Using Electronic Games to Empower Healthy Lifestyles, Prevention and Self-Care:

Theory and Research Findings

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I. Executive Summary

As new electronic game technologies and genres are being developed at a rapid pace, they are bringing us new forms of interactive entertainment that are well suited to support learning and health behavior change. This white paper discusses characteristics of electronic games as learning environments, pointing to the power of interactivity, feedback, immersiveness, simulations, compelling characters, dramatic stories, social interaction with other players, skill rehearsal, and challenging game-play goals to motivate learning, attitude change, skill development, and improved health behaviors. It presents demographics of game players to show the extensiveness and diversity of the game-playing population in the US. It points to six trends that are leading to wider acceptance of the use of games for learning, health behavior change, and other non-entertainment purposes, and it defines several types of games now available, such as exergames, mobile games, casual games, context-aware games, and alternate reality games.

The white paper then reviews theory and research pertinent to the design and effectiveness of health games, citing studies that demonstrate significant improvements in players’ health behaviors and/or outcomes. Included in the review are descriptions of the 12 studies now underway with funding from the Health Games Research national program (www.healthgamesresearch.org), funded by the Robert Wood Johnson Foundation and directed by author Debra Lieberman at the University of California, Santa Barbara. The paper concludes with a brief look at some promising ways that future health games could be integrated into health campaigns, health education, and health care.

II. Games as Learning Environments

Electronic games (“games”) bring together all the capabilities of today’s media, and this makes them powerful environments for learning and behavior change. Games offer immersive, engaging experiences that involve challenges, interactivity, simulations of complex systems, dramatic characters and story lines, animations, cinematics, and rich visuals and sounds. They foster social interaction and, when delivered online, bring new people and new sources of information into the mix. Well designed games are highly interactive. Like a good conversational partner, games recall and respond to all that the player has previously done. In so doing, they enable a great deal of player control, provide immediate feedback, and display a detailed and evolving game state that reflects all prior actions of both player and game. With so many capabilities in electronic games today, there is a growing trend toward designing games to improve learning and health.

People of all ages and backgrounds play electronic games enthusiastically for entertainment and fun, as well as for motivation and learning (Garris et al., 2002; Lepper & Henderlong, 2000; Lieberman, 2006; Ryan et al., 2006). According to surveys by the Entertainment Software Association (2008) more than 65 percent of US households play electronic games regularly. More than 40 percent of all game players are female, 41 percent of frequent computer game players are age 35 or older, 22 percent of frequent console game players are age 35 or older, and game playing among people age 50 and older is increasing rapidly. Game enthusiasts come from all socio-economic backgrounds and the amount of leisure time spent playing electronic games continues to grow (Ipsos-Insight, 2003). In a survey of 1,500 representative U.S. households (Entertainment Software Association, 2003), respondents ranked interactive games as the most fun form of entertainment, ahead of watching television, surfing the Internet, and going to the movies. Their top reasons for playing interactive games were, “It’s fun,” “They’re challenging,” and “I like to play with friends and family.” More than three quarters of all U.S. children play interactive games, and those who play games spend an average of about 1 to 1.5 hours per day playing them during leisure time (Entertainment Software Association, 2003; Ipsos-Insight, 2003).

More than half the population of the U.S. (age 35 and younger) has grown up with games and other computer-based media, and as a result many of them are completely comfortable with the technology, enjoy responding to interactive content, and often want and expect to be able to do something with a screen in addition to watching it (Rieber, 1996). These “technology natives” speak the language. People older than age 35 might be considered “technology immigrants,” many but not all of whom have learned technology as a “second language” but speak it fluently. Although there are more technology averse individuals in that group relative to “technology natives,” many “technology immigrants” play games avidly as evidenced by the Entertainment
Software Association’s report that 41 percent of frequent computer game players are aged 35 or older. Newer game interfaces are intuitive and natural to use (such as the Wii remote controller) and so no fluency is even needed. With most people in the US spending a significant amount of leisure time playing games, it makes sense for health communicators, health educators, and health product marketers to create game-based media that will reach people where they already “live” during leisure time – playing electronic games.

III. Serious Games for Learning and Health

Aimed at goals beyond pure entertainment, so-called “serious games” have addressed a variety of outcomes, such as learning, understanding, persuasion, attitude change, decision support, skill development, social skills, self-concepts, work collaboration, civic engagement, and recruitment. Health games have been designed and created to improve an individual’s lifestyle choices, prevention behaviors, self-care, disease self-management, or adherence to their treatment plan. On the clinical side, health games have been made to train clinicians; help them practice making diagnoses and delivering treatments safely in the virtual world of an electronic simulation-based game; assist with diagnosis and medication dosing as the clinician watches the patient play (especially in the areas of physical rehabilitation, cognitive functioning, and mental health); augment treatment delivery (such as the use of physical activity games to motivate and support physical rehabilitation); support patient management and delivery of patient education; foster communication with patients; and rehearse hospital staff responses to large-scale disasters and pandemics.

First, game technologies are becoming more powerful yet also more easy and intuitive to use and they now offer a wider range of activities, including physical activity. For example, the Nintendo Wii console’s motion-sensitive remote control interface has generated immediate and strong appeal across age groups, from toddlers to seniors, and dance pad games such as Konami’s Dance Dance Revolution also have an easy-to-learn interface that can provide a wide range of difficulty levels so that everyone from novices to experts can find their appropriate level of challenge. Ease of use has enabled more people to play electronic games and they are experiencing first-hand how engaging and impactful they can be. A mainstream audience is discovering that games need not be sedentary thumb-twitching experiences.

Second, a number of well designed and entertaining games have now been made for learning or health. Their success at improving knowledge, attitudes, motivation, skills, and behavior has demonstrated that interactive game-based entertainment can be an effective learning environment, and so the potential of games is becoming a reality that many are experiencing for themselves (Gee, 2003; Prensky, 2006; Ritterfeld et al., 2006; Squire & Jenkins, 2003). While some games are being developed intentionally for serious purposes, commercial off-the-shelf entertainment games are also being repurposed to attain learning and health goals with impressive results (Carson et al., 2006). Dance Dance Revolution is an example of repurposing, as schools and health clinics are using this entertainment game to improve students’ and patients’ physical fitness and weight management (Murphy et al., 2006; Unnithan et al., 2005).

Third, a growing body of research provides strong evidence that games for learning and health can be effective (Baranowski et al., 2003; Baranowski et al, 2008; Lieberman, 1997, 2006b; Raessen & Goldstein, 2005) and this has influenced opinion leaders and
decision makers to advocate the use of games for serious purposes, such as learning and health, and to encourage their organizations and constituents to use games. Fourth, research is producing validated design principles that are improving each consecutive generation of learning and health games (Vorderer & Bryant, 2006).

