What Consumers Actually Know: The Role of Objective Nutrition Knowledge in Processing Stop Sign and Traffic Light Front-of-Pack Nutrition Labels

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What Consumers Actually Know: The Role of Objective Nutrition Knowledge in Processing Stop Sign and Traffic Light Front-of-Pack Nutrition Labels

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Abstract
Examining the effects of what consumers actually know (i.e., objective knowledge) is an important gap in front-of-pack (FOP) nutrition research. In experiments with over 2,000 primary food shoppers, we examine the moderating impact of objective nutrition knowledge on key FOP nutrition symbols (Stop Sign labels, Traffic-Light labels, and a control) for effects on nutrient perceptions, nutrition use accuracy, disease risk, brand attitudes, and purchase intentions. Results support the effectiveness of the Stop Sign label over the Traffic Light label for key outcome measures, with the Traffic Light label performing better on nutrition use accuracy. Importantly, those with greater objective nutrition knowledge performed better than those with lower knowledge, controlling for subjective knowledge and demographics. These results are robust across three food nutrition profiles (healthy, moderately healthy, unhealthy), and more accentuated for the unhealthy profile. Serial mediation analyses are offered, as well as implications for marketing practice, theory, and public health.

Keywords
Nutrition labeling, Front-of-pack, Objective knowledge, Stop Sign labels

1. Introduction
Poor nutrition and consumption habits in the U.S. and around the world are directly associated with an increase in chronic diseases, such as cancer, coronary heart disease, type 2 diabetes, and stroke (Centers for Disease Control and Prevention (CDC), 2020, Dietary Guidelines for Americans, 2020, World Health Organization (WHO), 2020). Over the past 30 years in the U.S., there have been many public health and communication efforts to aid nutrition education, including the nutrition facts panel (NFP) and front-of-package (FOP) nutrition information on food packages. Because the nutrition facts panel (NLEA, 1990) is not always consulted when consumers purchase food products (Choinière & Lando, 2008), a wide array of voluntary FOP labels and systems have emerged in the U.S. and worldwide to help improve nutrition understanding and choices (Andrews, Burton, & Cook, 2017).

However, a very important omission in the study of FOP effects has been the need to examine the consumer’s objective nutrition knowledge in the processing of the FOP symbols (Andrews, Lin, Levy, & Lo, 2014). That is, what people actually know (versus what they think they know) is likely to result in more accurate comprehension of FOP information and correctly-held beliefs and intentions toward food products (Alba and Hutchinson, 2000, Petty and Cacioppo, 1986). Although one’s motivation and subjective nutrition knowledge (what one thinks they know) can be predictive of food attitudes and intentions (Andrews, Burton, & Kees, 2011), deficits in actual nutrition knowledge can limit one’s ability to correctly process and utilize health information leading to poor health choices and conditions (Wolf, 2011).

Currently, in the U.S., FOP nutrition labels are voluntary, with FOP labels appearing in a single favorable color (e.g., light blue, green, white), and often highlighting only positive nutrient levels (Andrews et al., 2014). However, efforts developed in other countries have been more proactive in their requirements and usage of FOP nutrition labels. One important consumer education and communication effort (yet not in the U.S.) is the provision of Chilean-style (“Stop Sign”) labels required for food products with high calories per serving (≥200 kcal), saturated fat (≥3 g), sodium (≥300mg), or sugar (≥18g) (Corvalan, Reyes, Garmendia, & Uauy, 2013). Since the introduction of black “stop sign” labels in Chile in 2016, public health officials in Canada, Israel, Mexico, Brazil, Peru, Uruguay, Argentina and Columbia plan to use variations of the labels, including the use of colors, shapes, and other easy-to-comprehend symbols warning consumers of long-term health risks (Ahmed, Richtel, & Jacobs, 2018).
Yet, much is unknown about the broader consumer processing and nutritional contexts for exactly how the Stop Sign and popular UK-based Traffic Light (TL) FOP labels affect consumers under different processing conditions. For example, how will important moderators, such as objective nutrition knowledge, heighten or attenuate any Stop Sign or Traffic Light label effects? Symbols that tend to emphasize nutrition evaluations, such as the Stop Sign labels, are likely to have stronger effects on nutrient and disease risk perceptions, attitudes and intentions. Whereas “reductive” symbols, such as the Traffic Light label, offer a reduced “snapshot” of the Nutrition Facts Panel to help aid a deeper understanding in the use of nutrition information (Andrews et al., 2011, Newman et al., 2018).

Our research seeks to extend prior nutrition knowledge and labeling work (cf. Andrews et al., 2000, Andrews et al., 2009) by concentrating on three primary questions: 1) Will the Stop Sign labels have stronger effects than the Traffic Light labels on nutrient and disease risk perceptions, attitudes, and intentions for a product high in saturated fat and sodium? Will these effects be strengthened for those higher in objective nutrition knowledge? 2) Will the Traffic Light labels be more effective than the Stop Sign labels in generating a more accurate understanding and use of FOP nutrition information? Will this effect be enhanced for those higher in objective nutrition knowledge and 3) Will the role of objective knowledge as a moderator of FOP effects extend to different nutritional profiles (e.g., healthy, moderate, unhealthy)? Implications of our findings for marketing practice, theory, and public health are offered.

2. Theoretical and practical background
2.1. Negativity bias
A theoretical premise that helps to guide our research is how negative information is weighed in decision-making relative to positive or neutral information. Compared to Traffic Light labels with multiple nutrients, Stop Sign labels present only negative nutrition information. When a negative nutrient exceeds a criterion level (e.g., 300mg. sodium; 3g. saturated fat), stop sign warning information appears on the FOP for that nutrient. Moreover, if none of the negative nutrients exceeds the criteria, no FOP information is presented. In contrast, Traffic Light labels can feature both negative and positive nutritional information. Favorable information displays a green signal, moderate shows amber, and unfavorable displays the red light. The psychological literature shows that negative information is weighted more heavily than positive information in consumer decision-making (Baumeister et al., 2001, Tversky and Kahneman, 1981). This “negativity bias” can dominate the effects of other information on risk perceptions, resulting in an enhanced cumulative effect of the processing and integration of unfavorable nutrient levels on nutrition and disease-related perceptions (Rozin and Royzman, 2001, Baumeister et al., 2001). Consistent with prospect theory (Tversky & Kahneman, 1981), there are asymmetric effects where potential health-related “losses” are weighed more heavily than any health-related “gains.”

Because the negative information is highlighted by the Stop Sign label, with minimal opportunity for counterbalancing due to favorable or neutral information, this FOP should lead to more unfavorable reactions toward the emphasized nutrients. These nutrient-related evaluations, in turn, should be related to disease risk perceptions and important outcomes to marketers and CPG food manufacturers, including brand attitudes and purchase intentions. In contrast, the Traffic Light labels offer the opportunity to balance nutrient perceptions that can be moderate or favorable, in addition to unfavorable. As such, relative to packages not presenting any FOP nutrition information, when a product can offer some mix of positive and negative nutrient information on the FOP, the Traffic Light labels should have diminished effects on the outcome variables compared to the Stop Sign labels.
2.2. Research on warning labels

In addition to negativity bias, research on the effectiveness of warning labels is pertinent to the effectiveness of the Stop Sign labels. Although NFP and FOP systems are important in nutrition education and decision-making, greater attention in warning consumers of the consequences of negative nutrients may be beneficial. A review of several decades of warning label research reveals that when appropriately designed and for the right audience, warnings can be effective in communicating risks and benefits to consumers (Andrews, 2011). This is true for many consumption problem areas (e.g., alcohol, prescription drugs, tobacco), but use of explicit warning labels is a relatively new to improving understanding and perceptions of nutrition information. Previous nutrition research has shown that warnings in the form of negative evaluative disclosures (e.g., “per serving fat levels determined to be high by the FDA”) were effective in reducing nutrient and disease risk misperceptions from ad claims for related nutrients (e.g., “No Cholesterol – Zero”) (Andrews, Netemeyer, & Burton, 1998).

Based on the above theory and research, the Stop Sign labels stressing only high levels of sodium and saturated fat (key negative nutrients) should result in higher scores for these negative nutrients and disease risk, and lower scores for brand attitude and purchase intent relative to Traffic Light labels and a no FOP package (control) condition.

