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The creation of an online grocery store for experimental purposes: A pilot study

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ABSTRACT

More households shop for groceries online than ever in the United States. Thus, changes in online grocery store environments can affect the nutritional quality of food choices on a large scale. In response, we built a simulated online grocery store for experimental purposes. This paper describes the development of an online grocery store that displays actual products, brands, sizes, prices, pictures, and ingredient lists sold in current online grocery stores in the United States. We ran a pilot study to evaluate this research tool by calculating adherence and accounting for participants' experiences. We assessed the impact of game elements (point scoring and a scoreboard) and different budgets on the nutritional quality of the food bundle in the final shopping baskets of participants (n = 654). Participants in the treatment group saw the nutritional quality rating system illustrated for each food item as 1 to 5 "crowns." Ordinary least square regressions compared the nutritional quality of the final shopping baskets between experimental groups. Participants who saw the game elements selected food bundles with 2.53 (CI 95% [0.72; 4.33], p = 0.006) more crowns in their final basket. Receiving a high budget ($50) increased the number of crowns by 2.78 (CI 95% [0.66;4.90], p = 0.010) compared to a low budget ($30). We found no significant interaction between the game intervention and budget level. Participants noted that the store was intuitive to navigate, had a high-quality interface, and easily found the products they often buy. The game elements encouraged shoppers to make healthier food choices. Our simulated grocery store can help researchers gain insight into online consumer behavior by testing interventions.

1. Introduction

Online grocery shopping surged during the height of the COVID-19 pandemic (Ellison et al. 2021, Redman 2021). Concomitantly, the United States Department of Agriculture (USDA) expanded the use of the Supplemental Nutrition Assistance Program (SNAP, formerly the Food Stamp Program) in online grocery stores. However, mixed early evidence of the healthfulness and cost-effectiveness of food selected online suggests that online purchases may differ from in-store food purchases (Coffino et al., 2021; Headrick et al., 2022; Huyghe et al., 2017; Olzenak et al., 2020; Chester et al., 2020; McCarthy et al., 2020). In addition, federal policy in the United States does not require the display of Nutrition Facts Panels for products in online grocery stores, potentially complicating healthful food choices online (Pomeranz et al., 2021).

Extensive research has explored the effect of intervention in simulated and actual in-store and online grocery stores (van Herpen et al., 2016; Hartmann-Boyce et al., 2018). However, given the importance and potential growth of online grocery shopping, researchers need accessible tools for evaluation. Simulated online grocery stores can potentially be practical and valid instruments to study food choices if they recreate the most salient aspects of real-life online grocery stores. Some researchers have used online grocery platforms to evaluate sustainable food choices (Demarque et al. 2015; Kanay et al. 2021; Panzone et al., 2021a; Panzone et al., 2021b), while others have assessed the impact of nutrition information on the nutritional quality of food purchases (Waterlander et al., 2011; Waterlander et al., 2015). For example,

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nutrition advice lowered the saturated fat of products in shopping baskets in Australia (Huang et al., 2006). Labels helped to change the nutrient profile score of foods sold in the Netherlands (Jansen et al., 2021) and improved nutrition indicators (Finkelstein et al., 2019) in Singapore but not in the US (Howe et al., 2022). Labels also reduced the demand for products high in sugar in Singapore (Ang et al., 2019) and decreased the purchase of pre-packaged foods, especially for the most unhealthy products in France (Egnell et al., 2021). Offering product swap suggestions in an online grocery store did not lower the energy density of selected foods (Forwood et al., 2015); however, product placement lowered the saturated fats of food selection in the United Kingdom (Koutoukidis et al., 2019) and the United States (Howe et al., 2022).

Despite the potential advantages of simulated online environments for research, studies so far have little detail about the construction of the stores (Hartmann-Boyce et al., 2018). Furthermore, descriptions miss product inclusion and exclusion criteria (Hoenink et al., 2020; Forwood et al., 2015), and simulated stores often exclude popular food and beverage brands (Waterlander et al., 2011). We constructed The Grocery Store to enable externally valid experimental tasks based on products representative of typical grocery stores in the United States. This article describes product selection and participants' experiences in The Grocery Store, which are important steps toward transparency of the digital food environments literature.

Further, we ran a pilot study, assessed adherence to experimental tasks, and asked participants open-ended questions about their experiences. Participants shopped for groceries constrained by a budget to assess the response to the nutrition value of selected foods in an environment where all products had the Nutrition Facts Panel. Economic analysis of consumer demand assumes optimization of a utility function that incorporates individual preferences and takes income and prices as given. The result of this optimization is a set of individual product demands expressed as functions of the budget parameters (McFadden & Fosgerau, 2012). Moreover, the quality of food consumption is lower for households with lower incomes in the United States and energy-dense foods cost less both in real-life grocery stores and in our store (Drewnowski, 2010; Waterlander et al., 2010, Zhang et al., 2018). In addition, the field of behavioral economics expands the basic economic framework to acknowledge that context and choice architecture can shape consumer choices (Caputo and Just, 2022). In this pilot study, we explore the effect of introducing game elements to the shopping experience on the nutrition quality of food choice.

Interventions should not exclusively focus on information and education (Kirschenbaum & Gierut, 2013), as knowledge alone is often insufficient to modify and maintain healthy behavior (e.g., healthy food choices) (Schaefer & Magnuson, 2014; Webb & Sheeran, 2006). Part of the sample was randomized into "gamified" conditions that included point scoring and visualization of progress to encourage healthy food choices latently. Gamification is the use of game elements such as points scoring, leaderboards, and progress indicators as incentives to engage and motivate behavior outside of game settings (Deterding et al., 2011; Hamari et al., 2014 Mekler et al., 2017, Seaborn and Fels, 2015). Recent articles suggested that granting points through audio clues from devices like Amazon Alexa and Google Assistant motivated housecleaning behavior (Braeuer and Mazarakis, 2022). Researchers in the gamification literature have used points, badges, and leaderboards based on Social Determination Theory, which suggested that game elements spured intrinsic motivations, thus altering behavior toward a predetermined goal (Ryan & Deci, 2000). Thus, a gamified environment does not necessarily produce "winners" competing against other participants, nor does it need to award real prizes.

