Mobile Phone User Interfaces in Multiplayer Games

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This study focuses on the user interface elements of mobile phones and their qualities in multiplayer games. Mobile phone is not intended as a gaming device. Therefore its technology has many shortcomings when it comes to playing mobile games on the device. One of those is the non-standardized user interface design. However, it has also some strengths, such as the portability and networked nature. In addition, many mobile phone models today have a camera, a feature only few gaming devices have.

The design of the keypad and joystick has an effect, especially, on multiplayer games, because the players playing against each other rarely have the same phone models. The user interface elements’ effect on playing mobile multiplayer games was studied with a within subjects test, where participants played five different types of multiplayer games with three mobile camera phones. The game results were analysed based on log data. Also, the participants gave their own evaluations based on their experiences.

The results show that a game that is based on steering and selection benefits from a phone model that has a joystick. A small keypad seems to fit typing games very well. Games using typing as their method of interaction are affected the most of all games by the player’s experience with typing text messages. Picture taking as a game interaction method suits all phone models from the user interface point of view. These interaction methods are also very well suited for the growing number of casual players. However, the user interface elements are not the only factors affecting performance. The speed of the phone’s hardware and software affect gaming performance in addition to the player’s experience in mobile phones and gaming on other devices.

Keywords and phrases: mobile multiplayer games, mobile user interfaces, mobile phone, mobile game design, minigame
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Appendices
1. Introduction

Some game developers believe that it is not possible to design games for mobile devices. It is true that one cannot design games similar to PC or console games for mobile phones. A mobile game is a game played on a mobile phone, PDA or other small handheld device. In this study mobile game indicates a game played on a mobile phone. Mobile phone is not primarily intended for gaming. As a game device, it has many weaknesses, such as a non-standard user interface as well as the characteristics of mobile technology and mobile network. All of these shortcomings together with a rapid evolution in technology complicate game design and may lead to a notion that it is not possible to design games for mobile devices.

The mobile phone has many failings, but also a few strengths as a game device when compared to actual gaming devices. One of the most important is that the mobile phone is connected by nature. It is also small and portable; users carry it with them nearly all the time. In addition, it has one feature the other gaming devices do not have: a camera.

One of the constraints that provide game designers a lot to think about is the user interface. Mobile phone user interfaces have not been standardized yet and there are hundreds of different user interface designs. Most mobile games use joystick as their interaction device [Koivisto et al., 2006]. Joysticks vary from each other based on the feel, physical and functional design. Due to these differences it is difficult to design games that are equally playable in all models [Koivisto et al., 2006]. Game developers may have to think about how to design a game that is playable with any or most of the different keypad or joystick models.

Variance in user interface layouts affects mobile multiplayer game design, in particular. Multiplayer games are games that can be played simultaneously by many players. When players are playing multiplayer games they rarely have the same mobile phone models. The main study question in this research is whether the mobile phone model the player is using has an effect on the player’s performance in a multiplayer game.

This study concentrates on testing the qualities of the joystick, keypad and camera in mobile multiplayer games. Keypad was chosen as another user interface element to be tested because it is common in mobile phones. There are also promising results that typing is a suitable and enjoyable gaming method in mobile phones [Koivisto et al., 2006]. Camera, on the other hand, is yet rarely used in games. However, it has a big
potential, because the number of mobile phone models with a camera is growing steadily.

The study focuses on the idea of casual gaming. Active gamers use devices specifically designed for gaming, but casual gamers use their own mobile phones. The majority of mobile gamers are casual gamers, who play when they have time [Fritsch et al., 2007].

The main research question can be split into smaller ones: is there a particular design of a user interface element that would suit gaming better than other designs? Is there a game interaction method that would suit all phone models, such as taking pictures?

Mobile user interface research concentrates on the design of new, improved ways of text input [Silfverberg, 2003] and joystick design [Chau et al., 2006]. Game design, on the other hand, focuses on developing mobile games that take the characteristics of the device into account. Koivisto et al. [2006] conducted tests on a text input based mobile game. They found out that text input is a suitable gaming method for a mobile game. Bucolo et al. [2005] as well as Suomela and Koivisto [2006] have developed innovative ways to use a mobile phone’s camera as a gaming device.

However, there is a lack of research that would combine these two fields. To our knowledge no empirical studies have focused on the suitability of different mobile phone models to gaming and whether the choice of the model has an impact on gaming performance. To learn about whether a mobile phone model and its user interface elements have an impact on how well the player does in a game we designed and implemented a within subjects test which dealt with using joystick, navigation key, keypad and camera in multiplayer gaming.

The tests were carried out with four sets of three participants who played mobile multiplayer games with three different mobile phone models. The games were designed so that they tested the quality and functionality of all user interface elements, the keys, joystick and camera in gameplay. The participants played five different multiplayer games on all three mobile phones. The games are implemented on the MUPE MiniGameServer, an application that enables very short multiplayer games in mobile devices. The game’s winning parameter is usually speed.

Initially it was hypothesized that a game that is based on steering and selection should be played with a joystick model and a model with large keys would perform well in number and word typing games. Picture taking as game interaction was presumed to suit all phone models. The final results, gathered from the game logs, proved our hypotheses right in some cases and wrong in others. They also showed that the user interface elements are not the only factor affecting a game’s results. Additionally, the results of user evaluations showed some interesting contradictions to the game log results. The participant’s opinions of perceived performance of the models and the
actual performance based on the game log data were different especially in typing games.

The thesis is arranged as follows. The next chapter will discuss mobile games, their genres and the special characteristics of multiplayer game design from the point of view of the technology. It starts with a discussion of the strengths and the weaknesses of mobile phone as a gaming device. It also introduces examples of mobile games that take the special requirements of the device and the technology into consideration in design. Chapter 3 focuses on mobile phone user interfaces. It describes the interface elements tested in this study in detail. It also makes assumptions on the quality of the elements in gaming. Chapter 4 introduces the method and apparatus of the tests. The test results are discussed in Chapter 5. The final chapter includes discussion and summarizes the findings.
2. Mobile Games

This chapter gives an overview on mobile games and mobile phone’s special characteristics as a game device. It also introduces the concept of multiplayer games and describes their differences to singleplayer games. The next section describes mobile game genres that differ somewhat from PC and console game genres, because of the restrictions posed by the technology. There are, however, genres that fit the device characteristics perfectly. The section on mobile multiplayer games illustrates the differences of multiplayer and singleplayer games in regard of technical requirements. Input styles used in mobile gaming are described and they are also tested later in this study. This chapter also introduces a few games developed particularly for mobile phones from the perspective of their input styles. They take into account the special characteristics of the device, e.g. the small keys, and use them to their advantage. They also cope with the shortcomings of the device and mobile technology by transforming their weaknesses to strength in game design.

There has been a significant growth in the mobile game market. According to market research, the mobile game revenue experienced a 61% growth in the late 2006 compared to previous year [Cellular-News, 2007]. However, mobile phone games are not popular all over the world. For reasons such as attraction towards gaming as well as the status of the local mobile network some countries are having a huge interest in games as well as other multimedia applications. In other countries there is no demand for them at all [Fritsch et al., 2007]. The study by Fritsch et al. [2007] also shows that the hardcore gamers had multiple devices they play on. Mobile phone gamers are usually casual gamers who play when they have time.

According to a worldwide study [Nokia, 2006a], mobile games are played most on the move and while waiting. Playing at home is also popular. On average a mobile gaming session lasts for 28 minutes. Players value most of all good gameplay, but replayability and genre are valued nearly as much [Nokia, 2006a]. Gameplay is a crucial element of game design that covers the idea as well as the interaction in the game in addition to the user interface elements of the game device [Nokia, 2006a]. The areas of replayability in game design and game genre are covered in more detail later in this study.
2.1. Mobile Phone as a Game Device

2.1.1. Strengths

The mobile phone has a few strengths compared to other gaming media. Firstly, it has a huge potential audience; there are ca. 2.5 billion mobile phone owners worldwide [GSM World, 2006]. According to Gartner, the number will climb up to 3 billion in 2010 [SMS.ac, 2005]. It makes the mobile phone market bigger than that of game consoles [Nokia, 2003b]. In addition, the mobile gamer profile is wider. A typical mobile gamer is older than a typical console gamer, and there are also more women amongst mobile gamers [Cellular-News, 2007].

Secondly, the mobile phone is a networked media, thus it easily enables multiplayer gaming. One of the appeals of multiplayer gaming is that the player is playing against another human being, not an Artificial Intelligence (AI) system. The social aspect of gaming is not to be dismissed either. A good multiplayer game encourages communication and builds strong connections between players [Nokia, 2003a].

Thirdly, the mobile phone has one feature the other gaming devices do not have: a camera. Camera games have a huge potential since there will be more cameras in mobile phones than in any other device by 2010 [Bucolo et al., 2005]. The quality of mobile phone cameras is getting better all the time.

Finally, the small size and portability of the device itself is an asset. People tend to carry their phones with them nearly all the time, which enables playing regardless of location and time. According to a study by Fritsch et al. [2007] the biggest advantage of mobile phone gaming is mobility. The participants of the test also regarded the fact that the phone has two, or more, functions in one device as an advantage. Results of a worldwide study [Nokia, 2006a] show that mobile games are played as much on the move as they are at home. They are also a popular way to pass some time while waiting.

However, mobile phone has more weaknesses than strengths as a game device. The next section will discuss them more closely.

2.1.2. Weaknesses

The mobile phone has its restrictions as a game device in many ways when compared to other devices specifically designed for that purpose. There are several weaknesses that relate to the physical features of the device and the characteristics of the mobile phone network. On the device side, its memory space, application size, processor power, battery life and display size as well as means of input are limited, [Bucolo et al., 2005; Kjeldskov, 2002; Nokia, 2003a]. Even though portability is an advantage, it can also be a failing. Dynamic use-context, i.e. using the device on the move and in various locations: in a bus, when walking or even while driving a car, can pose a challenge for game design. Also, the mobile network characteristics, such as connection, latency and bandwidth can restrict design.
According to Bucolo et al. [2005] a key challenge in mobile game development is the constraints imposed by the device itself. The game developer is generally limited to the 12-button keypad configuration as the primary user interface for the game. Mobile phone’s primary usage is not gaming, if we do not take into account the few devices specifically designed for the purpose, such as Nokia N-Gage. The keypad is designed for other uses, mainly making calls and accessing other functionalities. It is not originally intended even for writing text messages [Hiltunen et al., 2002]. Additionally, there is great variance in physical user interface design of the mobile phones and no design standard has been developed. Effect of keypad design on gaming performance is one of the key issues in this study and it will be discussed in more detail later.

When a game application is running it consumes memory. Memory is used to store graphics, create objects during playing and so on. Furthermore, games have to share the available memory space with other applications [Verity Technologies, 2006]. The amount of available memory space depends on the phone model. An average mobile phone has about 4 MB of memory, while some of the new phones, such as the multimedia phone Nokia N91, may have up to 8 GB of memory [Nokia, 2007].

Mobile phone technology places its restrictions on game application size. The allowed size of a game file is device dependent. For instance, in Nokia series 40 devices the maximum size of a game file is 64 kb, whereas in series 60 and up the file can be as large as the free space, but generally 100–200 kb. The game file includes graphics, sound and code for the game [Verity Technologies, 2006]. The limit on downloadable games has grown from 30-50 Kb to 300-500 Kb, which enables richer and deeper games. In addition, increase in the memory size allows the storing of more games to the device [Wisniewski et al., 2005].

Processor power for mobile phones today is 100 to 200 MHz [Bucolo et al., 2005; Pulli et al., 2005]. Pulli et al. [2005] predict that 400 to 600 MHz of processor power is available soon.

Increased processor capabilities and growing display sizes demand more power. Games should always have the light of the display turned on, which consumes more power, too. Battery life is thus an issue worth considering in game design [Pulli et al., 2005]. If the battery constantly runs out during gaming, the game is not useful for the player and loses the whole advantage of mobility. The battery life is usually between 3 and 6 hours of active mobile phone use [Nokia, 2007].

Different use-contexts require different amounts of attention from the user. There is a difference in the amount of attention a user can give a mobile phone while sitting on a sofa or walking on a street. Kjeldskov [2002] states that for mobile applications to be more usable while users are mobile, the user interface should be simple and interaction required kept minimal. Another aspect in use-context is that the mobile phone is not solely a gaming device and playing can be interrupted by a phone call. It is important,
especially in multiplayer game development, to consider how to handle dropout players. Drops may happen when the connection goes down or a player needs to quit the game for an incoming call. The gaming experience of other players should not be affected by the loss of one player. It is feasible to keep play sessions relatively short to prevent drops.

Mobile network related issues, such as latency and bandwidth, affect mobile game play and multiplayer games in particular. Latency is a feature of mobile networks that is a result of a packet’s travel time from server to client to server and back. The delay is shorter if the server is in the operator’s network. Latency is microseconds in computers and measured at best in milliseconds over the Internet. However, in an over-the-air-network, like mobile network, it can be sometimes measured in seconds, which makes it impossible to develop fast-action multiplayer games [Nokia, 2003a]. An example of a fast-action game is a game where the player needs to shoot quickly all enemies that appear on the screen. The player’s movements are fast and the game requires immediate responses from the server. After shooting an enemy, it would be frustrating to wait for feedback for even a second. Large latencies can occur when the mobile phone switches the network cell, the connection gets a timeout or the phone receives a call or an SMS [Koivisto et al., 2006]. Cell change occurs, for instance, when a user is travelling in a bus. The phone connects to the closest network cell and the connection may be down for a while during that time.

Bandwidth concerns online multiplayer game development, in particular. It becomes an issue when many players are trying to connect to a server at the same time [Nokia, 2004a]. Too much traffic may slow the connections down or disable the forming of a connection completely, depending on the technique used.

According to Fritsch et al. [2007] the biggest disadvantage of mobile games is the lack on graphics, which has to do with the size of the display, phone’s memory size and processor’s capabilities. More elaborate game graphics require more memory and the processor should be able to work with increased sizes of graphic files.

Some mobile games are designed specifically to suit the medium’s requirements. For instance, Ancient Runes [Koivisto et al., 2006] is a multiplayer game that uses latency as an advantage in the game design. There are also games that take advantage of the portability and special features of the device, such as one-button and camera games. These games and their special characteristics are discussed in more detail later.

2.2. Mobile Game Genres

Mobile games can be divided into genres in many ways. Wisniewski et al. [2005] present a list of categories in Table 1.
Table 1. Mobile Phone Game Genres [Wisniewski et al., 2005].

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sports</td>
<td>Bowling, Golf, Football, Basketball, Hockey, Soccer, etc.</td>
</tr>
<tr>
<td>Racing</td>
<td>All types of tracks (off road, drag, circuit) and all types of vehicles.</td>
</tr>
<tr>
<td>Action</td>
<td>Side-scrolling platform action games and some fighting games.</td>
</tr>
<tr>
<td>Adventure</td>
<td>Adaptations from complex PC adventure games.</td>
</tr>
<tr>
<td>Word/Trivia</td>
<td>Many different word and trivia games.</td>
</tr>
<tr>
<td>Arcade/Classics</td>
<td>Long-term favourites like Ms. PacMan, Galaxian, and Asteroids.</td>
</tr>
<tr>
<td>Logic/Puzzles</td>
<td>Includes games such as Tetris and plenty of other titles.</td>
</tr>
<tr>
<td>Strategy/Simulation</td>
<td>Some games exist for mobile devices.</td>
</tr>
<tr>
<td>Casino</td>
<td>Mostly casino card games such as poker and black jack.</td>
</tr>
<tr>
<td>Parlor</td>
<td>Mah Jong, Reversi and other board games.</td>
</tr>
</tbody>
</table>

Mobile game genres include all genres available for PCs and game consoles. Sports games are very popular and nearly all sports categories are covered in mobile games. Racing games are also very popular. A reason for their popularity may be that they are easy to play and little instruction is needed at the beginning. Action game category is dominated by side-scrolling platform games [Wisniewski et al., 2005]. An example would be any Mario Bros-type of a game. They are easy to play on any device, regardless of the display size. Word and trivia games work well across all devices, because they are not dependent upon phone, processor speeds and display limitations [Wisniewski et al., 2005]. They are also easy to implement as multiplayer games. Logic and puzzles are another favourite of players. This category is maybe the most successful, sales-wise [Wisniewski et al., 2005]. Casino games are suitable for a mobile phone, as they do not require as much from the device as for instance action games.

Adventure and fast-action games are more difficult to implement in a mobile device due to, for instance, restrictions of the network, which were discussed in Section 2.1.2.

Mobile game genres are examined later in relation to minigames. Minigames are very short games consisting of simple interactions. They are usually played in a sequence of several games. All of the genres above can be implemented as both singleplayer and multiplayer games in mobile phones. The following section will focus on multiplayer games and their design requirements.

