

# Wordster: Collaborative versus Competitive Gaming using Interactive Public Displays and Mobile Phones

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## ABSTRACT

We report the design, implementation and evaluation of Wordster, a word finding game played with public displays and mobile phones. The study shows how collaborative gaming in the single player mode enhances social interaction via co-location and spectator view. The usability and playability of the mobile multiplayer mode targeted for competitive gaming between players and realized by coupling a public display and a personal mobile phone into a distributed interface were found good in a controlled user evaluation. However, the adoption of the mobile multiplayer mode in an uncontrolled evaluation “in the wild” was poor, challenging the findings of the controlled user evaluation.

## Categories and Subject Descriptors

H.5.2 [Information Interfaces and Presentation]: User Interfaces – *evaluation and methodology, input devices and strategies, interaction styles*.

## General Terms

Design, Experimentation, Human Factors.

## Keywords

Public display, mobile phone, distributed UI, “in the wild”.

## 1. INTRODUCTION

This paper reports the execution and findings of a study tasked with the development of a new game into the so-called UBI-hotspots, a network of 16 large interactive public displays deployed around Oulu, Finland [16]. Using the new game as a probe, we explore two issues: first, how collaborative and competitive gameplay compare in fostering social interaction; and second, the usability, playability and adoption of a distributed user interface of the game where a hotspot is coupled with mobile phones. Finally, we compare the findings of controlled and uncontrolled user evaluations.

Thomas [21] has provided a comprehensive survey of visual, mixed and augmented reality gaming. However, the survey omits ‘conventional’ games based on public displays such as Flashlight Jigsaw [4], Polar Defence [9], MobiLenin [20] and Manhattan

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Story Mashup [22]. These games couple a public display with an additional control device, typically a mobile phone, and study various aspects of gameplay.

There is a rich literature on coupling public displays with mobile devices into distributed or hybrid user interfaces, e.g. [6]. While many candidate technologies have been proposed for this purpose, as of now there is no standard technology that would enjoy wide adoption among the general public. Currently QR codes appear as most potential solution, as they are becoming increasingly popular in print media with built-in support in modern mobile phones. Several approaches to couple the hotspots with mobile phones have been trialed, including a dedicated mobile client, Bluetooth, NFC/RFID, SMS and QR codes [2][10][16]. However, all of them have enjoyed only modest success in terms of adoption by the general public. At the same time the simple games available on the hotspots have become very popular [16]. Further gaming usage of the hotspots is reported in [15].

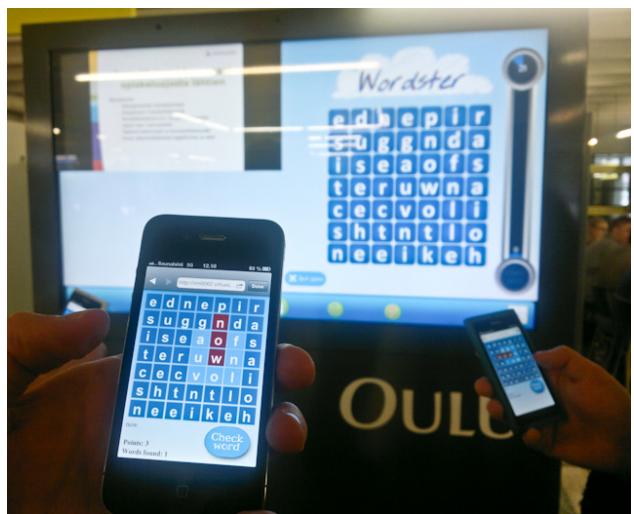


Figure 1. Wordster mobile multiplayer game in progress.

The game developed in our study is dubbed Wordster. It is a derivative of Boggle, where the goal is to find as many words as possible from a grid of random characters within a limited time. Wordster can be played both in a single player mode on the touchscreen of a hotspot and in a multiplayer mode with mobile phones (Fig. 1). This paper is organized as follows. Section 2 describes the elicitation of requirements driving the design and implementation of the new game presented in Section 3. Section 4 reports the execution and results of the two controlled user evaluations and the uncontrolled evaluation “in the wild”. Section 5 discusses the findings of the study.

## 2. ELICITATION OF REQUIREMENTS

Initial requirements for the new game were elicited by identifying the gaming affordances of the hotspots, analyzing their current gaming usage and conducting a questionnaire study.

