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Game Atmosphere: Effects of Audiovisual Thematic Cohesion on Player Experience and Psychophysiology

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ABSTRACT

Game atmosphere and game audio are critical factors linked to the commercial success of video games. However, game atmosphere has been neither operationalized nor clearly defined in games user research literature, making it difficult to study. We define *game atmosphere* as the emerging subjective experience of a player caused by the strong audiovisual thematic cohesion (i.e., the harmonic fit of sounds and graphics to a shared theme) of video game elements. We studied players' experience of thematic cohesion in two between-subjects, independent-measures experiments (N=109) across four conditions differing in their level of audiovisual thematic fit. Participants' experiences were assessed with physiological and psychometric measurements to understand the effect of game atmosphere on player experience. Results indicate that a lack of thematic fit between audio and visuals lowers the degree of perceived atmosphere, but that while audiovisual thematic dissonance may lead to higher-intensity negative-valence facial events, it does not impact self-reported player experience or immersion.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in HCI**.

KEYWORDS

games; atmosphere; audio; music; player experience; dissonance

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1 INTRODUCTION

The term 'game atmosphere' is used to describe a subtle but important, intangible, generally aesthetic quality in games that leads to emotional immersion. A multitude of games are lauded as "atmospheric" in their reviews [14, 38, 43, 44]. To the best of our knowledge, the concept of atmosphere in games—despite its prevalence and noted importance—has not been studied before empirically and does not have a fixed definition. Game developer Greg Kasavin notes that atmosphere is made up of thematic cohesion, internal consistency, and specific detail [42]. Others describe it as a feeling of immersion emerging from *coherence* among a variety of game elements (visuals, audio, narrative, game mechanics, and interactivity) [6]. Ernest Adams also recommended that game designers should create atmosphere by ensuring that a game is "aesthetically coherent and creates the appropriate mood" [2]. The aesthetics of games are a subjective experience and a rarely studied component of player experience (PX). According to the Mechanics-Dynamics-Aesthetics (MDA) framework, aesthetics "describes the desirable emotional responses evoked in the player, when she interacts with the game system" [36]. This is a significant component of game design given the importance of players' emotional experience in games for their immediate perception thereof, as well as for subsequent likelihood of replaying and word-of-mouth advertising. Niedenthal describes aesthetics as referring to "the sensory phenomena that the player encounters in the game" [59] (i.e., the visual and auditory elements). When visual and auditory components of a video game have strong thematic cohesion, and therefore contribute to the same aesthetic, players should experience or perceive a stronger emergent feeling of atmosphere.

Given the importance of atmosphere for PX and consequently for the sales of games, we attempted to verify the ties between atmosphere in games and audiovisual thematic cohesion. We did so by empirically exploring effects of audiovisual thematic dissonance on PX in two studies. In an online experiment (N=59)

and a lab study (N=50), we confronted viewers (online) and players (lab) with audiovisual thematic dissonance in the game Bloodborne [24]—itself often discussed in connection with atmosphere in games [16, 40, 50, 62]. Our results indicate that a lack of thematic fit between audio and visuals lowers the degree of perceived atmosphere, providing the first piece of empirical evidence for the connection between audiovisual thematic cohesion and game atmosphere. They also indicate that audiovisual thematic cohesion facilitates positive affective experiences. However, the results also show that thematic cohesion did not affect players' (or viewers') immersion and psychometrically assessed player experience. In this regard, the only significant difference occurred in players' brow-muscle electromyography (EMG) activation, which was of a significantly higher amplitude for the condition with dissonant music than for the condition with dissonant voiceover.

The study of atmosphere is important to games user research (GUR) and experience (GRUX) practitioners, and game designers seeking to understand and improve atmospheric experiences and avoid thematically dissonant experiences which break atmosphere. With this paper, we contribute a definition of video game atmosphere to the CHI PLAY community, as the emergent subjective experience occurring because of strong thematic cohesion between audiovisual game elements, which was validated by a total of 109 participants across two studies. We also provide evidence for the beneficial effects of perceived atmosphere on players' purchasing decisions and quality perception. Contrary to expectations coming from reading the existing literature, atmosphere in the form of strong audiovisual thematic cohesion did not impact players' immersion and psychometrically assessed player experience, leading us to conclude that game atmosphere may consist of additional aspects to audiovisual cohesion, likely including a relationship to interactivity and sound effects, in addition, which will have to be explored in future work. Finally, our results offer a starting point for this future research, implicating several components of narrative and game design as potential additional factors in eliciting video game atmosphere.

2 RELATED WORK

We discuss prior work on the concepts of atmosphere and aesthetics in games, and then report on the connection between music and player experience (in general and in terms of physiological effects).

2.1 Aesthetics and Atmosphere in Games

Simon Niedenthal defines video game aesthetics as "the sensory phenomena that the player encounters in the game" as well as the "aspects of digital games that are shared with other art forms" [59]. The definition of aesthetics is closely tied to the Oxford Dictionary definition of (non-game) atmosphere: "the pervading tone or mood of a place, situation, or creative work" [4]. Aesthetics also constitute one of the pillars of the mechanics, dynamics, and aesthetics (MDA) framework developed by Hunicke et al. [36]. Here, aesthetics describe desirable emotional responses evoked by interacting with games (it should be noted that 'desirable' does not necessarily mean positive-valence emotions [9, 52]). For Greg Kasavin, writer and designer for the game *Bastion* [27], atmosphere constitutes the game's "unique identity and unique feel". He notes that atmosphere "help[s] create immersion" and is made up of thematic cohesion, internal consistency of mechanics, and specific detail [42]. Other past work has described a game designer's job in relation to atmosphere as ensuring the game is "aesthetically coherent and creates the appropriate mood" with the use of "lighting, colour palette, weather and atmospheric effects, special visual effects, music, ambient audio, and special audio effects" [2].

Previous academic work has addressed game aspects which may affect atmosphere, but none have tried to define it or used the term with full intent, except Mueller et al., who studied the design of visual patterns for the aesthetic experience of games [55]. Further, earlier work in this area has reported no studies, or focused on other aspects (e.g., inducing fear [29]) instead of the experience of atmosphere. To our knowledge, there is no prior work that empirically explores the value of audio-visual thematic fit in creating atmosphere in games.

