Appetite 105 (2016) 71–84

Contents lists available at ScienceDirect

Appetite

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

Analysis of nutrition judgments using the Nutrition Facts Panel

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ARTICLE INFO

Article history:
Received 26 October 2015
Received in revised form
12 May 2016
Accepted 14 May 2016
Available online 17 May 2016

Keywords:
Lens model
Nutrition Facts Panel
Judgment accuracy

ABSTRACT

Consumers' judgments and choices of the nutritional value of food products (cereals and snacks) were studied as a function of using information in the Nutrition Facts Panel (NFP, National Labeling and Education Act, 1990). Brunswik's lens model (Brunswik, 1955; Cooksey, 1996; Hammond, 1955; Stewart, 1988) served as the theoretical and analytical tool for examining the judgment process. Lens model analysis was further enriched with the criticality of predictors' technique developed by Azen, Budescu, & Reiser (2001). Judgment accuracy was defined as correspondence between consumers' judgments and the nutritional quality index, NuVal®, obtained from an expert system. The study also examined several individual level variables (e.g., age, gender, BMI, educational level, health status, health beliefs, etc.) as predictors of lens model indices that measure judgment consistency, judgment accuracy, and knowledge of the environment. Results showed varying levels of consistency and accuracy depending on the food product, but generally the median values of the lens model statistics were moderate. Judgment consistency was higher for more educated individuals; judgment accuracy was predicted from a combination of person level characteristics, and individuals who reported having regular meals had models that were in greater agreement with the expert's model. *Conclusions*: Lens model methodology is a useful tool for understanding how individuals perceive the nutrition in foods based on the NFP label. Lens model judgment indices were generally low, highlighting that the benefits of the complex NFP label may be more modest than what has been previously assumed.

1. Introduction

In the last five decades, the rate of obesity has dramatically increased from 13% of American adults, in 1962, to 35% in 2012 (Flegal, Carroll, Kuczmarski, & Johnson, 1998; Ogden, Carroll, Kit, & Flegal, 2014). In addition to being associated with increased mortality and morbidity, obesity has steep economic costs for individuals and society. Some researchers estimate that obesity-related medical expenses account for 20.6% of U.S. national health expenditures, approximately $209.7 billion dollars in 2008 (e.g., Cawley & Meyerhoefer, 2012; Kim & Popkin, 2006). One important presumed contributor to obesity is the increased prevalence of highly processed, energy-dense foods in daily diet. At the national level, easy availability of high-calorie, low-nutrient foods at cheap prices has been accompanied by higher body weight and related medical issues (e.g., Institute of Medicine (IOM), 2005; McGinnis, Gootman, & Kraak, 2006). Although food decisions are influenced by price, they also depend on psychological factors pertaining to judgments of quality and understanding of nutrition. Thus, an important question is how individuals judge the nutritional levels of foods and whether those judgments are accurate. Fruits and vegetables are easy to classify as nutritious; processed foods, on the other hand, pose a challenge.

To address the issue of unhealthy eating, the US Nutritional Labeling and Education Act (NLEA, 1990) mandated the use of a standardized nutrition label. The law requires that packaged food products display a standardized nutrition label (the Nutrition Facts Panel, NFP) with information such as the product's serving size, servings per container, the amount of calories per serving, as well as amounts and percentages of daily values of several nutrients. The aim of the law was to provide consumers with nutritional information that was accurate, easy to read, and encouraged healthier food choices (Kessler, Mande, Scarbrough, Schapiro, & Feiden, 2003). Self-reports of NFP usage show a positive trend. A study by the US Agriculture Department found that the percentage of adults who reported using the NFP 'always or most of the time' went from 34% in 2007–08 to 42% in 2009–10 (Todd, 2014).

Abbreviations: NFP, Nutrition Facts Panel; CHB, Compensatory Health Beliefs; HBCL, Health Behaviors Checklist (HBCL).

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http://dx.doi.org/10.1016/j.appet.2016.05.014

However, the evidence that the NFP indeed helps consumers make better decisions is scant. For example, several studies indicate that there has been no aggregate improvement of American nutrient consumption since the implementation of the NFP (Burton, Garretson, & Velliquette, 1999; International Food Information Council Foundation, 2012).

Some early research indicated that the implementation of the NFP had positive effects on the comprehension and use of nutrient information, but later studies showed that these effects were limited. For example, Kristal, Levy, Patterson, Li, and White (1998) and Moorman (1996) found that NFP implementation increased label usage and reduced confusion among consumers, improving their acquisition and comprehension of product nutrient information. However, later studies found no such evidence and concluded that there was only a modest beneficial impact on public consumption habits (Balasubramanian & Cole, 2002; Variyam, 2008; Weil, Fung, Graham, & Fagotto, 2006).

The lack of a robust effect may be due in part to the variability in the use of information by different consumers. Elderly and less-educated individuals are more likely than others to find the NFP labels too difficult to understand; people who consume more unhealthy foods are less likely to search for information on food labels than those who see diet as connected to health, and people higher in motivation and lower in skepticism are more likely to acquire nutrient information from the NFP label (Balasubramanian & Cole, 2002; Kristal et al., 1998; Lin, Lee, & Yen, 2004; Moorman, 1996). These studies, nevertheless, have not directly addressed a key issue: whether the information in the NFP allows consumers to accurately judge the nutrition quality of the foods. This judgment is an important link between having NFP information and ultimately making food choices that improve nutritional intake. The present investigation aims at advancing knowledge of NFP information usage with regards to judgment accuracy. To that end, we use a well-known theoretical framework from decision making research, Brunswik's lens model (Brunswik, 1955; Cooksey, 1996; Hammond, 1955; Stewart, 1988), to demonstrate a quantitative analysis of the judgment process of consumers' evaluations of two categories of packaged foods: cereals and snacks.

1.1. *The lens model*

The lens model has been used in many domains to better understand evaluations, predictions, and many other types of judgments (e.g., psychiatric diagnosis, assessment of job candidates, assessment of creditworthiness, etc.). For example, meteorologists predicting a weather event, such as rain, make judgments by focusing on many physical variables in the environment that relate to the criterion rain (Stewart, Pielke, & Nath, 2004). The variables in the environment are cues such as temperature, humidity, and atmospheric pressure, which are proximal information to the judge. These cues also relate to the criterion and hence have ecological validity (Cooksey, 1996; Stewart, 1988). Judgment accuracy thus depends on whether a judge uses ecologically valid cues. Take physicians' judgments as another example. The accuracy of a physician's diagnosis is maximized by weighting the presence (absence) of symptoms in a way that reflects the objective relationship of those symptoms with the disease in question. Cues that strongly signal the presence (absence) of a condition should be used more heavily than weak or irrelevant cues. Applying these ideas to nutrition judgments, we posit that consumers have access to nutrient information on the packages to evaluate the nutrition quality of the foods. This information is conveyed via the NFP, along with other information on the package, and consumers may be accurate if their evaluations coincide with objective nutrition quality assessments (i.e., a nutrition quality criterion). In addition, the lens model analysis provides a way of extracting each person's policy for using and combining information to derive nutrition judgments. That is, the model provides a measurement tool for extracting the pattern of information usage of an individual. In terms of task characteristics, lens model (judgment) analysis research has identified two dimensions of the judgment context: familiarity and congruency. Familiarity refers to the level of familiarity that the judge has with the environment; task congruence pertains to the extent to which the task utilizes concrete information as found in the ecology, rather than abstract representations (Cooksey, 1996). The current study places the consumers in a condition of familiarity and congruency, but the level of familiarity varies as some individuals may naturally look at NFP information to make judgments of nutritional quality while shopping (thus have an experience similar to the experimental set up), whereas others may not. Congruence is high because the NFP information was used exactly as it appears in the products available in the market.

In terms of judgment accuracy, prior research indicates that accuracy can be debilitated by improper weighing of cues. For instance, individuals might focus on a nutrient that is irrelevant to the total nutritional value of the product, or they may base their judgments on only a few nutrients while ignoring relevant ones, or they might misinterpret negative nutrients as positive ones (Hardman & Hardman, 2009). We analyze these possibilities.

The lens model equation (LME) of judgment analysis (Stewart, 1988; Tucker, 1964) decomposes the correlation between a judgment (Y) and a criterion variable (O) into several components. The process begins by developing statistical models (usually linear multiple regression models) of the criterion (O) and the judgment (Y):

$$O = M_{O.X}(X_1, X_2, \ldots, X_n) + E_{O.X} \tag{1}$$

$$Y = M_{Y.X}(X_1, X_2, \ldots, X_n) + E_{Y.X}$$

where the X_i are the cues; $M_{O.X}$ and $M_{Y.X}$ represent models that describe the relations between the cues and the criterion, and the cues and the judgment, respectively. The E's represent the residuals or "errors" of the models and are not linearly related to the M's. In the current application of the lens model, O are nutrition scores derived from an expert system; Y are consumers' judgment of nutrition; X_i are the nutritional information that relates to both O and Y in the environment. Several statistics derive from Equation (1) and are used to describe the judgment process. We describe these statistics in more detail in the analysis section. Suffice here to say that a high relationship between O and Y would demonstrate that lay consumers have a good sense of the nutritional quality of individual foods relative to an expert system.

