IADIS International Journal on Computer Science and Information Systems
Vol. 10, No. 2, pp. 95-112
ISSN: 1646-3692

INCLUDING VISUALLY IMPAIRED PLAYERS IN A GRAPHICAL ADVENTURE GAME: A STUDY OF IMMERSION

Henrik Engström, Jenny Brusk and Per Anders Östblad. *University of Skövde, School of Informatics, Box 408, 541 28 Skövde, Sweden*

ABSTRACT

The aim of the project presented in this paper is that visually impaired and sighted players should be able to play the same game and share a gaming experience. The goal is that the game should be accessible to visually impaired players without any additional tools, such as text-to-speech, that may reduce the immersion. At the same time, sighted players should perceive the game as a regular game. This paper presents an evaluation of the game where the player immersion has been evaluated through a post test immersion questionnaire. The study was conducted with three independent groups: sighted players using graphics (n=10), blindfolded sighted players (n=10) and visually impaired players (n=9). Although progress in the game and the reported sense of control differed between groups, player immersion was very high in all groups. There were differences between the three groups only in one out of five immersion factors. The result shows that it has been possible to provide an immersive experience irrespective of whether the players are playing the game with graphics or using audio only.

KEYWORDS

Inclusive game design, immersion, questionnaire, audio games

1. INTRODUCTION

Although digital games have a broader scope than video games, there is still a very strong emphasis on the visual dimensions, which makes most parts of the game culture inaccessible to visually impaired persons.

There exists a few audio-only games particularly targeting visually impaired players and games that they can play by the assistance of various aids, such as the VoiceOver available on iOS devices. However, there are hardly any examples of graphical games that in their original design allow visually impaired and sighted players to play on equal terms and thereby making it possible for them to share the same gaming experience. One could argue that there is a difference between making a game accessible and making a game inclusive. Accessible means it is possible to play, inclusive means that the group to include is considered in every aspect of the game development process and that the gaming experience is as similar as possible regardless of whether the player have access to the graphics or not.

This paper presents a mobile game developed with the aim to be inclusive for both visually impaired and sighted players. The goal is that they should be able to play the same game and have a very similar experience. The game has been evaluated in a study that compares the self-reported immersion from three different groups of players. The two main groups are visually impaired subjects and sighted subjects playing with graphics. The third group, sighted subjects playing without graphics (blindfolded), forms a control group. The instrument used in this study is to a large extent based on the *Immersive Experience Questionnaire* (IEQ) developed by Jennett et al. (2008). The IEQ was specifically made for studies of computer game immersion. In this study, we have adjusted IEQ to be usable for studies that includes visually impaired players.

2. BACKGROUND

2.1 Inclusive Game Design and Audio Based Games

According to Barlet & Spohn (2012) it is currently not plausible that all games could be created to be equally playable and enjoyable for every human being. The current state of technology will not permit it. However, by developing new design principles and utilizing new technology it may be possible to take some steps towards that goal. They further state: “In short, we need to work to get every title to have the broadest audience possible and make sure that, for those left out of a particular title, there are other titles waiting for them to play” (p. 9).

There are a few different types of games visually impaired gamers tend to play (The Accessibility Foundation, 2015):

- Text-based games - made accessible to blind players via screen readers.
- Mainstream video games - some visually impaired gamers use audio cues in mainstream video games to play, e.g. fighting games where different punches, kicks etc. can be identified via their sounds.
- Audio games - games with only auditory and no visual output.
- Video games made accessible through modification - games that are modified by gamers themselves to be accessible (also known as “mods”).
- Video games that are accessible through original design – the category that best describes the game presented in this paper.

Text-based games and mods can be fully playable and even be designed specifically for visually impaired players. However, these types of games generally lack the production values of mainstream games (The Accessibility Foundation, 2015). As for audio games and games that are accessible to visually impaired gamers through original design, there are a few examples, for instance *bit Generations Soundvoyager* (Skip Ltd., 2006) and *Terraformers* (Westin, 2004). The most acclaimed audio games on the market are probably the *Papa Sangre* games (Somethin' Else 2011; 2013). In *Papa Sangre*, graphics is not used to convey any information and the game is fully accessible to visually impaired players. Several previous studies (e.g. Ekman, 2007; Oren, 2007) have reported that many sighted players experience difficulties navigating an audio-only interface, and audio-only games may therefore not attract a sighted audience.

2.2 Immersion

The study presented in this paper focuses on player immersion. A decade ago, Brown and Cairns (2004) pointed out that the term immersion is used inconsistently in the literature, and unfortunately this is still true (Cairns et al., 2014). There are related concepts such as presence (Witmer & Singer, 1998), flow (Csikszentmihalyi, 1990), cognitive absorption (Agarwal & Karahana, 2000) and user experience (Brockmyer et al., 2009) that all have contributed to the understanding of immersion.

In the field of virtual environments, the concept of presence has received a lot of attention. Presence can be defined as "the subjective experience of being in one place or environment, even when one is physically situated in another" (Witmer & Singer, 1998, p. 225). Presence is to a large extent related to the technologies used to generate and interact with the virtual environment. Is has its origin in studies of how virtual environments can support learning and performance of real world tasks and is not directly applicable for studies of computer games. Although some games are close to virtual reality applications, there are numerous examples of games that do not present a virtual world in which the player can experience presence.

The flow theory, proposed by Csikszentmihalyi (1990), is an important theoretical basis in game design and game studies. Flow can be defined as "a state in which an individual is completely immersed in an activity without self-consciousness but with a deep sense of control" (Engeser & Schiepe-Tiska, 2012, p. 1). Csikszentmihalyi (1990) suggests that in order to experience flow there are eight important elements to consider: clear goals; high degree of concentration; a loss of the feeling of self-consciousness; distorted sense of time; direct and immediate feedback; balance between ability level and challenge; sense of personal control; and intrinsically rewarding. Since computer games and gaming produce many of these elements, flow has been used as a basis for creating (Chen, 2007) and analysing games (Sweetser & Wyeth, 2005) as well as for evaluating the gaming experience (Fu et al., 2009).

