Exploring Accessible Design for Immersive Environments

GDEV60001 GAMES DEVELOPMENT PROJECT

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0.0 Abstract

Approximately 1 in 3 adults in the UK have some form of hearing loss, making up a significant portion of the population. Despite this, video game accessibility for hearing-impaired users is still somewhat lacking, with the accessibility features implemented often taking away from the overall immersion and enjoyment of the game.

This research paper explores some of the different accessibility features often implemented in modern video games, including subtitles, visual indicators, and the purpose of different visual design features to help set the tone for users without access to game audio. It then investigates how those features work to support the experience of hearing-impaired players, and the effect that each feature has on the overall video game experience for both hearing and non-hearing players.

As a part of this research, an artefact was created in the form of an arcade-style video game in order to test a variety of different methods that can be used to support hearing impaired users. This artefact was then tested with a number of play-testers in a variety of different configurations, both with and without audio, in order to gauge which features performed best, and led to the most enjoyable game experience for each group of players.

Overall, this study found that users with access to audio tended to perform better than those without, even with a variety of accessibility features implemented – however, this divide was not as pronounced as expected, and users with no audio but access to effective accessibility features would often perform better than users with audio alone. It also found that some immersion could be comfortably sacrificed in order to better support players, and that doing so would increase the overall enjoyment of the game.

1.0 Introduction

According to the UK Disability Statistics Research Briefing, published to the House of Commons Library on October 2nd 2024, approximately 16 million people in the UK have some form of disability – around 24% of the total population. Within this number, approximately 12% report hearing impairments, and a similar number report vision impairments. In almost all cases, these percentages increase with age – for instance, only 5% of children with disabilities report hearing impairments, compared to 22% of pension-age disabled adults. (Kirk-Wade et al., 2024)

As games become increasingly popular, it is more important than ever that games developers focus on improving accessibility for their users. According to data from the OFCOM Online Nation Report in 2023, approximately 56% of UK adults over 16, and a staggering 91% of 3-15 year olds, state that they play video games in some form (Online Nation 2023 Report, 2023). Considering these statistics, it is safe to say that games have become an increasingly important part of peoples childhoods and overall lives. As well as this, modern games are far more social than they were in previous years – increasing the impact of exclusion due to unmet accessibility needs. (S. L. R. Anderson & Schrier, 2022)

Accessibility within games has improved significantly since games first became popular, and continues to improve with time, due to the introduction and successful uptake of adaptive controllers, the advancement of technologies such as Virtual Reality, the growing understanding of disabilities and the increased awareness of the importance of providing accessibility features within games. However, there is still a significant progress to me made in this field, in order to provide a gaming experience for people with disabilities that matches the experience of able-bodied gamers,

with many commonly applied accessibility features feeling distracting and out of place, appearing unnatural and taking away from the overall immersion of gameplay.

This project intends to explore the varying methods for increasing accessibility for users with hearing impairments currently employed within the games industry, how those accessibility modifications impact gameplay for both abled and impaired players, and potential future improvements that could be made to current methods to improve accessibility for people with accessibility needs, with a minimal impact on gameplay and immersion.

2.0 Aims and Objectives

2.1 Aims

This project aims to explore potential methods to increase accessibility for players with auditory impairments. It should investigate the various methods commonly used by games developers in order to guide the player, set moods and tone, and inform the player of situational changes. It should also evaluate how these methods may be modified in order to better meet this aim. These methods should be capable of providing a game experience for players with hearing impairments that matches, as closely as possible, the experience of their hearing counterparts, while maintaining game feel and design integrity. It should not impact the gameplay where possible, either in a positive or negative fashion. A large focus should also be placed on maintaining immersion.

The methods studied should be unobtrusive where possible, capable of being used by hearing players without detracting from their overall game experience, becoming distracting or feeling out of place. The focus should be on how accessibility can be built into the games from the start of development, rather than being added at the end of the project as an afterthought – and how doing so can improve the experience for both abled and impaired players.

2.2 Objectives

In order to achieve this projects aims, an artefact will be constructed to test the researched methods. Some of the objectives for this project are outlined below;

- Research different forms of disability, focussing on hearing impairments
- Explore how hearing impairments affect how players interact with games
- Investigate common methods for increasing accessibility in games
- Research how these different methods increase accessibility
- Explore the various shortfalls of current accessibility methods
- Research how accessibility might be improved in games
- Apply the research in order to create a simple game artefact utilising a variety of accessibility methods
- Test the artifact with the help of external testers
- Evaluate the usefulness of the methods and how their application effected how users interacted with the artifact

3.0 Literature Review

3.1 Types of Disability

3.1.1 What is Disability

Under the UK Equality Act 2010, a disability is defined as a *'physical or mental impairment that has a substantial or long-term adverse effect on a persons ability to carry out normal day-to-day activities'* (Equality Act 2010; Chapter 15: Section 6, 2010). It is estimated that approximately 24% of the population in the UK have some form of disability, with the prevalence rising depending on age – approximately 11% of children and 23% of working-age adults, jumping to 45% of adults over the state pension age (Kirk-Wade et al., 2024).

We can also see that the prevalence of disability has increased consistently over the past few years, with the largest increase shown in people between the ages of 16 and 24 - increasing from approximately 8% in 2012, up to 17% in 2023 (Kirk-Wade et al., 2024). Within these numbers, there are many different types of disability to consider in regards to accessibility in games. Some of these categories will be expanded upon below.

3.1.2 Dexterity

Of disabled people in the UK, 25% report disabilities affecting their dexterity. (Kirk-Wade et al., 2024). These disabilities can make tasks involving small or precise movements difficult, and, in regards to video games, may mean that players with these disabilities may be unable to use traditional input devices, or may find these input devices incredibly difficult to use. (Yuan et al., 2011).

For this category of players, it is incredibly important that video games implement the ability to re-bind the control scheme, in order to support alternative control schemes or input devices that may better suit their individual needs. (Brown & Anderson, 2021). They can also be better supported by allowing them to change certain settings within the game – for instance, the sensitivity values for movement or turning – or, by allowing them to disable certain game elements – for instance, game sequences that involve quickly or repeatedly pressing keys. Doing so can make interacting with the game easier, and can make the difference between a game being an enjoyable experience, or entirely inaccessible to groups of users.

3.1.3 Memory

16% of disabled people in the UK report a disability affecting their memory (Kirk-Wade et al., 2024). Players with these conditions may struggle with remembering controls, or objectives, and they may need additional assistance recalling and navigating game environments (Yuan et al., 2011).

The ability to check controls easily, check objectives, and access a map can be incredibly helpful for these players, as it allows them to refresh their memory without breaking immersion entirely by needing to check information externally. Regularly restating important information can be incredibly beneficial as well, as it removes the requirement to check at all – significantly improving the game experience. This can also be beneficial for users without impairments, as it can make games easier to pick back up after a period of time away from it.

3.1.4 Vision

Approximately 12% of people who report a disability state that they have a vision impairment – however, this number is only representative of those that self-identify as having a disability, and does not include the percentage of individuals that do not consider themselves as such. (Kirk-Wade et al., 2024). Here, 'Vision impairment' can include poor vision, short or longsightedness, any form of

sight within the wide spectrum of blindness, or colour blindness. Players with these impairments may struggle with a wide variety of difficulties affecting their game experience; they may, for instance, struggle to see important game elements on the screen, be unable to clearly differentiate between enemies and team-mates or friendly characters, or be unable to read elements within the game. These effects are often more prevalent in games where the users do not have time to closely study their surroundings before reacting – such as first-person shooter titles.

The most common, and seemingly most effective, methods to increase accessibility for these individuals include the addition of audio descriptions and read-outs, which provide users with a description of environments, visual elements, or read out text; high contrast modes, which add an overlay to games, clearly marking important objects with bold, vibrant colours – using different colours to designated friendly characters, enemies, or important items; designs that take potential colour blindness into account (for instance, adding clearly identifiable symbols to objects that would normally only be differentiated by colour); and, the ability to resize game elements – especially UI and text. (Brown & Anderson, 2021)

3.1.5 Hearing
12% of people in the UK that report being disabled report having a hearing impairment. (Kirk-Wade et al., 2024). This report, however, does concede that – due to the way the question is asked – not all people who are legally disabled will be included, as they may not consider their condition to have a current high impact on their day-to-day activities (Kirk-Wade et al., 2024). RNID, a charity in the UK that supports people who are deaf, have hearing loss, or tinnitus, states that 1 in 3 adults in the UK – approximately 18 million people – have some form of hearing loss or tinnitus. The prevalence of hearing loss also increases with age, up to over half of the population in people aged 55 or more, increasing even further to 80% in people over the age of 70 (*RNID; Information and Support: Hearing Loss*, 2024).

This information really shows the particular importance of accessibility for people with hearing loss, especially as the population of people playing games gets older. It also demonstrates how large of a percentage of people may be unable to engage with video games like their peers, or who, at the least, may find themselves at a discouraging disadvantage.

Throughout this study, I will be looking at how individuals with hearing loss are affected in terms of their accessibility to games, and the methods that games developers currently employ to improve access for these individuals.

3.2 What is Accessibility?
3.2.1 Accessibility in General
'Accessibility' as a word can have many different definitions, depending upon its context. It can be used to refer to how easily a physical location can be accessed (Geurs & van Wee, 2004), as the ease with which people can reach different places and opportunities (Pereira & Herszenhut, 2023), or, in a digital context, to the extent with which a product, device, service or environment is both available and navigable for persons with disabilities, or other additional needs (Kulkarni, 2019).

3.2.2 Accessibility in Video Games
Accessibility in a video games context can also have multiple different definitions. 'The International Game Developers Association' defines game accessibility as *"the ability to play a game even when functioning under limiting conditions. Limiting conditions can be functional limitations, or disabilities*

— *such as blindness, deafness, or mobility limitations."* (Accessibility in Games: Motivations and Approaches, 2004). In the context of this research paper, this definition is the most appropriate.

3.3 The Importance of Accessibility

Video games are enjoyed by the vast majority of the UK population; According to the 'Online Nation 2024 Report', over half of people aged 16 and over in the UK play video games – approximately 52%. Of those individuals, the average time spent playing games was 7 hours a week. As well as this, approximately 90% of children aged 3 to 15 also play video games – a number that continues to increase each year (OFCOM, 2024). As the popularity of video games continues to increase, they continue to form an important part of peoples lives, often being a key way in which people socialise and make friends – especially in the younger population. (Perry et al., 2018). In this way, video games can be incredibly beneficial for individuals social development and overall wellbeing.

Individuals with disabilities often experience significant social exclusion, as a result of stigma or a lack of accessibility, with two thirds of people with hearing impairments reporting negative social experiences and exclusion as a result of their disability. (*RNID; Information and Support: Hearing Loss*, 2024). Because of this fact, it is only more important that games developers make an effort to increase accessibility for users, to avoid worsening this exclusion even further, and to help reduce the factors that lead to social exclusion in the first place – especially considering the growing usage of video games to fill social needs.

It is also believed that, when accessibility makes it possible, players with disabilities often experience a far larger positive impact from the act of play than able bodied individuals. A PopCap Games survey in 2008 found that individuals with disabilities tended to play games more frequently, and for longer – as well as indicating a much higher positive impact from doing so, reporting significant stress relief, improved mood, improved concentration, and feelings of belonging, as well as a welcome distraction from their impairments. (*Popcap Games Survey*, 2008). A different study also found that, through video games, players with disabilities often felt empowered to do more than they previously thought they could, gained a new perspective of their own abilities, and an overall greater sense of direction and purpose. (S. L. Anderson & Johnson, 2022).

For some disabled players, games also allow them to live their life through their characters, finding community and belonging in a space free from external stigma and their own physical limitations. Through games, users can live a life undefined by their abilities – without others being able to immediately judge them based upon it. The story of one individual who found joy and fulfilment as a result of video games is told in the documentary *'The Remarkable Life of Ibelin'*, which describes the life of Mats Steen, a young man with Duchenne muscular dystrophy. While, near the end of his life, he could only move his fingers – and his family believed him to be incredibly isolated – he was, in fact, living a rich life through the game 'World of Warcraft', amassing over 20,000 hours within the game, and making many friends who he would not have otherwise been able to meet or interact with. Video games had a significant impact on his life, and it is very likely that it has been, and continues to be, a tool for many others living similar lives.

Another aspect to note, in terms of why accessibility should be a priority for the games industry as a whole, is that - due to the large percentage of gamers in need of accessibility features (Online Nation 2023 Report, 2023) - implementation of appropriate methods, and the improvement of existing methods to provide accessibility to a wider variety of individuals, comes with a significant financial incentive for developers, as it widens their potential audience. This is reinforced by the previously mentioned points, that players with disabilities tend to both play video games more often, and for

longer (*Popcap Games Survey*, 2008), and that the population of disabled individuals is growing over time. (Online Nation 2023 Report, 2023)

3.4 Challenges to Accessible Experiences; The Importance of Audio in Video Games

Audio is an incredibly important aspect of the overall game experience for players, despite the fact that it is very often taken for granted. Audio can be divided into many different categories, each of which play a different role.

3.4.1 Music

Music in video games has a variety of uses. At its core, music is there to keep players engaged, and to aid in immersion (Xiaoqing Fu, 2015). That, however, is far from its only use; music is often used to convey information to the player in a variety of ways (Fernández-Cortés & Cook, 2021). It can be used to set the mood and tone of a scene, conveying a variety of emotions – from sadness to excitement. Intensifying music can be used to inform the player of approaching danger, or to encourage the player to continue moving forward, with subtle changes showing the player that they are following the correct path (Fernández-Cortés & Cook, 2021). Sudden changes in music can also be used, either to take the player off guard with sudden intensity, or to cause unease when the unexpectedly music stops.

For these reasons, the overall game experience is often affected very negatively by a lack of audio. This can be in the form of less engagement, or difficulties in keeping the player immersed (Xiaoqing Fu, 2015), as well as difficulties in conveying the intended emotions or tone.

The importance of music in video games can best be demonstrated by exploring examples of popular video games that have utilised it well.

One such example of good usage of music is in the game 'UNDERTALE' (Toby Fox, 2016). This game uses music to convey powerful emotions throughout, despite its very limited graphics – becoming incredibly popular as a result. It successfully uses music alongside dialogue to cause the player to feel a wide variety of emotions, setting each scene with a different track.

Another good example of music can be found in the game 'Project Zomboid', though for different reasons. Unlike 'UNDERTALE', which is a story-driven game, 'Project Zomboid' is a survival game – which means that there are no defined scenes to craft its music around. Instead, this game uses a 'dynamic soundtrack' – music tracks that respond directly to what is happening around the player, and vary different elements in response. When things are calm, the music is too – however, as things change, so does the music. As the danger increases, the music intensifies – the beat gets faster, new instruments and sounds are introduced, and everything gets a bit louder. When things are at their most intense, the music is too – almost as if affected by the players adrenaline directly. Danger is judged by a variety of factors – the players health and injuries, the number of enemies around, how close they are, and whether or not the player can clearly see them. Oftentimes, the music will change before the player even notices the danger – both setting the tone and acting as a form of 'early warning system' for approaching danger. Without audio, Project Zomboid is a far more difficult experience – so much that the video game itself allows the player to select 'deafness' – which mutes the game – as a 'trait', providing the player with certain advantages at the expense of a more difficult game.

