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ORIGINAL ARTICLE

A ludological view on the pervasive mixed-reality game research paradigm

Markus Montola

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Abstract During the last 10 years, numerous mixed-reality game prototypes have been built and studied. This paper is a game studies attempt at understanding the findings of that research. First, this paper will look into the paradigm of pervasive mixed-reality game research, analyzing how these games have been produced and studied. Then, there is an overview of some central, reoccurring findings of that paradigm that is written with the intent of generalizing lessons of individual experiments. Finally, there is a discussion on research methodology, analyzing how this type of research could better validate the findings that have to do with play experiences and game design.

1 Introduction

Since the turn of the millennium, a number of *pervasive mixed-reality game* prototypes have been developed and built in various research projects. This paper looks at that game genre from the perspective of game studies, analyzing the experiences produced by these games and seeking to understand the loose research paradigm that has produced them.

A paradigm denotes a "set of assumptions, concepts, values, and practices that constitutes a way of viewing reality for the community that shares them".[1] This paper is a study of a number of papers belonging to a loose paradigm that has produced and studied numerous pervasive mixed-reality games in the context of technological human–computer interaction research. Some paradigmatic properties of this research include: (a) interest in mixed-reality technologies, (b) common conceptual background in HCI research, (c) innovation as a central value, and (d) methodological practices revolving around exploratory prototypes. If these properties appear self-evident, that fact is exactly due to their paradigmatic nature.

Game studies is a multidisciplinary field of study and learning, with games and related phenomena as its subject matter [46]. In the core of game studies, there is the young discipline of ludology, study of games *as games*, instead of e.g. games as narratives, games as performances, or games as a way of applying emerging technologies.

This paper is about looking the mixed-reality pervasive game paradigm from outside. In order to understand the ludological value of this research, we need to forget about what's important in HCI for a moment and analyze what is important for understanding these games as games: How are these games experienced by players, what is relevant in designing for those experiences, and what kind of methodological requirements does the game studies analysis pose on prototype research.

On the other hand, this paper is also a comparative study of research papers. Exploratory prototype research faces two hazards related to validity and reliability. First, it is hard to tell whether a given finding is closely related to the prototype and the particular test setup. If a feature is problematic in a fast-paced street game for kids, the result might not apply to a tourist guide game for seniors. Second, the research often uses small test audiences (even below $n = 10$), which makes quantitative generalization difficult. By cross-examining findings from various prototypes and research groups, we can try to generalize findings. When results are mutually supportive, we can increase the

M. Montola (✉)
Nokia Research, Tampere, Finland
e-mail: markus.montola@uta.fi

[1] According to the 2004 edition of *The American Heritage Dictionary of the English Language*.

validity and reliability of our knowledge.[2] When the results are contradictory, we can look at the contradictions, in order to gain a deeper understanding of the underlying phenomena.

After looking into some typical research findings on player experiences, this paper looks at the methodological issues that are relevant for ludological understanding of exploratory game prototypes. In particular, we look into how technological novelty, serious research setups, and immature technologies influence the research of play experiences.

2 Pervasive mixed-reality games

The object of this study has been limited to games that are pervasive and that utilize mixed-reality interactions. This delimitation was chosen because a large number of comparable studies exist, and I believe that future research will benefit from a critical synthesis of earlier work.

This paper builds on author's earlier definition of *pervasive games*[3] [40, 42] as games that "expand the magic circle of play socially, spatially or temporally".

The so-called *magic circle of play* is a social and cultural contract that separates ordinary life from play, communicating a way of understanding events that happen within the circle. For example, the meaning of a boxing match comes from the idea that the fighting activity, when it takes place within certain spatial, temporal, and social boundaries, is not interpreted only as violence but is transformed into acceptable behavior—while the very same boundaries transform a polite discussion into unacceptable behavior [see 32].