### 2.1 UBI-hotspots as Gaming Platform

The hotspots are effectively 57-65" full HD LCD screens equipped with other computing resources such as a capacitive single-touch foil, a Bluetooth access point and two overhead cameras. A hotspot is either in a passive broadcast (digital signage) or in an interactive mode. In the digital signage mode the whole screen is allocated to the UBI-channel showing a customizable playlist. When the cameras detect a face or someone touches the screen, the hotspot changes to the interactive mode. There the screen is divided between the UBI-channel, now squeezed into the upper left quadrant of the screen, and a customizable UBI-portal occupying remaining three quadrants.

The screen is rendered as a large composite web page controlled spatiotemporally by an in-house screen real estate management system [12]. It controls the state machine realizing the interaction model and provides three alternate layouts of web pages for portal services. The pages are rendered by corresponding web server processes residing somewhere in Internet. The current version of the portal has seven service categories totaling 25-30 services, as old services are removed and new service are added regularly. Although all services can be used without authentication, a user can also create a personal hotspot account coupled with the Bluetooth ID of a mobile phone. Upon creating an account the user can personalize the hotspot and couple the account with a Facebook account, which allows posting of game scores on Facebook wall, for example. Further, a portal service may involve interaction with a mobile phone, for example, content upload or download to/from a mobile phone, or coupling the mobile phone with the hotspot into a distributed user interface.

Thus, a game has to be implemented as a web service that can use up to three quadrants of the screen equipped with a single-touch foil. Other potential interaction modalities include mobile phones and overheads cameras.

### 2.2 Current Gaming on UBI-hotspots

The hotspots have a service category titled Games having currently four single player games. Hangman is the traditional word guessing game where an animated man figure is hung after too many erroneous guesses. Ubitris is a derivative of the classical Tetris tile-matching game where the arrival speed of tiles increases as game progresses. In UBI Mosquitos the objective is to splash mosquitos and bees but not butterflies as they fly across the screen in increasing tempo. Belle Memory is a memory stimulation game where the player has to repeat increasingly longer sequences of objects of different color and shape in correct order. All four games are short, lasting few minutes at most.

The launches of portal services are logged in a database. The log data of Sep 2012 showed that all the four games were among six most popular services: #1 Hangman (18121 launches, 604 daily), #2 UBI Mosquitos (5258), #5 Ubitris (4054) and #6 Belle Memory (4021). On average 1048 daily games launched shows that the hotspots are a very potential platform for gaming. Although games were played on all 16 hotspots, there were great differences between locations: the hotspot placed in the lobby of the swimming hall contributed 69 % of all games played.

Two observation and interview sessions nearby two popular hotspots revealed that the four single player games were often played by small groups of children and teens. Few kids would maximize their chances in UBI Mosquitos by lining up along the screen so that each kid would splash mosquitos and bees on his/her own dedicated vertical sector of the screen. In Hangman the guessing of characters and words was often a collaborative effort. The UI and fast tempo of Ubitris and Belle Memory effectively limit them to single player games while the other members of a group participate as spectators cheering on the player. In the follow-up interviews the players asked for new, more challenging games into the hotspots.

### 2.3 Questionnaire Study

The questionnaire study comprised of a 6-day online survey and questionnaires completed in conjunction of the aforementioned observation and interview sessions. They yielded 79 respondents in total, 55 males and 24 females with median age in the 18-29 years bracket. 46 % of the respondents reported to play computer games frequently ('gamers') and their typical gaming session lasted at least 30 minutes. 89 % preferred traditional gaming devices (PCs, laptops, gaming consoles) over touch screen based devices (smart phones, tablets) to play games. However, 51 % reported to be interested in trying out a mobile phone as a controller for a multiplayer game played on a large public display.

When asked about the preferred maximum duration of a game to be played on the hotspots, 46 % of respondents stated 5-15 minutes and 37 % at most 5 minutes. Single-player (53 %) games were slightly preferred over multi-player games (47 %). Interestingly, as the only significant gender difference in the questionnaire study females preferred single-player games, whereas males preferred multi-player games. 65 % of respondents stated that seeing a ranking of the final scores is an important part of the playing experience. Comfortability with playing games on a large public display in a public setting correlated with age: while over 80 % of the respondents of at most 17 years reported being comfortable with it, slightly over 50 % of respondents of over 17 years had concerns about the public setting.

