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# Simplifying mental math: Changing how added sugars are displayed on the nutrition facts label can improve consumer understanding

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ABSTRACT

*Background:* Proposed variations to Nutrition Facts Labels (NFL) have included the display of added sugars (AS) content, but its impact on consumer understanding is poorly understood.
*Objective:* To examine the degree to which different formats for displaying AS influence consumer understanding, perceptions, and purchase intentions.
*Design:* Randomized-controlled online experiment.
*Participants:* A sample of 2509 U.S adults.
*Intervention:* Participants were randomized to 1 of 8 conditions and viewed 10 food or beverage images with either: (1) no label (control); (2) the current NFL (without AS); (3) the proposed NFL without AS; or the proposed NFL with AS in (4) grams, (5) grams and teaspoons, (6) grams and percent Daily Value (% DV), (7) grams with high/medium/low text, or (8) grams with high/medium/low text and %DV.
*Main outcome measures & statistical analysis:* ANCOVAs compared scores on quizzes that assessed the accuracy of judgments about AS, overall nutrition understanding and purchase intentions.
*Results:* Presenting AS in grams plus high/medium/low text with and without %DV led to the highest AS understanding scores (85% and 83% correct, respectively) compared to 70% correct when AS was not on the label or was displayed in grams only (74% correct). Displaying AS in teaspoons did not significantly improve understanding beyond grams alone. Consumers were best able to determine which of two products was healthier when AS was presented as %DV (68% correct) versus displayed in grams alone (60% correct), but %DV did not differ from high/medium/low text or teaspoons. None of the labels influenced purchase intentions relative to no label.
*Conclusion:* Displaying AS on the NFL in grams with high/medium/low text, %DV, or the combination of the two, improved consumer understanding more than presenting it in grams or teaspoons.


## 1. Background

Added sugars are caloric sweeteners, syrups and sugars that are not naturally present in foods but are added during food processing or preparation (What are added sugars, 2015). Besides being a source of calories, added sugars have little nutritional value. They are easily metabolized by the body and usually lead to quicker surges in blood sugar levels and insulin spikes compared to unprocessed, naturally occurring sugars (Arora & McFarlane, 2005; O'Keefe, Gheewala, & O'Keefe, 2008). Overconsumption of added sugars is associated with poor diet quality, excess body weight, Type 2 diabetes, and dental caries (Malik, Popkin, Bray, Després, & Hu, 2010; Marshall, Eichenberger Gilmore, Broffitt, Stumbo, & Levy, 2005; Sheiham & James, 2014; Yang et al., 2014). The adverse effects of added sugars have been recognized by several health agencies like the American Heart Association and the World Health Organization (WHO), which recommend lowering intake levels (Johnson et al., 2009; Guideline, 2016). The 2015 Dietary Guidelines for Americans suggests restricting total daily calories from added sugars to less than 10% (Dietary Guidelines for Americans, 2016; Scientific Report, 2015). Despite this, added sugars intake

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continues to exceed recommended levels (Welsh, Sharma, Grellinger, & Vos, 2011) and accounts for an average of 14.1% of total dietary energy in the U.S. across all age groups (Drewnowski & Rehm, 2014).

According to one estimate, 73.5% of the 85,541 unique packaged foods and beverages sold in the U.S contain added sugars (Ng, Slining, & Popkin, 2012), but the current Nutrition Facts Label (NFL) only displays the amount of "sugars" in a product, which is a combined total of both naturally occurring sugars and added sugars. Although sources of added sugars are displayed on the ingredient list, many consumers may not realize that these unfamiliar sounding names (e.g., sorghum, anhydrous dextrose, maltose) are actually added sugars (What are added sugars, 2015). To help consumers meet health agency recommendations, the Food and Drug Association (FDA) proposed a redesign of the NFL in February 2014 to include added sugars content displayed separately from "sugars" (Changes to the Nutrition Facts Label, 2016). In this version, the added sugars content was to be listed in grams. Since 2014, the NFL re-design proposal underwent two additional revisions. The first listed the amount of added sugars in grams along with a percent Daily Value (% DV) based on a maximum of 10% of total calories (Proposed Rule Food Labeling, 2015) and the second revision in May 2016 included text that read "Includes X g Added Sugars" under "Total Sugars" (Changes to the Nutrition Facts Label, 2016).

