3 GAMIFICATION AS BEHAVIORAL PSYCHOLOGY

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Those who advocate the benefits of a gamified or gameful world often advance a vision of the future in which all life and all work becomes increasingly playful, game-like, and rewarding; a future in which the world's problems can be fixed by mass collaborative game-like activities, which simultaneously stimulate and delight the participants, while also providing useful services to science, charities, and industry (McGonagle 2011; Schell 2010b). Given the current popularity of game playing as a pastime and the success of many early examples of gamification (e.g., von Ahn and Dabbish 2004; Khatib et al. 2011), it is difficult to not get caught up in this excitement. Notably, however, this excitement about gamification does not appear to have been generated by any specific new scientific or technological breakthrough. Indeed, there seems to be very little novel—theoretically or practically, from a sociological, psychological, or design perspective—about the gameful design of products, services, and activities (Deterding et al. 2011).

We argue that in order fully to appreciate gamification as a design tool, it is necessary to understand the spectrum of relevant social and psychological processes acting on both the designer and consumer of such products, services, and activities. In this chapter, we focus on one level of analysis, *observed* behavior, and introduce the field of behavioral psychology as an approach to understanding observed behavior in gamified products. Behavior analysis is a natural science branch of psychology and has been successful in developing principles and procedures for engaging users in a wide range of training programs and engendering behavior change, usually in an educational context (see Cooper, Heron, and Heward 2006). Of the many fields within psychology, behavior analysis has devoted itself to precision in the understanding of, and perhaps more importantly the control of, human behavior. A consideration of the principles generated by behavioral psychologists might be useful in explaining how specific game design elements motivate and maintain user engagement, and knowledge of the principles and processes defined by behavioral psychologists can readily help in the design of more useful and engaging gamified experiences. Given the tremendous strength of empirical grounding, behavioral psychology is a proven, valid, useful, and interesting lens through which we can investigate gamification.

To communicate the contribution of this chapter as clearly as possible, it is important to first provide a definition for the phenomenon of gamification. Deterding et al. (2011) suggest that the unique phenomenon of interest when discussing gamification is "the use of game design elements in non-game contexts." They identify that *game design elements* are "elements that are found in most (but not necessarily all) games, readily associated with games, and found to play a significant role in game play." Examples of game design elements are provided, which vary in terms of abstraction from the concrete (interface design patterns) to the abstract (game design methods). We specifically emphasize how the effects of characteristic game design elements (i.e., points, badges, leaderboards, time constraints, clear goals, challenge) can be explained through principles of behavior investigated and understood by behavioral psychologists for decades (see Skinner 1974).

A Gameful Life

Arguably, one of the catalysts for the current interest in gamification was a keynote speech by Jesse Schell (2010b). In his talk, he outlined a future where game mechanics are totally intertwined with our daily lives. Players receive game rewards for brushing their teeth, using public transport, eating certain branded foods, and so on. In a similar vein, Jane McGonigal (2011) argues that through careful use of game design elements, people can become motivated to solve real-world problems, do more work, and better manage their health (e.g., SuperBetter.com). The core idea is that through modifying the environment and giving suitably motivating rewards, the behavior of players can be changed for their own benefit (or that of their corporate masters).

Notably, in 1948 the behavioral psychologist B. F. Skinner released a science fiction novel called *Walden Two*, which tells the tale of a utopian community whose members live together bound by a strict set of rules defining how tasks are completed and rewards granted in such a way to encourage positive behavior change and maximize motivation. For example, working less desirable jobs earns more "labour-credits," which means those workers get more free time for leisure. *Walden Two* acts as an argument for how the principles of behavioral psychology can be used to help people become better motivated, productive, and healthy. Fascinatingly, the argument put forward by Skinner is strikingly similar to that advanced by McGonigal and Schell.

It seems that in order to design the type of world envisioned by McGonigal and Schell, what is needed is a deeper understanding not only of games and play but also of the processes through which it is possible to incentivize people to behave in an appropriate or productive manner. We need to understand how to measure, understand, predict, and control people's behavior. These are exactly the questions that behavioral psychologists have tried to answer through their research. The remaining sections of this chapter will introduce and discuss behaviorism as a philosophical approach to understanding the gamified world. This philosophy is the foundation for the practice of behavior analysis, and some interesting points of overlap between this philosophy and the assumptions underlying gamification will be considered. Subsequently, the very effective behavior control principles developed by behavioral psychologists will be reviewed. Many of these can be readily implemented in gamified products and services and are already being applied by researchers in the field of persuasive technology (Fogg 2002). We will provide

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an analysis of game playing from a behavioral psychology perspective and will conclude by offering some broad concerns and criticisms often associated with the behavioral approach.

The History and Philosophy of Behavioral Science

Behaviorism is an approach to psychology that attempts to understand all behavior, and all psychological events, in terms of the interactions of an organism in and with its environment (Hayes 1993). The work of a behavioral psychologist lies in investigating which specific features of the environment lead to particular behaviors of interest and in understanding how to replicate and control those behaviors through control of the environment (Catania 1998). This approach is steadfast in its adherence to environmental explanations of behavior because these lend themselves most readily to the development of means of controlling behavior (i.e., by manipulating the environment appropriately). Behaviorists eschew explanations of behavior in terms of free will or cognitive activity (e.g., decisions, intentions, etc.) because (a) these processes cannot be easily manipulated for the purposes of behavior control, (b) they usually constitute hypothesized rather than observable processes, and (c) as aspects of human activity, they must themselves be explained in terms of organism-environment interactions. For instance, we might explain the behavior of interacting with a vending machine in terms of a history of successful acquisition of candy bars upon the insertion of cash, as well as in terms of the current physiologic state of the individual engaged in the behavior (e.g., the person is food deprived). That is, given the individual's history of being naturally rewarded (i.e., reinforcement) by the delivery of food for inserting money correctly into a vending machine, and given that the individual has cash in his or her pocket, and given that the individual has not eaten for some time, he or she is likely to put some money in the appropriate vending machine slot. Put another way, the person's history of reinforcement is coming into contact with the current environment, and it is this history combined with the previously established functions of the various stimuli present (the vending machine, money) that explains the behavior (i.e., predicts and controls it). Of course, explanations of specific behaviors are usually more complex than this, but this example serves merely to outline the form that behavioral explanations typically take.