**H1.** Consumers exposed to the Stop Sign label will report higher levels of sodium/saturated fat, a higher probability of disease risk, and less favorable brand attitude and intent to buy than those exposed to the Traffic Light label and the FOP control condition.

2.3. The role of objective nutrition knowledge

In general, an important distinction in consumer research is between what individuals actually know (objective knowledge) and what they think they know (subjective knowledge) (Alba and Hutchinson, 2000, Carlson et al., 2009). Objective knowledge reflects factual and accurate information learned and stored in memory (Alba and Hutchinson, 1987, Moorman et al., 2004, Petty and Cacioppo, 1986), whereas subjective knowledge reflects an assessment or confidence in one’s knowledge, or a “feeling of knowing” (Alba and Hutchinson, 2000, Moorman et al., 2004). More knowledgeable consumers are better able and willing to process more detailed information than those lower in such knowledge (Alba & Hutchinson, 1987). In this research, we focus on objective nutrition knowledge and predict that it will affect judgments for a product high in saturated fat and sodium, and that it will moderate the effect of the FOP label type on those judgments. Saturated fat and sodium are selected as two of the primary negative nutrients to limit in reducing the risk of coronary heart disease, type 2 diabetes, hypertension, stroke, cancer, and related diseases (Dietary Guidelines for Americans, 2015-2020).

There are several theoretical reasons for the role of objective nutrition knowledge in the accurate processing and use of FOP nutrition information. For example, consumer expertise theory suggests that objective knowledge is related to cognitive ability, critical thinking and reasoning, and a propensity for numerical processing in deriving beliefs and attitudes toward a given object (Alba & Hutchinson, 2000). It also suggests that objective knowledge inferences are more accurate, resulting in performing behaviors with positive outcomes or avoiding behaviors with negative outcomes. So, why should consumers with greater objective nutrition knowledge rate a product with a higher level of negative nutrients more unfavorably than consumers with less objective nutrition knowledge? And, why should greater objective nutrition knowledge moderate the effects of the Stop Sign labels? There are two reasons for this rationale.

First, research examining nutrition perceptions of NFP and FOP information is grounded in the consumer’s ability (e.g., nutrition knowledge, health literacy), motivation, and opportunity to process nutrition information (e.g., sufficient time, free from distractions) (see Petty & Cacioppo, 1986). Sadly, in the case of consumer ability, approximately 48% of Americans have marginal health literacy skills or worse (Davis, Michielutte, Askov, &
Williams, 1998). Limitations in health literacy and knowledge can constrain a consumer’s ability to process and use health information leading to confusion, misunderstanding and poor health outcomes (Wolf, 2011). Yet, with higher levels of consumer ability, greater elaboration and scrutiny of nutritional information is likely, which in turn leads to more accurate information comprehension and correctly-held attitudes and intentions toward the food product in question (Petty & Cacioppo, 1986).

Some evidence of this is found in studies of nutrition advertising claims. In the case of advertised products that are perceived as more “nutritious” (vegetable soup with high levels of sodium), higher objective nutrition knowledge is needed for nutrition disclosures to reduce sodium content and hypertension risk misperceptions of ad claims (Andrews et al., 2000). Such effects also can extend to caloric knowledge for potentially-misleading calorie ad claims (Andrews et al., 2009). However, research has yet to examine if objective nutrition knowledge can affect processing and use of FOP nutrition information, as most prior work has simply assessed subjective nutrition knowledge (cf. Andrews et al., 2011). Thus, for a nutritionally-mixed (moderately healthy) food profile in our first study, we expect that consumers with higher objective nutrition knowledge will be better able to process and integrate the FOP information, enhancing disease risk evaluations and important consumer outcomes (brand attitudes and purchase intentions).

A second reason why objective knowledge should moderate FOP effects is that those high in objective knowledge think more critically about numerical information when making decisions and are more likely to form judgements that minimize the risk when that numerical information is negative (Alba & Hutchinson, 2000). Although prior survey research conducted in Uruguay has compared the Chilean Stop Sign label with other FOP labels (Arrua et al., 2017, Machin et al., 2018), it remains unclear how key moderators, such as objective nutrition knowledge, will affect the processing and use of these FOPs for a wider set of dependent measures. In our studies, and based on the above reasoning, consumers higher in objective nutrition knowledge should better utilize the high levels of saturated fat and sodium presented in both pictorial and numerical formats in the Stop Sign labels, and as a result, are predicted to react more strongly to the Stop Sign labels.²

**H2.** Consumers with greater objective nutrition knowledge will report higher levels of sodium/saturated fat, a higher probability of disease risk, and less favorable brand attitude and intent to buy than those with a lower level of objective nutrition knowledge.

**H3.** Objective nutrition knowledge and FOP label condition will interact. Consumers with greater objective nutrition knowledge exposed to the Stop Sign labels will report higher levels of sodium/saturated fat, a higher probability of disease risk, and less favorable brand attitude and intent to buy than consumers exposed to the Traffic Light labels and FOP control condition.

### 2.4. Nutrition use accuracy

The effect of the FOP symbols and objective nutrition knowledge on nutrition use accuracy is important, as it represents a direct test of the understanding and application of the nutrient information provided in the FOPs (i.e., recommended daily amounts to consume based on the FOP symbol) rather than the impact on perceptions, attitudes, or intentions (Andrews et al., 2011, Levy et al., 1996, Burton et al., 1994). Because the Traffic Light labels display not only poor, but moderate, and good nutrient levels, this format provides more diagnostic information and should be more effective in eliciting overall nutrient use accuracy scores than the Stop Sign labels. Such effects should be heightened for those with greater levels of objective nutrition knowledge. We predict the following:

**H4a.** Exposure to the Traffic Light labels should lead to greater nutrition accuracy than exposure to the Stop Sign labels or the FOP control condition.
For consumers with greater objective nutrition knowledge, the Traffic Light labels should lead to greater nutrition accuracy than the Stop Sign labels.

In addition, given the primary outcomes in H1-H3, we examine if these outcomes are sequentially related such that (negative) nutrient evaluations for sodium and saturated fat are linked to perceptions of disease risk, which, in turn, affect consumer purchase intent. Given the predicted direct and moderating role of objective knowledge in H3, we examine a conditional mediational model as shown in Fig. 1. That is, we predict that objective nutrition knowledge moderates the key linkages in a FOP label type → sodium/saturated fat → disease risk → purchase intent mediational model chain of effects. As knowledge increases (decreases), the mediational path should become stronger (weaker).

Fig. 1. Conditional serial mediation model. Note: High Sodium/Saturated Fat Levels and disease risk are expected to serially mediate the effect of FOP label type on purchase intention, but the mediation path is expected to become stronger (weaker) as objective knowledge increases (decreases).

3. Pretests

3.1. Pretest One: Color

The purpose of this first pretest was to test if the specific color of the FOP Stop Sign label (i.e., either red with white lettering or black with white lettering) affected nutrient evaluations. This sample consisted of 153 primary food shoppers sourced from Amazon’s Mechanical Turk (MTurk). Ages ranged from 20 to 70. The sample was designed to balance gender and four age quotas (18–31, 32–44, 45–57, 58 + ) matched to U.S. Census data. Fifty-eight of the participants were male, and the median age category was 32–44 years. Respondents were exposed to one of six conditions representing a 3 (Stop Sign label with daily values: red, black, none) × 2 (NFP: present, none) between-subjects design. Two stop signs were featured for the FOP symbols: “High in Saturated Fat” (with 5g and 25% DV listed) and “High in Sodium” (with 720mg and 31% DV listed) matching the back-panel NFP information (See Web Appendix A).

