

“You’ve Got the Music in You, Don’t You?” Designing Emotionally Engaging Musical Visualizations

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Abstract. *Integrating music and visualization in video games is crucial in enhancing emotional storytelling and immersion. Despite the recognized power of music to evoke emotions, the deliberate combination of music and visual elements to convey specific emotions in video games remains underexplored. This study addresses this gap by proposing a set of design principles to improve the emotional impact of musical visualizations in video games. They were applied and evaluated in two visualizations, and the results showed greater alignment with the intended emotional communication. Our findings give game developers practical insights to create more emotionally engaging visual experiences.*

1. Introduction

Music is an ideal match to accompany a virtual application in expressing a wide range of emotions and for painting complex moods [Collins 2013, Pouris and Fels 2012, Pokharel 2020], especially when it comes to entertainment like computer games, virtual environments, digital interactive art, and stories [Pereira and Chambel 2023, Stewart et al. 2010]. A crucial aspect of the immersive experience of video games is the use of music and its visualization (i.e., visual representation of music, such as dynamic visuals that respond to music, static visuals that evoke the music’s mood, and interactive elements that engage the player) [Peerdeman 2010].

However, while games often use music and visuals to enhance gameplay, they rarely intentionally combine these elements to convey specific emotions, particularly in cutscenes. Cutscenes are fundamental narrative tools in video games [Hooper 2018]. While some rely primarily on dialogue, others, such as *The Last of Us*¹, utilize them to showcase interactions and emotions. Games like *Gris*² demonstrate the power of combining music and visuals to tell a story without dialogue, using musical motifs and color palettes to convey specific emotions. This highlights a clear need to understand better the intersection of emotion, music, and visualization.

Our paper introduces design principles to enhance the emotional impact of visuals in relation to music —principles like maintaining visual harmony with music, conveying emotions through color, and balancing dynamic and static elements. This research originated from a project aimed at improving emotional communication through music visualizations in artistic contexts, particularly during a live Camerata performance, which

¹<https://www.playstation.com/pt-br/games/the-last-of-us-part-i/>

²<https://nomada.studio/gris-game/>

laid the foundation for this investigation. While tests in that setting highlighted how certain visual elements influenced audience emotional responses, this paper focuses on applying these principles to game design. Initially casual, this observation was later informed by research and the perspective of Self-Determination Theory (SDT) [Ryan and Deci 2017] applied to games. Although initially identified in live musical visualizations, we argue that these principles are applicable to game design since the core principles of emotional engagement remain consistent across mediums. Both music visualizations and games seek to create immersive, emotionally resonant experiences. We explore the potential of music visualization to foster emotional engagement and invite readers to consider how this powerful tool can deepen players' connection to the music, making players feel they've got music in them.

2. Identifying Potential Design Principles

This section outlines the methodology used to produce and evaluate musical visualizations. We initially investigated emotional communication through music visualizations in artistic contexts by conducting two evaluations: (1) a Field Test during a live performance, and (2) a Laboratory Test, where we refined and tested visualizations based on insights from the field. The results of both tests led to the design principles, outlined in Section 3, aimed at creating emotionally engaging visual experiences for game design.

2.1. Field Test: The Initial Evaluation

We evaluated five music visualizations developed outside the scope of this research as a computational design research project led by researchers from the Computational Design Group of the UFC Digital Experience Laboratory (LED) showcased at a live Studio Ghibli-themed concert by the Federal University of Ceará (UFC) String Camerata at the Museum of Image and Sound Chico Albuquerque. These visualizations had graphical elements that responded to the music's characteristics (pitch, intensity) but were not designed to explicitly convey emotions. The featured songs were *Itsumo Nando Demo* from *Spirited Away*, *Country Road* from *Whisper of the Heart*, *Sanpo* from *My Neighbor Totoro*, *Mononoke Hime* from *Princess Mononoke*, and *The Sixth Station* from *Spirited Away*.

Our evaluation consisted of (1) previous word associations and (2) field tests during a live presentation. Two researchers listened independently to each piece twice for word associations, documenting emotional responses and associated elements. For the field test, 57 participants gave feedback on the visualizations using The Product Emotion (PrEmo) measurement tool, a non-verbal scale that uses 14 illustrations to represent emotions—seven positive (e.g., joy, hope) and negative (e.g., sadness, fear)- to understand the emotions evoked by each visualization. After the performance, we applied the Intrinsic Motivation Inventory (IMI-TEQ-Br) Interest/Enjoyment dimension [Pereira Nunes and Darin 2024], to measure participants' motivation and interest, and the User Engagement Scale (UES-Br) [Miranda et al. 2021] to measure satisfaction with the visualizations.

