Design Considerations for Augmented Reality Location-Based Exergaming: Lessons from Pokémon Go

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ABSTRACT

Pokémon Go (PG) is renowned as the most successful and extensively studied 'augmented reality' (AR) game, locationbased game, and exergame, yielding a vast player base and extensive research body documenting PGs exercise benefits. Unfortunately, our prior work found that 48.4% of PG players never use the AR features, 37.5% use AR features less than 10% of the time, and only ~9% of players use the AR features more than 50% of the time. Thus, we previously argued that PG is not an 'AR' game in a realized sense because so few players use the optional AR features. This has implications for the interpretation of any previous work, especially with vulnerable groups, claiming the health benefits of AR for exercise that did not explicitly evaluate AR usage behavior. To understand why players opt out of PGs AR features, this paper examines player usage behaviors via a diverse, international survey featuring 64 PG players from nine countries. This work describes why players choose to opt in/out of using PGs AR features and concludes with seven design considerations for future AR location-based game and exergame development/evaluation. Moreover, this work explores challenges with the AR interface experienced by 6 disabled players.

1 INTRODUCTION

Augmented reality (AR) and exercise games are increasingly prominent research areas in healthcare, especially for their potential in rehabilitation and fitness [1], [5] due to AR's ability to enhance immersion [1], reach people at home [2], [3], its affordability [4], and exergame's promise to facilitate increased energy expenditure [5], strength [6], endurance [6], socialization [7]–[9], engagement [10], [11], motivation [1], [12], and exercise level over 30 days [13].

The merging of these strategies (AR and exergames) seeks to to motivate play and, therefore, exercise and rehabilitation [5] [14]–[16] Taken all together, AR exergames are situated to reach and facilitate greater healthcare and fitness outcomes for a broad range of diversely abled, socioeconomic, and physically located patients.

Much of the investigation into AR location-based gaming (LBG) and exergaming has focused on Pokémon Go (PG) as a case study for evaluating exercise and rehabilitation effectiveness. This is because PG advertises itself as an AR LB-exergame dedicated to real-world exploration to collect nostalgic 'pocket monsters' [17] and has been downloaded more than 500 million times worldwide [18]. Worded differently, PG is one of the most successful mobile games ever [17], especially among AR, exercise, or location-based games, and provides rich data for research exploring social, exercise, and game benefits of this 'AR' exergame experience [19].

However, prior work argues that PG is not, realistically, an 'AR' experience due to low player engagement with AR features [20] likely due to poor usability, arm fatigue, and AR making the game harder [16], [21], [22]. PG papers do show favorable results for "... improved physical activity over 30 days, positive behavioral changes, and increased environmental exploration" [16], [23]–[25]. Unfortunately, our previous review of AR exergames points out that the 25 PG papers we captured did not

explore the explicit benefits AR specifically provides, let alone whether AR features were even utilized or how AR engagement was monitored. Studies tended to capture tracked movement data or self-reports of player experiences outside a lab setting. Given the 'opt-in' nature of the AR features, this lack of explicit AR usage tracking is troubling. Whether participants used the optional AR components is unknown, rendering the relationship between "... the AR component with any reported outcomes unclear" [16]. This lack of explicit AR-evaluation is disquieting given the prominence of PG as a lauded 'AR' exergame, the large volume of research claiming the alleged 'AR benefits' of PG, and the subsequently designed AR exergames heavily inspired by the 'success' of PG's 'AR' experience/strategies as a guide [14].

To truly understand AR's role in exercise as well as AR usage behaviors, we conducted an international survey of 64 active PG players. This work will cover those results, which, to our knowledge, is the first of its kind to ascertain actual AR usage behaviors and the underlying motivations behind those behaviors.

This work will describe how and why players do or do not engage with AR, providing critical implications for future developers and researchers. These findings inform our seven considerations (in the discussion) to help designers and researchers understand how to fully capitalize on the unique benefits of AR for LBGs and exergames [16], what motivates AR exergame use, what disincentivizes AR engagement, insights into which AR mode players prefer (Basic AR vs. AR+), and how researchers can better explore measuring realized AR engagement. Moreover, as many exergames are for explicit clinical groups [16], this work also has implications for accessibility in AR exergame design. To this end, we asked all survey takers if they had a disability (~9% did) and how the AR modes impacted their play experience with PG. Finally, as exergames are intended to promote exercise and sometimes physical rehabilitation, our survey also inquired about injuries received during PG play experiences. These results have implications for future AR exergame design and their impacts on patient outcomes, while also recontextualizing the interpretation of past papers that did not explicitly evaluate AR usage behaviors.

