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LITTLE REWARDS, BIG CHANGES: USING EXERCISE ANALYTICS TO MOTIVATE SUSTAINABLE CHANGES IN PHYSICAL ACTIVITY

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ABSTRACT

Even using simple techniques like taking the stairs, many individuals struggle to maintain the motivation to be active. Health gamification systems can encourage activity by providing points earned through exercise that are redeemable for tangible extrinsic rewards. Using self-determination theory, we investigate rewards' effectiveness to promote exercise considering reward value, redemption frequency patterns, and fitness levels within a health gamification system. We find that rewards do significantly increase activity levels, and this effect is larger for advanced users who redeem multiple times for higher value rewards. We close by offering future research avenues and advice to optimize reward portfolios.

Keywords: Health gamification system; Tangible extrinsic rewards; Reward portfolio design; Reward effectiveness optimization; Redemption patterns; Fitness stage

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INTRODUCTION

Wearable fitness devices such as smartwatches and fitness trackers are becoming mainstream (Shin, 2017; Wu et al., 2016) as users' attempt to improve their overall health through the tracking of their physical activity (Attig & Franke, 2019; Nelson et al., 2016). These devices produce vast amounts of data that can enable socially aware managers and organizations to develop strategies to nudge wearable users to increase and sustain physical activity levels. We explore the effectiveness of rewards through the lens of self-determination theory (Ryan & Deci, 2000) to understand the combined impacts of reward value, redemption patterns, and fitness stage on physical activity. We do so through a large health gamification system that allows its users to earn points for their physical activity that can be redeemed for tangible extrinsic rewards. From this analysis, we highlight new data analytics and health gamification design research avenues, as well as report actionable insights for managers of gamification systems.

Gamification systems are commonly employed to change stakeholder behavior in desirable ways (Aparicio, et al., 2019; Koivisto & Hamari, 2019; Robson et al., 2016). Robson et al. (2015) define gamification as the application of game design principles in non-game contexts. Existing research shows that providing either intangible or tangible rewards through a health gamification system can improve users' motivation to engage in physical activity (González et al., 2016; Pyky et al., 2017; Royer et al., 2015). However, research has yet to scrutinize the design of reward portfolios in health gamification systems, and specifically, the effectiveness of rewards of different value and the impact of redemption frequency patterns. Moreover, there is little evidence of how rewards' effectiveness is impacted by heterogeneity in users' fitness

levels. We examine how reward value and redemption frequency patterns can motivate users in distinct fitness stages to engage in physical activity to optimize reward portfolios.

Before developing hypotheses, we examine the self-determination theory, behavior reinforcement, and gamification literatures to gain insights into how the design of reward portfolios and health gamification systems can more effectively foster physical activity. Then, we report the findings of an analysis of a health gamification system that includes 3502 users' observed physical activity over six months. Next, we discuss the implications of these results for researchers, managers, and designers of health gamification systems. We close by addressing several limitations of this study and offering some concluding thoughts.

LITERATURE REVIEW

Motivating Behavioral Changes

To design behavior change systems, we must first understand users' goals and behavioral regulatory tendencies. Thus, we adopt self-determination theory, which is an influential conceptual lens that explains how individual users achieve goals through various types of motivation: intrinsic, extrinsic, or amotivation (Deci & Ryan, 1985; Ryan & Deci, 2000; Ryan & Deci, 2017). Intrinsic motivation is experienced when users engage in something for the inherent satisfaction of activities, such as the satisfaction derived from exploring or learning. When activities are intrinsically motivating, they likely satisfy needs related to competence, autonomy, and relatedness. Extrinsic motivation is experienced when users seek outcomes that are detached from the activities undertaken. These outcomes can include money, peer recognition, gifts, status symbols, other external rewards, or even the avoidance of punishments. Finally,

amotivation is experienced when users lack the intention to act.

Self-determination theory is widely applied to understand users' motivations for engaging in physical activity to improve health (Ingeldew & Markland, 2008; Buckworth et al., 2007). Studies adopting this approach show that more autonomous motivations (i.e., want to) compared to nonautonomous motivations (i.e., have to) have positive associations with exercise behavior (Deci & Ryan, 2008; Teixeira et al., 2012). Although physical activity is motivated both intrinsically and extrinsically (Ryan & Patrick, 2009), the dominance of extrinsic versus intrinsic motivations is likely to change as users progress through fitness stages. In other words, extrinsic motivation is likely critical in compelling users to first adopt a fitness regime, while intrinsic motivation is likely necessary to sustain long-term commitment (Teixeira et al., 2012).