2.2 Music and Player Experience

Previous research suggests that audio has strong ties to inducing player emotions [21, 68, 70] and is capable of both enhancing and disrupting immersion [35, 63, 68, 75]. Music listening, specifically, is capable of inducing emotions through a variety of mechanisms including brain stem reflexes, evaluative conditioning, emotional contagion, visual imagery, episodic memory, and musical expectancy [8, 41, 65]. Existing research on effects of general music listening is difficult to apply to games, due to their interactivity and the resulting crossmodal interplay between visuals, game mechanics, and music perception [11, 21, 49, 84]. Effects of music on the video game experience have been discussed before, but nevertheless remain one of the least studied game components in our field. In a 2009 study, Cassidy et al. gave participants the opportunity to play a driving game while listening to self-selected or experimenter-selected high or low arousal music. Results indicated that those who self-selected their soundtracks enjoyed their experience more, were more efficient, reported the lowest distraction and reduced anxiety [18]. Those in the high-arousal experimenter-selected music condition had the worst experience and performance. Tan et al. studied the effects of unrelated background music in an adventure role-playing game [77]. While this study only assessed performance, it found that the highest scores were earned by those playing with game-unrelated music. Yamada et al. found that participants playing a racing game with its built-in music or "dark, agitated" experimenter-selected music had lower scores than those in a silent condition [86]. In contrast, Tafalla's 2007 work [76] found men to perform twice as well with a soundtrack compared to without, emphasizing the complexity and remaining unanswered questions regarding effects of music in games.

From a musicological perspective, music has been argued to help expand games' magic circle into the surroundings of the player, helping to underline the uncanny overlap between reality and virtuality, and hide the medium [21, 83]. Music has strong ties to engagement and immersion in the games context [22, 56]. This has been explored empirically, with one paper finding that for gamers with little experience the inclusion of background music and sound effects increases immersion, although music was not explored separately [87]. There is also evidence that music influences

game-unrelated mouse activity and increases feelings of flow [48]. A recent study by Rogers et al. [68] confirmed effects of music on players' immersion and affective state. However, a previous study exploring effects of music in virtual reality games showed that the addition of background music did not significantly affect psychometric qualities of player experience, although it did affect more qualitative measures [70] (similar results occurred for another recent study on music effects in VR [69]).

2.3 Atmosphere and Audio in Horror Games

Although games of diverse genres (from *Half-Life* [82] to *Proteus* [45]) have been described as atmospheric, the concept appears to be discussed particularly often when it comes to horror and survival horror games such as *SOMA* [25] or *Silent Hill* [79]. One paper referring to an "atmosphere of horror" analyzed visual features from a series of classic images [55]. Other papers, although not making claims about atmosphere directly, discuss the effects of lighting patterns on motivation, performance, tension, and the ability to elicit emotions, respectively [13, 46, 58, 73]. One of the few papers which mention atmosphere in terms of audio notes the "chilling atmosphere" of *Silent Hill* and found that auditory and visual forewarning intensifies emotional reactions to upcoming frightening events [64]. Further, in a study of players' affective state prior to and after scary events in a game, music was rated as the third scariest element after shock and sound [81]. Towards creating fear, suspense, and anxiety in games, there are many recommendations surrounding sound effects [80], but few when it comes to music. However, past work has pointed to an association between the musical avant-garde, loosely defined as favouring experimental techniques, and horror media, as a way to create tension [34, 54]. Music has been described as a way to signify a continuous atmosphere of danger, and keep players tense [67]. However, music perception is also a strongly subjective experience [5, 70]. There are individual differences, particularly in the enjoyment of music that evokes negative emotions—this enjoyment is further positively correlated with absorption (a similar concept to immersion), and music empathy [30].

2.4 Physiological Effects of Music in Games

Many psychophysiological studies of music effects were conducted based on horror media. In 2008, Palmer found systolic blood pressure (SBP) to significantly increase between a baseline condition and a horror film [61]. Such increases were also inversely correlated with fearlessness and positively correlated with cold-heartedness in questionnaire-based measures. Blackmore conducted an experiment using EMG to record and compare the startle reflex of participants while they watched a playthrough of a horror game and played the game, the latter of which increased the fear state [10]. Vachiratamporn et al. analyzed player affect before and after scary events in a survival-horror game, with results indicating that heart rate was best for classifying player affect, with a 90% accuracy rate [81]. Another study, this time focusing on fear-related stimuli in an audio-only game found several statistical features of electroencephalography (EEG) that can differentiate fear from calm [28]. The psychophysiological aspects of video game music outside of the horror genre have been explored to a more limited degree. A 2004 study of Quake III [37] players comparing a silent or built-in music condition found that those who listened to music had significantly higher cortisol levels after gameplay [33]. In a 2010 study, no significant differences were present for EMG and electrodermal activity (EDA), yet significant correlations were observed between EDA and EMG and some dimensions of a game experience questionnaire, indicating negative correlations between EDA and flow, and between facial EMG and competence in the sound-on / music-off condition [57].

It is following in the steps of these papers that we empirically explore the connection between atmosphere and thematic cohesion, to validate the following definition of atmosphere: the emergent subjective experience that occurs when visual and auditory components of a video game fit together thematically.

3 RESEARCH DESIGN

We conducted two experiments to explore the concept of atmosphere in games as an effect of audiovisual thematic cohesion on player experience. Specifically: Does audiovisual thematic cohesion (i.e., thematic consistency in the relationship between sound and visual stimuli) affect the perception of atmosphere and player experience of immersion and other emotional states?

Both studies presented participants with different sound stimuli to the same game (*Bloodborne* [24]) in a between-subjects design, comparing different degrees of audiovisual thematic cohesion or dissonance, and exploring effects of this exposure on participants. The first study acted as a supporting study to the main, second study. The supporting study consisted of an online experiment, in which online respondents were assigned to watch gameplay videos, whereas in the main study, participants played the game in one of the sound conditions in a lab setting (see Table 2). We conducted both experiments to engage larger numbers of participants across different contexts. Further, similar results in the supporting study as the main study could validate the main study and explore effects of audiovisual cohesion in a less cognitively demanding context: i.e., where there is less cognitive distraction from playing, thus potentially more focus on audiovisual cohesion. The supporting study also mitigated potential bias of a local sample by recruiting online on Facebook and Reddit.

Inclusion criteria for both experiments required that participants have normal or corrected-to-normal vision, that they play at least one hour of video games per week, and had never played *Bloodborne* before. Participants were compensated with entrance into a raffle to win one of four $50 Amazon gift cards (two per study).

3.1 Stimuli

In both experiments, participants watched or played *Bloodborne*, a Victorian-era inspired survival horror role-playing game by FromSoftware [24]. The game allows for control of various sound settings, allowing us to overlay different background music to analyze the effect of audiovisual thematic cohesion on PX. Its setting and difficulty are ideal for experiencing fear, emotional challenge [23], and gameplay challenges triggering fear of losing points [3].

