INVESTIGATING THE EFFECTS OF ACCESSIBILITY
A study on the influence of accessibility features for hearing-impaired players on the perceptions and immersion of non-disabled players

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Viktor Zryd

Supervisor: Mikael Johannesson
Examiner: Per Backlund
Abstract
Playing and enjoying games might seem like a simple task to most people even though many games rely heavily on sensory, cognitive and motoric ability. To create games that are accessible and inclusive to a wide range of audiences, it is important that design choices are considered carefully. This thesis aims to provide an investigation into closed captioning and enhanced speech bubbles. The goal is to clarify and to compare what effects these features have on the perception of situational and affective information and how they affect the immersion of non-disabled players. Two experiments were performed with a total of 38 participants at the University of Skövde. Each experiment investigated a separate accessibility feature and evaluated their influence on the gameplay experience. By performing two experiments, it was possible to identify the strengths and weaknesses of both features in comparison to each other. The results show that closed captions can have a negative effect on the immersion of the player and that enhanced speech bubbles increase immersion and provide additional affective information to the player.

Keywords: accessibility, inclusive games, hearing impairment, immersion, closed captions, speech bubbles
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1 Introduction

Playing digital games has become one of the most common forms of entertainment and games are something that many of us take for granted and see not only as a form of entertainment but also a way of socializing, learning new skills or escaping to another world where you can be the ruler of the galaxy. This cultural expression is however not always accessible to all people. Interaction with many games can be hindered by sensory impairments, motor impairments and cognitive disabilities (Heron, 2012, p. 30).

Even if a game is made accessible through existing accessibility features that does not always mean that the game becomes inclusive. Inclusive games build on the idea that there are ways to make games equally enjoyable for people who might have very differing backgrounds or conditions, as long as they are considered in every step of the game development process (Östblad, Engström, Brusk, Backlund & Wilhelmsson, 2014, p. 2).

Accessibility features can be used in many different ways and in some instances accessibility is associated with increased enjoyment for everyone, as in the case with colour-coded text or remappable keys (Barlet & Spohn, 2012). However, there is very little research on the influence of accessibility features on the gameplay experiences of non-disabled players and therefore it is difficult to state that an inclusive game is being developed unless the developers can make sure that they are making informed inclusive design considerations.

This thesis will look into this problem by performing two separate experiments focusing on two different accessibility features. The first experiment will focus on the usage of closed captions in a first-person puzzle game, an accessibility feature that is considered an industry standard in modern movies but is very rarely used even in high-budget games. The second experiment will focus on the usage of enhanced speech bubbles in a point-and-click adventure game being developed on the premise of being inclusive to visually impaired, hearing impaired and non-disabled players.

The goal is to create an understanding for how different accessibility features influence the immersion of non-disabled players and on how well those specific features can convey situational and affective information, two types of information that can be essential to the enjoyment of gameplay experience. By performing two experiments, it should be possible to compare the strengths and weaknesses of each accessibility feature.
2 Background

Digital games are one of the leading forms of entertainment media but they are not equally accessible to all people. Games are often more physically and cognitively demanding than traditional media due to their interactive nature, this can cause an issue for people with disabilities (Heron, 2012, p. 30). Cognitive disabilities can make the fast processing of information that games often require incredibly challenging, graphical and auditory interfaces can render a game completely unplayable by people with sensory impairments and the physical input that is often required by games can make it hard, sometimes impossible, for people with mobility impairments to enjoy a game.

This thesis is written under the assumption that accessible games (2.1) and inclusive games (2.2) are two separate approaches to creating games, as stated by Östblad, Engström, Brusk, Backlund & Wilhelmsson (2014, p. 2). Accessible games are games that include features that make them functionally playable by people with certain physical or cognitive disabilities, whether they were part of the original design or added through adaptation of the finished product. Inclusive games are rather games that are designed with the group to be included in consideration throughout the entire development process. This might seem like a minor detail, but it is important to distinguish the two terms, which are not mutually exclusive, since they are both essential to understanding the research.

2.1 Accessible games

Since games are one of the largest parts of the entertainment industry, the lack of accessibility to many games means that a lot of entertainment, information and educational material is inaccessible to large population of people (Grammenos, Savidis, & Stephanidis, 2009). Due to the large cultural importance that digital games hold, it could even be argued that the lack of access to digital games means that some people are excluded from an entire form of active participation in society. (Heron, 2012; Archambault, Ossmann, Gaudy & Klaus, 2007).

2.1.1 Viability

One of the reasons cited for a lack of accessible games is that it is not feasible from a business standpoint, that the added development costs of the features needed to make a game accessible is not proportionate to the size of the market of disabled gamers. However, by some estimations (Robinson & Walker, 2010; Barlet & Spohn, 2012) disabled gamers make up over 32.5 million potential customers in the United States alone, which is a substantial market.

Software developed with features that make it accessible to people with disabilities is also advantageous in developing a good product for all users. The design solutions used to make a product more accessible can also lead to a more efficient overall design (Newell & Gregor, 1997) and when implemented correctly, such solutions should not lead to the exclusion of other users (Keates & Clarkson, 2002). This is of benefit from a business standpoint as developers are constantly aiming to release better products.

An example of such a feature is remappable keys and alternative configurations. In many games, the player controls some kind of avatar that moves throughout the game world in either two or three dimensions. That movement is generally controlled through some kind of physical input such as a joystick, gamepad or mouse and keyboard. The complexity of the physical input required can be an obstacle to playing and enjoying the game for players with physically
disabled players. To combat this the developer could implement support for letting the player assign the different functions of the game to different keys on their control peripheral. This allows the player to adapt the control scheme to their needs. Remappable keys is one example of the many features that can be implement to not only create a more accessible game, but a game that is more enjoyable for all players (Barlet & Spohn, 2012).

2.1.2 Challenges
Designing accessible software is not without challenges. When designing games, the end user and their requirements must always be considered but many developers tend to use themselves or people close to them as a reference for those requirements (Heron, 2012). This is a problem in the development of any game, accessible or not, since it could lead to misinformed decisions in the design process. To be able to overcome the challenges that are particular to consumers with disabilities, they must of course first be identified.

There are mainly four areas that must be addressed in designing an accessible game; mobility, visual information, auditory information and cognitive processes. There are resources available with guidelines for designing products that are accessible to consumers for whom one or more of these areas can cause a problem. Many organisations and researchers are actively working with making these guidelines and requirements available to the development community, to the benefit of all developers, researchers and users (Barlet & Spohn, 2012; Vickers, Istance, & Heron, 2013).

2.2 Inclusive games
As previously stated, an accessible game is not by default inclusive (Östblad et al., 2014). Even if accessibility features such as closed captioning or remappable keys are implemented it does not mean that the gaming experience can be enjoyed to same extent as it can for a seeing player if the game was originally designed with only seeing players as the target audience. Accessibility features are put in place to make a game functional for disabled players, but that does not necessarily mean that the games are enjoyable for those players.

Inclusive game design is the process of considering the group to be included in every step in the development process, from idea to distribution (Östblad et al., 2014). When this group of people is part of the original design, the game can present an experience that is enjoyable to the same level for the intended audience as a mainstream game would be for an average user.

In discussing accessibility features the focus often lies on physically and cognitively disabled players and what their needs are. Inclusive game design is rather the idea of including a certain group of people into the development process. This group doesn’t need to be defined by a certain disability, it could be any group that is an underrepresented audience for mainstream games.

2.3 Hearing impaired players
Mainstream games are generally accessible to deaf players as most of the information that is vital to gameplay is conveyed graphically (Friberg & Gärdenfors, 2004) but situational and affective information is in many cases conveyed through sound (Ekman, 2005; Ekman, 2008). There are accessibility features that can be implemented to combat this lack of situational and
affective information, if such accessibility features are not used, the experience of playing the game could be considerably lessened.

2.3.1 Accessibility features

*Closed captions* are an accessibility feature that is commonplace in modern movies and is becoming more common in digital games (Heron, 2012). It is important to distinguish closed captions from subtitles. There is some division regarding what the difference between subtitles and closed captions are but this paper will adhere to the definition as established by Barlet & Spohn (2012). Subtitles are used to display what characters are saying and closed captions are used to describe the audio cues that are present in the game, sometimes also including dialogue. The most common usage for closed captions in games is to describe specific audio cues such as the sound of a gun firing but it can also be used to describe ambient sounds, which allows a hearing-impaired player to more easily understand the mood of a specific setting (Barlet & Spohn, 2012). Closed captions are yet another example of an accessibility feature that can be useful for non-disabled gamers as it increases the possibility of enjoying the game in settings or conditions that do not afford audio as a possible output method.

Allowing the player to change the font, size and colour of text in the game allows a more accessible experience as a hearing-impaired player may have to spend more time reading than non-disabled users. Differences in font and colour can assist in quickly informing the player of the source and meaning of specific text outputs (Barlet & Spohn, 2012). This is commonly used in MMORPGs such as *World of Warcraft* (Blizzard Entertainment, 2004) in which the colour of the text is an indication as to where the text originates (figure 1). For example, the colour of messages from other players are different from dialogue spoken by non-playable characters or messages written in other chat channels. This feature creates a better experience not only for hearing impaired players, but also for visually impaired and non-disabled players.