A manipulation check asked respondents on a 7-point scale as to whether “the symbols on the front of the package looked like stop signs.” Both the red (M = 5.78) and black (M = 4.89) FOP Stop Sign labels were significantly greater than the control (M = 3.25; p < .05) on this measure. Two additional 7-point scales measured whether (1) the symbols on the front of the package indicated that certain nutrient levels were high and (2) whether the symbols on the front of the package were warning that if one ate the chicken dinner, they would be consuming a high level of certain nutrients. Both the black and red FOP Stop Sign labels were significantly greater than the control on these measures (p < .05), with no differences between the black and red colors. The presence or absence of the NFP had no significant effects. Based on these measures, but also the greater contrast of the black background and white lettering, and actual usage in Chile and other countries (Corvalan et al., 2013), we elected to use the black stop sign labels with white lettering for the main studies. This first pretest also assessed the reliability of a 10-item objective nutrition knowledge measure shown in Web Appendix B (based on Andrews et al., 1998). It displayed adequate reliability (α = 0.70).
3.2. Pretest Two: DV%

The purpose of the second pretest was to test the effect of daily value (DV) (i.e., GDA) information on nutrition perceptions for the black FOP Stop Sign labels for use in the main studies. The current Chilean Stop Sign labels in use are all black yet could be enhanced with the provision of the nutrient amount and DV information similar to the Traffic Light labels. Using an MTurk sample, this pretest was conducted with 163 primary food shoppers from the U.S. ranging in age from 19 to 70. The sample used the same U.S. demographic quotas as in Pretest One. Participants were 57% male, and the median age category was 32–44 years.

Respondents were exposed to one of six conditions representing a 3 (FOP Stop Sign Black Label: with DVs; without DVs; none) × 2 (NFP: present, none) between-subjects design. As in Pretest 1, and in correspondence with the back-panel NFP information, two stop-sign labels were featured for the FOP symbols: “High in Saturated Fat” (with 5g and 25% DV listed) and “High in Sodium” (with 720mg and 31% DV shown). (See Web Appendix A). Two 7-point scales measured the degree to which the chicken dinner was (1) high in saturated fat and (2) high in sodium. (Higher scores indicate higher (unfavorable) levels of these negative nutrients.) Both the Stop Sign symbols with DVs and without DVs were significantly better than the control in influencing consumer perceptions of these nutrient levels ($p < .05$), with no differences between the FOP symbols with DVs and without DVs. (Perceived saturated fat and sodium were higher for symbols with DVs than those without.)

Finally, based on prior research, a nutrition use accuracy measure was constructed that assesses the use of the nutrition symbol information as part of consumers’ daily diets. Respondents were asked “If you were to consume FIVE servings of this product in a day (and nothing else), would you consume more or less than the recommended amount for each of the six following nutrients?” (Andrews et al., 2011, Levy et al., 1996, Burton et al., 1994). The six nutrients were saturated fat, sodium, fat, cholesterol, calories and added sugar, with a special focus on saturated fat and sodium due to their high levels in the food item used in the studies. Correct responses (“more” for saturated fat and sodium and “less” for the others) were summed, divided by six, and then multiplied by 100. For overall accuracy, there were no differences across the three FOP treatments, yet for saturated fat, there were significantly higher correct responses for the Stop Sign labels with DVs (81%) and without DVs (78%) versus the control (55%; $p < .05$). For sodium, the differences were in the same direction as for saturated fat but were not significant (with DVs 79%; without DVs 76%; control 67%; $p > .05$). Based on these overall results, but also to be consistent with the Traffic Light labels which provide DVs, and the DVs in the NFPs, we elected to use the Stop Sign labels with DVs for main Study One.

4. Study One

4.1. Design and measures

Study One respondents were 711 primary food shoppers based on the same demographic quotas for the U.S. population as in the pretests and were screened to ensure product familiarity and use. A professional research firm collected the data from a nationwide, online panel. The respondents received instructions encouraging them to examine both the front and back of the mock package for the chicken dinner product and respond to all questions. They then were randomly assigned to one of the treatment conditions (see below) displaying realistic front and back panels in full color (See Web Appendix A) before responding to key measures.

To test hypotheses 1–4, Study One included two primary independent variables. The first variable was a FOP label manipulation consisting of three conditions: Traffic Light label, Stop Sign label, and control (no FOP). The second variable was (measured) objective nutrition knowledge, consisting of a 10-item scale (see Web Appendix B) focusing on three key study nutrients (calories, saturated fat, sodium) drawn from prior research (cf. Andrews et al., 1998, Andrews et al., 2009). A median split at 5 ($M = 4.49$, $sd = 2.39$; $\alpha = 0.67$) was made such that “low” = 0–5 and “high” = 6 and above.3
Using measures modified from prior nutrition labeling research (e.g., Andrews et al., 2011), the following dependent measures were gathered: 1) perceived levels of saturated fat and sodium measured on 7-point scales ("low" to "high"; \( r = 0.77, \text{coef. } \alpha = 0.85 \)); 2) perceptions of disease risk measured on 7-point Likert-type scales for heart disease and high blood pressure, which are related to sodium and saturated fat consumption \( (r = 0.87) \); 3) attitude toward the brand – a summated scale measured with three 7-point items ("unfavorable" – “favorable”; “negative” – “positive”; “bad” – “good”; \( \alpha = 0.88 \)); and 4) purchase intent – a summated scale of two 7-point items (“unlikely” – “likely,” “not probable,” “probable;” \( r = 0.93 \)). We also assessed a total nutrition use accuracy score based on the perceived impact on six nutrients for eating five servings of the product (see Pretest 2). As a covariate, a single-item measure of subjective nutrition knowledge was gathered on a 7-point scale: "Compared to other people, how much do you feel you know about nutrition?" (almost nothing – a lot). Demographics (e.g., age, gender, education, income) also were collected and used as covariates.

4.2. Results: Study One

4.2.1. Main effects

Using MANCOVA, we first assessed the main and interaction effects of the FOP manipulation and objective nutrition knowledge. Table 1 shows univariate main and interaction effect \( F \)-values, as well as main effect mean values across FOP conditions and objective nutrition knowledge.

Table 1. Study 1: Mean scores for the FOP condition and objective nutrition knowledge.

<table>
<thead>
<tr>
<th></th>
<th>Sodium/Saturated Fat</th>
<th>Disease Risk</th>
<th>Attitude Brand</th>
<th>Intent to Buy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Means for FOP Labels</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stop Sign Label</td>
<td>4.29</td>
<td>4.09</td>
<td>4.07</td>
<td>3.91</td>
</tr>
<tr>
<td>Traffic Light Label</td>
<td>3.50</td>
<td>3.61</td>
<td>4.90</td>
<td>4.32</td>
</tr>
<tr>
<td>Control</td>
<td>3.78</td>
<td>3.73</td>
<td>4.75</td>
<td>4.40</td>
</tr>
<tr>
<td><strong>Main Effect Univariate F- values</strong></td>
<td>9.71**</td>
<td>4.15*</td>
<td>13.31**</td>
<td>3.55*</td>
</tr>
<tr>
<td><strong>Means for Objective Nutrition Knowledge</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>3.92</td>
<td>3.87</td>
<td>4.34</td>
<td>3.85</td>
</tr>
<tr>
<td>Low</td>
<td>3.74</td>
<td>3.75</td>
<td>4.80</td>
<td>4.57</td>
</tr>
<tr>
<td><strong>Main Effect Univariate F- values</strong></td>
<td>1.85</td>
<td>0.74</td>
<td>10.61**</td>
<td>19.65*</td>
</tr>
<tr>
<td><strong>Interaction Effect Univariate F- values</strong></td>
<td>5.60**</td>
<td>2.46*</td>
<td>7.47**</td>
<td>5.44**</td>
</tr>
</tbody>
</table>

Note: All means have been adjusted for NFP, subjective nutrition knowledge, gender, age, education, and income level as covariates.

* \( p < .05 \).

** \( p < .01 \).

\( H1 \) predicts that subjects exposed to the Stop Sign label would show higher mean scores for sodium/saturated fat and disease risk, and lower mean scores for brand attitude and intent to buy relative to the Traffic Light label and control conditions.\(^4\) We find a significant multivariate effect for FOP (Wilks’ \( \lambda = 0.94, F = 5.05, p < .01 \), partial \( \omega^2 = 0.028 \)), and all univariate effects are significant. Bonferroni contrasts show that subjects exposed to the Stop Sign label exhibit a higher mean score on sodium/saturated fat levels (\( M = 4.29 \)) than did Traffic Light label (\( M = 3.50, p < .01 \)) and control group subjects (\( M = 3.78, p < .01 \)). There was no difference between Traffic Light and control group subjects. For disease risk, those exposed to the Stop Sign label (\( M = 4.09 \)) reported higher risk than those exposed to the Traffic Light label (\( M = 3.61, p < .05 \)), but the Stop Sign label subjects did not differ from the control group (\( M = 3.73, p = .11 \)), nor did the control group differ from Traffic Light label subjects. Stop Sign label subjects showed a significantly lower attitude toward the brand (\( M = 4.07 \)) than Traffic Light label...
(M = 4.90) and control group subjects (4.75, p < .01, for both). There was no difference between Traffic Light label and control group subjects. For intent to buy, Stop Sign label subjects show lower intent (M = 3.91) than the control group (M = 4.40, p < .05), but not the Traffic Light label group (M = 4.32, p = .12). There was no difference between the Traffic Light label and control groups. Overall, H1 was mostly supported across the outcome measures.

