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Improving Accessibility for Shooter Games

An explorative study of the possibility to systematically improve the accessibility for shooter games

Master's thesis in Interaction Design and Technologies

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Abstract

Playing video games is an activity enjoyed by many for the diverse experiences that they offer. For players with disabilities, playing games comes with additional barriers that prevent them from enjoying the game. For someone who is deaf, a barrier can mean the inability to hear spoken dialogue and other background sounds essential to the game. Game accessibility is about removing those barriers. While progress has been made within game accessibility research, games still include unnecessary barriers. Games are usually not inaccessible by design but rather because of an information gap between game developers and the accessibility needs and solutions discovered in existing research. To address the information gap, this research explores how accessibility can be improved for shooter games by developing a heuristic tool applicable to examine the accessibility of shooter games systematically. The tool was evaluated by applying it on four games and by conducting a user test with people who are hard of hearing. Furthermore, the research explored the possibility of incorporating the tool in a game development process. The result adds to the knowledge of examining accessibility features systematically and the experienced issues in shooter games of players who are hard of hearing. Additional research is required to examine the validity, content, and usefulness of the tool.

Keywords: video game accessibility, accessibility, shooters, fps, interaction design

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Tommy Olsson, Stockholm, June 2020

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1
Introduction

Playing video games is for many an activity that is enjoyed for the diverse experiences that they offer. Video games are enjoyed for various reasons such as appreciating it as a form of art, experiencing storytelling in digital worlds where the player can affect the outcome, socializing by playing with other people, or as a way to unwind from the burdens of everyday life.
In the last decades, video games have taken a more central role in popular culture, and the number of players has greatly increased. In 2019 there was an estimated number of 2.5 billion players worldwide (Newzoo, 2019).
Games are a powerful tool for cultural and social integration, they contribute to connecting us together, as we share experiences through them (Heron, 2016).
According to Granic, Lobel, and Engels (2014) there may be positive psychological benefits from playing video games in terms of cognitive, motivational, emotional, and social benefits. A finding from their study shows that players seem to develop prosocial skills while playing games where cooperation and helping behaviors are required. In a study by Bavelier, Achtman, Mani, and Föcker (2012) the results indicate that players of shooter games allocate their attentional resources more efficiently in comparison to non-players. Playing action video games may also improve visuomotor control. Li, Chen, and Chen (2016) suggests that players of action games were better at learning a new sensorimotor pattern; this may indicate that experience with action games improves the ability to learn new sensorimotor patterns.

For some people being able to play video games comes with additional barriers. Barriers that can occur due to a disability or condition that limits the access and enjoyment of the game (Bierre et al., 2004). Game accessibility is about removing those barriers and to make games more inclusive and accessible for people with disabilities. Pushing for accessibility is vital for game developers if they want their games to be more inclusive. Accessibility is not something that targets a minority group of players as there are over 33 million disabled gamers in the USA alone (Barlet & Spohn, 2012), and it is estimated to be over 1 billion people that live with some form of disability worldwide (WHO, 2011). As games become accessible, more people can play and enjoy the games and take advantage of the benefits that games provide, resulting in a higher quality of life for more people. Increased accessibility allows for more people to participate in environments that they otherwise would have difficulties to be a part of (Garber, 2013).

Many of the barriers that players with disabilities face can be mitigated with the aid of assistive technology solutions in the form of hardware and software solutions.

The Xbox Adaptive Controller (Microsoft, n.d.) and Logitech G Adaptive Gaming Kit (Logitech.Games, n.d.) are examples of hardware solutions that help players with limited mobility to adjust the input methods of the game into positions that are more comfortable for the person. Software solutions are, for instance, solutions within the game. Some examples of software solutions are the options that allow players to remap the controls, the use of subtitles, and the option to recolor elements in the game and its user interface to make graphical elements more distinguishable (Accessible.Games, n.d.).

1.1 Research question

Related work demonstrates that accessibility is a complex design challenge, as someone who is non-disabled cannot fully understand how to understand what playing games is like for someone with a disability. Plenty of research within the field of gaming accessibility has been made, both within academia and community work. In previous research, solutions have been tested with players with disabilities. The discovered research is available for game developers in forms such as academic paper and guidelines, usable for improving the accessibility of their games.
While game accessibility research and solutions have made progress, video games are often inaccessible for people with disabilities, meaning that they are excluded from being able to play the game. It is of importance to include accessibility in mainstream games as gamers with disabilities want to play the same games for the same reasons as non-disabled gamers (Beeston, Power, Cairns, & Barlet, 2018). The inaccessibility of games is often due to a lack of knowledge of the developers as there seems to be a gap between the developer's awareness and the discoveries of accessibility needs and solutions from accessibility research (Westin & Dupire, 2016). Video games are generally not intentionally inaccessible, but the inaccessibility is rather because of oversights and mistakes during the development process, often due to lack of awareness of accessibility and of what constitutes as a useful accessibility feature (Heron, 2012).
Although there is an information gap, there seems to be a growing interest by game developers in accessibility. Developers are getting more aware of the importance of accessibility, and there seems to be a willingness to make their games more accessible.
Developers that are aware of the importance of accessibility may find the existing research overwhelming to grasp because of the format of academic research and the widespread accessibility solutions in different papers. While there are guidelines for creating accessibility solutions, guidelines are often not understood, ignored (Grammenos, 2008), and require a subjective judgment for validating the designs. Being able to subjectively judge how well a design works requires previous knowledge of the evaluator about accessibility. While some guidelines require subjective judgment, there are also checklists, usable for validating how the current solutions are carried out in a game in comparison to accessibility research. Checklists can be useful for validating the designs; however, they can be insufficient to use for examining if the working designs are consistently carried out throughout critical paths of a game.
As shooter games evolve, new barriers are introduced for players with disabilities,

barriers that need to be addressed by providing accessibility solutions. There is, therefore, a need for a comprehensible and developer-friendly tool that is useful during the development process to examine the game's designs throughout the game, and where the findings are usable in order to improve the accessibility of modern shooter games. A research question was raised for this thesis to address the topic:

- *How can the accessibility for modern shooters be improved through the use of a tool that systematically examines the designs of a game?*

The work was separated into three sections with different goals to address the research question.

- Develop and use a tool to systematically examine the accessibility of shooter games
- Evaluate the tool by conducting a user study
- Utilize findings from using the tool

2
Background

This chapter provides additional information to the introduced research problem and how it is approached and summarizes some of the previous work related to video game accessibility. Previous work includes work on disabilities and the different accessibility needs of players with disabilities, existing accessibility solutions, accessibility challenges for shooter games, factors that add to the inaccessibility of games and why it is crucial to continue working to improve the accessibility of games.

2.1 Disabilities and types of accessibility needs

According to WHO (2011), around 15% of the global population is estimated to live with some form of disability and this number is expected to rise due to an aging population and an increasing spread of chronic diseases. WHO defines disability as "Disability is the umbrella term for impairments, activity limitations, and participation restrictions, referring to the negative aspects of the interaction between an individual (with a health condition) and that individual's contextual factors (environmental and personal factors)."

When it comes to games, barriers can occur in games due to a disability that prevent's or limits the persons ability to play the game. Taking the disabilities and accessibility needs into consideration when designing is important for creating inclusive games. For some people, accessibility solutions can mean the difference between not being able to play the game at all to be able to play it. While for some, it can mean that a minor frustration is removed from the game that makes their experience more enjoyable. For someone who is deaf, a barrier can mean the inability to hear spoken dialogue, and other background sounds essential to the game. For someone with limited motor control, a barrier can mean not being able to get past to objects in the game that requires button holding due to the inability to hold down inputs continuously.
When designing for accessibility, disabilities can be thought of as mismatched interactions between the person and the game interaction when creating solutions. Which highlights the designer's responsibilities of creating accessible designs. (Holmes, 2018). When it comes to accessibility, there is no one fits all solution as everyone have different unique needs required to correct the mismatched interaction between the game and the person.
People with disabilities are a diverse group of people with a wide range of different needs. Some disabilities can be seen, whereas some are hidden or difficult to see,

and people with the same type of disability may be affected in different ways (CDC, 2017). There is an enormous spectrum of the types of disabilities that exist, and trying to classify them is a complicated task.
The types of disabilities have been categorized in many various ways, from a broad level of classification where a wide range of disabilities are chunked together, to a more detailed level of categorization based. One way of a broad level of classifying disabilities is the proposed taxonomy of disabilities for video games context by Aguado-Delgado, Gutiérrez-Martínez, Hilera, de Marcos, and Otón (2018). In their paper, the disabilities are categorized into sensory, motor, or cognitive disabilities; moreover, the disabilities are broken down into subcategories for each disability.
In their suggested taxonomy, a sensory disability includes, but is not limited to the subcategory of visual and auditory disabilities. Visual disabilities include among others, blindness, low vision, or color blindness. Hearing disabilities include deafness and hearing loss. The motor disability includes subcategories of paralysis, neurological disorders and repetitive stress injury. Cognitive disability includes the subcategories of memory loss, attention deficit disorder and dyslexia.
In Barlet and Spohn (2012), the types of disabilities and accessibility solutions are categorized into sections of mobility, vision, hearing and cognitive.
In a paper by Heron, Belford, Reid, and Crabb (2018), the authors developed a toolkit for evaluating the accessibility of tabletop games. In their toolkit, the scope of barriers that stops players from playing games focus on the symptoms and not root causes for barriers. The toolkit is extended by including factors such as socioeconomic impairments, with regards to cultural inclusion and economic considerations and intersectional issues, where combinations of impairments may have additional impact.

While categorizing disabilities can help with understanding the types of disabilities, and the different accessibility needs, the broad categorizations underscores the complexity of accessibility. As disabilities exist on a spectrum rather than a binary state, a person with the same impairment from the categories as another person may be affected completely differently. Low vision can for instance range from needing a pair of glasses to see clearly to be legally blind (a visual acuity of 20/200 or less). A hearing loss can include reduced hearing in one ear, to barely hear anything at all. A motor impairment due to neurological disorder can include not being to control the hand to not being able to control any body parts below the neck. These were only a few examples of the differences of types impairments within a subcategory of disabilities, to indicate the complexity of accessibility and the types of disabilities that accessibility solutions can address.

2.2 Related Work

Accessibility in games is a relatively new research topic. Nonetheless, the research has increased significantly within the last two decades (Westin, Bierre, Grammenos, & Hinn, 2011). In a systematic literature review by Aguado-Delgado et al. (2018), state of the art within the field of game accessibility was reviewed. Their paper presents some of the most significant work that addresses game accessibility that's been published within the last two decades.
This section includes some of the related work in gaming accessibility, research from academia, and other online resources.
In a paper by Grammenos, Savidis, and Stephanidis (2009), the authors introduce and explore the concept of universally accessible games. Universally accessible games refer to games that are adaptable to different types of accessibility needs. The authors present concepts and case studies of design suggestions on how to make games more universally accessible by adding solutions to the same game to make it playable by people with different disabilities. In the paper, different design suggestions and accessibility features are presented on how to make games more accessible. The example games of their paper are less complex in comparison to modern 3D shooters, but the same principles still apply when it comes to the types of accessibility needs.
In an early paper about game accessibility by Bierre et al. (2004), the authors present the different types of disabilities and limiting conditions that limit the attempts of playing games in terms of visual, auditory, motor, and cognitive disabilities. The authors provide examples of problems that occur in games and reasons for why these problems are problematic for people with disabilities, followed by approaches that developers can use to improve the accessibility of the games. The presented approaches are provided with examples of how they worked and were implemented in games specifically targeted with accessibility in mind.
In AbleGamer's paper Includification: A practical guide to game accessibility (Barlet & Spohn, 2012), the authors include an accessibility checklist that developers can use to check how accessible their game is by examining if accessibility best practices are used in the game. The checklist includes different accessibility features that can be used for console and PC, supported with explanations of whom the feature helps and how.

A significant proportion of the work made concerning accessibility in gaming occurs outside of academic papers, there are communities of developers (e.g. IGDA-GASIG (n.d.)), NGOs and charities (e.g. SpecialEffect (n.d.) and AbleGamers (n.d.)) and gamers themselves (e.g. Steve Saylor (n.d.) and Cherry Thompson (2018)) who engage in the community.
Furthermore, the internet is full of resources in different types of media of how games can be developed to become more accessible, ranging from YouTube videos to blog posts and websites providing guidelines for developers. Game Maker's Toolkit series Designing for Disability (Game Maker's Toolkit, n.d.) is a series of videos on YouTube containing design proposals for making games more accessible, motivated with what type of accessibility issues they help with together with examples of best practices. In a blog post by Hamilton (2020), the author provides a compilation of

user stories and quotes by players with disabilities of their own experiences.
There are multiple websites with guidelines created by the work of volunteers (Bors, 2015), and one of them is Game accessibility guidelines (n.d.), which is a website developed by industry experts that provides an extensive list of guidelines available for developers, utilizable for making games more inclusive. The guidelines address solutions for different types of disabilities, supported by how they can be implemented and how difficult they are to implement. Xbox Accessibility Guidelines include a set of best practices and guidelines intended to help designers and developers for generating ideas, developing, and validating the accessibility of their game Microsoft (n.d.).
While most of the guidelines and best practices come pragmatically from the community, there has also been academic work to validate the reliability of individual guidelines, demonstrating the usefulness of the sourced guidelines, even when they weren't originated from research.
One example of research that validates a guideline's reliability is a study by Rello and Baeza-Yates (2016). Their study examined the effects of using different fonts for screen reading. The result from the study indicates that using a sans serif font type resulted in the highest screen reading performance for participants with dyslexia. While the study did not test the effect directly for games, the study shows a positive effect from using a sans serif fonts, as recommended by one of the guidelines that suggest that an easy to read, sans serif font should be used.
In a paper by Khaliq and Torre (2019), the researchers specifically focus on how to improve accessibility in games for the visually impaired, people with low vision, color blindness, and blindness. The authors present visual, auditory, and techniques with examples of software solutions with best practices in games as well as hardware solutions used to make games more accessible.
Trewin, Hanson, Laff, and Cavender (2008) conducted a study where the authors identified problems that occur in video games and used strategies to overcome these problems by surveying players with different disabilities. To follow up on the stated problems, the authors created accessibility solutions for players who are blind or have low vision in a game named PowerUp. The implemented solutions in PowerUp were verified to work by a user study where legally blind (visual acuity of 20/200 or less) users participated.
In a paper by Porter and Kientz (2013), the authors present their findings from an empirical study. In the study, they investigated gamers with disabilities and their gaming habits, experiences, and accessibility issues of playing mainstream games. Their study's findings provide a richer understanding of how and why the players experience the issues and the different accessibility needs required by the players.
Another article that includes guidelines is by Garber (2013), where different assistive techniques usable by developers are presented. The assistive techniques in the article are categorized into whom the techniques help in terms of people with sensory, motor, vocal or cognitive impairments.