![Figure 1](image)

**Figure 1** Colour-coding in World of Warcraft (Blizzard Entertainment, 2004)

*Alternative Reactionary Input or subliminal cues* refer to when another form of sensory input, such as visual or vibrotactile feedback, is used to replicate the role that audio usually has in communicating an important aspect of the game state (Barlet & Spohn, 2012). First-person
shooter games may make use of a visual effect such as blood covering the screen to indicate that the player character is low on health or a flashing crosshair to indicate that the player has hit their opponent. Fighting games can make use of vibration through a controller to emphasize when a blow has been dealt to the player character. To a hearing-impaired player these kinds of cues can be essential to the experience and to non-disabled players they can also be beneficial in increasing the immersion and enjoyment of the game.

These features can allow hearing impaired players to functionally play a game that otherwise may be very hard or impossible to play. However, it is not obvious if these solutions actually solve the problems that are presented when there is a lack of auditory feedback.

### 2.3.2 Situational information

One role of game audio is to provide the player with information regarding the game state. This may include information about the environment (ambient sounds), the physical state of the player character or the state of other characters and objects. For the purpose of this thesis, we will define this type of information as situational information. When the auditory element of games is excluded, this type of information needs to be replaced by other means.

Closed captioning is a tool that can be used to provide such information. We can see examples of this in games like *Portal 2* (Valve Corporation, 2011) in which closed captioning is, among other things, used to graphically represent changes in the environment that are otherwise only conveyed through sound (figure 2), changes that occur in areas of the game that are obscured from the vision of the player.

![Figure 2] Closed captions in Portal 2 (Valve Corporation, 2011)

Another example of providing situational information through closed captioning is the representation of ambient sounds through text is *Half-Life 2* (Valve Corporation, 2004), a game in which colour-coded closed captions describe environmental sounds around the player character (figure 3).
The voice of different characters being represented through text of different colours is another example of conveying situational information to the player (Mangiron, 2013), in this case situational information of which character is speaking. When playing a game with audio, the voices of the characters are distinctly different and this can be represented through the use of colour. Alternative Reactionary Input could also be used to convey situational information, more specifically they are well suited to describe very sudden events that require immediate attention such as the health of the player character or the direction of damage dealt to the player.

2.3.3 Affective information

Sound is often used to convey affective information (Gottlieb, 2007, pp. 336-337; Ekman, 2008). This may be done through the use of ambience sounds that set a mood for a scene, music which is a clear example of sound that induces emotion and other sound effects that fall under the category of “affect” according to the commonly referred IEZA-categorization (van Tol & Huiberts, 2008). In designing games for hearing impaired players, other solutions must be utilized to convey emotion.

Conveying affective information is another area of use for closed captions and colour-coded text. Closed captions can be used to describe the way which a character is saying something which can contain affective information since the way a character speaks is often a clue as to the emotions of the character or the mood of the scene (Lee, Fels, & Udo, 2007, p. 3). For example, if a character speaks in a raised voice that could be a hint that the character is expressing anger. If such a detail is not translated graphically, a hearing-impaired player might be excluded from receiving this affective information.

Alternative forms of subtitling such as using enhanced speech bubbles as commonly used in comic books can be used to convey affective information (Mangiron, 2013, p. 45; Silverman & Fels, 2002, p. 293; Fels, Polano, Harvey, & Silverman, 2001). Beyond the use of generic speech bubbles, the use of different colours, styles and animations of such speech bubbles may be able
to express emotions. A problem with such graphical presentations is that they can become a subject of misinterpretation. To interpret the meaning of certain styles of speech bubbles, the player may have to be familiar with how they are used based on previous experience. Furthermore, only a small amount of scientifically published research has been done on using enhanced speech bubbles to convey emotion in games.

Animated facial expressions of character can also be used to convey information regarding the mood of a certain character (Lee et al., 2007, p. 2). Much care must be taken when implementing such animations as animations that are not interpreted in the way that they were designed to be interpreted may give the player the wrong kind of affective information and break the suspension of disbelief (Sato & Yoshikawa, 2004, pp. 707-708).

An aesthetic expression that is used to express emotion in most games and movies is music. Music could be considered a universal language that most people are able to understand. It is a medium often used to set the mood of a certain scene or event (Chion, 1994, pp. 8-9; Juslin & Laukka, 2003, p. 777), it is a very versatile instrument that is impossible to make use of for hearing impaired players. Music is sometimes conveyed through closed captions but in a very limited form (Harkins, Korres, Singer, & Virvan, 1995). It is worth mentioning that there are also other methods for visually conveying the affective information of music (Mori & Fels, 2009; Fourney & Fels, 2009) but further elaboration is not relevant to the focus of this research.

2.4 Immersion

The definition of the word immersion is somewhat unclear as gamers tend to use it in many different ways (Jennett, et al., 2008) but it is most often used to describe the degree of involvement of which a player has in a game. The term could also be used to describe the experience which a user has with other software but its main use is for gaming and virtual reality. Brown & Cairns (2004) performed an investigation of the term based on interviews with gamers and established three levels of immersion – engagement, engrossment and total immersion. Reaching these levels is a matter of removing obstacles, some which are based in human activity and some which are based in the construction of the game.

2.4.1 Levels of immersion

Engagement, which is the first level of immersion requires the player to dedicate time, effort and attention and so the human activity required to reach this level is a combination of concentration and preference. To become engaged in a game, it also needs to be a game that matches the preferences of the player. There are two major factors in regards to game structure that are important to allowing engagement – controls and reward system. The player must be able to master the controls and there must be some rewards for investing time and effort in the game. Engagement in a game means that the player becomes interested in the game and is willing to continue playing, however it does not mean that the player is experiencing an emotional attachment to the game (Brown & Cairns, 2004).

The next level of immersion is engrossment, a state in which the emotions of the player are directly affected by the game. Inducing engrossment is mainly a matter of the structure of the game. The quality of the aesthetics, tasks and story of the game are some of the main factors that afford this state. One requirement to establishing the state of engrossment is that the player is already engaged in the game, which causes a high level of emotional investment. In
the state of engrossment, the player becomes less aware of themselves and their surroundings (Brown & Cairns, 2004).

When the player reaches a state within which they are no longer thinking about the fact that they are playing a game and instead the game is the only thing that matters, they have reached the state which Brown & Cairns (2004) define as total immersion. An obstacle to reaching this state is the experience of presence (2.5.3) which will be discussed later. To allow the player to enter a state of total immersion the developers must make sure that the game not only makes use of visuals, plot and sound to induce emotion in the player, but also that the features of the game are relevant to the actions and locations of the characters (Brown & Cairns, 2004).

Through their research Brown & Cairns (2004) come to the conclusion that attention is key to the sense of immersion and that the three key elements of attention are visual, auditory and mental. They also conclude that attention is closely linked to the concept of flow which is another term often used to describe engaging experiences.

### 2.4.2 Flow

The term flow is often used in a very similar fashion to the term immersion but in the context of a wider array of activities. Flow is also a state in which a person becomes so highly absorbed or engaged in an activity that other thoughts and impressions are blocked out. Flow is by Csikszentmihalyi (1990, p. 71) described as an optimal state in which the skills of a person are adequate to cope with the challenges that are presented to them in a goal-directed manner that gives direct feedback performance. According to Csikszentmihalyi (1990, p. 49) there are eight elements that combine to create the experience of flow: there is a chance of completing the task, the ability to concentrate on the task, clear goals, immediate feedback, acting effortlessly in a way that screens out the worries and frustrations of life, an enjoyable experience that can be controlled, a lack of concern for the self and a sensation in which the person loses track of time. If we look at these components and compare them to the barriers to different levels of immersion (Brown & Cairns, 2004), it becomes clear that flow and immersion are in many ways similar. The main difference between them is that flow, according to Csikszentmihalyi (1990), truly is an optimal experience and therefore an extreme experience whereas immersion can occur on several different levels where the most common levels seem to be engagement and engrossment.

### 2.4.3 Presence

Another concept of engagement with a certain activity is presence, a term used to describe the experience of “being there” (IJsselsteijn, de Ridder, Freeman, & Avons, 2000), often within the context of virtual reality. Presence is optimally measured through both subjective, the self-reported experience of the person, and objective, the physical state of the person, measurements of presence (Zahorik & Jenison, 1998, pp. 81-82; IJsselsteijn et al., 2000). The field of research that focuses on the subject of presence is vast and therefore a short summary in which we focus on the relation between presence and games will be provided.