2.3. Mobile Multiplayer Games

Multiplayer games can be played simultaneously by many players so that they compete with each other. In local multiplay, there is a connection between the game devices. Playing may take place using one game device, such as a game console, where all the players are gathered around it. Mobile games may use a Bluetooth connection to connect to each other’s devices. Online multiplay uses the network to make connections between the devices and the server. Players play the game with their own game device,
but they can see and interact with the other players in the game. In mobile phone games, the players can install the game software to their device. This study uses Multi-User Publishing Environment (MUPE) as the game platform. In MUPE, the game interaction happens via a server, but the players need not be connected to it continuously. [MupeNet, 2006]

Mobile multiplayer games show the other players in the game in different ways. For instance, the players can be located physically close to each other, like in Assassin [Suomela and Koivisto, 2006]. They can have head-to-head gaming, where the other player’s game statistics are visible on the game display [Koivisto et al., 2006]. This study uses Minigames in the MUPE platform that can show the other players as pictures or other objects on a screen. Alternatively, they can be seen in the result list and chat. The Minigames are discussed in detail later.

The differences between singleplayer and multiplayer games focus on game design level as well as on mobile technology. The differences between them are seen in game design [Nokia, 2004b]:

- **Opponents are other people.** Players are playing against other people, not a machine.
- **Games should be repeatable.** The game should provide enough variance and challenge for infinite replayability.
- **Design should deal with drop-outs.** The game should be able to handle players leaving the game in the middle of it.
- **Game should feel balanced.** The game should feel winnable even for a first-timer.

First, the game should provide a certain amount of struggle, where the players work towards a goal, otherwise it is too easy and the players lose their interest. On the other hand, it cannot be too difficult either or the players consider winning impossible and, again, lose their interest. In multiplayer games it is the other players that provide the struggle. The game design should give players means to work towards a goal by helping or hindering each other.

Another aspect in designing mobile multiplayer games is that the game should be repeatable. The design should make it possible to replay the game infinitely. For instance, in a game like Sheep Game, which is described in detail in Section 4.1.1, the game design should always place the sheep in the field randomly. If they are in the same position every time the game becomes boring very quickly. In multiplayer games the variance in game design level is not always needed, because the other players can provide the variability.

Finally, player-matching issues do not occur in single player games. In multiplayer games it is common to have new players play against more experienced ones. As a result, newbies get obliterated and may lose their interest in the game. The game should
feel balanced, that is, all the players should feel that they have an equal chance of winning. There are a number of ways to achieve a sense of balance. A possible solution is implementing a player ranking and -matching system. Alternative solution is that a stronger or more experienced player may need more points to win than a less experienced player. Also, players may form alliances to balance the setting.

In multiplayer games the community aspect of the game is important. According to Gordon Walton: “they come for the game, they stay for the community” [Nokia, 2004b]. A sense of community can be enhanced in many ways. One option is to implement a challenging functionality, where a player can challenge his/her friend to the game via an SMS. Diplomacy has also its place in some games where it is possible to form alliances or hinder other players. Buddy lists and chats are one way to see if friends are playing at the moment and talk with them. Game web sites are another good way to provide a feel of community. There the players can have discussions, swap hints or view leader boards of the game.

The next section will introduce some mobile games that are designed with the device’s characteristics in mind. The solutions address the issue of the problematic small keypad and restrictions of the technology in multiplayer game design.

2.4. Examples of Mobile Games

2.4.1. Joystick Games

Joystick is the most common method of interaction in mobile phone games [Koivisto et al., 2006]. Alternatively the games can use the number keys 2, 4, 6 and 8 for directional movement and 5-key for selection. Usually, it is possible to use either one.

Snake (Figure 1) was the first mobile phone game and is still one of the most played mobile device games [Pulli et al., 2005; Nokia, 2006a; Wisniewski et al., 2005]. It was installed on the mobile phone and came with many Nokia models starting from 1997 [Nokia, 2003a]. In early phone models the keypad was used in gameplay as the interaction method, since the phones did not have joysticks yet.

Figure 1. Snake [Nokia, 2006a].
The idea of this singleplayer game is to catch as many “pieces” from the screen as possible. The snake grows in length every time it catches a new piece; therefore moving around becomes difficult very soon. Snake has evolved as a game with the evolution of mobile graphics and has got some new features, but the basic game idea remains the same.

2.4.2. One Button Games

All the one button games introduced here are singleplayer games. The game file is downloaded to the device via Internet and no network connection is needed for playing.

Skipping Stone is a game where the player keeps a stone jumping by pressing a button at exactly the right time (Figure 2). The gaming is based on the player being able to press a button rhythmically. [Sheffield, 2006].

In Nom the player plays a runner, who jumps obstacles, chases girls and gets dogs to follow him around (Figure 3). The game requires the player to rotate the device, because the runner uses all the sides of the display. Nom requires a sense of rhythm and a good timing technique from the player. [Sheffield, 2006; Gamevil, 2007].

In Tower Bloxx (Figure 4), the goal is to build skyscrapers from falling blocks. The higher they get, the more difficult it is to aim a block on top of another. [Digital Chocolate, 2007]

Skipping Stone and Nom from Korean Gamevil are million-sellers and they both saw a sequel released in 2005. Their strength lies in innovative gameplay and easy form of interaction. Also, their graphics are unusual and interesting. [Sheffield, 2006]

More important is that one-handed gameplay is well suited for mobile devices [Sheffield, 2006]. These games take the characteristics of the device into account and use it to their advantage. In Nom, the small handset is very easy to rotate. Skipping Stone requires pressing only one key, but the game design makes the minimal interaction interesting and engaging. Tower Bloxx relies on a similar method of interaction. Timing is of essence there as well, but the game does not require rhythmical key presses.
Reasons for the success of these games may be that they are easy to demo to other people [Sheffield, 2006]. According to a study, 62% of players would like to demo games to their friends and 79% would try out a demo sent by a friend [Nokia, 2006a].

According to Kuy C. Lee from Gamevil there are three points contributing to the success of one-button mobile games [Sheffield, 2006]. The first is that they are easy to play on a mobile device. Secondly, they are addictive. Lee states that “the simple nature of play makes it engaging, and a bit of difficulty makes the task at hand seem just out of reach”. The final point is the productivity in development of these games; one-button games are easier to develop than games needing more interaction.

2.4.3. Text Input Games

In Habbo Dreams the player’s character is trying to sleep peacefully, when nightmares begin to haunt him/her (Figure 5). To get rid of them the player needs to type the letters of the nightmare. The nightmares get worse level by level and the typing also needs to get faster. Habbo Dreams is a singleplayer game that is loaded to a device via Internet. [Habbo.fi, 2006]

In Ancient Runes two players compete in head-to-head battle. Each of them is a wizard who tries to defeat the other by using spells (Figure 6). The spells are divided into four categories: air, water, fire and earth. They are cast by typing runes (letters of the spell). For example, the spell Napalm requires the player to type in NAPAL# (keys 62725#), where # stands for a fire spell. One sequence of numbers corresponds to only one spell. [Koivisto et al., 2006]

Ancient Runes is implemented with the Multi-User Publishing Environment (MUPE). The game is played via the network, which the players connect to using 3G, GPRS or other available connection method with their mobile phones. The battle system of Ancient Runes relies on the memory, tactics and text input speed of the player, whereas Habbo Dreams lacks the strategy aspect and requires only typing speed and accuracy.

According to Koivisto et al. [2006], the text input based game system proved to be enjoyable and suitable game mechanics for a two-player-game. The tests with Ancient
Runes revealed that a player does not need to have much experience on typing text messages to do well in a typing based game. Furthermore, female test participants performed slightly better in the game than male participants.

2.4.4. Camera Games

According to Bucolo et al. [2005] the main ways of using camera input in existing mobile games is to provide phone position and orientation tracking. There are, however, picture-taking games developed for mobile phones, such as the Assassin (p. 14).

Mozzies, or Mosquito Hunt, is a game that uses a camera to give a live video background image for flying mosquitoes (Figure 7). It does not require picture taking, but aiming at and shooting the virtual insects [Bucolo et al., 2005]. Mozzies is a singleplayer game that does not need a connection to the network while playing.

Marble Revolution is also a singleplayer game that uses either a joystick or camera as an input device. The game is all about steering a marble through a maze (Figure 8). The camera mode differs from the traditional joystick input in that it uses the real world as a reference for the angle of the tilt. The player tilts the phone and the marble moves according to the input. The camera mode is supposed to mimic the feel of the old wooden tablet games. No active network connection is needed while playing. [Bucolo et al., 2005]

Mobile Maze (Figure 9) is a singleplayer game similar to Marble Revolution. In Mobile Maze the player tries to steer a ball through a maze. Bucolo et al. [2005] tested three different methods for input; joystick, panning and tilting for the game. The latter two use a camera to get real world reference of the phone’s movement. The researchers found out that the participants preferred the tilting interface to the other two. They regarded the joystick mode too easy and boring, whereas the tilting was considered to be frustrating yet challenging, thus making it more desirable as game mode.

SymBall (Figure 10) is a table tennis game where opponents fight each other in face-to-face combat. They are using their phones to control the racket and hit a virtual ball. SymBall is a two-player game where the actions of the players are transmitted from one phone to another via a Bluetooth connection. Both phones calculate the ball’s
trajectory independently, therefore the game can handle even long latencies. [Hakkarainen and Woodward, 2005]

Figure 9. Mobile Maze [Bucolo et al., 2005].

Figure 10. SymBall [Hakkarainen and Woodward, 2005].

Assassin is a game where the goal is to take a photo of your opponent without him/her noticing. After taking a picture of an opponent the player sends it to the opponent to receive a point. A point is awarded if the opponent admits that it is indeed a picture of him/her. Players may defend themselves against picture taking by selecting “defend” – function from the game screen. Assassin is a multiplayer game implemented on the MUPE platform. The players can see other currently active players as a name list on a screen. The game is meant to be played in a group of friends, so everyone will know each other by name. Players cannot be located too far away from each other, because they need to be within a picture taking distance, for instance, in the same office or a school building. The pictures are sent from a phone to another via a MUPE server. [Suomela and Koivisto, 2006]

Camera game design seems to focus on using the device to other purpose than taking pictures. Both maze games, Marble Revolution and Mobile Maze, use real world as a reference to tilting. Mozzies, on the other hand, shows the real world through the camera lens and adds the game elements on top of the image. SymBall substitutes the real world image from the camera with an image of the game. The camera is used to get real world reference to position the player’s racket [Hakkarainen and Woodward, 2005].

A downside of camera games is that using camera consumes more power. Also, in the case of Assassin, it costs to send the picture to the opponent.

The next chapter will discuss mobile phone user interface elements that are tested in gaming in this study. It includes also a hypothesis on what kind of user interface elements will perform well in gameplay and why.
3. Mobile Phone User Interfaces

3.1. Mobile Phone User Interface Elements

This chapter will concentrate on the physical user interface components of a mobile phone that are going to be tested in this study. Kiljander’s [Kiljander, 2004] classification of mobile phone components is used as a basis for Figure 11. The picture of a phone is from the user manual for Nokia E50 [Nokia, 2006b]. The figure illustrates a number of keys that are rarely used in active gameplay, including keys for accessing game menus etc; therefore it is not necessary to elaborate on their usage in this study. Here, the focus is on input devices that are relevant from gaming and game design perspective.

![Diagram of mobile phone user interface components in Nokia E50.](image)

Soft keys differ from other keys in that their function depends on the currently active application. A soft key can, for example, open an address book or a menu or close applications. Some of the keys are called special purpose keys without any further details on their functions. They are rarely used in games and their number and functions differ from one phone model to another.
Table 2 consists of all user interface components and their usage in mobile phones divided into input and output devices. The table is adapted from Kiljander’s thesis [Kiljander, 2004]; the rightmost column was added to illustrate the usage of the components in games. While at times menus are used during gaming and outside the game for making game definitions, the focus is on their use in actual gameplay.

<table>
<thead>
<tr>
<th>User interface component</th>
<th>Usage</th>
<th>Use in mobile games</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input devices</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keypad</td>
<td>Entering numbers, letters and other characters</td>
<td>Steering, selecting, entering text, jumping…</td>
</tr>
<tr>
<td>Joystick, navigation keys, rollers, wheels</td>
<td>Controlling the device in various tasks</td>
<td>Steering, selecting, jumping, shooting…</td>
</tr>
<tr>
<td>Rocker keys and other special keys</td>
<td>Controlling the device in various tasks</td>
<td>-</td>
</tr>
<tr>
<td>Soft keys</td>
<td>Controlling the device in various tasks</td>
<td>Accessing menus etc.</td>
</tr>
<tr>
<td>Call management keys</td>
<td>Managing phone calls</td>
<td>Red call management key for exiting the game</td>
</tr>
<tr>
<td>Clear-key</td>
<td>Erasing mistyped letters</td>
<td>Erasing mistyped letters</td>
</tr>
<tr>
<td>Volume keys</td>
<td>Managing volume settings</td>
<td>-</td>
</tr>
<tr>
<td>Power key</td>
<td>Switching the device on and off</td>
<td>-</td>
</tr>
<tr>
<td>Special purpose keys</td>
<td>Accessing camera, Internet, voice recorder, or opening hinges, slides or slip covers</td>
<td>-</td>
</tr>
<tr>
<td>Microphone</td>
<td>Audio input</td>
<td>-</td>
</tr>
<tr>
<td>Camera</td>
<td>Taking pictures</td>
<td>Taking pictures and observing tilt</td>
</tr>
<tr>
<td>Sensors</td>
<td>Sensing proximity, light etc.</td>
<td>Sensing proximity of objects [Björk et al., 2001]</td>
</tr>
<tr>
<td>Touchpad or touchscreen</td>
<td>Direct manipulation or handwriting recognition</td>
<td>Game interactions in iPhone [MacMillan, 2007]</td>
</tr>
<tr>
<td><strong>Output devices</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flat panel display</td>
<td>Conveying information to the user</td>
<td>Displaying game visuals</td>
</tr>
<tr>
<td>LED(s)</td>
<td>Indicating the status of the device: low battery, incoming call etc.</td>
<td>-</td>
</tr>
<tr>
<td>Earpiece and possible speaker</td>
<td>Audio output</td>
<td>Playing game sound effects and music</td>
</tr>
<tr>
<td>Buzzer</td>
<td>Playing ring tones and other audio</td>
<td>Playing game sound effects and music</td>
</tr>
<tr>
<td>Vibration motor</td>
<td>Tactile output in incoming call or message, gaming</td>
<td>Vibration effects</td>
</tr>
<tr>
<td>Laser pointer or flashlight</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2. User interface components in a mobile phone and their use in games.
Mobile phone design is not standardized. However, all mobile phones have at least some similarities when it comes to user interface elements. One of the most common input devices in a mobile phone is a keypad that consists of the numeric keys 0-9 and, usually, the keys * and #. The study will explore different design possibilities later.

A joystick and a navigational key are alternative designs of a control device. Other more rare options for the same purpose are rollers and wheels. Rocker keys are used, for instance, to control volume. Most of the input devices are different keys. Soft keys’ functionality depends on the application the user is currently managing. A phone may have two call management keys, one for answering a call and another for hanging up, or just one that is used for both purposes. There can be also other keys, but their number and the purpose is model dependent. For instance, all models do not have a separate clear-key. In that case, the functionality is assigned to a soft key. Other input devices include, for example, a microphone, which is featured in all models. Additionally, there are optional input devices, such as camera and various sensors.

According to Kiljander [2004], there are a smaller number of possible output devices in a mobile phone. Display and various devices for sound output are general features of a phone. Devices like vibration motor and laser pointer are model dependent.

The next sections explore some of the user interface elements in more detail. Keypad, joystick, navigation key, camera and display were chosen for deeper analysis, because they are central in the tests later in this study. The sections analyse the features of the devices also from a gaming point of view.

3.1.1. Keypad

Hiltunen et al. [2002] categorize the mobile phone as a one-handed device. The keys are pressed with one hand leaving the other free. However, there are people who write SMSs using two thumbs. SMS stands for Short Message Service. The service also known as text messaging was originally designed as a way for the operator to inform customers about service breaks. The possibility for customers to send SMSs was added because it was fairly easy to implement. At the time, designers could not imagine who would use such a hard-to-use system. [Hiltunen et al., 2002]

McMullan and Richardson [2007] state that the mobile phone’s keypad does not intuitively facilitate good gameplay. They mention that it is difficult to press the correct button while focusing on the screen using a small keypad where the keys are located close to each other. Usability-wise, a device with only one button that does one simple clearly indicated thing might be preferable to a device with multiple buttons. However, that kind of device would not rate high on a utility scale [Hiltunen et al, 2002, p. 152]. Similarly, a game with only one button would be easy to use. When you press it, the game would announce “You win!”. But such a game would not be fun and engaging [Nokia, 2006c]. However, popular and even complex one-button games have been
developed. Also, there are games that are based on text input, such as Ancient Runes. The games and their input mechanisms were discussed in more detail in Section 2.4.

