A research process for designing ubiquitous social experiences

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ABSTRACT
This paper investigates a research process focusing on the unpredictable collective and individual user behaviours which can emerge in ubiquitous social games. The fundamental premise of our research is that emergent interactions can both enrich the user experience and inform the design process of ubiquitous social applications, revealing creative opportunities. Rather than a side effect from the deployment of an innovative technology, emergence becomes the focal point of investigation of the paper. In light of the proposed design research process, we present the emergent phenomena observed in three mixed reality game applications and reflect on what we learned.

Author Keywords
Ubiquitous games, emergence, design process, collaborative play

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: evaluation/methodology, theory and methods, user-centered design, interaction styles, H.5.3 [Group and Organisation Interfaces]: synchronous interaction, collaborative computing, H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities.

INTRODUCTION
This paper investigates emergent, spontaneous user interactions, which arise from participation in real world, mixed reality experiences. We propose a research process focusing on the unpredictable, emergent user behaviours, in order to inform the design of ubiquitous social applications.

A key question motivating our research is how we can design pervasive applications that encourage variable user experiences, enhanced by spontaneity and collaborative interaction, without ‘over-prescribing’ the users’ interactions. We know that unexpected uses of technology can inspire novel applications. SMS-based coordination while being on the move, hijacking Bluetooth phones to communicate with random strangers in short range and blogs are a few examples. A lot of innovation is socially driven: the technologies to support blogging have been in place since the dawn of the web, yet it is only recently that this technique has self-organised into a social pursuit [9].

People engage in social play, and these unpredictable uses of new media influence technological innovation. In this context, we have been investigating playful social experiences with mixed reality games, to understand and explore their potential for encouraging spontaneous user interaction and unpredictable uses of the technology. Before detailing our approach to researching emergence, we define the kind of ‘play’ and ‘social phenomena’ that are the focus of this work.

Anthropologist Caillois [2] distinguishes between formally structured games and free play with his concepts of ludus and paida respectively. Ludus represents rule-bound, goal-oriented play, while paida refers to spontaneous, improvisational play. We are particularly interested in playful activities that are closer to the spontaneous play suggested by the concept of paida. The three game prototypes we have designed include elements from both concepts, with a more or less structured set of rules. For example, the first prototype is designed to encourage spontaneous social play in urban environments among adults and is bound by minimal rules, whereas the second game is designed as a learning experience for children, based on a more structured and complete set of rules with specific goals that need to be achieved.

We look into social play with the aim of finding out how we can design for emergent behaviours (and indeed if this is even possible). We have been fascinated by the potential of unpredictable collective collaboration in city environments.
Rheingold [10] highlights the empowerment of self-organization and large group coordination with mobile technologies. The results of such interactions can be very unpredictable. The rather apolitical phenomenon of Flash Mobs [8], characterized by remarkably low-tech coordination (email lists and on-the-spot handouts) illustrated that people do not hesitate to perform certain acts in public together with many others, which otherwise would have been quite embarrassing.

We are interested in both collective (e.g. flocking, spontaneous collaboration) and individual unpredictable behaviours that occur through the use of ubiquitous games. Mixed reality multiplayer experiences have a great potential in encouraging the expression of spontaneous user behaviour and social interaction in the real, physical world, that are motivated by their participation in a virtual game situation. The game ‘Uncle Roy All Around You’ [6] engaged participants in collaborative problem-solving through a fictional mystery. The collaboration between online and mobile players creates a link between physical location and interactions in a virtual space. Another good example of the potential of mixed reality games, is the ‘Seamful Game’ [4], which explores positive uses of infrastructure challenges. The game aims to harness negative aspects of infrastructure technologies (such as GPS inaccuracy), which are normally concealed and unexplained, and present them as game features allowing users to explore and understand them. For example, as players travel around a designated area collecting digital ‘coins’ in order to upload them in exchange for points, they develop an understanding of the network coverage and the effect of signal strength. In this way the patchy network coverage, which is usually seen as a problem to be overcome, or worse ignored, is turned into a feature of the game.