It is possible that some of the benefits found in music can be replaced instead by intelligent usage of shapes and colours, to help convey emotion and tone in the same way that music does. (Da Silva et al., 2018).

3.4.2 Speech and Dialogue

Many games involve spoken dialogue – either as NPC (non-player character) voice lines, to tell stories or to explain quests and objectives (Costello et al., 2019). This often includes key information, which can cause the game experience to be entirely inaccessible without. While many games now utilise subtitles, this still puts players who cannot hear the dialogue at a significant disadvantage to their hearing peers (Brown & Anderson, 2021).

Spoken dialogue often involves more aspects than just the words themselves. Tone of voice, sounds in the background and other audio elements, such as laughter, all play key roles in successfully communicating the actual meaning of what is being said. These things are not always included in subtitles or captions – and, without these crucial elements, things may be misunderstood, or may be otherwise unclear to the player.

3.4.3 Audio Cues

Audio cues – here used to refer to non-environmental, non-dialogue sounds used to inform the player of situational changes or otherwise convey information to the player – are oftentimes used in video games. These audio elements add an additional layer of feedback to the game, and help to draw players attention things happening around them. Without these cues, important things happening can easily be missed, leading to confusion – or even frustrating 'game over's.

Audio cues can also be used to show the player that their actions are doing something – providing valuable feedback. Without this, players may not know if what they are doing is actually working as expected. Audio feedback reinforces the players actions, leading to a greater connection between the player and their character, and, with this, significant improvements to immersion. Without these cues, players can become confused. It may be difficult for them to understand how to interact with the game, and may lead to a significant disconnect between the player and the game. (Costello et al., 2019).

3.4.4 Directional Audio

Most things that happen in games make some form of sound. This is to be expected, as most things done in the physical world also make noise. Oftentimes, these 'in-world' sounds are directional – that is, so long as the player is using headphones, or an appropriate surround-sound setup, the audio is designed to appear to the player as if it is coming from a specific direction. This can be incredibly important for gameplay, allowing the player to locate enemies or items of interest much more easily. (Nogueira et al., 2012)

This can unfortunately lead to players without this audio being left at a significant disadvantage. One common frustration for users with hearing impairments is that they can struggle to perceive incoming danger; many games utilise audio cues to show they player when they are about to be attacked, and it is common for these games to have no visual indication of the same. (Costello et al., 2019). This can cause an inherent feeling of frustration and unfairness of the player. Players with partial hearing – for instance, players who experience deafness or reduced hearing on one side, are also significantly impacted in their ability to make use of directional audio – as directional audio requires varied volume in each direction (or ear) in order to function as expected.

One specific example of environmental audio having a significant negative impact for hearing-impaired players can be seen in the game 'Resident Evil 2', where an enemy present throughout much of the game can only be detected by his footsteps. This leaves players who are hard of hearing completely unable to evade him, making the game experience unfair and not at all fun for the individual. (Brown & Anderson, 2021)

Another game that relies heavily on directional audio is 'Escape from Tarkov'. This game is a relatively unforgiving, realistic first-person shooter. The ability to hear footsteps – or gunshots - and know exactly where they are coming from so they can react appropriately is incredibly important for gameplay. Players must be able to quickly locate enemies, so that they can either attack or hide before being noticed themselves. As a part of this, being aware of the sounds that they themselves are making is also incredibly important. Without the audio element, players are at an immense disadvantage, and are likely to be targeted for this – leading to a frustrating game experience that is completely inaccessible for the hearing impaired player.

3.5 Designing Game Environments

3.5.1 Designing for Immersion

Immersion in games can be defined as 'the sense of being "in a game" where a person's thoughts, attention and goals are all focused in and around the game' (Xiaoqing Fu, 2015). Creating and maintaining immersion is incredibly important in games design and development, as strong immersion keeps players engaged and thinking about the game – whereas poor immersion can cause players to feel disconnected and demotivated, increasing their likelihood to stop playing. It is important to note here that immersion can not be equated to realism.

Immersion can be affected by a variety of factors, including elements outside of the game developers control – such as the players personal game preferences, or their physical environment and the distractions that come with it (Jennett et al., 2008). Despite this, the majority of factors affecting immersion are directly related to the gameplay itself, and external factors can be limited by good design. Good audio design, for instance, is key to creating an immersive experience – pulling the player into the game world, and keeping them engaged (Xiaoqing Fu, 2015). Much like audio, cohesive visuals are also important in aiding immersion – when things clash, it can be distracting, acting as a reminder that they are within a game. Having direct control of a character inherently aids immersion, placing the player themselves within the game world (Jennett et al., 2008), with this noted however, being able to relate to or understand the player character, and to see them as an extension of themselves, is incredibly important (Wood et al., 2007). This does not necessitate the player being able to personally relate to the character, however; within narrative games, an understanding of their characters place within the world – their purpose and motivations – is often sufficient to generate strong immersion.

Intuitive gameplay is also an important part of immersion; if players find themselves needing to think about or check the controls, or search for what they are supposed to be doing at any given time, they will be quickly pulled out of the game experience – breaking immersion.

Immersion has a direct impact on player enjoyment, affecting the amount of time a player is likely to spend within the game world, how positively they view the game, and how often they think about it outside of gameplay (Wood et al., 2007). Because of this, immersion is something that the majority of games should aim for.

3.5.2 Designing to be Intuitive; Fulfilling Player Expectations

Here, intuitive gameplay is described as gameplay that is designed to behave in ways that players expect, in order to correctly guide their actions and direction. Intuitive gameplay can be generated in a variety of ways.

Utilising affordances in games can ensure that players understand their path, and where to go next. These affordances can be visual or auditory, and generally fit into specific player expectations, which differ between different genres.

Most games rely on a players existing knowledge of video games, even if this is not intentional. Many games will not, for example, state which keys they expect the player to use for movement, or looking around the game. These are things which are often taken for granted, which can be a barrier for users with little or no previous experience with video games.

These player expectations, however, can be used to benefit designers when creating environments. For instance, when a player enters a large, empty area, and a door closes behind them, they will instinctively know that it is likely that they will be attacked. If a player instead finds themselves in a room containing nothing but large vases, players will often first try to break them – without that ability being indicated by the game itself. This behaviour comes from player expectations from similar video games.

In order to create a truly intuitive game experience, it is important for designers to be aware of these player expectations, and to design with them in mind. While subverting these expectations can lead to interesting, transformative gameplay when done correctly – if done poorly, players are likely to become confused or frustrated by the experience.

3.6 Accessibility in Video Games for people with hearing impairments

3.6.1 Subtitles

Subtitles are often used for dialogue in games, and it is now relatively uncommon to find a game that includes spoken dialogue that does not also include subtitles in some form, especially when compared to games from previous decades. It is not just dialogue, however, which can be represented using subtitles – important audio, such as footsteps or gunshots, can also be visually represented with appropriate use of subtitles. (Nogueira et al., 2012).

However, while subtitles are common, they are also often implemented poorly (Costello et al., 2019). Many games do not use subtitles of an appropriate size or colour, and it is common for subtitles to appear too late, or disappear too early to be read and utilised (Waki et al., 2015). Subtitles are also commonly unclear; they often omit important details, such as who the speaker is, and the tone of voice – which becomes even more confusing for users if the character that is speaking is not visible on screen (Brown & Anderson, 2021). This can be improved upon in a variety of ways – for instance, including the speakers name, or varying the colour of text for different speakers, and utilising 'tone indicators' in order to express the way in which characters are speaking. If doing this, it is important that it is applied consistently throughout, in order to avoid additional confusion.

Another difficulty posed by subtitles for dialogue is that dialogue is oftentimes used during gameplay, while the player is focussed on other activities. If the gameplay is too intense for the player to turn their attention to reading and processing subtilties, they may miss important information, leading to unnecessary confusion – especially if the information presented is not repeated anywhere else (Costello et al., 2019).

In order to appropriately utilise subtitles, certain rules should be followed;

- Subtitles should be sized appropriately for the players screen.
- Care should be taken to ensure that text shown matches the dialogue as closely as possible, as well as any other written information.
- Text shown on screen at any one time should be limited, to both prevent the player becoming overwhelmed, and to allow the player to easily read it, especially during gameplay.

- Subtitles should have clear contrast between the text colour and its background.
- Indications for who is speaking, and the tone they use, should be present to prevent confusion.
- Clear, readable fonts should be used, regardless of the games visual style.

These are discussed *in 'Designing for Disability: Evaluating the State of Accessibility Design in Video Games'* (Brown & Anderson, 2021), and backed up consistently throughout all examined research, including in *'The Ground Floor Approach to Video Game Accessibility: Identifying Design Features Prioritized by Accessibility Reviews.'* (S. L. R. Anderson, 2024).

3.6.2 Visual Indicators

Visual indicators are another way in which audio can be replaced or supplemented in video games. Much like subtitles, which provide a visual representation of spoken media, visual indicators can be used alongside audio cues, in order to ensure that users that are hearing impaired can benefit from the cues in the same way. (Costello et al., 2019)

These visual indicators can come in a wide variety of different forms. For instance;

- Flashing, pulsing or colour-changing icons to draw the players attention, often to indicate that something has changed, or is of particular importance.
- An on-screen mini-map, displaying the location of important items
- Visual icons appearing above items of importance or places of interest.
- Buttons changing visually when hovered over or clicked.
- Visual telegraphing of incoming enemy attacks.
- Arrows indicating the direction of important items, enemies or objectives.

However, there are many different forms which visual indicators can take that are not listed above.

When displaying visual indicators, it is important to ensure that the player does not become overloaded by information. Excessive indications can quickly become overwhelming, and lead to genuinely important information being missed or overlooked. (Costello et al., 2021) It is important to consider not just how important information is, but also how likely it is to be otherwise missed in the specific scenario, and how relevant it is to the player at that moment. In order to help ensure that visual indicators are clear and appropriate, it may be relevant to vary their colour in order to make it easier to assess what they are indicating, or, when using visual indicators to indicate the location or proximity of items or enemies, their transparency to indicate how close or far and indicated item is. Allowing players the ability to customise what does and doesn't receive indicators may be incredibly helpful in ensuring that irrelevant information is not displayed, but could also lead to frustration if players accidentally disable something that is important.

It is critically important that these indicators do not provide players with an unfair gameplay advantage. For instance, if an enemy would otherwise not heard by the player, it should not be indicated to them. (Costello et al., 2021)

3.6.3 Visual Design to Set Tone

Visual design is also an important element in communicating information to players with hearing impairments – though, this is also something that comes with significant benefits for all players, regardless of disability status.

In visual media, including games, lighting and colour are both incredibly important to set mood and tone in scenes, and to improve overall immersion. (Costello et al., 2019). Darkness, for instance, can

be used to obscure information, creating curiosity or tension depending on how exactly it is presented. Soft lighting is often perceived as comforting and safe by users, whereas harsh light can feel off-putting or clinical. Colour is equally important, as most colours can be recognised to indicate some form of emotion – the most common of these being the colour blue used to indicate sadness or despair, while red is often used to indicate danger or enemies. Without the presence of audio, these design elements often fill the role of music – setting the tone of the scene.

One study in particular, *'Representing Sentiment Using Colors and Particles to Provide Accessibility for Deaf and Hard of Hearing Players'*, looked closely at the way in which colours and shapes can be used to express emotions, and how players interpret that information. Despite the fact that most colours and shapes have common tone interpretations, this study found that players would often have a very different perception of the indicated tone, especially if the colours and shapes were used outside of clear context. This effect was especially prominent between users of different cultural backgrounds, as different cultures oftentimes assign different inherent interpretations to different colours. (Da Silva et al., 2018) In order to combat this, it is important that multiple design elements used to set tone are used together, and that scenes are presented with context where possible, as this increases the likelihood of players correctly interpreting the scene.

4.0 Research Methodologies

4.1 Artefact

For this project, the artefact will be a vertical slice of a 3D arcade-style game developed using Unreal Engine. The artefact will be designed to implement a variety of accessibility features, focussing on accessibility for users with hearing impairments.

There are multiple accessibility features included in this artefact, informed by the research from the literature review.

One feature was a mini-map, implemented to provide overall guidance to the player and to help make up for the inability to hear where things are coming from. This mini-map is displayed in the top right corner of the players screen, and uses a green arrow in the centre – displaying the players location – as well as red circular indicators to display the location of nearby enemies, and a 'bullseye' symbol used to display the location of pick-ups. When out of the visual range of the map, the red 'enemy' indicators disappear until that enemy is in range again – whereas the indicators for the pick-ups stay fixed at the edges of the map, indicating their direction relative to the player.

Another feature is on-screen visual indicators, in the form of red arrows, showing when enemies enter within a specified range of the player - with the range being the distance from which the player would be able to hear their footsteps. These arrows point in the direction, relative to the direction that the player is facing, that the enemy is, in order to provide the information that would normally be indicated by directional audio. The arrows also vary in transparency, depending on the players proximity with the enemy.
This feature comes in two variants – one, which will cause the arrows to appear automatically when an enemy enters the players hearing range, and another where the player must press a specific key to use a 'Scent' ability, which will show the arrows on screen if there are enemies in range.

This 'Scent' ability also comes with an additional feature; x-ray vision. When pressed, enemies hidden behind solid objects will be displayed through objects in bright red – and pick-ups will be displayed similarly, in green.

The final accessibility feature implemented is the 'panicked' state. This happens automatically when an enemy gets close enough to the player that they are going to deal damage imminently. When this is triggered, the screen darkens somewhat, and loses saturation. The x-ray vision described above will kick in – displaying the location of the enemies and pick-ups clearly on the darkened background. These sudden visual changes should accurately reflect that the player is in danger, in the same way that audio would be used to the same effect.

In order to test this project appropriately, discerning which accessibility features are most beneficial, and which ones players find distracting, all of the above features can be toggled on or off independently, allowing the artefact to be presented to candidates in a variety of forms.

4.2 Research Types

4.2.1 Primary Research

Primary research refers to first-hand data, collected by the researcher presenting it. This can include interviews, surveys, observations and focus groups, among other forms of data collection.

In this project, primary research will be collected from user feedback in the form of surveys. Gathering this data will allow the artefact to be assessed in regards to its effectiveness at meeting the projects aims. Data will also be gathered via observations of the candidates as they test the artefact, in order to gain a wider understanding of how individuals interact with the artefact when compared to one another.

4.2.2 Secondary Research

Secondary research refers to any data not collected by the researcher themselves, instead being compiled from existing trustworthy data sources.

