

Cultivating Engagement and Enjoyment in Exergames Using Feedback, Challenge, and Rewards

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Abstract

Objective: This article reviews theoretical and empirical evidence related to three mechanisms for encouraging enjoyment during exergame play: Feedback, challenge, and rewards.

Materials and Methods: A literature search and narrative review were conducted.

Results: Feedback is found in nearly all exergames, and richer, more in-depth feedback is associated with increased activity. Challenge is a vital component of any videogame, and exergames include physical as well as cognitive challenges. Flow states have traditionally been conceptualized as occurring when an optimal match between player skills and game challenge occurs. However, failure and retrial are necessary for feelings of overall satisfaction and fun, despite not necessarily being ideally fun or satisfying themselves. Rewards are a more complicated issue, with significant theoretical and empirical evidence suggesting positive and negative effects of reward systems. How rewards are integrated into the mechanics and storyline of the game likely impacts how they are perceived and, thus, their effectiveness. Finally, integration of these mechanisms into exergames requires specific attention to both cognitive and physical implementations. Movements that are not themselves enjoyable or engaging may lead to cheating and lower energy expenditure.

Conclusions: Feedback, challenge, and rewards are promising mechanisms by which exergames could become more enjoyable. How these concepts are operationalized can affect physical and psychological reactions to exergames. Attention to these concepts in future exergame development and implementation would benefit theory, research, and practice.

Introduction

EXERGAMES, DEFINED BROADLY, COMBINE physical movement (beyond fingers on a hand-held controller) with videogaming. Traditionally this combination has been intended to make exercise more fun and enjoyable and thus more likely to be continued over time. Feedback, challenge, and rewards are three mechanisms by which exergames may produce enjoyment. These three mechanisms are linked and may sometimes overlap; for example, rewards are a specific type of feedback that provides information on performance related to a challenge. The purpose of this narrative review is to provide an overview and synthesis of research on these concepts across multiple disciplines and to discuss their importance for future exergame research, implementation, and development.

Feedback

Feedback is a major bedrock of behavioral physical activity intervention. It is also a vital tool for game developers.

Michie et al.¹ defined feedback provision as to “monitor and provide informative or evaluative feedback on performance of the behavior.” Typically, for a physical activity intervention this would involve information on steps taken, time spent active, etc.

Videogames, by their very nature, provide many different types of feedback both periodically and continuously. Feedback provides players with information on their skill development and progress, which should support perceptions of competence. Indeed, comparisons of playing videogames with watching the same or very similar content have found greater self-efficacy² and learning³ from interactive gameplay. Feedback may be visual, auditory, or sensory and may be an explicit evaluation or a more automatic part of the game. Of course, all of these can (and likely should) be integrated into multiple layers of simultaneous feedback. For example, many traditional games use dozens of layers of feedback simultaneously: A progress bar for health, physical indications of health in the player avatar (stumbling,

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clutching the stomach when hurt), a number to indicate the amount of health left, other characters commenting on the main character’s state, etc.

Table 1 displays recommendations from two theories^{4,5} and guidelines for movement-based games.⁶ Many of these recommendations come from experienced game developers, and there is preliminary evidence that following the Social Cognitive Theory recommendations can produce greater physical activity in a clinical intervention setting.⁵ Basic feedback might provide a general idea of how well the player is doing (e.g., providing a “physical age” or other type of fitness score), but feedback that better adheres to these recommendations could provide context and meaning to player actions. Moment-to-moment feedback offers opportunities to empower mastery via visual, audio, and haptic cues (e.g., “you’re doing great!” or vibration upon reaching a milestone). Sustained feedback can offer further context, showing time left until the end of the session and/or progress toward a discrete goal. Cumulative feedback may use tools such as workout calendars, charts comparing accuracy with that of previous sessions and with that of similar players, and progress bars for different specific goals.