Few studies have examined how these proposed changes will impact consumer understanding of the NFL and whether other presentation strategies for added sugars might be more effective at communicating this important information. For example, researchers and advocates have suggested that presenting added sugars in more relatable formats such as number of teaspoons or with accompanying "high/medium/low" text may improve consumer understanding (Comments of the CSPI, 2014; Food labeling chaos, 2010; Roberto, 2012), but few studies have tested such formats. One study that randomly assigned 548 shoppers to different front-of-package nutrition labels found that adding high/medium/low text to traffic light labels or percent daily guidelines on labels increased consumer understanding of nutrient content (Malam et al., 2009). Another randomized experiment with 641 Canadians aged 16–24 found that displaying a %DV next to added sugars in grams led to more accurate estimates of added sugars content compared to either grams alone or including an ingredient list (Vanderlee, White, Bordes, Hobin, & Hammond, 2015). However, a randomized experiment with 213 adults found that those who viewed the current NFL without added sugars information for 20 cereals made nutrition judgments that were more highly correlated with an algorithm's score of overall nutritional quality compared to an NFL with added sugars in grams or an NFL listing added sugars under a "nutrients to avoid" heading (González-Vallejo & Lavins, 2015).

We sought to improve upon and extend the limited body of research on the inclusion of added sugars to the NFL by conducting a randomized-controlled online experiment that asked a large sample of U.S. adults to make nutrition judgments about a range of food products. The aim of this study was to examine the degree to which different formats for displaying added sugars influence consumer understanding, perceptions, and purchase intentions.

We hypothesized that for products containing added sugars, displaying added sugars information separately from total sugars would improve consumer understanding of added sugars content and decrease perceptions of product healthfulness and purchase intentions. We also hypothesized that displaying added sugars content in more meaningful formats (e.g., in teaspoons or accompanied by high/medium/low text) would increase consumer understanding of added sugars content and decrease perceptions of product healthfulness and purchase intentions relative to displaying added sugars in grams alone.

## 2. Methods

### 2.1. Participants

We recruited participants through Amazon's Mechanical Turk (MTurk), an online site where individuals can complete tasks for a small amount of money. All individuals over the age of 18 who were U.S. residents, familiar with using computers, and able to read English were eligible to participate. Data were collected in two waves, the first in January 2015 and the second in April 2015. Participants provided informed consent at the beginning of the survey and were compensated $1 for completing the survey. A total of 2992 participants initiated the survey. An entry was considered complete if participants responded to all parts of the survey and provided key demographic information (age, sex, ethnicity, and education status). We excluded 384 participants who failed to complete the survey and 99 participants who either had duplicate/identical IP addresses and/or completed the survey in less than one-third the average time (<7 min) because we felt that they could not have provided credible data in such a short period of time. On average, the survey took 23 ± 25 min to complete. Our final sample included 2509 participants (see Table 1 for description of study sample). All study procedures were approved by the Harvard T.H. Chan School of Public Health Institutional Review Board (IRB 14–2462).

### 2.2. Added sugars conditions

Participants were randomized to one of the following 8 conditions (see Fig. 1):

1. No label control.
2. Current NFL, which does not include information on added sugars.
3. NFL without added sugars, but with other proposed features including increased font size for calories and serving size, shifting %DV from the right to the left and displaying Potassium and Vitamin D content in place of Vitamins A and C.

The other five conditions included proposed NFL changes combined with different presentations of added sugars information.

4. Added sugars in grams (g)
5. Added sugars in g plus teaspoon text abbreviated as "tsp"
6. Added sugars in g plus %DV
7. Added sugars in g plus high/medium/low text
8. Added sugars in g plus high/medium/low text and % DV

The %DV for added sugars for each product was calculated based on the recommendations of the Dietary Guidelines for Americans for a 2000 kilocalorie (kcal) diet. This amounted to a DV of 200 kcal or 50 g (Dietary Guidelines for Americans, 2016). The high/medium/low text was based on added sugars content for each product. We defined "low" added sugars as ≤5% of DV (or ≤2.5 g), "medium" as 6–19% of DV (or >2.5 g ≤ 10 g) and "high" as ≥20% of DV (or ≥40 g) based on the FDA's recommendations (Food and Drug Administration, 2017).

We used an NFL template for all conditions based on the FDA's 2015 proposal because that is when we launched this study. The template we tested differed from the final revised NFL in three ways: 1) it included the term Sugars instead of Total sugars 2) it did