In this project, secondary research is conducted by performing an in-depth review of existing research on the topic of accessibility and environment design. This research forms the foundation for the project, providing an understanding of the current state of accessibility within video games, common methods for increasing accessibility, and how they may be expanded upon.

4.3 Data Types

4.3.1 Qualitative Data

Qualitative data refers to data that cannot be represented using numbers. While harder to compare and present, qualitative data can provide more insight and overall more information than numerical data can.

For this project, qualitative data will be collected in two ways.
One method is through open-ended questions within the survey presented to participants, which will allow them to provide more detailed, in-depth responses. This will allow participants to explain their experience with the artefact, as well as allowing participants to provide insights that may not otherwise be able to be gathered via closed questions and numerical data. This data will primarily inform the project of the experience of individual participants.
A secondary method that will be used in this project is data collected via notes taken while observing participants interactions with the artefact. This will allow for a more broad understanding of how users interact with the artefact, and for their interactions to be more easily compared between the different artefact configurations.

4.3.2 Quantitative Data

Quantitative data is data that can be represented using numbers. This data generally provides less information alone, but is far easier to compare, especially within a larger data set.

For this project, quantitative data will be collected via numerical-based and closed-ended questions within the survey presented to participants after testing the artefact. This data can be easily compared, and will allow for an understanding of the general experience of the participants.

4.4 Testing and Data Collection

4.4.1 Overview

This artefact will need to be tested in order to evaluate the effectiveness of the methods implemented for their specified purposes. This will be done by allowing a number of participants to test the artefact and provide feedback on their experience via a survey.

In order to facilitate more accurate testing in regards to how audio and the implemented accessibility modifiers affect participants' interactions with the artefact, the artefact will be presented to the participants in one of several configurations. These configurations include different combinations of the accessibility modifiers, and may be presented either with or without audio, in order to judge how player experiences differ.

4.4.2 Statistical Tests

When planning tests and comparing results, there are a number of different statistical tests that may be used.

A t-test is one example; this is a statistical test that can be used to compare the means of two groups of individuals, and is often used to determine whether something actually has an effect, or how that effect differs between two groups of individuals.

An Analysis of Variance (ANOVA) test may also be used; much like the t-test, this looks at the differences between groups in order to see if there is a statistical significance, comparing three or more different groups at a time. This can look at one or two different independent variables at once in order to analyse the effect these variables have on the results presented. In the case of this study, a one-way (single independent variable) ANOVA could be in the form of analysing how a persons access to audio (independent variable) influences their video game performance (dependant variable). A two-way ANOVA may be in the form of analysing how a persons access to audio, and the presence of accessibility modifications, influences their overall enjoyment of the game.

Another potential is the Kruskal-Wallis test, which is used to compare three or more independent groups in order to determine if there are any statistically significant differences between them or their results. This works by listing all data points for all groups in order, and assigning them a rank based on their position in this list. The rankings are then split back into their individual groups, and the rank totals and means are calculated for each group. This allows for the comparison of groups based on their position relative to each other, rather than raw values alone. A variant of this test is the Mann-Whitney U test, which can be used to compare two groups, rather than three or more. These tests are incredibly useful when working with a small data set, which makes them very relevant to this study, and potentially useful. It does however work best with numerical data.

Conjoint analysis is another option. This statistical test if often used for market research purposes, as it allows the comparison of many different combinations of answers to questions. Often, data for this test is gathered in the form of a survey, and compared in order to find which answers are favoured, and by how much. This data can be used to gauge user preferences, and how important

different factors are to participants. In the case of this study, this test could be utilised to gauge user responses to different implemented accessibility features, and the overall impact they have on accessibility and video game enjoyment.

These common tests will be kept in mind for designing the user surveys and analysing user data. A combination of data analysis methods may be used – however, in the case of this study, the conjoint analysis may work best.

4.4.3 Surveys
One way in which data will be gathered is in the form of a short survey provided to participants after they have tested the artefact. This survey will include a variety of numerical, closed-ended and open-ended questions, allowing for the gathering of both quantitative and qualitative data.

Questions on the survey will include questions about how the players believed audio impacted their gameplay, how they interacted with the implemented accessibility features, and how they felt that those features affected their overall gameplay, experience and immersion. Players will be asked to rate their game experience on a variety of metrics, which can then be compared and contrasted with candidates who played the artefact in different configurations.

A full copy of the player survey is presented in Appendix 1.

4.4.4 Observation
Additional data will be gathered by observing participants while they test the artefact. Notes will be made of any observations in regards to how participants interact with the artefact in its varying configurations. These observations will allow for the behaviour of different participants testing the artefact in different configurations to be most easily compared to one another, and for any obvious differences and similarities between user interactions to be noted. This data will be particularly useful, as it will be collected by one individual, removing much of the subjectivity posed by some questions, allowing their specific behaviours to be compared, rather than just their individual thoughts about the gameplay.

This method is also important, as the different candidates will not know how the game differs from other configurations, and so may not be as aware of how different modifiers are affecting them.

4.4.5 Ethical Considerations
As this project will be utilising external human participants, there are important ethical considerations to be made. For this project, those considerations come from the act of observing players and recording their data.

To ensure this project aligns with good morals and ethics, all participants will have a full understanding of the project and its intentions, and how they and their data will contribute to it. All data collected will be anonymous, with no identifying or demographic information being recorded, as it is unnecessary for this project and its goals.

4.5 Data Analysis
Data from the surveys will be analysed by comparing and contrasting response data between different individuals, from a variety of artefact configurations. This data will allow for the evaluation of which accessibility modifiers affected the players interactions positively, negatively, or neutrally – and how that information varies depending on whether or not the artefact is played with audio. This should allow the determination of which modifiers are most effective at improving overall accessibility without compromising the experience.

Data will also be taken from the observation notes, in order to make wider judgements as to how player behaviour varied between the different configurations, and which groups of players performed best overall.

4.6 Justification of Methods

4.6.1 Explanation of Methods

This study utilises a hybrid approach to data collection and analysis; utilising a variety of primary and secondary data, including both qualitative and quantitative data.

The primary research evaluated in this study will come primarily from the surveys and observations gathered from the candidates interactions with the created artefact. By gathering both qualitative and quantitative data, this ensures that the study will be analysing the most complete data set possible – making use of the benefits of easily-comparable quantitative data, as well as the more detailed, open-ended quantitative data.

Secondary research for this study will be gathered by evaluating research from a wide range of sources, informing the artefact creation process as well as ensuring that the research conducted is based in pre-established theory.

The usage of both surveys and observations was chosen, as it would provide both candidate-provided data, allowing insight into player experiences and thought patterns, as well as less subjective data gathered from observations of player behaviour, which could look more broadly at player behaviour as a whole when compared to other candidates.

Unreal Engine 5 will be utilised for the creation of the artefact, as it is a robust, reliable engine in which a game prototype can be built on a relatively short timeframe. This engine includes pre-built tools, allowing for the easy creation and implementation of many of the accessibility features that will be implemented into the artefact.

A selection of 10 individuals were chosen to playtest this artefact. While a larger candidate pool would provide more detailed responses, 10 participants is a manageable number for the scope of this study.

4.6.2 Potential Drawbacks

There are, unfortunately, some potential drawbacks of the methodology selected.

The first being that there is a relatively small candidate pool, making it difficult to exclude erroneous data from the study, and increasing the chances that data may become skewed in one direction or another. The small candidate pool also unfortunately means that data may be somewhat inconsistent if the study were to be repeated with a larger pool of candidates. To combat this, efforts have been made to ensure diversity within the candidate pool where possible.

Another drawback is that the sample group being utilised for this study is made up entirely of able-bodied individuals with a high degree of computer literacy. This is another reason that a study repeated with a different candidate pool may lead to different results.

This study has chosen not to collect any personal data, including demographic information, from individuals. This may make it difficult to compare these results with different groups at a later date – however, it is unlikely to have much impact on this study overall.

It should also be noted that the artefact created is intentionally not complex. While this is necessary due to timeline restrictions, it is possible that candidate responses may be different in a more complex experience, or while interacting with a game from a different genre.

5.0 Results and Findings

In total, the artefact was play-tested by a total of 10 candidates, in one of eight different configurations of the implemented accessibility features. The results from these playtests is presented below, followed by an analysis of the results.

5.1 Survey Results – Quantitative Data

Below is a presentation of the quantitative data results gathered by the survey. These are presented in the form of a series of pie charts, showing the percentage of candidates from different configurations that responded.
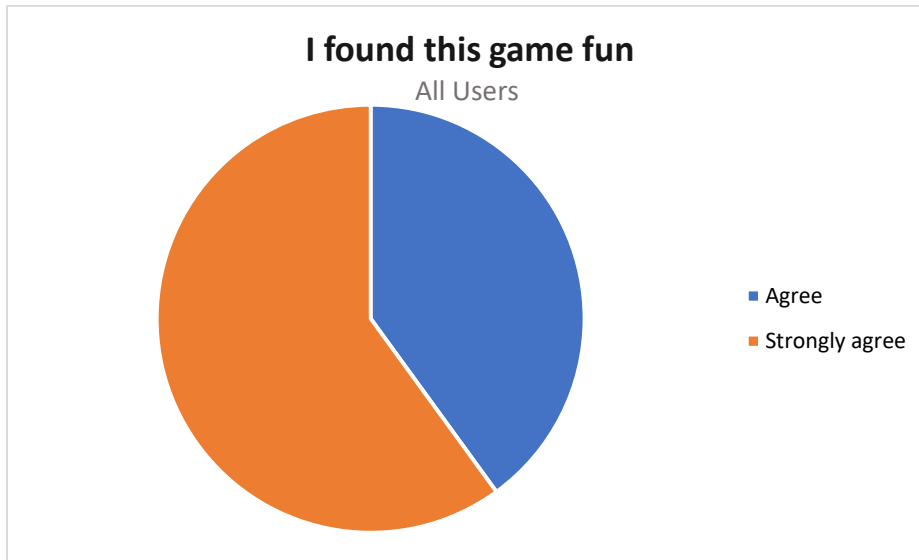
Figure 1 – Pie Chart displaying all users responses to the question 'I found this game fun'
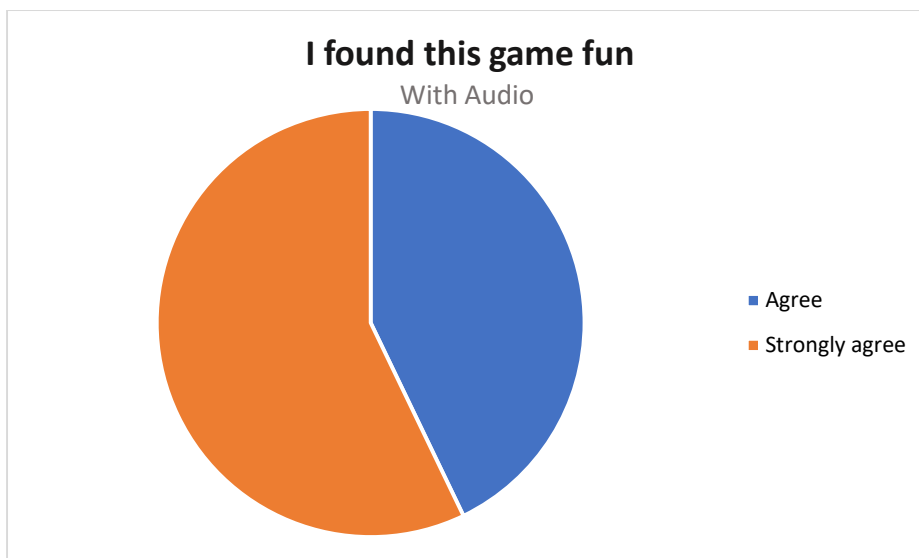
Figure 2 – Pie Chart displaying the responses to the question 'I found this game fun' from users with audio
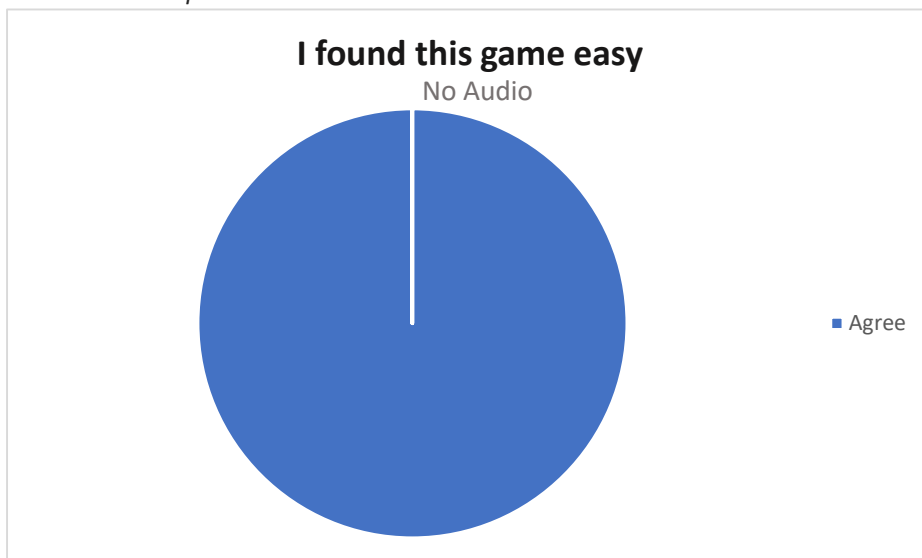
I found this game fun
No Audio
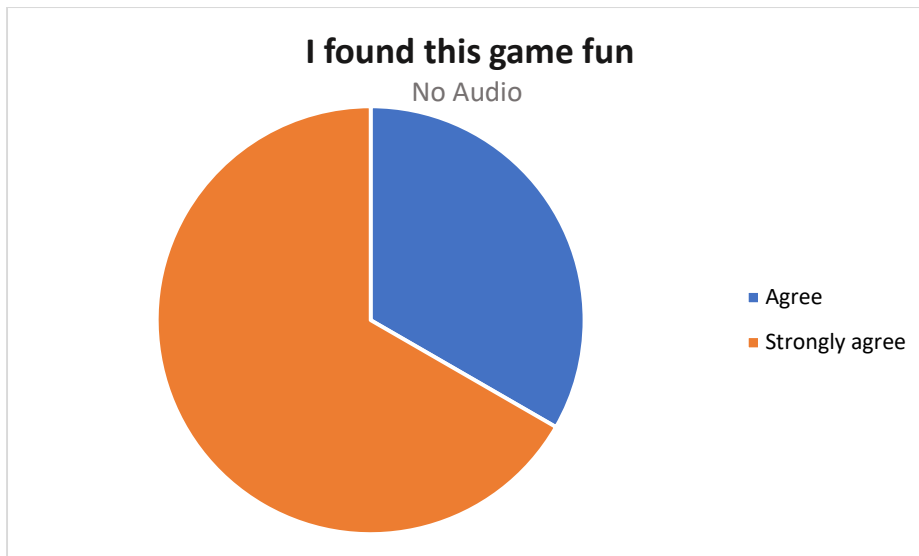
Figure 3 – Pie Chart displaying responses to the question 'I found this game fun' from users without audio

When asked if they believed that the game was fun, all participants agreed; with 60% of participants agreeing strongly. That is ¾ of participants who played the artefact with audio, and 2/3rd of participants who played without audio.