The state of exergame feedback

A content analysis of exercise- and workout-themed exergames found that all of the included games provided some type of feedback, and many provided multiple types of feedback.⁷ Feedback was typically paired with modeling by a virtual trainer or virtual self-modeling. Virtual self-modeling using a doppelganger avatar appears to be particularly powerful in encouraging behavior change, including both eating⁸ and physical activity⁹ behavior. Many exergames use camera-based controllers to display real-time video of the player on screen. These types of interfaces have been called “augmented virtuality” and can provide very rich feedback.¹⁰ Video of player movements can be used to display feedback related to accuracy of movement (e.g., placing color-coded lines over the player’s limbs) and consistency of accurate movement (e.g., a glowing outline around the body). Such visuals allow for more detailed, nuanced, and immediate non-

numerical feedback on performance. Integrating feedback into game visuals may be important for decreasing cognitive load during exergaming; more traditional and explicit feedback types may prove to be unpleasantly taxing in the context of an already fatigue-inducing game.⁶

Video-based feedback of this type appears to be highly motivating. A recent experimental study compared levels of “interface embodiment” (i.e., levels of feedback on body movement).¹⁰ The three levels were low (“Wii™ Fit” [Nintendo, Kyoto, Japan], no evaluation of movement, with real-time video from a separate Webcam), medium (Wii Fit, movement data evaluated by a balance board and avatar-based visual and audio feedback), and high (“Your Shape: Fitness Evolved,” movement data evaluated by camera, real-time video-based visual and audio feedback). The study found greater enjoyment and energy expenditure in the highest feedback condition.¹⁰

These findings show promise for all types of future exergames. Camera controllers for consoles are becoming more sophisticated, allowing for better representation of player movement, and mobile devices typically include high-quality cameras that could be used for similar purposes. Mobile devices also allow for use of built-in accelerometers and global positioning system to provide information about activity intensity, frequency, and duration. More research on interface embodiment and feedback integration is needed to guide more effective exergame development.

Challenge

Challenge in videogames is typically discussed in terms of flow. A flow state occurs when an optimal match between skill and challenge is found and is a highly intrinsically motivating experience.¹¹ However, many activities that are too difficult or too easy may also be intrinsically motivating, without producing a flow state. Difficulty, frustration, and failure are necessary components of any videogame, including exergames.

Caillois¹² proposed four game types: *Agon* (competition), *alea* (chance), *mimicry* (make believe), and *ilinx* (vertigo), which can occur separately or in combination in a single game. Lauwaert et al.¹³ proposed two additional types: *Repens* (surprise) and *repositio* (forced retrial). Both of these types can (and should) exist within the same game, and both are satisfying in their own way. Although *repositio* can certainly become frustrating and unpleasant, it is also critical to fun and satisfaction—Obstacles must exist meaningfully in order to produce the enjoyment of overcoming them. Failure is not necessarily enjoyable or satisfying (though there is some evidence that it can be),^{14,15} but it is crucial for overall enjoyment and satisfaction with the game.^{16,17} In fact, failure may be a mechanism for supporting relatedness in multiplayer games as teams work together to overcome challenges. Challenge must be balanced so that failures can support perceived relatedness and competence (when they are retried with new strategies and overcome) without reducing perceived competence.

Classic game structure provides opportunities for both *repens* and *repositio*, during periods both above and below the traditional flow line. Figure 1, adapted from the alternate model of flow of Falstein,¹⁸ shows a pattern of challenge similar to that found in a standard role-playing game. Some

TABLE 1. CHARACTERISTICS OF GOOD FEEDBACK

<i>Theory</i>	<i>Characteristic</i>
Social Cognitive Theory	Specific Clear picture of how well player is doing Compare with past accomplishments Compare with similar others Compare with specific goals
Self-Determination Theory	Provide rich information Empower feelings of mastery Use multiple levels (moment to moment, sustained, cumulative)
Movement-based game guidelines	Provide feedback on if, when, and how movement occurs Include audio and haptics as well as visuals Should not greatly increase players’ cognitive load

