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Adaptive Music in Minecraft and its impact on the player experience

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Abstract

Adaptive music is used in video games to enhance the player experience by dynamically adapting the soundtrack to in-game environments and events. Previous research suggested that this contributes to immersion, emotional engagement, and a perceived coherence between the game world and its soundtrack. In this thesis, we investigate the effect adaptive music has on the player experience in Minecraft. To examine this, a Minecraft mod was created that implemented adaptive music to a random selection of biomes, while the rest played standard Minecraft music. Participants were tasked to play the game, complete a goal within a given amount of time and complete a questionnaire. Each question handled a different aspect of the player experience, such as enjoyment, focus, scariness, calmness, exploration, and perceived music-environment fit or disruption. The results indicate that the adaptive music had only a limited but still observable impact on the player's experience. Instead, participants attributed their experiences more frequently to the gameplay and environmental factors. Adaptive music was associated the most with the perceived fit between the game and music, while in contrast, experiences like enjoyment, focus, scariness, and exploration were more influenced by gameplay elements, such as enemy encounters, terrain and environmental challenges. Minecraft's original music was more associated with calmness than the adaptive music. Although the results do not provide conclusive evidence that adaptive music substantially enhanced the player experience, they do suggest that adaptive music may strengthen the perceived coherence between the game's environment and its music. Due to the limitations such as time constraints, a limited sample pool, and not being able to separate the adaptivity from the effects of the music selection itself, further research is required to study the contributions of adaptive music systems in isolation.

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1 Introduction

1.1 Adaptive music

Adaptive music is a type of music that adapts to the players surroundings and play experience. It gives the player conscious and unconscious control over the music, which can create satisfying, intense or emotional moments for a player and make those moments feel unique. This is a great technique to assist the interactivity and dynamicity of the games themselves. The use of this has increased over the past few years [9]. The question that arises was how much a game effectively benefits from this type of music. To test this out, we wanted to alter a very interactive and dynamic game to use adaptive music. In story games, the music is usually scripted instead of dynamic. We wanted to avoid this, since we wanted the music to adapt itself on its own, rather than using scripted cues by the developer. Thus, we chose to apply our music to a sandbox game, since these games provide a lot more dynamicity in player choice and environments. To test the impact adaptive music has on the player experience in a sandbox game, we created a mod that implemented adaptive music in a game that normally does not have this, which ended up being Minecraft.

This experiment aims to answer the research question: what effect does adaptive music in Minecraft have on the player experience? Our hypothesis is that adaptive music has more of an impact on the player experience than regular music, making the game feel scarier or calmer, add cohesion to the game world, make the players more focused, encourage exploration and make the game overall more enjoyable.

1.2 Thesis overview

In this bachelor thesis written for LIACS and supervised by Giulio Barbero and Derya Soydaner, we discuss adaptive music, how it works and its potential effects on the players. In section 2, we explore existing literature on the subject of adaptive music, we discuss what research has already been done, and what we can apply. In section 3, we will discuss how to approach the experiment, what techniques and methods we will use for both our mod and questionnaire, how the experiment is designed, and what it will look like for the participants. In section 4, we go over all the observable results we have found, wherein these results will be discussed more in depth in section 5. Finally, we end with section 6, in which we will discuss all the limitations our experiment had, how they could be resolved in future research, and what conclusions we obtained.

2 Related Work

2.1 Music in video games and immersion

The popularity of video games has increased over the last few decades, with it now being one of the dominant forms of media, alongside films and television [5]. One of the key aspects in both video games and movies is the music accompanying the visuals. Video games are a lot more dynamic and interactive, with it being player directed. Player-directed means that a player has a varying amount of control over the action and story of a game. According to [7], player-directed events can be limitless in scope, yet their significance to the player might be similar or greater than those

intentionally designed by the developers. When music containing specific emotive qualities and associations is combined with narrative events and visual content, it achieves significant effects on memory, immersion and emotion perception. Immersion is defined by [10] as "how the music supports the player's involvement in the game" (p. 2). However, the music in video games tends to be a lot less dynamic than the other aspects of the gaming experience, which limits the effects that unique and context-specific music could add to the gameplay.

In [8], they concluded that immersion could be measured subjectively and objectively, but the definition itself is still hard to describe. To measure immersion subjectively, they made players fill out a questionnaire that asked them to measure their immersion themselves, and answer their emotional involvement, transportation control, autonomy, etc. To measure it objectively, they tracked their eye movement. This paper can give us insight in how to measure the immersion of the players, but lacks a concrete definition of the term. Still, we consider using their techniques, specifically the questionnaire, to measure the subjective engagement.

2.2 Interactive music

In an attempt to get around this, some games make use of interactive music. According to [5], "interactive video game music is composed as separate fragments that have the capability to interlock and overlay, all to be masterfully coordinated in the gameplay-responsive game music engine software" (p. 10). In [9], they describe a technique called "vertical layering", which means that instead of having one recorded audio track, the song consists of multiple separate tracks, each with their own different content, that can be layered on top of one another. This enables a song to have more flexibility, without having to transition to another song. While the paper mentions how adaptive music can increase a players skill, immerse them and tell a narrative, they never really specified how they measured this. An example that was not mentioned in this paper, but the use of this technique is explicitly shown and taught is in the game *LittleBigPlanet*, a platformer where interactive music was used to alter the mood and tone of a level without having to switch to another song.

Multiple studies have been conducted to improve this interactive music system, In this [6] research, they created a music composition tool that generated and manipulated audio samples and musical parameters in real time. The goal of this tool was to create smooth transitions between multiple musical patterns that portray different types of emotional states and moods, which could be relevant during gameplay (p. 1). The focus on the research was to assess both the level of interactivity and recognition of mood that the user may experience using the music generation system (p. 7). A research that went more in depth on the player's experience was [7], where they built an adaptive music system (AMS), and tested the players immersion and correlation with the game-world concepts with the AMS compared to the original game soundtrack, where the former is reported to have scored higher. The games they tested this system on was *Zelda Mystery of Solarus* (MoS) and *StarCraft II*, and were selected for having different mechanics, visual styles and settings, as well as being open source or having exposed game-states that could be used to model game-world contents. The results of this research show that games can successfully implement AMS, and that the participant's self-reported immersion and correlation of events increased using the AMS for short periods (p. 8).



