Design of Video Games for Children's Diet and Physical Activity Behavior Change

Tom Baranowski,
USDA/ARS Children's Nutrition Research Center, Baylor College of Medicine, Houston, TX, USA

Debbe Thompson,
USDA/ARS Children's Nutrition Research Center, Baylor College of Medicine, Houston, TX, USA

Richard Buday,
Archimage, Inc., Houston, TX, USA

Amy Shirong Lu, and
USDA/ARS Children's Nutrition Research Center, Baylor College of Medicine, Houston, TX, USA

Janice Baranowski
USDA/ARS Children's Nutrition Research Center, Baylor College of Medicine, Houston, TX, USA

Abstract

Serious video games (VG) offer new opportunities for promoting health related diet and physical activity change among children. Games can be designed to use storylines, characters, and behavior change procedures, including modeling (e.g., engaging characters make changes themselves, and face and overcome challenges related to fruit and vegetable (FV) and physical activity (PA) goal attainment and/or consumption), skill development (e.g., asking behaviors; virtual recipe preparation), self regulatory behaviors (problem solving, goal setting, goal review, decision making), rewards (e.g., points and positive statements generated by the program), immediate feedback (e.g., through characters and/or statements that appear on the computer screen at critical decision points), and personalization (e.g., tailored choices offered at critical junctures, based on responses to baselines questions related to preferences, outcome expectancies, etc). We are in the earliest stages of learning how to optimally design effective behavior change procedures for use in VG, and yet they have been demonstrated to change behavior. As we learn, VG offer more and better opportunities for obesity prevention that can adjust to individual needs and preferences.

Introduction

Youth obesity has risen dramatically over the past few decades (Ogden et al., 2006). Overweight and obesity combined reached approximately 50% in some US ethnic minority children (Baranowski et al., 2006). Obese youth are more likely to become obese adults (Serdula et al., 1993). The prevalence of obesity has been implicated in increased risk for

type 2 diabetes (T2D) (Fagot-Campagna et al., 2000). Increased fruit and vegetable (FV) intakes are the only food groups that have shown some consistency in association with decreasing the risk of obesity (Dennis, Flack, & Davy, 2009; Rolls, Drewnowski, & Ledikwe, 2005) and T2D (Kastorini & Panagiotakos, 2009). Unfortunately youth consumed well below the recommended minimum of five FV servings (Baranowski, Smith et al., 1997; Domel et al., 1993) and were physically active (PA) for much less than the recommended 60 min of moderate to vigorous physical activity (MVPA) per day (Troiano et al, 2008). Finding ways to help youth consume more FV and be more PA will help decrease their risk of developing adult obesity and T2D.

Serious video game (VG) interventions have been effective at promoting dietary change among youth (Baranowski, Baranowski, Cullen, Marsh et al., 2003). Our recent review demonstrated that most health-related VG had some positive outcome (Baranowski, Buday, Thompson, & Baranowski, 2008). Serious VG offer the promise of effective behavior change by immersing children in a story that exposes them to related behavior change procedures within the game (Baranowski et al., 2008), and have the potential for broad public health benefit because, once created, they can be made widely available at low cost. To the extent serious VG increase FV intake and PA, they can contribute to healthier lifestyle changes among children. Starting those changes early offers promise of preventing both adult and child obesity.

Model of Behavior Change

Behavior change interventions must be predicated on proven highly predictive and causal models of behavior (Baranowski, Cerin, & Baranowski, 2009). Mediators are intermediate variables in the pathways between the VG intervention and dependent variables, and represent the mechanisms through which the independent variables exert their effect (Baranowski, Lin, Wetter, Resnicow, & Hearn, 1997; Bauman, Sallis, Dzewaltowski, & Owen, 2002). Some VG have a narrow focus and tend to emphasize increased knowledge (Peng, 2009) which may be necessary, but insufficient, for behavior change (Contento et al., 1995). In behavioral interventions, mediators are obtained from the theory or theories selected to guide the development of the intervention (Baranowski, Anderson, & Carmack, 1998; Baranowski, Lin et al., 1997). It is common to have more than one mediator (Baranowski, Lin et al., 1997; Baranowski et al., 1998), and it is likely that behavior is moderated (i.e. different outcomes at different levels of the variable) by factors other than mediators (e.g. demographics) (Baranowski, Lin et al., 1997). It is critical to use theories that have high predictive value (otherwise changing a variable with low predictive value would not substantially change the behavior); are causal (changing a noncausal variable would not change the behavior); clearly identify and target mediators with specific change procedures (Michie & Prestwich, 2009); and assess potential moderators (to design different intervention procedures for different levels of the moderating variable) (Baranowski, Lin et al., 1997). A behavior change procedure is an activity or message delivered by the VG that is targeted at the meaningful mediator.

A conceptual model is helpful that describes the process by which behavior change occurs and identifies where behavior change procedures influence the process. The model in Figure

1 is a preliminary specification of such a model. The sequence of influences across the psychosocial (mediating) variables to behavior change is in the middle and top rows; the FV behavior change procedures are along the bottom. This model incorporates ideas from Self Determination Theory (Ryan & Deci, 2000), the Elaboration Likelihood Model (Petty & Cacioppo, 1986), and Social Cognitive Theory (Bandura, 1986; Baranowski, Perry, & Parcel, 2002). Specifying this model enables clear tests of whether the intervention components influence mediators which should in turn provide future guidance to enhance the effectiveness of methods to achieve change in the desired directions (Baranowski, Lin et al., 1997; Baranowski et al., 1998). Designing interventions to effect change in mediators is likely to result in a body of scientific knowledge about how interventions change behavior.

