Paula Alavesa

PLAYFUL APPROPRIATIONS OF HYBRID SPACE

COMBINING VIRTUAL AND PHYSICAL ENVIRONMENTS IN URBAN PERVERSIVE GAMES
PAULA ALAVESA

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Combining Virtual and Physical Environments in Urban Pervasive Games

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Abstract

Modern urban space, technological infrastructure, and sociability combine into a hybrid space that is the arena for urban pervasive games. Over the past two decades the changes in this game arena have been stealthy although substantial. Technological developments have helped to achieve true mobility of gaming devices, increased precision in localization, improved connectivity, and reduced orchestration required per player. Current pervasive location-based games can be played anytime anywhere. Subsequently, doors have been opened for a growing number of commercial games. These changes demand a new conceptualization of the urban game arena.

This thesis focuses on playful appropriations of hybrid space. Hybrid space is urban space that entails ubiquitous technologies. Therefore, playful appropriations of hybrid space are always, to some extent, digital as well as urban. Prior research has identified two metaphors for urban pervasive games —true mobility and true sociability. This thesis proposes an additional metaphor, called synchronicity, for binding together different realities in pervasive games. They can be anything from mirror world like realistic virtual environments, such as 3D virtual representations of a city, to abstract realities, such as the backstory of the game, or the space identity of a certain location. While location awareness is an important binding factor between the virtual and physical worlds in pervasive gameplay, synchronizable elements can be anything from encouraged collocated gameplay to semantic similarities between the combined realities.

This thesis is based on five game constructs that have been specifically designed and implemented as pervasive research games. Research data has been collected and analyzed with a mixed methods approach from field trials conducted in the wild. Constructive research is complemented with a literature review that maps the characteristics of current location-based mobile games and the game space. The main contribution of this thesis is the identification of the digital, abstract, and physical layers of reality in digital urban pervasive games. The second contribution is the identification and categorization of the synchronizable elements that bind these realities together. This thesis offers initial insights into translating this knowledge into the design of future pervasive games.

Keywords: game user research, location-based mobile games, pervasive games, player experience
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Tiivistelmä


Asiasanat: pelaajakokemus, pelikäyttäjätutkimus, pervasiiviset pelit, sijaintipohjaiset mobiilipelit
To my family and friends
Preface

Firstly, I would like to thank my supervisors Prof. Timo Ojala, Dr. Minna Pakanen and Dr. Hannu Kukka for coaching me through the research plans, field trials, and tribulations that have culminated in this thesis. I would also like to extend my gratitude to my thesis follow-up group, Prof. Jonna Häkkilä, Dr. Aulikki Herneoja, and Dr. Mikko Rajanen. Although you were introduced to the work quite late in the process, you provided me feedback and support that helped me better see the value of my research.

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2nd November 2018, Tuira-city, Oulu, Finland

Paula Alavesa
## Abbreviations

<table>
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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>A-GPS</td>
<td>Assisted Global Positioning System, localization that uses satellites, cellular bay stations and wireless hotspots for acquiring location data</td>
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<tr>
<td>AR</td>
<td>Augmented Reality</td>
</tr>
<tr>
<td>CAVE</td>
<td>A Cave Automatic Virtual Environment or, as originally defined, Audio-Visual Experience Automatic Virtual Environment</td>
</tr>
<tr>
<td>CK</td>
<td>City Knights and Campus Knights</td>
</tr>
<tr>
<td>CYSMN</td>
<td>Can You See Me Now, a classic pervasive game</td>
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<tr>
<td>e.g.</td>
<td>exempli gratia</td>
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<tr>
<td>GLONASS</td>
<td>Global Navigation Satellite System</td>
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<tr>
<td>GPU</td>
<td>Graphics Processing Unit</td>
</tr>
<tr>
<td>H’n’T</td>
<td>Here ‘n There</td>
</tr>
<tr>
<td>i.e.</td>
<td>id est</td>
</tr>
<tr>
<td>LBMG</td>
<td>Location-based Mobile Game</td>
</tr>
<tr>
<td>NPC</td>
<td>Non-player Character</td>
</tr>
<tr>
<td>PDA</td>
<td>Personal Digital Assistant, early handheld computing device</td>
</tr>
<tr>
<td>QR code</td>
<td>Quick Response code</td>
</tr>
<tr>
<td>RC</td>
<td>Research Contribution</td>
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<tr>
<td>RFID</td>
<td>Radio-frequency Identification</td>
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<tr>
<td>SAG</td>
<td>Street Art Gangs</td>
</tr>
<tr>
<td>TGD</td>
<td>Triadic design principles for game design</td>
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<tr>
<td>UI</td>
<td>User Interface</td>
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<tr>
<td>UX</td>
<td>User Experience</td>
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<tr>
<td>VE</td>
<td>Virtual Environment</td>
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<td>VR</td>
<td>Virtual Reality</td>
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List of original publications

This thesis is based on the following publications, which are referred to throughout the text by their Roman numerals:


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1 Introduction

Modern cities encompass technological infrastructure and networks that bind the citizens and the technology together in a profound manner. Urban citizens are connected to each other and the Web. This interconnectivity of people to each other and the surrounding city infrastructure shapes the modern urban space into a hybrid space. As a result, the playground for urban pervasive games is also reshaped. In this thesis, playful appropriations of the hybrid space are equated to pervasive games played in urban contexts (Falcão, Andrade, Ferreira, & Bruni, 2010; de Souza e Silva, 2009). Pervasive games expand what is considered traditional gaming (Montola, Stenros, & Waern, 2009). A simple example of this kind of expansion would be a board game played on the city streets with the players and bystanders as pawns, or the game of Pacman extended outside the 2D screen to the streets, as is done in Pac Manhattan (Chatzidimitris, 2016; Cheok, 2006; Pac Manhattan, n.d.). Pervasive games staged in urban environments can be considered playful appropriations of hybrid space. They are not just pastime distractions, but playful content that pervades the daily life of the players (Falcão et al., 2010; Klausen, 2014; Komninos, Pallot, & Schaffers, 2013; de Souza e Silva, 2009). They can be played anytime, anywhere, as is the case with current commercially successful games such as Pokémon GO (Niantic, 2016) and with more traditional games such as Geocaching (O’Hara, 2008).

The concept of pervasive games has been around for decades, although it took a while for the games to become as popular as they are now. Technological development during the last two decades has allowed substantial broadening of the scope of pervasive games. The development of mobile technology, connectedness, and both technological and computational advancements in locationing methods (Calabrese, Ferrari, & Blondel, 2014; Farman, 2013; Kaluža, Beg, & Vukelić, 2017; Kasapakis & Gavalas, 2015; Peña-Rios, Hagras, Gardner, & Owusu, 2017; Sheller & Urry, 2006; I) have made it possible to step into next generation pervasive games where true mobility and true sociability have been achieved.

The first location-based pervasive games relied on either self-reporting or backpacks filled with equipment and antennae for localization (Benford et al., 2004; Benford, 2006; Montola et al., 2009). Current smartphones possess the same or even more advanced technology in the palm of the player’s hand. Everything required is inside a device that is not game specific but for daily, practical use. Pervasive displays and projectors can be used to overlap digital game spaces with the virtual (II, IV, V), but a smartphone is an ideal mediator between the physical
and virtual game spaces. It is a device that blends with the daily life of the user while pervasive games are games that blend daily life with gameplay (Montola et al., 2009; Neustaedter, 2013). In addition to affecting the urban game space, technological development has allowed early pervasive games to mature (O’Hara, 2008) and has opened doors for new commercially successful games such as *Ingress* (Chess, 2014; Niantic Labs, n.d.) and *Pokémon GO* (Colley et al., 2016; Niantic, 2016).

Game context, in this thesis, is the urban environment which dictates what technology can be used in that space; for instance, playing indoors poses restrictions on what kind of signaling can be used. Precise synchronization of signaling can also be one requirement of urban pervasive games (Chatzigiannakis, Mylonas, & Vitaletti, 2011) however, when precision cannot be achieved, the ambiguities can be incorporated into the game design. This incorporation of ambiguities is called *seamful design*, a concept introduced by ubiquitous computing pioneer Mark Weiser, and it has been utilized as a design methodology in many academic pervasive games (Chalmers & Galani, 2004; Chalmers et al., 2005a; Weiser, 1994). In *Bill* (Chalmers et al., 2005), players shuttle between good and bad network coverage while playing the game. Network inaccuracy is also used in a similar way in other pervasive games such as *Treasure* (Chalmers et al., 2005) and *Feeding Yoshi* (Bell et al., 2006). One could conceive the network coverage as a seam, a rift, or a disadvantage in the ubiquitous infrastructure of the game environment. However, in seamful design, this rift is creatively used as an advantage in game design. There is also another possibility to perceive this seam: the gradient between good and bad network coverage can be used for overlaying another reality on top of the game map and the purpose of the pervasive game is then to entwine these two realities together.

Chatzigiannakis et al. (2011) approach the possibilities of pervasive applications and games from the perspective of technology, despite also naming an urban setting and players as influential factors for the gameplay. They recognize many future challenges for pervasive games (Chatzigiannakis et al., 2011). Many of these challenges have been surpassed by technological advances, but it could still be argued that we have very few true third generation pervasive games where nonconventional user interfaces (UIs) or sensor networks are used (Guo, Trætteberg, Wang, & Meng Zhu, 2010; Kasapakis & Gavalas, 2015). As in ubiquitous systems, pervasive games house the possibility for a more complex system heterogeneity, since interactive systems bring forth interdependence between medias (Chalmers & Galani, 2004). This complexity is not, however,
addressed thoroughly by current design guidelines for pervasive games (Benford, 2011; Crabtree, 2004; Montola et al., 2009). Furthermore, many of the seams utilized in seamful design are technical. De Souza e Silva (2006, 2009) proposes the concept of a hybrid reality game that stems from current theories of mobile computing and social interactions. Falcão et al. (2010) call this type of game “a playful appropriation of hybrid space”. This definition fits well into the idea of urban pervasive games as games that take advantage of the many possibilities of the ubiquitous infrastructure. Hybrid reality gaming is an essential subgenre of pervasive gaming. Therefore, the same definitions and most of the same theories apply; however, what de Souza e Silva (2009) calls a new logic of game space recognizes the advances made in mobile technology. The traditional expansions in pervasive gaming introduced by Montola are social, spatial, and temporal (Montola, 2005; Montola et al., 2009), whereas de Souza e Silva proposes replacing Montola’s temporal with mobility. This shift reflects the divide between the old and the more recent location-based or pervasive games, i.e., the true mobility (Sheller & Urry, 2006; Farman, 2013) provided by the advances in mobile and ubiquitous technologies. In hybrid reality games, the roles of social interaction and communication as the binding forces between realities is also recognized (de Souza e Silva, 2006, 2009). Social people in connection to the technology is also recognized as a unit of design by Weiser, more precisely: “social people in their environments plus their devices” (Weiser, 1994). In addition to mobility, sociability is therefore one theme or metaphor that combines realities in current pervasive games. Outside true mobility and true sociability there are, however, many unrecognizable combining factors that can be collected under a metaphor of synchronicity. Academic games tend to encompass only one environmental factor into the game design, which often relates directly to the research question. The possibility of using new technology is gimmicky in both academic and commercial games, making them more like games with a pervasive feature than true pervasive games. The layering of realities and the experience of multiplicity combines only two layers of realities sometimes even one directionally, hence the full potential is not achieved in what Farman (2011) calls the pleasure of experiencing virtuality.

1.1 Scope of the research

This thesis maps the current urban environment as a game arena for pervasive games. It explores the qualities required for combining realities, i.e., the synchronizable elements that fall under the metaphor of synchronicity. Although
location-awareness is elemental in hybrid reality games, these synchronizable elements can be more than just location coordinates and their conversion from one coordinate system to another. The objective of this thesis is to structure a new conceptualization for games that entwines abstract and mirror world like virtual environments or realities to the physical game arena. The thesis focus is on three sub-areas of human computer interaction (HCI) and game user research: pervasive games, player experience, and virtual and physical realities (Figure 1).

Game user research is an emerging field that uses methods adapted from HCI, game development, and psychology to study aspects of digital games (El-Nasr et al., 2012). However, the paradigms inherited from HCI and then incorporated into game user research follow traditional desktop computing and have their limitations when applied to pervasive games (Jegers, 2007).

![Fig. 1. Scope of the thesis: intersection of pervasive games, player experience, and the defining nature of hybrid reality that includes virtual and physical realities.](image)

The first focus area of this thesis is pervasive games. These games expand what is traditionally considered gaming. They are oftentimes played in an urban environment and entwine daily life with gameplay (de Souza e Silva, 2009; Montola et al., 2009). The context of gameplay has affected the research methods selected for the individual studies presented in this thesis. In addition, recent developments in the field of pervasive games and the current boom of commercially available games have resulted in substantial changes to the game arena for urban pervasive games. The research presented in this thesis (and
especially the constructive design research conducted in it) however, closely inspects specific aspects of pervasive games to be able to achieve more distilled knowledge of the topic.

The second focus area of this thesis is player experience (Nacke et al., 2009). Player experience can be understood similarly as user experience (UX). User experience is described in the ISO standard definition (ISO 9241-210, 2010) as “human perceptions and reactions that are outcomes of the use or anticipated use of a system, service, or product”. Player experience is analyzed from the interaction process of the game and the player (Nacke et al., 2009) as a part of game user research.

The third focus area of this thesis is the hybrid space (de Souza e Silva & Sutko, 2008) and the infused virtual and physical realities. In this thesis, the phrase “physical world” is used instead of “real world” to avoid branding some realities more real than others. The physical reality is the world we live and breathe in. Deviations from this reality are made possible by technological interventions or enhancements (Schnabel, Wang, Seichter, & Kvan, 2007). Virtual reality is thereby an artificially generated or emulated projection. The possibilities in the shape and form of virtual realities are only limited by our imagination (Hinske, 2007; Holtzman, 1994; Schnabel et al. 2007). However, when the environments are realistic, there is always some, even if just semantic, connection between the digital and physical realities. To achieve a holistic view on hybrid reality and its playful appropriations, one needs to capture the complexity of the realities that are combined by pervasive gameplay. Hybrid space is used in this thesis as defined by de Souza e Silva (2006): a combined physical and digital space, where the combining element is the mobile interface. This thesis aims to expand this definition by exploring the other factors (i.e., synchronizable elements) that combine realities into a hybrid space. Farman (2013) has a philosophical approach on how elements from virtual and physical blend in pervasive applications. He rejects strict separation of the virtual from the physical and states that virtual objects can create the same or similar effects as physical objects. In this thesis, the digital spaces from the definition of de Souza e Silva (2006) are described as realities that can be combined by the synchronizable elements in pervasive gameplay. Mirror world like (Feiner, MacIntyre, Haupt, & Solomon, 1993; Gelernter, 1993) realistic virtual environments are used as a parallel reality as well as a map-based projection of the physical game arena. As already stated, however, this thesis aims to recognize other parallel realities in the game arena as well.

