Monster Appetite: Effects of Subversive Framing on Nutritional Choices in a Digital Game Environment

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ABSTRACT
Americans' health has reached a dangerous obesity epidemic from overconsumption and unhealthy food choices. In response, persuasive games for health encourage healthier lifestyles typically by providing positive reinforcement for the desired behaviors. However, positive reinforcement is only one of the many possibly effective approaches. We explore two types of message framing in a nutrition game, Monster Appetite (MA). In MA, players' choices of high or low calorie snacks impact visual appearance of their monster avatar. MA utilizes two types of health messages: subversive, which encourages players to make unhealthy choices and focuses on costs, and inoculation, which encourages players to eventually defend healthy choices and focuses on benefits. We test message framing's effect by tracking users' purchasing behavior in our online snack shop, Snackazon. The study showed that when positive messages were embedded in MA mixed with negative visuals through the monster avatars, participants exhibited better snack choices post-gameplay.

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User interfaces.

Author Keywords
Framing; persuasive games; subversive approach; two-sided inoculation; behavior modification; nutritional choices.

INTRODUCTION
The obesity epidemic is one of America's largest public health challenges and a growing one in the rest of the world, one that creates disparities among race, ethnicity, region, and income. Currently, over 12 million American adolescents and 38% of adults are obese [31].

In response to these trends, an increasing number of technological interventions target improved health and wellness. Some of these technologies leverage successful offline intervention strategies, such as education and motivation; others rely on new computational affordances, from social media to video games. Video games, in particular, present an increasingly popular medium for countering the obesity epidemic and motivating individuals to adopt healthy behaviors in an engaging and persuasive way [7, 17, 18, 57, 70, 88]: 42% of all video game players surveyed in 2013 played health games [72]. These health games often use persuasively narrated health messages using the specific affordances of technology [30] in order to enhance their overall health impact. However, choosing the most effective persuasion techniques for these games remains challenging [9, 37, 42, 57, 77, 79]. Hekler et al. [40] suggest that alternative methods be used for persuasive technologies in health, acknowledging the room for improvement in HCI. In this research, we investigate an alternative way to design persuasive games to improve individuals' nutritional choices. Specifically, we are interested in different reinforcement mechanisms and approaches to coupling these mechanisms with persuasively framed health messages that could measurably result in successful behavioral modification across different health and game contexts [6, 82].

The vast majority of nutrition games developed thus far utilize positive reinforcement and benefit-oriented motivational messages through encouraging healthy behaviors and illustrating positive outcomes of such behaviors. However, these games demonstrated mixed results for behavioral modification [30, 73]. This approach contrasts with an alternative strategy often used in non-nutrition related contexts that emphasizes losses, costs, or negative consequences of undesirable behaviors. Emphasizing negative consequences has been successful in convincing people to quit smoking, comply with vaccination, reduce substance abuse, and screen for HIV, skin cancer, and blood cholesterol [75]. Closely related to the negative consequences approach is inoculation theory [63] through which "cognitions can be strengthened by exposing an audience to (mild) attacking arguments directed against the protagonist and then countering those negative arguments in the same communication" [29]. That is, one's original belief in a health behavior becomes strengthened when that belief is mildly attacked by a counter argument. This construct of inoculation is consistent with the notion of two-sided communicative appeal. It has been shown in marketing communication that people are more likely to trust sponsors that provide both the positive *and* negative arguments regarding its brands [29, 35]. Whether it be inoculation or two-sided appeal, this approach has rarely been tested in the context of nutrition games.

CHI 2017, May 6-11, 2017, Denver, CO, USA.

ACM ISBN 978-1-4503-4655-9/17/05 ...$15.00.
http://dx.doi.org/10.1145/3025453.3026052

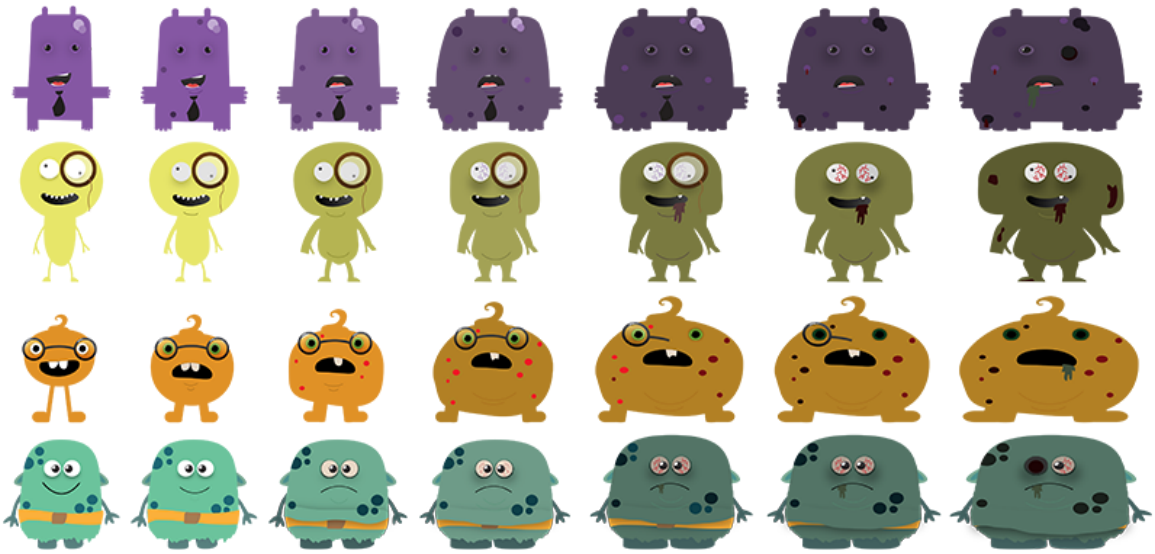

Figure 1. Avatars of all stages in Monster Appetite from light (left) to heavy (right).

