

Simulation & Gaming

<http://sag.sagepub.com/>

Serious Video Games for Health: How Behavioral Science Guided the Development of a Serious Video Game

Debbe Thompson, Tom Baranowski, Richard Buday, Janice Baranowski, Victoria Thompson, Russell Jago and Melissa Juliano Griffith

Simulation Gaming 2010 41: 587 originally published online 24 December 2008

DOI: 10.1177/1046878108328087

The online version of this article can be found at:

<http://sag.sagepub.com/content/41/4/587>

Published by:



<http://www.sagepublications.com>

On behalf of:

Association for Business Simulation & Experiential Learning

International Simulation & Gaming Association

Japan Association of Simulation & Gaming

North American Simulation and Gaming Association



Playful Methods. Serious Results.

North American Simulation & Gaming Association

Society for Intercultural Education, Training, & Research

Additional services and information for *Simulation & Gaming* can be found at:

Email Alerts: <http://sag.sagepub.com/cgi/alerts>

Subscriptions: <http://sag.sagepub.com/subscriptions>

Reprints: <http://www.sagepub.com/journalsReprints.nav>

Permissions: <http://www.sagepub.com/journalsPermissions.nav>

Citations: <http://sag.sagepub.com/content/41/4/587.refs.html>

>> [Version of Record](#) - Jul 27, 2010

[OnlineFirst Version of Record](#) - Dec 24, 2008

[What is This?](#)

Serious Video Games for Health: How Behavioral Science Guided the Development of a Serious Video Game

Simulation & Gaming

41(4) 587–606

© 2010 SAGE Publications

Reprints and permission: <http://www.sagepub.com/journalsPermissions.nav>

DOI: 10.1177/1046878108328087

<http://sg.sagepub.com>



**Debbe Thompson¹, Tom Baranowski¹,
Richard Buday², Janice Baranowski³,
Victoria Thompson⁴, Russell Jago⁵, and
Melissa Juliano Griffith⁶**

Abstract

Serious video games for health are designed to entertain players while attempting to modify some aspect of their health behavior. Behavior is a complex process influenced by multiple factors, often making it difficult to change. Behavioral science provides insight into factors that influence specific actions that can be used to guide key game design decisions. This article reports how behavioral science guided the design of a serious video game to prevent Type 2 diabetes and obesity among youth, two health problems increasing in prevalence. It demonstrates how video game designers and behavioral scientists can combine their unique talents to create a highly focused serious video game that entertains while promoting behavior change.

Keywords

action-adventure, adolescents, behavioral change, behavioral science, edutainment, ESCAPE FROM DIAB, game design, health behavior, obesity, theory, Type 2 diabetes, video game

¹USDA/ARS Children's Nutrition Research Center, Baylor College of Medicine, Houston, Texas, USA

²Archimage, Inc., Houston, Texas, USA

³Baylor College of Medicine, Houston, Texas, USA

⁴University of Texas MD Anderson Cancer Center, Houston, Texas, USA

⁵University of Bristol, UK

⁶USDA/ARS Children's Nutrition Research Center, Baylor College of Medicine, Houston, Texas, USA

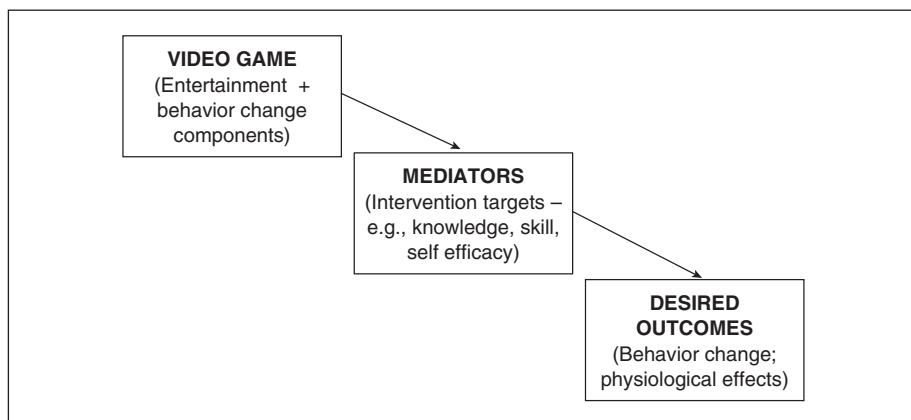


Figure 1. Behavior Change Framework—Video Games

Although rarely seen among youth 20 years ago, more recent estimates of the prevalence of Type 2 diabetes suggest it is becoming more common (Fagot-Campagna et al., 2000). Over the past few decades, substantial increases have also been seen in the prevalence of youth obesity (Ogden et al., 2006), a primary risk factor for Type 2 diabetes (Hussain, Claussen, Ramachandran, & Williams, 2007). Thus, preventing obesity should reduce risk for Type 2 diabetes (Hussain et al., 2007).

Obesity results from energy intake exceeding expenditure over the long term (Goran & Treuth, 2001). Low energy dense foods, such as fruit and vegetables, have been associated with weight loss (Rolls, Drewnowski, & Ledikwe, 2005). Physical activity, the major modifiable component of energy expenditure (Goran & Treuth, 2001), has been associated with lower levels of body fat in children (Goran, Reynolds, & Lindquist, 1999). Sedentary behaviors, such as amount of time spent watching television, has been positively associated with body mass index (Jago, Baranowski, Baranowski, Thompson, & Greaves, 2005). Youth diet and activity patterns are less than desirable (Baranowski, Smith et al., 1997; Domel et al., 1993; French, Lin, & Guthrie, 2003; Jago et al., 2005; Pate, Long, & Heath, 1994). Encouraging increased consumption of fruit and vegetables, increased physical activity, and reduced sedentary behavior should decrease risk of both obesity and Type 2 diabetes.

