Mining Behavioral Economics to Design Persuasive Technology for Healthy Choices

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ABSTRACT
Influence through information and feedback has been one of the main approaches of persuasive technology. We propose another approach based on behavioral economics research on decision-making. This approach involves designing the presentation and timing of choices to encourage people to make self-beneficial decisions. We applied three behavioral economics persuasion techniques—the default option strategy, the planning strategy, and the asymmetric choice strategy—to promote healthy snacking in the workplace. We tested the strategies in three experimental case studies using a human snack deliverer, a robot, and a snack ordering website. The default and the planning strategies were effective, but they worked differently depending on whether the participants had healthy dietary lifestyles or not. We discuss designs for persuasive technologies that apply behavioral economics.

Author Keywords
Persuasive technology, behavioral economics, health technology, default bias, present-biased preferences, asymmetric dominance, snacking, healthy eating, choice.

ACM Classification Keywords
H5.2. Information interfaces and presentation (e.g., HCI): User Interfaces.

General Terms
Design

INTRODUCTION

The role of information technology in people's daily decision making is steadily growing. For example, we decide which route and transportation to take to visit a friend's house, which restaurant to go for dinner, or which grocery products to buy based on the information and choices presented in information technology applications. This change offers tremendous opportunities for human-computer interaction (HCI) researchers to provide interventions to assist people to make self-beneficial or pro-social choices.

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Many researchers have investigated ways to use technology to convince people to adopt healthy or sustainable lifestyles [9]. One of the most common approaches has been to use information and feedback to encourage behavioral change. By inducing users to set goals and providing them with feedback about their current behavior, this approach seeks to increase people's awareness about an issue and to encourage them to change their behavior.

We suggest an alternative approach, drawn from the field of behavioral economics. Behavioral economics examines the gamut of large and small decisions people make about such choices as how much to invest in retirement savings, whether to join a health club, and whether to eat a delicious but caloric candy bar. The persuasive element in this approach consists of presenting choices in a way that leverages people's decision processes and induces them to make self-beneficial choices [3].

We argue that designs for HCI that leverage behavioral economics theory and research are a highly promising avenue for persuasive technologies. Although widely discussed outside the HCI and design communities in both academic and popular arenas (e.g., [31]), this approach has not yet influenced our field. The message of behavioral economics is simple: people are susceptible to decision bias, which often makes it hard for them to make self-beneficial choices. Thus, we should present choices in a way that helps people to make self-beneficial choices and understand the implications of their decisions as well—all without restricting their freedom of choice. Although behavioral economics principles can be applied in many domains, we address healthy eating, particularly workplace snacking. Workplace snacking is pervasive and often highly caloric; high-calorie snack choices are shown to contribute to obesity [22].

In this paper, we make three contributions. We first present different ways that behavioral economics approaches can be applied to the design of persuasive technology in the domain of healthy snacking. Second, we demonstrate through three experimental case studies the efficacy of behavioral economics approaches in comparison to other persuasive approaches. Finally, in testing these approaches, we inform behavioral economics theory by adding an understanding of how the theory works with people's existing habits and how it influences people's experience.

PERSUASIVE TECHNOLOGY FOR HEALTHY EATING

We are not the first to conduct HCI research in the domain of healthy eating. Researchers have designed technologies to encourage people to adopt healthy dietary lifestyles [2, 11, 21]. For example, Chi et al.'s intelligent kitchen provides nutritional information about ingredients at the time of cooking so people can adjust their ingredients accordingly [5]. Autom, a weight management robot, helps people keep track of what they have eaten that day and calculates caloric and nutritional information with respect to their set goals [13]. These and other applications help people make informed choices about what they eat by providing nutritional information, tracking their behavior, and providing feedback.

These applications are similar in that they provide information for people to better understand nutritional information about food. However, research points to some potential disadvantages of using information-centric techniques to motivate healthy eating. Providing calorie information about food that is about to be eaten can reinforce feelings of guilt about eating high-calorie food and reduce people's enjoyment of food [25]. Providing calorie information about certain foods at the moment of choice can even lead to an increase in calorie consumption. Wansink and Chandon found that labeling a snack food as "low fat" led people to eat more of it and they felt less guilty about doing so [32]. Other studies of nutritional labeling show very limited effects [e.g., 28].

APPLYING BEHAVIORAL ECONOMICS

We argue that behavioral economics could avoid the potential downside of information-centric approaches. Departing from the premise of economics that people make rational choices, behavioral economists have shown that people's decision making processes are biased by various situational factors, such as the manner in which options are presented and the times when the choices are offered, and the emotional or visceral state of the person at the time of choice [3, 15]. This understanding of people's decision biases provides a rich repertoire of tools that designers can leverage. In this section, we present three different ways that behavioral economics theories can be applied to design technology that promotes healthy eating.