In the most common keypad layout (Figure 12) there are twelve keys: ten for numbers 0-9 and two additional keys for characters * and #. The alphabet is divided among eight number keys according to an ISO standard [ISO, 1994]. Most mobile phones use Multi-tap and T9 systems to enter text. In a Multi-tap system, to enter the word CAR the user needs to press 222 2 777. A T9, or predictive, system would only require pressing 227, making typing faster and easier. Silfverberg et al. [2000] found out that typing with T9 system is approximately twice as fast as with Multi-tap.

Entering numbers happens in the same manner in Multi-tap. Alternatively, the user can choose the number mode in T9 to enter numeral characters only. In multi-tap other characters such as commas or brackets can be entered in two ways. Most commonly used characters are found by pressing 1. All characters are available in a menu, which can be accessed by pressing *. In T9 the most common characters can be found by pressing 1 and then * as many times as needed. Rarely used characters are entered using Multi-tap mode.

Keys, as well as other interface elements, will always need their space even though the devices are continuously shrinking. One way to make the objects fit is to make them smaller. Another is to make, for example, folding or add-on keypads. The size of the mobile device is restricted more or less by the size of a hand. Therefore, if the size of the keys grows too big, the other content, such as the size of the screen, is likely to suffer. According to Hiltunen et al. [2002, p. 151], 75% of the time using a handheld device is spent on viewing data and only 25% is spent on creating it. With that in mind, there is no sense in making the viewing too difficult. Indeed, increasing the size of the screen is a recent trend in mobile phone development, which is challenging from a keypad design point of view. There are, however, many different designs for keypad layout that try to take the restrictions of available space into account.

One of those is the Fastap system, which is featured in the keypad of LG AX490 (Figure 13). The design has actually two keypads, alphabetic keys and number keys. The alphabetic keys are raised over the number keys and the individual keys are also positioned far apart from each other. It is designed so that the contact area of each key is the same size as in a computer keyboard [Jones and Marsden, 2006, 15–16]. The developers claim that the design makes the typing of letters easier than in a standard keypad layout. In the Fastap system, user needs not worry about pressing multiple keys at the same time. The system is able to figure out which key the user meant to push.
Cockburn and Siresena [2003] compared the text entry speeds of T9, Multi-tap and Fastap systems. They found out that Fastap has several advantages over the other systems. It allows the input of both numbers and letters within the same interface mode. It does not require any training before use and even novice users could achieve a 6.3 wpm (words per minute) word typing rates with Fastap, compared to 3.6 wpm with Multi-tap and 3.9 wpm with T9. Also, its subjective workload is lower.

There are also other attempts at designing keypad layouts that would make typing easier and faster, such as the one-row keyboard [Silfverberg, 2003], Blackberry’s SureType [Blackberry, 2006] and Twiddler [Lyons et al., 2004a].

The one-row keyboard was Nokia’s attempt to make the T9 system faster by using more fingers in typing than the normal one or two used with T9. The keypad consisted of 10 keys, all in one row. The alphabet was distributed among the keys similarly as in T9. However, tests indicated that the system made the typing of words, in fact, slower than the T9 system. [Silfverberg, 2003]

The SureType system (Figure 14) developed for Blackberry is also similar to T9. The alphabet is divided among 14 keys in the same order as in a QWERTY keyboard. SureType is able to predict words or letter combinations based on the context. It can also “learn” new words, just like T9.

Twiddler is based on one-handed chording of letters. It has 12 keys divided into a 3x4 grid. In Figure 15 the user types a j-character by pressing the rightmost key on the top row and left key on the third row. The device faces always away from the user. Lyons et al. [2004a] found out that the speed of typing with Twiddler is faster than with
Multi-tap or T9 after 400 minutes of practice. Therefore they regard it as a good alternative for traditional methods of text input to mobile phones.

In addition, QWERTY-keypads (Figure 16) have become more and more common in mobile phones. QWERTY is the standard typewriter keyboard layout used in computer keyboards [Silfverberg, 2003], which starts with the letters Q, W, E, R, T and Y on the top left corner. A full QWERTY keyboard requires a lot of space and there are different approaches to resolving the problem. One of them is illustrated in Figure 16 which depicts the folding keypad of a Nokia E70. It comes with a similar design to computer keyboards with all numbers and other characters as well as function keys, such as clear and enter keys.

Wobbrock et al. [2007] have developed a gestural text entry method for a mobile phone, which relies on stroke-like gestures made with an isometric joystick to produce letters.
They found out that the text input system is highly competitive when compared to Multi-tap and T9.

Oniszczak and MacKenzie [2004] have designed a RollPad, which uses the standard keypad in a slightly new way. To type the letter k in RollPad the user presses 5. But to type j user presses 5 and adds a slight roll to left. Rolling motion to right would produce letter l in the same key. Oniszczak and MacKenzie [2004] compared RollPad to Multi-tap and found out that there were no difference in error rates and text entry speed between the two methods. RollPad produced a significantly lower rate of keystrokes per character.

Isokoski and Raisamo [2000] have developed a device independent text input method MDITIM. The method involves drawing strokes which form letters. For instance, the letter a is written with three strokes: up, down and left. The researchers found out that MDITIM method has different error rates and typing speeds when used with different input devices. It is also slower than the fastest device dependent methods.

There are also other designs, such as the iPhones touch screen, but they are ruled out of the study. The most common method of input in games is the use of joystick or navigational key. Their different designs are covered next.

3.1.2. Navigation Keys

A joystick and a navigation key are both used for controlling the mobile phone. They can be used, for instance, to access menus and move between the menu elements as well as making selections. Also, most mobile games use them as their interaction device [Koivisto et al., 2006]. There are 2 types of navigation keys: four-way (Figure 17) and five-way (Figure 18), where the fifth direction is selection, e.g. of an item in a menu, by pressing down. In addition to a four-way navigation key there is usually a separate selection key, as in the key above navigation key Figure 17.

![Figure 17. Four-way navigation key [Nokia, 2007].](image1)

![Figure 18. Five-way navigation key [Nokia, 2007].](image2)

The first navigation devices in mobile phones were separate keys for steering up and down, or left and right. Some models included four keys for steering in all four directions. Some phones feature a navigation key combined with the keypad keys, like in Figure 19. [Kiljander, 2004]
In some cases a navigation key is called a rocker key. Figure 20 illustrates such a case, where the key seems to rock when pushed to any of the four directions. In this study, the key in Figure 20 is called a navigation key.

LG U400, for instance, features a wheel as a control device (Figure 21). The inside circle around the OK-button rotates. The wheel is used to navigate e.g. in menus and through playlists.

Rollers are sometimes used as navigation devices in mobile phones (Figure 22). For instance, LG KE970 [LG, 2007] and Nokia 7110 [Nokia, 2007] feature a roller. The use is similar to a computer mouse or moving with a navigation key in menus.

LG KG800 has a touch user interface [LG, 2007]. Its layout and functionality are similar to those of the 5-way navigation key. It features arrows to all four directions as well as an OK-key in the centre (Figure 23). The keys are hidden when not in use but glow red when activated.

Today, many devices support 8-way navigation keys [Wisniewski et al., 2005]. Motorola’s E680i smart phones and N-Gage feature an 8-way navigation key [Motorola, 2005; N-Gage, 2007]. Some Nokia’s phone models, such as the 3100, support changeable gaming covers that also include an 8-way navigational key [Nokia, 2007]. An 8-way navigational key reacts to key presses in 8 different directions, where regular keys can recognise only 4 directions. Diagonal movement would be more preferable in games than a 4-way, since it makes moving faster.
3.1.3. Joysticks

Most mobile phones that have a joystick have either a four-way or a five-way joystick. To our knowledge there is not an 8-way joystick available for mobile phones. A four-way joystick allows movement up, down, left and right, whereas the five-way joystick adds another dimension; pressing. It is used in navigating in menus and making selections. The feel, or the responsiveness, of the joystick varies from device to device. Joysticks vary also in physical design from one another. Some have a very smooth surface and some have ridges that stop the finger from slipping away. Others have a sticky rubbery cover on them for the same purpose. Due to these differences it is difficult to design games that are equally playable in all models [Koivisto et al., 2006].

There has been a lot going on in the joystick design field lately. Samsung released a mobile phone SCH V970 with an optical joystick (Figure 24). Optical sensors react to finger movements, breaking down the way of navigating in a traditional four-way menu, where the user can move up, down, left and right. With the optical joystick the user is able to navigate the menus in any direction, even diagonally, and click on icons just like with a computer’s mouse. [Samsung, 2006]

Nokia has recently patented a pop-out joystick (Figure 25). A stylus can be inserted into socket in a mobile phone, which then works as a joystick. [Wong and Crampton, 2007] There is also another recent invention in the area of pop-out joysticks, the Compact Analog Thumbstick (Figure 26). The thumbstick looks and acts like a normal selection key when in the down-position. It can be, however, lifted up and extended into its full length. Then it works as a five-way joystick. It is specifically designed for gaming combining compactness and usability. [Elshin and Sekirash, 2007]

There are also other joystick designs, such as joysticks specifically for writing [Wobbrock et al., 2004; Chau et al., 2006].

Joysticks have an advantage over navigation keys in gameplay, because the player does not have to change the position of his/her finger, which makes changes in direction of movement faster. It takes a little while for the player to move the finger from one position to the other on the navigation key. The differences in times must be minimal,
but they multiply in games where there are many changes of direction. N-Gage QD addresses this problem by designing a navigation key that suits playing better (see Figure 20). It is cupped in design and moving it requires only little movement of a finger. Also, the finger does not slip away from it easily.

3.1.4. Camera and Display
The quality of mobile phone cameras is getting better all the time. All new camera phones have at least a VGA \(^1\) camera. Currently, the best quality for a mobile phone camera is 5 megapixels. Some models, like N70, have two cameras. The one on the back is usually of higher quality, whereas the one on the front is mainly meant for video calls. Therefore its picture quality is not very high.

Display sizes are generally not growing much more because people do not want their phones getting too big. Display resolutions are improving continuously, however, and colour displays are the norm [Nokia, 2003a]. All new phones come with a colour display, however their sizes and shapes can vary greatly. N80 has a 352 x 416 pixel display, while the smallest on the market are 128 x 128 pixels. A communicator style phone, like Nokia 9500 has a wide and flat display of 620 x 200 pixels. Some models, usually folding ones such as Nokia 6103, have two displays, one on the cover and another, bigger one inside the lid. The smaller one may still be black and white. Today, displays are able to support up to 16 million colors.

3.2. Assumptions on the Quality of the Interface Elements in Games
A game may use a number of interaction styles. It may use text or number input from the keypad or a key to make a selection. A selection can also be made using a joystick or a navigation key.

Many games can use different styles of input. For example, in a trivia game the player needs to move up and down in a list and select the correct alternative. S/he can use the joystick for steering and making the selection. Alternatively s/he can use the number keys for directional movement and selection. The games are designed so that the player can choose the input method s/he is most comfortable with. However, in this study the tests concentrate on the appropriate usage of the elements. Though it would be possible for a player to make a selection by using a key from the keypad, the tests focus on the typing capabilities of a keypad, because typing is what it is designed for. This section will introduce the interaction techniques this study will test. They will be discussed in relation to gameplay.

\(^1\) VGA stands for Video Graphics Array graphics standard for computers, where the picture is 640 x 480 pixels in size. That means it is a 0,3 megapixel camera (640*480=307 200).
3.2.1. Keypad

It is assumed that games involving writing are easier to play with a phone that has large and distinctive keys. It is also assumed that there is no difference between text and number typing. A phone that performs well in number typing should perform equally well in text typing.

Presumably, there is no difference whether the player uses T9 or Multi-tap in typing. Where the results are concerned, it is important to let the players use the input system they are most comfortable with. As noted earlier Multi-tap is slower than T9, therefore it is assumed that the users of T9 perform better in word typing.

3.2.2. Joystick

It is assumed that games are easier and faster to play with a model that has a joystick than one with a navigation key, because changing directions is faster with a joystick. A good joystick is one with a surface on which a player’s finger can get a good and steady grip.

Ease of selecting with a joystick is dependent on the quality of the device. In order to perform well in selection tasks the joystick should be firm and steady and give the user good response of where the user is trying to move the device. The quality of the surface is equally important in selection tasks as well.

3.2.3. Camera

In mobile games, the picture quality should not be an issue. It is assumed that the players do not care that much about the quality of the photo. They need not be top quality; it is sufficient that the players see what is in the picture.

To illustrate the camera resolution, a comparison of pictures taken with a VGA camera (Figure 27) and a 2 megapixel camera is shown in Figure 28.
There is a difference in clarity and colour. However, the content of the picture is still recognizable. In case of a game like Assassin (Section 2.4.4) the picture does not need to be high quality in order for the recipient to recognize if s/he is in the picture or not.

The actual act of picture taking usually happens with a joystick or a navigation key. It is assumed that their qualities may have an effect on the performance of a phone in a camera game.

Table 3 shows a summary of user interface components and interaction needed in various tasks in gaming.

<table>
<thead>
<tr>
<th>Interaction in a game</th>
<th>Typing numbers</th>
<th>Typing a word</th>
<th>Steering</th>
<th>Selecting</th>
<th>Taking a picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>User interface component</td>
<td>Keypad</td>
<td>Keypad</td>
<td>Joystick/ navigation key</td>
<td>Joystick/ navigation key</td>
<td>Camera (and navigation key/joystick)</td>
</tr>
<tr>
<td>Qualities of elements</td>
<td>Big, distinctive keys</td>
<td>Big, distinctive keys</td>
<td>Responsive joystick, good grip</td>
<td>Responsive joystick, good grip</td>
<td>All equally good</td>
</tr>
</tbody>
</table>

Table 3. User Interface Elements' Qualities in Games.

It is assumed that there is no difference between typing numbers and words, therefore the same kind of keys would suit both types of gaming. Similarly, a responsive joystick with a good surface material would perform well in both steering and selection type of interaction. In picture taking all phones would perform equally well.
4. Tests

This chapter deals with the test design. First it introduces MUPE, an application platform onto which the test games were implemented. The tested games are discussed in detail in the second section followed by a section on the tested phone models. An initial hypothesis on the interface elements and their qualities in gaming is given as a basis for further analysis. Finally, the last sections describe the test procedure, the participants and the phases of the study.

4.1. MUPE Platform

The games were implemented with the MUPE platform and its MiniGameServer. MUPE stands for Multi-User Publishing Environment; it is an Open Source application platform. It can be used for creating mobile multi-user context-aware applications, such as mobile multiplayer games, virtual worlds, collaboration applications and any other user authenticated services [MupeNet, 2006].

MUPE is a client-server system where the clients are run in mobile phones and the server is running anywhere in the Internet. A typical MUPE application has only one server and a larger number of MIDP clients. It works in MIDP 2.0 (Mobile Information Device Profile) compatible mobile devices. The games require a camera and GPRS connection. Both the MUPE client application and the MiniGame application need to be downloaded from a server and installed on the device. [MupeNet, 2006]

MUPE MiniGameServer is an application that supports multiplayer (2-8 players) mobile gaming. It enables the sequencing of short games; therefore it was perfect for testing.

4.1.1. Minigames

According to Wikipedia [2007] and Ludonauts [2004], a minigame is a small and simple game within another, bigger game. For example Puzzle Kombat and Chess Kombat are contained in Mortal Kombat: Deception.

Microgames, on the other hand, are very short (ca 5 seconds) single player games. The player tries to beat as many microgames as possible that keep appearing at increasing speed. For instance, the player is first presented with a one or two word instruction such as “Take picture!”. Then, the microgame will appear and the player completes the game following the instruction. [Wikipedia, 2007]
By definition, MUPE MiniGames could be called microgames, because they are very short and require quick reflexes from the player. However, they are multiplayer games and their speed remains constant. The MiniGames can last from 2 to 30 seconds and are played in a series of up to ten games called a session.

To illustrate the phases involved in a minigame Figure 29 contains a step-by-step description of Sheep Game implemented in MUPE MiniGameServer.

1. First screen of the game prepares a player for what is coming. It shows the game’s starting position in the background and a time slider (the rectangle behind the text) indicates when the game begins. The player has to wait for a couple of seconds for the slider to disappear before s/he can act. There is short advice on how to play or what is the aim of the game.

2. The game begins. The slider has disappeared and the player is able to move the lightning.

3. The player moves the lightning with the joystick/navigation key on top of some sheep and pushes the joystick/key. The goal is to strike all the sheep in five seconds.

4. The result screen shows the players’ names and points from the game. Since each player has their own collection of sheep, the results do not depend on the other players. A tie is possible, if two or more players manage equally well.

Figure 29, parts 1-4. Description of a MUPE MiniGame.
Table 4 includes the games genres by Wisniewski et al. [2005] discussed in Table 1 (Section 2.2), and an additional column describing whether that genre can be implemented as a minigame.

