GAMES FOR HEALTH JOURNAL: Research, Development, and Clinical Applications
Volume 2, Number 3, 2013

DOI: 10.1089/g4h.2013.0022

Disentangling Fun and Enjoyment in Exergames Using an Expanded Design, Play, Experience Framework: A Narrative Review

Robin Mellecker, PhD,[1] Elizabeth J. Lyons, PhD, MPH,[2] and Tom Baranowski, PhD[3]

Abstract

With exergames (as with physical activity in general), more intense and longer-duration game play should accrue more health benefits. Exergames, however, appear to be played for relatively short durations, often at medium or lower intensities. Ostensibly games are played for fun or enjoyment. Enhancing the fun or enjoyment experienced during exergame play should enhance the intensity and duration of physical activity, and thereby the health benefits. Research, reviewed herein, indicates fun and/or enjoyment in games are inherently laden with psychosocial, physiological, and embodiment substrates. Physical activity may also have separate or closely related psychosocial, physiological, and embodiment enjoyment substrates. Research is needed to integrate these levels of experience and to identify the game mechanics that enhance, and even maximize, the fun or enjoyment experienced in exergames, to thereby increase the health benefit.

Background

"Enjoyment" is a commonly stated reason for why people play videogames,[1] but also for why some are physically active.[2–4] The genre of exergames uses game play mechanics to require or encourage physical activity (PA).[5] Evaluation of exergame "enjoyment" has been reported,[6] but it is unclear what characteristic(s) of exergaming increases "enjoyment." An apparently approximately equivalent term, "fun," has been used for why children and adolescents play videogames.[7] Exergames usually entail some form of body movement, some of which have been identified as "enjoyable."[8] Videogame play and PA elicit similar physiological responses linked with enjoyment.[9,10] A clear understanding of what constitutes "enjoyment" or "fun," and how to increase it, may be useful to increase use of "games for health" and of PA (and thereby increase any cognitive or health benefits from playing these games).

This narrative review examines the psychosocial, physiological, and embodiment characteristics that have been associated with fun and enjoyment when playing videogames with and without PA, during PA and from body movement. Research is proposed to better understand these constructs and their interrelatedness, in the hope of increasing the initiation and maintenance of PA.

Design, Play, and Experience as an Organizing Framework

Videogames are more than the visual images and textual messages emanating from a visual screen. The Design, Play, Experience (DPE) framework expanded earlier work[11] by incorporating levels of game influence[12] (Fig. 1). From the DPE perspective, enjoyment or fun is the "experience" of game "design" features, which someone "played." Experiences have also been called feelings and emotional arousal. This review proposes additional DPE levels that may contribute to or account for fun or enjoyment when playing videogames and during PA. The analysis, herein, identifies the design features and game play interactions that may lead to the fun or enjoyment experience.

"Fun" Videogame Experiences

The experience of fun was measured using multiple adjective ratings. Forty-two adjectives were used to characterize a "…typical situation when you are having fun." An exploratory factor analysis revealed five fun experience factors: Sociability, contentment, achievement, sensual, and ecstatic.[13] This multiple characterization of the fun experience opens the possibility that fun is not a unitary experience. Different

[1]University of Hong Kong, Institute of Human Performance, Pokfulam, Hong Kong.
[2]Institute for Translational Sciences, The University of Texas Medical Branch, Galveston, Texas.
[3]USDA/ARS Children's Nutrition Research Center, Department of Pediatrics, Baylor College of Medicine, Houston, Texas.
The contents of this publication do not necessarily reflect the views or policies of the U.S. Department of Agriculture, nor does mention of trade names, commercial products, or organizations imply endorsement from the U.S. Government.