I found this game easy
All Users
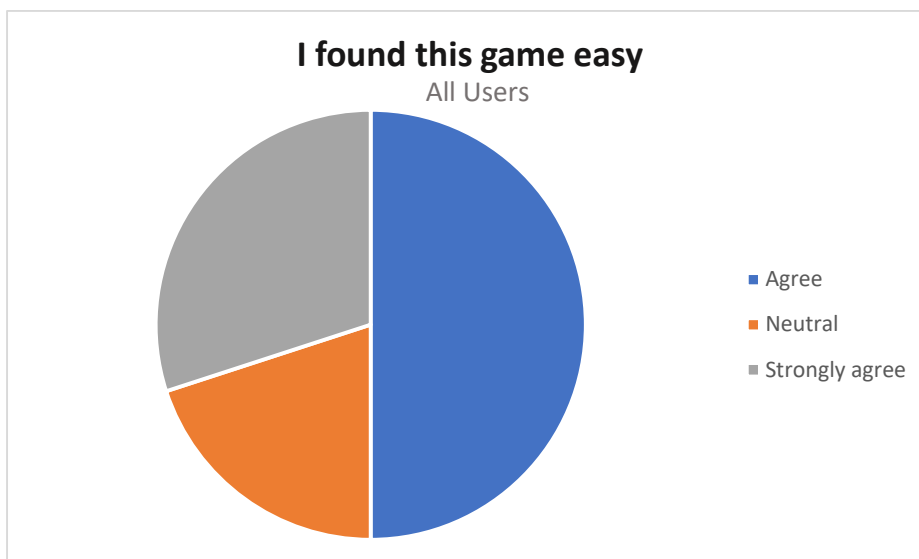
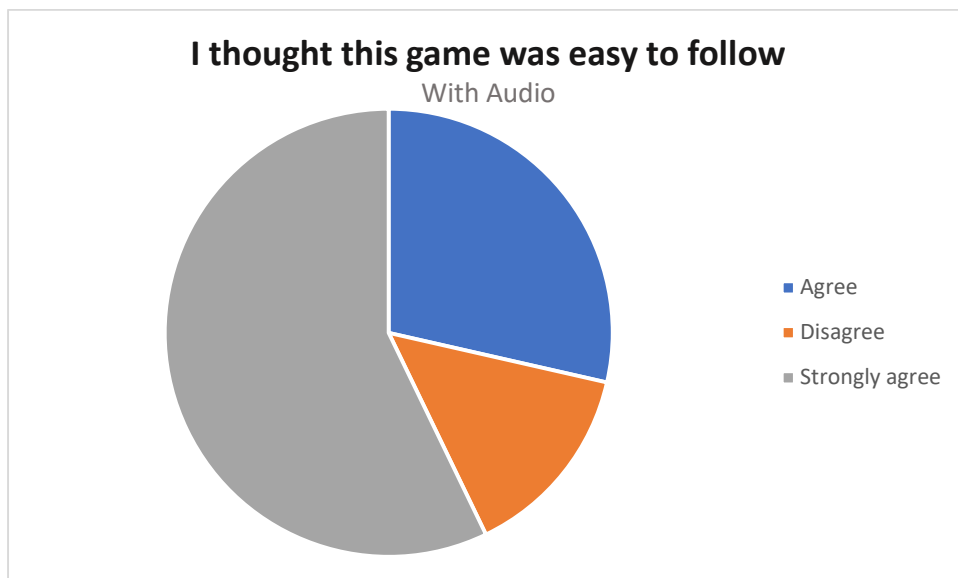*Figure 4 – Pie Chart displaying responses to the question 'I found this game easy' from all users*
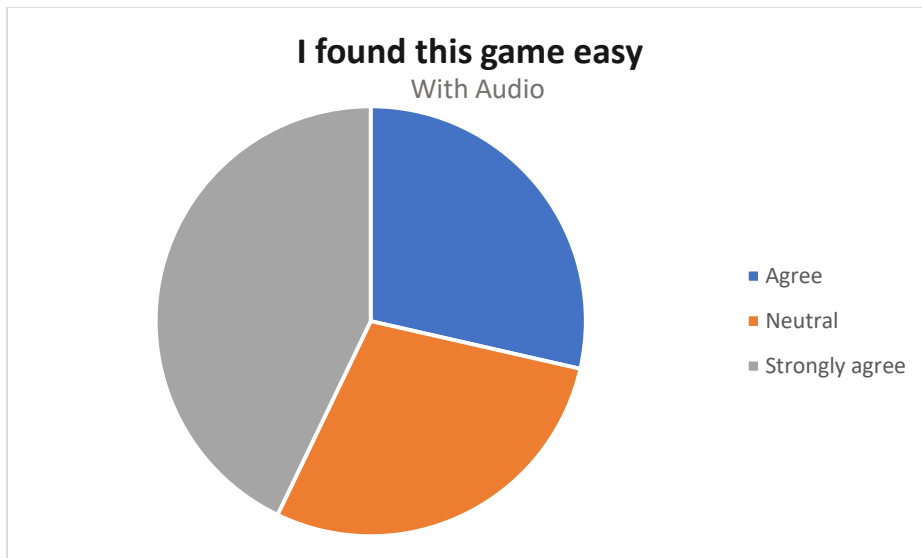
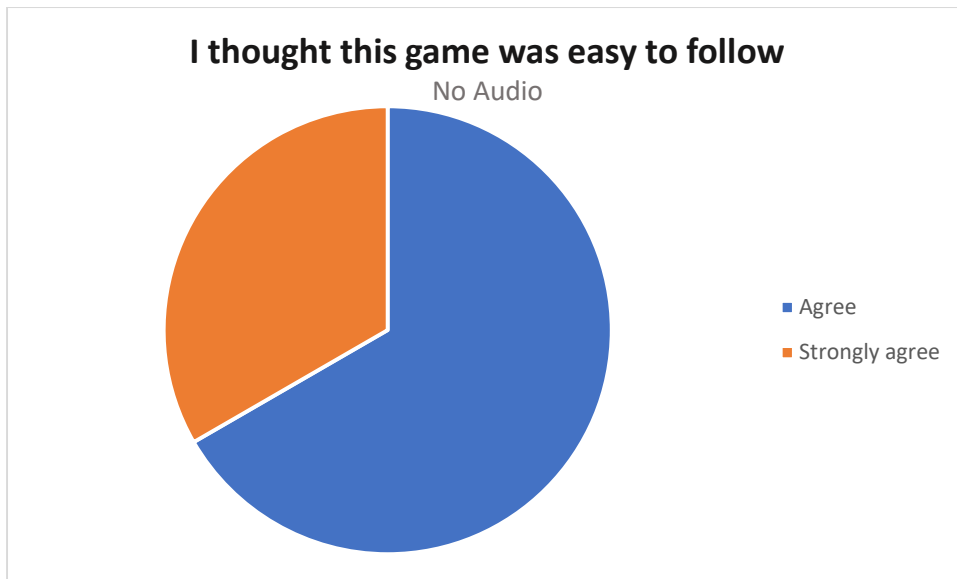*Figure 5 – Pie Chart displaying responses to the question 'I found this game easy' from users with audio*
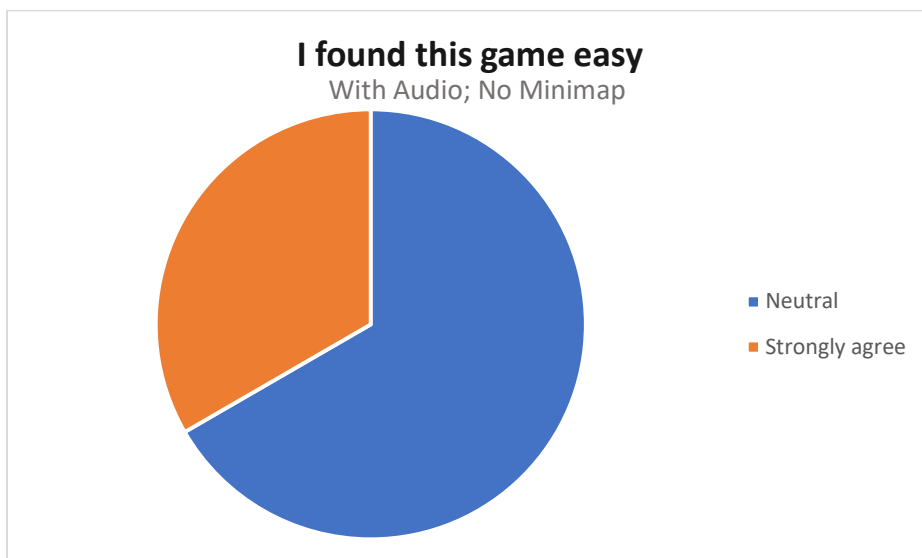
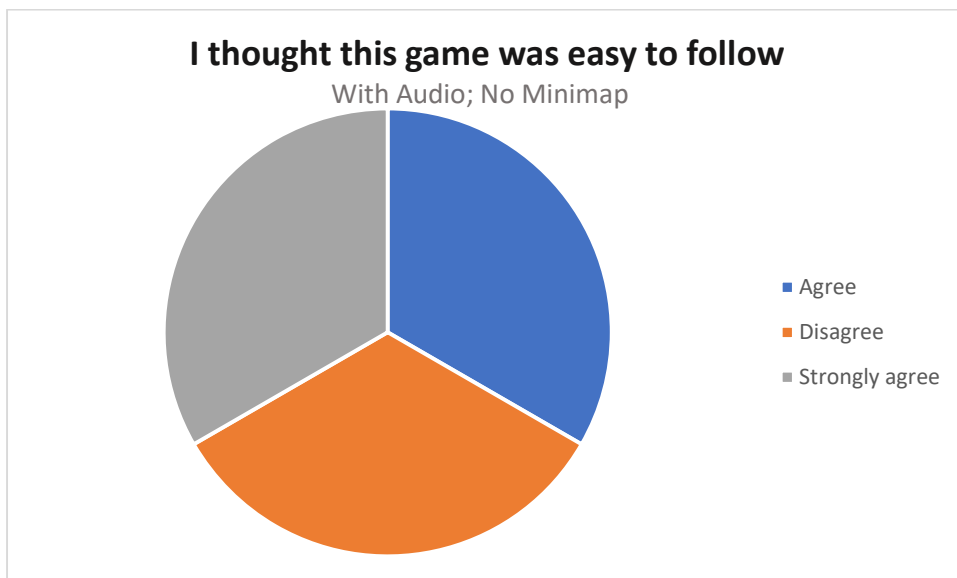*Figure 6 – Pie Chart displaying responses to the question 'I found this game easy' from users with audio and no mini-map*

When asked if they found the gameplay to be easy, 70% of participants agreed, with only 20% stating that they felt neutrally. That 20% was made up entirely of users that played with audio, but without the mini-map, split equally between the other different accessibility feature configurations.
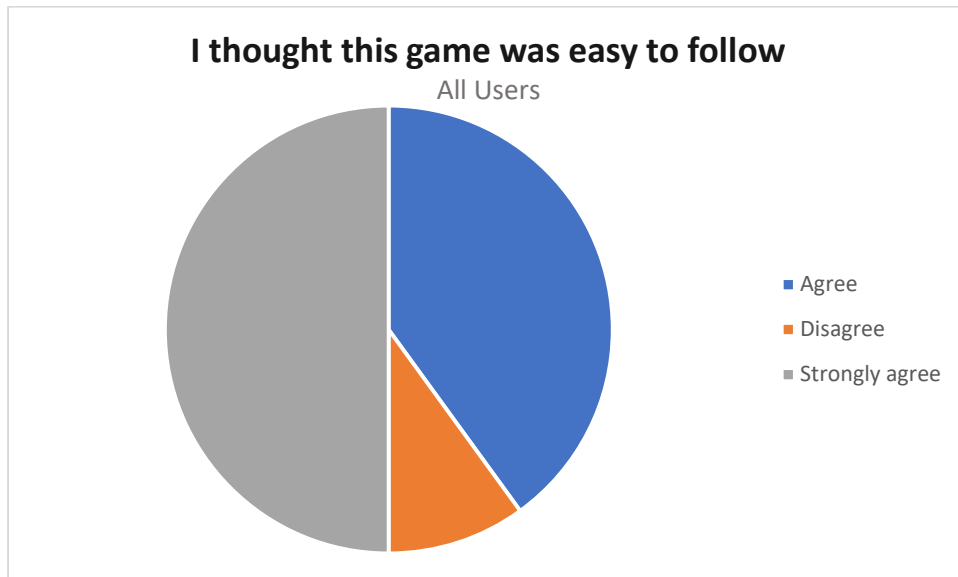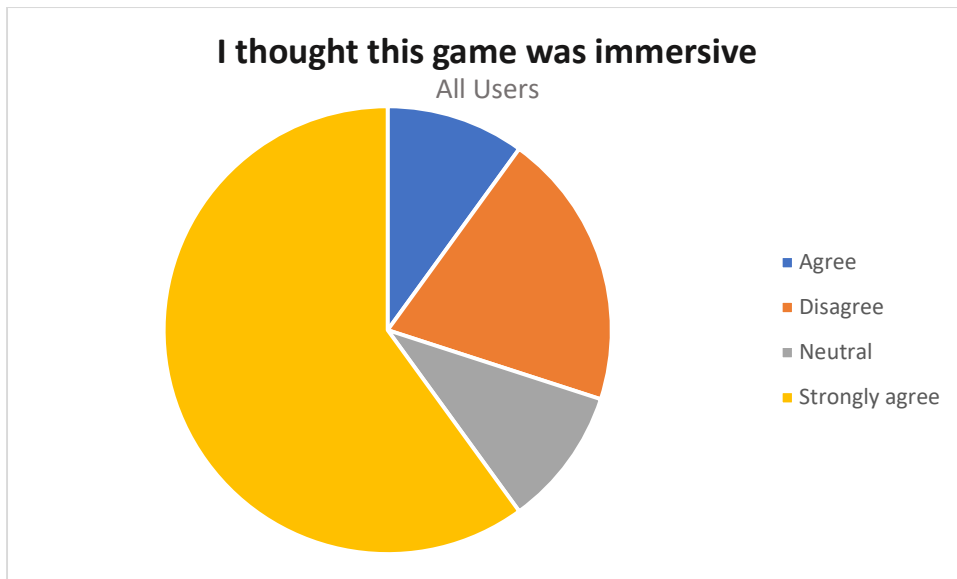

Figure 8 – Pie Chart displaying responses to the question 'I thought this game was easy to follow' from all users

Figure 9 – Pie Chart displaying responses to the question 'I thought this game was easy to follow' users with audio

I thought this game was easy to follow
No Audio

- Agree
- Strongly agree

Figure 10 – Pie Chart displaying responses to the question 'I thought this game was easy to follow' from users without audio

I thought this game was easy to follow
With Audio; No Minimap

- Agree
- Disagree
- Strongly agree

Figure 11 – Pie Chart displaying responses to the question 'I thought this game was easy to follow' from users with audio and no mini-map

When asked if they found the game easy to follow, only 10% disagreed, being made up of users that played the game with audio, but without the mini-map, and with accessibility features present.