Although there are similarities between flow and presence, Weibel & Wissmath (2011) show that they are distinct constructs. In their study, presence and flow were measured and compared between subjects playing three different types of computer games. They show that the results from the presence and flow questionnaires were positively correlated, but they did not covariate. In addition, Weibel & Wissmath (2011) show that flow positively affects enjoyment and performance while presence only has an indirect effect.

Immersion is a concept used in the fields of presence and flow but with very diverse meanings. Jennett et al. (2008) acknowledge the similarities between immersion and flow – both relate to how a person can become absorbed by an activity – but also highlight the difference that flow is an extreme experience while immersion is more of a continuum. In this way flow can be seen as the extreme end of immersion. In the presence context, immersion could refer to the response of the users or properties of the system itself (Slater, 1999). Kalawsky (2000, p. 2) states "[the] term immersion is also sometimes used erroneously to describe the experience of presence." The correct usage, according to Kalawsky (2000, p. 2), is that "[the] term immersion in fact refers to the extent of peripheral display imagery." This is in contrast to Witmer and Singer (1998, p. 227) who define immersion as "a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences." This latter view on immersion corresponds to how it is perceived in the computer game community as well as in the flow theory. As an example, Weibel & Wissmath (2011) conclude that presence relates to spatial immersion – the sense of being in the game. Flow, on the other hand, relates to immersion in the task – the sense of being absorbed by the game task.

Immersion can be seen as a general concept that incorporates many of the more specific terms. In this paper, we adopt the view expressed by e.g. Brown and Cairns (2004), Jennett et al. (2008), and Cairns et al. (2014) that immersion is a positive experience from interacting with a digital game. Jennett et al. (2008, p.643) propose the following definition: "immersion is concerned with the specific, psychological experience of engaging with a computer game". This is also how immersion should be understood in this paper.

2.3 Instruments to Measure Immersion

Numerous questionnaires have been developed that can be used to evaluate the immersion of a gaming experience. To give a few examples, Brockmyer et al. (2009) propose the *Game Engagement Questionnaire* (GEQ) based on previous work on absorption, flow, presence and immersion. Qin et al. (2009) present a questionnaire focused on studying the immersion in the narrative of a game. Calvillo-Gámez et al. (2010) present the *Core Elements of the Gaming Experience Questionnaire* (CEGEQ), which is based on a grounded theory approach. No single scale has been established as a norm (Nordin et al., 2014), which makes comparison between studies problematic. The diversity of questionnaires is many times motivated by the context in which they have been developed. As an example, the GEQ was developed to analyse the experience of playing violent video games and has therefore a question on how scared subjects felt.

One of the most used instruments is the *Immersive Experience Questionnaire* (IEQ) proposed by Jennett et al. (2008). IEQ exists in several versions with variations in questions and scales. The version used in this paper is the modified version (Jennett, 2010, Appendix 7) which consists of 31 questions that should be answered on a 7-graded scale. The IEQ Immersion score can be computed as the sum of the 31 questions (0-6) where negatively stated questions (i.e. where high numbers indicate low immersion), have been inverted. The questions have also been clustered according to five immersion factors: cognitive involvement; real world dissociation; emotional involvement; challenge; and control. A score can be computed for each immersion factor according to the same principle as the total immersion score.

The problem with IEQ and some other similar instruments, for example CEQEQ (Calvillo-Gámez et al., 2010), is that they are based on assumptions that the game contains graphics and/or that the subjects are able to use visual information. Hence, these instruments exclude visually impaired subjects. As an example, in the CEQEQ 6 out of 38 questions require subjects to be able to see in order to answer. The score can be computed by excluding questions but it may affect the validity of a comparison if one group has 20% more questions than the other. In the IEQ (Jennett et al., 2008) there is only one question, out of 31, that assumes that subjects are able to see. This question is to what extend subjects appreciate the graphics and imagery. This is relevant to most games – given that there are graphics and the subject is able to see it. Interestingly, the IEQ does not have a corresponding question related to the audio. This is a clear weakness of the IEQ – the importance of audio to the immersion of games is previously documented (Huiberts, 2010). An even bigger weakness with the IEQ related to inclusiveness is that the immersion score is computed by adding the response to individual questions to a sum. In this way the total immersion of the visually impaired is instrumentally lower when the question regarding graphics is excluded. In other words, visually impaired players are defaulted to have the lowest possible appreciation of the graphics and imagery. A better approach is to compute the immersion score using some statistical metric, such as median, that makes comparison possible and fair even when the number of questions varies.

The conclusion from this is that it is not possible to use IEQ unchanged in the context of this paper. When the experience of sighted and visually impaired players should be compared the instrument itself has to be inclusive.

3. THE GAME

The game developed in this project, *Frequency Missing*, is a point-and-click adventure game for iOS and Android devices, designed to include blind and visually impaired gamers without alienating the sighted audience. A lot of effort was put into making it as close to a commercial game as possible with regards to production values.

Following the tradition of other games in the genre, such as *The Secret of Monkey Island* (LucasFilm Games, 1990), the game is an interactive story with a protagonist that corresponds to the playable character and gameplay mainly consisting of puzzle challenges, interactive dialogues and exploration (Adams, 2014).

Adventure games are well suited for playing with sound only since they rely heavily on the story that by simple means can be told without visual representation. However, since they are also games, puzzles, navigation, and other features that require interaction must work equally well with and without graphics. This has been the main challenge for the project and it has led to some specific design choices that will be presented below.