Importantly, a behavior analyst would not explain the behavior of buying candy from a vending machine in terms of the hunger or the intention of the individual, as we so often do in commonsense reasoning and in softer branches of psychology (as well as much of cognitive psychology). That is, it is not acceptably scientifically rigorous to use, in explanation of behavior, a hypothesized internal and private state (i.e., hunger), the only proof for which is the very behavior it is supposed to explain (i.e., the candy purchase). More specifically, we can control the history and state of food deprivation of the individual, but we cannot *directly* control his or her level of hunger. We can also control the individual's history of reinforcement and so increase the individual's efficiency and frequency of using vending machines, but we cannot *directly* control his or her intentions to do so. In summary, behavioral psychology is utterly non-esoteric and is supremely pragmatic in its approach. To this extent, it dovetails well with the purposes of an engineer whose goal is to increase user engagement with a product or system, rather than merely understand it in hypothetical terms.

Notably, the constraints that have led behavioral psychologists to adopt their unique approach are remarkably similar to those operating on any technologically mediated system that attempts to modify human behavior, such as is often the goal of gamified technologies. Specifically, technology is good at objective measurement, analyzing patterns, and determining solutions based on executable functions. It is not good at intuitively inferring states of mind, thoughts, feelings, and emotions and effecting behavior change outcomes by nonempirical means. Essentially, a computer that is attempting to modify behavior, such as improving the frequency of reading or exercise, is operating under the same constraints as a behavioral psychologist, except that in the case of technology, these constraints are technologically rather than philosophically imposed. Therefore, the tools developed by behavioral psychologists to understand and control behavior are very relevant for anyone using technology to monitor and change human behavior.

In summary, the insistence on observation in attempting to change or maintain the actual behavior of individuals is what is unique and useful about behavioral psychology. We would suggest that it is also useful to take this approach when designing a game, gamified service, or, indeed, persuasive technology (Fogg 2002). Focusing on the actual observed behavior of a person, rather than some presumed inner state or intentions or some other commonsense-influenced model of behavior, will lead the engineer closer to finding means of maintaining the engagement of that person with his or her task.

B. F. Skinner and Radical Behaviorism

The basic science of behavior analysis is heavily indebted to the work of B. F. Skinner (i.e., Skinner 1953, 1959, 1974) and his contemporaries, who experimentally studied the behavior of animals such as rats and pigeons. A typical study by Skinner or his contemporaries involved an animal being placed into a specially designed box containing a lever and a food dispenser (often referred to by popular media as a "Skinner box"). The experimenter set up a contingency whereby the delivery of rewards or punishments was dependent upon either a fixed amount of time or some specific response (such as a lever press) produced by the animal. An experimenter kept a record of the behavior of the animal using a cumulative recording device (Skinner 1959) while the animal interacted with its environment. Numerous such studies were conducted, leading to considerable success in defining the now well-understood "principles" of behavior, such as operant conditioning.

Operant conditioning could be described as a set of circumstances in which the "consequences of behaviour may 'feed back' into the organism, and, when they do so, they may change the probability that the behaviour which produced them will occur again" (Skinner 1953, 59). For example, a rat may engage in many different behaviors while trapped in a cage. If one of these behaviors, such as pressing a lever, is followed by a favorable consequence, such as

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the delivery of food, the probability of this behavior occurring in the future will have been altered (in this case, we may expect that lever-pressing will be more likely in the future). The consequences of behavior have a direct and measurable impact upon the likelihood of that behavior occurring again.

Skinner specified the operant behavioral unit as a three-term contingency consisting of an *antecedent*, a *response*, and a *consequence*. He suggested that this concept could be used to describe all behaviors of organisms and that understanding the determinants of behavior simply required understanding the specific antecedents and consequences operating on that organism in that context. In an operant response, both an antecedent, such as an environmental context or stimulus, and a consequence combine to produce behavior (Skinner 1953, 65). Importantly, this definition allowed for a systematic program of research examining various antecedent and consequent conditions as determinants of behavior. This program of research led to technical, mathematical definitions of terms such as *positive* and *negative reinforcement*, *punishment*, and *avoidance*.

Positive reinforcement describes a situation in which the presentation of a stimulus as a consequence of an instance of behavior makes that behavior more likely to occur in that context in the future. There are countless examples of positive reinforcement contingencies implemented in gamified applications. For example, the rewarding of points, badges, leveling up, and access to new features as a consequence of appropriate behavior are all examples of this process.

Negative reinforcement describes a situation in which the removal or termination of an existing stimulus (or existing aversive condition) as a consequence of an instance of behavior makes that behavior more likely to occur in that context in the future. The game Farmville (Zynga 2009) provides an example of how this process can be implemented. In this game, crops must be harvested within a certain period or else they die. The reward for visiting and tending to your farm is the removal of impending crop death, a consequence of your negligence.

Negative punishment describes a situation in which the removal or termination of a stimulus as a consequence of an instance of behavior makes that behavior less likely to occur. *Positive punishment* describes a situation in which the presentation or addition of a stimulus as a consequence of an instance of behavior makes that behavior less likely to occur in that context in the future. These *aversive* contingencies (situations that people will work to avoid) are used less often in gamified applications because of the fear that they will lead to disengagement with the product. Specifically, if the consequence of eating a chocolate cake will be a disapproving message from a phone application, the easiest way of avoiding that feedback is to stop using the application rather than to change your eating behavior (Kirman et al. 2010). However, because games often use aversive consequences as key mechanics in game play, we should expect to see the prevalence of such aversive contingencies increasing in gamified products (Foster et al. 2011).

To apply reinforcement techniques successfully, it is crucial to understand the difference between a "reward" and a reinforcer. A reward is any stimulus given to a user on *the assumption* that it will increase the likelihood of the consequent behavior being repeated in the future. A reinforcer is any stimulus that *has been observed* to increase the likelihood of the rewarded behavior being repeated in the future. Crucially, the technical definitions provided earlier were defined based on careful observation and analysis of the single subjects (i.e., one animal, one person).

They do not refer to assumptions or to typical effects across a group of participants. The concept of reinforcement, therefore, is not theoretical, and the parameters of the various processes involved are well understood empirically. Essentially, if we have not carefully observed and measured behavior, we cannot describe the specific consequences that one should provide as a reinforcer, punisher, and so forth, in order to alter the rate and probability of that behavior in the future. However, if we have carefully measured and recorded behavior, as the creators of many persuasive gamified products do (e.g., healthmonth.com, Nike+), reinforcement techniques can be very effectively applied in the control of behavior rates.

Importantly, behavioral psychology is a form of selectionist analysis, entirely coherent with evolutionary biology (see Hayes and Long 2013). Evolutionary theory describes how behaviors and traits are selected by the environment across generations. Behavioral psychology, in contrast, explains how behaviors and traits are selected by the environment within the life span of the organism. In both cases, the analytic unit (the species or the behavior) is selected by the consequences of its occurrence.

