Tallinn University
School of Digital Technologies
Digital Learning Games

The effects of music on gameplay in video games

Muusika mõju videomängude mängimisprotsessile

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Authors Declaration

I hereby declare that the thesis “The relation between music and gameplay in video games” is a result of my independent work and effort. I certify that to
the best of my knowledge it does not infringe upon anyone’s copyrights. Where other sources of information have been used, they have been acknowledged. This thesis has not been submitted anywhere for any other comparable academic degree.
Thesis was finished under supervision of Mikhail Fiadotau.

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Abstract

The objective of this study is to determine the correlation between the intensity of game music and players' level of focus, as well as perceived difficulty of a game. To find any correlations, experimental research was done. The results showed that more intense music caused a higher perceived game difficulty and vice versa. The effect of music on focus, however, was also evident but more complex. Individual participants reacted differently to the same music. The study shows the importance of selecting the right game music in order to shape players' perception of and interaction with the game.

Keywords: game music, ludomusicology, focus, attention, perceived difficulty, difficulty, experimental research

Summary (English)

The effects of game music on experiencing a game have been largely overlooked. However, there have been a few previous studies that indicated an effect of game music on player experience. Additionally, related fields of media, such as movies, have already widely accepted the effect of music on experiences. Still, game music is often given lower priority than game visuals, despite potentially having a larger effect. Moreover, smaller games with a large emphasis on music have proven to be very successful.

The goal of the study was to find out how the perceived intensity of game music correlates with players' level of focus and perception of game difficulty.

To approach the goal, a mixture of quantitative methods and qualitative methods were used. The research was done through an experiment. The experiment had 34 participants play a game, with a survey to be filled out after each of the 3 stages. Out of those 34 participants, 6 participants were also interviewed and observed.

The results can be split into two parts, as the main research questions has two topics:

- The correlation between game music intensity and perceived difficulty
- The correlation between game music intensity and players' level of focus

Evidence of a correlation between game music intensity and perceived difficulty has been the result of the experimental research. The data showed that players were more likely to rate a stage as easier if the music was less intense. Conversely, if an easier stage had more intense music, it would be rated as more difficult.

Evidence of a correlation between game music intensity and players' level of focus wasn't found in the quantitative research. However, the interviews revealed that music did have an effect on a player's level of focus. That said, this effect differed from player to player. Some players noted that enjoying a relaxed music track caused them to relax and lose focus. Other players noted that enjoying the same music caused them to get more in the right state of mind to play, thus gaining focus. Similar results were observed with songs that were more intense or disliked. It helped some participants to focus, while others got distracted by it and reported to lose focus.

The results can be used practically in many situations. First of all, a sense of progression can be achieved through music rather than difficulty, or a combination of both music and difficulty. Additionally, looking at game music more critically is warranted, as interviews showed that disliked music can cause a loss of focus. Sometimes, therefore, it is better to avoid music. Especially for games that require focus, such as educational games, having music that the target audience enjoys or no music at all would be advisable.

Kokkuvõte (Eesti keeles)

Arvutimängu muusika rollile mängu tervikkogemuse juures on siiani vähe tähelepanu pööratud. Siiski on tehtud mõningaid uuringuid, mis leidsid, et mängu muusikal on kogemusele mõju. Lisaks on teised samalaadsed meedia valdkonnad nagu kino juba laialdaselt aktsepteerinud muusika märkimisväärset mõju tervikkogemusele. Sellele vaatamata pannakse muusikale vähem rõhku kui mängu visuaalsele küljele, kuigi muusika mõju kogemusele on potentsiaalselt suuremgi. Veel enam - väiksemad mängud, mille loomisel on rõhku pandud muusikale, on osutunud väga menukaks.

Uurimuse eesmärk oli teada saada kuidas mängija poolt tajutav mängu muusika intensiivsus on vastavuses mängija tähelepanu ja tajutud mängu raskustasemega.

Eesmärgi saavutamiseks põimiti kvantitatiivseid ja kvalitatiivseid meetodeid. Uurimust teostati eksperimendi teel. Eksperimendi raames mängisid 34 osalejat mängu, mille 3 astmest igaühe järel täitsid nad küsimustiku. Neist 34 osalejast 6 osalejat intervjueeriti ja vaadeldi samuti.

Tulemused jaotuvad kahte osasse, kuna uurimusküsimusel on kaks teemat:

- Korrelatsioon arvutimängu muusika intensiivsuse ja mängu tajutud keerulisuse vahel
- Korrelatsioon arvutimängu muusika ja mängija keskendumistaseme vahel

Eksperimentaalse uurimuse tulemusel leiti korrelatsioon muusika intensiivsuse ja mängu tajutud keerulisuse vahel. Andmed näitasid, et mängijad hindasid mängu kergemana siis, kui muusika oli vähem intensiivne. Vastupidiselt, kui kergemal mänguastmel oli intensiivsem muusika, hinnati mänguastet raskemaks.

Kvantitatiivne uurimus ei leidnud seost arvutimängu muusika intensiivsuse ja mängija keskendumistaseme vahel. See-eest intervjuudel tuvastati, et muusikal oli siiski mängijate keskendumisele mõju. See efekt oli aga mängijate puhul erinev. Mõned mängijad märkisid, et rahulik muusika omas rahustavat mõju ning selle tulemusel nende keskendumine halvenes. Teiste mängijate sõnul aitas sama muusika neil saavutada mängimiseks sobivat meeleseisundit ning keskendumine paranes. Sarnased tulemused olid ka intensiivsema ja üldiselt ebameeldivama muusika puhul. See aitas osadel mängijatel keskenduda, samas kui teiste osalejate sõnul oli see häiriv ning keskendumisele halva mõjuga.

Neid tulemusi on praktikas võimalik kasutada mitmetes situatsioonides. Esiteks, arengu tunnetust on võimalik saavutada muusika, mitte mängu raskusastme abil, või muusika ja raskusastme koosmõjul. Lisaks, arvutimängu muusika kriitilise pilguga vaatamine on põhjendatud, kuna intervjuud näitasid, et ebameeldiv muusika võib mõjuda keskendumisele häirivalt. Seetõttu on teatud juhtudel parem muusika kasutamisest hoiduda. Eriti mängude puhul, mis vajavad palju keskendumist (näiteks harivad mängud), on soovitatav kasutada muusikat, mida sihtgrupp naudib, või hoiduda muusikast sootuks.

Introduction

In video games, music is a crucial part of the experience. Just like with movies, music contributes massively to setting the atmosphere and changing a viewers mood. Would music be removed from movies, the result is usually something unsettling and unnerving. The same is true for video games. According to Zach Whalen (2007), video game music should be approached differently than film music though, as it lacks the predictability of a movie, due to the decision-making nature of games. Additionally, altering music in games can change meanings, actions, effects, and emotional response to the game (Wharton & Collins, 2001).

The importance of music in video games has been shown through the successes of some independently developed games that put a lot of focus on audio and music. One of the most successful independently developed games is *Bastion* (2011). This game, made by Supergiant Games, is one of the top 5 highest grossing indie games (Shaver, 2016). The reason for its success, in my experience, lies in the game's capability to dictate the mood of the player throughout the storytelling. In the game the story and the music are merged. In key moments of the story the game either plays a new soundtrack or a variation of a previous soundtrack, but with added vocals that are relevant to the storyline. Of course, these key moments in the story (and music) also go paired with a new gameplay experience: a boss fight that had been teased before, a new type of enemy, granting the player a new weapon or overwhelming the player with massive amounts of weak enemies. The game has been praised for this integration of the music with the storyline and gameplay and gives us a clear example of how music can help make a game excel and elevate other parts of the game.

The music composer of another such example, *Faster Than Light* (2012), Ben Prunty has the following to say about music in games: "It provides emotional weight to a scene, very similar to how music in movies works. It can work in tandem with the visuals to build an atmosphere. Most interestingly, by using these methods, a game's music can direct you, the player, by telling you what you should feel in a given scene." (Prunty, 2018). Conversely, music can also ruin an atmosphere. Ben Prunty gives the example of having jazzy saxophone music under the horror-ish game *Dark Souls* (2011). The unnerving effects of the music and sounds becomes apparent, as the jazzy music removes all sense of tension from the game, despite the game still being difficult.

Previous studies have already suggested that the presence of music in a video game can have a significant impact on the stress levels of a player (Hébert et al., 2005). This is also concluded in the study by Wharton & Collins (2001). The study also argues that the pacing of songs has an important effect on how a game is played.

As these previous studies already indicated that there is evidence of video game music altering the perception of a game, it is an interesting topic to study. Moreover, these previous studies also hinted at player's decisions changing based on the music. Furthermore, the pacing of the music has been found to be especially important. The findings of any research done in this field could be of value to (game) music composers as well as game designers, as music composition and gameplay (among other game elements) are both contributing to the experience. Especially the interaction of game music with components Mihaly Csikszentmihalyi's flow theory (1972/2000) can lead to insights on how game music can make a game more enjoyable. The theory of flow, however, consists of different components and has different models (as will be explained in chapter 1.2.1 Flow theory). For this study, I chose focus and challenge, two of the eight components of the theory of flow (Csikszentmihalyi, 1990).

This lead to the following main research question:
How does the perceived intensity of game music correlate with players' level of focus and perception of game difficulty?

To reach answer this question, some sub-questions must also be answered. Once the following sub-questions are answered, the main research question can also be answered:

1. Can low intensity (relaxing) music result in lower perceived game difficulty? Conversely, can high intensity music result in higher perceived game difficulty?
2. When music intensity and game difficulty progression do not match, does it result in a player's loss of focus? Conversely, when music intensity and game difficulty progression do match, does it increase a player's level of focus?

The answers to these questions are to be found through experimental research, in which a mix of qualitative and quantitative methods are used.

The research hypothesis of the study is that music intensity can have a significant impact on the players' level of focus and their perception of the game's difficulty.

The results of this study are likely to be applicable for any game genre and could especially improve games where music's influence is overlooked or even ignored. Especially games with a smaller audience or lower budget, such as educational games or serious games, could benefit by being made aware of the importance of music in video games.

1. Theoretical background

The main objective of the study is to find out if the intensity of game music correlates with players' level of focus and perception of game difficulty. Therefore, looking into related studies that have already been conducted within this field is warranted. First, an overview is given of the use of music in games. Then, the psychological theories associated with games will be explained. Finally, a connection between video game music and the psychology of games will be made by looking at the effects of music in games.

1.1 Overview of game music

In this section an overview is given of the history of video game music and audio, the differences between film music and game music and the different types of music used in different genres of games. Lastly, the implications thereof will be discussed.

1.1.1 History of video game audio

According to Karen Collins (2005), there have been three stages of video game music. The first stage is the characteristic blips and bleeps that old consoles and arcade games are known for. This is known as the 8-Bit Revolution. Some well-known games with such soundtracks are *Tetris*, *Pacman* and *Super Mario Bros*. The second stage is the 'in-between' stage, where technological developments expand the options of game music and because of that, more sophisticated music starts to develop. The final stage is what we have now, a stage where mainstream artists work on game music and the technology is at a stage that it is no longer restricting.

The very first video games, such as *Tennis for Two* in 1958, had no sound at all. It wasn't until Atari came with *Pong* in 1972 that sound was for the first time included in a game. Although articles have been written about how cleverly the sound was designed in this game, which consisted of little more than a 'pong'-sound whenever the ball hit a paddle, the sound was actually somewhat of an accident (Kent, 2001). According to Al Alcorn, the developer of *Pong*, he simply ran out of parts to use on the board. He was asked to develop a sound that would sound like a crowd is cheering or, when you lost, boo-ing. He had no idea how to do this though, so he used the parts he already had on the board and created the legendary pong-sound in just half a day.

The next evolution of game sounds was done in *Space Invaders* in 1978 (Collins, 2005). This was the first game to feature the presence of constant background music. Additionally, the sounds were context-based. As the player progressed, the game grew more difficult by increasing the speed and the background music would match this speed. Also, the game featured 6 different sound effects, for player actions such as firing a missile, as well as hitting enemies or being hit.

Commodore was the first to realise the potential that the market gaming at home could have. The 64K model became the best selling computer of all time, selling an estimated 22 million units (Collins, 2005). However, the problem during this 8-bit era was the limited capacity of the game cartridges. Because of this, only a very limited amount of game size could go to the music, meaning there were still games being produced without any music or very minimal music. As the technology progressed throughout the 80s and the game industry matured, however, the cartridges grew in capacity. This naturally resulted in audio and music improving as well.

Around 1987, the introduction of 16-bit machines began, which is the second stage of video game music. Sega came with the Mega Drive (Kent, 2001) which outclassed the previous 8-bit machines in capabilities (Collins, 2005). As a response Nintendo started to develop the SNES, which was released in 1991. This SNES contained a Sony SPC-700, a 8-bit CPU completely dedicated to sound. Additionally, it had a significant amount of cartridge memory (24 Mbit), that could partially be used for sounds.

After this short in-between stage, CD-ROM technology came out to replace game cartridges, cassette tapes and floppy disks, meaning two things: First off, more space was available for sounds and secondly, system-specific sound cards were no longer the deciding factor on what sounds or music would sound like. This second part was probably the more important breakthrough, as it made composing music a lot easier, as now it would sound the same on different systems. With previous technological barriers faded, music and sound effects in games have become an important part of video games.

The history of video games and the sound in video games may be important to consider when designing a game, as any audience familiar with a genre may have certain expectations about a game, which are coming from previous games with similar genres. Similarly, when conducting an experiment with an existing video game, participants' previous experiences with this particular video game or similar video games must be considered. When players are to play *Space Invaders* f.e., the participants will most likely expect the iconic music that accompanies the game. The absence of the music in this case might be different than when music is absent in a game they have no knowledge about. Even when using a newly designed video game for an experiment, expectations of the participants must also be taken into account. Participants who are familiar with a genre, may expect similarities in any game of the same genre.

1.1.2 Video game music vs. film music

Films and video games have grown a lot closer together over time. Daniel Erickson states that in RPGs (Roleplaying Games), there's thousands of pages of background information for characters (Newman, 2009). This is similar to how the film industry works, as to create believable characters and write believable dialogues, such a background is necessary. Cinematics and cutscenes with fleshed-out characters are part of nearly all major games nowadays and it isn't uncommon to have film stars starring in games either. Conversely, there are also films being made about games, with recent examples such as *Warcraft* and *Assassin's Creed*.

However, despite the more cinematic nature of many modern blockbuster games, there are also still plenty of games without cinematics. Zach Whalen (2007) argues that in general, video game music should be approached differently than film music. One obvious difference between the two media is the interactive nature of games. Films are predictable in nature, as all scenes are of a set and predetermined length. In games however, going through a scene may take one player only ten minutes, while the next player takes half an hour to do the same. Playing a five-minute soundtrack on repeat might therefore not bother the first player, but might get on the second player's nerves. Therefore, video game music needs to be designed with a certain unpredictability in mind.

On the other hand, not only can a player's actions alter the situation and thus alter what music would be most appropriate, video game music can also alter the decision-making of players (Wharton & Collins, 2001). When video game music is deliberately chosen to contrast the game thematic, the meaning of the game changes and a player's decisions along with it. A violent shooter game with the Benny Hill theme can make a player run away laughingly from the enemies chasing him, rather than turning to fight. Would this game have the usual rock or electronic music soundtrack though, it likely wouldn't even cross the player's mind.