The respondents' free-text requirements for the new game in terms of features and types could be summarized as follows: simple, funny and easy puzzle game with an addictive plot of finding words and a ranking list, and a multiplayer mode supporting social gaming.

## 3. NEW GAME: WORDSTER

### 3.1 Design

The design of traditional computer games involves three aspects: challenge, conflict and interactivity. An additional important trait for maintaining the motivation to play the game is the illusion of winnability [7]. However, the design of pervasive multiplayer games requires wider scope. The public setting and the presence of real persons as opponents introduce a tremendous change in players' perceived importance of playing the game. Instead of just winning or losing a game in private, a multiplayer pervasive game can become a public affair and thus significantly more meaningful. Regardless of eventually winning or losing, just the potential public glory or shame can make a public multiplayer game a much more emotional experience than a single-player game [19].

Further, the co-location of real persons can support the creation of a joyful interaction experience. Magerkurth *et al.* [13] argued that in terms of social richness co-located computer games are far behind other popular game types such as board games. They attributed the difference to board gaming sessions creating much stronger social situations than a computer gaming session. They suggested augmenting traditional entertainment technology with social and physical elements to form a new class of hybrid gaming applications. These hybrid applications should integrate the social dynamics of co-located groups with computer games via interfaces that do not distract the group situation. Both private and public interfaces should be available to foster social dynamics. To create private, shared and public information in the social domain, additional private interfaces to the virtual domain should be provided.

Given the requirements discussed in Section 2, we chose the new game ‘Wordster’ to be a derivative of Boggle. The challenge of the game is to score as many points as possible by finding words from a grid of random characters within a limited time. Each found distinct  $n$ -character word contributes  $n$  points to the score. The conflict arises from the rules of the game. First, only successive characters in adjacent cells can be combined into words that have to be generic terms of at least three characters in length. Second, a particular character can be used only once in a particular word. Third, a particular word can be used only once even if it appears multiple times in the grid.

Interaction with the game is designed as follows. In the single player mode there are only public game elements such as the character grid, ranking list, control buttons and playing instructions. They are placed on the large screen of the hotspot and manipulated with the touch screen foil. A multiplayer mode is provided for competitive gaming, pitting individual players against each other. The multiplayer mode introduces two interrelated challenges for interaction design. First, there are now private game elements, i.e. individual players’ character and word selections. Second, access and control to the shared display (game grid) have to be provided to multiple players concurrently.

These interaction challenges are solved by a distributed interface where the large screen of the hotspot provides the public interface for public game elements while personal mobile phones provide private interfaces and distribute access and control to the shared public interface to multiple players. Coupling a shared display with multiple mobile phones is an obvious way to leverage their complementary strengths to negate their respective weaknesses [17]. While shared displays typically offer greater conceptual power and larger presentation space, they often limit interaction to one user at a time. Personal mobile phones, on the other hand, disperse control and access to multiple participating users, though limited conceptual power and smaller screen sizes often hinder interaction.

### 3.2 Implementation

The game is implemented using standard client-server architecture. The game web server was realized atop JavaEE and Tomcat with the Spring application development framework. The game logic is written in Java and game data is stored in a MySQL database. All game server processes are executed in a single virtual machine furnished with 1 CPU and 4 GB of RAM. The public display UI and mobile phone UI are realized as web pages implemented with HTML5, CSS and JavaScript that are supported by a wide range of desktop and mobile web browsers. jQuery was

used for client-side scripting. A mobile phone is coupled with the hotspot by scanning a QR code displayed on the public display. The QR code stores game session ID and the URL of the game server, which is opened by the mobile’s browser, saving the user from the trouble of typing the address. The playing time is set to three minutes. Three sizes are available for the character grid: 5x5, 6x6 and 7x7. The grid is populated by selecting up to ten random words from a corpus and placing them randomly on the grid, after which empty cells are filled with random characters, weighting the selection based on incidence of character in given language. The game is available in two languages, Finnish and English, and the respective corpuses have 79675 and 73810 words.