In this paper, we describe the design of a persuasive game for encouraging healthy nutritional choices, Monster Appetite (MA) that utilizes unconventional persuasion approaches such as inoculation, and its evaluation study. In the game, users are asked to choose snacks of various caloric content for a monster, who is presented as an avatar, and view the impact of their choices on the monster's appearance. MA delivers persuasive messages in two different forms: 1) visual impact of the snack choices on the appearance of the monster, and 2) goals and text-based, *framed* messages that highlight the health impact of the chosen snacks. The framing of the visual appearance of the avatar is skewed in the negative direction: high calorie snacks chosen by users make the monster big, cheerless, and sickly in game time. Low-calorie choices keep the monster in its original state until a calorie-threshold is reached; only then the avatars grow in size. Figure 1 shows the monsters' growth as they consume more calories.

We combined the consistently negative visuals with persuasive framing for the game's goals and feedback messages. The first type of framing, *two-sided inoculation*, encouraged players to consume low-calorie snacks and had positively-framed pop-up messages that highlighted the benefits of healthy snacking. Thus, the two-sided inoculation combined both negative (visual) and positive (mechanistic and textual) aspects of low-calorie snacks. The second type of framing, *subversive*, encouraged users to choose high-calorie snacks and had negatively-framed pop-up messages highlighting the negative impact of unhealthy snacking, which were also illustrated by negative changes in the monster's appearance. These two framing approaches comprised our two treatment conditions. In the evaluation study, participants were asked to first choose snacks for themselves (baseline), then they were asked to play MA and choose snacks for their monsters in a limited timeframe (intervention); finally they were asked to make a second set of snack choices for themselves (post-intervention). This procedure comprising Session 1 was repeated for Session 2 after 24 hours. We examined the participants' snack choices before and after playing MA (inoculation-oriented vs. subversive), as well as their self-reported reasons for their choices.

MA's goal was to enable its users to vicariously experience excessive snacking via the avatars and expose them to the negative consequences of that particular behavior. As MA employs avatars that show the results of high-calorie intake, the consequences of careless eating are visual and therefore "tangible." The intention was to prevent the players from executing such negative behaviors in real life, therefore resulting in a positive outcome [14]. We were particularly interested in investigating original approaches to formulating messages that deviate from the traditional positive framing; both inoculation and subversive framing exemplify novel directions that may open new opportunities for delivering nutritional interventions in an innovative and fresh way.

The study results showed that both treatments had an effect on snack purchase processes, though in different capacities. The two-sided inoculation group selected low-calorie snacks statistically significantly more at post- than pre-gameplay; however their reasons for choosing snacks did not change. In contrast, in the subversive group, snack choices did not significantly change in caloric content pre-post gameplay; however, these participants listed caloric reasons for choosing snacks statistically significantly more at post- than pre-gameplay.

As a result, we propose that coupling compelling visual illustrations of the negative impact of unhealthy foods with inoculation messages can be an effective mechanism promoting healthy nutritional choices. Our main contributions include: (1) bringing message-framing to the forefront of HCI community's attention as a valid design strategy for persuasive health technology and (2) suggesting a new approach to discretely measuring short-term changes (with limited social desirability [81, 89]) to decision-making and purchasing in response

to nutritional interventions for promoting healthy, nutritional choices. Snackazon is a tool that embodies this method.

BACKGROUND AND RELEVANT WORK

Here, we cover the background on (1) persuasive game-based studies, and (2) message framing and its applicability.

Why (Persuasive) Games?

Games have been shown to be a successful tool in encouraging participants to actively engage in learning activities outside traditional learning environments [3, 47, 44]. One of the reasons why games are successful in this aspect is because they "engage players emotionally, socially, and culturally, in ways that traditional learning environments perhaps cannot" [11]. In the last five to six years, a small but significant body of research has been documenting these benefits of (video) games as they become increasingly diverse, complex, realistic, and social in nature [36]. The medical and health fields have picked up these benefits and positive effects of gameplay and have placed great efforts into gamifying medical interventions [18, 48, 65, 83].

As a matter of fact, games have had a long history of being used as a popular tool in health intervention and prevention programs [5, 7, 8, 38, 77, 80, 91]. Some uses of health games with promising results include those regarding cancer and other diseases, where patients have to follow a strict regimen for treatment. In such cases, the game works as an organizational (reminders and alerts) and motivational (gamification aspects) tool[48]. Others include video games that work as a distraction from pain and other undesired behaviors [54, 67].

Persuasive games are also regarded as a popular tool that have garnered attention as they have shown some positive effects on motivating healthy behaviors [12, 16, 38, 48]. Some persuasive games for health promotion and prevention are introduced here. Lunch Crunch [76] makes players fill out lunch trays with healthy items such as fruits and vegetables and trash unhealthy items such as sweets to educate the players on (un)healthy options. In Escape from Diab [93], the protagonist tries to escape the dreary land Diab by training others to increase their physical strength by healthy eating and exercising. A good guy encourages the player towards healthy goal attainment. A bad guy distracts the player from attempting to obtain that goal. This temptation voice, alongside the good guy, is the inoculation construct that is applied here. To the best of our knowledge this is the only nutrition game incorporating inoculation to this date.

FatWorld [74] is a game about politics and nutrition. Unlike most nutrition games, the goal of this game is not solely about choosing a healthy diet, but also about demonstrating the complexity of issues surrounding nutrition, such as budgets, the physical world, subsidies, and regulations. Players can choose a starting weight, health conditions, what to eat, and whether to exercise while serving food through their restaurant business.

LunchTime [71] is a role-playing slow-casual game in which players choose a health goal out of five options (manage weight, manage diabetes, manage blood pressure, build muscle, and general well-being) and choose meals from restaurants according to their health goals. The restaurant menus always include several options and points are awarded according to the relative healthiness of the meals in accordance with the health goal. OrderUP! [38] is a game in which players take a role as a server in a neighborhood restaurant and recommend their customers the healthy options to keep their job. LunchTime and OrderUP! have shown to increase the players' nutrition knowledge and general feelings for self-efficacy.

