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Playing for Real: Video Games and Stories for Health-Related Behavior Change

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Abstract

Background—Video games provide extensive player involvement for large numbers of children and adults, and thereby provide a channel for delivering health behavior change experiences and messages in an engaging and entertaining format.

Method—Twenty-seven articles were identified on 25 video games that promoted health-related behavior change through December 2006.

Results—Most of the articles demonstrated positive health-related changes from playing the video games. Variability in what was reported about the games and measures employed precluded systematically relating characteristics of the games to outcomes. Many of these games merged the immersive, attention-maintaining properties of stories and fantasy, the engaging properties of interactivity, and behavior-change technology (e.g., tailored messages, goal setting). Stories in video games allow for modeling, vicarious identifying experiences, and learning a story's "moral," among other change possibilities.

Conclusions—Research is needed on the optimal use of game-based stories, fantasy, interactivity, and behavior change technology in promoting health-related behavior change.

Background

Usual school health curricular and other behavior-change interventions targeted at children have had limited effectiveness.[1,2] New channels are needed to reach children that offer promise of promoting substantial health-related behavior changes. One such new channel is the video game, since many children spend numerous hours playing them.[3] Using video games to promote behavior change could capitalize on the children's pre-existing attention to and enjoyment of them. No review has appeared of health-related behavior-change video games. A common component of games is "story."[4] For those not familiar with games and stories, a simple glossary of terms appears in Table 1. This paper emphasizes the use of theory to enhance the possibilities for behavior change in the design and creation of stories and video games. The focus is on behavior change, because creating knowledge structures, while laudable in educational venues, is not sufficient to induce behavior change.[5]

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What is a game? Children and adults have played games since prior to written history,[6] suggesting that playing games meets enduring psychological needs.[7] A game is a physical or mental contest with a goal or objective, played according to a framework, or rules, that determines what a player can and cannot do inside a game world.[8] A video game is any game played on a digital device and encompasses a wide range of games played at arcades, over the Internet on personal computers, or on dedicated game consoles (e.g., Nintendo GameCube, Sony PlayStation, or Microsoft Xbox) or handheld units (e.g., Nintendo Game Boy, Sony PSP).

Games are played primarily for entertainment or "fun,"[9] but what constitutes "fun" is not well understood. Typical measures of enjoyment (or fun) have used synonyms of fun (e.g., enjoy, like, interested, pleasurable, energizing),[10] which do not elucidate the concept. In one study, statements of what constituted fun while being physically active (e.g., playing with friends, talking with friends, doing something daring, being really good at something) did not lead to separate factors in a principal components analysis (R. Jago, personal communication). In another study, six factors of fun in action video games included: novelty and powerfulness, appealing presentation, interactivity, challenging, sense of control, and rewarding.[11] Other aspects of a game that children likely find enjoyable are fantasy (e.g., imaginary characters, virtual worlds)[12] and interactivity.[13] Games satisfy the player's needs for autonomy, connectedness, and control.[7] To win the game, video games challenge players to use the information they obtain as they navigate the game world,[14,15] thereby providing an important education and training modality.[16] This has given rise to the emerging genre of "serious video games" that employ the medium's rich, role-playing, story-based environments to teach, train, and change knowledge, attitudes, and behavior.[17]

Prevalence of Video Game Use

Today's children and young adults are extensive users of digital devices,[3] and video games are a big part of their digital experience. In 2004, the average video game player was aged 30 years and had played computer games for almost 10 years.[18] The average child aged 8–10 years spent 65 minutes per day playing video games; 52 minutes/day among youth aged 10–14 years and 33 minutes/day among teenagers aged 15–18 years.[3] Thus, video games reach a large and diverse audience who expect extended contact, suggesting games can attract and maintain attention, a key component for effective behavior change.[19]

Games and Behavior Change

Theory provides the foundation for promoting behavior change.[7] A comprehensive model of learning for behavior change in video games is based on social cognitive theory (SCT) and the elaboration likelihood model,[20,21] and includes the following steps: attention, retention, production, and motivation. The elaboration likelihood model proposes that gaining and maintaining a person's attention is the first step in getting a person to process the information in a message to promote behavior change.[21] SCT proposes that behavior change is a function of enhanced skills and confidence (self-efficacy) in doing the new behavior,[19] while modeling[19] and feedback[22] are keystones for learning skills. Self-control procedures such as goal setting mobilize a person's personal resources and focus attention on making specific changes.[23] Games add an element of fun, an aspect of intrinsic motivation, thereby enhancing behavior change through enhanced motivation.[7] Use of electronic or video games for health-related behavior change is in the earliest stages of development, but incorporating theory-based change procedures provides reason to believe that they can be effective.

Methods

A search was conducted for publications on video games for health-related behavior change by searching the authors' personal files, contacting colleagues at professional meetings, and

searching the following terms in PubMed: games, video games, and interactive multimedia, as well as combinations of these terms. Inclusionary criteria included using the word game to describe their software, with the goal of attempting to modify lifestyle behavior change. Exclusionary criteria were interactive multimedia programs that were not games, or that were games but did not target lifestyle behavior change. Games that were not video games[24] were excluded. Twenty-seven articles about 25 different such video games were found and met inclusionary criteria through December 2006. These games addressed diet alone, physical activity alone, physical activity alone among the physically challenged, diet and physical activity combined, or other health-related behavior changes, as shown in Tables 2–6, respectively. Two authors abstracted all articles, and information in tables reflects consensus.

Results

There was substantial variability across studies in their design, the targets for change, and the characteristics (and reporting of characteristics) of the games. The two-group (treatment versus control) randomized clinical trial (RCT) was the most common outcome evaluation design, but several were single-group-only. Four of the physical-activity video game studies tested primarily whether the game offered the possibility of enhancing fitness,[24–29] with only two assessing whether the game changed behavior.[30,31] Several had ample samples for the evaluation,[32,34,35] while others were small pilot studies.[33] The primary outcome measure varied from knowledge[32,36]; to psychosocial variables[36]; to behaviors[33]; to anthropometric,[30] physiologic,[37] or health-outcome[38] variables. Many of the reports provided little data on the game's characteristics. Lack of comparability across game descriptions and outcomes precluded a meta-analysis or any systematic comparison relating games to outcomes. Most reported some positive outcomes, with only one reporting no evidence of change.[37]

All of the diet-alone change games employed (n=3) a story of some kind, but it was difficult to discern characteristics of the story in one report.[32] While one game was predicated on an operant form of learning theory,[32] two were predicated on social cognitive theories.[20,34] All the diet-alone change games resulted in some type of dietary change.