Measure	Description	Collected Online	Lab
Thematic Fit & Atmosphere	Agreement between responses to three 5-point Likert questions regarding how much atmosphere the stimulus had, how atmospheric it was, and how much thematic fit there was between the audio and visual elements of the stimulus. *In lab study: Questions regarding "atmospheric" and "how much atmosphere" collapsed into one question.* Thematic fit: *How well did the audio [element of the video/you heard] fit the theme of the visual environment and setting depicted?* on a scale of 1=*no thematic fit* to 5=*high thematic fit.* Atmosphere/ic: *To what extent would you describe the gameplay video you just watched as [atmospheric/having atmosphere]?* on a scale of 1=*not at all atmospheric / no atmosphere* to 5=*very atmospheric / a lot of atmosphere.*	X	X
Atmosphere through Game Elements	The importance of specific game elements to the experience of atmosphere and a game being perceived as atmospheric, and vice versa (*To what extent does the factor affect your experience of the game's atmosphere / your experience of the game as atmospheric?*), on a 5-point scale (1=*does not affect atmosphere at all*; 5=*strongly affects atmosphere*). Game elements: music, sound effects, environmental noise, setting design, graphical style, colour palette, immersion, story/narrative, enemy design, level design, sense of presence, flow, the presence of fog, high definition, multiplayer, and genre. *In lab study: Questions regarding atmosphere and atmospheric are collapsed into one with a slash ("atmosphere/ic").*	X	X
Influence on Purchase	How much a game's atmosphere or a game being atmospheric would influence participants' decision to buy it; two Likert questions on a 5-point scale (*1=not at all*; *5=a lot*).	X	–
Quality Perception	Whether a game being atmospheric influences participants' perception of its quality (*1=does not affect it all*; *5=strongly affects it*).	X	–
PANAS	The Positive and Negative Affect Schedule [20] consists of 10-item scales (1=*not at all*; 5=*very much*) resulting in two sum scores, one for positive affect and one for negative affect.	X	X
Frustration	Participant frustration with the stimulus was determined by adding "frustrated" to the list of PANAS items.	X	X
IEQ	The Immersive Experience Questionnaire [39] is a 30-item survey for measuring the experience of immersion in games on a 5-point scale (1=*strongly disagree*; 5=*strongly agree*).	–	X
PENS	Player Experience of Need Satisfaction questionnaire [66]. 21 items on a 5-point scale (1=*strongly disagree*; 5=*strongly agree*) keyed into one of three components: competence, autonomy, and relatedness.	–	X
PXI	The 35-item Player Experience Inventory [1] includes scales for functional aspects (goals and rules, audiovisual appeal, challenge, ease-of-control, progress feedback), and for psychosocial aspects (meaning, mastery, curiosity, immersion, autonomy) on a 5-point scale (1=*strongly disagree*; 5=*strongly agree*).	–	X
SAM	Participants rate their levels of dominance (1=*controlled*; 5=*in control*), happiness (valence; 1=*unhappy*, 2=*happy*), and arousal (1=*calm*; 5=*excited*) on a 5-point pictorial scale [12].	–	X
Physiological Measures	Skin conduction (SC), facial electromyography (fEMG), and heart rate variability (HRV) were collected as corollary measures of frustration, stress, and negative emotion, respectively.	–	X

Table 1: Factors collected (through a survey or physiological sensors) from in-lab and online experiment participants.

3.2 Experiment Design

In both studies, participants were randomly assigned to one of four conditions. These conditions differed in their audiovisual thematic cohesion, i.e., in each condition a different audio played in the background while participants watched or played *Bloodborne*. The operationalization of each condition can be found in Table 2 and the conditions are explained in the following:

(1) Cohesive No-Music Baseline (**BA**): No background music was present, utilizing silence as a "horror sound" [85] and representing the game's most common built-in music condition (large portions of *Bloodborne* do not feature background music; this is mostly played for boss battles).

(2) Cohesive Music (**CM**): Music from *Bloodborne*'s original soundtrack was played to ensure maximal thematic fit to the game. Based on an iterative process, the songs were arranged to line up with the gameplay in *Bloodborne*'s first level.

(3) Dissonant Music (**DM**): Happy music from YouTube was played, to ensure maximal dissonance from the dark atmosphere of the game, representing the type of music that can disturb immersion [35].

(4) Dissonant Voiceover (**DV**): Speech can easily disturb immersion [35], yet players often listen to podcasts or consume other media while playing [71]. In this condition, we played the audio of YouTube videos on the history of Nintendo and related franchises, chosen to be at least vaguely interesting, but thematically unrelated to the gameplay and setting of *Bloodborne*.

Sound effects remained audible in all conditions, while the music slider in the game was turned down to mute, with the corresponding sound condition audio overlaid. The duration of gameplay in the main study differed from the viewing duration in the supporting study, as the latter entailed more surveys, and online participants are unlikely to complete watching much longer gameplay videos (this was confirmed by a high number of incomplete responses). Given the differing lengths of gameplay in the lab experiment and the video in the online experiment, these conditions were operationalized differently to fit the length of the experiment. For the conditions in which music is present, enough songs were chosen to fill the length of the experiment to avoid negative side effects associated with game music repetition [7, 32, 35].

3.3 Measures and Analysis

Dependent variables included questions regarding perceived thematic fit and atmosphere, as well as measures for the players' affective state, immersion, and general player experience. Table 1 lists all these measures in detail, and indicates which were collected in which experiment. Since the collected data related to most measures did not meet the assumptions to perform an analysis of variance, we analyzed results via non-parametric Kruskal-Wallis tests followed by Dunn's post-hoc tests for pairwise comparisons with Bonferroni corrections.

3.4 Hypotheses

We expected to find evidence for the following hypotheses:

H1: Ratings of thematic fit and atmosphere are higher in audiovisually cohesive conditions.

H2: Audiovisually cohesive conditions elicit more positive and less negative affective experiences (measured by the PANAS, the SAM questionnaire, and self-reported frustration).

H3: Immersion and player experience (as measured by the IEQ, PENS, and PXI) are higher/more positive in audiovisually cohesive conditions.

	Supporting Study	Main Study
BA	**Bloodborne Sound Effects:** No background music present, only sound effects.	**Bloodborne Sound Effects:** No background music present, only sound effects.
CM	**Bloodborne Soundtrack:** The game's main theme ("Omen").	**Bloodborne Soundtrack:** Songs from the Bloodborne soundtrack: "Omen", "The Night Unfurls", "Lullaby for Margo", "The First Hunter", "Moon Presence", "Bloodborne", "Hail the Nightmare", and "Darkbeast".
DM	**Happy, Upbeat Music:** 'Something Cute" by FirstNote, and the My Little Pony "Friendship is Magic" theme song, chosen for their upbeat	**Happy, Upbeat Music:** Ukelele songs from the "HAPPY Music - Good Morning Ukulele Music - The Best SUMMER Music" YouTube video.
DV	**Unrelated Spoken Language:** An audio excerpt from YouTube video "History of NINTENDO CONSOLES: From the FamiCom to World Domination!"	**Unrelated Spoken Language:** Audio versions of the following YouTube videos (in this order): "History of NINTENDO CONSOLES: From the FamiCom to World Domination!", "The History of The Legend Of Zelda (ft. PeanutButterGamer) | A Brief History", and "The History of Pokémon | A Brief History".