However, the use of persuasive games in health does not come without challenges; there are very few health games that have been scientifically evaluated beyond testing participants' behavioral intention. Others have yielded inconclusive results regarding the effectiveness of games as an intervention tool [36] or a small-to-medium change in behavior or only correlational involvement between behavioral intention and change [97]. The more inconclusive areas for health game interventions include physical activity, nutrition, and (un)healthy eating, behavior-oriented research. The conflicting results indicate that additional research is needed, and the dearth of research on using inoculation and subversive-framing in nutrition-related activities incentivized us to develop the web-based calorie game, Monster Appetite.

Message-framing and Its Range of Applicability

The existing message framing literature suggests that there are topics that work well with negative messages, while there are those that affect people more intensely via positive messages. In the health domain, some success cases for negative messages include smoking cessation [75], preferences for mammography [4], and drug abuse [19]. On the other hand, some success contexts for positive messages include use of sunscreen [86], seat belts [98], and condoms [59].

Rothman et al. [84] explains why certain health messages work with particular frames: if the target behavior is seen as risky and uncertain (detection behavior) people respond well to negative-framing, while if the target behavior is viewed as safe and certain (prevention behavior) people react well to positive-framing. Negative-framing in particular works well in many health campaigns because of negativity bias (a heightened sensitivity to negative information) [85] and fear appeal [68].

In a non-health domain and recent example of successful negative-framing, a study investigated a self-monitoring system for personal productivity with a Korean audience [52]. TimeAware is an app developed to promote self-awareness of individual's productivity via a web-based visual information dashboard on computer usage. One version of TimeAware displayed productive activities (positive framing), while the other emphasized distracting activities (negative framing). The 8-week study resulted with only negatively-framed version of the intervention leading to a statistically significant increase in participants' productivity.

Ahn et al. [1] conducted an environmental virtual simulation experiment that contained positively- (experiencing the growth of a seedling into a tree by watering and pumping

nutrients) and negatively-framed (experiencing cutting down a tree with a virtual chainsaw) groups. After the virtual activity, water was "accidentally" spilled and participants were handed pre-counted paper napkins for cleanup. This veiled, discrete behavioral measure of counting the used napkins showed that both conditions used significantly less paper napkins (25% less than baseline) than the control group did, supporting framed experiences. Also, the positive condition elicited greater environmental behavioral intentions than the negative one.

As illustrated, message-framing has been utilized in many different fields with results that vary tremendously depending on the context as well as many mediating factors such as relevance and salience to an individual, cultural backgrounds, attitudes, risk-perception, detection vs. prevention characteristics [82].

Monster Appetite

Monster Appetite (MA) is a game that strives to remediate some aspects of the obesity epidemic by promoting awareness of the content of food, particularly regarding per-serving calories. The subversive factor (i.e., consuming high caloric content food items to make one's monster avatar unhealthy and overweight) raises players' awareness of high calorie values of common snacks. In MA, at the end of three rounds (which concludes a day in game time) framed messages pop up to summarize the avatar's consumption of that day (Figure 2 and 3). Two types of framed messages were employed: positively- and negatively-framed messages, with the framing highlighting the benefits and costs from following a specific health regimen [2, 15]. The following section describes the two versions of MA that were implemented with the two types of framed messages.

Subversive Game

Participants in this group played MA as a subversively-framed game. That is, the game's original goal to consume the highest-calorie snack items to keep their monster avatar overweight, sluggish, and inactive was maintained and the end-of-day pop-up messages were negatively framed. For example the following type of negative message would pop up:

SUMMARY OF DAY 2: You ate 2602 calories today. The HIGHEST possible calories your monster could have consumed today was 2892. If you had eaten 290 MORE calories to reach the HIGHEST CALORIC consumption of DAY 2, you would be at a HIGHER RISK for a cardiovascular disease.

The monster could get fatter or stay the same depending on how many calories were consumed. There was a total of seven monster stages (Figure 1) and each monster increased its size to the next monster with every additional 1500 calories consumed. There was not an option to go back to an earlier/healthier stage even if the minimally possible calories were consumed. Therefore, the goal was to feed the monster high-caloric snacks, the framed messages emphasized the negative consequences of such behavior, and the avatar embodied those consequences in a visual manner. This defined the subversive game group.

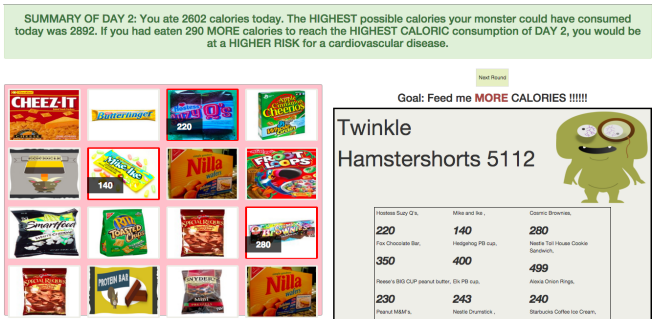

Figure 2. A screenshot of a subversive Monster Appetite game instance at the end of Day 2 with a negatively-framed message at the top of the screen as a green banner.

Two-sided Inoculation Game

Participants in this group played MA as a two-sided inoculation game. This version was the same game used by the subversive group, except that the game's goal was flipped and the pop-up messages were positive. The goal of the two-sided inoculation MA was to consume low-calorie items to keep one's monster avatar healthy, fit, and active. After the calories of each day were added to the total consumed calories, a positively-framed message popped up to emphasize the monster's state (Figure 3).

SUMMARY OF DAY 4: You ate 427 calories today. The LOWEST possible calories your monster could have consumed today was 386. If you had eaten 41 FEWER calories to reach the LOWEST CALORIC consumption of DAY 4, you would be at a LOWER RISK for a cardiovascular disease.

