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Perceptions of food healthiness among free-living women

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ABSTRACT

Background: Improving our understanding of food-related healthiness perception may be beneficial to assist those with eating- and weight-related problems.
Purpose: This study replicates and extends prior work by examining normative and person-specific predictors of the perceived healthiness of foods in a sample of free-living women.
Methods: One hundred sixty-nine women from the community judged the healthiness of 104 foods that varied in fat, fiber, sugar, and protein content. Mixed-effects modeling estimated normative influences of food-specific and individual-specific characteristics on each participant's utilization of the nutrients when judging healthiness.
Results: When judging healthiness, free-living women relied substantially on fat and fiber independently of other nutrients. In contrast, reliance on fat and fiber was moderated by the presence of protein and sugar. Three bivariate interactions emerged between: 1) fiber and sugar; 2) fat and protein; and 3) fiber and protein. Binge-eating symptoms and frequency of healthy food consumption positively correlated with independent reliance on fat as a predictor of perceived healthiness.
Conclusions: Public health campaigns should continue to encourage free-living women to consume adequate amounts of protein. Additionally, free-living women should be reminded that the presence of sugar in foods without nourishing components (i.e., fiber, protein) is problematic, and consuming these foods in excess should be avoided. Healthy food consumption appears to enhance perceptions of food healthiness.

1. Introduction

Several factors influence food choice, such as palatability, availability, affordability, portion size, and craving (Caltabiano & Shellshear, 1998; Gearhardt, Rizk, & Treat, 2014; International Food Information Council, 2014; Li, Harmer, Cardinal, Bosworth, & Johnson-Shelton, 2009; Wansink & van Ittersum, 2007). Among these factors is the perception of food healthiness (Paquette, 2005), which plays a role in the food selection and consumption process (Eertmans, Victoir, & Notelaers, 2006; Gravel et al., 2012; Grunert, 2010; Velazquez, Pasch, Ranjit, & Mirchandani, 2011). Enhancing knowledge about the healthiness of foods is often a central component of weight loss programs and national nutritional campaigns (Levy, Finch, Crowell, Talley, & Jeffery, 2007; USDA, 2010a, 2010b; Wadden et al., 2004). As such, an improved understanding of individuals' perceptions of food healthiness may have implications for treatment planning, the efficacy of weight loss interventions, and efforts to improve the health of normal-weight individuals.

1.1. Perceived food healthiness

"Food healthiness" has been defined and examined via several approaches. Some studies have relied on nutrient profiles to quantify a food's "healthiness" (Drewnowski & Fulgoni, 2008). Algorithms, such as NuVal (Katz, Njike, Rhee, Reingold, & Ayoob, 2010), combine a food's nutritional content with weighting coefficients to create a standardized healthiness value. This approach allows an easy comparison of the healthiness of hundreds of foods. Other work in this area has relied on the use of participant self-report, asking participants to identify which nutrients they prioritize when judging food healthiness (Carels, Konrad, & Harper, 2007a; Hoefkens, Verbeke, & Camp, 2011; Oakes & Slotterback, 2002). However, this direct assessment strategy is limited by potentially inaccurate reporting. Individuals may not be aware of the nutritional content of food, the extent to which certain

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nutrients influence their perceptions of food healthiness, or both.

Accordingly, the current work relies on an indirect approach to the measurement of nutrient-specific perceptions of food healthiness (Rizk & Treat, 2014). Using a labeled magnitude scale (LMS), participants rate the healthiness of foods with known nutritional properties. Unlike Likert-scale measures, use of an LMS provides ratio-scale judgments (Bartoshuk et al., 2004). Subsequent analyses quantify the extent to which each participant relies on each nutrient when judging food healthiness.

1.2. Qualifying and disqualifying nutrients

The nutritional content of a food is critical to evaluations of its healthiness. Prior work has described nutrients as either qualifying (i.e., those that tend to qualify a food in terms of its health benefit) or disqualifying (i.e., those that tend to disqualify a food in terms of its health benefit) (Hoefkens et al., 2011). Consumers appear to prioritize qualifying and disqualifying nutrients differently. For instance, according to consumers in one study, qualifying nutrients, such as fiber and protein, are more important than disqualifying nutrients, such as fat and sugar, when selecting which foods to eat (Hoefkens et al., 2011). In other work, consumers report that a healthy diet is characterized by decreased consumption of disqualifying nutrients, such as fat, sugar, and salt (Paquette, 2005). Fat content has also been implicated as a priority in healthiness perception via participant self-report (Carels et al., 2007a, 2007b; Oakes & Slotterback, 2002). The mixed nature of these findings may reflect in part the limitations of relying solely on self-reported nutritional focus when evaluating food healthiness.

Perceived food healthiness is relevant to nutrient consumption, which influences physical health. Excess consumption of saturated fats and trans fat is associated with a host of medical concerns, such as the development of hypertension or type-2 diabetes (e.g., Xin et al., 2012). However, appropriate consumption of specific types of fat, including polyunsaturated and monounsaturated fat, provides the body with energy, protects vital organs, maintains skin and hair health, and assists with vitamin absorption (American Heart Association, 2015a). Similarly, undue consumption of added sugar, which can be found in many processed foods (e.g., potato chips), can be detrimental for one's health (USDA, 2015). Recommended consumption of naturally occurring sugar, which can be found in fruit, for example, can be nutritious (American Heart Association, 2015b). Nonetheless, given that individuals tend to over-consume fat and sugar, these nutrients are prioritized in the current work and are referred to as “disqualifying nutrients.” Notably, the present work does not distinguish between sub-types of fat or sub-types of sugar. This is not to deny the importance of a more nuanced understanding of differential nutrient reliance when judging food healthiness. Rather, the focus on total fat and total sugar serves as a starting place for indirect investigations of perceived food healthiness and links to key individual differences characteristics.