Table 2: Operationalization of the four conditions in the supporting study (online) and the main study (lab).

H4: There are more frequent peaks in skin conductance for players in the audiovisually dissonant conditions.

H5: Players' heart rate variability is lower in audiovisually dissonant conditions.

H6: There are more negative-valence facial events in audiovisually dissonant conditions.

We expected that the audiovisually dissonant conditions (**DM**, **DV**) would be rated as having the lowest thematic fit, less atmosphere, and being less atmospheric than the conditions designed for thematic cohesion (**BA**, **CM**), since we used the original soundtrack and the original sound effects in these conditions (**H1**). Building upon this, we expected higher negative-affect scores (including frustration), and lower positive-affect scores for participants in the dissonant conditions in comparison to the cohesive ones (**H2**).

We held additional hypotheses for the lab study. Here, we expected that the audiovisually cohesive conditions would lead to improved player experience and increased immersion (**H3**). In terms of physiological effects, we expected more frequent peaks in skin conductance (SC) for players in the dissonant than in the cohesive conditions (**H4**), as previous work has shown that SC peaks are highest when users are frustrated and less in control of a situation [15]. We similarly expected players to experience lower heart-rate variability (HRV) indicating stress, and more negative-valence facial events in conditions of audiovisual dissonance [51] (**H5, H6**).

4 SUPPORTING STUDY: ONLINE VIDEO EXPERIMENT

The first study was conducted as a between-subjects online experiment, asking participants to view gameplay videos with differing audiovisual thematic cohesion, to gain insight into perceptions of atmosphere in games while participants are not distracted by playing themselves. We acknowledge that there is a difference between watching and playing a horror game [10], however atmosphere as created by the interplay between auditory and visual elements is something that games and movies share [59], therefore making this a viable source of data on atmospheric experiences. Further, given the increasing popularity of streaming websites such as Twitch, the consumption of games through a passive medium (watching) has never been more relevant.

4.1 Participants and Procedure

Participants were recruited online via the *r/videogamescience* subreddit[1], and asked to fill out a demographic survey. They were then assigned to one of the four conditions, and asked to watch a gameplay video (3 minutes 18 seconds) with the audio corresponding to the condition. Other than the audio component, the video was always the same excerpt from a walkthrough YouTube video[2]. Participants then answered several questionnaires, detailed below.

A total of 111 participants responded to the survey, yielding 59 finished responses in the online experiment. Participants had an average age of 25.7 years with a standard deviation of 6.25 years (8 participants did not provide their age), and 83.1% of them self-reported as biologically male.

4.2 Measures

The dependent variables in this experiment cover aspects regarding participants' understanding of atmosphere (in general and in regards to the stimulus) and aspects regarding participants' experience with the stimulus (see Table 1). First, we measured how atmospheric the condition was perceived to be, and the level of thematic fit between the audio and setting of the video watched, via three custom Likert questions. We then asked participants to rate specific game elements chosen based on the authors' reading of game reviews, and personal gaming experience (e.g., narrative, sound effects, genre) in terms of their perceived importance for atmosphere in games. Further, participants were asked to report whether game atmosphere impacted their purchasing decisions, and their perception of game quality. Finally, we included measures concerning viewers' affective state, operationalized via the two dimensions of the PANAS [20], expanded by an additional single-item measure of self-reported frustration.

4.3 Results of Supporting Study

In the following, we present the results of the supporting study regarding thematic fit and atmosphere (**H1**) as well as affective experience (**H2**). In addition, the study was used to investigate the effect of atmosphere on purchase intentions and the quality perception of a game.

Thematic Fit and Atmosphere. To investigate **H1**, we analyzed atmosphere and thematic fit in the different conditions. We found that the four conditions resulted in significantly different answers to the question of thematic fit ($\chi^2(3)=35.65$, $p<.001$), how atmospheric participants found the video ($\chi^2(3)=21.76$, $p<.001$) as well as how much

[1] http://www.reddit.com/r/videogamescience

[2] "Bloodborne 100% Walkthrough Part 1 – Central Yharnam". https://www.youtube.com/watch?v=eENiAHP-UH0

		BA	CM	DM	DV
	n	15	18	13	11
	Thematic Fit	4.27 / 0.80	4.28 / 0.58	1.46 / 0.88	1.55 / 1.29
	Atmosphere	4.00 / 0.76	4.39 / 0.70	3.00 / 1.00	3.45 / 1.13
	Atmospheric	3.93 / 0.80	4.39 / 0.61	2.54 / 1.33	3.18 / 1.17
PANAS	Pos. Affect	26.40 / 10.17	25.00 / 6.41	18.08 / 5.20	18.27 / 5.29
PANAS	Neg. Affect	17.27 / 6.27	13.89 / 4.69	14.92 / 5.39	16.27 / 4.56
	Frustration	2.00 / 1.51	1.44 / 1.15	1.54 / 0.88	1.82 / 1.33

Table 3: Mean / standard deviations for thematic fit, perceived atmosphere, and affective experiences when watching gameplay videos in the supporting online study.

atmosphere the participants thought the video had ($\chi^2(3)=18.00$, p<.001). Descriptive thematic fit and atmosphere measures can be found in Table 3. Post-hoc comparisons with Bonferroni correction revealed that each of the two audiovisually cohesive conditions (**BA**, **CM**) were perceived as significantly more thematically fitting than the audiovisually dissonant conditions (**DM**, **DV**); all p_{adj}<.001; r_{BA-DM}=.80, r_{BA-DV}=.53, r_{CM-DM}=.55, r_{CM-DV}=.54. Thus, we establish supporting result **SR1: Perceived thematic fit is significantly higher in audiovisually cohesive conditions**.

Regarding how atmospheric participants found the video, post-hoc comparisons revealed that both cohesive conditions ranked significantly higher than the **DM** condition (each p_{adj}<.05; r_{BA-DM}=.39, r_{CM-DM}=.58). Based on these findings, we establish **SR2: Audiovisually cohesive conditions were perceived as more atmospheric than the condition with dissonant music**. Additionally, the post-hoc comparison revealed that the **DV** condition was considered as significantly less atmospheric than the **CM** condition (p_{adj}<.05; r_{CM-DV}=.37), whereas no effect was found between the **DV** condition and the **BA** condition (p_{adj}=.77). Thus, we formulate **SR3: Participants considered the condition with cohesive music to be significantly more atmospheric than the condition with dissonant voiceover**.