I thought this game was immersive
All Users

Legend:
- Agree
- Disagree
- Neutral
- Strongly agree

Figure 12 – Pie Chart displaying responses to the question 'I thought this game was immersive' from all users

I thought this game was immersive
With Audio

Legend:
- Agree
- Disagree
- Neutral
- Strongly agree
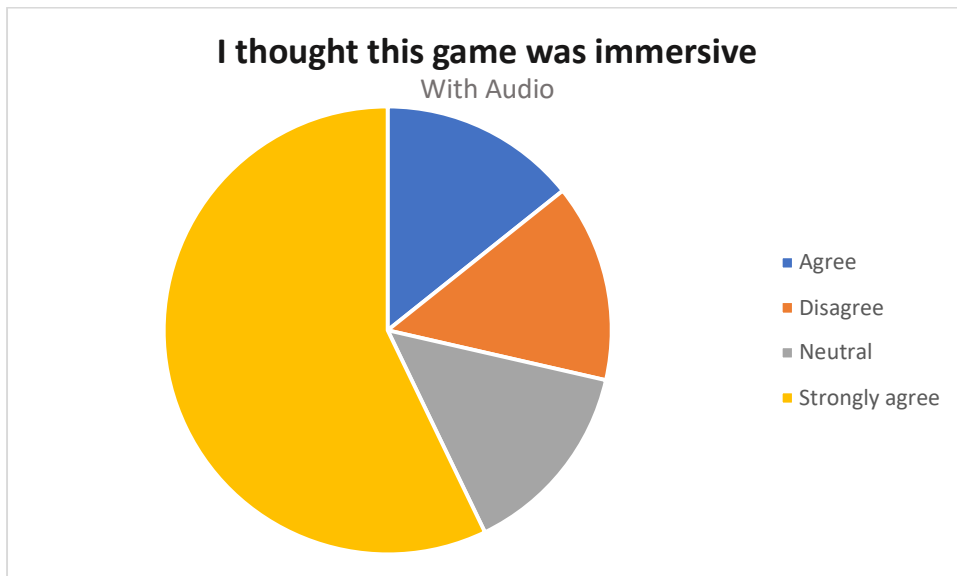
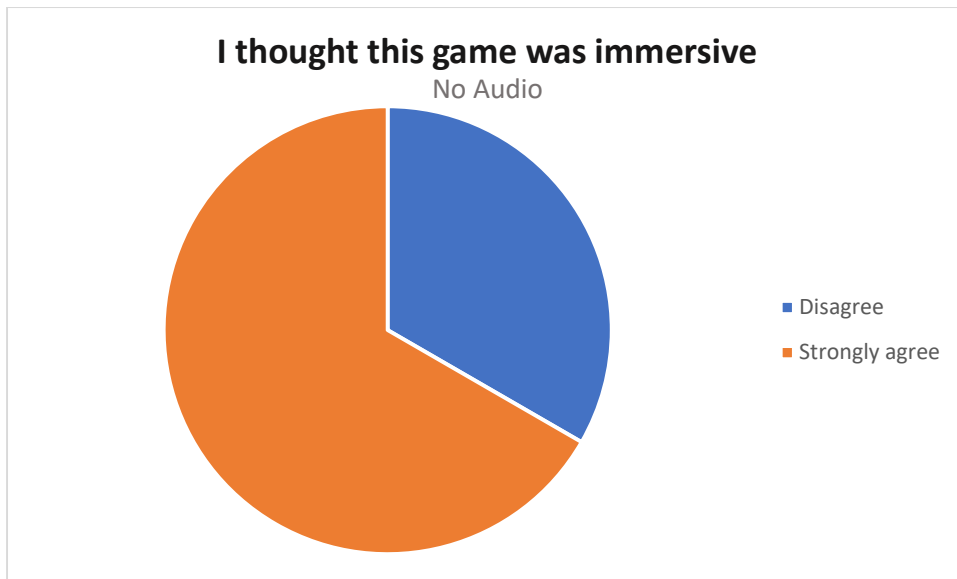*Figure 13 – Pie Chart displaying responses to the question 'I thought this game was immersive' from users with audio*

I thought this game was immersive
No Audio

Figure 14 – Pie Chart displaying responses to the question 'I thought this game was immersive' from users without audio

When asked if they found the game to be immersive, 70% of users agreed, and 20% disagreed, with 10% being neutral. The percentage that disagreed was split equally between those that played with and without audio.
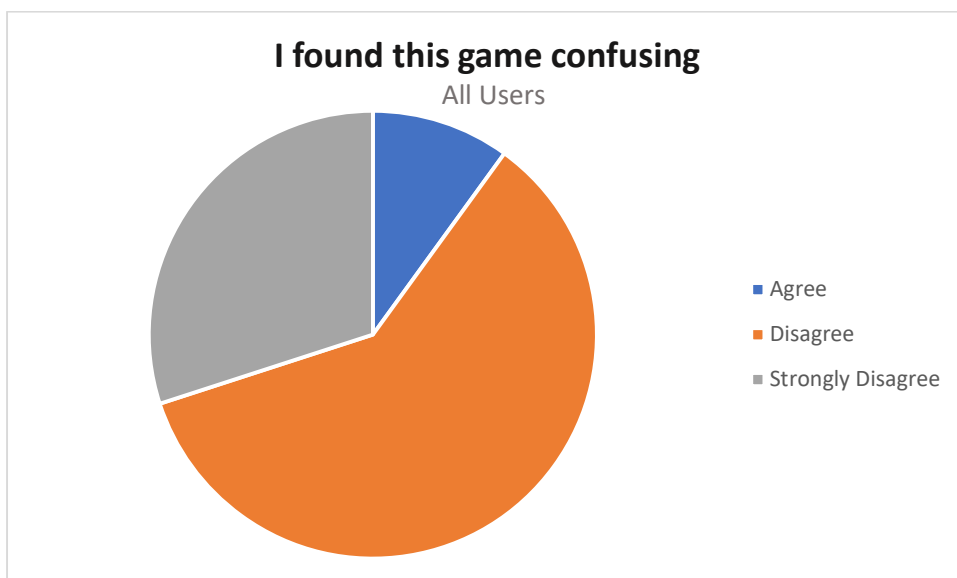
I found this game confusing
All Users

Figure 15 – Pie Chart displaying responses to the question 'I found this game confusing' from all users

I found this game confusing
With Audio

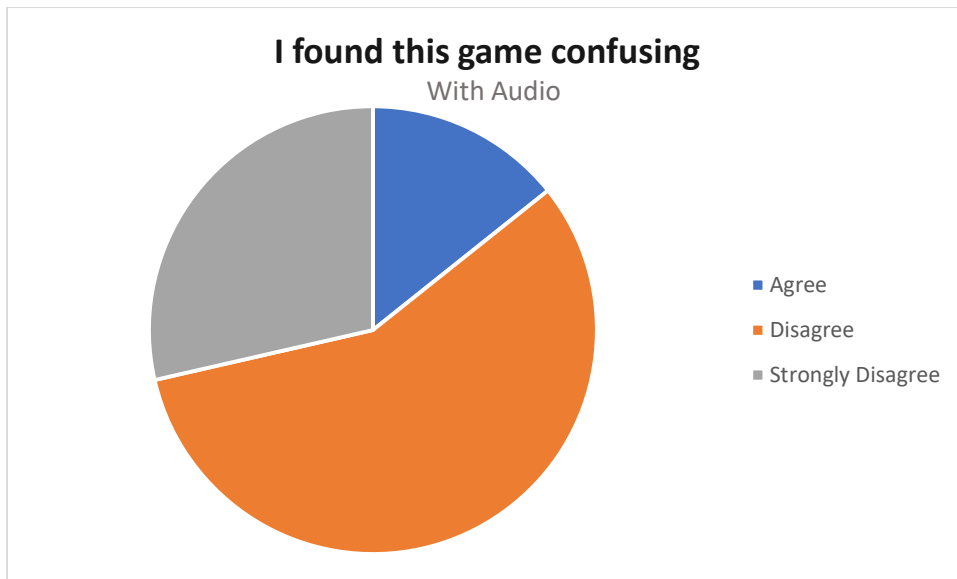*Figure 16 – Pie Chart displaying responses to the question 'I found this game confusing' from users with audio*

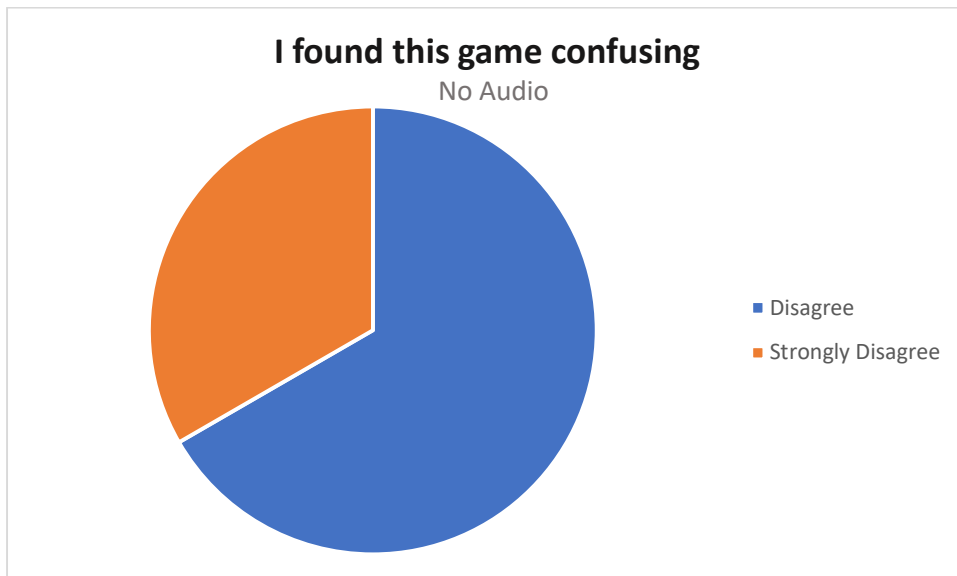## I found this game confusing
No Audio

Figure 17 – Pie Chart displaying responses to the question 'I found this game confusing' from users without audio

When asked if they found the game to be confusing, only 10% of users agreed. This 10% was made up of users that played the artefact with audio, no minimal, and full accessibility features.
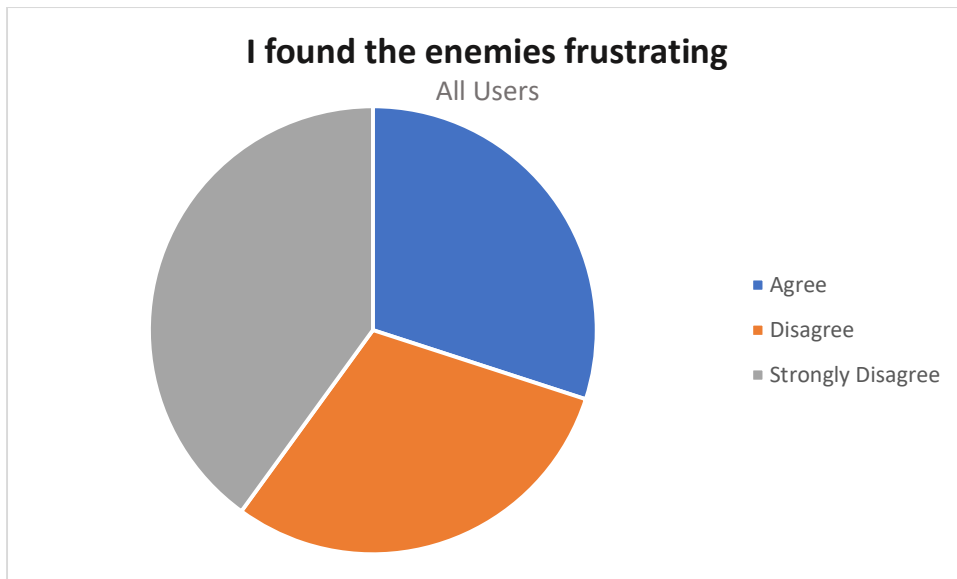
Figure 18 – Pie Chart displaying responses to the question 'I found the enemies frustrating' from all users
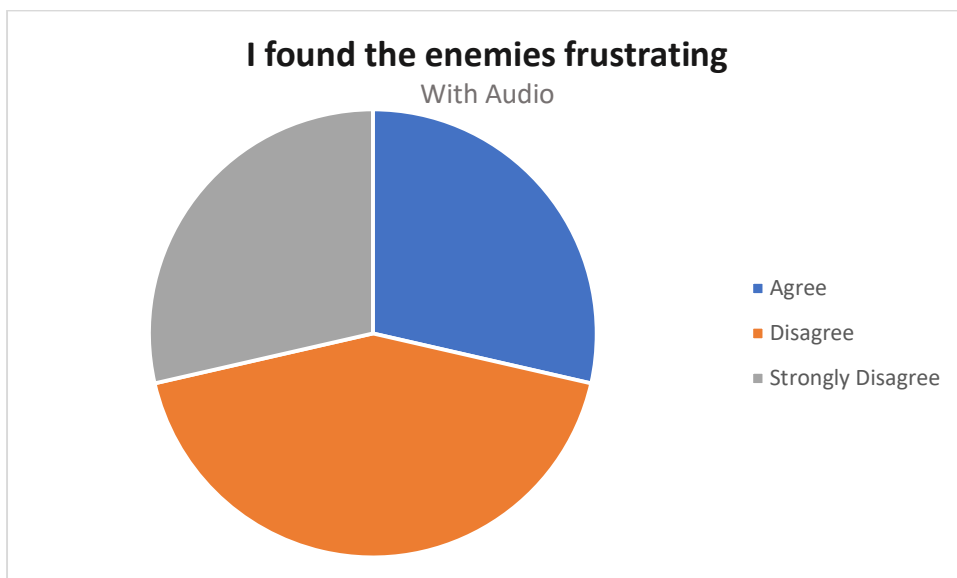