Jennett, et al. (2008, p. 643) argue that “presence is only a small part of the gaming experience: whereas presence is often viewed as a state of mind, we argue that immersion is an experience in time”. An immersive experience can occur without a sensation of presence and an experience of presence in a game can occur without a sensation of immersion (Jennett, et al., 2008, p. 643). Here we see a clear division in certain aspects of the field as Brown & Cairns (2004, p. 1299) argue that a sensation of presence is a requirement to achieving a state
of total immersion. These divisions are a glimpse into the vastness and controversy of the field. Nonetheless, the sensation of being present in a game is worth mentioning when discussing the subject of immersion.

2.4.4 Measurements
There have been several attempts at measuring immersion in a way that would fit most games as immersion is considered a widely applicable to describe many types of gaming experiences. In many cases, the method for studying immersion has been developed for a specific research project. Examples of this includes the Game Engagement Questionnaire (Brockmyer, et al., 2009) which was developed to measure the impact of violent video games on player behaviour or a questionnaire developed to measure player immersion in the narrative of a computer game (Qin, Rau, & Salvendy, 2009).

The Immersive Experience Questionnaire (IEQ) is a commonly used method for measuring immersion that was created by Jennet et al. (2008). The questionnaire was tested in different experiments and has been modified accordingly (Jennett, 2010, pp. 222-224). The questionnaire uses 31 questions that are answered through Likert scales. This allows for the calculation of an immersion score through summarization of the 31 questions. The questionnaire also allows for scores to be calculated according to five different factors: cognitive involvement, real world dissociation, emotional involvement, challenge and control.

A common problem with these different questionnaires is that they do not accommodate for games that are designed for players with sensory disabilities. For example, the IEQ in its original form may not be fitting for audio games (2.3.1) or tactile games (2.3.2) since some questions are focused on the visual presentation of the game. Due to this problem, studies on such games using the IEQ may have to use a modified version of the questionnaire in combination with some other form of measurement. This problem is not only relevant in the study of games designed for players with sensory impairment, the questionnaire may also require modification if the IEQ is not well-suited to the type of game that is being studied.

2.5 Previous research at University of Skövde
The research presented in this thesis builds on previous research performed at the University of Skövde regarding accessibility and inclusive game design. There have been efforts made at the university to not only educate about inclusive game design, but also to perform inclusive game development, creating games that do not exclude certain audiences because of gameplay mechanics or narratives that are not inclusive from the very start of the development process.

To be more specific, the research in this thesis builds upon the work of developing a game that allows sighted and visually impaired players to play the same game and find enjoyment in it without playing different versions of the game. A number of articles (Östblad et al., 2014; Wilhelmsson, Engström, Brusk, & Östblad, 2015; Engström, Brusk, & Östblad, 2015) have been published regarding this work and it is mostly focused on building a specific type of game that uses an interaction model that is accessible to both visually impaired and sighted players.

In this type of game, the player interacts with the environment, objects and different characters through the use of a touch screen and spatialized audio. By moving their finger across the screen, the player can locate different objects not only by seeing them, as in a traditional point-and-click game, but also by listening to them. Dialogue selections are also performed by holding down a finger on the screen and listening to what the characters say.
This allows a visually impaired player to play the game using only sound while still allowing a sighted player to play either with or without graphical elements. An example of a game that uses this interaction model is the commercially released game *Frekvens Saknad* (University of Skövde, 2015).

This thesis is part of a continuing effort to develop this type of game further to the point where it also inclusive to hearing impaired players. Since the game relies heavily but not exclusively on the usage of voices and sounds, it is important to study different implementations of accessibility features for hearing impaired players to identify how situational and affective information can be conveyed in a way that creates an experience that is inclusive to hearing-impaired players while not lessening the experience for non-disabled players.
3 Problem

Accessibility features are often described as a way of including disabled players into the experience of playing a computer game. However, there is a lack of research on how well such features perform that role. More specifically there is a lack of research on how well accessibility features work to convey the information a player needs about a certain situation and how they can be used to convey the emotions of characters or relationships between characters, especially in regards to games (Mangiron, 2013, p. 44). Some work has been done on the subject (Mangiron, 2016) and there are guidelines (Griffiths, 2009) that have been suggested but there are no established industry or research standards and no conclusive research on the influences of accessibility features for hearing-impaired players on the experiences of non-disabled players.

Without conclusive research on the subject being available, developers can only follow examples of previous games that have used such accessibility features and hope that those solutions are valid. Unless the use of accessibility features such as closed captions or enhanced speech bubbles is confirmed to adequately convey the information that the player needs to be informed of the gameplay or emotions contained in the game, it is problematic to state that a game using such accessibility features is accessible to hearing impaired players.

Beyond the problem of confirming the validity of accessibility features as a tool to include disabled players, there is also the problem of a lack of standards for their technical implementation in games. There have been standards regarding style, implementation and content of captions established for movies (Harkins, Korres, Singer, & Virvan, 1995) but those standards do not always translate well into games (Mangiron, 2013, p. 48). Many different approaches and technologies are used to develop games and therefore it is impossible to create a solution that works in every case. Furthermore, the perceived quality of games is heavily reliant on a coherent aesthetic and if accessibility features are implemented in the way that they are in movies it is possible that they would break such a cohesion. It could therefore be argued that formulating a single solution for creating accessibility in all games would not be feasible.

Instead of focusing on creating a strict set of rules to follow for accessibility features in games, it would be more useful to investigate what effect different types of accessibility features have on the immersion, which could be seen as a measure of enjoyment, and on the overall experience of the player. The availability and confirmation of such information would allow a greater opportunity for developers to make informed decisions regarding accessibility features for hearing-impaired players in their game. To create experiences that are not only accessible but also inclusive, it is also important to make sure that the design decisions taken to ensure accessibility do not exclude other players. For a game to be inclusive the designers of a game should make sure that all players can share the same experience, without being excluded.

Enhanced speech bubbles and closed captions are two drastically different features and could therefore have drastically different effects on the experiences of the player. Closed captions are seen as an industry standard in modern movies, but there has been little research done on how they affect players of a computer game. Enhanced speech bubbles are not the focus of much scientifically published researched either. It is therefore motivated to investigate these two specific features, to clarify their strengths and weaknesses.
Based on the information gathered and the conclusions drawn through this research, one main research question and two additional questions have been formulated.

1. How do accessibility features affect the immersion of non-disabled players?
2. What effects do closed captions have on the perception of situational information?
3. What effects do enhanced speech bubbles have on the perception of affective information?

To understand these research questions, some clarifications need to be made. Situational information (2.4.2) is information that the player receives regarding the game state, the context and environment of the game and the state of different characters and objects. Affective information (2.4.3) is what informs the player of the mood of a scene, the emotions and relations in and between characters and can also be information that induces emotion in the player themselves. These two kinds of information are often partly conveyed through sound and therefore it is important that the method for conveying it to a hearing impaired is proven to be effective.

By attempting to answer these research questions, it should be possible to come to some conclusions that can assist researchers and game developers in making motivated decisions in their research and development of games, to create more inclusive and immersive experiences.

3.1 Method

To contribute in answering these questions, two experiments have been employed. In conjunction with each other, the two experiments should be able to grant an understanding regarding not only how well the accessibility features convey information but also regarding how they affect the experience of a non-disabled player and in what ways their effects differ from each other. The two experiments were based on a similar design and therefore the process and data collection method of the second experiment was improved based on the experiences of the first experiment.

A quantitative analysis was performed in both experiments, using the IEQ Immersion Score and IEQ Immersion Factors that are produced through the use of the modified immersive experience questionnaire (Jennett, 2010, p. 220). The data gathered through the experiments was calculated according to the process detailed by the creator of the modified IEQ (Jennett, 2010, pp. 222-224).

- The IEQ Immersion score is calculated by adding the values of all 31 questions where responses to questions 6, 8, 9, 10, 18 and 20 are negated (as in 6 is valued as 2, 5 is valued as 3 and so on).
- The single question measure of immersion is an additional measure granted by the single question at the end of the questionnaire collecting data on the self-reported level of immersion.
- The cognitive involvement factor is calculated by adding the values of questions 1, 2, 3, 4, 17, 19, 21, 22, 25 and 29.
- The real world dissociation factor is calculated by adding the values of questions 6, 7, 8, 9, 12 and 14 where responses to questions 6, 8 and 9 are negated.
- The emotional involvement factor is calculated by adding the values of question 6, 7, 12, 19, 23, 24, 25, 26, 27, 29, 30 and 31.
- The challenge factor is calculated by adding the values of question 17, 18, 20, 22 and 26.
- The control factor is calculated by adding the values of questions 10, 11, 13, 14, 15, 16, 21 and 28.

Through comparison of these values in combination with responses to some additional questions, specified in each experiment, it should be possible to draw some conclusions regarding the effect of the specified accessibility feature on the gameplay experience of the player.

### 3.1.1 First Experiment

The first experiment focused on the use of closed captions, more specifically on how well closed captions can convey situational information and how the immersion of the player is affected by the presence of closed captions. To accomplish this, the experiment made use of the commercially released game *Portal* (Valve Corporation, 2007) to perform a participatory study. The first experiment also served as a pilot study for the second experiment, as it was used to motivate changes to the design of the experiment and the data collection process.