Mobility and location awareness are unique characteristics of mobile interfaces. When designing new types of mobile games, these aspects need to be explored
The terms positioning, locationing, and localization are used synonymously both in academic and other literature. In relation to GPS, positioning means acquiring location coordinates; whereas, depending on context, locationing or localization can have a wider meaning. Furthermore, positioning suggests that GPS is the only technology used in acquiring coordinates, which is not currently true. Positioning is also used in other scientific fields with a different meaning. For these reasons, in this thesis the word localization is used.

The scope of this thesis has several delimitations. The current definition for hybrid space is somewhat restricted by observing only the realities that are mediated by mobile interfaces (de Souza e Silva, 2006). One contribution of this thesis is extending this perspective by considering other elements in the game arena as mediators, which, in turn, highlights other possible realities. However, excluding one, the research game prototypes used in this thesis are played using smartphones.

The terms playfulness and gamification are sometimes used interchangeably. The games reviewed and constructed in this thesis are hedonistic, hence the term playful is used to describe the experienced and playful qualities of play as formulated by Deterding, Dixon, Khaled, & Nacke (2011). Pervasive games are not always digital (Montola et al., 2009). This thesis, however, is restricted to digital urban pervasive games played indoors and outdoors. Therefore, the phrasing playful appropriations of hybrid space is used. This thesis excludes gamification and therefore does not address playful design either (Ferrera, 2012; de Sousa Borges, Durelli, Reis, & Isotani, 2014).

Pervasive games and gamified applications do have similarities, however, as both are integrated to the daily lives of the people or players (Montola et al., 2009; Deterding et al., 2011). Observing the blending of daily life and gameplay can be difficult in research conducted using in the wild methodologies (Chamberlain, Crabtree, Rodden, Jones, & Rogers, 2012). In addition, a research game construct can be perceived as an intervention to daily life. Therefore, there may have been external factors and aspects that have not been considered in this thesis.

Although player experience is a focus of the thesis, only selected aspects of player experience, such as memorability or co-presence, are targeted. Other aspects, such as flow or presence, are addressed, but they were not primary targets in the field trials.
1.2 Research questions and contributions

This thesis aims to answer the following research questions (RQ).

**RQ1**: What game specific realities, i.e., layers, can be identified in a hybrid space environment?

**RQ2**: What tethers, i.e., synchronizable elements, are there between the identified layers?

Answering these questions will provide insight into how the hybrid space layers, e.g., the different realities (whether they are VEs or the backstory of the game), can be interwoven by game design that takes these layers and transitions between them into consideration.

The contributions of this thesis are divided into a theoretical part (Contribution A) and constructive research (Contribution B). This thesis is based on six original research papers, one of which describes a review-based characterization of location-based mobile games (Contribution A) and five of which are based on constructive research (Contribution B). The individual research contributions related to each original article in this thesis are:

**Publication I**: A review-based categorization of current location-based games (I) where the changes in the game arena of LBMGs are outlined and the characteristics of current games and the game space are described.

**Publication II**: A construct called Props to observe the storytelling potential in hybrid space and the significance of spatial similarity between the physical and virtual locations (II).

**Publication III**: A construct called Street Art Gangs for observing the balance of displacement and emplacement in hybrid reality games and the limitations of embedding virtual environments into the physical game scene (III).

**Publication IV**: A construct called Campus Knights, a mobile location-based game for observing the potential of using situated displays as Windows on the World (Feiner et al., 1993) to mirror world like VEs (IV).

**Publication V**: A construct called City Knights for exploring the use of mirror world like VEs in correct spatial context and the relationship of that context to memorability of the VEs (V). Furthermore, City Knights was used to study the
nuances of social interactions, specifically the subtle differences in co-presence during gameplay.

**Publication VI:** A construct called *Here ‘n There* for exploring the possibilities of using the balance of displacement and emplacement in game design and to explore the emergent sociability and ludic markers for player-player observation in location-based games using a truly mobile (i.e., map-based) depiction of the physical game arena (VI).

The constructive research was conducted using a variety of games that were specifically designed and implemented for this research. These pervasive research games, i.e., constructs, depict a variety of different virtual environments embedded into the physical game space (Figure 2).

![Fig. 2. Examples of the game constructs realized under this research: (left) Props (Publication II © 2014 Elsevier) storytelling system combines virtual and physical stage in CAVE environment to a hybrid stage; (middle) aesthetically and semantically similar virtual environments are linked through situated pervasive displays in City Knights (Publication V © 2018 Springer); and (right) truly mobile map-based depiction of the physical game area is used to visualize player locations in Here ‘n There (Publication VI © 2018 Sage).](image)

To be able to research specific aspects in designed and developed pervasive location-based games and player experience, an *in the wild* research approach is used. Pervasive games by definition pervade in the city walls and can be deeply rooted in the technological infrastructure of cities. They also pervade the daily lives of the players. The aforementioned features make the games inseparable from the urban and daily life context; therefore, they are an ideal target for *in the wild* research (Montola et al., 2009; Chamberlain et al., 2012). The purpose of this thesis is to develop a conceptualization for understanding current pervasive location-based mobile games in a way that is not just based on current theories on pervasive
and, more specifically, hybrid reality gaming, but also validated in field trials conducted in the true context of pervasive games, in the wild.

A mixed methods approach is used in data collection and analysis where both qualitative and quantitative methods are used to gain comprehensive knowledge from field trials. Qualitative data is collected through semi-structured interviews, video recordings, and field observation notes. Extensive quantitative data is collected through game analytics, e.g., logging the use of a game, which is a traditional part of data collection in games research. The guiding principles for the field trials and data analysis are applied from conducting interpretive field studies in information systems (Myers & Klein, 2011). In addition to the above described constructive research, this thesis has a theoretical contribution provided by a review-based characterization of current location-based mobile games.

1.3 Overview of the thesis

In chapter 2, the conceptual space of this thesis is outlined. The changes that have taken place in the past decade on pervasive gaming and location-based mobile games are highlighted, as they are the main justification behind presenting new conceptualization for designing pervasive games. In addition, the theoretical background of this thesis is presented by framing the three distinct elements (metaphors) that combine the different realities in pervasive games. These metaphors are: “true mobility,” “true sociability,” and “synchronicity.” The latter is a result of the efficient mapping of the digital and physical environments, an ideal that is not attainable in all cases. Although location awareness is crucial in these types of games, there are other synchronizable elements that can be used to bind game realities together. Recognizing the realities that constitute the environment for pervasive games is the target of RQ1. Identifying the synchronizable elements between realities is the focus of RQ2.

In chapter 3, the experimental setup is described. The context of pervasive games is described and specified as the justification for selected research methods. The timeline of the work as well as the generalization of the individual research contributions and specifics of the field trials presented in this thesis are outlined.

In chapter 4, the conceptual research part, Contribution A (I) is presented by explaining the research aim and key findings from an extensive review of current location-based mobile games.

In chapter 5, the experimental work (II-VI) in this thesis is described in chronological order. The constructs’ gameplay, design, and implementation are
outlined as well as the field trial setups, research aims, and key findings from each trial.

In chapter 6, the results are discussed in light of the research questions and literature. As a result, the synchronizable elements in pervasive location-based games, including the recognized layers of realities in the hybrid space of pervasive gameplay, are described. Chapter 7 concludes the thesis and sums up the research contributions.
2 Related research

In traditional games, there are boundaries that separate gameplay and daily life. Once inside those boundaries, the player is enveloped inside a distinguishable magic circle (Huizinga, 1955). The phrase pervasive game has been widely adopted to describe a game type that escapes from the boundaries of a clearly defined magic circle and pervades the strata of technological and social structures of modernity (Montola, 2005; Stenros, 2012).

Pervasive games constitute a widely varied genre of games that has a plethora of subcategories based on such things as the main design inspiration, utilized technology, or game mechanics on the field. What the games have in common is that they aim to expand what is considered traditional gaming and, oftentimes, they take place in physical city streets with varying levels of digital mediation (Montola et al., 2009; Benford & Giannachi, 2011). The current design principles, guidelines, and suggestions are so comprehensive that they may lack practicality. They also stem from the work done mainly on first generation pervasive games released before 2009 (Guo et al., 2010; Kasapakis & Gavalas, 2015) and could benefit from an update, as we are currently on the brink of beginning to play third generation pervasive games.

2.1 Pervasive games and urban play

Pervasive games are tightly coupled with the daily life of the players. The hybrid environment that acts as a game arena can be coupled with daily life, which adds to the complexity of the actual game arena (Montola, 2005; Montola et al., 2009; de Souza e Silva & Sutko, 2008; de Souza e Silva, 2009).

The main approaches to pervasive games can be crudely divided into technological and cultural. In the cultural approach, the aspects in gameplay that defy traditional gaming are central. In technological approaches, pervasive games are considered ubiquitous technology applications that would not exist without technology (Nieuwdorp, 2007; Valente, Feijó, & Leite, 2013; Valente, Feijó, do Prado Leite, & Clua, 2017). These approaches overlap in practice and there is a plethora of pervasive games subgenres. Making a distinction between them is not straightforward. Depending on the game mechanics or the utilized technology, there are a variety of subgenres or alternate names to these games. Spatially pervasive games can span from earth scale geogames (Montola et al., 2009) to the guts of the players as with indigestible games (Li, Brandmueller, Greuter, &
Mueller, 2018). Socially, they can expand from augmented tabletop games played at home (Benford et al., 2005; Montola et al., 2009) to games that are designed to adapt to changing social environments (Eriksson, 2005) or involve unknowing bystanders in gameplay (Kirman, Linehan, & Lawson, 2012). Temporally, the games can last indefinitely and take place at the time of the day that is traditionally reserved for daily life (Pokémon GO!, 2016). The following table presents a differentiation of pervasive game features and a broad categorization of them. The list is not exhaustive as there is a plethora of pervasive game genres characterized by specific game features (Table 1).

Table 1. Features of pervasive games and what aspect of the physical world these features are tied to (Eriksson, 2005; Benford et al., 2006; Derkker & Champion, 2007; de Souza e Silva, 2009; Magielse & Markopoulos, 2009; Benford & Giannachi, 2011; Southerton, 2013; Blum, Wetzel, McCall, Oppermann, & Broll, 2012; Klausen, 2014; Kamm & Beckerm, 2016; Li et al., 2017, II, III, IV).

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Feature</th>
<th>Example/Genre</th>
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<tbody>
<tr>
<td>Technology</td>
<td>True mobility</td>
<td>Location-based mobile games</td>
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<tr>
<td></td>
<td>Integrated VE (Map-based or 3D)</td>
<td>Mixed reality games</td>
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<td></td>
<td>AR</td>
<td>Hybrid reality games</td>
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<td></td>
<td>Ubicomp games</td>
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<td>Culture</td>
<td>Narrative</td>
<td>Cross media games</td>
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<td></td>
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<td>LARPs</td>
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<td></td>
<td></td>
<td>Interactive storytelling (Board game adaptations)</td>
</tr>
<tr>
<td>Game Arena</td>
<td>Sociability</td>
<td>Socially adaptive games</td>
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<td></td>
<td>Scale</td>
<td>Geogames</td>
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<tr>
<td></td>
<td>Time</td>
<td>Many commercial games</td>
</tr>
<tr>
<td>Mind</td>
<td>Emotion</td>
<td>Affective gaming</td>
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<td></td>
<td>Suspension of disbelief</td>
<td>Mixed reality games</td>
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<td>Mental models</td>
<td>Hybrid reality games</td>
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<td>Embodiment</td>
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<td>Body</td>
<td>Player Physiology</td>
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<td>Ingestible games</td>
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The individual games can belong to more than one category. As an example, a well-known pervasive game, *Pokémon GO*, is a mixed reality game with a map-based
virtual environment. The map view is the main interface to the game reality for the players. The game relies heavily on location data and could also be categorized as a location-based mobile game or location-aware mobile game. The scale of the game’s physical distribution, wide popularity, and the utilization of geocoordinates make it a geogame; one can play Pokémon GO almost anywhere in the world at any time. Although Pokémon GO is also called an augmented reality game, it is notable that the AR feature of the game is not necessary for gameplay (Niantic, 2016; Montola et al., 2009; Paavilainen et al., 2017). A specific form of pervasive games are hybrid reality games that combine realities via mobile interfaces and through social interactions. Urban context, mobility, sociability, and location awareness are the key qualities of hybrid reality games (de Souza e Silva, 2006, 2009). Pokémon GO would fit this category as well, at least when it is played in an urban environment, as it is a game that is played with mobile phones and the game reality is tightly coupled with location data.

In addition to pervasive game genres, the definitions of “the pervasive game” can vary. Montola describes pervasive games as games that expand traditional gaming:

“Pervasive game is a game that has one or more salient features that expand the contractual magic circle of play socially, spatially or temporally” (2005, p. 3).

His approach is cultural, and the definition is ludological. This approach encompasses play and playful appropriations, not just digital games (Huizinga, 1948; Nieuwdorp, 2007; Valente et al., 2013). He admits that pervasive games may require ubiquitous technologies, yet he also states that none of the expansions require technology (Montola, 2005). There are alternating views where the ubiquitous technologies and gameplay in pervasive games are considered inseparable (Benford et al., 2005; Walther, 2005b; Hinske et al., 2007):

“Pervasive Games are a ludic form of mixed reality entertainment with goals, rules, competition, and attacks, based on the utilization of Mobile Computing and/or Pervasive Computing technologies” (Hinske et al., 2007, p. 12).

Walther (2005a, 2011) states that pervasive games are play applications of pervasive technologies. He highlights the explicitness of computational tasks and physical space in his definition:
“Pervasive gaming implies the construction and enacting of augmented and/or embedded game worlds that reside on the threshold between tangible and immaterial space, which may further include adaptronics, embedded software, and information systems in order to facilitate a “natural” environment for gameplay that ensures the explicitness of computational procedures in a post-screen setting.” (2005, p. 114)

As one can see, whether pervasiveness is considered a property that separates these games from traditional games or games that utilize pervasive technologies, there are many alternate and, in most cases, overlapping definitions. The pervasive games genre is wide and contains many subgenres. One can be practical when approaching the dilemma of defining pervasiveness in games and simply ask what makes a game pervasive. Is it the technology that is used to play the game or the way the game is played in the physical world setting, or both (Nieuwdorp, 2007; Valente et al., 2013)?

Kasapakis divides pervasive games into three generations based on how advanced they are. He states that earlier categorizations focus on what he would call first-generation games which renders the earlier categorizations in some parts obsolete (Magerkurth, Cheok, Mandryk, & Nilsen, 2005; Kasapakis & Gavalas, 2015). Temporarily, his division is such that games released before 2009 are first-generation and games released after are second-generation. The third-generation games are those that we are on the brink of inventing as virtual environments, augmented reality, sensor networks, and built-in sensors are becoming available and integrated in wearable and mobile devices. Currently, it is not the technology that is preventing us from having third generation pervasive games, but the low adoption rate of those technologies by the public. In addition, new technologies are oftentimes used in simple game prototypes to explore the use of that particular technology in games (Kasapakis & Gavalas, 2015; Seneviratne et al., 2017). Valente (Valente et al., 2017) provides a detailed taxonomy, or categorization, of pervasive mobile games. His categories are based on social and technological (ubiquitous) aspects of gameplay. Although his categorization is relatively recent, it does present some outdated perceptions regarding the technical aspects in gameplay. Game autonomy (accessibility), persistence (permanence), and transmediality and device interdependence (autonomy) are somewhat obsolete as they are not defining characteristics in current games that are played on a global scale around the clock. This is due to technological advancements that have taken place in the past ten years of pervasive gaming (Calabrese et al., 2015; Farman, 2013; Kaluža et al., 2017; Kasapakis & Gavalas, 2015; Peña-Ríos et al., 2017; Sheller & Urry, 2006).
2.2 How has the game arena changed?