We organized the data into polar charts for PrEmo responses and calculated scores from IMI-TEQ and UES-Br³. Then, we selected the visualization for the song *The Sixth Station* by Joe Hisaishi and developed two alternative visualizations to test our hypotheses about the factors affecting the communication of emotions and identified potential design principles to improve effectiveness in evoking emotions.

³Quali-quantitative data analysis of Field Test and Laboratory Test - <https://bit.ly/3Y3XU6G>

2.2. Laboratory Test: Testing Design Considerations

Laboratory tests were part of our approach to validating an iterative design process for musical visualizations in the broader context of our project. We developed a music visualization following the design process Thunder⁴.

Two designers independently followed the iterative approach, which consisted of four steps: (1) Conceptualization, (2) Prototyping, (3) Implementation and (4) Evaluation. In the conceptualization phase, we aimed to understand the perceived emotional communication of the music to guide the selection of visual aspects such as colors and interactive elements. We used emotional mapping based on the interactive map of [Cowen et al. 2020] to identify emotional patterns and accurately represent the song's nuances. Word associations provided qualitative information to identify keywords and themes guiding the visual design. This combined approach ensured emotionally resonant and contextually relevant visualizations. Designers selected keywords and musical elements to guide the visual design, planning their visual representation within the illustration's context. Mood boards and sketches translated emotional concepts into cohesive visuals, integrating elements like frequency, timbre, and beat harmoniously with the music.

The prototyping phase involved creating and refining medium- and high-fidelity prototypes to enhance emotional communication and visual design. Feedback sessions after each iteration focused on refining emotional communication and aesthetics, leading to a high-fidelity prototype closely simulating the final visualization.

In the laboratory test, we assessed the high-fidelity prototype's effectiveness applying the design insights we had hypothesized before. Five participants (four male and one non-binary, aged between 20 and 28) viewed the Studio Ghibli-themed visualizations and the high-fidelity prototypes. We used three evaluation techniques: (1) Word Association – participants recorded emotions and elements they associated with the visuals during the presentation, (2) PrEmo, and (3) semi-structured interviews – which explored emotional, musical, and aesthetic aspects, and gathered feedback on the interaction between visuals and music.

The implementation involves transforming the high-fidelity prototype into interactive animations coded with *Processing* 4.3. These animations will dynamically respond to music captured with a microphone, allowing interaction with visual elements. As a final phase of our study, the implementation will undergo a field test in the evaluation phase to validate this approach using techniques from the initial evaluation phase.

We analyzed the results³ through word clouds, scatter polar charts, and content analysis, which confirmed that the visual elements successfully represented the music and conveyed emotions. These findings supported the development of the design principles discussed in Section 3.

3. Ethical Care in Participant Evaluation

In our evaluation stages with participants, we strictly followed ethical standards to ensure safety and anonymity. Given the sensitivity of emotional response data, we emphasized

⁴Thunder is a design process proposed by Nunes et al. (2024) for creating emotionally engaging musical visualizations. This research yielded valuable insights that informed the design principles introduced in this work. - <https://bit.ly/3Y2hfVL>

transparency and informed consent. Participants were fully briefed on the study's purpose, role, and rights, including the ability to withdraw at any time. All data collected was anonymized to protect privacy. Participants signed a Term of Free and Informed Consent (TCLE) detailing the study, potential risks, benefits, and data protection measures. While we haven't submitted the project for official ethics committee approval, we are completing this requirement. Meanwhile, ethical considerations have remained a priority, and we've taken steps to ensure our study aligns with ethical research practices.

4. Design Principles for Emotionally Resonant Music and Visuals

This section synthesizes the findings from both the Initial Evaluation and Laboratory Test and presents a set of design principles for enhancing emotional communication in game narratives that interact with music.

4.1. Principle 1: Create Contextual Relevance for Visual Elements

Consider a melancholic piano piece. A fitting visualization might show a lone figure walking through a muted, desolate landscape, with visuals syncing to the music—slowing the figure's pace and darkening colors as it intensifies. This deepens the connection to the music's emotional narrative, drawing players into the somber mood. In contrast, a bright pop song might feature a lively cityscape with vibrant colors and animations matching the rhythm, enhancing the celebratory mood. These examples show how aligning visuals with music's emotional tone creates a more engaging, immersive experience.