In a similar line of thought, the work presented in this paper aims to capitalize on the unpredictability of user behaviour, which is also usually considered as something undesirable or threatening for the iterative design process of interactive applications, as a positive and fascinating input in the process itself. The research process we propose is innovative in elevating emergence itself from a mere side effect of the deployment of an innovative technology to the primary focus of interest.

A RESEARCH PROCESS FOR EMERGENCE

User exploration and unpredictable interactions with a system that were not intended by its designers are common phenomena, at the core of human-computer-interaction research and prototyping processes. Early research in user exploration focused on task-oriented interaction. The design process for a simulated online help system [3], for example, took into account user exploration and unpredictable actions to identify the complexities of the advisory process. This early work pointed out the limitations in applying intelligence in this context to predict user behaviour with the aim to respond to any ‘unpredictable’ queries. Other approaches focused on how users learn to use technologies through trial and error [11] and therefore do not account for situations in which the misuse or ‘error’ actually has a positive effect on the experience of using an interactive product. A field study [7] suggested that there are negative, but also positive user perspectives on the unpredictable use of a new technology, expressed by the distinction between the “confused” versus the “surprised” user. The “surprised” user is interested in what he/she did, whereas for the “confused” user the interest lies in what he/she should be doing instead. The “surprised” user is willing to learn for future use, whereas the “confused” user is mainly focused at the task at hand. We view our research process as a means to encourage user discovery and surprise through play and exploration of new technologies.

In the context of multi-user applications, emergence is more than the unintended use of a design. Being able to simultaneously and collectively explore or “misuse” a system, poses interesting challenges as well as opportunities. For instance, providing feedback in response to collaborative actions performed spontaneously could have a further impact in emergent group behaviour. Andersson et al [1] have proposed a detailed framework of emergent interaction systems for a range of ubiquitous applications. They define such a system as an environment with a number of actors who share some experience/phenomenon, and whose behaviour is significantly influenced by a shared feedback loop picking up data from the individuals and their actions. This approach based on a collective feedback loop has not been explored with prototype applications by the authors, therefore we know very little about the kind of interactions that could emerge from such systems.

In the studies documented in this paper, we focus the investigation on the design process for emergent phenomena. A principal motivating question is: can we actually design for unpredictable social phenomena? Then, if this is possible, how can those emergent behaviours inform and inspire new design?

The paper positions our ideas and observations within the flow between design and evaluating an interactive application. The long-term aim is to understand how unexpected uses from the deployment of a new technology can drive its design and whether it is possible to incorporate those in the iterative design process. Our starting point is that emergent phenomena – unpredictable behaviours and uses of technology – come from a combination of design and external factors. These external factors are defined by the context of use through the deployment or experiment with an interactive product.

As Dourish [5] suggests, the focus of the design is not simply on ‘how can people get their work done,’ but ‘how can people create their own meanings and uses for the system in use’. Following a similar way of thinking about
the design of playful mixed reality applications, our aim is to identify both the design elements as well as the particular external factors that facilitate emergent social behaviours and unpredictable uses of technology.

Figure 1 shows our proposed research process, which relates to a traditional iterative design process in the field of Human Computer Interaction, but with a particular focus on emergence, in an attempt to: a) find out how a combination of design and external influential factors can encourage spontaneous user behaviours and b) how this entire process can further inform and inspire design.

Figure 1. Design for emergence: a research process focusing on a) emergent user behaviours and b) ways to inform and inspire design.

Emergence is a particularly intriguing buzzword for game designers as they try to incorporate emergent properties in their games to enhance the user experience. Emergent interaction based on simple, high level, variable rules, results in a different experience every time; a game that is interesting to play more than once. Game design is in fact, a second-order design problem [12] as the designer designs the rules of a game directly, but designs the player’s experience only indirectly. The experience of play depends on the emergent interaction and it is not always possible to anticipate how the rules will play out or how the player will behave within the game. Because of this uncertainty, it is indeed difficult to design a game based on a simple set of rules that will generate complex, yet meaningful and engaging interactions.

