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Design and Evaluation of a Computer Game to Promote a Healthy Diet for Young Adults

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This article reports the development and evaluation of a computer game (RightWay Café) as a special medium to promote a healthy diet for young adults. Structural features of computer games, such as interactive tailoring, role playing, the element of fun, and narrative, were operationalized in the RightWay Café game to afford behavior rehearsal in a safe and entertaining way. Theories such as the health belief model, social cognitive theory, and theory of reasoned action guided the content design of the game to influence mediators of behavior change, including self-efficacy, perceived benefits, perceived barriers, and behavior change intention. A randomized controlled evaluation study with pretest, posttest, and follow-up design demonstrated that this game was effective in teaching nutrition and weight management knowledge and increasing people's self-efficacy and perceived benefits of healthy eating, as well as their intention to be on a healthy diet. Limited long-term effects were also found: participants in the game-playing group had greater self-efficacy than participants in the control group after 1 month. This study validates the computer game–based approach to health promotion for young adults. Limitations and implications are also discussed.

According to the most recent National Health and Nutrition Examination Survey, 30.4% of adolescents and young adults 12 to 19 years of age are overweight or at risk for becoming overweight (Department of Health and Human Services, 2000). Many high school students and freshmen lack sufficient knowledge of nutrition to adequately deal with the impending weight gain (Matvienko, Lewis, & Schafer, 2001). College is even identified as an environmental risk factor for the development or exacerbation of disordered eating patterns (Compas, Wagner, Slavin, & Vannatta, 1986). According to the National College Health Assessment, only 7.3% of college students eat at least the five servings of vegetables and fruits recommended by the U.S. Department of Agriculture dietary guideline (American College Health Association, 2004).

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One important means of promoting healthy dietary habits is nutrition education (Boon & Clydesdale, 2005). Previous nutrition education programs for youth include lectures, written materials, and dedicated Web sites. Two recent reviews (Boon & Clydesdale, 2005; Doak, Visscher, Renders, & Seidell, 2006) indicate that most of the interventions studied to date produced meager results. One of the reasons might be that only general information is taught, and individually tailored information based on personal characteristics such as personal physical attributes are not communicated. Another possible reason for failure is that a majority of the nutrition education programs emphasize factual knowledge. Oftentimes, how to interpret and translate the knowledge into healthy behaviors is not addressed (Sapp & Jensen, 1997), for instance, how to make the transition between facts and application, and how to mix and match food items to balance their overall diet based on their individualized food pyramids. A simulation of a real-life diet in which people can rehearse weight management behavior by experimenting with dietary choices and learning how these

choices interact to affect the total diet as well as weight is needed.

With its particular structural features, a computer game seems to be an advantageous medium for providing both tailored nutrition knowledge and a simulated environment to translate knowledge into behavior in a trial-and-error way. As with any computer-based approach, computer game–based nutrition education can include the tailoring mechanisms applied in general computer-based nutrition education (Brug, Steenhuis, Van Assema & De Vries, 1996; Casazza & Ciccazzo, 2006). In addition, special features of computer games, for example, active participation afforded by simulated role playing, enable individuals to practice behavioral change in a safe and entertaining way (Lieberman, 1997; Street & Rimal, 1997). In addition, given that this generation of young people has grown up with digital media and computer games, using the format of a computer game seems to be a promising alternative. In fact, computer game–based instruction has been shown to be effective in increasing motivation, attention, and retention rate (Lee & Peng, 2006; Lieberman, 2006). Therefore, the purpose of this study is to empirically test whether a computer game equipped with features such as tailoring and role playing can be an effective channel for nutrition education and weight management intervention. More specifically, the study evaluated whether the game can (a) increase nutrition knowledge, (b) increase self-efficacy of healthy eating, (c) trigger the individual's intentions to be on a healthy diet, (d) increase perceived benefits of healthy eating, and (e) decrease perceived barriers to a healthy eating.

This article first lays out the theoretical background for why a computer game, a special medium with particular structural features, can be an effective channel for delivering health messages and for influencing attitudes and behavior. Then, a newly developed computer game, RightWay Café, is introduced. Structural features of computer games that promise health promotion effectiveness were implemented in the design of the RightWay Café game. To ensure the success of the computer game–based approach, the design of the content of the health messages embedded in the game was guided by behavioral change theories. A randomized controlled study to evaluate the computer game–based approach is reported. Finally, limitations and the direction for future study are discussed.

WHY STRUCTURAL FEATURES OF COMPUTER GAMES PROMISE EFFECTIVENESS

Interactive Tailoring

As with any computer-based program, a computer game–based health promotion program can provide users with tailored information and personally adapted feedback about their current knowledge, attitudes, and behaviors, as well as personally adapted suggestions for increasing knowledge and changing attitudes and behaviors. Computer-enhanced tailoring resembles real-time personal counseling to a certain extent, but comes with a lower cost. The rationale for using a tailored approach to health communication is that the tailored information is more personally relevant to the recipients and will be more attended to and thoughtfully processed by the recipients (Kreuter, Farrell, Olevitch, & Brennan, 2000). In the context of healthy eating, and weight management in particular, tailored information is even more important because the calorie requirements and food pyramid characteristics vary among individuals with different weights, heights, and activity levels. The tailoring mechanism of the computer game can provide personalized food pyramid information to each individual based on his or her particular physical attributes and activity level. In fact, a number of empirical studies have demonstrated that tailored materials outperform nontailored materials for increasing vegetable and fruit intake and for decreasing fat consumption (Brug, Oenema, Kroeze, & Raat, 2005; Kroeze, Werkman, & Brug, 2006).