The post-hoc comparisons of the second self-reported perceived-atmosphere question (how much atmosphere the video had) revealed that both cohesive conditions scored significantly higher than the **DM** condition (both p_{adj}<.05, r_{BA-DM}=.36, r_{CM-DM}=.54), which leads to **SR4: Audiovisually cohesive conditions were perceived as having more atmosphere than the condition with dissonant music**.

Participants also rated to what extent specific game elements affect their experience of a game's atmosphere or their experience of a game as atmospheric. Twelve of these components were rated significantly higher than the neutral median of 3: *music*, *setting design*, and *immersion* all had median ratings of 5, while *story/narrative*, *sound effects*, *environmental noise*, *colour palette*, *enemy design*, *level design*, *sense of presence*, *flow*, and *graphical style* had median ratings of 4. *Multiplayer* had a median rating of 1, which was significantly lower neutral, while the *presence of fog*, *high definition*, and *genre* did not differ significantly from the neutral rating.

Affective State. On average, participants reported a mean negative-affect score of 15.68 (*SD*=5.63), and a mean positive-affect score of 22.27 (*SD*=7.98). Frustration scores were low (*M*=1.66, *SD*=1.21). Table 3 shows descriptive measures across conditions. Regarding **H2**, we found no significant effects for negative affect between conditions ($\chi^2(3)=3.35$, p=.341), nor for self-reported frustration ($\chi^2(3)=2.40$, p=.49). However, positive affect differed significantly ($\chi^2(3)=12.91$, p=.005). As a result of post-hoc comparisons, we found that participants in the audiovisually cohesive conditions experienced significantly more positive affect than those in the **DM** condition (both p_{adj}<.05; r_{BA-DM}=.37, r_{CM-DM}=.35). Thus, we establish **SR5: Viewers of audiovisually cohesive gameplay experienced significantly more positive affect than viewers in the condition with dissonant music**.

Influence on Purchasing and Quality Perception. We also asked the online participants questions regarding the influence of a game's perceived atmosphere on their purchasing decisions and on how they perceive game quality. Participants responded positively with a median response of 4 when asked whether a game's atmosphere (*M*=3.57, *SD*=0.95) or a game being atmospheric (*M*=3.52, *SD*=0.95) would influence their decision to buy it. When asked whether a game being atmospheric influences their perception of its quality, participants had a median response of 4 (*M*=4.05, *SD*=0.95). One-sample Wilcoxon signed rank tests found that participant responses to all three questions were significantly higher than the neutral median scale value of 3 (p<.05).

5 MAIN STUDY: IN-LAB GAMEPLAY STUDY

This second between-subjects study was designed to explore effects of audiovisual thematic cohesion with more ecological validity, by asking participants to play *Bloodborne* in one of the mentioned audio conditions. In this study, we investigated hypotheses **H1**–**H6**.

5.1 Stimuli

This study was also conducted with *Bloodborne* [24], using a PlayStation 4 console and Dualshock 4 controller. The game's first level (consisting of Iosefka's Clinic and Central Yharnam locations) was chosen because they are the first areas players of the game would encounter and therefore serve as an introduction to the game's setting and themes. Further, given the game's notorious difficulty, the first level was thought to be the most accessible for new players.

5.2 Participants

The lab experiment ran a total of N=50 participants. As some participants did not answer all questions or had technical issues when capturing physiological data, some participants had to be left out of certain analyses. The number of participants are acknowledged in the respective subsections. Participants had an average age of 23.5 years (*SD*=5.79 years), and 80% of them self-reported as biologically male. Participants were recruited through posters on the university campus.

5.3 Procedure

The experiment made use of SC, HR, and facial EMG sensors, as well as a computer running iMotions, to record physiological and additional psychometric data. The experiment took place in a room containing a couch, speakers, and a TV (191 cm from the couch), designed to look and feel like a living room to maximize ecological validity.

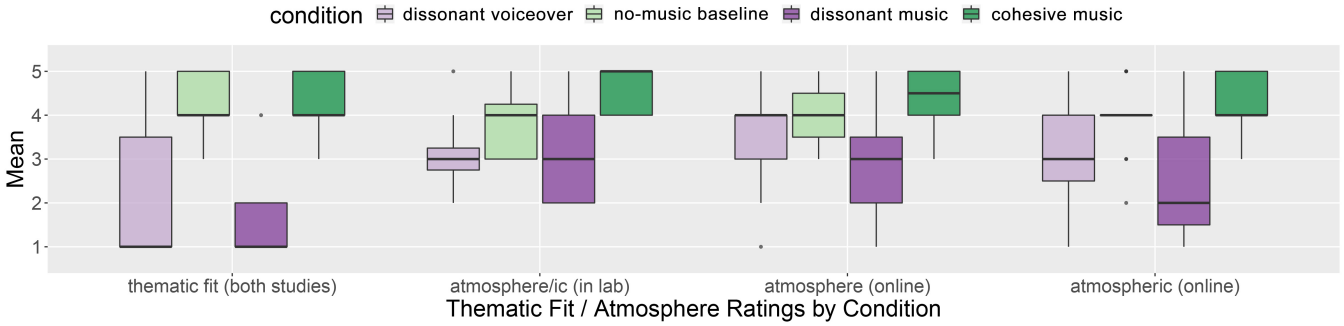

Figure 1: Average response on a Likert scale (1–5) for perceived atmosphere / thematic fit by thematic dissonance condition.

Baseline and Training. Once participants were in the testing environment, they were told to fill out a pre-test questionnaire on the computer at the experimenter's desk and were then fitted with SC, HR, and fEMG electrodes to their fingers and face (all electrodes were pre-gelled single-use). The participants were then asked to sit quietly for two to five minutes with their hands on their knees and palms facing up. During this time, baseline physiological data was recorded to the computer. SC sampling was collected at the iMotions default rate of 128 Hz; HR sampling was collected using a plethysmography ear-cuff at the iMotions default rate of 128 Hz. Facial EMG sampling was collected with two electrodes at the corrugator supercilii (brow) and two electrodes at the zygomaticus major muscle region (cheek), using the iMotions default rate of 1024 Hz. The experimenter recorded two minutes of baseline data once the phasic output on the live SC data feed stopped decreasing and became consistent.

Participants began in a *Bloodborne* location with no monsters to fight (Hunter's Dream). Each participant was then taught to play the game one button at a time, with explanations of the health, stamina, blood echo (points), and respawn systems. After some time to get comfortable with the controls, all participants were then instructed to begin playing.