Few of the physical-activity-alone promoting games employed story, emphasizing, instead, simply being physically active.[25,26,29,30] The decline in their use over time and the perception of their being boring within just 4 weeks of use[30] might be attributed to their lack of story. The two physical-activity-alone games that used story[39,40] used it in different ways, and targeted very different age groups. Three of the studies of the physical-activity-alone games assessed only the extent to which a single session attained a fitness-enhancing level of physical activity[25,26,29] with all raising concerns about the modest intensity of physical activity that was elicited. The fourth study[30] suggested that the duration of participation further limited what body composition outcomes could be expected from these games. One of the physical-activity-alone games obtained a decline in BMI among girls, but not boys,[39] while the other conducted with boys alone attained no BMI change.[40] The game that changed BMI paradoxically attained a small decline in moderate-intensity activity in boys and girls,[39] while the other attained a moderate increase in light physical activity, but no change in BMI,[41] and all objectively measured physical activity by accelerometry.

Four studies by one group provided innovative user interfaces (wheels or arm ergometry) to enable wheelchair users to be physically active and in doing that control action in a video game (see Table 4).[27,28,31,40] In each case, the interface enabled the participant to be active at a fitness-enhancing level in a one-time trial with the expectation that being able to play the video game would motivate physical activity at an acceptable level of intensity outside the laboratory. One study demonstrated that seven of eight spina bifida patients were sufficiently motivated to attain a fitness effect after 16 weeks of use of the armergometer interface.[31]

Four games proposed to change diet and physical activity (see Table 5). Three were developed by one group[1,20,41–43] and used story as an organizing framework with minigames inserted to deliver behavior change and self-regulation-related activities. The behavioral theory underpinning the first game, "Fun, Food and Fitness," has been presented,[20] and pilot study results have demonstrated some diet and physical activity change.[33] A second pilot study tested as a stand-alone electronic-health program resulted in both diet and physical activity change.[43] Preliminary 1-week outcomes of MetaKenkoh[33] demonstrated some diet and physical activity change. Two games benefited from alpha testing,[42] which enhanced several aspects of their functioning, but outcomes have not been published.

Three of the other health-related behavior-change games addressed behavioral issues in asthma. One demonstrated substantial changes resulting in fewer hospitalizations[38]; another demonstrated increased knowledge and more internal control, but no lung function improvements[44]; the third reported no demonstrable changes.[37] It is not clear from the publications what differences across the games, or the samples, might have accounted for the different outcomes. Five other games addressed diabetes-related behavior.[36,45] One of these games demonstrated substantial changes resulting in lower emergency room and urgent medical care use.[45] The other games were very limited in focus (e.g., trying to enable children to understand the need and value to balance food intake with insulin administration to control circulating glucose levels),[36] and demonstrated psychosocial changes at 3-months followup.[36] An action–adventure game with the child shooting cancer-causing agents in the bloodstream targeted medication adherence among pediatric cancer patients[46] and reported substantial psychosocial and regimen compliance change at 3 months after playing the game.[46]

Discussion

Playing most of these behavior-change video games led to a broad spectrum of desirable outcomes from knowledge increases,[32] to attitude changes,[36] behavior changes,[34] and other health-related[38] changes. This bodes well for the future use of video games to promote health-related behavior changes and warrants an intensive analysis of aspects of video games that offer the most promise of promoting behavior change. There appear to be two primary methods by which video games can influence behavior. The first involves the insertion of behavior-change procedures (e.g., goal setting) into the process of playing the game. The second involves the use of story and inserting behavior-change concepts in the story.

Theory-Based Procedures in Behavior-Change Games

Computers have been used to promote behavior change for some time[47]; however, most computerized behavior-change programs are not video games. SCT was the most commonly cited theory providing a foundation for behavior change.[19] Some reported using a full range of behavior-change procedures,[20] while others enhanced only knowledge.[36] As an example, the SQ! game integrated SCT-specified behavior technology procedures (i.e., goal setting, decision making, goal review, social reward) into game play.[34] SQ! goals included changing known environmental, personal, and behavioral factors regarding why children were not eating particular fruits and vegetables. The goals were tailored to whether these factors pertained to each child specifically: SQ! attempted to increase preferences for targeted fruits and vegetables and used self-regulation procedures, e.g., goal review and problem solving, when goals were not attained. Setting and attaining goals enhanced the fruit and vegetable intake among various student subgroups[48] and overall the video game achieved a 0.9 serving per day increase in fourth-grade children's fruit and vegetable consumption.[34] How diverse behavior-change procedures can be inserted in video games has been addressed elsewhere.[20]

Importance of a Story

A story is a narrative of a series of events.[4] Stories take place at a particular time (e.g., the winter of 1776, the week after college graduation); at a particular place (in a boat crossing the Delaware, on the bridge of a starship); and have characters. Ordinarily, one character, called the protagonist, takes the lead in the story. Protagonists can have external or internal conflicts. When protagonists oppose someone else, that character is the antagonist. The struggle between these two is the conflict, which is the motivating factor behind the story's action and plot.[4] Stories usually engage individuals by means of their empathy with the protagonist[4] and are effective when the protagonist shows change in values in the story (e.g., cowardice to courage, betrayal to loyalty), exemplifying a lesson that can be learned (also called the story's controlling idea[4] or moral, e.g., eating fruits and vegetables and being physically active to provide strength and stamina to escape from oppressive situations). These changes in values are engineered by the writer in terms of events that pose conflict for the protagonist. The conflicts can be the commonly reported barriers to making behavior change, and the protagonist's ways of overcoming the barriers can be the modeling of effective problem solving.

This very abbreviated exposition suggests that behavior change can be enhanced when stories address behavior-change issues, and the lesson to be taken from the story promotes health behavior changes. While stories have been used for health-related behavior changes (soap operas),[49] the exposition of how this has been done, especially using story structure to promote behavior change, has not been addressed. An example of such a story was Squire's Quest! (SQ!) a 10-session video game.[34] The story's controlling idea was that eating more fruits and vegetables gives strength to resist dangerous characters. SQ! used a variation of a common medieval story involving a king, queen, knights, invaders, and a struggle. Invaders were destroying a kingdom by destroying its fruits and vegetables, the source of energy. The king didn't have enough knights to fight off the invaders, so each player was asked to become a squire, a person in training to become a knight. As per medieval lore, squires must face and overcome challenges to become knights. The challenges in this game just happened to require that the squires eat more fruits and vegetables, resulting in an increase of 0.9 serving/day in fruit and vegetable intake. Thus, SQ! used a story to engage the students, maintain their interest and model the desired behaviors by key characters.