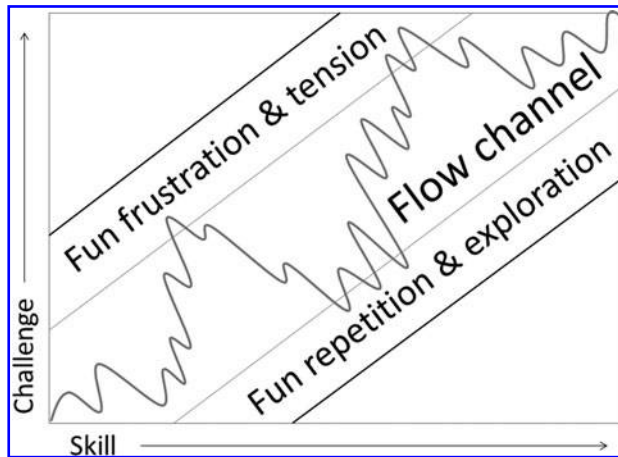


FIG. 1. An adapted model of flow in exergames.

periods of exploration are safe and easy, emphasizing a sense of wonder and discovery. Others are wrought with tension, threatening what might be around the next corner. Similarly, some challenges are frustratingly difficult, causing the player to reevaluate his or her strategy and retry numerous times, whereas others provide a sense of mastery as weaker enemies and puzzles are dispatched with ease. Studies of flow in videogames typically assume that a continuous increase in difficulty is ideal, but this is not necessarily true. A recent study manipulated an action game into three difficulty types (continuous increase, up-down, and down-up). The up-down condition, in which difficulty trended upward but not continuously, was found to produce greater immersion in the game than the other two conditions.¹⁹ Autonomy and competence, *repens* and *repositio*—All may be encouraged on either side of the standard flow channel. Such variations in difficulty may be particularly important in exergames, as players face both mental and physical exhaustion.

Rewards

Rewards are a controversial topic in psychology and public health. Reinforcement, along with punishment, is a commonly used behavior change technique based on operant conditioning. Although there is evidence that external rewards, such as money or tangible objects, can motivate weight loss and associated behaviors,^{20–22} there is also a large body of literature suggesting that external rewards can decrease intrinsic motivation.²³ That is, if a person engages in a behavior for the purpose of obtaining a reward, he or she is by definition no longer engaging in that behavior for its own sake. External rewards may encourage behavior as long as the rewards keep coming, but intrinsically motivated activity is more likely to produce long-term, sustained change.²⁴ Although little is known about the long-term effects of external rewards, preliminary evidence suggests that the drop-off in behavior maintenance predicted by Self-Determination Theory likely occurs.^{25,26}

Further complicating this issue is the nature of videogame rewards, which can provide competence support (thus increasing intrinsic motivation) while simultaneously providing an external reward that decreases intrinsic motivation.²⁷ It appears that a key factor in determining how rewards affect

motivation is player perception of the rewards as autonomy supportive or controlling.²⁴

Reward types and classic game structure

To provide a common language for discussing reward types, Table 2 presents three different taxonomies taken from the literature (two for rewards, one for punishment).^{16,27,28} Rigby²⁷ proposed two reward types that are relatively autonomy-supportive (verbal and task-noncontingent) and two that are relatively controlling (task- and performance-contingent). All of the types proposed by Hallford and Hallford²⁸ could be autonomy-supportive or controlling, depending on their use. Also included are several additional proposed reward types related to narrative and character in games.

“Classic game design” consists of a repeating pattern of meaningful choices that affect the progression of the game, followed by a systematic pruning of choices until a “choke point” of no choice is reached.¹⁸ Rewards of access (traditionally these might be keys or passcodes to a new part of the game, or a fight against a specific boss) in particular can obfuscate necessary limitations in player choice, making them seem inevitable, imperceptible, or even desired. Thus, in addition to their function as agents for autonomy support, rewards also serve as agents to distract from moments of reduced autonomy.

Rewards of glory are very prevalent in both exergames and exercise programs that have been “gamified.” These rewards are often implemented as virtual badges and achievements, in which rewards serve as performance feedback and indicators of reputation/status. Rewards of glory have great potential for increasing enjoyment by improving perceptions of competence and relatedness (in fact, achievement systems have been conceptualized as massively multiplayer meta-games based on player reputation).²⁹ This meta-game can have negative consequences on intrinsic enjoyment of individual games, when actions are undertaken for the purpose of increasing reputation rather than for their inherent enjoyment.