In the previously mentioned systematic review by Aguado-Delgado et al. (2018), the authors address articles of previous research of different topics within game accessibility, such as validation research, evaluation research, and solution proposals. The

authors conclude that even though much has been done in this field, there still a long way for games to become universally accessible. For games to be universally accessible, they conclude that further development of methodologies is required for solutions applicable during the game development process.
In an article by Grammenos (2008), the author mentions that while there are valuable guidelines usable for creating accessible games, these guidelines are often ignored or not understood by game developers. Grammenos mentions that previous research has established that guidelines in its original form often are ineffective and unusable for practitioners. The ineffectiveness is often due to guidelines being too abstract to be applicable in a specific context and that the guidelines often are conflicting, both of which require the practitioner of the guidelines to have a concrete idea of the issues that are addressed by the guidelines. To address the issue of guidelines being ignored or not understood, the author introduces a game named "Game Over!" that allows developers to familiarize themselves with guidelines in an actual game. The game includes intentionally bad practices and is what he calls a universally inaccessible game that is full of common barriers that gamers with disabilities experience when they are playing games. The bad practices are highlighted by increasing the barriers to an extreme level where being able to play the game becomes a difficulty for everyone. The inaccessibility of the game is meant as an educational tool in order to increase developer awareness about game accessibility and related solutions in a fun interactive way. Different barriers are conveyed through different levels of the game followed up with guidelines that designers and developers can use when they make games to avoid that these types of barriers occur for gamers with disabilities.
While game accessibility research and solutions have made progress, there still seems to be a gap between the developer's awareness of accessibility and the existing accessibility research (Westin & Dupire, 2016). Inaccessibility in games is not usually intentional design, and games are not made inaccessible by choice but rather because of oversights and mistakes (Heron, 2012).

Although there is an information gap, there seems to be a growing interest in improving accessibility by video game developers. Many game developers are associated with the previously mentioned IGDA-GASIG (n.d.), aiming to the aid game industry in making games accessible for all. Microsoft has taken action to raise game accessibility, and some of their work includes the previously mentioned Microsoft (n.d.) and Xbox Adaptive Controller (Microsoft, n.d.). Some of the measures taken by EA includes a buildathon where 150 employees volunteered to build assistive technology for disabled gamers (n.d.-b). At EA's Accessibility Portal (n.d.-a), visitors can explore the included accessibility settings of their games, receive support, and provide feedback to the games on how to make their games more accessible.
Recently, more games include settings that address accessibility. Some examples are Insomniac Games "Marvel's Spider-Man" where a dedicated accessibility section is included in the settings, where players can find options such as auto-completing quick-time events making the subtitles larger (Arguello, 2018). In Epic Games "Fortnite" players are offered options such as colorblind settings and the option to visualize sound effects.

Ubisoft Montreal hosted a workshop where disabled gamers were involved in sharing their experiences of the barriers they face in games, in order for Ubisoft to learn more about making games accessible by directly involving players with disabilities. The involvement of players with disabilities is highly important as someone who is non-disabled cannot fully understand what it is like for someone who is disabled trying to play games. A common saying within the disability community is "Nothing about us without us", this means for instance that someone with a disability is best suited for stating their needs (Maguid, 2019). Collaboration between developers, designers, and people with disabilities is central for achieving excellent accessibility (Thornton, 2019). The need to involve players with disabilities to create good designs underscores the complexity of designing for accessibility. The actual impact of barriers and accessibility solutions is difficult to understand for someone who is non-disabled. This means that when guidelines and solutions are created, they need to be based on the user experiences of players with disabilities. Despite the fact that many game developers already engage with involving players with disabilities during the development process, some developers are unaware and unsure on how to proceed with making games more inclusive and accessible, which raises the need for a combined effort between research and industry to identify best practices and to continue the efforts of increasing the accessibility and representation of disability in games (Holloway et al., 2019).

Previous work shows that there have been efforts to create games and research targeted explicitly for players with different disabilities. In a study by Yuan and Folmer (2008), the authors introduce the game Blind Hero, which is a rhythm game based on a modified version of the Guitar Hero clone Frets on Fire. Blind Hero is playable by people who are blind, as the visual stimuli are replaced with haptic stimuli through a stimulus-transformation glove. In another paper by Yuan, Folmer, and Harris (2011), the author presents additional games modified for players with specific disabilities. Gordon's Trigger Finger is a modified version of Half-Life 2 where the game can be played with reduced input as the navigation and aiming is automated. Terraformers is an FPS game targeted for visually impaired players, where audio cues are used to indicate aiming direction and to provide information about surrounding objects.
While these games allow players with disabilities to play games and show how solutions can make games more accessible, they do not solve the accessibility challenges regarding including gamers with disabilities to play commercially available games (Holloway et al., 2019). Gamers with disabilities play mainstream games and have the same motivations and reasons for playing games as non-disabled gamers for fun, relaxing, challenging, and social experiences. (Beeston et al., 2018).
While progress has been made, video games are often still inaccessible for people with disabilities. Game developers can always do more and go farther for making games more accessible, and the progress does not have to stop at good enough (Heron, 2012). Increasing the game developer awareness of accessibility and existing solutions known to have a positive impact can lead to greater consideration of accessibility during the development process, this can result in improved accessibility of their games. As the accessibility of a game improves, the range of players who

can enjoy their game increases, resulting in that more people can take part in the social and cultural context that games provide.

2.3 EA DICE

This thesis's work was carried out as a part of an internship, together with EA Digital Illusions AB (EA DICE, n.d.) and their UX research department. EA DICE (hereafter referred to as the company) is a video game development studio based in Stockholm, Sweden. The studio owned by EA (n.d.-b), and is known for franchises such as Battlefield, Star Wars Battlefront, and Mirror's Edge.

The author was hired for the role of a UX Research Intern to explore how to improve accessibility for shooter games. Being at the company provided access to the UX Research team, a network of internal accessibility experts across the company, research operations infrastructure, and game developers as well as an insight into the daily life of how AAA games are made.

2.4 Accessibility for shooter games

This thesis aimed to explore how to increase the accessibility for the game genre of shooter games by addressing accessibility challenges that players with disabilities may encounter and software solutions applicable in the game that mitigates the negative impact of these challenges.
As video games come in a wide variety of genres, complexity, and ways of interacting, the game's degree of accessibility varies, meaning that different types of solutions need to be taken into consideration. According to a survey by PopCap Games, 20.5% of casual games players have a disability (GamesIndustry International, 2008). It was reported that this group preferred genres that included games with simpler interactions such as word and trivia games, puzzles, and card games. The simplicity that these genres offer allows for a high degree of accessibility and could be why they are more popular for players with disabilities in comparison to non-casual games with higher complexity. Games that are considered as hardcore games (*e.g. competitive shooters*) may not be less desirable to play for the reason that they do not want to play them, but rather because of the low degree of accessibility the games offer. In a survey by Yuan et al. (2011), the authors present an overview of common issues that occur in different video genres for players with different types of impairments as well as strategies and use cases of where they have been used to make the game more accessible. This includes different strategies used for first-person shooter games.
The presented shooter games are over ten years old and consist of simpler interactivity and elements within the game. Many of the guidelines are still valuable today, but as video games evolve, new elements of shooter games have been introduced, which may introduce new barriers required to be addressed by further research. New elements can include multiplayer and communication with other players within the game, different roles and playstyles for different classes or the ability to construct

obstacles and drive vehicles.

Designing for accessibility for shooter games can be complicated, as they introduce additional challenges to address. The complexity of shooter games can result in solutions that are not applicable or difficult to apply to all types of shooter games. Shooters often contain multiplayer elements, leading to the difficulty level being hard to adjust or where accessibility solutions can give a competitive advantage for non-disabled players that affects the balance. Player to player communication is often required for its beneficial advantages. They are often real-time played, making control over pacing difficult. They often include elements where multiple inputs are used simultaneously, such as moving the character, aiming, and shooting, where the aiming often requires a high degree of control and precision. To identify enemies, the player often needs to be able to spot them at a far distance or be able to listen to their footsteps when they are nearby. When other players are spotted, the players need to be able to identify if that character is a friend or an enemy.

Nevertheless, even though shooter games are complex, many solutions that make games more accessible for people with different kinds of accessibility needs.
For example: For a colorblind person, distinguishing between items, teammates, and enemy players can be difficult or impossible, as the colors that distinguish them look the same. Some approaches to this issue are distinguishing the essential elements by more than color, using different palettes of colorblind-friendly colors (See Figure 2.), or allowing players to customize the colors fully.

Figure 1. Screenshot from Fortnite showing a side-by-side comparison of how the rarity color of weapons looks with default settings. The left image shows how it normally looks, and the right image shows how someone affected by deuteranopia may perceive the game. The simulation of the colorblindness created by using *Coblis - Color Blindness Simulator,* (n.d.)

Figure 2. Screenshot from Fortnite showing of how the rarity of color weapons look with deuteranopia settings activated. The image shows how someone affected by deuteranopia may perceive the game. The colorblind mode makes the colors more

distinguishable.

Someone who is hard of hearing may not able to identify where gunfire or other dangers are coming from, as they cannot hear this. To mitigate the barrier of not being able to hear dangers, an approach is to offer visual aid that indicates the direction of gunfire.
Some players are not able to continuously hold down buttons, for instance, for weapon zooming. An approach to this is to offer simpler control alternatives that allow the player to press the button once to zoom in and once again to zoom out, rather than holding down the button.

3
Theory and Methodology

This chapter describes relevant concepts and methods that were used during the work of this research.

3.1 Research through design

Research through design is a research method frequently used by research practitioners within the field of Human-Computer Interaction, where a design approach is selected to answer a research question for its topical and theoretical potential. In research through design, the resulting designs, often in the shape of artifacts and systems are the embodiment of the acquired insights and judgments of the designers, gained through the design process of solving a specified problem. By reflecting on the resulting designs, a range of topical, procedural, pragmatic, and conceptual insights can be acquired. In contrast to more traditional research methods such as natural sciences, research through design is argued to be unscientific as its lacking in validating theories. One major strength of research through design compared to traditional research methods is its usefulness in approaching the so-called wicked problems (Gaver, 2012). Wicked problems are complex and often unique problems that are difficult to define. Solving wicked problems is challenging as they are inherently unsolvable as the solutions do not provide binary true or false answers as the solutions instead are measured to be better or worse (Rittel & Webber, 1973).

3.2 Design thinking and iterative design

An iterative design process is useful for approaching the wicked problems and conduct research through design. According to Hartson and Pyla (2012) the iterative design process is the process of repeating parts of a design lifecycle to explore, fix, or refine a design, and the iterative process continues until the implementation of the design. The repeated process parts of a design lifecycle can vary, but they typically share similar parts. In The Wheel suggested by Hartson and Pyla (2012) the lifecycle includes the parts of

- *Analyze* - Understanding the user needs
- *Design* - Create design concepts
- *Prototype* - Realize design alternatives
- *Evaluate* - Verify and refine design

Sharp, Preece, and Rogers (2015) describe that the design process in interaction design consists of four base activities that are repeated in which the findings from each activity inform the others. The four base activities suggested by Sharp et al. (2015) are

- *Establishing requirements*
- *Designing alternatives*
- *Prototyping*
- *Evaluating*

The Interaction Design Foundation (n.d.) describes design thinking as an iterative non-linear process useful for addressing wicked problems, as the process focuses on the problems in a human centric-way. The process provides a means for creative thinking and problem solving, and it helps designers carry out relevant research, create prototypes, and to test out designs to ensure that they fulfill the user needs. The five phases of design thinking according to The Interaction Design Foundation consists of

- *Empathize* - Research Your Users' Needs
- *Define* - State Your Users' Needs and Problem
- *Ideate* - Challenge Assumptions and Create Ideas
- *Prototype* - Start to Create Solutions
- *Test* - Try Your Solutions Out

3.3 Design Methods

The following design methods were useful for different parts of the process of this research.