Behavior is typically the result of multiple influences, often making it resistant to change (Baranowski, Lin, Wetter, Resnicow, & Hearn, 1997). Therefore, behavior change must be approached as a complex, multistep process. Rather than attempting to change behavior directly, behavioral scientists attempt to change mediators. Changes in mediators, in turn, change behavior (Figure 1) (Baranowski, Lin et al., 1997).

Ideal mediators are highly predictive of a specific behavior (Baranowski, Lin et al., 1997). Behavioral theories typically guide the selection of mediators (Baranowski,

Lin et al., 1997). Theories providing mediators for entertainment-based media include social-cognitive (Bandura, 1986), self-determination (Ryan & Deci, 2000), and transportation (Green & Brock, 2000) theories, as well as the Elaboration Likelihood Model (Petty & Cacioppo, 1986). Examples of such mediators include immersion, attention, functional knowledge, self-regulatory skill development (e.g., goal setting, self-monitoring, decision making), self-efficacy, internal motivation, and feelings of competence, autonomy, and relatedness.

Behavioral theory also provides procedures that facilitate behavior change. The Elaboration Likelihood Model (Petty & Cacioppo, 1986) provides support that story characters viewed as credible, attractive, and likeable are more likely to be persuasive than others. Behavioral inoculation theory (McGuire, 1961) guards against counterpersuasion by identifying and refuting potential threats to goal attainment. Social cognitive theory (Bandura, 1986) specifies goal setting, modeling, and skill development as behavior change activities. Both social cognitive (Bandura, 1986) and self-determination (Ryan & Deci, 2000) theories emphasize the importance of feedback to guide and shape behavior during the change process.

School-based interventions to change diet and physical activity have had little success changing body composition (Thompson et al., 2006), suggesting different approaches are needed to attenuate the obesity epidemic and decrease risk for Type 2 diabetes among youth. Video games offer potential behavior change channels by embedding functional knowledge and change procedures such as goal setting, modeling, and skill development activities into a personally meaningful, entertaining, and immersive game environment (Baranowski, Buday, Thompson, & Baranowski, 2008). Video games also promote learning and social interaction (Wideman et al., 2007), create an environment in which their actions and decisions have an effect (Gee, 2004), promote creative problem solving (Gee, 2004), and enhance understanding by promoting systems thinking or helping the player see the "big picture" (Gee, 2004).

"Serious video games" are designed to entertain players as they educate, train, or change behavior (Stokes, 2005). "Games for health" are serious video games that focus on health (Baranowski et al., 2008). Some target prevention (Baranowski et al., 2003), whereas others target disease management (Brown et al., 1997). Serious video games for health may be an effective behavior change channel (Baranowski et al., 2003; Brown et al., 1997). However, to employ the medium's entertaining and engaging format to achieve change in knowledge, skills, or behavior successfully (Stokes, 2005), serious video game design teams should include entertainment (i.e., game artists, writers, designers, and software programmers) and behavior change (i.e., behavioral scientists, content specialists) experts. This article demonstrates how behavioral theory guided the design of a serious video game to prevent Type 2 diabetes and obesity among youth and how entertainment and behavior change experts worked together to create the game.

Escape From Diab (Diab)

Video Game Description

DIAB is a nine-level action-adventure video game told from a third-person perspective. It is designed to be played during leisure time on personal computers. Each level follows a preset structure that integrates passive cut-scenes and active behavior change procedures into immersive game play. Its target audience is 10- to 12-year-old males and females with access to a computer.

Behavioral Focus

DIAB promotes energy balance by encouraging increased consumption of low energy dense foods and beverages and increased energy expenditure (physical activity).

Design Team

DIAB was designed by a large, multidisciplinary group. Although there was a core group of design and behavior change specialists, the skills needed, and therefore team membership, varied depending on the stage of development. The game design studio consisted of a producer, director, video artists, animators, programmers, modelers, story writers, music composers, sound editors, storyboard artists, and voice talent. Behavior change and content specialists included psychologists, registered dietitians, exercise specialists, qualitative methods specialists, public health professionals, and experts in measurement, process evaluation, recruitment, data collection, and statistical analyses. Although the combined team worked in close collaboration, each group made unique contributions to the final product.

Youth Appeal

Early in the development process, 76 middle school youth participated in 16 formative focus groups, representing both urban and rural geographic areas. Most (81%) were African American or Hispanic (i.e., youth at risk of developing obesity and diabetes; Fagot-Campagna et al., 2000). In general, youth reported preferring action games and an ethnically diverse cast of male and female characters. Physical attractiveness was important, particularly in the main characters, and participants generally preferred characters that fit traditional gender roles. Although participants favored action video games with some violence, when asked how to design a nonviolent game to promote healthy lifestyle choices to teenagers, seven themes emerged: a central character who is captured and rescued, an antagonist who has an army, subtle or implied romantic feelings between a male and female character, obstacles that impede progress, a central character who acts as a traitor or double-agent, a central character who has an interesting history or genealogy, and a story centered around exploration and clue finding. Levels of game play and intellectual challenges also