Narrative and rewards

In addition to rewards that provide access to new areas of the game, rewards can also provide access to new parts of the game’s storyline or a better understanding of game characters. Traditionally, exergames have not included substantial narrative content, and it has been hypothesized that a lack of storyline may have contributed to ratings of those games as boring.³⁰ Following innovations in role-playing games, exergames increasingly use relationships as game mechanics and rewards. Narrative-related rewards may be tangible or intangible; that is, the game may provide a (virtual) “tangible” reminder of a character or may unlock access to new story clips or character insights.

Cut-scenes (noninteractive movie clips that interrupt gameplay to tell part of the game’s story) are a controversial type of reward. Because no interaction typically occurs during these scenes, they can create lulls in activity that may offer needed rest between more strenuous game sections, or they may needlessly decrease overall energy expenditure and interrupt steady-state exercise. It has also been argued that cut-scenes detract from feelings of autonomy because they interrupt interactive play with passive viewing. However, Cheng³¹ pointed out that even passive viewing can contribute to

TABLE 2. REWARD AND PUNISHMENT TAXONOMIES

<i>Taxonomy type</i>	<i>Description of reward function</i>	<i>Examples</i>
Hallford and Hallford ²⁸		
Rewards of glory	Bragging rights and feedback	Points, trophies
Rewards of sustenance	Maintain the status quo and prolong play time	Health packs
Rewards of access	Allow access to new locations or resources	Key
Rewards of facility	Enable or enhance player abilities	Power-ups
Rigby ²⁷		
Verbal intangible	Other characters provide intangible rewards to the player character	NPC thanks you
Task-noncontingent	Unexpected, random rewards	Random drops
Task-contingent	Reward player for engaging in a behavior	Trophy
Performance-contingent	Reward player for his or her successful performance of a task/behavior	Score
Narrative-related rewards (proposed)		
Story access	Allow access to new parts of the story or a different perspective on the story	Cut-scenes, story clips
Character access	Allow access to new characters or a better understanding of characters	Social links, supports
Tangible character rewards	A (virtual) tangible indicator of parasocial relationships with characters	Dog tags, memorials
Representational agency	Character does something cool, making the player in turn feel cool.	Cut-scenes
Juul ¹⁶		
Energy punishment	Loss of energy	HP/MP drain
Life punishment	Loss of a “life” or retry	Character death
Game termination punishment	Game session ends, and progress is lost.	Game over
Setback punishment	Losing abilities or forced replay	Return to last save point

HP, health points; MP, magic points; NPC, nonplayer character.

feelings of agency by (a) providing context and rationale for the player’s actions and by (b) expanding the player’s options for *feeling* that he or she has agency, even when he or she does not. He suggested that cut-scenes allow representational agency—That is, they allow player characters to do impressive things that they otherwise would not be able to do in-game. Because identification with a character can influence a player’s self-perceptions and behavior,^{32,33} cut-scenes may be a mechanism for increasing perceptions of competence. Although there is always risk when undermining autonomy in a videogame, cut-scenes do not necessarily have a net negative effect on motivation or even on perceived autonomy.

Punishment: The opposite of a reward?

Punishment is a special case; rather than providing positive feedback on skillful performance related to a challenge, punishment provides feedback on failure to overcome the challenge. The manner in which a game punishes failure likely impacts how failure is perceived by the player. Table 2 displays Juul’s taxonomy of punishment types in games. Preliminary evidence suggests that setback punishment should be used sparingly, as replaying a game section over and over can be demotivating.¹⁶ Thus, players feel challenged but not “stuck.” However, there likely is a place for some use of this punishment strategy, to encourage *repositio* play and reevaluation of player strategies.

