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Points-Based Reward Systems in Gamification Impact Children's Physical Activity Strategies and Psychological Needs

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Abstract

Gamification is an increasingly popular form of health intervention but its efficacy remains elusive due to a lack of clarity in its conceptualization and operationalization. This study aimed to isolate and determine the direct causal effect of one of the most popular game elements used in gamified interventions, the points-based reward system, on physical activity (PA) in children. A 72-hour field study with children aged 9 to 13 ($N = 67$) was conducted using a digital PA intervention featuring a virtual dog, with and without a points-based reward system. PA was assessed with an activity monitor, and overall PA, three levels of PA intensity, and PA strategies during the 3-day intervention were measured. Guided by self-determination theory, the impact of the points-based reward system on children's basic psychological needs was also investigated. Results indicated that the points-based reward system briefly increased PA engagement but did not significantly affect overall PA over time. When given equal number of points regardless of intensity, children approached the PA intervention strategically by engaging in significantly more light intensity and significantly less vigorous intensity PA than children who did not receive points. Results also suggested that the points-based reward system might promote perceptions of relatedness with the virtual agent featured in the gamified intervention.

Keywords

Children; Gamification; physical activity; self-determination theory; virtual agents

Physical activity (PA) is essential for healthy development in children and provides numerous health benefits, including lowered risk of obesity (Katzmarzyk et al., 2015), cardiovascular diseases (Owen et al., 2010), and mental health problems (Lubans et al., 2016). Considering that interventions are often far less successful once lifestyle habits are established in early childhood (Dehghan, Akhtar-Danesh, & Merchant, 2005) and that PA habits established during youth carryover into adulthood (Telama et al., 2014), older children provide a critical window for PA interventions that motivate and sustain healthy PA habits (Whitaker, Wright, Pepe, Seidel, & Dietz, 1997).

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The majority of youth fail to get the recommended amount of PA (Fakhouri et al., 2014) with older children experiencing a precipitous decline in PA compared to younger children (Basterfield, Pearce, Parkinson, Adamson, & Reilly, 2011). To address the need to promote PA among children, there has been a proliferation of interventions that seek to leverage the engaging nature of game elements in a nongaming context, popularly known as *gamification* (Deterding, Dixon, Khaled, & Nacke, 2011). Despite the growing popularity of gamified PA interventions, there has been a lack of clear conceptualization and operationalization, with the concept of gamification often conflated with fully fledged games (Johnson et al., 2016; Lewis, Swartz, & Lyons, 2016; Seaborn & Fels, 2015).

The current study aims to isolate and manipulate a single gamification element, the points-based reward system, within the context of a digital PA intervention designed for children. Guided by the framework of self-determination theory (SDT; Ryan & Deci, 2000), a field experiment was conducted over a 72-hour period in children between the ages of 9 to 13. By comparing the digital PA intervention with and without the reward system, we aim to demonstrate clear causal relationships that lead to the observed outcomes.

Gamification of PA Interventions

Recent discourse on gamification indicates to an emerging definition: Gamification is the selective application of game mechanics to a nongame activity that is not a fully packaged game (Deterding et al., 2011; Seaborn & Fels, 2015). A single game element incorporated into an otherwise nongame intervention is a gamified intervention but cannot be categorized as a fully fledged game that was originally created and designed to be a complete game.

Even within studies that look specifically at gamification, researchers often conflate the effect of multiple game mechanisms at once, making it difficult to demonstrate a clear path of causality for observed outcomes, and serving as a barrier to the advancement of theory and practice. One popular mechanism for gamified interventions is the use of points as a reward (Johnson et al., 2016; Lewis et al., 2016), perhaps due to its intuitively simple nature of reinforcement. However, when the gamified intervention is operationalized as a combination of different game mechanisms, the isolated effect of points-based reward systems on PA behavior remains unclear.

The notion of reinforcing desired behaviors with rewards is not new—Skinner studied the concept of operant conditioning decades ago (Skinner, 1953), and marketing strategies reward customers for their loyalty through loyalty programs (Kim & Ahn, 2017). This behaviorist principle holds that when external rewards are administered immediately following the desired behavior, individuals will be motivated to repeat the behavior to obtain further rewards; thus, points serve as a simple but effective mechanism to control behavior.

However, externally driven behavior changes are shortlived (Hanus & Fox, 2015). If children focus on earning tangible rewards during the PA intervention, the behavior change elicited by the intervention (e.g., increase in PA) is likely to end when their desire or need to obtain further external rewards stop (Lepper, Greene, & Nisbett, 1973). The promise of external rewards can cause individuals to focus on the reward rather than enjoy the activity (Lepper et

al., 1973). When a points-based reward system is applied to gamify a PA intervention, children may learn how to obtain maximum rewards with minimum effort using strategies to “beat the system” of the intervention rather than learning how to enjoy PA. Some work on exergames demonstrates that adolescents who played an exergame engaged in more light intensity PA than the control group, but no differences were found for moderate-to-vigorous PA (Staiano, Beyer, Hsia, Katzmarzyk, & Newton, 2017). Yet other studies demonstrated that exergames increased moderate PA (Maddison et al., 2011). The inconsistency in findings may be an artifact of operationalizing gamification with different sets of game mechanisms, leading to varying outcomes. In the current study, we will investigate the isolated effect of points-based rewards on PA intensity for children.