Stories have been told by every culture throughout human history,[50] thereby also suggesting that they meet some enduring psychological need. Different cultures have evolved somewhat different ways of conveying stories, although many elements are common to all.[51] The dominant format used in most Western society books, films, and video games is a three-act structure, a pattern Western audiences have come to expect: Act 1—exposition and the beginning of the conflict; Act 2—complications and climax; and Act 3—resolution and conclusion (denouement). Stories that do not adhere to these conventional storytelling rules risk alienating Western audiences. Why certain stories appeal to certain audiences is not clearly known.[41]

Story Genre

Patterns of story telling have evolved into story genre,[52] e.g., western, murder-mystery, and comedy. Melodrama was originally developed for the stage to focus on plot and action and reduce story complexity.[52] Most melodrama issues are reduced to struggles between good and evil, which appeal more to viewers' emotions than cognitions,[52] thereby presenting a potentially promising tool for behavioral intervention in serious games. Behavioral theory on the role of emotions in health-behavior change[53] will need to advance rapidly to capitalize on these possibilities.

Serials are a single narrative developed through a number of individual, linear episodes. Each serial episode forms a separate unit of a larger story. Serial melodramas often end with a cliffhanger, unresolved tensions in a storyline designed to motivate viewers' return to the next episode. Research on the Zeigarnik effect[54] presages an understanding of the role of cliffhangers in story and game design, but more research on this point is necessary in advancing their use and effectiveness in behavior change video games.

Episodic stories are also short, complete narratives. Instead of linearly building to a conclusion, they loosely arc and intertwine substories, related by the same characters and settings. Soap operas are episodic, melodramatic stories involving a group of individuals. Each character has his or her own story, which link in unpredictable ways from episode to episode. Episodic stories may function primarily to maintain attention. In serious video games, interrelated components among the differing stories could be used to reinforce behavioral-change messages in diverse situations. For example, each component story could deal with different barriers to eating more fruits and vegetables (e.g., distaste, home availability, skills to prepare more, and tastier dishes).

Game Immersion

Video games can encompass and capture a player's full attention, as if the player were actually part of the game environment. This has been called immersion, or presence.[7] Video game environments were confined initially to flight simulators and research laboratories[55]; realistic or otherwise complex virtual three-dimensional environments are now common in many video games. Game players become involved literally and emotionally in the story. While skilled game developers effectively create such immersive experiences regularly, the behavioral science of how this is achieved, or optimized, is not known. Immersion is believed to be a component of intrinsic motivation.[7]

Interactivity

Nine dimensions of interactivity in a website (i.e., accessibility, navigation, time, personalized content, delivery of message, data entry and use, entertainment, promotions, relationship) and 52 underlying variables have been delineated.[56] Subsets of these appear relevant to interactivity in a video game. Directly participating in story situations and taking first-person control of events are key aspects of interactivity in video games.[13] Just as in real life, players learn through planning, decision making, and personally witnessing cause-and-effect relationships. Role playing likely increases a player's personal stake in a video game's outcome. In part, role-playing performances combine the emotion of storytelling with the power of character immersion. The video game designer can structure the interactive options to provide meaningful feedback for player-made choices. The feedback can be in the form of reinforcement (e.g., statements of positive regard), information to make next choices, or experiential learning sequences (e.g., interactions with animated characters that provide theoretically specified experiences).

Fantasy

Fantasy, defined as the active use of imagination,[57] has facilitated active engagement among youth,[58] and is a primary source of intrinsic motivation.[34, 57–59] Both youth and adults engage in fantasy, although the content of the fantasies vary in that they tend to reflect personal interests and concerns.[57] For example, adolescent fantasies tend to include themes such as appeal to opposite gender, future vocation, sports, and achievement.[57] Fantasy has been reported to peak between late adolescence and early adulthood.[57] A review of text-based nutrition education materials found that fantasy was included in 16 of 30 of the materials reviewed.[60] The materials that included fantasy were described as more creative and fun than those not including fantasy, and they were more likely to use characters and scenarios to foster engagement.[60]

Fantasy contexts have also been used in video games.[58,59] Video games excel at "what if" scenarios, i.e., the ability to personally inhabit an improbable world, wander around on one's own, and interact with fantastic characters or events. Fiction and action–adventure stories may be better suited to video games' rich, immersive, fantasy role-playing environments than nonfiction genres. In a study of 7th- and 8th-grade children, focus groups to select video game storylines revealed that child participants preferred action–adventure over other genres (V. Thompson, personal communication). In another study with 3rd- and 4th-grade students, embedding educational information in fantasy contexts was found to result in significantly more learning and knowledge transfer than nonfantasy contexts.[58] The effect was not mediated by choice, i.e., choosing the fantasy context was no more effective than having the fantasy context assigned. The fantasy context used in the study was created by embedding educational information in simple stories that required a child to solve problems.[58] A video game program promoting asthma self-management to children aged 9–13 years[59] included elements of fantasy. The video game had motivational appeal, and children who used the game had gains in knowledge, self efficacy, and attributions leading to self-management. SQ! also used a fantasy-based game format to effectively promote fruit and vegetable consumption to 4th graders.[34]

Video Game Design and Structure

Video game cinematics (sometimes called cut scenes) advance a game's storyline, but are relatively short movie clips that are watched passively by players intermittently throughout the game. Unlike traditional passive-only media, video games depend on the player's action to move the story forward (via branching logic based on player selections). There is more than one ending in a video game (at a minimum, there are two: winning and losing), and sometimes multiple ways of getting to an ending. Players' actions, often called game mechanics, are the way that players navigate story environments, interact with story events, and chose story paths. The mechanics of game play need to be inventoried and their role in involvement and individualizing messages more clearly understood to be able to create successful behavior-change video games.

Age and Game Play

The kinds of games appealing to young children should be quite different from those appealing to adolescents or young adults, because of substantial differences in cognitive or emotional development throughout this age range. Research, however, has not as yet led to development of a theory of developmentally appropriate games. Thus, development of an age-appropriate intervention requires substantial formative research (e.g., focus group discussions, intensive interviews, observations) with the targeted demographic group on story and character concept, story arc, personality and visual representation, and alpha testing on fun and functionality of the interactive components. No health-related behavior-change games were found with stories for adults. While in theory, games with stories should be able to be designed for this demographic, little guidance was found in the published literature.