There have been significant changes in the environment where pervasive games, especially location-based mobile games, are set. These changes are tied to more sophisticated methods for game analytics and game event orchestrations, true mobility provided by mobile phones, and the ubiquity of localization technology. Early twenty-first century game events were by no means unsuccessful, games such as BotFighters (Sotamaa, 2002) span across three countries and Geocaching (Geocaching, n.d.; Neustaedter et al., 2013) was, and remains, a niche pastime distraction for many. But the games have been somewhat marginal and the potential for mass success (Flammer et al., 2009) unattained. The sudden commercial success of Niantic’s games Ingress (Niantic Labs, n.d.; Chess, 2014) and Pokémon GO (Niantic Inc., 2016; Paavilainen et al., 2017) are further indicators of the changes in the game arena. The developments on the game field warrant a division of past and current games into 1st–3rd generation games (Kasapakis & Gavalas, 2015). The changes affecting LBMGs and urban pervasive games or the achievements of the past two decades can be summarized as follows:

- True mobility of the gaming devices (Farman, 2013; Sheller & Urry, 2006; de Souza e Silva, 2009)
- Increased precision in localization (Kaluža et al., 2017; Peña-Rios et al., 2017)
- Better connectivity (Calabrese et al., 2015)
- Less orchestration per player (Kasapakis & Gavalas, 2015; I)
- Increased number of commercial games (I)

Orchestration is the upkeep required to host a pervasive game event. It has become easier due to technological advancements. Kasapakis & Gavalas define it based on Benford’s description:

“Orchestration refers to techniques, human support (e.g., actors), and infrastructure used by developers to manage live game action behind the scenes” (Benford et al., 2005; Kasapakis & Gavalas., 2015, p. 2).

Orchestration has been considered inseparable from and, to some extent, even beneficial to pervasive gameplay (Benford et al., 2003; Crabtree et al., 2004; Yule, MacKay, & Reilly, 2015). The amount of manual intervention on gameplay per player has gone down significantly from the early pervasive games (Kasapakis & Gavalas, 2015; I). Some forms of orchestration are still beneficial. Unarguably, quick response (QR) codes are still a usable way of embedding location-based
content, especially in the context of small museums, the charisma of the game host is key in small pervasive game installations, and observers on the streets keeping an eye on the players are beneficial for research (Linaza, Gutierrez, & García, 2013; Xu et al., 2012; Yule et al., 2015). Yet a global launch of a pervasive game would not be possible without highly automated game analytics and upkeep of the game’s status on servers.

2.2.1 True mobility

The technological facilitation of mobile gaming has improved since the early twenty-first century and, at the same time, there are more and more people adopting smartphones and embracing their features. One metaphor encompasses these changes well, true mobility (Farman, 2013; Lucero, Jones, Jokela, & Robinson, 2013). Current smartphones house computing power and provide connectivity and localization in a way that mobile devices used in early pervasive gaming did not.

The first commercial phone to contain GPS was launched on the market in 2002. At the same time, extra GPS modules for handheld personal digital assistants (PDAs) became available (Kaasinen, 2003). The PDA GPS module combination was used in early pervasive games (Kasapakis & Gavalas, 2015). The following is a quote from Sotamaa on the then-current limitations of mobile gaming:

“It’s obvious that a mobile phone has its limitations as a gaming device. Since lately the displays have not supported any multicoloured visuals that are quite essential in most of the video and computer games. Also the input methods are very limited in a mobile phone. . . Likewise the basic communications protocols (SMS, WAP) are not designed for gaming purposes.” (2002, p. 40)

At that time, the mobile interfaces had not matured enough to make the device an effective game controller, whereas the affordances of touch screens and projected visuals on the screen to create various types of interfaces are very different nowadays (de Souza e Silva & Sutko, 2008; Farman, 2013). There have been improvements with the computing power of the gaming devices as well. The current phones have built-in A-GPS and connectivity via a 4G mobile network all in a package that fits inside a pocket and weighs less than two hundred grams (Samsung, n.d.). Smartphones are widely adopted and, indeed in urban environments, are found in almost everyone’s pocket (Zhang, 2017) which further makes it possible for current pervasive games to achieve true blending with daily life.
2.2.2 True sociability

Better connectivity and a more widespread adoption of smartphones (Lehtonen & Mäenpää, 1997; Lucero et al., 2013) has paved the way for true sociability in the urban environment and has induced social implications for pervasive gameplay. The scale of these implications spans from interaction between individual people to citywide or global impact. Social aspects in gameplay have been found to be a key motivator for location-based games such as Geocaching and Pokémon GO (Gajadhar, 2008; O’Hara, 2008; Vella, 2017). Social interaction is perhaps not always fun (Paavilainen et al., 2017) and can be unpredictable or even scary (Lehtonen, 1997; Montola et al., 2009).

As pervasive games have the potential for various types of social interactions, there are recommendations on how to distribute these interactions in the game space. How much control there can be is defined by the accuracy of localization (Chalmers et al., 2004), although there are suggestions for using game related objects, such as pervasive displays, as hubs for collocated gameplay (IV). In Pokémon GO, the PokeStops and Gyms are fictive in-game digital items. Their location is tied to physical landmarks; this brings conceptual accuracy to the locations and provides an opportunity for the players to bump into each other (Pokémon GO, 2016; Paavilainen, 2017), which is why they can also be considered digital hubs for collocated gameplay.

Increased sociability, amongst the other pervasive gaming induced behavioral changes, has been observed, especially amongst Pokémon GO players (Kari, Arjoranta, & Salo, 2017; Schuller, Dunwell, Weninger, & Paletta, 2013). Although the idea for using pervasive games in sociability training has been around for a while, the possibilities of using pervasive games for positive behavioral change are somewhat unexplored, albeit simple game-like sociability training applications already exist (Schuller et al., 2013).

De Souza e Silva’s theoretical framework for hybrid reality gaming (de Souza e Silva & Sutko, 2008) is highly influenced by the sociability and connectivity brought on by mobile phones. Her framework has three dimensions:

- The playful characteristics of everyday life, based on the ontology of play (Fink, 1974) and street sociability (Lehtonen & Mäenpää, 1997).
- The effects of gameplay and the organizations of social mobile networks in urban spaces, which is founded on the collective action theory (Bimber,
Flanagin, & Stohl, 2005), new mobilities paradigm (Sheller & Urry, 2006), and the concept of smart mobs (Rheingold, 2002).

- Mobile technologies as playful interfaces, which originates from the first two dimensions.

The defining characteristics for hybrid reality games are mobility, sociability, and location awareness. It is notable that hybrid reality games are, by definition, urban and cannot be played without technology, i.e., mobile devices, which separates this definition from the purely ludological (Montola et al., 2009) definition of pervasive games. The location awareness and social connectivity mediated by mobile devices are essential as they function as many-to-many or multiplayer social interfaces, and the critical mass of infrastructure and people for hybrid reality gaming can only be found in urban environments (de Souza e Silva & Sutko, 2008).

2.3 Space, place, and location-based mobile games

Not just the common conception, but also the philosophical concept of space has been reshaped by advances in current technologies, especially in connectivity and communication. Urban space is no longer considered constant. It is in flux as people move by, embody it, and reshape its use (Falcão et al., 2010; Farman, 2011; Lefebvre, 1991). The process of space becoming a place is called place making; however, the place created is as dynamic as the antecedent space (Lefebvre, 1991). Pervasive location-based games can alter the perception of space for the players. Location-based games create new meaning for familiar places; gamers may become familiar with the networking hotspots of their town, and this knowledge carries on to their behavior outside gameplay (Broll, Ohlenburg, Lindt, Herbst, & Braun, 2006; Sotamaa, 2002; Tiensyrjä, Ojala, Hakanen, & Salmi, 2010). The location-tied contents and narrative affect the place identity of urban environments. Place identity itself can be divided into three components: the physical setting, the activities, and the meanings (Relph, 1976), in other words, schemas associated with the place. Other semantic qualities for place meaning can involve distinction, valuation, continuity, and change (Gustafson, 2001). These subjective place meanings become part of people-place relationships through daily life (Mäkinen & Tyrväinen, 2008).

Many pervasive games use localization techniques, though location-based mobile games are a subgenre of pervasive games in which the game mechanics are closely coupled with location data. There are plenty of options for localization, and
the technology and computing methods for indoor localization are advancing rapidly (Kaluža et al., 2017; Peña-Rios et al., 2017). The locations used in games and other location-based experiences can be tied to physical objects, such as quick response (QR) codes (Soon, 2008; V), radio-frequency identification (RFID) tags (Rashid, Bamford, Coulton, Edwards, & Scheible, 2006), or Bluetooth (Kirman et al., 2012). One of the most popular methods in location-based mobile games, however, is using purely digital localization data from assisted global positioning system (A-GPS). Since the technology is available globally and embedded in current smartphones it is a part of the ubiquitous infrastructure of modern cities. Using A-GPS also makes it possible to tie gameplay to locations without having to visit them, whereas planting QR codes or other tags globally for launching Pokémon GO would have been quite an ordeal.

Although many of the early twenty-first century geocachers used handheld GPS devices to locate the hidden caches (Webb, 2002), the location-based mobile games played in the early twenty-first century relied on backpacks full of gear (Benford et al., 2006) or separate GPS modules for slightly less accurate localization than A-GPS (Figure 3). Self-reporting, i.e., the players informing the game orchestrators of their location, was also explored as a localization method, although the use of self-reporting was advised against even when the ambiguity of location data was considered (Benford et al., 2004). The vast availability of automated localization has been one of the factors that has diminished the orchestration requirements of current location-based games. It has also improved the mobility of the players as they no longer must carry specialized equipment to play the game. The blurring of boundaries between daily life and gameplay is better achieved when the device used for both is at hand all the time.
Using localization technologies in location-based mobile games can be done with ingenuity that goes beyond just adding points of interest in a city. In A-GPS data, there is significant spatial variation in accuracy (location inaccuracy), which can be used to distribute players more randomly inside the game area (Chalmers & Galani, 2004) or be considered part of the natural unpredictability of the environment and one of the elements that brings excitement to pervasive gameplay (Crabtree, 2004; de Souza e Silva, 2006). Self-reporting and ambiguous A-GPS locations can be mixed in gameplay to provide game mechanics with a twist or just to provide the players more freedom of movement as they can choose where and how their location is projected to other players (BITLANTIS, 2017; IV). There is a layer in the cognitive place making process of the players that stems from the modern conception of space and lies between the emplacement and displacement or misplacement felt by people engaged in the use of their mobile devices.

### 2.4 Designing pervasive games

Much of the preceding research on design suggestions or guidelines for pervasive games has a technological starting point. The games are often categorized based on

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**Fig. 3.** Infrastructure used for localization. The complexity of the infrastructure can only be rivaled by the complexities of the computational methods also required in acquiring location data (Maghdid, Lami, Ghafoor, & Lloret, 2016; Peña-Ríos et al., 2017). In current state LBMGs, all of these require a mobile phone at the client’s side.
the underlying technology (Table 1) or the technological challenges encountered in designing games when there are technical limitations (Magerkurth et al., 2005; Broff et al., 2006; Valente et al., 2013). The *seamful design* concept has its foundation in recognizing technological hindrances and utilizing them in design. This is a popular starting point for pervasive games design (Weiser, 1994; Chalmers & Galani, 2004; Chalmers et al., 2005). Many pervasive games are inspired by the features of the physical environment or technical problems, and ambiguities in data or connectivity, technology is not present in the design frameworks, as depicted Figure 4. Digital exergames can be considered a form of pervasive game in which the existing design frameworks and the physicality of the players is taken into consideration. Despite Mueller and Young’s (2017) theoretical lenses for framing exergames as design oriented and grounded in philosophy, they contain technological considerations that frame the environmental possibilities, or *technology opportunities*, of exergames and make it easier for a designer to envision the future design space of exergames.

Integrated Project on Pervasive Gaming (IPerG) was a four-year project that produced several classic pervasive games, prototypes, and guidelines. In addition to publications, the project released deliverables that contained design kits, updated guidelines for pervasive games, and design guidelines for specific game types such as cross-media or socially adaptable games (Björk, Holopainen, & Lundgren, 2006; Björk, Eriksson, Holopainen, & Peitz, 2008; Crabtree & Oppermann, 2005; Montola et al., 2005; Paavilainen et al., 2009). Montola et al. (2009) provide a summary of these by describing design strategies for pervasive games in a holistic and pragmatic way. Their instructions are based on experiences of a wide variety of play, spanning from live action role-playing to digital pervasive games. The instructions are still quite useful despite being based on games staged before 2009. However, they themselves state,

> “Although we have tried to cover the major strategies found in the pervasive games of today, we are convinced that many more will emerge as a result of pervasive games maturing” (Montola et al., 2009).

Valente et al. (2013) present a technology inspired checklist of sixteen items for developing pervasive games; the list can also be used to guide designing gameplay as it describes the elements that contribute to game mechanics, such as the five strategies for handling technical limitations, known as the *uncertainty handling policy*: remove, hide, manage, reveal, and exploit. The example for revealing network issues for the players and letting them decide how to act is showing the
coverage in the game, which could also be interpreted as a design suggestion. One limitation in Valente’s checklist is that his review is restricted to mobile multiplayer games, although the selection boundaries are defined to include location-based mobile game features (Valente et al., 2013).

The observations of player behavior in the game field challenge the more traditional view on the relationship of gameplay, rules, and the physical world (Figure 4).

One cannot predict how the players will use the game in pervasive gameplay. They oftentimes find unusual or unexpected ways of using the game application for observing each other or they create emergent minigames that take advantage of the appropriation provided by the game mechanics (Benford et al., 2006; I; III). Therefore, the rules (and restrictions) of gameplay should not be at the core but, instead, at the same level as other game elements (Figure 4, right). Surprisingly current is Harteveld’s triadic design principles for game design (TGD). The inspiration for TGD lies in the field of traditional video games, but Harteveld states that the same principles apply to games in the physical environment, or what he calls analogue games and computer supported analogue games. He separates the three main design principles of play, meaning, and reality at the focal point of a triangle, with the corresponding game genres of entertainment games, educational games, and engineering models (Harteveld, 2011). TGD is particularly popular in designing simulation games, but pervasive games fit inside this triangle as they blend play and reality with varying levels of meaning or purpose (Montola et al.,

Fig. 4. Traditional view on (left) rules, play, and culture (redrawn from Hinske et al. 2007) and an adaptation of the triadic game design components (middle) by Harteveld (modified and redrawn from Harteveld, 2014). The original has in the center “design space”, which has been replaced here with “pervasive games”. Illustrated (right) is how the relations could be perceived in pervasive games when the aforementioned principles are combined.
The meaning (or seriousness) in pervasive games can be completely emergent, as in unintentional sociability training or exercise (Kari et al., 2017), or designed into the game as in pervasive exergames (Southerton, 2013; Park et al., 2012; Zombies, Run!, n.d.). However, this aspect is emergent from the context of pervasive gameplay, e.g., the physical environment pervasive games are situated in. Culture, rules, and subsequent norms, in addition to play, shape pervasive game design and, consequently, pervasive games (Figure 4, right). These shaping elements are a result of the context of gameplay.

