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ORIGINAL COMMUNICATION

Impact of nutrition knowledge on food evaluations

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Objective: This study explored whether nutrition knowledge interacted with evaluations of a food's healthiness to influence food attitudes (ie, global evaluations). Since attitudes guide behavior, understanding factors that impact food attitudes is one way to understand food selection and why factors such as nutrition knowledge have only a modest impact on food selection. We hypothesized that the relation between health evaluations and food attitudes would be stronger for people high in nutrition knowledge. We also explored the macronutrient composition of foods, and how it related to attitudes and health evaluations.
Design: Survey employing multilevel analyses to examine within- and between-subject influences on food attitudes.
Setting: Student unions at two universities in the Southwestern US.
Subjects: A total of 138 participants (mean age = 19.8; 69 males, 67 females, two unreported).
Interventions: Participants indicated their attitudes toward; experience with; and health, flavor, and affective evaluations of 24 foods before and after lunch and completed questionnaires assessing individual difference variables.
Results: Experience and evaluations of healthiness, flavor, positive affect, and negative affect all predicted food attitudes. Health evaluations were more strongly associated with attitudes for people high in nutrition knowledge.
Conclusions: These findings suggest a mechanism through which individual differences impact food attitudes and thus likely influence food selection.
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Introduction

As a result of the significant and varied implications of food selection and intake for health, there have been numerous attempts to increase nutrition knowledge and awareness in the hope that this will guide people toward healthier foods. These attempts range from large governmental approaches whose objectives are to provide basic information to a significant portion of their populations (eg, food pyramid, labeling requirements) to focused and intensive nutritional counseling (eg, Rask-Nissilä *et al*, 2000; Räsänen *et al*, 2003). Research examining the effects of general nutrition knowledge and programs designed to increase nutrition knowledge have found that nutrition knowledge influences food preferences and selection but that its effects are relatively modest (Axelson *et al*, 1985; Shepherd, 1992; Wardle *et al*, 2000; Räsänen *et al*, 2003). For instance, Räsänen *et al* (2003), reporting results from a longitudinal study of control and nutrition-counseled groups, found at the 7 y visit that people in the counseled group ate less saturated fat and salt than people in the control group; however, the total fat intake of the two groups did not differ significantly and was greater than the recommend fat intake. Thus, nutritional counseling influenced the types of fats eaten but did not reduce overall fat intake. These findings are encouraging because they suggest that increasing nutrition knowledge can affect food selection, but they also illustrate the need for more research. That is, development of more effective interventions will require a better understanding of the mechanisms through which nutrition knowledge influences food selection. Because, food attitudes are an important determinant of food selection (eg, Stafleu *et al*, 1994; Drewnowski & Hann, 1999; de Castro *et al*, 2000), the

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present study explores whether, and if so how, nutrition knowledge influences food attitudes.

Attitudes are relatively stable evaluative (like/dislike) summary judgments (for reviews see Petty *et al*, 1997; Eagly & Chaiken, 1998; Ajzen, 2001), and as such, attitudes have been a useful construct for examining food selection. First, attitudes summarize disparate information into a single evaluative judgment (eg, Shepherd, 1989; Tuorila, 1992; Stafleu *et al*, 1994; Drewnowski & Hann, 1999; Berg *et al*, 2000). This is particularly important for foods because food attitudes are (1) based on many different types of evaluative judgments such as sensory information (taste, appearance), cognitive beliefs (healthiness of the food), previous affective experiences (happiness associated with eating the food), and previous evaluative behavior (eg, Rozin & Vollmecke, 1986; Steptoe *et al*, 1995; Berg *et al*, 2000; Stein *et al*, 2003; Aikman *et al*, in press) and (2) the evaluative implications of these judgments can differ (eg, Grogan *et al*, 1997; Letarte *et al*, 1997; Cantin & Dubé, 1999). For instance, a person could have a very positive taste evaluation of cheesecake and a negative health evaluation. Second, because attitudes are evaluative summaries, they reflect all relevant underlying evaluative information and thus are good behavioral guides. Although numerous variables influence behavior and can overshadow the impact of attitudes on behavior in any given instance (eg, when a social situation requires one to eat a disliked food), attitudes are very predictive of behavior over time because they are relatively stable and thus exert consistent force on behavioral decisions (Ajzen & Fishbein, 1977; Fazio, 1990; Kraus, 1995). A person who has a more positive attitude toward corn than peas, for instance, may not always select corn over peas but will eat corn more often than peas over time.

The conceptualization of attitudes as evaluative summaries may also provide an explanation for the rather moderate effect of nutrition knowledge on food attitudes and intake. That is, nutrition knowledge likely influences evaluations of food healthiness that underlie food attitudes (Rozin & Vollmecke, 1986; Lewis *et al*, 1989), but there is less reason to expect that nutrition knowledge influences other evaluative bases of attitudes such as evaluations based on sensory experience (eg, taste). Since food attitudes reflect multiple bases, the effect of changing one base (eg, health evaluation) on behavior will be attenuated by existing bases that do not change (eg, taste evaluation). For instance, if a person's attitude and subsequent behavior toward cheesecake were based equally on taste ($+3$ on a 7-point scale from -3 to $+3$) and health (0 on 7-point scale), a two unit decrease in the health evaluation would change their overall attitude only 1 unit (from $+1.5$ to $+0.5$). Given that taste and health are just two of many evaluative bases underlying food attitudes (Aikman *et al*, in press) and that taste is more important than health for most people (Drewnowski, 1995; Glanz *et al*, 1998), it is likely that the effects of changing health evaluations on attitude are actually less than in the preceding example.