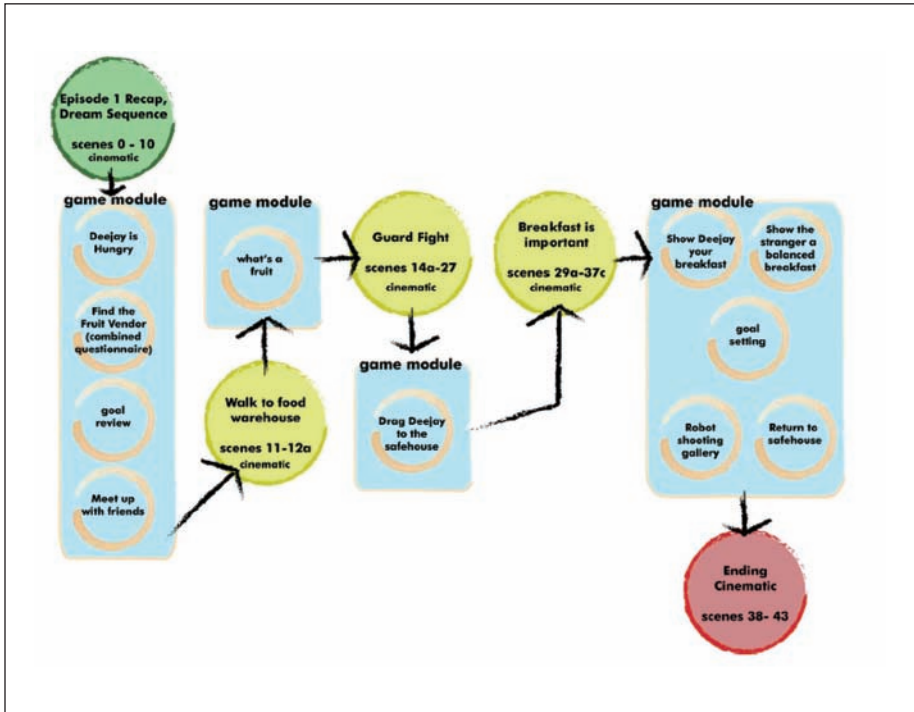


Figure 2. Working Version: Game-Flow Schematic–Episode 2

emerged as desirable features. This information from these focus groups was used to develop DIAB's characters, plot, and storyline and to select its genre (V. Thompson, personal communication, April 8, 2008).

Video Game Structure

Most of the story unfolds through prerendered animated movie clips (called “cut-scenes” or “cinematics”) of character interaction and dialogue, although some story development occurs between the player and nonplayer characters through interactive game activities (Figure 2).

Video game graphic user interfaces can be grouped into three types: 2-, 2-1/2-, and 3D. Two-dimensional, side-scrolling, “platform” games (such as SUPER MARIO BROTHERS, 1985). present action as if viewed through a telephoto lens located at some distance from the screen. All the artwork appears flat. Axonometric (2-1/2D) games (e.g., THE SIMS, 2000). look 3D but are not in true perspective. True 3D video games allow users to experience views of game worlds similar to real life. A well-known example, DOOM, 1994). pioneered the use of immersive, real-time rendered, 3D graphics in video game play.

Table 1. Theoretical Contribution

	SCT	SDT	TT	ELM	BIT
Change procedures					
Storyline	X		X	X	
Mini-games	X	X			
Modeling	X				
Feedback	X	X		X	
Choice		X			
Value-reason statements		X			
Tailoring				X	
Good guy/bad guy					X
Goal setting	X	X			
Implementation intentions	X				
Self-monitoring	X				
Goal review	X				
Problem solving	X				
Mediators					
Immersion			X		
Attention			X	X	
Knowledge	X				
Self-regulatory skill development	X				
Personal mastery	X				
Self-efficacy	X				
Autonomy		X			
Relatedness		X			
Competence		X			
Internal motivation		X			

Note: SCT = social-cognitive theory (Bandura, 1986); SDT = self-determination theory (Ryan & Deci, 2000); TT = transportation theory (Green & Brock, 2000); ELM = Elaboration Likelihood Model (Petty & Cacioppo, 1986); BIT = behavioral inoculation theory (McGuire, 1961).

A 3D game engine, TORQUE GAME ENGINE ADVANCED (TGEA) by GarageGames (TGEA), was used in DIAB. 3D STUDIO MAX BY AUTODESK, INC was used to create 3D models and animated sequences that enhanced the player’s immersion in the game. High-resolution (high polygon count) cinematic computer models of game worlds and characters were created with 3D STUDIO MAX BY AUTODESK, then animated and edited as movie clips. Low polygon count models were also created with 3D STUDIO MAX BY AUTODESK but exported to TGEA for real-time rendering during game play.

Theoretical Framework

Several theories, including social-cognitive (Bandura, 1986), self-determination (Ryan & Deci, 2000), behavioral inoculation (McGuire, 1961), and transportation theories (Green & Brock, 2000) and the Elaboration Likelihood Model (Petty & Cacioppo, 1986), contributed mediators and behavior change procedures. Table 1 provides an

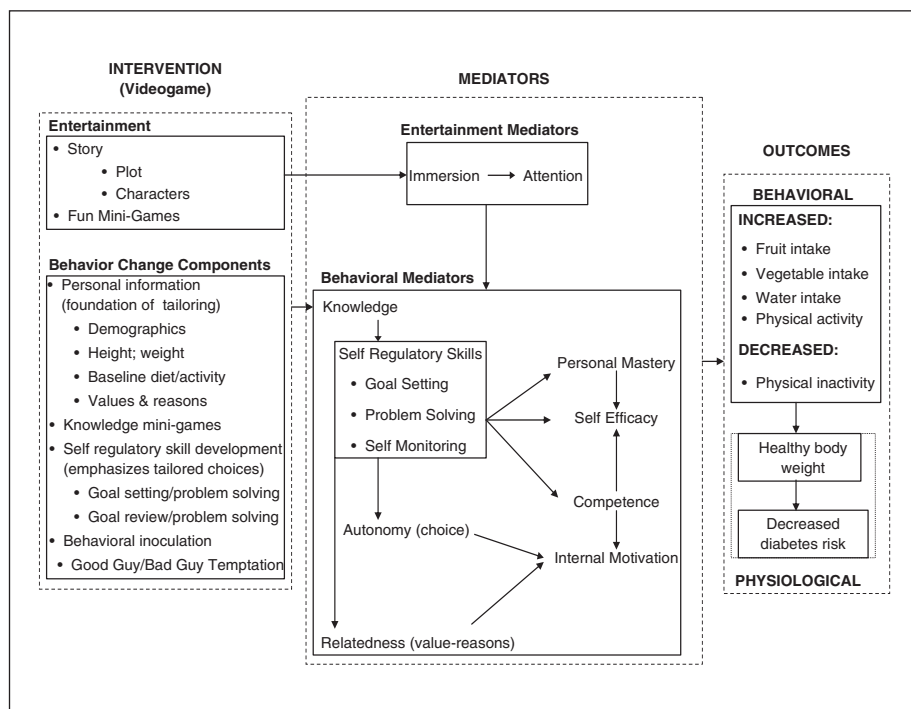


Figure 3. Mediators

overview of their contributions, and Figure 3 demonstrates how DIAB was designed to effect behavioral and physiological outcomes through these carefully selected mediators.