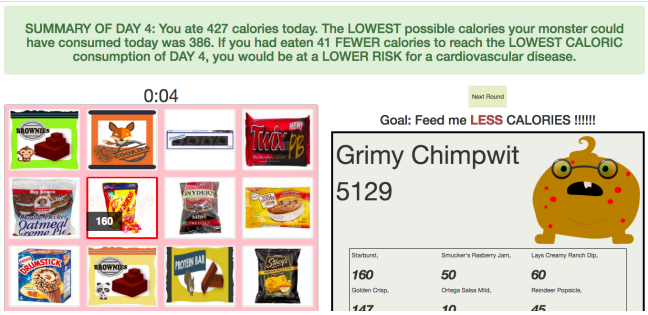

Figure 3. A screenshot of a two-sided inoculation Monster Appetite game instance at the end of Day 4 with a positively-framed message at the top of the screen as a green banner.

Note that only the goal of the game, and the text have changed. We chose not to use other visual cues, such as displaying the negative message in red text, to avoid introducing more variability in the results. The study took a conservative approach to framing so that any results could be clearly correlated to the content of the message framing.

As in the subversive game, the monster's size changed according to the caloric consumption. The monster could gain weight or stay the same in size depending on calories consumed. Because both games started with the healthiest monster avatar and players only observed heavier stages of the avatars as calories accumulate, the avatars only displayed negative consequences.

Hence, for this inoculation game the framed messages were positive and monster avatars served as the negative side of the two-sided appeal or inoculation construct.

Snackazon: Discrete Post-Manipulation Measure

In addition to developing Monster Appetite, we wanted to create a platform that would allow us to measure pre- and post-gameplay nutrition-related activities that was not a self-report measure, since self-reports are often subject to social desirability and inaccuracy [89].

Figure 4. A screenshot of a Purchase Decision Question (PDQ) page with three items selected in the right box in order of importance.

Therefore, we developed an online snack market for participants to go and choose snacks for delivery. This site, Snackazon, was used as a pre- and post-manipulation measure to evaluate participants' nutritional choices. The site tracked participants' information-seeking behavior (information-seeking behavior was captured by their clicks on nutrition buttons) and food choices (purchases of the snacks) and whether the food purchases were mediated by the items' nutrition information. As such, Snackazon presented a reasonable compromise between easy-to-capture but highly unreliable self-reports, and capturing individuals' nutritional choices in the real world and in the context of their real lives. While this approach can only show short-term impact of nutritional interventions, it avoids the most critical pitfalls of self-reports while still providing a low-cost way of assessing nutritional choices.

Every participant was exposed to five different pages with snacks and a Purchase Decision Question (PDQ) page (Figure 4) that appeared at the end of those five pages of snacks. Each snack page contained three snacks of similar type. Collaboration with our team's design experts led to the three-snack per page design, which avoids overwhelming participants with too many choices. Two pages included real snack items. For example, a page included Ritz Toasted Chips, Ruffles Potato Chips, and Garlic Rye Chips. The other three pages included imitated items [43], but participants were told that all items were real. For example, for the imitated items a page could include three types of pretzels that appear the same except for the packaging (Figure 5). The only way to distinguish the items (besides their packaging) was to click on the information icon below each snack item. The real snacks were only included to distract participants from figuring out Snackazon's real purpose. The real snacks could not be used because of confounding variables such as brand loyalty, allergies, preferences, familiarity, taste, etc. The categories of the snacks were picked by the most popular American snacks [20] that were commonly available in grocery stores and had high calories [99].

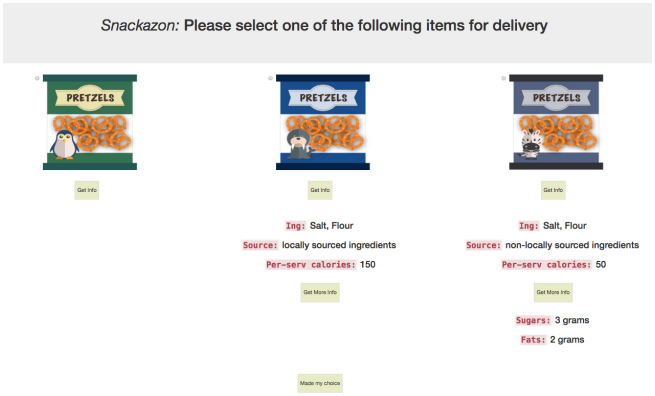

Figure 5. A screenshot of Snackazon showing the increasing information provided to the user by clicking "Get Info" and "Get More Info" buttons.

Each item had a "Get Info" button under it (Figure 5). This button was placed under every snack on all five pages. Once clicked, the "Get Info" button displayed Ingredients, Source, Per-serv calories, and a "Get More Info" button. Ingredients listed two of the major ingredients of a snack. Source included whether the snack item's main ingredients were grown locally or non-locally. Per-serv calories showed the per-serving calories of the snack. For the real snacks the "Get More Info" button revealed the sugar and fat information based on the items' real nutrition. For the imitated items both sugar and fat content were imitated. The "Get More Info" button allowed participants to look up further information about the snacks. The purchase decision-making process included two behaviors: selecting snacks on Snackazon (Snackazon Item Choices, SIC) and choosing reasons that influenced the selection of the Snackazon items collected through PDQs. All snacks had different per-serving calories, and were categorized as "Bad" (highest per-serving calories), "OK" (middle per-serving calories), or "Good" (lowest per-serving calories) choices, and were coded as -1, 0, and 1 respectively. Then, the three coded values were added together so that the highest number would represent the low-calorie choice and vice versa. The imitated snacks were made to represent categorical data without meaningful variance in the categories. Our team specifically created three categories (low, medium, high calorie) to observe clear

indications of the users' decisions and whether they would jump from one category to another post-intervention.

