BEHAV ANALYST (2014) 37:25–40
DOI 10.1007/s40614-014-0006-1

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Association for Behavior Analysis International

ORIGINAL RESEARCH

Gamification: The Intersection between Behavior Analysis and Game Design Technologies

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Published online: 29 April 2014

Abstract Deterding et al. (*Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, USA* 15: 9–15, 2011) report a recent rise in popularity of video game inspired software designed to address issues in a variety of areas, including health, energy conservation, education, and business. These applications have been based on the concept of *gamification*, which involves a process by which nongame activities are designed to be more like a game. We provide examples of how gamification has been used to increase health-related behavior, energy consumption, academic performance, and other socially-significant behavior. We argue that behavior analytic research and practice stands to benefit from incorporating successful elements of game design. Lastly, we provide suggestions for behavior analysts regarding applied and basic research related to gamification.

Keywords Gamification · Games · Game design · Behavior analysis · Innovation

Many enduring problems we face as a society require innovative solutions. A few examples include diseases that result from behavior excesses such as overeating or deficits such as physical inactivity, deficits in educational outcomes, and changes in our climate and the overuse of natural resources. While these problems are undoubtedly multifaceted, they are behavior problems at their core, and behavior analysts are poised to make contributions in these areas (cf. LeBlanc et al. 2013; Poling 2010). To address these problems, it may benefit behavior analysts to use, and contribute to, innovative developments created by professionals in other disciplines.

A series of developments have emerged (Deterding et al. 2011; Wingfield 2012) which represent one possible innovation to address social issues. This series of developments, which we collectively label as *gamification*, refer to efforts to redesign life activities by drawing inspiration from methods in game design (Deterding et al. 2011; Kapp 2012). Some of these activities include socially-significant behavior change such as improving health-related behavior, decreasing energy use, and improving technologies for teaching and learning. The notion of redesigning everyday activities by drawing inspiration from game design has not gone unnoticed in behavior analysis. For example, Skinner (1984) commented on how video games are excellent examples of contingency programming, in that players interact with an arrangement of contingencies where their behavior is guaranteed to be reinforced, contacting salient and immediate consequences—players are almost guaranteed to be successful when they play a video game. Skinner mentioned how other aspects in our lives could be similarly designed, stating, "No one really cares whether Pac-Man gobbles up all those little spots on the screen…What is reinforcing is

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successful play, and in a well-designed instructional program students gobble up their assignments" (p. 952). More recently, McGonigal (2011) has likewise recognized how we might capitalize on the success of games to address significant societal issues, stating, "If we take everything game developers have learned about optimizing human experience…I foresee games that fix our educational system. I foresee games that treat depression, obesity, anxiety, and attention deficit disorder…I foresee games that tackle global-scale problems like climate change and poverty." (p. 14).

While the term gamification did not begin to rise in popularity until 2010 (see Fig. 1), the basic concept of gamification has been around for much longer (see Coleman 1971 for a discussion of using games in an academic context). Although we use the term gamification in this paper, other terms have been used in relation to gamification such as serious games (Thompson et al. 2010), persuasive games (Bogost 2007), and alternate reality games (McGonigal 2010, 2011). Figure 1 depicts data from Google showing the increasing interest in gamification in relation to these three terms from January 2004 to December 2013.

Deterding et al. (2011) define gamification as "the use of game design elements in nongame contexts" (p. 10). Deterding et al. differentiate between "games" and "play," and in so doing distinguish between "gamefulness" and "playfulness"—terms that describe, respectively, the behavioral topographies that distinguish games and play. Thus, to Deterding et al., "gamification" refers to designing nongame activities using game design elements to bring about behavior that could be described as "gameful." Behavioral, analytically speaking, gamification is a way to engineer the real world by arranging contingencies to bring about game-playing (i.e., gamefulness) in a context in which game-playing does not normally occur (e.g., grocery shopping or exercising).

According to Deterding et al. (2011), game-playing behavior can be brought about by using a combination of five levels of game design (i.e., five game design elements), which are depicted in Table 1. Starting at the top of the table, the levels move from molecular elements (e.g., using particular schedules of reinforcement) to molar elements (e.g., conceptual models and overall strategies) of game design. The first, *game design interface patterns*, refers to elements of game design that address what the player would see directly on a screen (i.e., the user interface), the elements players would directly experience in nonelectronic games (e.g., the field size in a soccer match), and the ways in which the players interact with those elements. Badges and leaderboards are examples of interface patterns, which are visual indications of particular achievements (e.g., recruiting a character to join your cause in a game with a story). Leaderboards are visual indications of players' ranks with respect to one another. Second, *game design patterns and mechanics*[1] refer to game elements the player directly interacts with. However, unlike game design interface patterns, game design patterns and mechanics are reoccurring contingency arrangements players experience, rather than visual elements with which players interact. Elements include such things as storytelling, style of game-play (real time or turn-based), competition, cooperation, and character levels. The last three game design elements (game design principles and heuristics, game models, and game design methods, respectively) involve verbal practices on the part of the game designer. Game design principles and heuristics involve verbal behavior (cf., Mechner et al. 2013) used to resolve problems in game design. For example, in baseball one must go from first base to second, then third, and finally to home plate in that order. Game models refer to conceptual approaches used to understand players' game experiences, such as the Mechanic-Dynamics-Aesthetics (MDS) framework (see Hunicke et al. 2004) and the Core Elements of Game Experience (CEGE) framework (see Calvillo-Gámez et al. 2010). Finally, game methods refer to general strategies used to design games (e.g., user play testing).

In the following sections, this paper builds on Deterding et al.'s (2011) definition of gamification by offering a tentative functional definition of game-playing behavior, differentiating it from other classes of behavior. Following this definition, we provide several examples of how gamification has been or could be applied in the areas of health, environmental sustainability, education, business, and autism. A discussion regarding the relevance of gamification to behavior analysis follows, in which we identify potential collaborations between behavior analysts and game designers. Lastly, we highlight the use of gamification real-world

[1] In the game design literature, there is often discussion of *game elements* and *game mechanics* and the distinction between them is not always clear. For further discussion regarding these notions, see Elias et al. (2012), Hopson (2001, 2012), and Sicart (2008).

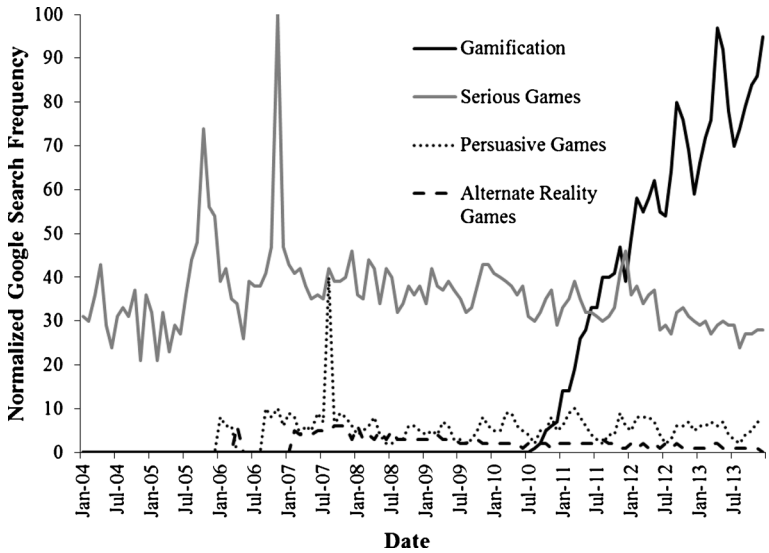

Fig. 1 A comparison of Google search frequencies (worldwide) of four different terms related to the notion of "gamification" from January 2004 through December 2013 (partial data). The data depict comparisons of the normalized frequency of searches for each term against the total volume of searches during that time period. A value of 100 represents the highest ratio among all compared terms during that period and a value of 0 represents that almost no searches were made for that term during that period. Data source: Google Trends (www.google.com/trends)

settings and conclude with suggestions for behavior analytic research.