Health Behavior Change Game Development

To capitalize on the possibilities of video games for promoting health behavior changes, behavioral scientists need to collaborate with professionals who can write an engaging story and have knowledge and skills in game design, formative research, story boarding, producing, directing, music composition (for games with music scores), computer art, animation, and programming. In larger projects, each of these skills is offered by different professionals, whereas in smaller projects, one person may play several or even all roles. For a health behavior-change video game, additional expertise is required in regard to content expertise about the health problem and/or the health behavior(s) of concern, and behavior-change

intervention design (theory and procedures). Initially there would be a vast divide in the understanding and even the languages used by these differing sets of professionals. Over time, they must learn to effectively communicate and respect each others' contributions.[61]

There is no consensus model for serious video game development strategy or process. The process used in part will reflect the amount of funding available. Greater funding will have larger teams and larger incubation periods producing more fully developed products. Lesser funding likely imposes an incremental developmental period where smaller products are added to earlier products. The Spiral Technology Action Research (STAR) Model was propounded to capture the latter[62] and capitalizes on action research methods.[63]

Time and Cost

Developing a video game is a time-consuming process. Some commercial video games take 3 or more years to develop. (The authors spent 3.5 years developing a health-related behavior-change game.) The costs of developing a commercially viable video game have been estimated in the millions of dollars. Major components of such costs are the high-end graphics, animation, and interactivity needed to attract and maintain attention for a sophisticated audience. As the qualities of commercial video games increase in sophistication, similarly high expectations will be created for health-related behavior-change and other serious video games.

Perhaps economies can be achieved by reusing and adapting computer program code (sometimes called game engines) to create new video games. Perhaps certain characters will achieve a level of notoriety that their original art work transferred to new video games will assure attention in the market place. It is not clear the extent to which the market exists that will buy health-related behavior-change video games (e.g., parents of children suffering from certain health issues, schools for health education curriculum, or just concerned parents). The ideal purchasers of serious video games would be the children themselves, attracted by the prospect of a fun experience. Proof of markets would enable software publishers and investors to invest capital in the development of behavior-change video games. Until then, or absent such markets, governmental or charitable organizations will need to invest in this development.

An Agenda for Research on Health Behavior-Change Video games for Children

To enable the field to advance, the outcome evaluations of health-related behavior-change video games need to employ state-of-the-art designs, adequately powered samples, valid and reliable measures of outcomes and mediators,[64] and be reported in a way consistent with other randomized clinical trials (e.g., see the CONSORT statement)[65] to ensure that data required for meta-analyses are available. Using the earlier framework for understanding behavior change (i.e., attention, retention, production, motivation), this section identifies priority research issues to better understand how change occurs in video games, and thereby how to better design them in the future.

Attention

The capabilities and limitations of diverse video game platforms deserve careful investigation. For example, the depth and breadth of the visual and audio experience on a full computer screen is quite different from that on a small handheld game unit. Whether the depth and breadth of this experience influences the player's immersion in the story is not known. The handheld unit may hold the same appeal for younger players (who are likely more prone to fantasy) as the larger units have for adults. Characteristics of the game that lead to intense involvement, and the effect of immersion on behavior change, need to be better understood. For example, players might come to a game expecting to be immersed in the story, thereby not requiring much effort on the part of the game (e.g., before children started a game, they expected it to be fun).[66] There may be elements of story, visual effects, or ability to participate in what happens (the

interactivity) that trigger or facilitate immersion. Players may have certain expectations for health behavior-change video games. These may vary from other video games. Health behavior-change video games may minimize possible difficulties caused by some expectations (e.g., "they can't be much fun because they are not first-person shooter games").[8]

Novelists and screenwriters may intuitively know how to tailor a story to maximize the involvement of an audience, but behavioral scientists likely do not. Research on how best to use the three-act structure to design games offers the possibility of enhancing effective behavior-change programming. Research on why audiences expect these story conventions offers the possibility of innovative approaches to the use of stories with new structures in behavior change gaming.

Retention

Emotion has been strongly linked to memory,[67] or retention. Stories are designed in part to evoke emotion.[4] Recent models predicting behavior have incorporated emotional variables.[53] Reinforcement mechanisms in video games influence positive and negative emotions.[68] How emotions influence health-related behaviors and its changes are not well known. An empiric literature needs to be generated on how aspects of story, components of games and stories within games, evoke emotional responses, which in turn enhance attention to and retention of messages and otherwise enhance (or inhibit) behavior change.

Production

Games promoting physical activity alone, whether for the fully abled or for those physically challenged, have emphasized primarily just being physically active (i.e., just producing the behavior), apparently assuming that the aspects of being active will be rewarding, or using commercially available nonactivity-promoting games as incentives for doing the activity.

Research is needed on the extent to which different categories of children (e.g., the usually inactive, the obese, different ages, both genders) are willing to initiate activity in response to these video games, how much activity is elicited, and for how long the behavior will be maintained. Mechanisms whereby such behaviors are elicited and maintained need to be elucidated. Activity-promoting video games with and without story need to be compared.

A number of video games are single-entity games,[32] while others use a series of smaller minigames that encapsulate and present behavior-change procedures.[69] These represent different uses of games; understanding when each is most appropriate and effective need to be delineated.

Industry and the military have used simulation experiences to train employees in how to better perform work-related behaviors, especially in virtual high-risk settings, where making a mistake in real life could have substantial personal and social costs (e.g., how to search for a missing soldier in a war zone). Similar kinds of simulated virtual experiences could be used to train parents to provide better food parenting,[70] or to train children how to "ask" for fruit and vegetables.[71]

Motivation

The theory of self determination (TSD)[72] has posited that intrinsic motivation, i.e., doing something because you want to do it, is a predictor of initial and continuing performance of a behavior.[7] "Fun" is an aspect of intrinsic motivation. Research needs to explicitly determine what aspects of playing a video game and of story are fun. This might be done experimentally by systematically varying aspects of games and testing their perceived fun,[66] by doing surveys

including items usually considered fun, or by comparing games that vary in their enjoyment ratings.

Mastery is another aspect of intrinsic motivation. A nine-factor solution with three higher-order factors captured adult's motivations to play massively multiplayer role playing games.[73] Consistent with TSD, "achievement" (an aspect of mastery) was one of the higher order factors. Boys were more motivated by achievement, while girls were more motivated by affiliative or social factors.[73] Similar measures need to be developed for health-related behavior-change video games.

Conclusion

Serious video game–based behavior change is an exciting form of media-based intervention. A peer-reviewed literature is emerging on this topic. The many desirable outcomes warrant moving forward in this area. A second generation of research requires models of pathways of effects, and testing theory-based propositions. This should include how to use story to affect variables on the pathways to change. Understanding how to harness the power of media-based video game interventions offers great promise to promote health-behavior change, but requires extensive research.