Extrinsic rewards that are desirable, relevant, and administered appropriately can be effective motivational instruments (Charness & Gneezy, 2009; Ryan & Deci, 2000; Tong et al., 2013). Behaviors that are positively reinforced tend to be repeated more than nonreinforced behaviors (Premack, 1959; Skinner, 1953), which can ultimately lead to habit formation (Rothschild & Gaidis, 1981). Behavioral reinforcement occurs when users learn the positive or negative associations between reinforced behaviors and certain tangible or intangible reinforcers (i.e., rewards or punishments; Crutzen & Peters, 2018).

Although behavior change can be reinforced successfully through extrinsic rewards, rewards that are contingent on task performance are known to undermine or "crowd-out" intrinsic motivation (Acland & Levy, 2015; Gneezy et al., 2011; Wu, 2019). In addition, the "style" in which a reward is given can also impact intrinsic motivation. For example, rewards given in controlling

ways undermine intrinsic motivation (Ryan et al., 1983), while rewards given in ways that enhance autonomy, competence, or relatedness may increase intrinsic motivation (Lewis et al., 2016; Van Dyck et al., 2018).

Designing Health Gamification Systems

Gamification is an increasingly popular technique that involves motivating users to learn or change behaviors by taking part in game-like experiences (Deterding et al., 2011; Jin, 2013; Robson et al., 2015; Dissanayake et al., 2018). Gamification systems provide users with relevant and desirable extrinsic rewards often in autonomous ways, which can act as powerful reinforcers and motivate behavior change (Charness & Gneezy 2009; Lewis et al., 2016). Gamifying an activity involves more than only the use of rules and rewards, or gamification mechanics. Gamification also involves user dynamics (i.e., social and interactive aspects) and the elicitation of users' emotions. Together, the successful implementation of these building blocks – mechanics, dynamics, and emotions – creates a powerful information system that stimulates users to change target behaviors (Robson et al., 2015, 2016).

Health gamification systems motivate users to change behaviors for the improvement of health. These systems have been designed to increase physical activity (Chen & Pu, 2014; Chen et al., 2014; Höchsmann et al., 2019), encourage healthy eating habits (Jones et al., 2014), reduce alcohol consumption (Boendermaker et al., 2015), and enhance mental wellbeing (Ludden et al., 2014). When designing rewards to motivate healthy behaviors, there are three key issues to consider: reward type, redemption dynamics, and heterogeneity of users (see Table 1 for selected studies on health gamification and rewards).

Health gamification systems use different types of rewards to reinforce behavior changes (Lewis et al., 2016; Robson

et al., 2015). Types of rewards range from simple accumulation of points (Nelson et al., 2016), to digital badges and medals (Allam et al., 2015; Hamari & Koivisto, 2014, 2015a, 2015b; Koivisto & Hamari, 2014), to digital storyline artifacts (Höchsmann et al., 2019; Kaczmarek et al., 2017; Pyky et al., 2017), to monetary incentives (Boendermake et al., 2015; Daryanto et al., 2010), and to tangibles of assorted value (e.g., beverages, clothing, or merchandise; Black et al., 2014; Mitchell et al., 2018; Patel et al., 2018). Through redeeming these rewards, users show not only long-term positive effects on desired health behaviors but also that these effects potentially could persist even when rewards are removed (Charness & Gneezy, 2009; Acland & Levy, 2015). Additionally, user dynamics can be fostered by including social support features and messaging between users that can augment the positive effect of rewards (Allam et al., 2015; Chen & Pu, 2014; Chen et al., 2014). Emotions are evoked in users when receiving these rewards that are essential to sustaining users' engagement with the health gamification system (Robson et al., 2015; Nelson et al., 2016).

Redemption provides a direct boost to extrinsic motivation to sustain engagement (Hu et al., 2010; Woolley & Fishbach, 2017). Redemption dynamics influence observed behaviors and can include users' tenure in the system (Black et al., 2014; Koivisto & Hamari, 2014), goal achievement (Patel et al., 2018; Mitchell et al., 2018), or frequency patterns. As these dynamics have rarely been the focus of gamification studies, the loyalty literature provides additional insights into the behavioral consequences of both saving and redeeming for rewards, including motivations for redeeming points (Smith & Sparks, 2009a, b; Kivetz & Simonson, 2002; Chan et al., 2016), saving points to obtain

higher value rewards (Stourm et al., 2015; Chun & Hamilton, 2016), and letting points expire (Dorotic et al., 2014). If point collection occurs closer to the redemption, users likely perceive greater system value (Hu et al., 2010), experience reduced opportunity costs (Woolley & Fishbach, 2017), and display more perseverance to achieve long-term goals (Woolley & Fishbach, 2017, 2018). Furthermore, reward dynamics that result in highly effortful redemptions influence both frequency patterns and reward values sought by users (Kivetz & Simonson, 2002; Smith & Sparks, 2009a, b).

