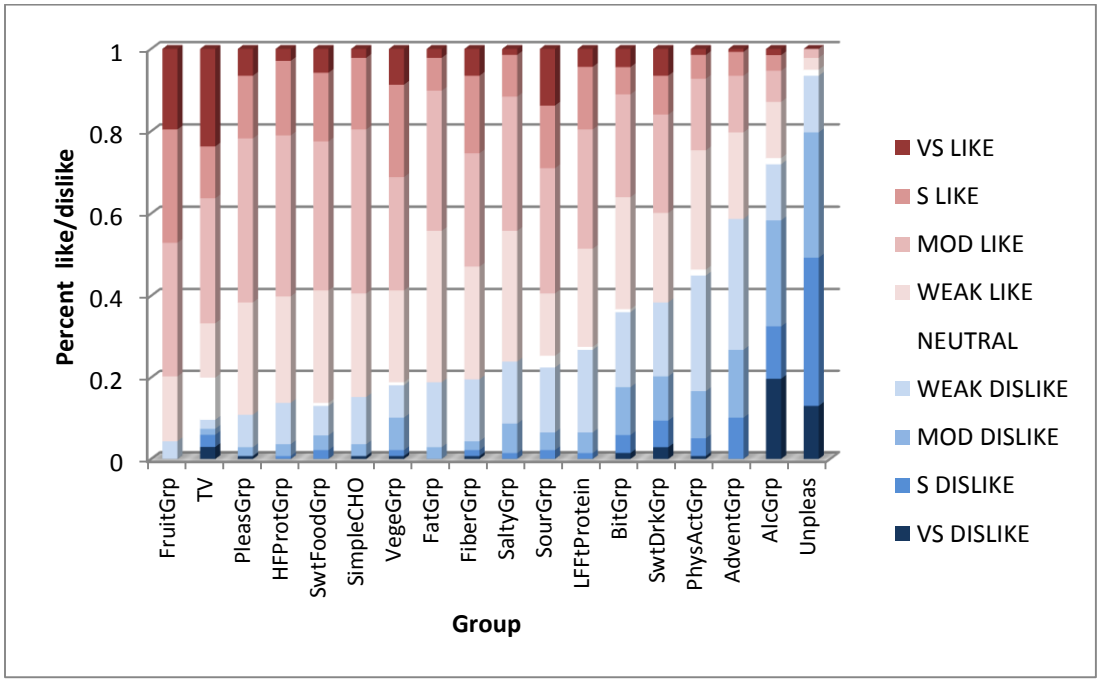

Figure 3: Percent of patients reporting likes/dislikes of various degrees for each category.

Does the index distinguish between groups with known differences in diet quality (i.e., concurrent criterion validity)?

To assess whether the index distinguished between groups with known differences in diet quality, we looked at a case-control study comparing post-op patient cases (n=29) who were successful (n=18) or unsuccessful (n=11) in achieving the excess weight loss to the pre-op controls (n=29) from the same bariatric surgery program of interest (Papasavas et al, 2015). Post-op patients who were successful reported significantly healthier dietary quality scores than did either the pre-op morbidly obese controls or post-op patients who were unsuccessful at achieving their excess weight loss goal (figure 4). Successful weight loss patients also had significantly higher Healthy Behavior Index Scores than both the pre-op and unsuccessful post-op group. The unsuccessful post-op group was not statistically different from the pre-op group. Thus, these findings support concurrent criterion validity of the liking-survey based healthy behavior and dietary quality indexes.