Theory Use in Entertainment Components

Entertainment likely attracts and holds the player's attention on the video game, thereby facilitating players' exposure to behavior change procedures. In DIAB, entertainment was achieved primarily through the storyline and video game characters. Game developers wove the behavior change components into the storyline and game play activities to help maintain entertainment value, thus enhancing immersion (Green, Strange, & Brock, 2002) and attention (Petty & Cacioppo, 1986).

Storyline. DeeJay, one of two protagonists, is an athletic adolescent from the present-day world. While playing soccer with friends, he chases an errant ball into an abandoned building and falls through a door, where he is knocked unconscious upon landing. He awakens to find himself in Diab, a colorless land inhabited by oppressed, disenchanting people. King Etes, Diab's evil ruler, maintains control of his subjects by promoting unhealthy diets and physical inactivity (Figure 4), which induce Diab

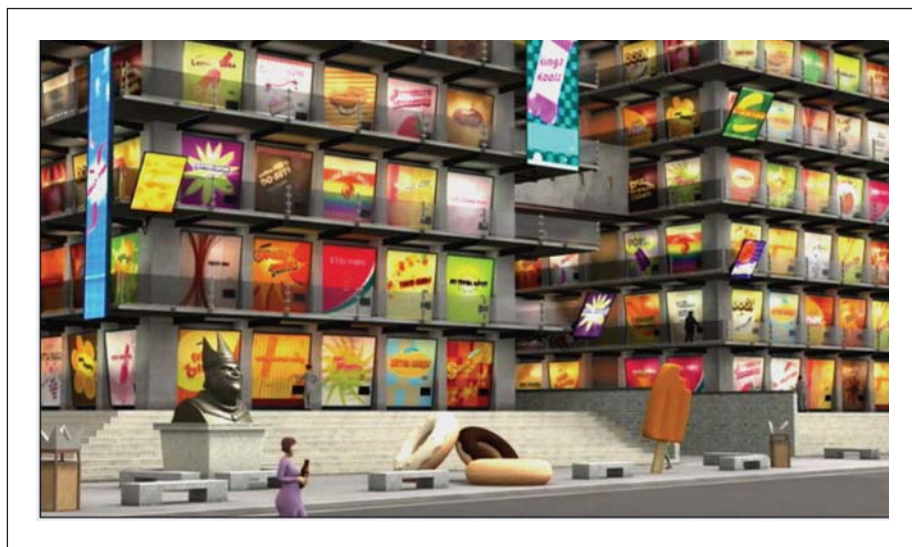


Figure 4. Junk Food Vending Machines

inhabitants to become indolent and easier to control. Noticing the athletic-looking DeeJay is obviously not from Diab, the King's guards immediately try to arrest him upon his arrival. Fortunately, DeeJay is befriended by a renegade troop of Diab youth around the same age as he who help him escape the guards. They take him into hiding and tell him of a mythical "Golden City" where everyone is healthy and fit. Realizing he can't easily return home, DeeJay decides to help his friends escape to the Golden City. He becomes their coach, introducing them to healthy eating and physical activity as a way to gain the mental acuity and physical fitness needed to outwit King Etes and "escape from Diab." He does this through modeling and persuasive dialogue.

Unbeknownst to DeeJay and his newfound Diab friends, King Etes is aware of their plot and tries to foil their attempt to escape (see Figure 5). In the final level, a showdown occurs among DeeJay, his friends, and King Etes.

Characters. The Elaboration Likelihood Model (Petty & Cacioppo, 1986) proposes that characteristics of the "message source" (i.e., the video game characters) affect their potential persuasiveness and that trustworthiness, attractiveness, and likeability are key attributes. Observation is an efficient way to learn how to perform a behavior successfully (Bandura, 1986) and occurs by watching others (i.e., models) perform the behavior and receive internal (e.g., personal satisfaction) or external (e.g., praise from others) rewards. Although youth models are often people (e.g., respected adults, peers), cartoon-type characters have also been used to model desired behaviors in behavior change interventions (Stewart, Seemans, McFarland, & Weinhofer, 1997).

For characters to serve as models, perceived similarity and competence are important attributes (Schunk, 1986, 1987). Thus, characters were created to have diverse appearances, including racial/ethnic origin, gender, body shape and size, facial



Figure 5. King Etes Spies on DeeJay and Friends



Figure 6. Story Climax Confrontation

features, and personalities (see Figure 6). In the early stages of development, the design team created and tested concept representations of the video game characters with multi-ethnic panels of middle school youth in focus groups. Based on their

suggestions, changes were made to the characters, including modifications to race/ethnicity, hair styles, clothing, facial features, and body size.

DeeJay, the male protagonist, is the expert on healthy diet and physical activity. His primary role is to convey practical knowledge regarding key skills, model healthy diet and physical activity behaviors, and provide persuasive dialogue to encourage the characters (and thus the player) to attempt and/or adopt healthier behaviors. Delinda, female protagonist and leader of the Diab youth, is initially the most receptive to suggestions offered by DeeJay. Throughout the video game, she encourages her friends to listen to his unusual, but intriguing, ideas on diet and activity. The other youth characters, two males and a female, have diverse strengths and weaknesses that are woven into the story arc. Throughout the story, the characters attempt behavior change, encounter barriers, and overcome them. In doing so, they gain the physical fitness and mental acuity necessary to outwit King Etes and his guards. Together, the young non-player characters provide a realistic and believable venue for modeling how to use the various skills and behaviors taught through the video game to overcome barriers efficiently and effectively and achieve behavior change goals.

King Etes and his guards were designed to be the antithesis of the Diab youth (i.e., unattractive, unappealing, and untrustworthy, with a hidden agenda). Part of the entertainment value of the storyline is the tension generated as DeeJay and the Diab youth attempt to outwit King Etes and his "henchmen."