Literature review

A literature review involves the processes of becoming familiarized with previous research and related work, to extract the essence from the previous work that will inform and be beneficial for the project. The literature review is typically a component of the research paper that collects and integrates the research on a given topic (Hanington & Martin, 2012).

Heuristic evaluation

A heuristic evaluation is a usability inspection method used by expert evaluators to examine an interface and compare it against a set of agreed-upon best practices, the so-called heuristics. A heuristic evaluation can be used without users' involvement and is often useful to inspect that baseline usability problems are fixed before the actual users are brought in to test the usability to make the usability tests more effective (Hanington & Martin, 2012). Besides inspecting a user interface, heuristic

evaluation have been used to evaluate the playability of games (Desurvire, Caplan, & Toth, 2004) and the accessibility of websites (Boudreau, 2019).

Design Workshop

A design workshop is a method that allows co-designing in a fun and efficient way. The workshop often contains exploratory, generative, or evaluative activities. They are typically planned and orchestrated by design team facilitators to prepare the workshop with an overview of topics and an agenda. (Hanington & Martin, 2012)

Ideation

Ideation is the process of generating ideas with an approach of not evaluating or judging the ideas, as that limits creativity. Ideation is used for generating a large quantity rather than the quality of ideas on a given topic. Ideation can be carried out either individually or in groups (Harley, 2017).

Playtest

Playtesting is an activity of the game design process where users are involved, to test and evaluate ideas and designs to gain feedback from users, which helps improve the overall experience of the game. In practice, a playtest can include the stages of creating a prototype, preparing questions and script, recruiting participants, playtesting, and analyzing the results. At best, playtests are carried out iteratively throughout the development process (Fullerton, 2014).

Observation

Observation is a data-gathering method that can be qualitative and/or quantitative, which helps in understanding the user's context, tasks, and goals. During development, the method can be used to investigate how well prototypes support these tasks and goals. Observations can often occur directly or indirectly by observing when participants perform the activities or in a recording. Observations can also take place in a natural or in a controlled environment (Sharp et al., 2015).

Interviews

Interviews are a research method used to collect self-reported data from direct contact with participants. An interview structure typically follows a script, with a different structure depending on the data the researcher wants to collect. The primary forms are either unstructured, structured, semi-structured and group interviews (Sharp et al., 2015).

Thematic analysis

Thematic analysis is a method for identifying patterns and themes extracted from qualitative data. By generating codes from the data, search for themes and occurring patterns from the codes. To identify what theme is conveying by defining it, after

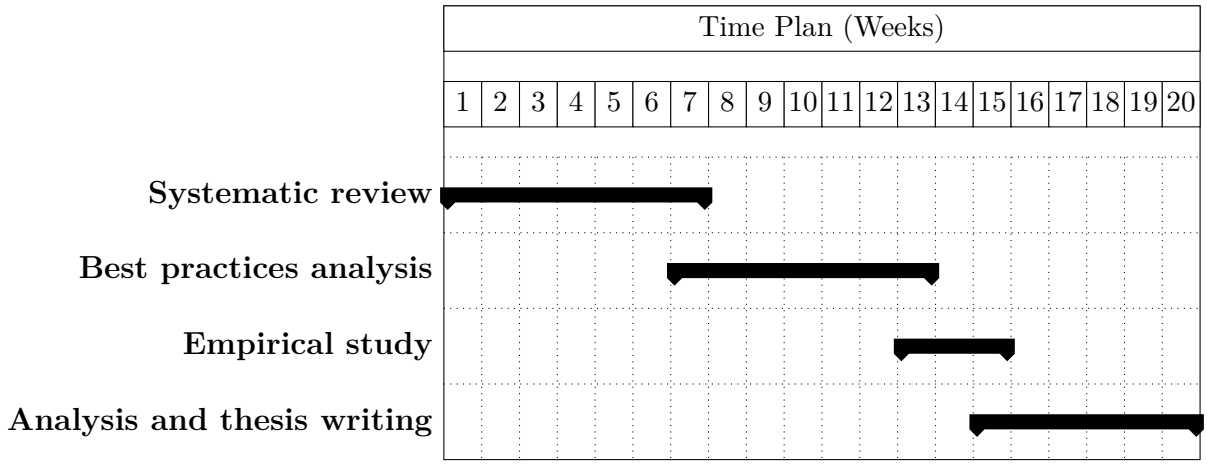
reviewing the themes (Maguire & Delahunt, 2017). One way of doing a thematic analysis is by using Affinity diagramming as a method used for thematic analysis by extracting data and assemble the pieces of data into meaningful groups until themes emerge. (Rosala, 2019)

User story

User stories is a user-centered design method that focuses on the perspective of users that are using a product. User stories are short, specific, and goal-oriented, and the method can help designers empathize with the user goals of a scenario taking the user perspective. Ideally, the user in a user story is based on research, often in the shape of a created persona (Domingo, 2019).

4
Planning

Prior to setting up a plan for the thesis work, a project plan had been set up together with the company for the internship. For the thesis, a similar time plan was planned to align with the internship's time plan. The time plan changed during the project due to unforeseen events such as COVID-19, increased interest in further elaborating the work in the first phase, and that the work and time took longer than anticipated for each phase. Motivations for the change of plan are further discussed in the discussion chapter.



Phase One

Objective

Systematic review: Analysis of the company's shooters to assess accessibility performance

Tasks

- Go through existing literature and online resources to gain more knowledge about the subject.
- Preparations for the game analysis. Prepare a checklist of things to look for during playthrough based on the literature and online resources.
- Analyze Battlefield 1, Battlefield 4, Battlefield V, Star Wars Battlefront 2 and collect data on current accessibility implementations. The collected data is based on the previously created checklist.
- Examine the accessibility of the company's most recent shooters.

Phase Two

Objective

Best practices: Analysis of best accessibility practices to address gaps identified in Phase One.

Tasks

- Based selected topics, informed by input from Phase One, source solutions and best practices from other games or media products.
- Identify best practices for accessibility in shooter games, or from other genres with elements that are applicable to shooters.
- Complete the previously created dataset with best practices.

Phase Three

Objective

Empirical study: To further explore the selected topics from Phase One. Investigate why current implementations are problematic and have a more detailed understanding of where problems occur and why.

Tasks

- Plan and conduct an empirical study with players with disabilities. Focus on qualitative data about user experiences, and the specific obstacles and frictions caused by identified selected topics from Phase 1.
- Goal to identify where problems occur and provide added detail on why those situations are problematic.

Phase Four

Objective

Data analysis and report writing

Tasks

- Analyze results from the empirical study
- Compile existing data and findings
- Write the report

5
Process

This chapter describes the process of the thesis and its three different sections of *Develop and use a tool to systematically examine the accessibility of shooter games*, *Evaluate the tool by conducting a user study* and *Utilize findings from using the tool*. The different sections aimed to have a design thinking approach, where the work is intended for different phases of a design process.

5.1 Develop and use a tool to systematically examine the accessibility of shooter games

The author suggests that there is a need for a tool used to evaluate the accessibility features in games in order to validate how the existing designs are carried out in comparison to recommendations by accessibility research. As a means to develop and evaluate such a tool, a systematic review was conducted with the use of two different tools: The Accessibility Checklist, which later evolved into The Accessibility Heuristics. The systematic review was performed on four of the company's shooter titles, to examine the existing accessibility features and to evaluate the usefulness of the tools.

5.1.1 Literature review

In order to examine the accessibility features in the games and to be able to perform the analysis, previous work on video game accessibility served as a base for the systematic review, containing research from academia and community work. The literature review included research with solutions known to have a positive impact on games for players with different accessibility needs, and the identified solutions were compiled into a list. The literature review served to establish the tool's requirements, to understand the user needs for such a tool from a developer perspective, and to the requirements of the tool itself for it to be meaningful to use.

5.1.2 Creating a tool for the systematic review

A tool usable to perform the systematic review had to be created before conducting the review. The first design of the tool contained the findings from the literature review, that were compiled into a checklist containing features to examine for in games.
The checklist on GameAccessibilityGuidelines.com served as a foundation for the

list of accessibility features (Game accessibility guidelines, n.d.). In that checklist, the different guidelines are categorized by the type of disability that the guideline helps in the categories of motor, cognitive, vision, hearing, speech, and general. This means that the same guideline appears under different types of disabilities. Under each type of disability, the guidelines are further categorized into the categories of basic, intermediate, and advanced.

Guideline	Implemented?	Relevant to mechanic?	Notes	Motor	Cog
Game Title					
Description					
Text display and readability					
Use simple clear text formatting					
Use an easily readable default font size					
Allow the font size to be adjusted					
Use an easily readable default font size					
Use simple clear language					
Highlight important words					
Contrast					
Provide high contrast between text/UI and background					
Provide an option to adjust contrast					
Provide a choice of text colour, low/high contrast choice as a minimum					
Make interactive elements that require accuracy (eg. cursor/touch controlled menu options) stationary					
Give a clear indication that interactive elements are interactive					
Color blindness					
Use more than colors to distinguish critical elements from each other (shapes, forms, shading, animations and other visual tricks)					
Allow users to change the displayed UI colors					
Visual cues					
Ensure no essential information (especially instructions) is conveyed by text alone, reinforce with visuals and/or speech					
Provide a choice of cursor / crosshair colours / designs					
Avoid placing essential temporary information outside the player's eye-line					

Figure 3. An early sample of the modified GameAccessibilityGuidelines checklist after re-categorizing, adding guidelines, removing duplicates, and implementation difficulty.

After evaluating the checklist, it was modified by removing the sorting of guideline to the type of disability group that the guidelines help for. Instead a field was added to the guideline, as the feature can help for different types of disabilities. The duplicates of guidelines were removed; one example is that the guideline of "Provide separate volume controls or mutes for effects, speech and background/music" was mentioned in the subcategories for Cognition, Hearing, and Speech. Two of these mention of the guidelines were then removed, and in the field next to the guideline that addresses the disability, the text of "Cognitive, Hearing, Vision" was added. Implementation difficulty was removed as the implementation difficulty would not relevant when examining if the feature is included or not in the game.
Moreover, solutions from academic literature and community work were researched to validate some of the existing guidelines and to add unaddressed guidelines.
For instance, some of the guidelines, such as providing subtitles, high contrast, and remappable controls, are also recommended by Bierre et al. (2004). Some guidelines are also recommended by Yuan et al. (2011), such as reducing required input,

providing audio cues, screenreaders, and visual representation of sound. Another example of where the guidelines are mentioned is in the paper by Barlet and Spohn (2012), where the author provides recommendations not to include any mandatory quick time or button-mashing events, as well as the recommendation to include adjustable sensitivity options and difficulty levels. Many of the guidelines were also repeated by the Xbox Accessibility Guidelines (Microsoft, n.d.).
Some examples of added guidelines from other sources are for example Bierre et al. (2004) and Barlet and Spohn (2012) recommends an unaddressed guideline of colorblind options, which is also recommended by Game Maker's Toolkit (n.d.) as well as separating elements by more than colors alone, this lead to that the guidelines of "Use more than colors to distinguish critical elements from each other (shapes, forms, shading, animations, and other visual tricks) and "Allow users to change the displayed UI colors" were added. GameMakersToolKit also recommended providing modifiable camera motions, leading to adding the guideline "Allow players to modify camera motions (Weapon bob, head bob, screen shake, motion blur, field of view and sensitivity control)". SpecialEffect (n.d.) recommends that "Within a game, accessibility features should be easy to find and equally easy to ignore if not needed:", this resulted in adding the guideline of "Accessibility features should be easy to find".

The guidelines were sorted into categories of areas where the guidelines are relevant in the games, based on Xbox Accessibility Guidelines (Microsoft, n.d.) categorization of Accessibility Guidelines. This resulted in a list of 109 guidelines categorized into 24 categories.

5.1.3 Tidy up the checklist

The many guidelines in the checklist had to be tidied up to be more manageable within the project's time frame, but also to be manageable for future use of the developers, as one of the tool's goals is that it should be practical to use. The usage of the tool should not be daunting, and the process should not be overwhelming. To keep the checklist more manageable, the next step of the process was to tidy up the checklist with the goals of identifying and keeping guidelines relevant to PC and console shooter games.
The process of tidying up the guidelines was carried out together with an accessibility expert within the company. A reason for each merger or removal was provided, and below are examples of removed guidelines and the reason why they were removed.

Guideline - Include an option to adjust the game speed
Reason - Inappropriate for the core tech of a MP shooter

Guideline - Ensure sound / music choices for each key objects / events are distinct from each other
Reason - Covered by similar guideline: Use distinct sound / music design for all objects and event

Guideline - Support text chat as well as voice for multiplayer
Reason - Covered by similar guideline: Support voice chat as well as text for multiplayer game

Guideline - Include some people with impairments amongst play-testing participants
Reason - Important during the development process but not relevant for the checklist

Guideline - Provide signing
Reason - Unlikely, particularly once considering that signing is not a single language

Guideline - Provide an option to turn off / hide background movement
Reason - Unlikely to be possible for shooters

Guideline - Ensure interactive elements are large and well spaced, particularly on small or touch screens
Reason - Not relevant for HD shooters

After tidying up the checklist, it ended up including 51 checkpoints in 12 categories. By merging similar guidelines, excluding guidelines that are unlikely to be implemented in shooter games, reorganizing and renaming the categories.