The PDQ aimed to find out what factors influenced participants' decisions when choosing snacks via Snackazon. PDQ asked participants to rank the top three factors that influenced their snack purchases. Since we were only interested in per-serving calories, the answers were coded as 3 (= per-serving calories was ranked first), 2 (= per-serving calories was ranked second), 1 (= per-serving calories was ranked third), or 0 (= per-serving calories was not selected). Here, again, the highest number represented the most desired outcome and lowest number–the least desired outcome. Our main question here was whether the chosen snack was the lowest in calories. These data, the calorie content of the chosen snack and the reason for choosing it, provided a picture of the participant's decision-making process about snacks at point-of-purchase and helped us assess to what degree caloric information about snacks mediated purchasing decisions on Snackazon. Snackazon used deception in that even though the participants were told their selected snacks would be delivered to them, they did not receive any snacks in the end. This was debriefed to everyone at the final stage of the study.

EVALUATION STUDY

We deployed our between-subjects design study online to evaluate the effects of framing by comparing the two versions of Monster Appetite, subversive and two-sided framing using inoculation.

Participants

The target population for this study consisted of adults 18 and over. Recruiting was conducted through social media sites (e.g., Twitter, Facebook, and LinkedIn), and Amazon Mechanical Turk.

This study used a pre- and post-, between subjects design. 225 participants enrolled in the study and of those participants 105 were in the subversive group and 120 in the two-sided inoculation group. Among the initial 225 participants, 136 completed Session 2 of the study. Among the 136 returnees 58 were in the subversive and 79 were in the two-sided inoculation group. Therefore, 60.4% of the 225 participants completed Session 2 ($N_{session1}$ = 225, $N_{session1\&2}$ = 136), which occurred at least 24 hours after completion of Session 1 (Table 1). The study was approved by an east coast university's Internal Review Board (Appendix G).

Research Questions

(1) How does the difference in framing of gameplay (subversive vs. inoculation) affect food purchases immediately after a participant finishes playing a game?

(2) How do the gameplay treatments (subversive vs. inoculation) affect the inclusion of "per-serving calories" as one of the reasons behind food purchases in Snackazon?

Our hypothesis was that participants in the subversively-framed game group would (1) choose/purchase the low-caloric snack items for (2) caloric reasons more so than those in the two-sided inoculation game group would have. This hypothesis was based on players' high-engagement and positive feedback with Monster Appetite's subversive mechanism from the pilot results [46].

Session	Activities
Session 1	Demographics Questionnaire (DQ) Food Frequency Questionnaire (FFQ) Snackazon (Rounds 1-5) Purchase Decision Question (PDQ1) Behavioral Intention Question (BIQ1) Gameplay (Monster Appetite) BIQ2 Snackazon (Rounds 6-10) PDQ2
24 HOURS LATER	
Session 2	Snackazon (Rounds 11-15) PDQ3 BIQ3 Gameplay (Monster Appetite) BIQ4 Snackazon (Rounds 16-20) PDQ4 Exit survey & Remuneration

Table 1. The chronology of the study. Refer to all appendices.

Study Design

This study compared two treatments (subversive and two-sided inoculation approach) in a digital game environment, and participants were evaluated on how they snack habitually (i.e., snacking behavior) through a food frequency questionnaire (FFQ—Appendix B) before they were randomly assigned to one of the framed treatments. More specifically, the subversively-framed group played the game with a goal of consuming the highest per-serving caloric items and observed the negative consequences, or losses, of excessive caloric consumption within game time. The other, two-sided inoculation-framed group played the same game with the goal to consume the lowest per-serving caloric items and observed the negative consequences, or losses, of moderate caloric consumption.

Pre-questionnaires were presented to participants followed by the first gameplay session, which was immediately followed by post-manipulation measures. This concluded Session 1. Session 2 was conducted at least 24 hours after the conclusion of Session 1 (Table 1). Many previous food-related research studies conducted delayed tests to study the sustainability of the intervention effect. Our team took a similar approach but given the brevity of the intervention the delay between the two sessions had to be brief. Session 2 repeated the same activities in Session 1, except for the informed consent, demographics survey (DQ—Appendix A), and food frequency questionnaire (FFQ—Appendix B). The two sessions allowed participants to play the game twice over approximately a 24-hour period.

Data Analysis

A Priori Tests–This analysis was conducted to verify that the two treatment groups were not different in terms of age, gender, education level, income level, and game experience (Table 2).

Category	N	df	Pearson χ^2	Asymptotic sig. (2-sided)
Age	225	5	2.996	0.701
Gender	225	2	1.222	0.543
Edu Level	225	3	3.267	0.352
Income Level	225	4	5.235	0.264
Game Expr.	225	4	4.702	0.319

Table 2. Chi-square tests for preliminary variables.

Because these variables were ordinal or nominal in nature, chi square tests were conducted to look for statistical differences between the two groups. It was expected that no significant differences would be found, but if differences were to be found further analysis would be conducted accordingly.

Snack Choices–Paired samples *t*-tests of the pre- and post-snack choices were conducted to see whether selections of snacks differed statistically significantly pre- and post-gameplay. As mentioned above, all snack items were categorized as "Bad" (highest per-serving calories), "OK" (middle per-serving calories), or "Good" (lowest per-serving calories) and were coded as -1, 0, and 1 respectively. Then, the added total scores for the three rounds per section (pre- and post- for Session 1 and 2) was calculated. The means of these scores, standard deviations, and results of the paired *t*-test comparisons of all the participants are reported in the Results section.

RESULTS

We explore our results in the following order: (1) a priori test for the entire population, (2) differences in pre- and post-gameplay snack choices across treatment groups, (3) differences in reasons why snacks were selected through PDQs pre- and post-gameplay across treatment groups, and (4) an additional analysis on users' feedback for the overall study.