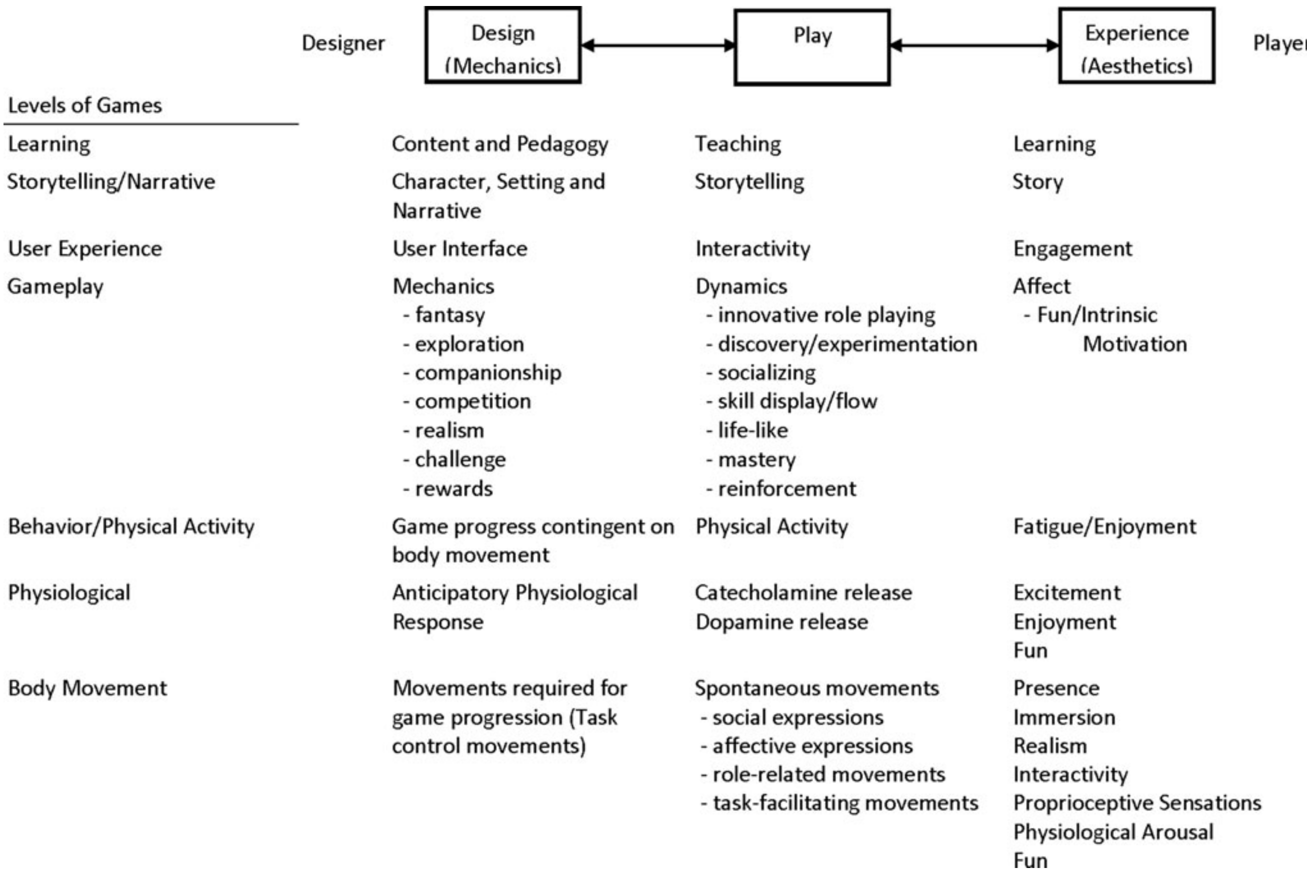

FIG. 1. Expansion of the Design, Play, and Experience framework to disentangle fun from game play and enjoyment for physical activity in exergames.

design features and game mechanics may influence the various types of fun.[13] Each construct may be a separate type of fun or indicators of some composite, latent fun experience.

Students rated 37 characteristics of game play in regard to how important they were "to their enjoyment of videogames.…"[14] Six exploratory factor analysis factors (for 28 items) emerged: Fantasy, exploration, companionship, competition, realism, and challenge. The authors reported how their factors related to 10 other published taxonomies. The six-factor structure was later validated.[15] Twelve videogame mechanics were identified, each leading to a different game play experience.[16] Of these, realistic sound effects, high-quality realistic graphics, based on a story, use of humor, character development over time, medium duration (days or weeks), rapid absorption rate, skill levels, and multiplayer features were frequently identified as the most enjoyment-enhancing structural characteristics of game design.[17] A limitation of the latter approach was that "fun" was identified as a design feature, but not further explicated. Thirteen categories of game design were rated in regard to their perceived importance for game enjoyment.[17]

These studies were limited by self-reported ratings of printed (not experienced) individual characteristics. Game enjoyment might be a simple sum of the ratings of these elements, a weighted average, or possibly some optimal combination of elements? None of these approaches was based on existing behavioral theories, which try to provide explanations for human behavior.

Fun in Behavioral Theory

"Fun" has not been a common topic in behavioral theory. Self Determination Theory, which emphasizes motivation to perform a behavior, has been used to identify the psychosocial characteristics for enjoying videogame play.[18] Intrinsic motivation is the ultimate motivation in Self Determination Theory, and enjoyment of doing the behavior is a defining characteristic of intrinsic motivation.[19] The experience of enjoyment was a function of the play characteristics of autonomy (the perception of making in-game choices), competence (the perception of being good at playing the game), and relatedness (the perception of relating to significant others or to personal values).[18] Alternatively, player effectance (i.e., the dynamic of the ability to influence game actions) (similar to Social Cognitive Theory's constructs of self-efficacy and outcome efficacy combined), but not control, was the primary determinant of game enjoyment.[20] An experiment that manipulated high and low negative reinforcement demonstrated that a lower-difficulty game that produced less feedback about failure led to greater game excitement (a proxy for game enjoyment).[21] Thus, the design feature of low negative reinforcement led to more enjoyment.