The general principles of behavior are at work in many gamified products, even where product developers are not fully aware of the fact. Indeed, those game design characteristics used to "gamify" products can often be described using the concept of reinforcement alone. In many cases, there is no need to refer to game play at all as an explanation of what a "gamified" service does to engage users. For example, there are many popular exercise applications, such as Nike+ (http://nikeplus.nike.com/plus) and Fitocracy (fitocracy.com), which use simple positive reinforcement contingencies to encourage exercise through the awarding of points, badges, and progression through levels in exchange for observed activity, such as completion and regularity of runs and other workout sessions. In these instances, badges are presented as the consequence of observed behavior on the assumption that the "earning" of that badge will make exercise more likely in the future. While these features are commonly seen in games, they have little to do with the concept of play. Other systems use forms of positive reinforcement to encourage healthier eating (https://foodzy.com/) and language learning (https://www.duolingo.com).

Scheduling Feedback

The use of consequences, whether real (e.g., points redeemable for credit) or virtual (e.g., points with social value in terms of comparing oneself favorably with others), is a crucial and central aspect of any program of behavior maintenance. But it is not simply a matter of providing encouraging feedback or points. The real science of behavior analysis lies in the scheduling of these behavior consequences.

Through experimental investigation of operant conditioning, behavioral psychologists discovered that there are significant temporal and contextual components that affect how the environment is responded to by an organism (Ferster et al. 1957). For example, the effect that any one stimulus, presented as a consequence of behavior (i.e., feedback), will have on subsequent behavior is determined primarily by the history of that organism encountering that

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stimulus previously, rather than any inherent feature of the stimulus itself (an exception to this are those stimuli that humans have unconditioned, genetically determined responses to, such as painful stimuli). Essentially, the power of any stimulus to function as a reward or punishment changes over time through experience (i.e., learning). Skinner and his colleagues specifically investigated how that process occurred and how to manipulate these factors in order to predict accurately and control subsequent behavior. Because the use of game design elements in non-game contexts is typically carried out to encourage, provoke, or maintain specific behaviors, these processes are important to understand in the design of gamified products and services.

Behavioral psychologists use the term *schedule of reinforcement* to describe important contextual aspects that define the organism's experience of reinforcement. Specifically, two variables were identified as significant: the *interval*, or amount of time that has passed since the last instance of reinforcement, and the *ratio*, or the amount of work that it takes to earn a reinforcer (Ferster et al. 1957). Researchers found that varying either of these had significant impact on behavior (figure 3.1). Four different configurations produce different patterns of responses in animals engaging with a lever that can be pressed to earn food pellets.

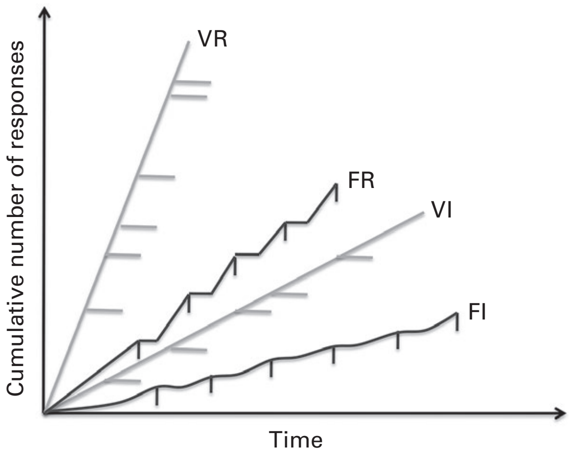


Figure 3.1
Illustration of prototypical behavior observed across four different schedules of reinforcement. FI, fixed interval; VI, variable interval; FR, fixed ratio; VR, variable ratio.

A fixed interval (FI) is a schedule in which only the first response after a specified amount of time has elapsed is rewarded, while premature responses are not reinforced at all. This schedule results in a pattern of behavior in which most behavior occurs in the minutes before reinforcement is expected and behavior rates reduce rapidly immediately afterward, until the end of the interval. Overall behavioral engagement under FI schedules is low. *Variable interval* (VI) schedules are similar to FI schedules, with the exception that the time for which reinforcement is unavailable oscillates around a mean, rather than being predictable. This schedule results in a steady but relatively low rate of response. *Fixed ratio* (FR) schedules deliver reinforcement after every *n*th response. For example, FR5 schedules provide reinforcement consistently after every fifth response. This schedule produces a high, steady rate of responding with a brief pause after the delivery of the reinforcer. *Variable ratio* (VR) schedules are similar to FR schedules, with the exception that rather than being predictable, the number of responses required for reinforcement oscillates around a mean. This type of schedule creates a high and steady rate of responding and is typically the most economical; a lot of work can be generated by few instances of reinforcement.

Variable ratios have been the source of much research and controversy. Because the work produced in response to a VR schedule is so out of proportion to the rewards offered, implementing this schedule in a game, gamified service, or work environment can be seen as exploitative. Indeed, work practices in which pay can be varied at will by employers (e.g., piecework) are very much frowned upon if not illegal in some jurisdictions. VR schedules have been advanced as an explanation for addiction to gambling, as both demonstrate evidence of unrealistic expectations of reinforcement for the actions taken (Haw 2008; King, Delfabbro, and Griffiths 2010). Indeed, Karlsen (2011) has extended this analysis to explain addiction in massively multiplayer online games. Needless to say, the implementation of VR schedules in gamified services, while an extremely effective strategy for motivating engagement, will certainly draw criticism on grounds of exploitation.

The research conducted on schedules of reinforcement demonstrates that it is not usually optimal to offer a reward or punishment after every action that a user takes. Rather, in order to sustain behavior over a period of time, it is necessary to manipulate either the number of responses required or the time elapsed before reinforcement is delivered (Ferster et al. 1957). Different schedules are appropriate in different contexts, depending on the type of behavior one wishes to engender in the user. Indeed, the literature (see Catania 1998; Cooper, Heron, and Heward 2006) suggests that if people have a consistent history of being reinforced for their efforts, the workload required to reach those same rewards can be increased gradually over time without losing the motivational effects of those rewards. Behavioral psychologists refer to this technique of progressively spacing out the delivery of reinforcement as *schedule leaning*. This technique is also observed in computer games, in which the first few tasks that a player completes are often reinforced through new items, new skills, and leveling up. As the player progresses and spends more time playing the game, the number of actions needed to produce a reinforcer is increased.