Self Determination Theory (SDT) (Ryan & Deci, 2000) posits motivation as the strongest factor driving behavior. Motivation can be intrinsic (i.e. the joy of doing the behavior – e.g. preference for eating FV, fun or enjoyment from playing games) or extrinsic (i.e. influences external to the individual- e.g. parent praises child for eating fruit). Intrinsically motivated behavior tends to be sustained for a greater length of time compared to extrinsically controlled behavior, which requires continued reinforcement from someone (e.g. a prize, etc). SDT posits three factors promote intrinsic motivation: (1) competence (similar to self-efficacy, abilities to successfully do the behavior), (2) autonomy (independence to choose the behavior, control over the behavior), and (3) relatedness (ties to other people, agreement with their own deeply held personal values). Food-related values explaining why people select certain types of foods have been documented (Resnicow et al., 2008). Previous studies have used personal values and their reasons (statements that tie values to behaviors) as motivation to change behavior (Resnicow et al., 2008). Reasons statements are similar to outcome expectancies, the only variable shown to repeatedly mediate dietary behavior changes (Cerin, Barnett, & Baranowski, 2009). In a study to repeatedly motivate obesity-related behavior change, a list of values and attributes was identified and given to the participants who were asked about their most important values and their relation with their health behavior. Motivational messages were then tailored to these personal values (Resnicow et al., 2008). Distinctions are drawn in the model (Figure 1) between initial motivation to play the game, motivation to continue playing, and motivation to change behavior. Each is critical to promoting health related behavior change through FV play, but influenced in different ways. Figure 1 is a starting point to guide VG development, and will be revised as we learn more both about how the behavior change process works (from basic behavior change research) and how to design VG procedures to promote behavior change.

The Elaboration Likelihood Model (ELM) (Petty & Cacioppo, 1986) proposes that messages are processed in two different pathways: central or peripheral. The central pathway is more likely to result in lasting change (Petty & Cacioppo, 1986), and involves conscious attention to and evaluation of the message (Petty & Cacioppo, 1986). The amount of elaboration (i.e., the cognitive effort devoted to processing a message) is determined by motivation and ability. If motivation and ability are high, elaboration is more likely to occur. If motivation and/or ability are low, elaboration is less likely to occur. Motivation is enhanced by personal relevance, while ability is enhanced by skill development (Petty & Cacioppo, 1986). Therefore, emphasizing personal relevance (i.e., tailoring to personal preferences and characteristics) (Kreuter et al., 2000) and enhancing ability to process and use the

information (i.e., skill development) (Baranowski, Baranowski, Cullen, Marsh et al., 2003) likely result in high message elaboration, i.e. the child thinking more thoroughly about the messages in the VG, and promote behavior change. Computer-based programs were an effective channel for tailoring to personal characteristics (Webb, Joseph, Yardley, & Michie, 2010) and enhancing message elaboration (Evans et al., 1998).

Goal setting, often associated with personal control (self regulatory skills) in Social Cognitive Theory (SCT) (Bandura, 1986; Baranowski et al., 2002), is thought to be a critical component of behavior change. Goals regulate behavioral performance through four mechanisms: 1) goals direct attention and activity towards actions that are relevant to goal accomplishment (Locke, Shaw, Saari, & Latham, 1981), 2) mobilize resources (personal and social) needed to achieve the goal; 3) when there are no time constraints, goals affect persistence (i.e., directed effort over time) (Locke & Latham, 1994); and 4) guide self regulatory skills (e.g. problem solving), avoiding distractions (Bandura & Simon, 1977; Gollwitzer, 1999; Locke et al., 1981; Terborg, 1976). Characteristics of the goals also appear to make a difference. Specific, proximal (Bandura & Schunk, 1981), appropriate (Maibach & Cotton, 1995) goals framed in terms of positive outcomes (Higgins, 1997) appear to be associated with goal attainment. Goal setting is a common feature in dietary behavior change interventions among youth (Baranowski et al., 1990; Baranowski et al., 2000, Coates, Jeffery, & Slinkard, 1981, Cullen, Bartholomew, & Parcel, 1997, Domel et al, 1993; Howison, Neidermyer, & Shortridge, 1988; Killen et al., 1989; Ma & Contento, 1997; Nader, Sallis, & Patterson, 1989; Parcel, Simons-Morton, O'Hara, Baranowski, & Wilson, 1989; Perry, Tremblay, Signorile, Kaplan, & Miller, 1997; Perry, Mullis, & Maile, 1985; Perry, Stone, & Parcel, 1990; Simons-Morton, Coates, & Saylor, 1984; Walter & Wynder, 1989; White & Skinner, 1988). A review of dietary intervention studies revealed use of the four step goal setting process was needed for positive results (Cullen, Baranowski, & Smith, 2001). Goal setting as a change procedure has recently been refined to consist of two separate, but connected, phases: goal intentions and implementation intentions (Gollwitzer, 1999). Goal intentions are a statement of what is intended (i.e., "My goal is to x") (Brandstatter, Lengfelder, & Gollwitzer, 2001), whereas implementation intentions are a statement of how (e.g., when/where/in what way) the goal will be achieved (e.g., "If y happens, I will z") (Gollwitzer, 1999). A critical feature of implementation intentions is that they provide an opportunity to determine in advance, rather than in situ, how to meet one's goal by examining possible situations and selecting the ones most likely to lead to goal attainment, thereby creating commitment to a specific response in pre-identified situations (Brandstatter et al., 2001; Gollwitzer, 1999). Thus, environmental cues, rather than conscious thought, trigger a goal-directed response, thereby automatizing behavior, even in times of high cognitive load (Brandstatter et al., 2001), thereby making it more likely the goal will be attained (Bargh, Gollwitzer, Lee-Chai, Barndollar, & Trotschel, 2001). Strong implementation intentions that link a cue with a planned response can even be effective at overcoming habitual behavior patterns (Gollwitzer, 1999). For implementation intentions to be effective, commitment to both goal intention and implementation intention is needed (Gollwitzer, 1999).