Games: Topographical and Functional Dimensions

Archeological evidence suggests that structured games have been a part of human culture since at least 2600 B.C. (Avedon and Sutton-Smith 1971). Many researchers have studied the cultural practices of games and how they contribute to social endeavors (see Avdeon and Sutton-Smith 1971; Bogost 2007; Caillois 1958; McGonigal 2011; Raessens 2006; Roberts et al. 2009) and evidence suggests that play and games serve multiple uses in socializing children and preparing them for life as adult members of social groups. For example, Pellegrini and Smith (1998) reviewed the relevant literature and concluded that physical play serves to improve children's motor capabilities. Roberts et al. (2009) discussed the association between the complexity of strategy games and the complexity of social structure in different societies, suggesting that complex strategy games may teach children the repertoires they need to thrive in the complex social environments they encounter as adults.

More recently, games have been incorporated into electronic devices, making them easily accessible. As a $67 billion industry in 2012, and expected to grow to $82 billion by 2017, the video game industry outperforms both the music and movie industries (Global movie ticket sales hit record high 2008; Barnes 2011; Gaudiosi

Table 1 Levels of game design elements (reprinted with permission from Deterding et al. 2011)

Levels (game design elements)	Description	Example
Game interface design patterns	Common, successful interaction design components and design solutions for a known problem in a context, including prototypical implementations	Badge, leaderboard, level
Game design patterns and mechanics	Commonly reoccurring parts of the design of a game that concern gameplay	Time constraints, limited resources, turns
Game design principles and heuristics	Evaluative guidelines to approach a design problem or analyze a given design solution	Enduring play, clear goals, variety of game styles
Game models	Conceptual models of the components of games or game experience	Mechanics-Dynamics-Aesthetics (MDA) framework; challenge, fantasy, curiosity, game design atoms, Core Elements of Gaming Experience (CEGE) framework
Game design methods	Game design-specific practices and processes	Playtesting, playcentric design, value conscious game design

2012; Raessens 2006; Factbox: a look at the $65 billion video games industry 2011). McGonigal (2011) reported that 350 million people collectively play 3 billion hours of video games per week—an average of 8.6 h per person—and that the average 21-year-old today has accumulated over 10,000 h playing video games.

Definition of Game-Playing Behavior

Many have defined a *game* in terms of the behavior involved. For example, Caillois (1958) defined games as activities that include nonobligatory participation, spatial and temporal separateness (i.e., games occupy their own time and space separate from "real life"), uncertainty in the results of the activity, economic unproductivity, rules that limit behavior, and a second or make-believe reality. Suits (1967) defined games as engaging in activities in which a goal or state of affairs is accomplished through abiding by rules that limit the scope of one's activities (see also McGonigal 2011). Others have argued that it is unnecessary to define games (see Elias et al. 2012; Wittgenstein 1997). Here, we distinguish *game-playing* (as a class of behavior) from a game. We define the latter as the environmental system with which a player interacts (i.e., the contingency arrangement) that serves to bring about game-playing.

Below, we build upon this definition, and on Deterding et al.'s (2011) notion of gamefulness, by offering a tentative conceptual, functional definition of game-playing. We build such a definition using Tiemann and Markle (1991) framework for defining concepts such as games. According to Tiemann and Markle, any exemplar of a concept (e.g., the concept of a chair, or in this case, game-playing) must have all identified critical features, while also varying with respect to a number of noncritical features. Although a full conceptual analysis of game-playing is beyond the scope of this paper, here we introduce six critical characteristics of game-playing (see Table 2). For each characteristic, the table also summarizes its definition and provides an example for each (drawn from the examples of gamification below). Below, we discuss these six characteristics of game-playing.

Direct Impact on the Game Outcome and Results In games, players' behavior directly impacts the outcome of the game. Although there may be delayed consequences for one's behavior (e.g., losing a chess game due to a bad move made earlier in the game), consequences for players' behavior are typically more immediate. This feature of game-playing is sometimes accomplished through conjugate schedules, in which the magnitude of the consequence is directly related to the magnitude of the response (e.g., Morgan 2010). For example, in bowling, the twist put on one's wrist is proportional to the curve of the ball when rolling. While not inclusive in all games (e.g., board games), conjugate schedules are at least present in many sport-related games. Coleman (1971) recognized the importance of players' behavior directly affecting the outcome of a game, stating, "Games enable the student to see the consequences of his actions in his winning and losing…Seeing the consequences of one's actions in a game develops a sense of predictable and controllable environment" (pp. 324-325). Additionally, this characteristic of game-playing serves to distinguish between active participants in games (those engaging in "game-playing") and spectators of games. For example, players on a soccer team are engaging in game-playing behavior over the course of the match; however, those individuals watching the game (i.e., the spectators) are not.

Clear Goals and/or end Conditions The second critical characteristic of game-playing is that the player is able to specify a goal or end condition. These goals or conditions may either be set prior to the start of the game (e.g., in soccer, the team with the most points after 90 min wins), or develop over the course of play (e.g., friends saying, "The first to 5 points wins!"). Goals may either specify the end of all game activity (i.e., end conditions), or they may specify the end of only some activity in the game. In this case, the goals should be considered "sub-goals" given the behavior that aids progress towards that goal encompasses only some of all the behavior in the game.

Rules and Barriers The player behaves within a set of rules or barriers that restrict player response variability. Rules, as descriptions of contingencies, provide verbal restrictions on what the individual can and cannot do while progressing toward another game element, like a challenge or goal. For example, a rule may be that an individual must achieve 100 points to advance from Level 1 to Level 2. Players' behavior may also be contingency-shaped, and thus generate their own rules regarding the game without being explicitly told what those rules might be (e.g., in a video game, a player may

Table 2 A non-exhaustive list of game characteristics, their definitions, and examples for each

Characteristics of game-playing	Definition	Example from PowerHouse and Zombies, Run!
Direct impact on the game outcome and results	A player's behavior directly alters the characteristics of the outcome or the process of obtaining the outcome	Power usage affects in-game statistics (PowerHouse) Running earns supplies (Zombies, Run!)
Clear goals and/or end conditions	A player is able to verbally specify a goal within a game or the conditions under which the game ends	Reduction in energy consumption (PowerHouse) Gathering supplies and outrunning zombies (Zombies, Run!)
Rules and barriers	A player's behavior is restricted by rules (verbal behavior) or by physical barriers	Time frame for power usage assessments (PowerHouse) Distances need to be covered for supplies to be earned (Zombies, Run!)
Probabilistic outcome	The topography of the game outcome or process towards the outcome is probabilistic	Reduction not guaranteed as nongame factors may influence usage (e.g., snow storm, vacation; PowerHouse) Fitness level or injury may impact outcome of the run (Zombies, Run!)
Development of strategies and heuristics	A player can verbally evaluate the state of the game, and successive games played allows for the development of increasingly complex strategies (nonverbal) and heuristics (verbal) that may alter the probabilities of different outcomes	Heuristics related to temperature control (e.g., "Use more blankets at night and keep the heat down"; PowerHouse) Taking breaks from running to allow the body to heal and develop after working out (Zombies, Run!)
NonCoerced Initiation	A player's initiation and termination of the game occurs in the absence of coercion	Players must log in (PowerHouse) or activate the application (Zombies, Run!) to see outcomes

create a rule about how to defeat a particular enemy). Barriers, however, may physically restrict behavior with or without any verbal behavior connected to the contingency. For example, in a standard game of tic-tac-toe, an individual cannot place more than five X's or O's in any one game, as there are not enough spaces available.