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Table 1

Glossary of terms

Antagonist: the story character in opposition to the protagonist
Behavior: observable aspect of the actions(s) of an individual, usually involving some body movement in space; the behavior can have multiple measurable characteristics in time, location, and change in external referents (e.g. type and amount eaten, distance moved)
Behavior change: difference in behavior over time
Behavior-change procedure: any means found to consistently induce a behavior change
Behavior-change theory: a set of proposition involving ideas and principles formulated to explain behavior change, usually leading to corollary or deduced behavior-change procedures
Cinematic: a passively watched video sequence in a computer game used for story development, background information or clues to the player
Cliffhanger: an uncompleted story segment at the end of a session or chapter, designed to induce tension or anxiety on the part of the viewer, and thereby increase their desire to return and see the ending of the story segment
Conflict: the struggle between the protagonist and antagonist in a narrative that motivates action and plot
Episodic story: a story divided into segments which are closely or interrelated, but presented separately
Fantasy: a story genre involving imagined, magical, or supernatural characters or events
Game: an activity or contest with a goal involving rules in which one or more people engage to have fun
Game engine: the core software component that provides the underlying technologies, simplifies development, and often enables the game to run on multiple platforms such as game consoles and desktop operating systems. Game engines typically includes a rendering engine for 2D or 3D graphics, a physics engine for collision detection, sound, scripting, animation, artificial intelligence and networking.
Genre: a style of expression in story telling, e.g. mystery, action adventure
Interactivity: the characteristics of a game that allows for the exchange of information between the person and the game
Melodrama: a story with stereotyped characters, exaggerated emotion and language, simplistic morality, and conflict
Plot: the sequence of events in a story
Protagonist: the story character who takes the leading part in a drama
Rules: an agreed-upon framework for playing the game
Serial: a story that is offered in parts, sequentially
Serious videogame: a videogame that uses computer-based entertainment technology to teach, train, or change behavior
Soap opera: a serial story dealing with the lives of people in a melodramatic manner
Story (storyline): the narrative
Story arc: a story that extends, or "arcs," over multiple story telling experiences, e.g. over multiple sessions or levels of a game
Story board: a sequence of sketched pictures depicting the sequence of events (plot, storyline) in a story
Story genre: one of several types into which all stories can categorized on the basis of form, style, or subject matter
Tailoring: the presentation of an interventions (usually one or more messages) to an individual, specific to some characteristic of that individual (usually based on information provided by that individual)
Videogame: a game interactively played with visual (and often audio) components on some digital device

Table 2

Diet-change games

Title	**"Store", "Guess Who", "Granny Smith ", "The Restaurant"**	**"Squire's Quest! (SQ!)"**	**Boy Scout 5ADay Badge**
Authors	MC Turnin et al.[32]	T. Baranowski et al. [34]	D. Thompson et al.
Reference	Diabetes Metab (Paris) 2001	Am J Prev Med 2003	Submitted
Target behavior	General nutrition (not targeted at specific food groups or dietary practices) Learned food categories Learned nutrient content of foods Selection of healthy foods for breakfast and lunch Nutritional balance for main meals	Increased fruit and vegetable intake among healthy children	Increased fruit and vegetable consumption
Story	Not clear from article	Kingdom of 5-A-Lot is invaded by Slimes (snakes) and Mogs (moles) who are destroying the kingdom's fruit and vegetable crop—the source of energy	Boy Scout comic characters face and overcome barriers to eating more fruits and vegetables
Protagonist	None	Child	Boy Scout characters
Antagonist	None	Invading Slimes (snakes) and Mogs (moles)	Problems encountered in increasing fruit and vegetable consumption
Struggle/conflict	None	Save the kingdom	Overcoming the problems meeting goals and eating more fruits and vegetables
Game			
Genre	Knowledge games	First-person action adventure: there are not enough knights to fight off invaders	Third-person role playing
Fantasy	Crane operator in warehouse Quiz show contestant Interacting with grandmother in her home Kitchen helper: chases runaway foods	Child is a squire in training to become a knight to help the king and queen save the kingdom	Comic strip characters encountering problems in making fruit and vegetable changes
Interactivity	Classify boxes of food according to categories using crane Guess food name from hints about its composition Correct grandmother's mistakes on selecting healthy foods	Practical knowledge games (e.g., what counts as a fruit) Goal setting with problem solving Recipe preparation Decision making Role-playing game characters	Knowledge games (e.g., what counts as fruits and vegetables, appropriate portions) Goal setting and problem solving Goal review
Role playing	Crane operator Contestant Grandchild Kitchen helper	Squire/knight Asking behaviors	None
Support	Calculator with nutrient composition of main foods	None	None
Behavior theory	Trial and error knowledge enhancement Reinforcement (points)	Social Cognitive Theory Self schema Goal setting	Social Cognitive Theory Elaboration Likelihood Model
Change methods	Repetition with feedback and accumulation of points Rewards	Tailoring goals to child's FV preferences Decision making Goal setting and problem solving	Modeling Increase preferences by associating with fun and increasing exposure Increase home fruit and vegetable availability with asking behaviors Prepare simple fruit and vegetable recipes Goal setting and problem solving Points Increase social support: buddy system—by having comic characters model asking friends for help solving problems and meeting goals Rewards
Target group	3rd–5th graders	4th graders	Boy Scouts aged 10–14 years
Time of exposure	1 hr 2x/wk for 5 wks (10 hrs total)	25 min, 2x/wk, 5 wks (10 sessions)	20 min/wk, 9 weeks – 20–25 minutes per week for 9 weeks
Evaluation and design	2-group RCT: School as unit Post assessment only	2-group RCT: School as unit of analysis Pre- and post-assessment	2-group RCT: troop as unit Pre-, post-, 2nd post-assessment

Title	"Store", "Guess Who", "Granny Smith ", "The Restaurant"	"Squire's Quest! (SQ!)"	Boy Scout 5ADay Badge
	Wait list control School was unit of randomization		
Primary outcome	Nutritional knowledge (8Qs) Dietary intake Eating habits	Fruit and vegetable intake	Fruit and vegetable intake
Measure	Nutrition knowledge (8 Qs) Dietary intake 3 day diet record – 3 consecutive days, with 1 w/end day) Eating habits (9 questions)	Four 24-hour recalls	FFQ
Sample size	16 schools 1876 participants	26 elementary schools 1578 4th-grade students	42 troops 473 Boy Scouts
Evaluation and results	Small but diffuse enhancements of nutrition knowledge, dietary intake and meal practices	0.91 fruit and vegetable servings more in treatment vs. control groups controlling for pre.	+0.38 servings fuit and vegetable (treatment vs. control difference) at post 1 +1.29 fruit and vegetable items home availability (treatment vs control difference)