An accomplished game designer considered "FLOW" to be the source of fun in videogames[22]; positive mental status, including enjoyment, was posited as primarily a function of the mechanics of FLOW.[23] FLOW can be a design feature and reflects the play of a game. FLOW involves the experiences of immersion in the activity, control over one's environment, and increasing intrinsic motivation, or enjoyment,[24] and results from a person's increasing skill commensurate with dealing with an increasingly difficult environment.[23] FLOW has been applied to media in general and games in particular.[25] Although low skill for low difficulty and higher skill for higher difficulty define FLOW, low skill in a high-difficulty environment leads to frustration or anxiety, and high skill in a low-difficulty environment leads to boredom.[24,26] The presence of a story or narrative accompanied by the player's immersion in[27] or transportation by[28] the story has also been proposed as an indicator of videogame enjoyment,[29] and story offers appealing opportunities to promote behavior change.[30] Thus, an engrossing story in which a player faces increasing challenges and can increase skills quickly enough to overcome the challenges, but not so quickly to get bored by the challenges, appears to provide an important game design structure for enhancing fun or enjoyment.

Different Types of People Having Different Types of Fun

Different types of people may experience different game design features and mechanics as fun[1]: Participants high in extroversion (a personality characteristic) tended to have higher experiences of videogame ecstatic and sociability fun, participants high in agreeableness tended to have higher experiences of sociability and lower experiences of sensual fun, and participants high in openness tended to have higher experiences of achievement fun.[13] However, low correlations (all <0.190) limited the confidence in or the importance of these findings.

A cluster analysis of personality characteristics with the 21 aspects of game play revealed six clusters (Dutiful Companion, Extroverted Fidelitist Companion, Introverted Fidelitist Explorer, Conscientious Companion, Introverted Challenge-Seeking Fidelitist, and Calm Challenge-Seeking Companion).[31] This analysis overcame the limitation of analyzing isolated individual aspects of game mechanics, but a clustering of the game mechanics alone and correlation with the personality characteristics would have been more useful for the current analyses.

Four game playing "types" have been identified: Achiever (high scores, fast times), Lost (low scores, slow times), Explorers (high scores, slow times), and Careless (low scores, fast times).[9] These "types" were related to intrinsic motivation for education and need to be tested for relation to game play fun or enjoyment.[9] Individual differences in personality and game play provide a potentially important perspective for understanding who experiences what kinds of fun, and perhaps tailoring game design features to characteristics of the player to maximize their experience of "fun."

This brief overview reveals that the experience of fun or enjoyment from playing videogames may be of different types, may be experienced differently by different types of people, and may reflect combinations of game design features. The design feature of FLOW (i.e., a game designed to provide more challenges as the player becomes more skilled) provides an interesting mechanic to enhance the experience of fun. None of these ideas or methods has been explicitly tested with exergames, nor have differences in these ideas been tested by age. The FLOW mechanics appear to offer a particularly appropriate and promising method to enhance the experience of fun or enjoyment exergames.

PA and Videogame Physiology

As proposed in the DPE framework (Fig. 1), PA and videogame play share common physiological responses.[10,32] Being physically active, exclusively, triggers a set of physiological responses, perhaps accounting for the enjoyment experience described when exercising.[33–35] Exercising places a demand on the cardiorespiratory system, which stimulates a release of catecholamines (dopamine, serotonin, norepinephrine, and acetylcholine),[36] resulting in increased heart rate, respiration, and cerebral blood flow. These neurotransmitters direct mood states and contribute to the experience of enjoyment.[37]

Sedentary videogame play also elicited greater physiological (i.e., heart rate, blood pressure, breathing frequency, and ventilation) responses than being seated quietly in boys 7–10 years of age.[10] Emotional responses and arousal (experiences) produced changes in respiration,[38] and increased blood flow released the "pleasure" (experience) neurotransmitters when playing videogames seated.[32,39] Some videogames offer self-awareness (spatial presence) that triggers the experience of arousal and enjoyment.[40] Sympathetic arousal, a key physiological component of human emotion, was associated with long-term game play.[41] Physiological benefits and the experience of enjoyment may be increased when combining PA and videogame play.[42] Virtual reality when coupled with PA enhanced enjoyment, physiological responses to aerobic exercise, and long-term psychological benefits.[42,43] Thus, both game play and PA induced similar physiological effects associated with the experience of enjoyment. Whether the effects or experiences are similar for both children and adults or what game design feature enhances the physiological responses has not been studied.

PA and Videogame Neuropsychology

The enjoyment felt during exercise may also result from the release of endorphins, otherwise known as hormones classified as opioids.[35] Opioid release has been connected with the brain's reward system[44] and associated with exercise addiction[44]; endorphin release may also be a factor in increasing and maintaining PA. Endogenous opioids are released during physical stress or pain (acidosis tolerance) and reduce the experience of anxiety or produce euphoria.[45] PA raised brain serotonin levels to such an extent that PA is commonly prescribed as a treatment for depression.[46] The amount and type of exercise needed to produce these effects are not clear, and intra-individual variation exists in the dose of exercise that produces benefits.[47]

Using near-infrared spectrometry, individuals playing sedentary videogames experienced increased cerebral blood flow,[39] which was shunted to the prefrontal cortex, responsible for the release of dopamine. An adult study using functional magnetic resonance imaging confirmed these findings, showing increased release of dopamine in the ventral striatum during videogame play.[32] Greater ventral striatum (reward center) volume is considered a result of dopamine release.[48] Videogaming activated regions in the brain (parahippocampal gyrus and thalamus) associated with cravings and addictions.[49] These changes and anatomical differences were apparent in frequent videogame players, which may explain the experience of enjoyment and sustained videogame play.[48] Although promising, these preliminary results appear to vary between individuals and videogames.[50] Attention to visual task and fine motor movements (tapping on the controller) may produce changes in blood flow within regions of the brain and may be age dependent.[51] Thus, research is needed relating game design features and the presence and absence of PA to neurophysiological responses, especially those related to the experience of fun or enjoyment. Whether these effects differ by age, personality characteristics, or game play style would be important to explore.