Because of these trends, momentum in the serious games field is growing. So, fifth, a wide-ranging array of stakeholders has become interested in serious games, including health care providers and insurers, behavioral health specialists, health educators and communicators, game producers, technology companies, investors, funding agencies, and policy-makers. Professional and academic associations are holding well-attended conferences with names such as CDC’s Strategic Look at eGames; Game Education Summit; Games for Health; Gaming to Learn; Meaningful Play; Serious Games Summit; and Virtual Learning in Health Communication. Online discussion groups such as Games for Change, Games for Health, Games Network, and Serious Games are lively forums for debate, discussion, and information sharing. Online reviews and blogs are also contributing to the marketplace of ideas, including Grand Text Auto, Kotaku, The Ludologist, Terra Nova, and Water Cooler Games. Recent books discuss serious game design and the cultural or educational significance of games (e.g., Bergeron, 2006; Bogost, 2007; Gee, 2003, 2007; Prensky, 2001, 2006; Squire, 2007) and some books present empirical research on the processes and effects of game play and use this evidence to recommend advances in the research, design, and implementation of serious games (Vorderer & Bryant, 2006; Raessens & Goldstein, 2005; Ritterfeld et al., in press). New journals (such as Computers in Entertainment, Games & Culture, and the International Journal of Gaming and Computer-Mediated Simulations) and more established ones are publishing peer-reviewed research in the field. University-based undergraduate and graduate programs are emerging to teach the art and science of game development (Entertainment Software Association, 2008).

Sixth, more funding and other resources are becoming available to support the research, design, and development of electronic games for learning and health. Federal agencies such as the National Science Foundation, the U.S. Department of Education, the National Institutes of Health, and the Centers for Disease Control and Prevention are awarding research and development grants that incorporate serious games, and foundations such as the MacArthur Foundation and the Robert Wood Johnson Foundation are sponsoring research projects and national programs to help advance theory, evidence, evaluation, design, and innovation in the areas of electronic media for learning and health. These valuable forms of support have helped spur the field’s momentum and have helped attract interest and participation.

More research support, funding, investment, and innovation are needed because many key questions are still unaddressed, new questions are always arising as technology and innovation continue to advance, and the potential of this form of learning and behavior change is not nearly fully realized, even though this young field is off to a strong start.

IV. What is a Game?

Essentially, a game is a rule-based activity that involves challenge to reach a goal. A growing number of genres and technologies are offering a wide variety of new ways to play, but the central characteristic of a game is its challenge, which motivates the player to strive to succeed. Games provide performance feedback and the ability to monitor one’s progress toward reaching the goal. Games can involve collaboration, competition, or playing alone with no collaborative or competitive elements.

Playing games is one of the fundamental ways humans learn (Huizinga, 1970). Electronic media bring new opportunities because they enable people to play games within virtual words that could not be replicated in real life, and they can support or augment game play that takes place face-to-face in the real world. Most of us have strong motivation to achieve and win in a game. Games test and develop our skills, stretch our capabilities, allow us to show off our talents, and can be tremendously engaging and fun.

The challenge posed by a game could involve creativity, knowledge, conflict, competition, cooperation, social skills, persuasive skills, visual or aural acuity, eye-hand coordination, memory, multi-tasking, logic, or solving a mystery or puzzle. This list is a small sample of the kinds of challenges a game could provide, and as our technologies develop there will be even more. Many other exciting game ideas are waiting to be created. Following are brief descriptions of a few types of games played today.
Computer games played on a personal computer or laptop, and console games played on a TV set, are screen-based and encompass a wide variety of genres and interfaces. They range from side-scrolling adventure games to first-person games to racing games and sports games, just to name a few.

Massively multiplayer online games (MMOGs) are extensive web-delivered game worlds in which players are characters that interact with other characters controlled by other players in real time. Players can communicate with each other to collaborate, barter, and share game tips.

Mobile games are playable on a handheld device such as a PDA or cell phone. As mobile phones become increasingly multi-purpose, multi-media, networked, and powerful, there will be increasingly rich opportunities to develop on-the-go gaming.

Casual games are simple, easy to learn, and can be played in a short time. Puzzles, visual challenges (such as Tetris), number games (such as Sudoku), word games, matching games, and trivia games are examples of casual games. They can be played on computers, consoles, and mobile devices.

Brain games are usually casual games but they can be more extensive, and are intended to maintain or improve cognitive and reasoning skills. They usually appear on mobile handheld devices like PDAs, cell phones, and the Nintendo DS, but can reside on any game platform or online.

A simulation is a model of a social or physical system containing interrelated, interdependent elements. It responds system-wide to any change made within it. Sim City and The Sims are well known simulation tools that enable the user to build a city and manage a family, with the goal of making each of them thrive. A simulation becomes a game when the user is given a goal to achieve at least one specific outcome within the simulated system.

A virtual world, such as Second Life or Whyville, is an online environment in which participants can create characters, places, and events. The world is constructed by the participants, who create their own avatar character(s) and interact with other people’s avatars, develop friendships, build items and construct buildings, sharing media and entertainment, buy and sell the items they have made, hold discussions and support group meetings, and find information. Games can take place in virtual worlds and can be generated by their participants.

Games for learning employ principles of interactive media instructional design to create interactive experiences in which players may achieve one or more of the following: increase their engagement in the topic, become more motivated to learn, change their attitudes, develop self-confidence, learn new content, develop deeper understanding, or learn and rehearse new skills, to name a few of the learning-related outcomes that could occur. Research in this field is helping to develop strategies and principles for the effective design of interactive games targeted to specific groups, such as by gender or culture or skill level, and also by age, taking into consideration children’s and adolescents’ developing cognitive, physical, social, and emotional needs and abilities.

Games for health apply health promotion and health communication strategies along with the pedagogical strategies used more generally in games for learning, in order to produce better health outcomes. Games have been designed to increase the health-related knowledge and skills of the general public and health professionals in the areas of prevention, self-care, adherence, health decision-making, disease management, clinical care, and emergency response. There are also games designed to diagnose neurological and mental health disorders, assess and adjust medication dosage, improve self-esteem and mental health, provide biofeedback, distract patients during painful or anxiety-ridden procedures, motivate activities involved in physical therapy, and provide phobia therapy.

Exergames are games that get the player moving, using physical challenges and interfaces that require movement and exertion. They involve the player in dance, aerobics, kick-boxing, sports moves, martial arts, biking, virtual window washing, or other forms of physical activity. Examples of commercially popular exergames are Dance Dance Revolution (in which the player must tap specific areas of a dance pad in time with music, using feet and sometimes hands), Sony’s EyeToy Kinetic (using a camera-based interface that puts an image of the player on the screen so the player can interact with objects on the screen), and games played on the Nintendo Wii platform. Research finds that exergames are appealing, motivating, and fun, and offer compelling game challenges, a chance to perform athletically or
expressively, and a way to meet and interact with others in friendships and communities. Studies find that certain exergames improve players' stress management, weight management, fitness, and health.