2.5 Presentations of city space: Abstract and virtual environments

The most commonly used interface for represented space, whether it is a virtual environment or a spreadsheet on a text editor, is the monitor screen with agency mediated by the click of a mouse or stroke of a keyboard. We have, however, been witnessing a shift in the mobility of visual interfaces from completely stationary to portable ones that fit inside most people’s pockets (Farman, 2013; Johnson, 1997). Location awareness and social connectivity provided by mobile phones are specific features of mobile interfaces that make it possible to create new types of games (Figure 5) (de Souza e Silva, 2009).

Fig. 5. LBMG players on the city streets: pervasive games combine true mobility of computing with the infrastructure and social opportunities of hybrid space (Publication III © 2015 Author(s)).
The game designers and developers act as world makers when creating traditional video games (Holtzman, 1994; Innocent, 2008). Despite simulation games being mostly associated with a high level of aesthetic realism, there are strategic or data simulation games where the simulation may be aesthetically very simple (Finzer, 2014; Grogan & de Weck, 2015). In simulation games, the level of realism of the virtual world can vary from abstract to fully realistic mirror world like (Gelernter, 1993; Harteveld, 2014) depictions; yet some aspects, such as data or the full architecture of the physical world are mapped into the virtual world, i.e., there is always at least a semantic connection between realities (Innocent, 2008). The same could be said about pervasive games, though the game world can be considered an overlay on the physical world of an alternate reality of sorts. Montola calls this more holistic form of world building in pervasive games reality fabrication, in which the game is designed to fit perfectly into the physical environment before it takes “a turn into more game like reality” (Montola et al., 2009). In location-based mobile games, the game overlay is digital whereas in live action role-playing (LARP), the overlay is narrative intense (Kamm & Becker, 2016). The level of abstraction of a virtual environment can vary from a simple map to a realistic mirror world like depiction of a city (Benford et al., 2006; Farman, 2013; Julin et al., 2018; II-IV).

Building a 3D environment for a game scene, even when procedural methods are used, requires a lot of resources (Ahearn, 2017; Akpan & Shanken, 2017). Realistic mirror-like representations of physical environments are readily available as 3D models to be used in various applications, including games (Biljecki, Stoter, Ledoux, Zlatanova, & Çöltekin, 2015). Efficient use of these models requires embedding them into the gameplay context in a meaningful way (Adams, 2014; Gelernter, 1993; Harteveld, 2011; Hunicke, LeBlanc, & Zubek, 2004). For current pervasive games, this embedding still requires specialized hardware, although viewing VE through a mobile screen is attainable (Schwebel, Severson, & He, 2017). In the classic location-based pervasive game Can You See Me Now (CYSMN) by Benford et al. (2006), players saw a 3D representation of their urban game arena, via their computer screens, over a decade ago.

CYSMN had parallel mirror-like VE for visualizing and observing runners, who were part of the game orchestration (Crabtree et al., 2004), while the players sat by their computer screens. I Like Frank and Uncle Roy All Around You are examples of similar games with VE and the physical world blending for a mixed reality experience. In these examples, the role of the player is fixed; in CYSMN the players on the streets are part of the game itself and the players in the virtual city scene are the participating players. In the two other closely related games, Uncle Roy All
Around You and I Like Frank, the role of the player is fixed to either a virtual city or the streets; however, the players are offered a free choice of what realm they play in from the start. The games are staged so that attendance by separated players on both sides of the physical and virtual streets is required for the game to work, distinguishing them from games where these environments would be truly blended for individual players. However, psychological misplacement was reported in CYSMN when players were able to glimpse a street runner on their screen and through an open window at the same time (Benford et al., 2006). These games present a good reference point in history when studying the evolution of location-based mobile games with VE as one hybrid layer, commonly known as mixed reality games (Benford & Giannachi, 2011; Hinske et al., 2007).

Just like the location-based mobile backpack games of the early twenty-first century, dynamic VR in a small scale indoor environment can be played with a backpack full of gear and VR goggles on. These installations, or VR arcades, are still far from truly mobile but show how the future of blending realities could be (Virtual Reality Game Zone | Helsinki | True VR, n.d.). Dynamic and truly mobile on-site blending of both virtual and physical realities via game design is still in its infancy (Gai et al., 2016). Yet, when map-based projections are included as VE layers, we suddenly have a plethora of truly mobile location-based games and applications, such as Pokémon GO (Niantic, 2016), Real Estate Tycoon (Reality Games, n.d.), and even Google Maps Navigation (Google, n.d.).

2.5.1 Views into the virtual

By analysts’ estimates, HTC has sold 420 000 units and Facebook/Oculus 240 000 units of their respective VR headsets during 2017 (Bol, 2017), suggesting a wide consumer acceptance of VR technologies. Despite this, Window on the World (Feiner et al., 1993), via a PC monitor, is still the most widely used way of accessing VEs (Burdea & Coiffet, 2003; Milgram & Kishino, 1994). Very large displays and immersive cave automatic virtual environments (CAVEs) are also well-established as Windows on the World in games, virtual environments and simulations (Cruz-Neira, Sandin, DeFanti, Kenyon, & Hart, 1992; Majumder & Sajadi, 2013). However, they are often deployed in restricted locations and there may be only one or a few such public displays in each city. The simplest and proportionally correct depiction of the physical world is a 2D map. When a map is viewed through a mobile interface, the mapped physical space is no longer an exclusive separate space, as it was during the days of paper maps. The interaction between the
represented and physical spaces is constructive and results in a new realization of space for the players (Farman, 2015). How the map reacts to the user’s orientation and location, in addition to how it projects routes and contents in relation to the physical environment, create a hybrid space (Farman, 2015; de Souza e Silva, 2006) which combines the digital map and the physical space together. The approach of using a map-based projection of the physical environment has been adopted by such games as Pokémon GO, Ingress, and Parallel Kingdom (Niantic Inc., 2016; Niantic Labs, n.d.; Parallel Kingdom, n.d.). In these games, the map reflects the environment in 2D, but many game-related digital items, such as player avatars and specific game locations, are shown in 3D. The advantage of map-based VE is that this makes the VE truly mobile and a more dynamic part of the gameplay.

2.5.2 Pervasive realities

The alternate realities in pervasive games do not have to be high definition 3D VEs. There are pervasive games where an alternate reality is built from the memories of the players. Rider Spoke is a game where players bike around the city and place memories and/or stories to corresponding locations. They can place audio snippets only on locations where there are no associated stories yet, weaving a tapestry of stories upon the city (Benford & Giannachi, 2011). In a game called Mythical: The Mobile Awakening (Björk et al., 2008; Holopainen & Waern, 2009) the game world is inhabited by mythical creatures and magic; the mobile phone interface provides the players a map to the game reality. In REXplorer (Ballagas, Kuntze, & Walz, 2008; Waltz & Ballagas, 2007), historical and mythological characters, “spirits,” are situated across the game arena of the city of Regensburg, Germany, and the game device, built specifically for this game, is a mobile detector for “paranormal activity” that signals the player when a spirit is nearby. In historical or museum applications, the story content and therefore the game is very location specific and the storytelling is one directional (Fencot, 2003; Knoller, 2010). Yet, games like Ingress also been noticed to mediate the transformation of local narrative to global and vice versa (Chess, 2014). What these games have in common is that their narratives form the alternate reality parallel to the physical game arena. In a similar way, any environmental data (Jacob, Nóbrega, Coelho, & Rodrigues, 2017; Lindt, Ohlenburg, Pankoke-Babatz, & Ghellal, 2007) can form an alternate reality on top of the city. The gameplay mediates these realities and the game mechanics determine the level and form of agency the players have. It is notable that in location-based games these realities can be tightly connected into a
multidimensional grid formed by the global coordinate system and the data currently provided by smartphones.

Avatars are players’ digital representations in the game reality. They can act as mediators between the virtual and physical. Although the use of avatars in games is widely adopted (Adams, 2014), how players relate to their avatars goes beyond slightly increased empathy. There is a suggestion that having an offline presence in a virtual game world in the form of an avatar causes a sense of displacement, similar to the displacement sensed in some location-based experiences and games. This sense of displacement is described as offline presence that extends to the physical self (i.e., real self) even when the physical self is not using the avatar (Behm-Morawitz, 2013; Belk, 2016).

2.6 Player experience in the context of pervasive games

The traditional metrics for player experience stem from the desktop computing paradigm. Pervasive game flow is quite different, however (Jegers, 2007). Csikszentmihalyi characterizes flow as a state of effortless and complete immersion into an experience. These moments he describes as “flashes of intense living against the dull background of everyday life” (Csikszentmihalyi, 1997, p. 1). Would we not like to think of a pervasive game experience as something similar? Yet there is a problem for research at the core of what makes pervasive games pervasive (independent of how pervasiveness is defined). Pervasive games are entwined with daily life and it is possible to achieve a flow state from activities that do not relate to gameplay, or it may be desirable that the gameplay does not drown the player in full immersion (Faccio & McConnel, 2017). Presence, in a similar manner, is one of the key aspects in player experience, but difficult to measure in the daily life environment (Slater & Steed, 2000; Usoh, Catena, Arman, & Slater, 2000).

Presence, according to Slater, has three aspects: the sense of being there, the individual’s recognition of what is there as real or present, and a memory of there as a real place (Slater & Steed, 2000). It can, additionally, be characterized as an everyday phenomenon and a basic property of a normal conscious experience (Seth, Suzuki, & Critchley, 2012). This would suggest that presence is, or can be, considered a basic property of pervasive games. This has not prevented game designers from focusing on presence when designing pervasive games (Holopainen & Waern, 2009; Kasapakis & Gavalas, 2017) — perhaps because it is such a well-known target for evaluation in traditional video games. Some means for measuring presence have drawbacks, however, that are a direct consequence of any experience
(virtual, digital, or physical) requiring a normal state of consciousness and some level of established engagement to the experience (Slater & Steed, 2000; Slater, 2002; Usoh et al., 2000). Presence, however, relates closely to immersive qualities of VEs (Cummings & Bailenson, 2016). The spatial simulation model framework (Wirth, Norris, Mapes, Ingraham, & Moshell, 2011) outlines the formation of presence into two constructive stages in which the user first creates a mental model, a schema, of the mediated environment (i.e., establishes that there is a there there). This stage is followed by acceptance of the environment as his/her frame of self-reference. The outcome of this process could also be called embodiment (Farman, 2013). Embodiment can happen through the same process in virtual environments (Cummings, 2016; Wirth et al., 2007).

2.7 Attention displacement between realities

Entwining mirror world like VEs, or more abstract realities, into urban pervasive gameplay so that attention displacement between physical and virtual is smooth requires a correspondingly smooth integration of the physical and the virtual. Although 3D models and their corresponding virtual environments have a meaning that is tied to their spatial structure and familiarity, meaningful experiences could be enhanced with designs that embed the virtual into the physical seamlessly. Further, the influence between physical and virtual environments can enhance player experience of such systems. Farman (2013) describes the interplay of mirror world like representations of physical reality (whether they are maps or 3D virtual environments) in mobile applications as "an experience of multiplicity" where the layering and the constant interplay bond the virtual and the physical together and create "the pleasure of experiencing virtuality."

Pervasive games entwine gameplay and daily life so that distinction between the two is not always clear. Embedding VEs into this context is not straightforward. If players are provided with access to both physical and virtual elements inside a single gaming experience, one or the other prevails in a way so the players, only on occasion, may take a peek into the other reality as in SAG (III), are immersed in tabletop VE like in CYSMN (Benford et al., 2006), or only share a communication link across the realities as was done in URAAY (Benford et al., 2004). There are only a few games where physical and virtual game scenes have been blended successfully. Typically, these feature a simple game scene shown on a mobile phone screen, e.g., a map enhanced with a few 3D objects and/or an avatar, providing a truly mobile VE, albeit with low aesthetic quality (Pokémon GO, 2016). Semantic
qualities are found to play a bigger role in the memorability of images than aesthetic qualities (Isola, Parikh, Torralba, & Oliva, 2011). Known landmarks make a realistic VE more memorable, this suggests that a similar link between semantic qualities and memorability exists for VEs (Mania, Robinson, & Brandt, 2005; Vinson, 1999).

2.8 “There is a there there,” layering of realities in a hybrid city

Hybrid reality games are pervasive games: they can be mixed reality games, location-based mobile games, or any game where there is a blending of conceptual realities by mobile technologies and social interaction. They can be defined as location-based mobile games that take advantage of localization. The resulting design elements of these games are mobility and location awareness, sociability, collaboration, and the configuration of the game space. How game space and playful spaces are defined by hybrid reality logic is what stands these apart from other conceptualizations of blending realities (De Souza e Silva & Delacruz, 2006; de Souza e Silva, 2009). Outside the dualism of mixed reality (Lifton & Paradiso, 2010; Milgram & Kishino, 1994), in which only virtuality and reality, i.e., the physical world, are perceived as the realities being mixed, there are a vast amount of possible adjacent realities. In pervasive games, these realities are then blended and blurred with daily life. Dual reality (Lifton & Paradiso, 2010) is not fixed on one axis, it is formed between reality and virtuality in an actuator mediated interplay between the two realities (Figure 6).
Fig. 6. Alternate views of the mixed reality continuum are both on one axis between virtuality and reality (top), Milgram & Kishino’s (redrawn from Milgram & Kishino, 1994) virtuality continuum (bottom), and Lifton and Paradiso’s (2010) dual reality where the dual reality lays more undefined between reality and virtual reality (redrawn from Lifton & Paradiso 2010).

Harvey and Sotamaa agree that “the imaginary level of city space” can contain the utopian plans and imaginations. The game narrative defines the meaning of in-game objects and locations and produces the sense of the game world. Yet the game world objects are not related to physical objects (Harvey, 1994; Sotamaa, 2002). The layering of realities in pervasive gaming is present in Walther’s more holistic definition of pervasiveness in which the computational tasks can be explicitly blended with the physical space. Physical objects are thereby opened to digital manipulation in a way which creates hybrid objects that exist within both the non-game and game worlds (Walther, 2005b). Walther also connects space with time at the conceptual level in a similar way that modern philosophies of space do and states that time provides space with depth, relations, and narrative (Lefebvre, 1991; Walther, 2005a, 2005b).

De Souza e Silva and Sutko’s (2008) definition for pervasive game space (Figure 7, right), or what they call hybrid space, highlights the blending of digital and urban play spaces. Mobility and the use of mobile interfaces is further emphasized and virtuality is perceived as a broader concept. VEs are any digital
spaces, such as social media platforms, chatrooms, and what they call represented spaces: the map-based or 3D VEs.

![Diagram of pervasive and hybrid reality game spaces]

Fig. 7. Pervasive and hybrid reality game spaces, (left) Walther’s definition of pervasive game space (redrawn from Walther, 2005b © 2018 Taylor & Francis), and (right) a depiction of de Souza e Silva’s hybrid reality game space and some of its key elements (illustration based on de Souza e Silva, 2008).