### 3.1.2 Second Experiment

The second experiment focused on the use of enhanced speech bubbles and how they work to convey affective information with a specific focus on the relationships between different characters. The experiment was performed using a game in development at the University of Skövde. The main reasoning behind using this game is that it is being developed with the goal of creating a game that is inclusive to players with different sensory impairments which makes it a suitable candidate for experimenting with different accessibility features. Another motivation in selecting this game for the experiment is that according to the inclusive design of the game, the accessibility features should not be optional, but rather part of the original design.

Fully voiced, enhanced speech bubbles of different designs were used in the game and were evaluated through a participatory study. In using this game, studying the influence of the chosen accessibility feature should contribute not only to answering the research question but also to the development of the game itself.

### 3.1.3 Ethical considerations

All the work of this thesis is in accordance with the guidelines for research ethics set in *Forskningsetiska principer inom humanistisk-samhällsvetenskaplig forskning* (Vetenskapsrådet, 2002), all participants were informed of the purpose of the research (to investigate the effects of accessibility features) and gave their informed consent for the results to be used as part of this thesis. The data gathered is completely anonymized, although it contains information about the age and gender of the participants, it is not possible to link any of the answers to any individuals.

Another consideration in the work of this thesis is the responsibility of the author to gather, present and analyze the results in the most transparent way possible. The author of this thesis has to the best of their capabilities attempted to make sure that there are no misleading interpretations or representations of information.
4 First Experiment

The first experiment had three purposes; investigating how the immersion of the player is influenced by closed captions, investigating how closed captions influence the perception of situational information and to refine the data collection method by identifying potential weaknesses in the process and evaluation of the experiment. In the first test, sessions of play utilizing closed captions will be compared with sessions of play without any captions.

4.1 Process

The game Portal (Valve Corporation, 2007) was used for the first experiment, this game was chosen because of its accessibility, steep but fair learning curve that is easy to approach even in a short time and the dependency on situational information that is part of the game. In Portal the player needs to be aware of their task, the environment around them and the movement and momentum of the in-game avatar. The game is revolved around solving puzzles through the use of player movement, timing and a tool that can be used to control two portals in the game.

The game also features an immersive environment, a prominent antagonist that guides the player and highly refined mechanics that offer a balanced and enjoyable experience to the player. Solving the puzzles in the game require the player to make use of the game controls, situational awareness, attention to the task and their experience of the earlier problems they encounter in the game.

Portal also allows the player to define if they want to play without subtitles, with subtitles (only describing the dialogue of characters) or with closed captions (extended subtitles also featuring description of the auditory elements of the game). The closed captions are colour-coded to emphasize different sources of sound in the game and in that way help the player identify the origin of the sound (figure 4).

![Example of closed captions in Portal](image)

**Figure 4** Example of closed captions in Portal (Valve Corporation, 2007)
4.2 Evaluation

Participants for the experiment were selected based on their gaming literacy. The participants should have some experience playing games so that the aspects of the game that are not relevant to answering the research question do not inhibit the experience of the players. The participants received no compensation for their participation and none of the participants reported any hearing impairment.

Before the main testing phase a pilot study was performed in which 4 different players were split into two groups. Each participant started by answering a pre-test questionnaire (Appendix A, p. I) regarding their gaming experience and potential hearing impairment after which they played the first session of the game for ten minutes. Group A started by playing their first session without any subtitles or closed captions and Group B played their first session with closed captions activated. After the first session both groups answered a mid-test questionnaire (Appendix A, p. I) and then played a second session for another ten minutes during which they switched game mode so that Group A played with closed captions and Group B played without any subtitles or closed captions. After the second play session, the participants answered a post-test questionnaire (Appendix A, p. III) containing an additional question regarding their preference of playing with or without closed captions. All players played on a laptop with sound-isolating headphones to minimize distractions from the surrounding environment.

After the pilot study, it was decided to change the mode in which the participants played without closed captions to a session in which they played with subtitles. This was done to focus the experiment on the effect of closed captions by limiting the impact of the changes made to the user interface between the two sessions. For the main experiment a total of 14 participants were used individually, split into 2 groups of 7 players (Appendix C). The rest of the experiment used the same form as the pilot study, with the exception of changing the session without closed captions to a session with subtitles but no closed captions.

4.3 Results

After the calculations (3.1) were made, the average values for all different factors, sessions and groups were identified. There were no extreme outliers in the data and no participants have been excluded from the results due to hearing impairment, gaming literacy or any other reason. The average scores are presented in the table below (table 1) after which short summaries along with graphs for the different categories can be found. The results for the added questions are presented at the very end of this heading.
Table 1 Average scores for the IEQ Questionnaire

<table>
<thead>
<tr>
<th>Category</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEQ Immersion Score (31 to 217)</td>
<td>171</td>
<td>176.143</td>
</tr>
<tr>
<td>Subjective Immersion (1 to 10)</td>
<td>7.714</td>
<td>7.857</td>
</tr>
<tr>
<td>Cognitive Involvement (10 to 70)</td>
<td>62.429</td>
<td>63.571</td>
</tr>
<tr>
<td>Real World Dissociation (6 to 42)</td>
<td>28.858</td>
<td>29.143</td>
</tr>
<tr>
<td>Emotional Involvement (12 to 84)</td>
<td>61.571</td>
<td>69.286</td>
</tr>
<tr>
<td>Challenge (5 to 35)</td>
<td>22</td>
<td>22.714</td>
</tr>
<tr>
<td>Control (8 to 56)</td>
<td>42.857</td>
<td>43.429</td>
</tr>
</tbody>
</table>

Looking at the IEQ Immersion Score (figure 5), we can see that Group A experienced a higher sense of immersion overall. Both groups were found to have experienced a greater degree of immersion in the second session than in the first session. The self-reported subjective measure of immersion also reflected these changes, but too a much smaller degree.
Cognitive Involvement changed in the basic same pattern as immersion, but the differences between the two sessions was negligible. The overall experience of Cognitive Involvement was higher in Group A than in Group B (figure 6).

The experience of Real World Dissociation followed a similar pattern as well (figure 7). Group A experienced a higher sense of Real World Dissociation than Group B but the difference between the two sessions is again negligible.
Figure 8  Emotional Involvement (12 to 84)

Emotional Involvement changed to a greater degree both between the two groups and between the two sessions (figure 8). Group A experienced an overall greater degree of Emotional Involvement than Group B but in both groups Emotional Involvement increased between the first and second sessions.

Figure 9  Challenge (5 to 35)

The sensation of Challenge did not change considerably between the two sessions, it was slightly higher in Group A than in Group B (figure 9).
The experience of Control showed no particular changes between the two groups or sessions (figure 10).

### Table 2 Player preference regarding caption type

<table>
<thead>
<tr>
<th>Preferences</th>
<th>Closed Captions</th>
<th>Subtitles</th>
<th>No opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>10</td>
<td>2</td>
</tr>
</tbody>
</table>

The results for the question of which type of captions the player preferred playing the game with (table 2) showed that a majority of the players preferred playing with subtitles over closed captions.

### 4.4 Discussion

Regarding the data collection method, it has some weaknesses that must be discussed. The process of the experiment was quite convoluted. Pausing the game to answer a questionnaire, switching the game mode and considering this a new session made the data unnecessarily difficult to structure. The structure of the different test sessions also made it very hard to calculate, structure, display and analyse the results in a way that is easy to understand and meaningful. Some interesting patterns can be seen as a result of the design of the experiment, but it is hard to know if those results could have replaced by other, more clear results if the process was simplified.

After the experiment, it was unclear what effect the intervention of the researcher during the middle of testing had on the player. Since the player is pulled out of the game and has to answer
a lot of questions that are not directly related to gameplay, it could have a severe impact on
the immersion of the player. Both groups showed an increase in immersion between the first
and the second session but again, it is unclear how this was affected by the pause between the
two sessions. Looking at the differences between the two groups, the results could be
interpreted as if the first mode in which the participant played the game strongly influenced
the rest of the gameplay experience.

The increase in immersion over time can most likely be attributed to the design of the game.
The gameplay of Portal (Valve Corporation, 2007) follows a refined learning curve, where
every level is designed to introduce the player to a new concept that they will need to master
to complete the upcoming puzzles. The player is always learning something new to try to solve
the puzzles and since the difficulty of the game increases at the same rate as the mastery of the
player, flow (2.5.2) has a great chance to be achieved. It would be interesting to further
investigate the increase in immersion during gameplay.

One aspect of the study that was not taken into account beforehand was that the literacy of the
player was never measured or confirmed. The literacy of the player could influence how they
are affected by the presence of subtitles or closed captions. If the player is focusing on the
captions but has trouble reading them quickly enough it could easily distract from the
gameplay more than for someone for whom it is easy to read them while playing at the same
time.

The experiment used quite a low number of participants, this makes the results more
susceptible to chance. Even though there were no extreme outliers in this experiment, if one
player is a type of player that does not become invested in this type of game, they can skew the
results strongly if that type of player is not represented in the opposite group. This fact
decreases the reliability of the research.