Gamification can help participants process information more automatically, especially for implicitly delivered messages (Baranowski et al., 2016). It can also enhance exposure to a health intervention (Baranowski, Buday, Thompson, & Baranowski, 2008) because it attracts, captures, and maintains attention by being fun (Ritterfeld, Cody, & Vorderer, 2009). Gamification has become a popular tool to incentivize behavioral change (Parisod et al., 2014), for example, to train physical and mental behavior to lower body mass index (Lu, Kharrazi, Gharghabi, & Thompson, 2013; Van't Riet, Alblas, Crutzen, & Lu, 2015), promote green energy consumption (Hamari et al., 2017), and help language learning (Vesselinov & Greco, 2012). We extend this literature by using game elements to inform the nutrition quality of foods in an online grocery store. We hypothesized that gamification and budget level change the final shopping baskets' nutritional quality.

2. Materials and methods

Researchers from the Visual Analytics Lab at the Department of Computer Science and the Friedman School of Nutrition Science and Policy at Tufts University created The Grocery Store, a simulated online grocery store built to be easily adaptable to our experimental goals. The Grocery Store is analogous in product variety, design, brands, sizes, prices, pictures, Nutrition Facts Panels, and ingredient lists to mid-sized grocery stores in the United States. This realistic environment serves multiple experimental purposes and facilitates the study of how food environments can affect food choices on a variety of topics, including nutrition quality, gamification, budget, sustainability, price, labeling, and others.

2.1. The Grocery Store data sources

The research team licensed Syndigo and Guiding Stars data to build the Grocery Store. Syndigo is a company that provides standardized images, Nutrition Facts Panel data, and product descriptions to online and brick-and-mortar grocery retailers (Syndigo, 2022). Guiding Stars uses algorithms informed by an independent science advisory panel to provide a rating system for fresh, packaged, and prepared foods. Participating retailers, for example, Ahold Delhaize in the United States, display the nutrition rating in brick-and-mortar stores as "Guiding Stars" shelf tags and in online stores. Researchers have evaluated the ability of the Guiding Stars system to encourage healthy food choices (Guiding Stars, 2018; Fischer et al., 2011; Sutherland et al., 2010).

The Guiding Stars system is consistent with the Dietary Guidelines for Americans and the Food and Drug Administration (FDA) labeling policy (Guiding Stars, 2018). The Guiding Stars algorithm evaluates the nutrient content of foods using the Nutrition Facts Panel and the ingredient list on the packaging (Guiding Stars, 2018) unless they are below a caloric threshold (for example, water and spices). In addition, the algorithm standardizes products to 100 kcal serving sizes for evaluation and consumer comparison. It only evaluates nutrients in foods with significant scientific consensus concerning health promotion or disease prevention (Guiding Stars, 2018).

The Guiding Stars system credits foods with points according to the presence of vitamins, minerals, fiber, whole grains, omega-3 fatty acids, and monounsaturated fatty acids (for fats and oils only). It deducts points for the amounts of trans fatty acids, saturated fatty acids, added sodium, added sugars, artificial colors, and food dyes. The algorithm produces a net score for each product from -41 to $+11$. The Guiding Stars company deems foods with a positive score as healthy and foods with a zero or negative score as unhealthy.

The Guiding Stars program uses visual cues – "Guiding Stars" – to indicate the healthiness of food. Participating supermarkets display one (healthy) to three (healthiest) Guiding Stars for food and beverage products on brick-and-mortar aisles and online. However, for products deemed unhealthy, those products do not receive Guiding Stars. Additionally, Guiding Stars does not evaluate products below a calorie threshold; thus, products like spices and water do not receive Guiding Stars. Therefore, we excluded these products and most beverages, except milk, from the Grocery Store. The 2022 revision of the Guiding Stars system rated water (Guiding Stars, 2022).

We used the Guiding Stars point system but converted the visual cues

from Guiding Stars to crowns and created a scale from one (lower Guiding Stars score) to five (higher Guiding Stars score) crowns. As a result, every food in The Grocery Store had a Guiding Stars score and the associated crowns. This greater granularity of one to five crowns, instead of one to three Guiding Stars, allowed for more differentiation between products, namely unhealthy foods, and gave research participants more information about every product. As a result, unhealthy foods, which comprised 89% of the products displayed in The Grocery Store, received one or two crowns instead of no Guiding Stars. The breakdown of the number of points and Guiding Stars is in Table 1.

2.2. Product selection for The Grocery Store

Previous research has used different simulated grocery store environments. For example, Koutoukidis et al. (2019) and Forwood et al. (2015) used a supermarket simulation in the United Kingdom with more than 11,000 items, whereas Machin et al. (2017) offered 232 products. For The Grocery Store simulation, we worked with Guiding Stars to identify the most purchased items within food categories representative of the sales at typical American mid-sized grocery stores. In addition, Guiding Stars provided information about product sales movement by category and appropriate aisle placement for the selected food items.

The movement sales of units or pounds purchased in partner supermarkets dictated the inclusion of products from the Guiding Stars database in The Grocery Store. We excluded products that were not food (for example, flowers) or not relevant for our experimental purposes (for example, spices, fats and oils, and infant and toddler foods). Most exclusions were due to the lack of enough sales movement suggesting a lack of relevance to the typical American consumer. The Grocery Store extracted 7,000 universal product codes (UPC) and Global Trade Item Numbers (GTIN) from the Guiding Stars database, of which about 4,800 scored zero or fewer Guiding Stars points. We matched the UPCs and GTINs extracted from Guiding Stars with UPCs and GTINs from Syndigo. The data from Syndigo included product information (pictures, ingredient lists, and nutrition information) (Syndigo, n.d.).

The Grocery Store excluded the 1,638 items from Guiding Stars without corresponding information from Syndigo. Product prices from the Guiding Stars database varied by item, company, market region, and period. The Grocery Store prices are the average retail prices over two weeks: The first week was October 12 to 18, 2019, which reflected the data extraction period from the Guiding Stars database. The second week was May 16 to 22, 2020, which reflected prices impacted by Covid-19 and excluded summer seasonality. We used an average retail price across markets for one week when the average retail price was unavailable for both weeks.