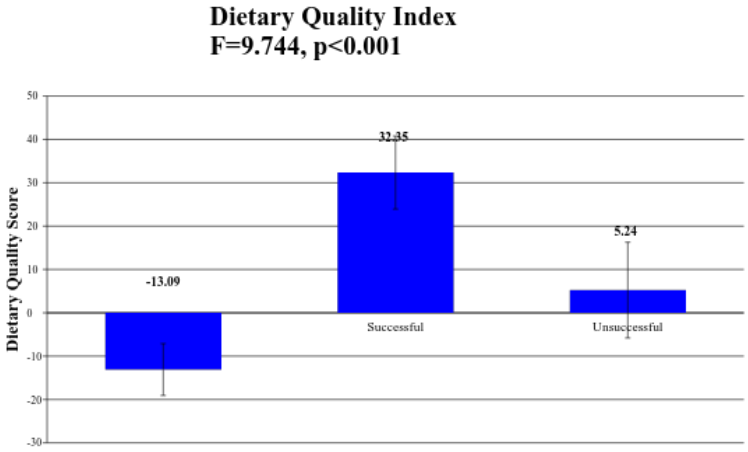

Figure 4: Dietary Quality differed significantly between successful bariatric patients and pre-op controls, but did not differ significantly between unsuccessful bariatric patients and the pre-op controls.

What is the underlying structure of the index (i.e., >1 dimension)?

Principal Component Analysis was used to assess whether only 1 dimension or more than one dimension was responsible for the variation of the data. Principal component analysis was conducted loading the components of the Dietary Quality and then Healthy Behavior Index.

For the Dietary Quality Index and with varimax rotation, two dimensions were represented and could be easily labeled into healthy and less healthy that explained approximately 50% of the variability across all of the group scores (Figure 5, left side). The first factor was labeled as less healthy and included high-fat proteins, fats, sweet drinks, sweet foods, salty foods, and simple carbohydrates; the unhealthy factor accounted for 31.5% of the variation.

The second factor was labeled as the healthy factor and included physical activity, vegetables, fruits, low-fat proteins, and fiber; the healthy factor accounted for 18.8% of the variation.

Next, we used principal component analysis to compare HBI with taste and pleasurable/unpleasureable experiences and observed four dimensions (Figure 5, right side). The first extracted factor could be labeled as unhealthy (23.3% variance) and consisted of simple carbohydrates, sweet foods, fats, high-fat proteins, sweet drinks, and TV. The second extracted factor (16%) consisted of fiber, bitter foods, adventurous foods, sour foods, low-fat proteins, fruit, vegetables, and physical activities. The third factor (8% variance) could be labeled as the social factor, consisting of the alcohol group and pleasurable group, which contained a number of social activities (e.g., going to a pub, going to a coffee house). The final extracted factor was the unpleasant factor (7% variance).