1.2. *The nutritional quality of foods*

The nutritional quality of foods (O) was assessed with a nutrition profile system. Nutrition profile systems are algorithms developed by experts to provide indices for the nutritional content of foods. Examples of such ratings are the NQI (Nutritional Quality Index), proposed by Hansen in 1973 (cited by Drewnowski, 2005), the Nutrient Rich Foods Index (NRF) (Nutrient Rich Food Coalition, 2010), and the Overall Nutritional Quality Index (ONQI) (Katz et al., 2009). We used the ONQI, which was developed by the Yale-Griffin Prevention Research Center in an effort to inform American consumers of the quality of the foods they consume. The ONQI summarizes the overall nutrition of a food into a single score (NuVal®) by considering favorable and unfavorable nutrients and ingredients on a per unit basis. The scores range from 1 to 100, with higher values indicating higher nutritional quality. Details about the development, components, and performance of the ONQI algorithm have been previously published (Katz et al., 2009; Katz, Njike, Rhee, Reingold, & Ayoob, 2010).

We selected the NuVal® system as our expert, because the ONQI method is the only one to have been validated against health outcomes, and has been endorsed by the American College of Preventive Medicine (2016). A large scale longitudinal study demonstrated lower body mass index, lower risk of chronic disease, and lower total mortality for individuals who consumed products with higher NuVal® (Chiuve, Sampson, & Willett, 2011; Reedy & Kirkpatrick, 2011). Validity of the system was also demonstrated by a psychometric study of expert judgment (Katz et al., 2009); studies have further shown that the availability of NuVal® scores on food labels increases the quality of foods selected and purchased by consumers (Helfer & Shultz, 2014; Nikolova & Inman, 2015). Additionally, the system is gaining market popularity and being adopted by a number of supermarket chains (e.g. Tops Friendly Markets, United Supermarkets LLC and Scolari's Food and Drug Company (NuVal® LLC, 2015)).

The importance of judging nutrition in individual foods is fundamental to having a proper diet, but should not be confused with it. Clearly, highly nutritious foods, such as blueberries, must receive high nutritional quality marks, but a healthy diet cannot be composed of only blueberries. Complementariness, distribution, and variety of foods are all essential to having a balanced diet (see p 1107S in Katz et al., 2010).

1.3. Goals of the study

This study presents a systematic analysis of consumers' assessments of nutrition quality of individual packaged foods (cereals and snacks). We selected breakfast cereals and snacks because cereal consumption is high in the USA, with retail sales expected to reach $US 10.3 billion in 2018 (Euromonitor International, 2014). Similarly, packaged snacks are widely consumed with generated sales amounting to 124 billion U.S. dollars in North American retail in 2014, with salty snacks having brought in the highest sales share of the total category (Statista, 2014).

This study utilizes Brunswik's lens model as a theoretical and analytical framework to assess the degree of correspondence between expert and lay judgments. This advances a novel application of the model (see review by Karelaia & Hogarth, 2008, for applications in other domains; see Orquin, 2014, for a similar approach), and importantly, it deepens our understanding of consumers' information usage when evaluating a fundamental aspect of nutrition. Surveys indicate that consumer understanding and use of NFP information varies according to demographic differences such as education, age, and gender as well as according to personality differences (International Food Information Council Foundation, 2009; Kristal et al. 1998; Moorman, 1996). We also investigate if such differences relate to judgment processes.

2. Methods

2.1. Participants

Participants were 196 individuals living in the United States, at least 18 years of age, recruited through Amazon's Mechanical Turk (www.MTurk.com)[1] and the psychology participant pool of a Midwest university in the U.S. Participants were predominantly female (65.8%), and not currently dieting (66.3%), with 34.7% reporting that they were employed, and 5% were on disability. The sample was largely Caucasian (81.1%), but it also included African Americans (6.1%), Hispanics (4.1%), and Asians (8.2%). The mean age was 28 ($SD = 12$), and the average BMI (calculated from self-reported height and weight) for this group was 24.7 ($SD = 6.6$), which is in the normal range (according to U.S. Center for Disease Control and Prevention, 2011). Over half (57.5%) reported an annual income of less than $20,000 per year. With relation to health, 16.3% reported having health issues or other dietary restrictions that influenced their food choices. Over half the sample (59.2%) said they used the NFP 70% of the time or more. Of the participants, 99 completed the survey for cereals (51 MTurk participants; 48 university students), and 97 completed the snack survey (53 MTurk participants; 44 university students). There were no significant differences between the two food conditions for gender, dieting, employment, race, age, BMI, income, health issues, eating out, nor for self-report about the general use of the NFP.

2.2. Procedure

The study was an online survey that lasted between 45 and 60 min and individuals received compensation ($0.90) for their participation on MTurk, or 1 research credit for participation as part of the subject pool. Participants completed either the snack or cereal condition (randomly assigned to this between-subjects manipulation). Within each condition, participants viewed either 40 cereals or 40 snacks which were randomly presented (see Appendix for the list of products) and answered questions concerning each item (see measures below). The instructions for the evaluation of food products stated:

"In this part of the study we want you to evaluate some common packaged foods. For each food item you will see a screen with a picture that shows its front packaging information. You will also have its Nutrition Facts Panel and the list of its ingredients. This information should be helpful as you evaluate the foods with regards to their nutrition. Please view each item and then answer the questions that follow as best as you can so that they represent your opinions. In addition to evaluating each food item, we will ask you to hypothetically purchase the item by placing it in a shopping cart if you think it is desirable (a yes/no answer). For this part, assume cost is not an obstacle to possessing the item. However, also consider that you wouldn't want to add something to your cart that you wouldn't consume."

They then completed a survey consisting of the Compensatory Health Belief Scale (Knäuper, Rabiau, Cohen, & Patriciu, 2004), The Health Behaviors Checklist (Vickers, Conway, & Hervig, 1990), and the Need for Cognition scale (Cacioppo, Petty, & Kao, 1984). This was followed by a demographic section.

2.3. Stimuli

The group of snacks and cereals were selected with the following criteria: 1) that they were currently in the market, 2) that they comprised a wide array of brands, 3) that they expanded the various product types in terms of nutrition, and 4) that they had computed NuVal scores which were obtained from Yale-Griffin Prevention Research Center. From a judgment analysis perspective, we followed Brunswik's concern for having a representative design and hence used real food products found in the market with variable nutrition levels, but the samples were not fully random. However, as noted by Stewart (1988), there are challenges to carrying out judgment analysis (JA) following the lens model ideals when working in real domains; thus, the researcher must

[1] A review of Mechanical Turk by Buhrmester, Kwang, and Gosling (2011) suggests that this tool can provide high-quality data at least as reliable as what could be obtained through traditional recruitment methods, with significantly more diversity than the average college sample.

compromise. As stated by Stewart: "… the design of a JA study may require compromise between the ideal design and practical limitations" (p 46).

2.4. Measures

Nutrition Rating Snack/Cereal Questions. For each food product, participants saw a picture of the box of cereal (or the snack) along with an enlarged NFP panel. An example is found in Fig. 1. Participants responded to the following questions for each food: "How healthy is this cereal/snack?" (0 = Not Healthy to 100 = Extremely Healthy); "How well does the cereal/snack meet nutritional requirements?" (0 = Does not Meet them to 100 = Meets them extremely well); "How nutritious is this cereal/snack?" (0 = Not nutritious at all to 100 = Extremely nutritious); "How well do you know this cereal/snack?" (0 = Not at all to 100 = Extremely well); "How many times a week do you consume the item" (free response); "How much do you like this cereal/snack" (0 = Not at all to 100 = Like a lot). For responses from 0 to 100 participants selected from values rounded to the nearest 10 (i.e., 0, 10, 20, etc.). Choice was measured with the following binary question: "Add to my shopping cart" (Yes or No).

The Compensatory Health Beliefs Scale (CHB). The CHB scale (Knäuper et al., 2004) is a 17-item scale designed to measure the degree to which individuals endorse compensatory beliefs concerning health behaviors. The scale asks participants to rate on a 5-point Likert-type scale from 0 (totally disagree) to 4 (totally agree) how much they agree with each sentence (e.g., Exercising can compensate for smoking). Higher scores indicate a greater endorsement of CHBs. The original scale showed good internal consistency (Cronbach's $\alpha = 0.78$); the present study displayed similar results ($\alpha = 0.79$). Validity assessment demonstrated that increased endorsement of CHBs were associated with higher BMI, increased risky-health and weight-regulating behaviors (e.g., dieting), and decreased health-related self-efficacy (Knäuper et al., 2004). Given these findings, CHB was measured in order to assess whether individuals who score high in CHB tend to rely less on factual nutritional information, resulting in less accurate judgments.

