Understanding the Creation of Human-Virtual Entity Bonds through the AR Mobile Game Peridot

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Abstract

Virtual entities in computing games create bonds with the people who engage with the game. This paper explores these bonds: how they are created, what game features influence them, and how the human-virtual bonds benefit players. This exploration primarily takes place through a diary study of eight people who played the augmented reality mobile game Peridot. Drawn from a pool of self-described game enthusiasts who have knowledge in human-computer interaction methods, the eight people, new to Peridot, played the game for 10 days and wrote daily diary entries about their experiences. Following an in-depth collaboration with the players to reflect on and analyze the diary contents, this paper amalgamates these firsthand gaming experiences with prior research to contribute pragmatic recommendations for improving user engagement and the formation of virtual bonds in gaming environments.

CCS Concepts

• **Human-centered computing** → **User studies**; **Human computer interaction (HCI)**; • **Security and privacy** → *Human and societal aspects of security and privacy*.

Keywords

Diary Study, Virtual Entities, Human-Virtual Bond, Game

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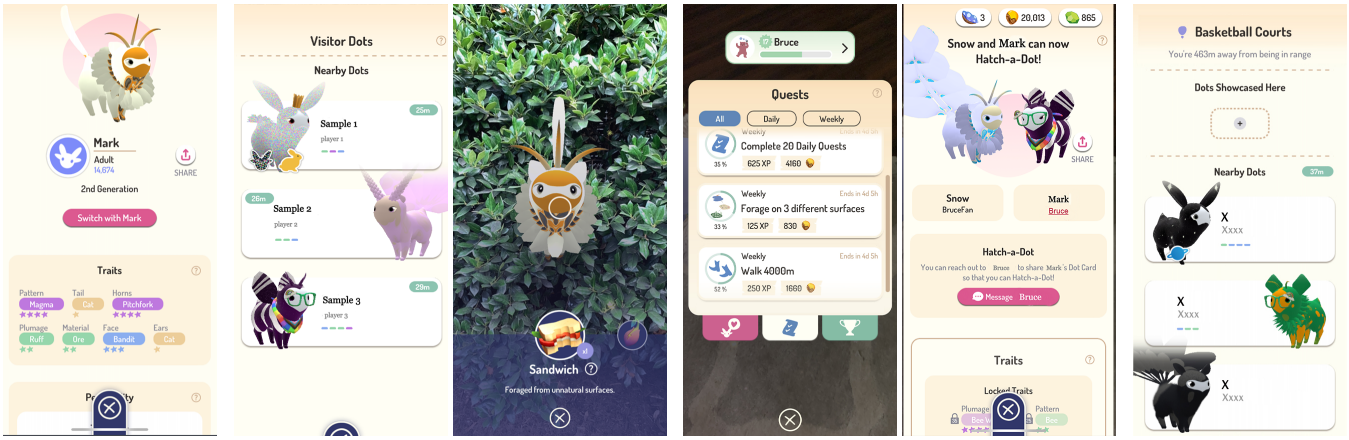
1 Introduction

Virtual entities, also known as virtual pets or digital pets, are imagined creatures that serve as artificial companions for humans [10, 45]. Digital pets were first popularized in Bandai's electronic game Tamagotchi [1, 12], an egg-shaped device with a digital display that required the user to help it with sleep, play, feeding, and discipline, and even resulted in funeral ceremonies[16, 49]. Much like the bonds humans share with their living pets, individuals can also form deep emotional connections with their virtual entities [6, 16, 31]. In human-animal relationships, companionship offers tangible positive effects, such as social support [40, 58], mental relaxation [13, 14], and long-term health benefits [5, 34]. However, there is a limited discourse on human interactions with virtual entities, particularly with regard to how bonds form, positioning it as a crucial area of exploration [36, 55].

Virtual entities have become increasingly popular, especially in the gaming industry. Trends of virtual entities can be categorized into three types: advanced realism, development of entertainment, and benefits such as emphasized physical activity and healthy lifestyle [15]. These are often seen in exergames, digital games that integrate physical activity with gameplay to promote health, well-being, and enjoyment [42, 44, 59]. There remain questions regarding the impact of different game mechanics on the bond between players and virtual entities. For instance, Seaman [2] integrated voice recognition technology, but its unusual appearance deterred many players. This highlights the importance



(a) Different Dots (b) AR interface and Task Settings (c) Hatch new Dots and display on Habitats

Figure 1: Peridot, Niantic, Inc. released in May 2023. (a) Each dot has unique DNA with different traits and appearances. (b) Players interact and meet their Dot's desires through the AR interface. (c) Players can meet new friends and hatch new Dots.

of understanding and implementing effective game mechanics in virtual-entity-based video games. The goal is to identify elements that maintain player engagement and foster greater enthusiasm for physical activity [29].