Modeling a gradual improvement in performance (i.e., "coping style"), rather than perfect performance from the beginning (i.e., "mastery style"), is likely helpful when trying to learn how to perform a new behavior or skill (Schunk, 1986, 1987). Therefore, throughout the video game, characters demonstrate how to persevere if success is not immediate and how to use self-regulatory skills (i.e., goal setting, problem solving, and self-monitoring) to attain goals and change behavior. Having the characters model how to overcome difficulties (Schunk, 1986, 1987) and emphasize positive emotions that accompany success (Bandura, 1986) likely enhances self-efficacy. Therefore, in the video game, characters convey the pride and satisfaction of goal achievement and behavior change. To be credible, however, positive emotion needs to appear natural and not forced or contrived. This is achieved through dialogue (e.g., "I did it!"), character interactions (e.g., DeeJay congratulating other characters for successfully performing a behavior or achieving a goal), and body language (e.g., smiling, looking excited or pleased when a goal is achieved).

Theory Use in Behavior Change Components and Procedures

Tailoring. Tailoring refers to feedback or guidance that customizes information to personal characteristics (Kreuter, Strecher, & Glassman, 1999). Computer-based tailoring has been shown to be effective at promoting behavior change (Kroeze, Werkman, & Brug, 2006). Tailoring effectiveness can be explained in part by the Elaboration Likelihood Model (Petty & Cacioppo, 1986). To enhance personal relevance in DIAB, players answer questions about their personal diet and physical activity preferences,



Figure 7. Data Collection for Tailoring

behaviors, and practices during initial video game set-up and at strategic times throughout the video game (see Figure 7). An algorithm converts this information into response options tailored to personal characteristics.

Knowledge mini-games. Practical, behavior-specific knowledge is a necessary, but not sufficient, component of behavior change (Bandura, 1986) and provides the foundation for making informed choices. For example, to make healthy diet and activity choices, youth need to understand which foods are fruit and vegetables and which are not (e.g., strawberries are fruit, strawberry-flavored gelatin is not), how to select appropriate portion sizes, the relationship between portion size and calories, and how to distinguish between sedentary and moderate-to-vigorous physical activities. Knowledge is conveyed, reinforced, and tested as youth play mini-games (see Figure 8). This approach was selected in an effort to help the player learn the content while being entertained through personal challenge (e.g., meeting an attainable, but difficult, goal).

Goal setting. In DIAB, goal setting is a multistep process that includes the formation of both a goal and implementation intention (i.e., an if/then plan related to goal attainment) (Gollwitzer, 1999), connection of the goals to personal values (i.e., to foster relatedness) (Ryan & Deci, 2000), and inoculation against threats to goal attainment (McGuire, 1961). Because autonomy enhances internal motivation for an action or behavior (Ryan & Deci, 2000), numerous choices are offered to the player throughout goal setting. For example, the player is offered a choice of behaviors from which to set goals based on the video game level (Levels 1 through 4: diet; Levels 5 through 8: activity). Players also choose the specific goal they want to work on within behaviors



Figure 8. Energy Balance Mini-Game

(e.g., meal/snack to eat another fruit) and the days of the week to attempt this goal (Sunday through Saturday).

Problem solving. Although barriers interfere with goal attainment and behavior change, problem solving produces strategies to overcome barriers (Frauenknecht & Black, 1995). In DIAB, players develop an implementation intention (i.e., plan) to overcome anticipated barriers to goal achievement. To facilitate this activity, players are presented with a menu of common youth-reported barriers to healthy diet or activity choices. Players are prompted to choose a barrier they anticipate/think they may encounter when trying to meet the goal. They are then offered a menu of possible solutions and asked to choose one they are willing to try if the barrier is encountered (see Figure 9). In the next episode, players report if they met the goal (i.e., goal review). Consistent with Elaboration Likelihood Model (Petty & Cacioppo, 1986), the problems and solutions presented in goal setting must be perceived as believable and realistic by the player (i.e., personally relevant). Therefore, prior to inclusion in the video game, the problems and solutions were tested with youth through cognitive interviews.

Motivational statements. Self-determination theory (Ryan & Deci, 2000) proposes that internal motivation is enhanced by helping individuals see the connection between a behavior and something that is important to them, like a personal value (i.e., relatedness, a basic need that influences internal motivation). As part of the goal-setting procedure, players are presented with a menu of value statements from which they select the one that is most important to them. They then select a reason from a menu



Figure 9. Creating an Implementation Intention

of value-specific reasons that tie meeting the goal with the value. For example, “getting good grades” is one value players could select from the menu. One possible reason connecting this value (“getting good grades”) to their goal (“eating fruit for breakfast”) is it “keeps you healthy so you can pay better attention at school.”

Goal review. During goal review, players report whether they attained the goal that they set in the previous episode. If they report the goal was not met, they are routed to a problem-solving component, where they are asked to identify the specific problem that kept them from achieving their goal. Next, they are offered a list of barrier-specific solutions and asked to select one they think will overcome the barrier. They are then offered an opportunity to reattempt the goal. This activity increases the likelihood of personal success (i.e., personal mastery), which increases self-efficacy (Bandura, 1986).