The concept of magic circle has evolved gradually. Huizinga [27] came up with the voluntary nature of play and its spatio-temporal separation from ordinary life. Bateson [4] and Goffman [22, 23] discussed how meta-communication frames the way playful interactions are interpreted: e.g. how the context of a boxing match frames the meaning of violent action. Suits [57] discussed how engaging in play is about restricting one's own behavior, and Apter [1] discussed how the framework of game protects the participants during play. Finally, Salen and Zimmerman [52] established the term magic circle to denote this structure.

The magic circle is a social structure in the sense that it is constructed in the act of play by players and outsiders—both the spectators and the boxers affirm the playful nature of the events happening during the boxing match. The play process both erects the magic circle and is confined by it. The circle is also a cultural structure: The ritual practices establishing a boxing match as a playful activity draw upon cultural conventions.

Pervasive games differ from the usual games in that they reject the confines of a classic magic circle: They are not played on an established playground, they are played at surprising times, and they tend to involve outsiders. Pervasive games often blur the boundary of game and ordinary life so much that it is hard to tell where the game starts and ordinary life begins.

The pleasures of pervasive gaming are twofold [42]. On one hand, pervasive games can take the pleasure of game to ordinary life: Whatever the players do, they know that the game is on and can surprise them at any time. On the other hand, pervasive games can take the non-safety of ordinary to the game: as the game is connected to the player's everyday context, the game can feel much more real and tangible than a purely isolated game.

This definition of pervasivity does not establish a clear-cut categorization but rather forms a scale of various properties: games that are played on the streets among outsiders always exhibit at some pervasivity [25, 35]. Features such as blurred play sessions [5], interacting with outsiders [8], and designing for coincidence [50] can make the experience of pervasivity much stronger. Thus, pervasive game is an umbrella concept that includes location-based and location-aware games, ubiquitous games, alternate reality games et cetera.

In here, I use *mixed-reality games* to denote games that utilize various mixed-reality setups, as discussed by Milgram and Kishino [39]. Many games feature augmented reality [10] or augmented virtuality [7]. A few games feature numerous play modes that can be placed differently in the continuum of virtuality [35]. However, the largest category would seem to be the games that are situated between Milgram and Kishino's "real environment" and "augmented reality". These games augment reality in a minimalist fashion; for example *REXplorer* [3] combines GPS with a paper map and self-reported positioning and uses no AR graphics.

From the players' perspective, it is not necessarily relevant whether the overlay of game world and physical world is implemented though hardware and software: The *PacManhattan* [31] players and game controllers use a map-street overlay similar to *Can You See Me Now?* [7], but it is questionable whether it is (technologically speaking) a mixed-reality system: The *PacManhattan* players report their positions to game controllers by mobile phones, who then update the game map manually.

[2] The relatively detailed referencing practice of this paper is used in order to stay away from speculation and rely more on results derived from the various prototype studies.

[3] The etymological origins of the term are in pervasive and ubiquitous computing, where any game using pervasive or ubiquitous technologies can be called "pervasive game" or "ubiquitous game" [see 47].

The majority of the games studied in this paper happen to be *event games*; games that are staged at defined social events where people go play. Typically, such events last from an hour to a day, and the game area varies between a city block to the whole city. Amusement parks, cruise liners, and tourist offices may stage event games on a daily basis, but from the players' perspective they are special events to be attended.

This distinction is relevant in relation to *service games* that are subscribed for months, or *product games* which players purchase and play whenever they want.[4] Due to the high cost and fragile nature of the custom hardware used in many of these games, few prototype games are staged as services, and even fewer are staged as products. The service examples include *Songs of North* [30], *Feeding Yoshi* [5], and *Mythical* [29]. Product games are even fewer, as most of these games require dedicated hardware that is expensive to build.