This paper explores these questions via a mobile virtual-entity-based exergame, Peridot [41] (See Figure 1). This game enables players to raise personal mystical pets, called "Dots", by utilizing augmented reality (AR) features to explore the real world and complete quests. In Peridot, as players engage with their virtual pets, meeting their pets' hourly desires contributes to a point system that guides their pet's development from infancy to teenagerhood and finally adulthood. The game leverages AR technology to enable these floating pets to interact with real-world objects, introducing distinctive quests like "find a flower" that encourage players to explore their physical surroundings. Each dot has its unique traits. The user needs to keep exercising and hatching new dots to get the desired look of the dot. This unpredictability adds an extra layer of excitement and personalization to the game, as players eagerly anticipate discovering the one-of-a-kind traits of their virtual companions and eventually forming a bond with the virtual entities. The primary objective of our experiment is to glean insights from the players' perspectives on the elements that drive the early adoption of such games–particularly in the early stages when bonds with virtual pets are formed. Our goal is to contribute valuable knowledge that can inform the development of future outdoor virtual pet games. Through this diary study, we hope to shed light on the dynamics of player engagement in outdoor AR exergames and to advance the understanding of user experiences in this innovative gaming domain. The main contributions of this paper are twofold: (1) identifying beneficial game features in Peridot that facilitate the formation of Human-Virtual Entity bonds and enhance players' gaming experiences, and (2) examining game mechanisms for outdoor AR-based human-virtual interaction video games.

2 Background and Related Work

This section provides an overview of related literature and background for this research paper. We examine how people establish bonds with virtual entities, one of the standout features of Peridot, and we position within the literature the key remaining questions regarding how bonds between humans and virtual pets (as well as real pets) are formed [36, 43] and the impact of the virtual society established by virtual pets on players [10].

2.1 Human-Virtual Pet Relationship

Virtual pets are digital or computer-generated creatures that individuals can interact with and care for, often simulating the experience of owning a real pet. They provide an interactive experience that requires feeding, training, and playing to ensure their happiness and health [15]. Traditional virtual pet games include Tamagotchi [1], Nintendogs [3], AIBO [17], and Furby [53]. The purpose of this type of game is to offer companionship [31], amusement and avenues for social engagement [35] and connection to real pets [33]. Engaging with these virtual creatures allows players to form bonds and cultivate emotional ties [6]. Previous research indicated that long-term interaction with virtual pets can improve users' quality of life [8] and emotional state [7]. Some virtual pets have characteristics of real pets, and owners can personify virtual pets as they would real ones [33, 39]. Chesney and Lawson [36] analyzed a survey involving 605 Nintendogs players and deduced that even though virtual pets cannot entirely replicate the companionship provided by real pets, they can offer a degree of camaraderie to many owners. Furthermore, these virtual pets can deliver some of the therapeutic and social advantages associated with real pets. Therefore, some sociologists and anthropologists point out that virtual pets represent a virtual socialized world, and they should not and cannot die [10, 43, 54]. Lin et al. [37] indicated that dynamic adaptation(Context-Based Responses, Learning behavior, Personality), personalized attachment, and multidimensional input are the main three expectations of virtual pet games. Pet Ownership

Session 2
Date and time: 6/7 starting at 9:00 am for 30 minutes.
Enjoyment(1-7): 5
Description: I found that the app has a daily task where users get a certain amount of growth value for completing daily tasks. My dot wanted to go out for 1000 steps today and wanted to see the flowers, so I took my phone outside for a while. The app's object recognition was not very accurate. When I saw the flowers, I pointed my phone at them, but the app didn't recognize them accurately. But when I pointed my phone at a flower alone, the app successfully recognized the flower. So I finished my task for the day.
Connectedness w/other users (1-7): 6
Description: I met another Peridot user today while I was out completing my daily tasks. We discussed some of the features of this app together. Sometimes the daily tasks require me to do some outdoor activities like my dot wanting to see a dog. Then I need to go out and find a dog to let my dot play with it. In that case, I will interact with the dog's host. And the hatch-a-dot function also is a good way to communicate with others.
Reflections: Overall, I found that the application did encourage me to get some exercise. This app motivates me breathe fresh air and feel the warmth of the sunshine because of the daily tasks, and I get good outdoor activities. This app also facilitates my communication with others. While I was waiting for the software to recognize the flowers with my phone, a passerby saw my interface and asked me what I was doing, and I interacted with him. It was amazing and I felt so relaxed.