Lifton and Paradiso state that there are many axes on which the worlds can be compared, but the virtual-reality axis is the most significant; hence, the dual reality theory does provide a possibility for the hybrid reality, where also social interactions and communication networks are taken into consideration (Lifton & Paradiso, 2010). Where the hybrid reality (Falcão, 2010; de Souza e Silva, 2009) definition falls short is in recognizing all the blending realities and perhaps also in recognizing the ramifications of ubiquitous technologies at the background of mobile interfaces. Albeit opening the scope by adding more dimensions to the dualistic mixed reality (Lifton & Paradiso, 2010; Milgram & Kishino, 1994), this new logic has opened the door for recognizing and adding dimensions to what mixed reality and hybrid reality in an urban context can be.

There is hardly a divide between cultural (ludological) and technological approaches into pervasive gaming anymore. Technology is an integral part of the urban infrastructure and is required for pervasive games. New technologies tend to result in new kinds of gameplay (de Souza e Silva, 2009). The theoretical observations on pervasive hybrid reality games do, however, remain at the level of observing formation of space oftentimes combined with philosophies of time (Farman, 2013; Sharma,
Alharthi, Dolgov, & Toups, 2017). To achieve a holistic view on hybrid reality and its playful appropriations, one needs to capture the complexity of what lies outside the walls of space. Farman (2013) has a philosophical approach to how virtual and physical blend in pervasive applications. He steps outside of separating virtual and physical and states that virtual objects can create the same or similar effects as “real” objects:

“We might even ask, what distinguishes the “real” space when a virtual interaction offers a very “real” experience. Instead, by understanding the space of the digital and the space of the material to have constant interplay and permeability between one another, distinguishing the space of the virtual from the space of the real does not inform a nuanced understanding of pervasive computing space, mobile media space, or space broadly conceived.” (Farman 2013)

Spallazzo and Mariani (2018) approach the bridging of realities by objects from another direction: from physical towards the digital. According to the study, physical objects can be tied either by context or semantic meanings to the virtual, which gives these objects the capability to transcend between the game reality and physical reality, further tethering these realities together in a meaningful way.

The virtual representations of space and the physical space are not separate. They are not about to render each other away either, i.e., VEs will not make the physical environment obsolete, even though there would be a mirror-like similarity between the worlds (Farman, 2013). In hybrid reality games, the realities are superimposed representations of each other. They do not completely overlap but are interwoven by social interactions (de Souza e Silva, 2009). The social interactions are mediated by ubiquitous computing technologies, the mobile devices, networks, and localization (Lifton & Paradiso, 2010). The persistence of memory and experiences also play a role in how hybrid reality is shaped in a similar way to how modern space is shaped by an embodied interaction in time. When a person has a presence in a VE, even when they are offline, they still sense that presence and feel as though some part of them is in two places at once (Behm-Morawitz, 2013). To take things even further, the process of a digital story or game element becoming real is similar to that as described by Potter (1996) when he discusses representations of reality through social construction or human cognition: mental models, representations, and ideas; albeit he describes the formation of facts and gameplay as mostly fiction. Even social presence and communication in an online community can be perceived as a digital abstract space (Jones, 1998).
2.9 The three metaphors combining realities

The defining features of pervasive games were divided into four categories in Table 2: technology, culture, game arena, and perception/cognition. These categories are tied to the factors that bind together the game content (i.e., the game reality) and both the physical game space and the daily life of the players. The features contain true mobility and sociability under technological and cultural aspects, yet many features related to player experience are left outside the scope of these two metaphors. Based on the contemplation of the previous chapters, we state that mobility and sociability are metaphors for combining realities. In addition, based on the work presented in this thesis, we present a third metaphor: synchronicity (Figure 8). The first two metaphors have been made possible with the technological advancements of the past two decades and the third is in part due to them. In some cases (due to technical or other hindrances), all affordances in the game mechanics do not perfectly fall under these metaphors, but for combining realities efficiently, one needs true mobility, true sociability, and synchronicity. Synchronicity is a result of the efficient mapping of the digital and physical environments, but it also contains the aesthetic and semantic qualities that combine the realities at the access points or the points of contact between the realities.

Fig. 8. Three metaphors for combining realities and their relation to player experience in games spanning realities. Mobility and sociability are a part of the current setup for citywide pervasive games, synchronicity is further mapped in this thesis.
In the following, a new high-level thematic structuring for hybrid space layers and the aspects that combine these layers is proposed. This structuring forms the theoretical grounding for the work presented in this thesis. The framework is more detailed and holistic in describing the combining factors in realities than the existing paradigms, such as dual reality (Lifton & Paradiso, 2010) or the virtuality continuum (Milgram & Kishino, 1994). This thesis embraces hybrid reality logic in accepting that, especially in location-based mobile games, the alternate realities (the virtual worlds) can be abstract. In addition, the structuring is game specific. It must be acknowledged that the intensity of gameplay, even when the game is entwined with daily life, is slightly different than that of daily life (Klausen, 2014; Stenros, 2012; III), which also warrants a need for game specific structuring of realities.

Localization is perhaps the most studied synchronizable element in pervasive games. The use of location data in pervasive game design and how the gameplay consequently unfolds is not simple, however. There are many techniques and technologies for localization (Kaluža et al., 2017; Peña-Rios et al., 2017) and many ways of using the location data, or its ambiguity, in game design (Chalmers & Galani, 2004; Crabtree, 2004; de Souza e Silva, 2006). The role of physical objects as tethers between realities has also been established by previous research (Spallazzo & Mariani, 2018). The metaphors are linked to player experience, but the game features that fall under these metaphors combine the parallel realities (Figure 9) inside the hybrid space.

![Fig. 9. Layering of Realities, the layers that create the hybrid space for pervasive games.](image)
3 Experimental setting

The empirical research methods and overview of the constructs of this thesis are described in this section. In addition to the justification and the need for using in the wild methodologies (Rogers & Marshall, 2017) for field trials in pervasive games research. In addition, the material and data analysis are described for each trial. The specifics and more detailed description of each trial can be found in later chapters.

3.1 Designing pervasive research games

When designing a traditional video game for research purposes, a small alteration to a functioning game is enough to create a study condition (Bowey, Birk, & Mandryk, 2015; Martin, 2014; Ollila, Suomela, & Holopainen, 2008; Peacocke, Teather, Carette, & MacKenzie, 2015), whether the target of the research is the location of a head-up display (HUD) (Peacocke et al., 2015) or spatial analysis of scene design in Splinter Cell (Martin, 2014). Prototyping pervasive games for research purposes can be challenging, as they are, for the most part, novel games in which the context and pervasiveness play a major role in how the gameplay is shaped. Many aspects of gameplay or game mechanics can be emergent and unexpected (Benford & Giannachi, 2011; Montola et al., 2009; Ollila et al., 2008); therefore, the research games should be carefully designed. There are many things that should be considered when designing a pervasive research game. First, a well-defined magic circle is what separates classical video games played on a screen or in VR from pervasive games played oftentimes outdoors. Second, a sense of presence or flow when playing such games is easier to measure with somewhat distinguishable metrics. But when it comes to pervasive games, the blending with daily life makes the sense of presence in gameplay ambiguous, since presence can be considered an everyday phenomenon and a property of normal conscious experience. Therefore, isolating measurements of presence in experiences situated in an everyday environment can be difficult (Cummings & Bailenson, 2016; Seth et al., 2012; Slater & Steed, 2000; Usoh at al., 2000). It is notable however that pervasive games do retain the qualities of their game origin; the competitiveness and some of the intensiveness of gameplay persist. While using information technology the players endure conditions they would not endure in normal circumstances (Ylipulli, Luusua, Kukka, & Ojala, 2014; III). In addition, the element of enjoyment or entertainment is a natural part of games and play (Harteveld, 2011). From a ludological perspective, human nature is intrinsically
playful, and this playfulness comes across in our daily life (Huizinga, 1955). Consequently, the context of daily life can be assumed to be playful as well (Fink, 1974; Harteveld, 2011). These elements need to be taken into consideration when designing pervasive games for research.

3.2 In the wild field trials in urban context

It is not just the context of gameplay (the city streets) that is an integral part of pervasive gameplay but also the way it is entwined with the daily life of the players. Many aspects of game design can be inspected closer and researched in a controlled environment. Considering the complexity of pervasive games (Ollila et al., 2008; Montola et al., 2009; Benford & Giannachi, 2011), this would be an oversimplification, hence much of the justification of running in the wild research (Rogers & Marshall, 2017) applies for pervasive games in addition to the fact that the blending of the game space with everyday life cannot be observed in a lab environment. In pervasive games research, one must assume that a player is not a disembodied mind, but a person acting in a setting with continuity to his/her actions.

In the wild is a methodology coined when mere in situ was not enough to describe the full complexity of an uncontrolled experimental setup. The phrase was introduced decades ago by anthropologists (Quéré, 1996; Rogers & Marshall, 2017). They suggest an approach that takes research on topics with highly social and practical aspects away from the dialectical reasoning of empirical lab experiments and more towards exploration in the appropriate spatial and temporal contexts.

Research presented in this thesis is not purely ethnographical, as the games themselves represent an intervention. However, the games do blend with daily life to some extent and this blending is a defining feature of pervasive games, even if it is not always fully achieved. As pervasive games expand to the domain of daily life, they encompass elements such as social awkwardness, pleasure gained from acting against social conventions, coincidental or emergent incidences (Montola, 2011; Stenros et al., 2011), or “being a small part of a big game world” (Montola, 2011). Therefore, the same reasoning as when defending semi-ethnographical and interpretive approach, applies to the in the wild field research conducted for this thesis. The individual studies in the constructive part of this thesis were field trials, defined by Brown et al. (2011, p. 1657) as “testing new systems with groups of users in relatively unconstrained settings outside of the laboratory”.

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### 3.3 Contributions

The following Table 2 summarizes the contributions in the constructive research conducted for the thesis.

**Table 2. Summary of contribution.** Q=questionnaires, SI=semi-structured interview, VA=video analysis, QM=qualitative methods, MM=mixed methods, F=female, M=male, O=other, A=age, VE=virtual environment.

<table>
<thead>
<tr>
<th>Publication</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
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<tbody>
<tr>
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<td>Props</td>
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<td>Campus Knights (CK)</td>
<td>City Knights (CK)</td>
<td>Here 'n There (H'nT)</td>
</tr>
<tr>
<td>Method</td>
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<td>Field Trial</td>
<td>Field Trial</td>
<td>Field Trial</td>
<td>Field Trial</td>
</tr>
<tr>
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<td>In the wild (Downtown)</td>
<td>Semi-controlled (Indoors)</td>
<td>In the wild (Downtown)</td>
<td>In the wild (Downtown)</td>
</tr>
<tr>
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<td>9 (Pilot) + 12</td>
<td>9</td>
<td>9 + 13</td>
<td>3 + 3 + 2</td>
</tr>
<tr>
<td>Material</td>
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<td>Game Diary Observation</td>
<td>Field Observation Q 7-point scale</td>
<td>Field Observation Interview Q 7-point scale</td>
<td>Video Interview</td>
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<tr>
<td>Game Analytics</td>
<td>-</td>
<td>Mixpanel* Game Analytics**</td>
<td>Server log</td>
<td>Server log Unity Analytics</td>
<td>Server log</td>
</tr>
<tr>
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<td>CAVE Laptop Projector &amp; Canvas</td>
<td>PC</td>
<td>Situated Display</td>
<td>Situated Display</td>
<td>Mobile phone</td>
</tr>
<tr>
<td>Focus</td>
<td>Aesthetic qualities, setup, and storytelling potential</td>
<td>Displacement and emplacement, accessibility of VEs</td>
<td>Potential of pervasive displays as VE access points</td>
<td>Memorability of spatially realistic VEs, Co-presence</td>
<td>Player-Player observation</td>
</tr>
</tbody>
</table>

* (Mixpanel | Product and User Analytics for Mobile, Web, and Beyond., n.d.)
** (Easy Integration with All Major Platforms., n.d.)

The field trials of the research games presented in this thesis ran during 2013–2016. The publications describing them have been (or will be) published during the years 2014–2018, (Figure 10). One of the constructs, Props (II), field trial pilot was conducted as early as February 2013.
3.4 Material and data analysis

The constructive research method (Bang, Krogh, Ludvigsen, & Markussen, 2016; Koskinen, Zimmerman, Binder, Redstrom, & Wensveen, 2011) was used for the design, implementation, and in the wild research of this thesis. The field trials were all conducted using in the wild methodologies (Chamberlain et al., 2012). They were guided by the Klein and Myers guidelines for conducting interpretive field research, which were originally created for information systems research and not games; they are, however, adaptable to field studies using technological interventions (Klein & Myers, 1999; Myers & Klein, 2011). Klein & Myers (1999) describe interpretive research in organizational contexts, such as trying to capture a moving target, as relationships between technology, organizations, and people that are constantly changing. This is very similar to conducting research on games played in hybrid space, where the relationships between technologies, players, gameplay, and daily life are in constant flux. The guidelines were adopted to be used in the field trials mentioned in this thesis, apart from study II. In addition, they provided high level guidance in the analysis of interpretive qualitative materials. Apart from the theoretical contribution of this thesis, the methodology in the field trials is constructive research, where pervasive games were deployed and used to answer RQ1 & 2. Each construct, except study VI, was piloted before the field trials to assure that basic usability issues and technical weaknesses would not affect the research outcome. The Here 'n There (VI) game was not piloted because it was tested in the field during the design and development process.
The gathered material (Table 2) is comprised of rich qualitative data such as interviews, video recordings, player diaries, and game analytics data including location coordinates, player activity, and usage of the specific game applications. The data analysis varied depending on the quality and amount of the gathered material and the specific targets of research. The goal has been to report the field trial setup for the reader so that they gain a holistic view of events, which will facilitate critical inspection of the results gained from studies conducted in an unpredictable environment.

The research presented in this thesis has been conducted following the ethical requirements established by the Finnish Advisory Board on Research Integrity (TENK Guidelines | TENK, n.d.). Research data is stored so that it is not linked to personal information. Informed consent was requested from subjects and underage participants have provided signed consent from their parents. Only material that has been relevant to the research has been saved; for instance, location data of the subjects has been edited after the field trials to contain only coordinates inside the game area. Only anonymized transcripts and other anonymized data have been reported or shared by the researcher with fellow observers and researchers.
4 Contribution A: Characterization of location-based mobile games and the game space

The theoretical contribution of this thesis is, in part, founded on a review-based characterization of 30 current location-based mobile games, including many (10) commercial ones (I). The review was conducted as a systematic review, but the availability of the games (especially the commercial ones) made it possible to add a slight autoethnographic element, i.e., all available games were also played and tested as part of the review process. Selection of the sampled games was thematic, based on the search phrases “location-based game” or “location aware game.” The search was further refined to contain only games that can be played using mobile equipment, which resulted in the exclusion of many classic pervasive LBMGs such as CYSMN (Benford et al., 2006). The aim, despite the inclusion of a few classic games, was to be able to present a current state-of-the-art characterization of LBMGs.