Event games are particularly useful format for new technologies and interaction practices, as they can be powerfully controlled by the game organizer, and a large number of people can use limited hardware.[5]

These games are all research prototypes, motivated by technological [3, 6–8, 10, 12, 14, 15, 25, 28, 35, 53, 60], game design [8, 10, 21, 28, 30, 51], and educational [3, 19, 25] research, as well as by artistic goals [7, 8, 10]. The goals of the implementation have a strong influence on the research; projects that are created for art tend to have much larger test audiences than projects that are created for technology. Games staged for studying game design tend to focus on enjoyable and novel gameplay, while educational games stereotypically focus on conveying some subject matter to players.

2.1 A brief portfolio of games

The following portfolio of brief game examples should illustrate the similarities and differences of pervasive mixed-reality games.

Can You See Me Now? [7] was a chasing game, where some players played virtual characters running on the map and the others were runners on the actual streets. The aim of the street runners was to catch the PC players on the overlay map. The feeling of runner presence was augmented by audio feeds, allowing the PC players to hear the breath, voice, and surroundings of the runners.

REXplorer [3, 59] is a tourist guide leading the players around the old town of Regensburg. On their way, the players use mobile phones to communicate with spirits of the original residents of the town. At river Danube, the players are able to communicate with a salt trader, for instance, who tells about the life of the salt traders in historical Regensburg. Players are free to navigate their way through Regensburg by picking quests from the spirits and following them around.

Feeding Yoshi [5] was a location-based long-term WiFi game played as a part of everyday life; players trade fruit with each other and feed them to cute "yoshi"-creatures. The yoshis are represented by secure wireless networks, while open networks represent plantations where fruit can be grown. The players plant virtual seed at plantations, grow fruit, trade them, and finally feed the yoshis. The game exploits the WLAN stations as a random environment where players operate.

Epidemic Menace [20, 21, 35] was a mixed-reality game, where two teams competed in preventing an epidemic in a campus area. As the virus was invisible, they had to use augmented reality technology to see the virus. The basic dynamic of the game revolved around various play modes afforded by different gaming devices. For example, the HQ players were able to use a "satellite" map to coordinate field workers, who could use their short-range devices to exterminate viruses.

In addition to these four games, I have looked into numerous games ranging from mobile phone prototypes [29, 30, 48] to pervasive live-action role-playing games [43, 55] and from educational children's games [2, 19, 51] to early technology prototypes [12, 53]. Furthermore, this paper has also been informed by a few pervasive games that lack mixed-reality technologies (e.g. *PacManhattan*) or mixed-reality games that are rather weak in their pervasive qualities (e.g. *Epidemic Menace*). Two games under scrutiny, *Mogi* [33, 34] and *Botfighters* [11] were long-running commercial service games. References to such games are used when their results are applicable to pervasive mixed-reality games.

3 Play experiences of pervasive mixed-reality games

The studies discussed in this paper often discuss how players experienced the prototype games, what features were appreciated, and how gameplay should be designed. The majority of studies report that the test audiences were pleased with their play experiences, and in many cases they would like to play more [see 2, 3, 7, 8, 10, 12, 14, 21, 35, 60]. None of the studies present un-appreciative overall opinions.

Roughly speaking, the central reported pleasures revolve around novelty, physicality, sociality, and new technology.

[4] The event game/service game/product game—thinking was used collectively in IPerG project (http://www.pervasive-gaming.org), but it has not been published in this form before.

[5] Somewhat comparable development can be seen e.g. in movie distribution, from movie screenings (event) to television (service) and video cassette distribution (product).

In this paper, we focus on a few largely social findings due to their practical design value: social framing and awkwardness, limited view on game world, and local and global experiences.

3.1 Social framing and awkwardness

Unlike regular play described by Huizinga [27], a pervasive game does not "proceed within its own proper boundaries of time and space according to fixed rules and in an orderly manner". Pervasive games break these boundaries, moving play away from its usual place in the (Western) culture, into the domain of ordinary life. While doing so, pervasive games also expand socially, involving outsiders in play.