While the principle of ensuring contextual relevance does not, per se, guarantee player autonomy, it potentially empowers players to become more active and interpretive of the visualization within the broader narrative context. This approach aligns with SDT by facilitating the player's experience of meaning and purpose, which are key features of autonomy Ryan and Deci (2017). By aligning visual elements with the emotional message conveyed by the music within the broader narrative context, designers can enhance player autonomy by allowing the player to construct the interpretation and engagement with the musical visualization.

Making musical visualizations contextually relevant – by grounding visual elements within the music's emotional narrative – offers a more meaningful and engaging experience through deeper interpretation and connection with the visual elements. We applied this principle in our prototypes, ensuring they aligned with the existing narratives of Studio Ghibli movies. For instance, in *The Sixth Station*, we chose visual elements based on the specific film scene where the music played, maintaining narrative coherence. We created mood boards with reference images and visual elements reflecting the film's aesthetic and narrative. The sea waves' height responded to the music's frequency, the clouds' movement to its tempo, and the stars' intensity to the beat.

Participants who viewed visualizations where elements were directly connected to the music and narrative context, such as the water representing frequency in Alternative 1, reported greater interest and engagement. One participant stated, "*They [frequency waves] are the manifestation, very intelligent by the way, of sound waves. Thus, as a mechanical wave propagates in water, so does sound. It's an interesting game of meaning.*"

However, elements presented in a technical manner, such as frequency and beat bars in the *Sanpo* visualization, were distracting and hindered emotional connection. Par-

ticipants found these visuals overwhelming and disconnected from the story. One participant remarked, *“those music elements there [frequency bars], are very unnecessary.”* Another stated, *“When I want to interpret the animation, I end up not looking at Totoro [a movie character]; I end up looking at the passing bars, at the equalizer on the left of the image, at the expanding spheres. So, I think it gets in the way.”* Consequently, the *Sanpo* visualization evoked fewer emotions, with participants using words like *“bubbles,” “movement,”* and *“sound elements”* instead of emotionally charged terms. In contrast, the alternatives elicited expected emotions like *“loneliness”* and *“sadness,”* as confirmed by free word association and PrEmo results, aligning with designers’ expectations.

The need for providing context to visual elements aligns with the work of [Dickey 2006], in which design heuristics for constructing narratives in game designs are proposed. In his heuristic “Establish the physical, temporal, environmental and emotional, and ethical dimensions of the environment,” he puts emphasis on planning the placement and function of elements to evoke desired emotions and present the narrative. In this context, the heuristic “Develop cut scenes to support the development of the narrative storyline” also supports our approach because we look into the application of visual elements responsive to music in transmitting emotions within the narrative context. This principle, however, focuses on how visual elements responding to music can enhance the emotional depth and impact of the story.

This goes beyond cutscenes, recognizing that visual elements like musical visualizations also enhance the narrative’s impact by emphasizing emotional storytelling. These not only convey information but also evoke emotions, creating a more engaging player experience. This aligns with the broader use of music and visuals to deepen the player’s emotional connection to the narrative. By acknowledging the interactive nature of music-responsive visuals, our approach adds complexity and engagement, allowing for dynamically generated elements based on musical characteristics, unlike pre-scripted cutscenes.

Applying this principle in game design, aligning visuals with the music’s emotional narrative fosters a deeper player connection to the story. This enables players to actively interpret and engage with the visuals, enhancing autonomy and meaning within the game for a more cohesive, emotionally impactful experience.

4.2. Principle 2: Maintain Harmony Between Visual Elements and Music

Imagine a character walking through a dark forest with a melancholic melody playing. As the music intensifies, trees sway, branches creak, and shadows shift with the song’s crescendo. When the music softens, the visuals also calm, with the wind gently moving leaves and shadows fading. This synchronization of visuals and music immerses viewers deeper into the emotional world of the story.

Maintaining harmony between gameplay, visual elements, and music requires ensuring a dynamic and responsive relationship between the visuals and the music’s emotional narrative. This principle might help foster a sense of competence in players as they perceive a clear and consistent connection between the visual and auditory elements. The idea is that designers could improve a player’s mastery experience by ensuring the visual elements respond dynamically to shifts in the mood and intensity of the music. If well connected to the gameplay, this can help players to realize better and express the emo-

tional journey of the music. By no means could one achieve a sense of competence in a game only through such a harmonic connection, but it contributes to strength feedback.