The technique of schedule leaning is evident in online social network games (Deterding et al. 2010) and particularly in massively multiplayer online role-playing games, such as World of Warcraft (Blizzard Entertainment 2004). For instance, let us consider the archetypal example of the popular role-playing game Dungeons and Dragons (Gygax and Arneson 2000). In this game, players gain "experience points" (XPs) through play. After gaining a certain number of XPs, a character moves up a "level" and gains additional strengths and abilities. However, the number of XPs required to level up increases with each level that is completed, progressively increasing the time taken to complete each subsequent level (the completion of levels and leveling up is presented as a reward in such games; table 3.1). Given the prevalence of this technique in games across media, we should consider it as a characteristic game design element that has itself been selected by its consequences for game and other product developers, but

Table 3.1

Learning schedule of reinforcement in terms of character levels in Dungeons and Dragons (third edition)

Character Level	Experience Points (XPs) Required
1	0
2	1,000
3	3,000
4	6,000
5	10,000

Source: Gygax and Arneson (2000).

in the absence of a dedicated behavioral analysis to guide such developments.

Notably, commentators (e.g., Bartle 2011) have criticized the use of techniques such as variable reinforcement ratios and schedule leaning in games, suggesting that they are in fact so effective when used properly that they are exploitative of users. Critics suggest that for some players, the schedules even remain effective long after the player has ceased having fun or "playing." The player is then seen as engaging in a repetitive, monotonous, menial task, analogous to a low-wage job, rather than a fulfilling, challenging experience. Essentially, game researchers suggest that the use of these game design elements equates to lazy or uninspired game design, and that good games should maintain engagement and motivation through the provision of inherently interesting experiences (Bartle 2011).

Given that game researchers are increasingly uncomfortable with the use of these game design elements within self-contained games, it should not be surprising that concerns have been raised about the application of these techniques to non-game contexts (i.e., Bogost 2011a). It is important to remember, however, that these techniques have been used successfully in special education for decades and have helped to transform the lives of countless individuals suffering with developmental delay and other behavioral problems (see Cooper et al. 2006; Rehfeldt and Barnes-Holmes 2009). Token economies (a specially designed context where appropriate behavior is rewarded through earning of tokens that can be saved up and exchanged for preferred items) provide a particularly clear example of how topographically gamelike behavioral interventions can have profoundly positive effects on behavior in even the most challenging environments (Corrigan 1995). Regardless of whether you consider these game design elements as useful tools or potentially exploitative practices, knowledge of the effectiveness of these techniques, as well as the controversies around their use, is essential for the designers of gameful experiences.

Evaluating the Effectiveness of Feedback

To apply schedules of reinforcement successfully, it is crucial that we remain mindful of the difference between a reward and a reinforcer. As stated earlier, a reward is any stimulus (points, badges, etc.) given to a user on *the assumption* that it will increase the likelihood of the rewarded behavior being repeated in the future. However, simply providing people with rewards is of little value unless there is a check to see whether subsequent behavior has changed as a consequence (if not, then the reward was not a good reinforcer). In both experimental and applied settings, behavioral psychologists continually test whether the feedback they offer produces changes in the target behavior (i.e., learning), and consequences are systematically modified "online" in order to achieve the desired behavior rate.

Especially in applied contexts (see Cooper et al. 2006), many different types of rewards are offered, and the psychologist must analyze data to understand better whether consistent patterns of behavior are observed after each reward is presented. This process is necessary as there are very few (if any) stimuli that function as a reinforcer or punisher for all people at all times. For example, some people find listening to classical music to be the highlight of their week, while many find it boring. Delicacies such as caviar, kokoretsi (organ meat), oysters, and Marmite are often seen as repulsive to different palates (Kirman et al. 2010). Thus, it is necessary to evaluate the impact of different rewards in order to evaluate whether those rewards are ones that the person, as an individual, is motivated to obtain. If the targeted behavior does increase as a consequence of the delivery of a particular reward, then that stimulus can be classified as a reinforcer in that context. The identified reinforcer can then be used in the future as a consequence of behavior that the psychologist wants to reinforce. The same process is applicable in the identification of punishers. In the context of a game, for example, a behavior analyst would offer a wide range of rewards for effective behavior, initially emitted at low rates on a rich schedule (e.g., an FR1), and then "lean" the schedule in tandem with a narrowing of the range of rewards being provided, all the while removing those rewards that do not function as reinforcers.

The above procedure is clearly applicable to both stand-alone games and non-game contexts alike. Taking an example from computer games, Ultima Online (Origin Systems 1997) provides many possible types of behavior for the user to engage with, from crafting to exploring and fighting, all of which provide the possibility of advancing within the game. The completion of a masterwork piece of armor by a player who enjoys crafting is rewarded by the game in the same way as defeating a dragon (i.e., through gained skill points). As a result, the different histories of individual players are catered to, and a wide variety of different individuals can experience the same reinforcing consequences from the same game, even though their behaviors differed markedly.

The clear implication of an analysis of reinforcement effectiveness for gamified products is that there should be different types of rewards available to users, and the application should include some simple way of evaluating which rewards are most reinforcing for each user. Behavioral psychologists have developed precise methods for doing exactly that, and it appears that these techniques may be ideal for use in technology such as computer games or gamified applications. For example, Herrnstein's matching law (Herrnstein 1961) is a mathematical way of determining which contingencies an organism finds most rewarding when multiple options are available. Herrnstein found, in experiments with animals, that the amount of time and work that was devoted to each of the options was consistent with the rate at which that work was rewarded. Essentially, the matching law is a mathematical way of determining which contingencies that individual organism found most rewarding. Understanding the matching law can help game designers create uniquely adaptive and engaging games or gamified products and services, as Herrnstein's algorithm allows us to monitor the relative attractiveness of each of the various reinforcers on offer with a given game. Through continually monitoring a player's behavior, a system can automatically calculate which rewards are eliciting the most work from that person (i.e., which are most reinforcing).

In an application such as foursquare (foursquare.com), for example, through monitoring user behavior, the application could easily identify that a given user is twice as likely to check in at further locations that day after receiving a large check-in bonus than after receiving a badge. Using the matching law, the application could deduce that check-in bonuses are twice as reinforcing for that user as badges. Thus, using this simple strategy, it is possible for a gamified application to evaluate dynamically the reinforcing strength of each of the available game rewards for each individual player and make adjustments to its own reward system to exploit these data.