Therefore, one of the most challenging trade-offs we have faced is how much context, structure and rules we need to provide. Games exist within a hierarchical rule structure: there are games rules, house rules and social rules. The rules of the game are internally designed into the game and can be implemented in the game mechanisms. House rules are the local interpretation of what is fair and how the game should continue – they are often enforced by a referee. Social rules are a mixture of the laws of the land and commonsense behaviours enforced by the local authority and citizens.

Interpreting and testing these rules is a predictable human behaviour, but the ways in which people do so is unpredictable and will emerge over time. A design for emergence would minimise the complexity of the intrinsic games rules so that users can easily understand the design and be able to extend it through experimentation and collaboration.

The sections below discuss how three mixed reality multiplayer games, Citi Tag, Savannah and Schminky, designed for different contexts and audiences can encourage emergent user behaviours. First we describe the methods used in the design research process and how these relate to other methods deployed in the field.

DESIGNING FOR EMERGENCE THROUGH UBIQUITOUS GAMES

A mixed reality game of “tag”

Design approach
In order to explore spontaneous interaction and emergent collaboration we designed and developed CitiTag, a mixed reality game inspired by the simplicity and spontaneity of children’s playground “tag”. The motivating principles were to try and keep a lightweight design approach and very simple game rules, in order to provide a minimal structure that would encourage experimentation and play. We developed a prototype to try out with groups of people that would enable us to observe what people actually do in a real world setting. There is a certain risk involved in this approach, in that there is no guarantee that group collaboration will emerge ad hoc and that we, as researchers, were uncertain and speculative about the kind of behaviours that would emerge. This, however, made the whole process of designing and trying the game out with users even more exciting. Participants were recruited to play the game and to provide feedback through follow-up group interviews and an individual questionnaire. Two user trials were carried out, one in an open field space at the Open University campus (9 participants) in Milton Keynes, UK and another in a square in the city centre of Bristol, UK (16 participants). We used video observation to capture and understand the user experience during play in both trials.

Overview of CitiTag
The CitiTag prototype is a scalable, multiplayer, wireless location-based game, played using PDAs connected to a wireless network and GPS (Global Positioning System). At its very essence, CitiTag is a mediated game of “tag”, but with two teams (Red versus Green), where players roam the city, trying to find players from the opposite team to “tag” or “tagged” teammates they can rescue. The metaphor of “tagging” is communicated in the interface as entrapping and “untagging” as freeing other players (figure 2). Players...
receive alerts on the device screen with a sound when in proximity of an opponent they can tag. They then have to tap on the screen to respond to the event. The actual location is not displayed as this would encourage users to look more at the screen rather than to observe their surroundings.

**Rules**

The concept and design of CitiTag are purposefully simple to provide just enough context and to encourage experimentation without over-prescribing rules. The rules are based on two actions: “tagging” and “untagging”. When a player gets tagged he/she cannot tag others and has to find a member of his/her team to free him/her. The game finishes when all members of one team get tagged.

![Figure 2. The CitiTag game screens: the default state, an alert that the user got tagged, an alert to rescue a friend](image)

**External factors**

Comparing the two user trials revealed a clear difference between the quick, action game sessions in the campus field and the more strategic ones, with evolving cooperation and group convergence in the city environment in the Bristol trial. Players were able to move peripherally, hide and work out strategies with others in the city, actions that were much more difficult to perform at the Open University campus trial, because the location was smaller and completely exposed. In Bristol, the trial attracted the attention of several passers-by, a couple of which conversed with the participants, whereas the trial in the open field was more self-contained and a few observers at the location were completely excluded from the experience. We also observed that group dynamics varied play. For example, people surrounded individuals together in an attempt to tag them when they identified a person from the opposite team. We also had the case of the “invincible pair”: two players who just went along together and kept rescuing each other without the need to say: “let’s do this”. Similarly, groups were formed in an ad hoc fashion, one person would rescue someone else and they would stay together. Then they would find another person and rescue them and so on, resulting in clusters of players moving along together. As one participant explained in the group discussion: “It seems to work! We got about five people in one session and kept ourselves released and then kept walking and we got more people, so it did seem to work”.