Figure 1: Examples of different biomes in Minecraft: plains, grove, badlands and caves

2.3 Game environment

In theory, an open-ended sandbox game such as Minecraft would be a suitable environment to implement a self-adapting music system, since the game is mostly player-driven and lacks tightly scripted events. Minecraft also has a lot of distinct areas in the world that separates different environments, such as forests, deserts and oceans. These areas will be referred to as a **biome**: a region in the Minecraft world with distinct geographical features, plants, creatures, temperatures, humidity levels, colors, etc [1]. Examples of these biomes can be found in Figure 1. The original music in Minecraft, composed by C418, plays sparsely and is not linked to certain events or player states, making the times it does play feel special and unique. However, with Minecraft having so many different environments and states in which a player could be in, sometimes the relaxing music feels mismatched. Thus, a music system that adapts to the players surrounding could have the added effect of making the game more immersive, improving the correlation with a variety of concepts, and potentially enhancing emotional engagement towards certain game-states. In this report, the definition of emotional engagement refers to emotional cohesion (does the emotional tone of the music match the emotional moment in the game) and enjoyment. Minecraft is also known for having a big modding community. **Modding** by definition is the act of changing a physical object or (in this case) software to do something new. Minecraft having a large modding community helps us with finding frameworks and documentation to mod the game, which is especially useful since this means we can alter the game without having to dive into the source code itself.

3 Methodology

3.1 Approach

To test the hypothesis, we built a mod that uses adaptive music. The mod was made using an API named Fabric [3]. Fabric is a lightweight modding toolchain for Minecraft: Java Edition, and was designed to be simple and easy-to-use. The website of Fabric provided a template to build upon and a documentation. The mod is written in Java, as this is the same language Minecraft itself was written in.

In terms of adaptive music, we decided to go for vertical layering music. We chose this because we could use a quality existing soundtrack that was built with the different variation of layering in mind, instead of having to make the music in-game. It is also substantially easier to implement in Minecraft, since Minecraft’s sound and music controls are limited and not documented well. This mod has 3 different decision variables for music control; temperature, scariness and intensity. During gameplay, these variables will reactively change depending on the environment and game state we refer to as environmental variables, wherein they control the music once they

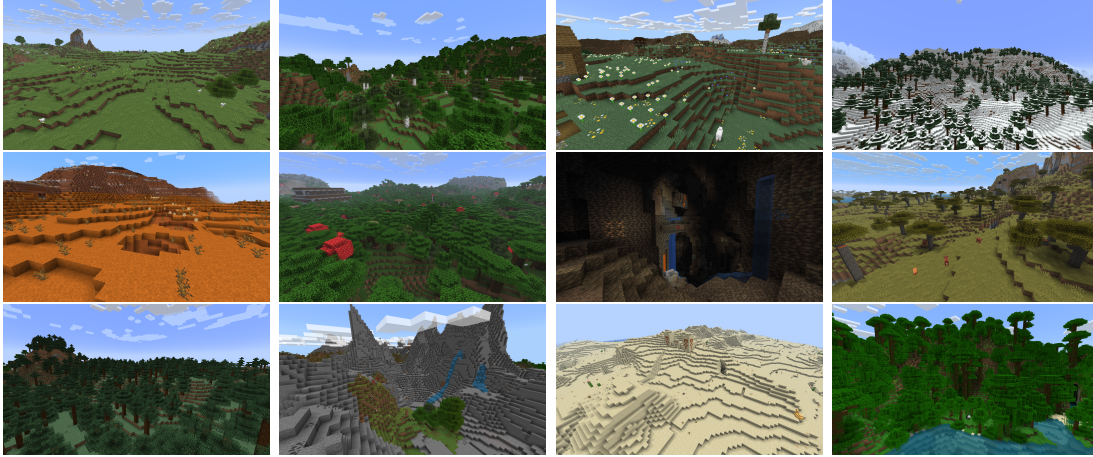


Figure 2: The biome groups along with an example biome from that group; named from left to right: Plains, Forest, Meadow, Snowy, Badlands, Dark, Caves, Savanna, Taiga, Mountains, Desert and Jungle

reach a certain threshold. In short, the environmental variables have influence over the control variables, and the control variables influence the music.

These environmental variables include all sorts of things, such as light level, monsters nearby, temperature of the biome etc. The music control variables have control over six tracks: Calm, Intense, Warm, Cold, Friendly and Scary. The music used is named "The Wilderness", composed by Mat Clark and Kenneth Young, and originates from LittleBigPlanet, a game that used vertical layering in certain tracks to change the mood of the song, and was the entire inspiration for this entire project [4]. Since the original song was based on an arctic/bunker area, we had to do some interpretations of which tracks best suited each theme. The final selections are visualized in Table 1. For experimental reasons, the mod will have an altered approach, where only certain and random

Instruments	Theme
Bass (Bass Guitar and Double Bass)	Calm
Drums (Drum Kit, Electric Guitar, Percussions and Bells)	Intense
Accompaniment A (Celeste and Harp)	Friendly
Accompaniment B (Nuendo 3 Synth)	Warm
Orchestra (E.W. Symphonic Orchestra and Trumpets)	Cold
Melody (Santur and Oud)	Scary

Table 1: The instruments provided in the song and the theme we assigned them to.

biomes have this adaptive music turned on, while the rest will play the normal Minecraft music. This makes it so that we have states to compare. We divide every biome in the world into a group, with similar biomes falling under the same group. For example, all biomes with snow fall under the same category. To visualize what groups there were, we show examples in Figure 2.

The mod chooses six of these groups of biomes randomly at the start of the game to enable adaptive music, and will only be reset once the game has shut off entirely. Eventually, participants

will be asked to fill in a questionnaire, like in [8], where they have to give biomes where they felt the most scared/calm/focused. With our approach, the goal is to find a correlation where the biomes with adaptive music are the ones most mentioned by the player. If the music had less or no effect, the biomes with no adaptive music would be mentioned as well. We can easily compare this, since the biomes chosen for adaptive music will be logged after playing.

3.2 Methods

Before the experiment starts, we give our participants a rundown of what their goal is in the game, and the rules surrounding it. We will give them a questionnaire that asks how much Minecraft they have played and what their feelings are regarding Minecraft’s original soundtrack, but avoid spoiling that the game uses adaptive music to avoid the bias. After the first part of the questionnaire is answered, they are asked to pause the questionnaire until they have completed the experiment. The participants will all play on the same world, with the same goal and same path. This is to avoid the world generation having any effect on the results, since it is less important than the music in this particular experiment. We also wanted to avoid certain participants having very divergent experiences than another, due to that also affecting the results. If a certain biome is more recognized by one participant, while the another has never been, it makes comparison a lot more difficult.

The goal we gave our participant was to find certain colors of wool, which we manually scattered among chests in the world. This goal makes it so that the participant has a reason to go to many different biomes, thus exploring the world and activating many adaptive music environments. The participant starts out with in-game items, such as compasses pointing to certain points in the world, a book containing some rules mentioned before the experiment, along with a button to teleport to the start in case they get stuck, and a stone sword to get food and fight the monsters. The game uses a day/night cycle, where at night monsters spawn due to the darkness. Since we are required to study how scary biomes are perceived at night, we want to avoid the participants from passing the night by either passing the night save in a house, or skipping the night by sleeping in a bed. This day and night cycle is also the reason why the experiment will take 45 minutes, because we want to emphasize the effect the music has at night in multiple biomes.