Frequency Missing consists of four chapters and has a total play time of approximately 1.5 hours. In the study presented in this paper, subjects played the first of these chapters, including an introductory tutorial.

3.1 Story and Setting

The player takes the role of Patricia, a newly recruited reporter at a radio station somewhere in Sweden. Arriving on her first day Patricia learns that Richard, her friend and now colleague, mysteriously disappeared three days ago. The objective for the player is to find out what has happened to him.

The radio station consists of a lobby from which three offices and a newsroom are accessed (see Figure 2, right). At the station Patricia gets introduced to her new colleagues: Karl, a technician and Patricia's office mate; the boss, with no name; Monica, the receptionist; and Stephanie, the news anchor. Through dialogue with these characters, the player can find out more about the colleagues and the circumstances around Richard's disappearance. In addition to dialogue, the story is narrated by means of Patricia's inner voice, a common feature of point-and-click adventures.

In order to progress the game the player has to explore the environment, engage in dialogue and solve puzzles. The very first puzzle is introduced in the tutorial at the beginning of the game and aims to introduce the player to mystery while getting acquainted with the interaction model as described below.

3.2 Interaction Model

The game uses a first-person perspective and the player interacts with the environment by dragging and tapping one finger on the screen. To include the blind players in the game, design tools such as auditory icons and voice-over are used. Auditory icons can be described as "everyday sounds that convey information about events by analogy to everyday sound-producing events" (Encelle et al., 2011, p. 125).

3.2.1 Exploring the Environment

Since the game must be equally playable independently of whether it is played with or without graphics, all information and events that are conveyed by graphics are also conveyed by sound. All rooms, for example, have unique ambiance tracks that reflect the setting of the scene, e.g. in the lobby there is low murmur of voices.

Similarly, all interactable objects have their own unique 3D sound, The closer the active finger is to an object, the stronger its sound volume becomes and the stereo panning tells if the object is to the left or right of the finger. In addition to 3D sounds, there is a clear and audible interface sound when an interactable object is located. Moreover, the zone within which a player can click on an object is enlarged when a finger enters it. This is to avoid punishing players for making small finger movements once an object has been activated. Every action and event that is not diegetic (directly connected to the game environment) is highlighted by an interface sound.

3.2.2 Collectible Items

Like most other adventure games, there are items in the environment that the player can pick up and use for solving the puzzles. Typically, this would require an inventory, a well-established game feature for storing collectible items. However, to implement an inventory that both groups of players can manipulate equally intuitive turned out to be very difficult to achieve. Instead, the player can pick up an item in the game environment that will be used automatically when the circumstances are right. For example, in the first chapter of the game there is only one collectible item, the key to Richard's locked office.

3.2.3 Dialogue

The dialogue system follows the traditional branching tree concept, with a list of dialogue options displayed on the screen from top to bottom. Similar to other games in the genre, the dialogue takes place in a separate gameplay mode (Adams, 2014) in which the camera zooms in on the non-playable character as if he or she was standing face-to-face with the playable character (see Figure 1, right). To facilitate voice-over (read by the lead actress), the player can only choose among a range of topics rather than complete utterances. This adjustment also ensures that sighted and visually impaired players are provided with equal amount of information. The voice-over is activated when the player holds a finger over one of the options, but there is some delay before the voice over starts so players that have access to the graphics might never discover this feature in the game.

All dialogue is voice acted by experienced actors, following a hypothesis that using text-to-speech could reduce the level of immersion the player could experience. To make all speech clear and audible, since audio-only players can't access the subtitles, all background sounds (music, ambiance) are lowered in volume and filtered in their high frequencies whenever a character speaks.

Figure 1. Screenshots from the game illustrating the two main gameplay modes. A user can search for, and activate interactable objects in the exploration mode (left) and select dialog options in the dialog mode (right)

Figure 2. Screenshots from the game illustrating the difference in perspective between rooms in the game, and highlights of interactable objects in the boss' office (left) and the lobby (right)

3.2.4 Critical Path

In order to complete a chapter, the player has to traverse a series of key events in a particular order, referred to as the critical path. The critical path for the first chapter of the game (shown in figure 3) consists of 31 steps of which the first four are tutorial steps before the actual game begins. These 31 steps are thus the absolute minimum number of interactions that has to be completed in order to finish the chapter.

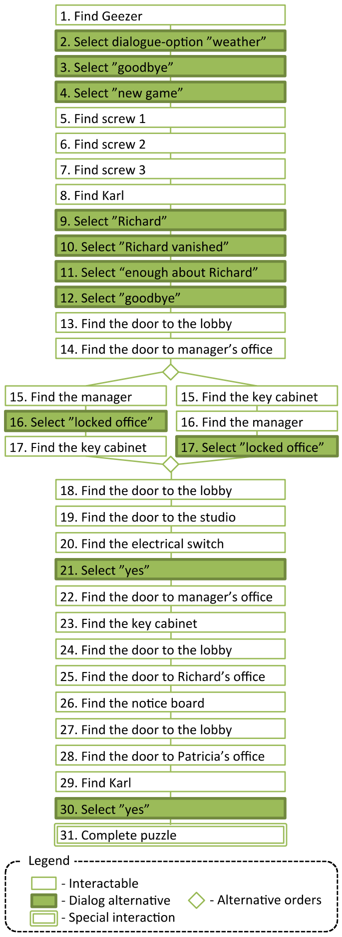

Figure 3. The objectives of the 31 steps in critical path for the test session

As shown in Figure 3, there are three different types of user actions in the critical path: activation of interactable ("Find…"), selection of dialog alternative ("Select…"), and special interaction. The only special interaction in the first chapter is an audio-based puzzle in the final step ("Complete puzzle").