The present work also prioritizes two “qualifying” nutrients: fiber and protein. A complex carbohydrate, fiber, assists the body in digestion and increases sensations of satiety (Schwartz, Kaye, Nunn, Spiro, & Garcia, 2012). Consumption of protein facilitates muscle growth and development (Thompson et al., 2000), and a recent analysis of the National Health and Nutrition Examination data demonstrated that the average American is not consuming enough protein on a daily basis (Fulgoni, 2008). Appropriate intake of fiber and protein helps to regulate and to maintain the body's needs, while excess consumption of these nutrients is relatively less problematic than that of fat and sugar. Consequently, these nutrients are conceptualized as comparatively more nutritious or qualifying.

The prevalence of overweight and obesity, especially as they pertain to dietary-linked physical illnesses (e.g., metabolic syndrome), suggests that individuals are making poor choices about their ingestive behavior (Mendoza, Drewnowski, & Christakis, 2007; Mirmiran, Noori, & Azizi, 2008). These findings have had an impact on public health initiatives, which encourage consumers to decrease their fat and sugar intake and to increase their fiber and protein intake (American Heart Association, 2012; Snyder, 2007; USDA, 2010a, 2010b; World Health Organization, 2012). Thus, the current study prioritizes the indirect assessment of reliance on fat, fiber, sugar, and protein when judging food healthiness.

1.3. An initial evaluation of perceived food healthiness

In a recent study, college-aged women judged the healthiness of foods that varied in fat, fiber, sugar, and protein using the LMS procedure (Rizk & Treat, 2014). This indirect assessment method revealed extensive reliance on fat and fiber, moderate reliance on sugar, and minimal reliance on protein when these nutrients were considered in isolation (i.e., as main effects). Participants' significantly greater reliance on fat than sugar was noteworthy, given that excess sugar consumption also is unfavorable for one's health (Johnson et al., 2013; Teff et al., 2009). This finding may indicate that individuals have not fully internalized the negative consequences associated with excess sugar intake. It may also suggest that consumers are considering the energy density of foods, recognizing that high-fat, high energy dense foods have the potential to be the most problematic for one's health (Drewnowski, Brunzell, Sande, Iverius, & Greenwood, 1985).

Interestingly, the extent to which participants relied on “qualifying” or “disqualifying” nutrients depended on the values of other nutrients. For instance, participants relied less on sugar when judging the healthiness of a food that was also high in fiber (e.g., a granola bar). As another example, participants relied less on fat when rating the healthiness of a high-protein food (e.g., barbecued brisket). These examples suggest that healthiness perception is affected by the combination of nutrients in food, and they raise the intriguing possibility that disqualifying nutrients may be utilized less when qualifying nutrients are present. This implies that, when foods contain at least one qualifying nutrient, individuals may believe they are healthier because they discount the unhealthy aspects of the foods.

At the individual differences level, as expected, self-reported disordered eating positively predicted reliance on fat when rating the foods, suggesting that fat content was more salient to those who reported significant concerns about their weight and shape. Body mass index (BMI) did not significantly predict reliance on the nutrients. This finding was not surprising. Though BMI ostensibly has been linked to caloric misperception (Livingstone & Black, 2003), evidence suggests that caloric misperception is related to the larger amount of food selected by high-body mass people, not their BMI (Chandon & Wansink, 2007).

1.4. The current study

The current study addresses three aims: 1) to investigate free-living women's reliance on fat, fiber, sugar, and protein when judging food healthiness; 2) to evaluate person-specific predictors of reliance on these nutrients; and 3) to extend and to replicate prior work (Rizk & Treat, 2014). Free-living women judge the healthiness of 104 foods with known nutritional properties, using our LMS rating procedure. Mixed-effects modeling estimates participants' average reliance on the four nutrients and person-specific predictors of nutrient utilization during the healthiness task.

The present work extends our initial indirect evaluation of perceived food healthiness in three significant ways. First, we oversample those who have a high BMI and include free-living women ages 18–40, thus increasing the external validity, or generalizability, of the work. Second, we examine binge-eating concerns as a predictor of nutrient reliance when judging food healthiness. Third, we explore potential links between healthiness perceptions and self-reported healthy and unhealthy food consumption. In sum, the current study extends prior work in the area of food healthiness perception by improving the generalizability of the sample and including novel individual differences predictors.

1.5. Hypotheses

Consistent with prior work (Rizk & Treat, 2014), at the normative (or nomothetic) level, we hypothesize that 1) free-living women will show greater reliance on fat and fiber, relative to sugar and protein, when assessed in isolation (or as main effects). Additionally, we expect that 2) free-living women will rely less on disqualifying nutrients (i.e., fat or sugar) in the presence of qualifying ones (i.e., fiber or protein), as quantified in bivariate interactions between nutrients.

At the person-specific (or idiographic) level, we explore four potential individual differences correlates of participant reliance on nutritional characteristics when judging food healthiness: BMI, self-reported binge eating symptomatology, self-reported healthy food consumption, and self-reported unhealthy food consumption. On the basis of past work, we expect that 3) BMI will be unrelated to nutrient utilization when judging food healthiness (Chandon & Wansink, 2007; Rizk & Treat, 2014). We anticipate that 4) those women who report more difficulties with binge eating, similarly to those who reported disordered eating in our prior study, will rely to a greater degree on disqualifying nutrients when judging food healthiness (Rizk & Treat, 2014). Finally, we explore the possibility that 5) women who consume more healthy food – or less unhealthy food – will focus more on both qualifying and disqualifying nutrients when judging food healthiness, since reliance on health-related nutrients may be related to dietary health behavior (Petrovici & Ritson, 2006).