The heterogeneity of users can pose a troubling challenge to health gamification system designers in crafting reward portfolios that account for this diversity in terms of demographics (e.g., age, gender, location, education, employment, etc.; Black et al., 2014; Boendermake et al., 2015; Kaczmarek et al., 2017; Koivisto & Hamari, 2014; Mitchell et al., 2018; Pyky et al., 2017), psychographics (e.g., personality traits, psycholinguistic characteristics, regulatory orientations, life satisfaction, etc.; Daryanto et al., 2010; Pyky et al., 2017), health indicators (e.g., weight, alcohol use, blood pressure, etc.; Boendermake et al., 2015), and observed behaviors (e.g., fitness level; Mitchell et al., 2018; Patel et al., 2018). While some of these characteristics are not likely to change (e.g., demographics, psychographics), other aspects of users evolve through sustained engagement with the health gamification system (e.g., health indicators, observed behaviors). The behavioral change successes of these systems are linked to the ability to adapt reward types and redemption dynamics to user heterogeneity.

Table 1: Selected Studies on Health Gamification and Rewards

Study	Gamification intervention	Reward design issues investigated			Key insights
		Reward type	Redemption dynamics	User heterogeneity	
Allam et al. (2015)	Social support and web-app for arthritis patients	Digital badges and medals	-	-	Positive effect of social support and gamification on fitness, empowerment, and reduced health visits
Black et al. (2014)	Youth center reward program for HIV testing	Tangibles of assorted value	System tenure	Demographics, behaviors	Increase in HIV, pregnancy, and other health tests from active participation in the reward program
Boendermake et al. (2015)	Cognitive retraining of automatic appetite process	Monetary incentives	-	Demographics, health	Social game elements increase aspects of user experience and motivation to train
Daryanto et al. (2010)	Health club fitness reward program	Monetary incentives	-	Psychographics	Regulatory fit impact on exercise intensity is stronger over time than nonfit impact
Hamari & Koivisto (2014)	Exercise support web app	Digital badges and medals	-	-	Identified flow state (i.e., sustained engagement) conditions and outcomes
Hamari & Koivisto (2015a)	Exercise support web app	Digital badges and medals	-	-	Extended social influence impact on individual exercise behavior
Hamari & Koivisto (2015b)	Exercise support web app	Digital badges and medals	-	-	Relationship between utilitarian, hedonic, and social benefits
Höchsmann et al. (2019)	Fitness game app for Type 2 diabetes patients	Digital storyline artifacts	-	-	Increase in intrinsic motivation to engage in physical activity in the intervention group
Kaczmarek et al. (2017)	App-based game	Digital storyline artifacts	-	Demographics	Health motivation and social motivation for game playing are related to health outcomes.
Koivisto & Hamari (2014)	Exercise support web app	Digital badges and medals	System tenure	Demographics, behaviors	Perceived enjoyment and usefulness of the gamification system decline with use tenure
Mitchell et al. (2018)	Game app to earn loyalty program points	Tangibles of assorted value	Goal achievement	Demographics, behaviors	Increase in steps, especially for physically inactive users
Nelson et al. (2016)	Smart wristbands and activity tracking	Accumulated point balance	-	-	Activity trackers with gamification have strong empowering capabilities
Patel et al. (2018)	Fitness app supporting fitness incentive program	Tangibles of assorted value	Goal achievement	Behaviors	Effective behavioral change as a result of joining the fitness incentive program
Pyky et al. (2017)	App service supporting physical activity	Digital storyline artifacts	-	Demographics, psychographics	Significant improvement of life satisfaction, especially for men with low life satisfaction
The current study	Points for exercise web app	Tangibles of assorted value	Frequency patterns	Behaviors	Increase in fitness from redemption and combined effect of reward value, redemption, and fitness stage

As Table 1 shows, the current study adds to the literature on health gamification systems and focuses on all three reward design issues. Specifically, in the next section, it conceptualizes effects on reward effectiveness from variations in reward value and redemption frequency patterns across three fitness stages.