Then, there are also games that allow players to choose their own music. As an example, the *Grand Theft Auto III* game (and other GTA titles) has the presence of music linked to the radios inside cars. It is possibly to add your own music files to the game, which can then also be played through the car radios in the game. In a 'sandbox' type game such as GTA, where the player is meant to have a lot of freedom, this can be absolutely fine and even help players get in a more comfortable state of mind. In other games, where manipulating a player's emotional state is more important, this is best avoided as it would mean losing control over player experience.

Furthermore, music and sound effects are expected (by experienced players) to be integrated with gameplay (Wharton & Collins, 2001). It may even lead to less immersion and less ability to concentrate when the music isn't part of the gameplay, but just added on the side. Because of this, video game music should be considered an integral part of the overall experience and be kept in mind when designing the gameplay.

That being said, similarities between film music and video game music must be mentioned as well. The amount of work that goes into creating a memorable experience and writing a script is comparable to that of Hollywood-based films (Peerdeman, 2006). Additionally, big record companies are also getting involved with games, just as they have with films. Music games like *Guitar Hero*, but also racing games like *Need For Speed: Underground*, are giving opportunities to record companies to reach a broader audience, just like having a song featured in a big blockbuster movie would.

In the end, video game audio and music can be broadly divided into linear and adaptive (Lawrence, 2012). This is linked to the concept of nonlinearity (Collins 2008), which refers to the amount of meaningful choices a player can make in a game. When the audio is linear, many of the same principles of film music apply. Music is played at set scripted events, to create a mood at that moment. Because of this, it's fairly predictable, and in that sense similar to films. Although timing may vary to some degree, the games linear music is usually applied in, are also linear. However, this need not always be the case, as some open world games (with a lot of freedom, and thus unpredictability) just have music playing without being influenced at all by player actions. Adaptive music, though, is very different from film music, as it is directly influenced by player actions (Collins, 2008) as well as the game itself. In an open world game such as The Elder Scrolls III: Morrowind, enemies are randomly generated, which means they can spawn in different locations. However, when the player becomes a target of an enemy, the music changes to a more intense combat music.

1.1.3 Music across different video game genres

When looking at video game music, it is important to first look at the different genres of games. As some games are meant to be played for hundreds of hours, most notably slow-paced strategy games, the music will have to cater to this. Then, more action-focused genres have more distinguishable high and lows in gameplay, which means that music will also vary more between situations. Of course, there are also games that revolve entirely around music. For example, the game called Osu!, where the player has to click along with the rhythm of the song. A well-known example is the *Guitar Hero* series, where the players even have a remote controller shaped like a guitar to play along with the songs being played.

Video games are divided into genres by the types of interactions that are available in the game (Apperley, 2006). Other than that, there's usually also a theme or iconography present, such as science-fiction, western, medieval, etc. The theme should of course also influence the instruments and type of music, but is less relevant to the relation between gameplay and music. The genres as named by Thomas Apperley are: simulation, strategy, action and role-playing. However, Mark Wolf (2001) names quite a few more genres, although it follows a similar categorization, based on the interactivity. A few of the genres he names are, alphabetically sorted: abstract, adaptation, adventure, artificial life, board games, capturing, card games, catching, chase, collecting, combat, etc. As there is such a wide variety of games, it's only natural that there are a lot of different categorizations. Then, there are also games that deliberately mix several genres, to create a whole new genre. Each of the main genres can also be divided into subgenres. A strategy game, for example, can be either turn-based (like chess is) or real-time.

Generally, music tends to be similar within a video game genre. Strategy games tend to use longer tracks, as they're usually meant to play in long succession. This is especially the case for turn-based strategies, as games can last over 5 hours. Action games, however, are typically shorter and can therefore also use more intensive and shorter tracks. Naturally, horror games will make use of silence as well as suspenseful sounds and music, while children's games may have more uplifting tunes playing.

1.1.4 Discussion

Although originally audio and music had only a small place in the world of games, things have changed considerably now. Because there's such a wide variety of games and games can even be hard to be categorize, it also means music and other audio have different roles per game. While some games are very linear, with choices only having limited or no effect on the narrative, this also results in more linear music. In that case, the game's music can follow many of the same principles as film music (Peerdeman, 2006).

When designing a new game, it is also important to look at previous games of the same genre or with similar core gameplay features. Generally, previous experiences with similar games will dictate what players expect from new experiences (Wharton & Collins, 2001). Similarly, when conducting experiments with an altered version of a well-known game, it is important to keep in mind that the subjects may notice those changes if they are familiar with the non-altered version of the game.

When looking at the music of games, the genre is generally the first thing to consider. The genre usually dictates the pace of the game, with genres like strategy being played longer successively than games of the action genre. Because of the difference in the time that a game is played without breaks, it also means the music has to last longer, to avoid excessive repetition.

1.2 Psychological theories

In this section the psychological theories associated with games are presented and explained. The theories that are covered as the theory of flow, immersion, GameFlow, attention, arousal, anxiety and stress. These theories have some overlap and are quite related to each other, so the differences and overlaps are also explained. Additionally, the results of studies in these areas as well as the implications are discussed.

1.2.1 Flow theory

Mihaly Csikszentmihalyi originally formulated the theory of flow in 1975 (Engeser & Moneta, 2014). The flow is described by him as: "the sense of effortless action they feel in moments that stand out as the best in their lives." (Csikszentmihalyi, 2007). One of the easiest ways to 'find' this state of flow is, he states, in games. Games present a clarity of goals within a self-contained universe. Flow activities give clear goals and present immediate feedback.

Another important aspect of flow is the level of challenge. When a person has to fully use his or her skills to overcome a challenge, but the challenge is still manageable. When a challenge is too difficult, it is possible to re-enter the state of flow after learning new skills. Once the challenge becomes too easy, the difficulty should be increased.

Originally, the concept of flow was found through interviews (Csikszentmihalyi, 1972/2000), where participants were asked how it feels when an activity is going well. Other subjective measures, such as questionnaires and experience sample methods have been used as well to measure flow (Nakamura & Csikszentmihalyi, 2002). Additionally, there's evidence that it can also be objectively measured. This can be done through the measurement of salivary cortisol levels, which would be lower than expected, when flow was indicated (Lopez & Snyder, 2009). This lower salivary cortisol level suggests reduced stress levels and lower blood pressure. However, there is some discussion about how to best measure flow (Engeser & Moneta, 2014). One way to measure flow is the Flow Questionnaire (FQ), in which flow is described and participants are asked to name situations where they experienced a state of mind similar to the description. Then, there's also a experience sampling method (ESM), which makes use of having participants fill in a experience sampling form (ESF) 8 times a day. Finally, there's also a componential approach, which uses more standardized scales. More on the measurement of flow can be found in the Methodology chapter.

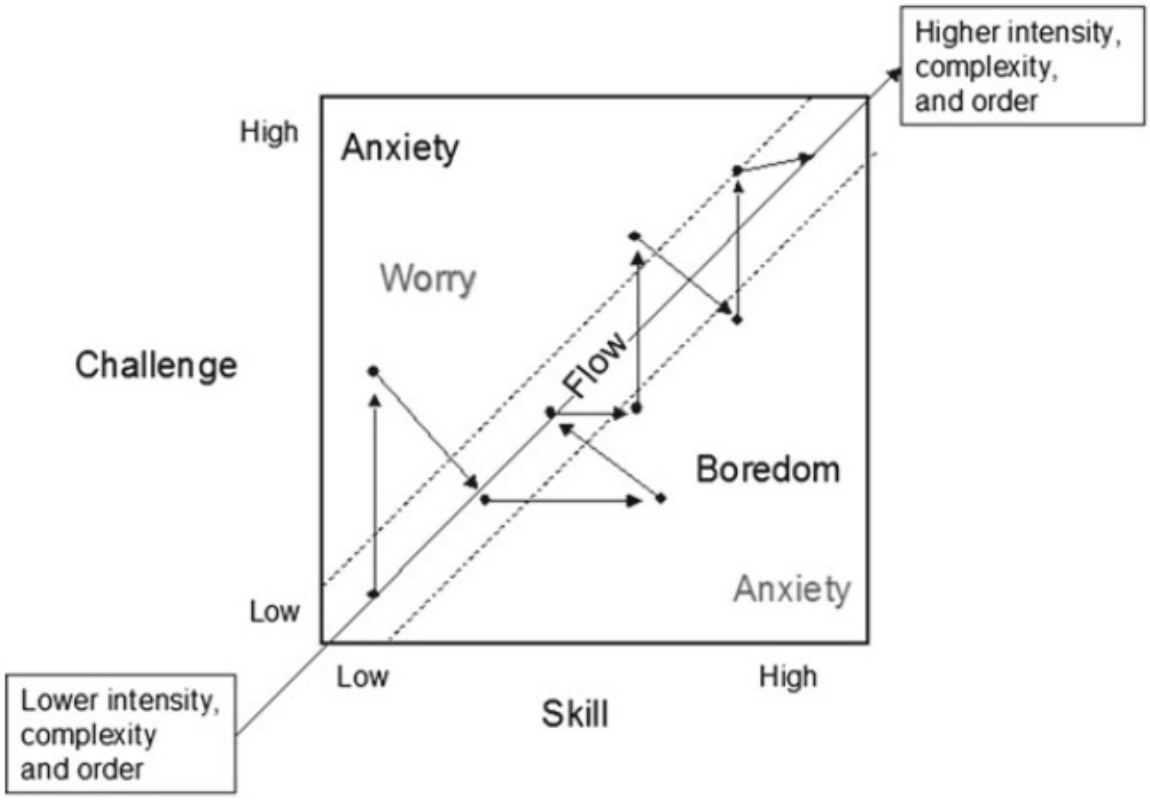

Figure 1.1: The first model of the flow state (From Csikszentmihalyi 1975 /2000)

There are multiple models of flow. The previously mentioned componential approach of measuring flow is based on the componential model. The multiple models of flow are: the first model of the flow state (see figure above), the quadrant model, the experience fluctuation model, the absolute difference regression model, the nine-factor componential model and the one-factor componential model. The first model of the flow state and the absolute difference regression model both represent flow as a state that is more likely to occur when challenge and skilled are balance. The intensity of flow increases as challenge and skill increase. The quadrant model and experience fluctuation model represents flow as a state that is more likely to occur when challenge and skill are on average higher than other moments of the

week. Finally, both componential models represents flow as a either a single construct or 9 interrelated constructs (Engeser & Moneta, 2014). However, later a flow model specifically for digital games has also been developed (Sweetser & Wyeth, 2005). More on this can be found in the chapter 1.2.3 GameFlow.

Originally, in the first model of the flow state, Mihaly Csikszentmihalyi (1990) stated that enjoyment can be achieved through performing tasks, with 8 major components:

1. The tasks have a reasonable chance of completion;
2. The ability to focus on the tasks;
3. The tasks present clear goals;
4. The tasks provide immediate feedback ;
5. Deep but effortless involvement that removes from awareness the frustrations and worries of everyday life;
6. Sense of control over our actions within the task;
7. No concern for the self, during the task;
8. Alteration of the concept of time, hours can pass in minutes and minutes can look like hours.

The purpose of flow is to encourage the returning to the same activity, because of the experience that it gives (Lopez & Snyder, 2009). Because of the experiential rewards, the person is encouraged to return to the activity and grow his or her skills over time. Because of this, it is a very interesting concept for game design, as having a player return to the game over time, to increase his or her skills, is usually exactly what a game designer wants to achieve.

Mihaly Csikszentmihalyi states (2007), in a review of his own book ‘Finding Flow’, that flow occurs when the person is doing his or her favorite activity. Among listed example activities is listening to music. A study by Susan O’Neill (2011) even suggests that it’s easier for flow to occur when listening to music for those who are musicians themselves. According to the study, musicians with high performance spent more time per day listening to music. 23.3% of the musicians got in the state of flow when listening, as opposed to 10% of non-musicians. However, non-musicians indicated spending more time per day on games (nearly twice as much) and reported flow occurring more often when playing games, when compared to musicians. 46.7% of the non-musicians in the study experience flow during sports or games, as opposed to 31% of the musicians.

This confirms what was mentioned above, that flow encourages the returning to the same activity. Additionally, Nakamura and Csikszentmihalyi suggested the term “psychological capital”, which is a learned set of skills that not only allows people to enjoy what they do, but also increases the chances of enjoying the activity in the future (Lopez & Snyder, 2009). Skilled musicians indicate they like playing music, spend more time playing and listening to music as well as flow occurring when listening to music, seems to confirm the concept of psychological capital. Because of this, when doing experiments with how music influences the perception of games, it is important to ask about the musical background of any subject.

1.2.2 Immersion

When playing successful video games, players put all their attention to the game and stop noticing things around them (Garris, 2008). This ability of successful games to draw people in is usually described as immersion. Willingness to play is also associated to immersion (Cheng & Cairns, 2005). However, immersion is not very easily defined, as there are multiple stages of immersion. Additionally, it is hard to measure immersion, as someone who is immersed no longer notices the world around him or her. Asking this person if he or she is immersed will then naturally break this immersion, as you shift this person's attention from the game to the outside world. In this sense, immersion is similar to flow, as the flow theory also mentions the "deep but effortless involvement that removes from awareness the frustrations and worries of everyday life." However, although flow is very focused on clear goals and achieving those goals, immersion is more about being drawn into the game world (which could happen through visuals, audio and narrative). As such, immersion could also be seen as just a part of flow, namely the removal of awareness of the outside world (Sweetser & Wyeth, 2005).

To try and define immersion, Cheng and Cairns (2005) set up an experiment where they tried to deliberately break participants' immersion through altering a game while participants were playing this game. Through this methodology, they reasoned, it might be possible to find what breaks immersion and thus what immersion is. In their experiment they manipulated the qualities of behavioural and graphical realism. Graphical realism is, for example, how close to realism the lightning, shadows and shape of objects are. Behavioural realism is how close the behaviour of game objects is to the players' expectations of the behaviour of those objects.

A given example is: how high the playable character can jump. When performing the experiment, they made a simple game with two areas. The first area looks more realistic and behaves more realistic. The second area looks very cartooney (in the style of The Simpsons) and has increased gravity. The participants had to perform simple tasks in both areas and were asked to report their experience afterwards.

The results were quite surprising, as even these abrupt and significant changes did not seem to break immersion. None of the participants reported a negative experience and some even stated they did not notice a change at all, while playing. However, when specifically asked about the change afterwards, they did confirm the change occured. The results of the studies were against the expectations, as the researchers had expected that inconsistencies in realism would negatively impact immersion. However, it seemed that once immersed, players can ignore shortcomings of the game to a much higher degree than expected.

If considerable visual changes do not break immersion, then perhaps music can also be ignored once a player is already in a state of immersion. Since music was not a part of this experiment, it would warrant extra research and a similar experiment could be conducted that also takes music into account. It is possible music has a much higher effect on immersion than visual graphics, especially when abruptly changed.