Figure 19 – Pie Chart displaying responses to the question 'I found the enemies frustrating' from users with audio
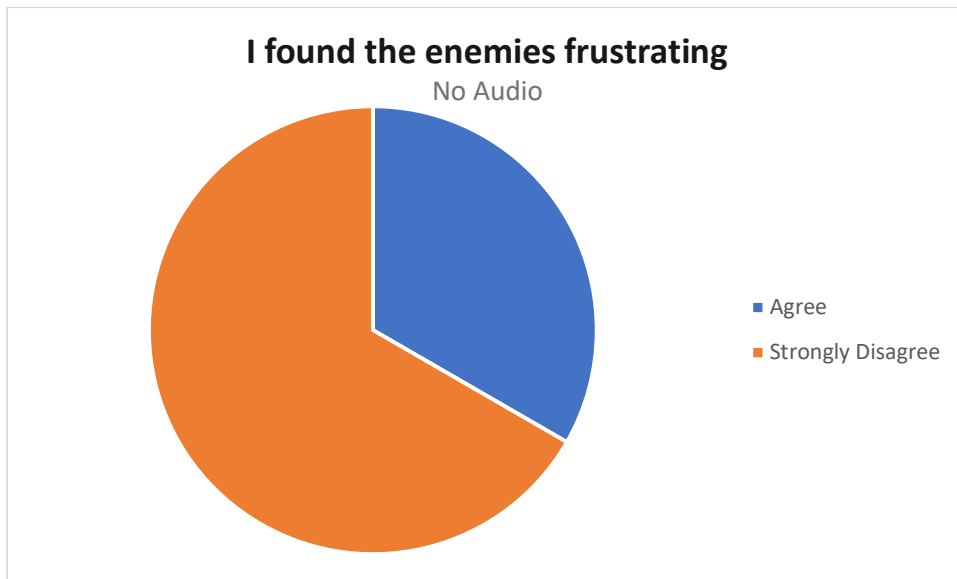
I found the enemies frustrating

No Audio

- ■ Agree
- ■ Strongly Disagree

Figure 20 – Pie Chart displaying responses to the question 'I found the enemies frustrating' from users without audio

When asked if they found the enemies to be frustrating, 30% of players agreed. 20% were players that played the artefact with audio, and the other 10% played without. 10% played with the mini-map and minimal accessibility features, 10% played with the mini-map and full accessibility features, and 10% played without the mini-map and full accessibility features.
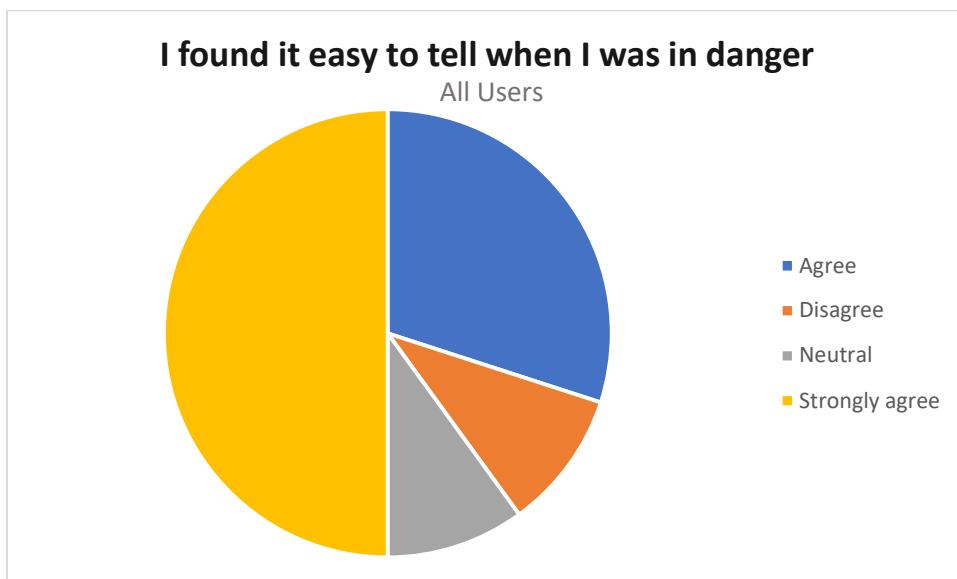

I found it easy to tell when I was in danger

All Users

- ■ Agree
- ■ Disagree
- ■ Neutral
- ■ Strongly agree

Figure 21 – Pie Chart displaying responses to the question 'I found it easy to tell when I was in danger' from all users
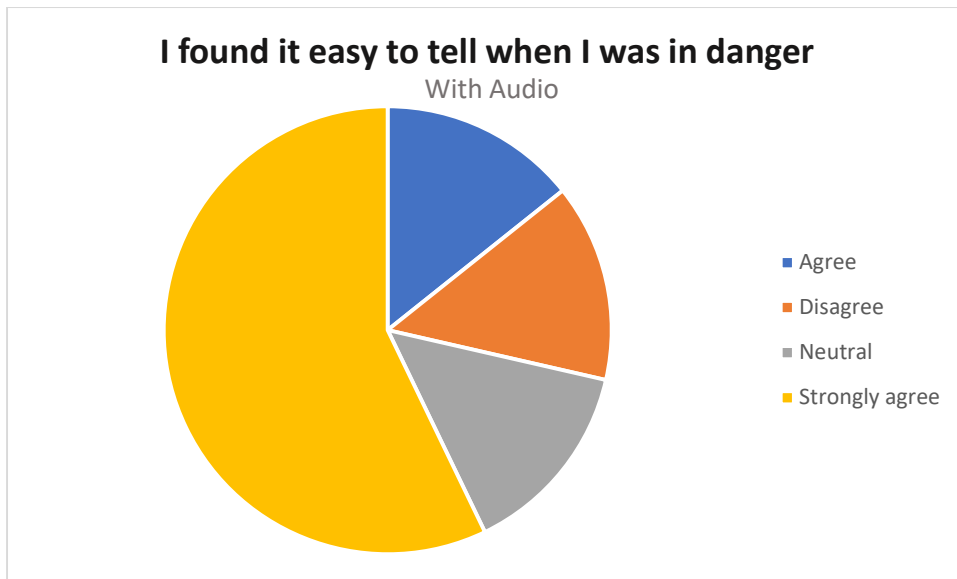
Figure 22 – Pie Chart displaying responses to the question 'I found it easy to tell when I was in danger' from users with audio
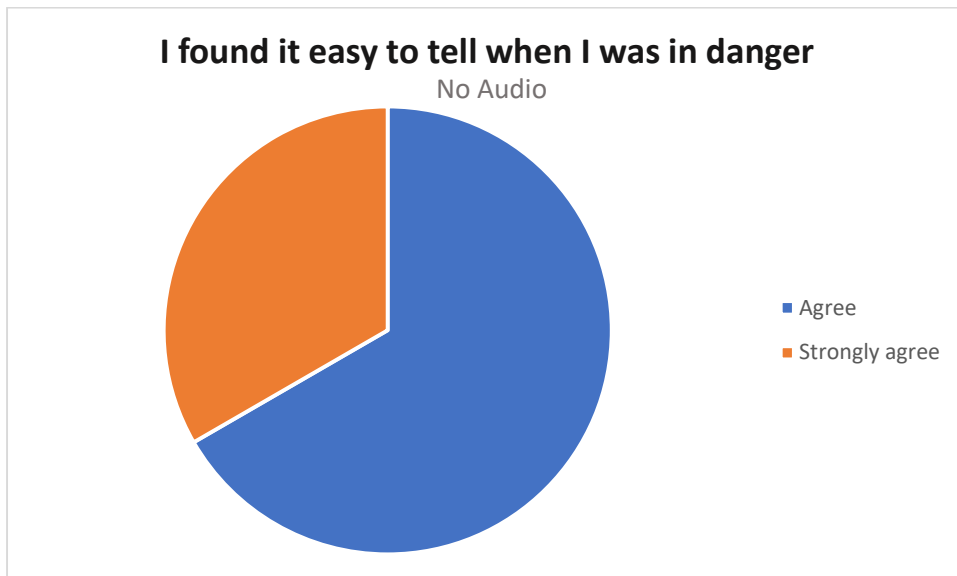

Figure 23 – Pie Chart displaying responses to the question 'I found it easy to tell when I was in danger' from users without audio

When asked if they found it easy to tell when they were in danger, 80% of users agreed. 10% of users felt neutrally, and 10% disagreed. Both the neutral and disagreeing users played with audio, with the one that felt neutrally playing with the mini-map, and the one that disagreed playing without it.

The following questions were presented to users that played the artefact with audio.
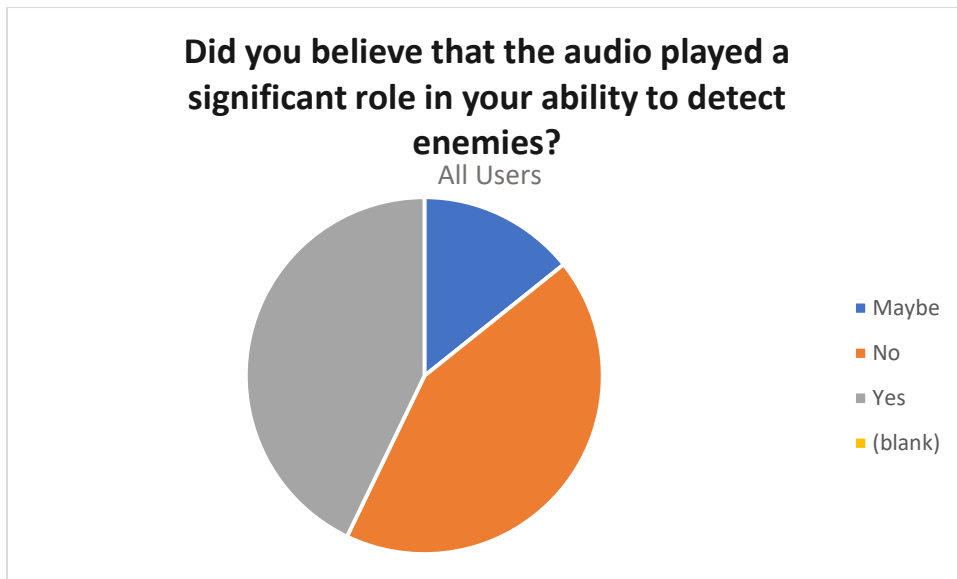
Figure 24 – Pie Chart displaying responses to the question 'Did you believe that the audio played a significant role in your ability to detect enemies?' from all users

When asked whether they felt that audio played a significant role in their ability to detect enemies, the answers were relatively evenly split; with 42% stating that they felt it did, 42% stating that they felt it did not, and the remaining participants stating that they were unsure.
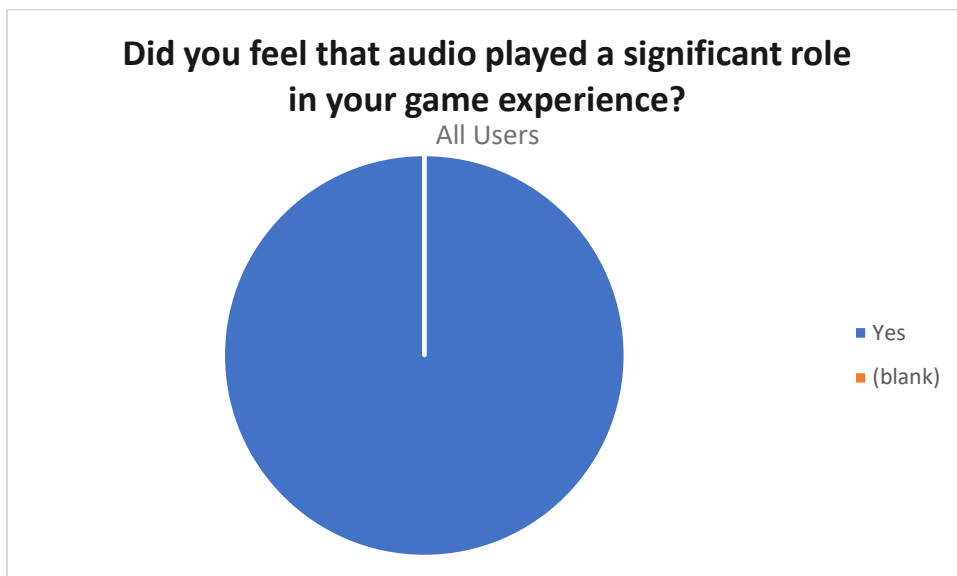

Figure 25 – Pie Chart displaying responses to the question 'Did you believe that the audio played a significant role in your game experience?' from all users

When asked whether they felt that audio formed a significant part of their game experience, all users said yes.
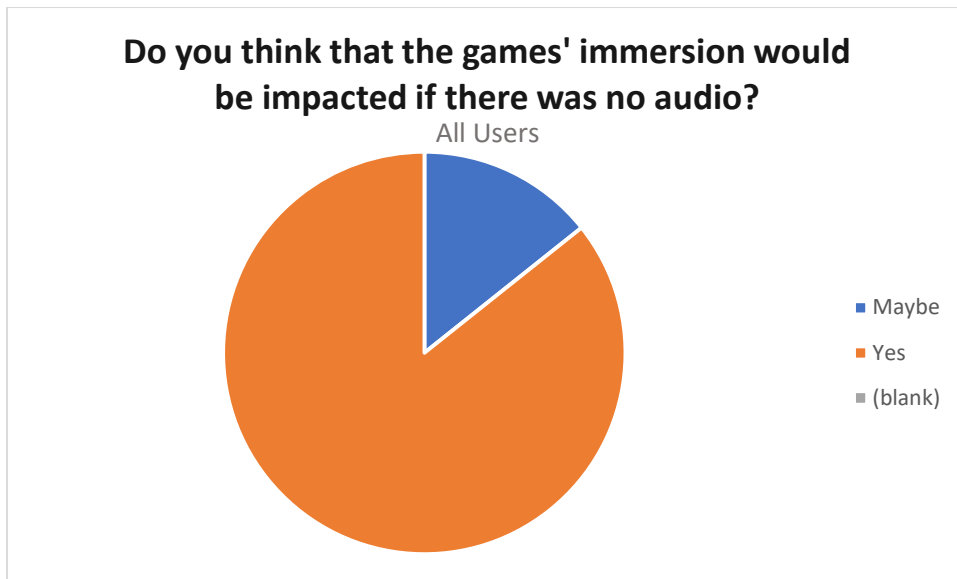
Do you think that the games' immersion would be impacted if there was no audio?

All Users

Legend:
- Maybe
- Yes
- (blank)

Figure 26 – Pie Chart displaying responses to the question 'Did you think that the games' immersion would be impacted if there was no audio?' from all users

When asked whether they believed that the games immersion would be impacted if the game did not have audio, 85% stated that they did, with the remaining 15% stating that they were unsure.

Did you think the game would be less fun without audio?

