DYNAMIC GAME AUDIO ANALYSIS IN THE CONTEXT OF HORROR GAMES

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ABSTRACT

This article aims to highlight the relationship between ludonarrative contexts in games and their use of Adaptive Music. To better suit the interactive nature of games, Adaptive Music functions as a way for the soundtrack to respond to the game environment. The research presents the development and application of a new structured analysis model, designed for observing Adaptive Music across a large number of games, enabling descriptive analysis of the collected data. As part of the model, the study provides a categorical definition of the ludonarrative elements that compose scenes from horror games and identifies 30 contexts in which Adaptive Music was used. The results indicate that 76% of the 221 unique Adaptive Music applications in the 10 horror games studied occur in only 6 main identified contexts. The initial search for a relationship between implementation techniques and contexts suggests that each context shows different tendencies but tends towards up to two of the three Adaptive Music techniques — Horizontal Re-sequencing, Vertical Layering, and Run-Time Mixing — with a greater number favoring Horizontal Re-Sequencing. Additionally, it was observed that only 29 applications used multiple techniques simultaneously and that most applications are never reused throughout the remainder of the games.

1. INTRODUCTION

Audio has been a key component for games since their conception [1]. The first appearances of sound in games occurred around 1970, with the first commercially successful titles, such as Computer Space and Pong. Although there was a limited variety of sounds, the sound effects already provided an upgraded experience through immediate feedback. In subsequent years, with the establishment of arcades, the sounds of video games became a characteristic related to their marketing and advertising [2,3]. According to [1], "*The more distinct the sound of the game, the more it highlighted itself in the arcade and bar spaces around*".

Game audio — a set of sound practices and technologies applied to digital games — has always been limited by the technology of its time, which contributed to the popularization of new music genres like *Chiptune* [4]. Nowadays, audio presents a series of significant benefits that make it indispensable for digital games [5–7]. In an interview [8], *Steven Spielberg* evidences this idea by saying, "*Our ears lead our eyes to where the story is*".

According to [1], audio in contemporary games serves two key roles: fostering *presence* and *immersion*. *Presence* is a physiological phenomenon in which sensory information is used by the brain to create the sensation of being present in a given environment. *Immersion* is psychological in nature and refers to the experience of becoming absorbed in the game's imaginary world. Both are fundamental to enhancing player immersion and engagement.

One of the ways to increase aspects such as *immersion* and *presence* is to use the **Dynamic Audio** (**DA**) [9, 10]. DA refers to audio that responds to changes occurring during gameplay. Within this broad concept, **Adaptive Audio (AA)** denotes audio that reacts specifically to changes in the game's internal state, such as moving between areas, entering a state of crisis, or executing a combo. AA can be applied to sound effects, like footsteps sounds that react in response to the qualities of the floor; as well as to game music, like music that changes when approaching an enemy; in that case, we use the term **Adaptive Music (AM)**, which is the focus of this study.

In the field of game audio studies, some articles seek to comprehend the role of the DA present in one specific game, including the use of Adaptive Music. Previous works did case studies of the games ***Journey*** [1] [11] and ***Songs for a Hero*** [2] [12]. These studies contain examples that showcase the importance of AM and its applications in the different contexts present in the studied games. However, there's still a knowledge gap in the scientific literature regarding the broader relations between **AM** and the Ludonarrative Contexts [3] in which they are inserted in video games. As there are several types of games and those directly influence different aspects of the AM being used, in this work, our main research question is: "**What are the standardized contexts found in horror games regarding the use of Adaptive Music techniques?**"

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[1] Available at: https://thatgamecompany.com/journey/
[2] Available at: https://alendadoheroi.com.br/
[3] Ludonarrative refers to the interplay between a game's mechanics (*ludo*) and its narrative elements [13]

2. THEORETICAL FRAMEWORK

2.1 Categories of Dynamic Audio

Music in video games has its own unique characteristic: interactivity. In games, as well as in cinema and other contexts, audio must be cohesive with the proposed themes and scenes. In games, however, the audio must also respond appropriately to the player's actions. This interactivity creates, therefore, a new aspect of complexity in the audio, making it nonlinear. [14] makes a great analogy, arguing that linear music is like being on a train line designed with a start and end in mind. Whilst non-linear music comes closer to being in an entire subway system, where you can leave at any stop and embark on a new line.