Robots and smart toys can provide electronic games in which the player interacts with a three-dimensional object. The object may or may not have a screen display. For example, a talking doll could play a game with a child completely through physical movement, voice recognition, and audio, with no screen displays or digital images used at all. Also, haptic interfaces sense position and pressure, enabling game interfaces that are entirely physical.

Virtual reality games take place in three-dimensional virtual worlds in which the player physically moves while seeing a visual display of the world no matter which way they look or turn. The game responds to the player's physical location in the virtual world.

Real-world games take place in the physical world and are supported by standalone or networked digital technology. Geocaching is an example of a real-world game supported by wireless online technology and a global positioning system (GPS) that indicates the player's longitude and latitude. Players post clues online so that others can try to find hidden caches of treasure or trinkets, and they must follow the clues to hike to the spot where the cache is located. They may take one of the items and some place other items there as well. The tag line for this game is, "The sport where you are the search engine."

Context-aware games take place in a mediated world or in the physical world, and they respond to information gathered from the player's environment. A context-aware game collects both physical information about the player and data the player has entered into the system. It uses these inputs to determine the player's current progress and game state. Information can come from four types of sources: (1) the environment (location of the player, location of items in the environment that may contain radio frequency identification (RFID) tags or sensors), (2) physical activity (movement of the body such as reaching or tossing, or movement that changes the player's geographical location from one place to another), (3) body data (brain waves, stress level, breathing rate, heart rate, galvanic skin response, facial expression showing emotional state), and (4) other people (their comments, votes, recommendations, interpretations, and descriptions). The brain wave sensors used in biofeedback games such as Journey to Wild Divine are examples of the physiological data that can be input into context-aware games. GPS is used in location-based games such as the Japanese game Mogi where players explore their physical surroundings to collect hidden virtual items. Players interact with the Mogi world via software on their GPS-equipped mobile phone. As they move throughout the (real) city, the software updates their position and lets them know when they are near any virtual tokens they could collect. Their goal is to gather as many tokens as possible, trade them with other players for rarer tokens, and build the ultimate Mogi collection. Players move throughout the real world and their geographic location is the main source of context within the digital game. Their physical location determines the kind of experience and feedback the game provides. Games that use the player's location as an input to the game experience are sometimes called pervasive games because they extend the gaming experience off the screen and into the player's natural, physical world.

Alternate reality games are off-the-screen games that provide a fictional world within the player's real world. They sometimes use inputs from the player's context, as in context-aware games. Since the entire world is the game environment, anyone the player meets could potentially be a game character (if that person is playing the game). When this happens, daily life takes on an added dimension of being a game, itself. Normal daily activities such as driving to work, shopping in the grocery store, or crossing a street could become activities that affect players' progress in the narrative of a game. Alternate reality games use the same media and tools that are used mainly for real-world, nonfiction purposes, including newspapers, magazines, the web, e-mail, and phones. A player may, for example, receive a phone call from a fictional character, intended for the player's game character, and so the player must play along in the fictional story. In these fictional interactions players solve plot-based challenges, mysteries, and puzzles, often working together with a community to analyze the story and coordinate their real-life and game play activities. There is an improvisational aspect to many alternate reality games because events are often based on new ideas and inputs from other players. This generates interesting stories and interactions that were never programmed or produced, adding freshness to the experience and putting control in players' hands, for a much lower cost than the pre-produced console games being sold today.
These are just a few examples of electronic game technologies and genres now available, and certainly many more will soon appear.

**V. Health Games: Theory and Research Findings**

Games are experiences. As players learn and solve problems in games, they rehearse skills and become immersed in the game's challenges and story line (Gee, 2003, 2007). Like other media, electronic games are experienced as real in many ways, because players feel as if they are really in the game environment and they develop emotionally rich relationships with game characters (Reeves & Nass, 1996). Following is a review of selected theories and research findings that are pertinent to health games and that build upon their experiential qualities.

**Constructivist Health Games**

Learning tends to be more enjoyable and the learner more motivated when there is a compelling reason to learn (Bruner, 1960, 1961; Coleman, 1971; Locke & Latham, 1990). Good teachers know how to make a subject worth knowing, so that students are eager to learn in order to attain an outcome that matters to them. These teachers establish clear goals, their students know why they are learning, and there are plenty of opportunities to apply what they have learned (Bransford et al., 1999). Furthermore, these teachers adapt to their students' skills, interests, and learning styles to make learning more personally meaningful and achievable (Hannafin & Land, 1997). This successful approach to learning can be used in games, especially in the areas of constructivist learning, immersiveness and perceived reality, learning by teaching, and dynamic assessment.

Constructivist learning is a well tested and validated approach that situates learning in an experiential and applied environment, where learners take an active role and personally construct their own knowledge in authentic situations that allow them to build on what they already know (Honebein et al., 1993). By building on students' prior knowledge and learning styles, and giving them choice and autonomy, learning becomes more relevant and interesting.

During leisure time, digital interactive games can deliver constructivist learning opportunities that people will eagerly play for the fun of it. Games involve challenge to reach a goal, and serious games can pose compelling and motivating challenges during leisure time that require the player to learn new content, engage in higher-order thinking and problem solving, make decisions, interact with others collaboratively and in leadership roles, and try out new experiences that would be difficult or impossible in the physical world. Within a well designed game, learners have a safe and private environment in which they can try out and rehearse new skills, receive helpful feedback, progress at their own pace, and learn how and why things work beyond simply memorizing a series of facts. In addition to the sometimes desirable private aspects of learning with games, learners interested in social interaction can talk with others about a game, show it to others, or play it with others either face-to face or, in some cases, online.

Two examples of constructivist games designed to improve health behaviors are HopeLab's Re-Mission and Nintendo's Rex Ronan. *Re-Mission*, a cancer education video game played on a desktop computer, challenges players to save the lives of various young cancer patients by going inside their bodies, shooting their cancer cells with chemotherapy, and administering other treatments. A randomized controlled study found that playing *Re-Mission* improved adolescent and young adult cancer patients’ cancer-related knowledge, self-efficacy (belief in one’s ability to carry out a specific behavior, in this case it was self-efficacy for engaging in certain cancer treatment-related behaviors), and adherence to their prescribed cancer treatment plan (Kato et al., 2006; Kato et al., 2008).

Other studies of *Re-Mission*’s effects (Lieberman, 2008a, 2008b) have been conducted with healthy young adults who do not have cancer, and have found that (1) playing the game strengthens beliefs and attitudes about cancer – such as perceptions of the severity of cancer and of one’s own susceptibility to getting cancer – that are predictors of better cancer prevention behaviors and self-care, and (2) inclusion of dramatic story elements and a focus on the cancer patient characters’ needs, personalities, and aspirations enhance players’ learning about cancer, empathy and caring about the characters, and beliefs and attitudes about cancer that are predictors of better cancer prevention and self-care, such as self-efficacy and perceptions about one’s own susceptibility to getting cancer; on the other hand, exclusion of dramatic story elements and exclusion of the cancer patient characters’ needs, personalities, and aspirations focuses
the player on game mechanics, which in this case involve the shooting of cancer cells with chemotherapy, and this pure game-play focus enhances players’ positive attitudes and self-efficacy related to the use of chemotherapy, which in essence is a “health mechanic” taught in the game. Re-Mission, like many other constructivist games, puts players into a challenging environment where, in order to succeed within the simulated virtual game world, they must learn and then apply new knowledge and skills to achieve a compelling goal.