2.3. The grocery store display

The Grocery Store contains 5,362 UPCs and GTINs commonly sold in American grocery stores from various national and local brands and sizes. The Grocery Store displays products by movement (most to least sold) and is organized into ten categories: Bakery, Breakfast, Canned Goods, Dairy & Eggs, Dry Goods & Pasta, International, Frozen, Pantry, Produce, and Snacks. In addition, the categories represent 54 smaller sub-categories, such as Bread, Canned Soup, and Fresh Fruits. The detailed list of subcategories by category of food in the Store and the number of items of each is in Appendix 1. From the nutrient information, the research team developed Nutrition Facts Panels following the FDA guidelines for packaged foods with data from Syndigo (2021). All participants could see the Nutrition Facts Panels and ingredient lists by clicking on the items.

Table 1
Guiding Stars point system.

General foods and beverages points	Meats, poultry, seafood, dairy, and nuts points	Guiding Stars Visual Cues	Grocery Store Crowns
5 to 11	3 to 8	3	5
3 to 4	2	2	4
1 to 2	1	1	3
−2 to 0	0	0	2
≤ −3	0	0	1

Note: The Guiding Stars program has separate rating algorithms for general foods and beverages, and meat, poultry, seafood, dairy, and nuts. The Guiding Stars algorithm has 4 point intervals for its visual cues, giving zero to three Stars. We disaggregated the point interval of −41 to 0 further into −2 to 0 and ≤ -3 for The Grocery Store crowns.

2.4. Pilot study

We ran a pilot study to test adherence to experimental tasks (defined as shopping for 12 food items from a list), the impact of gamification (point scoring and a scoreboard) and different budgets on the nutritional quality of the food bundle in the final shopping baskets of participants. In addition, after participants completed the shopping task, we surveyed them about the store navigation and the ease of finding products they typically purchase when doing their real grocery shopping.

We recruited participants (n = 654) in Amazon Mechanical Turk. At the end of the experiment, twenty-one participants, randomly selected from the study sample, answered open-ended questions about their shopping experience in The Grocery Store. The inclusion criteria for participation were being physically in the United States, aged 18 to 65 years, comfortable reading English, and having an Amazon Mechanical Turk approval rate of 90% or more. The team received IRB approval from Tufts University under protocol #00001170. The experiment randomly assigned participants to one of four experimental conditions: Presence or absence of gamification (hereafter called the “game”) and high ($50) or low ($30) budgets (a 2 × 2 full factorial design). We set the budget values according to a pre-pilot test with 59 participants in which the mean expenditure was $30.49 (SE 3.97), the median expenditure was $31.23, and no one spent more than $48.51. The subjects in the condition with the game saw crowns and a scoreboard (Fig. 1), while participants in the non-game version did not see the crowns or scoreboard (Fig. 2).

No participant saw the underlying Guiding Stars scores, but all participants could see the Nutrition Facts Panel for all products (Fig. 3). Those in the game conditions saw one to five crowns for every item in The Grocery Store. The instructions page defined and displayed the crowns as “one crown (least nutritious) to 5 crowns (most nutritious)”, but they were not explicitly encouraged to choose products with more crowns. The Grocery Store instructed participants to browse the categories and sub-categories (corresponding to aisles) and select desired products. Participants received instructions to place selected products on the 12-item shopping list – bread/bakery; rice/grains/pasta; beans; soups; sweet snacks; salty snacks; crunchy snacks; milk; cheese; vegetable/fruit; breakfast/cereal; and eggs.

Online shopping studies commonly use shopping lists to standardize shopping baskets and make them more readily comparable (Forwood et al., 2015; Koutoukidis et al., 2019). Following previous studies (Forwood et al., 2015; Koutoukidis et al., 2019), we provided a shopping list to support comparability across bought products, collectively and individually. The reason is that nutrition scientists are interested in dietary quality (the quality of foods consumed). However, the typical instruments used to measure dietary quality, such as 24-hour recalls, food frequency questionnaires, food diaries, and weigh food records, are not valid to measure the quality of food purchased. With the list, we do not know the impact of changes in food purchases on dietary quality, but we can observe a change in the quality of foods purchased for breakfast or a snack. If foods purchased change, the dietary quality potentially has changed, holding everything else constant. The absence of a shopping list would make comparing baskets difficult to understand the dietary quality change. Also, we based list items such as bread and cheese to

Fig. 1. An example showing eight products from the Produce category (aisle) with their crowns.

Fig. 2. An example showing eight products from the Produece category (aisle) without crowns (Note: While this image has the scoreboard, participants did not see the scoreboard in the no-game version of the experiment).

increase observing socioeconomic purchase variability (Forwood et al., 2015).

The shopping list served as means to encourage the completion of the shopping exercise and was merely for guidance since participants were free to include foods from any category of The Grocery Store in any of the shopping list items. For example, they could include a cereal for the soup shopping list item or an apple as a crunchy snack. Finally, when consumers shop, they have different goals: some shop for a single meal, the week's food needs, or various needs. However, allowing a "free shop" would mean we would have a potential confounder: the motivation for the shopping trip. The shopping list mitigates unobservables such as intent, foods at home, or social desirability. This design helps to see how consumers shop when looking for similar classes of products.

As participants selected products, The Grocery Store discounted the price from the remaining budget (Fig. 4). They could replace any item in the shopping cart until the check out. Finally, participants could check out having spent more than the initial budget because we wanted to avoid participants choosing cheaper products that they do not consume in real-life only to be able to checkout and complete the task. Also, we wanted to understand how or if the budget binds. For example, the $30 group should feel that their choices were constrained but still have the possibility of buying 12 items they consume in real-life, while the $50

Reese's Puffs, Corn Puffs, Sweet & Crunchy, Peanut Butter

General Mills Sales

$3.30
per Unit

Add to Cart

Nutrition Facts

Serving size	1 Cup
Amount per serving	
Calories	**170 kcal**
	% Daily Value **
Total Fat 4.5 grm	5%
Saturated Fat 0.5 grm	4%
Trans Fat 0 grm	
Cholesterol 0 mg	0%
Sodium 210 mg	9%
Total Carbohydrate 30 grm	11%
Dietary Fiber 2 grm	7%
Total Sugars 12 grm	
Includes 12 grm Added Sugars	24%
Protein 3 grm	
Vitamin D	10%
Calcium	10%
Iron	20%
Potassium	2%

**The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

*Nutrient value not reported or 0.