Many studies indicate that players feel uneasy while playing these games that take play out of its culturally established place. Uneasiness has been reported in games that require obvious gestures [3], role-playing [41], equipment [5, 25], sound effects [3], or acting in a "ridiculous" manner [20]. Interestingly, both dangerous and highly surveyed areas of the city can make players feel uncomfortable [5].

We can use Goffman's [23] theory of social frames to understand this awkwardness: different social frames apply to different situations and acting out of frame causes awkwardness. For example, a CEO takes the role of a patient when visiting her physician. All reasons of awkwardness listed above support the use of Goffman's model in understanding the phenomenon: Visible play with devices and gestures causes awkwardness especially when it is clearly observable but also inexplicable for the spectator. In highly surveyed and dangerous areas of the city, the feeling can be amplified by danger of intervention by the people claiming control over the area.

When the reason for strange behavior is obvious and culturally accepted, the embarrassment caused by out of frame action is less significant: In carnivals, such as bachelor and freshman parties, acting against the usual frames is a source of enjoyment. While games can be utilized to defy this social threshold [see 49], it remains powerful and meaningful. Indeed, acting playfully or even ridiculously against social conventions is pleasurable in many in pervasive games [see 31, 38, 41].

Feeling of multiplayer presence is central for mitigating awkwardness, as the ongoing game serves as an alibi for acting against the social frame and thus mitigates social pressure [41]. Maintaining such an alibi in a spatially expanded game requires constant reassurance that others are still playing.

Researching this awkwardness with research playtests is challenging, since they often take place in what Apter [1] calls a serious (*telic*) mindset instead of a playful (*paratelic*) one. As the playtesters are given game equipment, briefed about the game and the research, and the tech support staff tweaks the technology, the study may often impose a serious disposition toward the game. If the players were playing the game spontaneously or out of their own initiative, they would probably approach the experience in a more playful mindset.

Apter's reversal theory states that when people in paratelic mindset get aroused, they experience excitement: For example, the arousal caused by reaching a record score in *Tetris* is highly exciting, while playing on a too easy level is boring. But, according to Apter, the dynamic is reversed for telic activities: Anxiety is caused by an arousing goal-oriented task, people in a telic mindset rather prefer low arousal and relaxation that follows.[6]

This issue of play attitude, rather than details of gameplay or technologies used, is a likely reason for why games such as *PacManhattan* [31] and *Go Game* [38] are enjoyable forms of play, even though the aforementioned studies have found it problematic to take play out of its established cultural slot.

Inspiring a playful attitude is no easy task, as any professional entertainer can tell, and inspiring it depends strongly on cultural factors. As spatially expanded games lack the Huizingan separation of play and ordinary life, they will need to develop and use other methods, possibly such as costumes [10, 31, 35], to inspire and maintain playfulness. One way to cope with the lack of architecture is the physical, bodily behavior: the players tend to gather in groups, facing inwards, and use their own bodies to arrange momentary magic circles for playing [24, 41].

Taking play out of its culturally established place causes tension, which players try to mitigate by establishing their own ad-hoc zones of play. The feelings inspired by that such tension depend largely on the players' stance toward the play activity.

3.2 Limited view on game world

As pervasive play is dispersed spatially, socially, and/or temporally, it is often impossible for a single player to observe the entire game. While this might at first appear problematic, this limited view on the game world seems to often be a highly enjoyable feature. Players seem to enjoy game setups, where their perception of the game world feels limited to a small part of the entire game. Such feeling of limited perception seems to be a thrilling element that

[6] Apter's reversal theory can of course be criticized. Its main ambiguity relates to the concepts of "telic" and "paratelic", and how they relate to, for example, people who genuinely love their work. For such cases, Csíkszentmihályi's [16] flow theory may be more appropriate. Nevertheless, playful attitude (and lack of it) is a central part of game experience.

inspires players to immerse into the game. As long as the players do not know what exactly there is in the game, they do entertain themselves with their own imaginations and assumptions.