Role Playing for Behavioral Rehearsal

In the virtual game environment, the player assumes the role of a particular character (an avatar). The player can actively select meals and try out dietary strategies for his or her avatar. Based on the virtual diet and the avatar's personal attributes, the computer game can calculate calorie consumption and simulate weight gain/loss. By trial and error, players will learn how to choose meals at the cafeteria so that they can meet the daily calorie requirement and have a balanced diet in which calories are distributed among grains, vegetables, fruits, milk, meat & beans, and oils according to their-personal food pyramids. This virtual experience afforded by role playing in the game environment is similar to enactive learning as suggested by Bandura (1986). The subtle difference here is that the enactment is through the player's avatar in this safe simulated environment. A successful enactive experience (mastery experience) of diet and weight management in the game can increase players' self-efficacy for managing their meals and weight in real life. According to social cognitive theory, self-efficacy is one of the most important determinants of whether behavioral change takes place, because unless people believe that they can produce desired effects by their actions, they have little incentive to act for behavioral change. Self-efficacy also affects whether people mobilize the motivation and perseverance needed to succeed, their ability to recover from failures and relapses, and how well they maintain the habit changes they have achieved (Bandura, 2004).

In addition, previous research has shown that role playing is a powerful mechanism for influencing people's attitudes (Janis & King, 1965; Peng, Klein, & Lee, 2006). When people role-play a character, they need to adopt the perspective

of this character. Therefore, they are likely to be influenced by the goals, beliefs, and attitudes of this character. For instance, when people role-play a health-oriented character whose goal is to commit to healthy eating, they are likely to adopt favorable attitudes toward healthy eating. In fact, developing favorable attitudes toward healthy eating is an inevitable step toward actually adopting healthy eating, according to theory of reasoned action (Ajzen & Fishbein, 1980).

Role playing is also the best approach for situated learning (Lave & Wenger, 1991). The first step toward healthy dietary practices is to have the nutrition knowledge to guide behavior, that is, knowing which category a specific food belongs to in terms of the food pyramid, estimation of portion size, and so forth. All this information could be best learned through situated learning, that is, learning while people are actually choosing a food to eat. The game provides a virtual environment, a virtual café, for the players to learn this information in a situated manner. Players can pretend that they are going to have meals in the café and select and combine the food items. The game will provide them with instant feedback about, for example, how many calories their foods contain, servings for the food pyramid, and so forth.

The Element of Fun for Intrinsic Motivation

Game playing is intended and expected to be fun. The element of fun in computer games can trigger people's intrinsic motivation to pay close attention to the program and engage themselves with the program in which the educational materials are embedded (Garris, Ahlers, & Driskell; 2002; Malone, 1981; Malouf, 1987). Empirical studies have demonstrated that the element of fun in computer games is effective in increasing learning motivation and retention of the subject matter knowledge (Moreno & Mayer, 2000; Randel, Morris, & Wetzel, 1992; Ricci, Salas, & CannonBowers, 1996). In addition, the element of fun also echoes the entertainment–education (E-E) approach (Peng, 2005a) to attitude and behavior change. E-E is the process of purposely designing and implementing a media message to both entertain and educate (Singhal, Cody, Rogers, & Sabido, 2004). Numerous E-E programs have been empirically demonstrated to be effective for health interventions such as HIV intervention, immunization promotion, and diabetes management. Traditional formats of E-E programs include soap operas, radio dramas, music videos, street theater, and Web sites. Computer games are now emerging as a new trend in E-E (Peng, 2005b).

Narrative for Persuasion

Narrative is one of the characteristics of many E-E programs. Interestingly enough, narrative is also one of the most distinctive features of some computer games. Slater and Rouner (2002) suggest that the reason why E-E programs are effective interventions for attitude and behavior change is mainly because of their narrative. While using E-E programs, people are so engaged in the narrative that they experience suspension of disbelief (i.e., they treat all the narratives as well as the embedded persuasive messages as if they were true) and they make little effort to counterargue because absorption and counterarguing are fundamentally incompatible. Persuasive information is thus communicated implicitly through the narrative. In addition, as the processing of narrative persuasion precludes cognitive resistance or counterargument to persuasive contents in the narratives, individual behavior change is possible even when the behavior advocated is inconsistent with some of the initial beliefs and attitudes of the individual. Therefore, the narrative feature of computer games can also facilitate attitude and behavior change.

DESIGN OF THE RIGHTWAY CAFÉ GAME

Game Structural Feature Design

Based on the prior rationale, the RightWay Café game with those critical structural features was developed (see Figure 1 for general game interface). It is a role-playing game that simulates a 3-week period in a similar fashion as the popular game, The SIMS. The background story of the game is set in a hypothetical reality TV show called "Star of Healthy Lifestyle" on campus and the game player is a competitor in this show. The person who can best manage his or her daily diet in a healthy way will win. At the beginning of the game, the player will create his or her avatar by entering personal information, such as name, weight, height, age, gender, physical activity, and body frame. Even though the player can create any profile desired, the participants of this study used their own personal information to create their avatars. Based on the specific physical attributes of the avatar, the game provides tailored healthy eating information: (a) optimal weight for this particular avatar, (b) suggested daily calorie consumption for this avatar, and (c) personal food pyramid for this avatar. The goal of the player is to manage daily calorie consumption and physical activity to enable the avatar to reach optimal weight. The player's food choices also need to match up with the avatar's personal food pyramid. For instance, the player creates a female avatar who is 20 years old, 5 ft 6 in., 160 lb, with medium body frame, and 30 min a day exercise on most days. Based on this profile, the game provides the player with tailored information that (a) the optimal weight for a 20-year-old, 5 ft 6 in. tall female is 145 lb, (b) the suggested daily calories are 2,200, and (c) these 2,200 calories should be contributed by 7 oz of grains, 3 cups of vegetables, 2 cups of fruits, 6 teaspoons of oils, 3 cups of milk products, and 6 oz of meat so as to match the suggested personal food pyramid. As this avatar is a bit heavier than the optimal weight, the player needs to either