To examine how individual differences in nutrition knowledge affect food attitudes, it is essential to examine individuals' reactions toward a wide range of foods because the effects of nutrition knowledge might manifest in different ways depending on other person or food characteristics. For example, a person with high nutrition knowledge and a family history of heart disease might have a different pattern of health evaluations and food attitudes compared to a person with high nutrition knowledge and a family history of diabetes. Until recently there have not been adequate statistical methods for examining the evaluative bases of individual food attitudes because statistical approaches based on the general linear model assume that observations are independent. This assumption is not true for attitudes because they are nested within individuals. To circumvent this statistical limitation, researchers have tended to either (1) examine only a couple of food attitudes (eg, skim *vs* whole milk) (eg, Berg *et al*, 2000) or (2) aggregate across large classes of food attitudes (eg, vegetables) (eg, Frank & van der Klaauw, 1994). Both of these approaches can produce misleading results because the impact of a variable such as nutrition knowledge may be (1) missed if it does not manifest for the specific foods that are examined or (2) obscured by aggregating across many foods if the effect manifests in only some of the foods (see Baranowski *et al*, 1999). Relatively recent statistical advances (Hox, 1995; Kreft & de Leeuw, 1998; Raudenbush & Bryk, 2002) allow us to examine hierarchical data sets in which certain units of observation (eg, food attitudes) are nested within higher-order units of observation (eg, individuals) (see Aikman & Crites, 2005 as a research example that uses both hierarchical and more traditional analyses).

To explore whether, and if so how, nutrition knowledge might influence food attitudes, we assessed nutrition knowledge and assessed attitudes (positive/negative evaluations), evaluative bases of attitudes (cognitive beliefs (health), sensory information (flavor), positive affect (happy), negative affect (depressed), and experience (how often eaten)) regarding 24 distinct foods. Since each of these evaluative bases has been found to be an important component of food attitudes (Aikman *et al*, in press), we predict that each will be significantly associated with food attitudes in this study. Based on previous research and theory (Aikman, 2003; Baker & Wardle, 2003), we believe that nutrition knowledge might impact attitudes by influencing the strength of the association between health evaluations and attitudes. Specifically, we predict that health evaluations will be more strongly associated with food attitudes for people who have more nutrition knowledge.

We also conduct exploratory analyses to investigate whether the macronutrient composition of foods predicts attitudes and evaluative bases of attitudes. As discussed above, attitudes are conceptualized as evaluative summary judgments that guide behavior. A potential source of evaluative information is the macronutrient composition of foods. A food's macronutrient composition, for instance, might affect sensory evaluations (eg, taste, texture, etc.), cognitive evaluations (eg, healthiness), or other evaluative bases that help to form attitudes. Thus, we examine the relation between attitudes and macronutrient composition and also the relations between each evaluative base and macronutrient composition because macronutrient composition may have different effects on different evaluative bases. Research suggests, for instance, that people find the sensory qualities of fat appealing but also believe that eating too much fat is unhealthy (Schiffman *et al*, 1998). Thus, attitudes toward a given high-fat food might be based on very positive sensory evaluations because people like the feel, taste, and smell of the food and negative health evaluations because they know that high-fat foods are relatively unhealthy. This example also illustrates the importance of nutrition knowledge with regard to the effect of macronutrient composition on health evaluations because one must have some knowledge about a food's composition (high in saturated fat) and the health implications of this for macronutrient composition to impact health evaluations. Thus, we predict that nutrition knowledge will interact with macronutrient composition in predicting attitudes and health evaluations.

Methods

Participants

A total of 138 people participated in this study (see Table 1 for demographic data). The sample consisted of 47 volunteers who were recruited at the student union at the University of Texas at El Paso (UTEP) and 91 volunteers who were recruited at the student union at New Mexico State University (NMSU). No significant differences across variables of interest were found between these two samples, and thus the samples were merged for ease of presentation.

Stimuli and materials

The 24 foods included in this study were selected by the experimenters as representative items of the six categories in the food pyramid (white bread, spaghetti, tortillas, rice, potatoes, salad, corn, broccoli, apples, oranges, bananas, grapefruit, milk, cottage cheese, yogurt, eggs, beef, chicken, fish, refried beans, French fries, potato chips, cake, donuts).

Table 1 Participant demographics

Variable	*Females*	*Males*
Gender	69	67
Age	19.8 (3.65)	22.9 (8.82)
BMI	24.2 (4.50)	24.2 (5.00)
Nutrition knowledge	31.1 (6.83)	33.6 (7.96)
Restraint	8.42 (5.26)	6.70 (5.04)

Two participants did not report their gender. Average age is the only significant difference between the males and females in this sample—there were 11 males who were 30 or older but only two females.

Although we used these (food pyramid) categories to guide our selections to ensure inclusion of a wide range of foods, multilevel analyses allows us to look at individual foods rather than collapsing across categories of foods; therefore, individual foods and not food categories were the units of the analyses.

Various evaluations of these foods were assessed using a series of scales: 7-point bipolar scales (−3 to 3) were used to assess attitude ('negative' to 'positive'), health evaluations ('unhealthy' to 'healthy') and flavor evaluations ('bad' to 'good'); 5-point unipolar scales (1 'not at all' to 5 'extremely') were used to assess positive affect (happy) and negative affect (depressed) that would be experienced by eating the foods; 4-point unipolar scales (1 'not at all' to 4 'very') were used to assess general familiarity with each food; and 6-point unipolar scales (0 'never' to 5 'everyday') were used to assess how often each food is typically eaten (ie, experience with the foods).[1]

A physiological state questionnaire assessed tiredness, hunger, fullness, and thirst using 5-point unipolar scales (1 'not at all' to 5 'very'). This questionnaire also included 20 Positive and Negative Affect Scale (PANAS) items (Watson *et al*, 1988) for assessing current positive and negative mood.

Relatively stable person variables were also assessed—(1) a nutrition knowledge questionnaire consisted of twenty questions from the General Nutrition Knowledge Questionnaire for Adults (Parmenter & Wardle, 1999),[2] (2) a dietary restraint questionnaire consisted of the 21 restraint subscale items from the Three Factor Eating Questionnaire (Stunkard & Messick, 1985), and (3) a demographic questionnaire consisted of questions that asked participants to indicate their gender, age, ethnicity, and height and weight (so body mass index (BMI) could be computed).

Procedures

From approximately 11:00 h till 3:00 h, experimenters recruited participants at the student unions at UTEP and NMSU by displaying a sign inviting people to complete a set of questionnaires for $4.00. Individuals who approached the experiments were told about the study, and those who were interested in participating read and signed an informed consent form. Participants then received the first set of

[1]We do not report analyses involving familiarity because (1) familiarity and experience are conceptually similar, (2) the experience measure has more variance and better psychometric properties (eg, more normally distributed), and (3) preliminary analyses revealed that the two predictors had comparable patterns of results.