Table 3

Physical activity change games

Title	**Dance Dance Revolution**	**Dance Dance Revolution**	**Dance Dance Revolution & Eye Toy: Movin'**
Authors	B. Tan et al.[29]	V.B. Unnithan et al.[25]	L. Lanningham-Foster et al.[24]
Reference	Int J Sports Med 2002	Int J Sports Med 2006	Pediatrics 2006
Target behavior	Physical activity	Physical activity	Physical activity
Story	None	None	None
Protagonist	None	None	None
Antagonist	None	None	None
Struggle/conflict	None	None	None
Game			
Genre	First-person simulation participator	First-person simulation participator	Activity promoting
Fantasy	None	None	None
Interactivity	Repeat computer-generated pattern of lights going off on squares to music	Repeat computer-generated pattern of lights going off on squares to music	None
Role playing	Dancer	Dancer	None
Support	None	None	None
Behavior theory	Intrinsic motivation/fun	Intrinsic motivation/fun	Action
Change methods	Goal setting Challenge (increasing levels of difficulty)	Goal setting Challenge (increasing levels of difficulty)	Action by doing
Target group	17.5±0.7 year olds	11–17 year olds	9.7 (± 1.6) year olds
Time of exposure	Pushed participants to their highest level of difficulty (self-selected) Highest level to complete 3 to 6 songs	45 min to 1 hour of familiarization Approx 12 min of play	One time
Evaluation and design	Approximately 10 min (6 consecutive songs) Assessment at highest level after 2 wks of familiarization	One-time assessment during completion of the work out mode	Interactive Group: Extreme Skate Adventure Active Game 1: Eye-Toy: Movin: "Jellyfish Jam" Active Game 2: Dance, Dance Revolution "Samba"
Primary outcome	Fitness potential	Fitness potential	Energy Expenditure (EE) over rest and walking while watching TV
Measure	HR & VO_2 peak	HR & VO_2 peak on least difficult mode for 12 min	Indirect calorimetry
Sample size	40 boys and girls	10 overweight & 12 non-overweight youth aged 11–17 years	25 (15 lean, 10 overweight)
Evaluation and results	Met minimum ACS guidelines for attaining fitness Achieved heart rate of 137 bts/min Achieved VO_2-dance of 24.6 ml x min^{-1} x min^{-1} (medium intensity)	Achieved a HR that would promote difference in fitness Percent of VO_2 reserve, however, did not meet levels for increasing fitness Although the obese expended more energy, there were no differences between obese and lean groups	Walking at 1.5 mi/hr while watching TV increased EE by 100 to 150 % Playing game increased EE less than walking Playing DDR increased EE 150% to 200%
Title	**Dance Dance Revolution**	**Interactive Multi media for Promoting Physical Activity (IMPACT)**	**Fit for Life Boy Scout Badge**
Authors	KA Madsen et al.[30]	MI Goran and K Reynolds[39]	R Jago et al.[41]
Reference	Arch Pediatr Adolesc Med 2007	Obes Res 2005	Prev Med 2006
Target behavior	Physical activity	Increase physical activity Decrease inactivity Limit increase in BMI Alter physical activity related psychosocial variables	Increase physical activity
Story	None	Children traveling around the globe in search of ingredients to concoct an antidote to the elixir of evil Snidwitt, who wants everyone to hate physical activity	Boy Scout characters faced and overcame barriers to be physically active
Protagonist	None	Child	Boy Scout characters
Antagonist	None	Snidwitt	Problems encountered in increasing physical activity
Struggle/conflict	None	Not clear	Overcoming problems meeting goals and being physically active
Game			

Title	**Dance Dance Revolution**	**Dance Dance Revolution**	**Dance Dance Revolution & Eye Toy: Movin'**
Genre	Activity promoting	Not reported	Third-person role playing
Fantasy	None	Not reported	Comic strip characters encountering problems in increasing physical activity
Interactivity	None	Not reported	Knowledge games (e.g. what counted as a physical activity) Goal setting, goal review, problem solving
Role playing	Dancer	Not reported	None
Support	None	None	None
Behavior theory	Action by doing	Social Cognitive Theory	Social Cognitive Theory Elaboration Likelihood Theory
Change methods	Action by doing Biweekly telephone encouragements to use DDR	Increase physical activity outcome expectations Modeling of physical activity Behavior capacity Goal setting, self motivating, social reward Self efficacy Environment change	Modeling Goal setting, goal review & problem solving In-home physical activity against a stop watch Rewards (points)
Target group	Obese youth aged 9–18 years	4th-grade students (9.5+0.4 years)	10–14 year old Boy Scouts
Time of exposure	Instructed to use game 30 min/day, 5days/wk	45 min/lesson, 8 lessons Other components of intervention	25 min/session, 9 sessions
Evaluation and design	Single group: baseline, 3mo, 6mo	2-group RCT: School as unit	2-group RCT: troop as unit Baseline, immediate post, 6 mo post
Primary outcome	Time of use of DDR BMI z-score	Ht, wt, BMI Accelerometry over at least 3 days	Accelerometry over at least 1 day
Sample size	30 children	4 schools 209 children	42 troops 473 Boy Scouts
Evaluation and results	Declining use overtime (x = 95 min/wk at week one to 50 min/wk at 6 mo) Energy expenditure declined over time Children reported DDR to be boring within 4 weeks.	BMI z-score increased in boys, decreased in girls % time in light-intensity activity decreased in boys and increased in girls Increases in self efficacy, social norms, and outcome expectancies when ethnicity included as a covariate	Among spring participants in the treatment group, sedentary activity decreased by 12 minutes between baseline and post 1, while light-intensity activity increased by 12 minutes

Table 4

Physical activity change games for people with disability

Title	**Game Wheels**	**GAME (Cycle)**	**Game Cycle**
Authors	O'Connor et al.[27,40]	Fitzgerald et al.[28]	Widman et al.[31]
Reference	Neurorehabil Neural Repair 2000 Need Eng Phy 2001	J Spinal Cord Med 2004	J Spinal Cord Med 2006
Target behavior	Physical activity	Physical activity	Physical activity
Story	None	None	None
Protagonist	None	None	None
Antagonist	None	None	None
Struggle / conflict	None	None	None
Game	Wheelchair interface used to enable participants to play commercially available games	Arm-ergometer interface with a computer enables player to control commercially available game play as if with a joy stick	None
Genre	None	None	None
Fantasy	None	None	None
Interactivity	None	None	None
Role Playing	None	None	None
Support	None	None	None
Behavior theory	Operant conditioning/reinforcement	Operant conditioning/reinforcement	Operant conditioning/ reinforcement
Change methods	Player can control videogame by driving a wheelchair	Player can control videogame play by using hand ergometer	Player controls videogame play by using hand ergometer
Target group	Wheelchair users	Hand ergometer users/athletes	Adolescents with spina bifida
Time of exposure	16 min (in main study)	19-min session	3x/wk, 16wks
Evaluation design	Phase 1: selection of game Phase 2: single-group evaluation with midprogram assessment Main study: one trial with game wheels and one without	One trial with videogame play and one without	pre, 16 wk post
Primary outcome	Fitness	Fitness	Fitness
Measure	O_2 consumption, HR	VO_2, VCO_2	VO_2 reserve, HR reserve
Sample size	Phase 1: 35 Phase 2: 10 Main study: 15	13 persons with disability	8 persons with disability
Evaluation and results	Phase 2: 9 of 10 participants reached at least 50% of max $V0_2$ and 60% of max HR Main study: Game Wheels enabled participants to reach training zone faster	GAME (Cycle) appears to be similar to arm ergometry re: energy expenditure	6 of 8 reached 50% VO_2 reserve 7 of 8 reached 50% HR reserve 7 of 8 increased max work capability after 16 wks training