Non-linear music is a form of **Dynamic Audio** (**DA**), an umbrella term for audio that responds to events occurring during gameplay [15]. DA encompasses several categories, the most prominent being *Interactive Audio*, *Adaptive Audio*, and *Generative (Procedural) Audio*. Interactive Audio refers to music and sound effects that respond directly to the player's actions or input [15]. Typical examples include footsteps triggered while walking, sounds produced when collecting items, or music in rhythm games that changes according to the player's performance.

Adaptive Audio, in contrast, responds to changes in the game's internal state rather than to direct player input. Whitmore [16] defines it as "*audio and music that reacts appropriately to—and even anticipates—gameplay*." For example, in *Sackboy: A Big Adventure*, the percussion layer fades out whenever the player stops moving and returns when movement resumes. Here, the music adapts to the player's current gameplay state rather than to a specific input. In practice, the distinction between Interactive and Adaptive Audio is not always strict, and both may coexist. For instance, in *Minecraft*, footsteps are triggered by the player's movement (interactive), while their sound varies according to the surface material (adaptive).

A third category is *Generative* or *Procedural* Audio, in which music or sound effects are synthesized during gameplay through algorithms, neural networks, or other procedural techniques [17]. Although this area has received increasing research attention, particularly with recent advances in artificial intelligence, it remains relatively uncommon in commercial games. Furthermore, because procedural techniques are often difficult to identify without access to implementation details, this category is outside the scope of the proposed analysis model.

2.2 Implementation Techniques

Among the implementation techniques of AM in games, there are two considered to be the most common, them being **Horizontal Re-Sequencing (HS)**, which consists of manipulating the order and transitions between segments of the music, and **Vertical Layering (VL)**, which adds or removes elements present in a certain segment of the music [3, 15]. Both techniques require the music and audio to be composed and planned with this implementation in mind [16].

When planning a song using HS, it is necessary to create it in small, interchangeable segments. These parts may then be connected according to the game's environment. This logic is usually made *in-Engine*, or via other *middleware* tools like FMOD [4] or Wave Works Interact Sound Engine (Wwise) [5].

Similarly to sequencing, when making music using VL, the music is divided into bluedifferent files, each containing individual instruments. These files can be manipulated to introduce or remove instruments. When making these changes, it's possible to make many of the music's elements, such as tone and intensity, adjust according to the events in the game.

In more complex applications usually found in larger games, it is relatively common to see both composing techniques being used simultaneously. Combining techniques this way adds a new layer of challenges during the piece's composition.

Another, less discussed, technique is **Run-Time Mixing**, in which the music becomes adaptive through processing and manipulation of the audio *in-Engine* [16]. The lack of discussion seems to be due to the technology required for its implementation not existing at the time these terms were initially created. Collins mentions this point in her article published in 2007: "*There is no real-time mixing of games audio (yet)[...]*" [14].

Due to technological advancements from the last decade and the increased accessibility of computers and game development tools, adaptive audio has become more common in game development [18]. Uses of RTM, like spatial sound and occlusion, which required the development of proprietary tools, are now widely available even for amateur developers on Engines like Unity [6] and Unreal [7].

3. METHODOLOGY

The primary contribution of this study is the development of a preliminary analysis model for investigating the application of Adaptive Music techniques in video games. The model is presented as a research artifact and provides a structured approach for systematically collecting and organizing data on Adaptive Music applications. In this work, the model is evaluated through its application to a set of horror games, and the resulting dataset is analyzed to investigate possible patterns in the use of Adaptive Music techniques within this genre.

The proposed model addresses both the quantitative and qualitative aspects of game audio. Quantitatively, it enables the descriptive analysis of larger amounts of application data than are typically considered in traditional case studies. Qualitatively, contextual characteristics are represented through categorical tags, while perceptual aspects, such as intensity, clarity, and complexity, are evaluated using Likert scales [19]. Together, these elements provide a richer description of Adaptive Music applications and facilitate the identification of potential design patterns.