Probabilistic Outcome All games involve elements of variability. Games vary with respect to the skills of the players, specific events that occur within the game, and the outcome of the game. While the goals and conditions that end the game need to be clear to the players (e.g., a typical soccer match ends after 90 min), the specifics of the game outcome, or the specifics of progress towards the outcome, are probabilistic. This kind of variability is related to the use of variable schedules of reinforcement and punishment for activities within the game. Given the outcome is probabilistic, players are unable to specify exactly how the outcome will look (e.g., the point spread or winner of a game).

Development of Strategies and Heuristics The player is exposed to conditions that allow for the development of strategies and heuristics that serve to: (1) evaluate the state of the game (e.g., one's position relative to other players), and (2) alter the probabilities of different outcomes. Strategies in this case refer to patterns of responding that have resulted in a player accomplishing a goal or overcoming an obstacle in the game. These patterns may be verbal or nonverbal forms of responding. For example, a nonverbal strategy in baseball may be related to a batter's positioning as a result of contingency-shaping. Heuristics, however, refer to verbal rules that describe one's strategies (cf. Mechner et al. 2013). The variability previously mentioned, which is inherent to games, allows for the development of heuristics and strategies that alter the probabilities of different outcomes. The development of these heuristics is related to the concepts of problem-solving (Skinner 1953), creativity or induced variability (Neuringer 2003), and a behavior analytic account of heuristics (Mechner, et al.). In order to evaluate the effectiveness of these heuristics, players must also be able to specify their position with respect to the state of the game (e.g., by how many points they are ahead). For example, a chess player may analyze a player's moves in an effort to classify the opponent as novice, experienced, or expert. Once classified, the style of game must change to match that type of opponent.

NonCoerced Initiation A last distinguishing characteristic of game-playing is that the player may begin or end a game in the absence of coercion (see, Sidman 2000). A tentative clarification of this characteristic might be that a player plays the game because he "wants to," not because he "has to." This characteristic of game-playing involves arranging the contingencies such that the behavior required to begin the game is a highly probable sequence. For individuals with a history of reinforcement with games, starting a game is likely already a highly probable response. Individuals who have never played games before might experience coercive social contingencies making it more likely they will play the game (i.e., social encouragement or peer pressure). However, no behavior with respect to games can be considered game-playing until the player's initiation with the game occurs in the absence of coercion. If a player continuously starts or ends a game solely due to coercion from another, then that behavior would not function as game-playing despite its formal similarities. In these circumstances, the behavior that resembles game-playing reduces aversive stimulation provided by another person. For example, imagine a child whose parents coerce the child into playing soccer. Imagine as well that the child continues to play due to aversive contingencies arranged by his parents even when he reports hating the game. According to our definition of game-playing behavior, the child playing soccer would not constitute game-playing behavior, despite the fact that he is playing a game, as his initiation with the game functions only to reduce aversive stimulation provided by his parents.

Maintenance of Game-Playing Behavior

In addition to describing the characteristics of game-playing, it is important to note potential variables responsible for the maintenance of game-playing behavior once it occurs. While such an analysis will require extensive empirical investigation, here we offer several suggestions as to the variables that may be involved.

Novelty Many games, especially video games, are designed on electronic platforms with the ability to offer novel stimulus presentations throughout one's game-play experience. In a video game with a story, for example, one will constantly experience new environments, new dialog, new characters, new items, and new abilities for their character. It is possible that variability in reinforcer presentations in games can serve to maintain responding. Evidence from the behavior analytic literature suggests that variability in reinforcer presentations can function to evoke higher amounts of responding (Egel 1980), and increase percentage of on-task and correct responding on academic tasks (Egel 1981). It is also possible that such novelty in video games is related to progressive schedules of reinforcement (see Jarmolowicz and Lattal 2010) in that players emit progressively more behavior as they advance in the game, and as a result they gain access to novel elements of the game.

Cooperation and Competition A significant number of games involve some element of cooperation and competition, for example the majority of sports and board games. The social reinforcement that one contacts from interaction with others in games may serve the function of maintaining one's game-playing behavior. However, it is important to note that competition in games necessarily involves negative reinforcement—indeed almost all games involve elements of negative reinforcement (e.g., video games where players avoid damage or death). For some people, competition in games may function to maintain responding while it may function to decrease or eliminate responding for other players. Negative reinforcement that functions to maintain responding is differentiated here from coercion used to initiate responding. Initiation with a game is likely functionally distinct from maintenance of responding. In order for behavior to be game-playing, the player must not initiate due to coercion. However, once the player initiates, the maintenance of his behavior may occur due to negative reinforcement during the game.

Strategies and Heuristics Finally, players may maintain responding in games due to the increasingly complex strategies and heuristics that will likely develop as they play the game. Increasingly complex strategies and heuristics suggest an increase in the player's ability to control the game environment and its related elements, which may serve as a reinforcer for the player's game-playing behavior (see Schneider 2012; Skinner 1953). Strategies and heuristics also alter the probabilities of different outcomes in the game making it more likely one will win or lose, and thus providing more control over the game. For example, a player playing connect four may come up with a strategy to win against their friend that allows him to win a larger portion of the

games; the friend may then develop a method to counter the player's original strategy.

Examples of Gamification

We turn now to examine three areas of behavior change that are designed such that the behavior evoked by them more closely resembles game-playing: health and fitness, behavioral sustainability, and technologies for teaching. These topics are by no means exhaustive; rather, they were selected either because they demonstrate successful outcomes or because they serve as potential exemplars of gamification. Further analysis of game characteristics of each example could be conducted; however, due to space limitations, the characteristics will be applied to only one example in the following section, and two examples are used in Table 2 (Zombies Run! and PowerHouse).

Behavioral Health and Fitness

Given that the obesity rate exceeds 35 % in the United States (Ogden et al. 2012), improving individual levels of fitness and increasing levels of activity are of critical importance to our nation's health and well-being. Gamification has been used for this purpose, improving a wide variety of behavioral health-related outcomes (McCallum 2012). Gamification applied to issues related to health and fitness is possibly the most common area of application for gamification. Journals have been created dedicated to applications of games and technology to particular health issues (see the journal *Gerontechnology* as an example of one that focuses on technological solutions for lifestyle issues for older populations). Baranowski et al. (2008) reviewed 27 research and pilot study articles that used 25 different games to improve health outcomes including diet, physical activity, and self-management skills for individuals with asthma and diabetes. The styles of games included fast-paced activity games such as Dance Dance Revolution, and role-playing games where players take the part of a character in a story. An example of the latter is The Asthma Files, where the player takes on the role of a secret detective who discovers information about asthma self-management. All 27 articles reviewed reported improvements in measured outcomes; however, the maintenance of continued play varied by study. Baranowski et al. suggested that the critical factor underlying this difference was the inclusion of a story in the games.

Another application of gamification to fitness is the Zombies, Run! application (Six to Start 2012). Downloadable for android and iPhone, this app uses interactive storytelling and a variety of rewards to increase the frequency of users' real-world running. The rewards can be used to improve the living conditions for a virtual group of zombie-apocalypse survivors. With respect to the six characteristics outlined in Table 2, Zombies, Run! provides a clear example of each. Players have a direct impact on the game in that their actions help determine if their virtual community receives supplies. The more the player runs, the more he or she is able to collect the necessary supplies. Within each mission (i.e., run) is a clear goal, such as finding water or medical supplies which is achieved through running long enough. Furthermore, players can set their workout for sporadic zombie chases in which the player must run faster for a brief time to get away from the virtual zombie, in which the player is alerted through their headphones or speaker. Rules are clear, in that one must cover a set distance to succeed. Barriers are most likely related to the individual's current running abilities, which also feed in to the probabilistic nature of the outcome. Strategies and heuristics relate directly to the goals, such as "I need to run faster when the zombies chase me so I can live." Additional heuristics may relate to overall fitness strategies such as "Taking a day off once in a while permits me to run even further when I start up again." Finally, the application is only in effect when the player opts in, meaning the player has to physically start the application with each run and is thus noncoercive.