Feedback. Well-crafted feedback can enhance self-efficacy (Schunk, 1986) and feelings of competence (Ryan & Deci, 2000). For example, in the fruit knowledge mini-game, the player has a limited time to differentiate storage boxes of fruit (e.g., apples) from nonfruit items (e.g., apple pie) in the warehouse. At the end of the knowledge mini-game, a score sheet appears on the screen. All the correctly identified fruit appears under a green check mark, whereas all the incorrect selections appear under a red “x,” thus providing feedback on correct and incorrect responses. Other procedures used in the knowledge mini-games to provide instant feedback regarding whether the player’s choice is correct or incorrect include sound effects and/or graphics (see Figure 10). General feedback, to enhance a sense of accomplishment and personal pride in a job

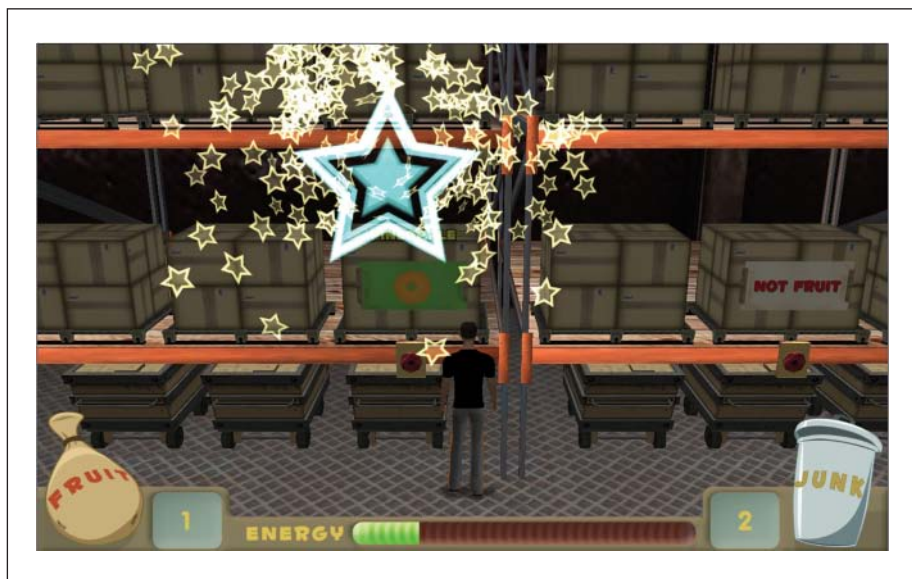


Figure 10. Immediate Feedback: Knowledge Mini-Game

well done, is also included at various places in the video game and included statements such as, “Great! You picked well!” (i.e., goal setting). Feedback is also specific, positive, and realistic: “You’ve met goals before and you’ll do it again. No one’s asking you to be perfect, just try.”

Behavioral inoculation. Players are “inoculated” to withstand persuasive arguments against goal attainment (McGuire, 1961). Referred to as the “good guy/bad guy” segment by the design team (see Table 2), the narrator (the voice that guides the player through the behavior change activities and provides feedback) is the good guy who encourages the player and supports the player’s goal attainment throughout the video game. The bad guy, represented by one of King Etes’s guards, stands for the “voice within” (e.g., self-doubts) and external pressures (e.g., friends, conflicting goals) that discourage goal attainment. After the player sets a goal, the bad guy makes a statement that discourages the player from attempting the goal. The good guy then affirms the goal by reminding the players of the reason they wanted to achieve the goal (i.e., restating the reason the player selected that connects the goal to a personally held value). In part, this segment is comical and adds an element of fun into the goal-setting process.

Debriefing

Video games are experiential, thus providing for active learning (Crookall, 1990). Serious video games that simulate life encourage learning transfer, but how to accomplish this may not be readily transparent to the player (Peters & Vissers, 2004).

Table 2. Good Guy/Bad Guy Example

Session Number	Focus	Dialogue
Session 1	Peer influence	GOOD GUY: Be prepared. Sometimes, it may be hard to meet your goal. BAD GUY: Ha ha ha ha . . . who wants to meet THAT goal? You don't want to be left out, do you? [Sounding cajoling] Just be like everyone else and fit in! GOOD GUY: Don't worry, you will still fit in. Just remember WHY this goal is important to you. [Player-selected value/reason statement appears on screen]

Debriefing can help achieve this goal (Crookall, 1990, 1992). By reflecting on the game after playing it, debriefing helps the player make meaningful connections between the game experience and the “real world” (Crookall, 1990), thereby likely enhancing transfer of knowledge and skills. Debriefing is typically conducted after game play by asking players to respond to a series of open-ended questions that explore their perceptions toward the game (Lennon & Coombs, 2005). Debriefing can promote active learning by deconstructing the experience, exploring alternative responses, and linking observations and experiences in the virtual world to those in the real world (Gaba, Howard, Fish, Smith, & Sowb, 2001). It can also provide guidance to game developers on modifications to enhance both game play and transfer of knowledge to the real world (Lennon, 2006). Participants have reported favorable reactions to debriefing sessions (Gaba et al., 2001).

Debriefing, in its usual form, is not a component of DIAB. However, alpha testing, a method to identify difficulties that may affect game playability, occurred throughout game development. During alpha testing, players played an episode of the game and then participated in an interview lasting approximately 1 hour. Questions asked during the interview assessed the players’ grasp of the knowledge and skills presented in the episode as well as their perceptions toward the game play experience, all of which are key aspects of debriefing. Examples of questions asked included what they thought about the game, what they learned from playing it, what was most interesting and/or fun, what was hard, what was easy, and what grade (A, B, C, D) they would give it. The interviewer probed as needed to clarify, understand, and expand responses, thus providing insight into the game play experience from the player’s perspective. Early alpha testing of goal setting, goal review, and related components indicated the players generally comprehended they were setting “real world” goals and that they were answering questions about themselves, although some players reported not being certain to whom the goals were targeted (Thompson et al., 2007).

As the primary intent of serious video games for health is to change behavior, future research needs to explore how best to incorporate debriefing procedures into game design to enhance learning transfer from the game world to the real world. In DIAB,

players set real world behavior change goals in the game world. Knowledge (i.e., portion size, energy balance) and skills (i.e., goal setting, self-monitoring) learned in the game world enhance the likelihood of achieving these real world goals. In the following episode, players report whether the goals they set in the previous episode were attained in the real world. Thus, goal review could provide an opportunity for seamlessly incorporating debriefing into the game itself. For example, goal review could be expanded to include a “dialogue” between a character and the player, where players respond to debriefing questions posed by the character. Another approach could be to have players identify knowledge, skills, and strategies learned in the previous episode(s) that helped them achieve their goals. In DIAB, if goals are not achieved, players are routed to problem solving, where they identify barriers that kept them from meeting their goals; they then select a solution that could help overcome the problem. Expanding this to include a dialogue between a character and the player about why this solution may be effective and how one could implement it could enhance transfer of knowledge and skills obtained in the game world to the real world. Adding a brief session at the end of each episode where the players reflect on what they learned and how to apply it to help them meet their goals could also be a novel way to incorporate debriefing into serious video games for health.