[4] Fmod is available at: https://www.fmod.com/
[5] Wwise is available at: https://audiokinetic.com/
[6] Unity is available at: https://unity.com/
[7] Unreal is available at https:/unrealengine.com/

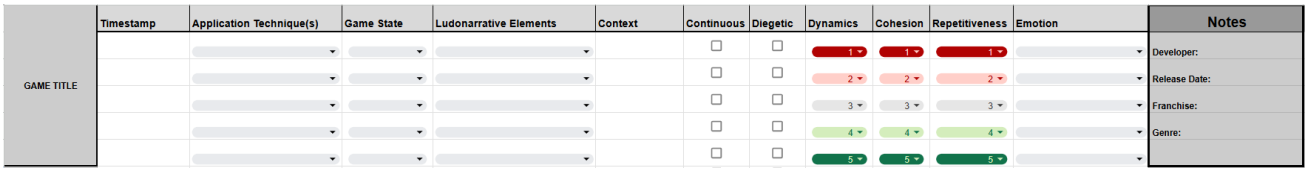


Figure 1. Template of the Analysis Model (Available in this google link.)

This research is exploratory in nature, as there is a lack of studies investigating the broader relationship between Adaptive Music and the contexts in which it is applied. Consequently, this work aims to initiate this discussion and provide a foundation for future research rather than draw definitive conclusions from the collected data. Because the study is exploratory, the proposed model should be regarded as a preliminary contribution, with its evaluation limited to the horror genre. Likewise, because parts of the analysis rely on subjective assessment, the findings should be interpreted as indications of potential trends rather than generalizable conclusions.

4. THE ANALYSIS MODEL

For the purposes of our research, we consider an analysis model to be a structure used to organize data, helping in its interpretation, focused on answering a specific hypothesis about its topic. In this case, the collected data are unique applications of AM in games. We created the model with the intention of making it suitable for games of all genres and sizes, although, to limit the scope, this study will specifically observe horror games. Some choices presented during the creation of the model could have made it better suited to the horror genre and its elements, but were avoided in order not to make the model niche to a specific genre.

An empty *template* of the model can be seen in Figure 1. During its structuring, we determined two categories to keep in mind for each field: whether it is neutral or judgemental, and whether it is essential or auxiliary. Essential fields are those necessary to find patterns between context and application techniques. Auxiliary fields, on the other hand, refer to other important characteristics of AM that may prove relevant during data analysis and subsequent research, and that may indicate, for example, the intention or quality of the application.

The formatting of the data in the model was designed to allow for in-depth descriptive analysis, covering both quantitative and qualitative data. We avoided the use of open unstructured text fields, favoring structured "*multiple-choice*" fields or Likert scales, which allow for the timely application of a large amount of data from multiple games in the model.

The model consequently presents a less in-depth character for case-by-case analysis when compared to traditional structures and processes adopted for current case studies. We do not put it forward as a replacement for case studies, but as an alternative designed for the observation of large amounts of data.

Finally, the model was designed to be applied by the same person who collected the data. Especially due to its judgmental fields, where the experience of the game scene and the overall gameplay and narrative context have a great influence on aspects of the application that would be lost if the analysis is performed with only access to short clips of each application.

4.1 Proposed Model Fields

Game Title: Game title and table name. Each game has an individual model table that can later be compiled into a separate database for analysis.

Game Genre(s): The genre(s) of the game. This field is omitted from the analysis presented in this paper because all selected games belong to the same genre.

Timestamp: Hyperlink with *timestamp* to a video of the application, allowing the viewing, organization, and review of the audio.

Application Technique(s): Which of the three application techniques were used among: Vertical Layering, Horizontal Re-Sequencing, and Run-Time Mixing.

Game State: Where in the game the application occurred, among: *Menu*, *Loading*, *Core Gameplay Loop* and *Auxiliary Gameplay Loop*. *Gameplay Loop* is defined as a sequence of player actions that repeats during the game and defines how the player engages with the challenges presented to them [20]. For our purposes, we took a generalist view when defining the *Core Gameplay Loop*. We considered not only the ***"smallest repeatable unit of gameplay"***, but a collection of the *Loop(s)* or *System(s)* most relevant to the game's core. In a game like **Valorant** [8] , we would consider all elements of a match as part of the *Core Gameplay Loop*, not just the shooting mechanic. This was done to avoid scenarios in which the definition of the *Core Loop* varies between analyses, leading to wildly different results when looking at the same game. ***Auxiliary Gameplay Loops***, by contrast, are game systems that don't fit into the main game's premise; a common application of these *Loops* would be *minigames*.