4. THE STUDY

The game has been evaluated through formal user tests where subjects have been asked to play the first chapter of the game and then answer a questionnaire. In total, 29 subjects participated in the test, divided into three groups: sighted subjects playing with graphics (SG) and sighted subjects playing without graphics (SNG) both consisting of five men and five women each, and visually impaired subjects (VIG) consisting of five men and four women. The ages of subjects vary between 15 to 39 years of age (average age is 22.5). There is also a variation in subjects' previous experience of using games and previous experience of audio (playing and recording music). Of the visually impaired subjects the degree of impairment varied: some were blind from birth, some could distinguish light from dark and some could read the text on the screen.

The gaming device used during the tests was an iPod touch 5G, with a 4" touch display. The headphones were a pair of AKG 240 Studio. All responses from subjects were transcribed directly by the experiment leader. No audio or video recordings were made. As a compensation for participation all subjects were given a €15 iTunes gift card.

The progress subjects made in the game has been evaluated in terms of how far they reached in the *Critical Path* (see Figure 3). The players had a maximum of 25 minutes to complete the chapter. During the play session, the progress of the subject was monitored and if a subject spent three consecutive minutes without making any progress, the experiment leader provided some hints. The nature of the hints given depended on the type of obstacles a subject experienced. It could for example be related to the game logic (e.g. to search for items), the feedback system (e.g. to listen for interface sounds) or the subject actions (e.g. to make slower swipes on the touch screen).

Statistical analyses have been performed using SPSS version 22.

4.1 The Instrument Used

We have developed an adjusted version IEQ, which handles the weaknesses discussed earlier. It has also been adjusted to handle some of the problems discovered in a pilot testing. These problems relate to how the questionnaire is used and presented to subjects in a study including both visually impaired and sighted subjects. A pen and paper version of the questionnaire can obviously not be used. A computer-based version is an alternative, but requires a deep understanding of what type of tools all involved subjects use. Instead, we decided to use an oral version where the experiment leader read the questions and subjects respond orally. In this way the application of the instrument is identical to all groups. The pilot test however revealed that it was time consuming to read questions and labels for the endpoints of the scale. In addition, subjects expressed hesitation on the order of the scale and the labelling of endpoints. To avoid misunderstandings and to reduce the time to present the questions, we decided to have the same labelling for all questions. All questions starts with "to what extent did/were you..." and the subjects are instructed to answer with a number between 1 and 7 where 1 denotes "to a very low extent" and 7 denotes "to a very high extent".

The final instrument contains 18 questions, shown in Table 1, of which 14 are directly taken from the IEQ and 2 are adjustments for the specific type of game (Q12 & Q13). IEQ was created to have pairs of questions with the same content phrased twice - one time with a negative wording and one time with a positive wording (Jennett et al., 2008). The reason for this was to control the wording effect. For example, both "To what extent did you find the game challenging?" and "To what extent did you find the game easy?" are included in IEQ. In the adjusted version, used in this paper, we have reduced the number of questions by removing this kind of redundancy.

Two new questions have been added (Q15 & Q16) and they relate to how subjects appreciate the audio and the narrative. The question regarding graphics and imagery (Q14) is included in the questionnaire, but is only posed if a subject has experienced the graphics. The responses to Q4 and Q6 are negated when the immersion score is computed.

Table 1. The questions used in the immersion questionnaire. Q14 is posed if a subject has experienced graphics

Immersion question
Q1: To what extent did you feel you were focused on the game?
Q2: To what extent did you put an effort into playing the game?
Q3: To what extent did you feel you were trying your best?
Q4: To what extent did you notice events taking place around you?
Q5: To what extent did you find the game challenging?
Q6: To what extent did you feel that you just wanted to give up?
Q7: To what extent did you feel motivated while playing?
Q8: To what extent did you feel like you were making progress towards the end of the game?
Q9: To what extent did you feel emotionally attached to the game?
Q10: To what extent were you interested in seeing how the game's events would progress?
Q11: To what extent did you feel as though you were moving through the game according to your own will?
Q12: To what extent did you feel you were able to locate objects that were interactable?
Q13: To what extent did you feel you were able to re-locate objects that you had previously discovered?
Q14: To what extent did you enjoy the graphics and the imagery?
Q15: To what extent did you enjoy the audio and the music?
Q16: To what extent did you enjoy the narrative?
Q17: To what extent did you enjoy the game as a whole?
Q18: To what extent would you like to play the game again?

As discussed above, the immersion score in IEQ is computed as a sum. This makes the maximal score higher for sighted players as the question regarding graphic and imagery is excluded for players who have not seen the graphics. In this study, the immersion score is instead computed as the median of the answers. An alternative would be to compute the average, which is used in many other questionnaires (Weibel & Wissmath, 2011; Fu et al., 2009). The treatment of Likert scale data is however controversial. The debate (see e.g. Norman, 2010) relates to what type of statistical operations that may be applied to data that is of ordinal type. In this paper we have chosen to take a conservative approach and use statistical methods that are accepted and well established to be used with ordinal data.

4.2 Result

All 29 subjects completed the test. Of these, 16 finished the whole chapter. There were significant differences between the groups in terms of the progress they made in the game. Only 33% from the SNG finished the chapter, compared to 44% of the VIG subjects and 90% of the SG subjects. The median critical paths for the groups were 22 (SNG), 25 (VIG) and 31 (SG).

We see two potential effects that a difference in performance can have on the experienced immersion:

1. The audio-based interaction makes the task more frustrating to the player, in which case the immersion of the game could be negatively affected.
2. The audio-based interaction makes the task different but not frustrating, in which case the immersion could be affected in any direction

This section presents the results of the immersion questionnaire in order to conclude what effects the differences in progress had on the perceived immersion.

4.2.1 Immersion Score and Immersion Factors

The immersion score was computed as the median of the 18 questions (17 for players who did not see the graphics). Figure 4 shows the boxplots of the median immersions for the three groups.