Hypothesis Development

The design of health gamification systems that promote increased or sustained physical activity requires an understanding of what we term the motivational utility of the extrinsic rewards provided to users. A reward's *motivational utility* is based on the perceived ability of that reward to influence users' levels of physical activity (Keeling et al., 2013; Stourm et al., 2015; Smith & Sparks, 2009). We argue that a reward's motivational utility is affected by reward redemption, a user's fitness stage, and the value of that reward. First, reward *redemption* provides extrinsic motivation to engage in additional physical activity (Hu et al., 2010; Woolley & Fishbach, 2017). When users redeem for rewards, they receive extrinsic motivational boosts that enhance their ability to sustain higher levels of physical activity (Woolley & Fishbach, 2017, 2018). For this reason, we expect any redemption to increase exercise point collection relative to users who do not redeem. Formally:

H1: Users who make any reward redemption will collect more exercise points than users who do not make a reward redemption.

A user's *fitness stage* is likely to affect the motivational utility of a reward. Fitness stage can be calculated using average daily fitness levels from observed physical activity tracking data (as is common practice in studies on exercise: e.g., Tappe et al., 2013; O'Donovan et al., 2009; Watson & Mock, 2004; Lee & Paffenbarger, 2000) and is commonly categorized as novice,

intermediate, and advanced. "Novice" users are characterized by a relatively low level of daily physical activity and relatively lower intrinsic motivation to engage in physical activity. Compared to novices, "intermediate" users have a higher level of daily physical activity and related intrinsic motivation to engage in it. At the extreme, "advanced" users have the highest levels of daily physical activity and demonstrate well-developed fitness practices reflecting high levels of intrinsic motivation. These differences in intrinsic motivation are likely to change how users react to reward redemption. Specifically, because more advanced users will likely have higher intrinsic motivation than less advanced users (Acland & Levy, 2015; Gneezy et al., 2011), advanced users are more likely to exhibit the "crowding out" of intrinsic motivation that accompanies redemptions for extrinsic rewards. However, this effect likely depends on both the user's *number of redemptions* and the *value of the reward*.

Specifically, more redemptions are likely to have a positive motivational effect on novice and intermediate users' physical activity levels. A different effect is likely to be observed with advanced users, although we believe the effect is qualified by the value of the reward that they redeem. As higher value rewards require more exercise points than lower value rewards, their redemption is naturally spaced out over a longer period. We argue that the delay will not affect novice and intermediate users but will impact advanced users. Novice and intermediate users, who have relatively lower levels of intrinsic motivation that can be crowded out, will likely show boosts in exercise points collected after redemptions, irrespective of whether redemptions are for high- or low-value rewards (Hu et al., 2010; Woolley & Fishbach, 2017).

In contrast, advanced users are likely to be more sensitive to the time delay

differences associated with low- versus high-value rewards. Advanced users who redeem for multiple low-value rewards are likely to exhibit no change in exercise point collection compared to users who redeem for a single low-value reward because of crowding out of intrinsic motivation (Acland & Levy, 2015; Gneezy et al., 2011). However, the temporal spacing afforded by high-value rewards will enable advanced users to maintain those rewards' motivational utility even if advanced users redeem them multiple times. Hence, we propose a three-way interaction between reward value (low or high), number of redemptions (zero, one, or multiple), and fitness stage (novice, intermediate, or advanced), as follows:

- H2a: Novice users who redeem for multiple *low*-value rewards will collect more points than novice users who redeem for a single *low*-value reward.
- H2b: Novice users who redeem for multiple *high*-value rewards will collect more points than novice users who redeem for a single *high*-value reward.
- H2c: Intermediate users who redeem for multiple *low*-value rewards will collect more points than intermediate users who redeem for a single *low*-value reward.
- H2d: Intermediate users who redeem for multiple *high*-value rewards will collect more points than intermediate users who redeem for a single *high*-value reward.
- H2e: Advanced users who redeem for multiple *low*-value rewards will *not* collect more points than advanced users who redeem for a single *low*-value reward.
- H2f: Advanced users who redeem for multiple *high*-value rewards will collect more points than advanced

users who redeem for a single *high*-value reward.

DATA, METHOD, AND RESULTS

Data and Method

To test the hypotheses developed above, this paper analyzes a large-scale health gamification system deployed at a major university. The system is free of charge to its users and aims to improve their activity levels during daily life. Users earn points for activity (e.g., walking steps, running, swimming, skiing, bicycling, etc.) that is recorded by users' wearable fitness trackers (e.g., Apple Watch, Fitbit, etc.) and automatically entered into the system through their trackers' mobile applications. These exercise points can be redeemed for lower value rewards, such as hot beverages or discounts at popular retailers, or can be saved up for higher value rewards, such as university-branded water bottles, hoodies, or T-shirts.

The dataset reports activity and redemption data for 3,502 users over a six-month period, after removing inactive (i.e., those that earned no activity points during our period) and outlier (i.e., ages below 18 and above 65 years) user accounts. There were 900 new users within the dataset, but these users were randomly distributed across the variables of interest. The length of time in the system was not a significant indicator of exercise point collection. Table 2 details the users' age and gender statistics in our sample.