Self-determination theory (Ryan & Deci, 2000) provides a useful framework for delving into the underlying psychosocial variables that promote engagement in gamified interventions and PA behaviors. Individuals naturally gravitate toward acts that are inherently pleasurable. SDT stipulates that there are three basic, universal, and cross-developmental psychological needs that motivate people to find inherent pleasure in activities (Ryan & Deci, 2000). One need is perceived autonomy, wherein individuals integrate the value of an action into their own value systems rather than simply being driven by extrinsic regulations (Ryan & Connell, 1989). The second need is perceived competence, or the feeling of confidence and efficacy of carrying out that action. Finally, the internalization of the value of an activity is more likely to occur when individuals feel connected, included, and cared for by others—a sense of relatedness. Prior work suggests that some features and formats of video games satisfy the inherent psychosocial needs of players, which may explain their universal popularity (Ryan, Rigby, & Przybylski, 2006). However, there is little work that isolates the effect of individual game elements on these basic needs.

PA outcomes are often moderated by biological sex, with boys being more physically active than girls (Trost et al., 2002), and boys and girls engaging in different types of activities during free play (Faucette et al., 1995). Biological sex was selected as a moderating variable to account for sex differences in PA found in prior research. Also, based on prior findings that PA declines relatively linearly during childhood and adolescence (Corder et al., 2016; Metcalf, Hosking, Jeffery, Henley, & Wilkin, 2015), chronological age was entered as a covariate for PA related measures in ensuing analyses. The current study aims to isolate the effect of the points-based reward system on children’s PA and address the direct effect of a points-based reward system in a gamified intervention on psychological needs. Investigating the effect of a points-based reward system on PA strategies will serve as a critical knowledge in designing effective gamified interventions.

Method

Participants and Design

A sample of 68 children between the ages of 9 to 13 (age $M = 11.24$, $SD = 0.85$) was recruited from a summer camp in the southern United States. Children were from counties with similar median household income (approximately \$28,000). To minimize contamination between experimental conditions, children were randomly selected in a single cabin and assigned to the same experimental condition. Children in a single cabin shared the

same time schedule throughout the day and moved through the program as a group. One child was dropped due to technical failure, and the final data set comprised 67 children (male $n = 26$, female $n = 41$; African American $n = 10$, White Caucasian $n = 46$).

The PA Intervention

Both experimental conditions used the same interactive digital PA intervention. The PA intervention was designed for children to be able to interact with a virtual agent through a digital platform, but it did not provide children with any game elements (e.g., points, badges, “unlocking” levels) and could not be considered a game.

The PA intervention was administered through a kiosk with a large television displaying a life-sized virtual dog, a motion and voice detection device (Kinect for Windows) set up on top of the television, and a computer (Figure 1). The virtual dog’s features allowed children to set and meet PA goals, with the virtual dog providing accurate evaluation and reinforcements (see Ahn et al., 2015, for detailed descriptions of the kiosk). Children were able to personalize their virtual dog by giving it a name and choosing the colors of its collar and tag. Every child wore an activity monitor, the Fitbit Zip, to track PA and interact with his/her dog.

To provide children with experiences of mastering self-determined goals, the virtual dog asked children to set the duration (30, 60, or 90 minutes) and intensity (light, moderate, vigorous) of the PA goal. After setting the goal, children had to leave the kiosk to engage in unstructured PA. When children felt that they met the PA goal, they approached the kiosk. The kiosk automatically recognized the unique radio-frequency identification marker for each Fitbit, and evaluated the success or failure to meet the PA goal. Every time a child stood in front of the kiosk wearing the activity monitor, data were automatically downloaded and compiled in an activity log that tracked each child’s overall PA and intensity measured by the Fitbit algorithms. As children set and met more PA goals, they were able to vicariously experience the benefits of PA by watching their virtual dog become fitter, happier (e.g., wagging tail), and more responsive to their commands.

The reinforcement children received when they met the PA goal was the main manipulation. In the points condition ($n = 39$), every PA goal children achieved was rewarded with points. No weights were given for different levels of PA intensity; all intensity levels were rewarded with the same number of points based on their total amount of PA. With the points they earned, children could purchase tricks for the dog to perform. Tricks available for purchase ranged from basic moves that required minimal points (e.g., sit, lay down) to more sophisticated ones that required more points (e.g., spin around, moonwalk).

In the no-points condition ($n = 28$), successful PA goals were not rewarded with points. When children achieved PA goals, they were able to interact with a virtual dog that had the full capacity to perform all levels of tricks, without being limited by points or unlocked levels. This naturalistic interaction aimed to mimic the unstructured human-pet interaction in the physical world. In both conditions, if the child did not meet his or her goal, the virtual dog indicated that the goal had not been met and encouraged the child to engage in more PA.