[2]We eliminated a handful of questions from the original Parmenter and Wardle (1999) scale because the items would not have been clear to our participants (eg, because some items had food descriptions that are not commonly used in the US). A number of questions on this test required multiple answers that were each scored as correct or incorrect, which resulted in a questionnaire that had 54 questions.

questionnaires from the experimenter. This questionnaire included all food evaluation scales (attitude, health, flavor, positive affect, negative affect, familiarity, and experience) and the physiological state and mood questionnaire. The experimenter asked participants to complete this set of questionnaires, return it when finished, eat lunch and return to get the second set of questionnaires after eating. When participants returned after eating, they received the second set of questionnaires, which consisted of five food evaluations (attitude, health, flavor, positive affect, and negative affect), the physiological state questionnaire, and the person variable questionnaires. After completing these questionnaires, participants were paid and thanked for their participation.

Analyses and results

As discussed above, multilevel analyses are designed to deal with situations in which units of observation are nested within higher-order units of observation (Hox, 1995; Kreft & de Leeuw, 1998; Raudenbush & Bryk, 2002). In this study, there are three levels of observation—foods are nested within measurement sessions, which are nested within individuals. Thus, the first-level variables are ones that can change across foods within an individual and measurement session such as attitude and evaluations of flavor and health. The second-level variables are state variables that can change across different measurement sessions such as hunger and fullness. The third-level variables are relatively stable person variables such as gender and nutrition knowledge. To examine whether nutrition knowledge (third level) interacts with health evaluations to influence attitudes toward foods (first level variables), we made foods the units of the analyses, which created a data set consisting of 6624 observations (ie, 24 foods by two measurement sessions, pre- and post-meal, by 138 participants). Since we were interested in higher-order interactions, we centered all predictors by subtracting the mean of the 6624 observations for each variable (Kreft *et al*, 1995; Wainer, 2000). We used MLwiN to conduct the multilevel analyses and used MLwiN's iterative generalized least-squares procedure, which is generally equivalent to maximum likelihood, for estimating the models (Rasbash *et al*, 2004). Finally, because we performed a number of significance tests and many of these analyses were exploratory, we used $P<0.01$ as the alpha level in these analyses.

Is each evaluative base significantly associated with food attitudes?

We first ran an intercept only model to estimate the variability in attitudes across individuals, measurement sessions, and foods. This revealed interclass correlations of 0.100 for individuals and 0.001 for measurement sessions; thus, 10.0% of the variance in attitudes was due to person variables and 0.1% of the variance was due to measurement session variables with the remainder due to differences across foods.[3] We then explored whether we could account for some of the variance in food attitudes by regressing food attitudes on nutrition knowledge and the five evaluative bases (health, flavor, positive affect, negative affect, and experience). This analysis revealed a significant nutrition knowledge effect as people higher in nutrition knowledge had more positive attitudes toward the 24 foods used in this experiment relative to those lower in nutrition knowledge (see Table 2). As hypothesized, all five evaluative bases significantly predicted food attitudes in the expected direction as the 99% confidence interval associated with each regression coefficient did not include zero. Specifically, more positive attitudes were associated with (1) favorable flavor evaluations, (2) favorable health evaluations, (3) increased positive affect, (4) decreased negative affect, and (5) more experience with the foods (see Table 2). A principal advantage of multilevel analyses is that they allow one to investigate whether the slopes of these relations vary across individuals and measurement sessions. To investigate this, we allowed the slope parameters associated with the five evaluative bases of attitudes to vary across individuals. This significantly improved the fit of the model, χ^2 $(20)=1151.13$, $P<0.001$, demonstrating that there is significant variability in the impact of the five bases on attitudes across individuals (Table 2—Individual Variance). Next, we allowed the evaluative bases of attitudes to vary across measurement session to investigate whether the impact of these bases differed in the two measurement sessions. This also significantly improved the fit of the model, χ^2 $(20)=359.78$, $P<0.001$ (Table 2—Session variance). Thus, the significant improvement in the fit of the model that occurs when the slopes of the evaluative bases are allowed to vary across individuals and measurement sessions demonstrates that relative importance of flavor, health, positive affect, negative affect, and experience for predicting attitude vary due to variables that differ across both individuals and measurement session.

Does nutrition knowledge moderate the strength of the association between health evaluations and attitudes?

We explored whether nutrition knowledge moderated the association between the five evaluative bases and attitudes

[3]Based on our previous research (Lozano *et al*., 1999), we expected food attitudes to be significantly more positive in the pre-meal than post-meal measurement sessions. The low measurement session variance demonstrates that this did not occur. One potential explanation for this is a relatively large number of prototypical snack foods (eg, apples, oranges) in the study. We conducted exploratory analyses to investigate whether the effect of hunger changes from the pre- to post-meal sessions affected attitudes toward meal and snack foods differently. These analyses revealed that attitudes toward prototypical meal, but not snack, foods were more positive when participants were more hungry (premeal) compared to less hungry (postmeal). Since this hunger effect is not a primary focus of this study, we will not discuss it further.