Fig. 1. Example of a screen with food product information.

The Health Behaviors Checklist (HBCL). The HBCL (Vickers et al., 1990) measures four behavioral factors thought to contribute to a person's health. The checklist contains 40 items, 27 of which are used in scoring to represent four health domains in two general areas: preventative health behaviors and risk taking behaviors. The four domains are: (1) wellness maintenance behaviors (e.g., "I take vitamins"); (2) traffic-related risk taking (e.g., "I speed while driving"); (3) accident control behaviors (e.g., "I have a first aid kit in my home"); and (4) the use of potentially harmful substances (e.g., "I don't drink alcohol").

Participants respond to each item on a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree) in terms of the degree to which each statement describes their typical behavior. Items are reverse coded when necessary so that higher scores indicate greater care to their health. In the present study, the overall score based on the 27 items from the subscales was found to have good reliability ($\alpha = 0.82$) as was the overall score of the 40 items ($\alpha = 0.86$). Validity for the scale was advanced by Booth-Kewley and Vickers (1994). The use of the HBCL in the current study is to assess whether individuals endorsing generally healthy behavioral patterns are also more accurate at judging nutritional information from the NFP. That is, general habits and risk taking behaviors in other life domains are expected to relate to food evaluations, because the concept of health concern is multidimensional (e.g., a person who is careless in driving may also never worry about eating healthy).

18-Item Need for Cognition Scale (Cacioppo et al., 1984). Need for cognition refers to the tendency of enjoying intellectual activities. Individuals high in need for cognition find cognitive challenges satisfying and studies have shown a relationship between need for cognition and academic performance (Sadowski & Gülgös, 1996). The short form of the Need for Cognition Scale is an 18-item questionnaire. Sample items include, "I prefer watching educational to entertainment programs," "I am not satisfied unless I am thinking," and "I prefer my life to be filled with puzzles that I must solve." The scale uses a 5-point Likert-type response format (1 = extremely uncharacteristic, to 5 = extremely characteristic); higher scores on the test indicate a greater need for cognition or enjoyment for doing cognitively demanding activities. The questionnaire was found to have high internal reliability ($\alpha = 0.90$) with a sample of 527 participants in the original study and had equally high reliability in the present study ($\alpha = 0.90$). Validity for the scale was advanced by Cacioppo and Petty (1982). We measured need for cognition with the expectation that individuals high in need for cognition would have higher accuracy in nutrition judgments due in part to their more elaborate processing of information.

Demographic Questions. Participants answered a set of questions concerning their height, weight, age, gender, highest level of education, annual income, and employment. Information was also gathered concerning their eating habits, medical history, and use of NFP when making purchases. Participants also rated the importance of the various nutrients in the NFP both in general and in relation to their use in this study. Finally, they were asked qualitative questions concerning their participation in the study, and factors they believed would influence their choice of healthy vs. unhealthy foods. An area of particular interest was to assess the extent to which age, education, and general patterns of good habits (such as reading of NFP information) would relate to judgment accuracy.

Body Mass Index (BMI). BMI was calculated as the individuals' weight (kg) divided by height squared (m^2). The Center for Disease Control and Prevention's standard weight categories for men and women 20 and older are as follows: Below 18.5, Underweight; 18.5–24.9, Normal; 25.0–29.9, Overweight; 30.0 and above, Obese (Center for Disease Control, 2011). Higher scores indicate greater weight to height ratio. This information was collected via the self-report demographics questions on the survey.

3. Results

3.1. Analyses of self-reports in the survey

Out of the 196 participants, the vast majority (87.7%) reported using the NFP when evaluating the food items in the study. The frequency with which individuals reported using the NFP in this study varied according to the sample from which they were recruited ($\chi^2(1) = 17.85$, $p < 0.01$); a greater number of participants recruited from MTurk (96.2%) reported using the NFP for this study than university students (77.2%); this difference may stem from the fact that the majority of students have meal plans and hence shop for packaged foods with less frequency. The frequency with which individuals reported using the NFP did not differ according to food products ($\chi^2(1) = 3.03$, $p = 0.082$).

Additional questions about using the information on the food packages showed that 73% of participants reported reading the ingredients; 68.9% using the NFP, 62.2% reading the expiration data; 49.5% attending to health claims (e.g., 100% whole grains, low sodium, American Heart Association (AHA) approved); 34.7% looking at the picture/images on the package; 31.1% attending to organic labeling; 24.5% looking for instructions for consumption/use; 21.9% checking for local site of production; 18.4% attending to GMO (genetically modified organism) information; and 3.1% focusing on games/entertainment ($N = 196$). Chi-square analyses conducted to examine whether selection of food package information varied according to sample and condition found that a greater proportion of MTurk participants (78.8%) selected ingredients as information they read/look for on a food package compared to student participants (66%), ($\chi^2(1) = 3.892$, $p = 0.049$), again this self-report difference may stem from the less frequent purchasing of packaged foods by students who are on meal plans.

3.2. Lens model analysis

Fig. 2 is a graphical representation of the lens model as it pertains to this study.

As seen in Fig. 2, a lens type figure is created by linking proximal information—the cues—to both the judgments made by a person (Y) and a distal criterion in the environment (O). A measure of accuracy in lens model terminology is the correlation between Y and O, termed achievement (Stewart, Moninger, Grassia, Brady, & Merrem, 1989; Stewart & Lusk, 1994; Stewart, Roebber, & Bosart, 1997).[2] Greater accuracy is achieved by consistently using information that is predictive of the criterion. In terms of nutrition judgments, Fig. 2 shows that the cues, or predictor variables, are information in the label such as the nutrients present in the NFP. The figure also shows that the criterion O is the nutrition quality of the food as measured by NuVal® scores.[3]

A partitioning of the correlation between Y and O (the achievement) results in several indices which follow from Tucker (1964) (as cited by Stewart, 1988). The lens model equation takes the following form:

$$r_{YO} = R_{O.X} G\, R_{Y.X} + C\sqrt{1 - R^2_{O.X}}\,\sqrt{1 - R^2_{Y.X}} \qquad (2)$$

where:

$R_{O.X}$ is the correlation between O and $M_{O.X}$, a measure of environmental predictability. $R_{Y.X}$ is the correlation between Y and $M_{Y.X}$, a measure of judgment consistency when applying a judgment rule that uses the cues. Equation (2) demonstrates that the level of judgment accuracy as measured by r_{YO} (the achievement index) depends not only on the consistency of the judge but also on the predictability of the criterion in the given environment (Hammond, Stewart, Brehmer, & Steinmann, 1975; Stewart, 1988).

G is the matching index defined as the correlation between the models $M_{O.X}$ and $M_{Y.X}$. This estimates the accuracy that would be achieved if there were no errors in the system. Another way to understand *G* is that it provides a measure of the agreement in information usage between the models. Consumers with higher *G* would be considered more insightful about nutrition as their models coincide with the model of the NuVal criterion.

The procedure for deriving models for the environment (one model per product type) and for each judge (sample size equal to 196 individuals) considered key nutritional information in the package found in the NFP as independent variables. In consultation with an expert nutritionist from the Yale-Griffin Prevention Research Center, and the published nutrient list considered by the NuVal system (see Katz et al., 2010) a set of 12 nutrients were selected to be included in these models. Clearly food packages contain many more pieces of information (at least 20 pieces), but assumptions must be made with regards to an initial set of key information used by consumers. In particular, because participants were instructed to use the NFP in this study (see focal stimulus in Fig. 1), we restrict our analysis to nutritional information in the NFP only. However, even with this restriction the number of observations to predictors was less than ideal, and furthermore, some cues must correlate with each other as nutrients are not independently determined. Nevertheless, we echo Stewart (1988) about the goal of reaching a balance between statistical demands and psychological constraints. Thus, participants evaluated 40 cases, a number that is limited, but considered reasonable given time and cognitive constraints (see Cooksey, 1996, p. 123). We further overcome the statistical challenges for conducting multiple regression by using the criticality of predictors analysis proposed by Azen, Budescu, & Reiser (2001).

