Differential exercise patterns between 'hardcore' and 'casual' players of Pokémon GO and Harry Potter: Wizards Unite

KATHLEEN YIN, MATTHEW D. LEE, KIRAN IJAZ, JAMES SMITH & LOUISE A. ELLIS

ABSTRACT

We report data from an online mixed-methods survey that assessed the exercise routine and play experiences of players for *Pokémon GO* (PGO) and Harry *Potter: Wizards Unite* (HPWU), two augmented reality (AR) games that encourage outdoor walking. Both games significantly increased the extent of exercise for players, however exercise patterns differed between the two games' player bases, with further variations between self-identified 'hardcore' and 'casual' players. Players also reported on key design differences between the games that had a major influence on their outdoor walking behaviour. We propose that these findings could highlight design practices that can affect exercise outcomes in exergames in future works.

Keywords: Serious game, exergame, Pokémon GO, Harry Potter: Wizards Unite

INTRODUCTION

Sedentary lifestyle and its consequential obesity are now global issues, with millions at risk of health conditions that may be exacerbated by obesity (Hruby & Hu, 2014). 'Exergames', defined as games used with the purpose of encouraging its users to increase physical exercise levels, have been developed both academically and commercially for arcade machines (Bogost, 2005), consoles (Boulos, 2012), virtual reality (Warburton et al., 2007), combined with the use of treadmills or other exercise equipment (Ahn et al., 2009; Bolton, Lambert, Lirette, & Unsworth, 2014), and handheld devices such as mobile phones (Laine & Suk, 2015; Witkowski, 2013). However, while exergames have shown promise in a controlled classroom setting (Fogel, Miltenberger, Graves, & Koehler, 2013) and in children (Maloney et al., 2012), such games have not consistently succeeded at increasing physical exercise when used for general adult consumers.

In contrast, *Pokémon GO* (PGO), a free-to-play mobile game developed by Niantic and released in 2016, was one of the most successful exergames in recent years. In the first few months after launch, as many as 45 million people played PGO every day (with 380 million playing at least once a month), with several early studies finding that PGO increased walking in all players regardless of socioeconomic factors such as ethnicity or income (Althoff, White, & Horvitz, 2016; Barkley, Lepp, & Glickman, 2017). The game's physical exercise effect was also greatest in individuals who had previously led more sedentary lifestyles (Wong, 2017). In 2018, Niantic released *Harry Potter: Wizards Unite* (HPWU), a game very similar to PGO but with a Harry Potter theme. HPWU did not achieve the same level of commercial or physical exercise success as PGO, despite nearly identical gameplay and user interface. While the two games are compatible in the intended physical outcome, this discrepancy in player uptake is interesting and warrants investigating the differences in player experience between the two games. Moreover, self-identified 'hardcore' and 'casual' players also demonstrate quantitatively different exercise patterns, suggesting the interplay between player habits and design factors is integral in the efficacy of exergames focused on outdoor exercise.

Here we present a study that examines the differential exercise patterns for players of PGO and HPWU. Our research objectives are:

- Do players with different self-identification (e.g., Hardcore, casual) have different exercise profiles in these two games?
- Why do players with different self-identification behave differently in these games?
- Do players have different exercise profiles between PGO and HPWU?
- What aspects of the games' different designs contributed to these exercise profiles?

With these results, we hope to highlight designs that can increase motivation for players to conduct physical exercise, while also addressing the existing play pattern and mindset of different populations.

Related Works on Exergames

There is well-established literature demonstrating the potential for video games to improve physical activity, social interactions, and mental health (Chao, Scherer, Montgomery, Wu, & Lucke, 2015; Jones, Scholes, Johnson, Katsikitis, & Carras, 2014; Peng, Crouse, & Lin, 2013; Ryan, Rigby, & Przybylski, 2006; Şimşek & Çekok, 2016). Exergames were found to be effective in different settings such as clinical rehabilitation (Chao et al., 2015; Şimşek & Çekok, 2016), amongst young children (Garde et al., 2016), and promoting general exercise (Peng et al., 2013). Extensive comparisons have been established between exergames and standard exercise to demonstrate how exergames were able to produce physiological exertion similar to normal exercise. Based on multiple parameters such as heart rate (Bonetti, Daniel G, Danoff, & Miller, 2010), oxygen consumption (Penko & Barkley, 2010)], and electrocardiogram readings (Maddison et al., 2007), exergames in general demonstrated measurable physiological benefits comparable to standard light exercise such as walking (Rahmani & Boren, 2012).

PGO and HPWU can be considered as exergames as they both use location-based GPS and in-built phone speedometers to track player location and movement, with walking a certain amount of distance being required to accomplish in-game achievements. In that sense, outdoor walking is the gameplay, as progress in the games cannot be made if the player remains stationary. Outdoor walking is also the main way to find interactive items and obtain resources, thus allowing one to keep playing the game. Within as little as 6 months after release, PGO was already recognised to be a very complex and contextualised behavioural intervention, with the game increasing the exercise duration across all of its players regardless of socioeconomic status (Althoff et al., 2016; Clark & Clark, 2016).

During the COVID pandemic, PGO and HPWU also demonstrated an ability to act as buffers against mental health concerns (Ellis et al., 2020), as well as maintaining exercise levels amongst its players well above the weekly exercise requirements recommended by the World Health Organisation. While players of the two games reported an average of 7.5 hours of outdoor exercise per week before the pandemic, they reported an average of 6.5 hours during the pandemic and associated the maintenance of exercise routines with game play (Ellis et al., 2020). Such studies demonstrated that the two games have a definite relationship with improving or maintaining levels of outdoor physical exercise, even though durations of severe physical isolation such as during COVID lockdowns.