At least six participants from the Bristol trial mentioned pairing as a strategy they used in the game to keep rescuing each other. This phenomenon is an example of emergent collaborative play. Another player in Bristol introduced a new role, a creative extension to the game through cheating: a “secret assassin” broke the game rules by joining the opposite team and then switched back to the original at the very last minute to tag as many people as possible whilst being among them. In this way, the player explored the potential of mixed reality: being physically with one team, but virtually at the opponent’s end.

CitiTag illustrates that it is indeed possible to design for emergence. We found that a mixed reality game with simple rules and structure can provide just enough context for spontaneous interactions to be observed in field trials. Moreover, a range of factors influences the balance between “designed” and “user generated” experience. The design for emergence diagram in Figure 3 outlines the combination of design and influential external factors observed in the CitiTag studies. Whereas the technical failures (GPS, wireless network) were disruptive and brought about the negative, “confused user [7]” effect because of the unpredictability in the technology, the impact of the other factors was positive. Emergent user interaction and collaboration related to playfulness, imagination and the possibility of different outcomes that the rule structure accounted for. As external factors will
always vary, we can only facilitate emergence through design, albeit with unknown outcomes. The aforementioned examples however indicate that to some extent we can manipulate some external factors like the location and the group dynamics to learn how they influence the emergence of individual and group behaviours.

**Figure 3. The design for emergence process in CitiTag.**

An urban ‘Savannah’ for children

**Design approach**

The “informant design” [13] approach was deployed as a research method for the second prototype described in this paper, a location-based educational game for children called Savannah. Children participants were recruited to try out early prototypes of the learning experience and gave feedback through follow-up group interviews. The rationale for this approach is that rather than treating children and teachers as equal partners with the development team (as in participant design), informant design involves intended user groups at various stages, where and when their expertise can be maximized and where their knowledge is required. The goal was to inform the design team of key issues related to the children’s experience, helping to improve the second iteration of the prototype. Teachers also contributed to the design process to create an holistic learning environment rather than simply trialing the digital resource.

The research trials conducted with the second iteration of the prototype comprised of 35 children from 6 different schools over a period of three days.

**Overview of Savannah**

The Savannah prototype is a game that enables children to play at “being lions” in a virtual savannah by navigating a real playing field. In the field children use GPS linked PDAs and headphones that show them the sights and sounds of the virtual savannah they are navigating as lions. The game comprises three levels in which children have to 1) claim their territory, 2) hunt as lions in the wet season, and 3) survive the competing demands of hunger and thirst in the dry season. Prior to and after playing as lions in the field, the children work in “the den”, which is a site indoors where they interact with teachers and resources to prepare for and reflect on their play.

**Rules**

Rules of the game were both hard coded into the game logic and implemented through human arbitration. For example in the first level when children need to claim their territory they have a fixed number of “sprays” indicated on their PDA which get used up each time they press the “spray” button. This was programmed into the application and could not be changed real time.

There was also an interface through which a “games master” or “facilitator” could see the actions that have taken place in the system and decide in real time what consequence they should have. For example the result of a coordinated group attack on an animal was given as a text message to the players on their field – usually either “your attack succeeded” or “your attack failed”. The result of the attack also influenced the hunger and energy levels on the screen, which could be set by the “games masters”. This structure allowed us to use the first prototype to determine which rules should become “hard coded” and which were best judged in real time. We could use the feedback from the game experience to guide our next iteration.

**External factors**

One of the main external factors in Savannah was the setting. As the trials were in a school setting during lesson time the children were within the wider context of the “rules of the school”. The experimental context, where researchers who were observing and running the experiment outnumbered the children was also a factor. The main influence seemed to be to make the children feel more “privileged” or “special” to have been chosen to partake and to have so much adult attention. However as the length of the trial was over several hours all groups eventually forgot the observers as they became engrossed in the game.