With the constructivist approach, in which learners are often eager to learn so they can succeed in reaching a goal, the desire to find facts, solve problems, develop skills, and understand how and why systems work is internally driven. The game is not delivering “sugar coated” or “stealth” learning to make learning sweeter or more invisible to the player. Instead, learning in a well designed game can be an enjoyable process and a rewarding achievement. Learning is more likely to be experienced as fun when there is a good reason to learn, the material is tailored to the individual learner’s abilities, the system provides helpful feedback and support, and the learner has some personal control over the process.

Rex Ronan, a Super Nintendo game published in 1993, challenges the player to remove from the human body the debris and damage caused by smoking. The game is targeted to pre-adolescents ages 10 to 12, who tend to hold strong anti-smoking attitudes but are also at risk for starting to smoke around age 13 and throughout the teen years. The game is designed to strengthen their current anti-smoking attitudes and to give them vivid images of the disgusting effects of smoking and its specific impacts on the body. Players play the role of Rex Ronan, experimental surgeon, who shrinks to near-microscopic size and enters the body of his patient who is ravaged by the effects of smoking. Using a laser scalpel, players guide Rex as he removes the tar, phlegm, plaque, and pre-cancerous cells in his patient’s mouth, esophagus, lungs, and other body parts, and then ultimately fights the most formidable enemy, nicotine addiction. A pretest-posttest study (Tingen et al., 1997) gave pre-teens the Rex Ronan game to take home for two weeks to play as much or as little as they wished. After two weeks, compared to their pretest responses before taking the game home, they developed significantly stronger anti-smoking attitudes, had stronger resolve not to start smoking, and were able to give more specific reasons why smoking is bad for the body. For example, one study participant said, “That white stuff clogging the arteries is called plaque, and I don’t want any of it so I’ll never start to smoke.”

Immersiveness and perceived reality are also characteristics of digital interactive games that help make them effective environments for learning and behavior change. Games, like many other media formats, elicit feelings of presence, of really being there (Lee, 2004; Lombard & Ditton, 1997), an authentic experience that can bring up the same kinds of arousal, physiological response, and empathy that real experiences do (Picard, 1997; Reeves & Nass, 1996). On an emotional level, players may strongly identify with a character that is like them in some ways or that they aspire to be like (Cohen, 2001), and when a game requires that they assist a character who needs help they may develop caring and nurturing feelings toward that character and may identify so strongly with that character’s plight that they begin imagining that they too might some day have similar problems to confront in their own lives, and this could motivate them to learn more and take action on their own behalf (Lieberman, 2008a). Game players are directly engaged in the world of the game and receive feedback for their own actions. They gain first-hand experience while mastering problems in the virtual world of a game, and this experience of mastery and seeing it lead to effective decisions can be a powerful way to learn, more effective, say, than carrying out problem-solving exercises on paper and receiving external acknowledgement in the form of a grade (Prawat & Flowden, 1994).

Simulation Health Games
A simulation is a representation of a social or physical system that lets the user adjust its conditions and components and then observe the systemic changes that result (Aldich, 2003; Heinich et al., 1996; Rieber, 1996). Game-based simulations provide a specific game goal that challenges the player to make choices within the simulated system that will lead to desired outcomes. Simulations lend themselves to learning in a variety of topic areas and, in the health field, social systems and body systems have been simulated to help people understand how they work and how certain decisions can lead to benefits or harm. Simulations are artificial worlds that have some properties of the real world. For example, there are simulations that enable users
to learn how infectious diseases affect the body, how cells grow and change, how hospitals can be managed effectively (Barnett et al., 2005), how to keep a family happy and prosperous, and how to use medications and avoid environmental triggers to keep a virtual character's asthma under control (Lieberman, 2001).

Simulations can simplify a view of a system by eliminating some of the variables; they can speed up or slow down time so that processes and outcomes are easier to observe; they allow the user to manipulate variables that are not immediately alterable in the real world; and they are safe because any dangerous outcomes are depicted but not physically experienced. Simulations are often used as the basis for serious games because they provide a world in which the player can make decisions and see or even virtually experience the consequences (Millians, 1999). A new simulation health game, called Pulse!!, is under development for the military's training of emergency medical personnel. It provides a virtual patient that arrives in the emergency room with a set of symptoms and needs further testing, diagnosis, and treatment. The player can examine the patient, order tests, see the results, make a diagnosis, and administer treatments and surgeries, and the patient's body responds realistically. Many illnesses and injuries are included in this simulation game, allowing the player to make many diagnostic and treatment decisions. Pulse!! may eventually become available for the general public to play.

**Principles of Learning in Health Games**

In addition to using constructivism, immersion, and simulations to enhance learning, health games can be designed with other validated learning strategies such as role modeling (Bandura, 1986); placing learning and problem solving into a familiar context so that learners can more readily draw on their prior experiences in that setting (Cordova & Lepper, 1996); scaffolding, feedback, and other forms of learner help and support (Arroyo et al., 2004); adaptive instruction that adjusts to the learner's performance and abilities to keep the material challenging but not too easy or difficult (Schwartz et al., 1999); intelligent tutoring and coaching (Mayer & Moreno, 2002); the use of multiple media modalities to enhance learner understanding and transfer of skills (Moreno & Mayer, 2002); the development and rehearsal of planning skills (Mayer et al., 1999); and the use of fantasy and narrative to enhance engagement and to provide a framework for remembering and applying what was learned (Parker & Lepper, 1992).

Another approach that is applicable to health games is learning-by-teaching (Biswas et al., 2005). Games can provide teachable agents that motivate the player to learn the material so they can teach it to a virtual agent character. Games can also build peer teaching into the activity. For example, cooperative games can present situations in which two or more players teach and help each other in order to win as a team, as in the diabetes self-management game Packy & Marlon, which offers a cooperative two-player option that requires both players to keep their character healthy. This leads to a great deal of advice-giving and strategizing between the two players so that they both can maintain their character's health (Brown et al., 1997).