The study relied on four main variables: exercise point collected, fitness stage, number of redemptions, and reward value. *Exercise points collected* records the points that users earned for their activity during the study period and was used as the primary dependent variable ($M = 1622.74$, $S.D. = 2321.11$). Users' *fitness stages* were calculated by dividing the "daily average points collected" ($M = 24.82$, $S.D. = 37.47$) into three categories to facilitate the

comparison of these stages and observed exercise behaviors. Specifically, these stages are classified as either “novice” (under mean, $n = 2071$), “intermediate” (mean to +1 standard deviation, $n = 1279$), or “advanced” (above +1 standard deviation, $n = 152$). We acknowledge that this classification is correlated with our dependent variable (i.e., exercise points collected), but the fitness stage classification aids in the understanding of different behaviors within the classifications, especially comparing the least and most active users, rather than comparing physical activity levels across stages. Furthermore, by defining fitness stage as we have, we identify not only future research avenues but also managerial implications for the design and operation of reward-based

motivation systems that are sensitive to user activity levels. *Redemptions* reports redemption behavior and categorizes users as having either zero redemptions ($n = 2689$), one redemption ($n = 360$), or multiple redemptions ($n = 453$). *Reward value* accounts for differences in the utility derived from the average redemption and categorizes rewards as low value (i.e., 400 points and under; e.g., coffee, coupons; $n = 331$) or high value (i.e., over 400 points; e.g., branded clothing, towels, water bottles; $n = 482$). The next section reports exercise point collection differences between the various categories of fitness stage, number of redemptions, and reward value.

Table 2: Sample Characteristics

Demographic variable		n	Sample percent
Gender	Male	1241	35.4
	Female	1948	55.6
	Undisclosed	313	8.9
Age	18-24	1970	56.3
	24-34	916	26.1
	34-49	240	6.7
	50-65	57	1.6
	Undisclosed	319	9.1

Results

To test H1, we first conducted a 3 (number of redemptions: zero, one, or multiple) x 3 (fitness stage: new, intermediate, and advanced) between-subjects ANOVA with total exercise points collected as the dependent variable. We included fitness stage in our analysis of H1 because of the interaction effects that we investigated later in H2a-f. Furthermore, we conducted this analysis first because it uses the wider sample of users who redeemed and did not redeem, while our investigation of H2a-f included only users who redeemed.

The analysis revealed several significant main and interaction effects (see

Table 3). This included significant main effects of redemptions ($F(1, 3493) = 313.52$, $p < .001$) and fitness stage ($F(2, 3493) = 296.22$, $p < .001$). More importantly, a significant two-way interaction between fitness stage and number of redemptions occurred ($F(4, 3493) = 35.64$, $p < .001$; see Figure 1). Confirming H1, Bonferroni adjusted post-hoc comparisons found that across all fitness stages points collected were significantly higher for users who made multiple versus one redemption ($p < 0.001$), as well as one versus zero redemptions ($p < 0.001$).

Table 3: Effect of Redemption on Exercise Points by Fitness Stage

Number of Redemptions	Fitness Stage			<i>Grand Mean</i>
	Novice	Intermediate	Advanced	
Zero	553.75 ^{a,b}	2359.07 ^{c,d}	2601.16 ^{e,f}	1140.70
One	1678.11 ^a	3517.18 ^c	3989.42 ^c	2837.13
Multiple	2141.34 ^b	4523.16 ^d	8188.28 ^f	4467.86
<i>Grand Mean</i>	712.23	3016.65	5127.16	1745.47
<i>n</i>	2071	1279	152	3502

Note: Superscripts indicate significant differences based on Bonferroni adjusted post-hoc pairwise comparisons with a familywise error rate of 0.05.

A 2 (reward value: small vs. large) x 3 (number of redemptions: zero, one, or multiple) x 3 (fitness stage: novice, intermediate, and advanced) between-subjects ANOVA with total exercise points collected as the dependent variable revealed significant main and interaction effects (see Table 4). This included significant main effects of reward value ($F(1, 801) = 28.16, p < .001$), redemptions ($F(1, 801) = 21.36, p < .001$), and fitness stage ($F(2, 801) = 56.99, p < .001$). A significant two-way interaction between the number of redemptions and reward value occurred ($F(1, 801) = 14.50, p < .001$). The other two-way interactions were not significant. More importantly, a significant three-way interaction occurred between reward value, number of redemptions, and fitness stage ($F(2, 801) = 7.38, p = .001$; see Figure 2).