Due to restrictions related to the mod’s intrinsic bugs and to further focus the experiment exclusively on the musical variable, we want to avoid players to experience ‘death’ in-game, while still preserving the emotional effects related to the risk. In order to do so, we tried to give the players some effects ingame that gave them more health generation and resistance. This has an added effect of making the game easier for everyone to play, regardless of their level of Minecraft knowledge or skill. If the player were to die ingame however, the solution to fix the bug was to exit and re-enter the world. If the player were to die right at the end of the game, we cut the game off as well, since they have at least completed the goal in visiting every biome that we wanted to research.

Finally, a very important detail is that we need all players to experience the same things. Since Minecraft is an open world game, this proves difficult. A solution to this problem without having

to make the world linear was to give them a specific path to follow, using ingame compasses. In this way, we were able to partially control their movement without completely restricting them, letting them visit every biome in a similar way. The path they need to take is also given in the book, in the case they forget or need a reminder. Along the path, we also added a few additional wool blocks, which are not linked to any compass to add a bit of extra path control, and give the player more reasons to explore a certain biome. The wool blocks attached to these biomes are optional, since these were biomes they had to travel through regardless.

4 Results

4.1 Experiment

Overall, 20 different participants have successfully completed the experiment. During the experimentation itself, we were not actively observing their gameplay, as to not disrupt their immersion. While we did not want to disrupt the players immersion while playing, they were allowed to ask questions before and throughout the gameplay that did not involve the experiments main conditions. There were participants who have not played the game in quite a while, and lost familiarity with the controls and were completely unfamiliar with some game mechanics that were introduced in later years. In terms of controls, we gave the participants a quick rundown of all the important controls, added with a little experiment world in which they could run around it and get used to it. This seemed to work, since even when these participants struggled slightly with the controls at the start of the experiment, they eventually became used to it, meaning no further control related questions were asked throughout the rest of the experiment. The unfamiliar game mechanics were a lot more difficult to solve. Specifically, a mechanic called "powdered snow", a block that spawns on snowy mountains, looks identical to normal snow, and which makes the player sink through it and effectively become stuck and disoriented. The world generated with this mechanic, and did not come with an option to prevent this. When working on the world, we attempted to remove as much powdered snow as we could, but unfortunately were unable to remove all of it. Thus, a lot of participants came in contact with it and panicked. To avoid this, we assisted them in case they really did not know what to do, as to continue the experiment.

The idea was to get some scores of how many times a biome was mentioned and whether they did and did not have adaptive music, but this proved difficult due to how the participants identified certain biomes. Each response was formatted very differently, were too specific, and used different spellings which made it a lot more difficult to immediately add formulas to the sheet. To solve this, we decided to use Claude [2] to help us with getting the important information out, adding 4 columns for each questions that contained the number of biomes mentioned, which biome the participant specifically mentioned, how many of those did have adaptive music and how many of those did not. It also helped us categorize certain biomes into certain groups (which is also how the mod works). For example, biomes with snow will all be under the category Snowy. Naturally, we double checked to see if it got everything correct, and fixed things they missed. Whenever a participant mentioned a location (village, mansion, ...) rather than a biome, we interpreted the response as a mention of the biome group that location resides in. Then, below these columns, we added some tables that go over each biome and see how many times they were mentioned,

and how many did and did not have adaptive music. This will give us more insight in the overall effectiveness of the adaptive music in specific biomes.

4.2 Notes on collected data

4.2.1 During experiment

There were a couple of issues during the experiment. One issue came from the fact that some participants lost track of the path. Specifically, when going from the Village to the Badlands, some participants found a wool block in the mountains and thought that this meant they had to follow the next compass, skipping the Badlands entirely. Fortunately, them skipping the wool block happened only once, as for the next participants we stepped in to prevent them from straying off the path as well. The participant skipping the Badlands was tasked to backtrack to the Badlands, to at least have experienced the biome.

Some participants died near the end of the run. While this is a deviation from the standard run, we argued that it did not affect the data since they still did traverse every biome. Thus, instead of having to backtrack to their location, we decided their experimentation was complete. Two participants however died too early and were asked to exit and enter the world to resolve the lack of music issue.

4.2.2 In results

After the experiments, the results also showed a couple of issues. There has been an oversight in the mod that prevented one biome (River) from ever getting adaptive music. Thus, every participant had normal Minecraft music playing there. Despite this, we still decide to keep this in, as it is still valuable information.

Secondly, it seems that some participants filled in that they heard adaptive music in biomes where they technically should not have. This response could be caused by two different circumstances. The first of these is caused by an overlap of biomes, where the game acts as if the player is in a specific biome, while they are not. An example of this is in the caves, where the mod often acts as if they are in a savanna biome. This is unfortunately something that is just part of the game, and completely outside of my control. The second explanation of this phenomenon is when participants simply misremember which biome they were in when they heard it. One example of this is participants mentioning hearing adaptive music in the mountains, while they were technically in a snowy mountain, which exists in a separate biome group.

While these issues do not drastically alter the results, it is important to keep in mind when going over them.

4.3 Pre-experiment questions

We asked the participant whether how much experience they have with the game, and their feelings surrounding the music. Both these questions along with the amount of answers are shown respectively in Table 2 and Table 3. The results show that there is a major skew towards people that do know about Minecraft, where only one participant answered they have not played it a lot and none that they have never played it before. Note that the responses do not differentiate

between people who know about it from the past or still play to this day. This is by design, since the amount of experience with the game is more important and valuable to us than the recency in which they played the game. In Table 3, it is worth to mention that the majority (55%) of the participants is fond of Minecraft’s music. This, also, is valuable data to us, since it can establish whether or not there is a slight bias in favor of the original soundtrack.

Response	Amount
I have played Minecraft a lot, and know a lot about the game	19
I have not played Minecraft that often	1
I have never played Minecraft	0

Table 2: Responses of the question ”Please select the option that applies to you the best”

Response	Amount
I know about Minecrafts music and am very fond of it	11
I know about Minecrafts music but do not have any special feelings surrounding it	8
I know about Minecraft’s music but do not like it	0
I do not know Minecraft’s music	1

Table 3: Responses of the question ”Please select the option that applies to you the best”

4.4 Mentioned biomes and music overall

To start, in Figure 3, we visualize how many times each biome has had adaptive music, along with how many times adaptive music was mentioned over all the topics. Do note that participants were able to respond to multiple questions with the same biome.

In Figure 4, we visualize an overview of how many biomes were mentioned for each topic, and how many of them did or did not include adaptive music. In Figure 5, we visualize the amount of times the music has been mentioned for each topic. In the latter figure, do note topic Fittest and Disruptive have questions that explicitly asks the participant about the music, and thus every response is counted as mentions of music.

From Figure 5, we can conclude that the music has been most frequently associated with Enjoyment and Calmness, and is less relevant for Focus, Scariness and Exploration. In terms of game cohesion, adaptive music has been mentioned to fit a biome or situation more often than the standard Minecraft music, though the gap is not substantially big. In terms of how disruptive the music felt, both soundtracks seem to be mentioned equally. In further subsections, we go into detail which biomes were mentioned specifically, and what responses were given.