Beyond the Skinner Box

The Skinner box apparatus is one of the most frequently misrepresented aspects of discussions on games and gamification. The Skinner box was a simple apparatus designed to observe and measure the behavior of animals (we should not expect it to provide entertainment for humans). However, this does not mean that the behavioral processes that behavioral psychologists discovered through this apparatus are not generalizable to more complex behavior. For example, a reinforcer was defined experimentally as any consequence that improves the likelihood of a behavior being repeated. This can be anything from a drop of sugar solution to a more complex consequence such as the resolution of a particularly surprising or opaque narrative arc, a particularly "juicy" cut scene, or other in-game event. What is genuinely useful is the insistence that the observation of behavior is key in understanding, predicting, and controlling it. Notably, Bogost (2011b) wrote:

> Game mechanics are the operational parts of games that produce an experience of interest, enlightenment, terror, fascination, hope, or any number of other sensations. Points and levels and the like are mere gestures that provide structure and measure progress within such a system.

If the contribution of behavioral psychology to our understanding of gamification is that it demonstrates how to provide structure and context for behavior, to observe, measure, and incentivize progress (i.e., learning), then it provides useful explanatory power for the phenomenon of gamification.

Understanding Game Playing

There are many ways of defining and analyzing game playing—in terms of physiology (Nacke, Grimshaw and Lindley 2010), social behavior (Kirman and Lawson 2009), immersion or flow (Ijsselsteijn et al. 2007), uses and gratifications (Sherry et al. 2006), and many other methodologies. The current analysis does not reject or overlook those definitions. Rather, an alternative is advanced as a means of explaining how the often-complex behavior observed in game playing can be understood in the context of the experimental findings of behavioral psychology research.

The behavior of computer game playing was first subjected to a basic behavior analysis in book-length format by Loftus and Loftus (1983). The authors proposed a technical account of the type of game playing seen in early 1980s video games, using basic experimentally defined behavioral psychology principles such as operant conditioning, extinction (the reduction in behavior rates induced by the removal of reinforcement), and schedules of reinforcement (described earlier). The authors drew a direct comparison between a person playing the popular arcade 0 game Pac-Man (Namco 1980) and a rat in one of B. F. Skinner's classic experiments (a comparison repeated much since). Loftus and Loftus's account is both rigorous and interesting and appeared valid at the time, when success at contemporary games was based primarily on reaction times and reflexes. Of course, modern games provide more complex and interesting challenges to players than those analyzed by Loftus and Loftus. However, similar low-level behavioral processes may provide some insight into players' engagement with some aspects of more complex games. For example, the variable difficulty levels available in most modern games may be seen as a method of adapting the schedules of reinforcement inherent in a game in order to produce the most game-playing behavior in the user.

Modern games often involve problem solving in addition to, or in place of, fluid stereotyped responses to a limited number of stimuli. For example, popular (4X) strategy games such as Civilization V (Firaxis Games 2010) and Eclipse (Tahkokallio 2011) require a player not only to fight battles with multiple units of different characteristics but also to build economies, military bases, towns, cities, and empires. Many valid strategies can be adopted for pursuing such goals. B. F. Skinner attempted to explain precisely this type of problem solving using the principles of behavioral psychology. In his book *Science and Human Behavior*, Skinner (1953) describes how even the complex behavior of problem solving could be explained in terms of basic behavioral principles. Consider the following passage:

> A person has a problem when some condition will be reinforcing but he lacks a response that will produce it. … solving a problem is, however, more than emitting the response which is the solution; it is a matter of taking steps to make that response more probable, usually by changing the environment. (Skinner 1974, 123)

Skinner suggested that, contrary to appearances, the behavior that solves a novel problem is not a brand new behavior or insight, but is simply a novel arrangement of already established behaviors (i.e., "taking steps to make that response more probable"; Skinner 1974, 123). For instance, a child who has been taught to pull a chain on the ceiling to flush a toilet, and also to climb on a step to reach objects, may one day climb on a step to pull a chain that is out of reach. This appears to be a form of insight, but it might be better described non-mentalistically as *response chaining*—the mere coming together of previously established behavioral units. Skinner contends that such a process could be applied to understanding many types of real-world problem solving, and we suggest that this includes those observed in many forms of game play, although more complex forms of problem solving are now understood to be possible (see later).

Notably, Gingold (2005), in explaining the appeal of the game Wario Ware (Nintendo 2003), appeals to a form of response chaining, without naming it such. Specifically, Wario Ware consists of a large number of simple minigames that last approximately five seconds each, grouped according to theme. The player must quickly learn the rules of each minigame to progress. At the end of each level, the skills learned in the preceding minigames must be combined in order to pass a more complex game (i.e., chaining of previously learned simple behaviors). Gingold proposes that the process of gradually learning simple behaviors and combining these as the game progresses explains the appeal of the game. Indeed, this explanation could also apply to the fascinating and hugely popular modern puzzle games in the Portal (Valve Corporation 2007) series. The structure of these and may other puzzle games, such as World of Goo (2D Boy 2008), seems optimized to take advantage of the human capacity for problem solving in terms of response chaining, which, in the field of game design, has been referred to as *scaffolding*. The simple requirement that responses be chained into long behavioral units provides some explanatory power for the engaging structural properties of simple games. However, as we will now see, game complexity may also extend to include more recently analyzed forms of problem solving than mere response chaining.

Complexity and Challenge in Games

Understanding, investigating, and manipulating the challenge or complexity presented by games is an area in which behavioral psychology may be particularly useful. Specifically, appropriate challenge and complexity are often proposed as an explanation of why a given computer game succeeds in maintaining player attention and enjoyment across the period of game play (i.e., Koster 2005). However, there is no technical definition of game complexity offered in the literature. Without such a definition, how can we know which forms of complexity are most reinforcing for an individual or along which parameters to alter such complexity? In one recent paper, a behavioral definition of complexity was offered in terms of a concept called *derived relational responding* (Linehan, Roche, and Stewart 2010, Linehan 2008). Before we consider the utility of this new definition, we must first consider what we mean by the term *derived relational responding*.

The simplest example of derived relational responding is a psychological phenomenon called stimulus equivalence (Sidman 1971; see also Sidman 1994, 2000). In his research, Murray Sidman showed that once people had been explicitly taught to choose an arbitrary stimulus "B" in the presence of an arbitrary stimulus "A" and also to choose a third arbitrary stimulus "C" in the presence of stimulus "B" (where these stimuli were things like randomly chosen Chinese characters), then a number of untrained responses emerged, including choosing "C" in the presence of "A" and "A" in the presence of "C." It has now been shown conclusively that humans can derive novel stimulus relations between various indirectly related objects or occurrences in the environment, and this phenomenon cannot be accounted for in terms of mere response chaining. In addition, this single psychological ability is considered to be a foundational unit for all human reasoning and logical thought (see Dymond and Roche, 2013).