Looking at the results it is unclear how well situational information was conveyed through the
closed captions, the modified IEQ (Jennett, 2010, pp. 222-224) alone may not be adequate to
grant an understanding of this and therefore it will be of importance to add more additional
questions in the second experiment.

It is important to note that the design and contents of the game is the main factor in affecting
the immersion of the player and so these results are most likely to be strongly influenced by
the type of game that is chosen for evaluation. The second experiment will feature a different
type of game, which hopefully can show what differences there are between the genres. The
immersion of the player could also have been affected by the design and presence of the user
interface-element that contains the captions themselves.

4.5 Conclusion
If the aspects of the experiments that have been discussed in the previous section are taken
into account, we can arrive at some interesting conclusions.

A majority of the players preferred playing without closed captions, this is reflected by their
lowered sense of immersion as the group that started playing with closed captions experienced
a lower immersion than the group who started by playing with only subtitles. This indicates
that the first part of the game is important in setting the experience for the entire gameplay
sequence.
The experiment structure and data collection method was unessescarily complicated which created difficulty in gathering, structuring, displaying and analyzing the data. Due to this, it is difficult to judge how situational information was perceived, due to the lack of additional questions beyond the modified IEQ (Jennett, 2010, pp. 222-224). The lack of changes in Challenge and Control did however indicate that closed captions did not provide any additional situational information that was useful in completing the challenges of the game for a non-disabled player.

The decrease in Emotional Involvement for the group starting with closed captions could indicate that the concurrent use of sound and sound description through captions lessens the emotional impact of different sounds and voices, possibly as a result of the player being implicitly informed of what to experience.

This first experiment provided some interesting results and discussion, however the information is quite unreliable and so the main use of this experiment is to inform a strong foundation on which to build the second experiment.
5 Second Experiment

The second experiment had two purposes; investigating how the immersion of the player is affected by the presence of enhanced speech bubbles and in what way enhanced speech bubbles influence the way that affective information is perceived, specifically in the way of relationships between characters and potential changes in emotional involvement.

In this experiment these two questions will be answered through usage of the IEQ Immersion Score, the IEQ Immersion Factors (2.5.4) and a game which the players will play in different modes. One group will play the game with enhanced speech bubbles and sound, one group will play with normal speech bubbles and sound and one group will play the game without sound but with the enhanced speech bubbles.

This experiment differs from the first experiment not only in its purpose but the experiment process and evaluation method has also been refined based on the experiences gathered in performing the process and evaluation of the first experiment.

From the first experiment it was noted that the process of the experiment itself was very complicated. This made it very difficult to organize, understand and analyse the results gathered. The second experiment therefore uses three different groups of participants rather than two. This might seem like an increase in complexity but in this experiment the participants will only play one session of the game where only the way affective information is conveyed will change.

5.1 Process

For this experiment a completely different game in development was used, hereafter referenced to as “the game” since the game is still in development. The game was used mainly because of the inclusive design philosophy behind it, the possibility of modification to the game to perform the experiment and the fact that a large part of the experience of the game is focused on different characters and the relations between them. This affords a great opportunity to study the influence of how affective information is conveyed. All the characters in the game are voiced and the game features a complete sound design, allowing for fair comparison between players playing with or without sound.

The game is based in an inclusive design philosophy and is a continuation of the research performed at the University of Skövde regarding inclusive game design. One of the main values in the development of the game is that it should be equally enjoyable for players with hearing impairment, visual impairment and non-disabled players. The game design aims to avoid some of the design choices made by games that are usually developed for visually impaired players, since they can often exclude non-disabled or hearing impaired players. This value comes with with the requirement that all interaction should be possible without the use of vision or sound. The game is a 2D point-and-click game for mobile devices with a heavy emphasis on narrative, which is conveyed through dialogue, environments, characters and the relationships between those characters. This emphasis on narrative means that conveying affective information is an important factor in the overall experience of the game.

There is a need to acknowledge that the game is vastly different from Portal (Valve Corporation, 2007) in its gameplay mechanics, control scheme, platform and aesthetics. The game is based in a completely different type of gameplay of aesthetic.
Three different groups will play the game in different modes. Group A will play the game utilizing both sound and the enhanced design of the speech bubbles. Group B will play the game with normal speech bubbles and sound and Group C will play the game with enhanced speech bubbles but without sound.

In the version of the game that Group B will play the design of the speech bubbles is very generic. The design itself conveys no affective information but all of the information from the speech bubbles is gained by reading the contents (figure 11).

![Figure 11 Example of a neutral speech bubble](image)

The speech bubbles that Group A and C experienced have been enhanced to convey affective information. They utilize three additional designs that portray different emotions. The first enhanced speech bubbles is designed to convey happiness or positivity (figure 12).

![Figure 12 Example of a positive speech bubble](image)
The second type of speech bubble is designed to convey anger or frustration (figure 13).

![Example of an angry or frustrated speech bubble](image)

**Figure 13** Example of a angry or frustrated speech bubble

The third type of alternate speech bubble is designed to convey sadness or negativity (figure 14).

![Example of a sad or negative speech bubble](image)

**Figure 14** Example of a sad or negative speech bubble

These different types of speech bubbles will be connected to the mood of the character and the content itself. For example, if a character says something positive or is happy, that design of speech bubble will be used for that line of dialogue.

Group C will play the game without sound. The intention is that the results of the test should be able to grant an understanding of the differences in immersion when playing with and without sound and of which type of information can be conveyed through the enhanced speech bubbles.
This enhanced design of speech bubbles can be argued as an inclusive design feature since it is a feature that should not affect any player in a negative way. It should help to include all types of players in the game without excluding any others. The player will not be able to change the design of the speech bubbles themselves during gameplay.

5.2 Evaluation

The participants for the experiments were randomly selected from students around the University of Skövde to which the researchers had no personal connection. One reason behind this is that these students held a wide range of gaming literacy, even though most of them were in some way familiar with games. A second reason these participants were selected was due to their availability, since the game is played on a mobile device it was tested in everyday situations using sound-isolating headphones to decrease the influence of distractions from the surrounding environment, the gameplay session itself took roughly ten minutes and answering the questions took another five to ten minutes. The participants received no compensation for participating.

The sessions of the experiment begun by the participant being asked to answer a pre-test questionnaire (Appendix B, p. I) containing a few questions regarding their gaming habits, age, gender and any potential hearing-impairment. After answering the pre-test questionnaire the participants played through a section of the game that requires the player to interact with a few different objects in the environment and with two different characters, not including the player-character. After playing the game, the players were asked to answer a post-test questionnaire (Appendix B, pp. II-IV) containing the questions from the modified IEQ (Jennett, 2010, pp. 222-224) along with a few added questions (Appendix B, p. IV) regarding the events of the game, the relationships between character and their opinions regarding the design of the speech bubbles. A total of 24 players participated in the test, split evenly into 3 groups of 8 participants (Appendix C).

5.3 Results

The results were calculated according to the instruction by the author of the modified IEQ (3.1). There were no extreme outliers in the data and so no participants have been excluded from the test. None of the participants reporting having severe hearing-impairment (Appendix C) and therefore were all included in the results. The averages of every category and group was then calculated and are presented below. Along with the table containing the averages (table 3), there are short summaries regarding the different categories presented along with graphs in the coming section. At the end of the section the results of the additional questions will be presented.
Table 3 Average scores for the IEQ Questionnaire

<table>
<thead>
<tr>
<th>Category</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEQ Immersion Score (31 to 217)</td>
<td>144.25</td>
<td>129.625</td>
<td>126.25</td>
</tr>
<tr>
<td>Subjective Immersion (1 to 10)</td>
<td>7.125</td>
<td>6.5</td>
<td>5.75</td>
</tr>
<tr>
<td>Cognitive Involvement (10 to 70)</td>
<td>49.5</td>
<td>45.5</td>
<td>46.25</td>
</tr>
<tr>
<td>Real World Dissociation (6 to 42)</td>
<td>26.5</td>
<td>23.75</td>
<td>24.25</td>
</tr>
<tr>
<td>Emotional Involvement (12 to 84)</td>
<td>50.125</td>
<td>44.375</td>
<td>41.875</td>
</tr>
<tr>
<td>Challenge (5 to 35)</td>
<td>19.125</td>
<td>18.375</td>
<td>19.875</td>
</tr>
<tr>
<td>Control (8 to 56)</td>
<td>36.25</td>
<td>16.375</td>
<td>31.625</td>
</tr>
</tbody>
</table>

Figure 15 IEQ Immersion Score (31 to 217)

Looking at the total IEQ Immersion Score, it becomes clear that Group A (enhanced speech bubbles and sound) experienced the highest sense of immersion, Group B and C experienced similar levels of immersion (figure 15).
There were no major differences in the Cognitive Involvement of the players, with Group A averaging slightly higher than the other groups (figure 16).

Figure 16 Cognitive Involvement (10 to 70)

The sense of Real World Dissociation again showed no major differences between the groups, with Group A averaging slightly higher than the other groups (figure 17).