4.1 Research goals

The idea of playful appropriations of ubiquitous technology and social possibilities of urban environments has existed for decades as pervasive playfulness. Most of the applications we have witnessed, however, are from the beginning of the twenty-first century and coincide with the wide adoption of mobile technologies (Kasapakis & Gavalas, 2015; Montola et al., 2009; I). There have been few commercially successful location-based games thus far and there has perhaps not been a need for understanding the requirements of commercial games when designing pervasive games. Despite this, the early games were academic research games or restricted game events. The justification for the research is founded on the changes in the environment where pervasive games of today are staged. These changes were already described in the background of this thesis and listed here to remind the reader.

- True mobility of the gaming devices (Farman, 2013; Sheller & Urry, 2006)
- Increased precision in localization (Kaluzia et al., 2017; Peña-Rios et al., 2017)
- Better connectivity (Calabrese et al., 2015)
- Less orchestration per player (Kasapakis & Gavalas 2015; I)
- Increased number of commercial games (I)
These changes warrant a new inspection of the characteristics of the current location-based mobile games (a subgenre of pervasive games) (Montola et al., 2009). The characteristics defined here also extend to describing the game space. The characteristics are based on the restrictions (and, to some extent, rules) placed on the players through game mechanics.

### 4.2 Key Findings

There are three dimensions in LBMG gameplay: *freedom of movement*, *player interaction*, and *interaction with the environment or the game* (Figures 11-13). These dimensions define the game space as a result of affordances and restrictions that are either enforced or suggested to players, i.e., they are a result of game design and game mechanics. *True mobility* is manifested as the possibilities for designing games for *freedom of movement* (Figure 11).

![Fig. 11. Freedom of movement as one characteristic of LBMG gameplay (Modified from Publication I).](image)

*True sociability*, in turn, can be seen in the dimensions of the *player-player interaction* (Figure 12). Although emplacement and displacement as a result of construction of space (Benford et al., 2006; Farman, 2011; III) are not mentioned in the graph itself, *freedom of movement* is considered to be the feature that promotes complexity of pervasive gameplay, which can result in a sense of displacement for the players.
Interaction with the environment frames gameplay through the interactable elements in the environment, which includes the digital game contents (Figure 13). This depiction drew inspiration from the hybrid reality logic brought forward by de Souza e Silva (2009). Sociability and community are amongst the defining features of urban pervasive games, i.e., hybrid reality games. The urban infrastructure is further utilized in games in a way that, despite the main interface for gameplay being the screen of the smartphone, the environment provides other opportunities for interaction. This is especially true in games that are set to urban outdoor spaces, as these game arenas are full of opportunities, obstacles, surprises, and danger.

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**Fig. 12. Player-player interaction in game space (Modified from Publication I).**

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**Fig. 13. Framing the game space through interactions with the environment. Here the specificity of the characterization for LBMGs can be seen as Props (II) is difficult to position on the graph (Modified from Publication I).**

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5 Contribution B: Constructive research

In the following subchapters, the constructs Props, Street Art Gangs (SAG), Campus Knights, City Knights (CK), and Here ‘n There (H’nT) are described. The design choices of each game construct are clarified. In addition, the field trials and the key findings from each trial are described.

5.1 Props

Visual displays for improvisational storytelling are not a new thing, in fact, they have been around since the days of cave paintings. Some old storytelling traditions such as kamishibai in Japan (Orbaugh, 2012) or kavat in India (Rukmini Bhaya, 2012) are reminiscent of the old days, but in recent years the story boxes have become increasingly digitalized. There are storytelling cubes, mats, and rooms where both physical and digital are combined to inspire children’s storytelling (Cassell & Ryokai, 2001; Sugimoto, Ito, Nguyen, & Inagaki, 2009). Props (Figure 14) is a game-like storytelling system that mediates improvisational and collaborative storytelling. The physical stage and the projected visuals of the virtual stage form a hybrid stage. The hybrid stage is shared by participants adopting the role of either storytellers, actors, or stage managers.

Fig. 14. Props storytelling system in action (modified from Publication II).
5.1.1 Gameplay

The virtual stage is modeled after a well-known stage in downtown Oulu, Finland. The participants have differing roles in the setup: they can be either actors, narrators, audience, or prop masters (i.e., the person or people setting up the virtual stage from the remote one). Each role differs in their agency to affect the story contents. The interplay of the participants contributes to the narrative potential (Fencott, 2001) of the overall system. The items on the remote virtual stage can be manipulated multiple ways by the prop master, and the changes are seen in real-time on the virtual stage. The UI also contains a button for placing a random background, scene, and item on the stage to inspire sudden turns in the storyline or to provide an easy option for affecting the story contents.

5.1.2 Design and implementation

Props was purposefully designed to extend physical space into the virtual city. In this case, the physical space does not need to have any ties to the virtual; the virtual stage can be projected to any surface, canvas, or inside a CAVE. In addition, the same virtual stage is accessed via a PC or laptop to gain access to the inventory of individual props for staging the projected stage. The players can size, position, and move their props on the stage or even on the surrounding streets.

![Fig. 15. Action shot of the Props “remote stage” and UI.](image-url)
The collection of props has been extended since, but at the time of the publication of the study presented in this thesis, the game contained three backgrounds, nine scenes, and 38 prop items and effects. Animation of the props and effects heightens the 3D effect and the illusion of the extension of stage space. The models and the effects were created specifically for Props to assure complementary aesthetic design when items are combined on stage.

The game is implemented on top of the RealXtend game engine for building collaborative 3D virtual worlds (RealXtend Tundra, 2012). The 3D scene is modeled after a performance stage and its surroundings (Figure 15). The 3D scene is viewed with dedicated viewer software that is available for Windows and Mac OS. The 3D scene can be hosted on a Meshmoon server in the cloud.

The usability of the Props system was evaluated (Alavesa & Zanni, 2013) by presenting the game as part of a children’s story hour during the 2013 Oulu Improvisational Theatre Festival with an experienced and active amateur improvisational performance group (Improvisaatioteatteri Uniikki Unikorni, 2010).

5.1.3 Field trials

Three field trials were staged, two with adolescents in differing setups (conference room and CAVE) and one with adults (Figure 17).

![Fig. 16. Props pilot study with children: a narrator and a performer (left) took over the physical stage as children (right) placed props and guided the performers (modified from Alavesa & Zanni, 2013).](image)
The first two field trials took place with adolescents between 14–16 years of age. The first field trial took place in a CAVE where two analyzable 50 minute storytelling events took place with 20 participants in total. The second field trial
took place in a conference room with two video recorded events and 17 participants in total. The last field trial took place in a CAVE with adult participants, average age of 36 years. Two storytelling events (i.e., field trials) with seven participants in total were conducted. All events were guided by members of the Unique Unicorn improvisational group.

5.1.4 Research goals and key findings

The aim of the research was to explore the narrative potential of mediated interactions in a storytelling environment that is staged in a less immersive setting (conference room), as opposed to a more immersive one (CAVE). Some observation was also made on the potential of the items in the prop inventory to inspire storytelling in audiences of all ages. In addition, the direction and the nature of influence between the environments (virtual, physical, and remote stages) and people participating in the collaborative storytelling was observed. Church-Murray’s (Murray, 1997; Church, 1999) aesthetic qualities of VEs, as defined by Fencott (2001), was used as the theoretical lens for analysis. The original model contains the elements and connectivity between four dimensions: agency, narrative potential, transformation, and presence and co-presence. Fencott’s model has been influenced by Laurel, Strickland, & Tow’s (1994) work on narrative potential in VEs. We updated it to better suit game-like playful systems by adding the element of *enjoyment*. Video analysis as well as analyzing the told stories were the main research methods.

The virtual environment in Props is adjoined via gameplay into the physical stage. The player roles show the influence of their actions through different affordances to both realities. In the physical environment, the influence is manifested as narrative. Therefore, the narrative potential was one target for research during the field trials. The findings show that an immersive setting influences the storytelling potential. The agency displayed by different age groups during improvised storytelling varied. Results show that the interaction from the direction of prop items and prop masters towards the narrators was dominant. The stories had only slight effect on how the prop masters set the hybrid stage. The digital game content was therefore an important mediator in creating narratives.
5.2 Street Art Gangs

*Street Art Gangs* (SAG) is a location-based mobile game that relies on the existing urban infrastructure and the capabilities of current smartphones. One part of the utilized infrastructure is the multiuser virtual city scene that can be accessed with a PC or Mac, by observing players. The virtual city in SAG is viewed with dedicated software called Meshmoon Rocket, which is a commercial version of the realXtend open source game engine for building collaborative 3D virtual worlds (Alatalo, 2011; Meshmoon Rocket, n.d.).

Fig. 18. SAG, (left) Virtual game scene (Publication III © 2015 Author(s)), (middle) a detail of a local landmark being virtually smudged with the tag of the team “Green Shamans,” and (right) a few snapshots from the mobile phone of one of the game participants, who was playing the game during his/her daily activities.

5.2.1 Gameplay

In SAG, teams of players compete for ownership of the town by occupying locations and marking them with their gang’s tag. The locations for tagging are situated in specific locations around downtown Oulu, Finland. The game application functions as the “spray can” for the players (Figure 19). In addition, the game status, the ownership of locations, is projected on the virtual city scene. Player avatars and a police officer, i.e., a non-player character (NPC), patrols the streets of the virtual cityscape. Considering the game mechanics, an important part of the game is the possibility for competing players to interrupt, i.e., “bust” other players’ tagging process and thereby gain points.
The competing teams in SAG are named by the colors (e.g., purple, green). Once a player acquires an ownership of a location (s)he gains 100 points. Players can also “bust” a player of a competing team while that player is tagging a location. They gain 10 points for each successful bust. If the busted player does not interrupt tagging (which takes 30 seconds to complete), (s)he can be busted multiple times. A tagging player can also get busted by the virtual policeman (a NPC) patrolling in the virtual game world. The availability of locations for busting or tagging is affected by the ambiguity of localization, hence a player can be physically quite far from a location while attempting either.

In the virtual game world, the players are portrayed as avatars dressed in their team colors (Figure 20). When a player gains ownership of a physical world location, graffiti of the assigned team color is shown at the corresponding location in the VE, hence the name of the game as “Street Art Gangs.”
5.2.2 Design and implementation

The virtual cityscape was expanded from nine to almost thirty blocks between the SAG pilot and the first field trial. The delay in the building process gave room for a truly incremental design and development process.

In the design, social aspects of pervasive gameplay were taken into consideration by having the participants play in teams. The following interference strategy was used for inspiring collocated gameplay between competing teams. The busting feature was added for this purpose. The game application was color coded for each team and the players wore beanies in their “gang” color to provide the players with a ludic marker (Montola et al., 2009) for identifying fellow players.
This was planned to enhance team bonding, i.e., community formation, considered to be one of the key qualities of hybrid reality games (de Souza e Silva, 2009). In addition, each team had a logo, a distinct tag in the VE, and a backstory. The game application can also be used to observe fellow players indirectly as it has a real-time leader board. “Busting” or attempting to bust fellow players can also be used to indirectly observe where other players could be.

SAG has a traditional client server architecture, comprised of two clients and two servers. One client was the mobile application for playing the game on the city streets and the other was the PC application for viewing the game status (and the location of the patrolling police NPC) in the 3D virtual city. Of the servers, one was for upholding and keeping the game status, and the other was for logging the player coordinates for research and real-time player tracking.

5.2.3 Field trials

Field trials were staged in downtown Oulu, Finland. The pilot game took four days and the consequent field trial took two days, so half of the game time was over a weekend. Two days before the beginning of the tournament, players took part in a preliminary lecture with an introduction into the gameplay, including guidance on how to access the virtual game world. In addition, player IDs were created, and they were given smartphones with a 4G mobile data plan and the game app readily installed; furthermore, links for the game diary were on the phone desktop. The players were instructed to play between certain hours — 18 hours a day in the pilot and 22 hours a day during the field trial. Their access to the game area (Figure 21) and application was not restricted. The suggested hours were there to make it possible to always have an observer in the field during the game time. The purpose of running the game for several days was to encourage and be able to observe blending of daily life and gameplay.

Players were male, aged 13–30 years. The pilot had three teams of three players, and the field trial had three teams of four players. In both trials there was one team that was notably less active during gameplay than the other teams.
5.2.4 Research goals and key findings

The research was explorative in the wild research with the goal of evaluating and applying hybrid reality logic in implementing and observing gameplay. No specific results were expected or targeted for analysis, albeit aspects of de Souza e Silva’s (2009) new logic on hybrid reality games was used to structure the results. The aim was to gain a holistic view on gameplay as the game trials took days and the players had to attend school or work while still actively playing the game.

The material collected was comprised of field observations, questionnaires, and self-reporting from the streets in the form of photos and game diaries. Game analytics (i.e., logging of player activity and coordinates) was also implemented into the game application, both the mobile application and the virtual game scene.

Key findings from the trials were that gameplay in the city streets is intense and the players endure conditions they would not endure when using ubiquitous technology in general (Ylipulii et al., 2014). The mobile game application also allowed the players to “see” around street corners and they used it to keep an eye on their fellow players’ movements and whereabouts. They acknowledged their presence in the virtual city street, e.g., felt the offline presence, despite the intensity of the gameplay and unavailability of the access to the virtual game scene. These factors affected the players’ perception of space and their strategies in gameplay.
In SAG gameplay, the virtual city streets were adjoined to the physical city street through what turned out to be a weak connection. The displacement the players sensed, in addition to acknowledging their offline avatar, were indicators of the linkage between their minds and the gameplay. Ambiguity of localization provided the players a means of having a presence in two differing, unlinked locations—in the physical environment and the digital game space. This linkage was further tethered by the affordances they had in adjusting their reported location when busting fellow players.

5.3 Campus Knights and City Knights

In City Knights (V) and Campus Knights (VI, Figure 22), medium-sized situated public displays (46” full HD LCD panels) are used as access points to a mirror-like virtual campus or city. The available computing power in displays may not be capable of rendering VRs, but many VEs can be visualized with web browsers supporting WebGL (Evans, Romeo, Bahrehmand, Agenjo, & Blat, 2014). Further optimization offered by game engines, such as Unity (Unity 3D, n.d.), makes it possible to display 3D environments on displays even with outdated hardware, which makes any pervasive display a potential Window on the World (Feiner et al., 1993). These displays have further potential as hubs for collocated gaming.

Fig. 22. Campus Knight in action: the view into the virtual campus is situated spatially to a similar location in the physical campus. The situated display offers a hub for collocated gameplay. (Modified from Publication IV 2016 © Author(s))
The types of displays used in Campus Knights are easy to move and situate; in addition, they are often found in several locations in most cities in the form of pervasive displays. They are also often connected to the internet, which makes them a more integral part of the computing infrastructure of the city (Kostakos & Ojala, 2013; Leikas, Strömberg, Ikonen, Suomela, & Heinilä, 2006; Tuulos, Scheible, & Nyholm, 2007).

5.3.1 Gameplay

Campus Knights and City Knights have three distinct game phases: quest phase, conquering a location, and “the boss fight.” Each phase is designed for a different type of social interaction. In the quest phase, the players search for specific locations marked by QR codes (Figure 23); the locations can be found based on clues given by the game’s mobile application. In Campus Knights, there was only one location where the players could get in-game currency for scanning the QR codes. In City Knights the number of quests was 42.