FLOW and Physiology

Using the mechanics of FLOW (see above), exergaming might provide the ultimate experience of enjoyment or fun because PA and game play both elicit such experiences. Videogames increase levels of both dopamine,[32] a known mood enhancer, and cortisol,[52] an indicator of positive stress. Activation of the opioid system is responsible for the "runners high" and experiences of euphoria during sustained physical exertion.[35] Salivary cortisol from videogame play could be attributed to the challenge feature of videogame play, a critical component of the FLOW model. Using electromyography and subjective measures of FLOW, videogame play was shown to generate changes in facial musculature and increased FLOW responses, indicating that players were engaged in an activity they enjoyed.[53] Frequent active game play increased FLOW, as well as the experience of enjoyment. Despite the connection among videogame play, FLOW, and PA, few exergames have been designed to maximize the construct of FLOW. An understanding of the physiological responses connected with FLOW during videogame play and PA and of possible differences by age, measure of "fun," personality type, or game play style may explain exergame initiation, intensity, and sustained play and provide a basis for a next level of development of active videogames.

Body Movement in Videogames and Enjoyment

Embodiment (i.e., manipulating body posture) can influence emotions and physiological responses[54] and thus is a potential target for interventions to encourage sustained PA. For example, as a design feature, placing individuals in a "high power" standing position with a wide stance decreased cortisol levels and increased testosterone levels and feelings of being "powerful,"[55] and body movements considered "positive," such as head nodding and arm flexion, increased preference for pieces of music.[56] We have incorporated a taxonomy of five categories of game play-related movements (i.e., task control, task facilitating, role related, expressions of affect, and social expressions)[57] in to the DPE framework. Task control movements are game play mechanics and thus correspond to the design area; the other four movement types are spontaneous reactions to the game that occur during play. All five movement types may influence player experience in several ways.

Task-control design movements required for game progression were associated with the experience of presence and immersion (likely related to fun) when perceived to be natural and meaningful.[35,57–62] For example, slicing a Wiimote (Nintendo of America, Redmond, WA) controller like a sword may increase the experience of being present in the game and might be more enjoyable than pressing a button to swing a sword. Beyond increasing immersion, movement may also increase the experience of fun by providing haptic feedback (such as proprioceptive sensations or physiological arousal). Rich or "juicy" feedback has been conceptualized as a vital component of the experience of fun in videogames,[63] and the addition of bodily feedback may have contributed to greater fun.[8] Well-implemented task-control movements could affect multiple aspects of videogame experience by increasing realism and interactivity.[64]

Spontaneous task-facilitating movements may influence game play and experience by improving performance or perceptions of performance. These movements are not required by the game but may improve players' precision or timing (e.g., tapping one's foot to the beat). Thus, body movement may influence experiences of competence[65] or self-efficacy,[66] which predict enjoyment and continued play over time.[18,67]

Role-related movements may influence narrative and storytelling-related play experiences. Stories in traditional games increased arousal and emotional response[68]; stories acted out physically may increase these reactions because of increased immersion. Narrative contributed to identification with the values of story characters[69,70] and enabled players to "try on" different attributes they might have wished to have.[71] For example, games in which players embody physically fit characters (e.g., Olympic athletes, warrior heroes) may encourage them to "try on" the persona of a fit individual who enjoys PA.

Expressive movements depicting affect in a game (e.g., raising one's arms overhead after beating a level) can produce emotion via a feedback loop: The experience of enjoyment both produced, and was produced by, body movements during motion-controlled gaming.[57,58] Some camera-based games, such as Kinect® (Microsoft, Redmond) "Adventures," explicitly encourage triumphant affective expressions by providing opportunities to make one's own trophies by striking a pose upon completing a level. These poses may contribute to feelings of fun during play.

Playing with friends produced greater physiological arousal, feelings of presence, and positive affect than playing alone or with strangers.[72] Expressions of social behavior include motions used to interact with another player (e.g., taunting gestures when winning or pointing gestures to direct movement during cooperative play). When compared with playing the same game without motion controls, motion-controlled games produced more utterances and more instrumental and empathic movements.[57] Multiplayer exergames may thus increase movements beyond those required by the game. It is possible that these movements could increase feelings of co-presence, or relatedness, leading to the experience of greater fun/intrinsic motivation.[18]