<table>
<thead>
<tr>
<th>Genre</th>
<th>Minigames in that Genre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sports</td>
<td>Simple sports games, such as curling</td>
</tr>
<tr>
<td>Racing</td>
<td>Players can have short (ca 10 second) races against each other</td>
</tr>
<tr>
<td>Action</td>
<td>Short action games</td>
</tr>
<tr>
<td>Adventure</td>
<td>Ten second snapshot of an adventure</td>
</tr>
<tr>
<td>Word/Trivia</td>
<td>Multiple choice questions, word guessing and writing</td>
</tr>
<tr>
<td>Arcade/Classics</td>
<td>Pacman: eating one monster</td>
</tr>
<tr>
<td>Logic/Puzzles</td>
<td>Rotating images/parts of images, simple jigsaw puzzles</td>
</tr>
<tr>
<td>Strategy/Simulation</td>
<td>Rock, paper, scissors?</td>
</tr>
<tr>
<td>Casino</td>
<td>Simple card games are possible, for example, poker</td>
</tr>
<tr>
<td>Parlor</td>
<td>Snapshot of a parlor game</td>
</tr>
</tbody>
</table>

Table 4. Mobile game genres in minigames.

At the moment there are ca 30 games developed for the MiniGameServer. The majority of those are logic and puzzle games. In that category it is feasible to use for instance players’ pictures as game material. A puzzle as a minigame could be as simple as moving a piece of a picture to its proper place. Puzzles are easy to implement and there can be many variations of one idea. Racing game involves moving a car, or a player’s picture, from the starting point to the finish line. Action games are more difficult to implement. Sheep Game (Figure 29) could be labelled as an action game.

Word and trivia games are another common minigame category. Trivia is simple to implement as a multiple-choice list. Word writing and guessing games can go under this category, but they also could belong to logic and puzzles. The classic Rock Paper Scissors game is an example of a strategy game. Card games make good minigames, too. A card game could involve playing just one hand of poker. Minigames can include all categories of mobile games, at least as a snapshot, meaning they can be simple as eating just one monster in a Pacman style of a game.

Game interactions and means of winning are simple. Players can compete in speed, for example typing speed, where the quickest wins. Another similar type of a game could involve typing the longest sequence of letters within a preset timeslot. In a racing game the car moves a number of pixels at one key press. In that case, the player needs to press only one key repeatedly. In all of the game types mentioned above the winning parameter is speed. There are also games that are based on pure luck, such as Rock Paper Scissors. A luck game can involve a setting of leader vs. others, where players try to guess which object one of them, the leader, chose from the screen.
The games are loaded on the device from the server. Graphics and code for the MiniGames are loaded before the game begins, for instance, when the players see the results screen from a previous game. The game results are sent to the server when the game ends and the server sends all players’ combined results back to the device. By handling the connection between the server and the client this way, the application manages to avoid the problem that arises from network latency.

Minigames are played as a session of ten games. The next section will discuss sessions more deeply.

4.1.2. MiniGames Session

A MiniGame session is played as follows (Figure 30):

1. A player is in the Lobby and creates a new game session or joins an existing one. The number of games in a session is set in the code and it cannot be modified by the session creator.
2. Other players join, or are already waiting, and the session is started.
3. They play game 1.
4. The results of game 1 are shown on the results screen. The next game is loaded at the same time in the background. The games are either randomly chosen from a pool of games, or a genre, e.g. card games, is preselected by the session creator.
5. Players repeat steps 3 and 4 until the number of games in the session is reached.
6. Total results of all games in the session are shown.
7. Players return to the lobby.

Figure 30. MiniGames Session.

The lobby screen is illustrated in Figure 31. There the player can choose between joining existing sessions and creating a new one. The two topmost sessions Free session one and two are sessions where everyone is free to join. The number 7/8 tells that there are seven players already joined while eight is the maximum. Private session is a session where anyone with a proper password can join. Password is requested when the player is trying to join by choosing the name of the session. Ongoing sessions are already on the way. If a player wants to join those s/he will have to wait until the session is over.
The player creating a new session can name it the way s/he wants. The status (free/private/ongoing) is visible in a colour code in the name’s background: green, yellow and red, respectively.

MiniGames can include a chat functionality. However, it is not implemented in the test version.

The design of MiniGamesServer makes it possible for the players to take a picture of themselves and upload it to the server. When the player enters a session s/he sees who else is there from a list of player names and their pictures. The picture can be used in games, for instance, in a game where players guess whose picture is shown by choosing a name from a list. The game is easy if the players all know each other. If they do not, the game supports creating a player community.

4.2. Test Games

The tests will involve five different games: Number Game, which is a typing game, Curling, a movement game, Sheep Game, a movement and selection game, Type a Word, another typing game and Take a Picture, where the players take a picture with the camera. Type a Word and Take a Picture were created specifically for this study. The rest of the games were chosen from a pool of thirty or so existing games for MUPE MiniGamesServer. The games are designed for a 176x208 display, however, the most recent version on MUPE uses a larger resolution, 240x320. The tested user interface components and interaction types in the games are discussed further in Section 4.4; first a brief introduction to the test games is given.

In the typing game Number Game (Figure 32), the players are competing in typing numbers that appear on the screen. When the correct number is typed it is replaced by another that appears in the same location in the display. The numbers move gradually closer to the target area, which is reached in 8 seconds. During that time a maximum of nine numbers appear, if the player is typing fast enough. The fastest and most accurate player or players win.

Another typing game Type a Word is a game where the player needs to type the eight-letter word that appears on the screen. When the game begins the players see the word on the screen and are automatically moved on to the writing application, the one that is also used for writing SMSs. Then the player is able to choose whether s/he wants to use a predictive system in typing or not. The choice is made the same way as when writing SMSs. This choice needs to be done only once with every phone during practice round. In the actual test round the setting is already in place. In Type a Word the fastest
and most accurate player wins. Both typing games test the typing qualities of the keypad and the skills of the player.

In the steering game, Curling (Figure 33), the aim is to steer the ball to the target area by using the joystick or the navigation key. At the start the ball is in the upper part of the display and the goal area is at the bottom. When the game starts the ball starts to move downwards at a random speed. The player’s task is to steer the ball towards the goal by slowing down the ball’s movement by pushing the joystick to the opposite direction where the ball is going. The aim is to stop it as close as possible to the goal area. The final distance is the distance in pixels from the goal where the player manages to steer and stop the ball. The largest distance to the goal in the games was 247 pixels. This game tests the steering capabilities of a navigation key or joystick.

Sheep Game (Figure 29) is a movement and selection game where the player moves the lightning bolt on top of sheep. Press of a navigation key or joystick strikes the sheep under the bolt. The aim is to hit all the sheep in the field in a few seconds. There is not enough time to make more than three or four strikes. Winning this game depends as much on quickness of the fingers as it does on luck. The sheep are randomly scattered around the field at the start of the game. If they happen to be close to each other, the game is easier to complete in time. The game tests the quality of the joystick or the navigation key in its movement and selection capability.

Take a Picture is a simple game where the player takes a picture as fast as possible. The get ready screen advises the player to “Take a picture. Hurry!”. The camera is turned on automatically. After taking the picture it is shown to the player on the screen. This is not really a game; it just tests the capabilities of the phone in picture taking. Because of the restrictions of the MiniGamesServer design there is not yet a possibility to use the pictures the players take in the games. The fastest player wins this game regardless of the content of the picture.

4.3. Mobile Phone Models
The mobile phone models chosen for testing were Nokia E50, N70 and N91 (Figure 34.) E and N series phones and some older models were available to choose from. Series E models are designed specifically for business use. Series N, on the other hand,
is an entertainment line of phones. Series N phones are designed for picture taking, like the N70, or for listening to music, such as the N91. The selection of tested models does not include N-Gage or any other game phone, because the aim is to study how well a normal phone’s interface elements would suit playing mobile games. After all, a majority of the phones are not intended for gaming.

Figure 34. Tested Models (from left): N70, E50 and N91.

The MiniGame application is running in all phones. Figure 34 shows a comparison of the screen resolutions. MiniGames is designed for 176x208 resolution, which is used in N70 and N91.

The requirements were that the models should have different kinds of user interface elements. A phone with big number keys (E50) and another with small ones (N91) were chosen. N70’s key size is between the other two. Also there are two models with a joystick (E50 and N91) and one with a navigation key (N70).

There are also differences in display resolution and physical size of the devices, but these were not decisive factors. All the models available had very high quality cameras ranging from 1.3 to 2 megapixels. Unfortunately, there were no phones available for testing with a lower quality camera. Although N70 has two cameras, another one with a lower resolution (see Table 5), the higher quality camera was used in the games, because it was not technically possible to use the other one.

Table 5 illustrates the tested elements, joystick, navigation key and camera in the chosen models. Elements of mobile phones were added to the table that have an effect on game design as previously discussed in Section 2.1.2.
<table>
<thead>
<tr>
<th></th>
<th>E50</th>
<th>N70</th>
<th>N91</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joystick</td>
<td>5-way</td>
<td>-</td>
<td>5-way</td>
</tr>
<tr>
<td>Navigation key</td>
<td>-</td>
<td>5-way</td>
<td>-</td>
</tr>
<tr>
<td>Camera</td>
<td>1.3 megapixels</td>
<td>2 cameras: VGA &amp; 2 megapixels</td>
<td>2 megapixels</td>
</tr>
<tr>
<td>Display size</td>
<td>240 x 320 px</td>
<td>176 x 208 px</td>
<td>176 x 208 px</td>
</tr>
<tr>
<td>Picture resolution</td>
<td>1280 x 960 px</td>
<td>1600 x 1200 and 640 x 480 px</td>
<td>1600 x 1200 px</td>
</tr>
<tr>
<td>Weight</td>
<td>104 g</td>
<td>126 g</td>
<td>164 g</td>
</tr>
<tr>
<td>Dimensions</td>
<td>133 / 43.5 / 15.5mm</td>
<td>108.8 / 53 / 21.8mm</td>
<td>113.1 / 55.2 / 22mm</td>
</tr>
<tr>
<td>Keypad area/total contact area</td>
<td>8.8/8.8 cm²</td>
<td>5.5/5.5 cm²</td>
<td>3.8/6.5 cm²</td>
</tr>
<tr>
<td>Memory</td>
<td>70 MB</td>
<td>22 MB</td>
<td>4 GB – 8 GB</td>
</tr>
</tbody>
</table>

Table 5. Models for Testing and Their Components' Qualities

There were no information about the processor speeds on Nokia’s website. Therefore the speeds shown in the table were gathered from various sources. All sources seemed unanimous about the speed of E50 and N70’s processor, however, there were two different figures for N91. It was inconclusive which one is correct.

The next pictures illustrate the size of the user interface elements. All figures are in millimetres. The pictures are retrieved from various sources and the measurements are added by the researcher. All the measurements are approximations obtained by measuring the device dimension by hand.

The keypad size of E50 (Figure 35) is 8.8 cm². An individual key’s area is 63 mm² on the left and right rows and 84 mm² in the centre row. Clear-key has an area of 40.5 mm². The area for the joystick is 12.25 mm² and its total contact area is 1.8 cm². Total contact area includes the area of the key and the surrounding empty area where there are no other user interface elements.
N70’s keypad, including the 12 keys in a standardized keypad only, is 5.5 cm² in size (Figure 36). Size of the keys is 42.8 mm² on the rows on the left and right. The keys 2, 5 and 8 are 40.5 mm² and 0-key is 36 mm² in their total contact area size. The navigation key totals to an area of 1.6 cm². The clear-key has an area of approximately 34 mm². The ridge in the edge of the navigation key is about 1 millimetre high.

In N91, the height of the joystick from the surrounding metal is ca 1 millimetre (Figure 37). It has an area of 22.5 mm². The size of the keypad is 3.8 cm² and its total contact
area’s size is 6.5 cm². Though the number keys are small, 10.5 mm², in total they have a contact area of 82.5 square millimetres.

![Figure 37. N91 Keypad and Joystick Dimensions, Picture from GSMArena [2007].](image1)

The dotted line in Figure 38 is the edge of the phone’s cover also marked to Figure 37. As it can be seen from the figure the keys are only about 0.2 millimetres above the edge of the cover. The keys are located 3.5 millimetres below the sliding cover’s edge and are 1 mm high.

![Figure 38. N91 Cross-Section, Picture drawn by the researcher.](image2)
4.4. Initial Hypotheses on the Quality of the Interface Elements in Games

Table 6 shows the games for testing and the user interface components and interaction needed as well as the winning parameters. The winning phone is the model that wins in the log results. Points are awarded to the players and a winner of a game is determined based on the logs.

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Number Game</th>
<th>Curling</th>
<th>Sheep Game</th>
<th>Type a Word</th>
<th>Take a Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Typing</td>
<td>Steering</td>
<td>Steering and selection</td>
<td>Typing</td>
<td>Taking a picture</td>
</tr>
<tr>
<td>User interface component</td>
<td>Keypad</td>
<td>Joystick/ navigation key</td>
<td>Joystick/ navigation key</td>
<td>Keypad</td>
<td>Camera (and navigation key/joystick)</td>
</tr>
<tr>
<td>Winning parameters</td>
<td>Speed and accuracy of typing</td>
<td>Accuracy of steering</td>
<td>Speed and accuracy of steering and selection</td>
<td>Speed and accuracy of typing</td>
<td>Speed of picture taking</td>
</tr>
<tr>
<td>Qualities of elements</td>
<td>Big, distinctive keys</td>
<td>Big, distinctive keys</td>
<td>Responsive joystick, good grip</td>
<td>Responsive joystick, good grip</td>
<td>All equally good</td>
</tr>
<tr>
<td>Hypothesized winning phone</td>
<td>E50</td>
<td>E50</td>
<td>E50</td>
<td>E50</td>
<td>All equally good</td>
</tr>
</tbody>
</table>

Table 6. Games and Their Tested Parameters.

Number Game and Type a Word are similar games involving speed and accuracy of typing. Curling and Sheep Game both involve the use of a joystick or a navigation key. The difference is that curling requires only movement whereas in Sheep Game the selection functionality is needed as well. Also, Sheep Game requires more accuracy of movement.

4.4.1. Joystick and Navigation Key

It is assumed that Sheep Game is a lot easier and faster to play with a phone model that has a joystick than one with a navigation key. This should also be seen in the game log data where it is possible to see the number of caught sheep per game.

In Curling Game, there may be some difficulties in steering the ball diagonally with a navigation key. Therefore it is assumed that this game, too, is easier to play with a joystick. This can be proved with the log by comparing the final distances of the ball to the goal when the game ends.

Based on the initial hypothesis on the user interface elements’ performance in games in Section 4.4, it is assumed that the games are the easiest to play with either of the joystick models, E50 or N91. The two joysticks were, however, different in their
design. In E50 the joystick is made of plastic that holds the grip better than the other model’s smooth surface. It also has an engraved groove that makes it more difficult for the finger to slip. N91’s joystick is not that high up as E50’s, either.

N70’s navigation key is five directional with a separate button for selection in the middle. It has about one millimetre high ridge located on the edge of the key. The ridge comes in handy in stopping the finger from sliding to the surrounding keys. The green and red call management keys as well as two soft keys are located right next to the navigation key. The player has to be careful not to hit the surrounding keys while steering.

4.4.2. Keypad

It is assumed that typing games are easier to play with a phone that has large keys and a model with very small keys would not perform well in these games.

The placement of the clear-key may make playing more difficult in Type a Word. It is located in different places in all models, since its placement is not standardized. In E50 the clear-key is inconveniently placed next to the red call management key that is used for exiting games and other applications. The clear-key is also smaller than the other keys used in games. In N70 the clear-key is located on the bottom right corner of the keypad next to the keys 9 and # and in N91 on the top right corner of the keypad next to the keys 3 and 6.

The size of the keys is presumed to have a significant effect on gaming performance. In E50 the keys are 63–84 mm² in size. The keypad’s size is 8.8 cm², which makes it the largest keypad in the tested phones. N70’s keys’ sizes range from 36 to 42.8 mm² and the size of the keypad is 5.5 cm², making it the smallest on the tested models. The keys in N91 are 10.5 mm² in size; however, their contact area is 82.5 mm², which is almost as large as the biggest keys in E50. The size of its keypad’s total contact area is 6.2 cm².

According to McMullan and Richardson [2007] it is difficult to press the correct key using a small keypad and at the same time focusing on the screen. Thus, it is hypothesized that the typing games are easiest to play with E50, because of its large keys. Models with smaller keys will not perform well. It is assumed that the worst performer is N91. The number of mistyped numbers is available in the log of the Number Game. It is assumed that players make more mistakes using N91 and N70 than E50. In addition, it is also assumed that an unfamiliar placement of the clear-key will have a negative effect on the speed of writing in Type a Word.

In both Type a Word and Number Game experience of writing SMSs may help. Also, if a player can write without looking at his/her fingers, the games are faster to play.
4.4.3. Camera
It is assumed that the players do not care much about the quality of the pictures and rate all the cameras equally in picture taking game.