1.2.3 GameFlow

Penelope Sweetser and Peta Wyeth (2005) coined the term GameFlow, a model to evaluate the enjoyment of a player in games. This concept borrows from Csikszentmihalyi's flow theory and seeks to apply it specifically to games. GameFlow overlaps also with immersion in the sense that it "requires concentration, a sense of challenge, control over the game and finally, emotional involvement and real world dissociation" (Garris, 2008). However, it also includes clear goals, immediate feedback and social interactions, which also makes it overlap with the theory of flow more.

The GameFlow criteria for player enjoyment in games are:

1. Concentration;
2. Challenge;
3. Player skills;
4. Control;
5. Clear goals;
6. Feedback;
7. Immersion;
8. Social interaction.

Most of these criteria are directly linked to the concept of flow, with the exception of social interaction. Social interaction is described as: supporting competition and cooperation between players. This does not necessarily mean online or multiplayer functionality, but the presence of timers or scoreboards to compare performances with other players is enough.

However, some successful games do not have this functionality or sometimes scores are completely ignored by player, leading me to believe social interaction is not an absolute must to have enjoyment. To validate their criteria, only two very similar games were used for validation. In order to test the validity of their criteria, I would suggest to try to take away each criterium, to see if the players can still enjoy the game without it.

To use the GameFlow model, a game can be evaluated by each criterium separately. The idea behind the model is that a game that scores higher on average for each separate criterium, will also be enjoyed by players more and can thus be seen as the more enjoyable game overall.

When trying to discover the effect of music on flow (or on GameFlow), it could be interesting to gauge the effect of music (whether good or bad) on each of these criteria. My expectation is that music mostly affects concentration and immersion. However, music affecting the perceived challenge, or even player skills and control is also possible.

1.2.4 Attention

The theory of flow, immersion and GameFlow all mention the attention of a player being completely directed towards the task or game. Because of this, it is also important to understand what attention is and how it can be measured. According to Daniel Berlyne (1960), attention can mean two things in psychology. It can refer to the processes that determine an organism's alertness, which refers to how behaviour is changed by the presence of the entire environment. It can also refer to which part of the environment has the most dominant influence on the behaviour of an organism, in which case it refers to the focus. The focus of attention is closely tied to the performance, meaning that when a person concentrates on some stimuli (for example, a conversation), the person will typically react faster to this than to other stimuli that are out of focus.

The focus of attention can either be selected voluntary or involuntary. When the focus is deliberately put on an object, the selection is voluntary and goal-directed. Contrarily, if the environment determines the selection of focus, then the selection is involuntary or stimulus-driven (Hoang Duc et al., 2008). An experiment by Charles Shagass et al. (1976) suggests that giving subjects a task resulted in the gaze following an intended target object more actively. The gaze refers to the focus point of the eyes. Whenever eye-tracking showed that a subject was no longer following the target object, the person was no longer actively working on the task, indicating a loss of attention. There is also a close relation between saccades and attention. Saccades or saccadic eye movements are sudden and fast moves of the gaze, as opposed to smoothly going from one point to another point. When attention is present, it appears involuntary selection of focus may happen more easily (Hoffman & Subramaniam, 1995). Moreover, evidence suggests that a shift of attention is first preceded by a shift of the gaze, meaning that the gaze is key to determining the selected object of attention (Rizzolatti et al., 1987; Deubel & Schneider, 1996). However, when very fast saccades occur, it is likely to indicate a loss of attention (Fischer & Weber, 1993).

To conclude, to determine whether a person is immersed or flow is occurring, the attention of this person can be measured. Tracking the gaze is one way to determine whether the focus of attention is indeed the game, as intended, or not. If fast saccades occur, it is likely that the person is not immersed. Alternatively, it may also be determined through a questionnaire or interviewing a person.

1.2.5 Arousal

Another relevant psychological concept is that of arousal. Attention and arousal are closely linked, as the the area of the nervous system that is most associated with attention is called the 'reticular arousal system' (Berlyne, 1960). When this system becomes more excited it results in a state of more awareness and more readiness to react to stimuli. As such, arousal is a spectrum. Arousal can range from deep sleep to extreme excitement (Janelle, 2002).

As with attention, eye-tracking can also be used to measure arousal. When emotionally aroused, pupil diameters increase, no matter whether the arousal is considered negative or positive (Bradley et al., 2008). An experiment by Margaret Bradley et al. in 2008 measured the pupil diameter along with skin conductance and heart rate. By showing emotionally arousing pictures, such as pictures of naked people, emotional arousal was expected. The results indeed showed that heart rate, skin conductivity and pupillary changes all increased.

1.2.6 Anxiety and stress

As mentioned before, arousal can be either positive or negative. In the case of negative arousal, it refers to stress or anxiety. According to Robert B. Malmo (1957), the term 'anxiety' can refer to a brief increase of arousal due to stimulation. It can also refer to the chronic condition of being physiologically overreactive to any stimulating situation. Stress is most commonly defined as situational demands exceeding perceived available coping resources (Selye ,1956). Anxiety can be seen as a component or result of stress and is usually defined as a state where feelings of worry, uncertainty and concern dominate (Janelle, 2002).

Christopher M. Janelle (2002) states that emerging evidence indicates a change in behaviour regarding gaze can be reliably detected when a person is anxious. When in the state of anxiety, performance appears to be lower. Because of this, in most games it is better avoided. However, stress and anxiety can also be intended, for example in the case of horror games.

One important thing to note is that music can raise stress and anxiety levels. Although playing loud techno-music in a violent and fast-paced action shooter seems like a good match, research has shown a considerable amount of increased stress (Hébert et al., 2005).
As the test only compared techno music at 100% volume to having silence, it could be said that the fault lie with the choice of music, with techno being too present. Therefore, it may be wise to avoid music that's too intrusive, even when it logically fits the game's genre. Other studies about music confirm this thought, as evidence suggests music is also able to reduce stress or anxiety (Knight & Rickard, 2001).

1.2.7 Discussion

Generally, game players are meant to have fun. Therefore, understanding what fun is and how players can enjoy a game is crucial. Naturally, this points towards psychology and especially the concept of flow comes up a lot within the game design field. Understanding the theory of flow is important to understand why people enjoy playing games, as well as why they return to them. Properly inducing flow may get people hooked to a game and so having flow occur is typically the goal of a game designer. Due to the theory of flow being a generic concept, the model of GameFlow was suggested to be able to analyze games and why they might not work, but generally it uses the same principles (Sweetser & Wyeth, 2005). However, it does add the criterion of social interaction, which I don't agree with. Although many games do make use of high scores, some players only use it to compare high scores to their own previous results.

Immersion is a term that refers to being able to concentrate on the game. As such, it's a component of both flow and GameFlow. When a game is immersive, it can refer to the cohesion of the visuals, audio and narrative. However, as long as players can concentrate on a game and forget the world around them while playing, there's immersion. Since it is a criterion for flow occurring, immersion is important to achieve and music may play a large role in this. (Garris, 2008)

Also related to flow and immersion is attention. Since players need to be able to concentrate on the game, it naturally means that their attention is directed to the game. As their attention is directed to this game, it means they're likely to perform better. However, attention comes in various degrees, which is related to the psychological term of 'arousal'. The more aroused a person is, the better the person is able to concentrate. As such, it is important to have the difficulty of the game being just right, so that a high level of attention is required, meaning arousal will generally be higher too. However, arousal can also be negative, in which case we're speaking of anxiety or stress. In this case it can have an opposite effect and cause worse performance. Although this may be intended in the case of horror games, anxiety and stress for longer of times is generally better avoided.

As studies suggest that music can either induce stress and anxiety as well as lower it, it can also mean that music has a large impact on arousal and thus attention and flow (Knight & Rickard, 2001). Arousal can be detected through measuring skin conductance, heart rate and pupil dilation.

1.3 Effects of music in games

In this section the connection between video game music and psychology is made by looking at the effects of video game music. The study of video game music has also been named ludomusicology, so first this term is explained briefly. Next, the effects of music tempo and the different ways of interacting with music and audio are explained, as well as the implications of being able to interact with audio. Then, the physiological responses to music are covered. Finally, in the discussion the implications of video game music having an effect are being discussed.

1.3.1 Ludomusicology

Ludomusicology is a fairly new term, combining ludology (the study of games/gameplay) with musicology (the study of music). The term originates from the work of Guillaume Laroche (2007) and was later used independently by Roger Moseley (Hart, 2018). The term is used to describe the study of video game music, which means placing musicological studies, music theory and the sociological studies of music, in a video game context. Due to the novelty of the term, most studies that look into the effect of music in video games do not use this term, however it is possible that the field of ludomusicology expands, making it a more accessible term.

1.3.2 Effects of music tempo

According to a study conducted by Alexander Wharton and Karen Collins (2001), music tempo has a significant effect on how a game is approached. Results of this study indicated that music had an effect on the tactics used by players, or how they perceived their own tactics. With certain types of music, but also without music, players approached a game more carefully. Interestingly, players are also okay with some degree of anxiety when playing a game, but would eventually prefer to switch music that would make them less anxious. For their experiment, they chose the game Fallout 3: Operation Anchorage, a action/strategy shooter. 15 volunteers were invited to participate in the studies and play this game. The participants were allowed to swap out the game's music with their own music. Quite a few interesting discoveries were found in this empirical study. For one, they indicated that despite having played the game before and knowing the songs they chose, they found it hard to choose a song that increased their immersion in the game. Shorter songs, that changed too often, was described by one participant as "distracting and too intense". Songs with vocals, especially when matching the general iconography of the game, were also found to increase immersion.

This matches my own experience with the game *Bastion*, where the vocals of songs match the storyline. When the participants found themselves losing immersion, their response was usually to play high-energy music to attempt to reconnect to the game. Reportedly, music genres such as big band, country and classical guitar did not work well with the military iconography of the *Fallout 3* game, which lead to a loss of immersion. On the topic of music tempo, the same study concludes that participants of the study either changed tactics or perceived their tactics differently. One participant states that more upbeat songs helped her rush through certain areas of the game much faster. Another participant thought he used less caution and was more aggressive when an upbeat trip-hop song was playing. In contrast, using low-tempo songs led to reports of feeling less active and less aggressive, or even in slow-motion. This could mean that music affects a player's perception of control or player skill, as mentioned in the GameFlow chapter.

In a study by Kineta Hung (2001), it is found the music tempo changes how moving images are perceived. When showing images in the same pace, but with increased music tempo, participants asked the moderator whether the images were shown in a faster pace. Moreover, when subjected to familiar music, there is evidence of more information being processed and thus the expectation of more time having passed (Cassidy & Macdonald, 2010). When subjected to unfamiliar music, participants of the study of Cassidy and Macdonald have underestimated the elapsed time. This effect was increased when high-arousal music was used. This means that using fast tempo music leads to players thinking less time has elapsed. In their experiment with racing games, the participants expected their lap times to be the fastest when the fast tempo music was used. Moreover, the study found the participants had the best experience and the best performance when they were able to select their own music. Additionally, while the participants set better times with high beats-per-minute music, they were also less able to stay on the track with high arousal and high beats-per-minute music. This resulted in a less enjoyable experience overall, especially when compared to driving with self-selected music.

The choice of music and music tempo will be crucial in my experiment, as evidence shows a clear link between immersion and choice of music. The choice of music can be made somewhat instinctively, with obvious mismatches better being avoided, unless to deliberately break immersion. The evidence suggesting that people interpret visual pacing differently with different music tempo is promising, as it also suggests increased music tempo may make a game seem faster and thus more difficult. Then there's also the actual increased difficulty, that may happen through music. Evidence suggests more mistakes being made with high arousal music, which can lead to frustration.

1.3.3 Interactive audio

Interacting with sound is different than just listening to sound, as it adds a level of involvement that alters the way sound is experienced (Collins, Kapralos & Tessler, 2014). In The Oxford Handbook of Interactive Audio (2014), Karen Collins, Bill Kapralos and Holly Tessler approached authors working with interactive audio and gathered approaches to the idea of interacting with sound. This book tries to capture the most important findings of various authors and compiled them into six chapters.

First of all, the book argues that the line between being the author and being the audience has blurred. As players can move around in a world where sound originates from positions and objects, the players are the ones creating the sounds by controlling the game or a character. When games (or other media) have sounds which come from actual sources, it is called diegetic. When the music or sound does not have an actual present source, it is non-diegetic. Background music, for example, is usually non-diegetic. However, in the game *Grand Theft Auto III* (and later titles), the music starts playing when you enter a car. It is justified by having radios present in the car, which makes it diegetic, despite it being background music.

Secondly, the book looks at the influence of interactivity on the meaning of sound. The difference of audio in games when compared to audio in films comes mostly through this influence of interactivity, and the altering of the meaning of sound through this interactivity. An example of a sound that has been giving a meaning through games is *Super Mario*'s mushroom sound. When, in the game, Mario picks up a mushroom, he grows and becomes stronger. The visualization of Mario growing is accompanied by a short melody, which is now associated with 'powering up'. Similarly, the sounds of losing a life by jumping into the wrong place in Super Mario also has a characteristic sound that will from then onwards always be associated with failure by anyone who has played the game. When designing a game's audio, it is key to have memorable audio fragments to give feedback to the player when either succeeding or failing a particular task.

Then the book approaches the psychology and emotional impact of interactive audio. The authors of the book state that one of the least explored areas of immersion is the influence of sound. This comment is very relevant to this study, as my hypothesis rests on the assumption that sound can have a huge influence on both immersion and thus flow occurring. In survival games, such as Playerunknown's Battlegrounds, hearing footsteps behind you can mean you're about to lose the game. Hearing those same footsteps while you're in hiding though, can mean you're in a position to ambush your opponent instead, giving you the advantage. The emotional responses to these situations will obviously be very different. In the first situation, you may experience a jumpscare and try to turn around as fast as possible. In the second situation, your heart may start pumping faster as you try to catch your opponent while he is unaware of your presence.

To make believable interactive audio, though, the real world's audio has to be imitated (Stevens & Raybould, 2011). Because players have an idea of what certain sounds from the real world sound like, they expect it to sound the same in the game. Because of this, some knowledge of the physics of sound is needed. One concept to take into account is sound propagation. When a sound managed to reach your ears directly, also called 'dry', it sounds different then when it reaches your ears through bouncing off objects (indirectly, or also called 'wet'). Usually though, the ear receives sounds both directly and indirectly. The more a sound bounces, the more reverberation (or in short, reverb) the sound has. This causes an echo-like effect. For example, in a bathroom, a player will expect more reverb than in the open air.

Also important in some games is the use of sound spatialization. For first person games in particular (games where the player has a 'looking through the eyes of the avatar' perspective), the field of view that players have it typically between 65 and 85 degrees. However, things that are not seen may still be heard. As mentioned before with the example of Playerunknown's Battlegrounds, doing these sounds right may be a case of life or death. It is important to simulate the physics right, so that sounds that come from behind you do actually sound like they're behind you. For one, they should be less loud than the sounds that emanate from an audio source in front of the player. Distance and location is not the only important matter though. When the player enters the house in a game, the outside sounds would immediately sound different, despite being almost the same distance away. Then, if the player closes the door of the house, the sounds would have to be muffled or even no longer hearable.