Session 6
Date and time: 6/13 starting at 2:30pm for 30 minutes
Enjoyment(1-7): 7
Description: I was really enjoy this game today. I trained my dot today and taught my dot some moves. This feature is also good for better user engagement. It is real interesting to see my dot laying on the floor and rolling around. I feel like I was playing with a real pet. The only issue is the high battery drain. I have to keep charging my phone and that somehow influence the experience. After the training, I found a good-looking dot through the map function and made my dot hatch a new dot with others' dots. This is also a good design to attract users.
Connectedness w/ other users (1-7): 6
Description: I use "hatch-a-dot" function. Today this app made me want to go out and exercise because I wanted to go find better-looking dots and also give me a break. This app also makes me feel very excited because I can let my dots hatch new dots. The app has enabled people to communicate online through the hatched-a-dot feature. The app also improved my communication skill as I sent out hatch-a-dot requests to some users and interacted with them.
Reflections: Today's use of the app felt truly beneficial. It prompted me to step away from my academic tasks, venture outdoors, and engage in some physical activity. I appreciated observing the birds, squirrels, and trees with my dot. However, some elements of the app still strike me as somewhat awkward.

Figure 2: Sample diary entries from one of the Peridot players showing their quantitative and qualitative feedback

was a critical component of being able to start and sustain that relationship-building process [19, 37, 39].

Players could benefit from both real pets [13, 32, 51] and virtual pets [7, 8, 36]. Extant research, however, has mainly focused on companionship and the emotional support it brings to players but has not thoroughly considered the interaction patterns and bond formation with virtual pets, as well as the psychological changes these bonds bring to players, such as exercise motivation and the desire to explore the outdoors. Chesney and Lawson [36] noted that their research findings were based on screen-based virtual pets, and future work should seek to understand people's attachment to virtual pets and the benefits this relationship can bring. Our diary study further explored which factors accelerate the formation of people's attachment to virtual pets in a more realistic environment, and discussed the impact of this relationship on game enthusiasm and exercise motivation.

3 Methodology

This section outlines the methodology and research design decisions for this paper. A diary study is a research method where participants record specific observations, experiences, or thoughts about their interaction with a product, service, or routine over a defined period [11, 47]. Diary studies were highly effective in capturing real-time feedback and user emotions, providing deeper insights into players' needs and expectations [26]. In particular, it proves especially useful for HCI observations in outdoor settings [22], where tracking user behavior and emotions can be more challenging due to dynamic and unpredictable environments. Moreover, diary studies are instrumental in identifying and analyzing potential ethical issues that may arise during user interactions with software, offering a unique perspective on the ethical dimensions of technology use [21]. Diary studies offer a structured yet flexible method to gather qualitative data, enabling researchers to better analyze interactions and experiences in real-world contexts. We employ a four-phase diary study approach [20].

3.1 Phase A - Preparations for Conducting Diary Studies

For this diary study, we recruited 8 people who had expertise in HCI methods and who were self-described gamers with recent and frequent game-playing experience. The experiment was conducted in June 2023, one month after the release of Peridot. The 8 recruits, chosen from a pool of 25 people, volunteered to take part in the Peridot investigation because they were familiar with other exergames (including others from the same design company as Peridot) and were interested in learning about the new game Peridot. We decided that 8 committed recruits would provide sufficient qualitative output for our exploratory purposes for the new game, as the numbers were in line with other diary studies [18, 24, 25, 52, 56]. Summary work has noted that diary studies tend to be small, but even one diarist can generate a lot of data [30], and our desire to conduct intensive follow-up investigations with our recruits necessitated a small number.

To develop a rigorous diary study, the first author spent an initial week thoroughly exploring the game Peridot. This involved understanding its core features, mechanics, rewards system, and user interface to grasp its essence and user engagement strategies. This preliminary analysis helped shape the research direction, formulating specific research questions and hypotheses about Peridot's design and its impact on players, setting the stage for a focused investigation into player engagement and broader human-computer interaction implications.