Procedure

The data collection process began on Monday afternoon and terminated on Thursday afternoon. PA in the camp comprised of free play and loosely structured programs. Children in different experimental conditions participated in separate orientation sessions to learn the basic rules of wearing the activity monitor and how to interact with the virtual dog. On Thursday afternoon, a self-report survey was administered in a computer laboratory. Children received an orientation on how to answer Likert-type items, and researchers assisted children throughout the survey process.

Measures

PA Duration and Intensity.—The total amount of PA in minutes that the children engaged in during the entire intervention was tracked by an activity monitor in three categories of intensity—light, moderate, and vigorous, based on Fitbit's algorithm. Studies have demonstrated at least moderate validity for using Fitbits to measure PA (Schneider & Chau, 2016).

Perceived Autonomy.—The autonomy subscale from the *Intrinsic Motivation Inventory* (IMI; Ryan, 1982) was used to assess the level of perceived choice, volition, and freedom for PA elicited by the experimental conditions. Table 1 specifies the assessment items used as well as the reliability as measured by Cronbach's alpha.

Perceived Competence.—The competence subscale from IMI assessed the perception of confidence and efficacy in PA.

Perceived Relatedness.—The relatedness subscale from the IMI assessed the formation of friendship and social interactions between the children and the virtual dog.

Statistical Analysis

Data were analyzed using the Statistical Package for Social Science (SPSS) software (version 24.0 2017; SPSS Inc., Chicago, IL). Analysis of variance tests were conducted with two categorical independent variables, experimental condition and sex. PA duration and intensity were measured daily by the Fitbit devices, and psychological needs (perceived autonomy, competence, and relatedness) were assessed using self-reports. We used repeated-measures analysis of covariance to test the impact of points-rewards over time. A multivariate analysis of covariance was used to test the impact of points on the three psychological need variables to protect against the inflation of Type 1 error rates (Cramer & Bock, 1966). Statistical significance was established at $p < .05$ for all tests and η^2 values were used to report effect sizes.

Results

Points-Based Rewards and Total PA

An analysis of covariance (ANCOVA) with total PA as the dependent variable, and experimental condition and sex as the independent variables, controlling for chronological age¹ revealed a significant main effect of sex, $F(1, 58) = 14.68, p < .001, \eta^2 = .18$. Boys

engaged in more total PA during the intervention than girls. No other main or interaction effects were significant, all $ps > .10$. Sociodemographic details for the sample are reported in Table 2, and descriptive statistics for all dependent variables are reported in Table 3.

Points-Based Rewards and PA Strategies

Total daily measure of PA was taken every evening and included as the within-subjects variable in a repeated-measures ANCOVA, controlling for age. Experimental condition and sex were included as between-subjects factors. The interaction effect between time and experimental condition was significant, $F(3, 174) = 4.01, p = .01, \eta^2 = .07$, suggesting that children in different experimental conditions varied in their PA strategies throughout the intervention (Figure 2). The interaction is largely driven by children in the points condition who demonstrated a spike in their total PA on Wednesday. An ANCOVA of daily PA on Wednesday revealed that children in the points condition performed higher levels of PA than children in the no-points condition, $F(1, 58) = 5.32, p = .025, \eta^2 = .07$. By the next day, the PA levels of children in the points condition plummeted, and a univariate ANOVA of daily PA on Thursday demonstrates that there is no significant difference between the experimental conditions, $F(1, 58) = .02, p = .88$.

The interaction effect between time and sex was significant, $F(3, 174) = 3.29, p = .02, \eta^2 = .06$, suggesting that boys and girls varied in their daily PA levels throughout the intervention. The interaction was largely driven by boys' higher level of PA on Tuesday than girls, $F(1, 58) = 14.58, p < .001, \eta^2 = .19$. Similarly, on Wednesday, boys engaged in higher levels of PA than girls, $F(1, 58) = 6.29, p = .015, \eta^2 = .09$.

Points-Based Rewards and PA Intensity

A multivariate analysis of variance (MANCOVA) was performed on the means of three levels of PA intensity. The main effects of experimental condition, $F(3, 56) = 11.57, p < .001$, and sex were significant, $F(3, 56) = 10.27, p < .001$. The interaction effect was not significant, $F(3, 56) = 1.60, p = .20$.

Tests of between-subjects effects revealed that the main effect of experimental condition influenced children's PA strategies in the light, $F(1, 58) = 3.94, p = .05, \eta^2 = .05$, and vigorous, $F(1, 58) = 4.64, p = .035, \eta^2 = .05$, intensity PA but not in the moderate intensity PA, $F(1, 58) = 1.25, p = .27, \eta^2 = .01$. Children in the points condition participated in more light intensity PA than those in the no-points condition. Interestingly, this pattern was reversed for vigorous intensity PA: children in the no-points condition performed higher levels of vigorous intensity PA than children in the points condition.