The other sharp contrast was also between the environment of the den and the environment of the outside playing field or “savannah”. We had deliberately designed the game so that as much as possible the act of going outside and putting on your equipment should symbolise “putting on your lion skin” so that outside the children effectively became lions and inside they could reflect on the experience as people.

**Observations and emergent behaviors**

During the trials we observed emotional responses to the play as the children responded visibly and audibly to the responses from the system. When they received a message that their attack was successful they cheered and punched the air; when they received a message that they were in danger they ran. An interesting aspect of the game is its physical nature, which arguably contributes to the directness of the experience. When the children were running away from the elephant they were actually running and not moving an avatar in a desktop computer game,
when the children were told they were too hot, the children moved into a watery area and began ‘attacking’ the water by pressing the “attack” button on the PDA as they assumed that this would enable them to drink. When music was played the children would dance. In general, cues in the game would naturally trigger a physical response such as running, dancing, calling to one another to co-ordinate attacks and performance.

When energy levels became dangerously low children became increasingly anxious, whilst never losing sight of the reality that they themselves were not going to die, there was evidence that they had engaged sufficiently with the lion role that they were assuming that they talked in first person terms “I am going to die” and “I must get water” rather than “My lion is going to die”.

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All of the trial groups became gradually aware that working in groups rather than isolation was likely to lead to greater success and also encouraged collaborative activities among the children. The children coordinated their movements through the virtual space and worked together to perform attacks on prey. These behaviours were reinforced by the facilitators’ awarding of energy points, and were largely seen to be spontaneously developed behaviours. Indeed, it was one of the features that the boys in particular mentioned after playing: “Because we learnt to trust each other and know that if you attacked something, the others wouldn’t leave you on your own to get killed”.

One of the groups experimented with using physical markers on the field to depict safe areas, areas with water and animals. They gathered together as many props as they could find such as boxes, cartons and poles and placed these around the field so that they could act as visual cues when energy or water levels were getting low.

The design for emergence diagram (figure 4) summarizes the influential factors and emergent behaviours observed with Savannah. This kind of behaviours that combines the physicality of the place with the virtual game world is exactly the kind of emergence that is distinctive in the pervasive game space. Our intuition is that design that utilizes and builds upon these strong physical and virtual connections will distinguish these kinds of experiences from non-mobile computer gaming.

The flexible game architecture that allowed rules to be dynamically created and tested as part of game play is a very useful mechanism for refining design based on emergent behaviours and feedback. Being able to award collaborative behaviour on the fly is important for a game that aims to encourage children to learn from each other through play and experimentation. This research method appears to be a valuable tool for influencing emergent group behaviour in real time and can potentially inform the design process for games and applications, in which synchronous group interaction plays an important role.

Spontaneous interaction in a café: Schminky

Design approach

Schminky was a sound based game played on a mobile computing device that was trialed within a café for a week. Over the course of the week one hundred and forty different people tried the game and five people came back on different days to play again.

The purpose for designing and introducing the game was to observe what impact pervasive games technologies might have on social spaces and to see if we could design a game that used technology to increase social interaction amongst people in the café rather than isolate or alienate people. We engaged a sound artist who had intimate knowledge of the café to work with us to design the game and to produce the content for the game. We also worked with the café staff and owners to bring their perspective to the design.

Overview

The game involves the solving of musical puzzles. Four buttons on the device are mapped to four different musical sounds, for example a voice note, a low base beat, a rhythm sequence and a tone (figure 5). One or more of these sounds is randomly played within a background music track and the user needs to select a sound that is not playing. At the easiest level only one of the sounds play. The user needs to complete a series of correct choices in a certain time to progress to harder levels where more of the sounds are playing.

The intention was to introduce something into the environment that would enhance and encourage social interaction. Consequently, the game also allows users to form a group of people to play together. A player can broadcast a message around the café to all the other Schminky players to join them in a group game. Recipients of the message can accept or decline the invitation. Once the group is formed players take turns to complete the levels. Each person needs to succeed before the game can continue. We were interested to see if this game rule would encourage collaborative behaviour, so that players who
were struggling could be helped by others in the group, who would be able to hear what was happening.