Default bias

When people make choices, they tend to favor the default option or the status quo, rather than taking the time to consider and then adopt an alternative state [14, 27]. People tend to take "the path of least resistance," and keep doing what they have been doing, or doing what comes automatically, even when they can make improvements. The reasons for this decision bias could have roots in people's limited attention and tendency to "satisfice" [27], their perception that an organization's selection of a default option constitutes a recommendation (see [8]), and the implied popularity of the default option.

Default biases have been blamed for a wide range of undesirable outcomes, including Americans' excessive consumption of fries and large sodas as part of "supersized" meals at McDonald's [18]. Yet if carefully designed, the default bias can be a powerful tool to propel people toward self-beneficial behaviors (see [18, 30]).

HCI design can leverage the default bias in many ways, by making healthy choices more convenient and salient physically and cognitively. In the domain of snacking, featured healthy snacks can be made easy to access, e.g., on websites, on vending carts, and so forth. For example, on a website, the checkbox of healthy snacks among available options could be selected as the default, reducing the need to select one of these options explicitly. Or when presenting sale items at a bakery, a system could filter and first offer items that are made with whole grain flours. For a kiosk system, the placement of buttons, the number of clicks or the number of screens a user has to access to choose an item could be decreased or increased to change the perceived priority of a snack or sandwich order.

An eldercare robot working in a nursing home could organize the physical placement of food in a way that the healthy food is placed closer to an elder's room. In addition, a snack delivery robot might only deliver healthy snacks to people's offices, but require people to walk to the robot to get unhealthy snacks.

Convenience can be further leveraged using sensing technologies that tell people when they are near healthy snacks. For instance, if shoppers are in a food court in a mall, the system could present healthy choices to them via mobile phone as convenient food options.

Present-biased preferences

Present-biased preferences represent people's tendency to weigh the pros and cons of present choices more heavily than future choices, and to underestimate their needs in the future. This decision bias is also known as "time discounting" [20]. The tendency typically promotes unhealthy eating because the immediate pull of tasty food is likely to eclipse considerations of future health consequences. However, present-biased preferences can be used to encourage healthier choices if people are asked to plan ahead. Read and van Leeuwen [26] gave their participants a choice of snack to be eaten in one week or at the time of eating, the next week. They found that their participants chose far more unhealthy snacks for immediate choice than for advance choice.

Present-biased preferences can be leveraged by strategically designing the time that technology applications prompt users to make certain choices. Researchers in context-aware technology have been designing applications that can sense the current activity of people and learn their routines over time [6]. A meal planning application or a restaurant reservation system that nudges people to make a choice when they are less likely to be hungry (i.e., 1-2 hours after their lunch) might be as effective as the application that uses persuasive messages or calorie information, and it might be felt to be less intrusive.

Asymmetrically dominated choices

People tend to make choices that are easier to judge as superior than other alternatives. One example of this tendency is the "asymmetric dominated choice" [12], which means placing a choice option next to an inferior option to increase its attractiveness. For instance, consider a cookie as compared to a large, shiny Fuji apple and a small withered apple. By pairing the Fuji with the withered apple, the Fuji's value seems much higher, and choices of the Fuji will increase.

Relevance of behavioral economics to HCI theories

The above-mentioned behavioral economics theories have some linkages to other theories and principles commonly used in the field of HCI. Both approaches identify factors that influence decision-making and derive design principles from them. Theories about information processing limits (e.g., the model human processor [4]) and human cognition (e.g., cognitive tunneling [32]) predict when people are likely to use heuristics in decision making, as does behavioral economics. Research on user interface design offers design principles for designing displays, controls, and response options (e.g., consistency, reduce short-term memory) to improve ease of use and efficiency of interfaces [24, 29]. Designs for interfaces drawn from behavioral economics theories have a different goal, that is, to encourage self-beneficial choices, even when they are not what users want most. For example, in contrast to the practice of putting most used-menu items in a salient and accessible location on a screen, using a default strategy from behavioral economics would have us place less frequent or less popular items that are healthy in a more convenient place, with the hope that people would choose the most convenient item, rather than their usual item.

Challenges in applying theories to design

It is not immediately clear how one can apply behavioral economics to persuasive technologies to support beneficial choices in everyday domains such as eating. The intervention design should be powerful enough to work against people's existing unhealthy preferences and habits (e.g., their favorite sweet). Eating can especially be driven by strong visceral urges that could overcome any particular architecture of choice [19]. At the same time, the intervention must avoid intrusiveness. For example, offering a default option might hamper people's enjoyable experience of making a choice.

We argue that systematic design iteration and evaluation of theory-based design is critical to assess whether it is desirable and powerful enough to lead to changes in people's decision making. Some interventions may not be effective enough to result in behavioral change, and others may be perceived too forceful and manipulative.

We have begun to explore ways of using behavioral economics principles in the everyday domain of snacking and to evaluate them experimentally. We measured people's existing habits (i.e., diet style) and enjoyment of their choices to test whether the strategies would be effective for people with unhealthy eating habits, and whether the strategies would have a negative impact on people's experience.