Ludonarrative Elements: What are the ludonarrative elements, that is, elements pertinent to *gameplay* and the *narrative*, involved in the application? For this field, we used a list of "*Tags*" we developed based on game design books [21, 22], since, during our research, we did not find an appropriate list for our purposes. We elaborated the list by separating, both, the main elements of a game, which we called "*subjects*", and the main "*actions*" related to them. Then, creating a *Tag* for each plausible combination of *action* and *subject*. The selected *subjects* and their definitions are shown in Table 1.

By combining these *subjects* with the following actions: *Introduction, Transition, Shift, Conclusion, Repetition, In-*

[8] Available at: https://playvalorant.com/en-gb/

Environment	Setting or ambient, including the space and objects intrinsically linked to the game world.
Opponent	Entity antagonizing the player, generating conflict in *gameplay*.
Obstacle	Non-character elements creating conflict, e.g., hazards or barriers.
Character	Entity not generating conflict in *gameplay*.
Player	The player's character(s) or in-game representation.
Objective	Clearly defined goal, e.g., *quests*.
Sequence	Distinct segment of the game, e.g., level, *minigame*, or chase.
Narrative	The story and events of the game.
Mechanic	Recurring system element enabling actions that influence the game state [23, 24].

Table 1. Model tags to map Actions and Subjects

teraction, Progression, and Ambientation. We created the utilized complete list of elements, that includes "*Ambientation by Environment*" and "*Progress towards Objective*". (The full list is available in Table 4).

Context: A concise and descriptive sentence about what is happening in the game's ludonarrative. This field aims to **clarify** and **group** applications based on their ludonarrative elements and the game's context. We also include, as a project artifact, the initial list of contexts that were discovered and categorized during the initial application of the model (The full list is available in Table 2).

Continuous: We check this field if the application, or adaptive effect, is continuous. In cases of RTM applications, a continuous effect does not start or end based on the player's actions, instead, remaining active at all times. The most common example of a continuous effect is spatial sound, where the music plays based on the position of some game element; the music is adaptive since it depends on the player's position in the world, but it is continuous because the effect is constantly applied.

Diegetic: We check this field if the music is diegetic. We'll call a "*diegetic sound*", one that originates within the world of the narrative [15], such as music coming from a speaker or a character singing.

Dynamics: How dynamic is the music on a scale of 1 to 5. Dynamics is a musical term that, at its most basic, indicates the degree of volume or intensity of a piece of music, as defined by [25]. The term can also encompass concepts such as timbre, pitch, and composition, and how they influence the emotion of the music. We also added the concept of counterpoint to this field of the model, that is, the entry, change, and exit of tracks and instruments as part of the dynamics. This definition was selected as a way to measure overall change in the music. We defined the scale with 1 being *"Little variation in one of the dynamic elements, being intensity, pitch, timbre, emotion, or composition, without variation in counterpoint"* and 5 being *"Large perceptible dynamic change, with alterations in intensity, composition, and counterpoint that cause a change in the overall feeling of the music, from calm to intense or vice versa"*.

Cohesion: How well the music and application, or adaptive effect, fits within the ludonarrative events of the game on a scale of 1 to 5. We are taking into account aspects such as tonality and emotion related to the narrative, but also technical aspects such as timing and application. The field intends to be an initial indicator of the possible immersion caused or removed by the application, given that bringing more substantial measurements of immersion would fall outside the scope of the current model and make its application on large amounts of data difficult. We defined 1 as "*Great dissonance between the music and the game*" and 5 as "*Great consonance between the music and the game, without application problems and demonstrating an aspect of coherence and justification for the existence of the application*".

Repetitiveness: The expected frequency of each unique application during a typical playthrough, measured on a five-point scale. This field distinguishes isolated applications from those that recur throughout the game, providing an indication of how pervasive each Adaptive Music application is. A score of 1 is assigned to applications that are unique and theoretically impossible to occur more than once during a single playthrough. Scores between 2 and 4 represent increasing levels of expected recurrence. A score of 5 is assigned to applications tied to a game element, system, or mechanic that is repeated several times during gameplay and could theoretically be repeated indefinitely.