Ingredients

Whole Grain Corn, Sugar, Reese's Peanut Butter (Peanuts, Sugar, Monoglycerides, Peanut Oil, Salt, Molasses, Corn Starch), Dextrose, Corn Meal, Corn Syrup, Canola Oil, Salt, Hershey's Cocoa, Caramel Color, Trisodium Phosphate, Natural Flavor. Vitamin E (Mixed Tocopherols) Added to Preserve Freshness. Vitamins and Minerals: Tricalcium Phosphate, Calcium Carbonate, Zinc and Iron, Vitamin C (Sodium Ascorbate), a B Vitamin (Niacinamide), Vitamin B6 (Pyridoxine Hydrochloride), Vitamin B2 (Riboflavin), Vitamin B1 (Thiamin Mononitrate), Vitamin A (Palmitate), a B Vitamin (Folic Acid), Vitamin B12, Vitamin D3.

Fig. 3. An example of how a product from the Breakfast category (aisle) is displayed in the Grocery Store when the participants from the non-gamified group click on them.

group should not feel constrained. After checking out, participants answered sociodemographic questions and a subsample (n = 21) were randomly selected to answer open-ended questions about general navigation, navigation in the aisles, checkout, and finding the items they typically consume. Each person could only participate in the experiment once. We conducted data analyses with Stata 16.1/IC. Characteristics of the participants are in Table 2.

3. Results

Of the initial sample (n = 654), only 23 (3.5%) participants exceeded the assigned budget. Of these, 22 were in the $30 budget group. The full sample comprised mostly individuals aged 25 and 34 (n = 299) and 35 to 44 (n = 206). Most were men (n = 421) and white/Caucasian (n = 468). Most had an income between $35,000 and $74,999 (n = 300), were college-educated or more (n = 479), were primary grocery shoppers (n = 601), and were online grocery shoppers (n = 401). However, 48% answered that they often did not have money to buy enough food, 31% often had to cut the size of their meals, and 44% said they could not afford a healthy diet. The randomization algorithm sent one of every four participants to the control and the game and low-budget groups; the low-budget groups summed 156 participants.

3.1. Quantitative results of the pilot study

The 12-item shopping list allows participants to collect between 12 and 60 crowns in their final basket. We conducted separate analysis with the whole sample recruited (n = 654) and with those who adhere to the shopping task (n = 503), defined as having a final shopping basket with exactly 12 products (Fig. 5). We did not have a target sample size, but this pilot will help us calculate the sample size for a future, larger study. The analysis with the whole sample showed that participants in the no-game and low-budget group had an average of 28.30 (SE 3.23) crowns, while those who saw the game and low budget had 29.11 (SE 3.28) crowns (Fig. 6). Those in the high-budget group that did not see the game had an average of 29.95 (SE 1.89) crowns, but participants in the game had an average of 33.02 (SE 2.11) crowns. The number of Guiding Stars points was positive for those who saw the game elements (mean = 2.49; SE = 0.14) and negative (mean = -4.98; SE = 0.27) for those who did not see the game elements, independent of budget. Ordinary least squares (OLS) regressions compared the number of crowns in the final shopping baskets between groups for the whole sample (Table 3a) and only for those who adhered to the experimental tasks (12 items in the final shopping basket; Table 3b).

Participants in the game group chose products with an average of 2.53 crowns (CI 95% [0.72;4.33], p = 0.006) more than the participants not in the game. In addition, the high budget relative to the low budget led participants to choose foods with more crowns in the final shopping basket: A $50 budget increased the number of crowns by 2.78 (CI 95% [0.66; 4.90], p = 0.010) compared to having a $30 budget. Finally, we estimated a model of the game's interaction and budget. With the interaction term, all of the coefficients are insignificant. Participants who adhered to the shopping task (n = 503) spent on average $25.93 (SE 1.27) in the low-budget group and $31.96 (SE 3.49) in the high-budget group. The odds ratio of adherence given the high budget was 1.514 (CI 95% [1.118; 1.910]). The game was relevant to explain the nutritional