OVERVIEW OF EXPERIMENTAL CASE STUDIES

In our experimental case studies, we focused on three strategies, pursuing the following research questions.

Study 1: Do planning and default choices work effectively in promoting healthy snack choices?

Study 2: Do default choices work in presenting healthy snack choices when a robot offers the snack? Can we strengthen the effect of default by manipulating cognitive load through a robot's dialogue?

Study 3: Do default choices work when they are implemented on a screen-based interface? How well do the default choices work when compared to asymmetric choice and information-centric approaches? Can we strengthen the effect of default by manipulating perceptual load using a screen interface component?

We implemented these strategies on three different platforms, one with a human snack deliverer, a second using a snack delivery robot, and a third using a snack ordering website.

STUDY 1: DEFAULT VS. PLANNING STRATEGIES

We conducted a between-subjects field experiment over two days. The design was a one-way factorial with three conditions: Control, Default, and Plan. The participants were randomly assigned to one of the three conditions.

Participants

We recruited 61 faculty, administrative staff, and graduate students in a university (Control condition: N = 21; Default condition: N = 20; Plan condition: N=20). Seventy-four percent of the participants were female. People who were allergic to the snacks or had medical conditions that could influence their choices of snacks could not participate.

Procedure

An experimenter visited participants in their offices in the afternoon (2:00 p.m. to 4:30 p.m.) on two days, carrying snacks in a bag. The experiment was double blind, and the experimenter was not aware of the hypotheses of the study. On both days, the experimenter offered participants a choice between two types of apples and two types of cookies. We used two types of apples and cookies to discourage people from choosing a different snack category on each day only for the sake of diversity [16]. On Day 1, the experimenter asked participants whether they wanted to participate in the test of a new snack delivery service. Once they agreed, participants were randomly assigned to one of three conditions: Control, Default, and Plan.

Control condition. On Day 1, the experimenter told participants about the next day's visit, and asked them to choose a snack to eat now: "We have two options: apples or cookies. Which snack would you like to have?" We did not counterbalance the order of snacks because the same snacks

were used in all conditions. On Day 2, the experimenter visited the participants again, and gave them the same choice.

Default condition. On Day 1, the experimenter asked participants to make a choice of an apple or cookie. The experimenter also told participants that the snack for Day 2 would be apples, but that they could change the snack: "I brought two snacks today, but for the next visit, I will only bring apples. If you would like to have a cookie instead of an apple, please tell me." On Day 2, the experimenter brought the snack the participant specified but offered to get a different snack if the participant wished.

Plan condition. On Day 1, before choosing the snack for that day, the experimenter asked participants to plan ahead for Day 2 by saying, "I brought apples and cookies today, but for the next visit I will bring only one of the snacks. Can you tell me what snack you would like to have for the next visit?" On Day 2, the experimenter returned and brought the planned snack, but gave the participant the option of changing his or her mind.

At the end of the Day 2 visit, all participants completed a brief survey.

Measures

The effectiveness of each strategy was measured as the percentage of participants choosing apples for Day 2. We also measured whether they changed their choice on Day 2 when the experimenter delivered the snacks. To measure the influence of the strategies on the enjoyment of their snack choice, we asked participants on Day 2 to rate on 5-point Likert scales how much they had enjoyed their snack on Day 1 and how much they thought they would enjoy their chosen Day 2 snack. We also asked participants whether they were currently on a diet or vegetarian.

Results of Study 1

On Day 1, 51% of the participants chose apples and 49% chose cookies. On Day 2, 33% of the participants in the Control condition chose apples. There were no differences depending on participants' gender, or whether they were on a diet. However, vegetarians only ate apples, so we used this factor as a control variable in all the regressions. We used mixed model regressions to control for the within subjects variable of Day 1 vs. Day 2 choice.

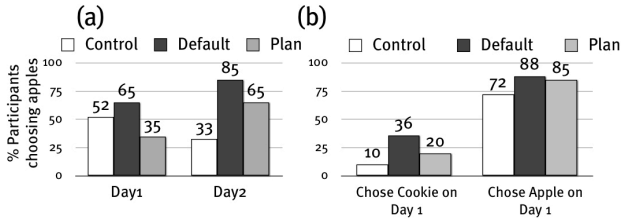

Figure 1. (a) Percentage of participants choosing an apple in the Control, Default, and Plan conditions on Day 1 and Day 2; (b) Percentage of participants choosing an apple on Day 2 depending on their choice on Day 1.

Effect of the default option strategy

In the Default condition, 65% of the participants chose an apple on Day 1 and 85% did so for Day 2. That is, all but two participants in the default condition chose an apple for Day 2. This is a marginally significant increase in the healthy choice from Day 1 to Day 2 ($F [1, 39] = 2.51$, $p = .10$; Figure 1a). The percentage of the participants choosing an apple for Day 2 was greater in the Default condition than in the Control condition ($F [1,71] = 12.01$, $p < .01$). All but two participants stayed with their choice when the snack was delivered on Day 2.