**Table 1**
Participant characteristics.

| Characteristics | Total sample N = 2509 | |
|---|---|---|
| **Age** | | |
| Mean years, SD | 36.4 | 12.3 |
| Median year | 33.0 | |
| **BMI**, (mean kg/m$^2$, SD) | 27.0 | 6.9 |
| **Sex**, (n, %) | | |
| Male | 1018 | 40.6 |
| Female | 1485 | 59.2 |
| Other | 6 | 0.2 |
| **Race**, (n, %) | | |
| White | 2087 | 83.2 |
| Black | 187 | 7.4 |
| Asian | 137 | 5.5 |
| Other | 98 | 3.9 |
| **Ethnicity**, (n, %) | | |
| Hispanic | 173 | 6.9 |
| Non-Hispanic | 2336 | 93.1 |
| **Education level**, (n, %) | | |
| High school/GED | 252 | 10.0 |
| Some college | 979 | 39.0 |
| College graduate | 948 | 37.8 |
| Postgraduate | 330 | 13.2 |
| **Relationship status**, (n, %) | | |
| Married | 963 | 38.4 |
| In a relationship | 582 | 23.2 |
| Single | 678 | 27.0 |
| Divorced | 157 | 6.3 |
| Widowed/separated | 129 | 5.1 |
| **Annual household income**, (n, %) | | |
| <$50,000 | 1283 | 52.8 |
| $50,001 - $75,000 | 554 | 22.8 |
| $75,001 - $100,000 | 318 | 13.1 |
| $100,001 - $125,000 | 148 | 6.1 |
| >$125,000 | 127 | 5.2 |
| **Employment**, (n, %) | | |
| Employed/self employed | 1764 | 70.3 |
| Unemployed | 305 | 12.2 |
| Retired/student | 440 | 17.5 |
| **Currently dieting**, (n, %) | | |
| Yes | 1116 | 44.5 |
| No | 1393 | 55.5 |
| **Grocery shopping for self and household**, (n, %) | | |
| All/most of the shopping | 1924 | 76.7 |
| Some of the shopping | 490 | 19.5 |
| Little/none of the shopping | 95 | 3.8 |
| **Perceived label understanding**, (n, %) | | |
| Good | 1536 | 61.2 |
| Fair | 911 | 36.3 |
| Poor | 63 | 2.5 |
| **Frequency of nutrition label use**, (n, %) | | |
| Always/often | 1508 | 60.1 |
| Sometime/never | 1001 | 39.9 |
| **Nutrition label influence**, (n, %) | | |
| Large extent | 1036 | 41.3 |
| Small extent | 1210 | 48.2 |
| No influence | 263 | 10.5 |

not include the language added in 2016 that explains total sugars "includes X g added sugars"; and 3) the %DV was displayed on the left side, as initially proposed, and not on the right as is currently proposed.

Within the groups displaying added sugars information, we hypothesized that conditions five through eight, which provide information to interpret added sugars content, would improve consumer understanding and influence purchase intentions more than presenting added sugars information in grams alone and the addition of "high/med/low" text would be more influential than grams or %DV alone.

Throughout the study, participants viewed food products with their corresponding NFL displayed next to the product (nutrient information was obtained from manufacturer websites), except for those in the control group who saw the product images without an NFL (See Fig. 2).

### 2.3. Survey procedure

In the first part of the survey, participants viewed images, one at a time, for four commonly consumed products (Kellogg's Raisin Bran (cereal), Coca Cola (beverage), Clif Chocolate Brownie Energy Bar (snack bar), and Home Run Inn Classic Cheese Pizza (frozen dinner) accompanied by the NFL to which they were randomized. Participants then answered the following five questions per product to assess label understanding: 1) How many total servings do you think this product contains?; 2) If you ate the entire container of this product, how many calories would you have eaten?; 3) If you chose to consume only X g of total carbohydrate in one eating occasion, how many servings of this product could you have? (Nutrient amounts for this question were chosen to be easily divisible by the existing carbohydrate content of each product; 23 g for the cereal, 10 g for the beverage, and 15 g for the energy bar and frozen dinner); 4) If you were to consume this entire product in one sitting, what nutrients do you think you would have in excess of the daily recommended amount? (Participants were asked to check all that apply among the following nutrients: calories, total carbohydrates, added sugars, total fat, saturated fat, cholesterol, sodium, vitamin D, Calcium, None); and 5) Do you think this product has a low, medium or high amount of added sugars? Participants were also asked "How likely are you to buy this product this month."

The second part of the survey asked participants to view three pairs of products (Soft Family Bread vs. **Whole Grain Honey Oat**; Kellogg's Frosted Flakes vs. **Frosted Cheerios**; Vitaminwater vs. **Gatorade**) (bold items indicate which product is healthier based on algorithm described below) and answered the following three questions for each product pair: 6) For each nutrient listed (total fat, added sugars, sodium, calcium, and iron), please tell us which product you think has more of the specific nutrient per serving of the product; 7) For each nutrient listed, please tell us which product you think is healthier based only on that specific nutrient, per serving, for the average person; and 8) Please select the product you think is healthier, per 100 grams, for the average adult (participants could select either product or indicate that the products are the same). Participants were also asked "How likely are you to buy this product this month" [1 = extremely unlikely to buy; 7 = extremely likely to buy] for each of the products in the comparison task. The questions used in this survey were adapted from studies screening for health literacy (Weiss et al., 2005) or testing consumer understanding of front-of-package (Roberto & Khandpur, 2014; Roberto et al., 2012) or back-of-package labels (Lando & Lo, 2013).