We therefore wish for this publication to present an understanding on *why* PGO and HPWU were effective in encouraging exercise, viewed from the perspective of design factors and user experience. Moreover, as very few studies have been conducted on HPWU, we wanted to know if design differences between these two games caused exercise differences in the two player populations. Lastly, as a prequal to the work done during the COVID pandemic, this paper examines how people exercised with these two games before the pandemic, when contextual factors such as remote play features (installed by Niantic during 2020 to reduce the need for outdoor exercise) and physical lockdown did not significantly influence outdoor exercise behaviour.

Related Works on Self-identified Player Classifications

Our paper also found differences in quantitative and qualitative data from people who self-identify as different kinds of 'gamers', which is a way for a game player to identify their usual video game play pattern and mindset (Ip & Jacobs, 2005). People who self-identify as hardcore gamers invest a significant portion of free time and resources to games, while also often possessing more knowledge, skill, and understanding of game industry and culture (Kirman & Lawson, 2009; Tuunanen & Hamari, 2012). Those who identify as casual gamers only play on a casual, on-and-off basis, often paying little attention to the subtleties or content of the medium (Kirman & Lawson, 2009; Tuunanen & Hamari, 2012). There are 2 more groups that were investigated in our study: 1) In-between gamers, those who behaved somewhere between the two extremes of hardcore and casual gamers and recognised themselves as being in that position, and 2) No-identification gamers, who have not established a self-identification with the medium (Manero, Torrente, Freire, & Fernández-Manjón, 2016). This type of segmentation exists separately from other traditional gamer classifications, such as Bartle's famous taxonomy on game player types (Bartle, 1996) that focuses on how the player interacts with the game and with other players. Instead, our classification reflect how one perceives the extent of one's own involvement, the pattern of one's own behaviour, and the willingness to correlate oneself with a specific population of players.

Work on the validity of using this kind classification on PGO and HPWU does have precedent. Hardcore, in-between, casual, and no-identification players reported different constraints and enablers that affected how much they played the games (Smith, Lee, Ellis, Ijaz, & Yin, 2021), while each player group also exhibited differences in user experience between PGO and HPWU (Smith et al., 2021). For example, hardcore PGO players reported experiencing a lack of confidence regarding mastering PGO, but this was not observed for hardcore HPWU players. Conversely, casual HPWU players complained about the game requiring people to walk for too long and they did not have enough time to do daily tasks or return to a location on time, but casual PGO players had no such concerns (Smith et al., 2021). This indicates that people self-identifying as different kinds of

gamers experience PGO and HPWU differently. As gameplay in both games is directly translated to outdoor exercise, we have reasons to suspect these player groups require different design elements to encourage them to exercise and to continue their routine.

METHODS

Pokémon GO and Harry Potter: Wizards Unite

In both games, players explored a cartoon-art version of the real world based on Google Maps data (Image 1). Significant landmarks, such as shopping malls, libraries, or train stations, are symbolised by tall buildings where players can group up to conduct group challenges (seen in Image 1 as tall, coloured buildings called Gyms in PGO and tall elongated buildings in HPWU called Fortresses). Minor landmarks, such as a piece of wall art or a small suburban park, are represented by a small teal cube in PGO called Pokéstops and a small blue building in HPWU called Inns. These locations provide resources to players and are renewable after a certain number of real-time hours. Players must walk to the vicinity of these landmarks to activate these in-game features, enforcing the need for outdoor exercise.

While walking, players will also encounter creatures in both games. PGO players catch Pokémons, small animals that can be levelled up to better conduct challenges, while HPWU players catch Foundables, which are people or significant items from the Harry Potter franchise. These creatures have various statistics and are vital for play progression. Lastly, both games also offer a 'gift box' to players after walking a certain amount of distance (such as 5 kilometers), with PGO hatching a Pokémon Egg and HPWU opening a Portkey. These items may present rare or unique Pokémons or Foundables, further encouraging walking. Daily and weekly goals for distance walked are also present to give a small reward at the end of the week based on total distance walked in the past 7 days.

Once players encounter a Pokémon or Foundable in their travels, they can catch it on-screen. PGO players throw a ball at the Pokémon through a finger flick gesture, while HPWU players trace a sigil on their screen. Once captured, the player returns to the overworld map.

Image 1: Pokémon GO (left) and Harry Potter: Wizards Unite (right) overworld in-game screenshot. All rights reserved by Niantic, Inc.

Recruitment

The study's ethics approval was obtained from the Macquarie University Human Research Ethics Committee for Medical Sciences (Reference No: 52019601512435. Project ID: 6015).

A mixed-methods survey was conducted online via convenience sampling over 2 weeks in February 2020. The survey was conducted via the Qualtrics platform and was distributed to 4 subreddit forums dedicated to PGO or HPWU, r/WizardsUnite, r/PokemonGO, r/harrypotterwu, and r/

TheSilphRoad. A recruitment post was written by the research team in each subreddit, and the moderators of each subreddit were contacted for the posts to be pinned to the top of the subreddit. The recruitment posts were pinned in all 4 subreddits for 2 weeks. Following the conclusion of data collection, data was downloaded from Qualtrics.

Survey

This paper is a part of a larger study and consisted of 70 quantitative and qualitative questions. Players were eligible to play if they were over 18 years of age, played either PGO or HPWU for at least a week, and played the games in English (we wished to avoid misunderstandings of in-game terms in the survey). Information presented in this paper include general demographics information (age, gender, and country of residence) and self-identification ('hardcore', 'casual', 'something in between', or 'I have no idea' in terms of general playing style).