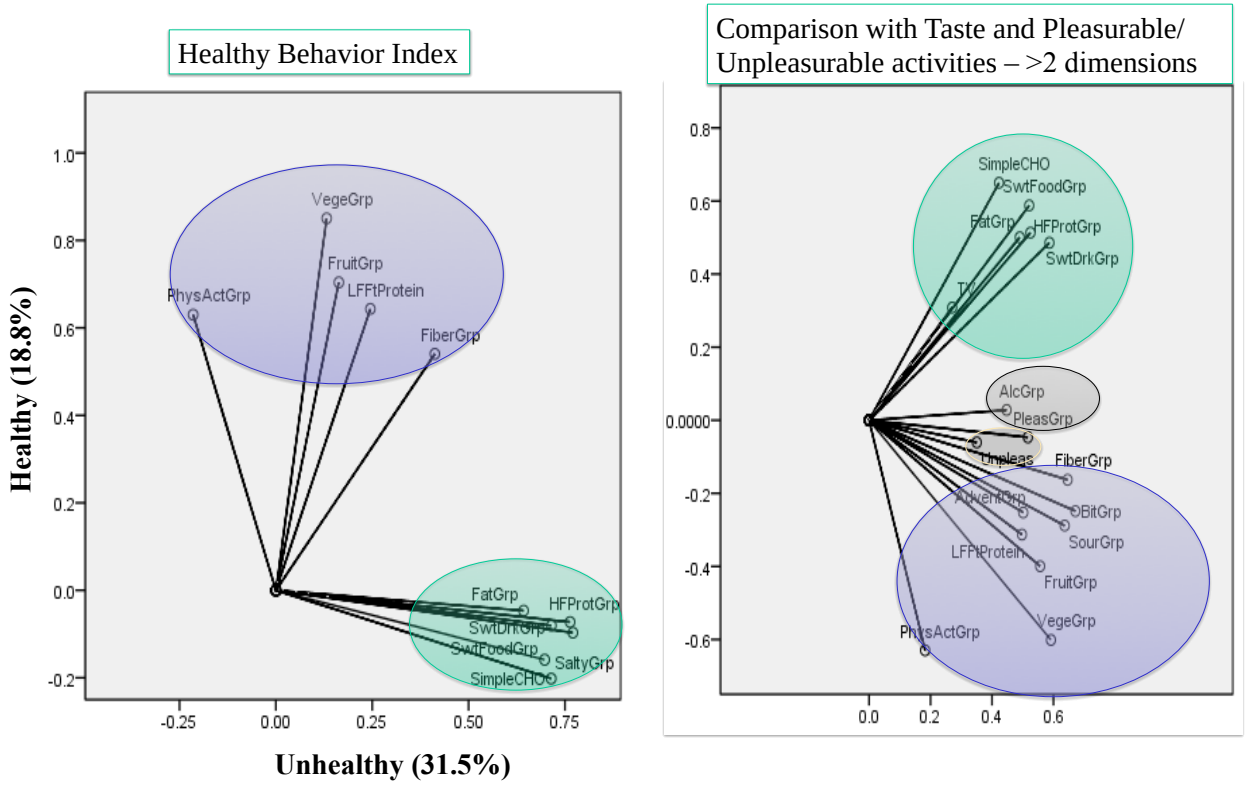

Figure 5: Principal Component Analysis shows the index has greater than one dimension that are easily identified as healthy and less healthy.

Reliability:

How internally consistent is the total score?

To evaluate how internally consistent the total score is, we calculated Cronbach's coefficient alpha for each of the Dietary Quality/Healthy Behavior Index groups (Table 5). The items within the groups showed reasonable alpha's, with the highest correlations among vegetables, sweet foods, and physical activities (from highest to lowest). The overall index alpha also was reasonable at 0.6 for the Dietary Quality Index and 0.65 for the Healthy Behavior Index.

Table 5. Internal Reliability Coefficients for Groups in the Healthy Behavior Index (Cronbach's Alpha)

Sweet Foods	Sweet Drinks	Fat	High-Fat Protein	Salty	Refined CHO	Vegetables	Fruits	Whole Grains	Low-Fat Protein	Physical Activity
0.73	0.6	0.45	0.6	0.55	.71	0.8	0.6	0.54	0.44	0.72

What are the relationships among the index components? Which components have the most influence on the total score?

Spearman correlation coefficients were calculated for each Dietary Quality/Healthy Behavior Index group to judge intercomponent correlations and determine which groups contributed most to the HBI score (Table 6). The groups that contributed the most were sweet drinks, high-fat protein, and sweet foods (from highest to lowest).

Table 6. Spearman correlation coefficients calculated to determine which groups contributed most to the HBI score.

	Sweet Foods	Sweet Drinks	Fat	High-Fat Protein	Salty	Refined CHO	Vegetables	Fruits	Whole Grains	Low-Fat Protein	Physical Activity
Correlation Coefficient	-0.51	-0.62	-0.39	-0.57	-0.48	-0.47	0.42	0.27	0.28	0.31	0.43
Sig. (2-tailed)	***	***	***	***	***	***	***	**	**	***	***

p<0.01;*p<0.001

DISCUSSION:

An efficient assessment of dietary quality and lifestyle behaviors is needed for clinical settings. In this study, we determined that a Dietary Quality Index and Healthy Behavior Index (HBI), an index generated from a novel liking survey of foods and activities, was valid and reliable when tested with a convenience sample of morbidly obese adults seeking bariatric

surgery. The indexes are feasible for patients and researchers to screen for diet, food preferences and lifestyle behaviors associated with obesity risk in bariatric surgery patients in clinical settings.

This patients were able to complete the survey in a short amount of time and researchers or clinicians can process it rapidly and inexpensively into sensory, nutritional, and lifestyle indexes. The indexes, both Dietary Quality and Healthy Behavior, were valid and reliable according to the criteria set forth by Guenther et al (2014) and consistent with the findings reported for the Healthy Eating Index 2010.