5.1.4 Performing the systematic review by using the Accessibility Checklist

Subtitles and captions			
Provide subtitles for all important speech	X	In singleplayer the cinematics and important ingame speech are provided with subtitles. Video tutorials are provided with subtitles.	No subtitles in multiplayer. Annou be useful when for instance the a are losing objective x.", "Enemy is Fox"
Provide subtitles for supplementary speech	X	Some subtitles for NPC conversations in War Stories	No subtitles for supplementary sp be useful for deaf/HoH-players fo multiplayer when someone is thro a soldier yells "Grenade!", or in S main-characters are speaking.
If any subtitles / captions are used, present them in a clear, easy to read way	X	During the video tutorial of gamemodes (conquest) the white subtitle text is made easier to read with a black transparent background around the text	In some areas where subtitles are are provided with a with white text read against some backgrounds
Ensure subtitles/captions are or can be turned on before any sound is played	X	Subtitles are activated by default.	
Ensure that subtitles/captions are cut down to and presented at an appropriate words-per-minute for the target age-group		[1][2] 49 - 54 signs before line break. (exl. white space) [3] Recording shows the pacing.	No subtitles in multiplayer
Allow subtitle/caption presentation to be customised	X	Subtitles can be turned on and off. Subtitle size can be adjusted where players can select from a small, normal or large font.	
Provide captions or visuals for significant background sounds			No closed captions in the game
Ensure no essential information is conveyed by sounds alone	X	Announcements are supported with text, visuals, and speech	
Ensure that all important supplementary information (eg. the direction you are being shot from) conveyed by audio is replicated in text / visuals	X	When the player is being shot at, visuals reinforcements of sound is displayed around the character that indicate that the player was shot, where it is coming from and how damaging it was. - Visual cues when a grenade is nearby - Gunfire from vehicles and weapons are visible	

Figure 4. Sample from the first review of Battlefield V.

Each guideline in the checklist contained a checkbox field for marking if the guideline was fulfilled or not. A description field was used to describe how it was implemented. A notes field was used for adding notes of interesting finds related to the implementation. Additionally, there was a field with "Accessibility need" containing information

about the types of accessibility need that the guideline helps for, as well as a field for screenshots and recordings.
The author did the procedure of applying the checklist by playing through parts of each game while going through the checklist. The author had previously had time to be familiar with the guidelines of the settings and started by marking the easily spotted checkboxes in an unorganized manner. If a feature was spotted, it was marked as implemented in the checklist and noted with how the implementation was carried out. After the easily spotted guidelines where identified, the author went through the list, one guideline at a time, and actively examined if and how the feature was carried out.
The findings from the four different games were later compiled into the same spreadsheet to make the findings comparable.

Guidelines	Implementation
Input - Interaction methods and modalities	
Allow controls to be remapped / reconfigured	Extensive and contextual (soldier, vehicle driver, pilot Allowing players the freedom to map their controls in There is also key remapping and mouse axis mappin Players are able to reset settings for just one mode if
Include an option to adjust the sensitivity of controls (analog settings)	Includes extensive sensitivity options for both gamepa and triggers.
Avoid repeated inputs (button-mashing/quick time events)	There are no 'quick time events' requiring repeated pr
Avoid / provide alternatives to requiring buttons to be held down	There are multiple options to toggle hold actions on o
Ensure controls are as simple as possible, or provide a simpler alternative	Includes options to turn on and off toggle hold actions Due to the nature of the squad focused gameplay, diff
Do not make precise timing essential to gameplay – offer alternatives, actions that can be carried out while paused, or a skip mechanism	No identified QTE's or precise timing events in the ga
Support more than one input device	The game allows a gamepad and mouse/keyboard to

Figure 5. Displayed is the category of "Input - Interaction methods and modalities" of Battlefield V from the compiled spreadsheet.

5.1.5 Accessibility Heuristics

Results from applying the previous checklist resulted in a list of current accessibility features in the games, how they are implemented, and areas where there is no current implementation.
Applying the checklist, worked as a tool to examine if a game included an accessibility feature or not. By using the Heuristic Checklist approach, some questions arose about the usefulness of the tool and how it could be improved.
An issue that occurs with the checklist is that it may be difficult to conclude if some of the accessibility features are implemented or not. For instance, if the feature is implemented in one area of the game, but not consistently applied throughout the game. Does this mean that the guideline is fulfilled, and would it then be checked off the list or not?

After evaluating the checklist, a set of heuristics was developed as continuing work to improve the tool for analyzing accessibility features. The accessibility checklist was valuable for examining features that are only implemented once in a game. However, the checklists can be insufficient to use for examining if the designs are consistently carried out throughout critical paths of a game.
Within the UXR department at the company, a set of heuristics had previously been developed and used for UI evaluation to identify UI-related issues in games objectively. This set of heuristics worked for identifying where issues may occur in a feature flow of navigating a user interface, and it was considered that maybe this the way of using the heuristic could work for identifying accessibility issues as well. The template and approach of using the heuristics were used as the basis of the accessibility heuristics.
Rather than just checking off features from a list, the aim of the accessibility heuristics was to take a more user-centered approach by taking the user's perspective. By applying the heuristics to certain scenarios of user flows of a game, the heuristics aim to investigate where accessibility issues may occur in this scenario. Furthermore, intention for the accessibility heuristics was that the heuristics should be able to be used and applied to a game by developers, even though they may lack knowledge about accessibility and what good accessibility is. The accessibility heuristics should be usable to assist game developers with a tool to explore the accessibility of their game.

Contrast and legibility	***Rating***	***Notes***	***Task (when is this an issue)***
Text and other meaningful information can be easily distinguished and read by players of the game.			
Foreground/background contrast ratio of text is at least 4.5:1	☐		
Foreground/background contrast ratio of meaningful graphics are at least 3:1	☐		
Important information is conveyed by means other than just color alone	☐		
Adjustable UI colors	☐		
A choice of cursor / crosshair colours / designs are provided	☐		
Essential temporary information is placed inside the player's central visual field (not in the periphery)	☐		

Figure 6. Displayed is an empty heuristic of the category "Contrast and legibility"

The heuristics contain 13 heuristics and 59 guidelines (See Appendix A). Each heuristic contained a goal statement and relevant guidelines of accessibility features accompanied with checkboxes that can be crossed. The naming and goal state-

ments are based on the overview of the guidelines as they are described in Xbox Accessibility Guidelines, and the Web Accessibility Heuristics by Boudreau (2019).

The criteria for a heuristic to be fulfilled is that the goal statement seems to have been achieved, in the accessibility heuristics this is specified by fulfillment of check-boxes next to the guidelines.
One of the main aspects that differ the heuristics from the previous checklist is that the evaluation is goal-driven rather than feature-driven, meaning that they should be applied to a scenario with a user goal, rather than just examining the feature of the games. In order to make the heuristics more goal-oriented, all of the guidelines are accompanied by a Task-field, where the identified blockers that can occur when trying to reach the end state of the goal are noted. The guidelines also include a Notes-field, where the identified blockers are described qualitatively.

5.1.6 Performing the systematic review by using the Accessibility Heuristics

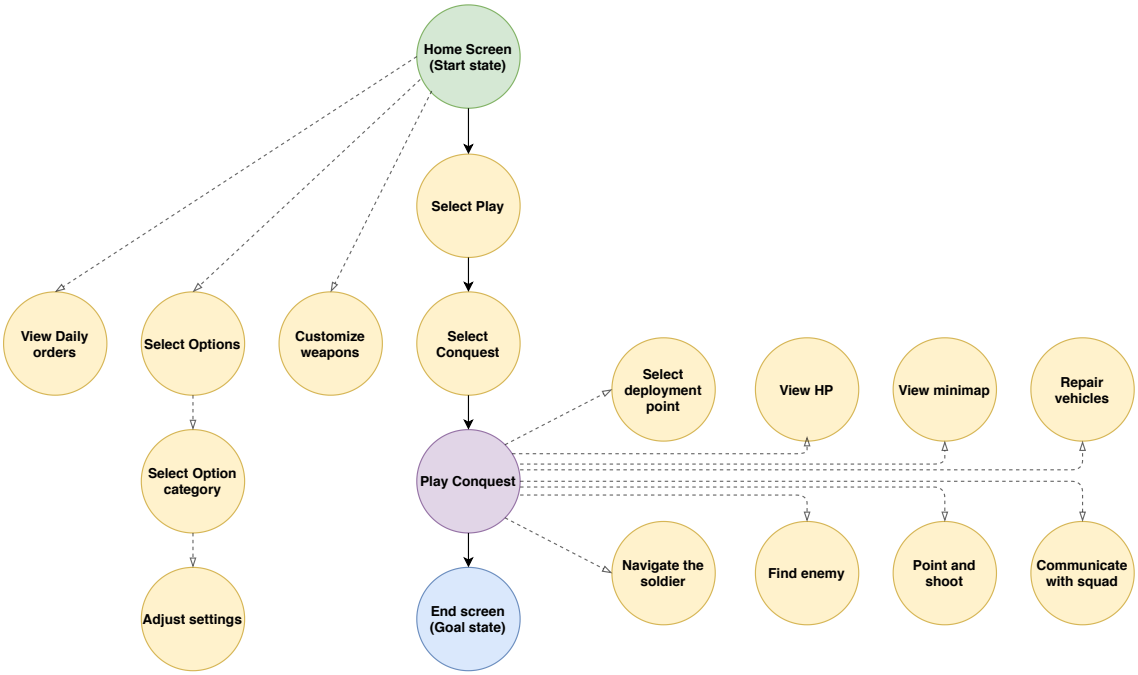


Figure 7. Illustration of tasks in the user story "Player wants to play Conquest"

The heuristics are used by
1. Identify a user story with a user goal. An example can be that "User wants to adjust the sound settings" or "User wants to play the first singleplayer level of the game."

2. In the user story - Identify and list the tasks in the expected task flow. In a linear game, this can mean the order that the tasks are executed, in a less linear game, the tasks are the available tasks in the scenario. For a user that wants to play the first singleplayer of the game, the tasks can include the process from launching the

game to navigating the menus, adjusting the options, receiving mission objectives, controlling the character, aiming and shooting, steering a vehicle.
See Figure 7. for an example illustration of a user story and its included tasks.

3. Go through the tasks and compare them to the heuristics and guidelines. If there is no identified blockers in a task for a guideline, then that checkbox can be checked. If there are identified heuristic violations, the examiner should make a marking in the field belonging to the guideline to mark where the tasks occur, and in the notes field describe why and how the identified blocker can become an issue.

4. Set an appropriate rating for how well the heuristic is met. (1 - Heuristic is met, 2 - Heuristic violation causing low friction, 3 - Heuristic violation causing medium friction, 4 - Heuristic violation causing high friction, 0 - Feature is not relevant in the user story)

User story	
Player wants to play conquest	
Feature Flow	Sum of issues per task
Home screen	4
Activate accessibility feature: Select Options	2
Activate accessibility feature: Select option category (controls, gameplay, audio, video, key bindings)	2
Activate accessibility feature: Adjust selected settings	1
Meta: View storyline progression and objectives	1
Meta: View chapter rewards	0
Meta: Armory - Browse items in armory	4
Meta: Armory - Select and buy item in armory	0
Meta: Assignments - View daily orders	1
Meta: Assignments - Special Assignments. View, select and activate assignment	0
Pre-game: Your company - Browser through soldiers, vehicles and airplanes	0
Pre-game: Your company - Customization. Weapon selection and customization. Appearance selection. Vehicle customization	0
Pre-game: Create/join squad	0
Pre-game: Communicate with squad	1
Select Play	1

Figure 8. Sample of the user story and identified tasks of "Player wants to play Conquest" for Battlefield V.

Heuristics			**Usability issue 1**
Subtitles and captions	***Rating***	***Notes***	***Task (when is this a***
Players should be able to understand everything that is taking place in a ga	4 - Heuristic violation causing		
Subtitles are provided for all important speech	☐	No subtitles in multiplayer. Major a	Receive announcemen
Subtitles are provided for all supplementary speech	☐	No subtitles in multiplayer	Toss grenade
Captions or visuals are provided for significant background sounds	☐	No subtitles in multiplayer	Find enemy
Subtitles/captions are presented in a clear, easy to read way (e.g. size, bac	☐	No subtitles in multiplayer	
Subtitles/captions are cut down to and presented at an appropriate words-p	☐	No subtitles in multiplayer	
No essential information is conveyed by sounds alone	☑	Announcements are conveyed with	
No essential information (especially instructions) is conveyed by text alone	☐	Announcements are conveyed with	
All important supplementary information (eg. the direction you are being sh	☐	Includes visual indicators of shot di	
Text prompts can be progressed through at the players own pace	☐	Players are able scroll through prev	Receive hints/tooltips

Figure 9. Sample of the heuristic "Subtitles and Captions" in the of "Player wants to play Conquest" for Battlefield V.

In this study, for the four games, a Singleplayer and Multiplayer were evaluated to test a broader range of what is included in the games. In all of the games the heuristics were applied to the scenario of "Player wants to play the first level of the campaign", which was chosen as this is the first level that players are introduced to when they are playing the campaign. For the multiplayer modes, the mode of

Conquest was selected for the Battlefield games as this is a game mode that was included in all three of the Battlefield games. Supremacy was selected for Star Wars Battlefront 2 as this is a game mode similar to Conquest, which makes the findings between the games more comparable.
The scenarios were stated "Player wants to play Conquest" or "Player wants to play Supremacy". In the scenarios, all of the identified tasks were listed.
Ideally, whole games should be played through to examine the full game, but this would not be manageable by the examiner that uses the heuristics, in this case for the author and for the timeframe of the project. The manageability of the tools should not be overwhelming if a developer were to use the tool in the future.