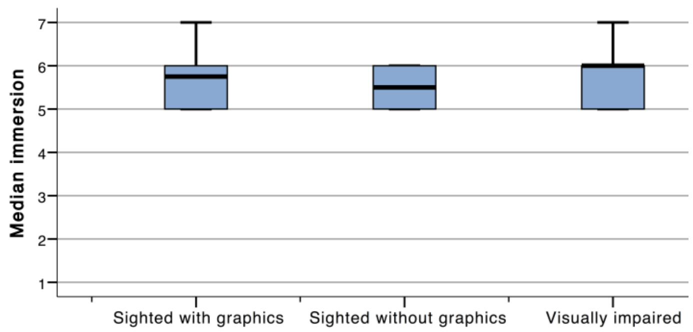

Figure 4. Boxplots of the immersion score of subjects in the groups: sighted with graphics (n=10), sighted without graphics (n=10) and visually impaired (n=9)

As can be seen in Figure 4, there are only small differences in immersion between the groups. The median score varies between 5.5 (for SNG), 5.75 (SG) to 6.0 (for VIG). The differences are not significant (p=.712 using a Kruskal-Wallis H test). Note that the lower and upper quartiles are the same for all groups. It is clear that the difference in progress has not had any obvious effect on the total immersion of subjects. Moreover, the immersion is quite high for all groups, which indicates that the game has been successful in providing an immersive experience to players. No subject had a median immersion below 5.

As suggested by Jennett et al. (2008), the immersion questions could be grouped according to five factors. Table 2 shows the immersion factors for all groups together with the result of a Kruskal-Wallis H test for each factor.

Table 2. Comparison of the immersion factors between the tree groups using a Kruskal-Wallis H test

Immersion factor	Sighted with graphics	Sighted without graphics	Visually impaired	$\chi^2(2)$	p
Cognitive involvement (questions 1, 2, 3, 5, 7, 8, 17)	5.5	5.5	5.0	.367	.832
Real world dissociation (question 4)	5.0	6.0	6.0	1.451	.484
Emotional involvement (questions 7, 9, 10, 17, 18)	5.5	5.0	6.0	1.379	.502
Challenge (question 5, 6)	5.0	5.5	5.5	1.325	.516
Control (question 8, 11, 12, 13, 14, 15, 16)	6.0	4.5	5.5	13.636	.001

The first four factors have small variations between the groups and there are no differences that are significant. There is a tendency that SNG and VIG have higher real world dissociation. This seems reasonable, as SG may be more aware of real world events through visual observations during gameplay.

For the last factor, *control*, there is a significant difference between the groups. This difference is in line with the progress of the groups where SNG made less progress than both VIG and SG. It is important to note, however, that the difference is isolated to the control factor and that there seems to be no negative effect on other factors. For example, on emotional involvement, SG has a median value, which is lower than that of VIG.

This result shows that differences in progress between the groups have made the immersion slightly different. The hypothesized effect that the slower progress would cause frustration that ruins the immersion cannot be observed.

4.2.2 Response to Individual Questions

Figure 5 shows the boxplots for each question for all subjects (n=29).

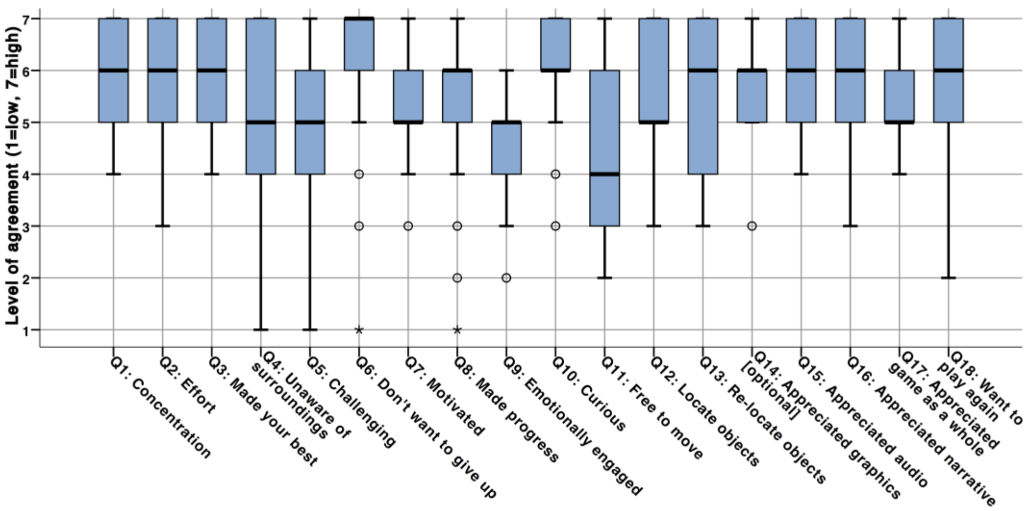

Figure 5. Boxplots for individual immersion questions for all subjects (n=29)

As can be seen in Figure 5, most questions have a median at 5 or above and the lower quartile at 4 or above. Only question 11, regarding the ability to move freely, has a lower quartile below 4. The boxplots in Figure 5, indicate that there is in general little variation in the responses to questions. The highest inter-quartile range is 3 and almost half of the questions have an inter-quartile range of 1. This low variation for the whole population does not imply that here are no differences between the groups. To explore potential differences between groups on individual questions, a Kruskal-Wallis H test was conducted. This revealed a significant difference between groups on question 8, 12, and 13. The biggest difference is on question 13, which relates to the ease of relocating objects that has been previously discovered. The Kruskal-Wallis H test showed that $\chi^2(2) = 17.951$, $p < .001$, with a mean rank score of 22.50 for sighted players with graphics, 7.00 for sighted players without graphics and 15.56 for visually impaired players. The other two questions with significant differences, question 8 (p=.002) and question 12 (p=.020), relate to the progress and the ease of locating new objects in the game. The boxplots of the three questions for the three groups are shown in Figure 6.