Table 2 Regression coefficients, multilevel variance estimates, and standard errors associated with nutrition knowledge (Nut. Know.) and five evaluative bases (Flavor, health, positive affect, negative affect, and experience) when attitudes are regressed on these predictors

			99% CI	
Regression Coefficient	*Estimate*	*s.e.*	*Low*	*High*
Nutrition knowledge and evaluative base main effects				
Intercept	1.3930	0.0294	1.3171	1.4689
Individual variance	0.0484	0.0154		
Session variance	0.0651	0.0141		
Stimulus variance	0.7664	0.0153		
Nut. Know.	**0.0162**	0.0034	0.0074	0.0250
Flavor	**0.3223**	*0.0237*	0.2612	0.3834
Individual variance	*0.0281*	*0.0083*		
Session variance	*0.0500*	*0.0093*		
Health	**0.1763**	0.0196	0.1257	0.2269
Individual variance	*0.0302*	*0.0066*		
Session variance	*0.0240*	*0.0047*		
Positive affect	**0.1866**	0.0175	0.1415	0.2318
Individual variance	*0.0000*	*0.0000*		
Session variance	*0.0286*	*0.0065*		
Negative affect	−**0.2201**	0.0252	−0.2851	−0.1551
Individual variance	*0.0350*	*0.0107*		
Session variance	*0.0141*	*0.0085*		
Experience	**0.2238**	0.0165	0.1812	0.2664
Individual variance	*0.0147*	*0.0048*		
Session variance	*0.0121*	*0.0046*		
Nutrition knowledge and evaluative base interactions				
Flavor* Nut. Know.	−0.0029	0.0031	−0.0109	0.0051
Health* Nut. Know.	**0.0075**	0.0025	0.0011	0.0140
Positive Affect* Nut. Know	0.0041	0.0022	−0.0016	0.0098
Negative Affect* Nut. Know	−0.0084	0.0033	−0.0169	0.0001
Experience * Nut. Know	−**0.0072**	0.0021	−0.0126	−0.0018

Regression coefficient effects that are significant ($P<0.01$) are in bold.

by adding the interactions between nutrition knowledge and each of the five bases to the model. Adding these interaction predictors to the model significantly improved its fit, χ^2 $(5)=25.31$, $P<0.001$. As hypothesized, there was a significant positive interaction between nutrition knowledge and health evaluations. The simple slopes for this interaction reveal that the relation between health evaluations and attitudes is stronger for people high (1 s.d. above mean) relative to low (1 s.d. below mean) in nutrition knowledge (see Figure 1a). For instance, a change from the minimum health evaluation (−3) to the maximum health evaluation (+3) is associated with an attitude change of 1.4 units on the 7-point attitude scale for high nutrition knowledge individuals and a change of 0.7 units for low nutrition knowledge individuals. There was also a significant interaction between nutrition knowledge and experience. The simple slopes for this interaction reveal that the relation between previous experience (how often eaten) and attitudes is stronger for people low (1 s.d. above mean) relative to high (1 s.d. below mean) in nutrition knowledge (see Figure 1b).[4]

[4]We performed comparable analyses using dietary restraint to explore whether dietary restraint moderated the relation between evaluative bases and attitudes. These analyses revealed significant interactions between (1) restraint and health as the association between health evaluations and attitudes was stronger for people higher in restraint and (2) restraint and flavor as the association between flavor evaluations and attitudes was weaker for people higher in restraint.

Is macronutrient composition associated with food attitudes?

The objectives of these analyses were to explore whether macronutrient composition is associated with food attitudes and whether any association is moderated by nutrition knowledge. To conduct these analyses, we used approximate values for grams of carbohydrate, fat, and protein for each food. These macronutrient values were obtained by searching the USDA Nutrient Data Base for items that matched our stimuli and then averaging across all the relevant USDA items.

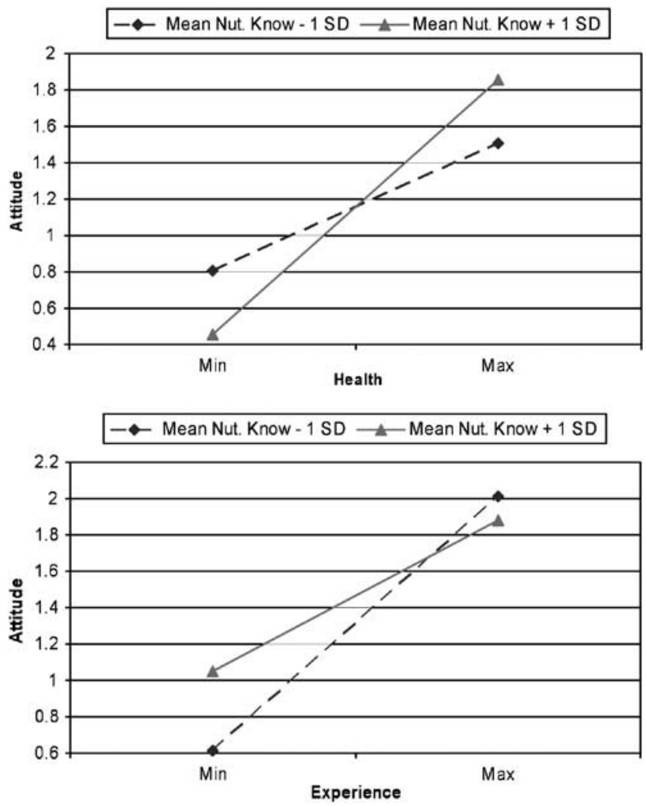

Figure 1 The two graphs in this figure depict the findings associated with regressing attitude on nutrition knowledge, the five evaluative bases, and the interactions between nutrition knowledge and the evaluative bases. (a) (top)—simple slopes depicting the significant interaction between nutrition knowledge and health evaluations predicting attitude; the graph depicts the relation between health and attitude for people high and low in nutrition knowledge. (b) (bottom)—simple slopes depicting the significant interaction between nutrition knowledge and experience predicting attitude; the graph depicts the relation between experience and attitude for people high and low in experience.

To investigate the association between macronutrient composition and attitudes, we regressed attitude on nutrition knowledge and grams of carbohydrates, fat, and protein. We then allowed carbohydrates, fat, and protein to vary across individuals so we could, in a subsequent step, assess whether these three first level variables interacted with nutrition knowledge. As can be seen in Table 3 (Attitude: Macro Main Effect), grams of fat and protein significantly predicted attitudes—increasing fat content was associated with more negative attitudes and increasing protein content was associated with more positive attitudes. We then added the three nutrition knowledge × macronutrient interaction terms to explore whether nutrition knowledge moderated the effect of the macronutrient predictors. This revealed significant nutrition knowledge × carbohydrate and nutrition knowledge × fat interactions (Table 3—Attitude: Macro × Nut. Know). To investigate these interactions, we plotted the simple slopes associated with them. As can be seen in Figure 2a, increasing carbohydrates from 2.6 to 40.4 g (±s.d. from mean carbohydrates of all 24 foods) is associated with more positive attitudes for people low in nutrition knowledge and less positive attitudes for people high in nutrition knowledge. A comparable change in fat content is associated with more negative attitudes for both high and low nutrition knowledge individuals but the amount is greater for those high in nutrition knowledge (see Figure 2b).