**Principles of Behavior Change in Health Games**

Health behavior change theories and message design strategies can enhance the effectiveness of health games. Examples include tailoring, or customizing, of health messages to more closely match the characteristics, interests, culture, and health status of the individual, which can lead to improvements in attention to health messages, engagement, perceived quality and relevance, learning, retention, and health behaviors (Kreuter et al., 2001); use of gain frames to depict the benefits of engaging in a health behavior and loss frames to depict the risks of not doing so, and selecting either a gain frame or a loss frame strategy based on the individual’s dispositions and motivations (Mann et al., 2004); designing media differently, according to the Elaboration Likelihood Model, for people who are highly involved and interested in a health issue (e.g., give them plenty of the information they seek) versus those who are not highly involved (e.g., use humor, vividness, sex appeal, and other techniques to attract attention to a simple but powerful health message), and in these ways increase cognitive processing of health messages, a strategy known to lead to more significant learning and attitude change (Petty & Cacioppo, 1986); using role modeling and rehearsal of skills, among other approaches, to increase the individual’s sense of self-efficacy, or self-confidence, to carry out desirable prevention and self-care behaviors (Bandura, 1997); using the Extended Parallel Process Model with its emphasis on changing health behavior by increasing people’s perceptions of the severity of a health problem and of their own susceptibility to experiencing it, as well as perceptions of efficacy related to one’s own abilities (self-efficacy) and related to the benefits of the recommended health behavior (response efficacy) (Witte et al, 2003); and
fostering communication and social support through
game play because social connections are associated
with better prevention behaviors, coping skills, and health

Packy & Marlon, a Super Nintendo adventure game, 
published in 1994, that uses experiential learning, 
role modeling, peer teaching, message tailoring, skill
rehearsal, and social interactions to improve young
people’s diabetes self-management, was evaluated in 
a six-month controlled trial. The game involves playing
the role of a character that has diabetes; players manage 
their character’s blood glucose monitoring, insulin use, 
and food selections for four simulated days, while the 
character tries to save a diabetes summer camp from
maurading rats and mice who have ransacked the camp.
Keeping their character’s blood glucose within the normal
range, through appropriate insulin and food, helps players
win the game.

In a controlled trial, diabetic children and adolescents 
were randomly assigned to take home either the Packy 
& Marlon game or an entertainment video game with
no health content. Study participants were young people
ages 8 to 16 who were outpatients of diabetes clinics 
at Stanford University Medical Center and at a Kaiser
Permanente clinic. They were told they could play their 
game as much or as little as they wished, as long as they 
followed their parents’ rules about when and for how
long they were allowed to play electronic games.

The study found that participants in both groups played
their game about 1.5 hours per week on average over
the course of six months, but the Packy & Marlon group,
and not the entertainment game group, increased
their communication about diabetes with family and
peers, gained more diabetes knowledge, increased
their perceived self-efficacy for diabetes self-care,
improved their diabetes-related skills, and increased their
appropriate self-care behaviors. As a result their urgent
care and emergency visits related to diabetes decreased
by 77 percent, dropping from an average of about 2.4
visits per child per year down to about 0.5 visits per child
per year. The group that received the entertainment
video game experienced no significant changes in
diabetes-related skills, behaviors, or outcomes (Brown et
al., 1997; Lieberman, 2001).

Six similarly designed randomized controlled trials of
Bronkie the Bronchiasaurus, an asthma self-management
super Nintendo game published in 1995, conducted
with asthmatic children and adolescents. The studies
found improvements in the treatment group’s asthma-
related knowledge, self-efficacy, self-care skills, and
behaviors, and 35- to 40-percent reductions in asthma-
related urgent care and emergency visits, missed
school days, and parents’ missed work days due to
their child’s asthma. The control groups that received
an entertainment game with no asthma content did
not improve in any of these measures. The trials were
conducted by large healthcare providers and clinics and
they enrolled their own patients. The results were not
published. Other studies of the effectiveness of
Bronkie the Bronchiasaurus used pretest-posttest
measures (Lieberman, 1997; Lieberman, 2001) and,
like the clinical trials, found increases in players’
asthma knowledge and perceived self-efficacy for
asthma self-care.

These studies of diabetes and asthma self-management
games demonstrate that well-designed action-adventure
video games can significantly improve learning, skill
development, and behavior change.

Exergames
Exergames are electronic games that involve the player
in dancing, aerobics, kick-boxing, sports moves, martial
arts, stationery biking, balancing, virtual window washing,
or other forms of physical activity and exertion as the
way to interact with a game. An increasing number of
exergames, most recently the Wii Sports and Wii Fit
games, are popular in the US and research is finding that
certain exergames can improve players’ stress levels,
weight management, fitness, and health. Some people
play exergames to get a good workout, and others play
mainly for entertainment and social interaction but they
enjoy the health benefits as an added bonus. There are
players who were not very active in the past and have
found that playing exergames is a manageable and
enjoyable way to get regular exercise.

The current best-selling dance pad game, Dance Dance
Revolution (DDR), has often been repurposed as a
health game to increase players’ physical activity and
weight management. It can be played in arcades or on
home video game consoles. It is now being used as a
health game in schools, medical clinics, workplaces, and
gyms across the country.

Several studies investigated the health and fitness
outcomes of young people who played DDR. One study
found improvements in players’ blood pressure, fitness
scores, and endothelial function (arteries’ ability to deliver oxygen) (Carson et al., 2006; Murphy et al., 2006). Another identified the impacts of the game on students in 20 schools that used DDR in physical education and health classes, and found that some of the youngsters lost five to ten pounds after playing the game every day during the first few weeks (Barker, 2005). A third study with 35 overweight children ages 7 to 12 found that playing DDR at least five times a week led to the children feeling more coordinated, less winded, and less self-conscious. They developed stronger self-esteem, on average, improved their aerobic fitness, and reduced their chances for developing diseases associated with obesity, such as diabetes and heart disease. Study participants’ parents reported that most of the children stopped gaining their typical three or four pounds a month and, with increased self-confidence, started exercising and playing sports regularly in daily life (Brubaker, 2006). Based on the positive results of these studies, the state of West Virginia now plans to use DDR in all of its 1500 public schools and is developing a school-based DDR curriculum.

Nutrition
Currently several studies are underway to investigate the impacts of health games on eating habits and nutrition. One study of the game Squire’s Quest, a computer-based game for the elementary school curriculum, took place in 26 public schools. The game is designed to encourage goal setting about food, recipe preparation, decision making, and making healthy food requests to parents, and a main goal of the game is to increase the daily number of fruit and vegetable servings players eat. For the study, fourth graders played Squire’s Quest twice a week in 25-minute sessions during a five-week period and were compared to students who did not play the game. When the five weeks were done, those who played the game increased their daily fruit and vegetable servings by .91 servings. They were eating an average of 4 servings a day before they played the game, and increased their servings to almost 5 a day after five weeks (Baranowski et al., 2003).

Regulating Brain Waves and Attention
A few biofeedback games have been produced recently, in which players must keep their brain in a particular wave state in order to progress in the game. Images, sounds, and events in the game provide the biofeedback to the player and show the current wave state. Biofeedback games have been used to motivate players to self-monitor and regulate their attention. In one study, players with attention deficit disorder (ADD) improved their ability to sustain their attention after playing a brain wave biofeedback game (Pope & Bogart, 1996). The game is based on a biofeedback system that was developed to assess the mental engagement of airplane pilots. When the system detects, from the player’s brainwaves, that attention is waning, the game becomes more difficult to play. The player can only succeed in the game by maintaining an adequate level of attention, and is motivated to attend in order to win the game.