4.4.4. Study Design
In order to test the above hypotheses the test was designed as a within subjects test. It was decided that three different phone models would be tested and each test group would be comprised of three participants who would play multiplayer games with each of the phones in turns. With a within subjects test we were able to gather more reliable information about the phones. In a between subjects setting it would have been necessary to have more participants to get as many players per phone.

We chose test games from the existing pool of games and designed and implemented a couple of new ones. The games were chosen and new ones were designed on the grounds of their interaction style and their suitability for testing the user interface elements.

The order of the phones was varied between the participants and the groups and the order of the games was varied between groups. The game order was changed from the code of the MiniGames application between the groups by an employee at Nokia. The instructions inside games were in Finnish.

Data from the test was gathered with questionnaires filled by the participants and with game logs from the game server. The questionnaires focused on the participants’ opinions of the user interface elements and their performance in games. The game logs provided data on the participants’ input during each game, such as the number of pressed keys. By analysing the logs it was possible to find out the winner of each game.

The researcher was present during gaming and wrote down participants’ most interesting comments and helped if there were any problems.

4.5. Test Procedure
Altogether there were 12 participants (6 female, 6 male, mean age 17.3) in the multiplayer game tests. They played in groups of 3. In this section the game test procedure will be explained and the detailed description of the participants is given in Section 4.6. together with an outline of the study phases.

When the participants arrived they were first asked to fill out a background questionnaire (Appendix 1a), which included questions about their mobile phone usage and background and interest in gaming. After they were finished they had a chance to try out the phones that were laid out on the table in front of them. They were also asked to fill out a questionnaire (Appendix 1b) about the models, regarding their possible previous experience on using them and first thoughts they had on them after trying them out. Then the aim and the proceedings of the test were explained. The participants were
asked to consider the performance of the user interface elements in all the games during playing.

After that they started playing the games. MUPE client and the MiniGames application were already installed on the devices and ready to use. The five games were played in a session that lasted about 2 minutes. Participants played two consecutive sessions, the first was a practice round and the second the game round. Figure 30 in Section 4.1.2 illustrates the structure of one session, or round, in the tests. Then the participants filled in a mid-game questionnaire (Appendix 2) about the model they were playing with. The games were played in the same order on both rounds. That way it was easier for the players to get ready for the next game during the actual gaming round and to remember the game when they were filling in the questionnaire.

When they were finished with the questionnaire they proceeded to play the same sequence of games with another mobile model. They played three sets of two sessions in total so everyone could try all the phone models. After playing and filling out the questionnaire about the last model they were asked to complete the post-game questionnaire concerning all the models (Appendix 3). Table 7 summarizes the test procedure.

<table>
<thead>
<tr>
<th>Round</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Background questionnaire</td>
</tr>
<tr>
<td></td>
<td>Time to try the phones + fill pre-game questionnaire</td>
</tr>
<tr>
<td>1</td>
<td>Practice</td>
</tr>
<tr>
<td>1</td>
<td>Test</td>
</tr>
<tr>
<td></td>
<td>Mid-game questionnaire</td>
</tr>
<tr>
<td>2</td>
<td>Practice</td>
</tr>
<tr>
<td>2</td>
<td>Test</td>
</tr>
<tr>
<td></td>
<td>Mid-game questionnaire</td>
</tr>
<tr>
<td>3</td>
<td>Practice</td>
</tr>
<tr>
<td>3</td>
<td>Test</td>
</tr>
<tr>
<td></td>
<td>Mid-game questionnaire</td>
</tr>
<tr>
<td></td>
<td>Post-game questionnaire</td>
</tr>
</tbody>
</table>

Table 7. Test Procedure.

A decision was made to use the word joystick of the navigation key in the questionnaires because it was a simpler term and widely understood. Also, it would not have been practical to mark the model on a questionnaire and use a different term for the element in the questionnaire of N70. The order of the phones was varied between the participants, therefore the questionnaires should have been ordered according to a participant. It was easier to have the participants mark the model they played with.
Thus, all mid-game questionnaires were alike for all participants, regardless of what model they had used in that round. However, one participant in the final test commented on the use of the term when he was evaluating the qualities of N70 after a game session.

4.6. Phases of the study

4.6.1. Internal Pilot Test 1

Two pilot tests were conducted before the actual testing. The first one was arranged at the premises of Nokia Research Centre with one Nokia’s employee who was involved with the development of the MUPE platform as a participant. He was experienced in mobile gaming, game development and mobile phones in general. The test was arranged during a normal workday in a quiet corner of the office.

The pilot revealed that a few things in the questionnaires needed improving. The post-game questionnaire (Appendix 3) needed pictures of the phone models. The table in the pre-game questionnaire needed also clarification. The column featuring multiplayer games was moved first, because the tester filled in all board games before realising the first column was about single player games. In addition, a question regarding the amount of mobile phone usage was added to the background questionnaire (Appendix 1).

There were also changes to the games. The original number typing game was too fast to be able to test the qualities of the keypad. Therefore, it was replaced by Number Game, where the participants had to type more. Sheep Game replaced a game dealing with simply pressing a button. This, too, was too easy and straightforward. In addition, Sheep Game combined both pressing and steering with the joystick or the navigation key. A word guessing game was replaced by a word typing game, where the players were able to choose whether they want to use the predictive system in typing or not. It would have been difficult to implement in the other game. It is important to let the players modify the typing settings so that they are using the phone just as they usually do. Otherwise, it might have had an effect to the results.

Also, it was not possible to implement a picture game where players were supposed to measure the quality of the actual picture taken in the game. Therefore, an additional question regarding the use of the pictures was added to the post-game questionnaire.

4.6.2. Pilot Test 2

There were 8 participants in the second pilot test, two in the first group and three in the remaining groups. The tests were conducted at the university’s usability laboratory. The participants were students of a usability course who were recruited to the test by their teacher (Table 8). They were between 20 and 28 years of age, the mean being 23 years. The names are changed, but gender remains the same. There were five males and three females. Six out of eight participants played mobile singleplayer games rarely, less than
a couple of times a month. The same number of participants also said they had never tried mobile multiplayer games. Only one of the participants exhibited high gaming activity, he played singleplayer games several times a week. One of the participants owned an N70. In addition, two out of eight participants had previously tried the model a couple of times.

The duration of the gaming is calculated based on the game log’s first and last log entry. The time does not include filling background, pre-game, the last mid-game and post-game questionnaires, but does include time spent answering 2 of the mid-game questionnaires. The differences in playtime are explained by pauses in gaming due to phone reboots after jamming and variations in times used to fill in questionnaires.

<table>
<thead>
<tr>
<th>Group</th>
<th>Name</th>
<th>Gender</th>
<th>Age</th>
<th>Experience</th>
<th>Mobile Game Experience</th>
<th>Playtime</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Singleplayer</td>
<td>Multiplayer</td>
</tr>
<tr>
<td>P1</td>
<td>Matias</td>
<td>M</td>
<td>22</td>
<td>Rarely</td>
<td>-</td>
<td>Rarely</td>
</tr>
<tr>
<td></td>
<td>Esko</td>
<td>M</td>
<td>20</td>
<td>Rarely</td>
<td>Never</td>
<td>Never</td>
</tr>
<tr>
<td>P2</td>
<td>Asko</td>
<td>M</td>
<td>23</td>
<td>Never</td>
<td>Never</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Liisa</td>
<td>F</td>
<td>21</td>
<td>Owns N70</td>
<td>Rarely</td>
<td>Never</td>
</tr>
<tr>
<td></td>
<td>Ilari</td>
<td>M</td>
<td>23</td>
<td></td>
<td>Often</td>
<td>Never</td>
</tr>
<tr>
<td>P3</td>
<td>Kaisa</td>
<td>F</td>
<td>20</td>
<td>N70</td>
<td>Rarely</td>
<td>Rarely</td>
</tr>
<tr>
<td></td>
<td>Leena</td>
<td>F</td>
<td>28</td>
<td></td>
<td>Rarely</td>
<td>Never</td>
</tr>
<tr>
<td></td>
<td>Aki</td>
<td>M</td>
<td>27</td>
<td>N70</td>
<td>Rarely</td>
<td>Rarely</td>
</tr>
</tbody>
</table>

Table 8. Background of Pilot Test Participants and Groups’ Playtime.

In the second pilot there were a lot of technical difficulties due to the new games. Games that used the phones’ software for writing and picture taking did not work completely in multiplayer mode. Due to many jammed phones and reboots with the first test group the rest of the tests were run in singleplayer mode. One participant in the first group commented that the games were much more fun as multiplayer games.

Some of the pilot’s participants said they were a little nervous about playing games and the test being recorded on video. There was not much talking during testing, because the participants did not know each other well and the test was not run in multipler mode.

The test was recorded on video, but we had technical difficulties in watching it afterwards due to bad quality of the image burned on a CD. There was not a real need to look at the video later, so it was decided that the actual test would not be taped.

After the second pilot still a few changes were made to the questionnaires. A question about writing without looking at fingers was added to the background questionnaire. The third question about the frequency of using a mobile phone in the same questionnaire was also modified. The alternative about using it a few times a day was deleted. A 1-5 scale was added to the question about the quality of the display in
mid-game questionnaire (Appendix 2). Also, a question about the quality of the pictures was added to the post-game questionnaire (Appendix 3).

### 4.6.3. Final Tests

The actual tests took place at Nokia Research Centre’s premises. There were 12 participants aged between 17 and 18. Six of them were male and six female. Table 9 illustrates participants’ gender and age, experience on the tested phones and mobile games as well as the duration of the gaming in the test. The names are changed, but gender remains the same.

Four out of the 12 participants in the test had tried either E50 or N91 once or twice before. In addition, five participants had some experience on N70, but not more than one or two trials.

<table>
<thead>
<tr>
<th>Group</th>
<th>Name</th>
<th>Gender</th>
<th>Age</th>
<th>Experience</th>
<th>Mobile Game Experience</th>
<th>Playtime</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Niina</td>
<td>F</td>
<td>17</td>
<td></td>
<td>Singleplayer: Once a week, Multiplayer: Never</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Sara</td>
<td>F</td>
<td>17</td>
<td>N70, N91</td>
<td>Rarely, Never</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aleksi</td>
<td>M</td>
<td>18</td>
<td></td>
<td>Rarely, Rarely</td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td>Suvi</td>
<td>F</td>
<td>17</td>
<td>N70</td>
<td>Rarely, Rarely</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Anna</td>
<td>F</td>
<td>17</td>
<td></td>
<td>Rarely, Rarely</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teemu</td>
<td>M</td>
<td>17</td>
<td>N70, N91</td>
<td>Once a week, Rarely</td>
<td></td>
</tr>
<tr>
<td>T3</td>
<td>Jussi</td>
<td>M</td>
<td>18</td>
<td>N70</td>
<td>Never, Never</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Mia</td>
<td>F</td>
<td>17</td>
<td>N70</td>
<td>Rarely, Never</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tommi</td>
<td>M</td>
<td>18</td>
<td></td>
<td>1-2 times/month, Rarely</td>
<td></td>
</tr>
<tr>
<td>T4</td>
<td>Juha</td>
<td>M</td>
<td>18</td>
<td>E50</td>
<td>Rarely, Rarely</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Maria</td>
<td>F</td>
<td>17</td>
<td>1-2 times/month</td>
<td>Rarely</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Janne</td>
<td>M</td>
<td>17</td>
<td>E50</td>
<td>1-2 times/month, Rarely</td>
<td></td>
</tr>
</tbody>
</table>

Table 9. Background of Test Participants and Groups’ Playtime.

All but one were students in a school that has student projects with Nokia Research Center. One participant was a trainee working at the center (Juha). The tests were conducted during their working day at the NRC premises.

The NRC student project involved game development, so the participants were interested in gaming and game design. However, background information questions revealed that they did not play much on their mobile phones. 11 of them played singleplayer mobile games once or twice a month or less, and 8 participants played mobile multiplayer games rarely, less than a couple of times a month, while 4 did not play mobile multiplayer games at all. However, some of them demonstrated high console and computer gaming activity. That will be discussed in relation to the results later in this study.
The participants were familiar with the place and each other. They were recruited from the twenty or so students that were working at the centre that day. Before the tests an employee of the centre sent them email about the upcoming tests. The students who wanted to take part in the tests came in groups of three to the recreation space where the tests were conducted. A new group came as soon as the other one was finished.

The tests did not go without problems. In the first group, one participant pressed E50’s joystick in Take a Picture before the picture had appeared on the display. This jammed the device and the MUPE application had to be restarted in all phones. Participants in all the remaining groups were therefore advised to let the camera software load completely first before proceeding to take a photo. Also, they were advised to push the cancel button in N70 if it did not show a picture at all, because it had a tendency to jam sometimes in picture taking.

The atmosphere was more relaxed in the test than in the pilot test. The participants all knew each other and the facility very well. The relaxed mood could be observed from the conversations during gaming. There was more talk during the tests than in the second pilot. Probably the games being played in multiplayer mode boosted the level of conversation. Also, another point contributing to it is the fact that the players were friends and familiar with the premises.

The next chapter introduces and discusses the test results. They are divided into participants’ initial impressions, their evaluations on the quality of the phones and results gathered from the game logs. A winner analysis is also given.
5. Results
The results cover participants’ initial impressions on the models used in the test, their verbal evaluations and numeric ratings as well as game log and winner analysis. User evaluations are reported from both the second pilot (groups P1-P3) and the test (groups T1-T4). Game log analysis consists of results of the actual test only.

The number of games played in each group was different due to e.g. restarting a game session after a jammed phone was rebooted. Therefore the games in the beginning of the game set were played more times than the ones at the end.

5.1. Participants’ Initial Impressions
Before the playing began, the participants had time to try out the phone models. They were asked to fill out their first thoughts on the phones on a pre-game questionnaire (Appendix 1b). These initial impressions of the phones were collected from their answers to the questionnaire. The aim of the test was told to the participants only after they had filled out the questionnaire. By doing so, their opinions were not influenced by the aim of the test. Some only commented on the menu layouts, but a majority of them took notice, especially, of the keypad layout and design. Many also commented the qualities of the joystick and the display.

Many participants commented on the “feel” of a phone or its user interface elements. Most of the participants who had commented on N91, said it is too big and heavy a phone. Additionally, it seemed complicated to use, just by looking at it. Most participants did not like the keypad layout; some commented it was “weird”. The keys were placed too low under the cover and they were too small. N91’s joystick, on the other hand, got some good initial reviews; it had a good feel. However, some participants felt that a finger slipped away from the joystick easily and it had no feel of control. Jussi (group T3) commented: “I was not sure whether I was pushing down or steering to the sides”. Leena (P3), who owns a communicator N9300, favoured N91 out of the three. She liked the big display and felt that the keys had a good feel to them. However, she, too, felt that N91 was big.

N70’s appearance got negative comments from the participants. They felt that it was big and clumsy. By looking at the phone, Aki (P3) got the impression that it has a sliding cover or it can be opened in some other way, though he had tried the model previously. The placement of the keys in the bottom part of the phone’s user interface did not please him. He said, “the phone does not fit well into my hand, the keys are too
The keys in N70 did not get praise among the participants, most of them thought they were either too small, too close together or clumsy. On the other hand, many liked the big size of the display. The navigation key did not raise any comments on the pre-game questionnaire.

All participants generally liked E50. Most of them liked the joystick saying it had a good feel. One participant (Mia, T3) felt it was too sensitive, making selections in wrong places. Two said that the sharp edge of the joystick hurt their finger. The keypad divided opinions, however; approximately half of the participants liked the keys whereas the other half did not. Some commented that the keys were hard to press or they had a lousy feel. Others thought that the layout of the keypad was good and the keys had a good feel. E50’s display got only good reviews; participants liked its sharpness and clearness. The model was also of good size that fits one’s hand nicely. Only Leena (P3) felt that is was shaky or unsteady.

Two participants commented on the placement of the clear-key in the models. Aleksi (T1) noted that it was located in a different place in E50 than what he was used to. In E50 it is located on the right side of the joystick between a soft key and red call management key (see Figure 35, Section 4.3). In his phone, N-Gage QD, the clear-key is located on the top right corner of the user interface on top of the key 3. However, Aleksi could consider buying E50 if it had a better keypad. Niina (T1) made a comment about the key placement in N70. In her Nokia 2600 the clear-key is located on the left side of the navigation key. In N70 it is on the opposite corner of the keypad, on the bottom right next to the keys 9 and #.

One participant of the pilot test, Matias (P1), commented on the test models saying he did not like any of the keypad layouts. He owns a Nokia 3510 in which keys are approximately the same size as in E50, but they are more distinctive and well apart from each other. He found it difficult to use the newer keypad layouts and felt that it was too easy to push multiple keys simultaneously. Matias also did not like the S60 menu structure and the fact that there are many applications. In his view, there was too much “unnecessary stuff”.