Quantitative results presented here included three questions. 1) "In a given week, how many days did you typically walk for 30 minutes or more prior to playing Pokemon GO or Wizards Unite?" with the options 0-7 and 'prefers not to say'. 2) "In a given week, how many days do you typically walk for 30 minutes or more now?" with the options 0-7 and 'prefers not to say'. 3) "Typically, how many hours a week do you / did you play Wizards Unite?" with the options being 'less than an hour', '1-5 hours', '6-10 hours', '11-15 hours', '16-19 hours', and '20 hours or more'. 4) "Typically, how many hours a week do you / did you play Pokemon GO?" with the same options as the previous question. We assessed the answers to these two questions as they outline any changes in exercise patterns after playing the games for all populations.

Qualitative results presented include results from two questions only, "Overall, do you prefer playing Pokemon GO or Wizards Unite? If you have a preference between the games, why do you prefer that game?" and "Which game got you to do more walking? Which game was more fun?". We assessed the answers to these questions because they revealed specific preferences and complaints players had with the two games, especially on how these factors affected their extent of outdoor exercise.

Data analysis

Self-reported quantitative data was extracted from Qualtrics and directly imported into SPSS (version 25.0, IBM Corporation). Differences between self-identified player types were assessed using Pearson Chi-square analysis for both exercise and play duration per week for both games. This work was carried out by the researchers KI and LAE.

Qualitative responses were analysed through thematic analysis using NVivo v12 Plus (QSR International). The participant's game preference regarding fun and walking were extracted and the reasons provided by the participants towards their preference was coded inductively by the researchers KY, MDL, and JS. Codes were developed inductively according to the Braun and Clarke model of thematic analysis (Braun & Clarke, 2008). The entire research team was consulted throughout the qualitative analysis process to resolve disagreements until consensus was reached.

RESULTS

Demographics

The survey received valid answers from 1052 participants, with 762 (72%) having played PGO and 691 (66%) having played HPWU. General demographics data are presented in Table 1.

Characteristic	Number of participants
Gender	
Male	381 (36%)
Female	470 (45%)
Other/unindicated	201 (19%)
Age	
18-25 years old	240 (23%)
26-35 years old	460 (44%)
36-45 years old	183 (17%)
46-55 years old	80 (8%)
> 55 years old	43 (4%)
Unindicated	46 (4%)
Country of Residence	
USA	515
Europe	292
Other Americas	87
Oceania	62
Asia	40
Middle East	9
Africa	3
Unindicated	44

Table 1. Basic demographics data

The largest group of players were those who self-identified as female casual players, taking up 64% of female participants and 35% of all participants. The second-largest group were male casual players (40% males, 18% all). The smallest group was male players who could not self-identify (3% males, 1% all), followed by female hardcore players (5% females, 3% all) (Table 2). Males are significantly more likely to play more seriously than females ($p = 0.00$). Meanwhile, all age groups were represented in a similar manner across the player groups (Table 2).

Percentages are out of total numbers in a gender group (for the Gender column) or in an age bracket (for the Age group column).

Self-identified player group	Gender		Age group	
Hardcore				
	Male	69 (18.2%)	18-25 years	30 (12.5%)
	Female	22 (4.7%)	26-35 years	49 (10.7%)
			36-45 years	17 (9.3%)
			46-55 years	11 (13.8%)
			> 55 years	5 (11.6%)
In-between				
	Male	148 (38.9%)	18-25 years	84 (35.0%)
	Female	101 (21.5%)	26-35 years	125 (27.4%)
			36-45 years	54 (29.5%)
			46-55 years	21 (26.3%)
			> 55 years	14 (32.6%)
Casual				
	Male	151 (39.7%)	18-25 years	118 (49.2%)
	Female	299 (63.8%)	26-35 years	250 (54.3%)
			36-45 years	98 (53.6%)
			46-55 years	41 (51.3%)
			> 55 years	16 (37.2%)
No-identification				
	Male	12 (3.2%)	18-25 years	8 (3.3%)
	Female	47 (10.0%)	26-35 years	35 (7.6%)
			36-45 years	14 (7.7%)
			46-55 years	7 (8.8%)
			> 55 years	8 (18.6%)

Table 2. Self-identification according to gender and age

Exercise patterns between self-identified groups

Participants across all player types had a significant increase in exercise frequency after starting to play PGO or HPWU, as suggested by paired sample t-tests. Participants were asked to indicate how many days they walked for at least 30 minutes in a typical week before and after they started playing. Hardcore players had significant changes in their exercise patterns ($p = 0.00$), walking for 2.78 days a week on average ($SD = 0.22$)

prior to playing and 4.99 days (SD = 0.21) after starting to play. Casual players walked for 3.05 days a week (SD = 0.10) before playing and 4.58 days (SD = 0.09) after (p = 0.00). The in-between group walked 3.21 days a week (SD = 0.14) before playing and 5.00 days (SD = 0.12) after (p = 0.00), and the no-identification group walked 3.08 days a week (SD = 0.26) before playing and 4.80 days (SD = 0.25) after (p = 0.00). Notably, the hardcore group had the lowest level of weekly exercise prior to playing PGO or HPWU, suggesting they had the most sedentary lifestyle out of all player group. (Table 3).

	Self-identified group	Mean (days per week)	Standard deviation
In a given week, how many days did you typically walk for 30 minutes or more prior to playing PGO or HPWU?	Hardcore	2.78	0.22
	In-between	3.21	0.14
	Casual	3.05	0.10
	No identification	3.08	0.26
In a given week, how many days did you typically walk for 30 minutes or more now?	Hardcore	4.99	0.21
	In-between	5.00	0.12
	Casual	4.58	0.09
	No identification	4.80	0.25

Table 3. Exercise patterns between the different self-identified groups

Hardcore players are more likely to prefer PGO while casual players are more likely to prefer HPWU, with statistical significance (p = 0.03) (Image 2).