4.4.1 Biomes mentioned enjoyment

To discuss which biomes had an impact on Enjoyment, we visualized the results in Figure 6. This plot shows how many times a biome that was mentioned for this topic was adaptive or not, and

Total adaptive biomes and total music mentions when adaptive

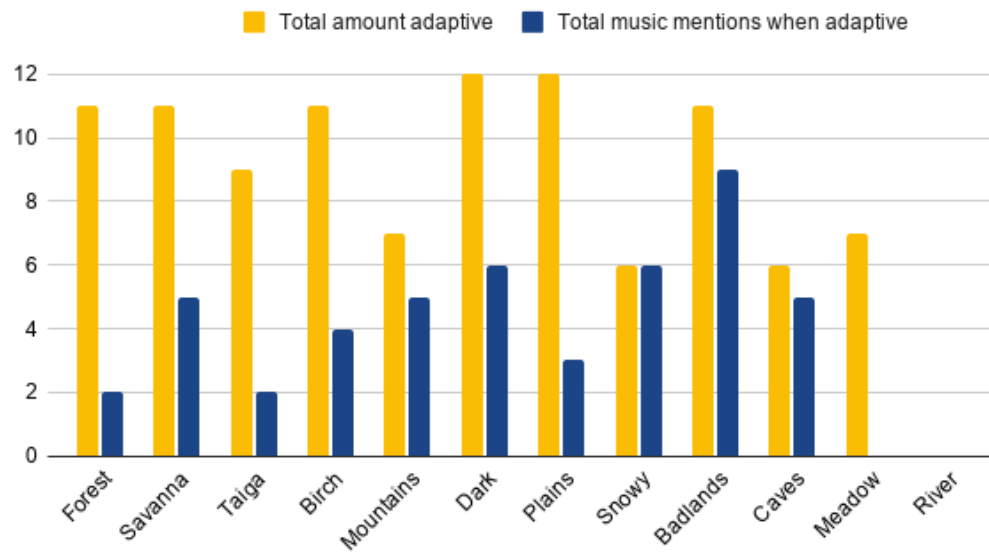


Figure 3: Total amount of times each biome has had adaptive music

Biomes with and without adaptive music and total per category

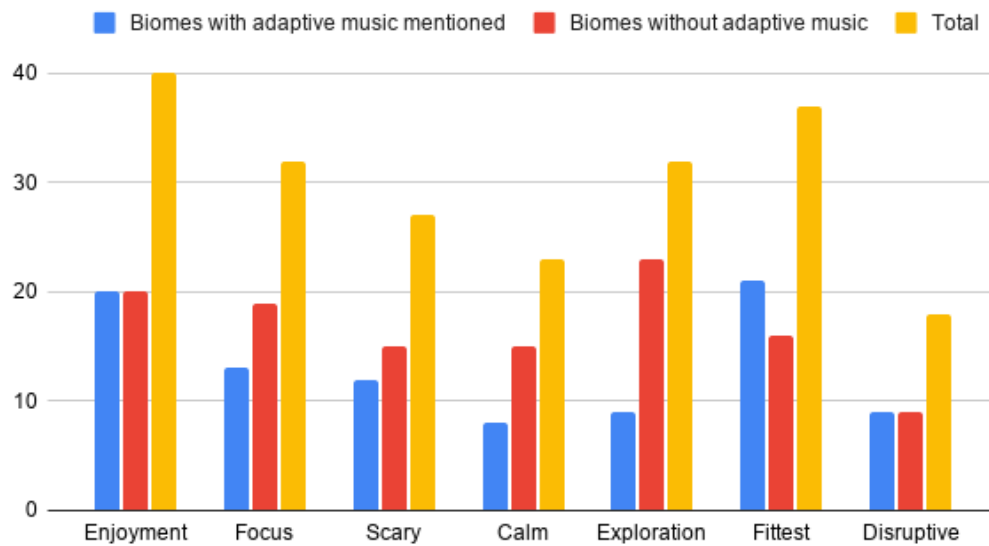


Figure 4: How many biomes were mentioned per category, and how many did and did not have adaptive music.

Amount of music mentions per category

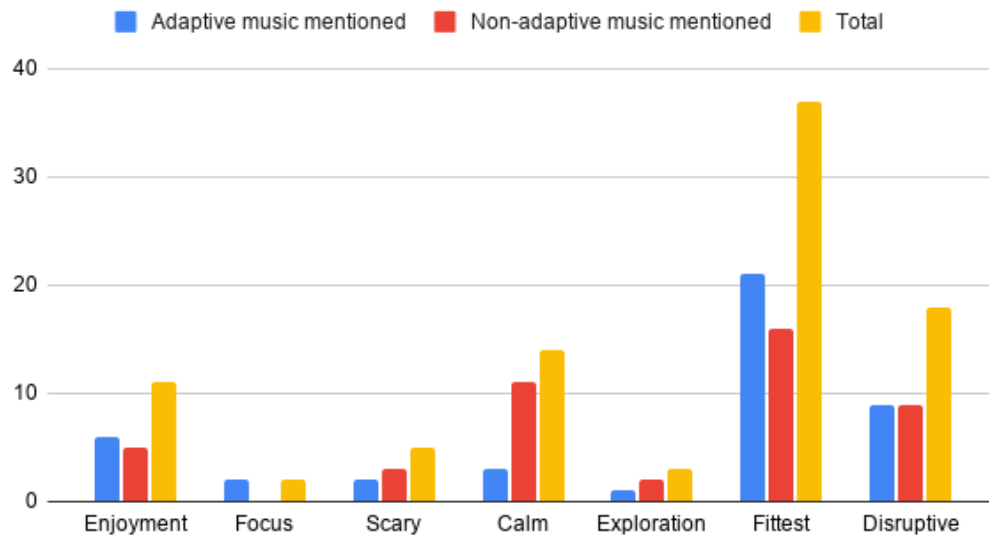


Figure 5: A plot visualizing the amount of times music has been mentioned per topic.

