Music and imperfect information influence player behavior

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Abstract—The video game industry grows bigger and bigger with each year and this growth does not seem to slow down anytime soon. With that, it's important for society and video game developers to know how this media affects the players playing the game as it's already a very big industry, with large numbers of players playing video games every day. Game designers have, and are using information horizons to influence the players in different ways, an example of this is making the player play more cautiously. There have also been previous studies that have shown that music has an impact on a player's behavior and performance while playing a video game, making players more stressed and aggressive being a conclusion for some studies. With this in mind, this study delves deeper into how music in conjunction with information horizons affects a player, playing a video game. This was done by using a controlled experiment in conjunction with a first-person shooter game, the goal of the game being clearing out a linear level of turrets using an automatic rifle. One group of test subjects played a version of the game consisting of high-tension music and information horizon in play, with another group of test subjects playing the same game without these effects in play. Data was collected in the background from each test subject's playthrough and this data was then analyzed and compared between both groups. From the data gathered it seems that music made the players play faster and more aggressively, with the information horizons effect being diminished by the music's overpowering effect. This is in line with numerous previous studies that have gotten similar end results from the effects of music in video games, with an existing research gap with regards to information horizon making the effects of the information horizon unclear. The end results showed that group 1, playing the version of the game with high tension music and information horizon in play, had fired their weapons more, been less accurate with their shots, destroyed turrets slower, had more deaths, and played faster. These results indicate increased stress levels and aggressiveness with group 1's test subjects.

1. Introduction

In today's society, video games are tremendously popular; the global market value was anticipated to be 115 billion dollars in 2018 and is likely to approach 138 billion by 2021 [14].

The term "interactivity" is usually associated with video games. Indeed, one of the fundamental characteristics that distinguish video games from other cultural objects or media is their participatory nature. According to some, players in video games "do not simply consume a pre-existing piece of media, but rather are active participants in the building of their experience" [1]. This is frequently given as irrefutable proof that video games are the

purest form of a new paradigm of cultural consumption [8]; one that requires the player's explicit participation. This is sometimes contrasted with a more vertical form, which is typically linked with "older" media such as television, film, or literature, indicating a transition.

However, the players' experience with sound and the reactions it may provoke is unaffected. Classical or modern musical works are typically associated with sound. Sound, on the other hand, is much more than "music," but a well-crafted element that enriches visual and interactive experiences known as audiovisual metaphors. Sound design is an important feature of both movies and digital games, in which sound designers fine-tune the intended emotional experience by applying professional knowledge to the specific information on-screen. This method is more difficult in digital games since sound must fit player engagement and a digital environment that switches between numerous graphic styles during the game [11].

Information horizon is a concept used by game developers. It is the effects of what kind of information or lack of information a player has at any given time, and how that affects the player. There are different spectrums when it comes to information horizons[12]. One example could be taken from the game Amnesia: The Dark Descent, which is a horror game. In this game, the game developers brought forward the information horizon that if the player stays in the dark for too long or looks directly at a monster, the player's sanity gets decreased. This results in consequences in the form that the player could die or get more easily detected by the monsters. This made players avoid staying in the dark and avoid looking directly at the monsters while playing the game. This information horizon was reinforced by adding sound effects and a blurring effect on the player's field of view when the players' sanity got decreased. The information horizon that they used in this game was all fake information, made to influence the players without having to worry about balancing the mechanic. [15]

The main research question (RQ1): Does music in conjunction with information horizon have an effect on players' performance?

This paper will answer this through a quantitative controlled experiment, where data will be collected from two versions, one using music and information horizons and the other being a control version without these.

There is a lack of studies on information horizons, meaning this paper will be an entry point into the subject that other papers will be able to build upon. Music's influence in games is a well-studied subject, this paper can be used to reinforce other relevant studies' results and/or contradict said studies.

2. Related Research

2.1 Music

In the video game industry music is often an underappreciated part of game development and also within the studies of video game design, there are not many studies dedicated to the “audio” part of video games [16] and how it affects players' mindset and behavior in moment-to-moment gameplay.

Music is known to have a physiological effect on people, which is no different in video games where increased stress is known to be one of the effects [5]. This study showed that after playing the video game, increased cortisol levels were discovered through saliva samples taken before and after the playing session, where a significant difference was noted.