Heuristics			**Usability issue 1**
Input - Interaction methods and modalities	***Rating***	***Notes***	***Task (when is this an issue)***
Players can efficiently interact with the game using the input method	2 - Heuristic violation causing		
Controls can be remapped/reconfigured	☑		
Controls are remappable/reconfigurable before the game starts	☑		
Keyboard/Gamepad inputs are fully reconfigurable, including menu a	☐		Home screen
Includes an option to adjust the sensitivity of controls (analog setting	☑		
Player is not required to quickly repeat inputs (button-mashing / quic	☑		
Player is not required to hold down inputs	☐		Communicate with commo
Precise timing events are not essential to gameplay	☑	No precise t	
Controls are not unnecessarily complex by default	☑	Includes sin	

Figure 10. Sample of the heuristic "Input - Interaction methods and modalities" in the scenario of "Player wants to play Conquest" for Battlefield V.

5.2 Evaluating the tool - User study

By evaluating the findings from performing the systematic review, the result indicated that the features related to hearing accessibility were underdeveloped, meaning that the features related to hearing accessibility had the lowest amount of features that were carried out according to the recommendations suggested by the guidelines. By analyzing the results from the systematic review, it was considered that it would be interesting to continue investigating the hearing accessibility, by analyzing if the heuristics address the issues that are experienced by players in need of hearing accessibility features. Evaluating the tool served to test if the tool is valid and reliable for examining the accessibility of a game.
A user study was conducted with people who are hard of hearing to evaluate parts of the heuristics. The user study consisted of playtesting and semi-structured interview questions in order to gain insight into their accessibility needs in shooter games.
The aim of the study was to qualitatively understand the issues that players who are hard of hearing experiences, in order to examine if the issues are taken into consideration by guidelines in the heuristics.
Key research questions for the user study was to investigate and provide added detail on

- Where do problems occur, and why? Why are those situations problematic?

- What are existing features that participants find helpful in terms of hearing accessibility?
- How do the participants approach option customization? What are they looking for, and why?
- How do these problems and helpful features impact the participants overall experience with the game?

Participation

7 participants who are hard of hearing volunteered explicitly to participate in a hearing accessibility study for shooter games. Each participant participated in a two-hour one-on-one session that involved playtesting and semi-structured interview questions.
Prior to the user study, all participants were asked to install Zoom (n.d.) and Battlefield V on their home PC.

Procedure

The user study occurred over Zoom calls where the users and the researchers participated from their PC in their home, and communication was made through speech. During the interview questions, the researcher's face was visible by using a web camera to a degree to make lip reading possible in order to provide visual aid. Additionally, Zoom's built-in live transcript was enabled during the calls. The calls were recorded for post-analysis.

Each participant participated in a two-hour one-on-one session that involved playtesting and semi-structured interview questions. Each session consisted of

- A study brief followed up with general accessibility questions.

  During the first interview session, the participants were asked questions that include talking about their hearing impairment and how this negatively affects their experience with gaming, and to explain coping behaviors that are used when problems occur. Participants were also asked about communication preferences as well as what options they are looking for and about other beneficial features in FPS games.

- Game session 1
  For the first game session, the participant was asked to play the introduction level of Battlefield V. The level involves linear gameplay and takes around fifteen minutes to complete. The introduction level includes storytelling that provides context for the game, which is presented by the visuals and speech, with subtitles turned on by default.

- Questions about game session 1 experience
  After the first game session, the participants were asked questions about their experience of being able to follow the storytelling and the use of subtitles.

- Break
- Game session 2
  In the second game session, the participant was asked to play Conquest for around one hour. Conquest is a game mode where players in two teams with up to 64 players fight for key locations on the map. In conquest, combat is carried into effect by soldiers using weapons and other tools and through fighting vehicles such as tanks or planes.
- Questions about game session 2 experience
  After the second game session, the participants were asked questions about their experience about understanding game objectives, different states of the game, if teammates needed assistance, and about their understanding of where dangers were coming from and locating enemy soldiers to shoot. The session ended with asking about their general satisfaction of Battlefield V when it comes to hearing accessibility and if there were features that they would have wanted to see in the game to make the experience more enjoyable.

Thematic Analysis

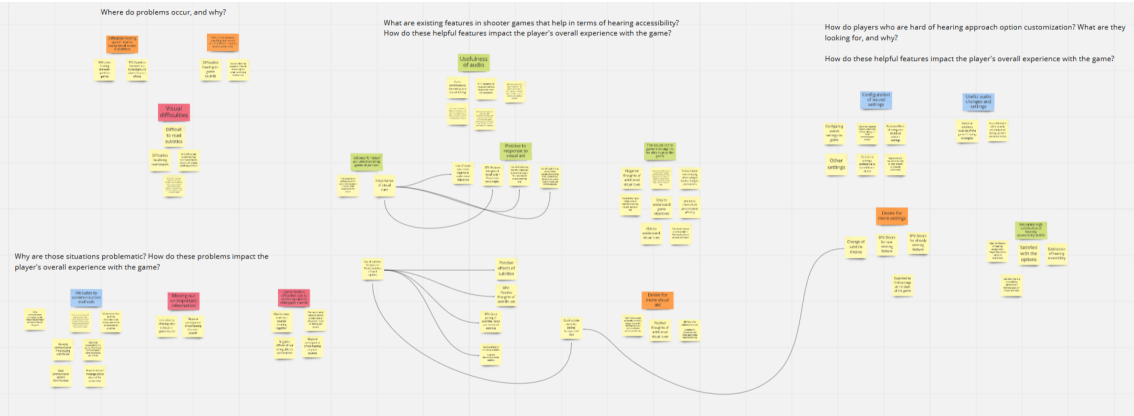


Figure 11. Miro was used for organizing themes

Thematic analysis was conducted to organize and find themes in the collected data. The interviews were transcribed. Relevant segments of text in the transcript were coded with themes that encapsulate that segment. The codes were later grouped into suitable themes, following with iterations of evaluating the themes and regrouping them.

Comparing the findings to the heuristics

After analyzing the results from the user study, the guidelines relevant to hearing accessibility were compared to the findings in order to identify if the accessibility heuristics address the issues experienced by the participants of who are players who are hard of hearing.

5.3 Utilize findings from using the tool

A goal for the tool is that it should be valid and reliable for being able to examine the accessibility of the games. Besides that, the systematic review findings need to be communicative to game developers to be meaningful.
The requirement opened up to explore how the results from the systematic review can continue after the analysis, by examining how the findings can be utilized and communicated to developers, and to test how they fit in a design process to establish requirements and define user needs and problems, which in turn can be used to generate ideas and solutions that solve the defined issues.

The following section presents how the possibility of following up on the results was explored through a report, presentations, and a workshop.

5.3.1 Internal report and presentation

For the first approach to explore how the findings can be used in a design process, the information gained through the heuristic analysis were compiled into a report to answer questions relevant to development. The report was sent out within the company and presented at two times, in a 30-minute presentation format. The report included findings from the systematic review about

- Strengths - To highlight findings of areas with accessibility wins, where the current features are implemented according to recommendations by accessibility research, to imply that those features should be preserved.
- Opportunities - Section that addresses where the features are not carried out according to accessibility research, where barriers may occur for players with different accessibility needs, and how the barriers might prevent players from accessing or enjoying parts of the game. These barriers were presented as potential opportunities to improve accessibility.

5.3.2 Workshop

In the previously presented report and presentation, potential accessibility opportunities from the reviewed games were presented, containing areas in the games where there are possibilities for improving accessibility.
A workshop within the company was conducted to approach these accessibility opportunities and as a way to engage developers in acting on the opportunities. The author co-hosted the workshop together with a UX Researcher and a UX designer. Developers and designers within the company with different areas of expertise participated in a 3-hour workshop with the goals of following up on the opportunities discovered from the systematic review. Based on the presented areas of accessibility opportunities and goal statements of the heuristics, the goal of the workshop ideate on accessibility solutions that will increase the level of accessibility.

Preparation

Prior to the workshop, a Miro (n.d.) Whiteboard was set up. The authors role for the workshop was to prepare with the material to include content based on the findings from the systematic review. The board included workshop instructions and an overview of the goal statements of the heuristics. Eight frames were created on the board, each filled with sections that included

- Accessibility goal statements - Containing information of what players should be able to do
- Existing features - Capturing the strengths by listing solutions from the games, acknowledging the features that are carried out according to accessibility recommendations and that they should be preserved
- Opportunities - Missing features or unsolved issues with details on the problems and why it is causing players friction

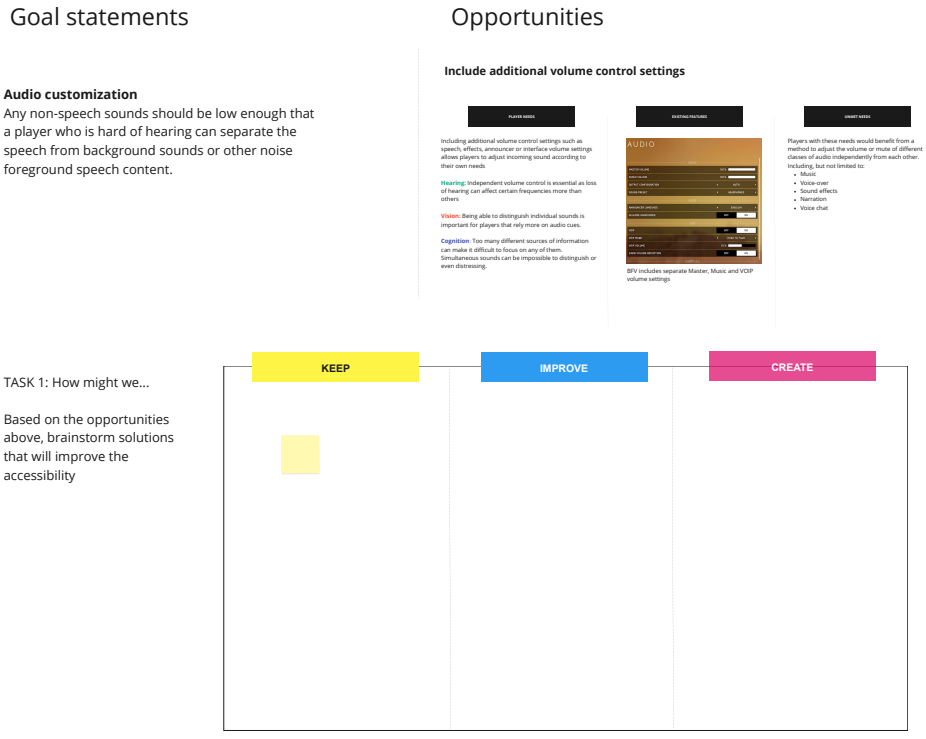


Figure 12. Sample of an empty frame from the workshop

6
Results

This chapter presents the results of the three sections of which the study was divided into to tackle the research problem. The three different sections included *Develop and use a tool to systematically examine the accessibility of shooter games*, *Evaluate the tool by conducting a user study* and *Utilize findings from using the tool*.

6.1 Develop and use a tool to systematically examine the accessibility of shooter games

A systematic review was conducted with the use of two different tools: The Accessibility Checklist, which later evolved into The Accessibility Heuristics. The systematic review was performed on four of the company's shooter titles, to examine the existing accessibility features and to evaluate the usefulness of the tools.

6.1.1 Creating a tool for the systematic review

The Accessibility Heuristics (See Appendix A) is the latest results of an iterative process of developing, evaluating and improving a tool used for systematically examining the existing accessibility features in shooter games. The tool is usable to systematically identify areas where the current features are fully or partially carried out according to accessibility recommendations and to identify areas where barriers may occur, with the potential of partially or fully blocking play for some players.

6.1.2 Performing the systematic review

The method was tested in different scenarios of four different games. Using the method resulted in data containing information on how the current features of the games are implemented in comparison to the recommendations from accessibility research. Areas of strengths and weaknesses could be identified, meaning areas where current features are fully or partially accessible according to the recommendations, as well as areas where barriers may occur, with the potential of partially or fully blocking play for some players. Furthermore, it was established that the potential accessibility barriers could be mitigated by either 1) consistently applying existing features, 2) tweaking existing features 3), or create new solutions. By applying the tool on the company's four different games, differences between the games could be observed. By examining the differences, progress over time could be identified. This helped in examining if there were any improvements from the company's earlier

titles to later installations or if there were any accessible features in the previous games that weren't included in later installations.

6.2 Evaluating the tool - User study

The results from the user study are divided into sections of audio, visual, communication methods, and settings.

6.2.1 Audio

The main difficulties that the participants experienced in terms of perceiving audio are difficulties in hearing speech due to background sounds, music, and effects. The participants felt that the speech often got drowned out by other sounds, both during the narrator speech in the singleplayer level and during announcer speech in the multiplayer mode.
Additionally, the participants often felt that it was difficult to hear anything at all, as too many different sound sources were transmitted simultaneously. During the simultaneous transmission of sounds, the participants experienced that all of the perceived sounds blended together, making it difficult to distinguish between them. As a consequence of the addressed issues, the players felt that they were missing out on information essential to the game, such as storytelling, instructions, and information useful to make informed decisions. The inability to distinguish between different sounds due to noises blending made it difficult to concentrate on the game.