Research suggests that design features and feedback that help players understand and master challenges lead to greater competence and engagement [Miller et al. 2019]. Thus, ensuring that visual elements dynamically respond to shifts in mood and intensity of the music, according to the gameplay, aligns with these findings, as it enhances player competence and helps them achieve a greater enjoyment and pleasure in the experience.

During the laboratory test, participants became confused when visual elements were out of sync with the music. One participant noted, “*These lights too, I don’t know if they are there from the sound, if they are just flashing randomly if they sometimes appear.*” Another mentioned, “*I don’t know if she gives me a lot of emotion because I think she is idle...when the sound comes you can’t get the idea of it diminishing or extinguishing*” from *Mononoke Hime*. This indicated dissatisfaction with animations that didn’t match the music’s dynamics. Overly sensitive elements also caused discomfort, with one participant saying, “*This one in particular I found to be very polluted...when the music comes on I already...completely eats these...bubbles off the screen*” in *Sanpo*. Compared with the word associations, these visualizations conveyed few emotions, focusing more on elements like bubbles, movement, and sound. For example, the *Sanpo* visualization prompted words like bubbles and sound elements, while *Mononoke Hime*, though evoking some emotions like melancholy, was mostly associated with ambient scene descriptors like mystery, magic, and night.

This demonstrates that when adding an animated element to the scene, it is important to consider its synchronization with the music. Therefore, prior planning of what each element will represent for the music and how they will react to musical elements, such as beat and frequency, is essential to maintain the participant’s focus and emotional connection. This fact may relate to our UES-SF-Br results from the initial test, which showed a slight reduction in Focused Attention (FA) over time, suggesting a possible decrease of interest over time.

Bauer and Suter (2021) emphasizes the importance of sound and visual elements in video games to ensure the player’s perception of the virtual world through their eyes and ears. He reports the need for careful placement to create a believable illusion within the game’s narrative, warning that poor execution can lead to a loss of interest and engagement. This relates to our insight of as we focus on the emotional impact of synchronizing music and visuals. We further expand Bauer’s work by highlighting the emotional impact of incorporating music and visuals into a game. While Bauer highlights creating a convincing virtual world, we emphasize how the dynamic interplay between music and visuals enhances emotional depth and player involvement. This approach aims to create an emotionally resonant narrative, deepening the player’s connection to the music and enhancing the overall experience. It goes beyond merely placing visual elements, resulting in a more engaging and dynamic experience.

Applying this principle in game design, where visuals respond dynamically to music’s mood and intensity, can create a more cohesive experience. This alignment helps players better understand and navigate the game’s emotional landscape, fostering a sense of competence and engagement. This strengthens the player’s connection to the narrative,

enhancing their overall experience and enjoyment.

4.3. Principle 3: Orchestrate Color and Symbolism in Storytelling

Picture a lone figure on a cliff under a dark sky, accompanied by a melancholic tune. As the music intensifies, the wind rises, clouds swirl, and the cliff glows with an ethereal light. The figure subtly shifts posture, reflecting the music's intensity and conveying a sense of longing. Muted colors mirror the melancholy mood, deepening the emotional connection. This visualization draws players into the figure's solitude, aligning visuals with the music to create a shared emotional journey and strengthen the bond with the music's message.

While the meaning of colors and visual elements can be contextual, subjective, and culturally biased, careful selection and application of such can, in musical visualization, potentially give rise to a sense of relatedness among players. By aligning colors and visual elements to resonate with the music's emotional themes, designers can create a shared emotional experience, which, in turn, might give rise to feelings of connection and belonging —both critical components of relatedness [Ryan and Deci 2017].

The choice of colors and visual tones should align with the emotions conveyed by the music. It is essential to plan the aesthetic composition of the visualization in advance, considering the emotional significance of colors and the representation of visual elements. During the conceptualization phase, our prototypes were guided by mood boards based on the emotions identified through word associations. Alternative 1 used darker, night-related tones to evoke melancholy and loneliness. Alternative 2 also used dark night colors but explored a transition from day to night, starting with lighter tones and ending with darker ones⁵. Both alternatives included visual elements such as stormy clouds, an empty sea, nightfall, and the character's solitude to convey feelings of loneliness and sadness (see Figure 1).