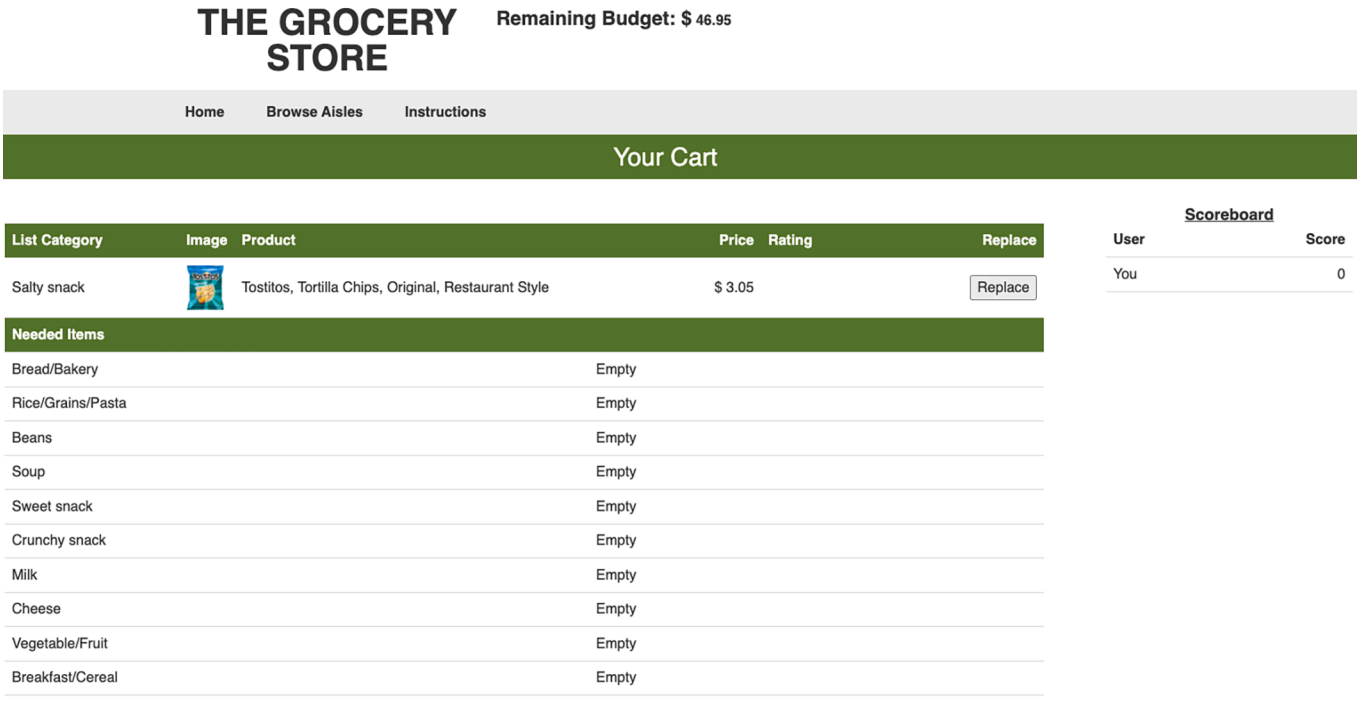

Fig. 4. An example of a shopping cart showing one snack included in the snack shopping list item. Selecting this item priced at $3.05 lowered the original budget from $50 to $46.95. The participant could replace the item by clicking "Replace.".

quality of the final shopping basket of those who adhered to the experimental tasks (p-value < 0.001), but the high budget was not (p-value $= 0.921$). However, in the model of the interaction of the game and the budget, the coefficients are statistically insignificant.

In the full sample (n = 654), higher expenditures correlated with more crowns, but this correlation disappeared for the subsample of participants (n = 503) that adhered to the instructions of selecting 12 items (Fig. 7). Only 3.5% (n = 16) of the total sample spent more than the initial budget, and only 1.0% (n = 7) spent more than the initial budget after non-adherent participants were excluded. According to an exploratory analysis, the budget became significant for the regressions with interactions between game and budget after excluding those who spent more than the initial budget (Appendix 2). All variables but the interaction between game and budget were significant when the regressions had game, budget, expenditure (money spent during the game), the interactions of these variables and the number of products in the final shopping basket as explanatory variables (n = 654).[1] The effect of game, budget and expenditure was positive, but diminished the higher the expenditure (Appendix 3).

3.2. *Open-ended responses about the experience in the grocery Store*

Five of the twenty-one participants who answered open-ended questions about their shopping experience in The Grocery Store mentioned minor website navigation problems. One stated that the pictures were small, and two said the images loaded slowly: "Just slow loading times for the product photos, otherwise good." Eighteen participants did not mention any issues with the navigation in the aisles (categories and subcategories) of food in The Grocery Store: "The aisles were very easy to navigate, and I found everything I needed quickly." Two participants suggested changes: adding a search bar and the experimental shopping list on the side. All participants said they did not have a problem with the checkout process: "The checkout process was seamless, easy to replace, and easy to see the items in the cart." Overall, the navigation seemed intuitive and easy to most: "I had no issues, the task was very understandable and intuitive."

4. Discussion

Building an online grocery store that mimics real online platforms presents challenges. Our goal was to create a simulated online grocery that represented nationally available products and avoid scrapping data from accessible websites. Our team initially tried to build The Grocery Store with data from the United States Department of Agriculture (USDA) Branded Food Products Database. However, this database did not present enough product diversity to match the contemporaneous grocery stores. Therefore, we purchased and merged data from Syndigo and Guiding Stars, and built Nutrition Facts Panels for all products in The Grocery Store according to the FDA's guidelines using data from Syndigo. The Guiding Stars Scientific Advisory Panel revised the algorithm according to the Food and Drug Administration modifications after we built the current version of The Grocery Store (Guiding Stars, 2018). The Grocery Store products and scores do not include the Daily Value and Nutrition Facts Panel revisions of 2020. We excluded nonfood products, foods Guiding Stars did not evaluate, and foods with relatively low sales. As a result, we had 5,376 products and prices representing top-selling items in grocery stores.

The Grocery Store was a reasonable representation of real online grocery stores. Most participants who completed the open-ended questions about their experience in The Grocery Store described the navigation as intuitive and easily found the products they often purchase in real-life online grocery shopping. In addition, the pilot test results showed that most participants completed the grocery shopping task and that gamification improved the quality of final shopping baskets. This pilot study identified challenges with the experiment, for example, we learned of problems with slow loading issues of pictures, which may have hampered adherence to experimental rules. However, an important finding was that the participants in the higher budget had higher odds of adhering to the experimental rules. In addition, we observed that the randomization process generated few participants in the control

[1] We thank an anonymous reviewer for suggesting this additional exploratory model specification.

Table 2
Characteristics of participants by study group (n = 654).