Table 5

Diet and physical activity change games

Title	Fun, Food & Fitness! (FFF!)	MetaKenkoh	Escape from Diab!	Nanoswarm: Escape from Inner Space
Authors	T. Baranowski, et al.[27,33]	Southard and Southard[35]	T Baranowski, R Buday, et al.	T Baranowski, R Buday, et al
Reference	Ethn Dis 2003 Computers & Education, 2007	Circulation 2004 Clin Invest Med 2006	Not submitted	Not submitted
Target Behavior	Prevent obesity by eating 5 servings of fruits and vegetables, drinking 5 glasses of water, doing 12,000 pedometer counts/day (or 30 min of lifestyle physical activity)	Diet and physical activity	Increase fruit and vegetable intake Increase water intake Increase physical activity Decrease physical inactivity to 2 hrs or less/day	Increase fruit and vegetable intake Increase water intake Increase physical activity Decrease physical inactivity to 2 hrs or less/day
Story	Fun, Food & Fitness! (FFF!) Friends have a FFF club They help each other overcome barriers to eating more fruits and vegetables and being more physically active	Rowgoth gives people free verve and pods to move around, which makes them weak; Rowgoth then overpowers them	King Etes is oppressing the citizens of Diab by not allowing them to eat fruits and vegetables or be physically activity A renegade troop of middle schoolers is resisting King Etes DJ is mentoring renegade group of youth to help them eat better and become PA to build their strength to escape from Diab	Dr. Gunderson created nanobots to help the environment, but they appear to become renegades by invading human bodies One of the middle school research assistants (RAs), Fred, comes down with symptoms of diabetes; RAs have to eat fruits and vegetables and be active to keep Fred alive Dr. Gunderson's RA help him learn why the nanobots have turned on people
Protagonist	Six African-American girls aged 8 years who just finished attending 4-wk summer day camp	Child player	DJ (a middle school soccer star)	Gifted young scientists working in Dr. Gunderson's laboratory (middle school age)
Antagonist	Problems encountered in generalizing diet physical activity to usual life	Rowgoth (invading alien)	King Etes	Nanobots
Struggle/conflict	Overcoming problems, meeting goals	Helping people overcome verve which gives people free energy, and moving around on pods	Resist King Etes Find and eat forbidden fruits and vegetables, be physically active, and escape Diab	Increase PV intake & PA to help save Fred Find why Nanobots are attacking people & stop them
Game				
Genre	Third-person role playing	Adventure	Third-person action adventure	First-person action adventure
Fantasy	Comic strip type characters Encountering problems outside camp	None	Immersion in Diab	Immersion in 2030 MECHS Lab
Interactivity	Help character select ways to overcome problems	Trivia man poses questions which the child can find answers to	Diverse knowledge games (What is fruit?) Energy balance game	Diverse knowledge games (What is energy balance?) Energy balance game
Role playing	None	Hero, helping save MetaKenkoh	Characters role play changing their behaviors	First-person player called "Wings"
Support	Links to other websites Calendar of local PA events	Museum's ebooks (source of answers)	None	Vitalink provides information
Behavior theory	Social Cognitive Theory Elaboration Likelihood Model	None specified	Social Cognitive Theory Elaboration Likelihood Model Inoculation Theory Self Determination Theory	Social Cognitive Theory Elaboration Likelihood Model Behavioral Inoculation Theory Self Determination Theory
Change methods	Modeling Increase preferences by associating with fun and increasing exposure Increase fruit and vegetable availability at home with asking behaviors Prepare simple fruit and vegetable recipes Goal setting and problem solving/ decision making Rewards and friendship beads	Requires child wear pedometer (which is source of energy to play game)	Goal setting, goal review, problem solving, decision making, implementation intentions Knowledge game to clarify what behaviors count Energy balance game Tailoring goals to usual diet and physical activity practices Offering choices (a menu) for goals to target	Goal setting, goal review, problem solving, decision making, implementation intention Knowledge game to clarify what behaviors count for behavior change Energy balance game Tailoring goals to usual diet and physical activity practices Offering choice (a menu) for goals to target Tailoring motivation messages to child's values and corresponding reasons

Title	Fun, Food & Fitness! (FFF!)	MetaKenkoh	Escape from Diab!	Nanoswarm: Escape from Inner Space
	Increase social support: buddy system Train in dancing Decision making		Tailoring motivation messages to child's values and corresponding reasons Temptation to not attain goal with reaffirming reason statement Modeling	Temptation to not attain goal with reaffirming reason statement Modeling
Target group	African-American girls aged 8 years	Youth aged 9–11 years (89% white)	Children aged 10–12 years	Children aged 10–12 years
Time of exposure	30 min/wk, 8 wks	Not clear	1 hr/session, 9 sessions (9 hrs total)	1 hr/session, 9 sessions (9 hrs total)
Evaluation and design	2-group RCT; child as unit (pilot study)	2 group RCT: child as unit	2-group RCT: pre, mid, post and 2 months post	2 group RCT: pre, mid, post and 2 mons post
Primary outcome	Changes in total kcal, fruit and vegetable intakes, physical activity	Child diet, physical activity, TV watching Parent is source of data and pedometer	Three 24 hr recalls (FV, water) 6 days Accelerometry (MVPA, PI)	Three 24 hr recalls (FV, water) 6 days Accelerometry (MVPA, PI)
Sample size	35 (pilot study)	63 (with complete data)	150 00 trt; 50 ctl)	150 (100 trt; 50 ctl)
Evaluation and results	Treatment group consumed 232 kcal less that control group Treatment group consumed +1.2 svgs fruits and vegetables/day more than control Treatment group consumed +1.4 glasses of water/day more than control Some evidence for greater physical activity in treatment group than in control group	Increased activity in 3 of 4 groups at 1 week Decline in step counters over 3 months This is an interim report of outcomes, primarily at the end of one week	Study not yet conducted	Study not yet conducted