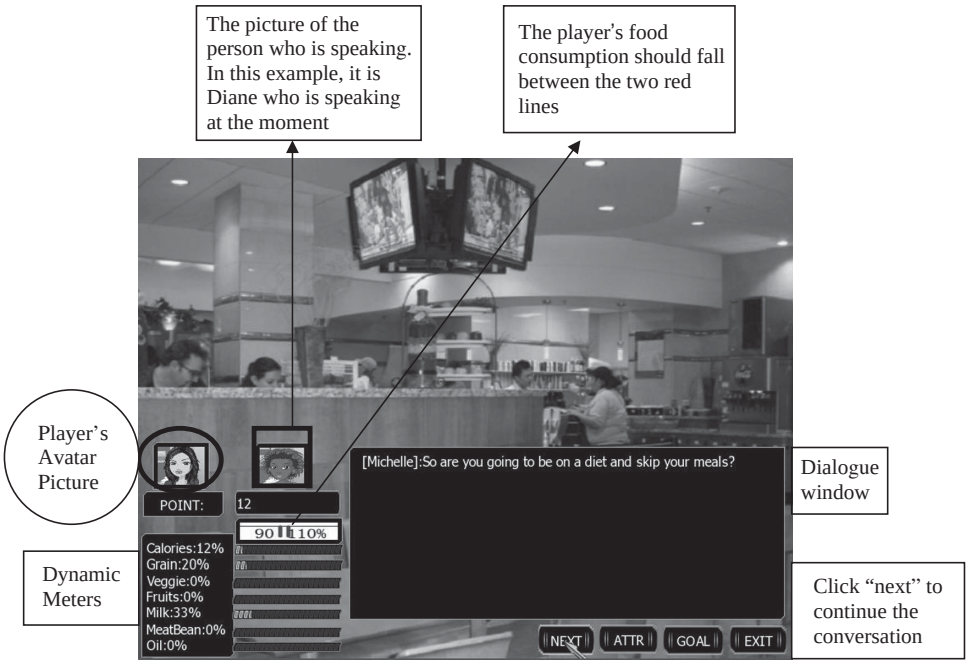

FIGURE 1 Screen shot of the game interface in one scene when the player is chatting in the cafeteria with Diane.

consume about 95% of the required calories (2,100 calories) or engage in more than 30 min a day of physical activity to reach optimal weight.

While role-playing in the game, the player rehearses diet and weight management skills by choosing breakfast, lunch, dinner, and snacks for his or her avatar/character in the game. There are eight categories: entrée, side, salad, dressing, fruits, drinks, dessert, and snacks. Figure 2 is a screen shot of the food selection interface. Before deciding what kind of food to "eat," the player can check the nutrition information by clicking the picture of each food item, For each item, the following nutrition information will be provided: total calories, serving size, equivalent servings for the six food pyramid categories (grains, vegetables, fruits, oils, milk, and meat & beans), and the potential benefit or harm of consuming this food item. If the player decides to choose an item, he or she can click "ADD" to put the item into the plate and the meters on the bottom left corner will dynamically update to indicate the nutrient consequence of consuming this particular food item. At the end of each week the game will simulate the weight change based on the foods the player chooses. Constructive feedback and reviewers will also be provided to the player. Through trial and error, players observe the consequence of their food choices on weight change in the virtual environment. The game simulation provides a virtual environment in which people can experiment with food

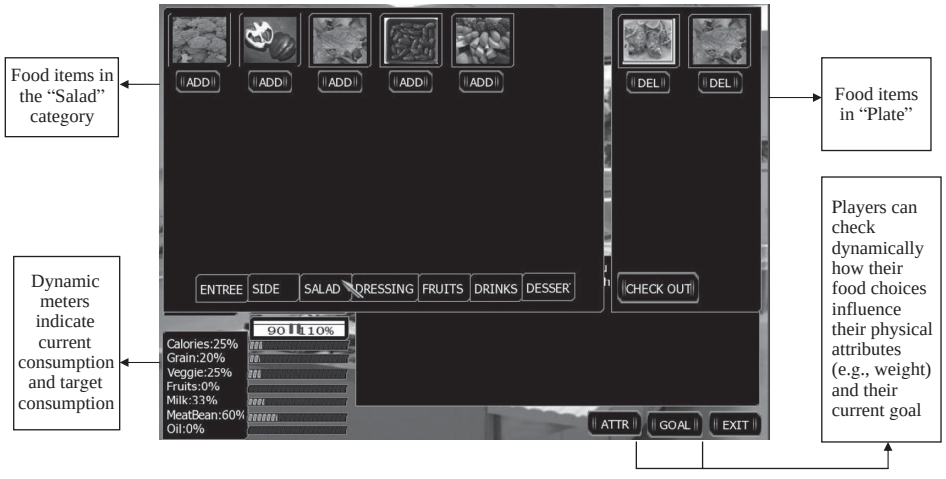

FIGURE 2 Food selection interface.

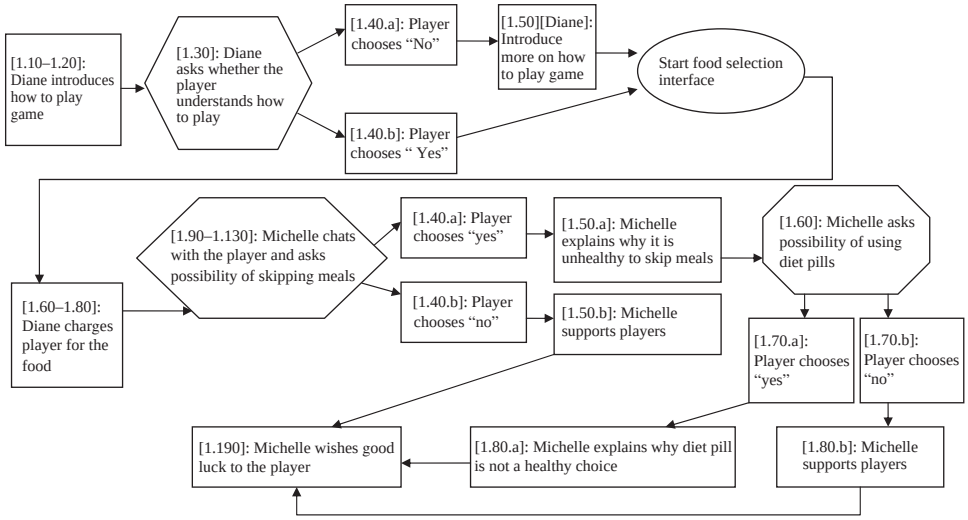

FIGURE 3 Flow charts of the narrative branching in Scene 1.

selections and exercise control so as to increase their self-efficacy of healthy eating.