Guenther et al (2014) analyzed the scores of archetypal menus to determine whether the Healthy Eating Index-2010 (HEI-2010) demonstrated construct validity in that it awarded perfect scores to the healthy diets; resembling our comparison of the group scores of the individuals who scored highest and lowest on the index. The HEI-2010 scores ranged from 0 to 100, with 100 being maximum diet quality; the Diet Quality Index had a range of -250 to 250, where 250 was maximum diet quality. Guenther et al observed nearly perfect scores for the menus considered, while the maximum value observed in our sample was 136. This was expected since our sample of interest was morbidly obese surgery candidates. The diet quality and healthy behavior indexes further demonstrated construct validity by being normally distributed, congruent to that of Guenther's HEI-2010 indicating that the index is able to identify important differences in diet quality. Guenther et al provided evidence for concurrent criterion-related validity by comparing scores of groups with known differences: men versus women, smokers versus non-smokers, and age differences. HEI-2010 scores were significantly higher for women, non-smokers, and adults ≥51years compared with adults aged 20-30 years. Meanwhile, we established concurrent criterion validity by comparing scores of successful versus unsuccessful bariatric patients and found the index gave significantly higher scores to successful patients compared to unsuccessful patients. Since our sample had a greater proportion of women, we did not compare gender differences. Principal component analysis showed that the HEI-2010 had 5 dimensions, while the Healthy Behavior Index had 2 dimensions. When the Healthy Behavior Index was compared with taste and pleasurable/unpleasurable activities, 3 dimensions were observed. The observed variation in internal reliability among groups of the Healthy Behavior Index was much the same as that of HEI-2010; the HEI-2010 had a standardized Cronbach's coefficient alpha of 0.68, while we observed values of 0.6 for the Dietary Quality Index and 0.65 for the Healthy Behavior

Index. The group found to contribute most to our HBI score was sweet drinks (Spearman correlation coefficient = -0.62), much the same as the findings that empty calories contributed most to the HEI-2010 score (Spearman correlation coefficient = -0.67).

The diet quality and healthy behavior indexes are consistent with evidence-based healthy diet and behavior guidelines. High and low scores correspond with liking for healthy and less healthy behaviors. The Healthy Eating Preference Index developed by Sharafi et al (2015) was shown to correlate significantly with carotenoid status, and to predict carotenoid status more accurately than reported frequency of intake. The indexes have good variation across a sample and have a normal distribution. Previous work has verified that the index measures diet quality independent of diet quantity (Sharafi et al, 2015) and positive changes in the indexes associated with more favorable weight loss across bariatric surgery (Papasavas et al, 2015). The diet quality and healthy behavior indexes are comprised of at least 2 dimensions that explain nearly 50% of the variation across the scores. The index is reasonably reliable; the groups and overall indexes have an internal consistency shown by Cronbach's alpha.

Variations of this liking survey have been used in other studies and are in agreement that this novel method of dietary assessment is a valid and reliable tool. Our study is in agreement with Hayes et al (2010) who concluded that variation in reported liking correlates with consumption. Our results are also in agreement with Sharafi et al (215) who concluded that a liking based Healthy Eating Preference Index correlated well with nutritional biomarkers and Pallister et al (2015) who found that reported liking correlated with blood metabolites.

The main strength of this study is the utilization of multiple statistical approaches to determine that the Healthy Behavior Index has construct validity and reliability. A large sample of patients was used and the index showed significant variation and a normal distribution. One limitation of this study was that the index was not compared to normal weight controls. Another limitation is that the index was not validated by nutrition biomarkers as other studies have done in the past. Future studies should explore the association between reported liking and hormone levels before and after bariatric surgery. This survey was also previously in print form, but has been adapted to an electronic form that is less susceptible to participant error and can be more accurately measured, eliminating researcher bias. The electronic form will allow index scores to be calculated at a much greater rate.

In conclusion, a liking derived dietary quality index demonstrated construct and criterion related validity, as well as reliability. The survey is rapid and easy to complete, and can be quickly processed by clinicians to evaluate patients on healthy lifestyle behaviors.