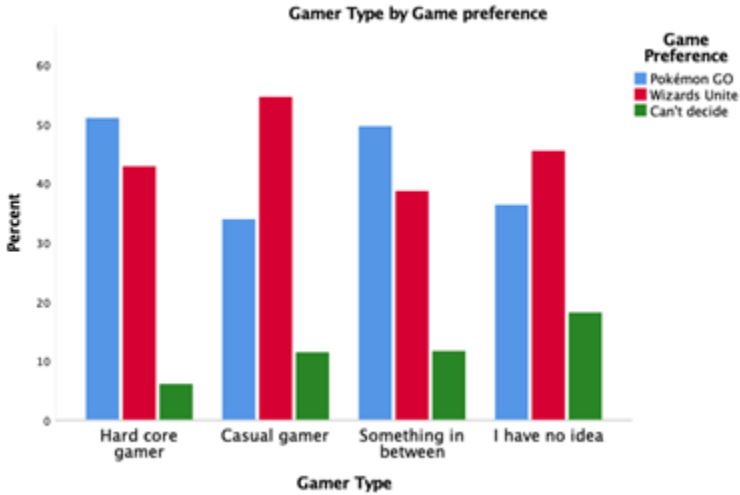

Image 2: Self-identified gamer type by game preference

Qualitative findings between self-identified groups

Self-identified groups had different preferences between PGO and HPWU, as well as with the different design features in the two games.

Design preferences of hardcore players

The most predominant theme in the hardcore group was that they preferred to continue to receive profit for their efforts. This was highlighted with how PGO would give a miniscule profit for every repeated catch of a Pokémon one already owned (this new Pokémon can be turned into candy to increase the power of other Pokémons), but HPWU gave no rewards whatsoever for repeated catches of Foundables already in possession. Hardcore players found this design in HPWU to be particularly discouraging. Other main themes included liking deep games with talent (and thus gameplay) customisation. This was observed in HPWU, where one can put points into talent trees to specialise for a specific role in the team. Players felt this allowed for more strategic play. Players also liked PGO has a larger and more engaged community that allowed for better group play experience, but also noted PGO has a lot more 'cheaters'

(those who modified GPS data on their devices to deceive the game server into thinking they are physically travelling) than HPWU.

Design preferences of in-between players

The themes in the in-between group have a marked shift from that of hardcore players. The most prevalent theme is that they prefer games with more content. This group of players liked whichever game that they felt 'had more to do'. Other main themes included liking games that had a better sense of achievement and purpose. Players stated walking with PGO had a better purpose as they could deliberately hunt certain Pokémons, and completing daily achievement was a better motivator. This group also reported PGO has a larger and more engaged community, and also noted they prefer a clear-defined objective seen in PGO, such as 'catch 3 Flying-type Pokémon'.

Design preferences for casual players

Casual players demonstrated marked differences in motivation compared to the two previous groups. The greatest determinant to whether they play is their level of engagement with the original franchise the game is associated with. Overwhelmingly, casual players stated they prefer HPWU because they are already HPWU fans, with comments such as 'I grew up with Harry Potter' and 'I've been a fan since the first book'. They also stated they prefer to play games that rely on other people less, opting to prefer HPWU as the game does not encourage socialisation or interactivity, therefore allowing casual players to play at their own pace and convenience. The large variety of different objectives offered by HPWU was preferred by this group instead of the rigid, clear-defined PGO objectives, as the large variety of tasks allowed HPWU to constantly offer something new and the player would 'not get bored'. These factors may explain the large shift in quantitative preference data from PGO to HPWU in the casual player group.

There are still casual players who preferred PGO. Casual players preferring PGO liked games with an engaged community and liked to have

more content to play, echoing the preferences demonstrated by hardcore and in-between players.

Design preferences for no-identification players

A very small section of our participants were no-identification players, and they demonstrated a preference profile similar to casual players. The most dominant theme was preferring HPWU due to already being a fan of the Harry Potter franchise, and that was motivation enough to keep playing.

Exercise patterns between PGO and HPWU for each self-identified group

Players demonstrated different exercise patterns between PGO and HPWU. Specifically, players across all self-identified groups played more PGO than HPWU. This was especially highlighted in the hardcore group, where close to 35% of the PGO players indicated they played PGO for more than 20 hours every week, but only close to 15% of HPWU hardcore players indicated they played for this duration. More in-between and casual players for PGO also indicated they played for more than 20 hours every week, compared to their HPWU counterparts. The distribution of PGO players according to amount of time played per week tended to peak at higher values than with HPWU players. The only exception to this trend was with the casual group, where HPWU players tended to play more than the PGO group. Given our understanding from sections 3.2 and 3.3 that HPWU has a specific appeal for the casual group, it is possible that the factors previously covered are contributing to casual players playing more HPWU than other groups.