The method of Azen et al. (2001) consists of using the bootstrapping (resampling with replacement) procedure in which a large number of samples is obtained per set of observations and *p* predictors. For each sample, all $2^p - 1$ subset regression models are fitted and, using the multinomial distribution of the probability that each of the $2^p - 1$ subsets is the 'best model' for the data, a single parsimonious model is selected. The criticality of the predictors is determined based on the probability that many models include the predictor, and, in our application, the criticality was derived by considering the adjusted R^2 as the goodness of fit measure. For each participant, a set of 10,000 bootstrapped samples were created in order to derive each person's best model. The same

[2] We note that accuracy may be measured in various ways; for example as the average of square deviations of two variables (e.g., Murphy, 1988). In the present application, we do not expect an exact match between judgment and criterion, however. The relative agreement of the variables as measured by the correlation of Y and O (i.e., the achievement index) is an appropriate accuracy measure in the current context. We thank Dr. T. Stewart for further clarification on this point.

[3] For ease of presentation we refer to NuVal® as simply NuVal in what follows.

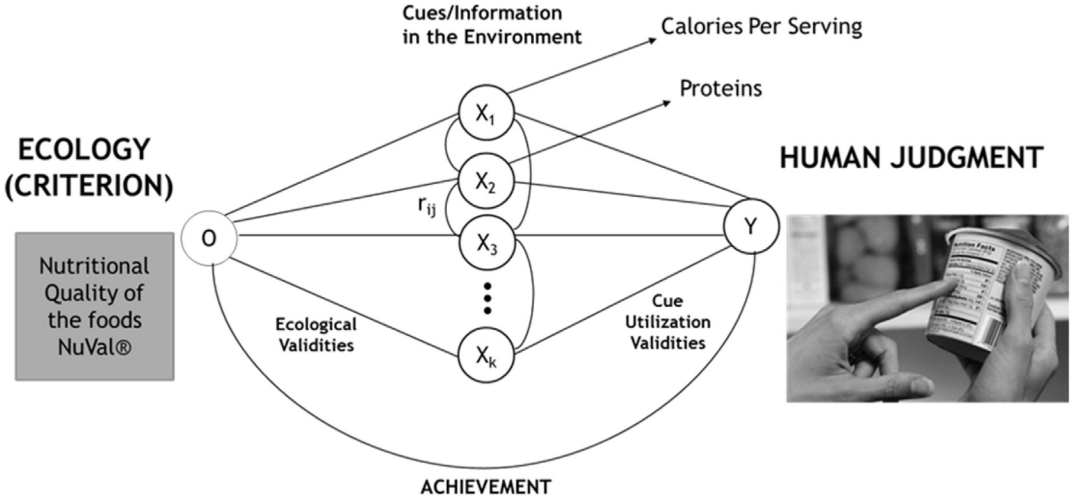

Fig. 2. Lens model representation of the classic-double system design as it applies to the current study (adapted from Cooksey, 1996. p. 61).

Table 1a
Pearson correlations and descriptive statistics of cereal nutritional variables and NuVal.

	NuVal score	Calories	Total fat (g)	Saturated fat (g)	Polyunsaturated fat (g)	Monounsaturated fat (g)	Sodium (mg)	Potassium (mg)	Carbs (g)	Dietary fiber (g)	Sugar (g)	Protein (g)	# of included vitamins and minerals
	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13
x1	.												
x2	0.05	.											
x3	0.22	0.23	.										
x4	0.04	−0.07	0.53*	.									
x5	0.35*	0.18	0.88*	0.46*	.								
x6	−0.02	0.21	0.79*	0.34*	0.58*	.							
x7	−0.69*	0.05	−0.15	−0.13	−0.21	0.02	.						
x8	0.14	0.64*	0.31*	−0.13	0.34*	0.20	0.03	.					
x9	−0.01	0.92*	−0.05	−0.19	−0.11	−0.01	0.04	0.53*	.				
x10	0.29	0.70*	0.26	−0.08	0.20	0.17	−0.23	0.77*	0.70*	.			
x11	−0.60*	0.41*	0.05	0.13	−0.03	0.09	0.51*	0.34*	0.43*	0.18	.		
x12	0.27	0.57*	0.27	−0.14	0.29	0.22	−0.18	0.70*	0.39*	0.69*	−0.07	.	
x13	−0.27	−0.17	−0.00	0.10	−0.10	0.09	0.40*	−0.12	−0.12	−0.26	0.24	−0.34*	.
Mean	33.2	134.45	1.41	0.09	0.45	0.33	139.07	116.87	29.04	3.60	8.42	3.67	7.03
Median	27.00	120.00	1.0	0.00	0.50	0.00	153.84	70.00	25.00	3.00	9.00	2.50	8.00
S.D.	19.6	36.69	1.18	0.22	0.70	0.51	75.12	114.01	9.15	2.75	4.54	2.88	3.24

*$p \leq 0.05$, two-tailed.

was done when predicting the environment.[4] See Azen et al. for further details of this method.[5]

Analysis of the Environment. The left side of Fig. 2 shows the relationships between each cue (nutrient) and the environmental criterion (NuVal scores) as well as the relationships among the cues. Tables 1a and 1b shows correlations among the nutrients and with NuVal within a food product. Descriptive statistics for each variable appear at the bottom of the tables.

As seen in Table 1a, the expert system NuVal relates positively with polyunsaturated fat and negatively with sodium and sugar in the sample of cereals. Several bivariate significant correlations are observed among the nutrients in particular with calories, which is expected. Calories correlate positively with total carbohydrates, dietary fiber, sugar, and protein. Calories amount is also positively related to potassium. Types of fat correlate with each other and total fat correlates with potassium. Components of carbohydrates correlate with each other (carbohydrates correlate with dietary fiber and sugar), they also positively correlate with protein. Protein correlates positively with calories, potassium, total carbohydrates and dietary fiber, but negatively with the total number of vitamins and minerals. Thus, the patterns of relationships observed within this sample of cereals is rather complex given that some desirable nutrients, such as potassium, relate to undesirable nutrients, namely sugar. In the same vein, the fact that cereals high in vitamins and minerals also tend to be high in sodium is problematic for a consumer's attempting to increase good nutrients and decrease less desirable ones.

Table 1b shows the results for the snacks. Correlations show the expected pattern with regards to calories and fat (total, saturated, and monounsaturated). Potassium was also found to be positively correlated with calories. However, calories show negative relationships with total carbohydrates, and protein. This is in part explained by the negative relationships observed between total carbohydrates and total and saturated fats; the same occurs with protein. In other words, the negative associations between fats and both carbohydrates and protein (which usually are expected to

[4] We note that the procedure generates a total of 4095 models, hence, 10,000 observations are a reasonable number to produce a proper multinomial distribution.

[5] The procedure was done in SAS. The syntax is lengthy and found in the supplemental materials.

Table 1b
Pearson correlations and descriptive statistics of snack nutritional variables and NuVal.

	NuVal score	Calories	Total fat (g)	Saturated fat (g)	Polyunsaturated fat (g)	Monounsaturated fat (g)	Sodium (mg)	Potassium (mg)	Carbs (g)	Dietary fiber (g)	Sugar (g)	Protein (g)	# of included vitamins and minerals
	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13
x1	.												
x2	−0.25	.											
x3	−0.31	0.97*	.										
x4	−0.49*	0.70*	0.74*	.									
x5	−0.34*	0.30	0.25	0.55*	.								
x6	−0.01	0.31*	0.21	0.15	0.68*	.							
x7	−0.43*	−0.35*	−0.31	−0.19	−0.24	−0.30	.						
x8	−0.02	0.36*	0.26	−0.02	0.17	0.56*	−0.17	.					
x9	0.35*	−0.87*	−0.94*	−0.64*	−0.10	−0.11	0.19	−0.20	.				
x10	0.61*	−0.25	−0.28	−0.25	−0.05	0.23	−0.35*	−0.11	0.26	.			
x11	0.17	−0.03	−0.13	−0.04	0.03	0.29	0.05	0.26	0.14	0.20	.		
x12	0.33*	−0.41*	−0.45*	−0.55*	−0.27	−0.01	−0.10	0.13	0.40*	0.13	0.07	.	
x13	0.46*	0.21	0.12	−0.19	−0.26	0.18	−0.18	0.37*	−0.07	0.32*	0.25	0.21	.
Mean	14.43	143.5	7.64	1.26	0.85	0.84	206.38	46.38	16.90	1.23	0.98	1.88	3.05
Median	14.00	150.0	9.00	1.50	0	0.00	205.00	0.00	16.00	1.00	1.00	2.00	3.00
S.D.	7.96	15.78	2.93	0.65	1.45	1.54	91.01	113.79	2.93	0.530	0.77	0.40	1.88

*$p \leq 0.05$, two-tailed.

Table 2
NuVal beta-weights and R^2 values within product category.