2 BACKGROUND – DEFINING PGs 'AR' MODES

When PG was released in 2016, it only had what we will refer to as Basic AR Mode. In Basic AR mode, Pokémon are not contextually integrated into the environment; instead, they appear as static elements in the video feed, fixed relative to the player's camera view. For example, if the player moves closer to the Pokémon, it slides backward to keep the same distance from the player. Furthermore, the Pokémon remains visible in the center of the screen regardless of the player's orientation, which restricts the depth of interaction. Our prior work argues that Basic AR mode is not 'true' AR [20] as defined by Azuma, [26].

In 2017, Niantic (the PG company) added AR+ mode. In contrast to Basic AR mode, where Pokémon remain fixed relative to the camera, AR+ mode introduces dynamic interactions with the player's movements. In AR+, Pokémon respond realistically as players approach them, adjusting their position in 3D space. An 'alertness' bubble appears to show the Pokémon's awareness,

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turning red as the player gets closer, signaling the Pokémon's potential to flee. This mode allows players to move around and even turn away from the Pokémon, significantly enhancing the immersive and interactive experience.

We acknowledge that as of April 2, 2024, Niantic has removed basic AR mode as a playable option from PG. However, at the time of our survey, Basic AR mode was still available and had been included in all prior studies. We argue that findings from Basic AR mode can still offer insights for future development. Compellingly, our survey revealed that players preferred Basic AR mode over AR+ (see section 4.1).

3 METHODS

We crafted a survey to understand AR usage behaviors, how these impact exercise, and why players do or do not use the AR features. Questions were informed by 125 comments on a PG subreddit post (800,000+ members) asking whether other members use PG's AR features, which sparked discussion about why players do/not. Our survey leveraged best practices for UX question design [27] and included questions with multiple-select options and free-response boxes. With moderator permission, we posted to the r/pokemongo subreddit's official PG discord with over 30,000 international members. We posted about the survey 3 times a week over three weeks. Participants needed to be 18+ and play the game at least once a month.

The survey had embedded logic, meaning that participants saw different questions based on their prior answers. E.g., a player who said they never use the AR features was filtered to a question about why this might be, vs. a player who said they do use the AR features being filtered to a question asking which AR features they use. We note this as we wanted to be clear that any 'leading' questions (like "*What AR features do you use?*") came after an earlier confirmation of intent.

4 RESULTS

We were able to secure 64 completed survey responses appropriate for inclusion, representing the following demographics and player profiles:

- Nine countries (Canada, India, Japan, Nepal, The Netherlands, New Zealand, Norway, The United Kingdom, and The United States)
- 40 men, 16 women, 4 nonbinary/transgender, 2 other, and 2 prefer not to say,
- Ages 18-58, Avg. 26.24
- 6 with self-identified disabilities that impact how they play (~9% of total respondents),
- 47% play for 11 or more minutes in a single play session, 34% play for 30+ minutes; 53% have been playing since the game came out in 2016, 95% for longer than 6 months; 59% said they play more than once a day, 92% said at least once a week, while all play at least once a month,
- 59% said they play in a suburban area with a population of 15,000-49,999. 28% said they play in an urban (50k-150k), ultra-urban (151k-499k), or mega-urban area (500k+). 13% said they play in a rural (6-14.9k), ultra-rural (2-5.9k), or mega-rural area (<2k),
- 58 players said they play by themselves sometimes, 43 said they play with friends sometimes, and 20 said they play with family sometimes, and
- 48% said they are team mystic, 34% Valor, and 17% instinct.

The most reported reasons why people play PG was that they enjoy collecting Pokémon (17%), they like the franchise (13%),

they use PG to exercise (11%), and that PG helps them relax (11%). Less reported reasons were that PG helps them explore (8%), improves social interaction (7%), and that players enjoyed the Gyms and Raids (7% each). Only one player (.29%) said they play partly because of the AR features of PG.