Preliminary Analysis: A Priori Test

Statistical Package for the Social Sciences (SPSS) was used to analyze the data and alpha was set at 0.05. The first step analyzed participants' demographic information. A chi-square test of independence was performed to compare the frequency in the age ranges in the two-sided inoculation (n = 120) and subversive (n = 105) conditions. The relation between these variables was not significant, $(\chi^2(5) = 2.996, p = .701)$. A chi square test of independence was performed to see if there were any significant relationships within gender, education level, income level, or prior game experiences between the two treatment groups. No statistical significance was found between the two groups in their gender $(\chi^2(2) = 1.222, p = .543)$, education level $(\chi^2(3) = 3.267, p = .352)$, income level $(\chi^2(4) = 5.235, p = .264)$, and prior game experience $(\chi^2(4) = 4.702, p = .319)$ as shown in Table 2. Based on the preliminary results, we assumed the groups were equal at the beginning of the study regarding their demographics (age, gender, education level, income level, and prior game experience) and statistical tests were run without consideration of the impact of these variables on the dependent variables.

Pre- and Post-Gameplay Snack Choices

This section explores the paired samples *t*-test of the snack choices pre- and post-gameplay. As shown in Table 3, there was a statistically significant difference between pre- and post-gameplay snack choice means in Session 1 (M = -.392, SD = 1.64, $t(78)$ = -2.12, p = .037) but not in Session 2 in the two-sided inoculation group. Also, when the snack choice means of Session 1 pre- was compared to Session 2 post-gameplay in the two-sided inoculation group, there was a statistically significant difference (M = -.494, SD = 1.76, $t(78)$ = -2.49, p = .015). However, no statistical significance was found in the subversive group. ***Participants exposed to positive messages with negative visuals through the monster avatar (two-sided inoculation) picked "better" snacks with lower per-serving calories among the snack choices post-gameplay.***

Pre- and Post-Gameplay Purchase Decision Questions

This section explores the paired samples *t*-test of the reasons for choosing snacks via Purchase Decision Questions (PDQs) pre- and post-gameplay. As mentioned above, the coded PDQ score was dependent upon whether the "per-serving calories" reason was chosen and what rank it received out of the three options. The means of the scores in each section (PDQ1, PDQ2, PDQ3, PDQ4), standard deviations, and results of the paired *t*-test comparisons across all the participants pre- and post-gameplay are presented in Table 4.

There was a statistically significant difference between pre- and post-gameplay PDQ means in Session 1 (M = .386, SD = 1.24, $t(56)$ = 2.36, p = .022) but not in Session 2 in the subversive group. Also, when the PDQ mean of Session 1 pre- (PDQ1) was compared to Session 2 post-gameplay (PDQ4) in the subversive group, there was a statistically significant difference (M = .474, SD = 1.43, $t(56)$ = 2.50, p = .015). However, no statistical significance was found in the two-sided inoculation group. Participants exposed to negative messages with negative visuals through the monster avatar (subversive) chose "per-serving calories" as a reason for snack choice statistically significantly more often in post-gameplay.

A factor to consider is the non-statistically significant snack choices for the subversive group (Table 3). However, PDQ allowed ranking for snack choice reasons. Hence, one explanation is that the PDQ reasons included "per-serving calories" as one of the *higher* ranked reasons by the end of Session 1 and conclusion of the study compared to the beginning of it.

Additional Analysis: "Qualitative" Feedback

In our study we did not explicitly collect qualitative data on different aspects of the gameplay and other activities. However, at the end of both Session 1 and 2, there was an opportunity for participants to provide open-ended feedback. The motivation behind this particular way of obtaining qualitative data, as opposed to the more explicit and guided approaches, was to avoid social desirability by minimally soliciting comments. If participants mentioned how fun or engaging the activities were without prompting, we identified their response as honest - unaffected by the social desirability effect. We used inductive thematic analysis to analyze the feedback we received and found some emerging patterns, listed below.

Condition	Pair	N	Mean	Std. Dev.	t	Sig. (2-sided)
Two-sided Inoculation	Sess1 pre to Sess1 post	79	-0.392	1.644	-2.121	0.037**
	Sess2 pre to Sess2 post		0.063	1.399	0.402	0.689
	Sess1 pre to Sess2 post		-0.494	1.760	-2.492	0.015**
Subversive Group	Sess1 pre to Sess1 post	57	0.088	1.948	0.340	0.735
	Sess2 pre to Sess2 post		-0.035	1.488	-0.178	0.859
	Sess1 pre to Sess2 post		-0.140	2.224	-0.477	0.636

Table 3. The pre- and post-gameplay snack choice means paired samples *t*-test by treatment group. $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$

Condition	Pair	N	Mean	Std. Dev.	t	Sig. (2-sided)
Two-sided Inoculation	PDQ1 to PDQ2	79	-0.101	1.364	-0.660	0.511
	PDQ3 to PDQ4		0.165	1.091	1.340	0.184
	PDQ1 to PDQ4		0.165	1.245	1.175	0.244
Subversive Group	PDQ1 to PDQ2	57	0.386	1.236	2.358	0.022**
	PDQ3 to PDQ4		0.263	1.158	1.716	0.092*
	PDQ1 to PDQ4		0.474	1.189	2.504	0.015**

Table 4. The pre- and post-gameplay means paired samples *t*-test of snack choice reasons by treatment group. $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$

There were a total of 74 and 34 comments at the end of Session 1 and 2 respectively (N = 108). All comments were categorized into eight different topics (SNACK, MA, PDQ, GEN, MISC, SYST, FUN, and LEARN—Appendix J) and then further finely categorized. Because some comments consisted of several large concepts those were counted as more than one comment for the purpose of tallying different topics that were mentioned. When all unique topics were counted a total of 100 and 53 comments were coded for Session 1 and 2 respectively (N = 153). After general or miscellaneous comments, feedback regarding PDQ and FUN tallied at the top. Comments regarding PDQ mainly consisted of wanting more options (explained in the next section). For the FUN category, we list a few that illustrate instances of engagement through fun, excitement, learning, and self-reflection in Table 5.