Is macronutrient composition associated with the evaluative bases of attitudes?

We conducted five sets of analyses examining the impact of nutrition knowledge and macronutrient composition on each of the evaluative bases (flavor, health, positive affect, negative affect, and experience). These analyses mirrored the analyses examining the impact of nutritional knowledge and macronutrient content on attitudes (ie, first explored main effects of macronutrient composition and then examined nutrition knowledge by macronutrient interactions). The findings from these analyses are reported in Table 3.

The analyses revealed two significant effects involving carbohydrates—a carbohydrate main effect when predicting health evaluations and a carbohydrate main effect when predicting experience. The carbohydrate health main effect demonstrates that increasing carbohydrate content is associated with lower health evaluations. The carbohydrate experience main effect reveals that the higher carbohydrate foods were reported as being eaten more often.

There were six significant effects involving fat content. As might be expected, the relation between fat composition and flavor evaluations and fat composition and health evaluations differed—increasing fat content was associated with more positive flavor evaluations and less positive health evaluations. Increasing fat content was also associated with more negative affect, which is evaluatively consistent with its effect on health because increasing negative affect is associated with less positive attitudes. In addition to these three main effects, there was also a main effect of fat on experience as participants reported eating higher-fat foods less often. As predicted, there was a significant nutrition knowledge by fat content interaction on health evaluations. As can be seen by examining the simple slopes associated with this interaction (plotted in Figure 2c), increasing fat concentrations were associated with relatively more negative health evaluations for people higher in nutrition knowledge. Similarly, a significant nutrition knowledge by fat content interaction predicting negative affect demonstrated that increasing fat content was associated with more negative affect for people high in nutrition knowledge (see Figure 2d).

There were two significant main effects involving protein content. First, increasing protein content was associated with more positive health evaluations. Second, the significant main effect for experiences revealed that the higher protein foods were reported as being eaten more often.

Table 3 Regression coefficients and standard errors associated with macronutrient (Macro; carbohydrates, fat, and protein) main effects and nutrition knowledge (Nut. Know.) × macronutrient interactions when attitudes are regressed on these predictors

		Predictor					
		Carbohydrates		*Fat*		*Protein*	
Dependent variable	*Predictor effect*	*B*	*s.e.*	*B*	*s.e.*	*B*	*s.e.*
Attitude	Macro Main Effect	−0.00126	0.00231	**−0.03043**	0.00607	**0.01945**	0.00495
	Macro × Nut. Know.	**−0.00084**	0.00029	**−0.00217**	0.00075	0.00041	0.00063
Flavor	Macro Main Effect	0.00130	0.00181	**0.02348**	0.00579	−0.01018	0.00520
	Macro × Nut. Know.	−0.00046	0.00023	−0.00045	0.00074	−0.00030	0.00067
Health	Macro Main Effect	**−0.03559**	0.00199	**−0.11461**	0.00510	**0.02782**	0.00405
	Macro × Nut. Know.	−0.00063	0.00025	**−0.00208**	0.00063	0.00032	0.00052
Positive affect	Macro Main Effect	−0.00126	0.00150	0.00995	0.00409	−0.00314	0.00416
	Macro × Nut. Know.	−0.00046	0.00019	−0.00029	0.00052	−0.00005	0.00053
Negative affect	Macro Main Effect	0.00297	0.00129	**0.01889**	0.00387	−0.00471	0.00292
	Macro × Nut. Know.	0.00016	0.00017	**0.00149**	0.00048	−0.00067	0.00037
Experience	Macro Main Effect	**0.01028**	0.00212	**−0.01281**	0.00442	**0.03592**	0.00435
	Macro × Nut. Know.	−0.00046	0.00027	−0.00060	0.00057	0.00009	0.00056

Significant effects ($P<0.01$) are in bold.

Discussion

This study explored whether nutrition knowledge moderated the relation between health evaluations and food attitudes. This study examined five distinct types of evaluative information hypothesized to underlie attitudes—sensory information (flavor), cognitive beliefs (healthiness), positive affect (happiness), negative affect (depressed), and previous experience (how often eaten). As expected, all five of these evaluative bases significantly predicted attitudes. The findings also revealed, as hypothesized, that the association between health evaluations and attitudes is stronger for people high in nutrition knowledge relative to those lower in nutrition knowledge.

The results of this study are both encouraging and discouraging with regard to the impact of nutrition knowledge on food selection. They are encouraging because the findings are consistent with previous research and theory and thus illustrate a mechanism through which nutrition knowledge might influence food attitudes and subsequent consumption. Previous research, for instance, suggests (1) that people with more nutrition knowledge tend to eat healthier diets but that the effects of nutrition knowledge are relatively modest (Axelson *et al*, 1985; Shepherd, 1992; Wardle *et al*, 2000; Räsänen *et al*, 2003) and (2) that attitudes summarize disparate types of evaluative information (eg, flavor, health, etc.) into a single evaluative judgment that then helps guide behavior (eg, Fazio, 1990). The current study helps explain the relatively modest effects of nutrition knowledge on behavior because it suggests that multiple types of evaluative information underlie food attitudes and that nutrition knowledge moderates the effects of some but not all of this evaluative information. Specifically, the present findings demonstrate that the relation between attitudes and health evaluations is stronger for people high in nutrition knowledge and that the relations between attitudes and evaluations based on flavor, positive affect, and negative affect do not differ due to nutrition knowledge. This implies that increasing nutrition knowledge will make health a more important determinant of attitudes but that overall attitudes (and subsequent behavior) will change less because other evaluative bases are not affected by nutrition knowledge.