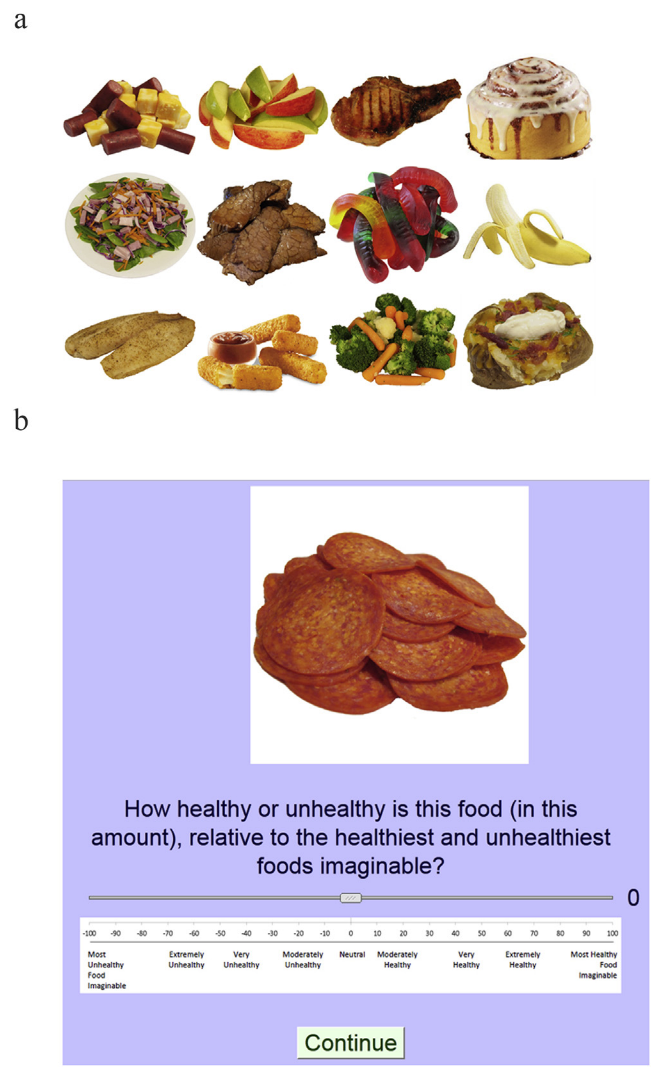

Fig. 1. 1a. Sample stimuli that vary in fat, sugar, protein, and fiber content. 1b. An example of the labeled magnitude scale (LMS) used for perceived healthiness ratings.

2. Method

2.1. Participants

Participants for this study were 169 women, living freely in the community of Iowa City, IA, with a mean age of 27.02 years (SD = 8.63). The racial/ethnic breakdown of the sample was 76.1% White/Caucasian, 8.8% Black/African– American, 11.5% Asian American, 2.7% Hispanic/Latino, and 0.9% Other. BMI ranged from 18.50 to 55.10 with a mean of 28.35 (SD = 7.29). None of the sample met criteria for underweight, 40.2% of the sample met criteria for normal weight, 23.1% of the sample met criteria for overweight, and 36.7% of the sample met criteria for obesity. Participants were paid $35 for their participation.

2.2. Food stimulus set

One hundred and four photos of moderate amounts of foods that varied in terms of their fat, fiber, total sugar, and protein content were presented to participants on a computer. The set included 13 individual fruits and 12 individual vegetables. The remaining foods in the set were comprised of cheese, eggs, red meat, white meat, seafood, candy, sweets, fried foods, whole grains, sugared cereals, nuts, beans, and lentils. See Fig. 1a for sample stimuli (e.g., baked tilapia, fried cheese sticks, steamed vegetables, loaded baked potato, banana, gummy worms, etc.). Nutritional characteristics for each food were obtained from the nutritional label, food company websites, or www.nutritiondata.com. Pearson correlations of fat and fiber, sugar and fiber, and protein and fiber revealed no significant multicollinearity problems.

2.3. Healthiness Rating Task

The Healthiness Rating Task (Rizk & Treat, 2014) asks participants to use a labeled magnitude scale to rate the healthiness of each food stimulus on a scale anchored by “the most healthy food imaginable” (100) and “the most unhealthy food imaginable” (−100). Intermediate anchors were spaced appropriately to obtain ratio-scale judgments. This measure differs from Likert-scale approaches, as it allows for valid comparisons of participants' healthiness judgments; prompting participants to rate each food relative to their own examples of the healthiest and unhealthiest foods reduces potential individual differences confounds in anchor interpretations. See Fig. 1b for a screen shot of a judgment trial.

2.4. Measures

2.4.1. Binge Eating Scale (BES)

The BES (Gormally, Black, Daston, & Rardin, 1982) is a 16-item questionnaire used to assess behaviors and emotional responses associated with binge eating. For each question, participants select a response from three to four options, which are weighted numerically. Scores range from 0 to 46, with higher scores indicating more severe pathology. In the current sample, BES scores ranged from 0 to 40 with a mean BES score of 13.96 (SD = 8.97). Using 17 as a cut-off score (Robert et al., 2013), 36.1% of the sample met the cut-off for a potential diagnosis of binge eating disorder. The BES appears to be reliable and valid (Hood, Grupski, Hall, Ivan, & Corsica, 2013).