Incorporating VG elements that resonate with a target audience makes video games more appealing. Transportation Theory posits that one can be immersed into a story at the diegetic

level (i.e., the game's story world) through mental imagery, emotional investment, and disregard for what is going on in reality, and likely affect beliefs or attitudes in accordance with the narrative (Green & Brock, 2002; Green & Brock, 2000). Because VG can be interactive narratives, transportation in a VG world also includes participatory activity in a virtual reality. Thus, the game environment must closely match player's expectations; the player's actions must have a significant impact on the game environment; and the established conventions of the environment must remain consistent throughout the game. Therefore, serious VG that have personal appeal, are perceived as personally relevant, and meet player's game-play expectations are more likely to create an immersive experience. While making immersion possible, the story can also be the source of SCT-based change procedures, such as modeling of behaviors, overcoming barriers to change, and enhancing motivation through the story arch and moral of the story (Baranowski et al., 2008).

Video Game Enabled Change Mechanisms

Researchers have started to systematically categorize intervention procedures and thereby promote comparability across studies (Michie & Prestwich, 2009). VG behavior change procedures need to be interfaced with these categories. Knowing how best to design these change mechanisms through VG delivered procedures is in early development. The original Squire's Quest! (SQ) (Baranowski, Baranowski, Cullen, Marsh et al., 2003), was a 10-session, 5-week Interactive Multi-Media version of the GIMME 5 curriculum, which took approximately 20 minutes/session to complete. The major themes of the GIMME 5 curriculum were included in SQ!, which was evaluated among elementary school students (Baranowski et al., 2000; Domel et al., 1993). In the VG, a child-friendly medieval motif with a castle, knights, king, queen and wizard, was used to promote FV intake. Based on SCT (Bandura, 1986) and ELM (Petty & Cacioppo, 1986), SQ! was designed to a) enhance children's preferences for FV, by increasing exposure and by virtually preparing FaSST (Fast, Simple, Safe, and Tasty) recipes; b) increase the home availability and accessibility of FV by using "asking skills" (i.e. activities to have children ask for their favorite FV at meals and snacks, put FV on the shopping list, ask to go shopping for their favorite FV, ask to go to fast food places that offer FV, and select FV off the fast food menus); c) reach out to parents through recipe preparation assignments; and d) virtually train the children in preparation of simple FV recipes and to set recipe goals (i.e., skill development). In addition, SQ! employed the self control techniques of setting goals for change, self monitoring performance, problem solving with unattained change goals, and self reward for attained goals (Bandura, 1986; Baranowski et al., 2002; Baranowski, Baranowski, Cullen, Marsh et al., 2003). Outcome analyses from 1600 4th grade students attending 26 Houston area elementary schools revealed an increase of 0.9 servings of FV after completing SQ! (Baranowski, Baranowski, Cullen, Marsh et al., 2003). Secondary analyses revealed that meal-specific changes occurred (Cullen, Watson, Baranowski, Baranowski, & Zakeri, 2005): fruit snack and lunch consumption of regular vegetables, two of the SQ! goals, significantly increased. The lack of change at breakfast and dinner indicated further work in this area was warranted. Attaining recipe preparation goals also resulted in more FV intake (Cullen, Watson, Zakeri, Baranowski, & Baranowski, 2007) and students with low baseline F preferences, attained more F goals resulting in increased post F consumption (Cullen et al.,

2004). Among those with low baseline V consumption, attaining one V goal was related to higher post V consumption. For boys and those with high baseline FV consumption, attaining three general goals was related to increased FV intake. Low income students who attained the specific goal to consume F at snack, or FV at a convenience store, reported greater intakes of the target items (Cullen et al, 2004). This is one of the first reports that goal setting was effective in promoting dietary change among children.

The Girls' health Enrichment Multi-Site (GEMS) Fun, Food and Fitness (FFF) study pilot tested (n=39) an obesity prevention intervention among 8 year-old African American girls (Baranowski, Baranowski, Cullen, Thompson et al., 2003). The intervention included a four-week summer day camp followed by an 8-week web-based intervention. Skills (asking, negotiation, goal setting/review, problem solving, decision making, self reward, and motor skills) were taught during the summer day camp and reinforced and generalized during the 8-week web-based intervention. The web-based intervention included theory-based comic books, problem solving, decision making, goal setting and review, and fun game links. A corresponding 8-week parent (primarily mothers) web-based intervention was delivered to augment the girls' intervention. Self regulatory skills (e.g., problem solving, goal setting, and goal review) were major components of both web-based interventions. No separate evaluation of these skills was conducted due to the small sample, but changes in dietary intake between the treatment/comparison groups were in the desired direction (Baranowski, Baranowski, Cullen, Thompson et al., 2003).

The Fun, Food and Fitness treatment girls' web site was converted to a stand-alone e-Health intervention, called Food, Fun and Fitness Internet Program for Girls (Thompson, Baranowski, Cullen, & Baranowski, 2007). In the original GEMS FFF project, log on rates were less than desirable (<50%) (Baranowski, Baranowski, Cullen, Thompson et al., 2003). This was a concern, since log on rate determines intervention dose. The goal of this study was to determine the effect of reinforcement schedule (i.e., immediate vs. delayed) on log on rate. The log on rate was 74.5% and attrition was <10% (Thompson, Baranowski, Cullen, Watson, Canada et al., 2008). Significant increases were also observed in FV consumption, physical activity, and FV self efficacy between baseline and post assessment (Thompson, Baranowski, Cullen, Watson, Liu et al, 2008). While recruitment of participants for studies is often challenging, families were eager to participate in this web based intervention with cartoons and games (Thompson et al., 2006).