Research Agendas

Psychosocial agenda

The existing DPE questionnaires need to be criterion or construct validated in diverse age, gender, ethnic, and other demographic groupings to ensure they are measuring what they purport. Differential item functioning analysis methods should be used to ensure the items mean the same thing across groups.[73] Physiological variables may provide the most appropriate objective validation. Validated questionnaires on game design and play need to be applied to exergames to identify the characteristics most strongly related to experiences of fun or enjoyment and related physiological responses. Exergames could be designed that systematically varied in-game choices and control over game progress (Self Determination Theory posited influences on intrinsic motivation) to assess their effects on enjoyment. FLOW appears to provide the clearest design guideline for engineering fun experiences, but this needs to be more thoroughly tested with validated measures in diverse populations. Validated personality tests should be applied prior to exergame play, and the ensuing game playing "type," aspects of game enjoyment or fun, and physiological responses should be assessed. Experimental studies measuring experiences and physiological responses simultaneously need to assess the time-related correspondence between the different types of the experience of fun and physiological responses, to assess if these are different aspects of the same processes or different phenomena. Longitudinal studies are needed that relate aspects or components of game playing fun or enjoyment to maintained exergame play duration (i.e., long-term behavior and health benefits).

Physiology agenda

PA and videogame play effects on the neurophysiological system suggest that the processes involved in the release of the neurotransmitters and subsequent effects on mood states are complex and dynamic. Both videogame play and PA influence the reward system and enjoyment, which contribute to enhanced PA. Determining whether the physiological system releases hormones (endorphins), their anatomical effects on the brain, and the relation to the experience of enjoyment may identify game design features that could be used to increase PA and contribute to sustained exergame play.

Most of this research has been done with adults. Children may have different physiological responses to stimuli. In view of the scant literature on physiological responses to videogame play and PA in children, future studies need to determine age-related differences in physiological responses, what components of game design enhance these physiological responses and result in enjoyment and fun, and the amount and type of exercise needed to produce the physiological effects that stimulate enjoyment, as well as the intra-individual variation in the dose of exercise that produces pleasurable responses. Recent advances in *in vivo* assessments have advanced knowledge on the emotional states when playing videogames, and these tools will provide more robust findings of the physiological responses during videogame play and PA.[74]

Whether psychophysiological responses associated with FLOW are individualized, determined by the videogame experience, and what pathways or biochemical responses are affected remain unclear. Although some physiological responses associated with FLOW and enjoyment during exergaming have been highlighted, many of these processes likely remain to be identified, which is complicated by the lack of a valid and reliable subjective assessment of FLOW.[75] Few exergames have been designed with the construct of FLOW or the physiological responses to play, despite the connection, among FLOW, PA, and videogame play. The dearth of information on the neurophysiology of FLOW during videogame play and PA, combined with the recent advances in objective measurement, reinforces the need for using both subjective and objective measures when assessing neurophysiological processes.

Embodiment agenda

Embodiment (both design and spontaneous play movement) studies may explain disappointing intervention results by investigating the relationship between movement and exercise-related outcomes (such as frequency, duration, and intensity) that may be mediated by enjoyment. For example, home-based studies using "Dance Dance Revolution" (DDR) (Konami Digital Entertainment, El Segundo, CA) have shown marked decreases in play over time.[76–78] Lack of realism in DDR task-control movements may decrease perceptions of fun (i.e., movement during DDR game play is not a realistic facsimile of dancing). Recent games (e.g., "Just Dance" [Ubisoft, Montreuil, France]) contrast with DDR in having more realistic dance game play wherein players mimic on-screen models' real dance moves that are part of complex, choreographed routines. Longitudinal studies that compare games with less realistic to more realistic task-control movement would be able to investigate long-term impacts of movement realism on enjoyment and the experience of enjoyment on adherence to exercise over time.

Social play of DDR was more successful than an individual home-based intervention.[78] The "Make Your Move" mode in "Dance Central 3" (Harmonix Music Systems [Cambridge, MA] and Backbone Entertainment [Emeryville, CA]) offers a mechanism for close investigation of the effects of social body movements on play experience. This mode allows one player to invent dance moves in different categories (e.g., "pirate," "controversial") and requires the opposing player to perform them. Although the moves become part of the game (and thus task-control movements), their purpose is social expression and interaction. The social aspect of the movements may lead to more humorous movements and social interaction, potentially impacting exercise frequency and duration, and more difficult and strenuous movements, potentially impacting exercise intensity.

Conclusions

Ostensibly games are played for the experience of fun or enjoyment. Research indicates fun or enjoyment in games has psychosocial, physiological, and embodiment substrates. PA may have separate or closely related psychosocial, physiological, and embodiment substrates. Research is needed to integrate these levels and to identify the game design characteristics that enhance, and even maximize, the fun or enjoyment experienced in exergames and from PA, using multiple diverse cross-validating methods. Ultimately, exergames need to be designed to maximize the experience of fun, based on what has been learned, and then tested for their effects on the initiation, intensity, and maintenance of game play and PA. More intense and longer-duration exergame play should accrue more health benefits. A lot of "fundamental" research needs to be done!

Acknowledgments

Support for E.J.L. was provided by a K12 grant (Building Interdisciplinary Research Careers in Women's Health) from the Office of the Director, National Institute of Child Health and Human Development, and the National Institute of Allergy and Infectious Diseases of the National Institutes of Health (number 5K12HD05023) and by the Institute for Translational Sciences at the University of Texas Medical Branch, supported in part by a Clinical and Translational Science Award (number UL1RR029876) from the National Center for Research Resources, now at the National Center for Advancing Translational Sciences, National Institutes of Health. This work is also a publication of the U.S. Department of Agriculture (USDA/ARS) Children's Nutrition Research Center, Department of Pediatrics, Baylor College of Medicine, Houston, TX, and had been funded in part with federal funds from the USDA/ARS under Cooperative Agreement number 58-6250-6001.