The final part of the survey assessed participants' general nutrition label use by asking, "On average, how much do nutrition labels influence your food and drink choices?" and "How often do you look for nutrition information on packaged foods when you are grocery shopping?" Participants' general nutrition knowledge was assessed with the following four questions: What is the average recommended intake of saturated fat for a healthy adult? (Correct response = Up to 20 g); What is the current recommendation for daily calorie intake for a normal weight adult? (Correct response = 2000 kcal); Is brown sugar a healthier alternative to regular (white) sugar? (Correct response = Both products are the same); Do you think these foods are high or low in added sugars? [Food (correct response): Banana ("does not contain added sugars"), flavored yogurt ("high"), regular ice cream ("high"), tomato ketchup ("high"), canned fruit in natural fruit juice ("high")]. The latter two questions were taken from the validated general

**Condition 1 - Product image only (control)**

**Condition 2 – Current NFL, no added sugars**

| | |
|---|---|
| **Total Carbohydrate** 46g | **15%** |
| Dietary Fiber 7g | **28%** |
| Sugars 18g | |
| **Protein** 5g | |

**Condition 3 – Proposed NFL, no added sugars**

| | |
|---|---|
| **15%** | **Total Carbs** 46g |
| **28%** | Dietary Fiber 7g |
| | Sugars 18g |
| | **Protein** 5g |

**Condition 4 – Proposed NFL, added sugars (g)**

| | |
|---|---|
| **15%** | **Total Carbs** 46g |
| **28%** | Dietary Fiber 7g |
| | Sugars 18g |
| | Added Sugars 15g |
| | **Protein** 5g |

**Condition 5 – Proposed NFL, added sugars (g) + teaspoons**

| | | |
|---|---|---|
| **15%** | **Total Carbs** 46g | |
| **28%** | Dietary Fiber 7g | |
| | Sugars 18g | |
| | Added Sugars 15g | **(4tsp)** |
| | **Protein** 5g | |

**Condition 6 - Proposed NFL, added sugars (g) + %DV**

| | |
|---|---|
| **15%** | **Total Carbs** 46g |
| **28%** | Dietary Fiber 7g |
| | Sugars 18g |
| **30%** | Added Sugars 15g |
| | **Protein** 5g |

**Condition 7 - Proposed NFL, added sugars (g) + high/medium/low text**

| | | |
|---|---|---|
| **15%** | **Total Carbs** 46g | |
| **28%** | Dietary Fiber 7g | |
| | Sugars 18g | |
| | Added Sugars 15g | **(High)** |
| | **Protein** 5g | |

**Condition 8 - Proposed NFL, added sugars (g) + high/medium/low text+ %DV**

| | | |
|---|---|---|
| **15%** | **Total Carbs** 46g | |
| **28%** | Dietary Fiber 7g | |
| | Sugars 18g | |
| **30%** | Added Sugars 15g | **(High)** |
| | **Protein** 5g | |

**Fig. 1.** Added sugars label images for each study condition.
Note: This figure shows sections of the Nutrition Facts Labels (NFLs) with different formats for displaying added sugars. In the survey, all images in conditions 2 through 8 included a picture of the product next to an image of the entire NFL. The image of the product has been blurred for this publication.

nutrition knowledge questionnaire for adults (Parmenter & Wardle, 1999). Information on age, body mass index (BMI), sex, history of chronic diseases, education, race and ethnicity, employment, income levels, weight, grocery shopping patterns, dieting, and current relationship status was also collected.

### 2.4. Study outcomes

#### 2.4.1. Added sugars understanding quiz

Our primary outcome was consumers' understanding of added sugar content. To generate this quiz score, we summed responses to all 14 questions about added sugars (Questions 4, 5, 6, 7 described above) and converted that sum to a percentage correct score out of 100%.

#### 2.4.2. Nutrition label understanding quiz

Our second outcome was consumers' overall understanding of nutrient content. To generate this score, we summed responses to all 92 nutrition questions, including the 14 questions about added sugars (Questions 1 through 7 described above) and converted this to a percent correct score.

#### 2.4.3. Nutrition quiz for other label changes

We were also interested in assessing how the other proposed NFL changes (increased font size for calories and serving size and shifting %DV from the right to the left) impacted overall nutrition understanding relative to the current NFL label. To do this, we summed responses to all 74 nutrition understanding items (questions 1–7 described above) excluding questions about the nutrients

**Nutrition Facts**

**12 servings per container**

Serving size 1 cup (59g)

**Amount per 1 cup**

**Calories 190**

| % DV* | |
|---|---|
| 2% | **Total Fat** 1g |
| 0% | **Saturated Fat** 0g |
| | ***Trans* Fat** 0g |
| 0% | **Cholesterol** 0mg |
| 9% | **Sodium** 210mg |
| 15% | **Total Carbs** 46g |
| 28% | **Dietary Fiber** 7g |
| | **Sugars** 18g |
| | **Added Sugars** 15g **(High)** |
| | **Protein** 5g |
| 10% | **Vitamin D** 1mcg |
| 2% | **Calcium** 20mg |
| 25% | **Iron** 5mg |
| 6% | **Potassium** 210mg |