Moreover, it was found that some appreciated the use of audio in the game and found it useful. Participants thought that it contributed to the setting and overall feeling of the game. The speech was easy to hear when there were no other sounds besides speech, or when background sounds are reduced during speech. Background music and effects are appreciated but not during speech.
Participants appreciated the audio use and thought that the information conveyed over audio was valuable. Some thought the audio was more useful than visual cues for localizing danger and when teammates needed assistance. Information conveyed over audio was useful for understanding objectives and the different states of the game.

6.2.2 Visuals

Participants reported that the visuals are their primary means for perceiving what happens in the game, they had a higher reliance on visual cues than audio.
According to the reporting, the visual cues and text were helpful in understanding game objectives. The visual cues were useful for localizing where teammates and enemies. By looking at bullet trails, gunfire, and explosives, the participant got a sense of enemy locations. The map helped to identify objectives, deciding where to go, and to localize enemies.

Figure 13. Screenshot from Battlefield V showing the subtitles during the introduction level.

During the introduction level, the subtitles were useful for perceiving the spoken speech and understanding the story, especially during moments of simultaneous sound usage. Some participants thought positively about the subtitle display when it came to the pacing and placement of the subtitles and thought that the size and colors were clear. The discreteness and the lack of background for the subtitles were appreciated. Some participants thought that they were not intrusive on the gameplay, which allowed them to feel more immersed in the experience, as they only had to focus on the subtitles when speech was not heard.

On the contrary, some participants thought that it was difficult to read the subtitles. Participants felt that it was hard to localize teammates and enemy players and that it was difficult to understand whose team fired bullets. Some participants thought the visual cues on the battlefield were unclear, too small, and unnoticeable.
Furthermore, there were contradicting feelings about the amount of visual aid in the game. Some participants were not optimistic about the idea of more visual cues and thought that the existing visual cues are good enough.
The current visuals were sufficient for being able to identify the objectives and to localize teammates and enemies. The amount of subtitles and how they were presented is satisfactory to be able to understand the story. Some participants had no desire for more additional visuals and felt that more visuals would be too much. They believed that additional visual aid would do more harm than help and cause additional confusion as they experienced that there are already loads of visuals on the screen.

However, some participants wanted more subtitles and visual cues. When it comes

to subtitles, some wanted additional subtitles in Conquest to represent that something is captured rather than having to rely on color alone when they were unable to hear the announcer. Another person felt that they might have missed information as all audio information was not conveyed through subtitles; this made them feel uncertain if they could perceive all necessary information.
Participants thought that it would have been useful if there were subtitles when teammates needed support or request things. Regarding visuals, there was an expressed request for visuals that indicate where enemies are. Not by pinpointing their exact spot but showing where the action is happening within a vicinity. This would with planning the navigation of which areas to go to and areas to avoid.
One participant wanted more descriptive subtitles for non-spoken sounds during the introduction.

6.2.3 Settings

Concerning settings, there appeared to be some settings that participants find especially useful. Some settings are included, while there were some that would have improved their experience if they were in the game.
It was appreciated that the subtitles were enabled by default before any speech started. Participants felt that the subtitles were useful and that subtitles are the most critical feature regardless of the game. Some participants expressed that they would have wanted larger subtitles. In one case, the participant reported that they could not find the subtitle settings, as it was not customizable from the beginning of the game. Furthermore, some participants wanted the option to adjust the text color and add a text background. They stated that this would reduce the required focus for reading the text, resulting in being able to perceive everything.
As speech often was hard to hear, the most requested features for the game were 1. Option for more adjustable volume control settings, mainly separate volume controls for effects and speech. This would enable them to lower the effects volume and keep speech volume up.
Effects were experienced to have a dominant presence in the audio, which drowns out the speech (e.g., engines, bullets, and explosions), making it difficult to perceive spoken sounds. 2. The option to reduce game volume when the narrator is speaking, meaning that all other audio would be dampened during speech.

One participant found it hard to concentrate on the story presented in the introduction, as they could not adjust the game volume before the game started. It was observed that this person was the only participant out of 7 that customized any settings, even though they were made aware that option customization is allowed and encouraged.
Many of the participants exclusively played with headsets, which they felt make the gaming experience more enjoyable. The blocking of ambient noise and the customization and surrounding sound of the headsets contributed to being able to hear more clearly, allowing for better spatial awareness and focus, which provided to the feeling of being immersed in the game.

6.2.4 Attitudes to communication methods

Participants reported that voice communication makes it harder to concentrate on the game. It was stated that voice communication is muted as the information is difficult to perceive, as there are no subtitles.
Those who use voice communication prefer only to use communication if they are playing with people they know, who are aware of their hearing needs. When voice communication happens, they prefer external voice communication software such as Discord and Xbox Live party over in-game voice communication. When they are not playing with people they know, they prefer text and visual communication. Visual communication (ping, tagging) allows more focus on the game rather than trying to figure out what was said.

6.2.5 User study conclusions

It emerged that although all participants have a hearing impairment, their personal experience could differ significantly. Some of the participants did not experience any downsides in the game related to hearing, while some considered it to be troublesome at times.
The result adds to the knowledge of the issues experienced in shooter games by players who are hard of hearing and adds additional validation to some of the guidelines that mitigate the impact of the issues. Regarding audio, the main two issues are that speech can be difficult to hear due to being drowned out by background noise, and it is difficult to distinguish between sounds when too many types of sound are conveyed simultaneously. The information conveyed through speech was useful, and the background music and effects were appreciated, just not during speech.

Similar findings were found concerning the visuals; participants had different opinions and varying experiences. Some participants thought that the current visual cues and subtitles in the game is sufficient and had no desire for additional visuals. In contrast, other participants thought that the current visuals were lackluster and would have wanted more visual cues and subtitles in the game. Some of the additional visuals that the player wanted in the game are already included, meaning that the current visuals may not be as apparent as they would need them to be. One example is that right now, in the game mode Conquest, information about when a base is captured is conveyed through audio. This information is also conveyed through simplified text at the top part of the screen, but not as subtitles. Another example is that the participants would have wanted subtitles for when teammates needed assistance, this information is currently conveyed through text in the chatbox in addition to the spoken sounds and visual icons. The varying experiences of the participants underscore that there is a broad spectrum of disabilities, even for similar types of disabilities, making it unfeasible to create a one-fits-all solution that will cover everyone's accessibility need.
Further investigation is needed to establish if they would have experienced the same issue, given more time familiarizing themselves with the game or if the current visuals need to be enhanced and moved to appropriate areas of the interface. It would have been valuable to add knowledge through the use of methods such as longitudi-

nal diary studies or by including participants with more experience with the game, to explore if they experience the same issues when they have passed the onboarding stage of a game.

In terms of settings, it appeared to be a desire for both already included settings, as well as settings that are not in the game. Players expressed that they would have wanted larger subtitles, and the option to adjust separate volume controls. These are options that to a degree already is included in the game.
This might indicate that the currently available options are unclear, as well as where they can be found.
Besides, there is currently no option to adjust these options before the game starts. This might contribute to the impression of the options not being in the game.
Furthermore, there was a wish for settings not included in the game, for settings related to subtitle display and audio customization. Participants wanted to be able to adjust the subtitles in terms of text color and subtitle background. When it comes to audio customization, the game currently includes separate volume controls for Master, Music, and VOIP volume. The participants expressed a desire for additional volume controls to be able to adjust Effects and Speech volume as well as the option to dampen and reduce all other sounds when speech is utilized.
Moreover, participants expressed that headphones are a useful assisting tool outside of the game, which highlights the importance of headphone optimization in the game.
Regarding player to player communication, the participants expressed a preference of textual or visual communication when they did not play with people they knew.

The result indicates that there are no default settings that will cover everyone's accessibility needs, as the participant's needs and preferences vary, even though they all have a hearing impairment that negatively affects their ability to play. Results suggest that by providing additional options allows for further personal customization. Moreover, by presenting the accessibility settings before any cinematics or gameplay would inform players about existing features and allowing for setting customization according to their needs before anything starts. Leading to less frustration, required concentration, and missing out on important information.

6.2.6 Comparing the findings to the heuristics

By comparing the results to the set of heuristics, it was affirmed that the guidelines address many of issues, some need to be evaluated for further clarity, and some issues are not fully taken into account.

Relevant guidelines from the heuristics that addresses the identified issues from the user test

- *Foreground/background contrast ratio of text is at least 4.5:1*
- *Foreground/background contrast ratio of meaningful graphics are at least 3:1*
- *Subtitles are provided for all important speech*
- *Subtitles are provided for all supplementary speech*

- *Captions or visuals are provided for significant background sounds*
- *Subtitles/captions are presented in a clear, easy to read way (e.g. size, background, line breaks)*
- *Subtitles/captions are cut down to and presented at an appropriate words-per-minute*
- *No essential information is conveyed by sounds alone*
- *All important supplementary information (e.g. the direction you are being shot from) conveyed by audio is replicated in text / visuals*
- *Separate volume controls or mutes for effects, speech and background/music are provided*
- *Key audio is not drowned out by background noise*
- *Both voice and text chat is supported for multiplayer*
- *Visual means of communication is provided in multiplayer*
- *Real-time transcription between speech and text is supported in multiplayer*
- *Details of accessibility features are provided in-game*
- *Accessibility features are easy to find in-game*

Fully addressed by the heuristics

One of the most important features according to the participants is that games should include subtitles. Regarding the use of subtitles the heuristics include the guidelines of *Subtitles are provided for all important speech* and *Subtitles are provided for all supplementary speech*. Furthermore, the appearance of how the subtitles are presented is of importance. The pacing of the subtitles was appreciated by participants, highlighted of the guideline *Subtitles/captions are cut down to and presented at an appropriate words-per-minute*.
As players who are hard of hearing rely more on visual aspects, its important that the visual cues are visible. Some players found the text difficult to read and that the visuals were lackluster or not clear enough. Recommendations by the guidelines suggest the contrast ratio for text (not specifically subtitles) and graphic elements to be at a level suitable for someone with loss of contrast sensitivity by the guidelines of *Foreground/background contrast ratio of text is at least 4.5:1* and *Foreground/background contrast ratio of meaningful graphics are at least 3:1*. Additionally, one participant wanted the game to include more audio descriptions in the subtitles. This is addressed by the guideline *Captions or visuals are provided for significant background sounds*, which also emphasizes that important sounds can be conveyed by other means than captions by using visuals.
According to the participants the visuals are the primary way that they perceive information in games, besides the previously mentioned features guidelines also suggest that all important information conveyed through audio also is conveyed through visuals by the guidelines of *No essential information is conveyed by sounds alone* and *All important supplementary information (e.g. the direction you are being shot from) conveyed by audio is replicated in text / visuals*.

In regard to perceiving sounds, the most common issue is that speech is not heard due to background sounds and that too many different sources of sound are transmitted simultaneously, making it difficult to focus on any of them. Solutions that address

these issues are addressed by the guidelines of *Separate volume controls or mutes for effects, speech and background/music are provided*, and *Key audio is not drowned out by background noise*

Participants reported that they only use voice chat while communicating with people they know, often because they cannot perceive the information transmitted through voice communication. Alternative communication methods are suggested in addition to voice communication by the guidelines of *Both voice and text chat is supported for multiplayer*, and *Visual means of communication is provided in multiplayer*. It was also reported that the voice communication is not used as it is not supported with subtitles, as a way to address this issue is suggested by the guideline of *Real-time transcription between speech and text is supported in multiplayer*.

Partially addressed by the heuristics

Players expressed different preferences and needs concerning how subtitles should be presented. Some wanted larger text, while some thought that the current size is good. Some wanted a background for the text, while some appreciated the discreetness of the text display. One of the guidelines that partially addresses this is *Subtitles/captions are presented in a clear, easy to read way (e.g. size, background, line breaks)*. Players with other types of disabilities are likely to have different needs; a suggestion to better cater to the different needs is to rename the existing guideline or add a new one guideline such as "A choice of subtitle text color / size / background styles are provided".

Participants wished for accessibility settings that are currently existing in the game, meaning that current settings are not presented clearly enough. As well as a desire to be able to adjust the settings before any cinematic or gameplay starts. Two guidelines partially address the importance of the ease of access and visibility of the included settings. The guidelines are *Details of accessibility features are provided in-game*, and *Accessibility features are easy to find in-game*.
A suggestion to improve the guideline of *Details of accessibility features are provided in-game* is to clarify what is suggested by adding examples "Details of accessibility features are provided in-game (e.g. through hints and loading screens)", as well adding a new guideline of "The settings include a separate Accessibility section."
To address the issue of being not being able to adjust any options before any cinematic or gameplay starts, a new guideline is suggested to get added of "Accessibility settings are available before any cinematic or gameplay starts at the first launch of the game"

Unaddressed by the heuristics

Furthermore, the participants reported using headphones exclusively while playing games. Right now no guideline addresses the used audio hardware; a suggestion is to include a guideline of "Include audio settings optimized for headphones" placed under the Heuristic of "Support for assistive technologies" with the goal statement of "Players can easily find accessibility features and use assistive technologies of their

preference."