All Users
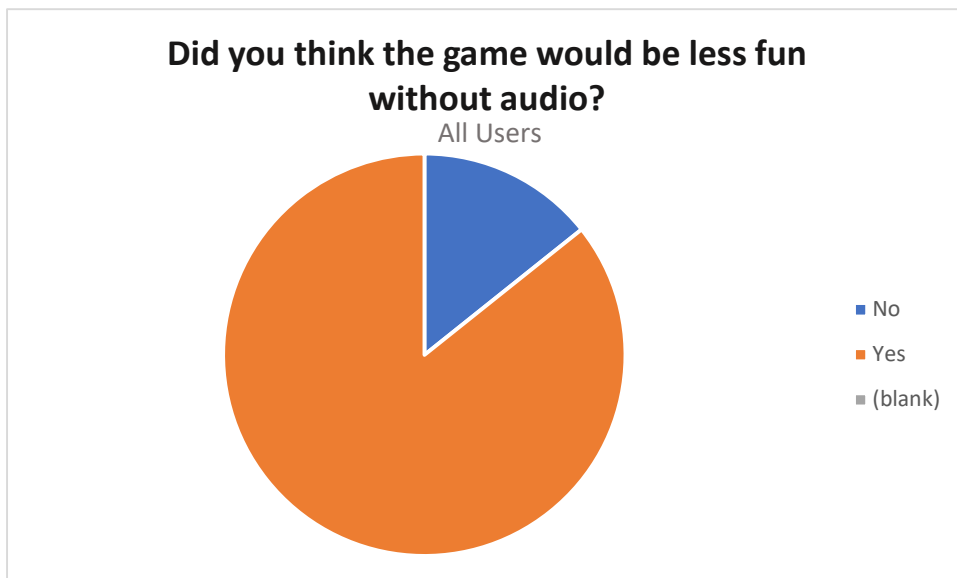
Legend:
- No
- Yes
- (blank)

Figure 27 – Pie Chart displaying responses to the question 'Did you think that the game would be less fun without audio?' from all users

When asked whether or not they believed the game would be less fun without audio, 85% agreed, while 15% disagreed.

The following questions were presented to all participants that played the artefact with the mini-map enabled.
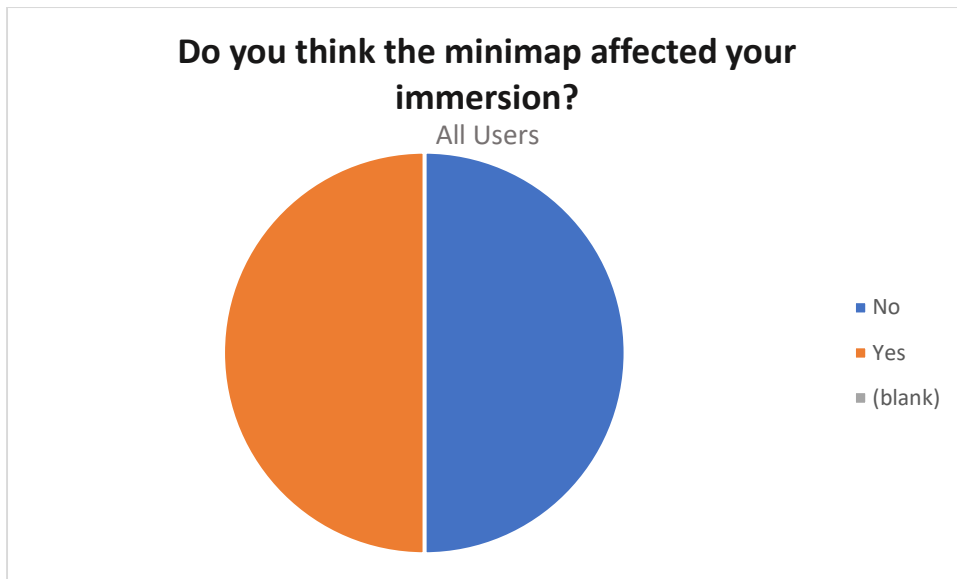
Figure 28 – Pie Chart displaying responses to the question 'Did you think that the mini-map affected your immersion?' from all users

When asked whether or not they believed that the mini-map impacted their immersion, the answers were split evenly between yes and no.
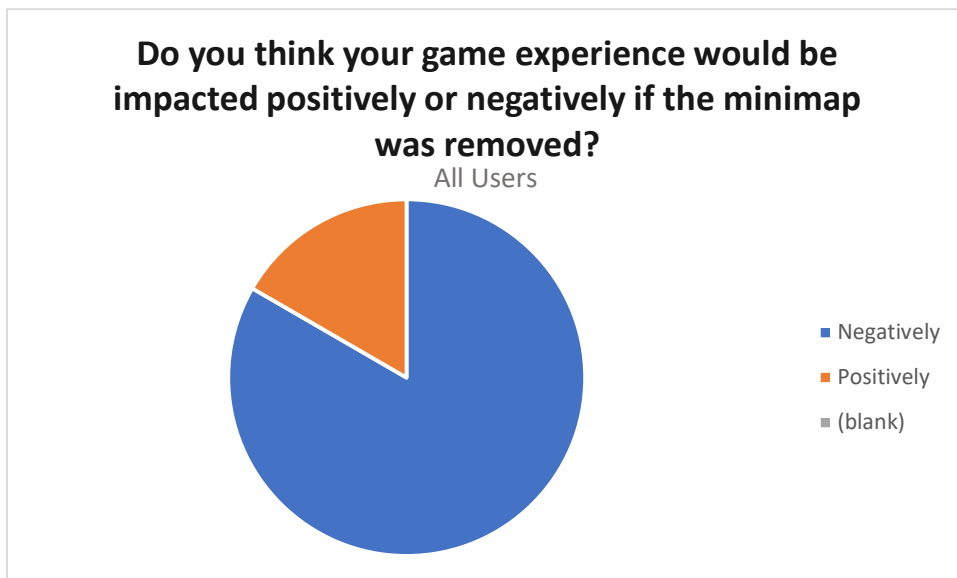

Figure 29 – Pie Chart displaying responses to the question 'Did you think that your game experience would be impacted positively or negatively if the mini-map was removed?' from all users

The same group of users were then asked whether they believed their experience would be negatively impacted if they did not have access to the mini-map. 84% of users agreed, with the remaining 16% disagreeing.

Users were then asked about the other accessibility features. These users were split into two groups. The first group played the game with the ability for their character to 'scent' the air. If an enemy was in range, pressing this key would show indicators pointing towards the enemies direction, and would show and x-ray effect on screen, displaying enemies in red, and pickups in green. The second group did not have this ability; instead, the same effect would apply automatically when enemies were in range.

The following questions were presented to the first group.
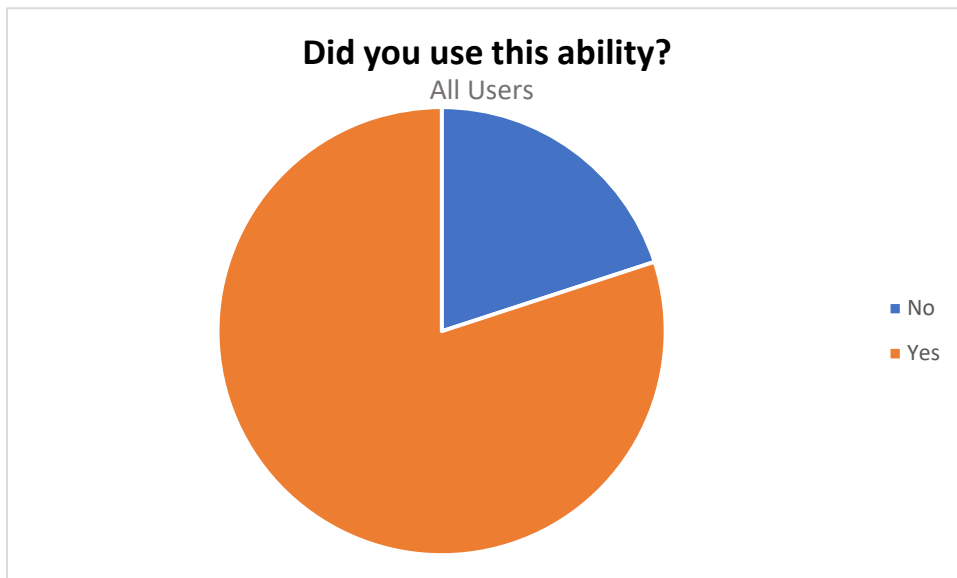
Figure 30 – Pie Chart displaying responses to the question 'Did you use this ability?' from all users

The first group was first asked whether or not they used this ability while playing. 80% of players stated that they did, while 10% did not.
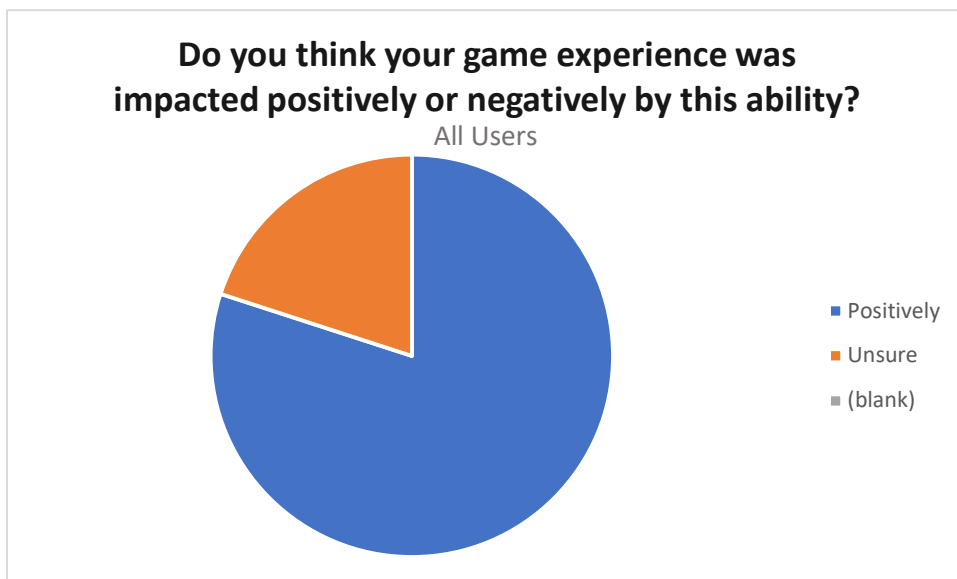
Figure 31 – Pie Chart displaying responses to the question 'Do you think that your game experience was impacted positively or negatively by this ability?' from all users

When asked whether they felt that the ability affected their gameplay positively or negatively, 80% of players believed that it had had a positive impact; this was 100% of players that indicated that they had used the ability at all.

The following questions were then presented to the second group.
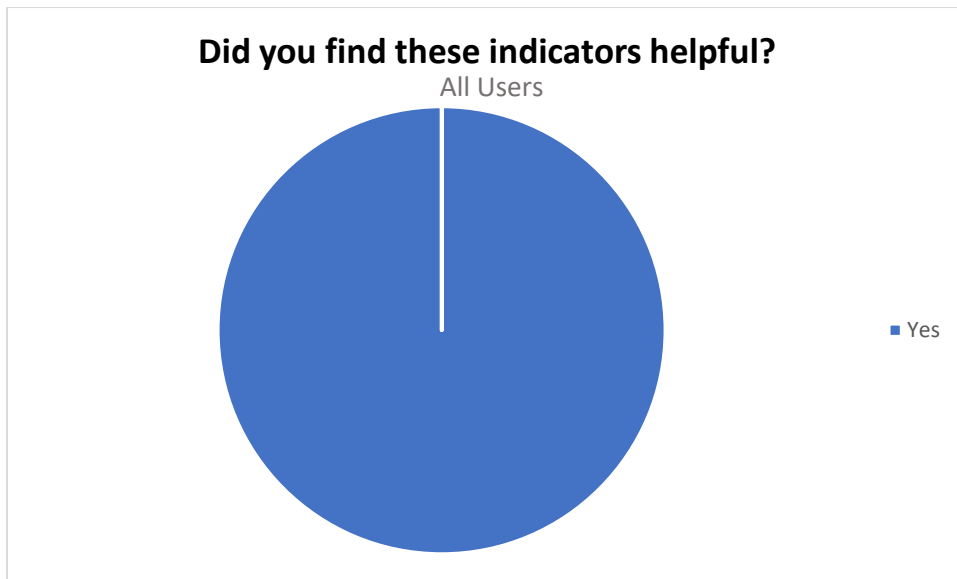
Figure 32 – Pie Chart displaying responses to the question 'Did you find these indicators helpful?' from all users

When asked whether they believed that the indicators had been helpful while playing, 100% of these users stated that they had been.
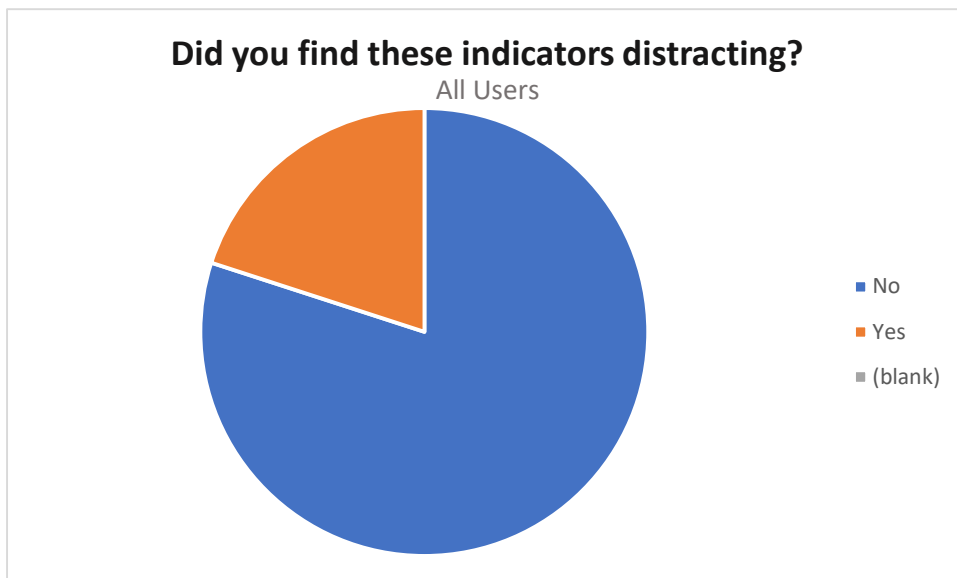
Figure 33 – Pie Chart displaying responses to the question 'Did you find these indicators distracting?' from all users

They were then asked whether they had found these indicators distracting from gameplay; 80% said they had not been, though 10% stated that they had found them distracting.

5.2 Survey Results – Qualitative Data

Participants were also presented with a number of open-ended questions which allowed them to type a response.

When asked to describe any game elements that they believed impacted the games immersion, many players noted that the automatic dimming of the screen and x-ray vision that happened when enemies got too close increased the games immersion, fitting with the animal theme of the game, and giving the intended result of expressing fear and danger visually. This comment was made by

both users that played the game with audio, and those that played without.

The 'scent' mechanic – a mechanic which allowed players to press a key, highlighting nearby enemies and food items, and showing on-screen markers indicating the location of enemies, was commented on by most players which utilised it as positively impacting immersion. Conversely, players which instead had these markers appear automatically when enemies entered audio range felt that this detracted from the games immersion.

Multiple users which played with audio stated that they believed that the directional audio implemented in-game had had a positive effect on immersion.