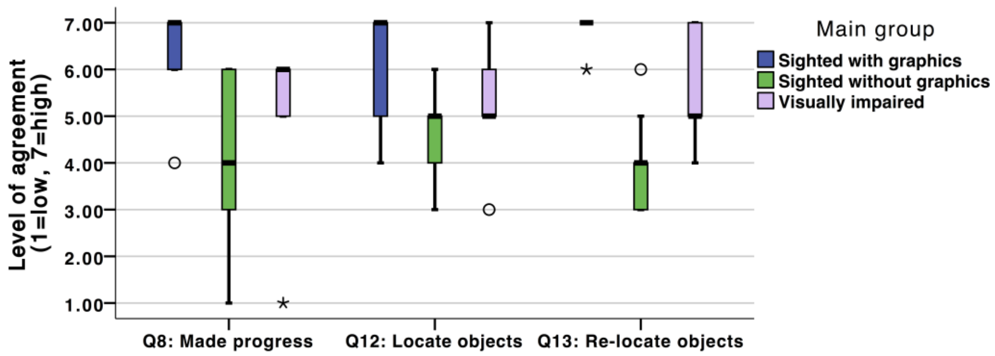

Figure 6. Boxplots of the three questions where there were significant differences between the groups

Note that all three questions are included in the *control* factor discussed above for which there were significant differences between the groups. Figure 6 confirms the observation that it is mainly subjects from SNG that experience problems with locating objects and progressing in the game. This is in line with observations made in several previous studies (Ekman, 2007; Oren, 2007). Sighted players are in general not used to rely solely on listening and there is a substantial barrier to cross for them to be able to enjoy audio-based games.

Although this game is not intended to be played as an audio-only game by sighted players, it appears that they still appreciated the experience. The cognitive and emotional involvement does not differ from the other groups.

4.2.3 Factor Analysis

The ability to experience the graphics of the game is not the only factor that may affect immersion. Other factors, such as age and previous experience of gaming may also have an impact. We have conducted a factor analysis to explore the impact of age, gender, gaming and audio experience have on immersion. Figure 7 shows the boxplots of the immersion of all subjects (n=29) for these four factors.

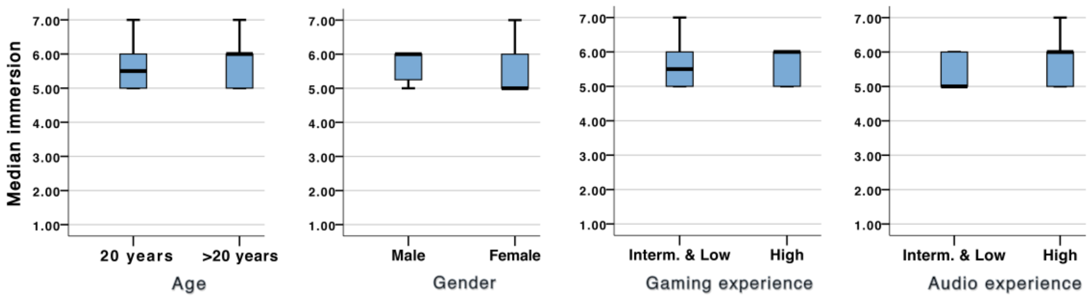

Figure 7. The immersion of subjects (n=29) factored on age, gender, gaming experience and audio experience

The upper quartile is 6.0 for all groups and the lower quartile is 5.0 for all groups except male subjects where it is 5.25. This suggests that there are no major differences between groups in any of the categories. The median differs the most between males (median=6.0, n=15) and females (median=5.0, n=14) and between subjects with high experience of audio (median=6.0, n=16) and those with intermediate or low audio experience (median=5.0, n=13). None of these differences are however significant.

The comparisons shown in Figure 7 are made for the whole population. A deepened analysis has been conducted to explore if there are differences in the three main groups (SG, SNG, VIG) with respect to these factors. This analysis reveals that only the audio experience factor has a trend that is consistent in all groups - subjects with high experience of audio have a higher median immersion. For the other factors, there are differences in trends between groups. The most consistent pattern is for SG and SNG, which have reversed trends for all factors. As an example, Figure 8 shows the immersion of female and male subjects for the main groups. The immersion of female subjects is higher (median=6.0, n=5) than that of male subjects (median=5.5, n=5) in SG. Among SNG the trend is reversed and female subjects have a lower immersion (median=5.0, n=5) compared to male players (median=6.0, n=5).

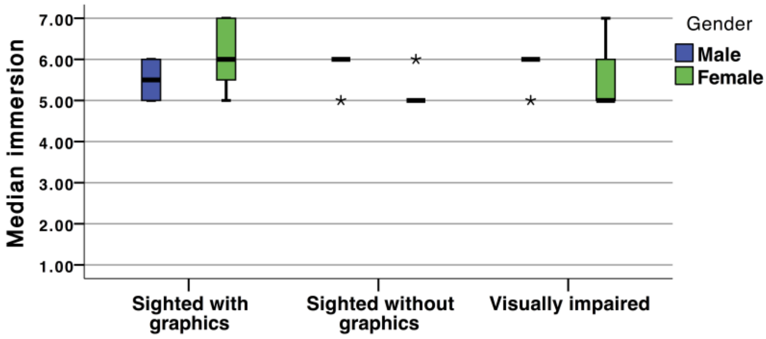

Figure 8. The immersion of female (green/right) and male subjects (blue/left) in the groups: sighted with graphics (n=10), sighted without graphics (n=10) and visually impaired (n=9)

The same pattern is visible for the age and game experience. Subjects above 20 in SG have a higher median immersion (median=6.0, n=7) than younger subjects (median=5.0, n=3). Younger subjects, on the other hand, have higher immersion in SNG (median=6.0, n=5) than older subjects (median=5.0, n=5) in the same group. In the same way, subjects with high gaming experience have a lower median immersion (median=5.0, n=6) in SG than those with intermediate or low gaming experience (median=6.5, n=4). In SNG, experienced gamers have higher immersion (median=6.0, n=6) than inexperienced (median=5.0, n=4).