The results also illustrate how difficult it is to effect significant attitude change merely by increasing nutrition knowledge. As demonstrated in this study, health evaluations are only one of many types of evaluative information that predict attitudes. Therefore, even if it is possible to dramatically alter health evaluations toward foods by increasing nutrition knowledge, the associated change in food attitudes will be much smaller. For example, a 6-unit change in a food's health evaluation (maximal change on the scale used in this study), for a person with an average level of nutrition knowledge in this study, would equate to a 1.0 unit change in attitude (with all other predictors at mean values); and the attitude change would be only 1.4 units for a person one standard deviation above the mean level of nutrition knowledge! In contrast, an equivalent 6-unit change in a food's flavor evaluation would result in a 1.9 unit change in attitude. Thus, these attitude findings are consistent with research that has demonstrated that increasing nutrition knowledge has only a very moderate effect on behavior. Furthermore, attitudes are only one determinant of

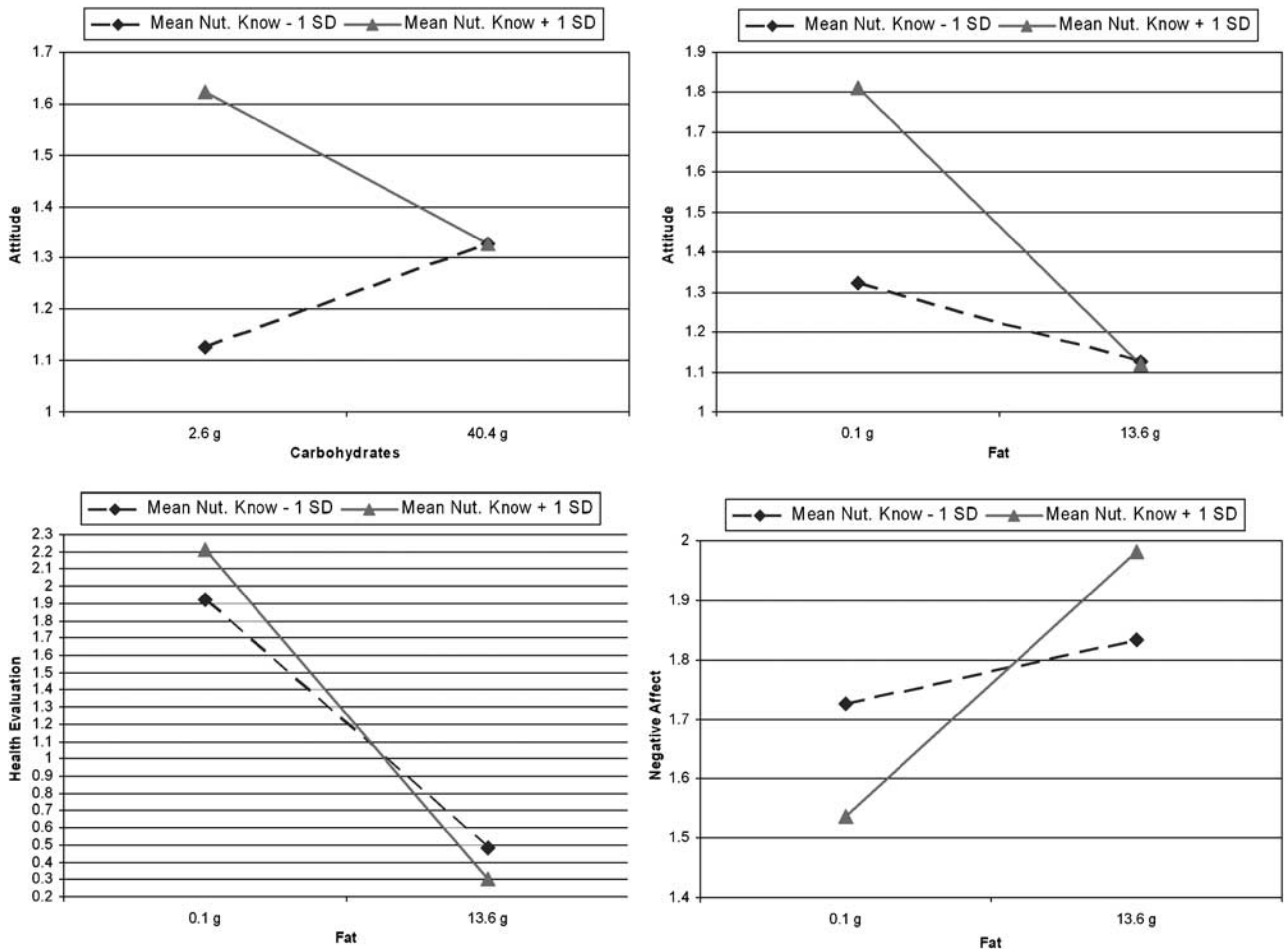

Figure 2 The four graphs in this figure depict the findings associated with regressing attitude and the evaluative bases (health and negative affect) on nutrition knowledge, macronutrient composition, and the interactions between nutrition knowledge and macronutrient content. (a) (Top left) — significant nutrition knowledge by carbohydrate interaction predicting attitude illustrating the relation between carbohydrates and attitudes for people high and low in nutrition knowledge. (b) (Top right) — significant nutrition knowledge by fat interaction predicting attitude illustrating the relation between fat and attitudes for people high and low in nutrition knowledge. (c) (Bottom left) — significant nutrition knowledge by fat interaction predicting health evaluations illustrating the relation between fat and health evaluations for people high and low in nutrition knowledge. (d) (Bottom left) — significant nutrition knowledge by fat interaction predicting negative affect illustrating the relation between fat and negative affect for people high and low in experience.

behavior and their effects can be moderated or even overridden by other factors such as social factors, cost, etc.