Mentions of music per biome for topic "Enjoyment"

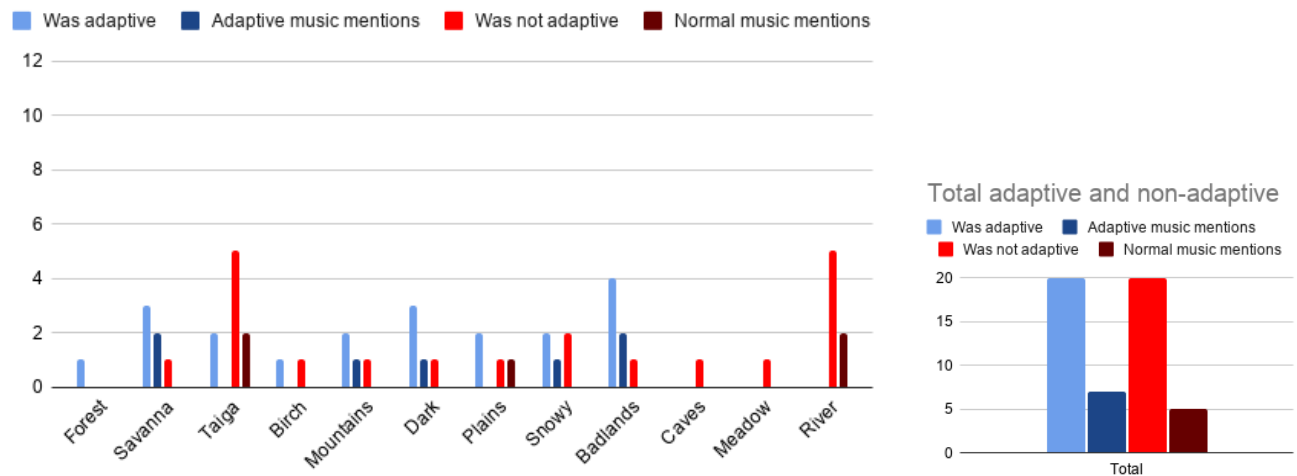


Figure 6: Biomes and corresponding music mentioned for topic Enjoyment

Mentions of music per biome for topic "Focus"

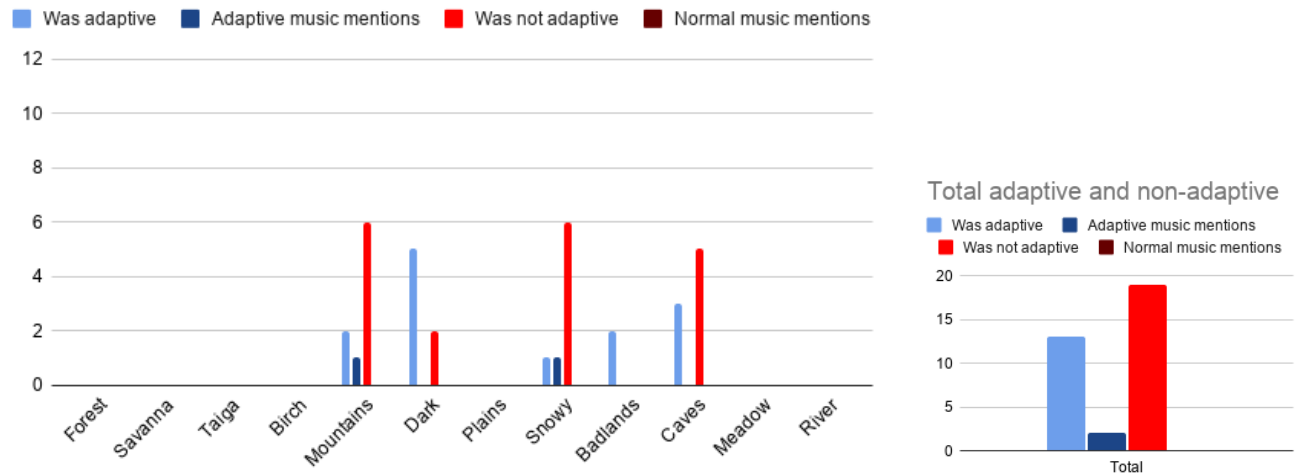


Figure 7: Biomes and corresponding music mentioned for topic Focus

how many responses for that biome mentioned the adaptive/normal music. Through this, we can establish whether the music itself had an impact on their response or if different reasons were given. For example, while the Taiga was mentioned a total of 7 times, the music was only mentioned twice. Note that this plot only keeps track when music was explicitly mentioned. Thus, responses that mentioned immersion or their feeling playing it did not get included in this table, as it is too vague of a response to know for certain whether a participant referred to the music when writing it. Other responses that did not mention the music included the environmental aesthetics, challenge, excitement, ease of traversal, or the ease of gathering resources that a biome had.

Overall, adaptive music was mentioned a total of 7 times, while the standard Minecraft music was mentioned a total of 5 times. The biomes where the adaptive music had an influence over the enjoyment were the **Savanna**, **Mountains**, **Dark Forest**, **Snowy** and **Badlands**. In contrast, biomes where the standard Minecraft music made an impact on the enjoyment includes **Taiga**, **Plains** and the **River**. For both adaptive and standard music, no in depth explanation was given other than their enjoyment of the music.

4.4.2 Biomes mentioned focus

On the topic of Focus, looking at Figure 7, it seems as if music had little to no impact on the participants focus, being only mentioned twice. In most responses, their focus seemed to be mostly affected by the amount of enemies, the difficulty in climbing mountains, and the struggle with powdered snow. Still, the music did get mentioned in the **Mountains** and **Snowy** biomes. The first response in the snowy biome mentioned that the music made them feel heroic, like they were a knight going on a quest. The second response noted that the biome felt very strange to them because of the music, keeping them slightly on edge.

Mentions of music per biome for topic "Scariness"

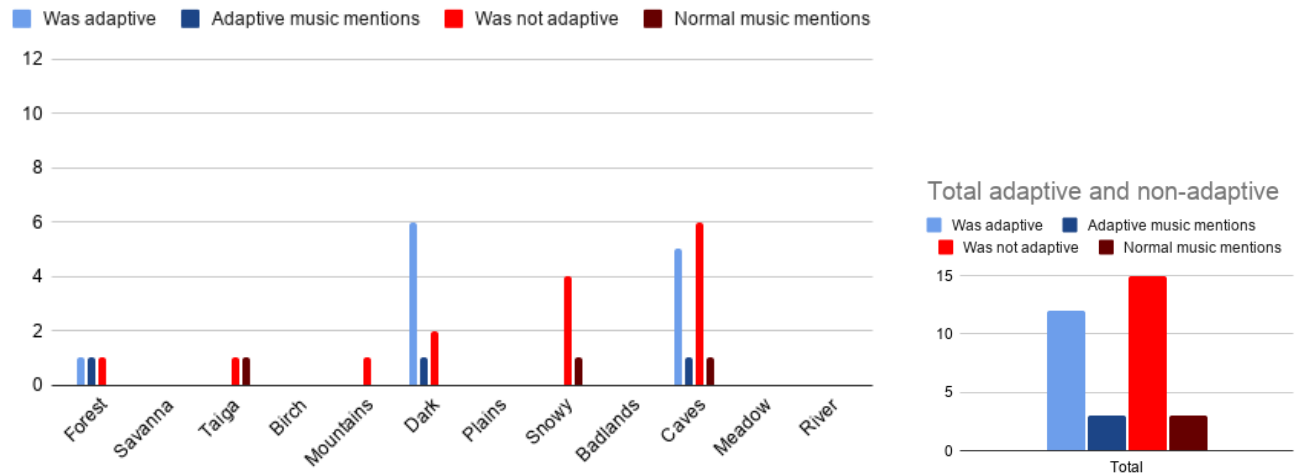


Figure 8: Biomes and corresponding music mentioned for topic Scariness

4.4.3 Biomes mentioned scariness

In Figure 8, an overview of which biomes the participants felt scary were mentioned, and whether or not music played a role in this is visualized. Surprisingly, it did not seem as if music had that much effect on the scariness of the game. In fact, the participant who mentioned the **Taiga** and **Snowy** biome, mentioned that he did not hear any music at all, and felt as if that made the game scarier. The lack of hearing music is not incidental, as standard Minecraft music is very sparsely played and sometimes just does not play any music at all. The only other non-adaptive music mention was in the **Caves** biome, though they did not elaborate further. Overall, it seems that the biomes with adaptive music that had any effect was the **Forest**, **Dark Forest** and **Caves** biome, where they proclaimed the music made the experience scarier. Other non-music related responses mostly included the darkness of a biome, amount of mobs and once again the powdered snow in the **Snowy** biome.