The most notable difference between SNG and SG with respect to factors is that of gender. As can be seen in Figure 8, all except one female subject in SNG have a lower immersion than the median immersion of the female subjects in SG. It should be noted that the sub-group size is small (n=5) so it is difficult to draw any definitive conclusions from these observations. In addition, it should be noted that the gaming experience factor has a very unbalanced distribution of female and male subjects. Only 3 out of 16 subjects with high gaming experience are females and only 2 out of 13 subjects with intermediate or low gaming experience are male. This makes it impossible to distinguish if observed differences relates to gender or gaming experience. There are potential explanation models that support both. SNG is exposed to navigation without visual landmarks and there are studies on gender differences in spatial orientation (see Coluccio & Louse (2004) for an overview), which may explain the observed differences. The gaming experience, on the other hand, may affect the experienced difficulty level and the novelty of the experience. This *novelty factor* may play a role for both experienced and inexperienced players. For example, the joy of solving puzzle elements for the first time may explain the high immersion of subjects with intermediate or low gaming experience in SG. Subjects with high gaming experience will most likely have solved puzzles similar to the ones in the studied game and will hence not experience the same joy. Experienced gamers may on the other hand find the audio-only interaction novel and challenging, which may increase their immersion. This observation is also in line with the theory of flow proposed by Csikszentmihalyi (1990) and his concept of the flow channel, which describes the relationship between one's skill and the challenge one face. An activity becomes boring when the challenge is too easy and frustrating when it is too difficult. When the challenge instead matches one's skills it is possible to enter a state of flow, "the optimal experience".

A conclusion of the factor analysis is that there are indications that factors, such as age, gender, previous experience of gaming and audio, may impact on immersion but none of the observed differences are significant. Further studies are needed to analyse how these factors impact immersion and performance.

5. CONCLUSION

This paper presents a study where the same mobile game has been played by subjects with very different prerequisites – ranging from experienced gamers playing it as a regular game with graphics, to subjects with very limited previous gaming experience who played it blindfolded with audio as the only feedback mechanism. The aim with the game is to enable visually impaired and sighted players to have a shared experience. In the study, three different groups were compared with respect to the progress they made in the game and their level of immersion when playing the game. The three groups were sighted playing with graphics, sighted playing without graphics and visually impaired. All groups were mixed with respect to gender, age and previous experience of games and audio. The instrument used to observe immersion was a version of the Immersive Experience Questionnaire (Jennett et al., 2008) adjusted to be used for audio-based games and visually impaired subjects. The result shows that although there was a difference in progress between the groups, it had limited effect on the immersion. The only factor that showed a significant difference between the groups was *control*, i.e. how subjects perceived that they could control and interact with the game. The interaction with the game, when it is played using graphics, is very close to the conventions of its genre – point-and-click adventure games. The interaction with the game, when it is played using only audio, is novel and utilises diegetic auditory icons where left to right panning and volume is used to help players locate objects. Naturally, it takes longer time to locate interactable objects on the screen using audio only, but the result from this study indicates that it does not generate frustration that affects the overall immersion. This is an important result as it shows that it is possible to create games that are inclusive - sighted and visually impaired players are able to, and enjoy playing the very same game. And importantly, the visually impaired are able to play without the aid of external tools or complex mechanisms that may interfere with the gaming experience. It would be interesting to explore the potential of extending the audio-interaction by introducing binaural sound feedback (Rumsey &

McCormick, 2009), which may provide new opportunities and may improve the precision in the navigation.

In the presented study, a group of blindfolded sighted players were included as a control group. The results indicate that this group had the lowest score on almost all observed immersion values. This is also the group that reached shortest in the critical path, thus made the least progress in the game. This indication may be useful in a game development process. As visually impaired are in minority, they are generally harder to recruit. In testing, it is often important to use first time testers. If the same person is repeatedly used in the testing of, for example, a new interface that person may learn to use it through the tests. The experience for a first time user may be quite different. With a limited amount of visually impaired testers, it becomes crucial to use them in the right phase of development. Blindfolded sighted players can be used in early stages to identify fundamental design flaws. If blindfolded players are able to use the game, it is likely that visually impaired players will also be able to use it. This approach will increase the probability that tests on visually impaired subjects will give more valuable results, focusing on their immersion rather than on fundamental interaction problems. It should be emphasized that results from blindfolded sighted players cannot be equalized with those from visually impaired. There is strong evidence that visually impaired persons can develop compensating abilities (see eg. Fieger et al., 2006) and this may affect the user experience.

No significant differences with respect to background parameters, such as age, could be found in the presented study with regards to immersion. However, there are some indications that there are differences in performance depending on previous gaming experience and gender, but the number of participants in each main group is too small to be able to make a meaningful comparison of subgroups. We are currently exploring some of these aspects in a study that focuses on an isolated part of the audio-based navigation used in the game presented in this paper.

ACKNOWLEDGEMENT

This project has been co-funded by The Swedish Post and Telecom Authority and the University of Skövde.

REFERENCES

The Accessibility Foundation, 2015, *Gaming with a Visual Disability.* Available online: http://www.game-accessibility.com/index.php?pagefile=visual [last accessed May 8, 2015]

Adams E., 2014. *Fundamentals of Game Design.* Pearson Education, New York, NY, USA.