To play the game, the user has to first select the Wordster icon from the UBI-portal’s Games service category. Then the user has to select between “single player mode” and “mobile multiplayer mode”. User may also view instructions on the gameplay at this phase. If the user selects the multiplayer mode, then players can join the game by scanning the QR code rendered on the public display with their personal mobile phones to connect to the game server. Once the size of the character grid has been selected, the grid is shown on the public display, together with current score and remaining playing time. The player selects characters from the grid to create a candidate word and the “Check word” button allows the player to check the eligibility of the candidate word. If the word is eligible, the number of characters in the word is added to the score. Guessed eligible words are shown on the display. Once game is over, the final score(s) of the player(s) are displayed. At the end of each game, the player is asked to enter her/his nickname. In the multiplayer game the character grid, the “Check word” button and score are shown in the private UI on the mobile phone.

## 4. EVALUATION

### 4.1 First Controlled User Evaluation

The first controlled user evaluation was conducted with a functional prototype of the single player version of the game (Fig. 2(a)). The purpose was to assess the usability of the prototype and the playability of the game. The two-hour evaluation session was conducted at a hotspot located on the university campus on early weekday afternoon. Bypassing people were invited to play the game and during playing they were asked to think aloud all thoughts related to the game. After completing a game they were asked to fill in a questionnaire (4-point Likert scale) based partially on the game playability heuristics defined by Desurvire *et al.* [8]. Upon returning a questionnaire a player was rewarded with a voucher to a nearby cafeteria. During each game we also counted spectators and bystanders as defined by Finke *et al.* [9].

30 players played 23 games (9 in Finnish, 14 in English), so that 17 players played alone, five games were played by a twosome and one game by a threesome. These group games were the first concrete evidence of the social dimension of the (single player) game. Only three of the 23 games did not have any spectators and none of the games were completed without any bystanders. The average numbers of spectators and bystanders per game were 2.0 and 5.5, respectively. 14 spectators transitioned into players.

In terms of usability, the most important finding was that the placement and arrangement of the UI elements was suboptimal. The character grid was placed too high (“*Got a stiff neck*”, “*I’m too short to play*”). The current score and already guessed words

were placed too far away from the grid in the left hand half of the display, resulting in players gazing back and forth between the grid and the score. A group of players hoped that instead of touching the characters of a word one by one they could select the word with one swipe gesture. While the hotspots' touch screen foil does not support the swipe gesture, it was later implemented into the mobile UI of the multiplayer version. Several players complained about the poor responsiveness of the touch screen foil which is a recognized problem in the hotspots.

In terms of playability, the response was very encouraging. 28 (93 %) of the 30 players found the game addictive, easy and enjoyable, and would want to play the game again in the future. Several players requested for a multiplayer version of the game ("Please make a multiplayer version of the game where friends can see the same grid in their mobile phone screen and once the game is over, UBI spot will show the results").



Figure 2. Public UI prototypes: (a) version 1; (b) version 2.

## 4.2 Second Controlled User Evaluation

The second controlled user evaluation was conducted at the same hotspot on the university campus. The primary objective was to assess the usability and playability of the multiplayer version of the game. The setup was otherwise similar to the first evaluation, but the questionnaire was revised to cover the multiplayer version. The public UI had been redesigned to address the usability issues identified in the first user evaluation: the grid was enlarged and placed lower, the score was shown closer to the grid etc.

27 games played during the evaluation involved 47 players, 35 men and 12 women. 29 (62 %) of them classified themselves as gamers and 32 (68 %) reported having played a similar game before. Ten players elected to play only the single player version

of which five played the game together with their friends. The 22 multiplayer games involved 37 real players - if two real players were not available to establish a multiplayer game, then a researcher acted as a player. Of the 37 real players 29 borrowed a phone from the researchers. Two players had old low-end Android phones whose low resolution camera might have caused the QR reader to not work properly. One player had a brand new Nokia Lumia that did not render the grid at all. Of the eight players using their own phones five already had a QR reader installed in their phones and three installed a QR reader on the spot.

Table 1 shows statistics of selected questionnaire statements on the multiplayer game so that "strongly agree" and "agree" responses were grouped together, likewise "strongly disagree" and "disagree". Overall, players were satisfied with the usability and playability of the multiplayer game. Although only 57% were familiar with scanning QR codes with a mobile phone, 95 % found joining the multiplayer game easy. 81 % saw the benefits of playing Wordster with a mobile phone and 73 % were interested in playing games on hotspots with mobile phones. Only 8 % were not willing to play the multiplayer game again with their friends.