Effect of planning strategy

As compared to the Control condition results, participants in the Plan condition tended to choose an apple on Day 2 (Figure 1a). In the Plan condition, 35% of the participants chose an apple on Day 1, but 65% of the participants did so for Day 2, showing a significant increase ($F [1,39] = 5.22$, $p < .05$). Significantly more participants chose an apple for Day 2 in the Plan condition than in the Control condition ($F [1,71] = 4.87$, $p < .05$). All but three participants stayed with their planned choice when their snack was delivered. In the Control condition, there was no significant difference in terms of the number of participants choosing apples between Day 1 and Day 2.

Choice on Day 2 as a function of choice on Day 1

The results above do not control for people's preferences on Day 1. We ran a regression model predicting the choice of snack on Day 2 as a function of condition, choice on Day 1, and the interaction (Figure 1b). In all conditions, the participants who chose an apple on Day 1 tended to choose an apple again on Day 2 (Control: 72%; Default: 88%; Plan: 85%). However, the differences across conditions remained whereby more participants in the Default and Plan conditions chose an apple for Day 2 ($F [2, 49] = 5.4$, $p < .01$). There was an interesting difference among participants who chose a cookie on Day 1. In the Control condition, 90% of the participants who chose a cookie on Day 1 also chose a cookie on Day 2. In the Plan condition, 80% of those who chose a cookie on Day 1 also chose a cookie on Day 2. However, in the Default condition, only 64% of the participants who chose a cookie on Day 1 chose a cookie on Day 2. When compared to the Control condition, the Default is significantly different ($F [1, 49] = 4.77$, $p < .03$). This result suggests that the default option strategy could be effective in influencing people who like sweets to consider an apple as a snack.

Effect on enjoyment

Participants were asked on Day 2 to rate how much they had enjoyed their snack on the previous day, and how much they anticipated enjoying the snack that had just been delivered to them. There was no difference across conditions in how much participants liked the cookie versus the apple on Day 1, how much they expected to like a cookie or apple on Day 2, or how much people retrospectively say they enjoyed their Day 1 snack.

On the other hand, we did find a difference in people's anticipated enjoyment of their snack choice for Day 2 across conditions ($F [2, 43] = 3.0$, $p = .05$). Participants in the Default and Plan conditions said that they would enjoy the snack they chose for Day 2 slightly less than did those in the Control condition. (Control M = 4.6; Default M = 4.3; Plan M = 4.4) This analysis excludes the five participants who changed their mind when the snack was delivered on Day 2; those participants said they would enjoy their (changed) snack more (mean = 4.8). The drop in anticipated enjoyment occurred in both the Plan and Default conditions but was significantly different only in the Default condition ($F [1, 43] = 4.7$, $p < .05$).

Discussion of Study 1

The default option and plan strategies were effective in inducing people to choose healthy snacks. When the participants were asked to plan their future snack in advance, with or without the default, they chose an apple over a cookie. However, the default strategy was significantly more effective in influencing those who chose a cookie on Day 1 to switch to an apple on Day 2 than was the plan strategy. This finding suggests that the default option strategy may be a more powerful tool than planning ahead alone.

We also found that enjoyment of the Day 2 snack dropped in the Plan and the Default conditions. Possibly, participants felt implicit pressure to have a healthy snack, or simply did not like planning a snack in advance. Framing a healthy snack as the default snack that the delivery person would carry may have exacerbated this feeling. This finding suggested we select a design in the next study that would not involve planning ahead.

STUDY 2: DEFAULT STRATEGY APPLIED TO A ROBOT

In Study 2, we applied the lesson from the human-human experiment to the design of a robot. We focused on the default strategy because it was slightly more effective for people with less healthy lifestyles. We tested a different implementation of the default strategy because the default strategy seemed to reduce people's subjective enjoyment of their snack choice in Study 1. Instead of framing the healthy snack as the default choice, we changed the presentation of the snack choices by varying their convenience [7]. In the Default condition, we placed the healthy snacks in a slightly more convenient place than the unhealthy snacks. In addition, we introduced a cognitive load variable as a way to strengthen the effect of the default strategy. We speculated that higher cognitive load might consume participants' cognitive resources and cause them to opt for the default snack more when they were thinking about something else. This resulted in a 2 x 2 between subjects design, with Control versus Default strategy as one variable, and Low versus High Cognitive Load as a second variable. The participants were randomly assigned to one of four conditions.

Participants

Posters and a website offered people in our office building a free snack in exchange for walk-in participation in a study. The 119 participants (Control condition: N = 59; Default condition: N = 60) consisted of students, faculty, staff, and visitors. Thirty-nine percent of the participants were female. Those with allergies or medical conditions were excluded from the study.