Testing Phase. Participants were told to interact with the first teleporting headstone and to pick the 1st Floor Sickroom as their in-game destination. Participants played *Bloodborne* for a period of 25 minutes. This time frame was chosen to ensure enough exposure to the stimuli. Subsequently, they were asked to fill in questionnaires on their experience.

5.4 Measures

This study measured a larger number of dependent variables to include more aspects of PX and physiological responses, see Table 1. The pre-survey also collected demographic data.

5.5 Results of Main Study

Here we report the results with regards to the aforementioned hypotheses in the lab study.

Thematic Fit and Atmosphere. For the analysis of thematic fit, atmosphere and affective state we had to exclude two participants, since they did not answer the corresponding questions. The distribution of participants across conditions as well as means and standard deviations can be found in Table 4. Regarding **H1** and in line with results of the supporting study, we found that both thematic fit ($\chi^2(3)=26.78$, $p<.001$) and how atmospheric participants perceived the experience to be ($\chi^2(3)=19.63$, $p<.001$) differed significantly across the four conditions. Pairwise comparisons revealed that the perceived thematic fit was significantly lower in the **DM** condition than in both audiovisually cohesive conditions (both $p_{adj}<.001$; $r_{BA-DM}=.61$, $r_{CM-DM}=.65$). Based on this result, we establish main result **MR1: Perceived thematic fit is significantly higher in audiovisually cohesive conditions than in the condition with dissonant music**. For the remaining comparisons, no significant effects were found (each $p_{adj}>.05$). Thus, **MR1** is in line with **SR1** except that perceived thematic fit did not differ between the **DV** condition and the audiovisually cohesive conditions.

		BA	CM	DM	DV
	n	12	14	10	12
	Thematic Fit	4.25 / 0.45	4.29 / 0.61	1.40 / 0.52	2.75 / 1.55
	Atmosphere	3.83 / 0.84	4.57 / 0.51	3.00 / 1.05	3.08 / 0.90
PANAS	Pos. Affect	30.67 / 3.47	32.57 / 6.55	32.50 / 7.04	32.17 / 8.29
PANAS	Neg. Affect	22.33 / 6.13	23.86 / 9.38	18.20 / 8.16	21.00 / 7.24
	Frustration	3.17 / 1.34	3.14 / 1.75	2.70 / 1.16	2.83 / 1.34
SAM	Arousal	6.33 / 1.37	6.79 / 1.12	5.90 / 1.10	6.67 / 1.56
SAM	Valence	3.75 / 0.45	3.64 / 1.01	3.80 / 0.79	3.67 / 0.89
SAM	Domin.	2.67 / 0.78	2.86 / 0.95	3.00 / 0.94	3.25 / 0.97

Table 4: Mean / standard deviations for thematic fit, atmosphere, and affective states in the lab study.

Regarding atmosphere, post-hoc comparisons revealed **MR2: Both audiovisually dissonant conditions are perceived as significantly less atmospheric than the condition with cohesive music** (both $p_{adj}=.001$; $r_{CM-DM}=.54$, $r_{CM-DV}=.52$). Since the two questions assessing perceived atmosphere used in the supporting study were combined into one question in the main study, **MR2** is in line with the results of the supporting study (**SR2**, **SR3**, **SR4**).

Affective State. To investigate **H2**, we analyzed potential effects regarding affective experiences as measured by the PANAS, SAM, and self-reported frustration. On average, participants reported a

		BA	CM	DM	DV
	n	12	14	12	12
PENS	Competence	3.17 / 0.75	2.69 / 0.98	3.08 / 0.99	3.03 / 0.93
	Autonomy	3.00 / 0.80	3.10 / 0.81	3.42 / 0.77	2.92 / 1.10
	Relatedness	2.17 / 0.90	2.21 / 0.64	1.92 / 0.68	2.50 / 0.89
	Immersion	2.74 / 0.81	3.14 / 0.67	3.29 / 0.68	3.03 / 0.92
	Controls	3.25 / 0.97	3.29 / 1.12	3.36 / 1.03	3.42 / 1.06
IEQ	Immersion (sum total)	112.58 / 12.94	112.36 / 11.43	119.00 / 11.10	108.92 / 22.01
	Challenge	3.88 / 0.60	3.77 / 0.54	3.63 / 0.41	3.48 / 0.80
	Control	3.83 / 0.60	3.69 / 0.45	3.82 / 0.49	3.65 / 0.88
	RW Dissoc.	3.24 / 0.74	3.58 / 0.51	3.81 / 0.42	3.42 / 0.82
	Emot. Involv.	3.29 / 0.54	3.30 / 0.61	3.74 / 0.58	3.13 / 0.86
	Cog. Involv.	4.01 / 0.51	3.83 / 0.65	4.04 / 0.53	3.82 / 0.75
PXI	Meaning	2.61 / 1.00	2.74 / 1.12	2.89 / 0.77	2.83 / 1.18
	Mastery	2.94 / 0.47	2.52 / 1.04	3.04 / 1.18	2.79 / 1.13
	Curiosity	3.73 / 0.96	3.88 / 0.82	4.44 / 0.39	3.75 / 1.06
	Immersion	3.77 / 0.91	3.84 / 0.72	4.15 / 0.53	3.50 / 0.87
	Autonomy	2.92 / 1.05	2.81 / 1.10	3.36 / 1.11	3.42 / 0.91
	Progr. Feedback	2.44 / 0.95	2.36 / 1.24	2.58 / 1.02	2.42 / 1.26
	Goals & Rules	2.77 / 1.04	3.16 / 1.09	3.15 / 1.11	2.63 / 0.84
	Audiovis. App.	3.78 / 1.26	4.40 / 0.71	4.53 / 0.61	3.78 / 1.17
	Challenge	3.33 / 0.93	3.02 / 1.06	3.56 / 1.14	3.03 / 0.95
	Ease of Control	3.52 / 0.86	3.46 / 0.94	3.60 / 0.89	3.52 / 0.96

Table 5: Mean / standard deviations for general player experience in the lab study.

mean positive-affect score of 32.32 (*SD*=6.62), and a mean negative-affect score of 21.36 (*SD*=7.88). A Kruskal-Wallis test indicated that the different conditions did not result in statistically different positive-affect scores ($\chi^2(3)$=2.20, p=.53), negative-affect scores ($\chi^2(3)$= 4.96, p=.18) nor self-reported frustration ($\chi^2(3)$=1.20, p=.75).

For the SAM, arousal was overall rated positively (*M*=6.43, *SD*=1.31), while valence (*M*=3.74, *SD*=0.80) and dominance (*M*=2.96, *SD*=0.90) received lower ratings. A Kruskal-Wallis test indicated that the conditions did not result in statistically different arousal ($\chi^2(3)$=3.23, p=.36), happiness/valence ($\chi^2(3)$=1.10, p=.78), or dominance scores ($\chi^2(3)$=2.97, p=.40). Thus, **SR5** could not be replicated in the main study.