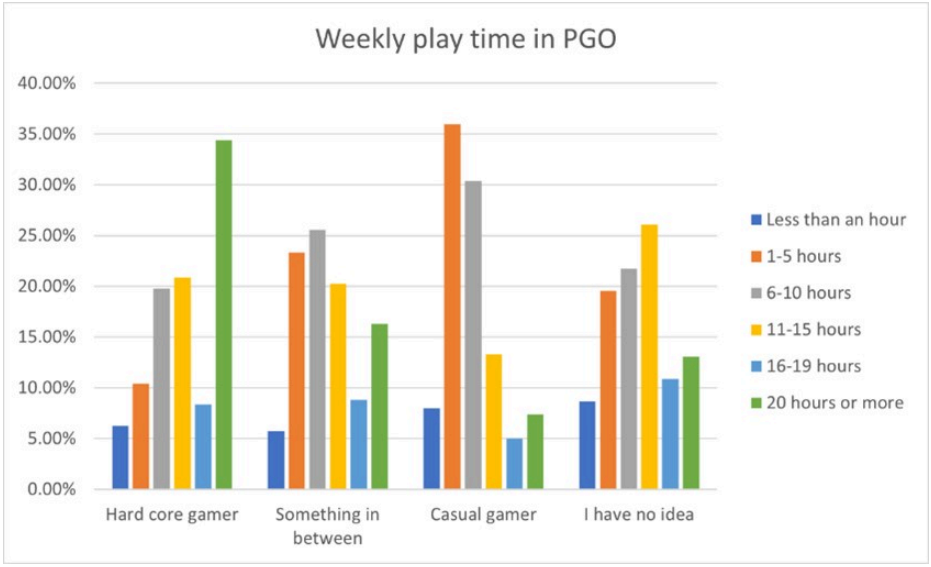

Image 3: Play time by player group in PGO

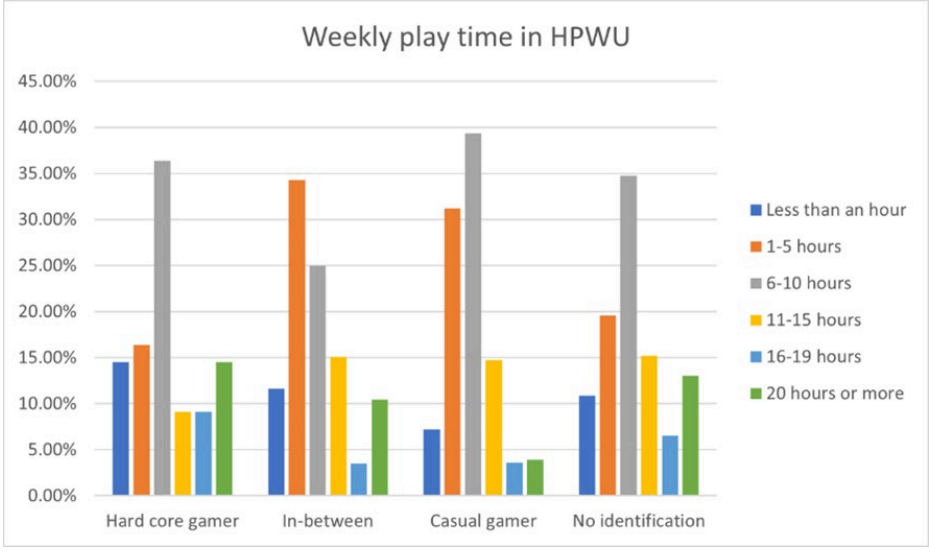

Image 4: Play time by player group in HPWU

Qualitative findings between games

PGO and HPWU appear to affect exercise differently. Across our participants, 76% stated PGO was the game that caused them to exercise more, while only 55% chose PGO as the more fun game to play. This trend was observed across all player groups. We therefore conducted qualitative thematic analysis on free-text data entered by participants to understand why players were walking more with PGO, but a sizeable cohort also reported having more fun with HPWU despite walking less with the game.

More meaningful rewards for walking in Pokémon GO

Participants indicated that clear, easy-to-understand, and useful goals were most beneficial for encouraging them to walk. PGO was noted for displaying exactly what the player was walking towards (i.e., a specific Pokémon) on the map, while HPWU only displayed the class of the Foundable. Participants therefore felt they were more likely to obtain a Foundable they had already collected in HPWU and were thus less incentivised to walk. Another design element is that walking a certain distance (e.g., 5 kilometres) in PGO allows one to hatch eggs into one Pokémon. However, walking for the same 5 kilometres in HPWU to unlock a Portkey only grants fragments of a Foundable. Participants therefore regarded unlocking one Portkey as less rewarding than hatching one PGO Eggs. Additionally, Pokeballs (items that PGO players require to catch Pokémon) can only be acquired via walking or from the cash shop, while Spell Energy (the HPWU resource players require to obtain Foundables) regenerates over time, providing players with much less pressure – and less reward – to walk.

Fun is increased by familiarity with the franchise and the availability of in-game activities

Fun was associated with being more familiar with the original franchise and how much game content was available for the player. Both Pokémon and Harry Potter have a strong fanbase and participants from either fanbase tended to select the franchise they were more familiar with as

being 'more fun'. Those who exhausted available content in one game also considered the other game 'more fun', as there was 'just more to do' in the game they had not played thoroughly.

Immersive gameplay in Harry Potter: Wizards Unite reduced walking

Gameplay in HPWU was highlighted as more difficult to play on a micro level, as tracing sigils on the phone required more finger dexterity and precision than throwing a ball to catch a Pokémon. Participants stated that HPWU was 'actually very very difficult to play while moving' and that they often had to stop walking to ensure gameplay accuracy. HPWU also encouraged immersive group battle at Fortresses, where each player in a team had a separate role (such as healing or dealing damage). While this was regarded as fun, participants noted once they entered a Fortress battle, they would be standing or sitting still for a long time.

Support technology for Pokémon GO enables more walking

Both PGO and HPWU support 'Adventure Sync'(allowing steps walked to be tracked while the app is not open, with rewards provided to players when the app is next opened), however this feature was only recently implemented in HPWU at the time of the survey, with some players being unaware of it or having technical issues. PGO, by contrast, has supported Adventure Sync since November 2018. In addition, PGO also supports 'Go+' (an Apple Watch-style wrist apparatus that automatically collects resources and catches Pokémon as the player walks), allowing players to 'play the game without being aware of it'. This led participants to be more immersed in exercise and more freedom to incorporate the exercise into daily routine.