	Control (n = 77)	Treat 1 (n = 252)	Treat 2 (n = 79)	Treat 3 (n = 246)	Total (n = 654)
Age (years) (%)					
18–24	1 (1.3)	10 (4.0)	1 (1.3)	8 (3.3)	20 (3.1)
25–34	35 (45.5)	124 (49.8)	42 (53.2)	98 (40.3)	299 (46.1)
35–44	24 (31.2)	77 (30.9)	20 (25.3)	85 (35.0)	206 (31.8)
45–54	13 (16.9)	22 (8.8)	9 (11.4)	31 (12.8)	75 (11.6)
55–64	4 (5.2)	14 (5.6)	6 (7.6)	18 (7.4)	42 (6.5)
65 or more	0 (0.0)	2 (0.8)	1 (1.3)	3 (1.2)	6 (0.9)
Income (%)					
Up to $34,999	21 (27.6)	75 (29.8)	21 (26.6)	59 (24.0)	176 (27.0)
$35,000 to $74,999	33 (43.4)	107 (42.5)	38 (48.1)	122 (49.6)	300 (45.9)
$75,000 or more	22 (28.9)	68 (27.0)	20 (25.3)	63 (25.6)	173 (26.5)
Race/ethnicity (%)					
Black/African American	9 (11.8)	38 (15.1)	11 (13.9)	46 (18.7)	104 (15.6)
Latino/Hispanic	2 (2.6)	4 (1.6)	2 (2.5)	10 (4.1)	18 (2.8)
Asian American	2 (2.6)	23 (9.2)	2 (2.5)	18 (7.3)	45 (6.9)
White/Caucasian	62 (81.6)	179 (71.3)	63 (79.8)	170 (69.1)	474 (72.7)
Other/More than one race	1 (1.3)	7 (2.8)	1 (1.3)	2 (0.8)	11 (1.7)
Gender (%)					
Men	51 (66.2)	162 (64.5)	56 (70.9)	162 (66.1)	431 (66.1)
Women	26 (33.8)	88 (35.1)	23 (29.1)	82 (33.5)	219 (33.6)
Education (%)					
Less than college degree	16 (20.8)	65 (25.8)	24 (30.8)	70 (28.5)	175 (26.8)
College degree or more	61 (79.2)	187 (74.2)	55 (69.6)	176 (72.5)	479 (73.2)
Primary grocery shopper (%)	71 (93.42)	226 (90.0)	75 (94.9)	229 (94.2)	601 (92.6)
Online grocery shopper (%)	50 (64.9)	154 (61.1)	55 (69.6)	142 (57.7)	401 (61.3)
Adherence to the tasks					
Did not exceed the budget	66 (85.7)	251 (99.6)	68 (86.1)	246 (100.0)	631 (96.5)
Purchased exactly 12 items	43 (55.8)	213 (84.5)	41 (51.8)	206 (83.7)	503 (77.4)

Note: SD is for standard deviation. Treat is treatment. The values in the table represent the number of individuals with percentages in parentheses unless otherwise indicated. We collected the self-reported sociodemographic data through a survey administered after participation in the experiment. The Control had a $30 budget and no game (crowns and scoreboard). Treatment 1 participants received a $50 budget and no game. Treatment 2 participants received a $30 budget and the game. Treatment 3 participants received a $50 budget and the game. A "primary grocery shopper" reports being responsible for purchasing their household groceries at least half of the time. "Online grocery shopper" is defined as doing groceries online twice or more per month.

group than anticipated. These discoveries were useful for restructuring The Grocery Store for future experiments.

Our experiment did not answer if the motivation for selecting foods with more crowns was intrinsic (achieve a high score) or extrinsic (eat healthier). Gamification may have worked as a game, influencing participants only to achieve higher score, or may have informed consumers about the quality of the shopping basket. Icons (or badges) that signal the quality of products and work as soft prizes increase self-efficacy (Sailer et al., 2017) and engagement (Hamari et al., 2017) in previous experiments. But so far, badges worked better when visible to third

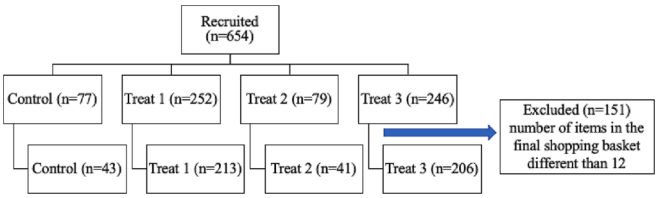

Fig. 5. Flow chart. Second row shows the number of participants randomized into each group and third row shows how many had 12 items in the final shopping basket. Those outside the United States, or not aged between 18 and 65 years, or not comfortable reading English, or with an MTurk approval rate lower than 90% were filtered before recruitment.

parties, as a social signal, for example, stimulating the reuse of hotel bath towels (Baca-Motes et al., 2013). Badge-like incentives that could not be socially exhibited did not motivate pro-social behavior (van der Weele & von Siemens, 2020), including for sustainable food choices in online grocery shopping (Panzone et al., n.d.). Even in the absence of social exhibition or competition, the crowns and the scoreboard together led to changes in the quality of the final shopping basket in our study.

Critics have questioned the moral legitimacy of gamification because it can harm players unintentionally, recklessly, negligently, or inadvertently (Bogost, 2015; Kim, 2015; Sicart, 2015). Scoreboards, leaderboards, and competition can be taken as a stick or a carrot depending on the context and design (Anderson & Pildes, 2000). For example, a leaderboard system displayed on video screens for the housekeeping staff at Disneyland hotels in California resulted in considerable anxiety, embarrassment, and shame among workers. The system, which workers nicknamed "the electronic whip," ranked employees' performance against their colleagues on a large screen. Some workers reportedly avoided taking bathroom breaks, while others became worried about losing their jobs (Lopez, 2011).

Companies should develop ethical frameworks for gamification that consider safety, security, privacy, transparency and accountability to avoid potential misuses, such as taking unfair advantage of workers and consumers (Kim & Werbach, 2016). Governments should regulate gamified environments based on adequate rational after identifying the individuals subject to gamification, considering their level of vulnerability, and the motivations of the organizations implementing it. Validated nutrient profile models and indicators that maximize the dietary quality of the population should be used whenever a point systems influence purchases or consumption of food.

The high budget increased the nutritional quality of the final shopping basket as measured by crowns. Still, the effect disappeared when only those who adhered were analyzed (final shopping baskets with 12 items). This result and the insignificant interaction between budget and gamification may be explained by the small sample size in the low-budget conditions. Furthermore, 15.26% (n = 76) of high-budget participants and 41.67% (n = 65) of the low-budget participants did not adhere to the shopping task. Low-budget participants may have adhered less to the task because foods with more crowns are more expensive in some categories of The Grocery Store. A low budget as an additional shopping constraint may have also imposed a cognitive load, making participants quit the task (Mani et al., 2013). Finally, the low budget group was smaller than anticipated, and we adjusted that randominzation for future studies. Future experiments should investigate what increases the likelihood of low-budget participants complete the task, including testing the effect of learning with repeated shopping trips. Progress in games requires repetition, and repetition targets automatic processes (Bandura, 1986; Ciavarro, Dobson, & Goodman, 2008).