2.4.2. Eating patterns questionnaire (EPQ)

Developed in a previous study (Rizk & Treat, 2015), the EPQ is a self-report measure of the frequency with which five foods are consumed: candies, sweets, fried foods, vegetables, and fruits. Specifically, the EPQ asks about the consumption of "Sweets (e.g., pies, cookies, cakes, ice cream, chocolate)","Candy (e.g., jelly beans, gummies, Starburst, Skittles)", "Fried Foods", "Fruits", and "Vegetables." The response options for the EPQ were modeled broadly after the response options on the Diet Behavior and Nutrition Questionnaire in the National Health and Nutrition Examination Survey, 2013 (Centers for Disease Control and Prevention, 2013). Frequency categories are never, 1 time per month or less, 2–3 times per month, 1–2 times per week, 3–4 times per week, 5–6 times per week, daily, 2–3 times per day, and 4 or more times per day. The frequency of consumption for each category was calculated to reflect consumption frequency per month. In the current sample, the mean (SD) number of times per month each food type was consumed was 12.35 (10.15) for Sweets, 6.94 (7.24) for Fried Foods, 6.22 (7.82) for Candies, 21.37 (9.07) for Fruits, and 20.90 (9.62) for Vegetables.

2.4.3. Anthropometric data

Height was measured using a portable stadiometer. Weight was measured using a digital scale. Participants removed their shoes prior to measurement. BMI was computed.

2.4.4. Procedure

These data were collected as a part of a larger study examining visual attention to food. During the first session, informed consent was obtained, and participants first completed the Healthiness Rating Task. Other data obtained during the first session are reported elsewhere. Approximately one week later, participants returned for a second session, in which they completed the BES and the EPQ. Additionally, their height and weight were measured.

2.5. Statistical analysis

A cross-classified, mixed-effects model was fit to the healthiness data using the lmer function in the lme4 package (Bates, Maechler, Bolker, Walker, & Christensen, 2014) in R (R Development Core Team, 2008), with p values and degrees of freedom estimated by the lmerTest package (Kuznetsova, Brockhoff, & Christensen, 2013). Effect sizes were calculated using recommended procedures for mixed-effects models (Oishi, Lun, & Sherman, 2007). The four nutritional characteristics were standardized prior to analyses (i.e., each variable was re-scaled, so that the new mean was 0.0 and the SD was 1.0) for ease of interpretation of our results. The four individual differences predictors were centered prior to analyses. Inspection of multicollinearity indices did not reveal any problems. A principal components analysis was used to create two consumption composites scores (i.e., Healthy Food Consumption (H_con) and Unhealthy Food Consumption (UNH_con)) from participant reports of the frequency with which fried foods, sweets, candies, fruits, and vegetables were consumed each month. As expected, two components emerged with eigenvalues greater than 1.0 (1.761, 1.576). The two orthogonally rotated components accounted for 66.74% of the variability in the consumption data. Candies, Sweets, and Fried Foods loaded strongly on the first component (0.74, 0.85, 0.60), which we labeled Unhealthy Food Consumption, but loaded minimally on the second component (0.03, 0.11, −.30), which we labeled Healthy Food Consumption. In contrast, Vegetables and Fruits loaded extremely strongly on the second component (0.88, 0.91), but very weakly on the first component (−0.01, −.03). Regression-based scores were computed for each participant for each of the two composites, Unhealthy Food Consumption and Healthy Food Consumption.

The fixed-effects structure included main effects of and all bivariate interactions between the four nutritional characteristics (i.e., fat, fiber, sugar, and protein); main effects for individual differences predictors (i.e., BMI, BES, H_con, UNH_con); and bivariate interactions between each nutrition characteristic and each individual differences predictor (e.g., fat*BMI, sugar*UNH_con). The maximal random effects structure supported by the data included random intercepts for subject and food, as well as random food slopes for BMI and consumption of healthy food. Use of the mixed-effects analytic approach allowed us to evaluate simultaneously but separately the normative influences of food-specific characteristics on participants' ratings of food healthiness and the influences of individual-specific characteristics on each participant's utilization of the nutrients when judging healthiness.

3. Results

3.1. Normative reliance on nutrients

The average healthiness rating was 3.6, indicating that the average free-living woman rated the average food to be near the mid-point of the healthiness scale (see Table 1). Examination of participants' reliance on the four nutrients revealed two main effects, consistent with Hypothesis 1. Note that the main effects are moderated by other nutrients, and we will turn to the bivariate interaction findings subsequently. The average utilization of fat was −19.702 ($p < 0.001$, $d = -1.138$), suggesting that free-living women's healthiness ratings decreased by 19.702 for each 1-g increase in a food's fat content. The magnitude of this effect suggests substantial reliance on fat content, such that high-fat foods were judged to be significantly less healthy than low-fat foods. Free-living women also relied positively on fiber when making their healthiness ratings, such that high-fiber foods were judged to be far healthier than low-fiber foods ($\beta = 16.108$, $p < 0.001$, $d = 0.981$). Participants did not reliably utilize sugar or protein, at the main effect level, when making their healthiness judgments, consistent with Hypothesis 1.

3.2. Interactions between nutrients

Three bivariate interactions emerged between the nutrients (see Fig. 2). First, a moderate-to-large, cross-over interaction was revealed between fiber and sugar ($\beta = 16.90$, $p < 0.001$, $d = 0.703$). When fiber was low, free-living women relied negatively and substantially on sugar (e.g., candy was judged to be far less healthy than white bread). In contrast, when fiber was high, free-living women relied positively on sugar (e.g., fruit was judged to be healthier than vegetables). Second, a moderate-magnitude, cross-over interaction emerged between fat and protein, such that

Table 1
Multilevel modeling results for healthiness rating task.