Current Status

DIAB’s outcome evaluation to examine change in diet and activity behaviors and their mediating variables began in May 2008. Process evaluation data are being collected to provide insight into the game play experience.

Conclusion

DIAB is an entertaining, but serious, theoretically grounded video game designed to reduce risk for Type 2 diabetes and obesity among youth. Emerging evidence suggests theoretically based serious video games can be effective at achieving change in both diet and physical activity. Little is known, however, about the processes and mechanisms through which behavior change occurs in a serious video game. This article elucidates the design of one such video game. It also describes how entertainment and behavior change experts combined their talents to create an entertaining, theoretically grounded serious video game. Future work needs to explore how to best incorporate debriefing into serious video games designed to change health behavior.

Authors’ Note

This research was largely funded by a SBIR grant from the National Institutes of Health, National Institutes of Diabetes, and Digestive and Kidney Diseases (U44 DK66724). This work is also a publication of the United States Department of Agriculture USDA/ARS Children’s Nutrition Research Center, Department of Pediatrics, Baylor College of Medicine, Houston, Texas, and had been funded in part with federal funds from the USDA/ARS under Cooperative Agreement

No. 58-6250-6001. The contents of this publication do not necessarily reflect the views or policies of the USDA, nor does mention of trade names, commercial products, or organizations imply endorsement from the U.S. government.

References

- 3D STUDIO MAX BY AUTODESK INC. (1996). Autodesk, Inc. San Rafael, CA.
- Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.
- Baranowski, T., Baranowski, J., Cullen, K. W., Marsh, T., Islam, N., Zakeri, I., et al. (2003). "Squire's Quest!" dietary outcome evaluation of a multimedia game. *American Journal of Preventive Medicine*, 24, 52-61.
- Baranowski, T., Buday, R., Thompson, D., & Baranowski, J. (2008). Playing for real: Video games and stories for health-related behavior change. *American Journal of Preventive Medicine*, 34, 74-82.
- Baranowski, T., Lin, L. S., Wetter, D. W., Resnicow, K., & Hearn, M. D. (1997). Theory as mediating variables: Why aren't community interventions working as desired? *Annals of Epidemiology*, 7, S89-S95.
- Baranowski, T., Smith, M., Hearn, M., Lin, L., Baranowski, J., Doyle, C., et al. (1997). Patterns in children's fruit and vegetable consumption by meal and day of the week. *Journal of the American College of Nutrition*, 16, 216-223.
- Brown, S. J., Lieberman, D. A., Germeny, B. A., Fan, Y. C., Wilson, D. M., & Pasta, D. J. (1997). Educational video game for juvenile diabetes: Results of a controlled trial. *Medical Informatics*, 22(1), 77-89.
- Crookall, D. (1990). Editorial: Future perfect? *Simulation & Gaming: An International Journal*, 21, 3-11.
- Crookall, D. (1992). Editorial: Debriefing. *Simulation & Gaming: An International Journal*, 23, 141-142.
- Domel, S., Baranowski, T., Davis, H., Thompson, W., Leonard, S., Riley, P., et al. (1993). Development and evaluation of a school intervention to increase fruit and vegetable consumption among 4th and 5th grade students. *Journal of Nutrition Education*, 25, 345-349.
- DOOM. (1994). ID Software. Mesquite, TX.
- Fagot-Campagna, A., Pettitt, D. J., Engelgau, M. M., Burrows, N. R., Geiss, L. S., Valdez, R., et al. (2000). Type 2 diabetes among North American children and adolescents: An epidemiologic review and a public health perspective. *Journal of Pediatrics*, 136(5), 664-672.
- Frauenknecht, M., & Black, D. (1995). Social Problems-Solving Inventory for Adolescents (SPSI-A): Development and preliminary psychometric evaluation. *Journal of Personality Assessment*, 64, 522-539.
- French, S. A., Lin, B. H., & Guthrie, J. F. (2003). National trends in soft drink consumption among children and adolescents age 6 to 17 years: Prevalence, amounts, and sources, 1977/1978 to 1994/1998. *Journal of the American Dietetic Association*, 103(10), 1326-1331.
- Gaba, D., Howard, S., Fish, K., Smith, B., & Sowb, Y. (2001). Simulation-based training in anesthesia crisis resource management (ACRM): A decade of experience. *Simulation & Gaming: An International Journal*, 32, 175-193.