There is also evidence of increased aggressive behavior in players when listening to more “exciting” music [16]. Using biometrics to note

changes in physiological states noted a marked increase in physical excitement when playing video games while more violent ones elicited a greater response than non-violent ones even without background music but when it was added an ever greater response was shown showing a direct impact from background music on the players. This shows that there is precedent in music affecting players through music.

In a study conducted to investigate the implications that music has on a player's risk behavior, it was found that music decreased the risk behavior of the players [13]. A game was created that incorporates risk behavior by allowing players to choose between a safe but less profitable path and a risky but potentially more rewarding path. [13] investigated the effect of music presence, tempo, and emotive inflection on players' in-game risk behavior and overall player experience in a mixed-design user study (N=60). It was discovered that the presence of music affected risk behavior during only the first playthrough of the game as this effect seemed to vanish as the player had already established knowledge about the game during multiple playthroughs.

An experimental research study [9] was conducted to find out if variation in music tempo had any influence on a player's performance in a game. Participants of the experimental research study played Tetris multiple times to varying degrees of music tempo in the background, with each session being recorded and compared to the other. The findings throughout the data collection of each game session suggested that variations in music tempo did not significantly influence the players' performance.

2.2 Visual

The visual style is used to set the tones of video games, a game that is more gritty looking is usually more realistic and difficult than a game with a softer more cartoony look [4]. Even when no change in-game mechanics there is a marked difference in player performance based on the visually perceived challenges when changing how the game looks, meaning that there is a subconscious effect on players causing players to underestimate the difficulty in less realistic-looking video games. This means that even when presented with the same game a shift is noted in players through stimuli outside the mechanics of the game.

As the difficulty in video games is known to be a key factor in the overall enjoyment of a game, [2] conducted a study to understand how low-level visual features of a video game, such as color, luminance or contrast could influence how the player’s performed in a video game. Two experiments were conducted where the participants had to conduct a top-down attentional guided shootings task, where the goal was to accurately hit as many successive targets as possible whilst being influenced by numerous distractors. The distractors included in the experiments had low-level visual features(color, contrast, and luminance). Results of the experiments showed that manipulating the low-level features of a game could influence player performance. More specifically it was noted that the shooting tasks of players got impaired by the low-level visual features of the game.

2.3 Imperfect Information

The game theory of imperfect information is a big part of game design where games deal with the information that a player has to work with, in chess, for example, is a game with perfect information, the whole field and pawns are available to both of the players meaning that they both have the all the information available to them, all the moves possible and positions and the moves that have been made up to that point [7].

Where the game with imperfect information

differs can be shown in the example of a three-coin game [3], where one player has access to three coins that can be either head (H) or tails (T) and has to place them in a configuration that is two H and one T. The second player's objective is then to make sure that the three coins are H whilst the first one is to have three Ts. The guesser in this game cannot see the coins and the swapper can change the positions of the coins not chosen if a coin is turned and no player wins the swapper announces the number of Hs and Ts and the game continues [3]. The guesser's lack of sight on the coin leaves the player with imperfect information.

This game design theory is widely used in the industry but few studies have been conducted on the effect that developers can have on a player.

2.4 Music and information effect on players

Music is known to affect players when playing a game through several studies. Studies conducted have shown that playing video games in conjunction with background music increases adrenaline, aggression, and stress[5][16]. More specifically, higher-tempo music seems to influence the player to become even more aggressive compared to lower-tempo music for example classical music or no music playing at all.[5] Even when players are playing games that are not violent, increased aggression is still found after a playthrough, but is at the same time significantly lower compared to that when players play violent video games[16].

With this in mind, one could think that having higher tempo music playing in the background of a first-person shooter, would influence player behavior in that the player will play more carelessly, take more risks, and/or have a more general aggressive playstyle.