Parameter	Estimate	Standard error	*T* value	df	*p* value	*d* value
Intercept	3.553	4.221	0.842	99.03	0.402	0.169
Fat	**−19.702**	**3.485**	**−5.654**	**98.69**	**<0.001**	**−1.138**
Fiber	**16.108**	**3.335**	**4.830**	**97.07**	**<0.001**	**0.981**
Sugar	−4.379	4.708	−0.930	96.97	0.354	−0.188
Protein	0.627	5.648	0.111	95.82	0.911	0.023
BMI	3.151	2.982	1.056	162.57	0.292	0.166
BES	**−0.167**	**0.072**	**−2.328**	**151.96**	**0.021**	**−0.378**
UNH_con	**2.432**	**0.660**	**3.686**	**151.96**	**<0.001**	**0.598**
H_con	0.585	0.692	0.846	164.48	0.399	0.132
Fat*Fiber	6.107	3.605	1.694	94.99	0.094	0.348
Fat*Sugar	0.912	4.559	0.200	94.99	0.842	0.041
Fat*Protein	**11.173**	**4.831**	**2.313**	**94.99**	**0.023**	**0.475**
Fiber*Sugar	**16.896**	**4.935**	**3.424**	**94.99**	**<0.001**	**0.703**
Fiber*Protein	**−13.216**	**5.588**	**−2.365**	**94.99**	**0.020**	**−0.485**
Sugar*Protein	6.416	5.588	1.107	94.99	0.271	0.227
Fat*BMI	−1.517	2.470	−0.614	167.46	0.540	−0.094
Fat*BES	**−0.150**	**0.059**	**−2.541**	**152.66**	**0.012**	**−0.411**
Fat*H_con	**−1.614**	**0.575**	**−2.809**	**170.15**	**0.006**	**−0.431**
Fat*UNH_con	0.590	0.538	1.096	152.66	0.275	0.177
BMI*Fiber	−1.911	1.903	−1.004	168.27	0.316	−0.155
BES*Fiber	0.068	0.044	1.527	152.93	0.129	0.247
H_con*Fiber	0.184	0.444	0.415	171.15	0.679	0.063
UNH_con*Fiber	−0.406	0.405	−0.995	152.93	0.321	−0.161
BMI*Sugar	−2.215	2.486	−0.891	169.15	0.374	−0.137
BES*Sugar	−0.006	0.059	−0.103	153.64	0.918	−0.017
H_con*Sugar	−0.111	0.578	−0.192	171.97	0.847	−0.029
UNH_con*Sugar	0.002	0.539	0.003	153.64	0.997	0.001
BMI*Protein	2.368	2.093	1.131	169.38	0.260	0.174
BES*Protein	−0.075	0.049	−1.545	154.94	0.124	−0.248
H_con*Protein	0.210	0.489	0.429	172.16	0.668	0.065
UNH_con*Protein	0.111	0.444	0.250	154.94	0.803	0.040

Note. BMI = Body Mass Index (centered); BES = Binge Eating Scale (centered); H_con = Healthy food consumption; UNH_con = Unhealthy food consumption. Significant effects are bolded.

negative reliance on fat decreased in the presence of protein ($\beta = 11.17$, $p = 0.022$, $d = 0.475$). When protein was low, free-living women relied negatively and considerably on fat (e.g., cake was judged to be far less healthy than crackers). However, when protein was high, free-living women relied less negatively on fat (e.g., steak was judged to be somewhat healthier than eggs). Each of these interactions was consistent with Hypothesis 2. Finally, a moderate cross-over interaction emerged between fiber and protein, such that participants relied more on fiber when protein was low ($\beta = -13.22$, $p = 0.020$, $d = -0.485$) (e.g., blackberries were judged to be moderately healthier than donuts).

3.3. Individual differences predictors of average healthiness judgments

Examination of the participant-specific predictors of variability in healthiness ratings revealed two reliable main effects. BES negatively predicted average healthiness ratings ($\beta = -0.1678$, $p = 0.021$, $d = -0.378$) to a small-to-moderate degree. As self-endorsed binge-eating symptomatology increased, perceived healthiness ratings decreased. Consumption of unhealthy foods positively predicted average healthiness ratings ($\beta = 2.432$, $p < 0.001$, $d = 0.598$) to a moderate degree, such that those consuming more unhealthy food perceived foods to be healthier than their peers who consumed less unhealthy food. Consistent with Hypothesis 3, BMI did not reliably predict average healthiness ratings among free-living women.

3.4. Interactions between nutrients and individual differences predictors

Two interactions emerged between reliance on a single nutrient and an individual differences predictor (see Fig. 3). First, reliance on fat interacted with BES to a small-to-moderate degree, such that those who endorsed greater binge eating symptomatology relied more negatively on fat, compared to their less symptomatic peers, when judging food healthiness ($\beta = -0.150$, $p = 0.012$, $d = -0.411$). This finding was consistent with Hypothesis 4. Second, reliance on fat and the consumption of healthy food (H_con) interacted to a similar degree ($\beta = -1.613$, $p < 0.005$, $d = -0.431$). As expected by Hypothesis 5, those who self-reported more frequent consumption of healthy food relied more negatively on fat when judging food healthiness, relative to those who reported less frequent consumption of healthy food.

4. Discussion

The current work investigated nutrient-specific (i.e., fat, fiber, sugar, and protein) and person-specific (i.e., BMI, BES, H_con, UNH_con) predictors of food healthiness judgments in a sample of free-living women. The perceived healthiness of 104 foods was assessed indirectly, using a labeled magnitude scale. A mixed-effects model provided estimates of participants' average reliance on the four nutrients and individual differences predictors of nutrient utilization when judging food healthiness.