4.1 AR Usage Behaviors and Rationale

Most compellingly, 48.4% of PG players never use the AR features, and an additional 37.5% use AR features less than 10% of the time. Only ~9% of players use the AR features more than 50% of the time (see Figure 1 for an absolute number breakdown of respondents for each level of PG AR usage). When players do use the AR modes, 34% weight both modes equally, 40% prefer the basic AR mode, and 26% prefer AR+.





Figure 1: A comparative graph showing the absolute number of participants who engage with AR at varying time levels.

The survey questions for the following sections were all "select all that apply," meaning that the reported percentages are non-exclusive with other listed entries. Therefore, results given will frequently sum over 100%.

4.1.1 AR Positives for General Gameplay

When players who preferred AR+ were asked why, they reported that AR+ was more immersive (33%), more engaging (23%), more fun (15%), and more motivating (8%). When players who reported basic AR were asked why, they reported that basic AR is easier (38%), it runs better on their phone (32%), and that basic AR was more engaging (13%). Interestingly, 10% reported 'other' reasons, which included game exploits to improve load times (reducing startup animations) by toggling in and out of basic AR mode and that they prefer that Pokémon slide with them and are not interactive. This sliding effect allows players to keep walking and playing as opposed to stopping to capture each Pokémon.

When players were asked what they enjoy about the AR features, players said they enjoyed taking pictures with Pokémon (41%), the AR improves game realism (28%), makes the game more fun (24%), that they enjoyed being able to walk up to the Pokémon (21%), that the AR features help them engage with the game more (21%). Of all AR users, the smallest group indicated that they actually enjoyed the increased challenge of the AR mode, and that the AR motivates them to play (13% each). Finally, free-responses indicated that there are AR specific rewards/incentives, like increased hearts that encourage AR-based play.

4.1.2 AR Negatives for General Gameplay

Players who never use the AR features said that the AR makes the game harder (59%), that the AR is not interesting (47%), and that it drains their battery faster, their phone cannot run the AR, or the AR is glitchy (11% each). When 'occasional' AR players decide not to use the AR features, they selected primarily social or efficiency-related concerns, including holding their phone up (41%) especially when pointing their phone at other people (61%), that AR made catching Pokémon harder (59%), that AR

slowed the game down (56%), and that their arms get fatigued holding the phone up (39%). 47% said the AR is not that interesting, with 20% saying AR made the game less fun, and 8% said their phones cannot run the AR. Several players reported 'other reasons' and indicated that sometimes completing an AR quest (to 'scan' an existing gym/stop) will permanently delete Pokéstops/gym. Hence, they are afraid to use the AR modes. We could not confirm that this is an actual PG bug or feature, but we were able to find 'conspiracy theory' Reddit posts about this alleged phenomenon, speaking to the power of community surrounding a game experience.

When asked whether players would recommend new players to use the AR modes, 58% said no, 19% said yes to both modes, 19% said they would only recommend the basic AR mode, and 3% said they would only recommend the AR+ mode.PG and Exercise

Most players (85.9%) use PG to help them start exercising or to enhance their exercise experience. When asked how PG helped their exercise, players reported (in equal proportion) that game mechanics required them to walk to hatch eggs, find Pokémon, go to Pokéstops, go to Pokégyms, to level their Pokémon, and that the game tracks their steps.

When asked about how intense their PG exercises are, 76% reported light exertion (can easily carry on a conversation), with 14% reporting a range between moderate (breathless conversation) to vigorous exertion (cannot speak). PG players predominantly performed walking (96.9%) above any other form of exercise, likely because the primary gameplay is traveling between destinations to engage with game objects. The secondgreatest contributor was loaded carrying (such as with a backpack), which 46.9% of players perform; running, which makes up 25% of PG player exercise; and general arm endurance reported by 21.9% of players. In addition to the type of exercise, the frequency is also rather high, with the majority of players playing PG several times a day (59.4%), and another 17.2% playing 6 of 7 days a week. While the most popular play session length is 10-30 minutes, especially amongst multiple-a-day players, approximately a third of 6-7 day a week players favor sessions lasting 90+ minutes. Conversely, more infrequent players had a lower proportion of long duration sessions. We theorize that active PG players are more likely to integrate the game into a regular exercise regimen.