The competition and challenge of the game, the reality TV show background story, and experimentation with food in the virtual game environment are all intended to make the game fun. In addition, the script of the conversation includes humor to add another element of fun to the game.

The player can chat with nonplayer characters in the game environment by choosing from several pre-set dialogue options. The player learns nutrition knowledge from his or her conversation with the nonplayer characters, for example, health-conscious college students, a school dietitian, a personal trainer at the gym, and cafeteria workers. The storyline unfolds when the player chooses preset dialogue branches. The player's choice determines the direction of the game. Figure 3 shows the dialogue flow in one of the 12 scenes in the game.

Game Content Design

The focus of this study was to investigate whether the computer game as a special medium can be an effective health education and promotion channel. However, without effective health message content, the computer game approach would not be successful even though it contains promising structural features. Therefore, behavioral change theories were adopted to guide the design of the health messages (content) embedded in the game, for example, conversations between the player and the virtual dietitian and virtual trainer, feedback and review content, and so forth. In particular, the mediators of behavioral change proposed in these theories, such as perceived benefits, perceived barriers, and behavioral intention of healthy eating, are addressed by the game content.

According to the theory of reasoned action (Ajzen & Fishbein, 1980), behavioral change is determined by behavioral change intention, which is codetermined by attitudes toward the behavior and the subjective social norm. In the RightWay Café game, positive attitudes toward healthy eating are promoted by providing positive feedback and rewarding points to players when they choose healthy food. Dialogues in the game set a descriptive norm that leading a healthy lifestyle is "cool" in the virtual environment. According to the health belief model (Becker, 1974), perceived susceptibility, perceived severity, perceived benefits, and perceived barriers predict the likelihood a person will adopt a recommended preventative health action. The game addresses the perceived benefits and perceived barriers elements of the health belief model. One of the benefits of healthy eating is to reduce the risk of major chronic disease in later life. However, it is hard for our target audience—young adults, to acknowledge their susceptibility in the long run. Therefore, the game does not stress the long-term detrimental effects of unhealthy eating, for example, cardiovascular disease. Instead, the game focuses more on the immediate benefits of healthy eating. For instance, young adults will be taught by the virtual dietitian what kind of foods with certain essential micro minerals will make them have better skin, better hair, and stronger muscles. Major barriers to healthy eating perceived by young people include being unaware of healthy food choices, inconvenience of healthy food (takes time to prepare), and the perception that healthy food is high in cost and less tasty (Croll, Neumark-Sztainer, & Story, 2001; Ross, 1995; Watt & Sheiham, 1997). To address these barriers, the virtual dietitian and health conscious nonplayer characters in the game introduce many healthy dietary choices that are widely available at a reasonable cost and at the same time convenient and delicious, for example, frozen yogurt and fruit smoothies.

According to social cognitive theory (Bandura, 1986), people are motivated to guide their behaviors by goals, aspirations, and challenges. Therefore, at the beginning of each

TABLE 1
Practical Strategies Matched with Theories in the Design of Game Structures and Contents

Intervention objectives	*Game structure design strategy*	*Game content design strategy*	*Theoretical underpinning*
Knowledge	Element of fun Interactive tailoring to provide individualized food pyramid and weight management goal	Embed the food knowledge (nutrition information) content in a fun game environment	Intrinsic motivation Situated learning
Self-efficacy	Role-playing for behavioral rehearsal in the simulated environment	Provide different foods for the player to choose in a trial-and-error way Positive feedback for successful trial Encouraging feedback for less successful trial	Social Cognitive Theory
Perceived benefits and perceived barriers	Narrative for persuasion	Embed the discussion of perceived benefits and barriers in the narrative, e.g., dialogues between players and nonplayer characters	Health Belief Model
Intention	Narrative for persuasion	The narrative of the background story and the dialogue promote a social norm and favorable attitude toward healthy eating, which are the two major determinants of intention	Theory of Reasoned Action Entertainment Education

trial (represents a week), the game provides explicit goals for the players to achieve. At the end of the week, the game gives personally relevant feedback about how well the players have performed to achieve these goals and how they can improve. For instance, using the female avatar example presented earlier (5 ft 6 in. and 15 lb heavier than her optimal weight), if she follows the suggested daily calorie consumption (consumes about 95% of the suggested calories and engages in more physical exercise) for a week in the game, the game will simulate a slight weight loss. The player will win points and get positive feedback on her progress and more tips. If she overacts and consumes less than 80% of the suggested calories, the game will simulate her weight loss but will provide warnings on a possible eating disorder and provide tips on how to achieve optimal weight in a healthy way. If the avatar eats more than the required calories and never engages in physical activity, the game will simulate her weight gain, warn the player about overweight issues, and provide tips on how to choose foods to reach optimal weight. Table 1 summarizes the matching between theories and the design of the game structures and contents.

To evaluate whether the RightWay Café game is effective, a randomized controlled experiment was conducted to compare the treatment group and the control group. Based on the previous discussion, it was predicted that:

H1: Participants who have played the RightWay Café game will have greater nutrition knowledge than participants in the control group.

H2: Participants who have played the RightWay Café game will have greater self-efficacy of engaging in healthy eating than participants in the control group.

H3: Participants who have played the RightWay Café game will have greater perceived benefits of healthy eating than participants in the control group.

H4: Participants who have played the RightWay Café game will have fewer perceived barriers to healthy eating than participants in the control group.

H5: Participants who have played the RightWay Café game will have greater intention to be on a healthy diet than participants in the control group.

Another important issue is whether the effects of the computer game–based intervention can be sustained in the long run. A follow-up questionnaire[1] was sent to the participants 1 month after the treatment to answer the following research question:

RQ: Does playing the RightWay Café have long-term impact?

METHOD

Participants

Forty participants (32 women) were recruited from two large undergraduate-level classes. Participants were randomly assigned to either the treatment group (which played the RightWay Café game) or the control group. The average age of the participants was 20. All of the participants completed the pretest and posttest questionnaires. However, one participant in the treatment group and seven participants in the control group did not fill out the follow-up questionnaire, which was sent 1 month after the treatment.