Immersion and General PX. On a descriptive level, we see that immersion (as measured by the respective PENS and PXI subscales, and IEQ sum total) tended to be lowest for the conditions without background music (**BA** and **DV**). Surprisingly, the **DM** condition consistently yielded the highest rating of immersion, generally followed by the **CM** condition. These results could suggest that the mere presence of background music may be more important than thematic fit for immersion. However, regarding **H3**, results of the Kruskal-Wallis tests indicate that the four conditions did not significantly impact PXI[3], IEQ, nor PENS subscaless. All descriptive measures per condition can be seen in Table 5.

Physiological Responses. Due to technical issues, physiological data was incomplete for 13 participants, which had to be removed for this part of the analysis. Thus, 9 participants remained in the **BA**, 8 in the **CM**, 10 in the **DM** and 10 in the **DV** condition. We expected more frequent peaks in skin conductance, a lower heart rate variability, and more negative-valence facial events in the audiovisually dissonant conditions (**H4–H6**). For the SC peaks/min (*M*=6.68, *SD*=2.44) and HRV increase over baseline (*M*=0.17, *SD*=0.18), results of the Kruskal-Wallis test indicate that the different conditions did not result in statistically significant differences with regards to skin conductance or heart rate variability.

Various measurements of EMG activation at the corrugator supercilii (brow) and the zygomaticus major muscle region (cheek) were also dependent variables for the physiological response. These measurements included normalized average EMG signal, normalized EMG amplitude average, EMG peaks per minute, and EMG event duration. The different conditions did not result in statistically different measurements at the brow and cheek muscles, except for the normalized EMG amplitude average at the brow muscle. This did vary significantly by condition ($\chi^2(3)$=9.00, p=.03). Post-hoc multiple comparisons revealed that the **DM** group (*M*=63.30, *SD*=18.67) differed significantly from the **DV** group (*M*=37.88, *SD*=16.20, p_{adj}=.03; r_{DM-DV}=.47). There was no significant difference for the two thematically cohesive groups (**CM**: *M*=39.73, *SD*=14.95; **BA**: *M*=46.23, *SD*=11.68). This leads to **MR3: The normalized EMG amplitude average at the brow muscle is significantly higher for players listening to dissonant music than those listening to dissonant voiceover**.

6 DISCUSSION

In this work, we explored thematic dissonance as a mismatch between the auditory and visual elements of a game. We consider audiovisual thematic cohesion in a game to be tied to players' experience of atmosphere; we thus expected audiovisual thematic dissonance to disrupt this.

The studies show that both players and viewers rated audiovisually dissonant conditions as having the lower thematic fit (**SR1, MR1**), as having less atmosphere (**SR2**, **SR3**), and as being less atmospheric (**SR4, MR2**), resulting in statistically different answers in comparison to the cohesive conditions. This, combined with the fact that the order of conditions from least atmospheric to most follows the same pattern as conditions ordered from least thematic fit to most, lends support to our proposed definition of atmosphere: the emergent subjective experience that occurs when visual and auditory components of a video game have strong thematic cohesion and therefore contribute to the same aesthetic. Consequently, these results provide evidence for **H1: Ratings of thematic fit and atmosphere are higher in audiovisually cohesive conditions**. HCI practitioners and game developers interested in the topic of video game atmosphere can now make recourse to a first academic definition thereof, supported by empirical evidence of a tie between atmosphere and strong audiovisual thematic cohesion.

Across both studies, there was no significant difference between the two cohesive conditions (i.e., the condition in which *Bloodborne*'s own soundtrack was present, and the baseline condition with only sound effects were rated similarly for atmosphere and thematic fit). This indicates that the addition of thematically fitting background music did not significantly affect atmosphere or thematic fit for this game. On first glance, this may be surprising, however large parts of *Bloodborne* are indeed without music by default; thus the existing sound effects and ambient noises may

[3]For the PXI's audiovisual appeal subscale, it should be noted that the items do not address auditory aspects.

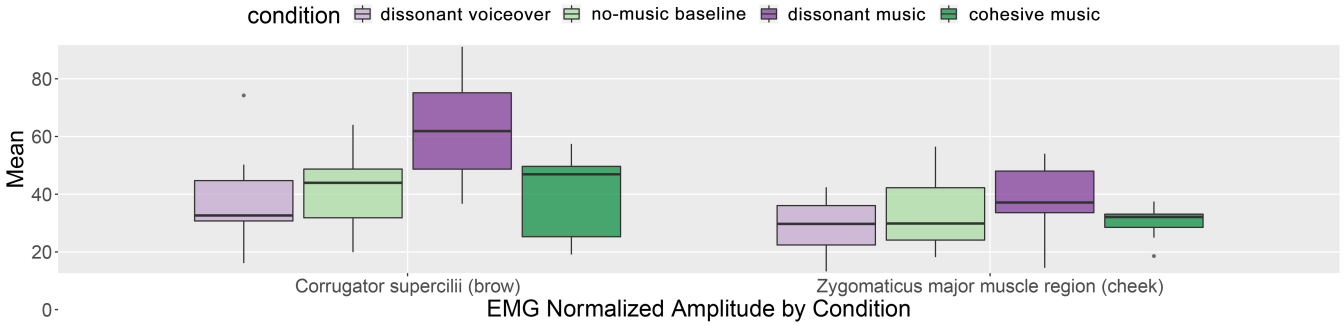

Figure 2: Normalized EMG amplitude average at brow and cheek muscles for each study condition.

have been designed to elicit a distinct, appropriate thematic tone together with the visuals on their own, using music only to intensify emotional events such as boss battles. However, even given this design, it is surprising that these conditions yielded no significant differences in perceived thematic fit or atmosphere. It seems that the power of carefully orchestrated sound effects and environmental noise to convey thematic fit is equivalent to that of aesthetically fitting music. Similarly, while the two dissonant conditions (with happy music, and unrelated voiceover, respectively) were rated as less atmospheric and thematically fitting than the cohesive ones, there was no significant difference between the dissonant ones. This is especially interesting in light of the many players who listen to podcasts or other media while playing; listening to unrelated content appears to lower thematic fit and the degree of perceived atmosphere, however the thematic tone of the additional content may not matter much.

Affective Experience and PX. The supporting study revealed that positive affect was significantly higher in both audiovisually cohesive conditions than in the **DM** condition (**SR4**). However, this result could not be replicated for players in the lab study. Affective state (in the form of positive and negative affect scores, self-reported frustration, valence, arousal, and dominance) was not significantly affected by the condition of audiovisual thematic fit in the lab study. Potentially, **SR4** could not be replicated in the lab study because participants interacted with the game (and did not only watch a video), which might shift their focus more to the interaction itself, leading to a potential lower focus on audiovisual thematic fit. Consequently, we see **H2: Audiovisually cohesive conditions elicit more positive and less negative affective experiences** as partially supported.