Table 6

Other health-related behavior games

Title	Watch, Discover, Think & Act	Wee Willie Wheezie	The Asthma Files	Packy & Marlon
Authors	LK Bartholomew, R Shegog, et al.[38]	K Huss et al. published[37] V Osund et al. developed the game	AC McPherson et al.[44]	Brown SJ, Lieberman DA et al.[45]
Reference	Patient Educ Couns 2000 J Am Med Inform Assoc 2001	J Pediatr Health Care 2003	Pediatrics 2006	Med Inform 1997
Target behavior	Asthma self-management (change in asthma-specific behaviors; change in self- regulation)	Preventing asthma symptoms	Promote self management skills in children with asthma	Improve self management of diabetic children & adolescents
Story				
Protagonist	Player	Wee Willie Wheezie, a boy with asthma	Child as secret agent	Child as character who has diabetes
Antagonist	Dr. Foulair		Not clear from publication	
Struggle/conflict	A mission to rescue plans for anti-pollution technology from the grasp of Dr. Foulair	Coping with an asthma hazardous environment	Not clear from publication	Tries to save a diabetes summer day camp from marauding rats & mice
Game				
Genre	Adventure	Role playing action adventure	Role play spy	Adventure
Fantasy	Not clear	Various homelike settings which present sources of allergens and irritants	Child is a secret agent	Not clear
Interactivity	Player makes choices to manage the game character's asthma	Children must click on their asthma medications to avoid allergies and irritants in a timely fashion to avoid asthma symptoms	As secret agent, children are encouraged to explore all game sections, finding out as much as possible about asthma self management. Interactive problem solving tasks	Keeping character's blood glucose within normal range through appropriate insulin and food
Role playing	Player as asthma manager	Player as avoider of allergens and irritants	Player as secret agent	Not applicable
Support	None	None	Personal digital assistant records what they learned; personal information could be input into PDA	Not applicable
Behavior theory	Social Cognitive Theory, Self Regulation Theory, Diffusion Theory	Framework including social support and learning theories	Not reported in publication	Not reported in publication
Change methods	Modeling, skill training, goal setting, self monitoring, persuasive communication, reinforcement, cues to action, attribution training	Feedback on change efforts	Knowledge enhancement	Not reported in publication
Target group	Inner-city youth aged 7–17 years with asthma Children aged 9–13 years with asthma	Inner-city, children aged 7–12 years with asthma	Children aged 7–14 years in pediatric respiratory outpatient clinics	Children aged 8–16 years diabetic patients
Time of exposure	Periodic primary care clinic visits over a 4-mo period	One 20-min session on each game; the control group played the Magic School Bus game only Wee Willie Wheezie had 3 levels	About 90 mins (1 lesson)	About 34 hrs over 6 mos
Evaluation and design	2 group RCT: pre & post assessment	2-group RCT: pre & post assessment	2-group RCT: pre & post assessment	2-group RCT: pre, 6 mos
Primary outcome	Health outcomes	Change in asthma symptoms	Asthma knowledge	Health outcomes
Measure	Number of emergency room and urgent health care visits	Spirometry Asthma severity Pediatric Asthma Quality of Life	Asthma Knowledge Assessment inventory	Number of emergency room and urgent health care visits
Sample size	137, 76	148, follow-up data on 101	101 (50 in trt, 51 in ctl)	59 (31 in trt, 28 in ctl)
Results	The intervention was associated with fewer hospitalizations, better symptom scores, increased functional status, greater knowledge and better child self management Trt group youth scored higher on self regulation, prevention strategies, greater	No evidence of change	At 1-month post- baseline: Treatment group had more knowledge, higher internal locus of control No effect on PEF, FEV, GP visits or hospitalizations. At six months post baseline:	At 6 mos: Treatment had higher self efficacy for diabetes self-management, more communication with parents, better self management.

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	self efficacy and greater efficacy-building attribution		Treatment group had lower steroids, lower school absence No effect on days off school, unscheduled visits to doctor or hospitalizations	Treatment group had a 77% decrease in emergency and urgent medical care.
Title	**Insulot – a cell phone game**	**Egg breeder, Detective, Buildup Blocks**	**Remission**	
Authors	N. Aoki et al.	N. Aoki et al.[36]	P.M. Kato, S.W. Cole, et al	
Reference	Diabetes Care 2005	MEDINFO 2004	(submitted)	
Target behavior	Teach relationships among plasma glucose level, food (carbohydrate grams), and insulin dosage	Diabetes control	Cancer-related medication adherence Knowledge Quality of life Self efficacy	
Story				
Protagonist	None	Egg breeder: child learns to breed a diabetic egg by selecting appropriate amounts of glucose, insulin and exercise based on plasma glucose level	Not clear	
Antagonist	None	Detective: while chasing a criminal, the player needs to take glucose or insulin based on plasma glucose level	Not clear	
Struggle / conflict	None	Buildup Blocks: player select low or high glycemic index food	Not clear	
Game				
Genre	Knowledge enhancement	Knowledge enhancement	Action adventure	
Fantasy	None	None	Missions in the bloodstreams of children with different kinds of cancers	
Interactivity	Three-window slot machine Algorithms interrelate plasma glucose, food and insulin dosage	Not clear	Players control a nanobot to destroy tumor cells with chemotherapy and radiation, fight bacterial infections with antibiotics, and manage treatment side effects 20 levels; 7 cancers	
Role playing	None	Not clear	Cancer fighter	
Support	None mentioned	None mentioned	None mentioned	
Behavior theory	Knowledge	Knowledge increase	Social Cognitive Theory Emotional Theories (not specified)	
Change methods	Knowledge enhancement	Increase knowledge	Not clear form materials available	
Target group	12–24 year old diabetic patients	Children (unknown ages) with type 1 diabetes	Adolescents and young adults aged 13–29 years diagnosed with cancer and expected treatment of >4 months	
Time of exposure	Not available in publication	One session	20 missions, average of 5.8 hrs	
Evaluation and design	Post-assessment alone	Play one game & immediate response to 13 Qs	2-group RCT: pre, 1 mo, 3 mo	
Primary outcome	Entertainment and usability	Knowledge, attitude 13 Qs	Cancer-related knowledge Quality of life Cancer-specific self efficacy Medical treatment adherence	
Measure	Not specified	Fun report	Not specified	
Sample size	30	58	375	
Evaluation and results	Game was reported to be an efficient and enjoyable learning tool	High fun ratings	At 3-mos follow up, Treatment group had more knowledge, higher quality of life, higher self efficacy, better medication compliance	