Emotion: What are the primary, and, if applicable, secondary indicated emotions of the song? For the selection of the list of possible emotions, we brought a variation proposed in [26] and later adapted to the format of a *wheel of emotions*. The wheel contains 8 main emotions: *fear, surprise, sadness, disgust, anger, anticipation, joy, and trust*. Each of these emotions has two variations for greater and lesser intensities. Less intense versions, in the same order as the main emotions, are: *apprehension, distraction, pensiveness, boredom, annoyance, interest, serenity, and acceptance*. The more intense versions are: *terror, amazement, grief, loathing, rage, vigilance, ecstasy, and admiration*. For this model, the semantics behind each emotion are ignored, taking into account only the primary emotions and variations in intensity. A primary emotion representing the music **must** be chosen, while a secondary emotion **may** be chosen if appropriate; the secondary emotion cannot be a different intensity of the primary emotion. *Plutchik's* wheel also has "*combinations*" of emotions that we chose not to include because they are less applicable to music. We emphasize that this field is not related only to the adaptive aspect of the music, but rather to its completeness, although the application also impacts emotion.

Notes: This is a free text field, outside of the data analysis, reserved for relevant information regarding the game or its applications as a whole.To fit the needs of our research, we used it as follows: Developer, Release Date, Franchise (if applicable), and Game Genre, followed by any miscellaneous notes. Based on the conducted data analysis, or game selection criterion of any subsequent research, information currently stored in this field, such as game genre, may be required as individual columns.

Context	Meaning	Count	HS	VL	RTM
Transition between Environments	Music adapting between environments.	49	32	5	14
Narrative Scene	Music during a narrative scene, emphasizing it.	29	21	10	5
Narrative Build-up	Music creating tension before a narrative scene.	28	15	13	2
Diegetic Device	Music from diegetic objects that reproduce sound in real life.	28	17	8	28
Chase	Music during a chase sequence.	24	0	0	0
Combat Event	Music emitted during combat.	10	10	0	0
Chase Ending	Music reinforcing the end of a chase.	6	3	2	1
Sound Leak	Music simulating emission from an enclosed space.	5	1	2	4
Change based on Proximity	Music adapting to player distance.	4	0	3	2
Search	Music during enemy search behavior.	4	0	2	2
Spatial Distortion	Music adapting to altered reality or player perception.	4	2	2	3
Narrative Resolution	Music reinforcing the end of a narrative scene.	3	2	1	0
Danger Indication	Music signaling upcoming danger or confrontation.	3	1	2	0
Scan	Music during environmental scanning.	2	0	1	2
Directional Indication	Music guiding the player.	2	1	0	0
Diegetic Instrument	Music from diegetic musical instruments.	2	0	0	1
Character Singing	Music sung by one or more characters.	2	0	0	2
Boss Fight Stage Change	Music adapting to boss fight phase changes.	2	1	0	0
Ambientation by Environment	Music emitted by the environment.	2	1	0	2
Minigame Beginning	Music signaling the start of a minigame.	2	1	0	0
Timed Obstacle	Music highlighting time-limited obstacles.	1	0	1	0
Chase Halt	Music providing a pause during a chase.	1	1	0	0
Diegetic Entity	Music from diegetic objects that do not reproduce sound in real life.	1	0	0	1
Boss Fight Beginning	Music initiating a boss fight.	1	1	0	0
Climb	Music during climbing.	1	0	0	1
Boss Fight Ending	Music reinforcing the end of a boss fight.	1	1	0	0
Power-up Collection	Music triggered by collecting a power-up.	1	0	1	0
Player Movement	Music adapting to player movement.	1	1	0	0
Switches	Music reacting to state changes (buttons, levers, etc.).	1	1	1	0
Race Beginning	Music signaling the start of a race.	1	0	1	0

Table 2. Occurrences by context, their meanings and technique where technique was used: HS (Horizontal Re-Sequencing), VL (Vertical Layering) and RTM (Run-Time Mixing).