Two wall-mounted tablet PC's present audio/visual representations of the social network being constructed as groups form and play the game. These representations generate music that reflects the richness of the network connections, and identify individual players as orbs moving in a 3D space, connecting them to each visually if they have played together.

**Rules**

Rules were implemented at several levels.

a) **within the sound game itself**, for example if you did not select the right button you did not progress onto the next level

b) **within the multi-player mechanics**, for example the rules for when you were able to invite people to play with you and which player had the next turn

c) **within the network representation**, for example the rule for determining that you have “had a game” with another player

d) **within the café**, for example players were expected to look after their device and return it after an “appropriate” amount of time

e) **within the wider environment** – Schminky was not available in the evenings when the café would become more of a bar, it would get very crowded and the music would be turned up very loud.

**External factors,**

The mood in the café, the amount of people and the music levels were all significant external factors. The game was designed for the daytime “café” mood when you can see people across the café, the music is quieter and the atmosphere is generally more relaxed.

The process for getting a device also had an impact on how easy it was to try out a game and would deter a casually interested visitor. Potential users were asked to register and give proof of their identity before they were issued a device.

**Observations & emergent behaviours**

Our approach to evaluating the effect that Schminky might have in the bar was to study the bar in its “normal” state over the period of a day and then to make the same observations when Schminky was in use. Data was gathered using video and ‘dot notation’ where every 15 minutes the placement of people in the bar was marked on an outline, blue for male, red for female. The outline was also annotated to record behaviours such as reading, on the phone, chatting etc. We were also keen to note any occurrences of interaction across tables or groups. We found that Schminky did indeed help to facilitate initial social contact among strangers and that players frequently drew together, even though they could play the game anywhere in the café. However we also observed groups of friends who wanted to exclude strangers and only play with the people in their group. The players would keep trying to reform their group so that any “strangers” were not part of it. As the game mechanic was focused on inclusion rather than exclusion the players resorted to social or rather anti-social tactics to achieve their desired goals.

![Figure 5. The Schminky game interface on PDA](image)

Most people played the game quite openly and the device and the headphones were a visual identification that encouraged other players to approach and ask what their Schminky name was and whether they wanted a game. However we also came across players who wanted to covertly play in a group and not reveal who they were in person. They enjoyed being able to accept or initiate group games but not engage in eye contact or acknowledge other players who were curiously looking around the bar trying to work our who they were playing with.

Apart from these “anti-social” emergent behaviours the game did encourage many more “social” interactions. The process of initiating games and looking around for players was described as “a new way of flirting” whereby the game acted as an excuse to approach other players and start a conversation. Helping other players in group games could also produce quite fun and dynamic interactions. For example hand gestures were often used to indicate the right button to press; devices or headphones were passed to more competent players to push on with the game and players would nudge or wave at each other if it was their turn. Many of these gestures were to compensate for the fact that players need to wear headphones and so verbal communication was not always effective.

The most common behaviour observed was for the users to uncover one ear from the headphones when they wanted to talk to one another. This was useful between turns in multi-player games. Indeed players were extremely resourceful in
integrating the game device with regular café activities, eating, drinking and talking. If players were just drinking they would place the device on the table, glance at the screen and interact when prompted. When food was on the table they generally placed the device on a free chair or in their lap until they had finished eating and then they would continue with play.

The trial period lasted a week and within that time we began to see “regulars” who would come in every day or bring friends to try out the game. We speculate that if the game had been available for a longer period of time the word of mouth effect would become even greater and the playing and social dynamics would become even more interesting.