Author Disclosure Statement

No competing financial interests exist.

References

1. Pagulayan RJ, Keeker K, Wixon D, et al. User-centered design in games. In: Jacko JA, Sears A (eds.). *The Human-Computer Interaction Handbook.* Mahwah, NJ: Lawrence Erlbaum Associates, Inc.; 2003: 883–906.
2. Williams DM, Papandonatos GD, Napolitano MA, et al. Perceived enjoyment moderates the efficacy of an individually tailored physical activity intervention. J Sport Exerc Psychol 2006; 28:300–309.
3. Biddle SJH. Exercise motivation across the life span. In: Smith D, Bar-Eli M (eds.). *Essential Readings in Sport and Exercise Psychology.* Champaign, IL: Human Kinetics; 2007: 378–390.
4. Dunton GF, Vaughan E. Anticipated affective consequences of physical activity adoption and maintenance. Health Psychol 2008; 27:703–710.
5. Barnett A, Cerin E, Baranowski T. Active video games for youth: A systematic review. J Phys Act Health 2011; 8:724–737.
6. Maloney AE, Stempel A, Wood ME, et al. Can dance exergames boost physical activity as a school-based intervention? Games Health J 2012; 1:416–421.
7. Olson CK. Children's motivations for video game play in the context of normal development. Rev Gen Psychol 2010; 14:180–187.
8. Pasch M, Bianchi-Berthouze N, van Dijk B, et al. Immersion in movement-based interaction. In: Nijholt A, Reidsma D, Hondorp H (eds.). *Proceedings of 3rd International Conference of Intelligent Technologies for Interactive Entertainment (INTETAIN), Amsterdam, The Netherlands*. Berlin: Springer-Verlag; 2009: 169–180.
9. Heeter C. Playstyles and learning. In: Ferdig R (ed.). *Handbook of Research on Effective Electronic Gaming in Education*. Hershey, PA: IGI Global; 2008: 826–846.
10. Wang X, Perry AC. Metabolic and physiologic responses to video game play in 7- to 10-year-old boys. Arch Pediatr Adolesc Med 2006; 160:411–415.
11. Hunicke R, LeBlanc M, Zubek R. MDA: A formal approach to game design and game research. In: *Proceedings of the Challenges in Game AI Workshop*, 19th National Conference on Artificial Intelligence, San Jose, CA. Palo Alto, CA: AAAI Press; 2004: 1–5.
12. Winn BM. The design, play, and experience framework. In: Ferdig R (ed.). *Handbook of Research on Effective Electronic Gaming in Education*. Hershey, PA: IGI Global; 2008: 1010–1024.
13. McManus IC, Furnham A. "Fun, fun, fun": Types of fun, attitudes to fun, and their relation to personality and biographical factors. Psychology 2010; 1:159–168.
14. Quick JM, Atkinson RK. A data driven taxonomy of undergraduate student video game enjoyment. In: Steinkuehler C, Martin C, Ochsner A (eds.). *Proceedings of GLS 70 Games + Learning + Society Conference.* Pittsburgh: ETC Press; 2011: 185–190.
15. Quick JM, Atkinson AL, Lin L. Confirming the taxonomy of video game enjoyment. In: Martin C, Ochsner A, Squire K (eds.). *Proceedings of GLS 80 Games + Learning + Society Conference.* Pittsburgh: ETC Press; 2012: 257–260.
16. Prensky M. *Fun, Play and Games: What Makes Games Engaging. Digital Game-Based Learning*. New York: McGraw-Hill; 2001.
17. Wood RT, Griffiths MD, Chappell D, et al. The structural characteristics of video games: A psycho-structural analysis. Cyberpsychol Behav 2004; 7:1–10.
18. Ryan RM, Rigby CS, Przybylski A. The motivational pull of videogames: A self-determination theory aproach. Motiv Emot 2006; 30:344–360.
19. Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am Psychol 2000; 55:68–78.
20. Klimmt C, Hartmann T, Frey A. Effectance and control as determinants of video game enjoyment. Cyberpsychol Behav 2007; 10:845–847.
21. Chumbley J, Griffiths M. Affect and the computer game player: The effect of gender, personality, and game reinforcement structure on affective responses to computer game-play. Cyberpsychol Behav 2006; 9:308–316.
22. Koster R. *A Theory of Fun for Game Design.* Scottsdale, AZ: Paragraph Press; 2005.
23. Csikszentmihalyi M. *Finding Flow: The Psychology of Engagement with Everyday Life*. New York: Basic Books; 1997.
24. Sherry JL. Flow and media enjoyment. Comm Theory 2004; 14:328–347.
25. Inal Y, Cagiltay K. Flow experiences of children in an interactive social game environment. Br J Educ Technol 2007; 38:455–464.
26. Teng C-I, Huang H-C. More than flow: Revisiting the theory of four channels of flow. Int J Comput Games Technol 2012; 2012:724917.
27. Lu AS, Baranowski T, Thompson D, et al. Story immersion of video games for youth health promotion: A review of literature. Games Health J 2012; 1:199–204.
28. Green MC, Brock TC, Kaufman GF. Understanding media enjoyment: The role of transportation into narrative worlds. Commun Theory 2004; 14:311–327.
29. Weibel D, Wissmath B. Immersion in computer games: The role of spatial presence and flow. Int J Comput Games Technol 2011; 2011:282345.
30. Baranowski T, Buday R, Thompson DI, et al. Playing for real: Video games and stories for health-related behavior change. Am J Prev Med 2008; 34:74–82.
31. Quick JM, Atkinson RK, Lin L. Empirical taxonomies of gameplay enjoyment: Personality and video game preference. Int J Game-Based Learning 2012; 2:11–31.