Robot

The Snackbot robot [17] (Figure 2) offered snacks during the experiment. The robot was 4'5" tall and carried a tray on which snacks were placed. We developed a custom dialog, speech, and audio manager system for the robot.

Procedure

The experimenter left the participant in a room with the robot. The Snackbot introduced itself, saying, "Good morning [afternoon]. My name is Snackbot and I'm from Carnegie Mellon University." The robot then asked the participant to answer a puzzle before taking the snack. The Snackbot then instructed each participant to take his or her

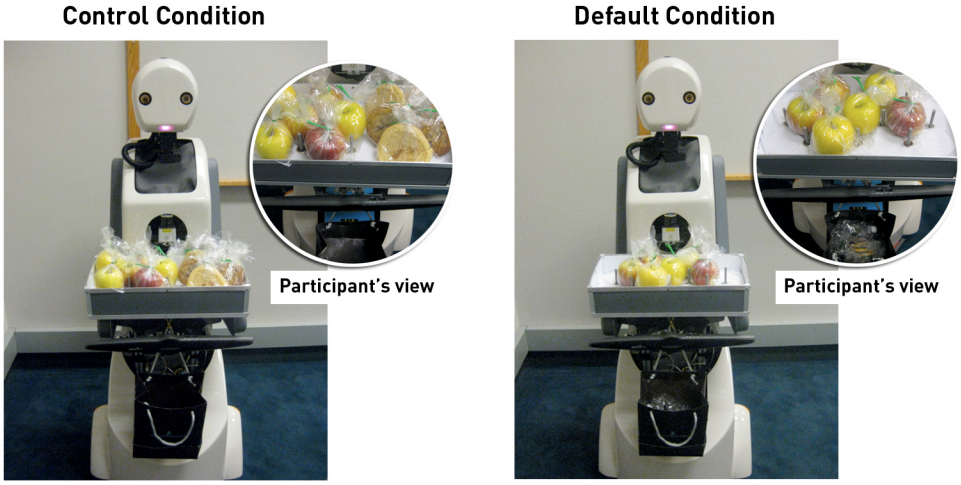

Figure 2. Manipulation of the Control and Default conditions in Study 2.

snack. As in Study 1, we used two types of apples as healthy snacks and two types of cookies as unhealthy snacks. After the participant chose a snack, the robot directed the participant to another room to fill out a survey.

Default vs. Control conditions. We created two types of snack presentation by slightly varying how convenient it was for participants to reach their snack (Figure 2). In the Control condition, six wrapped apples and six wrapped cookies were placed on the robot's tray. A bag hanging under the tray was left empty. In the Default condition, six wrapped apples were place on the tray and six wrapped cookies were placed in the bag hanging under the tray. The bag was easily visible to participants. After each participant left, the experimenter replenished the snacks, so that the number of snacks that each participant saw was the same.

Cognitive Load. Each participant had to answer a question before he or she chose a snack. In the low cognitive load condition, the robot asked the participant a very easy question, "What is two plus two?" In the high cognitive load condition, the robot said, "There are 102 offices on this floor. On average, there are two people in each office. If I visit each of these offices three times a week, on average, how many deliveries do I make?" Participants got a snack regardless of their answers. The cognitive load factor, as we manipulated it, had no effect on choices of snack, so we do not discuss this variation further.

Measures

The main dependent variable was the percentage of participants choosing apples. We also measured self-reported healthy eating behaviors by using a scale measuring healthy eating behavior [23]. The items included "read product labels," "take active steps to eat a well-balanced diet," "watch fat," and "watch sugar." The items were rated on a 5-point Likert scale, where 1 = almost never, 5 = almost always (Cronbach's alpha = .80). We divided the participants with an average score of less than 3 into a low healthy diet score group, and those with higher than 3 into a high healthy diet score group.

We measured each participant's anticipated enjoyment of his or her snack choice using a 5-point Likert scale. To measure experimental demand, we asked participants to say why they chose their snack. We also measured how hungry participants said they were at the moment of choice, since hunger level can be a factor that influences people's snack choice [26], and if they were vegetarian, vegan, or dieters.

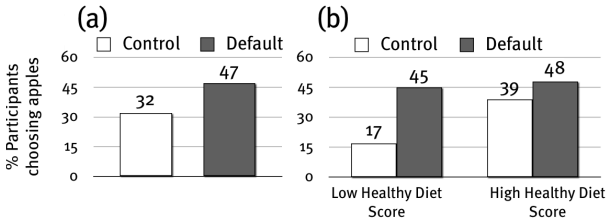

Figure 3. (a) Percentage of participants choosing an apple in the Control, and Default conditions in Study 2; (b) Percentage of participants with low and high healthy diet scores choosing an apple in the Control and Default conditions in Study 2.

Results of Study 2

Thirty-nine percent of the participants chose an apple from the robot. There were no differences due to participants' gender, or whether participants were vegetarian, or how hungry participants were. However, those who reported being on a diet tended to choose apples, so we used this variable as a control variable in all the regressions.