The Zombies, Run! application has a real-world counterpart called The Zombie Run (The Zombie Run, n.d.)—a 5-km obstacle race in which participants take part as either a zombie or a human. Similar to a game of flag football, zombies are tasked with "killing" humans by stealing their flags while humans are tasked with completing the obstacle course while avoiding getting their flags stolen by zombies. Other efforts have also been made to redesign races to make it more likely people will participate (i.e., they have been gamified in some way). The Color Run, for example, is an untimed 5-km race that has dubbed itself the "Happiest 5 k on the Planet" (The Color Run, n.d.). Racers wear white shirts and are doused in different colors every kilometer. The Color Run is the largest 5 k event, with over 600 k

finishers in 2012 (Hamilton 2013), and in which over 60 % of the runners in 2012 raced their first 5 k. Since the introduction of The Color Run, 543 national color runs have been created (Who else wants a list of all the color runs? 2013).

Similarly, Fitocracy is a social website designed to encourage, promote, and make fitness more fun. With features similar to Facebook and Twitter, users can add friends, follow other users (to see their activity), and participate in discussions. Unlike Facebook and Twitter, however, users have the ability to track, log, and post a variety of fitness activities including walking, running, swimming, weight lifting, dancing, and horseback riding. Users earn points for workouts, gain levels when a certain number of points are earned, and earn achievements or badges (visual indications of particular accomplishments) for social and fitness activities.

McGonigal (2011) provides another example of gamification that can be used with respect to psychological health. She created a game, SuperBetter (http://superbetter.com), which helped her recover from and cope with a concussion she suffered in the summer of 2009. SuperBetter is a superhero themed game that the user plays in real life, not digitally. As part of the game, the player creates a superhero alias, recruits friends and family who help the player (allies), and identifies opponents he or she fights throughout the game (anything that gives the player trouble or makes them feel worse). The game also requires players to identify "power-ups," or activities and skills the player can still do well despite their injury. Lastly, the player creates a list of goals with a varying range of difficulty. Thus, the game focuses on helping the player cope with their injury or impairment (e.g., depression, anxiety) and improve her quality of life by using her allies (i.e., friends and family), focusing on activities the player can still accomplish, and self-generating both short-term and long-term goals. For example, when encountering temptations to eat high-caloric foods while stressed, someone striving for better weight management may earn bonuses by drinking water and taking a walk around the block while "battling" an opponent based on those temptations (e.g., eating cookies). The battle is placed within a larger context of weekly to biweekly goals, such as fitting into an old pair of jeans.

Environmental Sustainability

The need to alter behavior related to climate change has been recognized by both climate scientists (Hansen and Sato 2012; Thompson 2010) and behavior analysts (e.g., Alavosius and Mattaini 2011; Chance and Heward 2010). Although the potential dimensions of behavior changes are broad (including behavior such as driving, recycling, composting, and consumer behavior), up to this point gamification for behavioral sustainability has focused primarily on energy conservation. Several publications (e.g., Bang et al. 2006; Reeves et al. 2011) describe an ongoing research project at Stanford University called PowerHouse—an online game designed to decrease energy usage in individuals' homes. PowerHouse connects with individuals' utility providers and tracks energy usage in the home. The program consists of a number of mini-games one can play that simulate real-world scenarios (e.g., running multiple home appliances at once), and users can play virtually to manage their actual home energy usage. Users can also see a dashboard that graphically depicts the last 24 h of real energy usage in their homes, users' in-game statistics, profile icons, and competition scores with other players. Gustafsson et al. (2009) describe a similar project called Power Agent, developed in Sweden. Empirical results regarding these projects have yet to be published.

Many companies have used gamification to change behavior related to energy conservation. Kuntz et al. (2012) describe a company, Cool Choices, which designed a mobile application to create lasting behavior change related to electricity conservation, water conservation, and driving efficiency. The game was piloted with teams of employees over the course of 6 months. Individuals earned points for posting photos and stories about their actions, and the number of points earned was based on the monetary savings of the activity and the difficulty of the task. Cash prizes were provided for individuals and teams with the highest scores. The authors report that Cool Choices is projected to reduce electrical, water, gasoline, and natural gas consumption. In line with Nevin's (2010) advice, "think locally, act locally" (p. 191), Cool Choices has created an interactive platform with salient programmed consequences for individual actions and group performances, while simultaneously leveraging the power of social contingencies.

Gamification has also been applied in the context of energy savings by companies partnering with electricity providers. Opower is one such company that partners with utility companies to promote energy efficiency. Power and utility companies are under pressure from states to meet particular conservation requirements (Redmon 2012), and Opower has developed an energy

solution called Behavioral Customer Engagement that they sell to these companies. Opower provides companies' customers with detailed home energy usage reports and allows utility company customers to compare their home energy usage against all other users, compete against others individually or on teams, and to join challenges and win prizes based on their performances. In their first 5 years of operation (2007–2012), Opower users collectively saved over 1 billion kWh of electricity, which is equivalent to over $120 million (Redmon 2012).

Greenify (Lee et al. 2013) is an online social platform developed by The Institute for Sustainable Communities at the Teacher's College at Columbia University that aims to foster sustainable communities. The platform has been designed to address three elements of sustainable communities: a healthy climate and environment, social well-being, and economic security. Greenify challenges users to create and accomplish missions related to changing energy, food, consumption, home, and transportation practices. Users earn a number of rewards for successfully completing these challenges—including points, badges, and character upgrades. Users also take part of a social network that incorporates social contingencies such as those found on Google+ and Facebook. Players' actions and outcomes are visible to other players and players may take part in group missions with other players. Lastly, players receive a virtual currency for successfully completing missions and challenges. These points may be used at local retailers, connecting ones actions in the application to the local community.

Technologies for Teaching

There are significant challenges in helping students in the United States and abroad to obtain proficiency in both reading and mathematics abilities (Peterson et al. 2011). An example of gamification in education is the computerized reading program MimioSprout (formerly known as Headsprout Early Reading and Headsprout Reading Comprehension programs). MimioSprout guarantees that a nonreader or beginning reader will read at a first grade reading proficiency in fewer than 30 h of individualized online instruction (Mimio, n.d.). In MimioSprout's programs, many of the learning sequences are presented in a game context, where each level increases in difficulty based on the student's performance. Students can progress through the program with minimal adult supervision. Students receiving both MimioSprout and traditional reading instruction outperform students who receive only traditional reading instruction. A randomly selected group of first graders at one New York public school received 30 h of supplemental MimioSprout training and performed 0.35–0.75 grade levels higher on standardized tests than students who received traditional instruction only (Mimio 2012).