A typical way of creating the feeling of a limited view on game world can be done through providing each player an experience of being a small part of a bigger whole. Whether it is about task-division [21], competition [5], team play [21], interdependent tasks [41], or a general feeling of being connected to a game that reaches beyond their immediate senses [8, 10], players seem to enjoy playing small parts in big pervasive games. Especially, the setups combining headquarters and street players have been explored [7, 31, 35, also 8 and 56].

One reason for the enjoyment is that players in such games feel that their actions and successes bear more relevance than it does in a single-player game—a collaborating team or a larger progress of the game depends on player success [see 41]. Another reason is that the game world seems lively and exciting when there is much happening around the individual player, and players feel that they can, but do not have to, explore it all.

Another way of inspiring the feeling of a limited view is through designing for coincidental and emergent play, which has often been reported as enjoyable. Players mistaking outsiders for players often get this kind of strongly memorable experiences; for example some players of *Go Game* [37] and *Prosopopeia* [43] have reported accidental encounters with outsiders among the best parts of the game. Some games have intentionally and successfully fostered such interpretations of non-game related people and places [see 8, 50, 56, cf. also 17].

Reid [50] and Dansey [17] discuss design guidelines for creating games that foster emergence and ambiguity.[7] Reid, for example, proposes that the designers should observe and document incidences in the play area in advance, in order to design play around typical occurrences. Based on earlier research,[8] the coincidental experiences can be classified in three categories, all of which have produced highly enjoyable experiences:

- *Actual coincidences*: players of *Prosopopeia* encountered a random outsider on the graveyard and had a game discussion that turned out to be one of the most appreciated parts of the game. [43]
- *Calculated coincidences*: in one mission of *Prisoner Escape from the Tower*, the player has to look for a virtual tower guard from the area where tower guards usually patrol. Success does not require seeing an actual guard, but it is quite likely that the players do see them in the course of the mission. [50]. Similarly, *Uncle Roy All Around You* told the player to follow the black-haired woman, counting on the likelihood that one is always in vicinity. [8]
- *Fabricated coincidences*: in *Go Game,* the players complete tasks around the town, which often involve outsiders. Sometimes, however, the people pretending to be outsiders are actually informed actors, who "coincidentally" happen to have a helpful stance toward the players [37]. Such fabricated coincidences also increase the likelihood of actual coincidences, as players start to assume that some outsiders are pretenders.

As emergence and coincidences seem to be enjoyable play experiences, it is interesting to note that the instances of emergence seem to never arise from the game technology, but from the social and physical contexts of play. The parts of gameplay that only involve direct manipulation of a mobile device are highly controlled and unlikely to generate coincidences.

When the player does not know where the game ends and where it begins, it is easy to feel and imagine that everything around the player is connected to the game. This "show a little, let them imagine the rest"—strategy resonates with some classic strategies of storytelling. For this particular reason, the horror movies often prefer to show a glimpse of a moving shadow rather than a good view at a horrible monster: Vivid imagination more than makes up for the lack of visual input. Pervasive games can do the same with the game world, by showing a small glimpse but telling that there is much more to be seen. Just like coincidences, this feeling can also be fabricated: *Momentum* game masters used various Internet channels to portray non-player characters, contributing to the feeling of a large and lively game world with many unseen players [56].

The players appreciate the feeling of being small parts of big game worlds, and that a limited perception on the game world and emergent play contribute to such feeling. The feeling is based on perception, instead of the actual fact of the matter.

3.3 Local and global experiences

The experiences produced by pervasive mixed-reality games are tightly connected to the way the local physical, social, and cultural environment is utilized in the play. Based on the games studied, we propose a four-layer categorization on localization levels of location-aware games, based on how they can be distributed.

[7] Here, I discuss coincidentally emerging play experiences. For player cultures and behaviors emerging in long-term play, see [33, 34].

[8] Inspired by Reid [50] especially, who presents a categorization to *natural*, *social,* and *feigned coincidences*.