Effect of the default strategy

We conducted regression analyses testing for the effect of Default versus Control conditions, controlling for whether participants were dieters. The participants were more likely to choose an apple in the Default condition, when apples were placed on the tray and cookies were placed in the bag. Thirty-two percent of the participants chose an apple in the Control condition, whereas 47% chose an apple in the Default condition ($F[1, 118] = 3.8$, $p = .05$; Figure 3a).

Effect of the default strategy on those with different eating lifestyles

We conducted another regression predicting snack choice, adding a variable for whether participants scored high or low on the healthy eating scale. The analysis shows a significant main effect of the Default vs. Control conditions ($F [1,118] = 4.54$, $p < .05$), and a significant main effect of the dieter control variable ($F [1,118] = 6.31$). The interaction with the high vs. low healthy eating scale was not significant. However, the Default condition showed an interesting trend and marginally significant influence on the choices of participants with a low healthy eating score. In the low healthy diet score group, 45% of the participants chose an apple in the Default condition whereas only 17% did so in the Control condition ($F [1, 114] = 3.37$, $p = .07$; Figure 3b). In the high healthy eating scale group, 39% of participants in the Control condition chose an apple whereas 48% did so in the Default condition.

Effect of the default strategy on enjoyment

We conducted a regression to compare the differences in participants' enjoyment of their choice depending on the conditions. Participants' perceived enjoyment did not differ between conditions (Control M = 4.34, Default M = 4.33). There also was no statistical difference in enjoyment of the two snack types (Cookie = 4.35, Apple = 4.30).

Awareness of the manipulation

The number of participants who chose "convenience" as one of the reasons why they chose their snack did not significantly differ across conditions (Control = 5%, Default = 11%). Also, when questioned after the study, participants did not indicate any concern with the difference in the location of the apples and the cookies.

Discussion of Study 2

Study 2 showed that making healthy snacks slightly more accessible and convenient is effective in influencing people to make a healthier snack choice. The default option strategy also was marginally effective in influencing

participants with less healthy dietary lifestyles to make a healthy choice. In contrast to Study 1, the default option strategy that varied convenience did not negatively influence the participants' perceived enjoyment of their snack. We think participants were not aware of any social pressure to choose a healthy snack. Those who chose an apple also did not seem to think that they chose it because it was right in front of them on the tray and less convenient than the cookie in the bag.

STUDY 3: DEFAULT, ASYMMETRIC CHOICE, AND INFORMATION STRATEGIES APPLIED TO A WEBSITE

The results of Study 1 and Study 2 show that framing an item as default and making a healthy choice physically more convenient can promote healthy choices. In Study 3, we applied the strategy to a screen-based user interface. We applied the default strategy on the presentation of choices to a snack ordering website, and compared it with an asymmetric choice presentation and information feedback approach. We also combined the Default with a dynamic visual design in the form of a banner to strengthen its effect. This resulted in a between-subjects design, with Control, Information Feedback, Default, Default with Banner, and Asymmetric conditions. The participants were randomly assigned to one of the five conditions.

Website

We used a website for people to order snacks to be delivered by the Snackbot (Figure 4). Participants selected a picture of a food item and dragged it to a picture of a shopping cart to place a snack order. We manipulated the presentation of snacks in the following manner:

Control: The website showed healthy and unhealthy snacks in two columns on one page.

Information: The website showed calorie information for each snack and a green banner to indicate healthy snacks.

Default: The website showed only two snacks at a time; participants needed to press "next" and "previous" buttons to browse the snacks. Healthy snacks were presented on the first two pages; unhealthy snacks were presented on the last two pages.

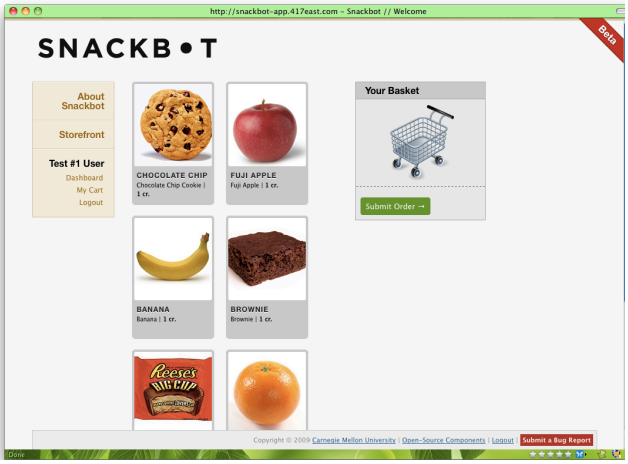

Figure 4. Snack ordering website used for Study 3 showing the Control condition.

Default +Banner: The website showed an animated banner of the Snackbot logo instead of the static Snackbot logo. The presentation of snacks was same as Default.