For novice users, multiple versus single redemptions had no effect on exercise point collection for users who redeemed for either low-value rewards ($M_{\text{multiple,low}} = 1749.12, M_{\text{single,low}} = 1258.34, F(1, 801) = 1.13, p = .29$) or high-value rewards

($M_{\text{multiple,high}} = 2720.75, M_{\text{single,high}} = 1991.61, F(1, 801) = 2.29, p = .13$). While we note that effects are in the hypothesized directions, the fact that the respective results are not significant leads us to reject Hypotheses H2a and H2b. Confirming H2c and H2d, intermediate users who made multiple redemptions collected significantly more exercise points than those who redeemed once, irrespective of the rewards being of low value ($M_{\text{multiple,low}} = 3899.66, M_{\text{single,low}} = 2774.91, F(1, 801) = 7.72, p < .001$) or of high value ($M_{\text{multiple,high}} = 5063.53, M_{\text{single,high}} = 3814.09, F(1, 801) = 17.51, p < .001$). Finally, for advanced users redeeming for low-value rewards, multiple redemptions had no effect on exercise point collection as compared to single redemptions ($M_{\text{multiple,low}} = 3434.93, M_{\text{single,low}} = 4305.50, F(1, 801) = .364, p = .56$), confirming H2e. However, advanced users making multiple redemptions collected significantly more exercise points than those who made a single redemption when rewards were of high value ($M_{\text{multiple,high}} = 9643.39, M_{\text{single,high}} = 3905.13, F(1, 801) = 57.53, p < .001$).

Figure 1: Effect of Redemption on Exercise Points Collected by Fitness Stage

Table 4: Effect of Reward Value and Redemption on Exercise Points by Fitness Stage

Reward Value	Number of Redemptions	Fitness Stage			Grand Mean
		Novice	Intermediate	Advanced	
Low	Single	1258.34	2774.91 ^a	4305.50	2086.02
	Multiple	1749.12	3899.66 ^a	3434.93	3200.82
High	Single	1991.61	3814.09 ^b	3905.13 ^c	3217.39
	Multiple	2720.75	5063.53 ^b	9643.39 ^c	5562.84
Grand Mean		1882.53	4100.36	7227.10	3745.77
n		247	483	83	813

Note: Superscripts indicate significant differences based on Bonferroni-adjusted post-hoc pairwise comparisons with a familywise error rate of 0.05.

Figure 2: Three-Way Interaction Effect of Reward Value, Fitness Stage, and Redemption Behavior on Exercise Points Collected

DISCUSSION AND IMPLICATIONS

Drawing on a dataset of the observed physical activity levels of 3,502 users of a health gamification system, we investigate how reward value and redemption patterns can motivate users in distinct stages of fitness to engage in physical activity. A central goal of this investigation is to better understand how to optimize reward portfolio design to maximize motivation to engage in physical activity. With two exceptions in the case of novices, our findings largely confirm our hypotheses predicting the effectiveness of different rewards and redemption behaviors in motivating users of different fitness levels to be physically active.

The results of our first analysis confirm the motivational benefit of any redemption within the system. Specifically, users who redeem one or multiple times in the system lead to significant increases in exercise points collection as compared to users who did not redeem. This finding corroborates earlier studies that show that rewards motivate increased physical activity (González et al., 2016; Pyky et al., 2017; Royer et al., 2015) and mirrors similar findings in the loyalty program literature on the positive compounding effect of redeeming rewards multiple times (Smith & Sparks, 2009a, b; Dorotic et al., 2014).

Our results also confirm that a significant interaction between reward value

(low versus high) and reward redemptions (single versus multiple), and different fitness stages (novice versus intermediate versus advanced) exists. While the singular roles of higher value rewards (Smith & Sparks, 2009a, b; Kivetz & Simonson, 2002), multiple redemptions (Smith & Sparks, 2009a, b; Dorotic et al., 2014), and fitness stage (Tappe et al., 2013; O'Donovan et al., 2009; Watson & Mock, 2004; Lee & Paffenbarger, 2000) are investigated in several past studies, we find significant patterns of observed physical activity in different levels of these three variables. This is a novel theoretical contribution to the literature. Specifically, users are observed to have increased physical activity levels if they are classified as advanced and redeem multiple times for higher value rewards. While significant effects were not found for novice users, intermediate users were found to have increased physical activity levels with multiple redemptions. These results show that the marginal benefit in the physical activity of multiple redemptions changes based on fitness stage and reward value. Our findings imply that researchers need to create more complex analytical frames that account for, and are sensitive to, the heterogeneity of users in terms of both their behaviors and other characteristics.