The main effect of sex influenced children's PA strategies in the fair, $F(1, 58) = 24.91, p < .001, \eta^2 = .28$, and vigorous, $F(1, 58) = 28.11, p < .001, \eta^2 = .31$, intensity PA but not in the light intensity PA, $F(1, 58) = 2.16, p = .15, \eta^2 = .03$. Boys engaged in higher vigorous intensity PA than girls. Similarly, boys also engaged in higher moderate intensity PA than girls.

¹All statistical tests were conducted again without chronological age entered as a covariate. The general direction and significance of the findings/results remained the same for all dependent variables.

Points-Based Rewards and Basic Psychological Needs

A MANOVA was performed with the three basic psychological needs. The main effects of experimental condition, $F(3, 61) = 1.92, p = .14$, and sex were not significant, $F(3, 61) = 1.11, p = .35$. The interaction effect was also not significant, $F(3, 61) = .26, p = .85$.

Tests of between-subjects effects revealed that the main effect of experimental condition influenced children's need for relatedness approached significance, $F(1, 63) = 3.77, p = .06, \eta^2 = .06$. Children in the points condition perceived higher relatedness than those in the no-points condition. Significant differences in experimental conditions were not found for autonomy, $F(1, 63) = 2.91, p = .09, \eta^2 = .04$, or competence, $F(1, 63) = .003, p = .95, \eta^2 = .006$.

Discussion

Amid increasing interest in the gamification of health interventions for children, the current findings make timely contributions to the theoretical and practical advancements of gamification. This is one of the first studies to investigate the isolated effect of the points-based reward system on children. In contrast to earlier studies on exergaming and active video games that demonstrate positive effects on increasing overall PA (Baranowski et al., 2012; Peng, Crouse, & Lin, 2013; Pope, Lewis, & Gao, 2015), current results indicated that the points-based reward system alone yields no significant impact on the total amount of PA in children.

However, the effect of the points-based reward system seems to be more nuanced than the conclusions from total PA alone. Tracking daily levels of PA suggests that children in the points condition briefly outperformed children in the no points condition on Wednesday. Furthermore, when the rewards shifted the focus of the PA intervention to points, children developed different strategies than when no external rewards were used. This is evident by the fact that children in the points condition engaged in significantly more light intensity PA, so as to gain more points, than children in the no-points condition. Children in the points condition also participated in significantly less vigorous intensity PA than children in the no points condition. Because overall PA yielded the same amount of points regardless of intensity, the fact that they opted for a strategy that earned the most number of points with the least amount of PA effort suggests that children may have quickly learned to "beat the system" in gamified contexts rather than to focus on the PA. The strategies were short-lived and the increase in PA dissipated by the end of the intervention. One possible explanation is provided by SDT, which stipulates that moving from intrinsic (i.e., enjoying PA itself) to extrinsic (i.e., engaging in PA for points) motivation reduces the likelihood of the motivation to engage in the behavior (PA) becoming internalized into the personal value system, discouraging long-term behavior change.

Psychological mechanisms are unlikely explanations for this because children in the points condition did not feel more autonomous or competent about engaging in PA than their counterparts. It is possible that children in the points condition felt that accomplishing future PA was easier because they engaged in more light intensity PA than children in the nopoints condition. Also, within the framework of SDT, it is difficult to interpret the degree of

internalization when it comes to overall PA versus PA intensity. Although we posit that children in the points condition were driven by external rewards, SDT does not discuss the intensity of effort (Ryan & Deci, 2000). That is, if children in both the points and no-points conditions engaged in the same overall amount of PA, but one engaged in more intense PA than the other, SDT would not distinguish between the two. Consequently, when children in the points condition engage in lighter intensity, but more overall PA than children in the nongamified condition, it is difficult to declare that children who engaged in higher intensity PA were more intrinsically motivated than those who engaged in lower intensity but greater amount of PA.

Sex was a meaningful predictor of both overall PA and intensity for the duration of the intervention. Echoing findings from earlier work (Abbott & Davies, 2004; Trost et al., 1997; Trost et al., 2002), boys and girls engaged in similar amounts of light intensity PA, which comprised approximately three quarters of the total PA, but boys engaged in more moderate-to-vigorous intensity PA, resulting in more overall PA. Given there were no significant interactions between sex and experimental condition, points-based rewards seem to have similar effects on both boys and girls. Sex differences were not found for any of the psychological needs variables.