4.1. Normative findings

At the normative level, participants relied on specific disqualifying and qualifying nutrients both independently and in combination with one another (i.e., as main effects and in bivariate interactions with one another). In terms of disqualifying nutrients, free-living women relied negatively and substantially on fat, such that high-fat foods were judged to be markedly less healthy than

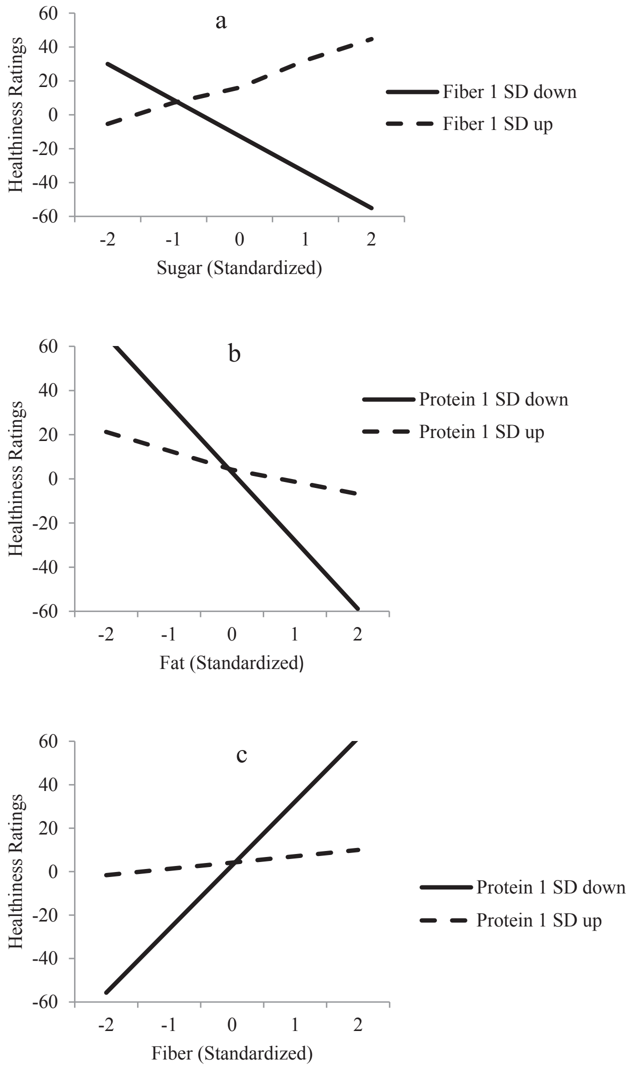

Fig. 2. *Bivariate interactions between nutrients.* Note. When making healthiness ratings, the extent to which participants relied on sugar, fat, or fiber depended on the fiber or protein content of the judged food: 2a) when fiber was high, reliance on sugar decreased; 2b) when protein was low, reliance on fat decreased; 2c) when protein was high, reliance on fiber decreased.

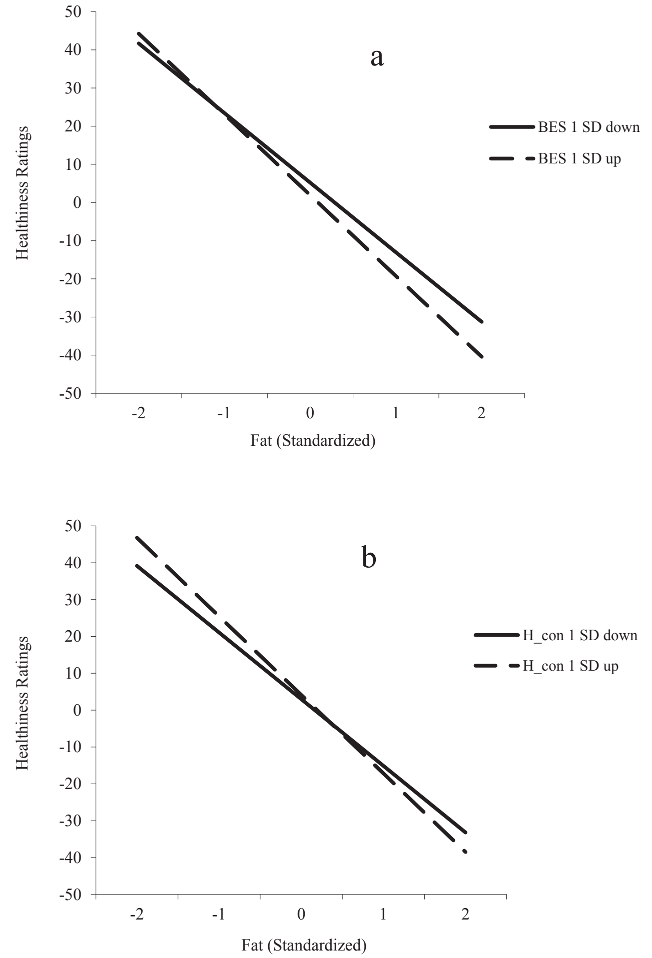

Fig. 3. *Bivariate interactions between nutrients and individual differences predictors. Note.* SD = standard deviation. When making healthiness ratings, participants relied more negatively on fat if 3a) they endorsed greater binge eating symptomatology (BES); 3b) they endorsed more frequent consumption of healthy food (H_con).

low-fat foods. Free-living women's extensive reliance on fat when judging food healthiness extended and replicated prior work (Rizk & Treat, 2014). This finding was not surprising, particularly given that public health initiatives encourage reduced fat consumption (USDA, 2010a, 2010b). In contrast to the findings for fat, free-living women did not rely substantially on sugar, independently of the level of other nutrients. This finding was unanticipated, given that a sample of college-aged women not only relied moderately on sugar but also demonstrated significant knowledge of the sugar content in foods (Rizk & Treat, 2014). The lack of reliance on sugar, independent of the presence of other nutrients, may be problematic for free-living women, as excess sugar consumption has been linked to negative health consequences (Johnson et al., 2007; Teff et al., 2009; Xin et al., 2012).