In general, the model a user owns has an impact on what s/he expects from a phone, like in Matias’ case. When the user is unfamiliar with the user interface it affects playing. In gameplay, some participants actually made keying errors because of the mismatch of the test phone and their own phone model. This will be discussed further with examples later.

5.2. User Evaluations

Due to technical difficulties the games in the second pilot were not played in multiplayer mode. The performance of the user interface elements is not affected by this. Therefore the user evaluation results of the second pilot are discussed here in
addition to the test’s evaluations, because they provided valuable information on the phones.

The players were asked to evaluate the user interface elements’ performance in games. The questions focused on the element used in the game, for instance, “how did the keypad perform in Number Game?” The evaluations were given on a scale of 1-5, where 1 indicated poor and 5 good performance. The distributions of the participants’ evaluations are represented as box plots, where the box indicates first and third quartiles and the median. The whiskers represent the maximum and the minimum of the given ratings. For instance, in Figure 39 the first box plot shows that the maximum value given for E50 was 5 and the minimum 2. The medium, the middle value of the data set, is 4. 1st quartile, or 25% of the values below the median, is shown as a striped box and the 3rd quartile, 25% of the values above the median, as even colored boxes. It shows that 50% of the given evaluations are between 3 and 4.25. The mean value, 3.75, is represented by a square with a connecting line to other box plots for easy comparison. In the box plot for N70 the median is 4, and the 3rd quartile does not show, because the maximum value within the top 75% of values is 4. If there is an even number of values in a data set, its median is the mean of the two middle values; therefore the median for evaluations for N91 is 3.5.

5.2.1. Keypad Evaluations

As expected, in typing games E50 got the best ratings in the test. This can be seen in the means and the smaller spread of the evaluation scores in Figure 39. In Number Game the median value for both E50 and N70 is 4. However, evaluations for N70 are spread wider.

![Figure 39. Number Game User Evaluations, Test, N=12.](image)

In Type a Word, on the other hand, E50 got a wider range of evaluations, median being 4 (Figure 40). The majority of the evaluations for E50’s performance in Type a Word were concentrated higher than the others’. N70’s range of evaluations spread wider and median is the average value of the scale. In the case of N91 the median is on the higher
side of the scale, which indicates that the range of the evaluations is slightly better than that of N70.

The participants of the second pilot test gave slightly different ratings to the phones, as can be seen from Figures 41 and 42. E50’s perceived performance was clearly the best and N91’s the worst in typing. The median of Number Game evaluations of E50 is 5 and the mean 4.38, which are both very high. Both values in other models are considerably lower.

The same can be seen from the Type a Word evaluations (Figure 42). E50 got the best and N91 the worst ratings. N91 got slightly wider range of ratings in Type a Word. N70’s evaluations’ median is on the higher side of the scale in both games.
Typing games’ results correlate with the hypothesis. It was previously hypothesized that E50’s big keys would receive good reviews from the participants, whereas the N91’s keys would be rated the lowest on perceived performance. This tendency is clear in the test results but even more so in the second pilot’s results, where the differences between models are more obvious. The participants rated E50’s keypad the highest and N91’s the lowest in both typing games as predicted. However, the first pilot test participant offered a good explanation for liking the keypad of N91. In his view, the keys were as good as N70’s because they were easy to tell apart, which made it easy to type without looking at fingers. Some participants commented on the N91’s small keys saying “it is easy to hit many at once”. Other factors making typing difficult with N91 were the cover of the keypad and the fact that the keys are located low so the cover can be slid over them.

5.2.2. Joystick Evaluations

Curling provided slightly different results from the hypothesis. It was hypothesized that the joystick models would perform the best in games involving steering and of those E50 would be better. The results indicate that the joystick models’ performance was rated better, however, the participants perceived N91 the best in Curling (Figure 43). Its range of evaluations covers the whole scale, but is concentrated on its top end. Median of answers is 4, whereas with other models it is 3. E50 was rated better than N70 receiving slightly better scores.
In the other steering game, Sheep Game, models with joysticks performed better again as Figure 44 shows. This time E50 got somewhat better evaluations in the test, with N91 left not far behind. The mean, median, 1st and 3rd quartile values are all 3 on N70 box plot.

The second pilot provided similar results. N91 was rated the best model to play Curling but it was also evaluated slightly better in Sheep Game than E50. N70 received the lowest scores in both games.

Most participants were happy with E50, however, some of them commented on the E50’s joystick saying it is stiff and too slow in movement. Aki (P3) and Anna (T2) said it slowed down the speed too much in Curling. Some participants felt it is not accurate enough for Sheep Game. However, E50 holds the grip better than N91. Jussi (T3) said “N91 was probably the most accurate, even though the joystick slips”. Reason for N91’s success in Curling could be that it responds to movement quickly. Liisa (P2) commented “it was the easiest to use. I did not need to press much for the joystick to
move to the right direction”. A couple of other answers commented on sensitiveness of N91’s joystick.

### 5.2.3. Camera Evaluations

Participants rated N91 the best performer in Take a Photo in the test (Figure 45). They commented during gaming that the camera software in N91 is the fastest (Researcher’s notes). The participants in the pilot did not notice a difference in the speeds of the phones (Figure 46). They rated N70 the best performer.

![Figure 45. Take a Photo User Evaluations, Test, N=12.](image1)

![Figure 46. Take a Photo User Evaluations, Pilot, N=8.](image2)

Interestingly, the variation evens out if the scores of both test groups are combined (Figure 47). The medians of E50 and N91 are 4 and with N70 it is 3. The means are almost equal ranging from 3 to 3.5 with all models.
The games are designed for a display size of N70 and N91. E50 has a larger display. Some participants pointed out the differences saying that the games seem to be “closer” in N70 and N91. The quality of the display was rated almost equal, mean scores ranging from 3.8 to 4 with all models.

5.3. Game Log Analysis

Game logs were retrieved from MUPE’s database for analysis. Analysis was possible for the data gathered from Number Game, Sheep Game, Take a Photo and Curling. It was not possible to use any of the data from Type a Word, because the game used the phone’s own software instead of MUPE software. Therefore MUPE was not able to detect, for instance, mistyped letters in Type a Word. It could only check if the final typed word is correct.

Based on the log data, we can find out both the number of total and mistyped key presses, the final distance of the ball in Curling, the number of caught sheep and the time it took for the players to take a photo in the camera game. It is possible to see the time an input occurred, the game it occurred in, which phone was used in playing and who the player was. With this information it is easy to detect, for instance, which phone won the most Sheep Games.

Table 10 shows the log results from Number Game; the percentage of presses from the maximum, mistyped presses and wins with each phone. The wins are calculated with ties and also without them. There were 79 instances of Number Game played in the log, which totals to a number of 25 sessions and four games that were played with two players only. That can happen, for instance, when a participant accidentally presses the red key and exits the application, but the other two keep on playing. These four instances are excluded from the percentages of wins, because all the players were not playing. However, it has no effect on the performance of the user interface elements, therefore they were included in the calculations of the number of presses.
The results were analysed using one-way within-subjects analysis of variance (ANOVA). Results show that N70 had the most key presses in Number Game. There is a significant difference in the number of presses between N70 and N91. \( (F_{1,24} = 11.5, p < 0.005) \) However, the difference is not significant between E50 and N70 \( (p > 0.05) \). N70 also had the largest percentage of mistyped numbers, although there is no statistical significance in the number of errors. Despite the difference in mistyped numbers, N70 performed the best in number typing with a 64% of wins, where the calculations also include ties. 9 out of 25 Number Games were ties. Without ties the best performer is still N70 with 50% of wins. The difference to N91’s performance is significant \( (F_{1,24} = 4.26, p = 0.05) \).

<table>
<thead>
<tr>
<th>Number Game</th>
<th>E50</th>
<th>N70</th>
<th>N91</th>
</tr>
</thead>
<tbody>
<tr>
<td>(75 instances)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presses of possible</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>maximum, %</td>
<td>88.5</td>
<td>92.6</td>
<td>80.2</td>
</tr>
<tr>
<td>Mistyped, %</td>
<td>2.6</td>
<td>10.7</td>
<td>3.3</td>
</tr>
<tr>
<td>Wins (incl. ties), %</td>
<td>52.0</td>
<td>64.0</td>
<td>36.0</td>
</tr>
<tr>
<td>Wins (excl. ties), %</td>
<td>37.5</td>
<td>50</td>
<td>12.5</td>
</tr>
</tbody>
</table>

Table 10. Number Game Results.

The high number of incorrect presses with N70 may be explained with the keypad design. The keys are close together and relatively small. The keypad and keys are the smallest of the tested models and it may have advantages compared to a bigger one. It takes time to move the fingers to the right place on a bigger keypad. It could also explain why the number of correct presses in E50 is lower than N70’s. N91’s number of presses was the lowest of the models. It could be explained by an unusual keypad design, where the keys are placed lower than the phones cover making them hard to reach. Other matters effecting participants’ performance in typing games are discussed in Section 5.4.

Table 11 illustrates the results of Sheep Game; the percentage of wins including and excluding ties as well as the number of caught sheep per phone. The total number of played Sheep Games was 82 in 26 sessions. Four of the games were played with two players. Their results are included in the number of caught sheep, but excluded from the wins.

E50 and N91 have a 50% change of winning Sheep Game. N70’s changes are considerably lower, 23%. In Sheep Game, there is a 69% possibility to win when the player has caught at least 6 sheep out of 8 possible. The rates of catching six or more sheep during a game were 61% with E50, 17% with N70 and 22% with N91.

Six of the 26 Sheep Games were ties. When the ties are disregarded the percentages change somewhat. The two joystick phones are the best performers, although there was
no statistical significance between the wins of N70 and N91 ($F_{2,50} = 3.6, p > 0.05$) when ties are included.

<table>
<thead>
<tr>
<th>Sheep Game</th>
<th>E50</th>
<th>N70</th>
<th>N91</th>
</tr>
</thead>
<tbody>
<tr>
<td>(82 instances)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wins (incl. ties), %</td>
<td>50.0</td>
<td>23.1</td>
<td>50.0</td>
</tr>
<tr>
<td>Wins (excl. ties), %</td>
<td>45.0</td>
<td>10.0</td>
<td>45.0</td>
</tr>
<tr>
<td>6 or more sheep caught %</td>
<td>61</td>
<td>17</td>
<td>22</td>
</tr>
</tbody>
</table>

Table 11. Sheep Game Results.

Comparing the game log data in Sheep Game revealed that the average number of sheep caught was the lowest with N70 and highest with the joystick models. Clearly, the models with a joystick performed better in this kind of game where sudden changes in the direction of movement were required, which proves the initial hypothesis. However, there was significant difference in the number of caught sheep between E50 and N91 ($F_{2,50} = 3.8, p < 0.05$). This should indicate that E50 performs the best in the game, but the results are different. This could only be explained by the element of luck involved in the Sheep Game, where the sheep are randomly scattered around the field at the start of the game. Also, the participants noted this: Liisa (P2) said “N91 was the best to play Sheep Game with, because the sheep were close to each other, but the joystick moved the best in N70.”

Table 12 presents the percentages of wins and losses with each phone in Curling. There were 60 instances and 20 sessions of Curling played of which none were ties. In Curling (Table 12) N91 proved to be the best performer. It dominated in the percentage of wins. The low percentage of wins with the other joystick model E50 was a surprise. The difference in performance between E50 and N91 is significant ($F_{1,19} = 5.63, p < 0.05$). E50’s low performance can also be seen from the comments and evaluations of the participants discussed in the previous section.

<table>
<thead>
<tr>
<th>Curling</th>
<th>E50</th>
<th>N70</th>
<th>N91</th>
</tr>
</thead>
<tbody>
<tr>
<td>(60 instances)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wins %</td>
<td>15.0</td>
<td>30.0</td>
<td>55.0</td>
</tr>
<tr>
<td>Losses %</td>
<td>85.0</td>
<td>70.0</td>
<td>45.0</td>
</tr>
</tbody>
</table>

Table 12. Curling Results.

Take a Photo log results are presented in Table 13. They include wins with and without ties as well as the percentage of losses. There were 69 instances of the game played in 23 sessions. Two-player games are not included in the calculations. There was a slight difference in the results of Take a Photo between E50 and N91 (Table 13). N91 won 60% of the games where E50 won 52%. 4 out of 25 games were ties between those two
models. N70 performance was significantly inferior compared to the other models, to E50: $F_{1,22} = 25.6, p < 0.0001$, and to N91: $F_{1,22} = 55.3, p = 0.00001$. The difference between E50 and N91 was not significant.

<table>
<thead>
<tr>
<th>Take a Photo (69 instances)</th>
<th>E50</th>
<th>N70</th>
<th>N91</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wins (incl. ties), %</td>
<td>52.0</td>
<td>4.0</td>
<td>60.0</td>
</tr>
<tr>
<td>Wins (excl. ties), %</td>
<td>36.0</td>
<td>4.0</td>
<td>44.0</td>
</tr>
<tr>
<td>Losses %</td>
<td>48.0</td>
<td>88.0</td>
<td>40.0</td>
</tr>
</tbody>
</table>

Table 13. Take a Photo Results.

The results are difficult to explain. However, they could be associated with differences in hardware, such as the processor or memory bus. Also, N70 has an older version of S60 platform.

5.4. Winner Analysis

Hypothesized winning phones and the actual winners are illustrated in Table 14. It includes the results of user evaluations from both the test and the second pilot, results of the analysis of the game performance from the game logs as well as winning parameters.

<table>
<thead>
<tr>
<th>Number Game</th>
<th>Curling</th>
<th>Sheep Game</th>
<th>Type a Word</th>
<th>Take a Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothesized winning phone</td>
<td>E50</td>
<td>E50</td>
<td>E50</td>
<td>E50</td>
</tr>
<tr>
<td>Best in user evaluations, Pilot</td>
<td>E50</td>
<td>N91</td>
<td>N91</td>
<td>E50</td>
</tr>
<tr>
<td>Best in user evaluations, Test</td>
<td>E50</td>
<td>N91</td>
<td>E50</td>
<td>E50</td>
</tr>
<tr>
<td>Best in game performance, Test</td>
<td>N70</td>
<td>N91</td>
<td>E50/N91</td>
<td>-</td>
</tr>
<tr>
<td>Winning parameters</td>
<td>Small keypad</td>
<td>Joystick, fastest phone</td>
<td>Joystick</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 14. Hypothesized and Actual Winners.

The game logs uncovered an interesting conflict between the participants’ evaluations on perceived performance and the actual performance of a phone. User evaluations seem to support the preliminary hypothesis of the user interface qualities better than the log results. Participants in the pilot and test were in favour of E50 in both typing games. In joystick interaction based games the models with a joystick, E50 and N91, were perceived to perform better than N70 with its navigation key. N91 was rated the best
phone to play Curling, whereas Sheep Game split the scores between E50 and N91. Where evaluations differ from the hypothesis, they reflect the log results. Participants commented on the fastness of N91, which could explain its success in Curling. The information on processor speed for N91 was inconclusive (see Table 5, Section 4.3). The apparent performance differences between E50 and N91 in Curling could most probably be explained by hardware design, because the software platforms are the same.

Take a Photo evaluations were different in the pilot and test. In the pilot N70 was rated highest, whereas in the test N91 got the highest points and N70 was rated the lowest. The test participants noted that N91 was the fastest device. The pilot participants did not notice a difference in the speed of the phones. The logs show that there were almost no difference between the performances of E50 and N91. N70, on the other hand, was clearly the lowest performing phone. The speed of the device depends on the qualities of its hardware, e.g. processor and memory bus. The mobile phone software platform (e.g. series 60) evolves at the same time with the underlying hardware, so it is difficult to say where the problem really lies. As new software versions become available, the underlying hardware is also upgraded. It is possible that both contribute to a speed increase, while at the same time, it is possible to reduce the performance with software or hardware design even though the hardware is faster on paper.

The differences in evaluations may have been affected by the fact that the participants in the test were acquainted with mobile phone games and participated actively in their development. They were more experienced in mobile technology than the participants in the pilot test, although both groups demonstrated equally little mobile phone gaming activity. The test’s participants have been involved in testing other MUPE based games as well. Also, in the test it was easier to compare the speeds of the phones as the games were played in multiplayer mode.