Social connections and support encourage more walking

Lastly, participants reported social connections affected walking. Many participants walked to join group activities in locations because they wished to meet friends who would also be there, or they walked because others in their social circle 'were giving peer pressure' to walk more.

Participants also formed groups with their friends to walk together, making play, exercise, and social relationships one combined venture.

DISCUSSION

Are Hardcore Players More Sedentary?

To date, there has been little exploration of physical activity differences between hardcore and casual gamers (Bosser & Nakatsu, 2006; Goodman, McFerran, Purves, Redpath, & Beeken, 2018; Peng & Day, 2016). While media use in general has been identified as a primary contributing factor to sedentary behaviour (Peng & Day, 2016) and hardcore gamers have been thought to be at greater risk of health risks as they dedicate a large portion of their leisure time to gaming (Bosser & Nakatsu, 2006), only one study has sought to examine physical activity differences between hardcore and casual gamers (Ellis et al., 2020). In that study, which also involved players of augmented reality games, individuals who identified as hardcore gamers were more physically active, exercising for nearly 28 percent longer than those who identified as casual, with this increased physical activity being linked to increase play time (Ellis et al., 2020).

Our findings mirror those of this earlier study, finding that among active players of augmented reality games, those who identify as hardcore are significantly more physically active than those who identify as casual (exercising for at least 30 minutes a day for 4.99 days a week, as compared to 4.58 days), though we also find that prior to playing an augmented reality game, those that identify as hardcore had been significantly more sedentary than those identifying as casual. This finding is consistent with early studies on *Pokémon GO* (Marquet, Alberico, & Hipp, 2018; Wong, 2017), which found more sedentary individuals demonstrated the most significant increase in physical activity after beginning to play, compared to individuals who were already active, and suggests this increase may persist over time. These early studies offered little explanation as to the mechanism driving this, given that interventions aimed at increasing physical activity are typically more effective among populations already active (Wong, 2017). The results of

our study, with hardcore gamers being more sedentary prior to playing an augmented reality game yet experiencing the greatest increase in physical activity and having the highest amounts of engagement with the game, suggests that these differences may be explained by differing preferences by player type.

Hardcore vs Casual Engagement Profiles in AR Games

Consistent with previous qualitative research into how enablers and constraints of AR play differed among player types (Smith et al., 2021), we found that different player types engaged with and prioritised different aspects of the game experience. In our study, hardcore players expressed a preference for in-game activities which maximised their reward/effort ratio, as well as gameplay elements which allowed for a degree of customisation. These players tended to invest their time in one or two well-optimised gameplay loops, caring more about depth than breadth of play. Hardcore players also indicated that they preferred games with larger and more engaged communities as it usually meant a smoother experience for group play and were uniquely disdainful of individuals who 'cheated.'

While in-between players also valued "rewarding" activities, their highest priority was experiencing a sense of achievement and purpose, either through setting in-game goals (with play allowing them to track this) or a game providing explicit, concrete goals for them to complete. This group also expressed a preference for games with a wide array of activities for them to spend their time on.

In contrast to the other groups, casual players did not seem to care about being rewarded, whether through in-game rewards or through a sense of achievement. Their priority was being able to play at their own pace and convenience, while not becoming bored and having an experience that engages with one of their existing fan identities.

These underlying differences in preferences between player types drive different playstyles, and likely account for intergroup differences in both play time and physical activity. This analysis presents a crucial step

towards understanding the heterogeneity of gamers and subsequently targeting interventions to different sub-populations.

Exercise across different AR games

Despite having been created by the same company and utilising the same underlying augmented reality technology, our study found that the exercise and play patterns of players differed significantly between PGO and HPWU. Consistent with previous studies (Ellis et al., 2020; Laato, Hyrynsalmi, Rauti, Islam, & Laine, 2020; Marquet et al., 2018; Wong, 2017), which identified a positive correlation between play time and physical activity, we found that players in the hardcore and in-between groups played more PGO than HPWU and reported exercising more while playing PGO. Qualitative data suggesting that this was because they found the gameplay of PGO to be more rewarding. In contrast, though casual players played more HPWU than PGO, they noted that PGO was the game that made them walk more. This likely has to do with the games' different features, as a study amongst HPWU beta players indicated that ~58% of respondents walked at least twice as slowly when playing HPWU compared to their normal walking speed (Laato et al., 2020). We also found that, consistent with previous literature (Ryan et al., 2006), 'fun' was not necessarily aligned with engagement, as a sizeable cohort also reported having more fun with HPWU despite walking less with the game, and overall, a larger percentage (76%) reported that PGO made them exercise more, compared the amount that found it more fun (55%).

Design differences

In our study, participants across all player groups suggested that PGO's design factors, such as incentivising physical activity and an interface optimised for mobile play, meant they were more inclined to walk when playing PGO compared to HPWU.

One prominent example is the experience of capturing Pokémon in PGO compared to collecting Foundables in HPWU. In PGO, one could see exactly what Pokémon one was heading towards on the overworld map, while in HPWU, one can only see the class of a given Foundable. This

distinction is crucial as there are no rewards given for collecting a duplicate Foundable in HPWU. This provides a level of appeal for all player types, as hardcore players can maximise their return on investment, in-between players can work towards their goals of catching certain Pokémon, and casual players can see a larger variety of Pokemon in the world, keeping the experience fresh.

Another design was the relative difficulty in conducting basic activities, given that tracing a sigil in HPWU was very difficult while moving. Moreover, whether one succeeded or failed in the sigil, one still consumed spell energy, a resource that did not naturally regenerate. This incentivised HPWU players to stop walking so they could make their spell "count." PGO players found it much easier to attempt to catch Pokemon while on the move, as all they needed to do was flick a Pokeball towards it with a finger. This incentivised them to continue to walk towards their next point of interest while playing. This level of difficulty also meant that HPWU was difficult to play with friends when one was not doing immersive group content, in contrast to PGO, which could be played casually while walking with friends.