Gamification has been applied to skills such as remembering and problem-solving for both younger and older populations. The computer program Lumosity incorporates games designed to improve recall, problem-solving, cognitive flexibility, response speed, and attention (Lumos Labs, n.d.). For example, Hardy et al. (2011) utilized Lumosity's programs for training visual attention (i.e., responding to complex stimulus arrays) and working memory (i.e., recall or matching to sample). The study utilized a pre-post group design with random assignment ($n=14$ for the experimental group, and $n=9$ for the control group) in which participants were given four cognitive assessments measuring visual attention, forward and backward special working memory, and letter memory. The first assessment required participants to focus on a central stimulus (black dot) on a screen while another stimulus appeared in a random location within 120 to 600 pixels of the central stimulus. Following this presentation, the participants had to click in the location they saw the presented stimulus. In the spatial working memory, assessments participants observed light blue blocks turn dark blue in a particular order, then were asked to click on the blocks in the order that they turned blue (forward task) and the reverse of the order in which they turned blue (backward task). The final assessment had participants observe letters appear in a particular order, and then type those letters again in the order in which they appeared. All assessments measured number of correct trials in both pre- and post-assessment phases. In training, participants were exposed to a 20-min training of Lumosity programs every day for 5 weeks. Participants in the control group were waitlisted and not exposed to the Lumosity games. Pre-post comparisons for the experimental group result showed significant differences ($p<0.05$ for all but the letter memory assessment) and effects sizes larger than 0.50 for all but the letter memory assessment. Effect sizes for the experimental group were higher for three of the four assessments when compared to those of the control group. A similar study found significant improvements when participants were exposed to

Lumosity's games for cognitive flexibility, verbal fluency, and processing speed (Kesler et al. 2013). Certainly, more research is needed to assess the generalization of skills enhanced through Lumosity and other similar programs; however, preliminary data indicate the potential for low-cost educational tools to be disseminated.

Gamification has also been applied to the design of school curricula. Quest to Learn is a public charter school in New York City for 6th through 12th grades (Corbett 2010; Quest to Learn, n.d.). The school is a project initiated by the Institute of Play, and supported by funding from the MacArthur Foundation and the Bill and Melinda Gates Foundation. Students learn the traditional material one learns in middle school through high school, but with a variety of nontraditional methods. First, students do not earn grades based on performance, but rather they earn numerical levels[2] that indicate how far a student has progressed in a particular topic. Instead of midterms or final exams, students fight boss levels—weeklong capstone projects where students work in teams to solve novel problems requiring their combined skills. Lastly, instead of assessing students' abilities using traditional quizzes, Quest to Learn assesses students' abilities by requiring students to teach a digital character (called a *teachable agent*) how to solve problems in different subjects.

Lastly, there are efforts to apply gamification to second-language learning. Duolingo is a free online language learning program available on mobile and desktop platforms that teaches six languages with plans to add upwards of 50 languages (Olson 2013). The program was designed with the goal to translate the entire web into different languages (Von Ahn 2011) by crowdsourcing individuals learning other languages, and to make language learning more fun for those individuals. Crowdsourcing is a method of recruiting voluntary participants online. This method of recruiting participants affords researchers the ability to attract a massive number of research participants. Each language is arranged in a series of levels composed of multiple lessons that build on previous material. Duolingo provides students a visual indication of their progress by way of a graphic depicting which levels they have completed and which they have not, information regarding how many words they have learned, and an indication of their progress in relation to friends linked from social websites. Students also earn points for completing levels and are provided opportunities to practice their language skills by translating websites and articles linked through Duolingo's main page.

[2] Levels are earned by accumulating a set number of points for each category of activities.

Other Examples of Gamification

The previous domains of application demonstrate more popular areas of gamification. However, gamification has been applied to a variety of other contexts as well. Several companies have used gamification for both employees and customers. Microsoft developed a program called *Ribbon Hero* that gamifies the process of learning how to use Microsoft Office suite (Bunchball 2012). Gamification has become so popular in business that there are now consulting companies that focus entirely on developing gamification solutions for clients. Bunchball is one such company, offering gamification solutions to retain customers, increase sales, and improve employee productivity.

Some behavior analysts might be interested in discussions of the potential use of games and digital technologies in interventions for autism spectrum disorder (ASD). Ferguson et al. (2012) participated in a roundtable discussion regarding the role of screen-based technologies (SBTs) and virtual reality technologies (VR), including television and videogames, in treating individuals with autism (see also Parsons and Cobb 2011). The participants of the roundtable suggest that such technologies offer the ability to provide these individuals with a more controlled environment with which to interact, and might be useful in addressing issues of generalization of learned skills. Preliminary research using exergames to increase physical activity and decrease repetitive behavior among individuals with autism has been shown to be effective (Anderson-Hanley et al. 2011). While SBTs and VRs do not necessarily involve elements of game design, interventions for ASD combining game design elements and virtual environments may prove to be effective.

Behavior Analysis and Game Design

Gamification has been influenced by a wide variety of work in psychology (Kapp 2012; Zichermann and Cunningham 2011). For example, Bang et al. (2009), in discussing learning processes related to game design, commented that:

> More recent research on behavior modification has suggested that behaviors can be controlled by adjusting the antecedents or the consequences of an action. That is controlling the possibilities for a person to take a certain action or controlling the feedback of an action. (p. 2)

In addition, two books describing aspects of gamification (Kapp 2012; Zichermann and Cunningham 2011) list four schedules of reinforcement (fixed ratio, variable ratio, fixed interval, and variable interval) as critical components of gamification design and human motivation driving why people play games, though their accuracy in describing the schedules varies. For example, Zichermann and Cunningham do not specify that interval schedules are response dependent, instead confusing them with fixed time and variable time schedules. Even though the accuracy of descriptions of behavior analytic principles varies, it is clear that games are successful even with their current linguistic taxonomy.

Behavior analysis might be able to assist game designers in sorting out conceptual and analytical frameworks to improve gamification. In the context of applied behavior analysis, Baer et al. (1968) stated that the practices should be conceptually systematic. They argued that a bag of tricks is transformed into a discipline by maintaining a technically precise vocabulary, a precise description of one's procedures, and keeping those procedures tied to basic research. Similarly, in game design, Hopson (2001) argued that behavior analysis offers a linguistic framework for understanding how the contingencies arranged in games affect players' behaviors. Hopson (2012) pointed out that in game design, contingencies counterproductive to the goals of the discipline are sometimes arranged, making a game less fun for the player. Having an improved understanding of basic principles of behavior and adopting a more conceptually systematic framework might allow for more effective identification of successful gamification strategies.

Successful games (i.e., those that bring about game-playing) could be analogous to the concept of behavior traps (Alber and Heward 1996; Baer and Wolf 1970), in which game designers are concerned with keeping players engaged in the game in the same way that educators are concerned with keeping children engaged with academic material. The concept of a behavior trap describes a set of natural contingencies of reinforcement, which in order to contact, require only a functionally distinct yet easily emitted response on the part of the organism. The set of contingencies that make up the "trap" function to shape and maintain skills targeted by those contingencies. Alber and Heward (1996) also suggest that behavior that occurs as a function of behavior traps is less sensitive to effects of satiation, thus making them ideally suited for educational tasks in which prolonged engagement is lauded. Behavior traps may be related to the sixth characteristic of game-playing—noncoerced initiation. In behavior traps, the individual's response to initiate the trap is emitted in the absence of coercion and the response is relatively low effort. Games that successfully bring about game-playing are similarly designed, in that the initiation with the game occurs in absence of coercion and the initiation response is usually low effort, and natural contingencies in behavior traps may be similar to those present in games that successfully evoke and maintain game-playing behavior. For example, in any video game with a story, once a player starts the game, the contingencies surrounding the game in addition to the story may serve to keep the player engaged for hours—i.e., the player becomes trapped.[3]

Perhaps of more interest to the behavior analytic community is what the field of behavior analysis stands to benefit from game design; the analysis of game-playing provided earlier and Table 2 represent a preliminary effort towards tying games to behavior analytic principles. In addition to Deterding et al.'s (2011) description of game design elements, game designers have described in a number of other resources strategies they use to design successful games (see for example Björk and Holopainen 2005; Crumlish and Malone 2009; Fullerton 2008). Further analysis of these design elements may allow behavior analysts to more clearly describe the process by which game designers arrange contingencies in games to make game-playing behavior more likely.