Table 15 summarizes the winners of all rounds, the phones they used and their comments on them. The information is ordered by group, where each group consists of 6 game sessions; two with each phone. For instance, in the first group, T1, on first round Sara won the practice session with E50 and Aleksi the game session with N70. On the practice session of the third round they tied the winning position. The winner of the round is the player who won the most games in that round.
<table>
<thead>
<tr>
<th>Group</th>
<th>Round</th>
<th>Winner</th>
<th>Phone</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>Sara</td>
<td>E50</td>
<td>Nice joystick. Small keys, difficult to press. Easy to take a photo, slow camera.</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Aleks</td>
<td>N70</td>
<td>Too small keys. Had to be wary of other keys in steering. Photo game is not camera dependent</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Niina</td>
<td>E50</td>
<td>Fast and easy joystick. Keys too close to each other for number typing, good for word typing. Slow camera.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Aleks</td>
<td>N91</td>
<td>Good joystick for braking. A bit too small keys for typing, ok for Number Game.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Aleks</td>
<td>E50</td>
<td>All phones equally good for photo game. Excellent keys for typing. Joystick didn't work well on Curling, but was very good in Sheep Game.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Sara</td>
<td>N91</td>
<td>Excellent joystick, went exactly where I wanted it to. Keys fairly easy to press. No problems with taking a photo.</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Teemu</td>
<td>N91</td>
<td>Lousy grip, only 5-way joystick. Keys close to each other, but easy to press, although in a small and confined place. Can't say anything about camera, photo game is sort of a typing game</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Teemu</td>
<td>E50</td>
<td>Continuous 8-way joystick would be better, lousy grip. Camera too slow to load. Keys too close, bad feel.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Anna</td>
<td>N91</td>
<td>Key presses easy to detect, fingers slip though, surprisingly easy to type. Easy to steer with joystick, slow to select. Slow, but easy to take a picture.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Anna</td>
<td>E50</td>
<td>Excellent joystick for steering, easy to select. Best keys, don't slip, good size. Camera easy to use.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Suvi</td>
<td>N91</td>
<td>Easy to steer, good feel, easy to change direction. Slow camera. Had press keys hard, they were small and difficult to hit.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Teemu</td>
<td>N70</td>
<td>5-way navigation key is really lousy for curling. Keys too close, bad feel. Camera jammed.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Suvi</td>
<td>N91</td>
<td>Easy to steer and select. Big keys, maybe too evenly spaced. Slow camera.</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Jussi</td>
<td>N91</td>
<td>Lousy joystick, grip slips. Fastest phone in camera game. Lousy keypad, keys not easily reached.</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Tommi</td>
<td>E50</td>
<td>Easy to steer and select. Big keys, maybe too evenly spaced. Slow camera.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Tommi</td>
<td>N91</td>
<td>OK joystick, could be better, a bit difficult to use. Significantly faster camera than in E50. Keys apart from each other, still in a small space.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Tommi</td>
<td>N70</td>
<td>Slow phone, selection key was a bit lousy. Pressed red key while steering. Slightly better keys than in N91, but not as good as E50. At first couldn't find Clear-key. Slowest camera.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Jussi</td>
<td>E50</td>
<td>Sharp edge in joystick. Fairly fast phone for photo game. OK keypad, but N70 was my favourite.</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Janne</td>
<td>N91</td>
<td>Easy to steer and detect movement in steering, joystick high enough. Slow to use camera. Small keys, well balanced phone.</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Juha</td>
<td>N70</td>
<td>Fast camera. Basic keypad, not for big fingers, clear-key in a wrong place. Ok joystick.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Juha</td>
<td>E50</td>
<td>Easy to steer. Camera easy to use. Big keys, easy to press.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Janne</td>
<td>N70</td>
<td>Lousy feel in joystick. Keys nicely close to each other.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Juha</td>
<td>E50</td>
<td>Easy to steer with joystick in Curling, not so good in Sheep Game. Ok camera. 0 was difficult to press in the keypad.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Janne</td>
<td>E50</td>
<td>Enough room to move the joystick, its high enough. Fast camera. Keys too far away from each other, badly balanced phone.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Maria</td>
<td>N70</td>
<td>I didn't notice a difference to others in Number Game, even though I got more points. Navigation key bad for steering games. Ok camera.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Juha</td>
<td>N91</td>
<td>Easy to steer, quite ok joystick. Camera easy to use. Keys too close to each other for Number Game, surprisingly nice to type words with.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Janne</td>
<td>E50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Juha</td>
<td>N91</td>
<td></td>
</tr>
</tbody>
</table>

Table 15. Winners of all Rounds, Their Phones and Comments on the Phones.
Table 16 consists of the participants’ favourite models in each game as well as an overall favourite, the model, which received the most marks per participant as a favourite. The table also shows the model(s) the participants used in winning a session. Only Mia did not have any wins at all.

Tables 15 and 16 show that some participants, for instance, Teemu (T2) and Tommi (T3) were able to win regardless of the model. There were altogether 5 participants who won with all phones.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Sheep Game</th>
<th>Curling</th>
<th>Number Game</th>
<th>Type a Word</th>
<th>Take a Photo</th>
<th>Overall Favourite</th>
<th>Wins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niina</td>
<td>E50</td>
<td>E50</td>
<td>N91</td>
<td>E50, N91</td>
<td>E50</td>
<td>E50</td>
<td>E50</td>
</tr>
<tr>
<td>Sara</td>
<td>N91</td>
<td>E50</td>
<td>N91</td>
<td>N91</td>
<td>E50, N91</td>
<td>N91</td>
<td>E50, N91</td>
</tr>
<tr>
<td>Alekski</td>
<td>E50</td>
<td>E50</td>
<td>E50, N91</td>
<td>N91</td>
<td>All phones</td>
<td>E50</td>
<td>All phones</td>
</tr>
<tr>
<td>Suvi</td>
<td>N91</td>
<td>N91</td>
<td>E50</td>
<td>E50</td>
<td>N91</td>
<td>N91</td>
<td>N91</td>
</tr>
<tr>
<td>Anna</td>
<td>E50, N91</td>
<td>N91</td>
<td>E50</td>
<td>N91</td>
<td>All phones</td>
<td>N91</td>
<td>E50, N91</td>
</tr>
<tr>
<td>Teemu</td>
<td>E50</td>
<td>E50</td>
<td>N91</td>
<td>N91</td>
<td>N91</td>
<td>All phones</td>
<td>All phones</td>
</tr>
<tr>
<td>Jussi</td>
<td>N91</td>
<td>N70</td>
<td>N70</td>
<td>N70</td>
<td>N91</td>
<td>N70</td>
<td>E50, N91</td>
</tr>
<tr>
<td>Mia</td>
<td>N91</td>
<td>N91</td>
<td>E50</td>
<td>N70</td>
<td>N91</td>
<td>N91</td>
<td>-</td>
</tr>
<tr>
<td>Tommi</td>
<td>E50</td>
<td>E50</td>
<td>N91</td>
<td>E50</td>
<td>E50, N91</td>
<td>E50</td>
<td>All phones</td>
</tr>
<tr>
<td>Juha</td>
<td>E50</td>
<td>N91</td>
<td>E50</td>
<td>N91</td>
<td>All phones</td>
<td>E50, N91</td>
<td>All phones</td>
</tr>
<tr>
<td>Maria</td>
<td>E50</td>
<td>N91</td>
<td>N70</td>
<td>N70</td>
<td>All phones</td>
<td>N70</td>
<td>N70, N91</td>
</tr>
<tr>
<td>Janne</td>
<td>E50</td>
<td>N91</td>
<td>N70</td>
<td>E50</td>
<td>E50</td>
<td>E50</td>
<td>All phones</td>
</tr>
</tbody>
</table>

Table 16. Participants’ Favourite Phones per Game.

Table 16 shows that some participants saw a difference between the two typing games as well as the two joystick games and chose different models as their favourites. Juha says the difference between E50 and N91 in joystick games is due to experience. N91 was the last phone with which he played. Mia says that she chose N70 as her favourite phone in Type a Word because the keypad was familiar. She had used N70 once or twice before for SMSs, calls and surfing the Internet. In Anna’s view E50 was the best for Number Game because its keys could be the most easily reached and it was the most accurate. The keypad in N91, on the other hand, was good for word typing, because it is easy to detect key presses and the player does not press the key too few or too many times. Tommi says that the keys for N91 were good in number typing because they had some space between them. Therefore they were easy to tell apart and he can effortlessly type without looking at his fingers. Tommi favoured E50 in word typing, because his phone, N-Gage QD, has a similar keypad design in that there is no space between the keys.

There were clear similarities in the models the participants chose as their favourites and the phones with which they won a session. A session consists of all games and all
interaction methods, therefore the differences between the phones even out and player’s own preferences are emphasized. Only Jussi did not win with his favourite model, N70.

Table 17 summarizes participants’ gaming activity in console and computer games, both single and multiplayer games are included. The wins column portrays the number of sessions won (see also Table 15), where the maximum is 6. Many of the sessions were ties. The last column represents the phones with which a participant won a session.

<table>
<thead>
<tr>
<th>Name</th>
<th>Console games</th>
<th>Computer games</th>
<th>Wins</th>
<th>Phones</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Singleplayer</td>
<td>Multiplayer</td>
<td>Singleplayer</td>
<td>Multiplayer</td>
</tr>
<tr>
<td>Niina</td>
<td>Rare</td>
<td>Rare</td>
<td>Often</td>
<td>Rare</td>
</tr>
<tr>
<td>Sara</td>
<td>Never</td>
<td>Rare</td>
<td>Once a week</td>
<td>Rare</td>
</tr>
<tr>
<td>Aleksi</td>
<td>Once a week</td>
<td>Rare</td>
<td>Once a week</td>
<td>Often</td>
</tr>
<tr>
<td>Suvi</td>
<td>Rare</td>
<td>1-2 times/month</td>
<td>Rare</td>
<td>Rare</td>
</tr>
<tr>
<td>Anna</td>
<td>Rare</td>
<td>Rare</td>
<td>Rare</td>
<td>1-2 times/month</td>
</tr>
<tr>
<td>Teemu</td>
<td>Once a week</td>
<td>Once a week</td>
<td>1-2 times/month</td>
<td>Once a week</td>
</tr>
<tr>
<td>Jussi</td>
<td>Rare</td>
<td>Never</td>
<td>Often</td>
<td>1-2 times/month</td>
</tr>
<tr>
<td>Mia</td>
<td>Rare</td>
<td>1-2 times/month</td>
<td>Never</td>
<td>Never</td>
</tr>
<tr>
<td>Tommi</td>
<td>Once a week</td>
<td>Often</td>
<td>Rare</td>
<td>All</td>
</tr>
<tr>
<td>Juha</td>
<td>Rare</td>
<td>Rare</td>
<td>1-2 times/month</td>
<td>Rare</td>
</tr>
<tr>
<td>Maria</td>
<td>Never</td>
<td>1-2 times/month</td>
<td>Rare</td>
<td>2</td>
</tr>
<tr>
<td>Janne</td>
<td>1-2 times/month</td>
<td>Rare</td>
<td>Often</td>
<td>1-2 times/month</td>
</tr>
</tbody>
</table>

Table 17. Console and Computer Gaming Experience.

The participants did not play mobile games actively. However, some of them demonstrated quite high console and computer gaming activity. The interesting fact about that is its positive effect on mobile gaming performance. Table 17 shows that Aleksi, Teemu, Tommi and Janne (marked by gray background in the table) play console and computer games the most of the participants. Almost all the female participants play multiplayer console games once or twice a month. However, they play only Singstar, where the main activity is singing. The game does not require active usage of game controls and does not provide the kind of experience on gaming that would be useful in the test. The males’ gaming is more device-oriented, meaning they use the game controls actively to control characters in games like Quake and Warcraft.

The participants who demonstrated higher gaming activity won more sessions than the others. Also, they were able to win regardless of the phone model they were using. One exception to this is Juha’s good performance, which can be explained by him being an employee of NRC and therefore familiar with mobile phones and mobile gaming.

Players’ previous experience with mobile phones has the most effect on the performance in typing games, of all games tested. The fastest style to type is without looking at one’s fingers. The participants who could write in such a manner typed 8.05
numbers per game and those who could not achieved an average of 7.33 numbers per game.

Table 18 consist of the results of Number Game. Participants’ results are evaluated from that game, because the performance in Number Game is not affected by luck or phone’s software and hardware. Therefore it is easy to evaluate the effect of learning and user interface elements using the game’s results. The learning effect involved in the game can be seen from Table 18, where the total number of presses and errors per game is shown. For example, the errors in Jussi’s row stand for 3 errors in practice session and 0 in test session in the first round. During the second round Jussi got 0 errors in practice session and 1 in test session and so on. The last column shows the order of the phones during the test.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Total number of presses</th>
<th>Errors</th>
<th>Order of phones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niina</td>
<td>[4,2], [9,9,10,9,9], [0,10]</td>
<td>[1,0], [0,0,1,0,0], [0,1]</td>
<td>N91, E50, N70</td>
</tr>
<tr>
<td>Sara</td>
<td>[6,1], [9,9,11,9,9], [0,8]</td>
<td>[0,0], [0,0,3,0,0], [0,1]</td>
<td>E50, N70, N91</td>
</tr>
<tr>
<td>Aleks</td>
<td>[9,10], [9,9,9,9,9,9], [9,9]</td>
<td>[9,1], [0,0,0,0,0], [0,0]</td>
<td>N70, N91, E50</td>
</tr>
<tr>
<td>Suvi</td>
<td>[9,9], [9,9], [2,0], [0], [0]</td>
<td>E50, N70, N91</td>
<td></td>
</tr>
<tr>
<td>Anna</td>
<td>[8,9], [9,9], [0,1], [1], [0]</td>
<td>N70, N91, E50</td>
<td></td>
</tr>
<tr>
<td>Teemu</td>
<td>[9,9], [10,9], [0,0], [1], [0]</td>
<td>N91, E50, N70</td>
<td></td>
</tr>
<tr>
<td>Jussi</td>
<td>[4,4], [9,10,9,9], [3,0], [0,1], [0,0]</td>
<td>N91, N70, E50</td>
<td></td>
</tr>
<tr>
<td>Mia</td>
<td>[6,6], [7,7], [8,7], [6,0], [0,0], [0,0]</td>
<td>N70, E50, N91</td>
<td></td>
</tr>
<tr>
<td>Tommi</td>
<td>[9,9], [10,9], [10,9], [0,0], [1,0], [1,0]</td>
<td>E50, N91, N70</td>
<td></td>
</tr>
<tr>
<td>Juha</td>
<td>[9,8], [8,9], [7,8], [1,0], [0,1], [0,0]</td>
<td>N70, E50, N91</td>
<td></td>
</tr>
<tr>
<td>Maria</td>
<td>[4,6], [6,7], [7,9], [0,0], [0,0], [0,0]</td>
<td>E50, N91, N70</td>
<td></td>
</tr>
<tr>
<td>Janne</td>
<td>[5,8], [10,10], [6,10], [0,1], [1,1], [0,1]</td>
<td>N91, N70, E50</td>
<td></td>
</tr>
</tbody>
</table>

Table 18. Performance in Number Game.

The learning effect could be seen for instance in Maria’s performance. Her results got steadily better with practice. Also, she did not see any difference between the models in Number Game (Table 13), therefore her results did not show a drop in performance level when the phones were switched. Jussi started with a low result, which could be the effect of not knowing how to play the game at first. In addition, he played first with a model (N91) he liked the least. His second round was significantly better. He had learned to play the game and played with his favourite model, N70. It could explain the slight drop in performance in the last round. Janne’s performance reflects also the evaluations of the phones in Table 15. He liked N70’s keys and picked it for his favourite to play Number Game with. The reason for his performance experiencing a drop with the last model could be explained by his comments in Table 13. In Janne’s view, E50 was badly balanced and he did not like the keypad design. Many participants,
like Teemu, were able to give a solid performance during the test regardless of the model they played with. Teemu criticises some of the phone models (see Table 13), but his performance is not affected by the differences in keypads. Also, the participants who played more with other gaming devices demonstrated less effect of learning, their performance being more or less steady from the start of the test to the finish.

Number of errors in Number Game got smaller as the test progressed. After playing two sessions of games on each three phones the participants had played each game multiple times. Some participants mentioned in the questionnaires that the last phone was the best to play with. They commented that the user interface elements were necessarily not the best to use, but they had already practiced the games many times and learned to play it better.

According to the game logs, the speed of the phone’s hardware and the qualities of its software have an effect on the results of Curling and Take a Picture. Slowing down the ball’s movement in Curling has to do with the qualities of the software where some models did not seem to slow down as much as others did. E50 did not perform well in Curling, but won the most Sheep Games where the interaction is different than in Curling. Sheep Game requires fast responses to changes in the direction of movement.

In Take a Photo the participants were advised to take a picture as soon as the camera software had loaded. Winning the game depends on the speed of the phone’s software and hardware instead of the quality of the user interface elements.

The results of Number Game are solely dependent on the interaction between the player and the user interface elements of the phone. The game logs revealed that N70 performed the best in number typing despite its large number of mistyped presses, over 10% of the total, contrary to the hypotheses and user evaluations. The good performance of N70 in Number Game can be explained by the small size of the keypad, 5.5 cm². In E50 it is 8.8 cm² and with N91 6.5 cm² (the total contact area). With a smaller keypad it is faster for the player to move his/her fingers to the next key. It is also easy to hit the surrounding keys, which can be seen in the large percentage of mistyped numbers. Unfortunately, the logs from the word typing game were not available and it was not possible to find out how N70 performed in it.