Research on the interplay between external rewards and intrinsic motivation in the context of health gamification (e.g., Lewis et al., 2016) reveals a complex relationship between these factors. Findings from the current research add to our understanding of this complex relationship. As the points and rewards studied in this research are not contingent on completion of any specific physical tasks but are rather collected based on any physical activity, the external rewards in this health gamification system are not likely to diminish the feelings of autonomy (c.f., Deci et al., 1999). Our research also suggests that in the context of

health and fitness, users' fitness stage must also be taken into consideration, as points redemptions provide a motivational boost to more advanced users. We suggest that the delay experienced in redeeming for high value rewards serves to protect advanced fitness users from the otherwise negative effect that extrinsic rewards are known to have on intrinsic motivation (Acland & Levy, 2015; Gneezy et al., 2011). These findings imply that gamification researchers need to incorporate this effect into their research design or risk misinterpreting or even demotivating more advanced users.

More broadly, this paper introduces two important theoretical concepts. First, we unpack the concept of rewards in gamification by showing that lower and higher value rewards can have differential effects on user behavior. This is consistent with research on gamification, which suggests that rewards should be tailored to different users in gamified experiences (Robson et al., 2014), as well as research on motivation that identifies contextual factors as important in understanding what compels users to behave in a certain way (Deci & Ryan, 2012). Second, this research highlights the issues surrounding user heterogeneity, specifically fitness stages in this case, and its impact on reward effectiveness. While other research identifies motivational differences based on users' characteristics (e.g., Teixeira et al., 2012), most studies treat users as homogeneous, thus potentially not discovering latent insights. By showing that not all rewards are created equal and identifying key factors in health gamification systems that can predict physical activity, we open the door to additional research that deconstructs rewards in other dimensions and contexts.

Managerial Implications

Our results provide evidence that health gamification systems positively

impact the observed physical activity when users redeem for tangible rewards, and in doing so add to the body of evidence that identifies gamification as an effective approach to motivating behavior changes related to health and wellbeing (Hamari & Koivisto, 2015a; Johnson et al., 2016; Koivisto & Hamari, 2019). These findings have three main implications for designers and managers of health gamification systems, as well as for public policy officials tasked with improving public health.

Inspire more redemption: We find that users who redeem even once are observably physically more active on average and that this impact is generally compounded when users redeem on multiple occasions. Thus, health gamification systems need to be designed in ways that boost users' redemption behavior using a selection of gamification mechanics, dynamics, or emotions (Robson et al., 2015). The need for careful development of mechanics that foster redemption is underscored by research on loyalty programs that reveals an inverse relationship between the complexity of the redemption process and the likelihood that users will redeem their points (Smith & Sparks, 2009a, b; Sharp & Sharp, 1997). Given this, designers are advised to use simple, easy-to-follow redemption rules when constructing health gamification systems. Gamification designers could be directed to create affordances surrounding rewards, even targeting specific low-hanging fruit (i.e., low value) rewards, to inspire non-redeeming users to redeem by showcasing attractive, relevant, and desirable rewards. They could also apply gamification dynamics and emotions to redemption activities so that the positive feelings of gaining rewards are shared more widely in local social networks, which might spur other users to redeem themselves and potentially create redemption norms.

Foster saving for larger rewards: Our findings highlight the effectiveness of higher value rewards in motivating physical activity, especially for advanced users. That is, users who save for higher value rewards are generally more physically active than those who redeem for lower value rewards. Health gamification systems could encourage saving behavior by applying gamification mechanics (Robson et al., 2015), such as periodic reports enabled by point collection and redemption analytics that motivate users to save their collected points for higher value rewards, particularly in the case of advanced users. Gamification designers could use mechanics to encourage point saving behavior by showing images of high-value rewards as grayed out or locked and then providing the point goals needed to redeem for those rewards. This could be an effective approach in helping redeeming users persevere toward achieving the point balance needed for high-value rewards.

While these first two managerial implications seem to be in conflict, in fact, they are complementary. For health gamification systems to have an effective impact on physical activity, users must first redeem for rewards to receive an extrinsic motivational boost. Then, to magnify redemption effects and sustain the increasing levels of physical activity, more advanced users need to be inspired to save for higher value rewards, which leads us to our final recommendation.