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APPENDIX:

A: Food Liking Survey

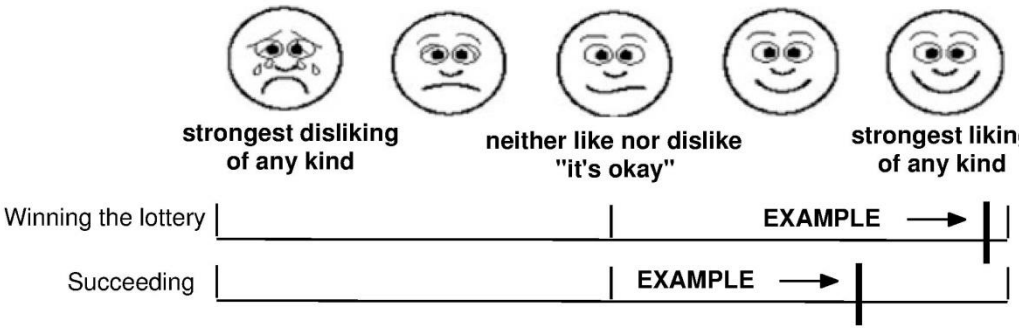
ID# _____ Date _____

Your Likes and Dislikes

This survey asks about your likes and dislikes for foods, physical activities, and experiences Examples of how to use the scale to report liking, neutral, and disliking are shown below.

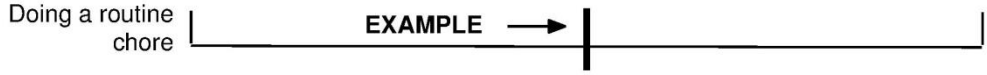
Liked Example

Like ranges from weak liking (close to neutral) to strongest liking of any kind (right most end). Here are example of ratings for liked or pleasant experiences.



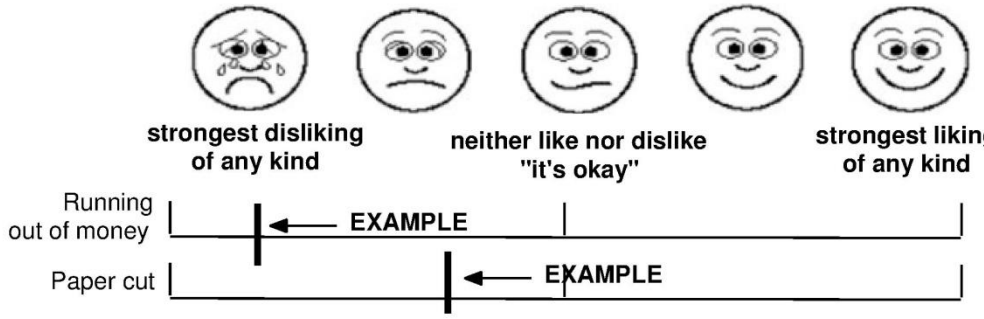
Neutral Example

Neutral (neither like nor dislike; it's okay) is the middle as shown in the example.



Disliked Example

Dislike ranges from weak disliking (close to neutral) to strongest disliking of any kind (left most end). Here are examples of ratings for disliked or unpleasant experiences.



IRB Review
IRB NUMBER: 15-038-6
IRB APPROVAL DATE: 10/16/2015
IRB EXPIRATION DATE: 10/15/2016

Please rate your liking or disliking of the following.

strongest disliking of any kind | **neither like nor dislike "it's okay"** | **strongest liking of any kind**

Never tried or done

Glare of headlights ☐ |_____|_____|_____|

Hearing your favorite music ☐ |_____|_____|_____|

If you have never tried or never done an item on the survey, please check the box.