In terms of qualifying ingredients, free-living women relied positively and substantially on fiber, rating high-fiber foods as significantly healthier than low-fiber foods. This result was expected, given the emphasis national nutrition campaigns place on increased fiber intake (USDA, 2010a, 2010b). Notably, this finding replicates and extends that of our previous work (Rizk & Treat, 2014), which demonstrated considerable reliance on fiber in college-aged women's perceptions of food healthiness. In contrast to prior work, however, the current pattern of results does not suggest significant reliance on protein among free-living women at the level of the main effect. The lack of reliance on protein may be troubling, since adequate protein consumption confers several health benefits, such as improving satiety and decreasing fat mass (Pal & Radavelli-Bagatini, 2013; Pesta & Samuel, 2014).

4.2. Bivariate interactions between nutrients

Across the nutrients, three bivariate interactions were observed, highlighting the importance of interpreting reliance on each nutrient in the context of other nutrients. First, reliance on fiber and sugar interacted to a moderate-to-large degree. Free-living women relied negatively and considerably on sugar when fiber was low (e.g., gummy bears were judged to be less healthy than an English muffin). However, when fiber was high, free-living women relied positively on sugar (e.g., mixed berries were judged to be healthier than broccoli). In other words, foods that are high in sugar but low in fiber (such as sugar-sweetened cereal or candy) are perceived to be unhealthy, whereas foods that are high in sugar but also high in fiber (such as mixed berries) are perceived to be healthy. For foods that contain both qualifying and disqualifying nutrients, the reduced reliance on disqualifying nutrients is concerning, because perceiving these foods as healthier than they are may be associated with excessive consumption of less-healthful nutrients. Second, reliance on fat and protein interacted to a moderate degree; negative utilization of fat diminished in the presence of protein. For low-protein foods, free-living women relied negatively and markedly on fat (e.g., powdered donuts were judged to be far less healthy than toast). In contrast, for high-protein foods, free-living women did not rely as negatively on fat (e.g., meatloaf was judged to be healthier than chicken). Both of these findings replicate and extend our prior work (Rizk & Treat, 2014), providing further evidence that free-living women may discount disqualifying nutrients (i.e., fat or sugar) when qualifying nutrients are also present (i.e., fiber or protein). Another possibility is that participants are relying less on sugar when judging the healthiness of foods like fruit, which is adaptive, and that they are relying less on fat when judging the healthiness of foods like salmon, which is also adaptive. Future investigations of food healthiness perception should tease apart more and less adaptive versions of these interactions, because they may also reflect women's sensitivity to more or less nutritious sub-types of fat and sugar. Finally, a moderate interaction emerged between fiber and protein. Free-living women relied more negatively on fiber in low-protein foods (e.g., apples were judged to be somewhat healthier than mushrooms). This pattern of results also was observed in our prior work (Rizk & Treat, 2014).

5. Person-specific findings

At the person-specific level, two individual differences characteristics reliably predicted perceptions of food healthiness. First, free-living women who endorsed greater difficulty with binge eating symptoms judged foods to be less healthy to a small-to-moderate degree. This finding may reflect a behaviorally adaptive perceptual process among those who struggle with concerns related to binge eating. Second, free-living women who reported more frequent consumption of unhealthy food perceived foods to be healthier to a moderate degree, relative to their peers who reported less frequent consumption of unhealthy food. This result suggests a potential lack of knowledge or attentiveness to the disqualifying nutrients in foods, which could have negative implications for healthful dietary behavior. Finally, BMI did not emerge as a significant predictor of healthiness ratings, replicating past research. Prior work has demonstrated that BMI is related neither to caloric misperception (Chandon & Wansink, 2007), nor to perceptions of food healthiness in a sample of college-aged women (Rizk & Treat, 2014).

5.1. Interactions between fat and individual differences predictors

In two instances, individual differences predictors moderated reliance on fat when judging food healthiness. First, utilization of fat – but not sugar – interacted with self-reported binge eating symptoms to a small-to-moderate extent. Free-living women who reported greater binge eating symptomatology relied more negatively on fat, relative to their less symptomatic counterparts. Consistent with the main effect of BES, self-reported binge eating concerns appear to serve as a protective factor against misperceiving the healthiness of foods. The Eating Disorder Examination–Questionnaire assesses relatively more restrictive eating pathology (Fairburn & Beglin, 1994). By virtue of their responses on this self-report measure, college aged-women who reported struggling with more restrictive disordered eating concerns also relied heavily on fat when rating food healthiness (Rizk & Treat, 2014). Disordered eating, whether it falls on the restrictive or disinhibited end of the continuum, appears to be related to enhanced reliance on fat; however, disordered eating does not protect against misperception on the basis of sugar. Second, free-living women who reported more frequent healthy food intake utilized fat – but not sugar – to a greater degree than women who reported less frequent healthy food intake. Though attitudes regarding healthy lifestyles behaviors have been linked to healthy food consumption (Hearty, McCarthy, Kearney, & Gibney, 2007), this study is one of the first to demonstrate an adaptive connection between healthy food consumption and perception of food healthiness. The causal direction of the relationship between healthy food consumption and healthiness perception cannot be determined in the current work and remains an important future topic to explore. On the one hand, greater consumption of healthy foods (i.e., fruits and vegetables) might increase the salience of the nutritional content for unhealthy foods. On the other hand, greater awareness of the nutritional content of unhealthy foods might prompt greater consumption of healthy foods. It has also been demonstrated that more frequent healthy food intake is associated with greater sensitivity to increasing portion sizes of unhealthy foods (Rizk & Treat, 2015). The current work and prior work provide two examples of the links between perception and behavior, such that engagement in dietary health behavior may be associated with adaptive perception of food healthiness. Notably, however, healthy food intake was unrelated to reliance on sugar when judging food healthiness. Thus, public health campaigns should continue to emphasize that the presence of sugar in foods without nourishing components (i.e., fiber, protein) is problematic, and consuming these foods in excess should be avoided. By increasing the perceived relevance of sugar to the healthiness of foods with no nutritional benefit, more frequent consumption of healthy food may become an individual differences characteristic that predicts even more protection against the misperception of food healthiness.