Failure, punishment, and replay are standard aspects of many game types that are common among exergames, such as dance games. Clever systems of punishment must be used to balance player desire for challenge with the clear

limitations of evaluation systems. The punishment types in Juul’s taxonomy are negative punishment (taking away something desired, in this case energy, a “life,” a turn, or progress through a level). Some exergames also use positive punishment (giving a negative stimulus). Two prominent examples are “Dance Dance Revolution” games (Konami, Tokyo, Japan), which include heckling from an announcer, and “Wii Fit” games, which visibly fatten the player’s avatar if she or he is overweight. Several experiments suggest that, in particular, forcibly fattening an avatar is unlikely to be enjoyed or effective.^{34–37} Failure and punishment are backbones of videogaming and can provide useful feedback, opportunities to later demonstrate mastery, and opportunities for social support; however, they can also discourage and shame.

Relationships of These Concepts to Movement and Engagement

Essential to the discussion of body movement in exergames are the related concepts of engagement and presence. These two concepts are defined very differently across and even within disciplines, but essentially refer to levels of distraction from the real world in favor of a technology-mediated virtual one. Typically, engagement is conceptualized as a broad term that can either include presence or exist on a continuum of distraction along with presence and related variables.^{38,39} Whereas presence is conceptualized as involving deeper immersion and a sense of “being there” in a virtual environment,⁴⁰ engagement is a less cognitively taxing form of distracted attention and involvement.⁴¹

Engagement is a type of “suboptimal experience,”⁴¹ as opposed to the “optimal” experience of flow.

Feedback, challenge, and rewards may affect enjoyment and active behavior by increasing feelings of engagement during exergaming. Body movement can directly affect feelings of engagement.⁴² Movements that feel natural and realistic are more likely to induce engagement and presence than perfunctory button presses or movements that feel meaningless and tacked on.^{43–47} Motion controls do not necessarily increase engagement⁴⁸; this lack of effect may be due to a lack of perceived naturalness of some motion controls or how they are implemented in some games. Furthermore, movements should be potential ends unto themselves in exergames; that is, the movements themselves should be fun rather than a means to an end. No matter how intrinsically motivating other parts of the game may be, extrinsically motivated movements will likely lead to common problems of unenthusiastic controller waggling, cheating, or cessation of play.

Compelling movements can be encouraged by and/or incorporated into feedback, challenge, and rewards. Clear, simple-to-understand feedback may be particularly important in movement-based games, as complex feedback may increase cognitive load and lead to premature exhaustion. Visual, auditory, or haptic feedback can guide player behavior,⁴⁹ for example, by increasing the tempo of music to encourage

more intense movement or by causing a controller to vibrate when movement accuracy falls below a particular threshold. Integrating such feedback into gameplay may also increase engagement by making movements feel more natural.

Movements that are difficult because of requiring precision, endurance, strength, balance, and poise can be alternated with movements that allow more relaxed play. Additionally, developers could incorporate less difficult nonphysical challenges (puzzles, exploration, etc.) during more difficult movements (and vice versa) to maintain interest and to reduce cognitive load. How movement can improve all aspects of a game should be considered, not just how movement can be used to increase energy expenditure.

Rewards can also involve movement themselves. The exergame “Kinect™ Adventures” (Microsoft, Redmond, WA) uses player movement quite cleverly by allowing players to pose triumphantly to create living trophies, which can be viewed and shared. Evidence on embodiment⁵⁰ and the Proteus effect,^{37,51} in which avatar behavior influences real world behavior, suggests that such powerful, triumphant poses could encourage feelings of competence in players. Many exergames unlock more difficult levels as a task- or performance-contingent reward, which could produce both more intense and more fun movements (e.g., in a more complexly choreographed and faster dance routine).