Computer-based manga-style comics (Allen & Ingulsrud, 2003) were designed along with parallel fact sheets promoting problem solving skills to overcome common barriers to physical activity among 14-15 year old African-American, Asian-American, Euro-American, and Hispanic youth. The study tested components of Dual Code Theory (Paivio, 1991) in relation to PA. Preliminary data suggest that computerized fact sheets, which encouraged the use of imagination, resulted in deeper levels of information processing and enhanced PA self-efficacy to a greater extent than the manga-style comics, which did not encourage the use of imagination. This suggests that fantasy-based storylines that encourage the use of imagination may promote deeper levels of information processing.

Two 8-week Boy Scout Achievement badge program interventions were developed: one emphasizing increased PA, and one emphasizing increased FV intake. Each program had troop activity and web interactivity components. The web-based interventions included Boy Scout characters modeling desired behaviors, goal setting and goal review. The Fit for Life Badge program (Jago et al., 2006) demonstrated an increase in the amount of light intensity PA in participants who began the program in the Spring, but no increase among participants who began the program in the Fall. This suggests that the intervention resulted in increased PA, but only if the participants received the intervention during a time period that facilitated increased PA. For the 5 A Day Badge program (Thompson et al., 2009), significant changes were observed in F consumption, home availability, and self-efficacy in the treatment group as compared to the comparison group immediately following the intervention, but not 6 months later. Low fat V consumption increased significantly in the Spring wave comparison group, but not in the treatment group.

Understanding player preferences and expectations should enhance the development of effective, immersive serious behavior change VG. While studies have reported ethnic and gender differences in time spent playing VG and game-play preferences, few have examined regional differences in these variables. We employed both quantitative (surveys) and qualitative (focus groups) methods to determine preferences for storyline genres and plot content of non-violent VG as well as computer access, knowledge and game-play frequency among low-income urban middle school students in Texas (n=196) and rural middle school students in North Carolina (n=66) (Thompson, Thompson et al, 2010). Lower income White and Other/Native American students played VG more frequently than African-American or Hispanic students. North Carolina students were more likely to have home computers than Texas students. Although focus group participants preferred action VG with some violence, they had positive reactions to challenging adventure VG with male and female characters of diverse ethnicities and narratives without overt sexual overtones.

Based on these middle-school student preferences, two VG, "Escape from Diab" and "Nanoswarm: Invasion from Inner Space", were designed to enable adolescents to modify diabetes-related lifestyle behaviors (FV and W intakes, PA, and physical inactivity behavior change) (Thompson, Baranowski et al., 2010). The games were immersive (story with interesting likeable characters), interactive (responded to player's input), adaptive (tailored to player's behaviors, values, and psychosocial characteristics), and entertaining (used compelling narrative, characters and settings to make learning fun). The games presented challenging, but doable: 1) practical knowledge-based games that used mastery learning to enable children to learn what constitutes desired behavior (e.g. "What counts as a vegetable?" taught children not to increase french-fries, avocados, or fried onion rings to meet their dietary change goals); 2) goal-setting activities tailored to a child's current behaviors and preferences; 3) problem solving routines to enable children to identify effective strategies to overcome likely barriers to behavior changes; 4) motivational statements tailored to a child's values; and 5) energy balance games to enable children to select appropriate portions and aerobic/strength enhancing physical activities.

Each VG had 9 sessions with approximately 40 minutes of game-play per session, totaling approximately 6 hours of total game-play. At the end of each session, the child could return

to re-play non-behavior change mini games, and related video segments, but could not redo the goal review or goal setting portions of the game. A session by session description of each of the components in Diab has been published (Baranowski et al., 2010). There was progressively increasing complexity in the energy balance games across sessions. Despite randomization there were some differences in mean levels by group at baseline and no differences at post 1 assessment. The preliminary diet outcome data analyses revealed statistically significant ($p<0.000$) impact on FV intake (effect size (f)=0.17), and it's component F (f=0.15, $p<0.002$) and regular V (f=0.09, $p<0.064$) at post 3. This reflected an increase in the treatment group of 0.42 FV servings and in the control group a decline of 0.61 FV servings, or a combined change difference of approximately 1 FV serving. For PA, there was a suggestive increase in minutes of MVPA (f=0.08, $p<0.107$). This reflected an increase in the treatment groups of 2.6 min MVPA at immediate post and in the control group a decline of 4.3 min MVPA in the same time intervals or approximately 7 minutes difference. These behavior changes are comparable to or better than most reported in the literature with children. There were no changes in BMI indicators, but the time interval (2-3 mo) was too short to expect changes. Post game questionnaires with children and interviews with parents revealed that most children (80-90%) enjoyed playing both Diab and Nano.

Active VG may promote enhanced physical activity. Several active VG have been demonstrated to promote moderate to vigorous physical activity when done by the right people under the right circumstances (Barnett, Baranowski, & Cerin, 2010). Two field studies, however, indicated that children often get bored with the games after a week and no longer used them (Barnett et al, 2010). We have been funded to conduct an experiment in which children were randomly assigned to receiving a Wii console and two active VG or a Wii console and two inactive VG, and observe their use and activity over a six week period per game. Children in both conditions wear an accelerometer for a week at baseline, the first and sixth weeks after receiving the first VG, and the first and sixth weeks after receiving the second VG. A nice feature of the Wii is an internal record of when a Wii VG was played on that unit, thereby providing an objective measure of VG use.