Contradictory to this there has been a study that has shown that having music playing in the background while playing a video game, made the player more careful as the player played more defensively and took fewer risks. But this effect only lasted for the first playthrough of the game as it seemed that when the players got used to the difficulty of the game that the music's initial influence on the players' behavior got removed.[13]

When players played a shooting game, it was noted that when the player perceived new information in the form of changing low-level interface changes (color, contrast, and luminance), the players performed worse. Fewer shots were accurate compared to those without the low-level interface changes in effect. These low-level interface changes did not interfere with the mechanics of the game [2]

Additionally, there has been evidence that changing the art style of a game influenced the player's behavior in that the players performed worse in specific art styles compared to other art styles, whilst the game was the same.[4]

These studies show an indication that changing the perceived information of a video game can have substantial effects on a player's behavior, whilst the information change does not change the game's mechanics, it still subconsciously affects the player's behavior.

3. Design

Information regarding the game and the software used to create the game is conferred in this section.

3.1 Overview

The game used in this study is an FPS game created in Unity for this study. The objective of the game is to clear out a level of turrets by destroying the turrets. While playing the game

the player has to use a rifle and shoot at the turrets to destroy them, the turrets fire projectiles at the player when spotted.

There are two versions of the game, version 1 and version 2, the versions are exactly the same except for two factors.

Factor 1. Information horizon: A tutorial section that brings forward that moving will negatively affect the accuracy and a chromatic aberration effect is being used when the player moves. The chromatic aberration effect used in the artifact could be described as a sort of blurring effect on the edges of the player's field of view. It is not part of the information horizon but is there to reinforce the information horizon, to make the information horizon more believable.

Factor 2. Music: Low-tempo tense music is being played in the background.

Version 1 of the game will have both of these factors in play while version 2 won't.

Figure 1. Overview of the level

3.2 Player

The player in the game can be controlled with the help of a mouse and keyboard. The player can walk, sprint, jump and reload their weapon by using the keyboard, while the mouse is used for aiming the weapon at turrets, firing the weapon, and aiming the weapon through its iron sights.

A fully automatic rifle is used by the player as a weapon to defeat enemies.

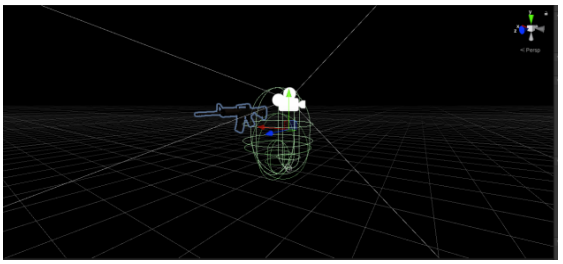


Figure 2. Image of the player

3.3 Enemies

There is one type of enemy in the game. The enemy is a stationary turret that scans the surroundings, if the player is in sight the turret fires projectiles at the player. The turret can withstand three shots from the player's rifle before it is destroyed.

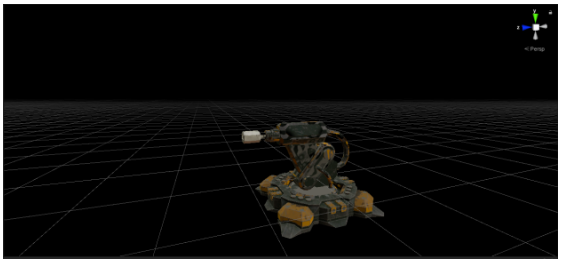


Figure 3. Image of the turret

3.4 Pickups

A medkit can be found in the level, if the player collides with the medkit the player gets their health back up to full. The medkit can be found around the middle of the level.

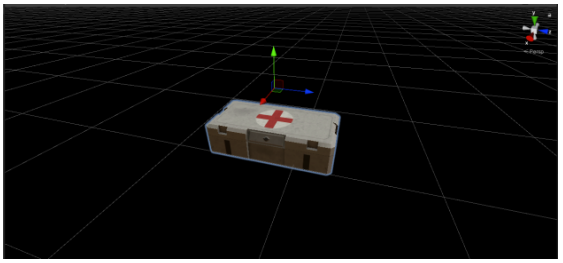


Figure 4. Image of the medkit

3.5 Heads-Up Display

The HUD consists of the player's current health, ammo count for the weapon, and a crosshair.