There were also other things that might have had an effect on the results. In Type a Word the players typed 8-letter words, of which one, nautilus, was not included in the phones’ dictionaries. Also, one of the test models had only an English dictionary, which had a big effect on typing in T9 mode.

The tests brought up noteworthy issues in keypad design. In the pilot and actual tests the participants sometimes hit the red call management key when trying to hit a key that was needed in the game. In Type a Word the players were able to erase mistyped letters by using clear-key. In Type a Word, Matias (T1) accidentally pressed the red call management key instead of the clear-key with both E50 and N91 and exited
the game on both occasions. The keys were located in a different place than what he was used to and were replaced by the red key. It is impossible to say whether Matias could write without looking at his fingers, because that question was added after the pilot test to the background questionnaire (Appendix 1a). Three players accidentally pressed the red key instead of the clear-key. A player’s finger accidentally touched it when he was using the navigation key in N70 to steer in the Sheep Game and was thrown out of the game. Some of the participants commented on the key’s placement on the mid-game and pre-game questionnaires (see Sec. 5.1). However, player’s typing capabilities do get better with practice and using a familiar phone model.

Some of the participants noted that the N70’s keypad seems familiar; it is very basic in its design. Familiarity of a phone affects performance positively. Player’s unfamiliarity with the interface affects gameplay, just as happened with clear-key in many occasions. The tested phone models were new to most of the participants, although some of them had little experience on some models. Only one of the pilot test participants owned an N70. Some participants found it hard to use the models, because they were different from their own phones. It had an effect on the user evaluation scores as well as log results. A phone model a participant owns has an effect on what s/he expects from a phone. This could be seen in the evaluations. Matias (P1) gave low scores to all models in typing games. Where the others gave E50 scores from 4 to 5, Matias gave it a 2. The owner of N70 evaluated the model’s performance always on the top of the score range. Especially in typing games, she gave N70 higher scores than any other pilot participants.

The next chapter presents the discussion and conclusions on findings of the tests. It discusses the most important findings in the tests, contribution to game design, concerns on reliability and validity of the study and ideas regarding further study.
6. Discussion and Conclusions

The study concentrated on testing the qualities of the joystick, navigation key, keypad and camera in mobile multiplayer gaming. There were five different minigames that tested the qualities of the interface elements in number and word typing, steering and selecting as well as taking a photo.

Two pilot tests were arranged before the actual test. The participants evaluated the perceived performance of the elements and their game statistics were collected to a log, which was analysed. The second pilot’s user evaluations were analysed in this study in addition to the user evaluations and game log results from the actual test. The winning phone is determined by the results in the logs. The tests were within subject tests with 12 participants, who were divided into groups of 3. They played the games with 3 different phone models, so that everyone got a chance to play with all phones.

The main research question was whether the phone model the player is using has an effect on game performance in multiplayer games. The study also aimed to find out if there is a particular design of a user interface element that would suit gaming better than other designs and if any game interaction method, such as taking pictures, would suit all phone models.

6.1. Most Important Findings

It was hypothesized that joystick models, especially E50, would be best performers in games that need steering and selection. In typing games E50 would perform the best, because of its big keys. All models would be equal in taking a photo. The results in the game logs support the hypothesis partly. The biggest surprise was that N70 had the most wins in Number Game, 64%. The joystick models dominated joystick interaction games. In Curling, N91 was clearly the best phone with 55% of wins and E50 and N91 tied the best performer’s spot in Sheep Game. N91 performed the best in picture taking with 60% of the games won.

The results show that the phone model has definitely an effect on the player’s performance in a multiplayer game. However, the user interface elements are not the only factors affecting performance, because it also depends on the speed of the phone’s hardware and software. Practice as well as player’s own preferences and experience have also an effect on how well a player does in a game.

Practice had a positive effect on the participants’ performance. They demonstrated very little mobile gaming activity, however, some of the test participants were very
active console and computer gamers. The results show that the player’s experience of console and computer games goes hand in hand with his/her performance in mobile games. Active players were able to win sessions regardless of the phone model they were using. They also won more sessions than the players who were less active in console and computer games. Additionally, those players demonstrated the steadiest gaming performance.

It is fair to say that a game that is based on steering and selection should be played with a joystick model. An exception would be any phone model specifically designed for gaming, such as N-Gage with an 8-way navigation key. A small keypad seems to fit typing games.

Picture taking as a game interaction method suits all phone models from the user interface point of view. This is supported by the participants’ evaluations, where the best phone to play photo game with received the most ties. However, if the game involves competing in the speed of picture taking the games are won with a phone with the fastest software and hardware.

6.2. Contribution to Game Design

To our knowledge there has not been previous study in mobile phone’s user interface element’s suitability for mobile gaming. It is important to study it, because interest in mobile gaming has grown over the past years. The number of mobile phone owners is also growing worldwide and the number of casual gamers, people who play for instance while waiting, is growing, too. Casual gamers differ from active gamers in that they play with their mobile phone, not with a specific gaming device. Therefore it is worthwhile to study the normal phone’s user interface elements performance in gaming.

The tests revealed an interesting difference between the two typing games. According to some participants of the test, the phones perform differently in number typing and word writing. The games require a different style of typing, and therefore they can produce different results. In Number Game, the keys are pressed one by one with a short space of time between them when the player looks at the screen to see what the next number is. This does only take a while, but there is a noticeable gap of time between presses. In the word typing game, on the other hand, the player is shown the word before the game begins. Then s/he can type it as fast as s/he can. There is no waiting and looking at the screen for the next letter. In addition, some players wanted to feel the presses in word typing, so they did not press too many or too few times. Others commented that Number Game is good to play with a phone where the keys are apart from each other. Players can tell where individual number keys are without looking at their fingers.

It was assumed that the participants would rate all phones equal in picture taking. 4 participants in the test and 2 in the pilot felt that all models were equally good in taking pictures. There were also two ties between E50 and N91 in Take a Photo in the test. E50
and N91 also tied the favourite’s position once or twice in all games. From the point of view of the hypothesis, it is noteworthy that picture taking received that many ties. It could mean that it would be a suitable gaming interaction method for all phones. Another fact supporting this conclusion is the differences between the groups in evaluations. When the test and pilot evaluations are combined the differences between the phones in photo taking even out. Also, taking a photo as a game method is very simple and it does not require previous experience in gaming.

6.3. Reliability and Validity Concerns

Other participants’ comments and actions might have had an effect on the evaluations in this study design. During testing the participants were in the same room, gathered around a table. This had an effect on the test group, where the games were played in multiplayer mode. Though the games loaded simultaneously in all phones, they did not start at exactly the same time in all phones. Some participants commented: “everyone else is already writing (in Type a Word) and my game is still loading”. It did not affect the game’s log results, but it could have affected the participants’ view on the speed of the phone. A comment about N91’s advantage in Take a Photo was spoken out loud while playing in group T3. Everyone in that group chose N91 as their favourite to play Take a Photo, on the grounds of it being faster or more responsive. Another example of group influence: a P1 participant asked if it was acceptable to rate all phones equal in Take a Photo. When he had voiced the question, another participant in the group gave all the models the same rating as well.

According to Teague et al. [2001] the participants are likely to make their evaluations too positive after a task. Therefore it would be necessary to ask their opinions as soon as possible after gaming and questionnaires were a good way of doing that. Users were asked to evaluate the user interface elements after playing two sessions on one phone. At the end of the test they were asked to choose the best phone for each game. Evaluations focus more on the negative events when they are gathered while the task is underway [Teague et al., 2001]. It would be difficult to gather data while playing, therefore the participants were asked to evaluate the user interface elements right after playing. Varying the order of the phones and games between the tests should compensate for the possibly too positive evaluations. Having them say their evaluations out loud during gaming might affect their own performance and the evaluations of other players.

The test participants were very familiar with each other and the premises where the test took place. This could be seen in relaxed conversations during testing. In the pilot test the surroundings were more unfamiliar and the participants did not know each other well. The atmosphere was not as relaxed and some of the participants admitted they were a little nervous about the test, especially because it was taped on video. This could
indicate that the atmosphere and the results in the test were closer to a real gaming situation where multiplayer mobile games are played in a group of friends.

The test participants were young and interested in mobile game development. They participated in mobile game development projects at Nokia Research Centre. It may have had an effect on the log results. It would have been useful to have the log data from the pilot in addition to the actual test’s logs to prove the validity of the results with a wider participant population. Also, the number of participants was low, which may have had an effect on the results.

According to Fritsch et al. [2007], young people are more interested in mobile gaming. Therefore the test participants are a likely target audience for games like these. They are young and they showed an interest towards mobile gaming by participating in mobile game development projects. Also, 4 of the test participants owned an N-Gage device, even though they did not play mobile games often.

Fritsch et al. [2007] hypothesized that the user interface elements would be the largest disadvantage in mobile gaming. However, they found out that mobile phones’ biggest disadvantage, from the players’ point of view, had to do with the low quality of game graphics. The screen sizes and the resolutions are continuously growing thus paving the road for more elaborate graphic images in mobile games. Likewise in the study presented here, some of the participants noted the quality of graphics during gaming. Also, one of the pilot participants mentioned that the games were not what he had expected. In his view they were too simple. On the other hand, test participants commented during gaming that the minigames were fun to play.

6.4. Further Study

Further study in the area could include testing with the participants’ own phones. In that way they would already be familiar with the interface elements. Participants’ comments support this. One participant mentioned that the games were too short. She was not sure whether she was able to get to know the user interface elements well enough. A few participants pointed out that some elements behaved in an unusual way, but maybe they would get used to them after a longer period of use. There were many comments by the participants on the fact that performance was better towards the end of the test when they got more practice and learned to play the games. The effects of practice can be seen in the logs. The learning effect cannot be completely avoided and it could be argued that it should not be. In order to get more reliable results, the users should get to play more.

To take the learning effect into consideration, the test design might include longer games, playing more sessions or testing on multiple occasions with the present game set. The practice games could be then discarded from the data. The test games should concentrate on using one interaction at a time, so the participants would be able to observe easily the functionality of an interface element. It may be worthwhile to
consider making the games also more straightforward, because some participants commented they did not understand how a game was supposed to be played, which affected the log results. If the games are played in a session consisting of a number of games, like in this study, the games should be kept relatively short. That way the participants will remember what happened in the first game.

Further study in the area with a larger number of participants is required to acquire statistically valid results. In further research it is important to choose the test phones carefully. They could include a model with a lower resolution camera. All phones should have the same display resolution if the games are designed for a certain size of the display and are not scalable. It is also important to get log data on all games and make sure the data is usable.

In the future game studies could involve testing an actual photo game, where the photos are used for some purpose in a game. It would also further clarify whether the quality of the pictures is significant for the players.

The selecting or designing games for the tests should focus on the enjoyment of the players. There were some comments about the fun factor of the tested games. Take a Photo confused some participants, because they did not understand the meaning of the game. It was also rated the most boring game, since it did not have a good game idea. The Sheep Game was voted the most enjoyable and fun game. It had a nice idea and it offered a challenge. Participants also liked Curling and Number Game for the same reasons. Some of test participants commented on the post-game questionnaire that Take a Photo was a boring game, because of its device dependency. The player could not influence the results, because the fastest device won.

It is possible to design games for mobile phones. Designers should consider the special characteristics of the mobile phone and its technology and use them to their advantage. There are many examples of fun and popular mobile games that are developed specifically the device in mind. For instance, MUPE MiniGames are short, which is ideal for games that are meant to be played while waiting. Also, the means of interaction are very simple. They deal with latency by loading the needed data in between active game sequences. Minigames are multiplayer games, which suits the mobile phone’s connected nature well. In addition, they include typing games and camera games. Both of these gaming methods are very well suited to the mobile phone.

Camera games have a huge potential, since the number of camera phones is continuously increasing. Camera games are suited to all phones in that they use simple interaction methods that are not dependent on the design of the user interface elements. However, if competing on the speed of taking photos, the phone with the fastest software and hardware wins. Camera games are also very well suited to casual gamers, since they do not require previous experience in gaming.
References


http://www.veritytech.com/data/Verity%20solo%20play%20mobile%20game%20design.pdf


Appendix 1

Nimi __________________________

Ikä __________________________

Mikä kännykkä sinulla on? Malli?

Mihin käytät kännykkääsi?

Kuinka usein teet jotain kännykälläsi?
   a. lähes koko ajan
   b. useita kertoja päivässä
   c. pari kertaa päivässä
   d. harvemmin

Kuinka paljon tekstiviestejä kirjoitat viikossa?

Onko ennakoiva tekstinsyöttö käytössä?

Osaatko kirjoittaa katsomatta näppäimistöön?

Onko kännykän kameran käyttö tuttua?

Oletko tottunut käyttämään puhelimen joystickiä?

Minkälaisia pelejä pelaat mielelläsi?

Urheilupelit
En ole kiinnostunut 1 2 3 4 5 Pelaan mielelläni

Rallipelit
En ole kiinnostunut 1 2 3 4 5 Pelaan mielelläni

Toimintapeli
En ole kiinnostunut 1 2 3 4 5 Pelaan mielelläni

Seikkailupeli
En ole kiinnostunut 1 2 3 4 5 Pelaan mielelläni

Tietokilpailupeli
En ole kiinnostunut 1 2 3 4 5 Pelaan mielelläni

Arcadepeli
En ole kiinnostunut 1 2 3 4 5 Pelaan mielelläni

Älypelit
En ole kiinnostunut 1 2 3 4 5 Pelaan mielelläni

Strategia ja simulaatiopeli
En ole kiinnostunut 1 2 3 4 5 Pelaan mielelläni

Kasinopeli
En ole kiinnostunut 1 2 3 4 5 Pelaan mielelläni
Kuinka paljon pelaat monin- ja yksinpelejä? Ympyröi.
Kerro myös mitä pelejä olet pelannut viimeisen puolen vuoden aikana.

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<th>Moninpelit</th>
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<th>Yksinpelit</th>
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Appendix 1

Jos olet pelannut moninpelejä, kerro miksi.

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Oletko pelannut pelejä, joissa käytettiin kameraa tai tekstinsyöttöä (Kännykällä/PC/Konsoleilla)

_________________________________________________________

_________________________________________________________

_________________________________________________________

_________________________________________________________
Appendix 1b

Oletko käyttänyt aiemmin mitään testattavista malleista? Ympyröi.

E50
a. olen käyttänyt paljon
b. olen käyttänyt jonkin verran
c. kokeilin kerran tai pari
d. en ole kokeillut

N70
a. olen käyttänyt paljon
b. olen käyttänyt jonkin verran
c. kokeilin kerran tai pari
d. en ole kokeillut

N91
a. olen käyttänyt paljon
b. olen käyttänyt jonkin verran
c. kokeilin kerran tai pari
d. en ole kokeillut

Mihin käytit?

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Millainen oli ensituntuma kännyköihin?

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________________________
________________________
________________________
   - E50
   - N70
   - N91

2. Miten puhelimen näppäimistö sopi numeropeliin? Miksi?
   Huonosti 1 2 3 4 5 Hyvin

3. Miten puhelimen joystick sopi curlingpeliin? Miksi?
   Huonosti 1 2 3 4 5 Hyvin

4. Miten puhelimen joystick sopi lammaspeliin? Miksi?
   Huonosti 1 2 3 4 5 Hyvin

5. Miten puhelimen näppäimistö sopi sanapeliin? Miksi?
   Huonosti 1 2 3 4 5 Hyvin

6. Miten puhelimen kamera sopi kuvapeliin? Miksi?
   Huonosti 1 2 3 4 5 Hyvin

7. Miten näyttö soveltu pelaamiseen? Miksi?
   Huonosti 1 2 3 4 5 Hyvin

8. Voititko? Miksi/mikset?

__________________________________________________________________________
Appendix 3

1. Millä puhelimella numeropeli sujui parhaiten? Miksi?
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________

2. Millä puhelimella curlingpeli sujui parhaiten? Miksi?
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________

3. Millä puhelimella lammaspeli sujui parhaiten? Miksi?
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________

4. Millä puhelimella sanapeli sujui parhaiten? Miksi?
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________

5. Millä puhelimella kuvapeli sujui parhaiten? Miksi?
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________

6. Olisitko käyttänyt sanapeliin mieluummin mallia E70?
Perustele.
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________

7. Olisitko käyttänyt kuvapeliin mieluummin mallia N90?
Perustele.
________________________________________________________________________________________________________________________
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Appendix 3

8. Mikä oli mukavin peli? Miksi?

__________________________________________________________________________________________
__________________________________________________________________________________________

9. Entä tylsin? Miksi?

__________________________________________________________________________________________
__________________________________________________________________________________________

10. Mitä kuville pitäisi tehdä (näyttää/hylätä)? Miksi?

__________________________________________________________________________________________
__________________________________________________________________________________________

11. Onko kuvien koolla väliä?

__________________________________________________________________________________________

11. Onko kuvien laadulla väliä?

__________________________________________________________________________________________

12. Miten/mihin käyttäisit kuvia?

__________________________________________________________________________________________
__________________________________________________________________________________________