The present findings in conjunction with recent attitude theory and research illustrate the importance of understanding both the bases of food attitudes and the mechanism through which person variables impact attitudes. Attitude research, for instance, suggests that situational factors can alter the relative importance of different types of evaluative information on attitudes and effect subsequent behavior (eg, Millar & Tesser, 1986, 1989; Wilson *et al*, 1989; Cantin & Dubé, 1999; Wilson *et al*, 2000), and Aikman (2003) has recently demonstrated that hunger alters the relative importance of different types of evaluative information on food attitudes. These findings have enormous implications for understanding the effect of nutrition knowledge on attitudes and behavior because situational variables such as hunger or eating in the presence of others might influence the relative importance of various types of evaluative information. The relative importance of health evaluations for determining attitudes, for instance, may vary across situations such that sometimes health evaluations are relatively more important and sometimes they are less important. This implies that increasing nutrition knowledge will not be sufficient for changing eating patterns because the impact of nutrition knowledge (via changes in health evaluations) can vary across situations. If people are going to change their eating patterns, they also need to know how various situations can affect their food attitudes and decisions so, for instance, they can avoid or use caution when making food choices in situations that de-emphasize health evaluations. Finally, because research suggests that attitudes can be changed more easily if the persuasive appeals are designed to counter the evaluative information that underlies attitudes (eg, Edwards, 1990; Millar & Millar, 1990; Fabrigar & Petty, 1999; Dubé & Cantin, 2000), understanding the types of evaluative information that underlie attitudes should allow more effective nutrition programs to be designed.

The findings of this study also illustrate the important link between theory and measurement that is essential for discerning the evaluative mechanisms underlying food choice (Ostrom, 1989; Yeomans & Symes, 1999). For instance, the macronutrient analyses illustrate how a single variable such as fat content can have very different effects on various types of evaluative information. That is, foods with higher fat content were evaluated as (1) more flavorful, (2) less healthy, and (3) were associated with more negative affect (recall that increasing negative affect is associated with decreasing evaluations). Thus, these different evaluative measures revealed very different results both in direction and magnitude. Flavor and negative affect, for instance, were opposite in direction and relatively similar in the magnitude of their effects (*t*-statistics of 5.0 and 4.9, respectively) whereas health and negative affect were in the same direction but differed in magnitude (*t*-statistics of 22.5 and 4.9, respectively). As would be expected based on attitude theory and research, the effect of fat on overall attitude appeared to encompass these three evaluations as increasing fat led to more negative attitudes, but the amount of attitude negativity was not as great as that associated with health evaluations and negative affect because the negativity from these two sources is countered by the positivity associated with flavor evaluations. These results illustrate how conflicting or even opposite findings could be obtained with studies using only slightly different evaluative measures. One reason that attitudes are sometimes viewed as not predictive of behavior is that attitude measures often do not reflect attitude theory, which conceptualizes attitudes as complex memory structures that integrate many different types of evaluations. To effectively examine attitudes and evaluative behavior, one must use measures that can assess this complexity so it is possible to discern how various person and situational factors affect attitudes and subsequent evaluative behavior.

The present study sought to investigate the relation between nutrition knowledge, food attitudes, and evaluative information that serves as the basis of food attitudes. To that end, it demonstrated that health evaluations are more strongly related to attitudes for people high in nutrition knowledge. This study also demonstrated that the macronutrient content of foods is more strongly associated with health evaluations for people high in nutrition knowledge. Since previous research has not systematically investigated how individual differences such as nutrition knowledge impact attitudes and the various types of evaluative information that are purported to underlie food attitudes, this study was a necessary first step. Future research will need to build on the present findings by exploring how the attitude findings observed in this study relate to evaluative behaviors such as food purchases and consumption.

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References

Aikman SN (2003): How do motivational states change attitude reports? The influence of hunger on the informational bases of food attitudes. Unpublished Doctoral dissertation, University of Texas at El Paso, El Paso, TX.

Aikman SN & Crites Jr SL (2005): Hash browns for breakfast, baked potatoes for dinner: Changes in food attitudes as a function of motivation and context. *Eur. J. Social Psychol.* **35**, 181–198.

Aikman SN, Crites Jr SL & Fabrigar LR (in press) Beyond affect and cognition: Identification of the informational bases of food attitudes. *J. Appl. Social Psychol.*

Ajzen I (2001): Nature and operation of attitudes. *Ann. Rev. Psychol.* **52**, 27–58.

Ajzen I & Fishbein M (1977): Attitude-behavior relations: a theoretical analysis and review of empirical research. *Psychol. Bull.* **84**, 888–918.

Axelson ML, Federline TL & Brinberg D (1985): A meta-analysis of food- and nutritionrelated research. *J. Nutr. Educ.* **17**, 51–54.

Baker AH & Wardle J (2003): Sex differences in fruit and vegetable intake in older adults. *Appetite* **40**, 269–275.

Baranowski T, Cullen KW & Baranowski J (1999): Psychosocial correlates of dietary intake: advancing dietary intervention. *Ann. Rev. Nutr.* **19**, 17.

Berg C, Jonsson I & Conner M (2000): Understanding choice of milk and bread for breakfast among swedish children aged 11–15 years: an application of the theory of planned behaviour. *Appetite* **34**, 5–19.

Cantin I & Dubé L (1999): Attitudinal moderation of correlation between food liking and consumption. *Appetite* **32**, 367–381.

de Castro JM, Bellisle F, Dalix A-M & Pearcey SM (2000): Palatability and intake relationships in free-living humans: characterization and independence of influence in north americans. *Physiol. Behav.* **70**, 343–350.

Drewnowski A (1995): Energy intake and sensory properties of food. *Am. J. Clin. Nutr.* **62** (5 Suppl), 1081S–1085S.

Drewnowski A & Hann C (1999): Food preferences and reported frequencies of food consumption as predictors of current diet in young women. *Am. J. Clin. Nutr.* **70**, 28–36.

Dubé L & Cantin I (2000): Promoting health or promoting pleasure? A contingency approach to the effect of informational and emotional appeals on food liking and consumption. *Appetite* **35**, 251–262.

Eagly AH & Chaiken S (1998): Attitude structure and function. In DT Gilbert, ST Fiske & G Lindzey (eds.) *The Handbook of Social Psychology* 4th ed., Vol. 1, pp. 269–322. New York: Oxford University Press.

Edwards K (1990): The interplay of affect and cognition in attitude formation and change. *J. Personality Social Psychol.* **59**, 202–216.

Fabrigar LR & Petty RE (1999): The role of the affective and cognitive bases of attitudes in susceptibility to affectively and cognitively based persuasion. *Personality Social Psychol. Bull.* **25**, 363–381.