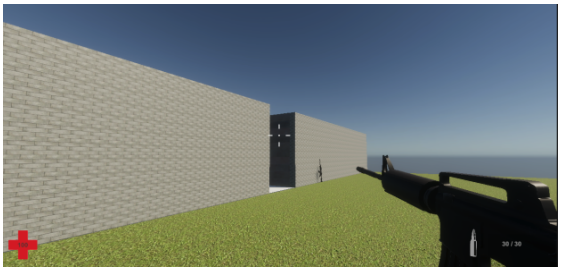


Figure 5. Image of the HUD

3.6 Win Condition

Winning the game is achieved by getting to the end point of the level. Throughout the level turrets are scattered at set positions, trying to stop the player from reaching the endpoint. The level design is linear and involves a lot of room clearing.

3.7 Lose Condition

Losing is achieved by the player getting defeated by the turret. The player is defeated when the player takes five shots from the turrets, resulting in the health of the player reaching zero. When the player is defeated the player gets the choice to either restart the level or quit the game.

3.8 How the game is played

The level in the game could be described as a linear maze where the player has to clear each room of enemy turrets. The main goal that the player has is to reach the end of the maze to win the game, whilst also avoiding getting defeated by the turrets. The movement of the game is more grounded and at a slower pace.

4. Method

To answer the research question (RQ1) in this study a controlled experiment will be conducted. The controlled experiment will follow the recommendations provided by [10]. There will be two groups of test subjects each playing one version of a level, each test subject in a specific group will only use one treatment on one object[10].

To answer RQ1, data is collected in the background while a test subject is playing a specific version of a level. The test subject's performance in a level will be measured by the time taken to beat the level, hits taken, shots fired, turrets destroyed, and quantity of losses/wins.

4.1 Data Collection

Unity was chosen as the game engine due to its ease of use and suitability to the genre.

The game needed to be of medium difficulty to make a difference in effectivity more notable and also stimulate players to keep them preoccupied [4], seeing as we need players to take the information given seriously and not just background whilst the game is being played.

The purpose of the collection of the objective data is to find out if any differences in both music and imperfect information can influence how the players “subconsciously” play an fps game. The increase or decrease in time completion, enemies killed and shots fired can be compared to previous research that has been conducted which shows that background music increases aggression[5].

4.2 Making different “versions”

To be able to answer RQ1 we will have to make different versions of the game, one that gives more of a “realistic” gritty feel to the game where the music will have low excitement levels as well as information given to the player explaining that the most effective way to play the game is taking time to ensure

safety, by clearing the level thoughtfully and not running into the different rooms guns blazing. This is to see how the players react to these stimuli and how fast they clear the level compared to when playing the other version.

The versions won't be different in any way when it comes to game mechanics, meaning that everything will be the same in the other version, which will have a higher excitement value with higher tempo music and the explanation that in this version a playstyle with more risk-taking is the effective way to clear the level, bringing up information about the game that matches this.

Both versions will be visually the same with version 1 having both music and imperfect information being the only difference, the goal of having these two versions will be to test how different the players approach the game when given information that has no direct impact on how the game can be played, only how it was intended. This is brought up by the developers of Amnesia: The Dark Descent in an interview about a similar system that gave players imperfect information for them to change their strategy [15]

4.3 Experiment Description

Before the experiment, the test subjects were contacted online to be prepared, by explaining how to experiment would be run, the subjects were sent a build of the artifact created for this study, either version 1 or version 2, where version 2 was the control version without music and imperfect information. The test subjects with version 1 will be called group 1 and test subjects with version 2 will be called group 2.

The test subjects were then instructed to play through the game until completing it and afterward sent a text file with the data collected inside of it. There was no time limit for the test subjects to complete the experiment, leaving that up to the subjects. After the data was sent in, the experiment was complete.

4.4 Hypothesis

The basis for the statistical analysis of an experiment is hypothesis testing [10]. The following hypotheses are stated for investigating research question RQ1.

Test subjects playing the version of the level with the information horizon and music in effect will play more slowly or cautiously and get hit fewer times than the test subjects playing the version without music and information horizon in play.