Although not all games need to apply these techniques, good sound design can add a whole new experience to games. Typically, visual design is prioritized over audio design. This is especially the case in 2D games, as these games are typically not from a first-person perspective, making spatialization less of an issue. However, in the game Limbo (2010), which is a 2D game, the audio is a crucial part of the game's atmosphere. As a result, the game has been acclaimed and several articles have been written about the unique sound design. In a feature interview with the sound designer Martin Stig Andersen (Bridge, 2012) it is stated that "Sound design can also manipulate the player's mind to give them a sense of place, for which game audio helps set the foundation of the game experience. Taking care with such base-level environmental effects is part of what can help make a game great."

1.3.4 Adaptive audio

Interactive audio is the audio that is triggered directly by the player(s); adaptive audio is unaffected by players' direct actions, but is generated by the game (Collins, 2009). The adaptive audio takes parameters from the game engine, such as the weather, time of the day and the presence of game objects. Because of this, adaptive sound effects cannot be repeated whenever the player wants to generate this specific sound, the conditions have to be met. Generally interactive sound effects are seen as predictable, while adaptive sound effects are there to occasionally surprise the player.

Adaptive music is used for the same reason. Because there are game genres that are meant to be played for many hours, even more than a thousand hours for some hardcore games, it means music will often be repeated. Adaptive music however is meant to make music more dynamic and unexpected. If a certain music track only plays when very specific conditions are met, it means this music track will be more special and thus may be able to cause extra emotions to be present. To deal with repetivity of game music, the game *Spore* (2008) has the density of instrumentation reducing over time, while some games have also taken the approach of fading out music entirely (Collins, 2009).

When designing adaptive audio, the sound effects and music have to be designed around specific cues. When a cue occurs, a sensible reaction should follow. For example, when the narrative has been building up towards a final confrontation with a game's villain, a more intense soundtrack would make more sense than having the same repeated music that the player has been hearing for the entire duration of the game. Karen Collin states that the cues have to relate to each other, to the gameplay, to the narrative, to the game parameters and even to other games of the same series (when the game is part of a franchise). Another approach to adaptive music is the use of procedural music. To avoid music being repetitive, certain instruments or a bassline can be introduced or be absent in certain situations. When reaching an anticipated high point of a game, adding a more intense bassline to a track that the player is already familiar with may have a similarly strong effect.

When designing an experiment around manipulating perceived difficulty of a game, both adaptive audio and procedural music techniques should be considered, to highlight narrative progress. Conversely, when the player anticipates more intense gameplay, making the music underwhelming could potentially break immersion.

1.3.5 Physiological responses to game music

Besides being there as entertainment, music also has been found to have psychological effects. As such, the presence of music has increased throughout the years. Music is now being used to influence behaviour, such as increasing productivity, making waiting more bearable when contacting support or simply sitting in the waiting room. Moreover, music therapy is being used to treat both mental and physical conditions. It has been proven that music can influence the emotional state of its listeners (Thayer & Levenson, 1983).

In an experiment set up by Julian F. Thayer and Robert W. Levenson (1983), with the goal of measuring the effect of music on the physiological state of people, volunteers watch a stressful film where 3 accidents happen. The stress level of the participants is measured by measuring the skin conductance level (SCL). In the experiment, the participants are divided into three groups. The control group sees the film with no music, another group sees the same film with documentary music (classed as 'decrease' music) and the last group sees the same film with horror music (classed as 'increase' music). The expectation of the experiment was that the horror music causes increased stress among the participants when compared to the control group, while the documentary music decreases the stress level. The results of the experiment indeed confirmed this, as the SCL of participants was higher than the control group with the horror music and the SCL was lower with the documentary music. Interestingly though, the heart rate showed little to no change. Therefore it is concluded that music can alter the state of anxiety, which then does affect skin conductance, but not necessarily heart rate. When conducting an experiment about the perceived difficulty of the game, measuring anxiety levels by measure the skin conductance can be considered.

While the previous study is about the physiological effect of music in films, the effect of video game music has also been researched, albeit to a lesser extent. When comparing the presence of classical music to having no music, most studies reported a relaxing effect (Hébert et al., 2005). The opposite is true for e.g. rock and techno music. In the study by Sylvie Hébert et al. the participants of the experiment were asked to either play the game *Quake III Arena* with no music, or with the built-in techno music. In the experiment the 52 volunteers were divided in either a group that would play without music or the group that would play with music. To avoid the results being influenced by other factors, the participants were not allowed to eat 30 minutes beforehand, nor perform intense exercise. The reason behind this was because the participants had saliva samples taken, both before, during and after the experiment, with four samples being taken per person in total. In the saliva samples, the cortisol levels were measured. The hypothesis was that the group with the music would have higher cortisol levels during and after the experiment, as higher cortisol levels is linked to stress. As *Quake III Arena* is a shooter game, it is possible that the increased stress could also be due to the performance of the players. During the experiment, this was also taken into account, but the music group did not perform any worse or better on average. Therefore, it can be said that increased stress was only caused by the presence of music. As expected, the results of the study indeed indicated a higher level of stress among the participants who played with the techno music.

1.3.6 Discussion

Musicology has only recently started to be applied to game music, which had led to the coining of the term Ludomusicology in 2007 (Hart, 2018). There are however, some less contemporary studies in this field, although the term ludomusicology wasn't used there. These studies do show that there is evidence of music affecting players. Most notably, music tempo changes the behavior as well as emotions of player (Wharton & Collins, 2001; Thayer & Levenson, 1983). Similarly, it may have an effect on the temporal perception of players (Cassidy & Macdonald, 2010; Hung, 2001). Those two findings are naturally related, as players may change their behavior in a game, if they think a lot of time has passed.

For audio to be believable, many real world imitation techniques need to be used (Stevens & Raybould, 2011). This is less relevant for music, but since sound effects and music are both part of audio, sound effects may also have an effect on the music. Especially when using adaptive audio, the change of game parameters might be accompanied by audio feedback, which could then lead to different music playing. An example: in *Left 4 Dead 2* (2009), a game about survival and fighting large amounts of zombies, you are stuck near the shore. However, there is a ferry that you can call towards you with the press of a button. However, this ferry generates noise, which attracts zombies. When you press the button, the parameters of the game change as more enemies are appearing. This is paired with a change to more intense music. The introduction of this music is preceded by the sound of a ringing bell and the movement of the ferry, which gives a clear link between sound effects and music.

Music can result in physiological responses (Thayer & Levenson, 1983; Hébert et al., 2005). These responses, generally resulting in arousal, can be measured. When measuring any effect of music, at least surveys and/or interviews should be used to measure the responses of participants. However, due to the subjective nature of these methods, the experiment may be more credible when it is accompanied by more objective data. In previous experiments on similar subjects, three more objects methods were found:

Saliva samples were taken to measure cortisol levels. However, despite the effectiveness of measuring stress this way, it will likely be harder to find participants that consent to this method, plus additional equipment is needed.
Skin conductance was measured. This may be the better option, as it is more easily measured than cortisol levels and participants may find this less infringing.
Heart rate was measured. This is most easily measured. However, heart rate may not necessarily change when when an emotional response is expected and even measurable by measuring the skin conductance. This makes it less reliable.

Although I have found no examples of eye-tracking being used for game related experiments, pupil dilation can also indicate arousal. Furthermore, tracking eye saccades can indicate the level of attention, which may make it a good alternative to the three other methods. Ideally, it would be used in combination with one of the above methods. (Janelle, 2002; Rizzolatti et al., 1987; Deubel & Schneider, 1996)

1.4 Implications

First of all, when setting up an experiment, participants' previous experience with playing similar games is relevant. This is because people who play games regularly may find it easier for flow to occur, in a similar way that skilled musicians have flow occurring more easily when playing an instrument (O'Neill, 2011). On the contrary, people who do not play games regularly, or at all, may get frustrated for reasons that have nothing to do with the presence or choice of music. Especially experience with a specific game genre may be considered, as the people may have certain expectations about the game already. When a very well-known game is selected for an experiment, such as Tetris or Pacman, people will most likely have an expectation of what sound and music will be accompanying this game. The absence of this music or sound may already cause some reaction. Moreover, according to the theory of flow, it might be easier to get participants to enjoy the game when they have had previous experiences with it. As people do tasks they enjoy, such as playing games, they may find it more enjoyable the next time too (Lopez & Snyder, 2009).

On the topic of familiarity, not only the game can have an effect on the responses, but music as well. When playing a game with self-picked or familiar music is playing, performance may increase and better experiences may be reported (Cassidy & Macdonald, 2010; Wharton & Collins, 2001). If an experiment is conducted with a specific song, it would therefore be relevant to ask if they know this song beforehand, as well as inquiring after any participants' favourite music genres or least liked music genres.

Then, the length of the experiment and length of the music must be considered. If an experiment with a strategy game is conducted, which may last an hour, then it may also result in the repetition of music. As some games deliberately fade out the music after some time (Collins, 2009), to avoid the repetitiveness of the music causing additional stress, it may be important to have a set duration for the experiment in order to avoid this influencing any responses to the music, or to have a game that doesn't vary as much in its duration.

Then, of course, the music with which the experiment is conducted must be selected carefully. As the tempo of music can decide on how visual images are interpreted or experienced, the beats per minute is important to pay attention to (Hung, 2001). Previous experiments usually used a silent (no music) group as a control group. However, the absence of music can also have an effect, as sometimes it creates a more eerie atmosphere, which might want to be avoided (Prunty, 2018). In some previously conducted experiments, participants were allowed to choose their own music. This can make participants more comfortable and make flow easier to occur in some cases, but could also completely break immersion when a non-fitting song is chosen. This would cause some degree of unpredictability, which might be better to avoid.

Due to the difficulties of designing a game's audio to be a believable imitation of the real world (Stevens & Raybould, 2011), it is likely better to select a game of the 'abstract'-genre (Wolf, 2001), where these expectations don't exist to the same degree as with realistic looking games. Examples of 'abstract' games are Tetris or Pacman. Alternatively, a successful game can be selected, to avoid bad design of sound effects impacting the results of the study. Non-diegetic games are also more suitable when trying to single out the effect of music in particular, as the predictability of music and sounds is increased, which may prevent surprising situations that may also alter any results.

When conducting an experiment regarding the effects of music in games, the physiological effects of the music can be measured. The best way to measure this may be eye-tracking, as through eye-tracking both attention and arousal may be detected. However, arousal may be harder to track through eye-tracking, as pupil dilation would have to be measured and this could also be affected by changes in lighting for example. Therefore, tracking gaze saccades to measure attention and using skin conductance would be the ideal setup to measure the effects of music on flow.

1.5 Conclusion

The main objective of the study is to find if game music correlates with players' ability to focus and perception of game difficulty. Previous studies suggest that music has a large impact on arousal and thus attention and flow (Knight & Rickard, 2001). Because of this implication of an effect being present, but no specific research being found of how a player's ability to focus changes, nor how their perception of game difficulty changes, more research is warranted. Although experiments do suggest techno music adding to stress (Hébert et al., 2005) and thus potentially suggesting more difficult gameplay, the use of techno music was only compared to having no music at all. As music can also reduce stress (Knight & Rickard, 2001), it would make sense to compare music that may cause stress to music that may reduce stress in an experiment, as well as comparing both to having no music at all.

2. Methodology

This chapter will cover the methodology used in this research, as well as the motivation behind it. The chapter will give an overview of how data will be collected, through what process and how the data will be analysed and processed. Additionally, the validity of the study will be discussed.

The research question of the study is:
How does the perceived intensity of game music correlate with players' level of focus and perception of game difficulty?

To reach answer this question, some sub-questions must also be answered. Once the following sub-questions are answered, the main research question can also be answered:

1. Can low intensity (relaxing) music result in lower perceived game difficulty? Conversely, can high intensity music result in higher perceived game difficulty?
2. When music intensity and game difficulty progression do not match, does it result in a player's loss of focus? Conversely, when music intensity and game difficulty progression do match, does it increase a player's level of focus?

2.1 Research methods

The research questions will be studied through an experimental research, with a mix of qualitative and quantitative methods for data collection. The purpose of the qualitative methodology is to get in-depth responses about people's experiences, perceptions, opinions, feelings and knowledge (Patton, 2002). Quantitative methodology, however, is used to collect numerical data, to find out how often a certain thing happens, without necessarily finding out 'why'. For this study, both numerical data and finding out the reason behind the data, are important.

As the field of ludomusicology is fairly new, there are not many experiments of previous studies to look at. However, this study is also about finding focus as well as perceived difficulty or challenge, both of which are concepts that are part of the theory of flow. The theory of flow was introduced in chapter 1.2.1 Flow theory. The state of flow can occur by performing a task that can be achieved when a person has to fully use his skills to overcome the challenge, without being too hard (Csikszentmihalyi, 2007). When flow does occur, it results in a state of complete concentration on the task (Engeser & Moneta, 2014). Additionally, the first model of flow shows enjoyment and focus coming from a balance of skill and challenge, thus also making it related to the perception of game difficulty. Flow is most commonly measured using a mixture of quantitative and qualitative methods. Interviews, surveys, questionnaires and experience sample methods have been most commonly used to measure flow (Nakamura & Csikszentmihalyi, 2002). Therefore, for this study a somewhat similar approach will be used. There has also been an attempt to measure flow quantitatively by developing a Flow State Scale (Jackson & Marsh, 1996). In this scaling method, participants can rate how much they agree with certain statements, on a scale from 1 to 5. A

similar survey with a 1 to 5 scale can be used for this study.
In qualitative data collection, there are three main methods for the collection of data:

1. In-depth open-ended interviews;
2. Direct observation;
3. Written documents.

For this study, a mixture of interviews and direct observation can be used. One of the main advantages of using in-depth interviews, is that they can be used to gain in-depth information about a topic of interest (Lankoski et al., 2003). In the case of this research topic, it will be important to know how the participants of the study experience the difference in music intensity. For example, if one person does not seem to lose focus at all with high intensity music, while most other participants do lose focus, interviews may reveal more on the reason behind this. In-depth interviews can therefor reveal exceptions or influence of factors that weren't thought of before. It can also confirm expected results, such as music taste making a difference.

To conclude, a mixture of qualitative and quantitative data will be used. A scale-based survey will provide quantitative data, which will be supported by in-depth interviews and direct observation to gain a better understanding of the topic.

2.2 Research process

The first stage of the research is literature review, to get a basic understanding of the research topic. Additionally, literature review will provide insight in what previous experiments on this topic have been done, and how the experiments have been conducted.

Following up on this information, an experiment can be designed. The experiment should provide insight into each of the sub-questions, first regarding perceived game difficulty:

1. Can low intensity (relaxing) music result in lower perceived game difficulty? Conversely, can high intensity music result in higher perceived game difficulty?

And then regarding a player's focus:

2. When music intensity and game difficulty progression do not match, does it result in a player's loss of focus? Conversely, when music intensity and game difficulty progression do match, does it increase a player's level of focus?

This means that the experiment will require both low intensity and high intensity music, which must be selected prior to the experiment. Additionally, a game to conduct the experiment with must be made. To find out about the loss or gain of focus as well as the perceived difficulty, a survey will also be developed. After developing a survey, an in-depth interview format will be developed, to get more insight on why the results of the survey are what they are.