Current findings also contribute to growing body of literature on adopting virtual agents in the context of health promotion for children and adolescents (Ahn et al., 2015; Ahn et al., 2016; LeRouge, Dickhut, Lisetti, Sangameswaran, & Malasanos, 2016; Wang et al., 2015) by suggesting that virtual agents may foster relatedness perceptions in children, particularly when the virtual agents deliver external rewards. Earlier research indicates that children perceive relationships and friendships differently than adults because their judgment of people remains relatively underdeveloped and self-centered until their cognitive abilities mature in adolescence (Bigelow & LaGaipa, 1980). To this extent, one possible explanation may be that children thought the virtual agent that gave them points was a better friend than a virtual agent that did not issue tangible rewards. The finding that children are able to perceive relatedness from a nonhuman, virtual entity presents the opportunity to expand the conceptual boundary of what SDT originally proposed as the psychological need for relatedness. Given that virtual agents are able to offer highly reliable and accurate feedback during human-agent interactions, it is possible that they are just as good at instilling feelings of closeness and intimacy as their human counterparts. Indeed, prior research indicates that when high behavioral realism is established, virtual agents may be perceived as an in-group member (Guadagno, Blascovich, Bailenson, & Mccall, 2007). However, it should be noted that the impact of the pointsbased rewards on perceived relatedness approached, but was not significant. Therefore, whether the innate human need for relatedness may be sufficiently satisfied through accurately and consistently timed feedback and rewards proffered from virtual agents poses an interesting theoretical question to be addressed in future research.

Limitations

The current findings are qualified by several limitations. First, motivations for engaging in PA among children are quite complex, involving individual, social, and environmental factors (Trost et al., 1997). Rewards and incentives are one of many variables involved in the

prediction of PA engagement in children. Future studies should assess and control for the impact of socioecological variables on children's PA. Second, the algorithms used to convert Fitbit's raw data to indexes of PA intensity reported in this study are not public. Some studies have demonstrated Fitbit's validity in measuring different PA intensities among children but the evidence is limited (Hamari et al., 2017; Schneider & Chau, 2016). Finally, an intervention period longer than 72 hours may have yielded different impacts of points-based rewards over time, particularly with a modified points-based reward. For example, combining positive verbal feedback of progress with points increases motivation to engage in a desired behavior (Kim & Ahn, 2017). Future studies may consider a longer intervention period with varied strategies of employing points-based reward systems.

Implications for Practice

Earlier studies have noted children's tendencies to favor lower intensity PA when they do not see immediate benefits of engaging in higher intensity PA (Sallis, Alcaraz, McKenzie, & Hovell, 1999). Current findings suggest that providing equal points for all levels of PA intensity exacerbates such tendencies, encouraging both boys and girls to engage in more light intensity and less vigorous intensity PA than children who did not receive points. Sallis et al. (1999) recommend interventions that provide greater incentives for higher intensity activities while increasing the costs of lower intensity activities to reverse this tendency but a closer look at the value of light intensity PA is warranted before accepting this recommendation.

Although not as robust as moderate-to-vigorous PA, light intensity PA leads to some health benefits (Carson et al., 2013). Considering the large number of children not meeting PA guidelines, particularly those participating in no or minimal PA, light intensity PA is often more feasible and may serve as a practical "gateway" toward PA of greater intensity. Current findings indicate that using points-based rewards briefly increases total PA, in particular light intensity PA, in both boys and girls. Therefore, encouraging light intensity PA through the use of points rewards may be an effective means to initially introduce a PA intervention to children who struggle to meet recommended levels of PA.

Conclusion

Points-based reward systems can briefly increase PA engagement but seem to have little impact on traditional sex differences in PA; boys still engage in more total and higher intensity PA than girls. However, because both boys and girls attempt to "beat the system" by engaging in more light intensity PA, harnessing this impact may help encourage more overall PA in children. Designers of gamified PA interventions may benefit from focusing on game elements (e.g., points rewards) that encourage perceived relatedness and social rapport between users and virtual agents. However, because the increase in PA is transient when the points are given regardless of PA intensity, a varied reward structure to incentivize different intensity PA or a more comprehensive reward and feedback system to sustain the PA change may be necessary.