3.2 Phase B - Collecting Diary Entities

Our efforts at collecting diary entries spanned ten days, during which all players were asked to install and interact with Peridot, version 1.0.3 (See Figure 1). The experiment duration was set for two weeks, excluding weekends, asking each participant to interact with the specified game, Peridot for at least 20 minutes each day. This arrangement guaranteed that every player would complete

a minimum of 10 sessions. To capture immediate and detailed reflections, players were asked to promptly and comprehensively document their experiences after each session, including test scenarios encountered, methods of interaction, and overall user experience. Each recorded entry was comprehensive, detailing the exact date, time, duration of interaction, enjoyment rating, and degree of connectedness, in conjunction with a descriptive account of the enjoyment, experiences, contemplations, and emotions associated with the utilization of the application (See Figure 2). The diaries were shared with the evaluator at the end of the 10-day session.

3.3 Phase C - Content Analysis of Diaries

This section outlines our approach in analyzing the content of the diaries, both by the researchers and the diarists. Upon gathering all the diary entries from the players involved, the researchers meticulously read through each individual's diary to gain a comprehensive understanding of their experiences with Peridot. This thorough review allowed the researchers to identify key areas that were particularly significant to the players. These domains included their perspectives on the game's mechanics, the nature of their bond with their virtual pets, and the different situations they encountered within their daily living environments. During this process, the team highlighted and took notes on several unique yet critical scenarios documented by the players [57], which provided valuable insights into the user experience and interaction with the game. The first author then developed a structured reporting framework that integrated direct quotes from each player's diary entries for the Reflection Writing Session (RWS). Players participated and reported detailed insights into their diary entries and explored and discussed the nuanced differences in their experiences. The session culminated with a discussion about potential enhancements and future directions for virtual-entity-based exergames like Peridot.

3.4 Phase D - Reflection

The reflection phase is intended to re-engage all diary stakeholders in both the Diary Entry (DE) and the RWS, creating a feedback loop that enriches the overall research [27, 28, 47, 50]. Our reflection session was asynchronous, taking place one month after the RWS and seeking to reflect on writings and conclusions and to assess sustained engagement with Peridot. All diary stakeholders described whether they were still actively playing the game, any changes in their frequency and manner of play, and shifts in the players' attitudes towards the game, focusing on changes in the original document crafted a month previously. This follow-up was essential for understanding the game's long-term impact on the players, assessing whether the initial observations remained valid, and reflecting on conclusions and lessons learned.

4 Findings

Our study involved 8 participants (3 females and 5 males) with an average age of 25 years (ranging from 21 to 30). All participants were trained in human-computer interaction, including diary study methods, and had experience with technology design, mobile devices, and mobile games. Over a two-week diary study, participants wrote 10 diary entries each, totaling 13,496 words. 5 participants voluntarily joined the RWS, with one contributing further to the analysis as a co-author. After 10 gaming sessions with the Peridot app, players reported an average enjoyment rating of 5.26/7. Sessions averaged 25 minutes, with the longest lasting 60 minutes. A follow-up conducted a month later revealed that the 5 RWS participants continued playing the game, though for shorter sessions, and maintained the perspectives they shared during the RWS. This section provides self-reflective insights, featuring key diary quotes.

4.1 Emotional Transference and Virtual Pets

Lin et al. offered an intriguing insight into how players connect with virtual pet simulation games [38]. While three primary categories of players—Pet-keepers, Animal Teammates, and Cool Hunters—had been previously recognized, we observed a novel category: Emotional Transference Players. In therapy, transference occurs when a client unconsciously projects feelings from a past relationship onto the therapist [23]. Here, transference is the act of the players unknowingly transferring feelings or emotions about real pets from their past or now onto the virtual pet. Significantly, this category encompasses players with a unique relationship with real pets, either present or past. Their engagement with virtual pets is rooted in their tangible experiences with their real-life pets. Certain circumstances, possibly geographical separations or temporary situations, prevent these players from interacting with their actual pets. While they cherish and maintain a deep bond with their real-life pets, these constraints evoke intense feelings of nostalgia and longing. In these scenarios, virtual pets become more than just digital companions. They stand as a conduit for these players to express their emotions, find comfort, and mitigate their longing for their pets.