4.4.4 Biomes mentioned calmness

In contrast to the previous section, Figure 9 refers to the biomes participants felt most calm in. Interestingly, it seems that the original Minecraft music is mentioned relatively more frequently than the adaptive music. Overall, the only biome that made the participants feel calmer compared to the biomes with standard Minecraft music was the **Birch Forest** biome, where they mentioned the music felt calm and happy. Other responses mentioned their Calmness came from the biomes feeling spacious, familiar and aesthetically pleasing.

4.4.5 Biomes mentioned exploration

Regarding the encouragement of participants to explore, Figure 10 indicates that music also had little to no effect on this. The only two biomes where the participants specifically referred to the adaptive music was in the **Snowy** and **Caves** biome. Interestingly, the phenomenon where a

Mentions of music per biome for topic "Calmness"

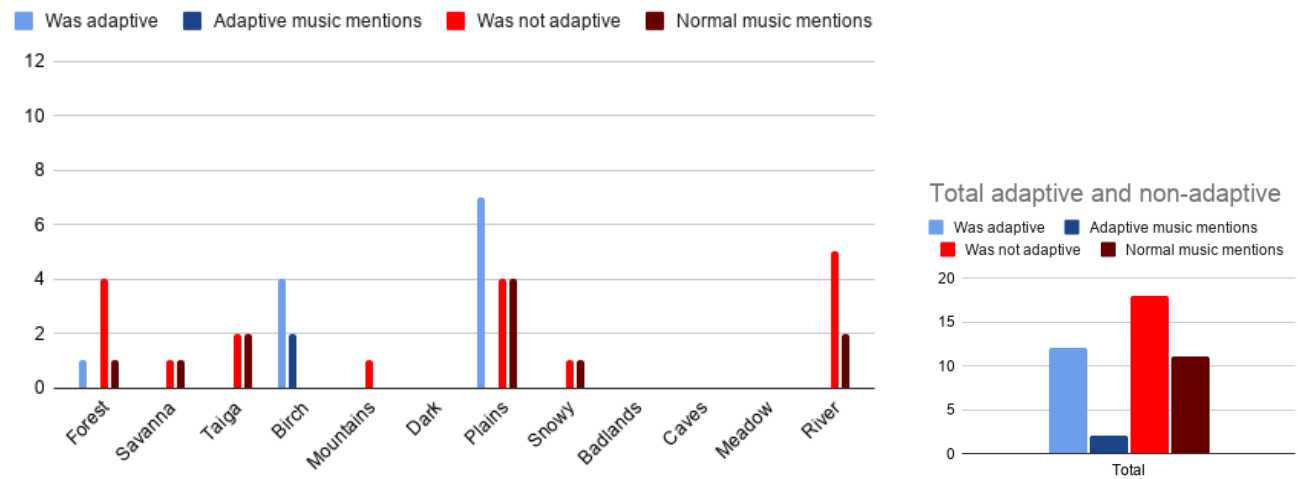


Figure 9: Biomes and corresponding music mentioned for topic Calmness

Mentions of music per biome for topic "Exploration"

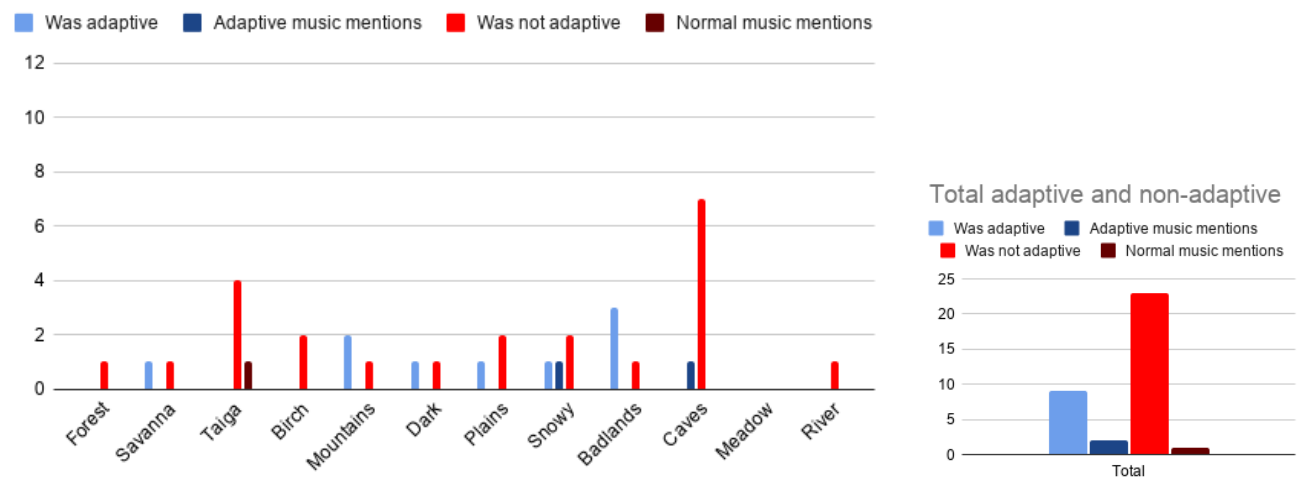


Figure 10: Biomes and corresponding music mentioned for topic Exploration

Mentions of music per biome for topic "Fit"