Variable	Cereal NuVal		Snack NuVal	
	Beta	95% CI	Beta	95% CI
Calories	0.72	−0.53, 1.96	−0.72	−1.91, 0.47
Dietary Fiber	0.45	−0.03, 0.93	0.39	0.16, 0.62
Monounsaturated Fat				
Polyunsaturated Fat	0.41	−0.05, 0.88	−0.31	−0.57, −0.05
Saturated Fat	−0.46	−0.85, −0.08		
Potassium				
Protein	−0.32	−0.76, 0.12		
Sodium	−0.37	−0.63, −0.10	−0.34	−0.59, −0.09
Sugars	−0.52	−0.80, −0.24	0.16	−0.06, 0.39
Total fat	−0.40	−0.88, 0.08	1.88	−0.03, 3.80
Total carbohydrates	−0.59	−1.87, 0.68	1.11	0.29, 1.93
# of Included Vitamins and Minerals				
R^2	0.71	0.74		
R^2 Adj.	0.63	0.67		

increase total calories) results in a net positive relationship between calories and fats only, and a negative relationship between calories and carbohydrates and protein. Other notable relationships are sodium and dietary fiber (significantly and negatively related); potassium and number of vitamins and minerals (significantly and positively related). Overall, the pattern of relationships appears also quite complex from a consumer's perspective of trying to maximize intake of good nutrients and minimize less desirable ones.

The lens model analysis to predict the environmental criterion, NuVal scores, was carried out with the Azen et al. (2001) criticality procedure as earlier discussed. The best reduced model for the environment containing a subset of the most critical nutrients (the $M_{O.X}$ in Equation (1)) appears in Table 2 with standardized coefficients for the nutrients included in the model along with 95% confidence intervals. We note that the nutrients included in the reduced model are *in combination* the best critical subset that predicts the observations. Because of the large sampling bootstrapping procedure and the non-parametric approach for their selection, their beta coefficients are considered reliable.

As seen in the table, the models show high level of environment predictability with $R^2_{O.X}$ equal to 0.71 for cereals, and equal to 0.74 for snacks (with adjusted values slightly lower). The food environments show slight different patterns of cue weights and this is expected because of the differential composition of the food products. In both products, dietary fiber is positively related with NuVal values whereas sodium is negatively related.

Analysis of the Judgments: Nutrient Use Consistency. The right hand side of Fig. 2 shows that an individual uses information in the environment (nutrients in the NFP) to make evaluations of each product. Participants gave three nutrition judgments per food and these responses were highly correlated with each other (median correlation equal to 0.85); thus they were combined into a composite (average) score to serve as dependent variable. As done with the environmental side, the Azen et al. (2001) procedure derived best models for each individual. Because the procedure reveals the best subset of cues (or independent variables) that are critical in predicting the dependent variable, each participant ended up with a different subset of predictors defining his/her model. In order to evaluate which nutrients were more commonly critical, and hence important, Tables 3a and 3b presents a column with the % of times that a nutrient was included in the final model in addition to median 95% confidence intervals. Proportions that were significantly greater than 50% by sign test are shown with an asterisk for ease of presentation. The median R^2 for predicting the judgments from the nutrients was equal to 0.49 across the samples. Tables 3a and 3b present summaries of the person models' results.

For the cereals, MTurk participants' R^2s ranged from 0.05 to 0.83 with $Mdn = 0.54$; the students' R^2s ranged from 0.19 to 0.78 with

Table 3a
Cereal participant judgments' beta-weight descriptive statistics and R^2.

Variable	MTurk cereal ($N = 51$)					Students cereal ($N = 48$)				
	% Models include nutrient	Mean	Median	Median standard error	Median 95% CI	% Models include nutrient	Mean	Median	Median standard error	Median 95% CI
Calories	78.43*	0.05	0.12	0.59	−1.25, 1.12	60.42	0.25	0.46	0.59	−0.82, 1.65
Dietary Fiber	54.90	−0.14	−0.26	0.34	−0.94, 0.42	58.33	−0.10	−0.22	0.25	−0.69, 0.40
Monounsaturated Fat	64.71*	−0.16	−0.29	0.20	−0.64, 0.13	47.92	−0.13	−0.22	0.21	−0.62, 0.18
Polyunsaturated Fat	49.02	−0.14	−0.23	0.31	−0.77, 0.37	58.33	−0.27	−0.33	0.28	−0.90, 0.20
Saturated Fat	50.98	−0.11	−0.14	0.15	−0.48, 0.13	64.58*	−0.07	−0.13	0.16	−0.40, 0.19
Potassium	62.75*	0.37	0.39	0.25	−0.11, 0.93	58.33	0.38	0.35	0.24	−0.02, 0.82
Protein	68.63*	0.25	0.27	0.25	−0.24, 0.75	60.42	0.19	0.31	0.22	−0.12, 0.69
Sodium	60.78	0.15	0.19	0.18	−0.19, 0.57	47.92	0.09	0.18	0.15	−0.14, 0.48
Sugars	84.31*	−0.36	−0.31	0.16	−0.69, −0.01	77.08*	−0.40	−0.44	0.16	−0.76, −0.11
Total Fat	72.55*	0.30	0.49	0.33	−0.29, 1.09	62.50*	0.28	0.30	0.34	−0.27, 0.98
Total Carbohydrates	64.71*	0.22	0.39	0.68	−1.16, 1.93	68.75*	−0.13	−0.13	0.57	−1.15, 0.68
# of Included Vitamins and Minerals	70.59*	−0.06	−0.15	0.14	−0.44, 0.16	77.08*	−0.24	−0.31	0.13	−0.57, −0.03
R^2		0.52	0.54				0.54	0.56		
R^2 Adj.		0.40	0.40				0.42	0.43		

* Proportion significantly greater than 50% by sign test, $\alpha = .05$.

Mdn = 0.56. For the snacks, MTurk participants' R^2s ranged from 0.13 to 0.87, with *Mdn* = 0.55; students' R^2s ranged from 0.11 to 0.55 with *Mdn* = 0.28. Thus, the level of consistency observed is variable with some individuals not using the nutrient information very much at all. Furthermore, the level of observed consistency is low when compared to that observed in other domains, for example, the level found in physicians' judgments of acute otitis media (González-Vallejo, Stewart, Sorum, Chessare, & Mumpower, 1998; see also; Karelaia & Hogarth, 2008). In terms of key nutrients included in person models, the domain of cereals tended to include calories, protein, sugar, total fat, total carbohydrates, and number of vitamins and minerals. Person models also included potassium and saturated fat, which were of less importance in the environment model. In addition, dietary fiber, which was an important nutrient in the environment model was less frequently predictive of people's nutrition judgments. Thus we observe discrepancies between nutrients that predict food nutrition of an expert system, and nutrients that predict subjective judgments of food nutrition.

Snacks showed a more variable pattern of nutrient inclusion in the two samples; a great majority of Mturk models included the nutrients of sodium, sugar, total fat, and total carbohydrates, which were in agreement with the environment model. We note that the sign of the median beta weights in the person models, however, were not always in agreement with those of the environmental model found in Table 2; this is likely due to the natural collinearity that is inherent in the nutrient composition of foods, thus, they must be interpreted with caution.

Median R^2s were further analyzed to determine whether consistency in cue usage varied as a function of food product. A test of the median indicated that student participants in the cereal condition (*Mdn* = 0.56) had higher consistency than those in the snack condition (*Mdn* = 0.28), $p < 0.001$; MTurk participants, in contrast, showed no differences in consistency as a function of food product $p > 0.05$.

Judgment Accuracy: The agreement between the judgments and NuVal was assessed with the achievement index, r_{YO} in Equation (2) (Stewart, 1988). The achievement index was computed for each individual judge and it ranged from −0.41 to 0.79; 44.4% of these correlations were statistically significant at the 0.05 level, and only one of these correlations was negatively related to the NuVal. Table 4 shows median values per sample and food product; in general, achievement is low and lower than results observed in environments of similar predictability (for example, see Cooksey, Freebody, & Davidson, 1986).

A test of median accuracy indicated that there was no difference in participants' judgment agreement with the NuVal between samples $p > 0.05$. There were differences across food products, with a median test indicating that participants rating cereals (*Mdn* = 0.25) had lower accuracy than participants rating snacks (*Mdn* = 0.33), $p = 0.016$. An additional median test comparing accuracy according to product domain, while controlling for sample, indicated that there was no difference between snack accuracy and cereal accuracy among student participants ($p > 0.05$), but median accuracy did significantly vary according to product domain for the MTurk sample, $p = 0.007$.

Agreement of Expert and Consumers' Models. The analyses thus far show that there is a rather low agreement between the best models that predict consumers' judgments and the best models predicting the NuVal scores with regards to key nutrients.

In order to more formally assess the cue pattern agreement between expert and consumers' models, the lens model matching index *G* was obtained for each individual. As discussed by Cooksey (1996), *G* measures the extent to which the criterion (NuVal) values and judgments would agree if both models were perfect. Another conceptualization of *G* is the agreement between the weights given to the cues (nutrients) and the function forms of both environmental and judgment models. This is a measure of the level of knowledge that the judge has of the environmental relationships (i.e., of cues and outcomes). Median *G* values appear in Table 4.