- *Physical games* require indivisible objects and places to function.[9] They can utilize prepared scenography [8], theatrical costumes and props [10], local augmented reality [25] and custom hardware [43]. These games are difficult to scale and restage, and there is a risk of damage to the physical equipment. Physical games are usually event games.
- *Local games* utilize the particular cultural and geographical context they were made for. Tourist games [e.g. 3, 18] are an excellent example, as they must connect tightly to their environment.
- *Global games* are made to work everywhere as long as the basic wireless infrastructure is present. Global games often work with GPS [26], Bluetooth proximity [48], WLAN proximity [5], or cell positioning (*BotFighters*[10]). Global games tend to be service games.
- *Glocal games* are games that also utilize local surroundings, but their content, gameplay and technology are developed in a flexible manner that allows localization and local content creation. They must be set up and run locally, but that process can be done efficiently, bringing local flair and physical environment to the game [see 9].

The localization level of the game has profound significance for the production, technology, business and play experiences of the game. While physical and local games are very hard to scale for large audiences, global and glocal games usually have to use less predictable and less intuitive[11] technologies, such as GPS, cell positioning, or WLAN positioning. The intuitiveness and the ease of development and production are central causes why it appears that non-professionally created pervasive games are often physical or local (e.g. *geocaching*, *treasure hunts*, *scavenger hunts*, *assassin games* et cetera [see 44 for the games]).

Seamful design [see 13] can be used as a way of dealing with uncertainty caused by unintuitive and unpredictable nature of such technologies. For example, *Treasure*[12] [2, 14] utilizes seamful design through clearly displaying uncertainty to players and utilizing as a game element: Players play with GPS and WLAN, collecting virtual coins by getting close in terms of GPS, and cashing their findings in zones with strong WLAN signal. In the context of *Treasure*, technological ambiguities are as much a part of the activity as blizzards are a part of mountain climbing.

Physical and local games can mitigate the wireless unintuitiveness without seamful design, through drawing upon the precise buildings and cultural contexts instead: *REXplorer* for example deals with GPS shadows and uncertainties through telling player to go to a particular landmark (instead of, say, certain coordinates) and using landmarks for self-reported positioning to confirm the player locations [3]. In a similar fashion, *Prisoner Escape from the Tower* instructs the players to avoid the Yeomen guards, as some of them carry Bluetooth beacons that catch the prisoners in contact. But as Reid [50] discusses, the point of the game is not in avoiding the beacons but in avoiding the guards: Not all guards even carry beacons, but the fear motivates players to avoid them anyway. All ambiguities are interpreted as strokes of luck by the players.

Glocal design seems to be a possible way of circumventing the problems of both global and local designs, offering both tangibility and scalability through localization. The open issue is: How to create global games that manage to exploit local environmental and cultural properties efficiently? The manpower required for localization of glocal games can be cut down through automation and user-created content. Automation can utilize various point of interest databases. User-localized content has not been sufficiently explored, considering the wide success of *geocaching* as a leisure activity.

Combining the localization modes can create powerful experiences (in the fashion of limited views on the game world). The global puzzle game of *Perplex City* concluded in a highly physical treasure hunt in England. While most players only participated online, and a precious few managed to join the physical treasure hunt, the play modes supported each other through added meaning: Online puzzles were given meaning by the actual treasure hidden in the forest, while the forest treasure hunt was a visceral culmination of a game that had lasted for several years. Finally, the stories told by the treasure hunters lived on in the internet, enriching the global game, providing the global player base a mediated experience the physical events. [44, cf. also 41].

The localization level influences the player experiences of pervasive mixed-reality games. Global games often need

[9] This kind of physicality does not correlate with the physical dangers of pervasive mixed-reality games. Instead, the distinguishable physical risk factors include playing in traffic [5, also 11], playing intensively [3], strong motivation to succeed [26], unclear communication between organizers and players [55], staring at the screen while playing [14] and using obstructive AR equipment [25]. One particularly interesting way of lowering the physical risk is designing game mechanics that require players to keep track of physical landmarks [see 3, 14] and other players [see 24].