Fazio RH (1990): Multiple processes by which attitudes guide behavior: The mode model as an integrative framework. *Adv. Exp. Social Psychol.* **23**, 75–109.
Frank RA & van der Klaauw NJ (1994): The contribution of chemosensory factors to individual differences in reported food preferences. *Appetite* **22**, 101–123.
Glanz K, Basil M, Maibach E, Goldberg J & Snyder D (1998): Why americans eat what they do: taste, nutrition, cost, convenience, and weight control concerns as influences on food consumption. *J. Am. Dietetic Assoc.* **98**, 1118–1126.
Grogan SC, Bell R & Conner M (1997): Eating sweet snacks: gender differences in attitudes and behaviour. *Appetite* **28**, 19–31.
Hox JJ (1995): *Applied Multilevel Analyses*. Amsterdam: TT-Publikaties.
Kraus SJ (1995): Attitude and the prediction of behavior: a meta-analysis of the empirical literature. *Personality Social Psychol. Bull.* **21**, 58–75.
Kreft IGG & de Leeuw JD (1998): *Introducting Multilevel Modeling*. Thousand Oaks, CA: Sage Publications.
Kreft IGG, de Leeuw JD & Aiken LS (1995): The effect of different forms of centering in hierarchical linear models. *Multivariate Behav. Res.* **30**, 1–21.
Letarte A, Dubé L & Troche V (1997): Similarities and differences in affective and cognitive origins of food likings and dislikes. *Appetite* **28**, 115–129.
Lewis CJ, Sims LS & Shannon B (1989): Examination of specific nutrition/health behaviors using a social cognitive model. *J. Am. Dietetic Assoc.* **89**, 194–202.
Lozano DI, Crites Jr SL & Aikman SN (1999): Changes in food attitudes as a function of hunger. *Appetite* **32**, 207–218.
Millar MG & Tesser A (1986): Effects of affective and cognitive focus on the attitude-behavior relation. *J. Personality Social Psychol.* **51**, 270–276.
Millar MG & Tesser A (1989): The effects of affective-cognitive consistency and thought on the attitude-behavior relation. *J. Exp. Social Psychol.* **25**, 189–202.
Millar MG & Millar KU (1990): Attitude change as a function of attitude type and argument type. *J. Personality Social Psychol.* **59**, 217–228.
Ostrom TM (1989): Interdependence of attitude theory and measurement. In *Attitude Structure and Function* ed AR Pratkanis & SJ Breckler pp 11–36. Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc.
Parmenter K & Wardle J (1999): Development of a general nutrition knowledge questionnaire for adults. *Eur. J. Clin. Nutr.* **53**, 298.
Petty RE, Wegener DT & Fabrigar LR (1997): Attitudes and attitude change. *Ann. Rev. Psychol.* **48**, 609–647.
Räsänen M, Niinikoski H, Keskinen S, Helenius H, Talvia S & Rönnemaa T *et al* (2003): Parental nutrition knowledge and nutrient intake in an atherosclerosis prevention project: the impact of child-targeted nutrition counselling. *Appetite* **41**, 69–77.
Rasbash J, Browne W, Healy M, Cameron B & Charlton C (2004): *MLwiN (Version 2.0)*. London: Multilevel Models Project.
Rask-Nissilä L, Jokinen E, Ronnemaa T, Viikari J, Tammi A & Niinikoski H *et al* (2000): Prospective, randomized, infancy-onset trial of the effects of a low-saturated-fat, low-cholesterol diet on serum lipids and lipoproteins before school age: the special turku coronary risk factor intervention project (strip). *Circulation* **102**, 1477–1483.
Raudenbush SW & Bryk AS (2002): *Hierarchical Linear Models: Applications and Data Analysis Methods*. Thousand Oaks, CA: Sage Publications.
Rozin P & Vollmecke TA (1986): Food likes and dislikes. *Ann. Rev. Nutr.* **6**, 433–456.
Schiffman SS, Graham BG, Sattely-Miller EA & Warwick ZS (1998): Orosensory perception of dietary fat. *Curr. Directions Psychol. Sci.* **7**, 137–143.
Shepherd R (1989): Factors influencing food preferences and choice. In *Handbook of the Psychophysiology of Human Eating* ed R Shepherd pp 3–24. New York: Wiley.
Shepherd R (1992): Application of social psychological models to fat intake. In *Dietary Fats: Determinants of Preference, Selection and Consumption* ed DJ Mela pp 9–25. London: Elsevier.
Stafleu A, de Graaf C, van Staveren WA & de Jong MA (1994): Attitudes towards high-fat foods and their low-fat alternatives: Reliability and relationship with fat intake. *Appetite* **22**, 183–196.
Stein LJ, Nagai H, Nakagawa M & Beauchamp GK (2003): Effects of repeated exposure and health-related information on hedonic evaluation and acceptance of a bitter beverage. *Appetite* **40**, 119–129.
Steptoe A, Pollard TM & Wardle J (1995): Development of a measure of the motives underlying the selection of food: The food choice questionnaire. *Appetite* **25**, 267–284.
Stunkard AJ & Messick S (1985): The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *J. Psychosomatic Res.* **29**, 71–83.
Tuorila H (1992): Preferences and attitudes related to fat-containing foods. In: *Dietary Fats: Determinants of Preference, Selection and Consumption* ed DJ Mela pp 27–41. London: Elsevier.
Wainer H (2000): The centercept: an estimable and meaningful regression parameter. *Psychol. Sci.* **11**, 434–436.
Wardle J, Parmenter K & Waller J (2000): Nutrition knowledge and food intake. *Appetite* **34**, 269–275.
Watson D, Clark LA & Tellegen A (1988): Development and validation of brief measures of positive and negative affect: The panas scales. *J. Personality Social Psychol.* **54**, 1063–1070.
Wilson TD, Dunn DS, Kraft D & Lisle DJ (1989): Introspection, attitude change, and attitude-behavior consistency: the disruptive effects of explaining why we feel the way we do. *Adv. Exp. Social Psychol.* **22**, 287–343.
Wilson TD, Lindsey S & Schooler TY (2000): A model of dual attitudes. *Psychol. Rev.* **107**, 101–126.
Yeomans MR & Symes T (1999): Individual differences in the use of pleasantness and palatability ratings. *Appetite* **32**, 383–394.