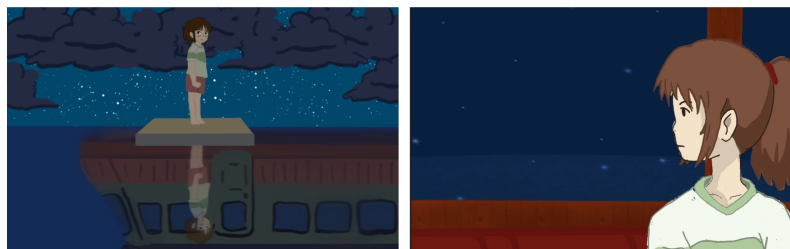


Figure 1. High-Fidelity Prototypes using color composition to evoke emotions.

The laboratory test showed that the choice of colors in the visualizations played a significant role in the feelings evoked by the participants. In the first part of Alternative 1, the use of pastel colors conveyed calm rather than the expected negative emotions. However, the transition of time and the darkening colors as the sun set in the second part reinforced negative emotions, as one participant noted, “*And the second one I found lonely, perhaps because it was darker because... in the other she was accompanied. And here she is alone. The time is because I see a transition in time as the sky darkens.*” The dark color palette of Alternative 1, which depicts a night scene, also brought out

⁵<https://bit.ly/3X6alsY>

negative emotions of loneliness and fear, as another participant mentioned, “*the tones of the animation, the colors of the animation. I can see that it has a melancholy... the sky, the dark clouds, the scenery, they are melancholic.*”

PrEmo results confirmed that both alternatives conveyed negative emotions, such as sadness and shame. Alternative 1 was more successful in transmitting them, while Alternative 2 also evoked “sadness” and “shame” but included positive emotions like “fascination”, “hope”, and “pride”. Word associations confirmed it, with Alternative 1 eliciting words related to negative emotions, such as “loneliness” and “sadness”, and Alternative 2 prompting words like “time”, “peace”, and “solitude”. The visualizations successfully evoked the emotions the researchers aimed to convey, but not equally.

An effective strategy for communicating emotions is visual elements that convey meanings naturally related to specific emotions. For example, the PrEmo results showed that the visualizations *Itsumo Nando Demo*, *Mononoke Hime*, and *Sanpo* were associated with positive emotions. The word association highlighted this relationship. *Country Road* features fireworks, bringing a feeling of festivity and happiness, as noted by one participant: “*the fact that they are fireworks... matches the feeling of joy that music also passes.*” In *Itsumo Nando Demo*, colorful brushstrokes around the character were related to “confetti” and “carnival,” evoking happiness. *Sanpo* showed colorful bubbles, evoking words like “party,” and “colors,” which related to feelings of “joy” and “fascination” from PrEmo. This is supported by Alternative 1, which primarily elicited negative emotions such as “sadness,” “loneliness,” and “melancholy.” One participant remarked, “[...] *there is a melancholy... the sky, dark clouds, the scenery, they are melancholic.*” This indicates that elements like night and stormy clouds successfully evoked the intended emotions.

The work of [Joosten et al. 2012] investigated how colors in video games influence players’ emotional responses, finding that red elicited a highly aroused, negative emotional response. In contrast, yellow elicited a positive emotional response. This supports the principle of choosing colors according to the objective of emotional communication in musical visualization. It highlights the use of color and visual symbolism as a language to express emotions, creating visualizations that connect deeply with the music’s emotional narrative. The choice of colors should not merely evoke negative or positive feelings but should align with the music’s specific emotional themes and nuances. By thoughtfully selecting colors and visual elements that resonate with the intended emotional message, designers can create a more subtle and impactful emotional experience for players, enhancing their understanding of the music.

In game design, aligning color and symbolism with the emotional themes of music can deeply impact player emotions. Dark, muted colors can evoke feelings of loneliness or melancholy, while vibrant colors and uplifting symbols can amplify joy and excitement. By carefully matching visual elements to the music, designers create more immersive and emotionally resonant experiences. This approach not only strengthens the narrative but also helps players connect with its emotional nuances on a deeper level.

4.4. Principle 4: Balance Dynamic and Static Elements

Imagine a busy, magical square during a festive celebration filled with bright colors and lively music. At the center is a fountain with water streams that move in time with a cheerful tune. Surrounding the fountain are various vendors: a mischievous goblin selling

glowing mushrooms, an elf juggling brightly colored scarves, and a bear loudly offering honey from a jar. During this bustling scene, there is a large dragon, its imposing presence commanding attention and giving the busy market a touch of greatness.