Figure 17 Real World Dissociation (6 to 42)
The factor of Emotional Involvement was the highest in Group A and lower in the other groups. However, there was also some difference between Group B and C, where Group C averaged a lower sense of Emotional Involvement than Group B (figure 18).

The sense of Challenge showed no drastic changes between the groups. Group C experienced a slightly higher factor of Challenge but the change is very minor (figure 19).
In the aspect of Control, Group A and Group C experienced a substantially higher sense of Control than Group B (figure 20).

The following results (table 4-6) were found regarding the relationships between characters, the results are based on an interpretation of the answers given by the participants when asked about the specific relationships about the characters. Their answers have been interpreted as describing either a positive, neutral or negative relationship between the characters.

**Table 4** Perception of the relationship between Jenny and Stenkross (Negative)

<table>
<thead>
<tr>
<th>Perception</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Neutral</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Negative</td>
<td>7</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

The relationship between Jenny and Stenkross is negative in the section of the game that the participants played, for example Stenkross tells Jenny that he will turn her into dinner. Most of the answers to the question were correct but Group A was most adept in correctly identifying the relationship. Group B was slightly better than Group C (table 4).

**Table 5** Perception of the relationship between Jenny and Lumina (Positive)

<table>
<thead>
<tr>
<th>Perception</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Neutral</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Negative</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
The relationship between Jenny and Lumina is a positive one. At the start of the game they do not know each other but to proceed Jenny must help Lumina and so they become friends. All groups provided exactly the same results regarding this relationship (table 5).

Table 6 Perception of the relationship between Lumina and Stenkross (Negative)

<table>
<thead>
<tr>
<th>Perception</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Neutral</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Negative</td>
<td>7</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Lumina and Stenkross have a clearly negative relationship in the game. When Jenny (the player character) encounters them Lumina is being bullied by Stenkross. Group A was most adept in interpreting their relationship with both Group B and C showing similar results (table 6).

Presented below (figure 21) is a graph presenting the number of correct answers each group had for each relationship. We can see that Group A was overall the best at identifying the relationships with Group B and C having an equal amount of total correct answers.

Figure 21 Number of correct answers regarding relationships between characters

The post-test also featured a question regarding the design of the speech bubbles, the participants were asked to describe their opinions about them. Many of the players liked the speech bubbles, mainly the players in Group A and C. There were some negative comments regarding the size and speed of the speech bubbles, and some players commented that they thought that the voice acting should more adequately reflect the emotion presented by the text and design of the speech bubble.
One participant in Group C (enhanced speech bubbles without sound) made the following comment: “They varied a lot, to convey emotion, I believe. I found it helpful since there was no sound to give hints about the characters feelings”. Another player, in Group A, made the following comment: “Good, helped to understand the plot”. These participants seem to have identified the purpose of the enhanced speech bubbles and felt it helped them in understanding affective information.

5.4 Discussion
At the beginning of the experiment the participants were asked to answer a question regarding their gaming habits to grant a rough understanding of their gaming literacy. This information was not essential to answering the question, it was still reasonable to collect it since it could have added to the findings of the experiment in unexpected ways.

The participants were selected based on availability and suitability to be included in the experiment, this was a deliberate and in the end valuable choice, since this selection granted information regarding the gameplay experiences of many different types of people. There was an even balance in gaming literacy, some were more experienced than others and that was useful in providing a fair representation of the players that the game is targeted at. The choice of using everyday environments for testing was in the end also motivated, it provided a setting for the test that had some distraction but in which the players could still mainly focus on the game, which is very similar to the kind of situation in which a player would usually play a mobile game.

The enhanced speech bubbles were designed to provide reinforcement for the emotion of the character, the graphical design of them is of course the subjective interpretation of the emotion of the creator. But it seemed quite clear to most participants what they represented, they used a design that is familiar to most people who have read comic books or children stories using speech bubbles. Some participants commented that they thought that some instances of the speech bubbles did not match the voice of the actor. However the combined comments suggested that this was only the case if in very few instances.

Using the questions regarding the relationships of the characters in the game was very useful in gathering knowledge on how well affective information was conveyed. The questions were straightforward to answer and they added information that the modified IEQ (Jennett, 2010, pp. 222-224) alone is not able to provide a full understanding of. To supplement this, short qualitative interviews could have been used at the end of the test to grant an even more comprehensive understanding of the experiences of the participants. However, such a form of data collection the evaluation that comes with it would be even more time consuming and complicated than the test already was.

5.5 Conclusion
In contrast to closed captions, the enhanced speech bubbles increased immersion in comparison between the two groups who played with sound. The enhanced speech bubbles may also have been a factor in the result that the players who played without sound but with speech bubbles were almost equally as immersed as the group who played with generic speech bubbles.
The enhanced speech bubbles added value to the experience not only in immersion but also in the understanding of affective information. The relationships between the characters were easier to understand, especially so when they were used together with fully voiced dialogue. According to the results gathered, it could be concluded that the main contribution of these enhanced speech bubbles is not accessibility, but rather inclusivity since they did not lessen the experience of non-disabled players but instead increases the quality of the game.

Enhanced speech bubbles also increased Emotional Involvement when used together with sound. However, Emotional Involvement was still lower in the participants that played without sound than in the group that played with sound and generic speech bubbles. This suggests that the enhanced speech bubbles to do not fully compensate for the absence of the affective information that could have been conveyed by sound. The majority of this affective information is conveyed through voices but the ambient sounds and sound effects used in the game could also influence the affective information that was conveyed.

The speech bubbles also seemed to increase the sense of control of the game, possibly as a result of the player feeling more in-tune with the character and therefore able to make motivated choices in the different dialogues of the game. This is however highly speculative as there was no particular focus on measuring control with additional questions in the study.
6 Conclusion

Regarding the main question “How do accessibility features affect the immersion of non-disabled players?” it can be concluded that accessibility features can have both positive and negative effects on the immersion of non-disabled players, depending on the type of accessibility feature that is being used.

Regarding the second question “What effects do closed captions have on the perception of situational information?” no reliable conclusions can be made based on these experiments, as the chosen method did not provide the results needed to make such conclusions. However, there were no major differences in the experience of control or challenge between the groups, which could indicate that the player did not receive any additional situational information through the closed captions.

Regarding the third question “What effects do enhanced speech bubbles have on the perception of affective information?” it can be concluded that enhanced speech bubbles did not only increase emotional involvement but also allowed the players to understand the relationships between characters more easily.

The results show that closed captions lowered the sense of immersion experienced by the player but that enhanced speech bubbles heightened the sense of immersion. Closed captions can be intrusive to the point where they lower the immersion of the player. They did in this case not affect the sense of control or challenge experienced by a non-disabled player and most of the participants in this study preferred playing without closed captions. Even though they are an established as a standard in modern movies and are being used in some high-budget games they are an accessibility feature that can make entertainment accessible to hearing impaired players but can also affect the experience negatively in some ways, therefore it could be argued that closed captions should not be part of an inclusive design.

Enhanced speech bubbles featuring an emotive design had a clear positive impact on the immersion of the player in the game tested as well as on their understanding of relationships between different characters through affective information. This became clear not only through their self-reported perception of the relationships, but also by the fact that the sensation of emotional involvement was lower in the participants who played without enhanced speech bubbles.

The enhanced speech bubbles also caused a higher sense of control, possibly as an effect of the player being able to more easily read the emotional state of different characters and therefore make more well-motivated choices in the dialogue of the characters. This result was however not a focus of the study and further studies are required for accurate conclusions to be made regarding the topic.

The absence of sound, even in players who do not have a hearing impairment, leads to a decrease in immersion and understanding of the emotional state of different characters. The human voice can convey many different emotions and this is fact was reflected in the results. A part of this loss of affective information could most likely also be contributed to the lack of ambient sounds and sound effects, not only the lack of voices.
6.1 Summary

Two experiments were performed to investigate the influence of closed captions and enhanced speech bubbles on the immersion of non-disabled players. Part of the assessment was also to determine how players perceived the information they received from the game based on the accessibility feature.

The first experiment used the game Portal (Valve Corporation, 2007) to evaluate the effects of closed captions and to evaluate the structure of the experiment and data collection process. 14 participants were used for the test and the results showed that playing with closed captions led to a decrease in immersion but there were no results to show any changes in how the players perceived situational information.

The second experiment used an inclusive game in development to evaluate the effects of enhanced speech bubbles. The experiment process and data collection method was altered according to the information gathered in the first experiment and a total of 24 participants were used. The results showed that usage of enhanced speech bubbles led to an increase in immersion over generic speech bubbles, that enhanced speech bubbles also aided in conveying affective information in form of character relationships and that immersion was lower in a group of participants who played without any sound.

6.2 Discussion

The changes implemented in the second experiment based on the experiences of the first experiment were very valuable. The first experiment showed that there were weaknesses not only in the process and structure of the experiment itself but there was also issues in the process, structure, organization and evaluation of the data that was collected. Using this information, the second experiment was made easier to conduct, easier to evaluate and granted a much more clear and reliable result.