DESIGNED VERSUS USER GENERATED EXPERIENCE

Our trials with CitiTag, Savannah and Schminky revealed a range of emergent behaviours that explored the physical context of those games as well as the rules and boundaries embedded in the designs. Cooperation strategies emerged as people became familiar with the game mechanics and ways to strengthen their actions. For example, in CitiTag some people paired up and surrounded lone opponents because they could rescue each other if they were together. Schminky players would negotiate turn taking and help each other to collaboratively push the game to the next level. Some of the individual behaviours that emerged were playful and truly unpredictable (e.g. becoming a “secret assassin”, engaging with passers-by in CitiTag or dancing, trying to “attack” the water in Savannah or excluding “strangers” in Schminky). Other emergent behaviours were spontaneous, yet implicitly suggested by the context of the game. Even though no one instructed or suggested to participants to put their hand up when “tagged”, some people did this gesture by associating the CitiTag game with the original tag game, or simply trying to draw attention. Similarly in Savannah, no one instructed the children when to attack an animal individually or as a group, but this kind of collaboration emerged spontaneously, after the children understood the rules and dynamics of the game. Attacking an animal simultaneously in Savannah and developing risk-assessment strategies are emergent behaviours that are very implicit in the game structure and rules, therefore predictable to some extent. The children also engaged with the role of the “lion” and brought their own interpretations of the game through their role-play. The “new way of flirting” with Schminky relates very closely to what the game design set out to achieve – to facilitate social interaction in a relaxed environment – therefore it is a predictable user behaviour. Playing secretly though, was more unexpected and illustrates how players created a meta-game, puzzling others about who they were.

Our conclusion is that emergence (both individual and collective) can vary between being truly unpredictable and implicit in the game/activity context. The boundaries between surprising user behaviour and behaviour that occurs through experimentation with the technology, the game rules and cooperation strategies, therefore somewhat predictable, are not very clear. As designers we can provide a certain structure and rules but we cannot enforce, we can only facilitate the emergence of collective action and unpredictability in a game.

Forming groups and the “invincible pair” in CitiTag illustrate how players defined and extended their relationships spontaneously without the game enforcing them. Considering that the actual game and dynamics are really simple (“tag”- “untag”), supposedly one could play the game just sitting in their office, having their mobile phone on their desk and other players could come within and out of their proximity range. But what transforms this experience, making it different every time depending on the

Figure 6. The design for emergence process in Schminky.

A future design would introduce different mechanisms for group co-ordination, chat and group formation. The observation method in this study was useful for identifying a range of social or anti-social behaviours and recording variations in group dynamics. In this case, it was possible to produce ‘dot notation’, whereas in the other two games discussed in this paper, such recordings were not very useful and even possible in an outdoors environment where people constantly moved, often getting completely out of sight. The interactions in CitiTag and Savannah were more fast-paced (participants running, hiding, dancing etc) and therefore a time-based sampling would miss a lot of the detail, which was recorded on video for later viewing. Unlike Savannah, Schminky did not incorporate feedback to individual players that would reward group collaboration. Although players could observe on the wall mounted PCs the visualization of the social network being constructed as they formed groups in real-time, this did not seem to have an influence on their behaviour when playing the game. The design for emergence diagram (figure 6) highlights the aforementioned emergent behaviours and provides a good framework for us to devise new experimental designs in order to see what new behaviours might then arise.
The boundaries between truly unpredictable emergence and emergence that is implicit in the context require further investigation to help us understand better the tensions between “designed” and “user generated” experience. The studies with Savannah illustrated that having a flexible rule structure, which can be changed in real-time when tried out with users can become a particularly useful research tool to investigate these issues in future work.

EMERGENCE FEEDING BACK INTO DESIGN
So far we have discussed how design and external influential factors in combination can encourage spontaneous user behaviours. We have focused on emergence in our process diagram in figure 1. But how does emergence fit in the iterative design process? Can emergence inspire design (the feedback loop in figure 1)?

Imagine that we introduced a hidden “cheat” action for CitiTag players to become “spies” or “secret assassins”. This suggestion would add an interesting dimension to play and it follows the more traditional approach of the iterative design process, to support the observed behaviours by modifying the design appropriately. However, this approach is somehow limited, because not all emergence can be translated into design. More importantly, what is the added value for the design itself if it supports what people already do spontaneously? The greater challenge is not to change the design to support what people already do, but to explore new creative possibilities by understanding how emergent behaviours occur. This is not an easy task though; from the above discussion on the tension between “designed” and “user generated” experience, it seems that design and emergence are almost two opposite forces. Design aims to provide well planned and confined game experience and emergence subverts the existing structure, enhancing the experience through the unexpected.