Fatigue after exercise with PG predominantly manifests as leg tiredness (46.9%) or soreness (20.3%), but also arm tiredness (29.7%). While the leg fatigue can be associated with the walking shared by almost all PG players, arm tiredness is likely derived from generally fatiguing motions from raising and using the phone during regular play. This might be due to a positive trend between duration of play and proportion of the time AR features are used; the players spending the longest sessions in-game exhibited the greatest prevalence of AR usage. However, the proportion of players that use AR at least half the time are small (<10%), so it is unlikely AR practically contributed to the experience of fatigue after exercise.

4.1.3 AR's interplay in PG Exercise

58% of players reported that the AR features neither improved nor detracted from their exercise experience, 33% said AR detracted, 8% said AR improved the exercise experience, and 2% said AR both improved and detracted from their exercise.

When players were asked how AR improved or detracted from the exercise experience, 10.8% reported that it made the exercise fun and less obvious; however, 54.7% reported it detracts by making the move more slowly than they would like, and 46.9% that it made them stop due to the glitchiness of the AR. These sentiments are repeated in players' free-response reasons why they do not use AR. Notably, "[it] feels inefficient having to focus more on the screen," and that "having AR (specifically AR+) enabled for certain tasks...can make them take significantly longer than otherwise. In a game where being efficient with time and speed makes a lot of difference to the playing experience, that can matter a lot." When asked specifically how AR detracts from exercise, participants highlighted that using AR "involves stopping to complete" and that "holding up your phone at a certain angle is difficult, especially when performing more strenuous exercises such as jogging or running." Among AR users, 38.7% report using the AR simply to take pictures with their favorite Pokémon (a non-exercise feature). Absolute numbers for impressions on the AR features' effects on exercise can be seen in Figure 2.



Figure 2: A comparative graph showing the absolute number of reported ways AR improves/detracts from PG exercise

4.2 PG Players with Disabilities & Injury Rates

All players with disabilities (~9%) said their disability impacts how much they play by a small (50%) or a moderate amount (50%), and their ability to exercise during play by a small (17%), a moderate (50%), or a significant amount (33%). The reported disabilities classes were visual, movement-based, or neurological. Players with disabilities did not exhibit significantly different exercise inclination from able-bodied players. Only 33% said their disability hinders their ability to use the AR features. The most frequently cited reason that a player's disability affects their ability to play PG is difficulty walking for extended periods. E.g., the limitations of PG for our survey respondents were centered mostly on the LBG features, not the AR features. However, one player did report that, despite these difficulties, the game still gets them out of the house and helps them make new friends.

A small portion (8%) of players had experienced an injury while playing PG, however this was mostly in the form of walking into something while distracted (6.3%) or exposure to the elements due to either sunburn, dehydration, overheating, or getting too cold (3.2% each). Our injury results indicate that the level of exercise players obtain with PG is not sufficient to cause fatigue or overexertion injury on its own, though one player with disabilities did indicate that they had been hurt playing PG badly enough to stop playing PG temporarily. Overall, 33% of players with disabilities indicated being hurt playing PG which is a much higher incidence rate than that of able-bodied players (~5%).

5 DISCUSSION

We would expect an "AR" exergame to have most of its player base engaging with the AR features. However, our survey reveals that 48.4% of players do not engage with AR at all. Of those that do use the AR features, they only do so rarely (73% of AR users, or 37% of the total participants, only use AR <10% of the time). Further, the small proportion of those who use the AR features is divided in half between the basic AR mode and AR+. As stated in our introduction, the only actual AR experience offered by PG is via the AR+ mode, meaning only 25% of players engage with genuine AR experiences to any extent. Moreover, most users would not recommend new users engage with the AR features of PG. Our results contextualize previous AR literature that was perhaps overly optimistic about AR's direct benefits and our understanding of them. Thus, we feel our initial argument that PG is not functionally an AR exergame stands.

While PG does facilitate exercise among its players, its AR features present an obstacle to play and exercise. The primary source of exercise PG encourages is walking between destinations in the real world to interact with game elements; however, these interactions are slower and more difficult in AR. While PG's AR modes add a new exercise component due to how the phone must be held up, loading players' arms, this motion is resisted by players due to its social implications (appearing to point the phone at other people).

Future work evaluating PG's effectiveness as an AR exergame needs to deliberately evaluate actual AR usage behaviors to understand the interplay of AR and exercise in game spaces. Further, future development of AR exergames that reference PG for design guidance should only do so strategically and carefully. In an earlier section, we noted Niantic's recent choice to disable the basic AR feature entirely. Given the evident preference for basic AR and the varying pros across basic AR and AR+, it will be worth conducting a future survey to see how this change impacts AR use.