H2 predicted that consumers with greater objective nutrition knowledge should perceive higher levels of sodium/saturated fat and a higher probability of disease risk, and lower means for brand attitude and intent to buy relative to consumers with a lower level of objective nutrition knowledge. We find a significant multivariate effect for objective nutrition knowledge (Wilks’ λ = 0.97, F = 4.96, p < .01, ω² = 0.028), but there were no differences between high and low levels of objective nutrition knowledge for sodium/saturated fat or disease risk. However, high objective nutrition knowledge subjects did show a lower attitude toward the brand (M = 4.34) and lower intent to buy (M = 3.85) than did low objective nutrition knowledge subjects (M = 4.80 and M = 4.57, respectively, p < .01 for both). Thus, the main effects for objective nutrition knowledge in H2 were partially supported.

4.2.2. Interaction effects

Of greater interest are the interaction effects between FOP conditions and objective nutrition knowledge. H3 hypothesized that subjects exposed to the Stop Sign label condition with greater objective nutrition knowledge would have higher mean scores on sodium/saturated fat and disease risk, and lower mean scores on attitude toward the brand and intent to buy than their counterparts in the Traffic Light label and control conditions. A MANCOVA across the six cells of FOP and objective nutrition knowledge with the same covariates alluded to above revealed a significant multivariate effect (Wilks’ λ = 0.91, F = 3.42, p < .01, partial ω² = 0.024).

Fig. 2A, Fig. 2B display plots for the effects on sodium/saturated fat and disease risk. For perceptions of high levels of sodium/saturated fat (F = 5.60, p < .01), we find the Stop Sign/high objective nutrition knowledge group mean (M = 4.54) is higher than the Stop Sign/low objective nutrition knowledge group mean (M = 3.85, p < .05). We also find that Stop Sign/high is greater than the control/low (M = 3.62), Traffic Light/high (M = 3.26), and Traffic Light/low group means (M = 3.75, all p < .01). For disease risk (F = 2.46, p < .05), we find the Stop Sign/high objective nutrition knowledge group mean (M = 4.39) is higher than the Traffic Light/high group mean (M = 3.45, p < .05). This effect is shown in Fig. 2B.

Fig. 2A. FOP/objective nutrition knowledge interaction for sodium/saturated fat.
Plots for the effects on attitude toward the brand and intent to buy are shown in Fig. 3A, Fig. 3B. For attitude toward the brand ($F = 7.47, p < .01$), we find the Stop Sign/high objective nutrition knowledge group mean ($M = 3.58$) is lower than all other group means ($p < .01$ for all). These other group means ranged from $M = 4.57$ (Stop Sign/low) to $M = 4.95$ (Traffic Light/low). For intent to buy ($F = 5.44, p < .01$), we find the Stop Sign/high objective nutrition knowledge group mean ($M = 3.32$) is lower than Stop Sign/low ($M = 4.51$), control/low ($M = 4.60$), and Traffic Light/low group means ($M = 4.61, p < .01$ all). Plots of the effects for these two dependent variables are shown in Fig. 3A, Fig. 3B. These effects largely support H3.
Finally, in support of $H_{4a}$, Table 2 shows that the overall nutrition use accuracy score for six nutrients (saturated fat, sodium, total fat, cholesterol, calories, and added sugars) was significantly higher for the Traffic Light labels ($M = 3.64$) than the Stop Sign labels ($M = 3.33$, $p < .05$). As predicted in $H_{4b}$ and shown in Fig. 4, this difference is more pronounced for those with higher objective nutrition knowledge (Traffic Light labels $M = 3.95$; Stop Sign labels $M = 3.33$, $p < .05$). These differences were not significant for those with lower objective nutrition knowledge (Traffic Light labels $M = 3.35$; Stop Sign labels $M = 3.35$, $p > .05$). Because a primary goal of FOP nutrition labels is to assist consumers in making healthful choices for a daily diet, examining how different labels impact evaluations for both more and less healthful products is a critical issue (Andrews et al., 2011). Ideally, the most effective FOP labels aid positive evaluations in the context of a daily diet for more objectively healthful alternatives, while decreasing evaluations for unhealthful choices. Therefore, the net effect is to enhance the overall recognized differences between more and less healthful nutrient levels.$^5$

Table 2. Effects of front-of-package nutrition information and objective nutrition knowledge on nutrition accuracy.

<table>
<thead>
<tr>
<th>PANEL A: ANOVA Results</th>
<th>Univariate F-Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent Variables</td>
<td>Nutrition Accuracy</td>
</tr>
<tr>
<td>Main Effects</td>
<td></td>
</tr>
<tr>
<td>Front of package information (FOP)</td>
<td>6.19$^a$</td>
</tr>
<tr>
<td>Nutrition Knowledge (NK)</td>
<td>8.68$^a$</td>
</tr>
<tr>
<td>Interaction Effect</td>
<td></td>
</tr>
<tr>
<td>FOP*NK</td>
<td>3.83$^b$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PANEL B: Means</th>
<th>Front of Package Information</th>
<th>Objective Nutrition Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable</td>
<td>No FOP Label (a)</td>
<td>Traffic Light Label (b)</td>
</tr>
<tr>
<td>Nutrition Accuracy</td>
<td>3.31$^b$</td>
<td>3.64$^a,c$</td>
</tr>
</tbody>
</table>

**Note for Panel A:** Numbers shown in Panel A of the Table are univariate F-values. Degrees of freedom for NK = (1,699). Degrees of freedom for FOP and FOP*NK = (2,699). Exposure to Back of Panel Nutrition Facts, age, gender, education, income and perceived subjective knowledge all serve as covariates. $^a p < .01$; $^b p < .05$; $^c p < .10$.

**Note for Panel B:** Main effect means shown in Panel B represent a summed nutrition accuracy score for whether a respondent felt that consuming FIVE servings of the product in a day (and nothing else) would be more or less than the recommended amount for each of the six following nutrients: saturated fat, sodium, fat, cholesterol, calories and added sugar. Correct responses (“more” for saturated fat and sodium and “less” for the others) were summed for a score ranging from 0 to 6. Superscripts adjacent to the means in Panel B indicate significant differences ($p < .05$ or better) according to Bonferroni contrasts based on predictions. For example, the superscript for the “c” cell (Stop Light Label) indicates that the nutrition accuracy score mean is significantly less than the mean for the cell labeled “b” (Traffic Light Label).
4.2.3. Serial and conditional serial mediation

Fig. 1 displays a mediational chain with objective nutrition knowledge as a moderator of key linkages. To assess the mediational roles of high sodium/high saturated fat and disease risk, while also testing effects of objective nutrition knowledge as a quantitative moderator, we performed a combination of PROCESS Models 6 and 85 (Hayes, 2018). Model 6 assesses serial mediation for the FOP label $\rightarrow$ sodium/saturated fat $\rightarrow$ disease risk $\rightarrow$ purchase intent chain, followed by the role of the (quantitative) objective nutrition knowledge as a moderator of this chain via PROCESS Model 85. The primary focus of these analyses is how the mediation chain is affected by consumers’ objective knowledge for each of the FOP comparisons: Traffic Light label vs. Stop Sign label, Control vs. Stop Sign label, and Control vs. Traffic Light label. Table 3 shows these results. Analyses were performed using 5,000 bootstrap samples and 95% confidence intervals, and subjective nutrition knowledge, gender, age, income, and education were used as control variables in all analyses.
Table 3. Direct Serial and Conditional Serial Mediation Effects of the FOP Label: The Moderating Role of Objective Nutrition Knowledge.