Design and Procedure

This was a randomized controlled experiment with pretest, posttest, and follow-up design (see Figure 4). Two weeks before the experiment, the link to an online pretest questionnaire was sent to the participants via e-mail. Two weeks

[1]Normally, to investigate long-term effects, the interval between the posttest and the follow-up should be more than a month. A 1-month interval was chosen for this study because the investigator would not have access to the participants 2 months after the intervention.

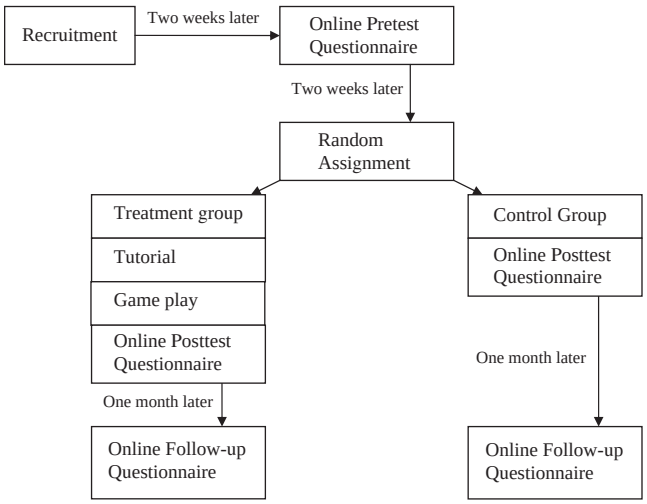

FIGURE 4 Evaluation study design.

after the pretest questionnaire was sent, another e-mail was sent to participants who were randomly assigned to the treatment group to invite them to the lab to play the game.

A PowerPoint tutorial was provided to the participants before they played the game. This tutorial described the background narrative of the game, the goal the participants needed to achieve in the game, and how to navigate and interact using the game interface. All participants used their own personal attributes (e.g., weight, height, etc.) to create their avatars in the game. All participants played the game from the beginning to the end. The average time of game playing was 42 min. When the game was over, the participants filled out the posttest questionnaire online. An online follow-up questionnaire was sent to the participants 1 month after they came to the lab to play the RightWay Café game.

For the control group, the link to the posttest questionnaire was sent via e-mail 2 weeks after the pretest questionnaire was sent. The link to the follow-up questionnaire was sent 1 month after the posttest questionnaire. The pretest, posttest, and follow-up questionnaires were generated using SurveyMonkey (http://www.surveymk.com).

Measures

Participants were tested on their knowledge of the food pyramid. Each participant was asked to input (a) his or her suggested daily caloric intake (1 point), (b) the six elements of the food pyramid (1 point for each element), and (c) his or her recommended daily serving sizes in each of the six food pyramid elements (1 point for each element). Using the information of the participant's height and physical activity level collected in the pretest questionnaire, suggested daily caloric intake and recommended daily serving sizes were calculated based on the U.S. Department of Agriculture food pyramid guidelines. The participant's answers were compared to the calculated numbers. One point was given for each correctly answered question. The maximum and minimum points the participant could get were 13 and 0, respectively. Knowledge of the food pyramid was tested at pretest, posttest, and follow-up.

Some nutrition knowledge that had been specifically addressed in the RightWay Café game was tested in the posttest questionnaire only. For 26 statements, the participants were asked to indicate whether they believed the statement to be true or false. Sample statements included: "Iron is an important element not only to make your blood cells carry oxygen, but also to prevent dull, lifeless hair" and "Cream cheese and butter belong to the milk group in the food pyramid." For each correctly indicated statement, the participant received 1 point. The maximum and minimum number of points the participant could get were 26 and 0, respectively.

A 14-item self-efficacy of healthy eating scale was created by modifying an instrument developed for adolescents (Reynolds, Yaroch, Franklin, & Maloy, 2002). The participants were asked to indicate how confident they felt about their healthy eating abilities, such as to eat at least two fruits or drink two cups of fruit juice every day, on a 7-point Likert-type scale ranging from "very little confidence" to "a lot of confidence". The full scale is included in Appendix A. Alpha coefficients for pretest, posttest, and follow-up were .86, .88, and .92, respectively. The alpha coefficients are comparable to other published self-efficacy scales, including the alpha coefficient (.86) reported in Reynolds et al. (2002), alpha coefficients of .91 and .76 for a 15-item two-factor vegetable and fruit consumption self-efficacy scale reported in Heatey and Thombs (1997) and Long and Stevens (2004), and a 5-item self-efficacy scale for vegetable and fruit consumption reported in Ma, Betts, Horacek, Georgiou, and White (2003), for which alpha coefficients for vegetable consumption and fruit consumption were .86 and .85, respectively.

Perceived benefits of healthy eating were measured using a 5-item scale. The participants were asked to use a 7-point Likert-type scale ranging from "strongly disagree" to "strongly agree" to rate statements such as "I will have healthier skin if I eat more fruits and vegetables"; "What you eat can make a difference in your chance of getting a disease, like heart disease or cancer"; "I will have a good figure if I eat healthy"; "Healthy eating can prevent gradual weight gain"; and "Having a healthy diet and doing exercises are the most effective ways to manage weight." Alpha coefficients for pretest, posttest, and follow-up were .83, .81, and .86, respectively.

Perceived barriers to healthy eating were measured using a 4-item scale. The participants were asked to use a 7-point Likert-type scale ranging from "strongly disagree" to "strongly agree" to rate statements such as "Healthy foods are usually tasteless"; "It is NEITHER easy NOR convenient to choose to eat a healthy diet"; "It is hard to find a snack

that is tasty and healthy"; and "Trying to find healthy foods will waste too much time for me."

Alpha coefficients for pretest, posttest, and follow-up were .75, .62, and .83 respectively. Intention to eat a healthy diet was assessed using a 10-item scale developed by the authors. Participants used a 7-point Likert-type scale ranging from "strongly disagree" to "strongly agree" to rate statements such as "In the future, I will try to measure/record my daily caloric intake everyday" (α = .95).[2] The full scale is included in Appendix B.