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References

- Abbott RA, & Davies PSW (2004). Habitual physical activity and physical activity intensity: Their relation to body composition in 5.0–10.5-y-old children. *European Journal of Clinical Nutrition*, 58, 285–291. doi:10.1038/sj.ejcn.1601780 [PubMed: 14749749]
- Ahn SJ, Johnsen K, Moore J, Brown S, Biersmith M, & Ball C (2016). Using virtual pets to increase fruit and vegetable consumption in children: A technology-assisted social cognitive theory approach. *Cyberpsychology, Behavior, and Social Networking*, 19(2), 86–92.
- Ahn SJ, Johnsen K, Robertson T, Moore J, Brown S, Marable A, & Basu A (2015). Using virtual pets to promote physical activity in children: An application of the youth physical activity promotion model. *Journal of Health Communication*, 20, 807–815. doi:10.1080/10810730.2015.1018597 [PubMed: 26020285]
- Baranowski T, Abdelsamad D, Baranowski J, O'Connor TM, Thompson D, Barnett A, ... Chen TA (2012). Impact of an active video game on healthy children's physical activity. *Pediatrics*, 129, e636–642. doi:10.1542/peds.2011-2050 [PubMed: 22371457]
- Basterfield L, Pearce MS, Parkinson KN, Adamson AJ, & Reilly JJ (2011). Longitudinal study of physical activity and sedentary behavior. *Pediatrics*, 127, e24–30. doi:10.1542/peds.2010-1935 [PubMed: 21173005]
- Bigelow BJ, & LaGaipa JJ (1980). The development of friendship values and choice. In Foot HC, Chapman AJ, & Smith JR (Eds.), *Friendship and social relations in children* (pp. 13–42). New Brunswick, NJ: Transaction.
- Carson V, Ridgers ND, Howard BJ, Winkler EAH, Healy GN, Owen N, ... Salmon J (2013). Light-intensity physical activity and cardiometabolic biomarkers in US adolescents. *PLoS One*, 8(8), 371417. doi:10.1371/journal.pone.0071417
- Corder K, Sharp SJ, Atkin AJ, Andersen LB, Cardon G, Page A, ... van Sluijs EM (2016). Age-related patterns of vigorous-intensity physical activity in youth: The International Children's Accelerometry Database. *Preventative Medicine Reports*, 16, 17–22.
- Cramer EM, & Bock RD (1966). Multivariate analysis. *Review of Educational Research*, 36, 604–617.
- Dehghan M, Akhtar-Danesh N, & Merchant AT (2005). Childhood obesity, prevalence, and prevention. *Nutrition Journal*, 4, 24. doi:10.1186/1475-2891-4-24 [PubMed: 16138930]
- Deterding S, Dixon D, Khaled R, & Nacke L (2011, 9). From game design elements to gamefulness: Defining “gamification.” Paper presented at the Proceedings of ACM MindTrek '11, Tampere, Finland.
- Fakhouri TH, Hughes JP, Burt VL, Song M, Fulton JE, & Ogden CL (2014). Physical activity in U. S. youth aged 12–15 years, 2012. *NCHS Data Brief*, 141, 1–8.
- Faucette N, Sallis JF, McKenzie TL, Alcaraz J, Kolody B, & Nugent P (1995). Comparison of fourth grade students' out-of-school physical activity levels and choices by gender: Project SPARK. *Journal of Health Education*, 26, S82–S90.
- Guadagno R, Blascovich J, Bailenson JN, & McCall C (2007). Virtual humans and persuasion: The effects of agency and behavioral realism. *Media Psychology*, 10, 1–22. doi:10.1080/15213260701300865
- Hamari L, Kullberg T, Ruohonen J, Heinonen OJ, Díaz-Rodríguez N, Lilius J, ... Salanterä S (2017). Physical activity among children: Objective measurements using Fitbit One and Actigraph. *BMC Research Notes*, 10, 161. doi:10.1186/s13104-017-2476-1 [PubMed: 28427441]
- Hanus MD, & Fox J (2015). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. *Computers & Education*, 80, 152–161. doi:10.1016/j.compedu.2014.08.019