A median test of *G* according to product domain indicated that these differences were significant, $p = 0.036$, demonstrating that there was a higher agreement in the domain of snacks (across sample *Mdn* = 0.47) than cereals (across sample *Mdn* = 0.40). An additional median test comparing *G* according to product domain, while controlling for sample, indicated that there was no difference between snack *G* and cereal *G* among the student participants ($p > 0.05$), but median *G* did significantly vary according to product domain for the MTurk sample, $p = 0.007$. Thus, generally, there was greater cue pattern agreement between the lay people judgments' policy and those of the experts in the domain of snacks, and this was more evident for the MTurk participants. The level of agreement may be considered moderate to low, however, in comparison to results in other judgment domains (Karelaia &

Table 3b
Snack participant judgments' beta-weight descriptive statistics and R^2.

Variable	MTurk snack (N = 53)					Students snack (N = 44)				
	% Models include nutrient	Mean	Median	Median standard error	Median 95% CI	% Models include nutrient	Mean	Median	Median standard error	Median 95% CI
Calories	58.49	0.46	0.81	0.57	−0.50, 2.03	34.09	−0.45	−0.67	0.80	−2.55, 1.09
Dietary Fiber	64.15*	0.27	0.29	0.15	0.02, 0.61	59.09	0.24	0.34	0.19	−0.06, 0.71
Monounsaturated Fat	41.51	−0.06	−0.15	0.21	−0.54, 0.44	59.09	−0.14	−0.16	0.31	−0.81, 0.48
Polyunsaturated Fat	47.17	0.03	−0.16	0.20	−0.50, 0.34	63.64*	−0.02	0.00	0.32	−0.74, 0.80
Saturated Fat	47.17	−0.24	−0.34	0.20	−0.71, 0.03	52.27	0.33	0.37	0.32	−0.14, 1.05
Potassium	39.62	0.04	0.19	0.16	−0.12, 0.47	54.55	0.14	0.24	0.21	−0.18, 0.63
Protein	43.40	0.12	0.18	0.14	−0.10, 0.49	52.27	0.18	0.23	0.18	−0.13, 0.57
Sodium	62.26*	−0.13	−0.21	0.14	−0.49, 0.08	47.73	−0.01	0.09	0.19	−0.34, 0.47
Sugars	66.04*	−0.08	−0.10	0.13	−0.36, 0.15	54.55	−0.05	−0.07	0.16	−0.47, 0.35
Total Fat	64.15*	−0.84	−1.20	0.62	−2.22, −0.09	54.55	0.07	0.06	0.69	−1.47, 2.09
Total Carbohydrates	54.72	0.10	0.32	0.40	−0.57, 0.77	59.09	0.42	0.60	0.52	−0.24, 1.31
# of Included Vitamins and Minerals	62.26*	−0.07	−0.08	0.15	−0.39, 0.17	54.55	0.19	0.24	0.19	−0.17, 0.62
R^2		0.55	0.55				0.30	0.28		
R^2 Adj.		0.46	0.46				0.16	0.16		

* Proportion significantly greater than 50% by sign test, $\alpha = .05$.

Table 4
Medians of participants' achievement and matching index.

Sample & product group	r_{YO}	G
MTurk Cereal (N = 51)	0.17	0.38
Students Cereal (N = 48)	0.26	0.42
MTurk Snack (N = 53)	0.30	0.50
Students Snack (N = 44)	0.33	0.43

Hogarth, 2008).

Predicting Judgment Consistency, Judgment Accuracy, and the Matching Index G from Person Level Factors. We conducted multiple regression analysis predicting the lens model indices from key person characteristics. We first transformed the correlations using the Fisher's z transformation.[6] These transformed values served as the dependent variables in the analyses using all of the sample participants (n = 196). First, because we had a large number of individual factors we eliminated variables that had very low correlations (<0.1) with the dependent variables; however, because of theoretical interest we kept gender, age, education, and annual income.

The linear regression model for predicting judgment consistency, $R_{Y.X}$, for the entire sample of 196 participants had the following independent variables: gender, race, age, education, annual income, employment status, Body Mass Index, CHB average score, CHB eating subscale, CHB stress subscale, CHB weight-regulation subscale, HBCL traffic subscale, health issues that affect food choices, current dieting behavior, NFP use during study, and food product rated. The model was significant ($F(16, 177) = 3.53$, $p < 0.001$, $R^2 = 0.24$). Education, had a positive relationship ($\beta = 0.37$) with consistency, indicating that those with higher education had higher consistency ($p < 0.001$). CHB eating subscale was negatively related to cue usage consistency ($\beta = -0.26$) indicating that higher compensatory health beliefs regarding eating was associated with lower consistency ($p = 0.026$). Condition ($\beta = -0.23$) was also negatively related to consistency, indicating that participants rating cereals had greater consistency than those in the snack condition ($p = 0.001$). Having health issues that affect food choices ($\beta = -0.13$) had a marginal negative relationship with consistency, indicating that participants reporting having a health issue that affected their food choices were less consistent than those reporting no such health issue ($p = 0.055$). No other variables in the model had significant coefficients.

In terms of predicting judgment accuracy, r_{YO}, the model included gender, age, education, annual income, snacking behavior, regular meal habits, NFP use during the study, and product type. The model was significant ($F(8, 186) = 2.40$, $p = 0.017$, $R^2 = 0.094$). NFP use during the study ($\beta = 0.15$) had a marginally significant coefficient, $p = 0.055$, as did product type rated ($\beta = 0.14$), $p = 0.054$, indicating that participants who reported higher rates of NFP use during the study, and those rating snacks (as opposed to cereals), had more accurate judgment ratings.

The linear regression model for predicting the matching index G had the following independent variables: gender, race, age, education, annual income, snacking behavior, regular meal habits, Body Mass Index, frequency of NFP use, NFP use during study, and food product rated. The model was significant ($F(11, 182) = 3.35$, $p < 0.001$, $R^2 = 0.17$). Race ($\beta = -0.17$) was negatively related to G, indicating that nonwhite participants' models' predictions had less agreement with the NuVal model's predictions than those of white participants ($p = 0.022$). Regular meal habits ($\beta = 0.17$) was positively related to G, indicating that participants who reported having regular meals had models that were in greater agreement with the expert's model ($p = 0.035$). Food product rated was also positively related to G ($\beta = 0.15$), indicating that those who rated snacks had higher G than those who rated cereals, ($p = 0.036$). No other variables had significant coefficients.

Choice Prediction. The questionnaire asked participants not only to judge the product in terms of nutrition level, but also whether they would place in their cart as if they were hypothetically shopping (assuming price was not a factor). Using the computed nutrition judgment variable—along with products' ratings of familiarity, liking, and frequency of consumption—logistic regression models were carried out for each participant to predict their choices. Regression models could not be computed for 13 of the participants as they did not add any of the items to their cart.

Out of the 183 participants who chose to add a product to their cart, 168 (85.7%) participants' models were significant with all of the independent variables conjointly predicting the choices

6 This is done in order to satisfy assumptions of the linear model analysis.

($p < 0.05$). The median values of the unstandardized coefficients were: $Mdn = 0.14$, for nutrition judgment; $Mdn = -0.016$ for familiarity with the product; $Mdn = 0.15$, for liking of the product; and $Mdn = 11.56$ for Frequency of Consumption. That is, higher nutritional assessments, liking, and frequency of consumption related to greater number of product selections.

Participant's choice to add an item to their cart was also correlated with the NuVal scores (point-biserial correlation) in order to assess the level of healthy choices. Out of the 183 participants who added at least one item to their cart, only 3 had significant positive correlations (p's < 0.05) between choice and NuVal, and these were no longer significant after using the Bonferroni adjustment to control for Type I error given the number of tests. Across products and samples the correlation between choice and NuVal ranged from -0.67 to 0.36, with a median of -0.032. Thus, although individuals' nutritional ratings, familiarity, frequency of consumption, and liking of the products related to their choice, ultimately the choices made were not healthy ones.