The data recorded will be of the following:

- **Time Completion:** How long it takes for a player to complete the level.
- **Turrets Destroyed:** The number of enemies the player killed throughout the level.
- **Shots fired:** How many rounds the player shot in general.
- **Hits taken:** How many rounds the player was hit by
- **Game Won:** If the player won the game

These data points based on the data that was being collected will be used to answer our hypothesis

- **Shots per second (Shots Fired/Time completion):** Metric used to see how aggressive our test subjects play.
- **Turrets Destroyed per second (Turrets Destroyed / Time Completion):** See how effective our test subjects are at playing the level.
- **Hits taken per second (Hits taken / Time Completion):** How reckless the test subjects are while playing the level.
- **Deaths per group:** (Sum Deaths /

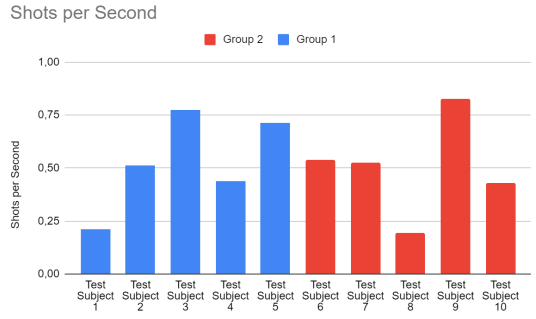
Amount Test Subjects): Amount of times test subjects in a group lost the game.

- **Average time per group:** (Sum Time Completion / Amount Test Subjects): See if a group is more effective at clearing the level.
- **Shots-per Turret Destroyed:** (Shots fired / Turrets Destroyed): How efficient the players' shots are.

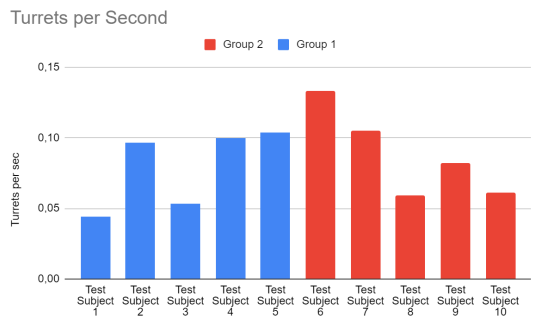
4.5 Sample Selection

The test subjects selected for this study had varying degrees of gaming experience. The two different test groups were equally distributed with five test subjects. The test subjects between both groups had the same forms of gaming experience, to increase the validity of the test results

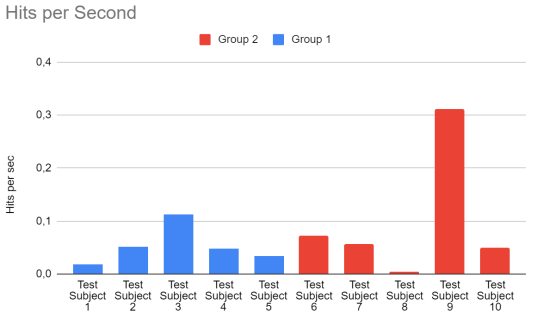
5. Results



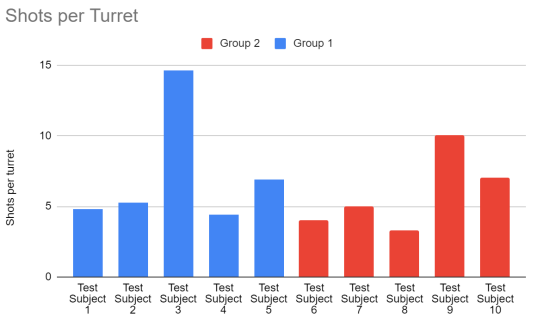
This figure shows the shots per second data. Group 1 Test Subjects used their weapons more, having 0.53 shots per second on average compared to group 2s 0.5 shots per second.



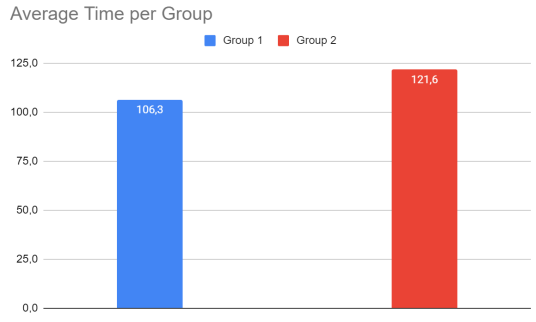
This figure shows the turret per second data. Group 2 test subjects destroyed turrets noticeably faster, having 0.09 turrets per second on average compared to group 1s 0.08 turrets per second.