The reliability of the experiments is something that needs to be discussed. The data collection process used a quantitative process with the modified IEQ (Jennett, 2010, pp. 222-224) providing the framework that was used to gather an objective measure if immersion. Even though the data collection method grants an objective measure, there are of course other factors that can influence the results and that must therefore be considered. The first experiment had several weaknesses; the participants were selected from a quite undefined population, the testing conditions for the first experiment were not clearly defined and so the participants played the game in a somewhat uncontrolled environment. This was not a problem for the second experiment, since that is the type of environment that mobile games are often played in.

An interesting observation during the research phase of the project was that a large part of the work in scientifically published sources on accessibility in games for hearing-impaired players focuses on teaching skills to deaf children such as sign language and vocalization. The research focuses mainly on serious games with a strong emphasis on communication, there seems to be a lack of research on how to make entertainment games more entertaining for hearing-impaired players.

It is important to note that both experiments were conducted on players without any hearing impairments. Hearing-impairment was simulated in the second experiment through the lack
of sound, but the experiences of people with hearing-impairment could and probably are very different from the experiences of the participants in these experiments.

Accessibility has to be an important part of serious games if the research community wants to make full use of the medium and connect with many different types of players. However, just making games accessible is not enough if you want to create experiences that are also enjoyable to experience for everyone, which is an essential part of fun and motivation.

### 6.3 Future Work

Looking at further continuation of this work, it would be of high value to examine the usage of not only closed captions and enhanced speech bubbles, but also of other accessibility features in other games. It is in many cases unclear whether or not a specific feature is accessible, inclusive, both or neither. With further research on the topic it should be possible to collect enough knowledge to establish clear and well-motivated standards for both the research community and for the industry as a whole.

At a smaller scale, it would also be highly interesting to make more in-depth studies of the games used in this thesis. Through changing the process of the first experiment and adding more questions regarding situational information, there is much more knowledge to be gained. By looking at larger parts of the second game, with more characters, narrative and puzzles, it would be interesting to investigate what other accessibility features could be used to improve the gameplay experience.

A finding made in this study, which is however very difficult to find any solid reasoning behind, is that the enhanced speech bubbles increased the sense of control experienced by the players of that game. Hopefully there will be further research into that specific question, as a result was shown here, but without enough background knowledge to come to any conclusions as to why.

One quite obvious continuation of this work would also be, of course, to study the effect that these accessibility features have on hearing-impaired players. How well they work to convey information to players who have little to no reference to what different sounds feel like. Closed captions are highly interesting in this regard. When a text box tells the player that a sound is heard, but the player has no reference but what that sound is like, the question is if that text actually conveys any valuable information at all.

This research should be of assistance to not only future research within serious games, but also within other areas and in the game development community as a whole. As more knowledge is gained regarding this topic, we should be able to make more well-informed decisions not only as researchers but also as game developers.
7 References


Appendix A - First experiment questionnaire

Note: For the evaluation, a digital version of this questionnaire was used.

1. Pre-test questions:
   1. Test group (filled in by instructor)
      - A
      - B

   2. Are you experienced in playing digital games? Please answer the question by selecting the relevant number.
      Not at all 1 2 3 4 5 6 7 Very much so

   3. Do you have a severe loss of hearing?
      - Yes
      - No

2. Mid-test questions:

Please answer the following questions by selecting the relevant number. In particular, remember that these are asking you about how you felt at the end of the game.

   1. To what extent did the game hold your attention?
      Not at all 1 2 3 4 5 6 7 A lot

   2. To what extent did you feel you were focused on the game?
      Not at all 1 2 3 4 5 6 7 A lot

   3. How much effort did you put into playing the game?
      Very little 1 2 3 4 5 6 7 A lot

   4. Did you feel that you were trying your best?
      Not at all 1 2 3 4 5 6 7 Very much so

   5. To what extent did you lose track of time, e.g. did the game absorb your attention so that you were not bored?
      Not at all 1 2 3 4 5 6 7 A lot

   6. To what extent did you feel consciously aware of being in the real world whilst playing?
      Not at all 1 2 3 4 5 6 7 A lot

   7. To what extent did you forget about your everyday concerns?
      Not at all 1 2 3 4 5 6 7 A lot

   8. To what extent were you aware of yourself in your surroundings?
      Not at all 1 2 3 4 5 6 7 Very aware
9. To what extent did you notice events taking place around you?
   Not at all  1  2  3  4  5  6  7  A lot

10. Did you feel the urge at any point to stop playing and see what was happening around you?
    Not at all  1  2  3  4  5  6  7  Very much so

11. To what extent did you feel that you were interacting with the game environment?
    Not at all  1  2  3  4  5  6  7  Very much so

12. To what extent did you feel as though you were separated from your real-world environment?
    Not at all  1  2  3  4  5  6  7  Very much so

13. To what extent did you feel that the game was something fun you were experiencing, rather than a task you were just doing?
    Not at all  1  2  3  4  5  6  7  Very much so

14. To what extent was your sense of being in the game environment stronger than your sense of being in the real world?
    Not at all  1  2  3  4  5  6  7  Very much so

15. At any point did you find yourself become so involved that you were unaware you were even using controls, e.g. it was effortless?
    Not at all  1  2  3  4  5  6  7  Very much so

16. To what extent did you feel as though you were moving through the game according to your own will?
    Not at all  1  2  3  4  5  6  7  Very much so

17. To what extent did you find the game challenging?
    Not at all  1  2  3  4  5  6  7  Very difficult

18. Were there any times during the game in which you just wanted to give up?
    Not at all  1  2  3  4  5  6  7  A lot

19. To what extent did you feel motivated while playing?
    Not at all  1  2  3  4  5  6  7  A lot

20. To what extent did you find the game easy?
    Not at all  1  2  3  4  5  6  7  Very much so

21. To what extent did you feel like you were making progress towards the end of the game?
    Not at all  1  2  3  4  5  6  7  A lot

22. How well do you think you performed in the game?
    Very poor  1  2  3  4  5  6  7  Very well
23. To what extent did you feel emotionally attached to the game?
   Not at all  1  2  3  4  5  6  7  Very much so

24. To what extent were you interested in seeing how the game's events would progress?
   Not at all  1  2  3  4  5  6  7  A lot

25. How much did you want to “win” the game?
   Not at all  1  2  3  4  5  6  7  Very much so

26. Were you in suspense about whether or not you would do well in the game?
   Not at all  1  2  3  4  5  6  7  Very much so

27. At any point did you find yourself become so involved that you wanted to speak to the game directly?
   Not at all  1  2  3  4  5  6  7  Very much so

28. To what extent did you enjoy the graphics and the imagery?
   Not at all  1  2  3  4  5  6  7  A lot

29. How much would you say you enjoyed playing the game?
   Not at all  1  2  3  4  5  6  7  A lot

30. When it ended, were you disappointed that the game was over?
   Not at all  1  2  3  4  5  6  7  Very much so

31. Would you like to play the game again?
   Definitely no  1  2  3  4  5  6  7  Definitely yes

   How immersed did you feel? (10 = very immersed; 0 = not at all immersed)
   1  2  3  4  5  6  7  8  9  10

**3. Post-test questions:**

Please answer the following questions by selecting the relevant number. In particular, remember that these are asking you about how you felt at the end of the game.

1. To what extent did the game hold your attention?
   Not at all  1  2  3  4  5  6  7  A lot

2. To what extent did you feel you were focused on the game?
   Not at all  1  2  3  4  5  6  7  A lot

3. How much effort did you put into playing the game?
   Very little  1  2  3  4  5  6  7  A lot

4. Did you feel that you were trying your best?
   Not at all  1  2  3  4  5  6  7  Very much so
5. To what extent did you lose track of time, e.g. did the game absorb your attention so that you were not bored?
   Not at all 1 2 3 4 5 6 7  A lot

6. To what extent did you feel consciously aware of being in the real world whilst playing?
   Not at all 1 2 3 4 5 6 7  A lot

7. To what extent did you forget about your everyday concerns?
   Not at all 1 2 3 4 5 6 7  A lot

8. To what extent were you aware of yourself in your surroundings?
   Not at all 1 2 3 4 5 6 7  Very aware

9. To what extent did you notice events taking place around you?
   Not at all 1 2 3 4 5 6 7  A lot

10. Did you feel the urge at any point to stop playing and see what was happening around you?
    Not at all 1 2 3 4 5 6 7  Very much so

11. To what extent did you feel that you were interacting with the game environment?
    Not at all 1 2 3 4 5 6 7  Very much so

12. To what extent did you feel as though you were separated from your real-world environment?
    Not at all 1 2 3 4 5 6 7  Very much so

13. To what extent did you feel that the game was something fun you were experiencing, rather than a task you were just doing?
    Not at all 1 2 3 4 5 6 7  Very much so

14. To what extent was your sense of being in the game environment stronger than your sense of being in the real world?
    Not at all 1 2 3 4 5 6 7  Very much so