* Percent Daily Values are based on a 2,000 calorie diet. Your daily value may be higher or lower depending on your calorie needs.

| | Calories: | 2,000 | 2,500 |
|---|---|---|---|
| Total Fat | Less than | 65g | 80g |
| Sat Fat | Less than | 20g | 25g |
| Cholesterol | Less than | 300mg | 300mg |
| Sodium | Less than | 2,400mg | 2,400mg |
| Total Carbohydrate | | 300g | 375g |
| Dietary Fiber | | 25g | 30g |

Note: The image of the product has been blurred for this publication.

**Fig. 2.** Sample survey image of a product with its nutrition facts label.
Note: The image of the product has been blurred for this publication.

that did not appear across all label conditions (added sugars, potassium and vitamin D) and converted this to a percent correct score. For this outcome, we only compared the NFL conditions to each other, excluding the control group.

*2.4.4. Healthier product quiz*

To generate this quiz score we summed all correct responses for the 3 items (question 8 described above) that asked participants to identify the healthier of two products and converted this to a percentage correct score. A response was coded as correct based on the Nutrient Profile Model algorithm, which allocates points for foods based on the amount of kcals, saturated fat, total sugar, sodium, fiber, and protein as well as fruit, vegetable, and nut content per 100 g (Nutrient profiling model, 2010). This scoring system has been validated with nutritionists (Arambepola, Scarborough, & Rayner, 2008) and is used to determine which foods can be marketed to children during children's television programming in the United Kingdom (Nutrient profiling model, 2010).

*2.4.5. Purchase intentions*

We averaged responses across all 10 items (for 4 products displayed one at a time and 3 displayed as pairs) that asked participants to rate their likelihood of buying the product in the next month from 1 = extremely unlikely to buy to 7 = extremely likely to buy.

*2.4.6. Nutrition label opinion*

At the end of the survey, participants were asked if the label to which they were randomized was easy to read, helpful in deciding what to buy, had too much information (reverse coded), was confusing (reverse coded), or took too much time to read (reverse coded). Responses were averaged across all 5 questions [1 = 'I strongly disagree' to 5 = 'I strongly agree']. These questions have been used by previous studies on nutrient labeling (Lando & Lo, 2013; Möser, Hoefkens, Van Camp, & Verbeke, 2010) and were only asked of participants randomized to a condition that displayed an NFL.

### 2.5. Statistical analysis

Continuous outcomes were compared using one-way ANCOVAs controlling for race. Significant omnibus tests were followed by post hoc Tukey HSD tests. Chi-square tests were used to examine categorical variables. All analyses were conducted using SAS 9.4.

## 3. Results

### 3.1. Participant characteristics

Participant characteristics are summarized in Table 1. Nearly 60% of the final sample was female, 83% was White and 51% had college degrees. Mean participant age was 36.4 ± 12.3 years and mean BMI was 27 ± 6.9 kg/m$^2$. Seventy-six percent of participants reported doing most or all of the grocery shopping for their household. There were no significant differences across groups on participant characteristics except for race (p-value = 0.04). Although we controlled for race in our analyses, this did not meaningfully change any of our results. Overall, the time spent on the survey varied across study arms ($p < 0.001$) as those in the control arm, having no labels to read, took the least amount of time (15 ± 10 min). None of the label conditions significantly differed from each other on completion time ($p = 0.64$) or across general nutrition knowledge ($p = 0.103$).

### 3.2. Added sugars understanding quiz

All results are summarized in Table 2. There were significant differences across study conditions for the primary outcome of added sugars understanding (see Fig. 3). All labels led to significantly higher quiz scores compared to the no label control group. Further, labels displaying added sugars information increased understanding compared to those labels without such information. Both label groups that viewed high/medium/low text significantly outperformed all other study groups, but did not significantly differ from one another. Although displaying added sugars in grams plus %DV was not as effective as including high/medium/low text, it did increase understanding more than displaying added sugars in teaspoons or in grams alone. Contrary to our hypothesis, adding a teaspoons label to added sugars in grams did not significantly improve understanding more than grams alone.

### 3.3. Nutrition label understanding quiz

As expected, the presence of any NFL led to significantly better overall nutrition understanding compared to no label. Similar to the results from the added sugars understanding quiz, display formats with added sugars information in grams and high/medium/low text produced the highest quiz scores in overall nutrition label understanding and those labels performed better than displaying the information in grams alone. The two high/medium/low text groups did not differ from one another or from presenting the information in %DV or teaspoons.