Therapy, Social Skills, and Pain Management
In a clinical context, interactive games have led to positive therapeutic outcomes for children and adolescents (Griffiths, 2003). They have helped young people undergoing chemotherapy and psychotherapy, children with emotional and behavioral problems, and youngsters with communication and social skill problems related to impulsivity, ADD, and autism. In addition to teaching young people how to regulate attention, manage emotions, and interact socially, interactive games can distract patients to reduce their perception of pain during physical therapy and medical procedures related to conditions such as Erb’s palsy, muscular dystrophy, and burns.

Phobias
Virtual environments have been used very successfully in exposure therapy for patients who have phobias such as fear of snakes, spiders, public speaking, elevators, and flying (Wiederhold, 2003). Under the guidance of a therapist, patients learn to approach the object of their fears in small, incremental steps. In the past this was done through direct experience, but now virtual environments are providing a more economical way to achieve the same outcomes. In one study, an interactive game provided effective therapy for auto accident victims who wanted to reduce their fear of driving (Walsh et al., 2003).

VI. Research in Progress
Studies of health games are now underway with funding from the $8.25 million Health Games Research national program (www.healthgamesresearch.org) that is directed by the co-author of this paper, Debra Lieberman, at the University of California, Santa Barbara, and funded by the Robert Wood Johnson Foundation’s Pioneer Portfolio (www.rwjf.org/pioneer/index.jsp). The program has awarded $2 million so far to fund 12 studies across the
US, and another $2 million will be awarded in 2009. The studies focus on learning processes and health effects with electronic games that encourage physical activity and/or that improve self-care such as lifestyle behaviors, prevention, and disease self-management. The aim is to discover and validate a broad set of theory-based and evidence-based principles of health game design that could be used effectively in future health games. Following are brief descriptions of the 12 funded studies that are now in progress.

1) Cornell University, Ithaca, NY

Mindless Eating Challenge: Persuasive Mechanisms in Mobile Health Games

Mindless Eating Challenge, a mobile phone game for adolescents ages 12-14, uses eating tips, mobile phone snapshots of food to be eaten, nurturing of a virtual pet or plant, and system and peer feedback to promote good nutrition and a healthy lifestyle. The game rewards and acknowledges the player’s good health habits and nutritional choices and it puts healthy eating tips into a context in which players must follow the tips in order to reach game goals. For example, if players make healthy choices, this will help their virtual pet or virtual plant to grow and thrive. Poor choices will make the pet or plant sick and weakened. By using the camera in their mobile phone, players record their healthy activities, for instance by taking pictures of the foods they eat. The pictures are shared with peers, and this makes use of social facilitation, the tendency for individuals to improve their behavior when others are present and/or aware of their behavior.

The study is a field experiment that examines the game’s mechanisms of persuasion by observing effects of positive and negative feedback (positive feedback only, versus negative feedback only, versus a combination of positive and negative feedback), and by comparing the impacts when the feedback is provided to players either by the system or by peers, in response to players’ tip compliance. A control condition involves having no game to play but receiving daily e-mails with helpful nutritional tips, and a non-intervention condition provides no game and no tips. The study is measuring outcomes including adherence to the healthy eating tips, self-reported body weight and BMI, satisfaction, attachment to the virtual pet, self-efficacy, response efficacy, eating habits, and exercise habits.

While this study is focused on healthy eating, the same game design principles could be applied to other health areas where behavior, especially habituation and motivation, are at issue. Better understanding of these principles will inform future design guidelines for delivering effective persuasive and motivational messages in mobile health games.

2) Indiana University, Bloomington, IN

BloomingLife: The Skeleton Chase

This study compares the impacts of competitive versus collaborative versions of an alternate reality game designed to promote physical activity and healthy lifestyles among college freshmen. It involves an interactive fictional story—a mystery that takes eight weeks to solve and that unfolds across a variety of media, including e-mail, websites, and text messages, and even phone calls that come from fictional characters. Players must meet a variety of real-world physical and mental challenges in order to gain clues to solve the mystery. The game runs in parallel with an 8-week physical education course covering topics such as lifestyle physical activity, fitness, body works workshop, general nutrition principles, alcohol awareness, sex education, and stress and health.

Outcomes of interest in this study are effects of the game on participants’ near term and longer term physical activity (measured with an accelerometer) and their physiological, anthropometric, and behavioral health outcomes.

3) Maine Medical Center, Portland, ME

Family-Based Exergaming with Dance Revolution

To increase overweight children’s physical activity and improve weight management, this study identifies impacts of the dance pad game Dance Revolutions in families that have at least one overweight child age 9 to 17. Family factors and family group dynamics are known to influence children’s weight management, so a strategy that brings families together to play Dance Revolution holds great promise.

The study involves 70 families and randomly assigns them to take home Dance Revolution or a pedometer for 12 weeks. Individual and family aggregate levels of physical activity are being measured at baseline and at 12 weeks, and at three time points measures are being taken of quality of life, BMI, body composition, and enjoyment of physical activity. Participants are keeping
weekly logs. The study also measures motivation, co-
activity levels among family members, and amount
of individual and family-wide physical activity, and the
relative importance of family, individual, and relationship-
specific factors in motivation to exercise.

4) Union College, Schenectady, NY

Seniors Cyber-Cycling with a Virtual Team:
Effects on Exercise Behavior, Neuropsychological
Function, and Physiological Outcomes

This study is an experiment that investigates
cardiovascular effects of a stationary bike system that
integrates interactive computing (cardiovascular exergame
software using a touch screen) with use of the stationary
bike. Players receive individualized feedback on their
biking workouts and can play with others competitively
or collaboratively in a screen-based virtual environment.
The software offers various workout modes: simple
biofeedback (heart rate monitoring); improvement
progress (racing against one’s own saved workouts);
competitive (racing others in real time, or racing
their saved workouts, or racing against programmed
challenges); collaborative (joining teams and leagues
that share group goals); and non-collaborative (racing in
groups but not participating in group goals).

The study is designed to identify individual and
situational factors that influence exercise behaviors
and health outcomes in community-dwelling adults,
ages 50 and older. It is a randomized clinical trial, with
data collected over a one-year period at two, three, six,
and twelve months. The study draws on the Theory of
Planned Behavior and theoretical constructs associated
with exercise behaviors including motivation, self-
concepts, social relationships, attitudes, and values. The
role of individual differences is also part of the study,
such as propensity for competition, collaboration, and
individualism, and degree of frustration intolerance.
Outcome measures include exercise behaviors
(frequency, duration, and intensity of exercise sessions);
physiological status (body composition, heart rate,
blood pressure, balance, dietary intake, hematological
biomarkers, and muscular function); cognitive abilities
(executive function tasks, neuropsychological interviews);
and psychological and social factors (personality, self-
concepts, social relationships, attitudes, and motivation).