The crowns may have led to an experimental demand effect that increased the intention to buy healthy products independently of gamification (Zizzo et al., 2010). Potentially, the presence of the crowns may have led to automatic information processing of the nutritional quality of the products. Automatic (i.e., impulsive) processes, involved

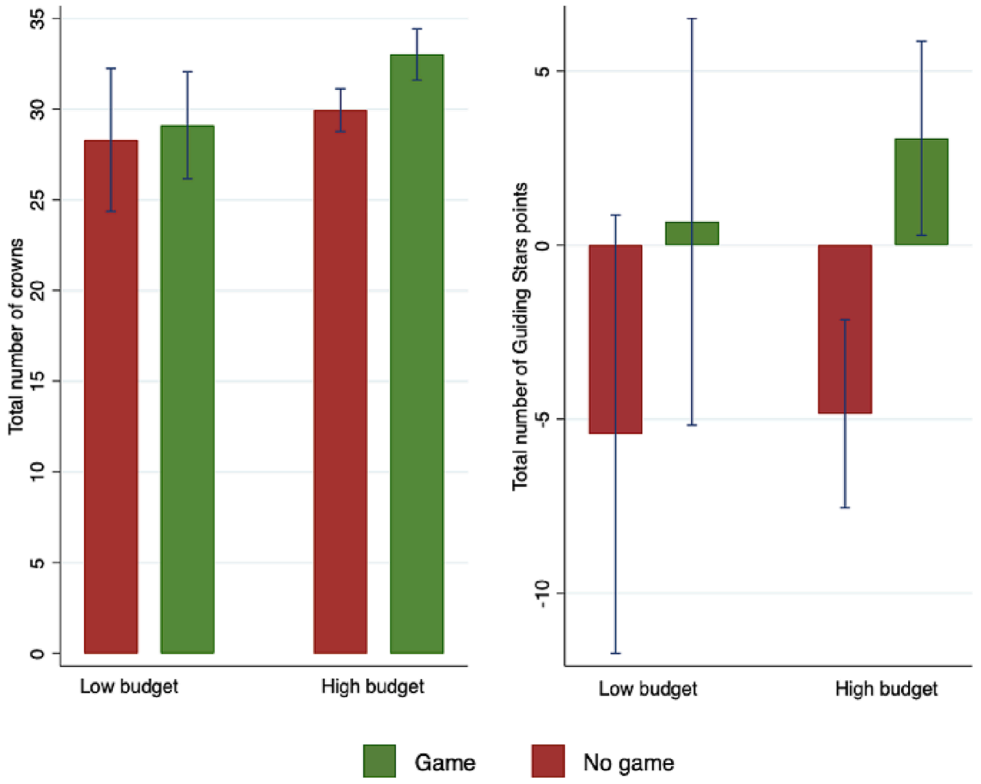

Fig. 6. Average and standard deviation of the total number of crowns and total number of Guiding Starts points by game condition and budget constraint.

Table 3a
Ordinary least squares model of the effect of the gamification intervention with a budget constraint on the nutritional quality of the final shopping basket as measured by total number of crowns (Full Sample).

	Coefficient	95% CI	P-value	Coefficient	95% CI	P-value
Game	2.53	(0.72; 4.34)	0.006	0.82	(-2.89; 4.52)	0.666
High Budget ($50)	2.78	(0.66; 4.90)	0.01	1.65	(-1.36; 4.66)	0.282
Game X High Budget				2.25	(-1.99; 6.49)	0.297
Constant	27.43	(25.37; 29.49)	<0.001	28.3	(25.66; 30.93)	<0.001
Observations	654			654		
R-squared	0.021			0.023		

Note: The most crowns that a participant could achieve was 60 crowns.

Table 3b
Ordinary least squares model of the effect of the gamification intervention with a budget constraint on the nutritional quality of the final shopping basket as measured by total number of crowns (Restricted Sample).

	Coefficient	95% CI	P-value	Coefficient	95% CI	P-value
Game	3.23	(1.90; 4.56)	<0.001	1.44	(-1.82; 4.70)	0.385
High Budget ($50)	0.09	(-1.69; 1.88)	0.921	−0.96	(-3.45; 1.54)	0.451
Game X High Budget				2.14	(-1.99; 6.49)	0.238
Constant	31.17	(29.42; 32.93)	<0.001	32.05	(29.77; 34.32)	<0.001
Observations	503			503		
R-squared	0.043			0.040		

Note: The most crowns that a participant could achieve was 60 crowns. We restricted the sample to include only participants who selected 12 items for their final shopping basket.

in all aspects of food consumption, require little or no cognitive effort, while deliberate (i.e., reflective) processes are slow and demand high cognitive effort (Van't Riet et al., 2012; Van't Riet et al., 2011). Thus, the crowns alone could shape the food choice of participants. Also, the shopping list may have activated self-control, altering the effect size of gamification (Davydenko & Peetz, 2020; Massara et al., 2014; Sjåstad & Baumeister, 2018). Some studies have permitted participants to shop freely, without a shopping list (Coffino et al., 2021; Egnell et al., 2021; Epstein et al., 2015), but two-thirds of individuals shop with lists in real life (Bassett et al., 2008; Thomas & Garland, 2004; Davydenko & Peetz, 2020).

This hypothetical exercise may have led to food choices potentially less representative of real-life shopping habits, while other experiments exchanged real-life money for physical products (Demarque et al., 2015; Muller, Lacroix, & Ruffieux, 2019; Kanay et al., 2021; Panzone et al., 2021a; Panzone et al., 2021b). Some of these studies had smaller sample sizes from a limited geographical area, in which participants had their food choices delivered. As we conducted this national experiment during