Players' evaluations of the game were also assessed. The players were asked to use a 7-point Likert-type scale ranging from "strongly disagree" to "strongly agree" to rate statements such as "Overall, this is an interesting program"; "Overall, this is a well-designed program"; "I enjoyed playing this game"; "It is easy to navigate in the game"; "The interface of the game is user friendly"; "The information presented in the game is credible"; "The information presented in the game is personally relevant to me"; "I feel the information presented in the game is tailored to me"; and "I learned a lot from this game."

Data Analysis

To test H1 through H4, analysis of covariance (ANCOVA) was used on the posttest and the follow-up utilizing the pretest as a covariate because ANCOVA has higher statistical power and precision over analysis of variance (ANOVA) to test the group difference over time (Rausch, Maxwell, & Kelley, 2003). ANOVA was used to test H5 because we did not have data at pretest or follow-up. As we had a high attrition rate (20%) at follow-up, we ran a series of analyses under different assumptions about the missing responses using (a) raw data, (b) mean substitution, (c) pretest value carried forward, and (d) posttest value carried forward. To explore the long-term impact, ANCOVA was used on the follow-up, covarying the pretest.

RESULTS

Nutrition Knowledge

ANCOVA demonstrated that the treatment group had a significantly greater score on food pyramid knowledge than the control group at posttest after controlling for the pretest score, $F(1, 37) = 6.82$, $p < .05$, $\eta^2 = .16$. Observed power to detect the effect was .72. ANOVA on the pretest score also assured that the treatment group and the control group did not differ significantly before the treatment, $F(1, 38) = .03$, $p > .50$, $\eta^2 = .001$. Therefore, H1 was supported. For the nutrition knowledge specified in the game, which was only assessed at posttest, ANOVA showed that the treatment group scored significantly higher than the control group, $F(1, 38) = 4.68$, $p < .05$, $\eta^2 = .11$. Observed power to detect the effect was .56. This indicates that the RightWay Café game is effective in teaching nutrition knowledge. One month after playing the game, both the treatment group and the control group had a decrease in food pyramid knowledge. ANCOVA on four different types of follow-up data (raw, mean substitution, pretest value carried forward, and posttest value carried forward) showed that the treatment and the control groups did not differ in food pyramid knowledge at follow-up after controlling the pretest score. This result did not show evidence of long-term effect of the game on nutrition knowledge. Table 2 summarizes the means and standard deviations of all of the dependent variables at pretest, posttest, and follow-up. Table 3 summarizes the ANCOVA and ANOVA results.

Self-Efficacy

The ANCOVA result showed that the treatment group had a significantly greater score for self-efficacy than the control group, after controlling for the pretest self-efficacy score, $F(1, 37) = 21.50$, $p < .001$, $\eta^2 = .37$. The observed power to detect the effect was .997. ANOVA on the pretest score also assured that the treatment group and the control group did not differ significantly before treatment, $F(1, 38) = 1.07$, $p > .05$, $\eta^2 = .03$. H2 was supported. At follow-up, ANCOVA on all four types of follow-up data showed that the treatment groups still had significantly greater self-efficacy than the control group after controlling the pretest score, which suggested a long-term effect on self-efficacy.

Perceived Benefits

The ANCOVA method showed that the treatment group had a significantly greater score of perceived benefits than the control group at posttest after controlling for the pretest perceived benefit score, $F(1, 37) = 7.57$, $p < .01$, $\eta^2 = .17$. The observed power to detect the effect was .76. ANOVA of the pretest perceived benefits score did not show group heterogeneity, $F(1, 38) = .77$, $p > .10$. $\eta^2 = .02$. Therefore, H3 was supported. At follow-up, when mean substitution was used, the data showed that the treatment group still had greater perceived benefits than the control group, $F(1, 37) = 4.56$, $p < .05$. $\eta^2 = .11$. The observed power was .55. However, when other types of follow-up data were used (raw data, pretest value carried forward, posttest value carried forward), ANCOVA results did not show that the treatment and control groups differed at follow-up.

Perceived Barriers

Inconsistent with H4, for perceived barriers the treatment group had a slight increase and the control group had a

[2]Intention to eat a healthy diet was assessed only at posttest due to data loss that resulted from a technical problem associated with the online survey engine.

TABLE 2
Means and Standard Deviations of Dependent Variables

	Treatment group			*Control group*		
	Pretest	*Posttest*	*Follow-up*	*Pretest*	*Posttest*	*Follow-up*
Self-efficacy	4.85 (1.06)	5.62 (.67)	5.52 (.88)	4.51 (1.04)	4.52 (.90)	4.33 (.93)
Perceived benefits	5.76 (1.37)	6.34 (.80)	6.04 (.93)	5.46 (.68)	5.55 (.93)	5.29 (.74)
Perceived barriers	4.67 (1.54)	4.97 (1.36)	2.93 (1.54)	3.82 (1.38)	3.63 (1.14)	4.05 (1.07)
Intention	—	5.92 (.71)	—	—	4.41 (1.16)	—
Food pyramid knowledge	4.20 (2.06)	10.00 (2.51)	7.26 (2.42)	4.35 (3.01)	7.60 (3.28)	6.31 (3.01)
Knowledge specified	—	18.75 (2.73)	—	—	16.80 (2.97)	—

Note. The standard deviations are in the parentheses. The follow-up data are raw data without mean substitution or pretest/posttest variables carried forward.

TABLE 3
Analysis of Variance Results at Posttest and Follow-up

			Follow-up							
	Posttest		*Raw data*		*Mean substitution*		*Pretest carried*		*Posttest carried*	
Dependent variables	*F*	η^2	*F*	η^2	*F*	η^2	*F*	η^2	*F*	η^2
Self-efficacy	21.50***	.37	8.35**	.22	10.40**	.22	7.74**	.17	7.78**	.17
Perceived benefits	7.57**	.17	4.10^{+}	.12	4.56*	.11	2.93^{+}	.07	2.91^{+}	.07
Perceived barriers	7.16*	.16	1.62	.05	2.50	.06	.92	.02	.47	.01
Intention	24.86***	.40	—	—	—	—	—	—	—	—
Food pyramid knowledge	6.82*	.16	1.25	.04	1.16	.03	3.91^{+}	.10	2.70^{+}	.07
Knowledge specified	4.68*	.11	—	—	—	—	—	—	—	—