Purchase Decision Question and Feedback

Purchase Decision Question (PDQ) page sparked some interesting feedback. Some participants (n = 19) felt that (a) they did not have 3 reasons why they made the selections they did, (b) the PDQ page was shown to them a bit too late to remember why they made the choices they made, or (c) the items did not cover all the reasons they had in mind for making their snack selections. For example, some of the feedback included:

- *"I wonder why nutrition fact wasn't an explicit option,"*;
- *"I looked a lot at the sugar/fat content...but that wasn't one of the options to drag into the box,"*;
- *"For many snacks, I only thought about 1 or 2 aspects of them, but I was forced to choose 3."*

Though we received some positive comments regarding fun and enjoyment as shown in Table 5, we did not officially measure engagement during gameplay and Snackazon to see if the affective appraisal was related to positive game experiences [64]. Therefore, from the feedback alone it was difficult to see whether the framing and interface worked as it was intended to: people fully engaged in reading the framed messages and observing the changes in the monster avatar's health and mood status. The pilot study [46] indicated that the subversive approach was fun and enticing for the majority. However, regarding framing, we also encountered some resistance that was indicated through the following participant's comments:

> *"The...game seemed a little forced...instructions clearly indicated to pick the foods I thought contained the most calories, so that's what I did. Pretty obvious that constantly choosing the items with the most calories would eventually kill the monster...If I'd gone against the game instructions by not picking the items with the highest amount of calories (which is how I would typically behave), would this have been against your intentions?"*

DISCUSSION

Previous research in technologies for health incorporated a wide range of behavioral theories and frameworks [62, 66]. In HCI literature, the field of persuasive technology for behavior change [37, 58, 94] has faced mixed results. Hekler et al. [40] recommend three ways to evaluate technologies regarding behavior change: mediational analysis, alternative experimental designs, and qualitative data. In our work, we developed an alternative experimental design, supplemented with qualitative data. We examined whether two relatively untested, alternative framing approaches (subversive vs. two-sided inoculation) for delivering nutritional messages in a digital game environment—Monster Appetite (MA)—would affect participants' immediate snack purchasing behavior. The seemingly small and inconsequential snack choices can nonetheless be highly important because proliferation of energy-dense snacks is contributing to the high-calorie diets common to individuals nation wide [26, 34].

Why framing or persuasion?

Delivering a complex, nutrition message or conveying healthful information in a simple way is challenging. In fact, the

Time	TOPICS (Subtopic)	Example Quotes
Session 1	LEARN (reflection) FUN (fun)	*"This was an interesting survey. Feeding that little green guy all those calories really made me think what I am putting into my body and how I might look. I also enjoyed the setup of the survey."* (SUBV)
	FUN (fun) LEARN (reflection)	*"That was a lot of fun!! I'm sorry that it ended. I have been struggling with getting myself to think about eating better. And I felt a bit differently after playing the game about being such a snack-horse. :) It will be interesting to see if I continue to feel different..."* (SUBV)
	MA (interface) LEARN (informing)	*"During the monster game, sometimes duplicates of certain foods would show up...sometimes I clicked one later...because...of curiosity...[of] calories...Also if you made it so that you have calorie thresholds and you get something for them or you 'win/lose' for it, it could make it so I want to click high calorie things more."* (SUBV)
Session 2	LEARN (reflection)	*"This survey made me really aware of my eating habits and food choices. I will definitely try to make healthier choices in the future."* (SUBV)
	FUN (fun) LEARN (reflection)	*"That was fun. I never could get the monster to smile or get out of the silver level."* (INOC)
	FUN (fun)	*"I really enjoyed this game! It was very clever and engaging..."* (INOC)
	LEARN (reflection) FUN (fun)	*"I was actually really hoping to get some of those items. Some of them I haven't had since I was a kid...I could buy them now, but...I would feel guilty. This was an interesting and fun study. I really enjoyed it!"* (SUBV)

Table 5. Voluntary feedback from participants at the end of Session 1 and 2. These are a few samples that show (in)direct engagement during the study.

2012 Food and Health Survey [32] showed half of those polled believed doing taxes was easier than figuring out how to eat in a healthy way. Moreover, many studies showed that simply delivering nutritional information in the form of Nutritional Facts Labels at the point-of-purchase produces moderate impact on individuals' choices [28, 55]. Part of the reasons for this lack of impact could be that informational displays do not directly speak to individuals on how nutritional choices will affect them personally. Therefore, campaigns with targeted messages can be more useful and meaningful to individuals in helping them to adopt healthy behaviors [13, 27, 95]. Negatively framed messages were shown to be particularly effective: negatively framed message regarding extra-large sodas have successfully decreased overall soda consumption nation wide [87]. Similar successful results were shown in regards to the fat consumption in the 70s (though with unintended consequences) [92] and to the highly negative, anti-smoking messages through the *Tips From Former Smokers* campaign [69]. As shown through these examples, carefully framed health-related messages have the potential to amplify the impact of nutritional and other health interventions and directly affect our nation's health.

The notion of framing has been previously explored within the HCI community; yet its framing-based studies have mostly been conducted in non-health contexts [39, 41, 51, 52]. At the same time, Web- [10, 33, 49, 78, 90] and mobile-based health interventions [21, 24, 25, 53, 61, 79] are on the rise as more Americans utilize eHealth and mHealth services. A meta-analytic review of web-based interventions [96] identified 85 studies between 2000 and 2008 and found they had a statistically small but significant effect on health-related behavior on average. A national survey [56] conducted on 1604 adult smartphone users showed that 58% of them downloaded at least 1 health app, 65% of those surveyed reported the health app(s) had improved their health, and a majority had a strong degree of faith in health apps' accuracy and effectiveness. In addition, as mentioned earlier, persuasive technology and games in particular, have been generating interest in tackling motivation for healthy behaviors [50, 70, 93]. Given this growing interest in utilizing interactive and mobile computing technologies for health, there is an opportunity to leverage success of traditional marketing campaigns that rely on persuasively framed health messages in the design of new interactive interventions. Our study showed that there exist many novel opportunities to frame health messages and the choice of framing can have a significant impact on both individuals' snack choices and their reasoning behind these choices. However, more research is needed to better understand how different types of framing can be incorporated in interactive technologies for health and the result of the long-term exposure to these interventions.