Asymmetric Choice: The website showed one Fuji apple and one smaller Macintosh as the first two snacks.

The sequence of snacks for each condition was randomized except Default and Default + Banner that were randomized within the healthy or unhealthy snack categories. For Asymmetric Choice, Fuji and Macintosh remained at the top all the time; other snacks were randomized.

Participants

We recruited passers-by in our office buildings. There were 100 participants (Control N = 20, Information N = 20, Default N = 19, Default + Banner N = 19, and Asymmetric Choice N = 20), of whom 44% were female. People with allergies or medical conditions were excluded.

Procedure

The experimenters set up a table in a public place and invited people to test the snack ordering website and receive a free snack of their choice. Once participants chose a snack on the website, the experimenters gave them a snack, and asked them to fill out a questionnaire. We used two types of apples, bananas, and oranges as healthy snacks and chocolate chip cookies, brownies, and two types of candy bars as unhealthy snacks [26]. We put all the snacks in paper bags, so that participants could not see which snacks were offered until they interacted with the website.

Measures

We used the same measures as we used in Study 2. The main dependent variable was the percentage of participants choosing a healthy snack.

Results of Study 3

Across conditions, 53% of the participants chose a healthy snack on the website. There were no differences depending on participants' gender, hunger level, or whether they were vegetarian or dieters.

Effects of the Default, Default+Banner, Asymmetric Choice, and Information Strategies

We conducted regression analyses testing for the main effect of the conditions. The main effect was significant ($F[4,95] = 15.89$, $p < .001$; Figure 5a). The participants were more likely to choose a healthy snack in the Default condition (100%) and Default + Banner condition (95%) as compared to the Control condition (42%; $F[1, 91]=21.44$, $p<.001$). The difference between the Default and Default + Banner conditions was not significant, nor was the difference between the Asymmetric Choice (47%) and Control conditions. Those in the Information condition were least likely to make a healthy choice (20%), a result statistically different from the Asymmetric Choice

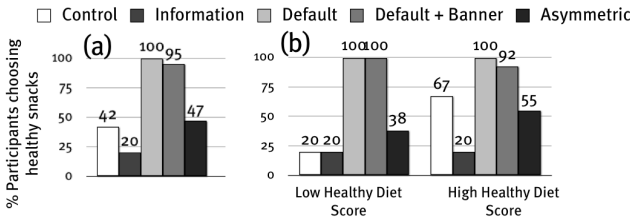

Figure 5. (a) Percentage of participants choosing a healthy snacks in Study 3; (b) Percentage of participants with low and high healthy diet scale scores choosing a healthy snack in Study 3.

condition (F[1, 91] = 4.91, p <.03) and, marginally, from the Control (F[1, 91] = 3.21, p<.08) condition.

Effects of the strategies with different eating lifestyles

We conducted another regression predicting snack choice, adding a variable for whether participants scored high or low on the healthy eating scale. The analysis shows a significant main effect of the different conditions (F [4,95] = 14.92, p < .001; Figure 5b). The interaction effect with the high vs. low healthy eating scale was not significant. The Default and Default+Banner conditions showed that they had significant influence on the choices of the participants with a low healthy eating score, as in Study 2. In the low healthy diet score group, all participants chose healthy snacks in the Default condition whereas only 20% did so in the Control condition (F[1,86] = 16.75, p <.001). The calorie information worked negatively in the healthy diet score group, similar to the behaviors of dieters reported in [7]. In the high healthy diet score group, only 20% of the participants in the Information condition chose healthy snacks in contrast to the Control condition where 67% did so (F[1,86]= 7.20, p <.01).

Effect of default strategy on enjoyment

We conducted a regression to compare the differences in participants' enjoyment of their snack choice depending on the conditions. Participants' perceived enjoyment did not differ across the conditions (Control M = 4.17, Default M = 4.53, Default + Banner M = 4.53, Asymmetric M = 4.34, Information M = 4.42) or between snack types (Healthy M = 4.45, Unhealthy M = 4.33).

Awareness of the manipulation

Most frequently mentioned reasons for snack choices were Taste (N=69), followed by Health (N=29), and Convenience (N=5). The distribution of the answers did not differ across the conditions. This finding suggests that the participants were not knowingly influenced by the convenience or information manipulation.

Discussion of Study 3

Study 3 showed that placing healthy snacks on the first page of the website is extremely effective in influencing people to make a healthier snack choice. Even though the "next page" button was right below the snack choices and clicking a button did not require much effort, very few people clicked the buttons. One explanation for this result could be that, even though the website was visually clean, participants were drawn to the photos of snacks first, and intuitively tried to place them in the shopping cart, without looking at the whole structure of the site [32].