5.2. Strengths and limitations

Some aspects of the current work are limited. First, this study explores reliance on only four nutrients when judging food healthiness. Our focus on fat, fiber, sugar, and protein is not to deny the relevance of other nutrients, such as sodium or carbohydrates, to the perception of food healthiness. Rather, these four nutrients were carefully selected to assess qualifying and disqualifying nutrients that could be investigated independently of one another, thereby minimizing problems with multicollinearity. Further, these four nutrients were selected because of their connections to physical health (Johnson et al., 2013; Maki & Phillips, 2015; Ventura et al., 2009; Xin et al., 2012). Additionally, this study is limited by its reliance on a short, self-report measure of consumption of healthy and unhealthy food. In the future, food diaries or 24-h dietary recall could be used to quantify consumption-related predictors of food healthiness perception in a more rigorous fashion (Shim, Oh, & Kim, 2014).

However, the current work includes a number of strengths. First, this work provides more support for the efficacy of an indirect measurement approach to perceived food healthiness. Current and past work (Rizk & Treat, 2014) employed this indirect approach, and results revealed similar patterns of results. Assessing perceptions of food healthiness using the indirect labeled magnitude procedure likely allows for a more accurate evaluation of the extent to which free-living women rely on nutrients when judging food healthiness, relative to measures which directly ask participants to report their nutritional reliance (Carels et al., 2007; Oakes & Slotterback, 2002). Further, use of the labeled magnitude scale provides ratio-scale judgments that are less vulnerable to individual differences confounds in interpretation of scale anchors (Bartoshuk et al., 2004). When generalized labeled magnitude scales have been used in past work, individuals have tended to make responses near the adjective labels, resulting in non-normal, ordered-categorical data (Hayes, Allen, & Bennett, 2013). Though this was not true for the current data, it would be interesting to contrast the generalized labeled magnitude scale with the generalized visual analog scale in future investigations of perceived healthiness. Second, the use of a large photographic (rather than semantic) stimulus set with known nutritional properties enhances the ecological validity of the work. Third, our adoption of a mixed-effects modeling strategy allows for separate, yet simultaneous estimates of nomothetic and idiographic reliance on each nutrient. Fourth, the inclusion of BES and self-reported dietary intake as individual differences predictors expands prior work. Finally, several of these findings serve as a replication and extension of prior work with undergraduate women in a broader population of free-living women. This increases our confidence in the findings and the potential utility of this novel indirect assessment method for assessment of nutrient influences on food judgments (see Gearhardt et al., 2014 for a related indirect assessment of nutrient influences on food craving and liking).

5.3. Conclusions and future directions

Public health campaigns should continue to encourage women to consume adequate amounts of protein and to decrease their consumption of sugar as it pertains to foods that do not contain any beneficial nutrients, in addition to minimizing fat intake and increasing fiber consumption. Both undergraduate and free-living women's decreased independent reliance on sugar and protein is concerning. It is unclear whether free-living women are unaware of the extent to which sugar or protein are present in foods, or if they do not perceive them to be relevant to food healthiness. In either case, free-living women are disadvantaged by relying less on disqualifying nutrients in the presence of qualifying ones when judging food healthiness or selecting foods to consume. The presence of sugar in foods without qualifying components (i.e., fiber, protein) is problematic, and consuming them in excess should be avoided. It would be interesting to examine how nutrient reliance might be combined to affect consumption of multiple foods, such as in a meal context. Additionally, the current study did not explore reliance on different sub-types of sugar content when perceiving food healthiness. Future work should investigate differential reliance on naturally occurring sugar and added sugar, as facilitated by the eventual adoption of the nutrition facts label proposed by the US Food and Drug Administration (2014).

Prior work has investigated explicit knowledge of the fat, fiber, sugar, and protein content of foods, demonstrating that nutritional knowledge was highest for sugar and lowest for fiber (Rizk & Treat, 2014). Nutritional knowledge was not related to nutrient utilization. However, prior work did not investigate nutritional knowledge of food groups or meals. Investigations of explicit knowledge of the healthiness of different food groups and indirect reliance on nutrients when perceiving food healthiness could provide useful insights in future research. Moreover, future work might profitably explore reliance on other nutrients to the extent that stimulus sets could be created. Perhaps other nutrients exert main effects or interact with fat, fiber, sugar, or protein when judging food healthiness. Given the well-established relationship between energy density and food healthiness, it also would be worthwhile to examine reliance on energy density as a predictor of healthiness ratings (Miller et al., 2009; Nicklas, Drewnowski, & O'Neil, 2014). Future work might also examine other individual differences predictors of reliance on these nutrients, such as genetics or personality, which have been implicated in the food choice literature (Byrnes & Hayes, 2015; Hayes, Feeney, & Allen, 2014). Additionally, the efficacy of training programs designed to enhance reliance on all four nutrients when judging food healthiness should be assessed. Improved perceptions of food healthiness have clear implications for those struggling with weight loss or weight loss maintenance, as well as those who want to maintain a healthy diet.

The indirect approach used in this work is cost-effective, scalable, and easily disseminable. As such, it would be worthwhile to determine whether it proves useful in applied contexts, given that the success of weight loss programs hinges upon clients' perceptions of food healthiness, as well as behavioral techniques (Lo Presti, Lai, & Hildebrant, 2010). It may prove helpful clinically to evaluate clients' utilization of nutrients when judging food healthiness pre- and post-treatment. Finally, this study provides another step towards examining the link between healthiness perception and dietary health behavior. Future work should continue to elucidate the extent to which one's perceptions of food healthiness are related to food selection and consumption.

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