Framing Effects in a Digital Game Environment

This study demonstrated that ***framing affected participants' snack choices and reasons for choosing those snacks (PDQs) in pre- and post-gameplay (Session 1) as well as comparing their choices and reasons at baseline and conclusion of Session 2***. However, the framing conditions affected the snack choices and purchasing motivations (PDQs) differently. That is, for snack choices we found statistically significant improvements in the two-sided inoculation group, while for PDQs we found improvements in the subversive group as observed in Tables 3 and 4.

These results indicate that in both conditions, exposure to MA increased participants' awareness of caloric content; yet this awareness had different effects in the two conditions. Our focus here was on the subversive condition, which was particularly engaging and attractive during our pilots [46].

Previous research showed games that allow their users to engage in activities deemed unacceptable or subversive in the real world may have a particular appeal for certain populations that are challenging to reach with more traditional public health interventions [23]. Overall, as the study progressed subversive group participants cared about "per-serving calories" statistically significantly more than they did initially when they started the study. This gradual appreciation of the importance of "per-serving calories" is promising and is consistent with the new initiatives within the FDA that raise public awareness of calories in foods (Figure 6). Though calories do not tell the whole story as a participant pointed out (*"things like pretzels might have low calories but they are empty calories"*), it is promising that an unconventional approach succeeded in bringing a nutrition fact to attention. There may be potential for the subversive framing approach in emphasizing and learning one particular aspect in nutrition in a game environment. Further investigation is needed to see if this result applies to other nutritional aspects in persuasive, game applications.

Yet this higher appreciation for calories as a reason for choosing snacks did not translate into increased preference for low-calorie food choices for the subversive condition. The subjective experiences of the participants may suggest a plausible explanation to this finding. While subversive gameplay may have felt like more fun, it was also perceived as somewhat forced and contrary to some participants' natural inclinations. Previous research suggested different individuals may be more predisposed to different types of gameplay, thus distinguishing different player types [70]. It is possible that subversive gameplay has a positive appeal only for a certain type of users. Further research is needed to examine possible connections between individuals' preferences in regards to player type and effectiveness of subversive approach to nutritional choices.

Improving Monster Appetite

This study identified a few opportunities for improving MA's design. One limitation of the current study was the avatars only changing in the negative direction in both conditions. In the two-sided inoculation game, even if the players were feeding the monster low-calorie snacks, eventually it fattened up. Hence, at no point did the participants receive positive reinforcement, nor observe good consequences of healthy snacking. As a result, the two-sided inoculation gameplay may have not been visually different enough than the subversive one, except for the end-of-day, pop-up framed messages. Addressing this issue could lead to possible future studies. For example, if the monster avatars started at mid-weight (stage four in Figure 1) and depending on how well or not the calories were controlled, the stages can move to a healthier or heavier stage. Another revision could be that players get to choose a starting weight like it was done in FatWorld [74] and they get to see changes in the avatar's health and mood based on their activities expressed through the avatars. Similar avatar-based, visual health games may want to consider flexible options for positive and negative visual feedback or messages.

Are We Having Fun?

Though no official affective data was collected regarding players' experience throughout the study, the qualitative feedback

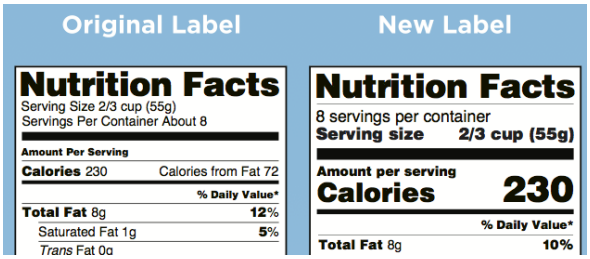

Figure 6. The new proposed Nutrition Facts Label—right—compared to the current version—left. The new label will be implemented by 2019.

provided an interesting picture of some of the participants' feelings. If we can safely assume that FUN and LEARN categories from Table 5 indicate a form of engagement, then engagement-related comments were the most frequented topic. Since the feedback solicitation at the end of Session 1 and 2 was generic, asking for any comments related to the entire study, it is promising that participants decided to voluntarily mention aspects that can be largely contributed to engagement. The collection of affective data can be useful in gauging awareness and user experience [14] to a persuasive health topic, and further actions taken based on those responses can be useful in game-based behavior studies. As intrinsic engagement [60] is one of the best affordances of games, it would be wise to implement a way to detect the level of engagement with any persuasive health game.

Future Research and Conclusion

To facilitate future work within the community, we have made the tools for this study, Monster Appetite and Snackazon, open source [45], so that they may provide a foundation for other game-based health studies. Specific areas of future research include designing persuasive games for other health contexts and lasting behavior change, making the framing and positive/negative reinforcements adjustable (e.g., choosing the beginning monster stage), adding features to let players know how far/close from "winning/losing" the game, and being able to add health goals to tailor the gameplay.

Our work contributes to the growing body of literature in the persuasive technology and games space, specifically in nutrition. We hope this study can help designers, developers, and dietitians further investigate different message delivery methods to inspire healthier nutritional choices. A long-term future goal is to make a persuasive mobile app that is seamlessly integrated in people's daily lives, especially for those who aim to change their current behavior in a positive way [22].

While we focus on persuasive nutrition games, we expect these results to generalize to other applications of persuasive health game-based behavior studies. However, documenting framing effects in games is only the first step to such a generalization. Further research is needed to understand the mechanism of the framing effects in persuasive games across application domains.

ACKNOWLEDGEMENT

This work was funded in part by the NSF Smart and Connected Health (Grant No. 1551708, PI Mamykina)

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