> *"[DE] I was tired at the office today and missed my cats during lunch. When I work from home, they sleep beside me, and I pet them to relax. It's a habit I developed during COVID-19. To cope, I opened Peridot and played with my Dots—it helped me relax, just like my cats do. I really enjoyed the session." - Player 8*

The bond between a human and their real pet plays a crucial role in enhancing player experience with virtual pets. Those with a strong bond with real pets tend to form connections with virtual pets more rapidly. This interplay between real and virtual emotional experiences resulted in heightened engagement in the game. Such players exhibit a deeper sense of attachment and investment in their virtual pets' well-being, demonstrating that virtual games often transcend mere entertainment, becoming platforms for genuine emotional expression and connection.

4.2 Motivation and Randomized Rewards

A significant feature of Peridot is its random reward mechanism [9]. As the diary study progressed and participants gained a deeper experience with Peridot, they found that the incorporation of a random reward mechanism adeptly mitigates the tedium and fatigue that players frequently encounter from repetitive tasks and actions. By infusing unpredictability and variance into the reward system, players are continuously kept on their toes, anticipating the unknown and deriving satisfaction from unexpected outcomes. Each session, though it might involve similar actions or missions, becomes distinct due to the element of surprise brought about by random rewards, maintaining a sense of freshness and excitement

in the game and preventing it from becoming stale or predictable. This is particularly evident among risk-taking players. For these individuals, the focal point often isn't the comprehensive gaming experience but rather the allure of a potentially enticing reward upon task completion. The weight of such rewards, in their perspective, may supersede the overall gameplay.

> *"[RWS] In Peridot, I often experience random rewards when digging, which I really enjoy. I like the idea of random rewards in games because they provide small incentives, even when progress is slow. As a risk-taker, I focus more on these rewards than the overall game. Overall, I think random rewards are a good feature—they keep games interesting and exciting." - Player 1*

However, consistent failure to secure expected rewards over an extended period can lead to mounting frustration. As a result, users may begin to harbor feelings of disillusionment and dissatisfaction. Over time, this can manifest as a broader negative attitude not only towards the specific game mechanics or system in question but also towards the game as a whole. Such prolonged disappointment can subsequently erode user trust, engagement, and loyalty, leading to decreased participation or total disengagement.

> *"[DE] I worked hard to hatch my Dot, but when it finally hatched, it was disappointing—plain, boring, and not what I hoped for. It felt deflating. When you put in so much effort, you expect a rewarding outcome, but the game doesn't seem to support that feeling." - Player 8*

4.3 Benefits & Concerns about Camera-based AR In Public

One of Peridot's most innovative features is its emphasis on outdoor gaming. Traditional pet simulation games are often indoor-centric. Peridot represents a shift in gaming by blending traditional pet simulation with AR, creating a nuanced mobile outdoor exergame experience. AR integration transcends 2D gaming by leveraging advanced computer vision and spatial computing to render 3D virtual pets in the real world, offering an interactive and immersive environment. This progression alters interaction fundamentally, as sensor fusion (using gyroscopes, accelerometers, and GPS) allows the game to react to players' movements and locations. This multimodal interaction enables more responsive mechanics, fostering a deeper, more meaningful bond between players and their virtual pets. This blend, rooted in advanced technology, showcases the potential future trajectory of gaming - where play, physical activity, and technology converge for a holistic experience.

> *"[DE] I fed my Dot and played tennis with it outside. I threw the ball, and my Dot would fetch it back. This app motivates me to go outdoors since I want my Dot to have plenty of space to play. It's also helping me step away from my keyboard." - Player 6*

Using AR in public settings raises ethical and privacy concerns, particularly with camera-based gameplay [4, 46, 48]. Players reported discomfort from holding their phones in specific positions for extended periods, as bystanders inadvertently caught in the device's focus often felt uneasy, leading to potential misunderstandings or confrontations. Additionally, the conspicuous physical movements required for AR games drew unwanted attention, making players self-conscious and reducing immersion. The awareness of being observed or judged detracted from the personal nature of the experience, diminishing overall enjoyment and engagement.

> *"[DE] Using the AR interface in public makes me feel embarrassed and a bit concerned. Sometimes passersby ask what I'm doing, worried I might be filming them, and I have to explain. Unlike Peridot, playing Pokémon Go involves more obvious motions, so it doesn't make me look suspicious, like I'm recording people on the street." - Player 4*

4.4 Promote Human-Human Interactions

The diary-based analysis revealed a compelling pattern: players increasingly documented interpersonal interactions in the latter half of the study. These recorded interactions invariably revolved around virtual pets or were instigated by the bond formed between humans and their virtual pets. Acquiring a new virtual pet serves as a catalyst for enhanced social interaction among players. The excitement and novelty of owning a unique digital companion invariably spark conversations and engagements within the gaming community. Players eagerly share their experiences, or simply flaunt their latest acquisition. This sense of community and camaraderie, spurred by the virtual pet, transforms what might initially be a solitary experience into a socially enriching one, fostering connections and collaborations among players.