Fig. 23. City Knights gameplay, (left & middle) the QR codes were dispersed around the downtown area. (right) After conquering a location, the players gather around a display to get access to the game VE and boss fight. (Publication V © 2018 SpringerNature)

After the players feel they have collected enough potions, spells, and items using the in-game currency collected from completing quests, they can commence the conquering of a location. Locations are zone-like areas around each situated display; the zones are further divided into sections. The more players in a given section trying to occupy that location, the faster the location is conquered. More than one team can battle over the ownership of a location at once and thereby also battle over which team gets to the boss fight first (Figure 23).
5.3.2 Design and implementation

Many pervasive games utilize the rich narrative-driven design and strategies learned from role-playing games (RPG) by creating digitally enhanced live action RPGs (Falk & Davenport, 2004; Flintham et al., 2007a, 2007b; Montola, 2007; Reed et al., 2011). Acquiring experience and game currency from smaller side quests provides a foundation for the epic end battle, builds a strong backstory, and creates the possibility for emergent or multi-branching storylines. This tradition of allowing emergence suits the chaotic daily life environment where pervasive games take place. Campus Knights was, in a way, a pilot for City Knights’ game design by exploring the potential of using situated displays, such as Windows on the World (Feiner et al., 1993). In City Knights, the game’s VEs can be accessed via situated displays on site downtown.

Campus Knights’ and City Knights’ (CK, the acronym is only used when there is no need to make distinction between the games) high level architecture (Samodelkin, Alavesa, & Voroshilov, 2016) is the same, except that City Knights has a more refined real-time player tracking; furthermore, the virtual 3D world (e.g., the boss fight battle scene in Campus Knights) was hosted on Meshmoon Rocket (Alatalo, 2011; Koskela, Pouke, Alavesa, & Ojala, 2016; Meshmoon Rocket, n.d.) and in City Knights on a Unity 3D engine (Unity 3D, n.d.) The game is played in the field using a smartphone application (Figure 24). The mobile interface mediates all game actions. It is also used to direct the movement of the player avatar in the VE access points by the situated displays.

Fig. 24. Screenshots from City Knights’ game application UI (Publication V © 2018 SpringerNature).
5.3.3 Field trials

Campus Knights (IV) was evaluated by a field trial on site at campus (Figure 22). Participants for the subsequent City Knights field trials (CK: FT1 and CK: FT2) were recruited via university mailing lists, social media, and a dedicated website. In CK: FT1, the participants formed three teams of three. In CK: FT2, the teams had 5, 4, and 4 participants. In CK: FT1, only two out of nine players were experienced in location-based games; while in CK: FT2, this number was twelve out of thirteen. The shift can be explained with the summer 2016 release of Pokémon GO taking place between the trials. A 15-25 minute introduction to gameplay was given just before the field trial, guiding the players through the gameplay and the overall features of the application. The players were sent off to play the game independently. Teams engaged in three 45-minute game rounds with 15-minute breaks in between for regrouping. The field trials took place in downtown Oulu, Finland (Figure 25).

![Field trial setup, CK: FT1 (left) and CK: FT2 (right). The displays were situated in the middle of each red zone that also depicts the area the players had to conquer before a boss fight. The letters A-C denote the VEs projected on those sites, corresponding letters are used in Figure 26. The quest locations are marked with black circles. (Publication V © 2018 SpringerNature)](image)

As the quality and similarity of the VEs used in CK are an important part of the setup, they deserve a more detailed description. The projected VEs in Campus Knights correspond spatially and aesthetically to their physical locations. To explore the memorability in relation to spatial similarity between the physical and projected virtual environments, we had a slightly different setup in CK: FT2 (Figure 26).
Fig. 26. Game scenes: The first column depicts the physical area and location of each situated display. The second column is the corresponding VE and the third shows an action shot of the boss fight in the corresponding VE. The first row shows an example of one of the scenes in the pilot held indoors at campus. The second row is the location with spatial realism. The third row shows the well-known location with added landmarks. The boss of this scene was a lesser-known landmark as well. The fourth row, (D), shows the scene depicting a generic street corner from the game area. The game scenes (B-D) were used in CK: FT2. In CK: FT1 (B) was used as it is, while the VE from (C) was used inside the physical environment from (D). (modified from Publication V © 2018 SpringerNature)
5.3.4 Research goals and key findings

The purpose of Campus Knights was to evaluate the game design and gain proof of concept for expanding the game city wide. It therefore acted as a pilot for City Knights. In the City Knights field trial 1 (CK: FT1), using City Knights as a construct, the research goal was to observe the subtleties in differences of co-presence and social aspects of collocated gameplay at the VE access points. For this purpose, the experience sampling method (ESM) was used (Hektner, Schmidt, & Csikszentmihalyi, 2007). In addition, structured interviews and game analytics were a part of the data collection. The participants gave informed consent upon answering a prequestionnaire. In City Knights field trial 2 (CK: FT2) the participants also answered an immersive tendencies questionnaire (ITQ; Witmer & Singer, 1998). This was done to assess any individual differences in reacting to the VEs. Some items in the questionnaire were answered on site: “How mentally alert do you feel at the present time?” and “How physically fit do you feel today?”

In FT2, a more specific aspect that also relates, to some extent, to co-presence and player experience was targeted. This aspect is the memorability and its relation to the spatial similarity between the VE access points (i.e., the situated displays used). The main material for this aspect was material from structured interviews that targeted the memorability of the VEs. The analysis of the material relied on schema that was based on a well-known theory on memory of places (Brewer & Treyens, 1981). Agreement testing was part of the analysis; in addition, the schema was adjusted by adding a category of false recollection, where the participants either did not remember a VE or remembered it incorrectly.

The findings suggest that memorability of spatially similar VEs is higher. The previously established connection between known landmarks and memorability (Vinson, 1999) was affirmed in the context of pervasive games. These results indicated how physical reality and virtuality can be linked in the mind by the shared qualities in the realities. Semantic qualities such as landmarks and spatial similarity link the virtual and physical, but the mediator of the semantic qualities is the mind where the mental maps creating the linkages are stored.

Providing players with the possibility for co-located gameplay, game events, and outside influence (for which we used the number of bystanders as an indicator) had a subtle influence on the sense of co-presence. The secluded quiet location has the highest sense of co-presence and there was a gradual change to a lower sense of co-presence when the players learned how to play the game. Surprisingly, the sense of co-presence by the displays was not as high as it was during the more
dispersed game during quests and conquering locations, but it turned out that the players collaborated during the quest phase. These results show how subtle the changes in player experience aspects, such as the sense of co-presence, can be during the unpredictable context of pervasive gameplay. The social aspects of gameplay stand out as their own layer in the hybrid environment.

5.4 Here ‘n There

In *Here ‘n There* (H’nT), emplacement and displacement are the inspiration for the game design. This is mediated by allowing location spoofing (e.g., self-reporting locations) as a game mechanic that mediates player-player observation (Alavesa, Lehto, Ojala, & Asare, 2016).

The early location-based games explored the use of self-reporting in LBMGs and advised against it even when the ambiguity of localization data is considered. Location spoofing, one form of self-reporting location data, is considered unwanted player behavior in most games. H’nT contains a VE as a map-based projection of the physical world (VI; Figure 27).

![Figure 27. Here ‘n There (left) UI and (right) an action shot from the streets (Publication VI © 2018 Sage).](image)

The simplest forms of representing realistic spaces are map applications. As described by Farman (2011), an actual place and a mobile map of a place are not exclusively separate places. Unlike with paper maps, there is constructive
interaction between the physical space and the represented space on the projected map, which results in a new realization of space for the players. The game design was also inspired by the balance of emplacement and displacement that describes the sensation of being there for an urban dweller who can be connected to more than one physical place via his or her mobile device’s interface. As a construct, H’nT was used to explore the method of player-player observation in the field. The methods then revealed what cues players use for this observation, i.e., what are the ludic markers (Montola et al., 2009) that suggest whether a person is a player.

5.4.1 Gameplay

In the game, players have the option of staying hidden, which allows them an opportunity to move in the physical game area. When a player is hidden, s/he is not able to detect other players on the game map or gain points. If the player comes out of hiding, s/he has 15 seconds to place fake markers on the game map, before the fake locations, as well as the automatically reported A-GPS location, become visible to other players. In the unhidden mode, the players can tap other players’ location beacons on the map to gain points. For fake location beacons, they get 1 point, for the A-GPS location 10 points. If they are near (within 40 m radius) to the player they are targeting, they get 5 points for a fake location and 20 points for the A-GPS location. The players can pan and zoom their game map to spot even far away location beacons of their fellow players. The game round ends after an agreed time: in our field trials, this was 10 minutes.

5.4.2 Design and implementation

The game design (Alavesa et al., 2016) is based on identified lack of a specific game type through the extensive review conducted for contribution A (I) of this thesis. During the review, it was noted that there are no research games where the players can both use self-reporting and automated locations during the game. The design process was iterative, but it was initiated with a concept design (Figure 28).
The final game design was refined through use case scenario, leading into design and implementation of the mobile application UI design and architecture. As the interest was in investigating the indirect and direct observation between players during gameplay, the aim in design was to support this. All game elements were placed on one screen, including a small real-time leaderboard. The players could identify each other from the leaderboard and the game map due to color coding. The idea was to provide the players all known means to use digital ludic markers, i.e., the game application, for observing each other. This way we could also compare the importance of digital and physical ludic markers for observation when analyzing our results.

5.4.3 Field trials: campus and downtown

There were eight participants in the three game trials which consisted of two ten-minute game rounds each. The participants were previously unknown to each other. They were recruited via an open call through a dedicated website and university mailing lists, and they signed up for the game by completing a pregame questionnaire that contained, in addition to a consent form, demographic questions. For the three trials, there were teams of three, three, and two participants, who were deployed to the game field from separate locations inside the game area: either campus or the downtown urban area. After a rehearsal and two game rounds, the players were instructed to gather in the same location for semi-structured interviews.
The players also carried on their person a small camera that recorded the game event. The video camera was used to assess the players’ involvement in gameplay, but its main contributions were the transcribed discussion and comments from gameplay and the moments in between game rounds. In addition, after the gameplay, structured interviews were conducted where the focus was on the methods used for player-player observation in the field. The material was analyzed and coded using a coding schema that was structured through discussion and adjusted after agreement testing between two observers.

5.4.4 Research goals and key findings

The purpose of Here ‘n There was to create a game for observing the subtleties and nuances in social interactions amongst players, more specifically the player-player observation and the nature of the ludic markers players use to deduce whether a person is a player or not.

Players search for other players spontaneously, which confirms earlier findings (Licoppe & Inada, 2006; Montola et al., 2009). However, they find behavioral and visual cues from the physical environment, i.e., physical ludic markers, more important in determining who is a player and who is not. The role of digital ludic markers, such as the real-time leaderboard of the game application, is not as important. The players, however, do combine information given by the game application in addition to the physical ludic markers to confirm or suspect a fellow player is part of the game. The localization forms a branching layer inside the hybrid game arena. The direction of influence between the virtual environment and the physical reality is mediated by the affordance the players have in adjusting their game status and reported locations.
6 Discussion

The constructive research presented in this thesis focuses mainly on the third metaphor (Table 2, Figure 8) for combining realities: synchronicity. The mapping of realities, i.e., identifying the realities in pervasive game space, was therefore the first goal of this thesis, followed by identifying the synchronizable elements, i.e., tethers, that bind these realities together in pervasive gameplay.

6.1 Structuring of the hybrid game arena

The first contribution of this thesis are the findings regarding the first research question: *What game specific realities, i.e., layers, can be identified in a hybrid space environment?* Evolution of the accessibility of the VEs can be seen when the game constructs are observed in chronological order. In Props (II) and SAG (III), the VE was only accessible to the player through a PC (or Mac) client, which required a completely orchestrated setting or led to a situation where the players on the streets ignored the virtual city. In CK (IV, V) the VE was brought to the players via movable situated displays that mimicked pervasive displays (which are a part of the urban infrastructure in many cities). The use of the VEs was also required by game design; each game round culminated in a boss fight that required the players to collect around a display and inside the VEs. In H’nT (VI), the projection of the physical city, i.e., the VE, was in a truly mobile form, in a form of a map. This thesis suggests that there are also other realities, i.e., layers, in the hybrid game arena. These realities are linked to the characteristics of pervasive games (Table 1) in addition to the conceptual and analytical work presented here. The following are the layers from the microcosm of the mind to the more abstract and vast realities:

1. **Mind:** Semantic qualities of the other realities, place identity, and translate, for instance, to memorability (III, V, IV).
2. **Physical environment,** which also encompasses the environment for the daily life of the players (I-IV).
3. **Social space** (individual players, teams, outsiders...) this is where the metaphors *true sociability* and *synchronicity* overlap (Figure 8, V, VI).
4. **Physical and digital location layer** is formed from both game-related points of interest in the physical environment as well as the digital location data. These together form a multidimensional scaffold, which becomes a layer of its own (I-VI).
5. **Virtual environments**, which can be realistic or abstract environments, such as realistic 3D VEs or the digital application used for gameplay (II-VI).

The structuring presented here reflects, in many ways, what is already known on the structure of hybrid space (de Souza e Silva, 2008; de Souza e Silva & Sutko, 2008). However, this particular structuring goes beyond the mobile interface and is gameplay specific. In addition, this conceptualization assumes that true mobility of the gaming devices and true sociability have been achieved in pervasive game spaces.

SAG (III) was designed to have interference between competing players. The busting (i.e., being able to interrupt other players) was implemented as an in-game battle system. Although the interference strategy was used to encourage collocated gameplay, the players did not always share physical space when “busting” other players due to location ambiguity. The location data and the physical location formed weakly bound layers of realities and the players learned to take advantage of being able to shuttle between the two. They turned smartphone localization on and off while playing the game and quickly learned to take advantage of the location ambiguity. Some players became specialized in this and used almost all their game time busting other players. Also, the social space is a widely studied structure in pervasive games (Eriksson, 2005; Goffman, 1963; Montola & Waern, 2006; O’Hara, 2008). This study does not explore the structure of this space in detail but acknowledges its importance as one of the realities for urban pervasive games. The relationship between co-location and collocation to the sense of co-presence was, however, found to be related to the context of gameplay in that it related to elements in the context of pervasive games (V).

The size of the game area may not be an issue for current commercial games that span globally, but in small-scale academic games it influences gameplay and the opportunities players have to interact. In SAG (III), when the players used a smaller game area in the pilot, there were situations where the whole city was conquered by one team, making it difficult for that team to play by tagging locations. When the game was played in a larger game area with more taggable locations, the dynamics of the gameplay were more versatile and offered the players more room for strategies. In H’nT (VI), the restricted area indoors again provided more possibilities for observing and interacting with other players, whereas outdoors they had difficulty finding each other. The differences in the sense of co-presence, however, are very subtle in pervasive gameplay (V), which reflects the complexity of the game arena.
Stenros (2012) identifies three boundaries of play in pervasive games that are linked to the psychological bubble, a sort of magical circle (Huizinga, 1955), where the player feels safe enough to be playful. This definition is quite close to the reality of *mind*, which, in pervasive games, also houses the foundations of semantic connections that bind the other realities and mind together. Stenros, Montola, & Mäyrä (2007) have studied mindsets between serious and playful in relation to the context of pervasive games and clarified, to some extent, the connection between *mind* and other realities when the connection is tethered by the attitudes of the players.