Even more innovative ways are needed to use VG to promote behavior change. Vegetable (V) consumption has been associated with lower caloric intake (Rolls, Ello-Martins, & Tohill, 2004), lower fat intake (Gorbach et al., 1990; Stevens, Glasgow, Toobert, Karanja, & Smith, 2003; Subar, Ziegler, Patterson, Ursin, & Graubard, 1994; Ursin et al; 1993) and lower body mass index (BMI) (Crooks, 2000; Tohill, Seymour, Serdula, Kettel-Khan, & Rolls, 2004). V parenting practices have influenced children's intake (Fisher, Mitchell, Smiciklas-Wright, & Brich, 2002). Authoritative parenting practices in particular were associated with increased children's V intake (Patrick & Nicklas, 2005) and decreased obesity (Wardle & Carnell, 2006). Interventions to enhance authoritative V parenting practices should increase children's V intake and lower risk of overweight (Epstein et al., 2001). Authoritative V parenting can be thought of as a skill based performance, i.e. a parent has a set of skills (or does not) for effectively encouraging their child to eat vegetables and uses those skills during meals. "Training" with simulations of interactions and feedback on performance should enhance skill based performance (Salas & Cannon-Bowers, 2001). Simulation of parent-child feeding interactions with modeling of the parenting behavior and feedback on quality of performance (i.e. "training") should build V parenting skills and self

efficacy (Salas & Cannon-Bowers, 2001). VG simulating real world experiences have been sophisticated enough to train adults in learning to fly airplanes (Goettl & al., 1996; Gopher, Weil, & Bareket, 1994; Jentsch & Bowers, 1998). We are working on simulating the parent's experience in parent-child feeding interactions to train parents in effective V parenting skills.

Discussion

Intervention research in general needs strong tests of models of behavior, behavior change and of the efficacy and effectiveness of the touted behavior change procedures (Baranowski et al., 2009). VG interventions need this as well. From a research design perspective a VG is a perfect purveyor of behavior change research because once programmed, it provides a constant stimulus. That is, in contrast to program delivery by humans, VG just delivers what was programmed in exactly the same way every time. Thus, it is not affected by how the deliverer felt that morning, whether they were experiencing a need to control or humiliate others, or other human frailties. In this way the VG is a perfect instrument for designing behavior change experiments. Since behavior change procedures (e.g. goal setting) do not work in isolation from other knowledge and motivational components of an intervention, one behavior change procedure in a VG can be selected and systematically varied within an otherwise constant intervention. For example, Thompson and colleagues selected goal setting within the original Squire's Quest! game, which was demonstrated to increase 4th grade children's fruit and vegetable consumption, and have systematically varied goal intentions (yes/no) and implementation (yes/no) intentions. Thus within the context of an otherwise successful intervention, the game will test the separate and combined contributions of goal and implementation intention to behavior change. This is a very promising method for testing change procedures that should be used in other studies.

Little has been said about "fun". VG playing is fun, which serves as an intrinsic motivator. Why VG playing is fun is probably some combination of active involvement (interactivity), overcoming challenges, making choices and observing consequences without placing one's self at risk, immediate feedback, increasing difficulty through levels of game play (difficult but not impossible challenges), and personally relevant story and characters, in meaningful situations. Research is needed on why VG are fun and how to maximize this fun experience to maximize the effectiveness of VG for behavior change.

Conclusion

Games can be designed to use storylines, characters, and behavior change components, including modeling (e.g., engaging characters face and overcome challenges related to FV and PA goal attainment and/or consumption), skill development (e.g., asking behaviors), self regulatory behaviors (problem solving, goal setting, goal review, decision making), rewards (e.g., points and positive statements generated by the program), immediate feedback (e.g., through characters and/or statements that appear on the computer screen at critical decision points), and personalization (e.g., tailored choices offered at critical junctures, based on responses to baselines questions related to preferences, outcome expectancies, etc). We are

in the earliest stages of learning how to optimally do this in VG. As we learn, VG offer more and better opportunities for obesity prevention.

Acknowledgments

References

Allen K, Ingulsrud J. Manga literacy: popular culture and the reading habits of Japanese college students. Journal of Adolescent and Adult Literacy. 2003; 46:674.

Bandura, A. Social Foundations for Thought and Action: A Social Cognitive Theory. Englewood Cliffs, NJ: Prentice Hall; 1986.

Bandura A, Schunk DH. Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation. Journal of Personality and Social Psychology. 1981; 41:586–598.

Bandura A, Simon K. The role of proximal intentions in self-regulation of refractory behavior. Cognitive Therapy Research. 1977; 1:177–193.

Baranowski T, Anderson C, Carmack C. Mediating variable framework in physical activity interventions. How are we doing? How might we do better? American Journal of Preventive Medicine. 1998; 15(4):266–297. [PubMed: 9838973]

Baranowski T, Baranowski J, Cullen KW, Marsh T, Islam N, Zakeri I, et al. Squire's quest! Dietary outcome evaluation of a multimedia game. American Journal of Preventive Medicine. 2003; 24(1): 52–61. [PubMed: 12554024]

Baranowski T, Baranowski J, Cullen KW, Thompson DI, Nicklas T, Zakeri I, et al. The Fun, Food and Fitness Project (FFFP): The Baylor GEMS pilot study. Ethnicity and Disease. 2003; 13(suppl 1): 1-30–39.

Baranowski T, Baranowski J, Thompson D, Buday R, Jago R, Abdelsamad D, et al. Video game play induced health behavior change among children. American Journal of Preventive Medicine, submitted. 2010

Baranowski T, Buday R, Thompson DI, Baranowski J. Playing for real: video games and stories for health-related behavior change. American Journal of Preventive Medicine. 2008; 34(1):74–82. [PubMed: 18083454]

Baranowski T, Cerin E, Baranowski J. Steps in the design, development and formative evaluation of obesity prevention-related behavior change trials. International Journal of Behavioral Nutrition and Physical Activity. 2009; 6:6. [PubMed: 19159476]

Baranowski T, Cooper DM, Harrell J, Hirst K, Kaufman FR, Goran M, et al. The STOPP-T2D Prevention Study Group. Presence of diabetes risk factors in a large U.S. eighth-grade cohort. Diabetes Care. 2006; 29(2):212–217. [PubMed: 16443862]

Baranowski T, Davis Hearn M, Resnicow K, Baranowski J, Doyle C, Smith M, et al. Gimme 5 fruit, juice and vegetables for fun and health: Outcome evaluation. Health Education & Behavior. 2000; 27:96–111. [PubMed: 10709795]

Baranowski T, Henske J, Simons-Morton B, Palmer J, Hooks P, Tiernan K, et al. Dietary change for CVD prevention among Black-American families. Health Education Research. 1990; 5(4):433–443.