32. Koepp MJ, Gunn RN, Lawrence AD, et al. Evidence for striatal dopamine release during a video game. Nature 1998; 393:266–268.
33. Wildmann J, Kruger A, Schmole M, et al. Increase of circulating beta-endorphin-like immunoreactivity correlates with the change in feeling of pleasantness after running. Life Sci 1986; 38:997–1003.
34. Wang GJ, Volkow ND, Fowler JS, et al. PET studies of the effects of aerobic exercise on human striatal dopamine release. J Nucl Med 2000; 41:1352–1356.
35. Boecker H, Sprenger T, Spilker ME, et al. The runner's high: Opioidergic mechanisms in the human brain. Cereb Cortex 2008; 18:2523–2531.
36. Hackney AC. Exercise as a stressor to the human neuroendocrine system. Medicina (Kaunas) 2006; 42:788–797.
37. Klein S. *The Science of Happiness: How Our Brains Make Us Happy and What We Can Do to Get Happier*. New York, NY: Marlowe & Company; 2002.
38. Homma I, Masaoka Y. Breathing rhythms and emotions. Exp Physiol 2008; 93:1011–1021.
39. Nagamitsu S, Nagano M, Yamashita Y, et al. Prefrontal cerebral blood volume patterns while playing video games—a near-infrared spectroscopy study. Brain Dev 2006; 28:315–321.
40. Ravaja N, Laarni J, Saari T, et al. Spatial presence and emotional responses to success in a video game: A psychophysiological study. In: M. Alcañiz Raya and B. Rey Solaz (Eds.), *Proceedings of the PRESENCE 2004,* Valencia, Spain: Editorial de la UPV; 2004: 112–116.
41. Poels K, van den Hoogen W, Ijsselsteijn W, et al. Pleasure to play, arousal to stay: The effect of player emotions on digital game preferences and playing time. Cyberpsychol Behav Soc Netw 2012; 15:1–6.
42. Plante TG, Aldridge A, Bogden R, et al. Might virtual reality promote the mood benefits of exercise? Comput Hum Behav 2003; 19:495–509.
43. Plante TG, Frazier S, Tittle A, et al. Does virtual reality enhance the psychological benefits of exercise? J Hum Mov Stud 2003; 45:485–507.
44. Le Merrer J, Becker JA, Befort K, et al. Reward processing by the opioid system in the brain. Physiol Rev 2009; 89:1379–1412.
45. Koltyn KF. Analgesia following exercise: A review. Sports Med 2000; 29:85–98.
46. Young SN. How to increase serotonin in the human brain without drugs. J Psychiatry Neurosci 2007; 32:394–399.
47. Meyer T, Schwarz L, Kindermann W. Exercise and endogenous opiates. In: Warren MP, Constantini NW (eds.). *Sports Endocrinology*. Totowa, NJ: Humana Press; 2000: 31–42.
48. Kuhn S, Romanowski A, Schilling C, et al. The neural basis of video gaming. Transl Psychiatry 2011; 1:e53.
49. Han DH, Bolo N, Daniels MA, et al. Brain activity and desire for internet video game play. Compr Psychiatry 2011; 52:88–95.
50. Matsuda G, Hiraki K. Sustained decrease in oxygenated hemoglobin during video games in the dorsal prefrontal cortex: A NIRS study of children. Neuroimage 2006; 29:706–711.
51. Nagamitsu S, Yamashita Y, Tanaka H, et al. Functional near-infrared spectroscopy studies in children. Biopsychosoc Med 2012; 6:7.
52. Keller J, Bless H, Blomann F, et al. Physiological aspects of flow experiences: Skills-demand-compatibility effects on heart rate variability and salivary cortisol J Exp Soc Psychol 2011; 47:849–852.
53. Nacke L, Lindley C. Affective ludology, flow and immersion in a first-person shooter: Measurement of player experience. Loading 2009; 3(5). http://journals.sfu.ca/loading/index.php/loading/article/view/72/1 (accessed February 17, 2013).
54. Price TF, Peterson CK, Harmon-Jones E. The emotive neuroscience of embodiment. Motiv Emot 2012; 36:27–37.
55. Carney DR, Cuddy AJC, Yap AJ. Power posing: Brief nonverbal displays affect neuroendocrine levels and risk tolerance. Psychol Sci 2010; 21:1363–1368.
56. Sedlmeier P, Weigelt O, Walther E. Music is in the muscle: How embodied cognition may influence music preferences. Music Percep 2011; 28:297–305.
57. Bianchi-Berthouze N. Understanding the role of body movement in player engagement. Int J Hum Comput Interact 2013; 28:40–75.
58. Bianchi-Berthouze N, Kim WW, Patel D. Does body movement engage you more in digital game play? and why? In: Paiva ACR, Prada R, Picard RW (eds.). *Proceedings of Affective Computing and Intelligent Interaction (ACII) Second International Conference, September 12–14, Lisbon, Portugal*. Berlin: Springer; 2007: 102–113.
59. McGloin R, Farrar KM, Krcmar M. The impact of controller naturalness on spatial presence, gamer enjoyment, and perceived realism in a tennis simulation video game. Presence (Camb) 2011; 20:309–324.
60. Skalski P, Tamborini R, Shelton A, et al. Mapping the road to fun: Natural video game controllers, presence, and game enjoyment. New Media Soc 2011; 13:224–242.
61. Schmierbach M, Limperos AM, Woolley JK. Feeling the need for (personalized) speed: How natural controls and customization contribute to enjoyment of a racing game through enhanced immersion. Cyberpsychol Behav Soc Netw 2012; 15:364–369.
62. Shafer DM, Carbonara CP, Popova L. Spatial presence and perceived reality as predictors of motion-based video game enjoyment. Presence (Camb) 2011; 20:591–619.
63. Deterding S. Don't Play Games with Me! Promises and Pitfalls of Gameful Design. Invited Closing Keynote, Web Directions @Media, May 27, 2011, London, UK. 2011. http://codingconduct.cc/1523514/Don-t-Play-Games-With-Me (accessed February 17, 2013).
64. Stach T, Graham TCN. Exploring haptic feedback in exergames. In: Campos P, Graham N, Jorge J, Nunes N, Palanque P, Winckler M (eds.). *Proceedings of Human-Computer Interaction—INTERACT 2011, Part II, Lisbon, Portugal*. Berlin: Springer; 2011: 18–35.
65. Deci EL, Ryan RM. The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. Psychol Inq 2000; 11:227–268.
66. Bandura A. *Self-Efficacy: The Exercise of Control.* New York: W.H. Freeman; 1997.
67. Klimmt C, Blake C, Hefner D, et al. Player performance, satisfaction, and video game enjoyment. In: Natkin S, Dupire J (eds.). *Proceedings of 8th International Conference on Entertainment Computing—ICEC, Paris, France*. Berlin: Springer; 2009: 1–12.
68. Schneider EF, Lang AG, Shin M, et al. Death with a story: How story impacts emotional, motivational, and physiological responses to first-person shooter video games. Hum Commun Res 2004; 30:361–375.
69. Igartua JJ. Identification with characters and narrative persuasion through fictional feature films. Communications 2010; 35:347–373.
70. Gabriel S, Young AF. Becoming a vampire without being bitten: The narrative collective-assimilation hypothesis. Psychol Sci 2011; 22:990–994.