Game	Developer	Date	Hltb	HS	VL	RTM
Alan Wake Remastered	Remedy Entertainment	2021	10.5h	10	3	10
Chernobylite	The Farm51	2021	14.5h	15	2	1
Hello Neighbor	Dynamic Pixels	2017	8h	0	1	2
Little Nightmares	Tarsier Studios	2017	3.5h	16	13	15
Mortal Shell	Cold Symmetry	2020	10.5h	1	1	2
Observer: System Redux	Bloober Team	2020	7h	9	6	9
Outlast 2	Red Barrels	2017	7.5h	28	10	19
The Dark Pictures: Devil in Me	Supermassive Games	2022	7h	0	1	3
The Evil Within 2	Tango Gameworks	2017	13.5h	32	14	15
Until Dawn	Supermassive Games	2015	8h	5	3	4
Total				**116**	**54**	**80**

Table 3. Selected games and the number of identified techniques.

4.2 Applying the Analysis Model

We applied the model to games within the horror genre, selected using the following criteria: "*Only horror games, published from 2013 onward, available for the PlayStation 4 and with a duration of less than 20 hours, prioritizing more recent games, made by different developers and from different subgenres*". The criteria were defined according to three main needs: **Availability**, we need to have access to the games; **Quantity**, we selected games with a higher expected frequency of unique applications; finally, **Variation**, we selected different games to diversify the techniques observed and categorize more contexts. Table 3 presents the complete list of games analyzed.

Having selected these games, we sought to collect the adaptive music applications present in them. For this purpose, we played the games carefully from beginning to end, recording and noting points where the applications were present. We avoided searching for and going through any optional content in the games. Even having taken precautions, data collection, more than other aspects of the research, is subject to human error, so we emphasize that some applications may have gone unnoticed during data collection.

We also created some acceptance criteria for the applications, to limit analysis time. Any applications which appear in music lasting less than 10 seconds were ignored for being too difficult to identify, going easily unnoticed. The same goes for small *stingers*, or sounds added on top of the music, used for emphasis. Generative audio was also ignored due to its difficulty of identification and rarity. We excluded music in *cutscenes* or other clearly pre-rendered applications, where the techniques were not applied in real time. Finally, we only applied the model to the first instance of any application; if it was repeated, we noted it via the "**Repetitiveness**" field, but did not include it in the model.

After collecting the data, we reduced the recordings to clips of up to 4 minutes, including, where possible, both the transition, an excerpt of the music, and the game events before and after the transition. After uploading these clips to *YouTube*, we added the viewing link to the table with the timestamp approximately 5 seconds before the application takes place. During the upload process, we also processed the data, removing applications that, upon second inspection, didn't have adaptive elements, as well as duplicate recordings. After processing, the data was applied to the model and analyzed empirically, with the assistance of the recorded videos to confirm any suspicions regarding the evaluated parameters.

We evaluated which adaptive music technique(s) were used in each application by carefully listening to aspects such as **timbre** and **dynamics**. After identifying the technique(s), we analyzed the gameplay footage to identify the adaptation trigger and its gameplay context. Whenever possible, the events that triggered each adaptation were reproduced during gameplay recordings to facilitate observation and verify the information recorded in the analysis model.

4.3 Data Analysis

After applying all the data to the model, we conducted a simple descriptive analysis. The main purpose of this analysis is to test the model. Additionally, the analysis itself aims to provide some indications regarding possible trends found, especially among the "***Application Technique(s)***" and "***Contexts***".

We found a total of 221 data points in the 10 games applied, averaging 22 points per game, but with a large variation between games, demonstrating a range of 51 applications between ***Hello Neighbor*** [9] with 2 applications and ***The Evil Within 2*** [10] with 53 applications. This range indicates that the trends found will be influenced by games with a higher number of applications, especially given the small number of games analyzed.

To begin the analysis, we sought to answer the following questions: "*How many **Contexts** were found?*"; "*What were the most frequent **Contexts**, **Application Technique(s)**, and **Ludonarrative Elements**?*"; "*Does there appear to be any relationship between the **Contexts** and the **Application Technique(s)**?*"; "*What do the fields of **Dynamics**, **Cohesion**, and **Repetitiveness** indicate regarding adaptive music in the games studied?*"; and "*In how many games did each **Context** have applications of adaptive music?*"

Among the collected data, we identified 30 different contexts (Table 2) and the most frequent were: "*Transition between Environments*", "*Narrative Scene*", "*Narrative Build Up*", "*Diegetic Device*", "*Chase*", and "*Combat Event*". Applications in these 6 main contexts comprised 76% of all applications analyzed. The relatively high number of contexts found indicates that adaptive music is being used in different situations, in creative ways, in games. But when looking at the frequency of the main contexts, we realize that there is still a pattern regarding where adaptive music is most commonly used.