### 3.4. Nutrition quiz for other label changes

There were no significant differences between NFL groups when assessing whether the other proposed design changes (increased font size for calories and serving size and moving % DV from the right to the left) promoted better label understanding.

### 3.5. Healthier product quiz

Those who saw added sugars in grams plus %DV were most accurate when identifying the healthier of two products and they did significantly better than the current NFL, the proposed NFL without added sugars, the proposed NFL with added sugars in grams only and the no label control groups (See Table 2). However, grams plus %DV did not significantly differ from labels with teaspoons or high/medium/low text, which scored better than the current label and no label.

### 3.6. Purchase intentions

There were no significant differences in purchase intentions across study arms.

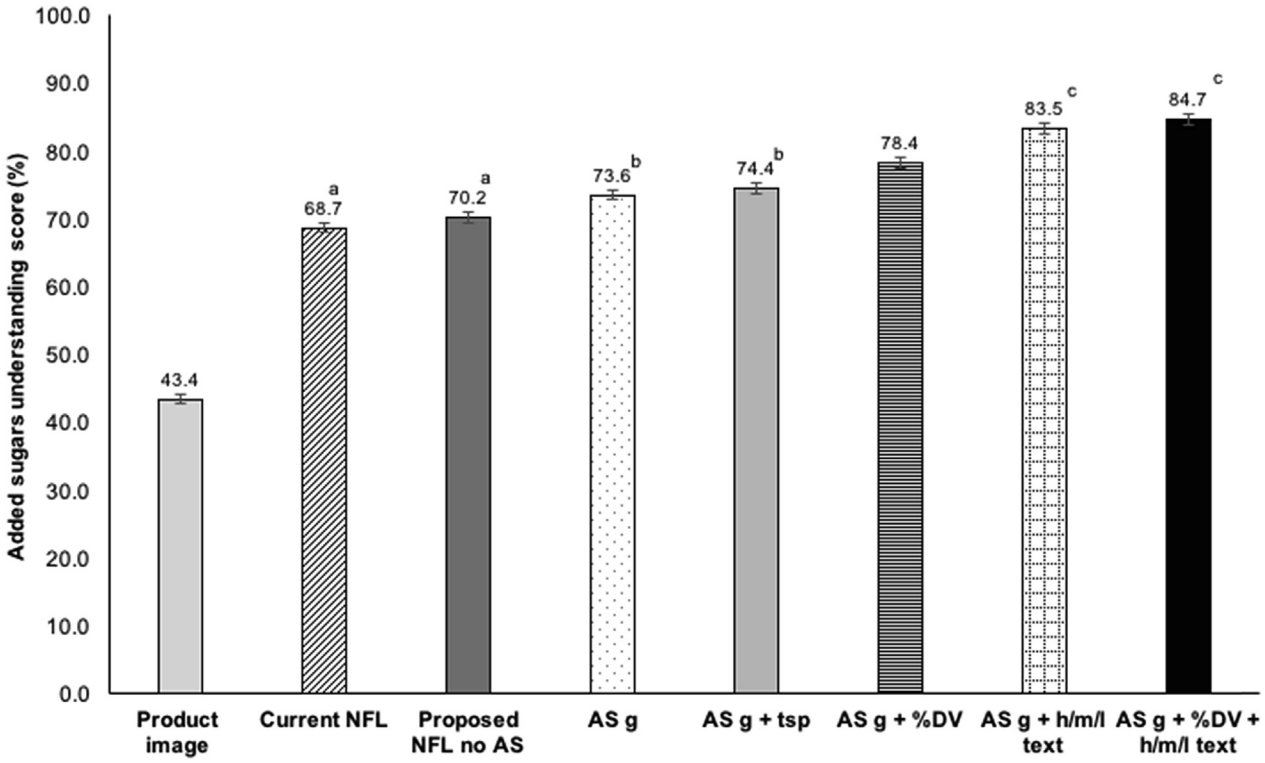
### 3.7. Nutrition label opinion

Across study arms (excluding the no label control participants), there were no significant differences in opinions about the labels that participants were randomized to. The mean label opinion score was 3.96 ± 0.68 on a 1–5 scale, indicating that participants tended to have a favorable opinion of the labels across added sugars formats (See Table 2).