When considering the responses of all 47 players, 94 % reported that playing together in a group brings additional joy. This is further evidence of Wordster's gaming challenge stimulating first and foremost social gaming within groups of people, but not necessarily so much between individual players. Further, 74 % stated that playing in public environment brings additional excitement to the gameplay.

Table 1. Statistics of selected questionnaire statements in the second controlled user evaluation (N=37)

| Statement   | Agree (%) | Disagree (%) |
|---|-----------|--------------|
| I am familiar with scanning QR codes  | 57        | 43           |
| I find joining the multiplayer game easy  | 95        | 5            |
| I find performance of the game's mobile UI fluid and playable enough                        | 86        | 14           |
| I see the benefit in using a mobile phone to play the game instead of the UBI-hotspot       | 81        | 19           |
| I find combining a mobile phone with UBI hotspot to bring added value to multiplayer gaming | 78        | 22           |
| I would like to use my mobile phone in playing games on UBI-hotspots                        | 73        | 27           |
| I would not play multiplayer game again with my friends                                     | 8         | 92           |

## 4.3 Uncontrolled Evaluation "in the Wild"

The final evaluation of the game was conducted as an uncontrolled evaluation "in the wild", in the hands of the general public using the hotspots on their own without any coaching, support and interference from researchers. For this purpose Wordster was deployed on Jan 21, 2013, on all 16 hotspots across the city, as one of the five games in the Games category in the portal. We collected quantitative data on the gameplay for 38 days from Jan 21 till Feb 27. During the 38-day period Wordster became the most popular service and the most popular game with 3206 launches. Hangman had 3031 launches, UBI Mosquitos 1174, Belle Memory 1159 and Ubitris 1014. Of course, the launch of a game in the portal does not necessarily mean that the game was actually played. Further, multiple games can be played after one launch. To refine the analysis of gaming behavior, we

introduce the concept of a Wordster session. A session starts when Wordster is launched from the portal. A session ends when the portal closes the Wordster page and returns to the main service selection menu after 90 seconds of inactivity.

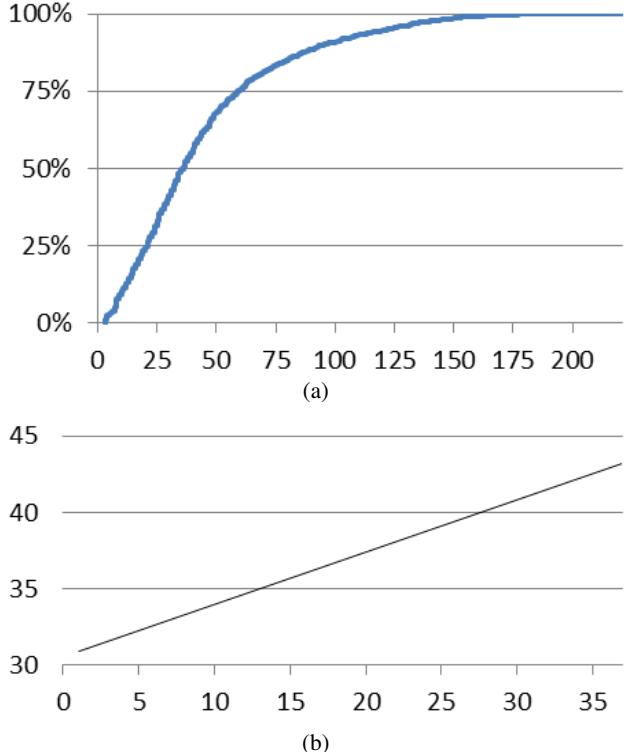
The 3206 launches (sessions) resulted in 1676 games played all the way to the end and scoring points. Additional 839 games scored points but were explicitly cancelled by the player. 113 games timed out without scoring any points and 1194 games were explicitly cancelled by the player without scoring any points. While we can only speculate about the reasons behind cancelled games, few sessions had quite many consecutive cancelled games, possibly due to a player sampling games to find a favorable grid. Only five of the 1676 completed games were multiplayer games played with mobile phones. 572 multiplayer games were selected to be played but the actual gameplay never commenced. This poor adoption of the distributed user interface by the general public is in stark contrast with the promising findings of the second controlled user evaluation. Of course, there are several potential reasons why a selected multiplayer game was never played despite the detailed instructions shown on the public UI how to scan the QR code with the mobile phone to join the game.