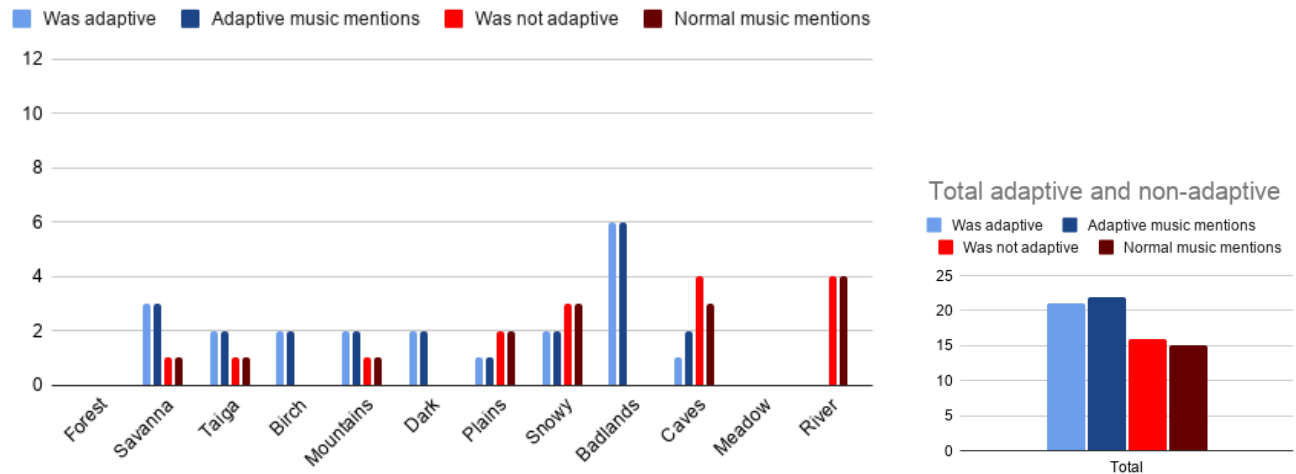


Figure 11: Biomes and corresponding music mentioned for topic Fit

participant refers to adaptive music despite the biome they were in not having any has occurred, as visualized by the Caves bar having an adaptive music mention despite the biome not being mentioned when it was explicitly adaptive. As we mentioned before, the Cave biome overlapped with another biome, playing the adaptive music despite the biome itself not being included in the adaptive music pool. With how this system is designed, the music that was played for this participant was the same music that would have been played if the biome had adaptive music. Thus, this response was interpreted as a participant that mentioned adaptive music. Other responses mentioned that their willingness to explore came from the sense of mystery, comfort, and the structures the biomes provided.

4.4.6 Biomes mentioned fittest

Figure 11 provides an overview of which biomes the participant felt the music fit the most to the game. As stated before, every response in this topic mentioned music, since the question specifically refers to the music. Overall, the biomes with adaptive music were mentioned more often than the biomes using Minecraft's original soundtrack, with the strongest contenders being **Savanna**, **Birch Forest**, **Dark Forest** and especially the **Badlands**. The Badlands specifically stands out as the only biome where all six mentions were referring to the adaptive music. In terms of original Minecraft music, the participants preferred the **Snowy**, **Plains**, **Caves** and **River** biomes music (though keep in mind that the river biome did not have a adaptive music variant, thus could not be compared). The phenomena where the Caves was mentioned to have adaptive music despite it explicitly not having it has resurfaced on this topic as well, and is similarly visualized as in Section 4.4.5.

Mentions of music per biome for topic "Disruption"

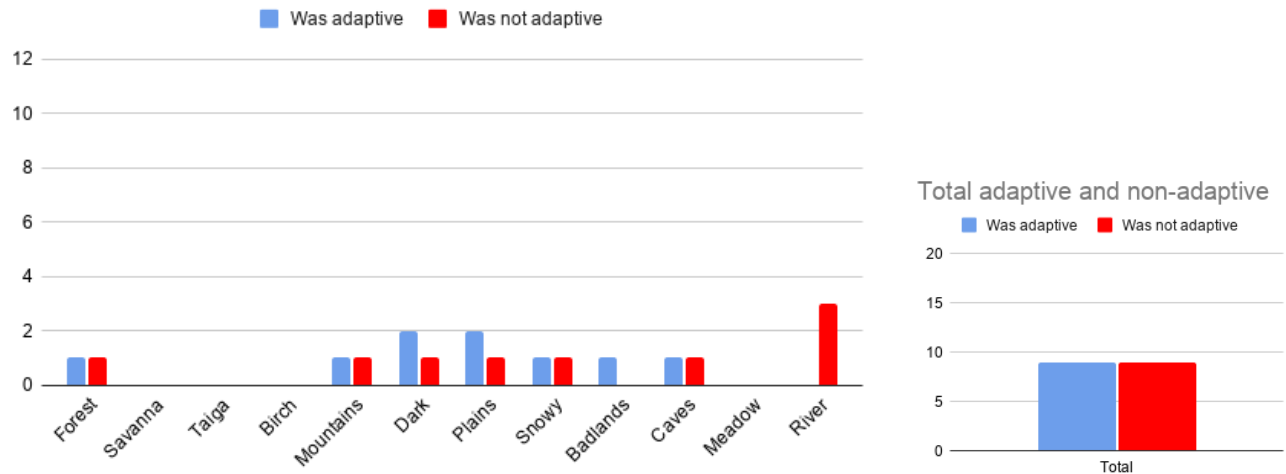


Figure 12: Biomes and corresponding music mentioned for topic Disruption

4.4.7 Biomes mentioned disruptive

Finally, we visualize the biomes in which participants found the music most disruptive in Figure 12. Similarly to Fittest, Disruption included questions that ask the participants to refer to the music. Thus, every response referred to the music, and does not need to be mentioned. In contrast to the previous section, there is no substantial difference to be found between the biomes with adaptive or regular music. For the adaptive music, participants referred to the **Plains** and **Dark Forest** the most, stating the music was too present and intense. Other participants that chose different biomes mentioned how the music when in combat felt too intense, making them anxious. As for the original music, participants mentioned the **River** instead, though their reasoning was about the music starting abruptly.

5 Discussion

5.1 Overall

To compare how much the music influenced the responses, we will compare the amount of biomes mentioned with the amount of times music is mentioned. The reason we choose to compare it with the biomes mentioned instead of the total number participants is because they were allowed to respond with multiple biomes, and thus give multiple explanations. Comparing both Figure 4 and 5 with each other, we find that in terms of responses, a relatively low quantity actually refers to the music. This finding suggests that other environmental or gameplay characteristics had more impact on the player experience than the music.

Furthermore, a paired t-test comparing adaptive and normal music mentions over all topics yielded a p-value of ~ 0.33 . Since our sample size is small and the meaningfulness of the tests are debatable, the p-values should be considered more exploratory rather than factual and be

interpreted with caution. Still, since we will do a paired t-test for each topic, the p-value threshold would need to be corrected by the amount of tests we will do to avoid false positives. Using Bonferroni Correction, we get $\alpha \simeq 0.0063$. Since our obtained p-value is > 0.0063 , it indicates that no real evidence of statistically significant difference was found between adaptive and normal music mentions.

5.2 Enjoyment

In total, of the 40 mentions of biomes, music was mentioned 12 times. It makes up of 30% of the total biomes mentioned on the topic Enjoyment. This suggests that participants associated in-game music with their enjoyment of a biome frequently. Whether adaptive music had any influence is unclear. Both adaptive and non-adaptive biomes were mentioned an equal amount of times (20/20), and the gap between the mentions of music is not substantial.