[10] While the game design and basic technology of *BotFighters* were global, its reliance on mobile operator services made it glocal in practice—it had to be launched separately everywhere.

[11] This unintuitiveness is partially derived from the fact that these technologies and playing with them are relatively new thing for the laymen, and partially from the fact that due to their relative newness, the wireless technologies are prone to ambiguity, malfunction, and unpredictability. Both of these factors are likely to change in the future.

[12] A.k.a. *Bill*.

to deal with un-intuitiveness of wireless technologies through e.g. seamful design, while local games can use local environment for the same task.

4 Methodological implications

While the previous chapter looked into some common game experience findings of pervasive mixed-reality game research, this chapter goes into methodological implications of this research. Again, this chapter is based on interest in gaming activities and hence discusses research methodology for studying game experiences. The primary purpose of staging the prototypes and conducting evaluations has often been something else, e.g. field-testing prototype hardware. This discussion only applies to game research findings.

4.1 Novelty value

It is well established that the new forms of physical gameplay and playing with new technology are fun. Pervasive game playtesters often compliment the novelty of the technology and gameplay [35]. If you give people a novel device and let them toy with it for an hour, they are quite likely to enjoy the experience just because playing with new toys is fun.

Thus, the novelty may cloud the judgement of playtesters: They are unable to provide reliable data on whether this kind of gameplay is enjoyable because it is new or whether the enjoyability derived from the other properties of the game. For example, the testers of *Treasure* found their interest in the game growing during the testing day [2], but half of the *Feeding Yoshi* [5] players found their interest dropping after a few days of play.

Different games approach novelty in different ways: While the playtime for a typical digital game is somewhere between 10 and 100 h, classic games like *chess* and *soccer* run out of novelty long before the player can even start to master them. Basing a game on novelty value works for event games for tourists and theme parks, where short play time and lack of replayability are not problems. In tourist games, the environment itself is the central novelty; thus, location-based games need to utilize the cultural value of the environment (instead of, for example, forcing the users to revisit places for several times [3, 51] or taking the players' attention entirely to the gaming devices).

Nevertheless, the issue of novelty value should be considered in all evaluations of fun in games. As the individual game instances of the longest contemporary service games last for several years (e.g. MMORPGs), it is critical to measure the enjoyability of the games in relation to time. Assessing the long-term viability of a game requires long-term studies.[13] Finding out how pervasive gaming would influence player lifestyles on the long run would require even longer play periods [see 11, 33, 34].

4.2 Studying fun in a serious manner

Some of the prototypes [2, 10, 14, 21, 25] studied have been evaluated in prototype play test settings focused on the evaluation, while others [3, 7, 8, 51, 56] have been evaluated in public trials with "real" and often paying audience.

From the user study perspective, this difference is central. The latter audiences are gathered based on actual interest on the game instead of the research, they expect to receive a technologically stable experience that has been perfected much farther. Compared to the first group, the people of the second group participate in the trials in self-defined groups; they come to play with their friends instead of random participants of the trial.

When trying to gauge whether something is "fun", these differences are critical. Playing with one's friends at a leisurely pace in a festive environment is very different compared to playing with other informants in a clear research setting. While traditional video games are usually play tested in laboratory environments, applying the same methodology on pervasive games is problematic: These games are all about contextual interaction with one's physical and social surroundings. The strong hypothesis is that the exactly same prototype can be experienced very differently, depending on how, where and when it is staged.

4.3 Researching games with immature technology

Games offer a challenging environment for testing new technologies. While an emergency call requires one successful positioning, a pervasive game may require thousands of positions every minute—and with a much better accuracy. Games also place requirements on battery life and robustness of the technology.