Given the plethora of literature on how social support and peer groups engaging in behaviours together encourage continuance of said behaviour, as well as the need satisfaction literature (Ryan et al., 2006), one can see how PGO's relative simplicity leads to it being a better exergame, both in the short and long-term.

Limitations

There are a few limitations to our study. Firstly, recruiting from Reddit indicates that the players are already invested in the games, and could be argued the group is more engaged than the average player and does not represent the entire population. However, this also meant the participants were very motivated to answer the survey and provided many in-depth responses for our qualitative questions.

Secondly, it is known that women are less likely than men to self-identify

as a game player, and even more so as a hardcore player, which may lead to errors in self-identification data.

Thirdly, the studies relied on self-reported exercise data and is open for recall bias. This aspect of the work could be improved through conducting prospective studies where we continuously monitor the exercise of new players of the two games over time.

CONCLUSION

Our study suggests that AR games like PGO and HPWU indeed made an impact on the physical exercise level of players, and specific design criteria can make such games better equipped at targeting specific player populations. Factors such as ensuring hardcore players are rewarded for their continuous efforts could make such games more effective in specific populations, increasing efficacy for selective groups in the population.

ACKNOWLEDGMENTS

We would like to acknowledge and thank the subreddit moderators for helping us with recruitment and their ongoing support with the project, as well as all the participants who answered the survey.

REFERENCES

Ahn, M., Choe, S. P., Kwon, S., Park, B., Park, T., Cho, S., . . . Song, J. (2009). *Swan boat: pervasive social game to enhance treadmill running.* Paper presented at the Proceedings of the 17th ACM international conference on Multimedia (MM '09).

Althoff, T., White, R. W., & Horvitz, E. (2016). Influence of Pokémon GO on Physical Activity: Study and Implications. *Journal of Medical Internet Research, 18*(12), e315. doi:https://doi.org/10.2196/jmir.6759

Barkley, J. E., Lepp, A., & Glickman, E. L. (2017). "Pokémon GO!" May Promote Walking, Discourage Sedentary Behavior in College Students.

Games for Health Journal, 6(3), 165-170. doi:http://doi.org/10.1089/g4h.2017.0009

Bartle, R. (1996). Hearts, Clubs, Diamonds, Spades: Players Who Suit MUDS. http://www.mud.co.uk/richard/hcds.htm

Bogost, I. (2005). *The Rhetoric of Exergaming*. Paper presented at the Digital Arts and Cultures Conference, Copenhagen.

Bolton, J., Lambert, M., Lirette, D., & Unsworth, B. (2014). *PaperDude: a virtual reality cycling exergame.* Paper presented at the CHI '14 Extended Abstracts on Human Factors in Computing Systems (CHI EA'14).

Bonetti, A. J., Daniel G, D., Danoff, J. V., & Miller, T. A. (2010). Comparison of acute exercise responses between conventional video gaming and isometric resistance exergaming. *Journal of Strength and Conditioning Research, 24*(7), 1799-1803. doi:https://doi.org/10.1519/jsc.0b013e3181bab4a8

Bosser, A.-G., & Nakatsu, R. (2006). Hardcore gamers and casual gamers playing online together. In R. Harper, M. Rauterberg, & M. Combetto (Eds.), *Entertainment Computing – ICEC 2006*. Springer.

Boulos, M. N. K. (2012). Xbox 360 Kinect Exergames for Health. *Games for Health Journal, 1*(5), 326-330. doi:https://doi.org/10.1089/g4h.2012.0041

Braun, V., & Clarke, V. (2008). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. doi:http://dx.doi.org/10.1191/1478088706qp063oa

Chao, Y.-Y., Scherer, Y. K., Montgomery, C. A., Wu, Y.-W., & Lucke, K. T. (2015). Physical and Psychosocial Effects of Wii Fit Exergames use in Assisted Living Residents: A Pilot Study. *Clinical Nursing Research, 24*(6), 589-603. doi:https://doi.org/10.1177/1054773814562880

Clark, A. M., & Clark, M. T. G. (2016). Pokemon Go and Research: Qualitative, Mixed Methods Research, and the Supercomplexity of Interventions. *International Journal of Qualitative Methods, 15*(1). doi:https://doi.org/10.1177/1609406916667765

Ellis, L. A., Lee, M. D., Ijaz, K., Smith, J., Braithwaite, J., & Yin, K. (2020). COVID-19 as 'Game Changer' for the Physical Activity and Mental Well-Being of Augmented Reality Game Players During the Pandemic: Mixed Methods Survey Study. *Journal of Medical Internet Research, 22*(12), e25117. doi:http://www.jmir.org/2020/12/e25117/

Fogel, V. A., Miltenberger, R. G., Graves, R., & Koehler, S. (2013). The effects of exergaming on physical activity among inactive children in a physical education classroom. *Journal of Applied Behavior Analysis, 43*(4), 591-600. doi:https://doi.org/10.1901/jaba.2010.43-591

Garde, A., Umedaly, A., Abulnaga, S. M., Junker, A., Chanoine, J. P., Johnson, M., . . . Dumont, G. A. (2016). Evaluation of a Novel Mobile Exergame in a A School-Based Environment. . *Cyberpsychology, Behavior, and Social Networking, 19*(3), 186-192. doi:https://doi.org/10.1089/cyber.2015.0281