Finally, the sample must be considered. How many participants will be needed and their experience with games must be inquired after. The existence of "psychological capital" must be taken into account, as this suggests that participants that play games regularly can also focus on games more easily (Lopez & Snyder, 2009). Therefore results of participants that regularly play video games may differ substantially from participants that rarely play video games. Ideally there will be around 10 participants in each group, for a total of around 30 participants. However, only around 2 people per group will be interviewed, for a total of around 6.

2.3 Experiment description

Most of the experiment will be conducted online, as gathering survey data and playing the game does not require presence in a particular location. Then, in-depth interviews will be conducted in a location that fits the participant.

In the experiment, participants will be asked to play a game. The objective of the game will be explained to the participants in the game itself. Through altering the intensity of the music in the game, the hypothesis that intensity can have an influence on the level of focus and perceived game difficulty, will be tested. While playing, the participants that will be interviewed will also be observed and the game will track their behaviour and mistakes. After this experiment a survey will be conducted as well as in-depth interviews.

For the experiment, the sample will be randomly divided into three equal-sized groups. All groups will be playing the same video game.

- Group A is the Control Group (CG), which is the group that will be playing the video game without music.
- Group B is the Matching Music Group (MMG), which is the group that will play the game with music which increases in intensity as game difficulty increases, and vice versa.
- Group C is the Non-Matching Music Group (NMMG), which is the group that will play the game with music which decreases in intensity as game difficulty increases, and vice versa.

2.4 Instruments

In this chapter each of the components of the experiment are explained in more detail. For the gathering of quantitative data, the two components of the experiment are: playing a video game and answering survey questions. For qualitative data, the partipant will also be observed and an in-depth interview will be conducted.

2.4.1 Video game

The main instrument used in the experiment is the video game that will be played. The video game will be developed in Unity (version 5.6.1f1) and is custom-made for the experiment. The game was made with a few requirements in mind. First of all, the game must have easily adjustable difficulty. Increasing difficulty will mean that players will have a smaller window to react (less reaction time). If the reaction time of the player is longer than the allowed reaction time, it will result in a penalty and negative feedback. Secondly, the game should be easily understood. The controls should therefore be very easy and limited, comparable to a game like *Flappy Bird*. Then, the game should be suitable to different pacing, so it can fit with different music pacing.

As a result, the following game concept was made. The game will consist of 3 stages of different difficulties. Each stage lasts forty seconds, regardless of player mistakes. The player will have to navigate a pre-set area, using only the spacebar to change direction from up to downwards, or from down to upwards. The stages of the game will be played in a set order. The first stage is an introduction level, with relaxing music. This stage is less relevant to see a difference of the effect of music. Then, the second stage will be the fastest and thus the most challenging. This is followed up by a third stage, which is easier than the second stage, but still harder than the first stage. To summarize, the difficulty could be seen as: 1-3-2, where 1 is easiest and 3 is hardest. Between each stage, there is an instruction screen, where participants are asked to fill out the survey, regarding the stage they've just played.

For the MMG, the music intensity is designed to match the game difficulty in stages two and three. For the NMMG, the music intensity contradicts the game difficulty in stages two and three. The music, therefore, should come in three intensities: low intensity, medium intensity and high intensity. To find this music, multiple open source music sites were used, where tags such as 'relaxing', 'tense', 'active' were used to discern between low and high intensity. In the end, three songs were selected from https://incompetech.com/, made by Kevin MacLeod. The order of intensity was then confirmed by having participants of the study play the game, order the chosen songs in intensity and then assigning them to the stage. All participants agreed that the order of intensity of the songs was, from least to most intense: Thief in the Night, Dreamer, Firebrand.

While playing the game, the participant will also be observed. Through observation, the amount of mistakes will be tracked as well as how comfortable or stressed the participant appears to be. None of the mistakes will have any actual impact, aside from mistakes being counted.

Figure 2.1 - Screenshots of the video game instrument: Gameplay

In the figure above, a screenshot of the video game instrument can be seen. The player controls the avatar, which looks like a bee. The player is tasked with avoiding the red-eyed barrels, through pressing spacebar to change direction of the avatar. The avatar will always be moving, either up or down. Upon hitting an obstacle, the bee will be recentered and be briefly invulnerable.

More screenshots, of the entire flow of the game, can be found in Appendix B - Video game screenshots

2.4.2 Survey

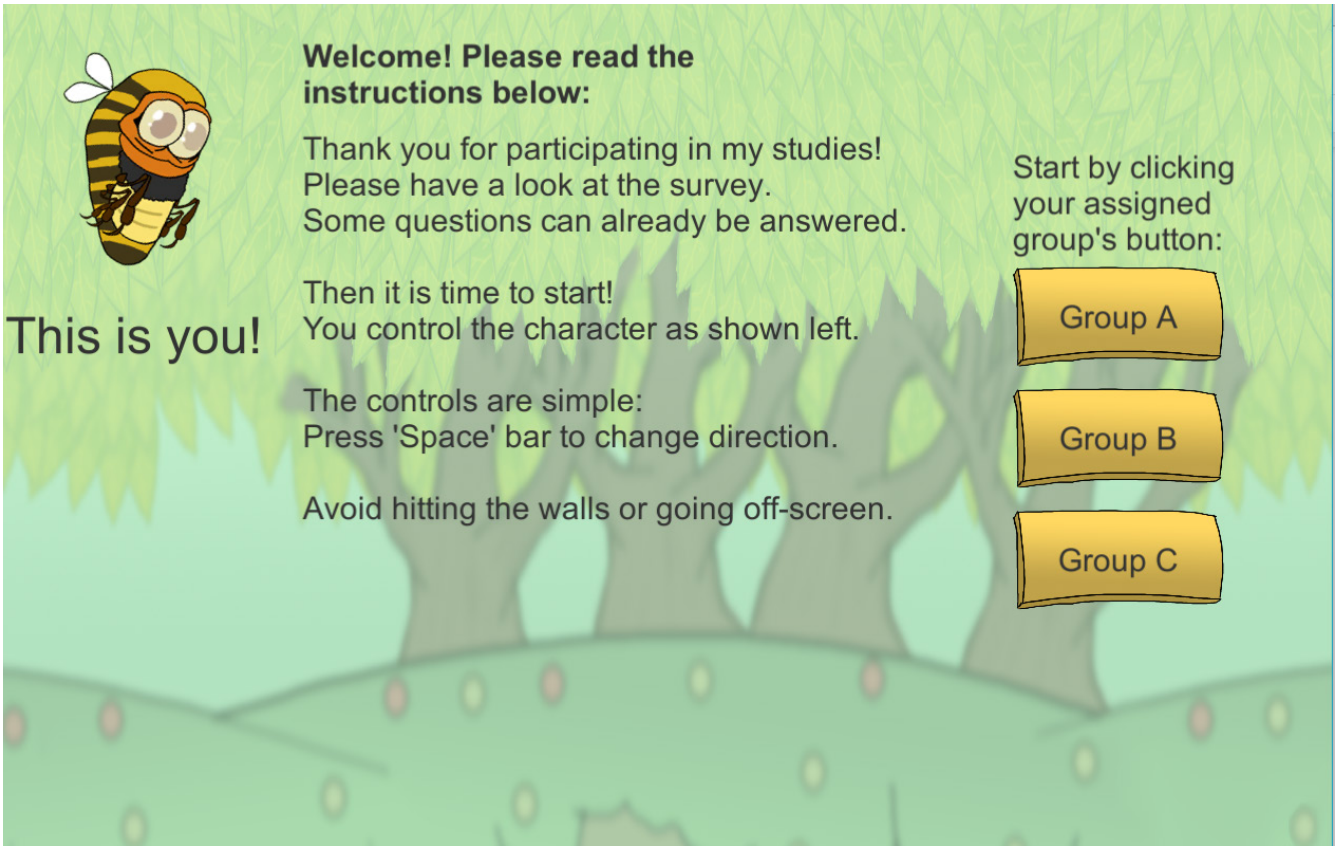

Figure 2.2 - Screenshots of the video game instrument: Introduction screen

During the experiment with the video game, a survey will be conducted. During the introduction screen, participants are asked to answer some basic questions (see figure above), such as experience with playing games, as well as the date of participation. Then, after playing each stage of the game, as described in the previous chapter, questions regarding the stage are asked. Finally, after playing the last stage, some more questions regarding all stages are asked. For each stage, there are two types of questions:

- The first type of questions of the survey asks participants to rate the difficulty of the game, on a scale from 1 (very easy) to 10 (extremely difficult) for each stage of the game.
- The second type of questions of the survey asks the participants about their expectations and focus. This is done through statements, to which the participant is asked to react by rating how much they agree with the statement. This is done on a scale from 1 (not at all) to 5 (completely).

The survey will be used to determine the effect, rather than the cause. For this purpose, any mention of music will be avoided here, to prevent a predisposition in the interviews that follow the survey. It is reasonable to think that if they're asked about the music in particular, they will focus on the music more and deduct that more intense music is intended to cause a higher perceived difficulty of the game, which could influence the results.

The full survey can be found in Appendix C - Survey format.

2.4.3 In-depth interview

Concluding the experiment, an in-depth interview will be held with about 2 to 3 people per group. In this interview, they will be asked to elaborate on their responses to the survey. The interview will focus on the reason behind their answers and thus may explain why the results are as they are. However, to avoid bias, questions along the lines of "Do you think music had an effect…?" will be avoided. The questions will instead be more open and will not refer to music at all at first. The last questions, however, will be inquiring about the music and effect of music more directly.

The full interview can be found in Appendix D - Interview format.

2.5 Validation

Prior to the experiment, each instrument has to be internally validated. A small pilot study with the game and survey will be conducted. This should point out whether the game works properly, whether the survey questions are clear and unambiguous and ditto for the interview questions.

Internal validation will be ensured by having each of the three sample groups play the exact same game. Additionally, the survey and interview will be conducted during the game, to avoid a difference in instrumentation or time between survey and video game having any effect on the results. Of course, the memory of the game will be fresh and the perception of each played stage will not be influenced by playing the other stages. As per the rules of an experimental research, the participants will be assigned to one of the three groups randomly.

To ensure external validation, the sample's previous experience with games will be taken into account. People that play games often may find it easier to focus on games, while people that rarely play games may find it boring or frustrating and lose focus more easily.

2.6 Reliability

To ensure the reliability of the data, very different songs will be played in the stages where music differs per group. In these stages, stage 2 and stage 3, there is one very fast and intense song playing as well as slower and more relaxing. This should result in no ambiguity regarding which song is more intense and has a higher tempo, thus ensuring reliable data regarding this issue.

Then, each group will be played the exact same game. The first stage is not as relevant for the data collection, as the music is the same in the MMG as the NMMG. Thus, it will serve as an introduction level and can familiarize players with the controls and allow their skill to grow prior to the second and third stage. This should allow for more unbiased data, as they were able to learn the game in the same environment, with the same music.

2.7 Data analysis

Quantitative and qualitative data will be collected and compared for each group: the Control Group, the Matching Music Group and the Non-Matching Music Group.

Each group will also have quantitative data extracted from the survey. The surveys cover the experiences of the participants and determine the effect of the cause-effect relation that may exist between music and perceived difficulty as well as level of focus in video games. There is the possibility of external factors causing distractions that may hinder focus, which could be identified through interview data. Other causes of a loss of focus can also be identified through the interviews. Naturally, the three groups will then be compared, to find the correlation between video game music and level of focus.

The data of the survey regarding perceived difficulty is to be compared between the three groups. Here the interviews will provide important insights as to why participants of the study may think a stage of the game might be more or less difficult, compared to the previous stage. The hypothesis suggests that music potentially plays a large role in this, so the survey results, as well as the interviews, are expected to reflect this.

2.8 Data presentation techniques

The quantitative collected data will be presented in both tables and graphs. The average result of each question or statement in the survey will be shown in a table, per group. Then, the differences per group will also be calculated. The averages of each group will then be added to a graph to make it easier to see the differences between the groups. Although the order in which the stages of the games are randomized, they will be put in order of difficulty for the presentation.

Of the qualitative data, meaning the interviews and observation, the most important findings will be included in the results chapter. The fully transcribed interviews will be included in the appendices.

2.9 Summary

The results of the study will be gathered through an experimental study. Surveys will be conducted to collect quantitative data. Interviews and observation will provide qualitative data. The experiment will have participants playing a custom-made video game, consisting of 3 stages. Each participant is randomly assigned to one of three groups:

- Control Group (CG) - Participants will be playing the video game without music.
- Matching Music Group (MMG)- Participants will play the game with music which increases in intensity as game difficulty increases, and vice versa.
- Non-Matching Music Group (NMMG) - Participants will play the game with music which decreases in intensity as game difficulty increases, and vice versa.

During the game, instructions will be given to participants regarding the survey. Prior to playing the game, in between each of the three stages as well as after the game, the participant will be asked to answer questions in the survey. Additionally, in-depth interviews will be conducted with some of the participants, to find more about the reasons behind the results of the survey.

The resulting data of the survey will be compared between the groups, to see if any conclusion about the hypothesis can be reached.

3. Results

This chapter will cover the results of the experimental research, as described in the methodology chapter. The chapter will present the collected data in tables and diagrams and will try to explain the results. The results will be ordered per research sub-question, as mentioned in the Methodology chapter.

3.1 Acquired data

The experimental research has been conducted with 33 participants in total, over a span of 10 days. All 33 participants took part in the quantitative study, where they were asked to play a game and fill out a survey in between the three stages of the game. 6 out of the 33 participants were also asked to be part of qualitative studies. In this case, their playing behavior would be observed and an interview would be conducted, as described in the methodology chapter.

Due to the randomisation of the groups, the groups A, B and C consisted of 13, 11 and 10 participants respectively. The goal was to get at least 10 participants in each group.

	Group A (No music)	Group B (Matching)	Group C (Non-Match)
Hardcore	7	2	6
Experienced	5	8	3
Casual	1	1	1

Table 1: Participants' previous game experience

Due to the randomized groups, the previous experience with playing games of the participants of the study varied. Only the casual gamers were equally divided with 1 per group. Group A was the most balanced group, with 7 participants considering themselves hardcore gamers and 5 considering themselves experienced. A difference can be seen in the participants assigned to Group B and C, with group B having a larger proportion of experienced gamers and group C having a larger proportion of hardcore gamers.

In the study, a fairly easy to grasp game was used, as the game had only one button to control the avatar. Therefore, I believe it is unlikely that there will be a large difference between experienced and hardcore gamers, playing this game. However, there is a chance that previous experience with similar games could have had an impact. One participant mentioned in the interview that he had played *Flappy Bird* and "a lot of similar games". Compared to other observed participants, he made a lot less mistakes and could navigate the first level easily, experiencing little challenge. Moreover, he was the only interviewed participant reporting boredom in the first level, or any of the levels. However, one participant told me she had no experience with these kind of games, yet made very few mistakes and looked very comfortable playing the game despite considering herself a 'casual' gamer.

3.2 Perceived game difficulty

The first research questions to be answered are about how a player's perception of a game's difficulty changes depending on music. The questions that need answering are:
Can low intensity (relaxing) music result in lower perceived game difficulty? Conversely, can high intensity music result in higher perceived game difficulty?