4. General discussion

The dietary consumption patterns of Americans have changed since the introduction of the NFP in 1993, but these changes have not supported healthier eating, instead consumption of unhealthy products remains high and rates of obesity and other chronic diseases are on the rise (Food & Drug Administration, 2015). We sought to investigate the direct link between the information present on packaged foods and judgments of nutrition based on the NFP. Using the methodology and theoretical underpinnings of Social Judgment Theory (Cooksey, 1996; Hammond, 1955; Stewart, 1988), we analyzed the judgment process of participants when evaluating the nutrition value of cereals and snacks. The Brunswik's lens model provides a theoretical framework and analytical tools for understanding the task characteristics of the decision making environment, and the information usage by judges in that environment. The key insight of Brunswik's model lies in recognizing that the person's judgment and the criterion being predicted can be thought of as two separate functions of the information (cues) available in the environment of the decision. The accuracy of judgment depends on how predictable the criterion is on the basis of the cues and the degree to which the function describing the person's judgment matches its environmental counterpart. The approach has been used in many fields, such as: collision detection judgments (Bisantz & Pritchett, 2003), judgments of spelling difficulty (Cooksey, Freebody, & Bennett, 1990), college graduate admissions judgments (Dawes, 1971), predicting violence among inmates (Cooper & Werner, 1990), employment interviews (Dougherty, Ebert, & Callender, 1986), physicians' diagnostic judgments (González-Vallejo et al., 1998), hail forecasting (Stewart et al., 1989), and others. In general, the psychological literature supports that the covert judgment process is more properly examined ideographically with the methodology of linear statistical modeling rather than based on self-report, which can include errors due to cognitive limitations and biases (Ericsson & Simon, 1993; Nisbett & Wilson, 1977).

In terms of the nutrition environment investigated, we narrowed the inquiry to two food categories that are highly consumed in the U.S., cold breakfast cereals and snacks. Using a validated measure of nutrition quality, NuVal, as the criterion, the study advanced analyses of the patterns of nutrients in the food categories of cereals and snacks that related to NuVal. The analysis of the food environments showed, not surprisingly, that the NFP information was highly predictive of the expert nutrition quality score.

Regarding the judgment process, individual level analyses were conducted in order to identify the information individuals use when making their evaluations. We remind the reader that the task presented participants with ideal conditions for using the NFP as the label was highly prominent and visible at the moment of making the judgments. Results showed that the judgments of nutrition were predicted from the nutrients in the NFP, but the level of prediction across participants was low with a median equal to forty-nine percent of the variance in judgments explained by the nutrients. Judgment consistency was slightly higher when judging cereals than when judging snacks; key nutrients included in individuals' models when judging cereals were calories, protein, sugar, total fat, total carbohydrates, and number of vitamins and minerals. Person models also included potassium and saturated fat, which were of less importance in the environment model. In addition, dietary fiber and sodium, which were important nutrients in the environment model were less frequently predictive of people's judgments. Snacks showed a more variable pattern of nutrient inclusion in the two samples; a great majority of MTurk models included the nutrients of sodium, sugar, total fat, and total carbohydrates, which were in agreement with their inclusion in the environment model.

In combination, these results demonstrate that although judgments of nutrition of foods can be generally predicted from the information in the NFP, the agreement of the expert system and lay judgment was moderate. Looking into judgment accuracy by directly comparing each person's evaluation of nutrition with the expert system NuVal scores, we found that participants' judgment accuracy was fairly variable. At the group level, the median values of the achievement index were higher for snacks than cereals, but overall these were of low to moderate size (highest median achievement was equal to a correlation of 0.33). Finally, the level of agreement between the judgment and environment models, as measured by the G index, showed moderate agreement as well, with the snack category having higher median values.

The finding that cue usage consistency in judgments varied according to product domain is in line with previous speculation that consumers interact with nutrient information differently based on the type of food (Balasubramanian & Cole, 2002). It is possible that when selecting snacks, individuals do not usually focus on nutrition (i.e., they eat for fun or taste) and hence are less likely to extract and use NFP information; on the other hand, cereals are a main breakfast item with important nutritional value. Hence, higher consistency in the cereal than in the snack domain may be in part due to differences in accessing and using information. However, further research is needed to support this conclusion as slightly higher accuracy was observed for snacks on the other hand. In addition, the level of consistency in using NFP information was predicted by the educational level (a positive relationship), and by the CHB eating subscale, which indicated that higher compensatory health beliefs regarding eating was associated with lower consistency. Past research has shown that individuals who score high on the compensatory health beliefs tend to show poorer health outcomes in several domains. For example, increased endorsement of CHBs have been found to be associated with higher body mass index (BMI), increased risky-health and weight-regulating behaviors (e.g., dieting), and decreased health-related self-efficacy (Knäuper et al., 2004). The current result adds to the list of negative characteristics related to holding high CHBs.

In terms of individual level factors predictive of judgment accuracy, we expected that higher levels of education, endorsement of good health habits, and higher levels of need for cognition were likely candidates to positively relate to judgment accuracy. Additionally, we expected a gender effect. A gender effect was found by Nayga (1996) who showed that males were less likely to self-report evaluating nutritional information from nutrition labels, and women had more positive attitude towards nutrition in general. Rasberry, Chaney, Housman, Misra, and Miller (2007) also found that female college students were more likely to evaluate nutrition information and they tended to be more knowledgeable. More, recently, Drichoutis, Lazaridis, and Nayga (2006) support a gender effect in label use based on a review of the literature. This study did not find a gender effect in isolation; instead, the results showed several demographic characteristics that were predictive of accuracy, including but not limited to gender, education, income, and higher frequency of using the NFP in the study. Finally, in terms of the match between best models of the lay judgments and of the expert system, the study found that the *G* index was higher for individuals reporting having regular meals and those self-identifying as white.

Drichoutis et al. (2006) concluded that nutrition labels are useful, but the study identified discrepant findings with regards to choice. Our study showed that food selections were predicted from the judged nutrition, familiarity, frequency of consumption, and liking of the products. Interestingly, the absence of a relationship between choice and NuVal indicated that consumers' choices, although predicted from their assessments of nutritional quality, did not result in healthier food choices.

The health problems associated with obesity are well documented and have received attention from researchers in various fields (e.g., Huckfeldt, Lakdawalla, & Philipson, 2011; Mechanick, Garber, Handelsman, & Garvey, 2012; Ng, Zaghloul, Ali, Harrison, & Popkin, 2011; Sallis, Story, & Lou, 2009). Since obesity presents economic problems, government intervention in the form of labeling legislation attempts to promote and influence individual consumption that supports health (Golan, Kuchler, Mitchell, Greene, & Jessup, 2001); however, the utility of such legislation is still under debate. The assessment of the value of nutrition labeling is a complex problem and there is a lack of studies that directly measure the use of nutritional information—other than via self-report—and the corresponding effects in consumption over time (Drichoutis et al., 2006). Our study exemplifies the dilemma of relying on self-report of NFP usage. As shown in our results, a very large percentage of the adults and student participants reported using the NFP regularly when selecting food products, and in particular in the current study. In spite of this high level of endorsement of NFP usage, their judgments of nutrition were only moderately related to the information found in the NFP, and importantly, their accuracy in judging nutrition was low even when the conditions for judgment were ideal in the sense that the NFP information was focal. In terms of decisions, the main factors predicting participants' choices, assuming constant cost, were assessments of nutrition, familiarity, consumption habits, and liking of the products, but these did not relate to healthier choices.

As described by Drichoutis et al. (2006), even though many people report that they would want to use a lot of information if available, research supports simpler formats for increased understanding. The NFP is a complex label, and FDA proposals for a simplified format were not found to produce more accurate judgments in a recent study (González-Vallejo & Lavins, 2015). Greater efforts are needed to more directly study information usage with well-developed methodologies such as the lens model, and importantly, we echo Drichoutis et al. conclusion for the need for large-scale studies that assess the value of nutrition labels on actual purchase and consumption behavior over time.

5. Conclusions and limitations

Lens model methodology is a useful tool for understanding how individuals perceive the nutrition in foods based on the NFP label. Judgment accuracy was low, highlighting that the benefits of the complex NFP label may be more modest than what has been assumed from past research. Food choices, although predicted from the subjective evaluations of nutrition, did not generally lean towards choosing healthier products. This finding presents further challenges to understanding how nutritional information impacts food selections and ultimately consumption.

Limitations of the approach must be noted. The derivation of judgment and environment models depends on the use of ecologically valid conditions for judgment. The current study used semi-random selections of food products that ranged in nutritional quality and are found in the market. In addition, the NFP information was exactly what appears on the actual products; thus, the situation may be considered high in ecological representation. However, the amount of information present in this ecology is very large and individuals can only evaluate a subset of products without taxing their cognitive systems; this presents the problem of deriving models from fewer observations than desirable relative to the number of predictors in the environment. Furthermore, the nutrients naturally correlate, leading to possible ambiguities when interpreting the sign of the standardized coefficients derived from multiple regression, and function forms may be other than linear. In spite of these shortcomings, we believe that this study advanced novel solutions. With the aid of both knowledge from a nutrition expert, and an experimental design that focused on NFP information only, we narrowed the possible nutrients to be considered for analysis. Furthermore, the study applied a novel statistical technique for deriving best models from a restricted set of observations. Using the Azen et al. (2001) bootstrapping procedure and the criticality metric, best reduced models were obtained from large samples (10,000 per individual) allowing for meaningful assessments of lens model statistics. In combination, the work revealed new ways of assessing the understanding of nutrition from the NFP label that go beyond self-report.