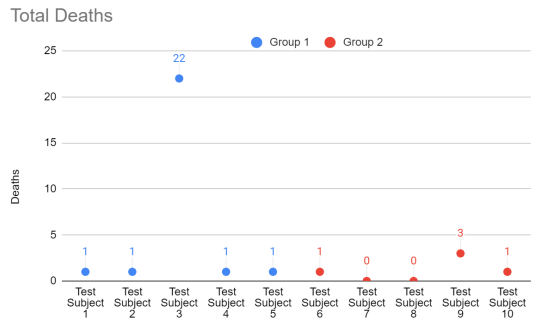
In this figure, we can see how many hits the players took per second. Group 1 took an average of 0.05 hits per second while Group 2 took 0.1 hits per second on average, a significant difference, possibly due to Test Subject 9.



In this figure, we can see how many shots the test subject fired compared to the number of turrets destroyed, the most optimal would be 3 shots per turret. In group 1 the average was 7.19 shots per turret, more than double the optimal performance. In Group 2 the average was 5.89 shots per turret which is a noticeably better performance compared to group 1.



This figure shows the average time of a run, Group 1 was significantly faster on average with 106.33 seconds on average compared to Group 2 at 121.6 seconds.



This figure shows the total death count, with group 1 having 26 total deaths and group 2 having 5 total deaths. Group 1's total death count was greatly inflated by Test Subject 3.

5.1 Analysing Results

After analysing and comparing the data that has been gathered in this study between both groups, our hypothesis seems to not have been correct.

Between the two groups, group 1 had a lower average play time than group 2, indicating that the test subject of group 1 was playing more aggressively, the fact that group 1 had higher shots per second strengthens this argument. Hits per second in group 2 was double that of group 1, perhaps indicating playing with calculated risk as taking damage without dying might have been a faster way of beating the game seeing as group 2 had fewer deaths.

The combined data gathering of group 1 having more shots per second and also more shots per turret indicates that the test subjects were playing more aggressively overall. Shooting at higher frequencies and at the same time being less efficient/accurate with their shots. That in conjunction with that group 1 had destroyed fewer turrets per second, supports the indication that the test subjects were not as cautious as group 2s test subjects were, instead playing more aggressively and impulsively.

What this data shows were in line with some of the previous studies made on musics' effect on player behaviour, which indicated increased stress levels and aggressiveness, which showed to be true in group 1s case as they had lower playtime and lower accuracy when playing the game, it seems that the effect of the music overpowered the information horizon that was implemented in this experiment in the game.

6. Discussion

6.1 Reflection

The development of the game used in this study's controlled experiments took the longest time. Perhaps using a modded game instead would have meant that more time could have been used in other parts of the study, at the same time a big flaw with using a modded game is that it becomes harder to record data from the test subjects. That could have been detrimental to this study's controlled experiment approach. Even if it took a large part of the development, the game worked well in conjunction with the controlled experiments and was vital in this study's findings.

6.2 Concerns and future work

The data saved after testing was created as a .txt file, meaning that test subjects could have easily edited the data, and this issue could have been addressed by making an encrypted text file to increase the validity of this experiment.

The number of test groups could be increased to address a potential issue, seeing as the information horizons effect was hard to determine as previous work on this area was hard to come by. Increasing the test groups to test information horizon and music separately would be a great addition to this paper, in conjunction with more testers for every group would also improve results, reducing the effect of outliers or indicating what causes these outliers.

The level created for this experiment was most effective for testing purposes during the first run, the test subjects were more careful in finding the turrets when they did not know the position of the turrets. This could be addressed by generating the levels procedurally to increase engagement on subsequent runs.

As mentioned before, a lack of research in the area of information horizon in video games made determining the effects of it difficult as there was not much to compare it to.

This study can be used as a base to complement further research into these areas, addressing the concerns of this paper would go a long way to improve the understanding of the effect of both music and information horizon.

6.3 Conclusion

According to some previous studies on the impact of music on player behavior, these studies suggested elevated stress levels and aggressiveness. This is in line with the end results gathered, noticeable in group 1 as the test subjects played more aggressively shooting more, playing faster, and being more inaccurate with their shots. With this in mind, this study confirms the indication that music has an impact on a player's performance in a video game, although the impacts from the information horizon are unclear as its effect appears to, as mentioned before, have been diminished by the influence of the music in the game.

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