Behavior analysis might also benefit by observing more general examples of how everyday activities could be redesigned, and consider how those redesigns relate to behavior concepts and principles. For example, Volkswagen (The Fun Theory, n.d.) has posted online videos demonstrating ways in which everyday activities could be redesigned—though these examples do not necessarily constitute games. The most widely viewed

[3] This might be akin to one becoming "absorbed" in a good book—once you start reading you cannot put the book down.

example is their musical piano stairs, in which they turned the stairs of a Swedish subway station into musical piano keys (both by sound and by appearance). The frequency with which individuals took the stairs instead of the adjacent escalator increased by 66 %. Another example from Volkswagen is the bottle bank arcade. In this arrangement, a recycling bin designed to look similar to an arcade game was placed on a public street. People walking by could recycle bottles by placing them in one of six circular holes, each of which had a light above it. If the light for a particular hole was lit, and users placed their bottles in the corresponding hole, they would earn points posted on a display board. In a 1-h period, over 100 people used the arcade, and in the same period a nearby conventional recycling bin was used only twice. While the piano stairs and recycling bank arcade are not necessarily examples of fully fledged games, and do not meet the standards of experimental rigor typically expected in behavior analytic research, they are both intriguing examples of how conventional activities might be redesigned.

Behavior analysts might also benefit from the application of gamification to research. For example, researchers at the University of Washington developed a multiplayer online game called Foldit in which users from all over the globe cooperate and compete with one another to develop models of protein structures by solving puzzles (Khatib et al. 2011). Since its initial release, Foldit has recruited nearly 230,000 players via crowdsourcing (Good and Su 2011)—the researchers arranged the contingencies in the game such that hundreds of thousands of people volunteered to play. Players are able to play Foldit without knowledge of the basic science behind the models. The researchers found that a community of users was able to create a more effective algorithm for solving complex protein folding problems than other previously published methods in the scientific literature. In effect, these researchers capitalized on users' creativity, problem-solving skills, and teamwork to aid them in addressing basic scientific problems. Such research methodologies, while not replacing the single-subject designs in behavior analytic research, may better allow researchers to replicate and extend research studies on a mass scale. Consider that in Foldit small variations between users could result in very large differences in outcomes. Behavior with respect to small variations could set the stage for highly-refined within-subject analyses given some crowdsourced task.

Gamification could also be applied to behavior analytic experimental preparations. It may help overcome the issue of having participants describe experimental arrangements as boring (Pilgrim 1998). The user interface and contingency arrangements typical of video games might also allow more flexibility in experimental tasks and stimulus arrangements. For example, recent studies have used an escalating interest task to study delayed discounting (Young et al. 2011; Young et al. 2013). The task involved a first-person shooter game where participants fire at targets on screen. The faster they fire, the lower the damage each shot does to the target (i.e., smaller, sooner reward), and the slower they fire, the more damage each shot does to the target (i.e., larger, later reward). This procedure, in comparison to others, allowed the researchers to assess changes in behavior as function of contingencies that changed quickly.

A Call to Research

Skinner (1984) suggested we take heed of the success of games. In the thirty years since his comments, game design has consistently improved and become even more successful. Gamification aims to take advantage of the popularity of games by redesigning everyday activities to beneficially impact peoples' lives. Given the amount of time spent playing games by people of all ages, it would behoove behavior analysts to consider games as an integral part of our cultural milieu—one that may have a positive impact on how we design and implement contingency management programs.

Research is currently lacking in key areas related to gamification. For example, little research has been conducted regarding the generality and maintenance of behavior change produced in games. In the literature regarding health and fitness, it would be useful to determine whether games are required to maintain improved physical activity, or if that behavior maintains in the absence of the game. The latter case might suggest that properties of the activity have acquired conditioned reinforcing properties, or that the activity has served as a behavioral cusp (Rosales-Ruiz and Baer 1997; see also Twyman 2011). In other domains in which gamification has been applied, research should focus simply on identifying the conditions under which gamification is effective.

Specific elements of games should be investigated regarding their effects on behavior—specifically the degree to which individuals prefer programs with various components and how well those elements maintain responding. Game elements here refer to design components of games (e.g., challenges, storytelling, character levels, etc.) rather than characteristics of game-playing. Some work has already been done in this area. Linehan et al. (2010) conducted several studies in which "challenges" in a game were defined as the number of trained relations in a stimulus equivalence procedure (two to five level relations), and they found that participants had lower percentages of correct responding when responding to equivalence classes with more stimuli. However, research with respect to other game elements is still lacking. Baranowski et al. (2008) suggested that storytelling might be a factor in the maintenance of behavior. Storytelling is a ubiquitous part of human culture, existent in movies, plays, music, books, games, and artwork, and yet how they maintain engagement has yet to be investigated.

Lastly, research could be conducted to clarify the characteristics of game-playing, and whether such an analysis is useful. There are examples of games that do not fit neatly into the list of characteristics listed earlier. For example, the game Candy Land does not promote the development of strategies and heuristics since the game is simple enough that any strategies and heuristics developed would likely be superstitious (i.e., you pick a card and go to the designated color). Some of the characteristics listed above may need refinement, or research may emerge suggesting that some characteristics should be removed or perhaps that others should be added.

Behavior analysts should consider additional publication outlets as means of disseminating their work. *The Games for Health Journal* is a relatively new journal dedicated to publishing work using games and gamification in relation to health conditions, including physical activity, dieting, asthma, and ASD. *Simulation Gaming* and *Games and Culture* are two others that may serve as outlets, depending on the nature of the work. Additionally, the open-access *Game Studies* journal may provide a means by which behavior analysts can offer additional analyses of game-related activity. For example, Medler (2011) analyzes the rewarding value of data derived from gameplay (e.g., achievements, cumulative data reports), which could benefit from a behavior analytic interpretation and potentially open lines of collaborative research.

Faculty interested in pursuing projects related to gamification may find support through the NIH's Small Business Technology Transfer (STTR) program. Appropriate projects are those with the potential to be commercialized and work toward improving human health. The STTR program requires a collaborative effort between a small business concern (SBC) and a research institution such that at least 40 % of the project is to be completed within the SBC and at least 30 % at the institution. Thus, the STTR requires a working relationship between faculty member and the SBC, which could be a game design company or any other relevant SBC. Specific details can be obtained at the NIH website.

The NIH Small Business Innovations Research (SBIR) program similarly supports research and development within business settings. The SBIR program allows small businesses developing technologies to maintain sole ownership of the intellectual property and this may be a crucial factor in selecting STTR or SBIR funding mechanisms. The focus on small business concerns supports economic development by companies not dominant in their fields (i.e., small businesses and start-ups). Both NIH programs spur commercially viable technologies developed via research and provide a source of funds for applied research and technology transfer.

Summary

In summary, games are a pervasive element of our culture and offer intriguing platforms from which to do behavior analytic work. Successful game design appears to align well with principles and concepts within behavior analysis. That humans collectively play over three billions hours of video games per week is strong evidence of this. We provided several examples in this paper to illustrate how game design is influencing interventions for socially-significant behavior change. Avenues of both applied and basic research integrating behavior analysis and game design exist, and it is likely that pursuit of these avenues would be mutually beneficial to individuals in both disciplines. It remains to be seen how our field will develop in the next few decades. Behavior analysts would likely benefit from taking inspiration from and incorporating useful elements from other disciplines.

References

Alavosius, M., & Mattaini, M. A. (2011). Editorial: behavior analysis, sustainability, resilience, and adaptation. *Behavior and Social Issues, 20*, 1–5.