6.3 Utilize findings from using the tool

Two approaches were explored to investigate how the results from using the tool can continue after the analysis, by examining how the findings can be utilized and communicated to developers, and to test how they fit in a design process to establish requirements and define user needs and problems, which in turn can be used to generate ideas and solutions that solve the defined issues.
This resulted in that a report was produced and sent out within the company to communicate the findings of the analysis. The report was presented at two times, in a 30-minute presentation format.

Furthermore, this also resulted in that a workshop was conducted to follow up on the report's findings. The workshop lasted for 3-hours and was conducted remotely by using the digital tools of Zoom and Miro. Game developers were involved during the workshop to ideate to create accessibility solutions based on the opportunities presented from the findings from the systematic review. The workshop participants could ideate on presented opportunities, which suggests that the findings from the accessibility workshop can be used in a design process for defining problems, which in turn can be used for generating ideas on improving accessibility.

7
Discussion

The work of this thesis resulted in a tool usable to evaluate a game's accessibility features. The tool is applicable to systematically identifying unaddressed areas where barriers may occur for players with disabilities, identifying areas with existing solutions, and ensuring consistent solutions throughout the game. In this thesis, the tool was tested by examining the accessibility of four shooter titles from the video game developer EA DICE. The analysis resulted in information on how current features of the games are carried out in comparison to the recommendations from accessibility research.

A user study with users who are hard of hearing was conducted to evaluate parts of the tool. By comparing the results of the user study to the accessibility heuristics, it was discovered many of the areas that cause experienced issues could be identified by comparing the game to the tool's guidelines. Some guidelines require further evaluation to address the causes of issues more accurately, and for some issues, additional guidelines are required to address fully address the cause of the issue. Furthermore, the user study results add to the knowledge of the types of barriers experienced by the user group.
The findings from using the tool were compiled into a report presented for developers within the company as an approach to explore how the findings can be communicated from researcher to game developers. The report contained information about what accessibility is and its importance while also including information about the games accessible implementations, and provide opportunities for improving accessibility.
To further explore how the accessibility opportunities could be followed up, a three-hour workshop was conducted. Developers participated to ideate for solutions that address the accessibility opportunities.

7.1 Process

The author suggested that although progress has been made within gaming accessibility research, further development is required for a comprehensible and developer-friendly tool that is useful during the development process to validate the game's designs throughout the game, where the findings are usable in order to improve the accessibility of the game. A research question was raised to address this issue:
How can the accessibility for modern shooters be improved through the use of a tool that systematically examines the designs of a game?

To address the research question, the work was divided into three sections.

- Develop and use a tool to systematically examine the accessibility of shooter games
- Evaluate the tool by conducting a user study
- Utilize findings from using the tool

7.2 Develop and use a tool to systematically examine the accessibility of shooter games

The review resulted in that two tools that were used to explore accessibility features systematically. The first tool consisted of an accessibility checklist where features in the game were investigated and compared to the recommendations provided by previous accessibility research. This resulted in a list of current accessibility features that are in the game, how they are implemented, as well as identifying areas where there is no current implementation.
By analyzing the findings, it was established that the tool was insufficient for examining the game's accessibility features and that there is a need for a more comprehensive tool.
The accessibility checklist worked to examine some of the features, primarily if the feature only is carried out once in a game, such as investigating if the options menu includes a specific setting. However, with this approach, it would be difficult to determine if a feature fulfills the criteria or not in some areas. Such as features that are not consistently applied in the same way throughout the games, e.g. if the text size uses a large accessible text size in some parts of the game, but a small text size on other areas. Would this mean that the feature fulfills the criteria or not?
When looking at accessibility features through the use of a checklist of features that should be included in the game, developers may find it difficult to understand why the features should be included as the feature may be too abstract to be put into the context of the game. Designers may intuitively not understand why something may be an issue. By taking a more user-centered approach through the scenarios, it would be easier to follow a user experience flow and to understand how issues may occur, making the experience more relatable for a designer.

The Accessibility Heuristics is the result of establishing a more comprehensive tool for examining accessibility features in games. Rather than just checking off features from a list, the accessibility heuristics aimed to take a more user-centered approach by examining the game from the user's perspective, by applying the heuristics to specific scenarios of user flows of a game. The findings from using the heuristics provide added detail to where and why in a user flow that barriers can occur.
By using the heuristics in different user flows the game, the outcome resulted in identifying areas of strengths and opportunities for improvement. The strengths can hint that the current feature should be preserved, and the opportunities imply that the current feature requires additional development to improve the accessibility of the feature. The insights from the findings can be used to put the features into a context, presentable for designers, which can lead to accessibility improvements.
This means that the tool is usable to identify areas where the current features are fully or partially carried out according to accessibility recommendations. The tool also identifies areas where barriers may occur, with the potential of partially or fully blocking play for some players. The identified potential accessibility barriers provide a means of evaluating a missing feature's potential impact, which opens up for the opportunity to develop a feature that solves, mitigates, or provides a workaround for the barrier. Furthermore, by analyzing where in the task flow that issues occur, it was discovered that the potential accessibility barriers could be mitigated by either 1) consistently applying existing features, 2) tweaking existing features , or 3) create new solutions. For instance, an example of an issue that can be mitigated by consistently applying existing features is that the games include toggle alternatives for actions that require button holding, but this is not offered for all the actions that require button holding. An example of an existing feature that requires tweaking is the subtitle sizing; even at the largest size setting, the size is at 40px at 1080p and not 48px, as recommended by the heuristics. A feature that needs a new solution means issues that are currently unaddressed.
The different ways of mitigating the barriers indicate that not all barriers are caused by missing features; in many cases, there are simpler solutions for creating accessibility designs. The result highlights the need for a process that not only evaluates if the accessibility feature is implemented or not but also for identifying areas where smaller changes can be made in order for the feature to be carried out according to the recommendations of accessibility guidelines.
By applying the tool on the company's four different games, differences between the games could be observed. By examining the differences, progress over time could be identified. This helped in examining if there were any improvements from the company's earlier titles to later installations, or if there were any accessible features in the previous games that weren't included in later installations.

One of the aims of the accessibility heuristics is that they should be usable by game developers in order to examine the accessibility features of their game, as well as a way to raise thoughts of the actual accessibility needs that players with disabilities have, by providing clear points of software solutions. The results of utilizing the findings from the review demonstrate some of the approaches of how the heuristics can become incorporated into the design process, through the insights that the find-

ings provide as well using the findings for preparation of material for an ideation workshop for accessibility solutions.
The tool can be used to inspect how well current features are carried out according to recommendations, to examine if there are areas accessibility has not been addressed and where barriers may occur. It can give some indication of an overall assessment of how well current solutions are carried out, and guidelines with a known positive impact for disabled players according to recommendations from accessibility research. However, using the heuristics and having all of the criteria fulfilled is no guarantee that the game is universally accessible.

7.3 Evaluating the tool - User Study

By comparing the results to the set of heuristics, it was discovered that the guidelines address many of the issues, some need to be evaluated for further clarity, and some issues are not fully taken into account.

7.4 Utilize findings from using the tool

The findings from the systematic review were followed up and presented within the company by a readable report and two presentations. In the presentation, different opportunities were presented with areas where accessibility can be improved. As a follow up to the accessibility opportunities, a workshop was conducted with the goal of generating ideas for solutions that address the opportunities.

The report, presentations, and the workshop were the result of exploring how the researcher can communicate the findings from the systematic review to developers and how the findings can proceed after the analysis. It was found that from performing the systematic review and from the user study that many of the issues experienced by participants are addressed by the guidelines with suggestions on how to mitigate these issues.
This opens up for the possibility of incorporating the use of accessibility heuristics in a design process.

By applying the accessibility heuristics, the tool can be used during the design process to validate if the current implementations are carried according to the accessibility research recommendations. Meaning that the tool can examine if the implementations are fully carried out according to the recommendations or if there are heuristic violations where changes are required to accomplish that. Changes that require either consistently applying existing features, tweaking existing features, or creating new solutions (See Figure 14.).

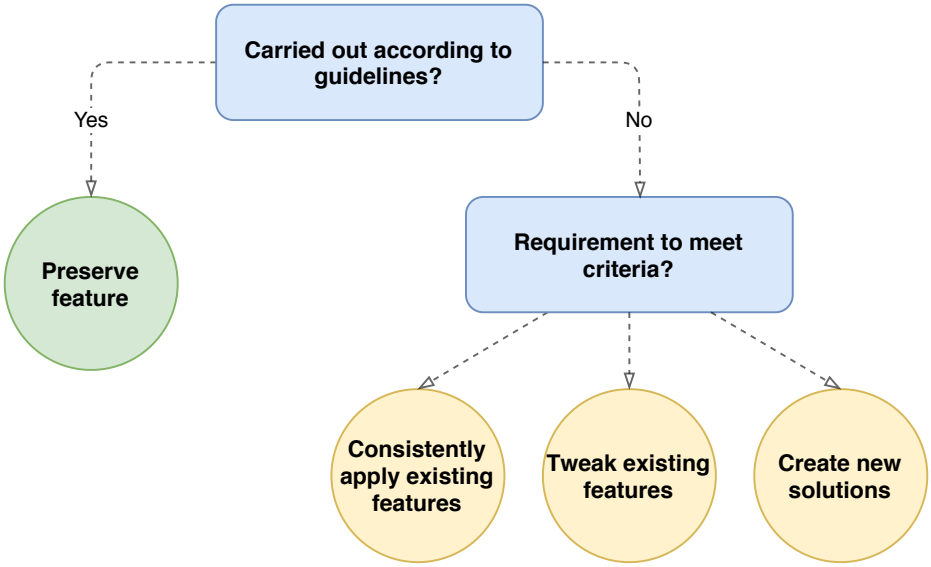


Figure 14. Use of accessibility heuristics to compare current implementations to accessibility recommendations

The workshop was conducted to examine a procedure to follow up on the identified opportunities discovered from the heuristic violations. This suggests that in a design process, using the heuristics are applicable for defining problems that need to be addressed and to ideate solutions that solve these problems. By addressing the issues and implementing solutions known to have a positive impact before involving users can, therefore, be helpful for improving accessibility.

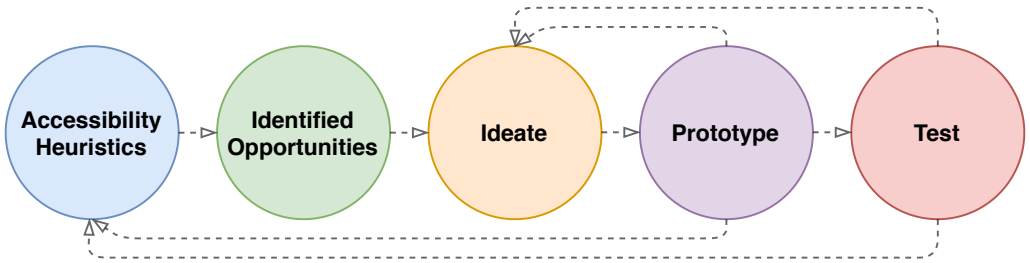


Figure 15. Suggested use of the accessibility heuristics in a design process

Ideally, as previously mentioned, the involvement of people with disabilities is essential for creating proper solutions. However, being able to involve and find people with disabilities for playtesting may be difficult. By implementing features that are carried out according to accessibility research, some unnecessary barriers can be avoided. The heuristics can contribute to compare the current implementations to the recommendations from accessibility research.

7.5 Contributions

Related work demonstrated that accessibility is a challenging design problem as someone who is non-disabled cannot fully grasp what playing games is like for someone with a disability. Academic and community research has been undertaken to address the accessibility needs in video games for people with disabilities. The related work is available in academic papers, different online resources and guidelines usable by game developers improve the accessibility of their games.
The existing research can be overwhelming to grasp because of the format of academic research and the widespread accessibility solutions in different papers, as well as the widespread of online resources. While the guidelines provide a more compact source of information, guidelines are often ignored and not understood as they are too abstract to put into a context, and require a subjective judgment for validating the designs. There are also checklists, usable for objectively validating the designs, which is valuable for examining features that are only implemented once in a game. However, the checklists can be insufficient to use for examining if the working designs are consistently carried out throughout critical paths of a game.
Previous work can also be excessive developers of shooter games, as the guidelines include solutions for a wider variety of genres that includes guidelines that are not applicable to their game.

The work of this thesis contributes to the knowledge of how accessibility can be improved for shooter games, through the use of a tool that systematically examines the designs of a game, through the development and use of a set of accessibility heuristics that contains 59 guidelines in 12 categories. The heuristics were developed to be usable and comprehensible for a developer of modern shooter games as the heuristics went through several iterations of evaluating and improving in order to be selective of including shooter specific guidelines used to evaluate designs objectively. To address the issue of guidelines being too abstract to be put into a context, the work demonstrates that by taking a more user-centered approach, the findings indicate where issues may occur and why for players with disabilities. The user-centered results can, in turn, make it easier and more relatable for a designer to understand why and where the features are used. In addition to the development and use of the heuristics, it was demonstrated that the findings of the heuristics are usable in a design process to identify where improvements can be made. The work contributes to the validation of some guidelines through the empirical evaluation of involving players who are hard of hearing.