71. Przybylski AK, Weinstein N, Murayama K, et al. The ideal self at play: The appeal of video games that let you be all you can be. Psychol Sci 2012; 23:69–76.
72. Ravaja N, Saari T, Turpeinen M, et al. Spatial presence and emotions during video game playing: Does it matter with whom you play? Presence (Camb) 2006; 15:381–392.
73. Chen T-A, O'Connor TM, Hughes SO, Frankel L, Baranowski J, Mendoza JA, Thompson D, Baranowski T. TV parenting practices: Item response modeling analyses: Is the same scale appropriate for parents of children of different ages.? Int J Behav Nutr Phys Act 2013 Apr 2; 10:41.
74. Boecker H, Henriksen G, Sprenger T, et al. Positron emission tomography ligand activation studies in the sports sciences: Measuring neurochemistry in vivo. Methods 2008; 45:307–318.
75. Lai YC, Wang ST, Yang JC. An investigation of the exergames experience with flow state, enjoyment, and physical fitness. In: *Proceedings of 12th IEEE International Conference on Advanced Learning Technologies, Rome, Italy*. Piscataway, NJ: IEEE; 2012: 58–60.
76. Madsen KA, Yen S, Wlasiuk L, et al. Feasibility of a dance videogame to promote weight loss among overweight children and adolescents. Arch Pediatr Adolesc Med 2007; 161:105–107.
77. Maloney AE, Bethea TC, Kelsey KS, et al. A pilot of a video game (DDR) to promote physical activity and decrease sedentary screen time. Obesity (Silver Spring) 2008; 16:2074–2080.
78. Chin A Paw MJM, Jacobs WM, Vaessen EP, et al. The motivation of children to play an active video game. J Sci Med Sport 2008; 11:163–166.

Address correspondence to:
Elizabeth J. Lyons, PhD, MPH
Institute for Translational Sciences
The University of Texas Medical Branch
301 University Boulevard
Galveston, TX 77555-0342

E-mail: ellyons@utmb.edu