We also conducted two short observation sessions at hotspots located at the swimming hall and at the university campus after the deployment. We observed people's behavior nearby the hotspots and conducted semi-structured interviews of the 26 players of eight distinct Wordster games after they had finished playing. Incidentally, a multiplayer game took place between two males during the other observation session. They were bypassing the hotspot and became intrigued by the QR code on Wordster's public UI that had remained visible after a preceding game. The players of three single player games also stated that seeing the public UI prompted them to start playing. One of the three players of the fourth single player game had seen someone playing the game earlier and wanted to try the game himself now. The players of the remaining three single player games reported that they found Wordster from the portal. The relevance of a service's visibility in the public UI of one multipurpose hotspots for the usage of the service has been studied by Kostakos *et al.* [11].

Actually, only three of the observed seven single player games were played by a single player. The other four single player games were played by groups of 2, 3, 6 and 10 players, respectively. The 10 player group comprised of boys and girls of 8-10 years in age. The players in these groups said that instead of playing against each other they preferred playing the single player game together because it was more fun and by cooperating they were able to achieve higher scores. This again demonstrates the social gaming aspect of Wordster. None of the 26 interviewed players reported to be uncomfortable with playing in the public setting.

The plot in Fig. 3(a) shows the CDF (cumulative distribution function) of the scores of the completed games. 50 % of the games achieved at least 36 points, top 10 % at least 95 points and the highest score was 221. According to the players' feedback the ranking list was of great relevance to their motivation to play. Some players reported to occasionally stop by at a hotspot to check their current ranking and to play a game to try to improve their weakened ranking. The plot in Fig. 3(b) shows a linear trend fitted to the average daily scores over the 38 days of data collected from field use. We see how scores improved as time passed, due to returning players learning to play the game better. The learning can also be verified from the ranking list entries of distinct nick names. For example, twosome "MIC and RICH" played in total

27 games in three different occasions (dates), scoring 34-67 points in the six games of the first occasion while the eight games of the last occasion all scored over 120 points.



**Figure 3. (a) CDF of scores; (b) Trend of daily scores.**

## 5. DISCUSSION

Past literature on audience participatory systems shows that the physical and social setting is essential to their success. For example, Churchill *et al.* [5] stipulated that social setting drives the extent to which the technology is perceived as functional or playful or both. Maynes-Aminzade *et al.* [14] went even further, arguing that social involvement is much more important than technological involvement: while people may be initially amazed about the technology enabling the interaction to occur, within 30 seconds they lose interest if the activity is not inherently entertaining.

Wordster both succeeded and failed in establishing the social setting. The single player mode played on the hotspots was without doubt a great success as a social setting. As Magerkurth *et al.* [13] argued, the co-location of people is an important factor contributing to the successful creation of the social setting in the single player mode. Wordster brings people together in front of the public display, and the game stimulates inter-personal communication within a group of people as they jointly pursue a common goal, which in turn strengthens their strong social experience as a group. However, the current design of the mobile multiplayer version of the game targeted for competitive gameplay failed to offer a social setting that people would have found desirable. Instead of pitting themselves against each other, people much rather preferred playing together the single player mode. This became very clear in the observations and interviews of players.

The spectator view studied for example by Reeves *et al.* [18] is another factor contributing to the crafting of a successful social setting. People often gathered in front of the hotspots to follow the gameplay and contributed to the social atmosphere by cheering on player(s) and even helping out with guessing the words. And once the hotspot became free, many spectators transformed into players. A related classical challenge of interactive public displays is how to entice people to interact with them [5]? Agamanolis [1] argued that half the battle in designing an interactive display is designing how the display will invite that interaction. Many players reported that seeing Wordsters's public UI on the screen of a hotspot prompted them to start playing the game. The challenge remains how to provide sufficient visibility to all competing applications in a multipurpose public display [11]?

Finally, the contrast between the encouraging assessment of the usability and playability of the mobile multiplayer game in the second controlled user evaluation and the poor adoption of the multiplayer game by the general public in the uncontrolled field study sends an important message to researcher community. What works with recruited test users in a controlled setting is not necessarily at all representative of what works with a large population of independent people using the system on their own. If this study had been 'concluded' after the second controlled user evaluation, we would have rather false expectations regarding the mobile multiplayer version of the game.

## 6. ACKNOWLEDGMENTS

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