Baranowski T, Lin L, Wetter D, Resnicow K, Hearn M. Theory as mediating variables: why aren't community interventions working as desired? Annals of Epidemiology. 1997; 7:89–95.

Baranowski, T.; Perry, CL.; Parcel, G. How individuals, environments, and health behaviors interact: Social Cognitive Theory. In: Glanz, K.; Lewis, FM.; Rimer, B., editors. Health Behavior and

Health Education: Theory, Research and Practice. 3. San Francisco: Jossey-Bass; 2002. p. 246-279.

Baranowski T, Smith M, Hearn M, Lin L, Baranowski J, Doyle C, et al. Patterns in children's fruit and vegetable consumption by meal and day of the week. Journal of the American College of Nutrition. 1997; 16:216–223. [PubMed: 9176827]

Bargh J, Gollwitzer P, Lee-Chai A, Barndollar K, Trotschel R. The automated will: nonconscious activitation and pursuit of behavioral goals. Journal of Personality and Social Psychology. 2001; 81:1014–1027. [PubMed: 11761304]

Barnett A, Baranowski T, Cerin E. Active videogames: An opportunity for increasing physical activity in youth. Journal of Physical Activity & Health. 2010 in press.

Bauman AE, Sallis JF, Dzewaltowski DA, Owen N. Toward a better understanding of the influences on physical activity: the role of determinants, correlates, causal variables, mediators, moderators, and confounders. American Journal of Preventive Medicine. 2002; 23(2):5–14. [PubMed: 12133733]

Brandstatter V, Lengfelder A, Gollwitzer PM. Implementation intentions and efficient action initiation. Journal of Personality and Social Psychology. 2001; 81(5):946–960. [PubMed: 11708569]

Cerin E, Barnett A, Baranowski T. Testing theories of dietary behavior change in young using the mediating variable model with intervention programs. Journal of Nutrition Education and Behavior. 2009; 41(5):309–318. [PubMed: 19717113]

Coates T, Jeffery R, Slinkard L. Heart healthy eating and exercise: introducing and maintaining changes in health behaviors. American Journal of Public Health. 1981; 71:15–23. [PubMed: 7258426]

Contento I, Balch GI, Bronner YL, Lytle L, Maloney SK, Olson CM, et al. The effectiveness of nutrition education and implications for nutrition education policy, programs, and research: A review of research. Journal of Nutrition and Education. 1995; 27:277–418.

Crooks D. Food consumption, activity, and overweight among elementary school children in an Appalachian Kentucky community. American Journal of Physical Anthropology. 2000; 112:159–170. [PubMed: 10813699]

Cullen K, Baranowski T, Smith S. Using goal setting as a strategy for dietary behavior change. Journal of the American Dietetic Association. 2001; 10:562–566. [PubMed: 11374350]

Cullen K, Bartholomew K, Parcel G. Girl Scouting: An effective channel for nutrition education. Journal of Nutrition Education. 1997; 29:86–91.

Cullen KW, Watson K, Baranowski T, Baranowski JH, Zakeri I. Squire's Quest: intervention changes occurred at lunch and snack meals. Appetite. 2005; 45(2):148–151. [PubMed: 15927302]

Cullen KW, Watson KB, Zakeri I, Baranowski T, Baranowski JH. Achieving fruit, juice, and vegetable recipe preparation goals influences consumption by 4th grade students. International Journal of Behavioral Nutrition and Physical Activity. 2007; 4:28. [PubMed: 17603875]

Cullen K, Zakeri I, Pryor E, Baranowski T, Baranowski J, Watson K. Goal setting is differentially related to change in fruit & vegetable consumption among 4th grade children. Health Education Research. 2004; 38:258–269.

Dennis EA, Flack KD, Davy BM. Beverage consumption and adult weight management: A review. Eating Behaviors. 2009; 10(4):237–246. [PubMed: 19778754]

Domel S, Baranowski T, Davis H, Thompson W, Leonard S, Riley P, et al. Development and evaluation of a school intervention to increase fruit and vegetable consumption among 4th and 5th grade students. Journal of Nutrition Education. 1993; 25:345–349.

Epstein L, Gordy CC, Raynor HA, Beddome M, Kilanowski CK, Paluch R. Increasing fruit and vegetable intake and decreasing fat and sugar intake in families at risk for childhood obesity. Obesity Research. 2001; 9:171–178. [PubMed: 11323442]

Evans J, Collier J, Crook I, Garrud P, Harris P, MacKinlay D, et al. Using multimedia for patient information - a program about nocturnal enuresis. British Journal of Urology. 1998; 81(Suppl 3): 120–122. [PubMed: 9634036]

Fagot-Campagna A, Pettitt DJ, Engelgau MM, Burrows NR, Geiss LS, Valdez R, et al. Type 2 diabetes among North American children and adolescents: an epidemiologic review and a public health perspective. Journal of Pediatrics. 2000; 136(5):664–672. [PubMed: 10802501]

Fisher JO, Mitchell DC, Smiciklas-Wright H, Brich LL. Parental influences on young girls' friut and vegetable, micronutrient and fat intakes. Journal of the American Dietetic Association. 2002; 102:58–64. [PubMed: 11794503]

Goettl B, et al. Alternating task modules is isoderonal distributed training of complex tasks. Human Factors. 1996; 38:330–346.

Gollwitzer P. Implementation intentions: Strong effects of simple plans. American Psychology. 1999; 54:493–503.

Gopher D, Weil M, Bareket T. Transfer of skill from a computer game trainer to flight. Human Factors. 1994; 36:387–405.