Customize reward portfolios: While we find that multiple redemptions and higher value rewards are associated with the highest level of observed physical activity, these effects depend on users' fitness stage. Specifically, advanced users are associated with significant boosts in physical activity only if they redeem multiple times for high-value rewards, whereas those who redeem for low-value rewards multiple times are associated with lower physical activity. In

contrast, intermediate users who redeem multiple times for rewards are associated with higher levels of physical activity than those who redeemed only once, regardless of whether they redeem for higher or lower value rewards. Managers of health gamification systems can use these findings to present different portfolios of rewards to users at different fitness stages to optimize reward effectiveness. For example, designers could build automatic notification systems into health gamification systems that send fitness stage-targeted messages to users who promote rewards tailored to activity levels. Reward portfolios can be customized to fit different fitness stages and thus be more effective at motivating users to increase or sustain physical activity levels.

LIMITATIONS AND FUTURE RESEARCH

As with any study, the current research has several limitations, which we discuss in the next several paragraphs. This study explains physical activity patterns by exploring the effect of tangible rewards' value and redemption frequency patterns. As a result, we use summary statistics that could not account for changes in users' physical activity, redemption frequency patterns, or fitness stages during the period of data collection. Moreover, because this study compares and contrasts different levels of physical activity across different redemption frequency patterns, high- versus low-value rewards, and novice, intermediate, or advanced fitness stages, we constructed several categorical variables out of continuous indicators to generate our results. We, therefore, encourage researchers to reinvestigate our findings using other methods, including experimental or interpretivist qualitative approaches.

Our research investigates a health gamification system that is implemented at a large university, and as a result, the users

consist of that university's community including students, faculty, and administrative staff. While our analysis reveals no effect of age on our key measures, it is possible that the university setting (i.e., the large number of young, student users) creates a context that limits the generalizability of our findings. Future research would benefit from exploring the implementation of similar health gamification systems in offices, hospitals, or other important settings to determine whether our findings depend on contextual factors not tested or studied.

Our research identifies a variety of exciting opportunities for future research that can track users through a "fitness motivation lifecycle" using more advanced statistical techniques, such as difference-in-difference analysis (e.g., Guo et al., 2018). Future research could investigate the constructs of interest using alternative theoretical lenses. We rely on self-determination theory (Ryan & Deci, 2017) as our main theoretical frame, believing that this theoretical lens is the most appropriate for investigating a health gamification system that uses tangible rewards to motivate physical activity. Yet, other theoretical approaches, such as regulatory modes (Higgins et al., 2003; Mathman et al., 2017), may offer complementary perspectives and provide additional insight. Future researchers could use field experiments to examine messaging or other inventions based on alternative regulatory or behavioral theories that could not only provide further depth into physical activity motivations but also improve health outcomes for users.

The rewards in the studied health gamification system are rewards to the users (e.g., coffee, coupons, and clothing). However, less is known about the effectiveness of rewards that are shared within a social group or team, or that go to other individuals in need (e.g., redeem for

clothing for the homeless, cans for the food bank, etc.). Future research could explore these types of rewards as a means of not only enhancing users' physical activity levels but also providing another social good in the users' local context. Furthermore, our study does not investigate the user experience or the design of the user interface, including the presentation and promotion of rewards, which present valuable avenues for future researchers to explore.

CONCLUSIONS

This article investigates the exercise point collection and reward redemption behavior of users in a large health gamification system. Specifically, we investigate the combined impact of reward value, reward redemption patterns, and fitness stage to change the effectiveness of tangible rewards in motivating increased physical activity. Our findings offer several contributions to research and practice. First, we introduce the notion of users' fitness stage to the literature, showing that users can be classified into outcome (i.e., physical activity) levels as a means of comparison and evaluation of gamification mechanics (i.e., different types of rewards). Second, we show that tangible extrinsic rewards' effectiveness varies in conjunction with fitness stages, reward value, and redemption patterns. We identify boundary conditions of the effectiveness of these rewards in a real-world

setting with users recording their physical activity passively using connected wearable fitness devices. Third, we uncover the complex relationships between a number of key variables (fitness stage, redemption behavior, and reward value) in understanding how health gamification systems can be used to inspire and reinforce healthy habits and behaviors. Fourth, at a practical level, we find that novice users (i.e., those with a relatively low level of physical activity) should be encouraged to redeem regardless of the rewards' value or the frequency of redemption. However, advanced users (i.e., those with a relatively high level of physical activity) should be encouraged to save their points to redeem for higher value rewards to space out extrinsic motivational boosts that may crowd out intrinsic motivation.

Our findings can be directly applied by public policy officials or designers of health gamification systems to nudge or motivate users to improve their physical fitness. As the physical health of global populations deteriorates (Karnani et al., 2016), research such as this can be used to guide the implementations of gamified interventions to inspire positive changes in health and wellbeing for individuals around the world. Ultimately, our results offer insights into designing and developing more successful and cost-efficient health gamification systems to increase health through sustained physical activity.

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