The concept of derived relations makes both the understanding of and systematic manipulation of complexity in games more amenable. Specifically, there are some types of derived relations that have been demonstrated as more complex than others. For example, *nodal distance* (see Fields et al. 1997, 1990; Arntzen and Holth 1997, 2000) is a means for analyzing the closeness of a relationship between related stimuli. Responding appropriately to directly related stimuli is an observably less complex task than responding to stimuli that are related through a series of *nodes*. Similarly, responding appropriately to stimuli that are the opposite of each other, bigger or smaller than each other, or different to each other is a measurably more complex task than responding appropriately to stimuli that are the same as each other (see Hayes, Barnes-Holmes, and Roche [2001] for a book-length analysis and discussion). Adopting the technical nomenclature of relational complexity offers game developers an empirical means of creating appropriate challenge levels in a non-haphazard way, based on empirically understood psychological processes, and of manipulating complexity systematically in a linear and stepwise manner across levels. It also provides a paradigm within which to understand the level of challenge presented by currently popular games. For an example of an experimental game built entirely on the concept of derived relations and nodal distance, see Linehan et al. (2010). For an example of an online educational program that uses the relational complexity game element and draws explicitly on reinforcement procedures and schedules of reinforcement, see case study 3.1.

Case Study 3.1

RaiseYourIQ

Summary

RaiseYourIQ is a suite of online cognitive training tools developed by behavior analysts to improve general cognitive functioning. It falls under the general rubric of a brain training system but is offered more as a clinical/educational tool than primarily as a form of entertainment. At their own convenience, users practice (twenty to thirty minutes several times per week) at a series of mental challenges, which take the form of deriving relations of increasing complexity across levels of the training. Each task involves nonsense words, and levels of the training consist of blocks of tasks of similar relational complexity. Extensive training at such tasks is understood to have wide intellectual benefits. The main product offered by RaiseYourIQ is called SMART (strengthening mental abilities with relational training).

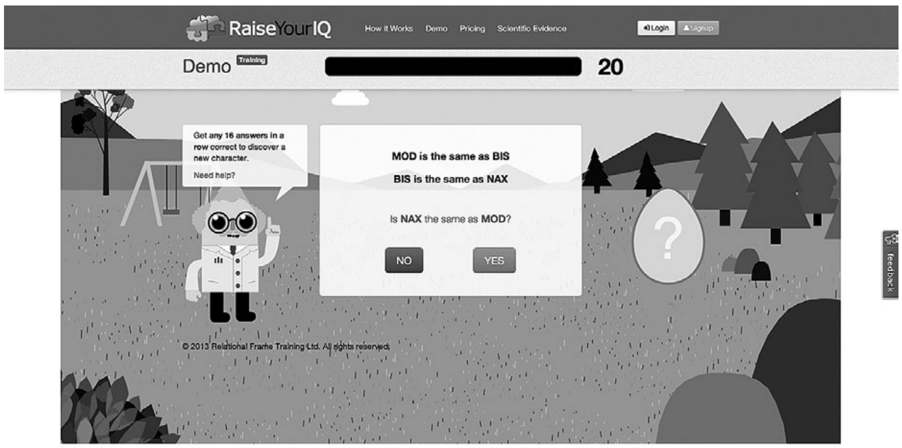
Facts and Figures

As a recent startup, RaiseYourIQ has only been online since October 2012 but currently has several thousand registered users.

Gameful Design Elements

- SMART uses explicit reinforcement through audio and visual feedback, points and badges, and optional updating of current point status on social media sites, but on a well worked out schedule that is "leaned" during test stages and during higher levels.
- To optimize learning rates, points and badges are awarded for revising previously completed levels, but on a diminishing rate (i.e., systematic leaning of schedule).
- E-mail reminders are sent to users if a hiatus in training is observed.
- Progress is tracked constantly in terms of speed and accuracy so that levels may be skipped if challenge is too low or stages regressed if challenge is too high. This optimizes challenge level and therefore engagement and learning.
- The use of multiple response consequences increases the likelihood of behavior coming under control of one of these (i.e., a reinforcer).
- A virtual professor provides helpful encouragement on a well worked out schedule that is as lean as possible.

Case Study 3.1
(continued)



Box Figure 3.1
A screenshot from SMART at RaiseYourIQ.com. The task shown is a one-node complexity task involving two types of relation (same and opposite), with responses consequated initially on a FR1 schedule by a wide range of rewards, including audio and visual feedback as well as points and badges.

Issues

Difficulties identifying a sufficiently broad range of reinforcers for a wide range of users online have been noted. Innovative solutions are being sought to broaden this range.

Outcomes

Increases in general intelligence have been reported in published studies (e.g., Cassidy, Roche & Hayes 2011). The creators have also claimed anecdotal evidence of improvements in reading and vocabulary as well as documented maintenance of IQ increases across four years (Roche, Cassidy, and Stewart in press). This is unique among brain training products but not surprising given the uniqueness of the relational training approach and its foundation in behavior analysis.

Related Cases

An increasing number of products claiming to improve general mental ability are available online. Many of these are simply games that should in principle help stimulate brain activity and neurogenesis (growth of brain cell connections). These other cases use commonsense game elements and are devised by game developers rather than psychologists, even where the core purpose of the game was inspired by psychological theory, such as the concept of neurogenesis. The market leader in this regard is Lumosity (lumosity.com).

Further Information

http://RaiseYourIQ.com

Applied Behavior Analysis and Behavior Modification

At the beginning of this chapter, we pointed out that the use of game design elements as a means of engendering engagement in non-game contexts often involves implementation of processes such as highly structured behavior measurement, algorithmic analysis of behavior, feedback loops, and reward mechanisms. This is especially apparent where the intention of the application is to change explicitly the behavior of the user (e.g., healthmonth.com). It is also the focus of much work carried out in the field of persuasive technology design (Fogg 2002). Notably, these processes (measurement of behavior, analysis, and feedback) are also the fundamental building blocks of behavioral interventions—also referred to as behavior modification, or, more recently, applied behavior analysis (Cooper et al. 2006). Applied behavioral psychologists have conducted a wealth of research on the optimal means for implementing these processes in order to motivate engagement and behavioral change. Thus, some knowledge of this field of research may be useful for those designers attempting to gamify their products or services.

Applied behavior analysis (ABA) is an umbrella term for a range of behavioral interventions that build upon the principles discovered by experimental behavioral psychology. These have been used to treat a huge variety of behavioral problems from developmental delays to autistic spectrum disorders (McEachin, Smith, and Lovaas 1993). They are, by definition, evidence-based, individualized interventions. The behavior of each participant is observed, measured, and analyzed, and treatment is driven by evidence of whether improvements are observed or not, and under what conditions those improvements were brought about. The interventions are typically (though not necessarily) delivered in an intensive one-to-one manner.