- Johnson D, Deterding S, Kuhn K-A, Staneva A, Stoyanov S, & Hides L (2016). Gamification for health and wellbeing: A systematic review of the literature. *Internet Interventions*, 6, 89–106. doi: 10.1016/j.invent.2016.10.002 [PubMed: 30135818]
- Katzmarzyk PT, Barreira TV, Broyles ST, Champagne CM, Chaput J-P, Fogelholm M, ... Church TS (2015). Relationship between lifestyle behaviors and obesity in children ages 9–11: Results from a 12-country study. *Obesity*, 23, 1696–1702. doi:10.1002/oby.21152 [PubMed: 26173093]
- Kim K, & Ahn SJ (2017). Rewards that undermine customer loyalty? A motivational approach to loyalty programs. *Psychology & Marketing*, 34, 842–852. doi:10.1002/mar.21026
- Lepper MR, Greene D, & Nisbett RE (1973). Undermining children's intrinsic interest with extrinsic reward: A test of the "overjustification" hypothesis. *Journal of Personality & Social Psychology*, 28, 129–137. doi:10.1037/h0035519
- LeRouge C, Dickhut K, Lisetti C, Sangameswaran S, & Malasanos T (2016). Engaging adolescents in a computer-based weight management program: Avatars and virtual coaches could help. *Journal of the American Medical Informatics Association*, 23, 19–28. doi:10.1093/jamia/ocv078 [PubMed: 26159466]
- Lewis ZH, Swartz MC, & Lyons EJ (2016). What's the point? A review of reward systems implemented in gamification interventions. *Games for Health Journal*, 5, 93–99. doi:10.1089/g4h.2015.0078 [PubMed: 26812253]
- Lubans D, Richards J, Hillman C, Faulkner G, Beauchamp M, Nilsson M, ... Biddle S (2016). Physical activity for cognitive and mental health in youth: A systematic review of mechanisms. *Pediatrics*, 138, e20161642. [PubMed: 27542849]
- Maddison R, Foley L, Ni Mhurchu C, Jiang Y, Jull A, Prapavessis H, ... Rodgers A (2011). Effects of active video games on body composition: A randomized controlled trial. *American Journal of Clinical Nutrition*, 94, 156–163. doi:10.3945/ajcn.110.009142 [PubMed: 21562081]
- Metcalf BS, Hosking J, Jeffery AN, Henley WE, & Wilkin TJ (2015). Exploring the adolescent fall in physical activity: A 10-yr cohort study (EarlyBird 41). *Medicine & Science in Sports & Exercise*, 47, 2084–2092. [PubMed: 25706294]
- Owen CG, Nightingale CM, Rudnicka AR, Sattar N, Cook DG, Ekelunch U, & Whincup PH (2010). Physical activity, obesity and cardiometabolic risk in 9-to 10-year-old UK children of white European, South Asian and black African-Caribbean origin: The Child Heart and Health Study in England (CHASE). *Diabetologia*, 53, 1620–1630. doi:10.1007/s00125-010-1781-1 [PubMed: 20454952]
- Peng W, Crouse J, & Lin J-H (2013). Using active video games for physical activity promotion: A systematic review of the current state of research. *Health Education & Behavior*, 40, 171–192. doi: 10.1177/1090198112444956 [PubMed: 22773597]
- Pope ZC, Lewis BA, & Gao Z (2015). Using the transtheoretical model to examine the effects of exergaming on physical activity among children. *Journal of Physical Activity and Health*, 12, 1205–1212. doi:10.1123/jpah.2014-0310 [PubMed: 25393714]
- Ryan RM (1982). Control and information in the intrapersonal sphere: An extension of cognitive evaluation theory. *Journal of Personality and Social Psychology*, 43, 450–461. doi: 10.1037/0022-3514.43.3.450
- Ryan RM, & Connell JP (1989). Perceived locus of causality and internalization. *Journal of Personality and Social Psychology*, 57, 749–761. doi:10.1037/0022-3514.57.5.749 [PubMed: 2810024]
- Ryan RM, & Deci EL (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Education Psychology*, 25(1), 54–67. doi:10.1006/ceps.1999.1020
- Ryan RM, Rigby CS, & Przybylski A (2006). The motivational pull of video games: A self-determination theory approach. *Motivation and Emotion*, 30, 347–363. doi:10.1007/s11031-006-9051-8
- Sallis JF, Alcaraz JE, McKenzie TL, & Hovell MF (1999). Predictors of change in children's physical activity over 20 months: Variations by gender and level of adiposity. *American Journal of Preventive Medicine*, 16, 222–229. doi:10.1016/S0749-3797(98)00154-8 [PubMed: 10198662]

- Schneider M, & Chau L (2016). Validation of the Fitbit Zip for monitoring physical activity among free-living adolescents. *BMC Research Notes*, 9, 448. doi:10.1186/s13104-016-2253-6 [PubMed: 27655477]
- Seaborn K, & Fels DI (2015). Gamification in theory and action: A survey. *International Journal of Human-Computer Studies*, 74, 14–31. doi:10.1016/j.ijhcs.2014.09.006
- Skinner BF (1953). *Science and human behavior* New York, NY: Free Press.
- Staiano AE, Beyl RA, Hsia DS, Katzmarzyk PT, & Newton RL Jr. (2017). Twelve weeks of dance exergaming in overweight and obese adolescent girls: Transfer effects on physical activity, screen time, and self-efficacy. *Journal of Sport Health Science*, 6, 4–10. doi:10.1016/j.jshs.2016.11.005 [PubMed: 28491483]
- Telama R, Yang X, Leskinen E, Kankaanpää A, Hirvensalo M, Tammelin T, ... Raitakari OT (2014). Tracking of physical activity from early childhood through youth into adulthood. *Medicine and Science in Sports and Exercise*, 46, 955–962. doi:10.1249/MSS.0000000000000181 [PubMed: 24121247]
- Trost SG, Pate RR, Sallis JF, Freedson PS, Taylor WC, Dowda M, & Sirard J (2002). Age and gender differences in objectively measured physical activity in youth. *Medicine & Science in Sports & Exercise*, 34, 350–355. doi:10.1097/00005768-200202000-00025 [PubMed: 11828247]
- Trost SG, Pate RR, Saunders R, Ward DS, Dowda M, & Felton G (1997). A prospective study of the determinants of physical activity in rural fifth-grade children. *Preventive Medicine*, 26, 257–263. [PubMed: 9085396]
- Wang C, Bickmore T, Bowen DJ, Norkunas T, Campion M, Cabral H, ... Paasche-Orlow M (2015). Acceptability and feasibility of a virtual counselor (VICKY) to collect family health histories. *Genetics in Medicine*, 17, 822–830. doi:10.1038/gim.2014.198 [PubMed: 25590980]
- Whitaker RC, Wright JA, Pepe MS, Seidel KD, & Dietz WH (1997). Predicting obesity in young adulthood from childhood and parental obesity. *New England Journal of Medicine*, 337, 869–873. doi:10.1056/NEJM199709253371301 [PubMed: 9302300]

Figure 1.