5) University of California, San Diego,
School of Medicine, La Jolla, CA

Behavioral Choice Theory Approach to Testing
Exertainment for Adolescent Physical Activity

The effectiveness of a health game depends on both
the way the game is designed and on the environment
and context in which it is played. This study uses
Behavioral Choice Theory as a framework for
understanding how adolescents ages 11-15 choose
among various exertainment games on the Xavix
system. Xavix offers exertainment games that use sport
equipment controllers for tennis, boxing, bowling,
cardio-fitness, and other sports.

The study is first analyzing six Xavix games to identify the
behavior change principles that seem to be incorporated
into each game. Then, in a laboratory study, the study
will observe adolescents’ physical, emotional, and verbal
interactions with Xavix games and will associate them
with the behavior change principles that were previously
identified. And finally, a field experiment will test whether
Xavix in the home leads to sustained physical activity
over a three-month period, comparing behavioral and
health outcomes that occur with several types of Xavix
games. The study will assess the frequency, intensity,
and duration of physical activity, using accelerometers
and data collected and stored by the Xavix system. Also
measured will be BMI, sedentary behavior, self-efficacy,
amount of game use, gender, and home environment
characteristics.

6) University of Central Florida, College
of Medicine, Orlando, FL

Practicing Relapse Prevention in Artificial-Reality
Environments [PREPARE]: A Game-Based Therapy
Maintenance Tool

This project uses electronic games to provide a
motivating practice environment for people diagnosed
with alcohol abuse or dependence and who are
currently undergoing treatment for their addiction. The
games are designed to help them acquire and maintain
relapse avoidance skills, using the Relapse Prevention
(RP) model, a cognitive-behavioral approach used in
the treatment of substance use disorders. The training
literature suggests that almost every new cognitive skill
degrades over time unless appropriate practice and
feedback are provided. Current therapeutic practice
provides little, if any, opportunity for patients to practice
newly acquired skills in a safe, realistic environment.
This study applies the RP model in a suite of mini-games, each targeted to reinforce a specific competency from the model. The games will ultimately be available to players within a larger Massively Multiplayer Online Game (MMOG) that has a realistic, compelling story line. The study will evaluate both the near- and far-transfer efficacy of the games.

A 12-week, randomized, controlled trial with 4-week follow-up will evaluate the RP game plus treatment as usual (TAU) for people with alcohol abuse or dependence, versus TAU alone. The primary outcome measure will be time to relapse as measured by the Time-Line Follow Back, a calendar-based instrument for assessing alcohol consumption by self-report. Cumulative number of days abstinent, percent drinking days, percent heavy drinking days, and drinks per drinking day will also be assessed. Laboratory measures will include breath alcohol level, carbohydrate-deficient transferrin, and liver function tests. Secondary outcome measures will include reduction in craving, treatment adherence, reduction in use of other substances, attitudes towards treatment, knowledge of RP skills, and changes in task-specific self-esteem for RP behaviors.

Individuals in the treatment group, as compared to the control group, are expected to: (1) have fewer relapses and longer times to relapse; (2) be more likely to complete the formal treatment program and follow-up appointments; and (3) have greater task-specific self-esteem for RP behaviors, more positive attitudes toward treatment, and greater knowledge of targeted skills.

This study leverages the University of Central Florida’s recent successes in embedding lightweight mini-games into larger, more immersive MMOG environments. With this technique, appealing game content is developed at a very low cost. Furthermore, this design approach and the study results are expected to have wide applicability to other treatment domains, in keeping with a trend toward using computer-assisted therapy in the substance abuse field.

7) University of Florida, Gainesville, FL

Action Video Games to Improve Everyday Cognitive Function in Older Adults

This study is investigating effects of an action-adventure driving video game, Crazy Taxi, on the visual attention performance of a group of community-dwelling older adults, an understudied population in the field of games. Players must navigate in the game through an urban environment, attending to speed and roadway features. Three randomly-assigned groups of participants are being studied: (a) a group that plays the Crazy Taxi action video game, (b) a group that uses a traditional visual attention training program, and (c) a no-contact control group.

The study has four specific aims. It will evaluate changes in video game play skill among players; compare improvements in visual attention performance; assess secondary benefits involving cognitive speed and cognitive components of everyday activities; and investigate participants’ engagement and perceived flow, as indicators of potential compliance with the training and effort expended during training.

8) University of North Carolina, Chapel Hill, NC

Presence: Predicting Sensory and Control Effects of Console Video Games in Young Adults

Two studies are investigating people’s motivations to expend energy during video game play, in a comparison of traditional and active video games played on home consoles such as PlayStation 3 or the Wii. Traditional video games use a game controller (a standard game controller or the Wii motion-sensing controller) as the interface to the game, and active video games require physical movement – beyond pushing buttons on a game controller or turning the wrist with the Wii motion-sensing controller – in order to interact with the game, using inputs such as a dance pad, balance board, or guitar.

The research focuses on presence and intrinsic motivation. Presence is the perception of actually being in a game environment, and the amount of presence a game player perceives is influenced by control, sensory, distraction, and realism factors. Intrinsic motivation is the desire to do something for its own sake, and not for external rewards. Both presence and intrinsic motivation have been found to increase the amount of time players spend with interactive games, but these two factors have never been measured and studied in order to predict an increase in energy expenditure in an active game that requires the player to move in order to play.

Two conditions that are expected to influence players’ feelings of presence and intrinsic motivation for game play, and may therefore lead to more energy expenditure in an active video game, are (1) type of game controller and (2) the perspective of the player. The first study
uses traditional video games to observe effects of game controller (traditional game controller vs. motion-sensing controller on the Wii) and perspective (first person vs. over-the-shoulder) on feelings of presence and intrinsic motivation for play, and also on energy expenditure. The second study observes effects of four active video games (using active controllers including guitar, drum, dance mat, and balance board) on presence, intrinsic motivation for play, and energy expenditure, to identify the controller that contributes to the most energy expenditure and to compare these games to the traditional games in the first study. Study participants are men and women ages 18-35. Primary outcomes are perceived presence and intrinsic motivation (measured by questionnaires) and energy expenditure (measured by indirect calorimetry and accelerometry). The findings are expected to lead to design principles aimed at making traditional games more active and making active games more compelling.

9) University of South Carolina, Columbia, SC

Commercially-Available Interactive Video Games for Individuals with Chronic Mobility and Balance Deficits Post-Stroke
About 5.7 million people in the US are living with long-term chronic effects of stroke and more than half of them have residual movement disabilities, including reduced mobility, reduced balance, and increased risk of falling. There is a need for innovative, economically feasible interventions to help patients overcome these problems.

Interactive games that display a realistic virtual environment on the screen – requiring the player to simulate real-world events and movements, by moving their body or manipulating objects as they might in real life – may offer a low-cost and effective approach. However, only a few studies have investigated effects of virtual games like these, and most of them have focused on motor recovery of upper extremities; only two have focused on lower extremity movements and overall balance following stroke.