**Table 2**
Raw means (standard errors) for outcome variables.

| Outcomes | No label Control N = 319 a | Current NFL (no AS) N = 329 b | Proposed NFL no AS N = 320 c | Proposed NFL with added sugars displayed as: | | | | | F stat. | p[d] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | g N = 301 d | g + tsp N = 310 e | g + %DV N = 308 f | g + h/m/l text N = 307 g | g + %DV + h/m/l text N = 315 h | | |
| **Added sugar understanding quiz**[a] | 43.37 b c d e f g h (0.67) | 68.69 a d e f g h (0.76) | 70.18 a d f g h (0.81) | 73.56 a b c f g h (0.74) | 74.42 a b c f g h (0.75) | 78.39 a b c d e g h (0.80) | 83.48 a b c d e f (0.78) | 84.74 a b c d e f (0.78) | 289.16 | <0.001 |
| **Nutrition label understanding quiz**[a] | 48.31 b c d e f g h (0.34) | 83.42 a g h (0.54) | 83.37 a g h (0.64) | 83.27 a g h (0.65) | 85.00 a (0.59) | 85.73 a (0.63) | 86.26 a b c d (0.62) | 86.19 a b c d (0.64) | 503.63 | <0.001 |
| **Nutrition quiz for other label changes**[a] | N/A | 86.63 (0.59) | 85.56 (0.68) | 84.84 (0.70) | 86.68 (0.62) | 86.95 (0.65) | 86.61 (0.64) | 86.33 (0.65) | 1.33 | 0.241 |
| **Healthier product quiz**[a] | 41.47 b c d e f g h (1.43) | 51.67 a c d e f g h (1.66) | 58.85 a b (1.68) | 59.58 a b (1.69) | 62.90 a b (1.70) | 67.97 a b c d (1.66) | 63.08 a b (1.74) | 64.34 a b (1.72) | 26.16 | <0.001 |
| **Purchase intentions**[b] | 3.24 (0.06) | 3.26 (0.06) | 3.23 (0.06) | 3.35 (0.06) | 3.22 (0.07) | 3.22 (0.06) | 3.21 (0.06) | 3.04 (0.06) | 1.64 | 0.118 |
| **Nutrition label opinion**[c] | N/A | 3.93 (0.03) | 3.96 (0.03) | 3.93 (0.03) | 4.02 (0.03) | 3.93 (0.03) | 4.03 (0.03) | 3.93 (0.03) | 1.30 | 0.253 |

AS = Added sugars; g = grams; tsp = teaspoons; h/l/m = high/medium/low.
Letter superscripts (e.g., a b c) indicate that a result is significantly different from the study condition with the corresponding letter based on Tukey-Kramer post-hoc tests.
[a] Percentage correct score measured from 0 - 100.
[b] Measured on 1 (extremely unlikely to buy) –7 (extremely unlikely to buy) Likert scale.
[c] Measured on 1 (strongly disagree)-5 (strongly agree) Likert scale.
[d] =Raw means are presented, but ANOVA F test statistics and p values are based on models controlling for race.




Note: Bars with the same letter do NOT significantly differ at $p < 0.05$; all other comparisons are significant at $p<0.05$.

**Fig. 3.** Percent correct on added sugars understanding quiz (means and standard errors) across study conditions.
Note: Bars with the same letter do NOT significantly differ at $p < 0.05$; all other comparisons are significant at $p < 0.05$.AS = Added sugars; g = grams; tsp = teaspoons; h/m/l = high/medium/low.

## 4. Discussion

As expected, we found that disclosing added sugars information to the NFL helped participants better estimate added sugars content. In addition, the format in which added sugars information was displayed on the label mattered. NFLs that displayed added sugars in grams plus high/medium/low text were easiest to understand when making judgments about added sugars content. This label format best helped participants to (1) extract and manipulate added sugars information from the nutrition label, (2) categorize added sugars amounts into meaningful levels (low/medium/high) (3) compare amounts of added sugars present in a serving of a product to determine the product with the higher amount, and (4) identify that a higher amount of added sugars per serving was less healthy. Participants viewing this label scored significantly higher in the added sugars understanding quiz than those in label conditions where added sugars was presented in grams or in grams plus teaspoons. Participants' ability to accurately comprehend added sugars information by adding "high/medium/low" text increased regardless of whether %DV information was also included.

These findings are consistent with front-of-package labeling studies that also found that the addition of high/medium/low text to traffic light or percent daily Guideline labels improved consumer understanding (Malam et al., 2009). Although adding high/medium/low text led to the greatest increases in consumer understanding, displaying added sugars information as %DV was more helpful than only displaying the information in grams or grams plus teaspoons. This was particularly true for the added sugars understanding quiz. For the nutrition label understanding quiz outcome, the display formats with added sugars information in grams plus high/medium/low text were the only ones to significantly outperform the grams only format, but there were no other differences across label designs. Past research has also consistently found support for using %DV to increase consumer understanding of added sugars information (Vanderlee et al., 2015). When examining our third nutrition understanding outcome (healthier product quiz), we saw that all the labels helped consumers identify the healthier of two products compared to no label, but only the grams plus % DV label outperformed other labeling formats. It did not, however, perform significantly better than labels with teaspoons or high/medium/low text.