To find the answer to these questions, participants were asked to rate the difficulty of the stage they played on a scale from 1 to 10. The rating was accompanied by the scale below:

1. Very easy - I did not find the game challenging at all.
2. Very easy to easy - The game challenged me very rarely.
3. Easy - The game had some challenge, but still gave me no problems.
4. Easy to balanced - The game was somewhat easy, but also challenging at times.
5. Balanced - The game was challenging at times, but not too difficult.
6. Balanced to difficult - The game was challenging and sometimes too difficult.
7. Difficult - The game was challenging and even occasionally too challenging.
8. Difficult to very difficult - The game was very challenging, often too much so.
9. Very difficult - The game was too challenging for me..
10. Extremely difficult - The game felt close to impossible to do.

The survey resulted in the following average difficulty rating per stage:

Stage number / Group	Group A (No music)	Group B (Matching)	Group C (Non-Match)
Stage 1 (easiest)	3.62	4.18	3.10
Stage 2 (hardest)	4.00	5.18	4.10
Stage 3 (medium)	3.46	3.82	4.10

Table 2: Average difficulty per stage

As each of the stages had the same difficulty per stage, any difference in rating can be attributed to one of the following reasons:

1. The players in a specific group had a lower skill than players in another group.
2. The players idea of what is considered difficult or easy is different.
3. The players' skills improved as they played more stages.
4. Anticipated difficulty affects the ratings.
5. The music intensity actually impacted their perception of the difficulty of the stage.

To find the final reason, where the music is actually making the difference, all the other reasons must be eliminated or diminished first.

First of all, the first two reasons can be found through making the players play the same level with the same music. Both group B (Matching Music Group) and group C (Non-Matching Music Group) played Stage 1 with the same music. Group A played the same stage, but without any music.

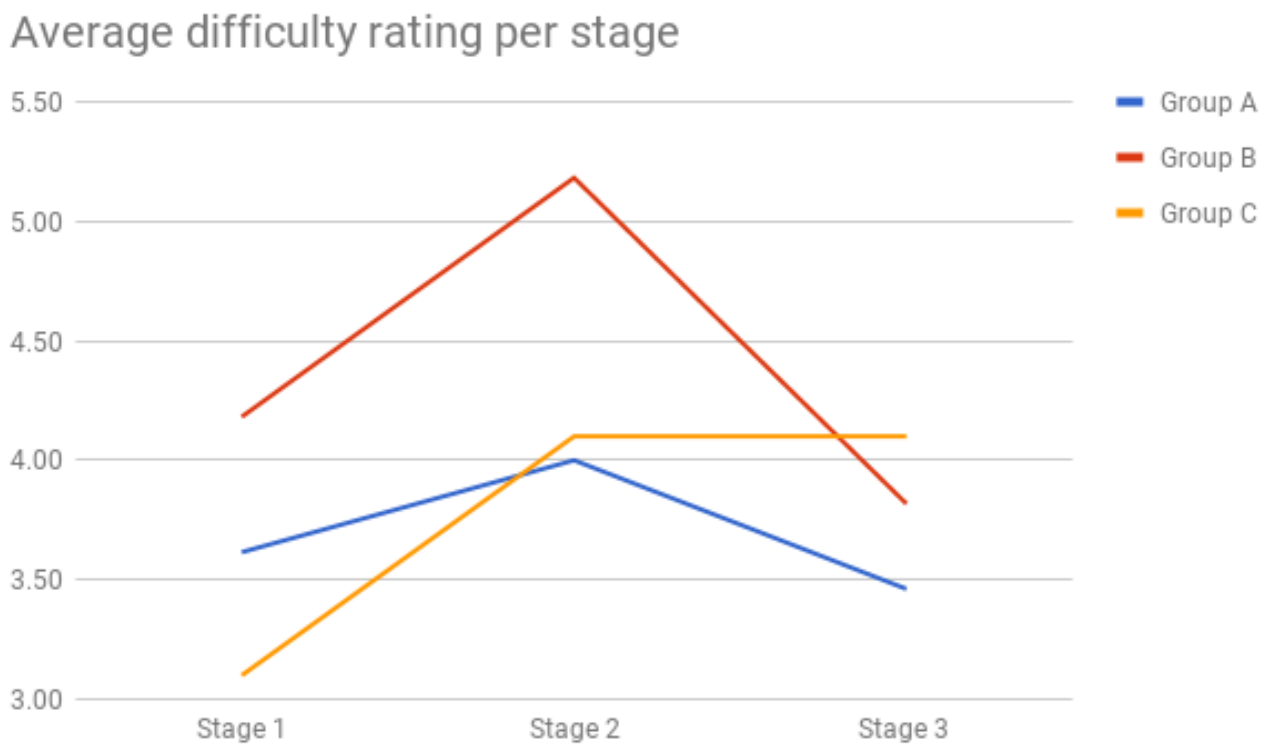

Figure 3.1: Average difficulty rating per stage

In the graph, it can be seen that group C and group B rated the first stage a bit differently, despite the stage being absolutely identical. On average, group B rated the first stage at 4.1 out of 10. This is similar to the control group rating of 3.9. However, group C rated the first stage as 3.1.

All groups rated the first stage quite similarly. Namely, they either called the stage ‘easy’ or ‘easy to balanced’.

Then, when looking at the second stage, a difference can be spotted. Both group A and group C rated the second stage as a bit more difficult, but kept rating it as ‘easy’ or ‘easy to balanced’. Note that group A played this stage without music and group C had music playing that was rather relaxed. However, the average group B participant, who played the same stage with very rhythmic and intense music no longer considered the stage to be easy. Instead, they referred to it as ‘balanced’. However, the rise of perceived difficulty for group B and C was similar. Both noted a considerable rise of difficulty in the second stage, when compared to the first stage. This is not unexpected, as by design, there is a big change in difficulty between the first and second stage. Less expected was the lack of rise in perceived difficulty for the control group. The control group barely rated the second stage as more difficult. However, this can be attributed to an aforementioned reason: the increasing of player skill during the stages of the game. Through interviews, the impact of player skill on perceived difficulty became apparent.

Finally, there's the difference between the second and third stage of the game. The third stage was designed to break the players' expectation of a third stage. Naturally, players expect later stages of the game to be more difficult as earlier stages. This has been confirmed in interviews, as when participants of the interview were asked why they expected the second stage to be more difficult, one response was: "Just because logic suggests it". However, the third stage of the game was actually significantly easier than the second stage of the game, and a bit harder than the first stage.

Thus, as player skill has increased and the stage has become slower with more responsive controls, logically players should rate it as the least difficult stage or at least easier than the previous (second) stage. Group B, where the music also becomes less intense as the level difficulty decreases, spots the decrease in difficulty without problems. The same can be said of the control group, group A, as they too rate the third stage as easier than the second stage.

The only group that does not rate the stage as easier, is group C (NMMG). The average difficulty rating of stage 3 by participants of the Non-Matching Music Group is the same as the previous stage.

Stage number / Group	Group A (No music)	Group B (Matching)	Group C (Non-Match)
More difficult or equally difficult	5	3	8
Easier	8	8	2

Table 3: Number of participants rating Stage 3 difficulty compared to Stage 2

When counting the number of participants in each group that thought stage 3 was as difficult or more difficult, an explanation for the stage 3 difficulty rating not rising for group C can be found. Apparently, 8 out of 10 participants in the Non-Matching Music Group thought that stage 3 was at least as difficult as stage 2. Conversely, most participants of both other groups did perceive the third level as easier. 61,5% of group A and 72,7% of group B realized that the last stage was actually not the hardest stage.

During the experiment, the participants were also observed. During the observations, I wrote down the number of mistakes made as well as how focused the participant appeared to be. Generally, the number of mistakes was highest in either the first or the second stage. This can be attributed to some participants needing more time to get used to the controls. This resulted in rather high amounts of mistakes in the first stage. Other participants, however, had no problem picking up the controls, which lead to them making more mistakes in the second stage when compared to the first stage. Generally, the observed participants made the least mistakes in the last stage. The following table shows, respectively, the group they were assigned to, their experience with games and the amount of mistakes they made per stage.

Attribute / Participant no.	1	2	3	4	5	6
Assigned group	A	A	B	B	C	C
Experience with games	Exp.	Casual	Exp.	Casual	Hardcore	Hardcore
Stage 1 (easy) mistakes	4	2	5	5	1	5
Stage 2 (hard) mistakes	5	11	4	6	2	6
Stage 3 (medium) mistakes	1	6	1	4	2	6

Table 4: Interviewed participants demography and mistakes made

Generally, the mistakes in the first stage seem to be around 4 or 5, with two outliers. Interestingly, it is both a participant (participant #5) that remarked being very familiar with this type of game as well as a zero-experience participant (participant #2) doing well in the first stage. The casual gamer, participant #6, stated to never have played similar games before. This only showed in the second stage though, as she could no longer keep up with the speed. Participant #5, however, barely did any worse in the faster stages of the game. The skill of participant #2 did not seem to increase much, if at all, during the different stages. For other participants, a clear rise in skill could be noticed, as most of the times the number of mistakes was close to equal in the second stage. Often the second stage had one mistake more and even one less mistake, in one case. Then, in the third stage, the amount of mistakes decreased again for all but one case. The least improvement in performance was seen in participants of group C, the mismatching music group. Both of these participants also reported in their interviews that they thought stage 2 and 3 were equal speed, while the other participants revealed in the interviews that they did think it became easier.

To conclude, it appears that music does correlate with perceived game difficulty. To answer the research questions:

- Can low intensity (relaxing) music result in lower perceived game difficulty?
- Can high intensity music result in higher perceived game difficulty?

The answer seems to be yes, in both cases. This seems evident in participants rating the stage with the most intense music as higher difficulty, compared to the stage with low or medium intensity in music. To get to this conclusion, both the average rating was taken, as well as counting the amount of participants that rated the difficulty of stage 3 as higher or equal to stage 2 (or vice versa). This conclusion gains additional support from the interviews, with the participants of group C stating they thought the speed of the stages was equal. Participants in group A and B both performed better in the final stage and reported it as being easier.

3.3 Players' level of focus

The first research questions to be answered are about how a player's perception of a game's difficulty changes depending on music. The questions that need answering are:

- When music intensity and game difficulty progression do not match, does it result in a player's loss of focus?

And vice versa:

- When music intensity and game difficulty progression do match, does it increase a player's level of focus?

To find any correlation between music intensity matching gameplay and focus, participants were asked to rate their focus on a scale from 1 to 5. Rating their focus as a '5' would translate to considering themselves very focused. Rating their focus as a '1' would translate to not being focused at all.

Stage number / Group	Group A (No music)	Group B (Matching)	Group C (Non-Match)
Stage 1	3.69	3.09	3.60
Stage 2	3.85	3.73	4.00
Stage 3	3.69	3.73	4.10
Focus difference rating	2.54	3.82	3.00

Table 5: Average focus rating per group

According to the table above, group C was more focused in general, despite this being the group with non-matching music. However, averages here are less useful, as it would be better to consider the amount of people in a group that considered themselves not focused (1 or 2 on the scale) or focused (4 or 5 on the scale). This gives us the following table for the participants reporting not being focused:

Stage number / Group	Group A (No music)	Group B (Matching)	Group C (Non-Match)
Stage 1	1	4	2
Stage 2	1	2	0
Stage 3	2	0	0

Table 6: Number of not focused participants, per stage

And similarly, a table for the participants reporting being focused:

Stage number / Group	Group A (No music)	Group B (Matching)	Group C (Non-Match)
Stage 1	8 out of 13	6 out of 11	7 out of 10
Stage 2	8 out of 13	6 out of 11	7 out of 10
Stage 3	9 out of 13	5 out of 11	8 out of 10

Table 7: Number of focused participants, per stage

However, these numbers still reveal little information. 6 out of 21 participants that played the first stage with music (group B and C), reported not being focused. However, group A only had one participant out of 13, that reported not being focused. In general though, it can be stated that most participants felt focused on the game, regardless of the music fitting the level.

Taking a similar approach as with difficulty, it might be more telling to see how many participants rated their focus as less or more, per stage. This gives us the following data:

Stage 3 focus vs. Stage 2 / Group	Group A (No music)	Group B (Matching)	Group C (Non-Match)
More focus	3	3	3
Less focus	3	2	2
Equal focus	7	6	5

Table 8: Number of participants rating their focus in stage 3 as more or less than stage 2's focus

The expected results would be that group C would report less focus going from stage 2 to 3, as the music would match less. Conversely, group B would be expected to report more focus. However, in most cases the focus appeared to stay the same across the stages. Strangely enough, some participants reported a change in focus between the stages, but then also rated their focus per individual stage equally.

The interviews here might give some extra insight as to why the results are as they are. One participant said the following:

> 'I liked the second level music. It was more like "Let's do this", I was anticipating like it would be much harder difficulty.'

This participant was part of group C and thus had music that was generally described as relaxed for the most difficult level. Yet, because he reported that this was the kind of music he would have in similar games, as well as that he liked the music, it helped him get into the flow and focus. However, when that same participant was asked to comment about the music of the third stage, which was the most intense, he had the following to say:

> 'The third one was … while it did fit in with the theme of the game, it didn't really mesh with me. It was the kind of level, can I get this level over as fast as possible, so I don't have to listen to this song anymore. That sometimes does happen. Like, I really hate this song, let me make sure that I beat this level, so that I can go on to something else.'

So, despite disliking the music, the participant still reported being focused in all three stages, but for different reasons. In stage 2, it seemed that liking the music helped to participant to focus and enjoy the stage. However, in stage 3 the participant wanted to focus on the stage, just to avoid having to play the stage with this music for a longer period of time.

Another participant, however, also reported disliking the same music. This participant was in group B, so he played with the most intense song on the (most difficult) second stage. He commented:

> 'So, the second one, I think it drew away my attention a bit. It didn't help me focus. The last one sort of did [help me focus].'

This comment suggests that disliking a song can cause attention to shift and can cause a loss of focus. Another interviewee stated a loss of focus when she did actually enjoy the song and the stage most:

> 'And then the third level definitely was more relaxing and I don't think I was as focused. It was more enjoyable though.'