Gorbach SL, Morrill-LaBrode A, Woods MN, Dwyer JT, Seller WD, Henderson M, et al. Changes in food patterns during a low-fat dietary intervention in women. Journal of the American Dietetic Association. 1990; 90:802–809. [PubMed: 2345252]

Green, M.; Brock, T. In the mind's eye: Transportation-imagery model of narrative persuasion. In: Green, JJSMC.; Brock, TC., editors. Narrative impact: Social and cognitive foundations. Mahwah, NJ: Erlbaum; 2002. p. 315-341.

Green MC, Brock TC. The role of transportation in the persuasiveness of public narratives. Journal of Personality and Social Psychology. 2000; 79(5):701–721. [PubMed: 11079236]

Higgins E. Beyond pleasure and pain. American Psychologist. 1997; 52:1280–1300. [PubMed: 9414606]

Howison D, Neidermyer F, Shortridge R. Field testing a fifth-grade nutrition education program designed to change food-selection behavior. Journal of Nutrition Education. 1988; 20:82–86.

Jago R, Baranowski T, Baranowski J, Thompson D, Cullen K, Watson K, et al. Fit For Life Boy Scout Badge: Outcome evaluation of a troop & internet intervention. Preventive Medicine. 2006; 42(3): 181–187. [PubMed: 16458955]

Jentsch F, Bowers C. Evidence for the falidity of PC-based simulations in studying aire crew coordination. International Journal of Available Psychology. 1998; 8:243–260.

Kastorini CM, Panagiotakos DB. Dietary Patterns and Prevention of Type 2 Diabetes: From Research to Clinical Practice; A Systematic Review. Current Diabetes Review. 2009; 5(4):221–227.

Killen J, Robinson T, Telch M, Saylor K, Maron D, Rich T, et al. The Stanford Adolescent Heart Health Program. Health Education Quarterly. 1989; 16:263–283. [PubMed: 2732068]

Kreuter, M., et al. Tailoring Health Messages: Customizing Communication With Computer Technology. Mahway, NJ: Lawrence Erlbaum Associates; 2000.

Locke E, Shaw K, Saari L, Latham G. Goal setting and task performance: 1969-1980. Psychological Bulletin. 1981; 90:125–152.

Locke, E.; Latham, G. Goal setting theory. In: O'Neil, H.; Drillings, M., editors. Motivation: Theory and Research. Hillsdale, NJ: Lawrence Erlbaum Associates Publishers; 1994.

Ma F, Contento I. Development and formative evaluation of a nutrition education curriculum aimed at reducing fat intake in Taiwan elementary students. Journal of Nutrition Education. 1997; 29:237–243.

Maibach, E.; Cotton, D. Chapter 3: Moving People to Behavior Change: A Staged Social Cognitive Approach to Message Design. In: Maibach, E.; P, R., editors. Designing Health Messages: Approaches From Communication Theory and Public Health Practice. Thousand Oaks, CA: Sage Publications; 1995. p. 41-64.

Michie S, Prestwich A. Are interventions theory-based? Development of a theory coding scheme. Health Psychology. 2009; 29(1):1–8. [PubMed: 20063930]

Nader P, Sallis J, Patterson T. A family approach to cardiovascular risk reduction: results from the San Diego Family Health Project. Health Education Quarterly. 1989; 16:229–244. [PubMed: 2732065]

Ogden C, Carroll M, Curtin L, McDowell M, Tabak C, Flegal K. Prevalence of overweight in the United States, 1999-2004. Journal of American Medical Association. 2006; 295(13):1549–1555.

Paivio A. Dual Coding Theory: retrospect and current status. Canadian Journal of Psychology. 1991; 45(3):255–287.

Parcel G, Simons-Morton B, O'Hara N, Baranowski T, Wilson B. School promotion of healthful diet and physical activity: impact on learning outcomes and self-reported behavior. Health Education Quarterly. 1989; 16(2):181–199. [PubMed: 2732062]

Patrick H, Nicklas TA. A review of family and social determinants of children's eating patterns and diet quality. Journal of American College Nutrition. 2005; 24(2):83–92.

Peng W. Design and evaluation of a computer game to promote a healthy diet for young adults. Health Communication. 2009; 24(2):115–127. [PubMed: 19280455]

Perry C, Mullis R, Maile M. Modifying the eating behavior of children. Journal of School Health. 1985; 10:399–402. [PubMed: 3853032]

Perry C, Stone E, Parcel G. School-based cardiovascular health promotion: the child and adolescent trial for cardiovascular health (CATCH). Journal of School Health. 1990; 60:406–413. [PubMed: 2255198]

Perry A, Tremblay L, Signorile J, Kaplan T, Miller P. Fitness, diet, and coronary risk factors in a sample of southeastern US children. Applied Human Science. 1997; 16:133–141. [PubMed: 9343861]

Petty, RE.; Cacioppo, JT. Communication and persuasion: Central and peripheral routes to attitude change. New York, Inc: Springer-Vergal; 1986. p. 34

Resnicow K, Davis RE, Zhang G, Konkel J, Strecher VJ, Shaikh AR, et al. Tailoring a fruit and vegetable intervention on novel motivational constructs: results of a randomized study. Annals of Behavioral Medicine. 2008; 35(2):159–169. [PubMed: 18401673]

Rolls BJ, Drewnowski A, Ledikwe JH. Changing the energy density of the diet as a strategy for weight management. Journal of American Dietetic Association. 2005; 105(Suppl 1):98–103.

Rolls B, Ello-Martins J, Tohill B. What can intervention studies tell us about the relationship between fruit and vegetable consumption and weight management? Nutrition Reviews. 2004; 62:1–17. [PubMed: 14995052]

Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American Psychology. 2000; 55:68–78.

Salas E, Cannon-Bowers JA. The science of training: a decade of progress. Annual Review Psychology. 2001; 52:471–499.