Contrary to our hypothesis, displaying added sugars in grams plus teaspoons did not improve consumer understanding of added sugars information or help participants identify the healthier of two products more than listing this information in grams alone. These results are consistent with findings from a similar experiment that randomized 2008 Canadians to one of six label formats. When participants had to determine the amount of sugar in products either high or low in sugar content, NFLs where total sugars were displayed as %DV led to more correct responses than the current Canadian label or an NFL with added sugars displayed with a teaspoons text label (Vanderlee et al., 2015). It is possible teaspoons are not a meaningful measurement for most people and that providing information in the context of a recommended daily allowance (i.e., %DV) is more helpful, especially among products where added sugar is not the primary ingredient. However, future

research should examine whether presenting added sugars in teaspoons is helpful for other products where the primary ingredients include added sugars like sugar-sweetened beverages. Another possibility is that the "tsp" abbreviation we used, although commonplace and recommended in the scientific advisory report for the DGA (Scientific Report, 2015), may have been confusing. These results suggest that including teaspoons to help consumers with low literacy levels make healthier purchase decisions (Scientific Report, 2015) may not achieve the desired goal, but this should be confirmed in lower-income populations.

Finally, none of the labels impacted purchase intentions. This is consistent with another experimental study, which also found no effect of NFL formats on purchase intentions (González-Vallejo & Lavins, 2015). There was also no evidence that the other proposed NFL changes impacted consumer understanding or purchase intentions.

Taken together, our results suggest that the addition of added sugars to the NFL may improve consumer understanding, but might have very limited impact on behavior. However, the inclusion of added sugars on the NFL might spur industry action to reduce added sugar content, similar to the industry response to the mandate to include trans fats on the label (Mozaffarian, Jacobson, & Greenstein, 2010).

This study has several limitations. We recruited a convenience sample of participants from an online community. Our sample differs from the U.S population in several ways. Based on 2010 and 2015 U.S. census data, the sample in this study had more White (83.2% vs 72.4%) (United States Census Bureau, 2010a) and female (59.2% vs 50.8%) (United States Census Bureau, 2010b) and slightly younger participants (median of 33.0 vs 37.2 years) (United States Census Bureau) than the free-living U.S population. In addition, our sample was more educated (51% had at least a bachelor's degree vs 32.5%) (United States Census Bureau, 2015a) but 52.8% reported an annual household income of <$50,000 which is lower than the U.S median of $55,775(United States Census Bureau, 2015b). Finally, although our sample had a slightly lower mean BMI than the U.S. average (27 vs 28.7 kg/m$^2$) (Flegal, Carroll, Kit, & Ogden, 2012), this mean is over the threshold for overweight (BMI >25 kg/m$^2$). Although not representative of the US population, evidence suggests that MTurk respondents are more diverse in age, gender, and education compared to college samples (Goodman, Cryder, & Cheema, 2013; Paolacci, Chandler, & Ipeirotis, 2010). In addition, we studied label responses in a controlled environment and do not know if these results would hold in real-world settings where consumers are exposed to more marketing, have a larger selection of products to choose from, and often have limited time and attention. Finally, one category of quiz questions that contributed to our primary dependent variable of added sugars understanding asked participants to identify whether products had low, medium, or high amounts of added sugar. It is therefore not surprising that those viewing a label with the same text performed better on those questions. Although those questions contributed to the superior scores for that condition, they also contributed to superior scores for the %DV group, which does not convey the identical information needed to answer the question. This could be viewed as a limitation of our dependent variable, but ultimately we want nutrition labels that help people make quick, basic judgments about foods, including how much of a certain nutrient it contains. It therefore makes sense to test labels that convey precisely what it is that we want people to know. Our results show some support for the display of added sugars in grams along with %DV as is planned for the new NFL. We did not, however, test additional display features, including the sentence explaining that added sugars is included in total sugars.

This study also has a number of strengths. These are some of the first data assessing how consumers engage with NFLs and the potential impact of the different ways in which added sugars information could be displayed on the label. Other strengths include a large sample size, a randomized-controlled design, inclusion of multiple products, and a variety of outcomes to assess NFL influence.

## 5. Conclusion

Nutrition education tools like the NFL have an important role to play in helping consumers understand basic information about what they are eating. Our results suggest that disclosing added sugars on the NFL might increase consumer knowledge of added sugar content and this effect can be increased by displaying such information in conjunction with high/medium/low text, %DV, or the combination of the two. In addition, the common recommendation to display added sugars information in teaspoons may not be an effective way to improve consumer understanding. Future research should examine whether other alterations to the NFL might further improve consumer understanding, keeping in mind that policy and/or voluntary industry strategies beyond NFL changes will likely be needed to meaningfully influence behaviors.

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## Conflict of interest

The authors of this study have no conflict of interest, including specific financial interests, relationships or affiliations to declare.

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