The virtual dog kiosk set up. The kiosk comprised a large LCD television with a Microsoft Kinect mounted on top to detect vocal and gesture commands from children (left panel). A child's personalized virtual dog would automatically appear when the child approached the kiosk wearing his or her Fitbit. The virtual dog evaluated whether the child had met the physical activity goal, provided feedback, and interacted with the child if the goal was successfully met (right panel).

Figure 2.
Repeated measure of daily PA during the intervention period by experimental condition.

Table 1.**Measurement Items.**

(1 = <i>Not at all true</i> ; 5 = <i>Completely true</i>)	Cronbach's alpha
Perceived Autonomy	
1. I believe I had some choice about being physically active	.71
2. I was physically active because I had no choice	
3. I was physically active because I wanted to	
4. I didn't really have a choice about being physically active	
5. I was physically active because I had to	
Perceived Competence	
1. I think I am pretty good at being physically active	.80
2. I think I was pretty good at being physically active, compared to other kids	
3. After being physically active for awhile, I felt I became pretty good at it	
4. I am satisfied with my performance at being physically active	
5. I was pretty skilled at being physically active	
Perceived Relatedness	
1. I felt like my virtual dog and I were not close at all	.82
2. I really doubt that the virtual dog and I would ever be friends	
3. I'd like a chance to interact with the virtual dog more often	
4. I felt like I could really trust my virtual dog	
5. I felt close to my virtual dog	

Table 2.Self-Reported Sociodemographic Data for Children in the Sample by Sex ($N=67$).

Demographic information	Boys n (% of N)	Girls n (% of N)
Age group (years)		
9–10	4 (6)	4 (6)
11–13	22 (33)	33 (49)
Missing	0	4 (6)
Weekly game play (hours)		
<10	16 (24)	19 (28)
10 or more	7 (10)	7 (10)
Missing or don't know	3 (4)	15 (22)
Ethnicity ^a		
Caucasian/White	20 (30)	26 (39)
Asian/Asian American	1 (1)	2 (3)
African/Black	2 (3)	8 (12)
Latino(a)/Hispanic	1 (1)	1 (1)
American Indian	—	4 (6)
Pacific Islander	—	2 (3)
Missing or Other	2 (3)	3 (4)

^aThe ethnicity variable allowed participants to choose all categories that applied and may reflect duplicate selections in the case of mixed-race participants.

Table 3.

Descriptive Statistics for All Dependent Variables.

Dependent measure	Points	No points	Total
Total physical activity			
Boys	1280.73 (286.81)	1289.74 (263.94)	1285.66 (271.02) _a
Girls	1147.64 (203.76)	984.55 (231.47)	1049.50 (229.45) _b
Total	1206.16 (286.81) _c	1129.00 (247.29) _c	1159.98 (268.11)
Light physical activity			
Boys	880.75 (169.05)	876.70 (174.24)	885.11 (168.08) _a
Girls	912.90 (160.94)	735.89 (170.94)	820.21 (186.99) _a
Total	897.16 (163.68) _c	808.16 (181.58) _d	851.22 (181.19)
Moderate physical activity			
Boys	194.89 (77.14)	172.78 (54.65)	180.09 (68.29) _a
Girls	115.49 (45.00)	98.96 (46.31)	108.20 (45.48) _b
Total	154.14 (71.00) _c	137.15 (63.58) _c	140.29 (68.06)
Vigorous physical activity			
Boys	205.09 (80.83)	240.26 (70.66)	223.35 (79.29) _a
Girls	119.25 (44.31)	149.70 (53.52)	134.73 (51.46) _b
Total	160.78 (74.84) _c	197.29 (77.03) _d	168.48 (76.60)
Autonomy			
Boys	4.16 (0.60)	3.86 (0.64)	4.05 (0.62) _a
Girls	4.36 (0.74)	4.06 (0.70)	4.23 (0.73) _a
Total	4.27 (0.68) _c	3.98 (0.67) _c	4.15 (0.69)
Competence			
Boys	4.01 (0.99)	3.86 (0.88)	3.95 (0.93) _a
Girls	3.68 (0.85)	3.82 (0.74)	3.74 (0.79) _a
Total	3.83 (0.91) _c	3.83 (0.78) _c	3.83 (0.85)
Relatedness			
Boys	3.90 (1.04)	3.16 (1.34)	3.61 (1.19) _a
Girls	3.86 (0.95)	3.49 (1.17)	3.69 (1.05) _a

Dependent measure	Points	No points	Total
Total	3.87 (0.97) _c	3.37 (1.22) _{c, †}	3.66 (1.10)

Note. All values were controlled for chronological age. Means and standard deviations within each row with no subscript in common significantly differ statistically. Subscripts “a,” “b,” and “c” refer to main effects of the sex variable, and subscripts “c,” “c,” and “d,” refer to main effects of the experimental conditions.

_† indicates that the main effect of experimental condition approached significance ($p = .06$).