7.6 Process reflection and ethical considerations

Being able to conduct the work at the company was valuable for the thesis, as it made it possible to bridge the academic work to the industry and to perform the work in a real context where games are made. The involvement of game developers and researchers within the company for parts of the process provided valuable insights for the work. The insights from performing the work at the company are less likely to have been achieved if the work had been carried out independently without a close connection to the industry.
The user playtest session was initially planned to be held at the company's office in Stockholm. Due to the COVID-19 situation, this was no longer possible, and the plans had to be changed. The playtest sessions then changed to be held online over Zoom and on the participant's computer. However, this turned out to have positive effects for the user group of people who are hard of hearing.
Being able to communicate over Zoom worked well without any significant friction. The participants were able to see the researchers face, while also being able to read the live-transcript in Zoom.
Furthermore, being able to conduct the playtests remotely allowed participants from different locations to be able to join. In the sessions, participants from all over Sweden and the United Kingdom were able to participate. Finding participants with different disabilities can be difficult, and in this case, being able to involve participants outside of the Stockholm region is likely to have helped with finding participants.
In a survey sent out to the participants after the playtest, it was reported that the captions during the Zoom-call were appreciated and that they probably would not have attended the playtest if they had to go to Stockholm. Remote playtesting worked for this work with people who are hard of hearing participated. Further investigation would be required to investigate how remote testing would work with players with other types of disabilities.
When conducting a qualitative research study with users with disabilities, there are additional ethical matters that need to be taken into consideration. As always, in qualitative research, there are standard ethical guidelines for ensuring privacy and anonymity, providing informed consent, and not causing any harm to the participants (Lichtman, 2012).
Empirical studies with players with disabilities the participant's disability need to be taken into account when designing the study, as well as attempting to make the study itself to be as accessible as possible. For instance, if participants with photosensitive epilepsy were to participate, the tests should be designed to minimize the risks of triggering a seizure. If participants that are deaf or blind are to participate, then it is necessary that instructions are conveyed in a perceivable way. This includes consent form and information about the study itself to ensure that, for example, the participants know that participation is voluntary and that they are free to cancel the study at any time. Furthermore, concerning ethical considerations, game developers also have some ethical responsibility for players of their games. Besides making the games more accessible to play, the players should not, for instance, experience pain from unconfigurable control schemes or have an epileptic seizure

triggered by the visual effects. There is an ethical responsibility to include gamers with disabilities during the development process as someone with a disability is best suited for stating their needs, and that the designs for the intended target group should not be carried into effect without representatives of gamers with disabilities, as suggested by "Nothing about us without us"

In the original plan of the thesis, there was no intention of conducting a workshop and involving developers more than raising awareness by presentations and reports. The original plan was to conduct a competitive analysis that addresses opportunities discovered from the systematic review by investigating how other modern shooters address the issues where the results were presented in a second report. The change of plan was mainly due to a couple of reasons. The original plan might have been too time optimistic and ambitious for the time frame of the project. In retrospect, trying to fit a competitive analysis between the systematic review and user study would possibly have reduced the quality in all areas, as the phases would have had to be rushed in order to be completed in time.
Developing the tool for the systematic review and applying it to the four different games and the specified user scenarios required more time than anticipated. During the systematic review, it was discovered that the first tool (accessibility checklist) was insufficient for effectively examining the accessibility of games. The insufficiency of the first method meant that there was a need to evaluate how the first method could be improved, create a better version, and conduct an additional systematic review. The author thought that it would be more interesting to elaborate on the development of the heuristics rather than to rush into another phase included in the original time plan.
Participants of the presentation of the findings showed a strong interest in accessibility after the presentation. The interest opened up for an opportunity to evaluate the heuristics in a development context and find out how the findings could be used to generate ideas in a design process. This was not something planned, but it gave a valuable opportunity to strike while the iron was hot.

Changing the plans might have turned out for the better as the workshop engaged developers in solving the problems that were addressed by allowing them to follow up on the information from the presentations by turning the findings and knowledge into practice rather than just watching a presentation. The goal of the was to find solutions, but this approach also turned into a means of engaging designers. The workshop was conducted remotely by using the collaborative tool Miro, which turned out to be a fitting substitute for conducting a real-life workshop.

7.7 Future work

Further evaluation of the accessibility heuristics would be necessary. Firstly by going through the naming and descriptions of the heuristics, goal statements, and checklist items. To ensure that it is clear enough and that its understandable of what they are trying to convey. To go through the placement of the items to investigate that they are placed under the most suitable heuristic. The use and content of the heuristics must be clear enough to be understood, as the intent is that they should be able to be used and applied to a game by game developers, even though they may lack knowledge about accessibility and what good accessibility is.
To further establish if the tool is usable, testing is required with developers, who are the actual users of the tool. By involving developers, the accessibility heuristics can be evaluated to examine if the guidelines are understandable and if its understood how they should be applied in a game, and how the findings can be interpreted. Furthermore, the content of the heuristics needs evaluation to examine if there are additional essential accessibility recommendations that could be included. For a shooter game, this could include examining and providing useful guidelines of the importance of being able to hide visual elements, the impact of tactile feedback from controllers, or visual recommendations for what is required for an enemy player to pop out from the background. Evaluation of the heuristics should also include reviewing if there are required changes to the current guidelines, for instance, if there are checkpoints that need to be expanded into several checkpoints or if guidelines should be more concrete. As discovered in the user study, further evaluation is required to address the experienced issues fully. The rating section in the heuristics that states the severity of the heuristic violation needs to be re-evaluated or removed. It was discovered while doing the work that it is not possible for a researcher to establish if a heuristic violation is severe or not for all players, as everyone's accessibility need and the causing issues can vary significantly. As seen in the user study, the experiences varied largely, even though all of the participants had a hearing impairment. The involvement of accessibility and usability experts would be beneficial to review the validity, content, and usefulness of the heuristics.

Many of the accessibility solutions have been tested in empirical studies from previous research. Further research is required for validating all of the guidelines by conducting more user tests with people with a larger variety of disabilities as well as a larger sample size of users. In this study, the user test adds knowledge to the subject of the experiences of people who are hard of hearing in shooter games.
However, the user study only consisted of one game and two game modes, and a small sample size of participants with similar types of disabilities. Additional research is required to validate further the use of the heuristics and the potential generalizability of its use in shooter games. Even though the heuristics were applicable to the four types of games and their game modes, it does not mean that they would work for all shooter games. The tested games have similar mechanics and dynamics, making them easily comparable to the heuristics. Additional tests with other types of shooter games with different elements are required to review the generalizability of the tool.

The use of guidelines can be used in a process to design accessible features before the involvement of actual users to identify where common accessibility issues can occur in the designs. The tool is applicable during development, together with other appropriate tools to test designs, tools that are helpful for designers in verifying that their designs are accessible. Coblis (*Coblis - Color Blindness Simulator,*, n.d.) is a software that simulates the most common types of color blindness by applying a filter over the screen. Tools such as WebAIMs Contrast Checker (*WebAIM: Contrast Checker*, n.d.) can be used to check if the contrast ratio between the background and text or graphical elements is at an accessible level. Another method to investigate where problems may occur for deaf or hard of hearing players is to play a game without sound or in a noisy environment, to investigate if the game is playable without sound.
Even though the guidelines and simulating the impairments can help validate the design, they are not a replacement for including actual users.

8

Conclusion

This research aimed to explore how accessibility can be improved for shooter games, by addressing the information gap between accessibility research and game developers. This raised the research question of *How can the accessibility for modern shooters be improved through the use of a tool that systematically examines the designs of a game?*

The work was separated into three sections with different goals to address the research questions: 1. Develop and use a tool to systematically examine the accessibility of shooter games. 2. Evaluate the tool by conducting a user study 3. Utilize findings from using the tool.
The result ended up with the Accessibility Heuristics, a tool tested on four different games. The outcome concludes that the tool could be used for identifying unaddressed areas where barriers may occur for players with disabilities and identifying areas with existing solutions. To further evaluate the tool, a user test was conducted with users who are hard of hearing to evaluate parts of the tool. By comparing the results of the user study to the accessibility heuristics, it was identified that guidelines from the tool address many of the experienced issues. Some guidelines require further evaluation to address the issue more accurately, and for some issues, additional guidelines are required to address the issue fully. Furthermore, the research explored the possibility of incorporating the tool in a game development process by compiling the findings from the review into a report and presentations, as well as conducting a workshop.

The work of the thesis adds to the knowledge of the usage of a tool to systematically examine the accessibility features of shooter games, in which the outcome can be used as a part of the design process to ensure higher accessibility in the games, by addressing the current features and areas where the accessibility can be improved. Furthermore, the user study adds to the knowledge of barriers experienced in shooter games by players who are hard of hearing.
Future research is required to examine the validity, content, and usefulness of the tool.

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Appendix A
List of Accessibility Heuristics

Text display, language and readability
Content in the game can easily be read and understood by players of the game

- Easy to read, sans serif font is used
- Text consists of mixed upper lower cases rather than all caps
- Line-spacing set to at least 1.5 in paragraphs with around 70 characters per line
- A easily readable default font size is used (28px+ for UI text, 48px+ for subtitles at 1080p)
- Simple clear language is used
- Text prompts can be progressed through at the players own pace

Contrast and legibility
Text and other meaningful information can be easily distinguished and read by players of the game

- Foreground/background contrast ratio of text is at least 4.5:1
- Foreground/background contrast ratio of meaningful graphics are at least 3:1
- Essential information is conveyed by means other than just color alone
- Adjustable UI colors
- A choice of cursor / crosshair colours / designs are provided
- Essential temporary information is placed inside the player's central visual field

Subtitles and captions
Players should be able to understand everything that is taking place in a game if they have difficulty hearing including full motion videos (FMVs), in-game non-player chatter (NPCs), and important audio cues

- Subtitles are provided for all important speech
- Subtitles are provided for all supplementary speech
- Captions or visuals are provided for significant background sounds
- Subtitles/captions are presented in a clear, easy to read way (e.g. size, background, line breaks)
- Subtitles/captions are cut down to and presented at an appropriate words-per-minute

- No essential information is conveyed by sounds alone
- No essential information (especially instructions) is conveyed by text alone
- Textual information is reinforced with visuals and/or speech
- All important supplementary information (eg. the direction you are being shot from) conveyed by audio is replicated in text / visuals

Sensory overload, photosensitivity, simulation sickness and PTSD
Aspects of the game that move or flash, or animate in other ways should be limited, adjustable and/or stopped. Playing the game should not harm the players

- Adjustable camera motions (e.g. motion blur, screen shake, head bob)
- Adjustable field of view (for 3D games)
- No flickering images and repetitive patterns
- An option to disable blood and gore is provided

Input - Interaction methods and modalities
Players can efficiently interact with the game using the input method of their choosing (i.e. mouse, keyboard, joystick)

- Controls can be remapped/reconfigured
- Controls are remappable/reconfigurable before the game starts
- Keyboard/Gamepad inputs are fully reconfigurable, including menu access
- Includes options to adjust the sensitivity of controls (analog settings)
- Player is not required to quickly repeat inputs (button-mashing / quick-time event)
- Player is not required to hold down inputs
- Precise timing events are not essential to gameplay
- Controls are not unnecessarily complex by default

UI navigation and handling
Players are provided with clear, consistent navigation through the game experience. Including navigation with assistive technologies and/or alternate input methods to navigate the UI.

- All areas of the user interface can be accessed using the same input method as the gameplay
- Interactive elements that require accuracy (eg. cursor/touch controlled menu options) are stationary

Audio customization
Any non-speech sounds should be low enough that a player who is hard of hearing can separate the speech from background sounds or other noise foreground speech content.

- Separate volume controls or mutes for effects, speech and background/music are provided

- Key audio is not drowned out by background noise

Communication experiences
Players with disabilities must be able to communicate with one another in games that support multiplayer communication

- Both voice and text chat is supported for multiplayer
- Visual means of communication is provided in multiplayer
- Real-time transcription between speech and text is supported in multiplayer

Memory
Players should be able to access reminders through UI, providing controls and summaries of any game-specific mechanics, or actions covered in tutorials be accessed at a later date

- Reminders of controls are indicated during gameplay
- Reminders of controls are accessible during gameplay
- Game objectives are accessible at any time during gameplay

Tutorials and practice
Players are offered an option/tutorial mode that allows for failure, in which players can practice at their own pace

- Includes a means of practicing without a permanent fail state
- Player can focus on practicing specific skills or aspects of the game
- Players can access the training mode at any point
- Includes contextual in-game help/guidance/tips
- Tutorial information is provided through multiple modalities - static visuals, animated visuals, and/or audio

Game difficulty
Players can enjoy and complete the game experience regardless of their skill level and/or various physical, cognitive, or sensory capabilities.

- A wide choice of difficulty level is offered
- Difficulty level can be altered during gameplay (either through settings or adaptive difficulty)
- Gameplay difficulty can be fine-tuned by various variables (e.g. fine-tuning difficulty options by customizable enemy perception, HP regeneration, footstep noise)
- Means to bypass gameplay elements that aren't part of the core mechanic are offered, via settings or in-game skip option
- Includes assist modes such as auto-aim and assisted steering
- All settings are saved/remembered

Accessible feature documentation

Players can get a sense of whether a title will be usable for them before they purchase it as well as be provided with support and guidance for the included accessibility features once the player has purchased the product

- Details of accessibility features are provided on game packaging and/or website
- Details of accessibility features are provided in-game
- Accessibility features are easy to find in-game

Support for assistive technologies
Players can easily find accessibility features and use assistive technologies of their preference.

- The game supports simultaneous use of input devices (e.g. use a gamepad and keyboard simultaneously)
- Player can use Windows On-Screen Keyboard while playing the game [PC]
- Screenreaders are supported [PC]