Alber, S. R., & Heward, W. L. (1996). "GOTCHA!" Twenty-five behavior traps guaranteed to extend your students' academic and social skills. *Intervention in School and Clinic, 31*, 285–289.

Anderson-Hanley, C., Tureck, K., & Schneiderman, R. L. (2011). Autism and exergaming: effects on repetitive behaviors and cognition. *Journal of Psychology Research and Behavior Management, 4*, 129–137.

Avedon, E. M., & Sutton-Smith, B. (Eds.). (1971). *The study of games*. New York: Wiley.

Baer, D. M., & Wolf, M. M. (1970). The entry into natural communities of reinforcement. In R. Ulrich, T. Stachnik, & J. Mabry (Eds.), *Control of human behavior: from cure to prevention* (Vol. 2, pp. 319–324). Glenview: Scott, Foresman and Company.

Baer, D. M., Wolf, M. M., & Risley, T. R. (1968). Some current dimensions of applied behavior analysis. *Journal of Applied Behavior Analysis, 1*, 91–97.

Bang, M., Torstensson, C., & Katzeff, C. (2006). The PowerHouse: a persuasive computer game designed to raise awareness of domestic energy consumption. *Lecture Notes in Computer Science, 3692*, 123–132.

Bang, M., Svahn, M., & Gustafsson, A. (2009). *Persuasive design of a mobile energy conservation game with direct feedback on social cues* (pp. 1–7). England: Proceedings of the Digital Games Research Association.

Baranowski, T., Buday, R., Thompson, D. I., & Baranowski, J. (2008). Playing for real: video games and stories for health-related behavior change. *American Journal of Preventative Medicine, 34*, 74–82.

Barnes, B. (2011). A year of disappointment at the movie box office. *The New York Times*. Retrieved from http://www.nytimes.com/2011/12/26/business/media/a-year-of-disappointment-for-hollywood.html?pagewanted=all

Björk, S., & Holopainen, J. (2005). *Patterns in game design*. Boston: Charles River Media.

Bogost, I. (2007). *Persuasive games: the expressive power of videogames*. Cambridge: MIT Press.

Bunchball (2012). *Enterprise gamification: The gen Y factor*. Retrieved from http://www.bunchball.com/resources/enterprise-gamification

Caillois, R. (1958). *Man, play, and games. (M. Barash, Trans.)*. Paris: Librarie Gallimard.

Calvillo-Gámez, E. H., Cairns, P., & Cox, A. L. (2010). Assessing the core elements of the gaming experience. In R. Bernhaupt (Ed.), *Evaluating user experience in games* (pp. 47–71). London: Springer.

Chance, P., & Heward, W. L. (2010). Climate change: meeting the challenge. *The Behavior Analyst, 33*, 197–206.

Coleman, J. S. (1971). Learning through games. In E. M. Avedon & B. Sutton-Smith (Eds.), *The study of games* (pp. 322–325). New York: Wiley.

Corbett, S. (2010). Learning by playing: Video games in the classroom. *New York Times*. Retrieved from http://www.nytimes.com/2010/09/19/magazine/19video-t.html?pagewanted=all&_r=0

Crumlish, C., & Malone, E. (2009). *Designing social interfaces: principles, patterns, and practices for improving user experience*. Sebastopol: O'Reilly.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: defining "gamification." *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, USA, 15*, 9-15.

Egel, A. (1980). The effects of constant vs varied reinforcer presentation on responding by autistic children. *Journal of Experimental Child Psychology, 30*, 455–463.

Egel, A. (1981). Reinforcer variation: implications for motivating developmentally disabled children. *Journal of Applied Behavior Analysis, 14*, 345–350.

Elias, G. S., Garfield, R., & Gutschera, K. R. (2012). *Characteristics of games*. Cambridge: MIT Press.

Factbox: a look at the $65 billion video games industry. (2011). *Reuters*. Retrieved from http://uk.reuters.com/article/2011/06/06/us-videogames-factbox-idUKTRE75552I20110606

Ferguson, B., Anderson-Hanley, C., Mazurek, M. O., Parsons, S., & Warren, Z. (2012). Game interventions for autism spectrum disorder. *Games for Health Journal, 1*, 248–253.

Fullerton, T. (2008). *Game design workshop: a playcentric approach to creating innovative games*. Amsterdam: Morgan Kaufmann.

Gaudiosi, J. (2012). New reports forecast the global video game industry will reach $82 billion by 2017. *Forbes*. Retrieved from http://www.forbes.com/sites/johngaudiosi/2012/07/18/new-reports-forecasts-global-video-game-industry-will-reach-82-billion-by-2017/

Global movie ticket sales hit record high. (2008). *ABC News*. Retrieved from http://www.abc.net.au/news/2008-03-06/global-movie-ticket-sales-hit-record-high/1063786

Good, B. M., & Su, A. I. (2011). Games with a scientific purpose. *Genome Biology, 12*, 135.

Gustafsson, A., Katzeff, C., & Bang, M. (2009). Evaluation of a pervasive game for domestic energy engagement among teenagers. *Computers in Entertainment, 7*, 2–19.

Hamilton, M. (2013.). The color run now largest 5-K series. *Runner's World*. Retrieved from http://www.runnersworld.com/races/the-color-run-now-largest-5-k-series

Hansen, J. E., & Sato, M. (2012). Paleoclimate implications for human-made climate change. In A. Berger, F. Mesinger, & D. Šinački (Eds.), *Climate change: inferences from paleoclimate and regional aspects* (pp. 21–48). Vienna: Springer.

Hardy, J. L., Drescher, D., Sarkar, K., Kellet, G., & Scanlon, M. (2011). Enhancing visual attention and working memory with a web-based cognitive training program. *Mensa Research Journal, 42*, 13–20.

Hopson, J. (2001). Behavioral game design. *Gamasutra*. Retrieved from http://www.gamasutra.com/view/feature/3085/behavioral_game_design.php

Hopson, J. (2012). 10 years of behavioral game design with Bungie's research boss. *Gamasutra*. Retrieved from http://www.gamasutra.com/view/feature/172409/10_years_of_behavioral_game_design_.php

Hunicke, R., LeBlanc, M., & Zubet, R. (2004). MDA: a formal approach to game design and game research. *Proceedings of the AAAI workshop on challenges in games*. AAAI Press

Jarmolowicz, D. P., & Lattal, K. A. (2010). On distinguishing progressively increasing response requirements for reinforcement. *The Behavior Analyst, 33*, 119–125.

Kapp, K. M. (2012). *The gamification of learning and instruction: game-based methods and strategies for training and education*. San Francisco: Pfeiffer.

Kesler, S., Hosseini, S. M. H., Heckler, C., Janelsins, M., Palesh, O., Mustian, K., & Morrow, G. (2013). Cognitive training for improving executive function in chemo-therapy treated breast cancer survivors. *Clinical Breast Cancer, 13*, 299–306.

Khatib, F., Cooper, S., Tyka, M. D., Xu, K., Makedon, I., Popovic, Z., Baker, D., & Users, F. (2011). Algorithm discovery by protein folding game users. *Proceedings of the National Academy of Sciences, 108*, 18949–18953.

Kuntz, K., Shukla, R., & Bensch, I. (2012). How many points for that? A game-based approach to environmental sustainability. *Proceedings of the American Council for an Energy-Efficient Economy Summer Study on Energy Efficiency in Buildings, 7*, 126–137.

LeBlanc, L. A., Heinicke, M. R., & Baker, J. C. (2013). Expanding the consumer base for behavior-analytic services: meeting the needs of consumers in the 21st century. *Behavior Analysis in Practice, 5*, 4–14.

Lee, J. L., Matamoros, E., Kern, R., Marks, J., de Luna, C., & Jordan-Cooley, W. (2013). Greenify: fostering sustainable communities via gamification. *Proceedings from the 2013 CHI EA Conference (ACM Press)*, 1497-1501.