When looking at the following graphs, of the percentage of focused participants per stage, another trend can be found:

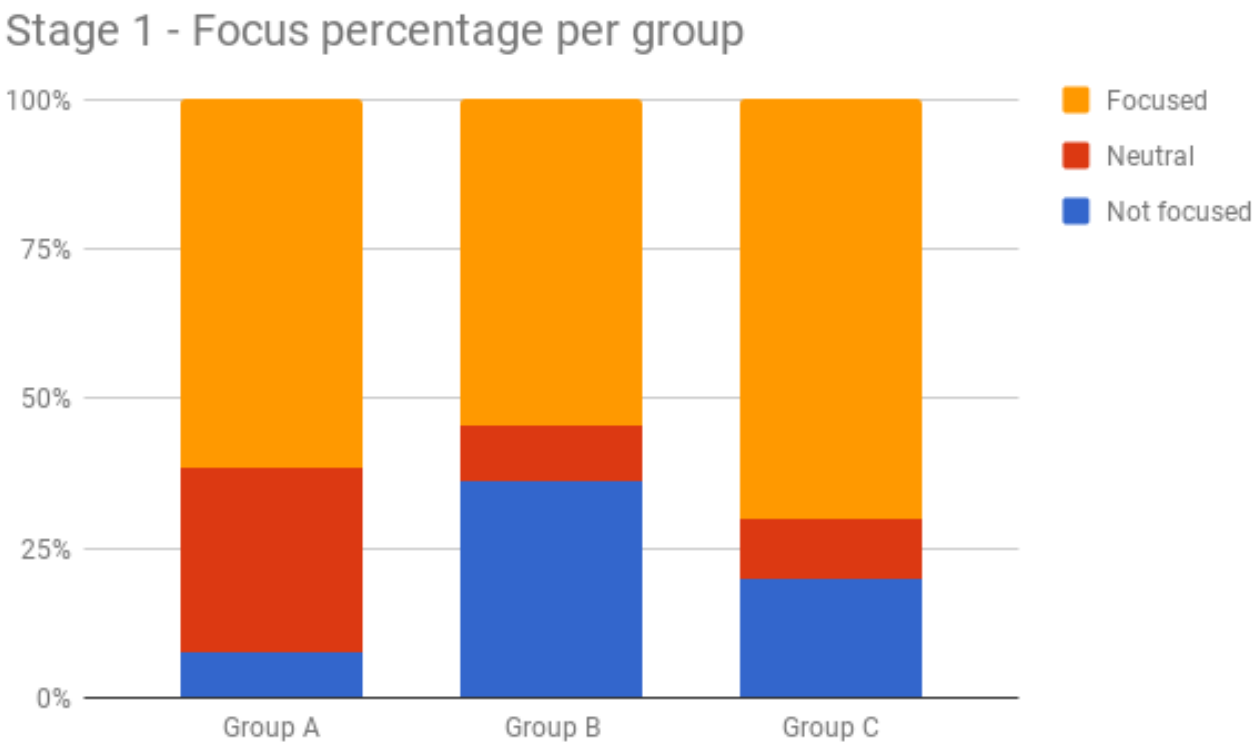

Figure 3.2: Focus percentage per group, in stage 1

On the stacked column graph above, which gives the percentage of participants focused on stage 1, it can be seen that 50 to 70% of the participants reported being focused.

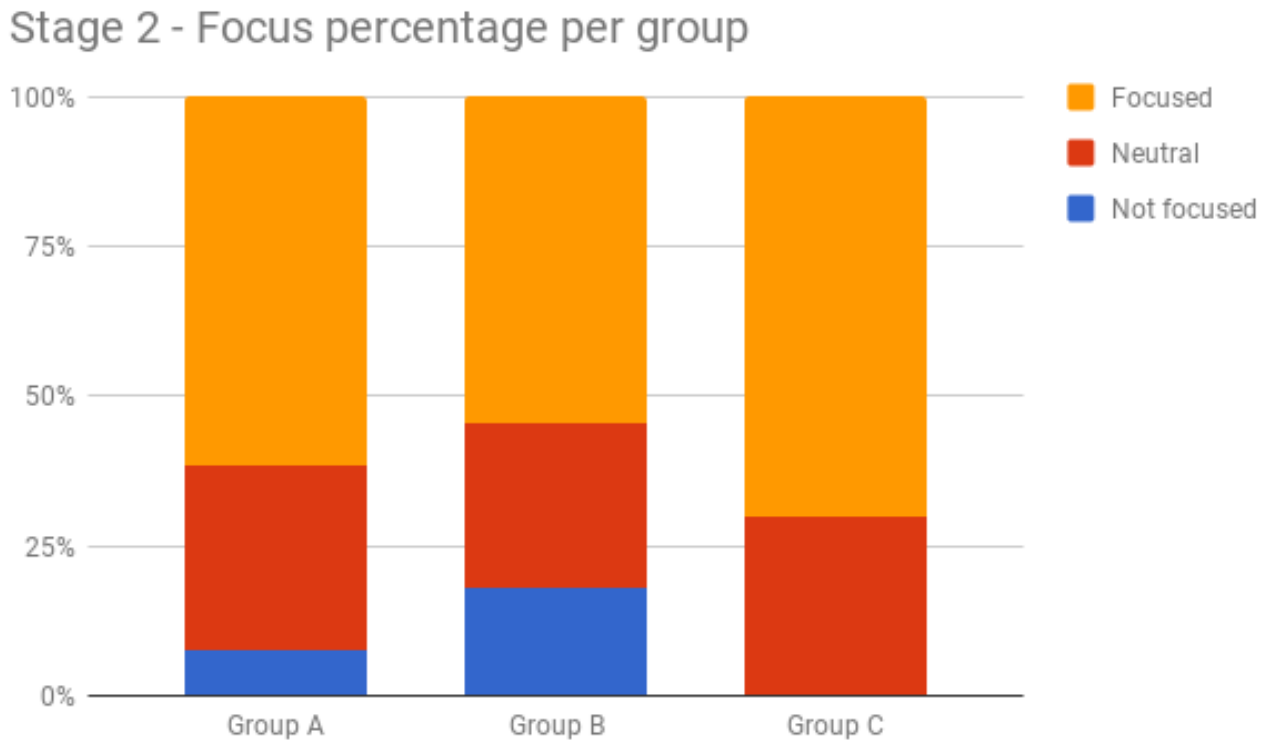

Figure 3.3: Focus percentage per group, in stage 2

Then, in stage 2, this number stays about the same, but the amount of participants that report not being focused decreases. Especially in group C, where the participants that reported not being focused now no longer report being unfocused. These participants, however, reported to be 'somewhat focused', as opposed to being mostly or fully focused. The group that changed the least, however, is group A. Group A, of course, differs in that there is no change accompanying the change of stages. This could mean that there is indeed a relation between the level of focus and having any music at all.

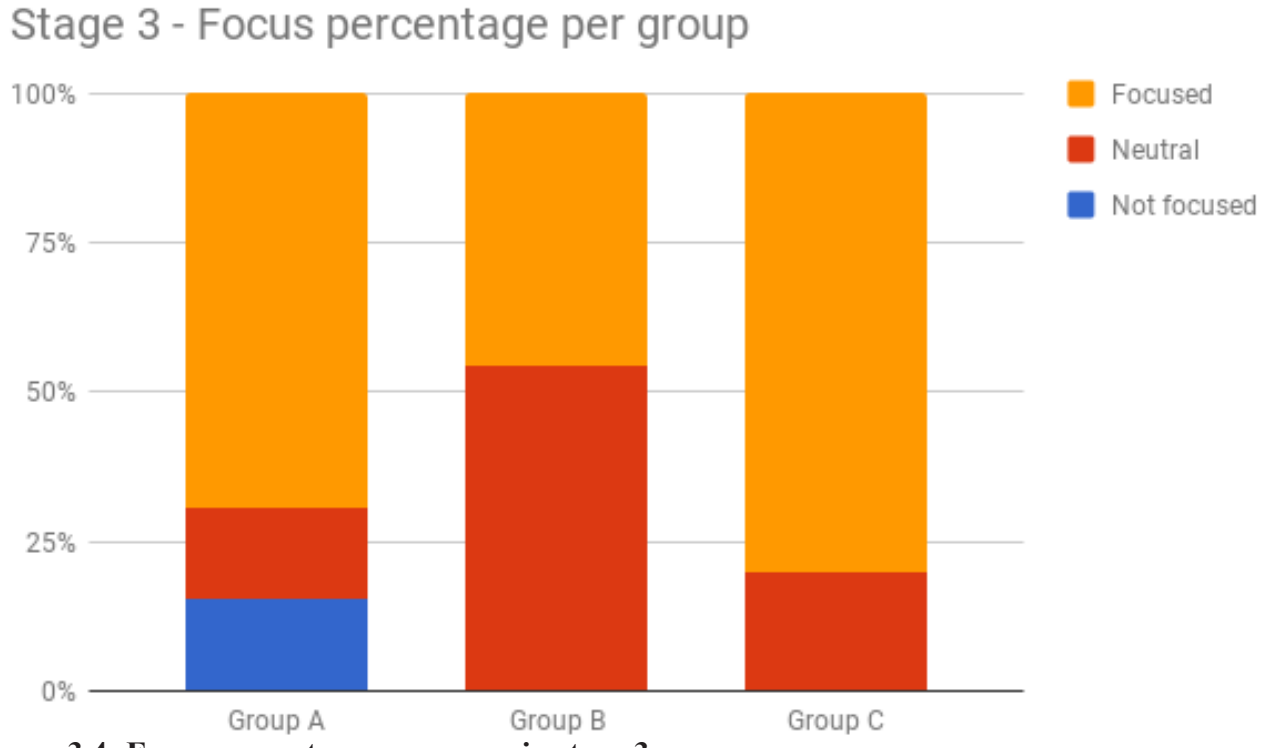

Figure 3.4: Focus percentage per group, in stage 3

Finally, there is stage 3. Again, it can be said that group A has not changed much. The majority of participants is still focused, while there's also still a small group reporting not being focused. However, both group B and C no longer have any participants reporting to not be focused. Group B however, after experiencing the most intense difficulty and most intense song, suddenly had more than 50% of their participants saying they were only 'somewhat' focused. The quote, that was also given before, may explain this phenomenon:

> 'And then the third level definitely was more relaxing and I don't think I was as focused. It was more enjoyable though.'

After experiencing the intense stage, participants may have reported their focus dropping, as they did not necessarily need to be as focused anymore, due to the music and difficulty level both nudging the player towards a more relaxed state of mind.

Group C, however, had a wholly different curve, as their focus seems to increase along with the music's intensity, rather than actual difficulty level. The interviews gave some mixed potential causes. First, the skill finally being considered to be at an adequate level was reported to increase focus and possibly enjoyment:

> 'On the third stage I could finally focus because I got how the controls work. How the tracks are… and what is the right position between them. So in the third stage, I could finally focus and could get my character move through all these obstacles and tracks without mistakes and … I was really focused at that point.'

Then, secondly, of the highest intensity song in the third stage was said:

> 'It didn't really have much of an effect on me. I was just focused on making as little mistakes as possible.'

Which suggests that the song could have been phased out to some degree and the focus in this case being more related to the gameplay only.

To conclude, it appears that music does have an effect on focus. To answer the research questions, however:
When music intensity and game difficulty progression do not match, does it result in a player's loss of focus? Conversely, when music intensity and game difficulty progression do match, does it increase a player's level of focus?

The answer does not seem at all clear. Interviews revealed some participants considering themselves more relaxed and less focused when they enjoyed the music. Even though the music was enjoyable and seemed to match the game difficulty, it actually resulted in less focus. A similar thing happened with a participant of group C, stating in an interview that he felt motivated and more focused, due to the intense song. When looking at the percentage of participants reporting to be focused, it seems most participants of group C also were most focused in the third stage. 80% of all participants in group C reported to be focused in the third stage, despite the music being designed not to match. The same (highest intensity) song did not acquire the same effect on the second stage, for group B. Therefore, it cannot be said that it was just the song causing focus to increase. However, the music in group C progressed more as would be expected: least intense music to start with, the most intense music on the last stage.

Because of these results, these research questions cannot really be answered yet. The interviews suggest that the impact of game music on a players' ability to focus is different per individual. It differs both in how much enjoyable a song is, as liking a song is of course very subjective, as well as whether relaxing (or vice versa, stressing) results in increasing or decreasing a players' ability to focus.

3.4 Conclusion

To conclude, the main research question should be answered:
How does the perceived intensity of game music correlate with players' level of focus and perception of game difficulty?

This question can only be answered partially. First of all, the intensity of the music does not seem to directly correlate with players' level of focus, but interviews did reveal the possibility of music having an effect. When music progressed from least intense to most intense, however, the most focus was achieved. Group C's focus level increasing with music intensity might also be attributed to the highest amount of participants calling themselves 'hardcore' gamers being in this group. Further research would be needed here, to draw any sort of conclusion.

Then, the correlation between the intensity of game music and the perception of game difficulty seems clearer. More intense game music made participants rate the stage as higher difficulty than stages with more relaxed stages. Additionally, the intensity of the game music indicated to change the expectations of the players, interviews found. As a result, this expectation could also be a cause of players rating the stages with more intense music as more difficult.

4. Discussion

This chapter will discuss the implications of the results found through the experimental research, as well as how this can be explained with the theoretical background studies. This should give a final conclusion on each of the research questions, if possible. Finally, I will attempt to point out the weaknesses or shortcomings of my approach.

4.1 Conclusion

To conclude this study by having the main research question answered, a conclusion is given for both topics of this study. The results are summarized and then compared to findings that were presented in the theoretical framework

4.1.1 Perceived game difficulty

First, I will briefly summarize the results of the experiment regarding the perceived game difficulty. Then, I will relate this to applicable studies that were mentioned in the theoretical background.

Stage number / Group	Group A (No music)	Group B (Matching)	Group C (Non-Match)
More difficult or equally difficult	5	3	8
Easier	8	8	2

Table 9: Number of participants rating Stage 3 difficulty compared to Stage 2

The table above sums up the results best. Of the participants of group C, only 2 out of 10 participants realized that the last stage was actually easier than the second stage. Participants with matching music or no music were more able to notice that the difficulty actually decreased after stage 2. As studies have shown that game music can affect how a game is approached (Wharton & Collins , 2001), the results are as expected. The music may have caused the particpant to approach the game as if it was harder. One participant of group C seems to confirm this, as he suggested that the rhythm with which he would hit spacebar was somewhat determined by the music:

‘Just because the beats were so off, it didn’t make me want to hit the spacebar so much.’

Also, studies have shown that music tempo changes how moving images are perceived (Hung, 2001). However, music intensity is not the same as music tempo, but for the studies songs were chosen that were both more intense as well as higher tempo. The songs used had a beats-per-minute of 65, 100, 164 respectively. This could mean that in the stage with the highest intensity, 164 beats-per-minute music, the participants perceived the stage as faster and thus more difficult. However, this could also mean that a slower tempo yet high intensity song could have different effects than a high tempo, high intensity song. Similarly, a high tempo, low intensity song could cause a different effect on perceived difficulty, which would need further testing.

In conclusion, I believe it can be said that game music has a significant impact on how a game's difficulty is perceived. Whether it is the music intensity, the music tempo or a combination of both having an effect on the perceived difficulty warrants further research.

4.1.2 Player's level of focus

The second goal of the studies was to find out if there is a correlation between game music and a player's perception of difficulty. The experiment did not result in any conclusive findings, as participants reported about equal focus across stages. However, the interviews reveal some of the lack of changes in focus that in the measured results. Some participants reported liking the medium-intensity song, but the effect on their focus was different. One participant said he got more relaxed, resulting in a loss of focus. Another participant, however, found his state of mind changing, describing it with 'Let's do this!'. These findings can explain why the intense music, can either cause focus or make people lose focus, depending on the individual. Similarly, the more relaxed music, which was generally enjoyed more, can also both cause a loss of focus or acquiring more focus, depending on the individual. It has also been reported that music can affect emotions (Thayer & Levenson, 1983), which in turn can have an effect on focus.

To conclude Studies have shown that music can have an effect on stress levels (Hébert et al., 2005; Wharton & Collins, 2001), which in turn can have an effect on focus. The exact effect, however, may vary from person to person. Conversely, a song can also cause relaxation rather than stress. Possibly, being too relaxed may cause a loss of focus, as this was reported by one of the interviewed participants.