Multiple users also spoke about the mini-map, and stated that they believed that it did significantly impact immersion in a negative way.

When users which were in the second group for accessibility features – containing the automatic arrows based on enemy proximity – were asked whether they believed that these indicators had affected their gameplay, all users stated that they had been useful in helping them detect enemies. Multiple users which had audio as well as these markers stated that they felt somewhat overwhelming, however – and that they felt that they were too big.

Users which did not have audio did not share these same feelings – instead, one user stated that they believed they had actually improved their immersion, while others echoed similar positive sentiments, stating that they felt that the game would have been much harder to navigate without them.

5.3 Observations

Alongside the surveys, most participants were observed while playing the artefact, leading to multiple notes on their differing performance.

Users with audio, the mini-map, and proximity-based indicators performed the best of the group, oftentimes surviving much longer than the other participants. It was noted that these players found it the easiest to avoid enemies, and to find pickups.

These users were closely followed by those that played with the 'scent' mechanic, though still with audio and the mini-map.

After these came players who played without audio, but with the mini-map – with those using proximity indicators performing better than the second group.

Players with audio but no mini-map came next, with players without the audio or mini-map performing worst of the group.

Players without audio tended to explore the world at a slower rate, spending much of their time using hiding spaces – oftentimes only leaving when forced. Players with audio, however, spent far more of their time moving from place to place – though, their response when confronted with an enemy tended to be more extreme than players without audio. Players with audio often appeared to be temporarily frightened by the approaching footsteps, which was not observed in players that did not have the audio element.

6.0 Discussion and Analysis

6.1 Analysis of Results

From the results outlined above, multiple things can be learned.

Its is clearly evidenced that participants that played the artefact with audio had an easier time while playing than the candidates which played the game without audio. This was likely due to the

combination of both the visual indications and the audio cues, providing the player with a clearer understanding of what was happening at any given moment during gameplay. This information is consistent with existing literature, such as in *'How Can Accessibility for Deaf and Hearing-Impaired Players be Improved in Video Games?'.* (Costello et al., 2019) It was expected that users without audio would find the artefact somewhat more difficult, due to the reliance on audio in video games in order to convey information. However, it was also found that, when utilising appropriate accessibility features, this divide was far less evident – with users self-reporting an equally enjoyable and immersive game experience overall. This is in line with the original hypothesis set out at the start of this study, which stated a belief that users could experience the same immersion and enjoyment from gameplay without audio, so long as that lack of audio did not impact their ability to play the game as intended.

When evaluating implemented accessibility features, it appears that users tend to prefer and find more benefit from features that they find familiar. The mini-map feature, for instance, led to a significantly improved game experience for most users – despite the fact that many users reported that it had had a somewhat negative effect on their immersion. The majority of users which utilised this feature stated that they believed that their game experience would be negatively impacted if the feature was not present. From observations, it can also be seen that these users performed better than those without access to the mini-map – even between users with and without audio. No users stated that this feature has a negative impact on their ability to focus on their gameplay. While the importance of immersion was stated earlier in the study, as emphasised by *'Measuring and defining the experience of immersion in games'*, (Jennett et al., 2008) this shows that immersion is not the most important factor in determining overall video game enjoyment.

Conversely, accessibility features with which users were less familiar were less favoured overall. Both the 'proximity indicators' and 'scent ability' received negative comments in regards to their impact on immersion. As well as this, some comments were made by candidates who had audio alongside these features as to them being 'overwhelming' or 'distracting'. Users without audio, however – especially those without access to the mini-map, and thus more reliant on these modifications – had far less negative comments to make, often praising the feature as significantly improving their ability to navigate the environment. This is in agreement with both *'Designing for Disability: Evaluating the State of Accessibility Design in Video Games.'* (Brown & Anderson, 2021) and *'How Can Accessibility for Deaf and Hearing-Impaired Players be Improved in Video Games?'*, (Costello et al., 2019), who discuss the importance of visual indications to support hearing-impaired users.

Despite the more negative sentiment, all users utilising these features did admit that the features were helpful, despite any negatives – and that they believed that the game would be negatively impacted if they were not present. Based on the qualitative feedback provided in the open-ended comment section at the end of the survey, some candidates – especially those with access to audio alongside these features – did feel that these made the game somewhat too easy. This, alongside the fact that some players felt somewhat overwhelmed, may indicate that some accessibility features are better as a feature that can be toggled on or off depending on user ability and preferences – rather than being built inherently into the gameplay. This is consistent with statements made in *'The Ground Floor Approach to Video Game Accessibility: Identifying Design Features Prioritized by Accessibility Reviews'*, (S. L. R. Anderson, 2024) which found that user settings are important in allowing users to modify their experience for their individual needs. This form of user customisation may lead to inconsistencies in user experience – however, this is a trade off that

may be necessary to make in order to provide an accessible experience for the widest variety of users, due to the diverse nature of individual accessibility needs.

6.2 Objectives

The primary objectives of this study were to apply the conducted secondary research in order to create a simple game artefact utilising accessibility methods, and evaluate the usefulness of the implemented methods and how their application affected user interactions with the artefact.

With the conducted research, both objectives have been met.

The game artefact created utilised a variety of the accessibility methods which were explored in the literature review phase of this study. These accessibility methods included;

- The usage of visual indicators to indicate sound and direction, shown in the implementation of the 'directional indicators' and the 'scent' mechanic
- The usage of colour to show tone changes within the game, through the dimming and discolouring of the screen when the player is in close proximity with an enemy.
- The usage of particle effects to indicate actions and tone, as applied by the bright, colourful particle effects shown to the player when they successfully collect a pickup, and the sharper, darker particle effects shown on the player character when they are injured.
- The usage of an on-screen mini-map to effectively show the player where things are, alongside the location of any important things that would normally create sound – such as the enemies, and the food items.

The other objective was completed by the primary research conducted involving candidates testing the created artefact, and the following analysis of the results. Through this, I found that all of the implemented methods are useful for supporting players both with and without audio. This data supports the information gathered in my literature review in all aspects, and reaffirms the fact that all of the implemented methods are useful for improving accessibility – however, some accessibility features may be irritating or overwhelming for players that do not need them, and others may cause the game play to become too easy for both hearing and non-hearing players if implemented incorrectly.

6.3 Criticisms of Findings

There are some criticisms that could potentially be made of the findings within this study.

For instance, this study was unfortunately only conducted on 10 individuals, which is a very small sample size. Due to this fact, it is possible that a larger sample size may decrease the variance between different categories responses. At this size, erroneous data cannot be accurately excluded, and minor discrepancies may appear far larger than they are in actuality. If this study was repeated with a larger sample size, it is possible that the findings could be quite different.

Another consideration is the candidates themselves. All candidates were adults between the ages of 19 and 30, with a high degree of computer literacy, and experience playing games. If presented to a more diverse candidate pool, the results could also vary significantly, and as such, it is not possible to state that this data is without bias.

It should also be noted that none of the candidates had any disabilities. While the study made up for this somewhat by removing audio for some candidates, a player without access to audio may respond quite differently to a player who is truly hearing impaired.

It is also true that many of the posed questions within the survey are somewhat subjective. It was found during the literature review that terms such as 'immersion' often had multiple definitions, and so it becomes difficult to be certain that candidates all share the same understanding of its meaning.

7.0 Conclusion

This project intends to explore the varying methods for increasing accessibility for users with hearing impairments currently employed within the games industry, how those accessibility modifications impact gameplay for both abled and impaired players, and potential future improvements that could be made to current methods to improve accessibility for people with accessibility needs, with a minimal impact on gameplay and immersion.

This study aimed to explore the varying methods for increasing accessibility currently used within the games industry to support users with hearing impairments, and how those modifications impacted gameplay. It also intended to explore which methods were most effective at meeting their goals, and how these features may be improved in order to decrease gameplay impact and increase immersion.

Throughout the literature review, the different accessibility needs for users with a variety of disabilities were investigated, with a focus on those intended to support hearing-impaired users.

The usage of audio within video games was explored, with the research showing that the most important audio categories, with the highest impact on gameplay and immersion, were music, speech and dialogue, audio cues, and the use of directional audio. With this information, the specific difficulties faced by hearing impaired users due to the reliance on these audio elements was outlined. The research continued by investigating the common accessibility features used to address these deficiencies, specifically the usage and drawbacks of subtitles, visual indicators, and visual design elements used to set tone.

From this research, an artefact was created, implementing a number of accessibility features within an arcade-style game. This artefact was then presented to a series of candidates in a variety of different configurations, in order to assess how their behaviour, enjoyment, and overall game experience varied depending on the usage of audio and these accessibility features.

This study discovered that, even while implementing all accessibility features, players with audio still performed better than those without. Despite this, however, it was also shown that – when implementing appropriate accessibility features – players could still enjoy the gameplay equally, or even more than, their peers.

Despite the importance of immersion for an enjoyable game experience, as discussed in the literature review, it was discovered that the most immersive accessibility features did not necessarily perform better, either in player sentiment or observation of performance. In fact, players tended to prefer features that were more familiar to them, such as the mini-map.

Overall, it can be concluded that the common accessibility features utilised are effective in meeting the goal of allowing access to games for individuals with hearing impairments, though they do not provide an identical game experience and do have space for further improvements. It is possible for accessibility features to be implemented in a way that has a minimal impact on immersion, and is woven directly into the gameplay – which is something many players prefer, as evidenced by the player preference for the 'Scent' mechanic over the automatic indicators. This added element of control does improve immersion, as the literature review suggests. It can also be concluded that immersion is not the most important factor in creating an enjoyable game experience – and, in fact,

some game immersion can be safely sacrificed in order to better support players, with minimal impact on the overall game experience.

8.0 Recommendations

While this study looked at a variety of different accessibility methods, it did not encompass all of the accessibility methods available to explore. As well as this, the sample size was relatively small, and the gameplay focussed on one specific genre and game style.

It may be beneficial for this study to be conducted with larger sample sizes, in order to confirm the results of this study. Future experiments may want to consider how different game genres may affect the user responses to different accessibility methods. In addition to this, it may also be beneficial to consider how the benefits and downsides of these features are affected within multiplayer games, and how accessibility features may need to be modified for these games.

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10.0 Appendices

Appendix 1 – The Player Survey

Exploring Accessible Design for Immersive Environments

Important Information about the study – READ BEFORE YOU PLAY;

What is this project? This game is presented as part of a research project; *'Exploring Accessible Design for Immersive Environments'*. The researcher is currently exploring methods for making games more accessible while maintaining the game experience, with a primary focus on accessibility for users who may be **hard of hearing** or **colourblind**.

Why do you need playtesters? A significant part of the research in this project is *exploring methods for improving accessibility* while *maintaining immersion and game feel*, and having *as little of an impact as possible on the overall game experience*. Your feedback will allow the researcher to understand how well the project manages this. As a part of the research, **the game may be presented to you in different states** – for instance, **the game may be presented without audio**, to assess how this affects the way that people play. *If this is the case, you will be informed.*

How will data be gathered? As a part of this project, **the researcher may be observing your gameplay**, and taking notes, in order to gain an understanding of how you play. This information will **not** include any personal information, and will simply include notes on areas where users have gotten stuck, and more general notes on how people interact with the game. Once you have played the game, a survey will be available for you to fill out.

How will my data be stored? All data gathered will be stored via *OneDrive*, and deleted once the project has concluded. Conclusions drawn from the research conducted will **not** include any personal information, or information gained from any single specific participant. **You may request to have your data withdrawn from the study at any time.** In order to do this, *please ensure you make note of your chosen participant indentifier*, so that your data may be located for deletion.
If you have any questions, please ask the researcher now. You may ask questions at any time throughout the study, and can choose to withdraw at any time during or after.

Confirmations:

1. I confirm that I have read the above information and that I understand the purpose of this study *

   ○ Yes

   ○ No

2. I confirm that I have been given opportunity to ask the researcher any questions that I may have *

   ○ Yes

   ○ No

3. I consent to the use of any data gathered via observation and the following survey for the purposes outlined above *

   ○ Yes

   ○ No

4. I understand that I may withdraw my consent at any time prior to the conclusion of the research project, and that I may request for my data to be deleted at any time. I understand that, for my data to be deleted, I must be able to provide the identifier used to locate my data *

   ○ Yes

   ○ No

5. Please provide a unique personal identifier in the box below. This can be any combination of letters and numbers. YOU MUST BE ABLE TO PROVIDE THIS IDENTIFIER TO THE RESEARCHER IN ORDER TO REQUEST DELETION OF YOUR DATA. IF YOU CANNOT DO SO, YOUR DATA CANNOT BE IDENTIFIED FOR DELETION; *

Overall Game Experience

6. Please rate the following statements:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
I found this game fun	○	○	○	○	○
I found this game easy	○	○	○	○	○
I thought this game was easy to follow	○	○	○	○	○
I thought the game was immersive	○	○	○	○	○
I found this game confusing	○	○	○	○	○
I found the enemies frustrating	○	○	○	○	○
I found it easy to tell when I was in danger	○	○	○	○	○

7. Were there any areas in the game that you found confusing or frustrating?

8. Please describe any parts of the game that you believe impacted the games immersion
   [Positively or negatively]

Impact of Audio

9. What letter did your given game code start with?

- ○ A
- ○ N

10. Did you feel that audio played a significant role in your game experience?

- ○ Yes
- ○ No
- ○ Maybe

11. Did you feel that audio played a significant role in your ability to detect enemies?

- ○ Yes
- ○ No
- ○ Maybe

12. Do you think that the games immersion would be impacted if there was no audio?

- ○ Yes
- ○ No
- ○ Maybe

13. Did you think that the game would be less fun without audio?

- ○ Yes
- ○ No
- ○ Maybe

Accessibility Modifications - The Minimap

14. Which of these matches your given game code?

    ○ -M--

    ○ -N--

15. Did you notice the minimap?

    ○ Yes

    ○ No

    ○ Maybe

16. Did you use the minimap to detect nearby enemies?

    ○ Yes

    ○ No

    ○ Maybe

17. Do you think the minimap affected your immersion?

    ○ Yes

    ○ No

    ○ Maybe

18. How do you think your immersion was affected?

    [   ]

19. Do you think your game experience would be impacted positively or negatively if the minimap was removed?

    ○ Positively

    ○ Negatively

    ○ Unsure

Accessibility Modifications - The 'Sniff' Ability

20. Which of these matches your given game code?

   ○ --P

   ○ --IX

21. Did you use this ability?

   ○ Yes

   ○ No

22. Did you find this ability helpful?

   ○ Yes

   ○ No

23. Do you think your game experience was impacted positively or negatively by this ability?

   ○ Positively

   ○ Negatively

   ○ Unsure

Accessibility Modifications - Proximity Indicators

24. Did you find these indicators helpful?

○ Yes

○ No

○ Maybe

25. Did you find these indicators distracting?

○ Yes

○ No

○ Maybe

26. How do you think these indicators affected your gameplay?

Thank you!

27. Any Other Comments?