Linehan, C., Roche, B., & Stewart, I. (2010). A derived relations analysis of computer gaming complexity. *European Journal of Behavior Analysis, 11*, 69–77.

Lumos Labs. (n.d.). Home page. Retrieved from http://www.lumosity.com

McCallum, S. (2012). Gamification and serious games for personalized health. In B. Blobel, P. Pharow, & F. Sousa (Eds.), *Proceedings of the 9th international conference on wearable micro and nano technologies for personalized health* (pp. 85–96). Washington, DC: Ios Press.

McGonigal, J. (2010). Jane McGonigal: Gaming can make a better world. [Video file]. Retrieved from https://www.ted.com/talks/jane_mcgonigal_gaming_can_make_a_better_world.html

McGonigal, J. (2011). *Reality is broken: why games make us better and how they can change the world*. New York: Penguin.

Mechner, F., Fredrick, T., & Jenkins, T. (2013). How can one specify and teach thinking skills. *European Journal of Behavior Analysis, 14*, 285–293.

Medler, B. (2011). Player dossiers: analyzing gameplay data as a reward. *Game Studies, 11*, n.p.

Mimio (2012). *MimioSprout results count outcome data and case studies*. Retrieved from http://www.mimio.com/en-NA/Products/MimioSprout-Early-Reading.asp

Mimio (n.d.). *Products: Reading instruction: MimioSprout*. Retrieved from http://www.mimio.com/en-NA/Products/Reading-Instruction.aspx

Morgan, D. L. (2010). Schedules of reinforcement at 50: a retrospective appreciation. *The Psychological Record, 60*, 151–158.

Neuringer, A. (2003). Creativity and reinforced variability. In K. A. Lattal & P. N. Chase (Eds.), *Behavior theory and philosophy* (pp. 323–338). New York: Klewer Academic/Plenum.

Nevin, J. A. (2010). The power of cooperation. *The Behavior Analyst, 33*, 189–191.

Ogden, C. L., Carroll, M. D., Kit, B. K., & Flegal, K. M. (2012). *Prevalence of obesity in the United States, 2009-2010*. Washington, D. C.: U.S. Department of Health and Human Services, Center for Disease Control and Prevention, National Center for Health Statistics. Retrieved from http://www.cdc.gov/nchs/data/databriefs/db82.htm

Olson, P. (2013). Duolingo takes online teaching to the next level, by crowd sourcing new languages. *Forbes*. Retrieved from http://www.forbes.com/sites/parmyolson/2013/09/25/duolingo-takes-online-teaching-to-next-level-by-crowd-sourcing-new-languages/

Parsons, S., & Cobb, S. (2011). State-of-the-art of virtual reality technologies for children on the autism spectrum. *European Journal of Special Needs Education, 26*, 355–366.

Pellegrini, A. D., & Smith, P. K. (1998). Physical activity play: the nature and function of a neglected aspect of play. *Child Development, 69*, 577–598.

Peterson, P. E., Woessmann, L., Hanushek, E. A., & Lastra-Anadon, C. X. (2011). *Globally challenged: are U. S. students ready to compete?* Retrieved from http://www.hks.harvard.edu/pepg?PDF/Papers/PEPG11-03_GloballyChallenged.pdf

Pilgrim, C. (1998). The human subject. In K. Lattal & M. Perone (Eds.), *Handbook of research methods in human operant behavior* (pp. 15–44). New York: Plenum Press.

Poling, A. (2010). Looking to the future: will behavior analysis survive and prosper? *The Behavior Analyst, 33*, 7–17.

Quest to Learn. (n. d.). About. Retrieved from http://q2l.org/about

Raessens, J. (2006). Playful identities, or the ludification of culture. *Games and Culture, 1*, 52–57.

Redmon, K. C. (2012). How Opower's Dan Yates persuades people to use less energy. *Washingtonian*. Retrieved from http://www.washingtonian.com/articles/people/how-opowers-dan-yates-persuades-people-to-use-less-energy/index.php

Reeves, B., Cummings, J. J., & Anderson, D. (2011). Leveraging the engagement of games to change energy behavior. *Proceedings from the 2011 ACM Computer-Human Interaction conference*, Vancouver, BC. Retrieved from http://gamification-research.org/wp-content/uploads/2011/04/23-Reeves.pdf

Roberts, J. M., Arth, M. J., & Bush, R. R. (2009). Games in culture. *American Anthropologist, 61*, 597–605.

Rosales-Ruiz, J., & Baer, D. M. (1997). Behavioral cusps: a developmental and pragmatic concept for behavior analysts. *Journal of Applied Behavior Analysis, 30*, 533–544.

Schneider, S. M. (2012). *The science of consequences: how they affect genes, change the brain, and impact our world*. Amherst: Prometheus Books.

Sicart, M. (2008). Defining game mechanics. *Game Studies, 8*.

Sidman, M. (2000). *Coercion and its fallout (Revised ed.)*. Boston: Authors Cooperative, Inc.

Six to Start. (2012). Zombies, Run! (Version 1.2.1) [Mobile Application Software]. Retrieved from https://www.zombiesrungame.com/

Skinner, B. F. (1953). *Science and human behavior*. New York: Macmillan.

Skinner, B. F. (1984). The shame of the American education. *American Psychologist, 39*, 947–954.

Suits, B. (1967). What is a game? *Philosophy of Science, 34*, 148–156.

The Color Run (n.d.). Retrieved from http://www.thecolorrun.com/

The Fun Theory (n.d.). Retrieved from http://www.thefuntheory.com/

The Zombie Run (n.d.). Retrieved from https://thezombierun.com/extreme/

Thompson, L. G. (2010). Climate change: the evidence and our options. *The Behavior Analyst, 33*, 153–170.

Thompson, D., Baranowski, T., Buday, R., Baranowski, J., Thompson, V., Jago, R., & Griffith, M. J. (2010). Serious video games for health: how behavioral science guided the development of a serious video game. *Simulation Gaming, 41*, 587–606.

Tiemann, P. W., & Markle, S. M. (1991). *Analyzing instructional content*. Champagne: Stipes Publishing Company.

Twyman, J. S. (2011). Emerging technologies and behavioural cusps: a new era for behavior analysis? *European Journal of Behavior Analysis, 12*, 461–482.

Von Ahn, L. (2011). Luis von Ahn: Massive-scale online collaboration. [Video file]. Retrieved from http://www.ted.com/talks/luis_von_ahn_massive_scale_online_collaboration.html

Who else wants a list of all the color runs? (2013). *Gametiime.* Retrieved from http://blog.gametiime.com/2013/03/27/who-else-wants-a-list-of-all-the-color-runs/

Wingfield, N. (2012). All the world's a game, and business is a user. *The New York Times*. Retrieved from http://www.nytimes.com/2012/12/24/technology/all-the-worlds-a-game-and-business-is-a-player.html

Wittgenstein, L. (1997). *Philosophical Investigations (G. E. M. Anscombe, Trans* (2nd ed.). Oxford: Blackwell Publishing.

Young, M. E., Webb, T. L., & Jacobs, E. A. (2011). Deciding when to "cash in" when outcomes are continuously improving: an escalating interest task. *Behavioral Processes, 88*, 101–110.

Young, M. E., Webb, T. L., Rung, J. M., & Jacobs, E. (2013). Sensitivity to changing contingencies in an impulsivity task. *Journal of the Experimental Analysis of Behavior.* doi:10.1002/jeab.24. Advance online publication.

Zichermann, G., & Cunningham, C. (2011). *Gamification by design*. Sebastopol: O'Reilly Media, Inc.