This randomized study of individuals who have chronic motor deficits following stroke investigates effects of commercially-available video game systems (Wii and EyeToy) on players’ mobility, balance, and fear of falling, and it compares the effectiveness of the two video game systems.

10) University of Southern California, Los Angeles, CA

Effectiveness of Social Mobile Networked Games in Promoting Active Lifestyles for Wellness
Wellness Partners is a game that uses cell phones and the web to provide a character-driven social game that uses elements from virtual pets, role-playing games, and online social networking to motivate real-world wellness through a player support system that consists of family members, domestic partners, and friends. This networked game offers a single player experience with a fictional game character that offers encouragement, reminders, progress checking, and it also offers communication with others. Players have the option to enlist members of their social network to be partners or helpers, to provide additional encouragement, community, and support. Players are rewarded with new character abilities, attributes, and props in the game environment if they complete quests and help others.

To assess the effectiveness and relative advantages and disadvantages of mobile social games in lifestyle change programs, the study’s methods include iterative play testing, a field experiment, and a survey. The study hypothesizes that a social game intervention will increase physical activity and perceived wellness more than a traditional lifestyle change program. The study is investigating the feasibility of a cross-gender, intergenerational social mobile game for lifestyle change and ways in which players respond socially to the game play experience, and it assesses the effectiveness of common social game reward mechanisms for initiating and sustaining healthy behaviors. It is studying factors that contribute to the game’s influence on physical activity and perceived wellness, such as intergenerational diversity and cooperation, players’ rates of interaction with other players, the diffusion of attitudes among players in the game network, the influence of game reward mechanisms and other game mechanics, how players recruit new players, who the players choose as their partners or helpers, whether the partners enroll in the game, and the activities players engage in with other players and how much they interact with each other.

Theories tested in the research include Social Network Theory, Social Support Theories, Diffusion of Innovations, Interdependence Theory, and Social Cognitive Theory.

Social mobile play can enhance the game player’s experience and invite more players to enjoy the games together as a community. The Wellness Partners game
is designed to broaden participation and to investigate players’ preferences and relationships while they improve their lifestyle behaviors. The study is investigating asynchronous and appointment-based game mechanics, social play for cell phones and the web, and the efficacy of an intergenerational network of existing ties and indigenous natural helpers (family, domestic partners and friends).

11) University of Vermont, School of Medicine, Burlington, VT

Breath Biofeedback Video Game [BBVG] for Children with Cystic Fibrosis
In this study, the research team is developing a breath controller and game software that combine into a breath biofeedback video game (BBVG) for young patients with cystic fibrosis (CF). The game, designed on the basis of Self Determination Theory, is intended to create an environment of self-determination regarding breathing awareness and related health behaviors, and its goal is to improve patients’ self-management and fitness by increasing (1) efficacy and adherence in self-administration of inhaled medicines, (2) engagement with respiratory exercises, and (3) awareness of respiratory status.

In collaboration with the target user group, the team is designing a novel, breath-controlled fitness video game that embodies design principles consonant with players’ need for autonomy (movement, practice, feedback, goal-oriented, progressive difficulty, distributed knowledge, and situated learning). A controlled field trial is now testing the hypothesis that, by providing interesting breathing challenges and visual feedback, a BBVG game can meet CF patients’ needs for autonomy/self-determination, concurrently increasing their engagement with breathing exercises and their adherence to self-administered inhaled medications. The observations and measures gathered in this study will make it possible to assess game design principles intended to support positive health behaviors, attitudes, and breathing patterns in this clinical group.

By improving patients’ awareness of their own respiratory mechanics, BBVGs are expected to foster the breathing muscle coordination needed to inhale medications, and improve detection of exacerbations of their disease (self-management). These outcomes are expected to increase the efficacy of inhaled medications and to increase patients’ participation in their own health care, keeping them healthier for longer periods of time. In the future, BBVGs may also have value for children and adults with asthma and other forms of chronic obstructive pulmonary disease.

12) University of Washington, School of Medicine, Seattle, WA

Video Games for Dietary Behavior Change and Improved Glycemic Control in Diabetes
Only about one-third of patients with diabetes are currently achieving satisfactory glycemic control, yet it has been known for over a decade that tight, excellent glycemic control reduces the rate of diabetic complications and slows their progression. With the prevalence of diabetes in the U.S. at 6.3 percent and on the rise, the development of innovative and cost-effective interventions to improve glycemic control is a critical national priority.

This study develops and tests educational video games to improve glycemic control in patients with Type 2 Diabetes. The games are built on the USDA Food and Nutrient Database for Dietary Studies (version 2.0), which the study team is extending to include photographs of common foods. After a period of user-driven design, a randomized controlled trial is investigating whether the video games improve glycemic control and decrease glycemic variability in patients with diabetes. The games are hypothesized to improve glycemic control by increasing the precision and accuracy of carbohydrate estimation and by reducing dietary energy density.

In addition to measuring clinical outcomes, web analytics and qualitative methods are being employed to explore two game design strategies: tailoring and tethering. Tailoring involves customization of game play toward the player’s unique nutritional goals and dietary preferences. Tethering embeds the educational task within the game play of a simple mini-game.

VII. Conclusion and a Look to the Future
This white paper has provided theories, research evidence, and design strategies that together comprise a well validated approach to the design of effective health games. In addition to the design choices made by the game development team, the process of game design...
should constantly involve the gathering and integrating of evidence. Game development teams should include experts in the subject area, in behavioral health, and in the needs and abilities of the game's target population, bringing the evidence of these fields to the table. Also, early versions of a game should be well researched in pilot testing during formative stages of development, with revisions made on the basis of pilot test results, and then after completion the game should be evaluated in the field to make sure it is appealing and effective.

Health games need not stand alone as health messages and health interventions. They can be integrated into health campaigns that use a variety of media and face-to-face approaches. Games could be made simply to attract people to a website or to reinforce a message that is covered in greater depth via other means. Or, a game could be the central activity of a campaign, with links to more information, to other media, and to other people who could provide advice, care, or support. This way, the game could be a springboard that launches the player into related activities.

The fields of behavioral health, tele-health, disease management and health communication provide many reasons why it would be especially effective to incorporate the player's current health status into a health game. For example, if the player's goal within a health game is to nurture a character who has a prevention goal or a health problem, the player could download their own health data (such as BMI, blood pressure, lifestyle and prevention habits, chronic conditions, medications, family health history) and the character could then have the same characteristics within the game as the player does in real life. By playing the role of a virtual character who shares similar demographics, psychographics and health status, a gamer will be interacting and engaging with their own health issues and learning about choices that lead to improved health outcomes.

Research on today's health games provides clear evidence that games can improve health behaviors and in so doing can improve health. The findings of the Health Games Research grantees, and of many more health games researchers throughout the world, are investigating essential issues and are developing impactful design principles that will raise the quality and effectiveness of health games. There is much more to be studied and developed in this field and the technology is opening new possibilities every day.

About the Authors

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