Agarwal, R. and Karahanna, E., 2000, Time Flies when You're Having Fun: Cognitive Absorption and Beliefs About Information Technology Usage. *MIS quarterly*, Vol. 24, No. 4, pp 665-694.

Barlet, M.C. and Spohn, S.D., 2012. *Includification.* The Able Gamers Foundation, ISBN-13: 978-1479289356.

Brockmyer, J.H., et al., 2009. The Development of the Game Engagement Questionnaire: A Measure of Engagement in Video Game-playing. *Journal of Experimental Social Psychology*, Vol. 45, No. 4, pp 624-634.

Brown, E. and Cairns, P., 2004. A Grounded Investigation of Game Immersion. *CHI'04 Extended Abstracts on Human Factors in Computing Systems*, ACM, New York, NY, USA, pp 1297-1300.

Cairns, P. et al., 2014. Immersion in digital games: a review of gaming experience research. *Handbook of digital games (eds Angelides, M.C. & Agius, H).* John Wiley & Sons, Hoboken, NJ, USA, pp 337-361.

Calvillo-Gámez, E.H. et al., 2010. Assessing the Core Elements of the Gaming Experience. In R. Bernhaupt, ed., *Evaluating User Experience in Games*. Springer, London, UK, pp 47-71.

Chen, J.. 2007. Flow in games (and everything else). *Communications of the ACM,* Vol. 50. No. 4. pp 31-34.

Coluccia, E., & Louse, G. 2004. Gender differences in spatial orientation: A review. *Journal of Environmental Psychology* , Vol. 24, No. 3, pp 329-340.

Csikszentmihalyi, M., 1990. Flow: The Psychology of Optimal Experience. Harper Perennial. London, UK.

Ekman, I., 2007. Sound-based Gaming for Sighted Audiences – Experiences from a Mobile Multiplayer Location Aware Game. *Proceedings of the 2nd Audio Mostly Conference*, pp 148-153.

Encelle, B. et al., 2011. Annotation-based Video Enrichment for Blind People: A Pilot Study on the Use of Earcons and Speech Synthesis. *The proceedings of the 13th international ACM SIGACCESS conference on Computers and accessibility*. ACM, New York, NY, USA, pp 123-130.

Engeser, S., and Schiepe-Tiska, 2012. A. Historical lines and an overview of current research on flow. *Advances in flow research*. Springer, New York, NY, USA, pp 1-22.

Fieger, A. et al. 2006. Auditory Spatial Tuning in Late-onset Blindness in Humans. *Journal of Cognitive Neuroscience*, Vol. *18, No.* 2, pp 149-157.

Fu, F-L. et al., 2009. EGameFlow: A Scale to Measure Learners' Enjoyment of E-learning Games. *Computers & Education*, Vol. 52, No. 1, pp 101-112.

Huiberts, S., 2010. *Captivating Sound: The Role of Audio for Immersion in Computer Games*. PhD Dissertation, Utrecht School of the Arts, Netherlands.

Jennett, C. et al., 2008. Measuring and Defining the Experience of Immersion in Games. *International Journal of Human-Computer Studies*, Vol. 66, No. 9, pp 641-661.

Jennett, C., 2010. *Is Game Immersion Just Another form of Selective Attention? An Empirical Investigation of Real World Dissociation in Computer Game Immersion*. Doctoral Thesis, University College London.

Kalawski, R.S. 2000. The Validity of Presence as a Reliable Human Performance Metric in Immersive Environments. *In proceedings of the Presence Workshop'00*.

LucasFilm Games, 1990. The *Secret of Monkey Island*. Computer game.

Nordin, A. et al., 2014. Too Many Questionnaires: Measuring Player Experience Whilst Playing Digital Games. *Seventh York Doctoral Symposium on Computer Science & Electronics.*

Norman, G., 2010. Likert Scales, Levels of Measurement and the "Laws" of Statistics. *Advances in Health Sciences Education,* Vol. 15, No. 5, pp 625-632.

Oren, M.A., 2007. Speed Sonic Across the Span: Building a Platform Audio Game. *CHI'07 Extended Abstracts on Human Factors in Computing Systems*, ACM, New York, NY, USA, pp 2231-2236.

Qin, H. et al., 2009. Measuring Player Immersion in the Computer Game Narrative. *Intl. Journal of Human–Computer Interaction,* Vol. 25, No. 2, pp 107-133.

Rumsey, F. and McCormick, T., 2009. *Sound and Recording: an Introduction*. Focal Press, Oxford, UK.

Skip Ltd., 2006. *bit Generations Soundvoyager.* Game Boy Advance game.

Slater, M. 1999. Measuring presence: A response to the Witmer and Singer presence questionnaire. *Presence: Teleoperators and Virtual Environments*, Vol. 8, No. 5, pp 560-565.

Somethin' Else, 2011. *Papa Sangre*. Mobile game.

Somethin' Else, 2013. *Papa Sangre II*. Mobile game.

Sweetser, P., and Wyeth, P. 2005. GameFlow: a model for evaluating player enjoyment in games. ACM *Computers in Entertainment*. Vol. 3, No. 3, pp 1-24.

Weibel, D. and Wissmath, B., 2011. Immersion in Computer Games: The Role of Spatial Presence and Flow. *International Journal of Computer Games Technology,* Vol. 2011, pp 1-14.

Westin, T., 2004. Game Accessibility Case Study: Terraformers – a Real-Time 3D Graphic Game. *Proceedings of the 5th International Conference on Disability, Virtual Reality and Associated Technologies, Oxford, UK, pp 95-100.*

Witmer, B.G. and Singer M.J., 1998. Measuring Presence in Virtual Environments: A Presence Questionnaire. *Presence: Teleoperators and Virtual Environments,* Vol. 7, No. 3, pp 225-240.