ABA programs are designed on the assumption that learning is maximized when high-performance targets are set and teaching is focused on the individual. Indeed, unlike in traditional education, the passing criterion in behavioral education is not 40 percent, but typically somewhere around 90 percent. If the learner does not reach this stringent passing criterion, he or she is required to repeat the program until the criterion is reached. This process will be familiar to any player familiar with use of "boss fight" mechanics as a way of testing learned in-game skills.

Indeed, ABA programs have structures that resemble characteristic elements of computer games in many striking ways (for an in-depth discussion, see Linehan et al. 2011). For example, highly engaging games usually share with ABA interventions clearly specified and measurable goals (such as to complete a section of game or level up the character), require a great deal of repetition of skills in order to reach that goal (fighting numerous similar enemies), are often conducted under time constraints, have clearly specified rewards for reaching the specified goal (stronger player/more weapons/access to new levels), and provide consistent feedback from the game state on how successfully the player is performing. In addition, successful games pay a great deal of attention to the rate in which complexity is increased over the course of game levels and to the balance and pacing of player advancement through these levels. These issues of rates, balance, and pacing appear to parallel precisely the process that the behavior analyst undertakes in designing an intervention.

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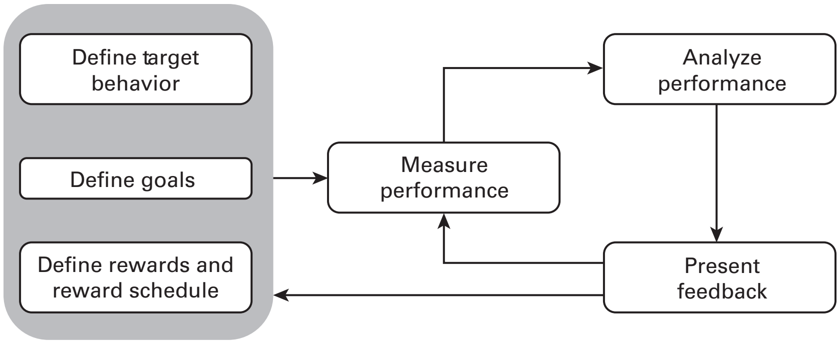

Figure 3.2
Diagrammatic illustration of the key processes involved in any behavioral intervention.

Besides the structural similarities between characteristic game design elements and the processes used for behavior modification, the other reason why this field should be of interest to the designers of gamified products is that there has been a great deal of empirical support for the effectiveness of ABA programs. Indeed, they have been extremely successful wherever implemented, from university modules (Saville et al. 2006) to secondary school (Olympia et al. 1994), primary school (Lindsley 1971, 1992a, 1992b), driver education programs (Bell et al. 1991), and challenging populations (Christopherson and Mortweet 2001). Behavioral teaching methodologies have been particularly successful as early interventions for children diagnosed with autistic spectrum disorders (Lovaas 1987).

ABA Processes as Game Design Elements

In this section, we will take a step-by-step look at some of the processes essential to any form of ABA, briefly explain some issues surrounding the implementation of those processes, and point out how they can be useful in the design of gamified products and services (figure 3.2). Obviously, we do not have space here adequately to summarize decades' worth of work by thousands of researchers. For those who wish for a more detailed account, we recommend Cooper et al. (2006).

Selecting and Defining Target Behaviors

The most basic and important step of any intervention is to define a target behavior clearly. This must be a clearly, objectively observable behavior that it is possible to measure via the technology on which the system is implemented. Whether or not participants have reached a behavioral goal should be judged by observation of that behavior, not by their answers to a questionnaire or other such self-report measure.

ABA programs, like games, break long-term goals (such as running a marathon) into short-term component tasks (the exercises expected each day over the course of training). Participants must demonstrate success at all of these short-term goals as they advance through the program before requiring performance of the more complex skill (asking someone to run a marathon without having completed sufficient training is not likely to have a successful outcome). Thus, the designer must clearly define not only the ultimate goal of the program but also the series of steps that learners must reach on their way to that goal. In this way, a hierarchy of observable behavior measurements is created, in which the most basic concepts and processes are taught first, and knowledge and performance are built methodically.

Measuring Behavior

Measurement refers to the process of assigning numerical values to observed behavior. This must be done in a coherent and meaningful manner so that the system can analyze that behavior and provide feedback. Notably, ABA programs typically measure not only accuracy (whether a target has been met or not) but also temporal aspects of performance (how long it took the person to reach that goal). Behavior analysts have found that measures that include temporal components, known as fluency measures, are a more accurate method for judging the efficiency of behavior than simple measures of accuracy. For example, knowing that someone has completed a five-mile run provides us with a lot less information about their expertise than if we also know whether the run lasted twenty minutes or an hour.

Behavioral psychologists have also found that imposing strict time constraints on behavior is a useful method for ensuring the learner attains expertise. Time constraints are also characteristic game design elements, and, as such, we can expect them to be used in many gamified services in the future.

Recording Data

Closely related to the process of measuring behavior is that of recording those measurements in a manner that is amenable to analysis. Because the dependent measure of all behavioral interventions is the change in behavior over time, applied behavioral psychologists typically use line charts to record and represent data. These charts are called *celeration charts*, as they are designed to represent accelerating and decelerating frequencies of target behaviors. In a gamified service, these data points must be recorded in a way that is easy for the game application to read and analyze. Just *how* the data are presented is open to the creativity of the designer.

It is also essential to decide on what specifically must be recorded. Behavior analysts aim to record every single instance of a target behavior and to plot these on celeration charts. For example, in a spelling exercise, the position of each letter in a word is checked and marked whether it is correct or not. In a gamified healthy eating application (i.e., https://foodzy.com), it is essential to record every meal, snack, and drink consumed in order to understand fully a user's dietary behavior.

Analyzing Behavior Change

The key metric used by behavior analysts in monitoring the success of learners is the change in their behavior over time. Essentially, once a learning outcome has been defined, the behavior analyst continually measures the learner performing that behavior and examines whether or not the learner is approaching that outcome. Using celeration charts, it is easy for the behavior analyst to understand the trajectory of behavior and to take appropriate action to ensure that appropriate behaviors are promoted and maintained, while inappropriate behaviors are modified or extinguished. If games and game-inspired applications are to automate this process of analysis successfully, they must similarly focus on identifying behavioral trajectory. Specifically, trajectories explain crucial temporal and contextual aspects of behavior that are not available when analyzing behavior in terms of means, individually or in groups. Luckily, analyzing change in behavior is relatively simple, once the preceding steps of defining, measuring, and recording behavior have been carried out in a methodical fashion.