TABLE 3. FUTURE DIRECTIONS FOR RESEARCH ON FEEDBACK, REWARDS, AND CHALLENGE

<i>Concept</i>	<i>Possible research questions</i>
Feedback	<p>Does specific feedback on movement accuracy improve motor skills and function?</p> <p>Does feedback that adheres to theory-based principles lead to improved outcomes in exergame trials when compared with standard feedback?</p> <p>Does play of an exergame that uses embodied feedback produce greater activity over time than play of an exergame that uses standard feedback?</p> <p>Is amount of positive feedback associated with motivation?</p> <p>How is feedback on negative outcomes related to different types of motivation?</p> <p>What method for communicating feedback on failure is preferred by exergame players?</p> <p>What is the relationship between fatigue and feedback type and amount?</p> <p>Are there negative consequences to using real-time video for feedback on body image and self-efficacy?</p> <p>How can exergames utilize wearable technology such as smartwatches for feedback provision?</p>
Rewards	<p>What kinds of rewards are most prevalent in currently available exergames, and does this prevalence differ by game genre?</p> <p>Are expected versus unexpected rewards of glory differentially related to intrinsic motivation?</p> <p>Does a cut-scene depicting “cool” actions by the player character differentially affect perceived autonomy and competence as compared with a similar cut-scene depicting neutral or uncool actions?</p> <p>Does adding narrative-related rewards to an exergame influence motivation, and is this relationship moderated by player preference for story-based games?</p> <p>Does providing choice among rewards that produce meaningfully different effects on the game influence motivation?</p> <p>Does explicitly framing cut-scenes as an opportunity to rest in between bouts of strenuous movement influence perceived autonomy and motivation?</p> <p>What type of punishment is preferred by exergame players?</p> <p>What is the relationship of different punishment types to motivation?</p>
Challenge	<p>How do players describe their experiences related to <i>repens</i> and <i>repositio</i> play?</p> <p>Do personality traits influence preference for difficulty level in videogames?</p> <p>Do players experience physical challenges and cognitive challenges differently when playing an exergame?</p> <p>What is the relationship among perceptions of physical competence, actual motor skill, and enjoyment of an exergame?</p> <p>Are integrated breaks necessary to sustain enjoyment of exergames?</p> <p>Is there a relationship between ratings of perceived exertion and ratings of exergame difficulty?</p> <p>What is the impact of failures on perceived competence and relatedness in the context of multiplayer exergames?</p>

Conclusions and Future Directions

Feedback, challenge, and rewards are mechanisms by which game developers can improve enjoyment of exergames, potentially leading to greater play and physical activity over time. Many questions remain as to optimal methods for implementing these mechanisms in exergames. Table 3 displays a list of preliminary research questions provoked by the discussion above, the answers to which might offer insight into best practices for future exergame mechanics. Each of these mechanisms requires thoughtful deployment due to their complex nature and the potential for interaction. How they are implemented is likely as important a question as whether they are implemented.

The breadth of research that currently exists across disparate fields points to the importance of creating multidisciplinary research teams for future studies. Further experimentation with game characteristics could help refine theories of motivation and their application to both activity and gaming, which could in turn produce improved behavioral and health outcomes.

Acknowledgments

During the writing and revision of this manuscript, E.J.L. was supported by an institutional research career development award (K12HD052023: Building Interdisciplinary Research Careers in Women’s Health Program) from the Office of Research on Women’s Health, Office of the Director, National Institute of Allergy and Infectious Diseases and the Eunice Kennedy Shriver National Institute of Child Health and Human Development at the National Institutes of Health, followed by an individual Career Development Award (K07CA175141). E.J.L. is also supported by a Beginning Grant-in-Aid from the American Heart Association (13BGIA17110021). This research was supported by the Institute for Translational Sciences, supported in part by a Clinical and Translational Science Award (UL1TR000071) from the National Center for Advancing Translational Sciences at the National Institutes of Health, the Sealy Center on Aging, and the Claude D. Pepper Older Americans Independence Center (grant P30AG024832) at the University of Texas Medical Branch. This publication was also funded in part by the U.S. Agency for Healthcare Research and Quality through grant R24HS22134. The author would like to acknowledge the assistance of the participants at the exergaming preconference workshop at the 2014 International Society for Behavioral Nutrition and Physical Activity Annual Meeting. Their questions and comments were instrumental in developing and improving the ideas expressed in this manuscript.

Author Disclosure Statement

No competing financial interests exist.

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