Element	Count
Narrative Emphasis	83
Transition between Environments	65
Change in Opponent Event	42
Introduction of Sequence	39
Ambientation by Prop	33
Introduction of Environment	22
Interaction with Prop	15
Interaction with Mechanic	13
Ambientation by Environment	12
Introduction of Obstacle	12
Interaction with Character	12
Progress towards Sequence	11
Conclusion of Opponent Event	10
Conclusion of Sequence	8
Interaction with Environment	6
Ambientation by Character	5
Introduction of Mechanic	4
Progress towards Objective	4
Conclusion of Obstacle	3
Conclusion of Objective	2
Change in Obstacle	1
Progress towards Obstacle	1
Change in Player State	1
Transition between Mechanics	0
Change in Objective	0
Repetition of Sequence	0

Table 4. Frequency of Ludonarrative elements

13 Contexts appeared in only one of the analyzed games. 10 of these contexts had only a single application, and 4 of them appeared only in ***Outlast 2*** [11]. Among them, "*Chase Ending*" had the highest number of unique applications with 6 instances. At the opposite extreme, "*Transition between Environments*", "*Narrative Build Up*", and "*Diegetic Device*" were present in 7 of the analyzed games. The games in which they are **not** present vary, but are mainly ***Hello Neighbor***, **Mortal Shell**, and ***The Devil in Me***, which collectively had only 9 applications.

The main "***Ludonarrative Elements***" that comprised the presented contexts shown in Table 4, were namely: "*Narrative Emphasis*", "*Transition between environments*", "*Introduction of Sequence*", and "*Change in opponent event*". "*Narrative Emphasis*" was especially present, being in 38% of all applications. Only 3 of the elements had no applicable data.

In the "***Application Technique(s)***", we saw a greater use of *HS*, followed by *RTM* and then *VL* across almost all games, as can be seen in Table 3. A total of 52% of all applications used *HS*, while only 24% saw the use of *VL*. If we disregard continuous applications, 37 cases of *RTM* would be removed, making it the least used technique in non-continuous applications, with 8 fewer applications than *VL*. Almost half of the applications of *RTM* were continuous, in large part due to the use of spatial sound in music to create diegesis or highlight some element within the game. Of the 221 data points, only 27 used more than one technique and only 2 used all techniques simultaneously, suggesting that the mixing of techniques is underutilized, especially between *HS* and *VL*, where there were only 7

[9] Available at: https://www.helloneighborgame.com/

[10] Available at: https://store.steampowered.com/agecheck/app/601430/

[11] Available at: https://www.playstation.com/en-se/games/outlast-2/

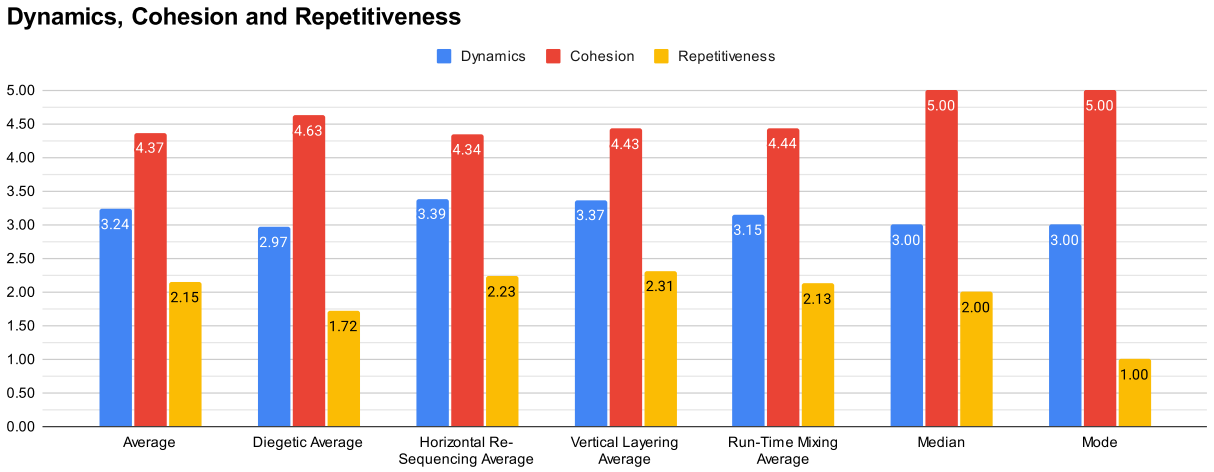


Figure 2. Likert Scale Values

cases containing both techniques.