<table>
<thead>
<tr>
<th>Mediation Paths</th>
<th>Total Sample Mediation</th>
<th>Indirect Effects (IEs) For Differing Levels of Objective Knowledge Moderator</th>
<th>Low Knowledge 95% CI</th>
<th>IE</th>
<th>Low Knowledge 95% CI</th>
<th>IE</th>
<th>Moderate Knowledge 95% CI</th>
<th>IE</th>
<th>High Knowledge 95% CI</th>
<th>IE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Serial Mediation of FOP Label on Intent to Buy (IB)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Traffic Lights vs Stop Signs) → Sodium/Sat. Fat → DisRisk → Intent to Buy</td>
<td>−0.04 (^a)</td>
<td>[−0.095, −0.001]</td>
<td>0.01</td>
<td>[−0.02, 0.06]</td>
<td>−0.03 (^a)</td>
<td>[−0.08, −0.0001]</td>
<td>[−0.10(^a) ]</td>
<td>[−0.20, −0.01]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Control vs Stop Signs) → Sodium/Sat. Fat → DisRisk → Intent to Buy</td>
<td>−0.04</td>
<td>[−0.11, 0.000]</td>
<td>−0.01</td>
<td>[−0.08, 0.04]</td>
<td>−0.05 (^a)</td>
<td>[−0.12, −0.005]</td>
<td>[−0.07(^a) ]</td>
<td>[−0.17, −0.008]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Traffic Lights vs Control) → Sodium/Sat. Fat → DisRisk → Intent to Buy</td>
<td>0.02</td>
<td>[−0.01, 0.06]</td>
<td>−0.03</td>
<td>[−0.09, 0.01]</td>
<td>0.03</td>
<td>[−0.001, 0.07]</td>
<td>0.07 (^a)</td>
<td>[0.02, 0.14]</td>
<td></td>
<td></td>
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<tr>
<td><strong>Indirect Effect through Nutrition Evaluation</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Traffic Lights vs Stop Signs) → Sodium/Sat. Fat → IB</td>
<td>−0.137 (^a)</td>
<td>[−0.267, −0.044]</td>
<td>−0.04</td>
<td>[−0.08, 0.07]</td>
<td>−0.11 (^a)</td>
<td>[−0.23, −0.02]</td>
<td>−0.33 (^a)</td>
<td>[−0.56, −0.15]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Control vs Stop Signs) → Sodium/Sat. Fat → IB</td>
<td>−0.082</td>
<td>[−0.185, 0.000]</td>
<td>−0.03</td>
<td>[−0.14, 0.08]</td>
<td>−0.04 (^a)</td>
<td>[−0.09, −0.01]</td>
<td>[−0.13(^a) ]</td>
<td>[−0.28, −0.02]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Traffic Lights vs Control) → Sodium/Sat. Fat → IB</td>
<td>0.044</td>
<td>[−0.02, 0.13]</td>
<td>−0.07</td>
<td>[−0.20, 0.03]</td>
<td>0.07</td>
<td>[−0.00, 0.17]</td>
<td>0.17 (^a)</td>
<td>[0.05, 0.32]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The total sample mediation in the first column in the upper part of the table examines the serial mediation of the FOP labels from Model 6 in PROCESS (Hayes, 2018). Then, the conditional indirect effects through objective knowledge are examined from Model 85 in PROCESS. The bottom portion of the table shows the more direct mediation through the nutrition evaluation (i.e., FOP → Sodium/Sat. Fat → IB). In general, the serial mediation paths of the Stop Sign label vs. either the Traffic Light label or no FOP control are significant and the mediation paths become stronger as objective knowledge increases.
The first column in the upper part of Table 3 examines the serial mediation for the total sample of the FOP label (FOP label $\rightarrow$ high sodium/high saturated fat $\rightarrow$ disease risk $\rightarrow$ intent to buy) from PROCESS Model 6 (Hayes, 2018). The serial mediation chain for the Stop Sign label, relative to the Traffic Light label and to the FOP control, is statistically significant. In contrast, the mediation chain for the Traffic Light label vs. control does not reach significance. The results for the more direct mediation chain of FOP label $\rightarrow$ high sodium/high saturated fat $\rightarrow$ intent to buy (from Model 6) is shown at the bottom of column 1. These results are consistent with those of the serial model. Results for the inclusion of the Stop Sign label vs. the other FOP conditions are significant (the confidence intervals do not contain a value of zero), but the comparison of the Traffic Light label vs. the control does not reach significance.

To understand and make inferences of the FOP labels through high sodium/high saturated fat evaluations and disease risk to purchase intent, it was proposed that a certain level of objective nutrition knowledge was required. These moderated mediation effects are examined using Model 85 in PROCESS (Hayes, 2018). The role of knowledge as a moderator of the mediation chain is shown in the right-hand portion of Table 3. For those with low knowledge, none of the mediation effects are significant. In contrast, for those with moderate or high knowledge, the serial mediation chains are significant (the confidence intervals do not contain a value of zero) for the Stop Sign label vs. Traffic Light label and control FOP conditions. For Traffic Light label vs. control, none of the mediation effects are significant, regardless of knowledge levels.

Model 85 results for the more direct mediation chain of FOP label $\rightarrow$ high sodium/high saturated fat $\rightarrow$ intent to buy across objective knowledge levels again are shown at the bottom of Table 3 in column 1. These results are consistent with those of the serial mediation model. For moderate or high knowledge, the mediation is significant. However, for low knowledge across all FOP comparisons, the mediation is non-significant.7

These mediation models suggest the following. For consumers with moderate or high objective knowledge, the Stop Sign label impacts the sodium/saturated fat evaluations, and this, in turn, affects disease-related risk and intent to buy. For those with low objective knowledge, there is little effect of the FOP label condition on the nutrient evaluations, and the serial mediation chain is non-significant.

4.3. Study One summary

The main conclusions from Study One are as follows. First, the Stop Sign labels served as an effective source of information for evaluating levels of negative nutrients and disease risks accompanying these negative nutrients relative to the Traffic Light labels or no information (control). Further, the Stop Sign labels served to lower brand attitude and intent to buy. These effects suggest a greater reliance on negative information in asymmetrically outweighing positive information in forming consumer judgments. For this product, the Traffic Light labels balance more favorable and neutral information with the negative nutrient information, and the Traffic Light labels have little effect relative to the FOP control in the ANOVAs or the mediation analyses for these outcome measures. Second, and in general, we find that actually knowing something about nutrition (objective knowledge) is effective in forming judgments about negative nutrients, disease risks, and consumer attitudes and intent for a product considered high in negative nutrients, and this knowledge leads to a conditional mediation effect. Third, the Traffic Light labels performed better than the Stop Sign labels on a wide set of nutrition use accuracy scores, and this effect was accentuated for those with higher objective nutrition knowledge.

Fourth, what we find to be the most intriguing of our findings are the effects for the moderating role of objective nutrition knowledge. In the MANCOVA results, in which objective nutrition knowledge was split as “high” or “low” at the median, and for the conditional serial mediation in which objective nutrition knowledge was left as a continuous quantitative variable, an interesting effect emerged, even with a host of control variables. In essence, in helping to make more informed judgments and potentially healthier food choices, the
Stop Sign label had stronger effects on outcomes for those who are higher in objective nutrition. This this also is the case for the Traffic Light labels in a test of nutrition use accuracy scores. Yet, it is generally those lower in objective nutrition knowledge that are the most vulnerable for making inaccurate nutrition judgments and poor food choices (Ikonen, Sotgui, Aydinli, & Verlegh, 2020), an issue we will discuss later in the paper.

5. Study Two

5.1. Overview

Study One examined the effects of different FOP label conditions for a product that is moderate in its overall nutrition level, with some negative nutrients at an unfavorable level (saturated fat, sodium), others that are more moderate (calories), and some that are more favorable (added sugar). In Study Two, we extend Study One findings by manipulating three levels of product healthfulness (i.e., healthy, moderate, unhealthy) through nutrients shown on the NFP, and again assess the potential moderating effect of objective nutrition knowledge.