### 6.2 Tethers binding realities

The second contribution of this thesis are the findings regarding the second research question: *What tethers, i.e., synchronizable elements, are there between the identified layers?* The individual elements vary on how they mediate the entanglement of the layers of realities; *cognitive jumps* obviously bind mind to other layers. This study further solidifies location awareness as one of the key features of hybrid reality games (de Souza e Silva & Sutko, 2008). Location data reaches through almost all layers and therefore forms a highly breached reality of its own. The following are the tethers recognized in this study:

1. **Social interaction:** Co-location facilitates collocation and the sense of co-presence. When co-location is combined with connectivity it becomes collocation, therefore this is also where *true mobility* and *synchronicity* overlap (Eriksson, 2005; V).
2. **Agency:** What players can and cannot do using the game, how the game mediates the interaction between the game layers (I, II).
3. **Location data** (binds and when it does not, creates a *physical and digital location layer*). Localization also contributes to the sense of emplacement or displacement and therefore contributes to the player experience in pervasive gameplay (III, VI).
4. **Cognitive jumps:** these are events where player’s perception and attention are shifted between realities. These events can be eased by considering the semantic qualities of the VEs such as spatial similarity (IV, V) and designing the gameplay for smooth attention displacement between realities.
5. *Narrative:* when the element of time is added to the mix, narrative is emergent even when there is not a strong backstory in the game (Chess, 2014; Jacob et al., 2017; Lefebvre, 1991; Walther, 2005a, 2005b; I, II).

6. *Physical objects* (Spallazzo & Mariani, 2018, I, VI).

Each feature that combines the layered realities of gameplay in pervasive games reaches through the layers. They all have an effect, even when it is not obvious. Evidently, social interactions are one of the synchronizable elements between game realities. Co-presence is a ponderable element that constitutes player experience, and the subtle difference in co-presence during pervasive gameplay offers insights to the social structuring of the game space.

This conceptualization can be used to redraw the figure (Figure 9) first introduced when describing the theoretical background of this thesis. At the same time, as the recognized realities in gameplay vary in reach and size, the shape of the graph needs to be remodeled (Figure 29). The layering of realities is not nicely stacked despite the variation in how vast they are, and the most striking jump occurs when one moves from mind to the physical reality that, in gameplay, can span the globe. The realities can also overlap and are somewhat entwined and interdependent.

![Fig. 29. How the realities are layered and entangled in pervasive game space. The orange arrow depicts the influence of the synchronizable elements, the tethers, between the realities.](image-url)
This conceptualization is not exhaustive — there are and will be other tethers for binding realities. As new technologies become part of the city infrastructures, the game arena changes, albeit the people we interact with through the new technologies and the playful nature of *homo ludens* (Huizinga, 1955) remain much the same. According to Huizinga (1955), games create a clearly defined magic circle. However, it is debatable how permeable the magic circle in pervasive games is (Ferrera, 2012; Harvey, 2006; Montola, 2005; Stenros, 2012). The model presented above requires for the game space to be permeable and undistinguishable from other realities. In fact, if the game space would be added into the model as its own reality, it would encompass the whole model like the *digital and physical location layer*.

### 6.3 Direction of influence between realities

While physical reality can easily influence the virtual, the direction from the virtual to the physical objects is problematic (Guo et al., 2010). However, the players in the conceptualization presented in this thesis are included in the structuring of game space. They are “physical world objects,” which facilitates a direct or indirect effect from virtual to physical.

In SAG, the players almost ignored the virtual game scene. They found the game in the streets more enticing, to quote: “It is just more fun to play on the streets.” How the digital realities embedded in the game design reach the players is affected by how strong the bond between the two is. Location data and the resulting layers of digital effects, or items that are bound to those locations, are perhaps the most directly linked realities. Even so, there needs to be an effect that motivates the players to take notice of the parallel virtual reality. In SAG, the policeman NPC (Figure 20) was able to bust the players on the streets, which resulted in loss of points and time for the players. However, this loss was not strong enough to have the players keep an eye on the virtual cityscape. Nevertheless, they recognized their avatars’ presence in the virtual environment and were curious to know how accurately their virtual presentation reflected their presence and actions in the physical world.

In H’nT, the players used mainly physical ludic markers (i.e. cues) to identify other players (VI). In Props (II), the digital game mediated messaging between the prop masters, storytellers, and audience. The players also had the option of directly shouting cues to the actors and storytellers. Unlike in H’nT (VI) where physical ludic markers (i.e., cues of player status) were dominant, in Props (Figure 14), the
digital cues (i.e., the prop items) on the projected stage affected the story content most and the prop masters had high agency in storytelling, perhaps only rivaled by the agency of the storytellers. This also highlights that digital objects can affect the physical world, to some extent.

6.4 How understanding structuring of pervasive games space can benefit game design

This thesis used established metaphors in pervasive games, the *true mobility* and *true sociability*, as a starting point. The thesis introduces *synchronicity* as an additional metaphor and identifies synchronizable elements binding together the game realities—physical, mental, digital, and virtual. As true mobility and sociability have become established, the games encompassing them have become traditional. Recognizing new elements in game space, such as the realities and the tethers that bind them, opens opportunities for novel game designs. Jegers (2007) defines the connection of game design and player experience as the path that goes through the game itself. This thesis focused on the characteristics of the digital and physical realities and how these realities can be combined. The synchronizable elements provide the game designers with both limitations and opportunities affecting the design.

The game application is the lens for observing VEs for the players and the game mechanics and game design play an important role when entwining these realities together. However, one needs to understand that simultaneously with the physical and virtual environments there are other realities in hybrid game space, and these realities are not necessarily mediated by the mobile interface in accordance to the strict definition of hybrid reality games (de Souza e Silva, 2006) and mobile interface theory (Farman, 2013). The metaphors for urban pervasive games (i.e., playful appropriations of hybrid space) define the basic requirements for gameplay. Under the third metaphor, *true synchronicity*, one can find the elements that are translatable to game features, i.e., game mechanics, which are the building blocks of player agency, mediate the interaction between players and realities, and affect player experience. Interaction with the environment (Figure 13) defines the game space based on how players can utilize the environment to facilitate gameplay (I). As the structuring of virtual and physical realities is more layered, so are the actual interactions with and through the realities when playing more complex pervasive games. The elements in Figure 13 show the interactable elements in play on the physical city streets. The complexity of the physical game
space is clearly seen in that the players do interact through it and with more than just their mobile phone interface. Despite mobile phones being elemental gaming devices in pervasive location-based games (Farman, 2013; de Souza e Silva & Sutko, 2008), there are other potential interfaces in the cityscape (I). Creative use of the game environment can set a game apart from more mundane pervasive games (Guo et al., 2010; Kasapakis & Gavalas, 2015).

The design of urban pervasive games can benefit from the knowledge of tethers that bind the realities inside the hybrid game arena together. Smooth attention displacement between the mind and other realities, such as VEs, can be implemented through either binding the access points for VEs or by using semantic similarities between realities or location data. The sense of displacement is a result of mind and physical environment layers being combined by a tether, such as location data, and be used as an inspiration for designing novel game experiences (VI).

One can imagine a place, from the cityscape clad in fiction from Mythical (Björk et al., 2008), or a distant planet, and feel as though they’re instantly there. There are limitations to how shared experiences can be when the travel happens inside the player’s mind, and the experience is subjective, to say the least. The only thing one shares is the part in the physical world and what information is provided by the game to feed your imagination. However, knowledge of how the mind works during gameplay can aid in design. The similarity of semantic qualities between realities can be observed, for instance, as memorability of the VEs (VI). This effect also highlights the persistence of digital realities in the mind and shows that the synchronizable elements combining the mind to other game realities can be something more intangible than the mobile interface. The offline presence of an avatar is a further indicator of the binding force of presence between a virtual environment and the emplaced body (I, III). The phenomenon is also an example of displacement between mind, physical environment, and VEs.

Although the physical environment is unpredictable and there will always be elements there (such as current norms and rules) that affect player agency, this is a synchronizable element that can be highly affected by game design and game mechanics. Therefore, agency is very much a gameplay related tether that also spans to the daily life of the players (Church, 1999; Murray, 1997; I; II).
6.5 Limitations

The conceptualization presented in this thesis has a vast theoretical, analytical, and practical foundation, yet it would benefit from further validation. This conceptualization is not exhaustive, as other unidentified genre specific synchronizable elements exist. In addition to validation, future constructive research could sharpen the view into what has been traditionally considered a blurry connection between realities in pervasive gameplay. On the other hand, the structuring of hybrid space (Figure 29) is not necessarily application specific, but it can be adapted to any game or application developed in the modern urban space. At the same time, the synchronizable elements in this space can be quite genre specific. For example, there is a different level of agency and narrative potential built-in or required from different applications. While this conceptualization expands the perspective on hybrid space beyond the mobile interface, it is still notable that smart phones were used in most research constructs in this thesis, and they will remain pivotal mediators in the hybrid space.

The field trials presented in this thesis suffer from a small sample size and a short duration — between ten minutes and four days. However, these shortcomings have been countered by collecting rich material and vast amounts of game analytics data (Table 2). The material collected has enabled the formulation of a timeline of events, which allows the reader (and the researcher) to understand the uniqueness of the events documented and the conditions in the field. In addition to small sample sizes, some of the individual field trials have an uneven gender distribution (II, IV, V). Props (II) events had more female than male participants; in CK (IV, V) there were more male than female participants; in SAG there were only male players (III). Only H’nT (VI) had an even number of participants from both genders. Gender differences in player experience are not addressed in this thesis, which is an important limitation and needs to be noted here.

The studies (I-VI) only briefly discuss the design implications of particular research results. Therefore, steering this research in that direction is left for future work.

6.6 Future work

The conceptualization presented in this thesis could provide a starting point for creating design guidelines for pervasive games and other applications. While the synchronizable elements can already be utilized in designing new games or novel
experiences taking place in modern urban environments, they could be further refined into design guidelines.

The conceptualization offers a framework for future research on a more comprehensive structuring of hybrid space. Pervasive games have a plethora of subgenres (Montola et al. 2009) and many of the individual studies in this thesis only focused on targeted aspects for a specific research game. Despite this, the individual studies, when combined with extensive literature review, each bring a new perspective to the presented conceptualization. For the future development and validation of this conceptualization, further constructive research is needed to solidify the recognized tethers and identify additional synchronizable elements between realities in the pervasive game space. In addition, it would be beneficial to develop more precise metrics for assessing player experience while aiming for optimal synchronicity of combined virtual and physical environments.

The structuring of the pervasive games presented in this thesis can be subject to change when the scope of a game or application under investigation diverges substantially from the city scale. For instance, some bodily games have a very small-scale environment inside the stomachs of the player (Li et al., 2018). Adapting the proposed conceptualization to other pervasive game types, and the extremes they present, would be an interesting challenge for future research. This thesis revealed that expanding the game area from indoors to outdoors (VI) or from a few city blocks to almost thirty city blocks (III) changes how players observe each other, strategize, and interfere, and these changes are not always expected. With SAG (III) we did witness more balanced player activity and gameplay when the game arena was expanded, but, at the same time, the players began using indirect ways of observing each other. This shift in observation strategies was also noticed with H’nT (VI): as the city arena expanded, the players spotted each other less often. It did not, however, improve the game balance. On the other hand, we had short-lived game trials (10 minutes). Hybrid space denotes modern urban space; therefore, the scale of the game arena is most times quite big. This topic, of the scale of the game arena, was only briefly discussed in studies presented in this thesis. However, the scale of the game arena, in addition to other topics such as the game balance, game genres, player strategies, social interactions, and especially privacy issues, do offer an interesting topic for future studies.

True mobility in pervasive games, and especially location-based mobile games, has changed the genre and brought on true blending of daily life and gameplay. As this has been achieved, the predicted potential of pervasive games is finally being realized. We are not yet at the same level of true mobility in embedding immersive
virtual environments into cityscapes; specialized VR devices are still needed for bringing fully immersive VEs to the city streets. However, VR technologies have challenges that could possibly be tackled by a better understanding of hybrid space and what is required for embedding the VEs into the daily living environment of people. Current VR headsets do not have powerful graphics processing units (GPUs) and mobile devices can show only small 3D VEs smoothly in accordance with best practices for viewing immersive VEs (Oculus VR), and the use of the required extra devices is anything but blended with daily life. They actually resemble the use of localization devices of early LBMGs (Benford et al., 2006; Webb, 2002).

Some devices, such as the Microsoft HoloLens, offer mobile augmented reality (AR) blending of virtual contents on the go, but these devices are still quite out of reach of everyday consumers. On handheld devices, the AR is already in use in Pokémon GO, yet it is there only as a gimmick that is not required for gameplay (Paavilainen et al., 2017). It would be an interesting target for future research to observe whether there is a similar trend in blending VEs and AR contents in pervasive gameplay as there has been with other technologies when the technology matures and gains true mobility and true sociability. VR equipment is becoming more mobile and being blended with AR technologies, as filtering the front camera view in VR is becoming available for commercial VR gear. These technologies will merge at some point so that the same devices will be used for both AR and VR. It would also be interesting to find out whether the “blurring of boundaries” between everyday life and play is in fact more important to pervasive gameplay than achieving full immersion; any full immersion is always behind a boundary of sorts, a well-defined magic circle.
7 Conclusions

A mere dual reality paradigm is not enough to describe the true complexity of the context of the gameplay in modern urban pervasive games. The game arena for pervasive games cannot be assumed to be fixed, as it inherits the qualities of its context: urban hybrid environment (de Souza e Silva & Sutko, 2008) and modern space (Lefebvre, 1991). According to the original definition from de Souza e Silva (2006), the boundaries of digital and physical spaces are blurred when combined into a hybrid space. The current hybrid space logic is somewhat restricted by its focus as mobile interfaces as mediators (Farman, 2013; de Souza e Silva, 2006).

This thesis brings together both theoretical and practical research conducted in 2013-2018. Both conceptual research and several in the wild field trials with pervasive research games have been staged to investigate the hybrid city as a game arena. The research results sharpen the view of the blurry boundary, identify some elements constituting the bonding between realities, and expand the understanding of the topic beyond the mobile interface.

The results of this thesis comprise three parts. First, a new metaphor, *synchronicity*, is introduced to complement the existing metaphors of *true mobility* and *true sociability* that have become intrinsic parts of urban pervasive games over the past two decades. Game elements or mechanics that fall under synchronicity bind the different realities together. Second, a multi-layered structuring of the realities in pervasive games is presented. The proposed structuring of the hybrid space is not exhaustive, although it is adaptable to other application areas. Third, constructive research identified individual synchronizable elements that serve as tethers between the realities. They can be different from localization which is traditionally used in combining realities.

The proposed conceptualization serves both designers and researchers. The synchronizable elements can be used in designing new games or novel experiences taking place in modern urban environments. The conceptualization offers a framework for future research on the structuring of hybrid spaces.
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