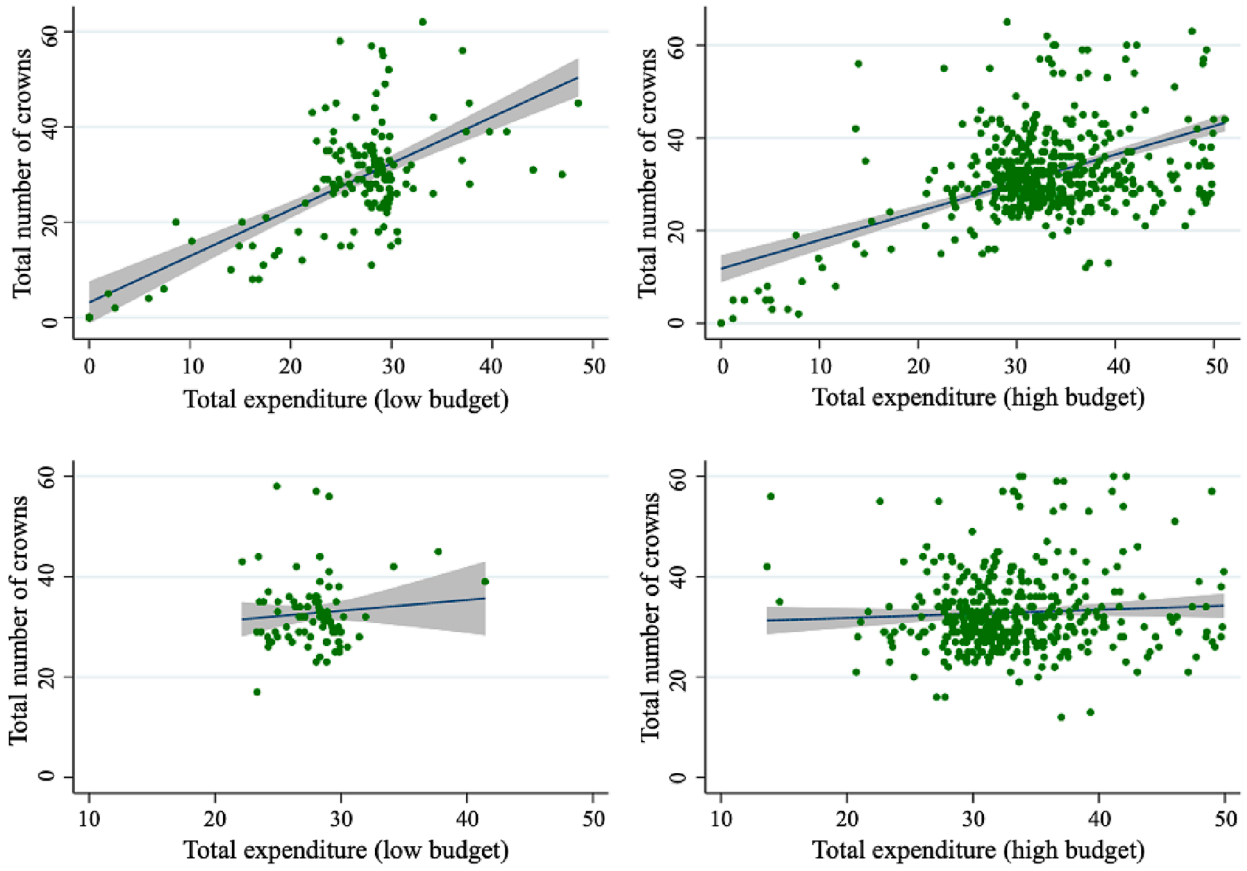

Fig. 7. Total expenditure in the experiment correlates with the total number of crowns in the final shopping basket independently of budget for the sample with all participants (charts in the first row; n = 654). The correlation diminishes when only those who adhered to the shopping task were included (12 items in the final shopping basket; charts in the second row; n = 503).

the early days of the Covid-19 pandemic, lock-down orders restricted our efforts. Still, our large sample with people from various occupations, age ranges, levels of income, and geographical areas has advantages over more tightly controlled samples frequently of students or from a single city. Admittedly, our sample had a disproportionate representation of young men, white/Caucasian, and college-educated. Future studies need to address these limitations.

A growing body of evidence identifies the contribution of unhealthy food environments to unhealthy eating (Swinburn et al., 2013), and the importance of public policy and regulation to promote healthy food environments and prevent disease (Duran et al., 2021). Nutrition regulations have focused more on physical than digital food environments. Scientific work on the regulatory aspects of online grocery stores is almost non-existent, but the existing studies show that nutrition information is not consistently provided (Headrick et al., 2022; Pomeranz et al., 2022). The literature has less information on the digital than physical food environments because digital environments are more novel and more rapidly evolving. Digital food environments are also harder to evaluate because they are personalized, while many individuals share physical food environments. Even the definition of food environments, typically the economic, political, socio-cultural and physical dimensions that affect food choices and nutritional status, exclude digital settings (Swinburn et al., 2013). Examples of digital food environments are online grocery stores, smartphone applications for restaurants, fast food delivery and ready-to-eat meal vendors, applications to monitor food consumption and give dietary advise, social media, and video streaming services.

The Grocery Store is a research instrument carefully built to reflect the typical online grocery experience in the United States so as to shed light into the topic. This simulated food environment is an ideal space for minimally invasive interventions, generally accepted by the public (Evers et al., 2018). Most participants found The Grocery Store similar to other online grocery stores. This pilot provided us with rich data to build a full randomized control trial.

5. Conclusion

Although experiments cannot replace real-life experiences, The Grocery Store is sufficiently similar to real online stores for externally valid research and has the potential to help scientists gain insights into consumer behavior. This pilot study further showed that gamification could facilitate healthier food choices. Modifying the characteristics of digital food environments can potentially improve the nutritional quality of food choices and, consequently, food consumption at a large scale (De Bauw et al., 2021; Swinburn et al., 2011).

6. Availability of data and materials

Deidentified individual participant data collected in this experiment will be shared upon reasonable request. Proposals may be submitted up to 36 months after article publication. After 36 months, the data will be available at Tufts University Dataverse but without investigator support other than deposited metadata.

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Ethics approval and consent to participate

The Social, Behavioral, and Educational Research Institutional Review Board of Tufts University (IRB #00001070) approved this study on 1/28/2021. Additionally, Duke University Campus Internal Review Board (IRB), Reference number 2021–0276, granted ethical approval for the involvement of human subjects on 05/19/2022. Electronic consent was obtained from each participant. Our work follows the Declaration of Helsinki and the Recommendation for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals.

CRediT authorship contribution statement

Bianca C. Braga: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing. **Sean B. Cash:** Conceptualization, Investigation, Writing – review & editing, Supervision. **Katrina Sarson:** Investigation, Project administration, Writing – review & editing. **Remco Chang:** Software, Software, Supervision, Funding acquisition. **Ab Mosca:** Conceptualization, Software, Data curation. **Norbert L.W. Wilson:** Conceptualization, Methodology, Formal analysis, Investigation, Resources, Writing – review & editing, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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