15. At any point did you find yourself become so involved that you were unaware you were even using controls, e.g. it was effortless?
    Not at all 1 2 3 4 5 6 7  Very much so

16. To what extent did you feel as though you were moving through the game according to your own will?
    Not at all 1 2 3 4 5 6 7  Very much so

17. To what extent did you find the game challenging?
    Not at all 1 2 3 4 5 6 7  Very difficult

18. Were there any times during the game in which you just wanted to give up?
    Not at all 1 2 3 4 5 6 7  A lot

IV
19. To what extent did you feel motivated while playing?
   Not at all  1  2  3  4  5  6  7  A lot

20. To what extent did you find the game easy?
   Not at all  1  2  3  4  5  6  7  Very much so

21. To what extent did you feel like you were making progress towards the end of the game?
   Not at all  1  2  3  4  5  6  7  A lot

22. How well do you think you performed in the game?
   Very poor  1  2  3  4  5  6  7  Very well

23. To what extent did you feel emotionally attached to the game?
   Not at all  1  2  3  4  5  6  7  Very much so

24. To what extent were you interested in seeing how the game’s events would progress?
   Not at all  1  2  3  4  5  6  7  A lot

25. How much did you want to “win” the game?
   Not at all  1  2  3  4  5  6  7  Very much so

26. Were you in suspense about whether or not you would do well in the game?
   Not at all  1  2  3  4  5  6  7  Very much so

27. At any point did you find yourself become so involved that you wanted to speak to the game directly?
   Not at all  1  2  3  4  5  6  7  Very much so

28. To what extent did you enjoy the graphics and the imagery?
   Not at all  1  2  3  4  5  6  7  A lot

29. How much would you say you enjoyed playing the game?
   Not at all  1  2  3  4  5  6  7  A lot

30. When it ended, were you disappointed that the game was over?
   Not at all  1  2  3  4  5  6  7  Very much so

31. Would you like to play the game again?
   Definitely no  1  2  3  4  5  6  7  Definitely yes

How immersed did you feel? (10 = very immersed; 0 = not at all immersed)
1  2  3  4  5  6  7  8  9  10

Did you prefer playing with or without accessibility features?
-  With
-  Without
Appendix B - Second experiment questionnaire

Note: For the evaluation, a digital version of this questionnaire was used.

This questionnaire is part of a study regarding game accessibility for hearing-impaired players. Please read and consider the questions carefully and answer them as truthfully as possible. Please answer all the questions, if you do not wish to continue with the evaluation, you may stop at any time without giving a reason.

Your answers will be completely anonymous and at the end of the questionnaire you will be asked to confirm that you allow your answers to be used as part of the result.

1. Pre-test questions

This part of the questionnaire should be answered before the experiment commences.

Which test group do you belong to? (Filled in by instructor)
- A
- B
- C

How old are you?
- Younger than 18
- 18 – 25
- 25 – 35
- 35 – 45
- 45 – 60
- Older than 60

What gender do you identify yourself as?
- Female
- Male
- Other

How often do you play digital games?
- Every day
- A few times each week
- About once each week
- Less
- Never

Do you have any form of hearing impairment?
- Yes, severe
- Yes, mild
- No, not that I know of

Wait for instructions from your instructor before continuing.
2. Post-test questions:

These questions should be answered after playing the game.

Please answer the following questions by selecting the relevant number. In particular, remember that these are asking you about how you felt at the end of the game.

1. To what extent did the game hold your attention?
   Not at all 1 2 3 4 5 6 7 A lot

2. To what extent did you feel you were focused on the game?
   Not at all 1 2 3 4 5 6 7 A lot

3. How much effort did you put into playing the game?
   Very little 1 2 3 4 5 6 7 A lot

4. Did you feel that you were trying your best?
   Not at all 1 2 3 4 5 6 7 Very much so

5. To what extent did you lose track of time, e.g. did the game absorb your attention so that you were not bored?
   Not at all 1 2 3 4 5 6 7 A lot

6. To what extent did you feel consciously aware of being in the real world whilst playing?
   Not at all 1 2 3 4 5 6 7 A lot

7. To what extent did you forget about your everyday concerns?
   Not at all 1 2 3 4 5 6 7 A lot

8. To what extent were you aware of yourself in your surroundings?
   Not at all 1 2 3 4 5 6 7 Very aware

9. To what extent did you notice events taking place around you?
   Not at all 1 2 3 4 5 6 7 A lot

10. Did you feel the urge at any point to stop playing and see what was happening around you?
    Not at all 1 2 3 4 5 6 7 Very much so

11. To what extent did you feel that you were interacting with the game environment?
    Not at all 1 2 3 4 5 6 7 Very much so

12. To what extent did you feel as though you were separated from your real-world environment?
    Not at all 1 2 3 4 5 6 7 Very much so

13. To what extent did you feel that the game was something fun you were experiencing, rather than a task you were just doing?
    Not at all 1 2 3 4 5 6 7 Very much so
13. To what extent was your sense of being in the game environment stronger than your sense of being in the real world?
   Not at all 1 2 3 4 5 6 7 Very much so

14. At any point did you find yourself become so involved that you were unaware you were even using controls, e.g. it was effortless?
   Not at all 1 2 3 4 5 6 7 Very much so

15. To what extent did you feel as though you were moving through the game according to your own will?
   Not at all 1 2 3 4 5 6 7 Very much so

16. To what extent did you find the game challenging?
   Not at all 1 2 3 4 5 6 7 Very difficult

17. Were there any times during the game in which you just wanted to give up?
   Not at all 1 2 3 4 5 6 7 A lot

18. To what extent did you feel motivated while playing?
   Not at all 1 2 3 4 5 6 7 A lot

19. To what extent did you find the game easy?
   Not at all 1 2 3 4 5 6 7 Very much so

20. To what extent did you feel like you were making progress towards the end of the game?
   Not at all 1 2 3 4 5 6 7 A lot

21. How well do you think you performed in the game?
   Very poor 1 2 3 4 5 6 7 Very well

22. To what extent did you feel emotionally attached to the game?
   Not at all 1 2 3 4 5 6 7 Very much so

23. To what extent were you interested in seeing how the game’s events would progress?
   Not at all 1 2 3 4 5 6 7 A lot

24. How much did you want to “win” the game?
   Not at all 1 2 3 4 5 6 7 Very much so

25. Were you in suspense about whether or not you would do well in the game?
   Not at all 1 2 3 4 5 6 7 Very much so

26. At any point did you find yourself become so involved that you wanted to speak to the game directly?
   Not at all 1 2 3 4 5 6 7 Very much so
27. To what extent did you enjoy the graphics and the imagery?
   Not at all  1  2  3  4  5  6  7  A lot

28. How much would you say you enjoyed playing the game?
   Not at all  1  2  3  4  5  6  7  A lot

29. When it ended, were you disappointed that the game was over?
   Not at all  1  2  3  4  5  6  7  Very much so

30. Would you like to play the game again?
   Definitely no  1  2  3  4  5  6  7  Definitely yes

   How immersed did you feel? (10 = very immersed; 0 = not at all immersed)
   1  2  3  4  5  6  7  8  9  10

Please describe what happened in the scene with the troll
   - Free text answer

Please describe the relationship between Jenny and Stenkross
   - Free text answer

Please describe the relationship between Jenny and Lumina
   - Free text answer

Please describe the relationship between Lumina and Stenkross
   - Free text answer

What did you think (if anything) about the speech bubbles that were used in the game?

Thank you for your participation!

Do you grant your permission for your answers to be used for a study regarding game accessibility?
   - Yes
   - No
Appendix C - List of participants

These were the responses given on the questions regarding background information of the participants.

1. Participants in the first experiment

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<th>Participant</th>
<th>Group</th>
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<th>Do you have a severe loss of hearing?</th>
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2. Participants in the second experiment

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<th>Participant</th>
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<th>Do you have any form of hearing impairment?</th>
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<tr>
<td>18</td>
<td>C</td>
<td>18-25</td>
<td>Male</td>
<td>About once each week</td>
<td>Yes, mild</td>
</tr>
<tr>
<td>19</td>
<td>A</td>
<td>18-25</td>
<td>Male</td>
<td>Every day</td>
<td>No</td>
</tr>
<tr>
<td>20</td>
<td>A</td>
<td>25-35</td>
<td>Other</td>
<td>Every day</td>
<td>No</td>
</tr>
<tr>
<td>21</td>
<td>B</td>
<td>18-25</td>
<td>Male</td>
<td>A few times each week</td>
<td>No</td>
</tr>
<tr>
<td>22</td>
<td>B</td>
<td>18-25</td>
<td>Male</td>
<td>Every day</td>
<td>No</td>
</tr>
<tr>
<td>23</td>
<td>C</td>
<td>18-25</td>
<td>Female</td>
<td>A few times each week</td>
<td>No</td>
</tr>
<tr>
<td>24</td>
<td>C</td>
<td>18-25</td>
<td>Female</td>
<td>Every day</td>
<td>No</td>
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