Recall that the Traffic Light labels differ from the Stop Sign labels in that the Traffic Light labels offer ordinal levels (Poor, Moderate, Good) of critical nutrients through the use of the red, amber and green color coding. In contrast, the Stop Sign label is dichotomous and it appears on the FOP only when there is an unfavorable level of a negative nutrient. This FOP symbol is absent when the nutrient is not high. For more healthful products then, the Traffic Light label can offer information that is more detailed, balanced, and potentially positive that can lead to more favorable evaluations. As previously noted though, there is considerable research that reveals that “bad is stronger than good,” (Baumeister et al., 2001, Tversky and Kahneman, 1981), and it is clear that the Stop Sign labels focus only on presenting negative information. So, an important question becomes... how do those high in objective nutrition knowledge process different levels of healthfulness displayed by the NFP when combined with differing FOPs (i.e., Stop Sign label, Traffic Light label, or control)?

In Study Two, we continue to examine the moderate (intermediate) objective nutrition level used in Study One as a comparison, but now include information conditions that are also less or more healthful. In the more unhealthful objective nutrition condition, sodium (1150mg, 50%DV), added sugar (25g, 50%DV), and saturated fat (10g, 50%DV) levels are all quite high, leading to red traffic lights in the Traffic Light label and Stop Sign label in these conditions for all three nutrients. Identical to Study One, the moderate condition has relatively high levels of sodium (720mg, 31%DV) and saturated fat (5g, 25%DV) (two red traffic lights in the Traffic Light label condition), but a favorable level of added sugar (1g, 2%DV) (green traffic light in the Traffic Light label condition). In the more healthful objective nutrition condition, saturated fat is low (.5g, Traffic Light label condition and no FOP in the Stop Sign label condition), and added sugar is low (.5g, 1%DV) (green in the Traffic Light label condition).

In addition to examining whether effects for H1 thru H4b of Study One replicate, Study Two predicts the following:

H5. Consumers exposed to unhealthy nutrition information should perceive higher levels of sodium/saturated fat, a higher probability of disease risk, and less favorable brand attitude and intent to buy than those exposed to intermediate and healthy nutrition information.

H6. Consumers with greater objective nutrition knowledge exposed to unhealthy nutrition information should perceive higher levels of sodium/saturated fat, a higher probability of disease risk, and less favorable brand attitude and intent to buy than consumers lower in objective knowledge exposed to unhealthy nutrition information.
5.2. Design and measures
The Study Two sample consisted of 1,087 primary food shoppers recruited from MTurk, with the same age and gender quotas as used in the pretests and Study One. In total, there were 18 cells of approximately 60 respondents each. These 18 cells represent a $3 (\text{FOP label type}: \text{absent (control), Traffic Light label, Stop Sign label}) \times 3 (\text{nutrition information profiles}: \text{healthy, moderate, unhealthy}) \times 2 (\text{objective nutrition knowledge}: \text{high, low})$ design. (See Web Appendix C for nutrition information profiles.) The nutrition information profile manipulation was based on the specific nutrient information and daily values shown in the NFP, and then applied to the FOP labels. The same 10-item objective nutrition knowledge scale of Study One was used in Study Two via a median split at 5 ($M = 4.70, SD = 2.38; \alpha = 0.66$) such that “low” = 0–5 and “high” = 6 and above. All dependent measures in Study Two were identical to those in Study One, with acceptable levels of coefficient $\alpha$ reliability ranging from 0.79 for the two-item perceived levels of sodium/saturated fat measure ($r = 0.66$ between the two items) to 0.98 for the three-item attitude toward the brand measure.

5.3. Results: Study Two
5.3.1. Main effects
A MANCOVA first assessed the main and interaction effects of the FOP manipulation, the nutrition information manipulation, and objective nutrition knowledge using subjective nutrition knowledge, gender, age, income, and education as covariates. For the FOP label manipulation and objective nutrition knowledge, the main effect results replicated what were found in Study One, again supporting $H_1$ and $H_2$. The $H_{4a}$ hypothesis for nutrition use accuracy also was supported in Study Two across all health conditions. Although $H_{4b}$ was in the predicted direction (including the unhealthy condition), it did not reach significance. These results are detailed in Web Appendix C. Here, we will focus on the new main effect hypothesis for the nutrition information manipulation ($H_5$) and the interaction effects ($H_3$ and $H_6$).

$H_5$ predicted that consumers exposed to unhealthy nutrition information in the NFP would perceive higher levels of sodium/saturated fat, a higher probability of disease risk, and less favorable brand attitude and intent to buy than those exposed to intermediate and healthy nutrition information. For high sodium/saturated fat ($F = 9.84, p < .01$), subjects in the unhealthy nutrition information condition showed a mean score ($M = 4.10$) higher than subjects in the healthy nutrition information condition ($M = 3.61, p < .01$). The intermediate condition ($M = 3.96$) also differed ($p < .01$) from the healthy condition. For disease risk ($F = 5.01, p < .01$), subjects in the unhealthy condition showed a higher mean ($M = 4.28$) than subjects in the healthy condition ($M = 3.87, p < .01$); there was no difference between the healthy and intermediate conditions. For attitude toward the brand ($F = 16.58, p < .01$), unhealthy condition subjects ($M = 4.20$) scored lower than healthy ($M = 4.96$) and intermediate condition subjects ($M = 4.58, p < .01$ for both). The intermediate condition also differed ($p < .01$) from the healthy condition. For intent to buy ($F = 3.63, p < .05$), unhealthy condition subjects ($M = 4.00$) scored lower than healthy condition subjects ($M = 4.40, p < .05$). The intermediate condition and healthy conditions did not differ. These results largely support $H_5$.

5.3.2. Interaction effects
We did not observe any three-way interactions for any of the dependent variables, nor any FOP label*nutrition information two-way interactions. However, we did observe FOP label*objective nutrition knowledge and nutrition information*objective nutrition knowledge two-way interactions. The following results focus on these significant two-way interactions.

$H_3$ concerns the FOP label*objective nutrition knowledge interaction. A MANCOVA was again conducted with the six cells comprising this interaction with subjective nutrition knowledge, age, gender, education, income, and the nutrition information manipulation as covariates. For this interaction (Wilks’ $\lambda = 0.92, F = 4.45, p < .01$, partial $\omega^2 = 0.019$), we observe the following univariate results.
The sodium/saturated fat and disease risk plots are shown in Fig. 5A, Fig. 5B. For sodium/saturated fat ($F = 6.37, p < .01$), the Stop Sign/high objective nutrition knowledge (NK) mean ($M = 4.41$) was higher than the Stop Sign/low NK ($M = 3.87, p < .05$), Traffic Light/low NK ($M = 3.52, p < .01$), and control/low NK means ($M = 3.66, p < .01$). In Fig. 5B, for disease risk ($F = 2.77, p < .05$), the Stop Sign/high knowledge mean ($M = 4.38$) was greater than the control/high NK mean ($M = 3.69, p < .05$).

Interaction plots for attitude and intent to buy are displayed in Fig. 6A, Fig. 6B. For attitude toward the brand ($F = 9.08, p < .01$), the Stop Sign/high NK mean ($M = 4.01$) is lower than all other means with the exception of the Traffic Light/high NK mean ($M = 4.18$). These other means ranged from $M = 4.62$ for control/high NK to $M = 5.08$ for Traffic Light/low NK ($p < .01$ all). For intent to buy (see Fig. 6B; $F = 9.19, p < .01$), the Stop Sign/high NK mean ($M = 3.67$) is lower than the Stop Sign/low NK ($M = 4.49$), Traffic Light/low ($M = 4.78$) and control/low NK means ($M = 4.57, p < .01$ all). Interaction plots for these two dependent variables are shown in Fig. 6A, Fig. 6B. These results are consistent with the FOP*objective nutrition knowledge interaction results of Study One, again supporting H3.
H6 predicted that consumers with high objective nutrition knowledge exposed to unhealthy nutrition information will perceive higher levels of sodium/saturated fat, a higher probability of disease risk, and less favorable brand attitude and intent to buy than consumers low in objective knowledge exposed to unhealthy nutrition information. As such, H6 compared the 6 cells of the nutrition information*objective nutrition knowledge interaction, adjusting for subjective nutrition knowledge, age, gender, education, income, and the FOP label manipulation as covariates. This multivariate nutrition information*objective nutrition knowledge interaction was significant (Wilks' $\lambda = 0.90$, $F = 5.87$, $p < .01$, partial $\omega^2 = 0.025$).