With these tensions in mind, we believe the feedback in the process of design for emergence (figure 1) is about identifying the sources of emergent behaviour in order to understand it and inspire design. The following examples suggest ways in which the understanding of emergent social behaviour can advance the design process.

We learned from CitiTag that people teamed up in pairs or groups to be able to rescue each other when tagged and we observed clusters of players moving around together. So if people can have advantages from being in a large group, we can speculate what would motivate them to form groups on a larger scale, maybe even across the entire city. Consider the individual behaviour of the “secret assassin”; it can inspire experimentation with flexible game house rules that would be introduced or defined by the players themselves in real-time. When playing Savannah the children mapped parts of the physical space using various objects they found as props. What would happen if those props had a role in the virtual world as well? So imagine for example that by moving the physical objects in space, the virtual map of the Savanna would change, simulating the dynamics of an imaginary environment (e.g. the lions moving their prey to a safer location or feeding their offsprings). In the Schminky trials players were observed using one headphone in order to be able to talk and collaborate with their group verbally. When the music in the café was too loud or their teammates were at a distance, they would make hand signals. These observations suggest clearly that in order for a pervasive game to succeed in increasing social interaction amongst people in the café, the design must facilitate communication with other players in multiple ways (verbal, visual) and support existing, non-mediated communication practices that normally take place in these environments. The game rules can be developed accordingly to encourage these interactions. For example, in order to solve a challenge, a player would need to go and speak to another player within the café or perform some other act that would encourage social interaction.

Users bending the game rules or behaving in unexpected ways would be seen as an admission of failure in most ubiquitous computing design, but our view is that it can be used as a positive, creative force that, if properly harnessed, can lead to emergent interaction and engaging user experiences. By elevating emergence to a primary status, we enrich the iterative design process for mixed reality applications.

CONCLUSIONS
In this paper we introduced the first steps of a process for studying the design of ubiquitous applications by focusing on emergent and unpredictable user behaviours, both individual and collective. We have just addressed the need to define and understand the creative tensions between “design” and “user generated experience”.

A further opportunity for future research lies in the feedback of emergence into the design process. We have certainly learned interesting lessons from the emergent phenomena in CitiTag, Savanna and Schminky that can inform the iterative design process and inspire experimentation with concepts that facilitate collaborative play, as discussed in the section above.

Ubiquitous computing technologies pose many unknowns, with numerous possible interactions between people, objects, networks and built environments. In this area, the design for emergence research process is particularly useful...
because it nurtures a culture of exploring the unpredictable. As technology becomes embedded in everyday artefacts, our modes of interaction are constantly re-defined. By observing spontaneous, intuitive uses of technology, we can discover new interaction paradigms as well as ways to satisfy our emotional and social needs.

In future work we would like to enrich our knowledge gained from the design for emergence process, by looking into how these findings could apply to other, not necessarily game-related ubiquitous computing applications. The kind of emergence we explore is important, so far we focused on real-time collaborative behaviour, either completely spontaneous or in some way inherit to a game context. An attempt to design for emergence that occurs over a period of time has also promising potential. Since a lot of learning occurs through collaborative interaction, the research process deployed in CitiTag and Savannah can also be relevant for the design of other learning technologies that involve social interaction and some form of collective input (e.g. distributed collaboration, simulations etc). To some extent, modifying the external factors in the design for emergence research process, such as the skills and background of individuals and groups participating in a collaborative activity, can become part of the design input itself.

In principle we are aiming towards a “design for social phenomena” research process that can inform the design of novel interactive technologies for social interaction. By understanding the sources of emergent behaviour, designers can be more informed and able to apply the discovered ideas in their creative process, which is far from straightforward. Longitudinal field trials would definitely benefit the study of emergence and would be very challenging, requiring us to develop a combination of methods for capturing and observing emergent interactions over a longer period of time or at larger scale.

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