Study 3 also shows that the Information condition, which showed calorie information, along with the green banner, influenced participants with a healthy diet style to choose unhealthy snacks. There might be two reasons for this effect. Participants might have thought that a candy bar has fewer calories than what they expected, so they might have indulged themselves in the high-caloric snack. An alternative explanation is that by just seeing the obvious healthy snacks indicated by the low calorie count may have made them satisfy their desire to consider healthy snacks, so that they instead chose unhealthy snacks [34].

GENERAL DISCUSSION

Study 1, 2, and 3 suggest that designs drawn from behavioral economics can be useful to promote healthy snack choices, and further, that technology can be persuasive using extremely simple techniques.

Efficacy of default, plan & asymmetric choice strategies

The default strategy was consistently shown to be effective in promoting healthy choices across different systems, even for participants with less healthy diet lifestyles (Study 1, 2, 3). The findings suggest that the default option strategy could be a useful tool to encourage healthy snacking, even among those who may not aware of their potential dietary issues. The planning strategy worked as well, but only with those who already had healthy eating habits (Study 1). The asymmetric choice strategy did not influence the participants' choices (Study 3). Our results are especially interesting given the failure of many information-centric approaches, including food labeling [28], and calorie information as shown in our Study 3.

Different designs and their influence on user experience

Our results suggest how a behavioral economics theory strategy is designed and implemented makes a difference in the outcome. Even when based on the same theoretical principle, the ways that we designed the default strategy influenced people's experiences differently. Being asked to think ahead, with or without a default, reduced participants' enjoyment of their snack choice. When implemented by varying physical placement of snacks on the robot (Study 2) and spatial position of snack choices on the website (Study 3), the default strategies did not reduce participants' enjoyment of their snack choice. These findings suggest that designs that do not involve conscious effort may work best.

We also speculate that different media might also influence people's decision-making differently. The percentage of participants who chose an apple in the Control condition of Study 2 was lower than those who chose an apple in the Control condition of Study 1. Even though we cannot compare Study 1 and Study 2 because they were conducted at different times, we propose that the difference might

have arisen from the difference between human-human interaction and human-robot interaction. Participants who interacted with a person in Study 1 might have felt social pressure to make a healthy choice. Evidently, this pressure did not apply to interacting with the robot.

Limitations and future work

Our experiments have limitations. First, we tested the proposed strategies with a one-time choice. Future work will examine the effectiveness of the strategies over repeated choices. Second, we tested the strategies with a snack choice. Even though we believe that choosing a snack is a typical example of everyday dietary choice, meal choices have different characteristics (such as higher stakes) that would need to be studied.

We believe behavioral economics research in general, not limited to the principles presented in this paper, has implications for broader areas in HCI. As sensors and systems that can readily track human behavior become more ubiquitous [6], behavioral economics is a theoretical approach that can be used to better time and structure information to help people make decisions that change their behavior. Beyond the domain of healthy snacking, designs drawn from behavioral economics can be harnessed in other HCI application areas such as healthcare, sustainability, education, and others.

Ethics of persuasive designs

This study, along with the general approach to influencing choices via behavioral economics, requires ethical analysis [1, 10]. Some may argue that using behavioral economics approaches to promote healthy choices, and persuasive designs more generally, do not pose a serious ethical dilemma, as they do not limit people's choices [3]. However, the reality is that whenever designers of technology make judgments on behalf of their users, whether good or bad, ethics comes into play. Even though full choices are presented, what if many of them are easy to miss or understand? When applying behavioral economics approaches, designers need to be aware of the balance between "subtly more convenient," vs. "too convenient to the extent it is the only option."

Another caveat in using behavioral economics approaches might be its lack of educational effect. In comparison to persuasive techniques that use informative messages (e.g., indicating consequences of choices), the behavioral economics approaches proposed in the paper do not provide any information that people can use to reflect on their behaviors and learn the consequences of their choices. If users are subsequently put in a new environment without the interventions, the changed behaviors may not continue. Designers using behavioral economics approaches should be aware of this potential problem, and consider using them with educational methods. New research is needed to understand the long-term effects of these techniques.

Finally, although we chose a domain, snack choices, about which there is general agreement as to the "healthy" choice and best interest of the user, the agreement of what is a best choice is controversial in many domains. For instance, some online companies use the default option strategy (opt out) to induce people to agree to receive commercial emails. Such strategies would seem to be questionable ethically because the user's best interest is not central. Ethical analysis of designs derived from behavioral economics would be a fruitful and important area for future work in HCI.

CONCLUSION

We investigated and evaluated three ways to apply behavioral economics research in the design of persuasive technology. Our studies show that extremely simple changes in user interfaces can have substantial impact on people's choices. Given the increasing role of information technology in people's lives, it will be the responsibility of the HCI community to acknowledge the importance of a simple design choice, and use this in a way that promotes self-beneficial choices. We believe HCI researchers and designers should look to the field of behavioral economics as it provides a deep understanding of people's decision making processes, and ways to harness them. We hope this work provides inspiration that knowledge from the field of behavioral economics can be combined powerfully with design thinking to create products and services that benefit humankind.

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