Note. Pretest measures are used as covariates. $Df = (1, 37)$ for all analyses, except for analysis of the raw data at follow-up, in which $df = (1, 29)$.
$^{+}p < .10$. $*p < .05$. $**p < .01$. $***p < .001$.

slight decrease. H4 was not supported. At posttest, the treatment group perceived the barriers to healthy eating to be greater than did the control group after controlling for the pretest perceived barriers score, $F(1, 37) = 7.16$, $p < .05$, $\eta^2 = .16$. ANOVA showed that there was a partially significant difference between the treatment group and the control group at pretest, $F(1, 38) = 3.39$, $p = .07$, $\eta^2 = .08$. One month after playing the game, perceived barriers decreased in the treatment group yet remained the same in the control group. ANCOVA on all four types of follow-up data indicated that the treatment group did not differ from the control group at follow-up after controlling the pretest score. This result did not show evidence of long-term effect of the game on perceived barriers.

Healthy Eating Intention

ANOVA indicated that the intention to eat a healthy diet was greater for participants who played the RightWay Café game than it was for the control group, who did not play the game, $F(1, 38) = 24.86$, $p < .001$, $\eta^2 = .40$. The observed power was .998. H5 was supported.

Game Evaluation

Evaluation of this game was quite positive. On a scale from 1 to 7, players indicated that they enjoyed playing the game ($M = 5.35$, $SD = 1.09$), they thought the game was interesting ($M = 5.85$, $SD = 1.18$) and well designed ($M = 5.75$, $SD = 1.16$), and they learned something useful ($M = 6.00$, $SD = 1.26$). They found the information presented in the game to be credible ($M = 5.64$, $SD = 1.24$), and personally relevant to them ($M = 5.71$, $SD = .76$). In particular, they found that the information was tailored to the individual ($M = 5.64$, $SD = .89$). In addition, they found it easy to navigate the game ($M = 5.79$, $SD = .81$) and found the interface to be user friendly ($M = 5.64$, $SD = .83$). Positive correlations were found between players' enjoyment of the game and their posttest self-efficacy ($r = .44$, $N = 20$, $p < .05$, one-tailed), healthy eating intention ($r = .59$, $N = 20$, $p < .01$, one-tailed), and perceived benefits of healthy eating ($r = .39$, $N = 20$, $p < .05$, one-tailed). Positive correlations were also found between the perceived information tailoring and their posttest food pyramid knowledge ($r = .41$, $N = 20$, $p < .05$, one-tailed), healthy eating intention ($r = .52$, $N = 20$, $p < .01$, one-tailed), and perceived benefit of healthy eating ($r = .55$, $N = 20$, $p < .01$, one-tailed).

DISCUSSION

The results demonstrate that the RightWay Café game is an effective medium for teaching nutrition knowledge and for influencing the mediating attitudinal variables of behavior change. Compared with the control group, participants who played the game had greater nutrition knowledge, greater self-efficacy for healthy eating, greater perceived benefits of healthy eating, and greater intention to commit to healthy eating after playing the game. The RightWay Café game also demonstrated long-term effects, especially for attitudes. One month after playing the game, participants who played the game sustained their increased self-efficacy and perceived benefits. This is quite a strong effect given that these participants were exposed to the RightWay Café game for only about 40 min. Unfortunately, participants who played the game did not fully sustain their nutrition knowledge. These results suggest that to fully sustain the knowledge, more than a one-time interaction with the intervention material (i.e., the RightWay Café game) is needed. One possible solution is to add the food selection component to some online games, such as Second Life or The Sims.

The RightWay Café game was evaluated positively by the players; they enjoyed playing the game and found it very interesting. Positive correlations were found between their enjoyment of playing the game and their self-efficacy and behavioral intention of healthy eating. This suggests that the element of fun is a significant contributor to the effectiveness of the game. In addition, there were positive correlations between the players' perceptions of whether the game was tailored to them and their learning of the food pyramid and their behavioral intentions. This suggests that interactive tailoring is a successful strategy.

However, this study did not provide direct evidence to demonstrate how role playing and narrative contribute to nutrition knowledge gain and the increase of intention, self-efficacy, and perceived benefit of healthy eating. Future experiments should be conducted to elucidate the underlying mechanism of how these structural features contribute to effectiveness. For instance , to test the unique impact of narrative, an experiment could be conducted in which two groups play different versions of the game: with background story versus without background story.

These findings have significant implications for health interventions. Although a trend of using serious games for health is emerging (http://www.gamesforhealth.org/), only a few studies (Brown et al., 1997; Kato & Beale, 2006; Lieberman, 1997; Thomas, Cahill, & Santilli, 1997) provide empirical evidence that computer games can be an effective medium in health interventions. This study enriches the evidence by showing the RightWay Café game as a successful example for delivering nutrition information and changing psychosocial determinants of healthy eating. For preventative health interventions targeted at children, adolescents, and young adults, the game-based approach is a promising alternative to lecture and pamphlet.

The RightWay Café game also provides specific design guidance for future game-based intervention. For instance, the element fun and interactive tailoring have been shown to be positively related to the outcome measures. For future game-based intervention, designers should take full advantage of these unique features of games. For interventions targeting behavioral change that requires rehearsal and practice yet is difficult to implement in reality, the role-playing feature of games can be an ideal alternative. For instance, for safer sex negotiation, if people have never practiced it before, it is really difficult for them when they are actually dealing with a partner. Unfortunately, it is usually not an option for people to practice this in real life. The game environment can provide a safe milieu in which they will not feel too embarrassed yet feel realistic enough to practice.

This study only verified that the game-based approach is effective. In order to convince users that the game-based approach is better, more empirical evidence is needed to demonstrate that computer games have advantages over other media by comparing the effectiveness of the computer game based approach with approaches using other media such as interactive Web sites or pamphlets. However, in order to avoid a confounding comparison, the content and information presented in different media should be comparable. In addition, possible mediators, such as enjoyment of using the game/interactive Web site/pamphlet and perceived relevance of information presented, can be measured to further verify the critical value of the element of fun and the interactive tailoring strategy.