Goodman, W., McFerran, E., Purves, R., Redpath, I., & Beeken, R. J. (2018). The Untapped Potential of the Gaming Community: Narrative Review. *International Journal of Serious Games, 6*(3). doi:10.2196/10161

Hruby, A., & Hu, F. B. (2014). The Epidemiology of Obesity: A Big Picture. *PharmacoEconomics, 33*, 673-689. doi:https://doi.org/10.1007/s40273-014-0243-x

Ip, B., & Jacobs, G. (2005). Segmentation of the games market using multivariate analysis. *Journal of Targetting, Measurement and Analysis for Marketing, 13*, 275-287. doi:https://doi.org/10.1089/g4h.2012.0031

Jones, C. M., Scholes, L., Johnson, D., Katsikitis, M., & Carras, M. C. (2014). Gaming well: links between videogames and flourishing mental health. *Frontiers in Psychology, 5*(260). doi:https://doi.org/10.3389/fpsyg.2014.00260

Kirman, B., & Lawson, S. (2009). Hardcore Classification: Identifying Play Styles in Social Games Using Network Analysis. In S. Natkin & J. Dupire (Eds.), *Entertainment Computing – ICEC 2009. Lecture Notes in Computer Science*. Springer.

Laato, S., Hyrynsalmi, S., Rauti, S., Islam, A. K. M. N., & Laine, T. H. (2020).

Location-based Games as Exergames – From Pokémon To The Wizarding World. . *International Journal of Serious Games, 7*(1), 79-95. doi:http://dx.doi.org/10.17083/ijsg.v7i1.337

Laine, T. H., & Suk, H. J. (2015). Designing Mobile Augmented Reality Exergames. *Games and Culture, 11*(5), 548-580. doi:https://doi.org/10.1177/1555412015572006

Maddison, R., Mhurchu, C. N., Jull, A., Jiang, Y., Prapavessis, H., & Rodgers, A. (2007). Energy expended playing video console games: an opportunity to increase children's physical activity? . *Pediatric Exercise Science, 19*(3), 334-343. doi:https://doi.org/10.1123/pes.19.3.334

Maloney, A. E., Bethea, T. C., Kelsey, K. S., Marks, J. T., Paez, S., Rosenberg, A. M., . . . Sikich, L. (2012). A Pilot of a Video Game (DDR) to Promote Physical Activity and Decrease Sedentary Screen Time. *Obesity, 16*(9), 2074-2080. doi:https://doi.org/10.1038/oby.2008.295

Manero, B., Torrente, J., Freire, M., & Fernández-Manjón, B. (2016). An instrument to build a gamer clustering framework according to gaming preferences and habits. *Computers in Human Behavior, 62*, 353-363. doi:https://doi.org/10.1016/j.chb.2016.03.085

Marquet, O., Alberico, C., & Hipp, A. J. (2018). Pokémon GO and physical activity among college students. A study using Ecological Momentary Assessment. *Computers in Human Behavior, 81*. doi:https://doi.org/10.1016/j.chb.2017.12.028

Peng, W., Crouse, J. C., & 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*(2), 171-192. doi:https://doi.org/10.1177/1090198112444956

Peng, W., & Day, T. (2016). Media Use and Physical Fitness In L. Reinecke & M. B. Oliver (Eds.), *The Routledge Handbook of Media Use and Well-Being, International Perspectives on Theory and Research on Positive Media Effects.* Routledge.

Penko, A. A. L., & Barkley, J. E. (2010). Motivation and physiologic

responses of playing a physically interactive video game relative to a sedentary alternative in children. *Annals of Behavioral Medicine, 39*(2), 162-169. doi:https://doi.org/10.1007/s12160-010-9164-x

Rahmani, E., & Boren, S. A. (2012). Videogames and Health Improvement: A Literature Review of Randomized Controlled Trials. *Games for Health Journal, 1*(5), 331-341. doi:https://doi.org/10.1089/g4h.2012.0031

Ryan, R. M., Rigby, C. S., & Przybylski, A. (2006). The Motivational Pull of Video Games: A Self-Determination Theory Approach. *Motivation and Emotion, 30*, 344-360. doi:https://doi.org/10.1007/s11031-006-9051-8

Şimşek, T. T., & Çekok, K. (2016). The effects of Nintendo Wii(TM)-based balance and upper extremity training on activities of daily living and quality of life in patients with sub-acute stroke: a randomized controlled study. *International Journal of Neuroscience, 126*(12), 1061-1070. doi:https://doi.org/10.3109/00207454.2015.1115993

Smith, J., Lee, M. D., Ellis, L. A., Ijaz, K., & Yin, K. (2021). Developing a novel psychographic-behavioral qualitative mapping method for exergames. . *International Journal of Serious Games, 8*(2). doi:https://doi.org/10.17083/ijsg.v8i2.422

Tuunanen, J., & Hamari, J. (2012). *Meta-synthesis of player typologies.* Paper presented at the Proceedings of Nordic Digra 2012 Conference: Games in Culture and Society, Tempere, Finland.

Warburton, D. E. R., Bredin, S. S. D., Horita, L. T. L., Zbogar, D., Scott, J. M., Esch, B. T. A., & Rhodes, R. E. (2007). The health benefits of interactive video game exercise. *Applied Physiology, Nutrition, and Metabolism, 32*(4), 665-663. doi:https://doi.org/10.1139/H07-038

Witkowski, E. (2013). *Running from zombies.* Paper presented at the Proceedings of The 9th Australasian Conference on Interactive Entertainment: Matters of Life and Death (IE '13).

Wong, F. Y. (2017). Influence of Pokémon Go on physical activity levels of university players: a cross-sectional study. *International Journal of Health Geographics, 16*(6). doi:https://doi.org/10.1186/s12942-017-0080-1