Interaction plots for sodium/saturated fat and disease risk are shown in Fig. 7A, Fig. 7B. For sodium/saturated fat ($F = 8.38$, $p < .01$), the unhealthy/high objective knowledge mean ($M = 4.34$) was higher than the healthy/high NK ($M = 3.62$), healthy/low NK ($M = 3.62$), and intermediate/low NK means ($M = 3.59$, $p < .01$ for all). As displayed in Fig. 7B, for disease risk ($F = 3.45$, $p < .01$), the unhealthy/high knowledge mean ($M = 4.49$) was higher than the healthy/high NK mean ($M = 3.67$, $p < .01$).
For attitude toward the brand ($F = 14.55, p < .01$), the unhealthy/high NK mean ($M = 3.63$) is lower than all other condition means that ranged from 4.25 to 5.09 ($p < .05$ or $p < .01$). For intent to buy ($F = 10.27, p < .01$), the unhealthy/high NK mean ($M = 3.41$) is lower than all other means, ranging from 4.18 to 4.64 ($p < .01$ all) with the exception of the intermediate/high NK mean ($M = 3.77$). Interaction plots for these two dependent variables are shown in Fig. 8A, Fig. 8B. In sum, H6 was supported.10
5.4. Study Two summary

As with Study One, we find that the FOP and objective nutrition knowledge main effects largely replicate in Study Two, including the effects related to nutrition accuracy. (See Web Appendix D). Additionally, when faced with NFP information suggesting that the product is “unhealthy,” subjects rated the product as having higher levels of sodium/saturated fat, greater disease risk, and lower brand attitude and intent to buy, relative to “intermediate” and “healthy” conditions. These effects are again consistent with a negativity effect in forming consumer judgments.

What is more important conceptually, and interesting to our study contributions, are the moderating effects of objective nutrition knowledge. As with Study One, the Stop Sign labels had stronger effects for those who are higher in objective nutrition knowledge. Similarly, when faced with information that the product is “unhealthy,” again we see the most pronounced effects for those high in objective nutrition knowledge.

6. Discussion

6.1. Summary and key contributions

The use of front-of-package nutrition labels to support and enhance consumer evaluations and choices of more healthful products remains a key issue relevant for CPG manufacturers, retailers, public health agencies and public policy. A recent meta-analysis finds that although FOP nutrition labels can help consumers identify healthy products, their ability to nudge consumers toward healthier choices appears somewhat limited (Ikonen et al., 2020). This begs the following questions: (1) What are the most efficacious FOP labels for use, and what are the relative advantages and disadvantages of formats that present primarily negative information versus those that may balance favorable and unfavorable levels of unhealthful nutrients related to disease risk? and (2) What consumer characteristics (e.g., objective nutrition knowledge) might moderate the relative effectiveness of FOP labels? Our research shows that the Stop Sign labels are most effective for aiding nutrient evaluations, perceptions of disease risk, brand attitudes, and purchase intentions by targeting high levels of negative nutrients (saturated fat, sodium). In turn, these effects are moderated by the consumer’s level of objective nutrition knowledge, with those with greater objective knowledge demonstrating stronger effects on these measures than those with less knowledge. These moderating effects extend to the sequential connection of the FOP label through the negative nutrient evaluations to disease risk, and subsequently to purchase intentions.

Interestingly, and in contrast to these results, when nutrient accuracy scores for a wider range of six nutrients are considered, the Traffic Light labels are more effective than the Stop Sign labels. Again, as indicated in Study One, these effects are stronger for those with higher levels of objective nutrition knowledge. Our findings from
both Study One and Study Two indicate that the FOP and objective nutrition knowledge effects appear fairly robust across varying levels of healthfulness of the nutrition profile. This overall pattern of results indicates that the ultimate issue is the specific objective of a given FOP label. That is, whether one is more concerned with identifying and avoiding negative nutrients to help mitigate adverse health consequences (e.g., with heart disease, high blood pressure, obesity), or focusing on a wider array of nutrients – some of which may promote favorable health outcomes. Importantly, it is those with the highest level of objective nutrition knowledge that are most strongly affected by the FOP label conditions. With this in mind, we now explore implications of our studies for marketing practice, public health policy, and marketing theory.

6.2. Implications for marketing practice
For grocery retailers, food manufacturers, and brands emphasizing consumer health (e.g., Whole Foods, Sprouts, Healthy Choice) the provision of useful FOP nutrition information may enhance brand attitudes and market positioning (Newman, Howlett, & Burton, 2014). If the goal is to contribute to an improvement in consumer health, we show that the Stop Sign labels can be quite effective in highlighting key negative aspects of food products, but they may overlook the overall value of meals with some favorable nutrient levels, or when one’s entire daily consumption is considered.

However, such targeting via Stop Sign labels might encourage manufacturers to favorably reformulate food products much like efforts during the launch of the NFPs to meet “healthy” claim guidelines based on limits on negative nutrients (Colas, 2018, Center for Science in the Public Interest (CSPI), 2006). Similarly, when transfat became required on the NFP, food manufacturers very quickly found alternatives that allowed transfat levels to fall substantially, and in many categories, be eliminated from CPG food items. Also, currently, many voluntary FOP systems (at least in the U.S.) do not discriminate via use of color coding or warnings for high and low levels of negative nutrients (e.g., Facts Up Front). That is, they opt for reductive formats without any evaluative component (Newman et al., 2018) by listing all nutrients with a single color (vs. the multi-color Traffic Light labels) or without warning symbols (vs. Stop Sign labels). This current limitation may offer an opportunity for strengthening the positioning of retailers (e.g., Whole Foods, Sprouts) and brands (e.g., Healthy Choice) focusing on consumer health. This point is particularly important to retailers and CPG marketers because there are many retailers and CPG firms currently implementing labeling systems in order to differentiate themselves from their competitors, and such labeling programs are likely only sustainable in the longer term if they offer benefits to both consumers and firms (Newman et al., 2014, Ikonen et al., 2020). It also is important that such FOP labels and systems be widely communicated (see next section) beyond a simple presence on a website so that greater understanding and usage can result for all consumers, extending beyond just those with the highest levels of nutrition knowledge.

Recently, a considerable amount of CPG food choice has shifted from in-store to online selections due to the COVID-19 pandemic. As a result, the provision of accessible nutrition package information can present processing challenges (FDA 2020). With such supply chain and retail purchase shifts (Esper et al., 2003, Scott et al., 2020), it is important that online nutrition labeling is apparent and prominent, yet does not overwhelm consumers. Nutrition information – including both FOP labels and NFPs – should be as accessible and as noticeable as branding and promotional information. The provision and effects for our FOP labels and NFP package information in this particular online environment indicates that this can be achieved and have an impact on consumers.

6.3. Public health and policy implications
As noted, those with lower objective nutrition knowledge tend to be the most vulnerable for making more unhealthy food-related decisions (Ikonen et al., 2020). Yet, our research suggests that the Stop Sign label is most effective for communicating unfavorable nutrient levels and these effects extend to disease-related evaluations,
and intentions for those high in objective nutrition knowledge. Similarly, in Study One, the Traffic Light label affected nutrient accuracy scores most strongly for those with higher objective nutrition knowledge. And, as shown in almost all interaction plots in the figures, there is essentially no effect of FOP labels or objective nutrition (NFP) information when objective knowledge is low. So, what can be done to raise objective nutrition knowledge levels? For example, is it possible to “nudge” objective knowledge levels from a low or moderate level to a higher level (i.e., a “6” or “7”) in the context of our objective nutrition knowledge measure? One answer to this question might lie in considering additional negative information on the FOP label at the point-of-purchase in the U.S., both online and in-store.

At the point-of-purchase, many consumers struggle to understand and compare information presented by the NFP, or they just do not have the opportunity (e.g., time) to make comparisons due to the additional cognitive effort to do so (Block & Peracchio, 2006). However, the provision of information on online retail store sites, which are being used more frequently for grocery shopping, should allow for creative communication of more detailed information about nutrient levels and their effects. In addition, other promotional elements should be considered beyond point-of-sale materials in conveying such information, such as learning from prior successful anti-obesity campaigns (“Let’s Move”) and using key influencers and targeted social media. Early efforts in understanding the NFPs tapped into some of these efforts rather than just passively allowing a website to explain how a FOP symbol or system might work.