Serdula MK, Ivery D, Coates RJ, Freedman DS, Williamson DF, Byers T. Do obese children become obese adults? a review of the literature. Preventive Medicine. 1993; 22:167–177. [PubMed: 8483856]

Simons-Morton B, Coates T, Saylor K. Great sensations: a program to encourage heart healthy snacking by high school students. Journal of School Health. 1984; 54:288–291. [PubMed: 6567715]

Stevens VJ, Glasgow RE, Toobert DJ, Karanja N, Smith KS. One-year results from a brief, computer-assisted intervention to decrease consumption of fat and increase consumption of fruits and vegetables. Prev Med. 2003; 36(5):594–600. [PubMed: 12689805]

Subar AF, Ziegler RG, Patterson BH, Ursin G, Graubard B. US dietary patterns associated with fat intake: The 1987 National Health Interview Survey. American Journal of Public Health. 1994; 84:359–366. [PubMed: 8129050]

Terborg J. The motivational components of goal-setting. Journal of Applied Psychology. 1976; 61:613–621.

Thompson D, Baranowski T, Baranowski J, Cullen K, Jago R, Watson K, et al. Boy Scout 5-a-Day Badge: outcome results of a troop and Internet intervention. Preventive Medicine. 2009; 49(6):518–526. [PubMed: 19765608]

Thompson D, Baranowski T, Buday R, Baranowski J, Thompson V, Jago R, et al. Serious Video Games for Health: How Behavioral Science Guided the Development of a Serious Video Game. Simulation & Gaming. 2010 in press.

Thompson D, Baranowski J, Cullen K, Baranowski T. Development of a theory-based internet program promoting maintenance of diet and physical activity change to 8 year old African American girls. Computers & Education. 2007; 48(3):446–459.

Thompson D, Baranowski T, Cullen K, Watson K, Canada A, Bhatt R, et al. Food, Fun and Fitness Internet program for girls: influencing log-on rate. Health Education Research. 2008; 23(2):228–237. [PubMed: 17595175]

Thompson D, Baranowski T, Cullen K, Watson K, Liu Y, Canada A, et al. Food, fun, and fitness internet program for girls: pilot evaluation of an e-Health youth obesity prevention program examining predictors of obesity. Preventive Medicine. 2008; 47(5):494–497. [PubMed: 18718846]

Thompson D, Canada A, Bhatt R, Davis J, Plesko L, Baranowski T, et al. eHealth recruitment challenges. Evaluate Program Planning. 2006; 29(4):433–440.

Thompson, V.; Thompson, D.; Baranowski, T.; Creighton, D.; Cullen, K.; Baranowski, J., et al. Internet Access and the Digital Divide. Nova Publishers; 2010. Understanding "serious video game" storyline and genre preferences related to game immersion among low-income ethnically diverse urban and rural adolescents. in press

Tohill B, Seymour J, Serdula M, Kettel-Khan L, Rolls B. What epidemiologic studies tell us about the relationship between fruit and vegetable consumption and body weight. Nutrition Reviews. 2004; 64:365–374. [PubMed: 15508906]

Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. Medical Science & Sports Exercise. 2008; 40(1):181–188.

Ursin G, Ziegler RG, Subar AF, Graubard BI, Haile RW, Hoover R. Dietary patterns associated with a low-fat diet in the National Health Examination Follow-up Study: Identification of potential confounders in epidemiologic analyses. American Journal of Epidemiology. 1993; 137:916–927. [PubMed: 8484383]

Walter H, Wynder E. The development, implementation, evaluation, and future directions of a chronic disease prevention program for children: The "Know Your Body" studies. Preventive Medicine. 1989; 18:59–71. [PubMed: 2710763]

Wardle J, Carnell S. Parental feeding practices and child weight. Acta Paediatricia. 2006; 96:5–11.

Webb TL, Joseph J, Yardley L, Michie S. Using the internet to promote health behavior change: a systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy. Journal of Medical Internet Research. 2010; 12(1):e4. [PubMed: 20164043]

White A, Skinner J. Can goal setting as a component of nutrition education effect behavior change among adolescents? Journal of Nutrition Education. 1988; 20:327–335.
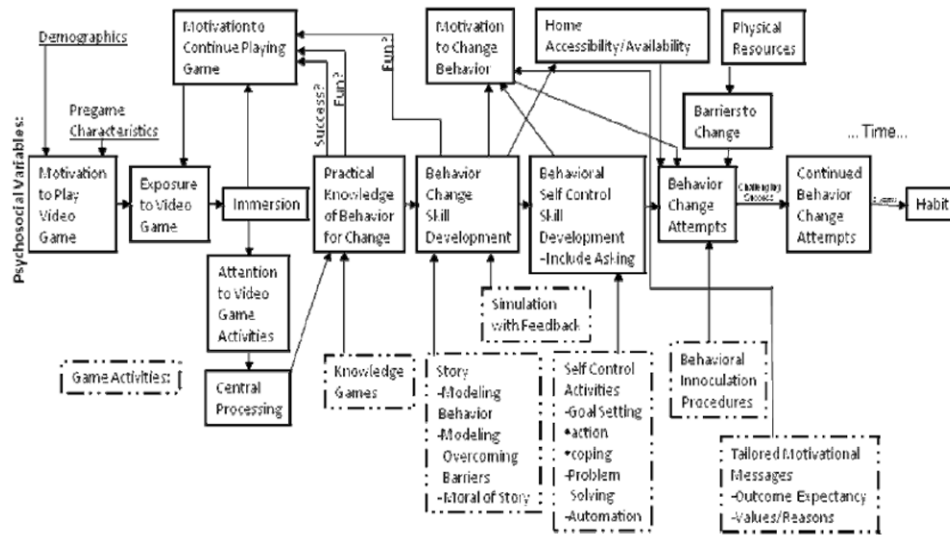
Figure 1.
Process Model of Possible Mechanisms for Children's Dietary and Physical Activity Change in Video Games