- Gee, J. (2004). Learning by design: Games as learning machines. *Interactive Educational Multimedia*, 8, 15-23.
- Gollwitzer, P. (1999). Implementation intentions: Strong effects of simple plans. *American Psychologist*, 54, 493-503.
- Goran, M., Reynolds, K., & Lindquist, C. (1999). Role of physical activity in the prevention of obesity in children. *International Journal of Obesity and Related Metabolic Disorders*, 23(Suppl. 3), S18-S33.
- Goran, M. I., & Treuth, M. S. (2001). Energy expenditure, physical activity, and obesity in children. *Pediatric Clinics of North America*, 48(4), 931-953.
- Green, M., & Brock, T. (2000). The role of transportation in the persuasiveness of public narratives. *Journal of Personality and Social Psychology*, 79, 701-721.
- Green, M., Strange, J., & Brock, T. (Eds.). (2002). *Narrative impact: Social and cognitive foundations*. Mahwah, NJ: Lawrence Erlbaum.
- Hussain, A., Claussen, B., Ramachandran, A., & Williams, R. (2007). Prevention of Type 2 diabetes: A review. *Diabetes Research and Clinical Practice*, 76, 317-326.
- Jago, R., Baranowski, T., Baranowski, J. C., Thompson, D., & Greaves, K. A. (2005). BMI from 3-6 y of age is predicted by TV viewing and physical activity, not diet. *International Journal of Obesity (London)*, 29(6), 557-564.
- Kreuter, M., Strecher, V., & Glassman, B. (1999). One size does not fit all: The case for tailoring print materials. *Annals of Behavioral Medicine*, 21, 276-283.
- Kroeze, W., Werkman, A., & Brug, J. (2006). A systematic review of randomized trials on the effectiveness of computer-tailored education on physical activity and dietary behaviors. *Annals of Behavioral Medicine*, 31, 205-223.
- Lennon, J. (2006). Reports & communications: Debriefings of web-based malaria games. *Simulation & Gaming: An International Journal*, 37, 350-356.
- Lennon, J., & Coombs, D. (2005). The GOOD-BYE TO DENGUE GAME: Debriefing study. *Simulation & Gaming: An International Journal*, 36, 499-517.
- McGuire, W. (1961). Resistance to persuasion conferred by active and passive prior refutation of the same and alternative counterarguments. *Journal of Abnormal and Social Psychology*, 63, 326-332.
- Ogden, C. L., Carroll, M. D., Curtin, L. R., McDowell, M. A., Tabak, C. J., & Flegal, K. M. (2006). Prevalence of overweight and obesity in the United States, 1999-2004. *Journal of the American Medical Association*, 295(13), 1549-1555.
- Pate, R. R., Long, B. J., & Heath, G. (1994). Descriptive epidemiology of physical activity in adolescents. *Pediatric Exercise Science*, 6, 434-447.
- Peters, V., & Visser, G. (2004). A simple classification model for debriefing simulation games. *Simulation & Gaming: An International Journal*, 35, 70-84.
- Petty, R., & Cacioppo, J. (1986). *Communication and persuasion: Central and peripheral routes to attitude change*. New York: Springer-Verlag.
- Rolls, B., Drewnowski, A., & Ledikwe, J. (2005). Changing the energy density of the diet as a strategy for weight management. *Journal of the American Dietetic Association*, 105, S98-S103.

- Ryan, R., & Deci, E. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well being. *American Psychologist*, 55, 68-78.
- Schunk, D. H. (1986). Vicarious influences on self-efficacy for cognitive skill learning. *Journal of Social and Clinical Psychology*, 4(3), 316-327.
- Schunk, D. H. (1987). Peer models and children's behavioral change. *Review of Educational Research*, 57(2), 149-174.
- THE SIMS. (2000). Electronic Arts, Inc. Redwood City, CA.
- Stewart, K., Seemans, C., McFarland, L., & Weinhofer, J. (1997). Social learning versus traditional teaching in an elementary school cardiovascular health promotion program. *American Journal of Health Promotion*, 11(3), 194-197.
- Stokes, B. (2005). Video games have changed: Time to consider "serious games." *The Developmental Education Journal*, 11(3). Retrieved August 20, 2007, from www.dea.org.uk
- SUPER MARIO BROTHERS. (1985). Nintendo of America. Redmond, WA.
- Thompson, D., Baranowski, T., Buday, R., Baranowski, J., Juliano, M., Frazier, M., et al. (2007). In pursuit of change: Youth response to intensive goal setting embedded in a serious video game. *Journal of Diabetes Science and Technology*, 1(6), 907-917.
- Thompson, D., Baranowski, T., Zakeri, I., Jago, R., Davis, J., & Cullen, K. (2006). Effectiveness of school-based environmental vs. individual approaches to diet, physical activity, and sedentary behavior change among youth. In R. Flamenbaum (Ed.), *Childhood obesity and health research* (pp. 157-174). Hauppauge, NY: Nova Science Publishers.
- TORQUE GAME ENGINE ADVANCED. GarageGames, Inc. Eugene, OR.
- Wideman, R., Owston, R., Brown, C., Kushniruk, A., Ho, F., & Pitts, K. (2007). Unpacking the potential of educational gaming: A new tool for gaming research. *Simulation & Games: An International Journal*, 38, 10-30.

Bios

Debbe Thompson (a U.S. Department of Agriculture, Agricultural Research Service [USDA/ARS] scientist/nutritionist and assistant professor of pediatrics at the USDA/ARS Children's Nutrition Research Center, Baylor College of Medicine) conducts research in child obesity prevention by promoting healthy diet and physical activity behaviors. She has been designing and testing multimedia projects (i.e., Web-based programs, video games) for 7 years.

Tom Baranowski (professor of pediatrics-behavioral nutrition and physical activity) is committed to better understanding the causes of pediatric obesity and to preventing it using video games.

Richard Buday, Fellow of the American Institute of Architects (FAIA), is president and founder of Archimage, a 25-year-old design studio. A professional architect by training, his firm has won more than 30 international awards for video games and interactive media, broadcast computer animation, print graphics, building, and interior design. He has taught at the University of Houston and is published extensively on computers in design.

Janice Baranowski (MPH, RD, assistant professor of pediatrics–behavioral nutrition and physical activity with the Children’s Nutrition Research Center, Baylor College of Medicine) conducts research that includes using video games to help children eat healthy and engage in physical activities. If it’s fun, kids play it; and when they play, it may change their behavior—our ultimate goal!

Victoria Thompson, formerly of Baylor College of Medicine, conceived the ESCAPE FROM DIAB storyline. She was also director of marketing/client relations at Archimage, Inc., before accepting a position at M. D. Anderson in the Department of Faculty Development, where she leads efforts to promote the use of social media as a tool for expanding professional networks among the faculty.

Russell Jago (PhD, University of Bristol, UK) is a senior lecturer in exercise and health sciences who examines innovative ways to encourage youth to be physically active.

Melissa Juliano Griffith is a research coordinator for the Children’s Nutrition Research Center at Baylor College of Medicine. She received her BS in computer science and business administration from Trinity University in 2001. She is currently working toward completing her MPH at the University of Texas at Houston, School of Public Health.