4.2 Practical implications

There are a lot of practical uses for the findings regarding perceived difficulty especially. To give players a sense of progression, without making a game too difficult and thus possibly frustrating, it appears music can help. If a game designer wants players to perceive progressing difficulty, it can be done with music as well as gameplay.

The results on focus can also have practical uses. The study shows the importance of selecting music that players may enjoy, which shows research music preference of a target audience may be vital to a game's success. However, it also shows that for some people, having a relaxing and enjoyable song may cause a loss of focus which in turn causes their performance to decline (Daniel Berlyne, 1960). Therefore, having a relaxing song when the game gets more difficult, is likely better avoided. More intense songs, however, do not always cause increased focus either, but more research on this would be warranted.

The findings can be used in a wide variety games, including educational and serious games. Especially any findings regarding focus could be of use for educational games, as it is likely to increase performance of students.

4.3 Limitations and opportunities for further studies

There are a lot of opportunities for further studies in the field of ludomusicology in general. However, the results to game music intensity having an effect on perceived difficulty and a player's level of focus are also not entirely conclusive.

As mentioned before in the theoretical framework, music can result in physiological responses (Thayer & Levenson, 1983; Hébert et al., 2005). Previous studies regarding stress were conducted with saliva samples, skin conductance and heart rate measurement. These methods could be used to determine whether a participant is stressed, which in turn could lead to more information about the level of focus or the reason as to why a participant can or can't focus.

Alternatively, the qualitative data of the experiment could have been expanded by using eye-tracking. Although I have found no examples of eye-tracking being used for game related experiments, pupil dilation can also indicate arousal. More important, however, is that tracking eye saccades can indicate the level of attention, which would give objective data regarding a player's focus. (Janelle, 2002; Rizzolatti et al., 1987; Deubel & Schneider, 1996)

This study also had a few shortcomings and limitations that may have negatively impacted the results or made the results inconclusive. First of all, the effect of music on video games is hard to study, even when made concise. Video game genres vary wildly, just as the music within video game genres. Moreoverly, music is very subjective, so even when made as objective as possible by looking at beats-per-minute or the instruments used, the impact of music will vary from person to person.

There were some limitations in the tools that were used. The research question was only investigated with one small custom-made game. There is a large chance that different games may cause different responses. Especially considering the importance of previous experiences with a game. This is evident from the interviews, where one participant had quite different responses to the game due to the familiarity with similar games. Secondly, the qualitative data was only acquired through interviews and observations, which are both rather subjective data. The experiment could have been improved by adding more objective data to measure focus.

Additionally, for the experiment the selected music had a direct relation between the music intensity and the music tempo. A study by Alexander Wharton and Karen Collins (2001) mentioned music tempo may have a significant effect. Therefore, it may be hard to conclude whether the music tempo or the music intensity had an effect. So, studies that compare high intensity, but low tempo songs with low intensity, but high tempo may give entirely different results.

Furthermore, more research could be done on the personal preferences of players. Perhaps by letting people choose their own music and then comparing their performance or focus to when they are playing with music that they reportedly dislike, important findings can be discovered. This would potentially solve the issue that the same song can either be disliked or liked by different person, which in turn would influence the results.

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Music:
“Dreamer”, “Firebrand”, “Thief in the Night”
Kevin MacLeod (incompetech.com)

Appendices

Appendix A - List of mentioned games

Games are listed as: Game Title (Publisher, Date)

- Bastion (Supergiant Games, 2011)
- Dark Souls (FromSoftware, 2011)
- Fallout 3: Operation Anchorage (Bethesda Softworks, 2009)
- Flappy Bird (dotGEARS, 2013)
- FTL: Faster Than Light (Subset Games, 2012)
- Grand Theft Auto III (Rockstar Games, 2001)
- Guitar Hero (RedOctane, 2005)
- Left 4 Dead 2 (Valve Corporation, 2009)
- Need For Speed: Underground (Electronic Arts, 2003)
- Osu! (Ppy Pty Ltd, 2007)
- Pacman (Midway, 1980)
- PlayerUnknown's Battlegrounds (PUBG Corporation, 2017)
- Pong (Atari, 1972)
- Quake III Arena (id Software, 1999)
- Spore (Electronic Arts, 2008)
- Super Mario Bros (Nintendo, 1985)
- The Elder Scrolls III: Morrowind (Bethesda Software, 2002)
- Tennis For Two (N/A, 1958)
- Tetris (Various publishers, 1984)

Appendix B - Video game screenshots

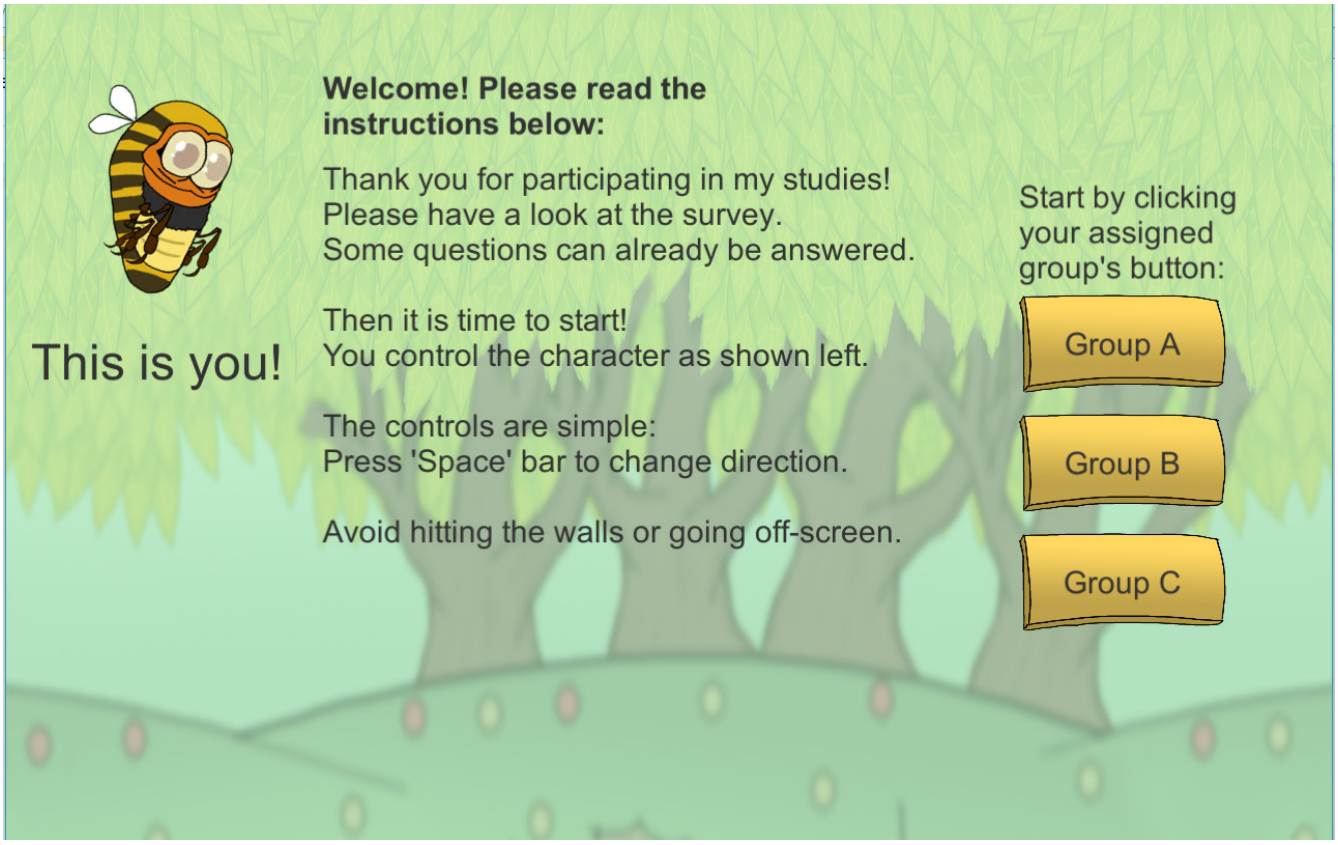

Figure B.1 - Video game instrument: Introduction screen

Figure B.2 - Video game instrument. Gameplay: mistake made

Figure B.3 - Video game instrument: Survey screen

Figure B.4 - Video game instrument. End screen

Appendix C - Survey format

Introduction

Please read and answer each question or statement below. Please check only one checkbox per question or statement. Personal data will not be shared to anyone and will purely be used for the experiment. The order of the stages of the game was randomised

What is the group you were assigned?

O Group A
O Group B
O Group C

How would you rate your previous experience with games?

O I have rarely or never played games.
O I have played some games, but only very occasionally.
O I consider myself an experienced gamer.
O I consider myself a hardcore gamer.

Date of participation

DD MM YYYY
____ / ____ / _____

Stage 1 questions

Part 1: Difficulty ratings

Please rate the difficulty for the stage of the game you just played, according to the scale below:

1. Very easy - I did not find the game challenging at all.
2. Very easy to easy - The game challenged me very rarely.
3. Easy - The game had some challenge, but still gave me no problems.
4. Easy to balanced - The game was somewhat easy, but also challenging at times.
5. Balanced - The game was challenging at times, but not too difficult.
6. Balanced to difficult - The game was challenging and sometimes too difficult.
7. Difficult - The game was challenging and even occasionally too challenging.
8. Difficult to very difficult - The game was very challenging, often too much so.
9. Very difficult - The game was too challenging for me..
10. Extremely difficult - The game felt close to impossible to do.

	1	2	3	4	5	6	7	8	9	10
I found the difficulty of stage 1:	O	O	O	O	O	O	O	O	O	O

Part 2: Statements

Please read each statement below and rate the degree of which you agree with the statement, according to the scale below:

1. Not at all - The statement is not true for me at all.
2. Mostly disagree - Overall I disagree with the statement more than I agree.
3. Neutral - I have no particular bias towards this statement.
4. Mostly agree - I mostly agree with the statement.
5. Completely - I completely agree with the statement.

	1	2	3	4	5
I felt focused on the game, during stage 1.	O	O	O	O	O
I got frustrated with the game, during stage 1.	O	O	O	O	O
I felt boredom while playing the game, during stage 1.	O	O	O	O	O

Stage 2 questions

Part 1: Difficulty ratings

Please rate the difficulty for the stage of the game you just played, according to the scale below:

1. Very easy - I did not find the game challenging at all.
2. Very easy to easy - The game challenged me very rarely.
3. Easy - The game had some challenge, but still gave me no problems.
4. Easy to balanced - The game was somewhat easy, but also challenging at times.
5. Balanced - The game was challenging at times, but not too difficult.
6. Balanced to difficult - The game was challenging and sometimes too difficult.
7. Difficult - The game was challenging and even occasionally too challenging.
8. Difficult to very difficult - The game was very challenging, often too much so.
9. Very difficult - The game was too challenging for me..
10. Extremely difficult - The game felt close to impossible to do.

	1	2	3	4	5	6	7	8	9	10
I found the difficulty of stage 2:	O	O	O	O	O	O	O	O	O	O

Part 2: Statements

Please read each statement below and rate the degree of which you agree with the statement, according to the scale below:

1. Not at all - The statement is not true for me at all.
2. Mostly disagree - Overall I disagree with the statement more than I agree.
3. Neutral - I have no particular bias towards this statement.
4. Mostly agree - I mostly agree with the statement.
5. Completely - I completely agree with the statement.

	1	2	3	4	5
I felt focused on the game, during stage 2.	O	O	O	O	O
I got frustrated with the game, during stage 2.	O	O	O	O	O
I felt boredom while playing the game, during stage 2.	O	O	O	O	O

Stage 3 questions

Part 1: Difficulty ratings

Please rate the difficulty for the stage of the game you just played, according to the scale below:

1. Very easy - I did not find the game challenging at all.
2. Very easy to easy - The game challenged me very rarely.
3. Easy - The game had some challenge, but still gave me no problems.
4. Easy to balanced - The game was somewhat easy, but also challenging at times.
5. Balanced - The game was challenging at times, but not too difficult.
6. Balanced to difficult - The game was challenging and sometimes too difficult.
7. Difficult - The game was challenging and even occasionally too challenging.
8. Difficult to very difficult - The game was very challenging, often too much so.
9. Very difficult - The game was too challenging for me..
10. Extremely difficult - The game felt close to impossible to do.

	1	2	3	4	5	6	7	8	9	10
I found the difficulty of stage 3:	O	O	O	O	O	O	O	O	O	O

Part 2: Statements

Please read each statement below and rate the degree of which you agree with the statement, according to the scale below:

1. Not at all - The statement is not true for me at all.
2. Mostly disagree - Overall I disagree with the statement more than I agree.
3. Neutral - I have no particular bias towards this statement.
4. Mostly agree - I mostly agree with the statement.
5. Completely - I completely agree with the statement.

	1	2	3	4	5
I felt focused on the game, during stage 3.	O	O	O	O	O
I got frustrated with the game, during stage 3.	O	O	O	O	O
I felt boredom while playing the game, during stage 3.	O	O	O	O	O

Final questions

Please read each statement below and rate the degree of which you agree with the statement, according to the scale below:

1. Not at all - The statement is not true for me at all.
2. Mostly disagree - Overall I disagree with the statement more than I agree.
3. Neutral - I have no particular bias towards this statement.
4. Mostly agree - I mostly agree with the statement.
5. Completely - I completely agree with the statement.

	1	2	3	4	5
My level of focus differed during different stages of the game.	O	O	O	O	O
My frustration changed during different stages of the game.	O	O	O	O	O
My boredom changed during different stages of the game.	O	O	O	O	O
I anticipated a higher game difficulty in the second stage of the game, compared to the first stage.	O	O	O	O	O
I anticipated a higher game difficulty in the third stage of the game, compared to the second stage.	O	O	O	O	O
I anticipated a higher game difficulty in the third stage of the game, compared to the first stage.	O	O	O	O	O

Appendix D - Interview format

Date of interview:
Interview start time:

Interview conducted by: Jeroen Bosch

Introduction

Thank you for participating in this interview. The interview will be about your experience of the game you just played, as well as your answers to the survey. In the interview, I will try to find out the reasons behind your experiences. The interview questions are open ended and you can talk about a topic or experiences as much as you like. Feel free to talk about anything that seems relevant to you, even if it is not relevant to the question. The interview will take 10 to 20 minutes.

Questions

1. Were the instructions to the game clear?
2. Can you describe your experiences of playing the first stage of the game?
3. Can you describe your experiences of playing the second stage of the game? How was it different to the first stage?
4. Can you describe your experiences of playing the third stage of the game? How was it different to the previous stage? How was it different to the first stage?
5. What stage did you think was the most difficult and why?
6. What stage did you think was the least difficult and why?
7. Can you describe the differences between the stages? (4 topics should be covered: How did you think the gameplay/music/challenge/amount of fun was different?)
8. Did the game frustrate you at any time?
9. Did you experience boredom at any time?
10. Can you describe your ability to concentrate on the game, throughout the three stages of the game?
11. How would you describe the music of the game?
12. What effect do you think the music had on your experiences?
13. Did the music give you any expectation about the difficulty?
14. How do you think the difficulty and the music related to each other.