When searching for patterns in the use of "***Application Technique(s)***" in relation to "***Contexts***", we noticed something interesting: in the 5 contexts with more than 10 applications, we see 4 of them using each Application Technique at least once, indicating that there is variety in the Techniques used within the same context. The data also suggest that each context tends to favor one of the three techniques, to varying degrees. We structured our search for trends as follows: we considered contexts with more than 10 data points, and that appeared in at least 4 of the games. We then compared the presence of each technique in this context with its average usage across all contexts to discover if the technique is used more frequently in that specific context. We also sought to compare usage between techniques in each context, derived from the data shown in Table 2.

Looking at this data, we have the following possible trends: in "*Transition between Environments*" we have a usage 13% above the average of *HS* while the other techniques have values well below the average, indicating a trend towards this technique. "*Narrative Scene*" and "*Chase*" show almost the same data, with an even greater presence totaling around 70% in *HS*, 18% above average, but also see a usage 10% above average for *VL* and 19% below average for *RTM*, indicating a trend for the other two techniques in both cases. "*Diegetic Device*" is directly linked to spatial sound, that is, *RTM*, and therefore is somewhat outside the scope of this search. But we do see a use of *VL* in its applications. Finally, "*Narrative Build Up*" shows an almost equal use of *HS* and *VL* with a tendency for layering 22% above its average, but a large under-utilization of *RTM* in only 7% of cases, 29% below its average usage.

Observing the values derived from the Likert scale fields in Figure 2, we attempted to infer reasons behind the observed values. The "***Dynamics***" field presents several similar values, around 3. These values are within the expected range, suggesting that most applications do not cause very drastic changes in the music. Interestingly, there is a 0.27 drop in the average dynamics in diegetic cases, suggesting that these applications are generally calmer. Diegetic cases also seem to negatively impact "***Repetitiveness***", thus being more unique, and positively impact "***Cohesion***", which we expected, as we supposed music that takes place within the world would theoretically be better integrated into world events. The different application techniques do not seem to significantly impact these fields' values. The high cohesion results are partially expected. Given the difficulty of implementing adaptive music, we expected the average quality of the applications wouldn't be low. However, the maximum values in the median and mode could indicate a leniency that should be adjusted for future applications of the model. At last, the low repetitiveness values, especially in its mode, indicate that most contextually unique applications of adaptive music in games are never repeated during the rest of the *gameplay*.

In the "***Game State***" field, we saw that all applications, with only two exceptions, were in the "*Core Gameplay Loop*" of the games. We attribute this to: the complexity of applying adaptive music, causing the applications to be more likely to appear at key moments in the games; the characteristics of the selected horror games, many of which did not feature "*Auxiliary Gameplay Loops*"; as well as the data collection criteria, in which we avoided searching for and playing through any additional content in the games, we suspect that most of the "*Auxiliary Gameplay Loops*" are located in portions not necessary for completing the games, and therefore went unplayed.

5. CONCLUSIONS

In this study, we developed a preliminary structured analysis model to pursue the relation between ludonarrative contexts and composing techniques in adaptive game music. We applied the model on 10 horror games, aggregating a total of 221 application data points, which we categorized into 30 unique contexts.

While pursuing tendencies between "***Application Technique(s)***" and "***Context***", we had partially inconclusive results given the amount of analyzed data in each context. However, the patterns found seem to point out that the great majority of contexts above the minimum number of applications tend to favor one or two specific tech-

niques. This apparent inclination may also have occurred due to the overall trend towards the use of "*Horizontal Re-Sequencing*", which was utilized in 52% of the analyzed cases. The extracted values from the field "***Repetitiveness***" indicate that a big portion of the reviewed applications are never repeated. This was a surprise for us, given that, in general, it is common to see assets and even code being reused in multiple instances throughout the same game.

Future work will evaluate and refine the preliminary model by applying it to additional game genres, assessing the relevance of its current fields and identifying new ones where necessary.

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