This scene shows this principle in action. Dynamic features add excitement and energy to the piece by pulling the eye around the scene. However, the majestic dragon, though static, helps to visually ground the viewer's eye on that part of the scene, emphasizing the focal point. This balance between movement and stillness prevents visual clutter. It keeps a clear visual hierarchy so the viewer's eye is drawn to the most important elements, making for a better experience.

This principle advocates for a balanced visual experience where dynamic and static elements work in harmony to maintain focus and engagement. It empowers players to focus their attention and navigate the narrative efficiently, fostering a sense of autonomy and control. Additionally, this balance enables players to master the presented visual information, enhancing their sense of competence. Visual clutter and overstimulation can be detrimental to player engagement and well-being. Research suggests that game designs offering clear visual cues and a hierarchy of importance, as proposed by this principle, help players navigate the game world efficiently and maintain narrative focus [Pillai et al. 2017]. This approach promotes player autonomy and competence by allowing them to focus on main narrative elements without feeling overwhelmed, thereby developing a sense of mastery as they understand and interpret the visual information.

For example, [Ryan and Deci 2017] study established that game designs that allow players to choose their way and chart the game world based on their preferences increase feelings of autonomy, leading to further engagement and enjoyment. Moreover, [Ryan et al. 2006] detail how control designs and the density and clarity of game feedback impact engagement through increased competence. These findings suggest that a balanced visual environment that underpins player autonomy and competence could significantly contribute to player engagement and well-being.

This principle aims to prevent the person from feeling overwhelmed by too many elements attracting their attention so that they do not lose connection with the emotional story. This way, balancing dynamic (moving) and static (still) elements is necessary to maintain interest without overwhelming the person. In our prototypes, we placed subtle interactive elements in the animation, which did not take the focus away from the most important element for our illustration, in this case, the main character. The prototyping and feedback sessions during the evaluation stage were very important to ensure this good practice. For example, in the medium-fidelity prototype of Alternative 1, an interactive train headlight was removed as it could cause visual discomfort (see Figure 2).

Laboratory tests showed that visualizations focusing on both static elements (main character) and numerous dynamic elements tend to disperse participants' attention, reducing emotional connection. Although content analysis has demonstrated that dynamic elements can coexist with character-driven storytelling without diminishing viewer engagement, like the fireworks from the *Country Road* that do not negatively impact the overall focus on the visualization since they are arranged harmoniously between the static elements, when static elements and dynamic are put together in a confusing and visually overwhelming way, viewers lose focus and emotional connection to the visualization.



Figure 2. Medium-Fidelity Prototype of Alternative 1.

This was evident in the *Itsumo Nando Demo* and *Sanpo* visualizations, which had a central static main character and dynamic abstract elements moving around him, where participants struggled to identify the main elements of the animation, sometimes indicating the static character, other times the dynamic elements, or a combination of both. This lack of balance disrupted the visual hierarchy, as noted by a participant: “*everything moves, with the hierarchy organized in a way that all things compete with each other to see what catches my attention the most.*” Even though the PrEmo results from the field test and laboratory test were in line with our word associations, indicating mainly positive emotions, the fact that *Sanpo* didn’t convey many emotions in the word association made by the participants can reinforce this emotional disconnection caused by the lack of balance of visual elements.

Integrating insights from both practices shows that carefully planning synchronized visual elements and maintaining a clear hierarchy is essential. Balancing dynamic and static elements in game design creates a more cohesive and engaging visual experience. It allows players to focus on key narrative elements without feeling overwhelmed and maintain a strong emotional connection to the story.

5. Conclusion

This research investigated the potential of musical visualizations to enhance emotional storytelling and player immersion in video games. Drawing from live artistic performances and game design principles, we identified key design considerations that can create more emotionally resonant and engaging experiences. Our focus was on effectively aligning visual elements with music to convey emotions, emphasizing the role of color choices and visual symbolism, and balancing dynamic and static elements.

Although these design principles were initially developed for artistic installations, they have broader applications in interactive environments. By aligning visuals with the emotional tone of the music, game designers can create more powerful and meaningful player experiences. However unlike artistic contexts where the experience is controlled, games introduce variability due to player interaction and subjective emotional responses. These factors can present some challenges in integrating the design principles into game development, requiring adaptations for the interactive nature of games. With that, future research should explore how direct player interaction with musical visualizations influences engagement and emotional response while refining these principles to better fit the dynamic nature of game design.

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