LIMITATIONS

Several caveats to this study must be considered when interpreting the results. First, this study has one problematic finding: the treatment group had greater perceived barriers than the control group after playing the game. The contradictory finding may be attributed to measurement issues. Compared with other dependent measures, the alpha coefficient of perceived barriers is relatively small. It might be because all of the items in this scale are negatively phrased. Although it is natural to phrase barriers in a negative way and the negative words were capitalized in the questionnaire, as these four items were mixed with other items in the questionnaire, the cognitive load demanded to process negative statements might have resulted in measurement error. An alterative explanation for the reversed effect on the barriers is that participants were ignorant of potential barriers or underestimated the barriers and the game playing experience made them realize how difficult it is to eat a healthy diet. However, participants had only three trials of daily meal management and food choice in their 40 min of

game playing. Like other video and computer games, it is more challenging and difficult for the player in the first few trials. But after repetitive trials, players' skills would be improved and the game would become less difficult for them. The fun element of the game would keep them trying without getting bored. It is very likely that the 40 min trial in the study is not adequate to provide participants with methods for coping with these barriers. However, in the natural setting, players could play the RightWay Café game over and over again to practice food management and weight management in a motivating way.

Second, the time interval between the treatment and the follow-up was relatively short (1 month). Depending on context, the time interval between treatment and follow-up in most long-term effect studies can vary from a couple of months to several decades. Given the short interval in this study, the interpretation of the long-term effects needs to be cautionary.

Third, all of the dependent measures were subjective psychosocial variables (e.g., self-efficacy) related to behavior change, and there was no direct measure of actual behavior change. Even though theories (e.g., social cognitive theory, theory of reasoned action) predict that these psychological variables are mediators of behavior change and many empirical studies have indeed verified that self-efficacy, intention, and positive outcome expectation (perceived benefit) mediate the effect of healthy eating promotion interventions on actual behaviors in different delivery channels other than computer games (Anderson, Winett, Wojcik, Winett, & Bowden, 2001; Brug, Glanz, van Assema, Kok, & van Breuklen, 1998; Kuppens, Eriksen, Adriaanse, Nijhuis, & Aaron, 1996; Resnicow et al., 1997; Reynolds et al., 2002; Slater, 1989), behavioral measures that fully attest to the effectiveness of using a computer game for healthy eating promotion are needed. In the future, behavioral measures, such as 24-hour food consumption recall (Slimani et al., 1999) or the Food Frequency Questionnaire (Willett & Lenart, 1998) should be included in the program. By doing so, it will be possible to verify the behavioral change theories by testing the mediating roles of the psychological variables (e.g., self-efficacy, behavioral intention). Furthermore, in addition to behavioral intention, favorable attitude toward and perceived descriptive social norms of healthy eating should have been measured to have in an in-depth understanding of the mechanism, based on the theory of planned behavior.

The sample used in this study is also a limitation. Even though observed power for data analyses in the study was acceptable, the small sample size limits its generalizability. In addition, the participants were predominantly female students. Although this interactive game provides gender- relevant messages for better targeting, for example, when the micronutrients information is introduced, the benefit of having better skin, hair, and nails is emphasized if the player is female, but the benefit of strengthened muscles is emphasized if the player is male; still, a majority of the content in the game is more oriented toward female players. To better target a male audience, a male-oriented version of the game should be developed and evaluated among male players. In addition, as the literature has suggested that people's lifestyle and habits are usually formed early in their lives, for example, in adolescence, it is important to instill the right nutrition information and promote a healthy lifestyle to adolescents and children. In the future, the game should be modified to fit these particular audiences.

In conclusion, a nutrition education and weight management computer game was developed under the guidance of the health belief model, the theory of reasoned action, and social cognitive theory. Unique features such as interactive tailoring, role playing and narrative were included in the game to provide an interesting, individualized, and enactive experience for the user. An evaluation study demonstrated short-term effects of the game in increasing nutrition knowledge, self-efficacy, and perceived benefits of healthy eating. However, 1-month follow-up showed that the treatment group had advantage over the control group only in terms of self-efficacy, indicating limited long-term effects of the game.

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APPENDIX A

1. I am confident that I can eat at least two fruits or drink two cups of fruit juice every day.
2. I am confident that I can plan meals or snacks with more fruits during the next week.
3. I am confident that I can choose meals with more vegetables.
4. I am confident that I can eat fruits and vegetables as snacks.
5. I am confident that I can eat at least one serving of vegetables at lunch and dinner respectively, given that 1 cup of salad is about half a serving.
6. I am confident that I can eat 3 cups of milk product every day, given that 1 cup of milk equals 1 cup of milk product or 2 slices of cheese equal 1 cup of milk product.
7. I am confident that I can spare 30 minutes to do exercise on most of the days.
8. I am confident that I can eat at least 10 different fruits and vegetables in a week.
9. I am confident that I can eat at least 6 oz of grains every day, given that 1 slice of bread or 1 cup of cereal is 1 oz of grains.
10. I am confident that I can watch for my total caloric intake in a day.
11. I am confident that I can balance my food pyramid.
12. I am confident that I can consume less than 7 teaspoons of oils everyday, given that 1 tablespoon of salad dressing or mayonnaise contains about 2 teaspoons of oils.
13. I am confident that I can eat at least three cups of vegetables every day.
14. I am confident that I can eat less than 7 oz of meat every day, given that 3 oz of meat is about the size of a deck of cards.

APPENDIX B

1. In the future, I will pay attention to how many servings of vegetables I eat every day.
2. In the future, I will pay attention to how many servings of meat/beans I eat every day.
3. In the future, I will pay attention to how many servings of fruits I eat every day.
4. In the future, I will pay attention to how much fat/oil I consume every da y.
5. In the future, I will pay attention to how many servings of mild products (milk, cheese, yogurt, etc) I eat every day.
6. In the future, I will pay attention to how many servings of grains I eat every day.
7. In the future, I will take into consideration how much nutrition the food will provide for me when I choose my meal.
8. In the future, I will read the nutrition information label before I buy foods or snacks.
9. In the future, I will try to measure/record my daily caloric intake every day.
10. In the future, I will try to follow a guideline of how much I should eat every day.