> *"[DE] Today, I got my third Dot and decided to visit the nearest Habitat to display all my Dots. I wanted to occupy all three display windows, and it felt cool to see a Habitat showcasing my Dots together. After a few hours, I received hatch requests, and some people even congratulated me on how good-looking my Dots are. I really enjoyed this session." - Player 6*

The interaction between family members takes on a unique dimension, especially in the context of shared experiences and activities. Our observations highlighted that Peridot serves not just as a topic of conversation but also as a catalyst for family bonding. When family members gather to discuss or engage in activities related to Peridot, it creates shared memories and experiences. These moments often lead to increased communication, deepening the emotional connection between family members.

> *"[RWS] As an international student, I often video call my parents to show them my real cats, though they sometimes criticize me for spending too much time and money on them. One day, I showed them my Dots, and their cute appearance sparked a positive conversation about both my real and virtual pets. The app also led to unexpected interactions with family members, as we shared news and talked about our Dots, creating conversations we wouldn't normally have." - Player 8*

5 Discussion

Through this longitudinal diary study, we found that the bond between players and their virtual pets initially stems from interest

in the game itself. In Peridot, core elements such as game mechanics, tutorials, visuals, and music influence players' attachment. A subpar experience at this stage can hinder immersion, supporting Duck's view that "attraction is the start of a relationship" [19]. Most participants formed a companionship [31] with their virtual pets through mechanics like hatching systems and random attributes, solidifying their bond over time.

Analyzing player interactions revealed emotional transference, where players anthropomorphize virtual pets with real pet-like qualities [33, 39]. AR technology enhances this effect, allowing virtual pets like Dots to evoke emotional connections. Research supports that real pets positively impact health [5, 34, 51], and our findings suggest that virtual pets can similarly influence players. As bonds deepen, players' exercise motivation shifts, aligning with literature that exergames improve short-term exercise engagement [29]. Relationships with virtual pets provide emotional support [36] and encourage physiological behavior changes, validating Chesney and Lawson's perspective.

We believe exergames like Peridot hold long-term potential to motivate physical activity by integrating virtual entities. Monitoring a pet's growth state as a reflection of player behavior fosters responsibility and engagement. However, strengthening the player-virtual pet bond remains essential. We propose the following suggestions:

- **Negative Emotional Feedback**: While Dots currently display positive emotions (e.g., happiness after feeding), incorporating temporary negative responses can mirror real pet care. For example, neglecting the Dot could result in symptoms of "virtual ailments," which are remediable through actions like exploring new areas or completing additional steps [10, 43, 54]. This approach fosters nurturing emotions and counters the perception of digital detachment. However, careful calibration is necessary to avoid overwhelming players, especially early in the bonding process.
- **AR-Powered Real-World Customization**: Future game developers could allow players to replicate their real pets' appearance, behaviors, and quirks within the game using AR. Traditional pet simulation games often offer limited customization, but advancements in AR technology could enable capturing physical traits and bringing them to life virtually. This deep personalization [37] can evoke stronger emotional connections, mirroring bonds with real pets and enhancing player engagement.

6 Future Work & Conclusions

In the evolution of AR gaming, fostering deep connections between players and virtual entities has become a significant aspect of digital interaction. This research advances the understanding of human-virtual entity bonds in the social exergame Peridot, particularly during early adoption when players form connections with virtual entities. Using a diary study approach, we examined the target audience's initial engagement, enthusiasm, and familiarity with such exergames, highlighting opportunities for future research. Our study explores the connections in Peridot, emphasizing meaningful mechanics like AR technology, random rewards, emotional virtualization, and social interaction to strengthen human-virtual bonds and motivate exercise. These bonds encourage physical activity and enhance human-human interactions, showcasing the dual benefit of such games. Diary studies proved invaluable in capturing real-time feedback and user emotions, offering deeper insights into player needs and expectations. This method enhances understanding of user experience and aids in designing more engaging and effective exergames. Future research should include a broader range of ages, genders, abilities, and interests to provide a more comprehensive and holistic perspective on game design.

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