Using a paired t-test comparing adaptive and normal music mentions for Enjoyment, we obtained a p-value of exactly 1.00. This indicates that there is no real evidence of a statistically significant difference was found between the two. The p-value can be explained due to the observation that participants referred to both the adaptive and normal music at near identical rates.

5.3 Focus

As stated in the results section, it seems that gameplay aspects they struggled with had more impact on the participants focus than the music. Overall, from the total 32 biomes mentioned on the topic Focus, only two responses (6.25%) mentioned the music, with both taking place in a biome with adaptive music. The two music-related responses suggested that the music added to the experience: where it made one feel heroic and the other feel on edge. An explanation why music seemed to be less mentioned could be due to focus being a feeling of intense immersion, where people might not notice the music when playing.

A paired t-test comparing adaptive and normal music mentions for Focus, which yielded a p-value of ~ 0.2 , also indicates that no statistical difference between the two was found.

5.4 Scariness

From the 27 biomes mentioned, the music was mentioned 6 times (22.2%). Similar to Focus, it is likely that gameplay aspects may have had a bigger impact on the participants feeling of scariness. The responses referred frequently to the amount of monsters, the darkness and powdered snow as primary reasons they felt scared in a certain biome. This suggests that the scariness was influenced mostly by environmental design and gameplay, rather than the music. While the adaptive music may have contributed to the scariness of a certain biome, it was not a primary factor from the participants perspective.

A paired t-test comparing adaptive and normal music mentions for Scariness yielded a p-value of 1, which indicates that there is no evidence was found for a statistical difference between adaptive

music and non-adaptive music mentions for scariness. The p-value here is, similar to the p-value for Enjoyment, caused by the identical rates of adaptive and normal music mentions.

5.5 Calmness

Aside from Fittest and Disruption, both topics that asked specifically about the music, Calmness is the highest amount of responses related to the music. From the 30 biomes mentioned, the music was mentioned 13 times (43.3%). The results showed that the adaptive music is only mentioned twice, which could be due to the specific music rather than the adaptivity functionality itself. A likely explanation could be that the track that was assigned to Calm did not evoke any calmness compared to Minecraft’s original soundtrack. Minecraft’s soundtrack is softer and a lot more on the background, thus is perceived as a lot more calming. Minecraft also has the benefit of having a well recognized soundtrack, where the majority of participants felt fondly about it. The familiarity added with the calm nature of Minecraft’s soundtrack might be a primary factor as to why it performed a lot better than the adaptive music. This theory is strengthened due to the fact that of the 18 non-adaptive biomes mentioned, 11 (61.1%) of the responses referred specifically to the music.

A paired t-test comparing adaptive and normal music mentions for Calmness yielded a p-value of ~ 0.03 . Despite this being the lowest p-value so far, it does not reach the p-value threshold due to the Bonferroni Correction we applied earlier. Thus, this indicates that no statistical difference between adaptive and normal music mentions was found.

5.6 Exploration

Just as with Scariness and Focus, the music seemed to barely have any effect on the participants encouragement to explore, and similar with these topics, seemed based solely off of environmental design. From the 32 biomes mentioned, the music was mentioned 3 times (9.4%). As was mentioned in the results, participants felt more encouraged to explore when the biome felt mysterious, was comfortable or relaxing enough, and had structures that were worth investigating. The three times music was mentioned, participants described that the music did have a positive effect to their sense to explore.

A paired t-test comparing adaptive and normal music mentions for Exploration yielded a p-value of ~ 0.6 , which indicates that no statistical difference between the two was found.

5.7 Fitting

The difficulty with measuring the fittingness of the music is, aside from being subjective, based on the musical elements present. As mentioned previously, the song was chosen from a different game, and thus not made with Minecraft’s environment and situations in mind. Still, while these findings can not be separated as to whether the participants perceived fit was caused by the adaptive music system itself or the specific music, it does suggest that the adaptive music was successful in creating a stronger sense of correspondence between the game environment and the music. This supports previous research [7] that found adaptive music can strengthen the relationship between game-world concepts and the soundtrack.

A paired t-test comparing adaptive and normal music mentions for Fit yielded a p-value of ~ 0.1 , which indicates that no statistical difference between the two was found.

5.8 Disruption

Similar to the previous section, the results seem to be linked to the specific soundtrack rather than the adaptability of the music. The main response given about the adaptive music was that it was too present, but with how the song is structured, it is always going to be present. For the original music, participants mentioned the River the most frequent, where their reasoning was about the music starting abruptly. This however is more of a limitation with the music system rather than the music itself. As mentioned before, Minecraft’s music system is not made with song switching in mind, and thus every transition from normal to adaptive would mean the music abruptly cuts off. Since the River biome is relatively small, is usually passed through twice and always uses normal music, many participants would have encountered the cutoff there the most, which is a reasonable explanation as to why it is mentioned the most often. As mentioned before, since the River does not have an adaptive variant, it is difficult to make assumptions if it were implemented properly.

A final paired t-test comparing adaptive and normal music mentions for Disruption yielded a p-value of ~ 0.5 , which indicates that no statistical difference between the two was found.

6 Conclusions and Further Research

6.1 Further Research

This experiment had a couple of limitations. Since the adaptive music system uses different musical material than the original Minecraft soundtrack, the effects of the adaptivity from the effects of the specific music is hard to separate.

Another limitation was the time it took for experimentation. Since not everybody has knowledge of how to mod their own game, and we needed to make sure everything went smoothly, we had to be present for every experiment done. This limited the amount of participants we were able to achieve, since we had to make sure it aligned with both their and our schedule. This tight schedule also forced some participants to rush through the game, which may have altered their experience. The next limitation came in the adaptivity of the music itself. Since this system was based solely on a soundtrack with six channels, only three decision variables could be used, since each variable controlled two tracks. Furthermore, the music chosen was from a different game entirely, and not made with Minecraft’s environment and scenario’s in mind. Thus, one could argue that certain channels did not fit entirely to the scenarios they had to portray.

The final limitation was that this experiment was based solely on subjectivity.

To address all these limitations, future research could improve by: comparing the exact same musical material adaptively and non-adaptively to isolate the effects of adaptivity itself, a bigger time window for the experimentation period as well as the experiment itself, choosing a song or preferably create one with more than six tracks that fits better to the game it is in and the

environment and scenario's assigned to the tracks, and study the physical observations that adaptive music might introduce (e.g. by measuring immersion via eye-tracking, as was done by the paper [8]).

6.2 Conclusion

Overall, the results show that adaptive music has only a limited impact on the most reported aspects of player experience. The statistical analyses done for every topic showed no significant difference between adaptive and normal music, though should be taken with a grain of salt due to the low sample size. For every aspect of the player experience, aside from the questions asking about the music, participants overall attributed their experience more frequently to the gameplay and environmental characteristics rather than the soundtrack. Despite this, the strongest indication of an impact that adaptive music provided was found in music-environment fit. These results suggest that adaptive music functions primarily as a supporting element that enhances the coherence of the game world, instead of impacting emotions such as enjoyment, focus, fear, calmness or curiosity.

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