EXAMPLE: Skydiving **Never tried or done** ☒

IRB Review
IRB NUMBER: 15-038-6
IRB APPROVAL DATE: 10/16/2015
IRB EXPIRATION DATE: 10/15/2016

	Never tried or done	strongest disliking of any kind		neither like nor dislike		strongest liking of any kind
 hot tea	☐					
 cheese cake	☐					
 salting food	☐					
 char-broiled meats	☐					
 eggplant	☐					
 cheddar cheese	☐					
 Tabasco Sauce	☐					
 raw onion	☐					
 going to a coffee shop	☐					
 orange juice	☐					
 Sweet coffee drinks & whipped cream	☐					

IRB Review
IRB NUMBER: 15-038-6
IRB APPROVAL DATE: 10/16/2015
IRB EXPIRATION DATE: 10/15/2016

	Never tried or done	strongest disliking of any kind	neither like nor dislike	strongest liking of any kind
 vodka, gin, scotch	☐			
 having a car accident	☐			
 tuna or salmon	☐			
 cookies, cake, pie	☐			
 ham	☐			
 High-Fiber bar	☐			
 strawberries	☐			
 crackers	☐			
 sour pickles	☐			
 seeing a mouse at home	☐			
 spinach/ greens	☐			
 pineapple	☐			

	Never tried or done	strongest disliking of any kind		neither like nor dislike		strongest liking of any kind
 jam/ jelly	☐					
 bicycling	☐					
 white wine at meals	☐					
 watching television	☐					
 lemon	☐					
 oatmeal	☐					
 cherries	☐					
 vinegar	☐					
 coffee or tea with sugar	☐					
 beets	☐					
 horseradish/ wasabi	☐					
 working up a sweat	☐					

IRB Review
IRB NUMBER: 15-038-6
IRB APPROVAL DATE: 10/16/2015
IRB EXPIRATION DATE: 10/15/2016

	Never tried or done	strongest disliking of any kind		neither like nor dislike		strongest liking of any kind
 red wine at meals	☐					
 pear	☐					
 cake icing	☐					
 white potato	☐					
 melon	☐					
 sauteed mushrooms	☐					
 playing sports	☐					
 extra virgin olive oil	☐					
 asparagus	☐					
 exercising with others	☐					
 raw carrots	☐					
 going to pub/bar	☐					

IRB Review
IRB NUMBER: 15-038-6
IRB APPROVAL DATE: 10/16/2015
IRB EXPIRATION DATE: 10/15/2016

Never tried or done

strongest disliking of any kind

neither like nor dislike

strongest liking of any kind

grapefruit ☐

corn flakes ☐

exercising alone ☐

white rice ☐

smell of freshly cut grass ☐

salad dressing ☐

fried fish ☐

banana ☐

pork chops ☐

lentils/ beans ☐

commuting (car, bus, train) ☐

	Never tried or done	strongest disliking of any kind		neither like nor dislike		strongest liking of any kind
 cilantro	☐					
 pasta/ noodles	☐					
 going to the gym	☐					
 mayonnaise	☐					
 chili pepper	☐					
 whole milk	☐					
 baked chicken	☐					
 olives	☐					
 dark chocolate	☐					
 garlic	☐					
 ketchup	☐					
 ice cream	☐					

IRB Review
IRB NUMBER: 15-038-6
IRB APPROVAL DATE: 10/16/2015
IRB EXPIRATION DATE: 10/15/2016

	Never tried or done	strongest disliking of any kind		neither like nor dislike		strongest liking of any kind
 black coffee	☐					
 cooling off on a hot day	☐					
 pizza	☐					
 plain yogurt	☐					
 fried chicken	☐					
 burn of spicy foods	☐					
 bagel/ rolls	☐					
 sausage	☐					
 soy sauce	☐					
 taking the stairs	☐					
 soda and sweet drinks	☐					
 salty pretzels	☐					

IRB Review
IRB NUMBER: 15-038-6
IRB APPROVAL DATE: 10/16/2015
IRB EXPIRATION DATE: 10/15/2016

Never tried or done	strongest disliking of any kind		neither like nor dislike		strongest liking of any kind
 broccoli ☐					
 tortilla or potato chips ☐					
 crisp bacon ☐					
 beer ☐					
 shrimp & shellfish ☐					
 butter/ margarine ☐					
 french fries ☐					
 whole wheat bread ☐					
 iced tea ☐					
 blue cheese ☐					
 skim milk ☐					
 fresh tomatoes ☐					

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