In the interim, we provide some considerations for future AR exergame development and research based on the findings above. AR generally was considered to improve game realism and improve fun. We see that the interactive features of AR+ were more immersive, engaging, fun, and motivating than the basic 'AR' mode. However, basic AR was preferred for running more smoothly on user devices and for allowing more flexibility of movement. Hurdles to AR adoption/use in the exergame space occur when the AR creates a harder and less rewarding game experience, limits the play experience through lagging or draining the device battery, makes the user feel socially awkward by using it, causes increased physical strain compared to non-AR modes, and the AR is not interesting enough to offset these weaknesses. It is worth noting that PG is primarily an exergame with AR features, meaning that complete AR exergame experiences will not have to compete with an easier, less-physical, non-AR version of their play experience. Future AR exergames looking to be inspired by PGs massive player base should consider these findings for their future development and interpretation of existing work:

- <u>Consider Actual AR Engagement:</u> Be thoughtful about whether the AR experience being provided/written about is actually AR. If the AR features are optional, ensure AR-based usage evaluations are completed to fully articulate 'AR's usefulness to the exergame experience as AR usage is not a given,
- Do not Hinder Use-Case for the Sake of Including AR: Ensuring the AR runs smoothly on the intended device AND for the intended use case (it does not get in the way of movement, etc). AR is most presently situated to foster and improve engagement and fun in the exercise experience but there is potential for poorly created AR to hinder motivation and exercise engagement,

- Think About the Social Implications of AR Usage: Socially awkward AR gestures will diminish the number of people willing to engage with exercise AR experiences in the presence of other people. However, PG has an AR incentive only available when you play with friends that was reported by our participants. Several participants reporting playing PG with friends/family, creating unique opportunities for AR to foster social interaction,
- **Strategic AR:** AR has opportunities to make both the gameplay and exercise experiences harder. This can be cleverly used to a developer's advantage and can be a terrible detriment if development is not thoughtful. Consider variable levels across both gameplay and exercise elements, as well as AR interaction options (as some players preferred elements unique to basic AR mode over AR+). Moreover, consider melding AR interaction, gameplay, and exercise where possible to render a thorough experience maximizing the benefits of AR and games simultaneously [16] that considers diverse user needs [28],
- <u>Safe AR for Everyone:</u> AR exergames can help people on their exercise and rehabilitative journeys, which means they can also cause injury and exclude players with disabilities. Variable play styles and difficulties will allow users to bring the difficulty to their physical level and open the door for more players,
- Novelty Ends: Once the novelty of AR wears off, players can be incentivized to engage with AR features in games with optional AR if they get more rewards, faster load times, and unique AR experiences not possible in the non-AR version of the exergame. Many players said the AR was not interesting enough to engage with. Creating compelling AR experiences (as mentioned in Strategic AR) can also help offset this diminishing novelty effect, and
- **ExARcise:** AR can create new exercise experiences in different parts of the body than a standard game experience can (holding up the phone for AR vs keeping the phone down low). Moreover, AR engagement is compelling and powerful (users taking photos with their Pokémon) but must be thoughtfully designed to render a meaningful exercise experience. E.g., it is possible to add AR features that add nothing to the exercise experience.

6 CONCLUSION

Pokémon GO is the most played AR location-based exergame, but its "AR" label may be misleading. Research often lacks explicit evaluations of AR usage, and the optional AR features, while offering unique interactions, do not align with the game's primary exercise focus. PG's success in encouraging prolonged walking is hindered by its AR features, which require players to stand still between destinations, interrupting their exercise flow. Our survey shows this results in lower AR engagement and reduced physical activity compared to non-AR players. Future designers and researchers of AR experiences should practice caution when ascribing positive traits to some product that optionally leverages AR, as the AR use-cases may have distinct goals or interactions working separately from the primary goal of exercise. This work serves to deepen the understanding of how AR is actually utilized by PG players, and illustrates a discrepancy between actual user perceptions and the removed researcher view that assumes that AR necessarily enhances an exercise experience. To help mitigate this moving forward and assist developers inspired by PG's 'success' as an 'AR' exergame, we offer seven data-driven considerations.

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