The downside is that exploratory prototypes seldom run flawlessly [e.g. 7, 8, 10, 21, 28, 29, 45, 51, 54].[14] Indeed, early prototypes are not even meant to be stable and robust: It

[13] Pervasive game trials running for more than 2 weeks are few. See [56] for a 5-week event-service hybrid, [5] for a month-long service and [29] for a week-long period of a persistent service. In addition to trials, see [11, 33, 34] for studies of player cultures that have evolved over long periods.

[14] These studies discuss or hint at technological problems during evaluations. Many others [such as 43] disregard problems and focus on findings that were likely to be unaffected by glitches. Based on informal discussions with researchers, it should be said that numerous other prototypes could be added to the list. The studies listed here deserve to be commended for pointing out their technological challenges.

is often more sensible to focus on fixing problems as they emerge than on testing the prototype until it runs flawlessly.

From the ludological perspective, the problem is that technology research is often interested in functional aspects of user experiences, while game research is interested in hedonic and emotional gameplay experiences. The frequent breakdowns, disconnections, ambiguities, and glitches are problematic especially when evaluating the latter.

In addition to stopping the play and thus hindering the playful experience, the glitches cause *confusion* in players [6, 8, 29, also 28]. The confusion in turn hinders their efforts on learning to use new technologies and how to play in new way, which can lead to players never playing the game as intended, and quitting the trials short.

The inherent ambiguities make wireless technologies challenging to use even when they function properly, and the distributed nature of pervasive games makes repairs difficult, as the players are not co-located with the tech support staff.

Thus, it can be said that using immature technologies, especially immature hardware, is a risky way of prototyping that should be avoided whenever possible [see 28, also 58]. Of course, immature technologies are sometimes necessary, for example for creating experiences that are genuinely dependent on such technologies.

In order to succeed in the game research evaluation, the designers should always have contingency plans for critical technology malfunctions. For example, the ludological research on *Momentum* was saved by the game designers' two contingency plans for prototype development problems, one to be used in the case where some functionalities were not delivered, and another for almost no prototype technology at all [56].

Stacking too many research questions and technological requirements on one prototype can also make it significantly harder to create proper designs [28]. Requirements can serve as creative constraints, but they can also hinder the designer work considerably.

5 Conclusion

In this paper, I have discussed the research paradigm of pervasive mixed-reality games research, identified a few typical play experience findings of that paradigm, and finally discussed some methodological challenges concerning hedonic play experiences.

The three reoccurring themes identified here—social framing and awkwardness, enjoyability of limited view, and importance of localization level—are just some of the basic themes. Other research questions, largely unanswered by this research paradigm, include for example:

- How do players experience the physical exercise in pervasive mixed-reality games?
- How to design pacing in unpredictable environment?
- What kinds of game challenges do these games present to players, and how to balance them?
- How is story content experienced in spatio-cultural context?

As there are already evaluations from numerous pervasive mixed-reality games, it has become more challenging to make new gameplay observations from small tests. It seems that a more comprehensive understanding of earlier research would have benefited many studies [see also 28], especially when creating hypotheses that would help build a big picture on how people experience these games.

From the ludological viewpoint, the central question is whether to explore new territory, or to find out more about known issues. In the former case, exploration could be more adventurous and take bolder risks through creating something genuinely new, even for tiny evaluation groups. In the latter case, more attention should be paid to identifying the research issues in the context of earlier studies and creating larger trial setups allowing more general results.

At the time of writing of this paper, it would seem that the ludological understanding of these games would benefit the most from an experimental large-scale game created for real customers with a focus on play experiences. A comparable example can be found from alternate reality games, where one exemplar, *The Beast*, gave direction to the entire genre [see 36]. In the field of location-aware gaming, the importance of *BotFighters* [see 11] has been similarly significant.

Having said all this, it needs to be added that the research done in the HCI paradigm is also immensely valuable for the development of pervasive mixed-reality games. For instance, various studies discuss how to design around technological problems [e.g. 2, 6, 7, 25], which is pivotal for developing successful games. All pervasive mixed-reality games benefit greatly from the new engineering innovations, as well as from the thorough understanding of the relevant technologies.

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