Here, a FOP label stressing negative nutrients in combination with quick and easy to process information of the disease risks associated with the negative nutrients could be beneficial. Currently, the Stop Sign label tells consumers that the product is “high” in a negative nutrient but does not specify the disease risk associated with that negative nutrient (e.g., heart disease, hypertension). In an online environment, in particular, it would be feasible to identify the specific links for a nutrient to online disease risk and specifics related to elevating objective nutrition knowledge. Such communications, in turn, may enhance consumers’ evaluation of the retailer (Newman et al., 2014). Given that consumers tend to strengthen the risk by weighing negative information more heavily, this additional piece of information of specific risk of a negative nutrient may act as an educational deterrent to making poor food choices – a potentially effective additional “nudge” in the right direction (Thaler & Sunstein, 2009). This could act as multi-faceted communication tool; it directly influences the effects of the negative nutrients, it functions indirectly through the mediation pathway that extends to purchase intentions, and it increases knowledge which positively influences desirable effects. Alternatively, our nutrition accuracy effects for the Traffic Light labels may work in more of a positive fashion by balancing the understanding of favorable and unfavorable nutrient levels, depending on the product and consumer.

6.4. Implications for marketing theory
Research shows that warnings can be an effective tool when appropriately designed for the right audience (Andrews, 2011), and the enhanced effects of negative information in general are well-known (Baumeister et al., 2001, Tversky and Kahneman, 1981). However, our studies extend these findings by showing how greater objective knowledge amplifies the weighting of the provision of a negative signal in a nutrition processing context. This finding is shown while accounting for subjective nutrition knowledge, age, gender, education, and income levels, and NFP information.  

Further, in an important extension of FOP labeling studies, we show a FOP label \( \rightarrow \) negative nutrient evaluation \( \rightarrow \) disease risk \( \rightarrow \) purchase intention mediation linkage that is contingent on objective knowledge. Specifically, high sodium/saturated fat perceptions and disease risk are shown to serially mediate the effect of FOP label type on purchase intention, but the mediation path becomes stronger (weaker) as objective knowledge increases (decreases). Yet, we also emphasize the nature of the divergence in the effects. That is, for the broad array of nutrient items evaluated, the negatively-focused signal tends to reduce nutrition use accuracy
relative to the more balanced traffic light signaling that can be positive (green), moderate (amber) or negative (red), allowing a more accurate processing of a set of nutrients

A primary point from our studies is the importance of examining what people actually know (i.e., objective knowledge) rather than what they think they know (i.e., subjective knowledge; Alba & Hutchinson, 2000), as we find the correlation between the two is positive but not strong (Study One r = .23; Study Two r = 0.12). Further, our predicted objective nutrition knowledge results remain after adjusting for subjective knowledge. Such findings are found in other more complicated processing environments for consumers, such as the role of financial literacy in processing financial information (Netemeyer, Warmath, Fernandes, & Lynch, 2018), and health literacy’s role in better understanding prescription drug information (Andrews, Kees, Paul, Davis, & Wolf, 2015).

6.5. Limitations and future research

Our findings are limited to the stimuli, procedures, samples, and outcome measures that we employed. We encourage researchers to examine other potential moderating and mediating conditions. These include the specific role of numeracy and health literacy (Tangari et al., 2014, Peters et al., 2006), prior health conditions (e.g., those with hypertension or on medically supervised diets) (Howlett, Burton, Tangari, & Bui, 2012), different types of nutrition knowledge measures and consequences (Andrews et al., 2009), and brand loyalty/prior usage (Cialdini, 1988, Smith and Swinyard, 1983). Certainly, there are other FOP labels, systems, and/or warnings (e.g., NutrInform Battery; Nutri-score; Dubois, Albuquerque, & Allais, 2021; red stop sign labels) that continue to emerge and may be worthy of further testing of effectiveness with important moderators, such as objective nutrition knowledge. To aid the generalizability of our findings, it also would be helpful to examine how the FOP labels and moderators perform using different product categories. As our current study did not use a quota sample on ethnicity, future FOP research could use quota or regional samples to generate balanced and large sample sizes to examine effects for ethnicity and vulnerable segments that may be at greater disease risk. Such research efforts are encouraged in the battle to increase nutritional knowledge in helping to reduce negative health consequences in the U.S. and throughout the world.

Declaration of Competing Interest
None.

References


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Notes

1Interestingly, this is in contrast to the FOP Smart Choices label originally advocated by many major CPG companies more than a decade ago that would have appeared on packages only in cases in which the product had a positive nutritional profile. Thus, unhealthy products not meeting the criteria would present nothing on the FOP.

2We assess these effects of objective nutrition knowledge while controlling for subjective nutrition knowledge, NFP presence, and demographics of gender, age, income, and education.

3Consistent with the first pretest, we examined effects of the FOP label manipulation and objective knowledge level across packages that included or did not include the NFP. For Study 1, we found only one significant effect of NFP as an independent variable. The high sodium / high saturated fat variable showed a higher ($F = 4.66, p < .05$) score when NFP was present. For all other dependent variables, the NFP produced no significant main or interaction effects. Given these results, and our focus on FOP and objective nutrition knowledge, we use the NFP only as a dummy variable covariate in the analyses that follow.

4Although there are significant interactions, the FOP main effects are of interest to consumer health advocates and to product marketers. Analyses generally indicate the main effects are interpretable (no disordinal interactions.)

5Nutrition use accuracy scores were also examined across FOP levels for just two of the key nutrients: saturated fat and sodium. The results indicate that nutrition accuracy was higher for the Stop Sign label (M = 1.34) than the Traffic Light label (M = 1.07; $p <.01$) due to the focus on the Stop Sign label on just these two nutrients. The interaction term for the FOPs and objective nutrition knowledge was not significant ($p = .089$).

6We conducted all of the above analyses in which objective nutrition knowledge was treated as a continuous quantitative variable and the FOP label was represented by two dummy coded variables in linear regression models. The regression-based results mirror those of the MANOVA /ANOVA results in terms of both statistical significance and effect sizes.

7There are similar effects found for simpler models that omit disease risk as a distal mediator in the model. In addition, this same mediational analyses were conducted with attitude toward brand as the final dependent variable in the chain of effects. The results were generally consistent with those found with intent to buy as the final dependent variable. These analyses are available upon request.

8We remind readers that we did match the TL and Stop Sign label conditions with the same guideline daily amounts (GDAs) in the form of the nutrient amount and daily value percentage (DV%) appearing in the FOP symbol when it was shown.

9As with Study One, we include an FOP control condition. For the more healthful favorable nutrition condition, there was a more moderate level of sodium (a yellow traffic light) because for the frozen dinner category it is extremely difficult to find products on the market that are very low in sodium. As in Study
One, we worked to keep nutrient levels consistent with frozen dinner products that could be found on the market.

For both studies, we also performed a parallel GLM in which we tested the effects of the FOP label manipulation with subjective knowledge as the moderator with a median split (4) at high and low levels, while using objective knowledge and all demographics as covariates. These analyses showed that subjective knowledge did not significantly interact with the FOP label manipulation for any outcome variable (all p-values > 0.10). However, we did find that subjective knowledge had a small significant main effect on disease risk. In Study One, the high subjective knowledge group mean for disease risk was 3.94; the low subjective knowledge group mean was 3.64 (F = 5.16, partial eta-square = 0.007). In Study Two, the high subjective knowledge group mean for disease risk was 4.30; the low subjective knowledge group mean was 3.74 (F = 25.66, partial eta-square = 0.024). In both studies, nutrition accuracy scores were actually lower (yet not significantly lower) for those with higher subjective knowledge. Also, as with Study One, we conducted the above analyses in which objective nutrition knowledge was treated as a continuous quantitative variable and the manipulated IVs as dummy coded variables in linear regression models. The regression-based results mirror those of the MANOVA/ANOVA results in terms of both statistical significance and effect sizes.

We also assessed if race/ethnicity affected our results. In Study One, African-Americans scored lower on objective nutrition knowledge, and higher on brand attitude and intent to buy than some of the other racial/ethnic groups. However, when entering race/ethnicity as a dummy-coded covariate in the MANOVAs, it did not affect the statistical significance or effect sizes of any other independent variable on any dependent variable. A similar pattern was found in Study Two.