Acknowledgments

The authors would like to thank the Diabetes Institute at Ohio University for support to this research via The Student Research Award, and NuVal® for providing the nutritional ratings for the food items used in this study. In addition the authors thank Mrs. Lauren Rhee MS, RD, LDN, from the Yale-Griffin Prevention Research Center and Dr. Thomas R. Stewart for helpful contributions to the model definitions and data analyses. We also thank Ms. Lina Himawan for assistance with the SAS coding and statistical analyses.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.appet.2016.05.014.

Appendix

Cereals used in the study

Name
Kellogg's Special K Original Lightly Toasted Rice Cereal
Posy Fruity Pebbles Sweetened Rice Cereal
Nature's Path Envirokidz Organic Gorilla Munch Cereal Gluten Free
Post Original Shredded Wheat Biscuits Made From 100% Natural Whole Grain Wheat
Kellogg's Unfrosted Bite Size Mini-Wheats Unfrosted Whole Grain Wheat Cereal. No Added Sugar.
Nature's Path Organic Corn Puffs Cereal No Additives Or Preservatives Fat Free Sugar Free Sodium Free 100% Whole Grain Goodness Organic Corn Puffs Usda Organic This Product Is Third-Party Certified Organic By Quality Assurance International (Qai)
Nature's Path 3 Generations Organic Qia Superfood Chia, Buckwheat & Hemp Cereal Apple Cinnamon Excellent Source Of Ala Omega-3 Certified Gluten-Free Usda Organic This Product Is Third-Party Certified Organic By Quality Assurance International (Qai)
Kashi Go Lean Protein & High Fiber Cereal Crunchy Fiber Twigs, Soy Protein Grahams And Honey Puffs
General Mills Cheerios Toasted Whole Grain Oat Cereal
General Mills Kix Crispy Corn Puffs With Whole Grain
General Mills Total Raisin Bran Crunchy Whole Grain Wheat & Bran Flakes With Plump, Juicy Raisins 160 Calories Per Serving 100% Daily Value Of 11 Vitamins & Minerals
General Mills Berry Berry Kix Lightly Sweetened Corn Cereal With Whole Grain Guaranteed Made With All Natural Corn
General Mills Cheerios Honey Nut Sweetened Whole Grain Oat Cereal With Real Honey And Natural Almond Flavor
General Mills Golden Grahams Cereal With Whole Grain
General Mills Cocoa Puffs Combos Chocolate & Vanilla Naturally And Artificially Flavored With Whole Grain
General Mills Cookie Crisp The Great Taste Of Chocolate Chip Cookies & Milk Whit Whole Grain Guaranteed
General Mills Lucky Charms Frosted Toasted Oat Cereal With Marshmallows New Swirled Marshmallow Charms With Whole Grain Guaranteed
General Mills Count Chocula Cereal Chocolatey Cereal With Spooky-Fun Marshmallows With Whole Grain
General Mills Frosted Corn Flakes Sweetened Flakes Of Corn With 11 Vitamins And Minerals
Kellogg's Special K Low Fat Granola Touch Of Honey 50% Less Fat Than Leading Granola
Kellogg's Krave Good Source Of Fiber & Made With Whole Grain Made With Real Chocolate! Double Chocolate Crispy Multi-Grain Cereal Outside, Smooth Chocolate Inside Cereal With Chocolate Flavored Center
Kellogg's Frosted Mini-Wheats Bite Size Lightly Sweetened Whole Grain Wheat Cereal Excellent Source Of Fiber
General Mills Cinnamon Toast Crunch Real Cinnamon & Sugar In Every Bite Crispy, Sweetened Whole Wheat And Rice Cereal
Kellogg's Special K Protein Plus Lightly Sweetened Wheat, Soy & Rice Flakes
Kellogg's Raisin Bran Two Scoops! Delicious Raisins Perfectly Balanced With Crisp, Toasted Bran Flakes Cereal Excellent Source Of Fiber & Made With Whole Grain
Kellogg's Corn Pops Cereal
Kellogg's The Original & Best Corn Flakes
Kellogg's Froot Loops Sweetened Multi-Grain Cereal Natural Fruit Flavors Now Provides Fiber
Kellogg's Apple Jacks Reduced Sugar
Kashi Good Friends High Fiber Cereal Trio Of Flakes, Twigs & Granola
Kashi 7 Whole Grain Honey Puffs 23 g Whole Grains
Kashi Golean Crisp! Naturally Sweetened Multigrain Cluster Cereal Toasted Berry Crumble With Cranberries & Wild Blueberries No High Fructose Corn Syrup
Kashi Go Lean Crunch! Protein & High Fiber Cereal Naturally Sweetened Multigrain Clusters
Post Raisin & Almond Trial Mix Crunch Cereal Lightly Crunchy Nuggets, Granola, Raisins, Almonds And A Touch Of Honey
Post Honey Bunches Of Oats Cereal Honey Roasted Crispy Flakes, Crunchy Oat Clusters & A Touch Of Honey!
Cascadian Farms Organic Honey Nut O's Organic Whole Grain Oat Cereal Touched With Golden Honey & Organic Almond Flavor
Quaker Life Cereal Made With Whole Grain
Quaker Life Cereal Cinnamon
Malt-O-Meal Raisin Bran Whole Grain Wheat & Bran Cereal With Raisins
Kashi Strawberry Fields Cereal

Snacks used in the study

Name
Lay's Stax Mesquite Barbecue Flavored Potato Crisps
Lay's Stax Brand Salt & Vinegar Artificially Flavored Potato Crisps
Lay's Stax Sour Cream & Onion Naturally & Artificially Flavored Potato Crisps
Cheetos Crunchy Cheese Flavored Snacks
Cheetos Cheddar Jalapeno Crunchy Cheese Flavored Snacks
Cheetos Flamin' Hot Limon Crunchy Cheese Flavored Snacks Made With Real Cheese!
Cheetos Puffs Cheese Flavored Snacks
Doritos Nacho Cheese Flavored Tortilla Chips
Snyder's Krunchers! Kettle Cooked Potato Chips Sweet Hawaiian Onion 0 g Trans Fat As Always 30% Less Fat Than Regular Potato Chips
Lay's Stax Cheddar Flavored Potato Crisps
Snyders Of Hanover Sourdough Hards Pretzels
Rold Gold Classic Style Thins Pretzels
Lay's Stax Original Potato Crisps
Ruffles Cheddar & Sour Cream Flavored Potato Chips Made With Real Cheddar
Cheetos Flamin' Hot Crunchy Cheese Flavored Snacks Made With Real Cheese 0 Grams Trans Fat
Ruffles Sour Cream & Onion Flavored Potato Chips Rrruffles Have Ridges
Rold Gold One Pound Classic Style Tiny Twists Pretzels
Chex Mix The Original Snack Mix Traditional 60% Less Fat Than Regular Potato Chips
Funyuns Onion Flavored Rings
Lay's Original Wavy Potato Chips Made With All Natural Ingredients No Msg No Preservatives No Artificial Flavors

(*continued*)

Fritos Brand The Original Corn Chips
Cheetos Flamin' Hot Puffs Cheese Flavored Snacks
Cheetos Crunchy Salsa Con Queso Naturally And Artificially Flavored Made With Real Cheese! O Grams Trans Fat Chester Cheetah Cheese Flavored Snacks
Doritos Spicy Nacho Flavored Tortilla Chips
Lay's Classic Potato Chips
Fritos Lightly Salted Corn Chips 50% Less Sodium Than Fritos Corn Chips
Fritos Brand Great For Dipping Scoops! Brand Corn Chips
Lay's Barbecue Flavored Potato Chips
Doritos Baked! Nacho Cheese Tortilla Chips Naturally & Artificially Flavored
Doritos Blazin Buffalo & Rich Flavored Tortilla Chips
Doritos Spicy Sweet Chili Tortilla Chips
Cheetos White Cheddar Flavored Puffs Made With Real Cheese
Tostitos Restaurant Style Tortilla Chips
Chex Mix The Original Cheddar 60% Less Fat Than Regular Potato Chips Naturally & Artificially Flavored
Doritos Cool Ranch Reduced Fat Flavored Tortilla Chips 25% Less Fat Than Regular Doritos Brand Tortilla Chips
Sun Chips Original Multigrain Snacks
Sun Chips Brand French Onion Flavored Multigrain Snacks Great Multigrain Taste! Made With All Natural Ingredients
Garden Of Eatin' Blue Chips All Natural Tortilla Chips Made With Organic Blue Corn
Troyer Farms Dan-Dee Seyfert's Buffalo Wing Flavor Kettle Cooked Potato Chips
Baked Tostitos Scoops Tortilla Chips

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