Presenting Feedback

Throughout the chapter, we have discussed feedback in great detail in terms of operant conditioning, scheduling of feedback, and ongoing evaluation of the effectiveness of feedback. Both engaging games and successful ABA programs use these basic processes in combination to ensure that the game is able to provide consistent, appropriate, and specific feedback to the player and to guide the player toward performing at a high skill level. It appears that adopting the following approach is useful in (a) offering a variety of rewards for appropriate performance, (b) offering persistent negative consequences for poor performance, which the player will work to avoid, and (c) directly presenting aversive consequences when the user does something that the service provider does not want him or her to do. Of course, whether any stimulus serves as a reinforcer or an aversive stimulus for any individual should be defined through careful observation of that individual's behavior. Care should also be taken to personalize the schedule on which feedback is presented. Designers who understand and use these processes will have a better chance of promoting and maintaining engagement with their gamified services.

Criticisms of Behavioral Psychology

It is almost a cliché that behavior analysis is not currently as popular as it once was as an approach to psychology, because it apparently failed to provide an adequate account of complex human behavior and in particular an account of language and cognition. Skinner did indeed concentrate most of his attention on animal research and never conducted a single experiment on humans. However, his 1957 text *Verbal Behavior* was an attempt to show how the basic principles of behavior discovered using animal populations would apply in the human case. It is fair to say, however, that it was relatively unsuccessful at that task. Critics like Noam Chomsky (1959) engaged in now legendary attacks on Skinner's position. The Skinnerian approach did not seem adequate to the task of describing behavior other than reflexive or directly trained operant behavior.

Complex Language and Cognition

As it happens, the critics were correct. Humans were more complex than animals, and it was Skinnerians who first came up with the evidence (see Galizio 1979). In particular, it turned out that animals and humans sometimes behave differently under schedules of reinforcement, and the reason had to do with the ability to follow verbal rules, which sometimes aid schedule learning but sometimes interfere with it (O'Hora and Barnes-Holmes 2001). Later on, it emerged that only humans appear to be able to derive relations (see the earlier section "Complexity and Challenge in Games") between stimuli, irrespective of the level of training supplied to do so (see Hayes et al. [2001] for an in-depth review and discussion). This represented a qualitative as well as quantitative difference in the complexity of animal and human behavior. Moreover, it turned out that the ability to derive relations underlies all forms of human cognitive ability and may even be definitive of human consciousness itself. In the meantime, new approaches to just about every aspect of psychology have been provided by behavior analysts. The approach to therapy has been transformed, and the analysis of creativity, cognition, language, spirituality, personality, and intelligence have all been re-energized (see Dymond and Roche 2013 for a book-length treatment of this issue). In effect, the current analysis is provided within that context and in the full knowledge that human behavioral repertoires are more complex than those of animals. While a detailed discussion of these differences is beyond the scope of the current chapter, it is worth pointing out that an awareness of these differences has made the analysis provided in this chapter possible. More specifically, our analysis of game complexity in terms of derived relations relies on the newly discovered analytical unit of the derived stimulus relations, which is suitable only for human applications and is one that Skinner did not live to see.

Intrinsic Motivation

Another criticism that has been leveled at behavioral psychology, and one which is especially relevant in the case of complex linguistic activities such as game playing, is in how it explains activities that seem motivated by intrinsic or private rewards, rather than extrinsic, observable ones. Because intrinsic motivations are not observable, their explanation would seem to lie outside the explanatory power of behavior analysis. Aside from the possibility that there may be observable physiologic responses (e.g., adrenaline) that can explain some of the appeal of such activities, the modern behavioral explanation suggests that coherence is an important reinforcer for humans. Coherence and sense-making serve as continually available reinforcers for further responding (Hayes et al. 2001). Humans appear to be highly motivated to achieve coherence and make sense in every context, even in the context of solving puzzles or playing games (see Barnes-Holmes et al. 2010). This is yet another shift in modern behavior analysis that is not familiar to the average psychologist. The move toward the explanation of behavior in terms of self-sustaining reinforcement loops is a major step toward explaining many forms of complex behavior, including game playing.

Questions of Values and Control

Behavioral psychology often provokes unease due to its pragmatic focus on understanding and controlling behavior. Specifically, the goal of behavioral psychology is to understand the processes through which any desired change in any observed behavior can be brought about. In the context of designing a society, such as that imagined by Skinner (1948), this raises questions regarding who is designing that society, what values are inherent in that design, and who is judging what constitutes appropriate and inappropriate behavior (i.e., the behaviors that should be reinforced or punished). Because the gamified world envisioned by McGonigal (2011) and Schell (2010b) is one in which a designer decides on these exact issues, perhaps we should be careful to hold these game designers to account in much the same way that behavioral psychologists have been.

Conclusion

Gamification, the process of using game design elements in non-game contexts, has rapidly emerged as a massively popular tool in the development of online services and applications. Seized by entrepreneurs and businesses as a way of increasing engagement with products, existing game designers and scholars have, unsurprisingly, been vocal about what they perceive as a desecration of their craft. However, both camps fail to understand the true powers of games as tools for learning, within the context of decades of research into the realities of behavioral psychology. Specifically, all games, and all gamified products and services, follow strict patterns of highly structured behavior management, feedback loops, and reward mechanisms in order to effect changes in player behavior. Just as one can beat the boss in battle by applying skills learned through the game or change one's lifestyle through participation in a gamified experience, game design elements have a predictable and measurable effect on one's behavior.

In this chapter, we have reviewed the field of behavioral psychology and described how behavioral processes are commonly implemented in both standalone games and gamification, through the use of characteristic game design elements. Starting from its origin in the early twentieth century, we have described behaviorism and its underlying philosophy as well as the (frequently misunderstood) core principles of operant conditioning, feedback schedules, and evaluation, relating these directly to techniques used in real games and gamified experiences. Building on this, we have explored the realities of complexity in games and the tried and tested approaches of ABA in effecting behavior change in real-world contexts. Finally, we discussed the key components of successful ABA programs in terms of game design. This includes the key processes of defining target behaviors, measuring and recording behavioral data, analyzing behavior change, and presenting appropriate personalized feedback.

Through a more thorough understanding of the principles of behavioral psychology, game designers and gamification professionals can better understand the processes at work when a player is engaged with his or her game, and the potential effects on the player's behavior. With the tools of ABA, designers have the ability to create measurably better-gamified experiences for the benefit of their players.

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