While the literature suggested that thematic dissonance and "breaking" of atmosphere should negatively impact player experience, the results of our in-lab experiment unexpectedly did not show such effects. The factors of player experience we investigated in the lab study showed no differing results based on the study conditions. Particularly the lack of difference in immersion is surprising, as this is very commonly described as an important factor in the experience of or a result of atmosphere in games [6]. As such, we did not find evidence supporting **H3: Immersion and player experience are higher/more positive in audiovisually cohesive conditions**.

Similarly, the physiological responses largely did not yield statistically significant differences between conditions, in neither skin conductance peaks per minute nor HRV percentage change. This reinforces the lack of difference found in the self-reported affective state data in the lab study. Therefore, neither **H4: There are more frequent peaks in skin conductance for players in the audiovisually dissonant conditions** nor **H5: Players' heart rate variability is lower in audiovisually dissonant conditions** is supported, given our data. EMG measures of brow and cheek activity overall also did not vary significantly between conditions. However, a difference could be found in normalized EMG amplitude average of the brow muscle, which did vary with condition. This indicates that players in the **DM** condition showed more intense negative-valence emotional events than players in the **DV** condition [51], likely indicating increased mental workload [31] (**MR3**). It further suggests that dissonant music has a stronger effect on player experience (PX) than dissonant voiceover does. This is interesting for game design in the sense that it shows a physiological effect of thematic cohesion in game audio, while suggesting that listening to unrelated voiceover (e.g. , podcasts or radio) does not affect PX as much. In light of exploring music effects in lab studies, this both highlights the importance of exploring the factor of thematic cohesion in future research, and further hints that the fact that many players listen to other media while playing (see below) is not necessarily a significant confound to consider, when applying results from lab studies to more general, in-the-wild gameplay. However, this significant difference could only be found between the two dissonant conditions. Thus, since no effects could be found between audiovisually cohesive and dissonant conditions, **H6: There are more negative-valence facial events in audio-visually dissonant conditions** is not supported.

These results are particularly interesting in light of the increasing number of players who listen to other media during gameplay (e.g., podcasts, audiobooks, Spotify), a phenomenon identified and described in recent work by Rogers and Weber [71]. Our results show that player experience was not detrimentally affected by overlaying unrelated and even thematically dissonant audio. Future work may have to explore effects of additional visual content, i.e., when players not only listen to the additional media, but also display and watch the media's visual content (e.g., Twitch, YouTube).

Despite the lack of difference in player experience and immersion, the participants' ratings of the cohesive conditions as significantly more thematically fitting and more atmospheric than dissonant conditions confirms the connection between atmosphere and audiovisual thematic cohesion, and supports the operationalization chosen in this study. Together, these findings may indicate that atmosphere is a more nuanced or long-term phenomenon than anticipated. The auditory aspects may have influenced these null results; there is precedence in the literature for surprisingly negligible or mixed effects of audio on player experience. For example, one study showed a lack of effects of adding music to a virtual reality game [70], while in other studies the specific music can either increase or decrease immersion [72]. Research in this area tends to explain this phenomenon through evidence that effects of music on both listeners and players are highly subjective [5, 19, 70]. Further, there is some speculation that music effects may be diminished when listeners are cognitively distracted [70]; the challenge provided by the gameplay in *Bloodborne* would likely qualify.

Adding Insult to Injury vs. Cognitive Load. Although the dissonant conditions largely did not cause an increase in negative-valence physiological responses, there is some support that thematic dissonance between background music and setting can increase the intensity of negative-valence muscle-activity events [51]. The intensity of activity in the corrugator muscle region as measured by the average amplitude of EMG signals from the brow muscle was significantly higher in the dissonant music (**DM**) condition as compared to the dissonant-voiceover (**DV**) condition. One possible reason for this could lie in the high difficulty of the game. Participants may have interpreted the happy music in the **DM** condition as relating to their performance in a mocking way, contributing to higher intensity in negative valence responses. The same would not have occurred during the dissonant-voiceover condition: there, the unrelated voiceover may have been thematically at odds with the setting, but would likely not yield a potential emotional interpretation by players. Another possible reason is that the happy music in our dissonant-music condition increased intensity because it was perceived as annoying. This would explain the intensified negative-valence responses even though joyful music could otherwise reasonably be expected to intensify activity in muscle groups associated with smiling rather than frowning. In future studies, we will additionally measure participants' individual perception and liking of the used background music to investigate this theory.

Links between music, cognitive appraisal, and workload have been pointed out in prior literature, indicating that specific music attributes such as perceived high arousal may increase cognitive load, but also depends on context [18, 21, 60, 74, 78]. In light of this, our findings reflect results of the study by Tan et al. in which players performed best with unrelated music as opposed to adaptive music that encouraged player attention to facilitate game progression [77].

Extending Atmosphere. Additionally the definition of atmosphere may need to be expanded to include other factors that contribute to thematic cohesion beyond the audiovisual components. It is possible that the contribution of the third pillar of video game experience, interaction, and its relationship to sound effects which ground the player as an actor in the game's space, is missing from our definition of game atmosphere, and imperative to cause the hypothesized effects of atmosphere on qualitative measures of PX. The results of the online experiment implicate additional factors which may influence whether players consider a game to be atmospheric — beyond the auditory aspects (music, sound effects, environmental / ambient noises) which were also rated highly. These additional factors include visual aspects (colour palette, graphical style, enemy design), and ones tied to narrative or game design (setting design, story / narrative, level design). Although those aspects tied to game design are still portrayed through visual and auditory means. Other emergent components of the player experience were also rated positively (immersion, sense of presence, flow). This of course cannot claim to be a comprehensive list, as participants rated a set of pre-defined options, but may constitute a starting point for future research. Future studies exploring atmosphere should investigate the manipulation of the thematic fit between the above elements of gameplay interaction and the audiovisual elements, in order to more deeply explore the effects of atmosphere on PX. This would provide a more generalizable definition of game atmosphere as the emergent subjective experience that occurs when visual, auditory, and interactive gameplay components of a video game have strong thematic cohesion. These results call for further study on what constitutes atmosphere in games, and how it affects player experience.

Furthermore, participants in the online experiment confirmed that a game's perceived atmosphere was a factor in their purchasing decisions, as well as in their perception of a game's quality. This emphasizes the importance of video game atmosphere for players, and accordingly highlights the merits of studying how atmosphere is perceived and potentially can be designed.

6.1 Limitations

In terms of operationalization, it is possible that the cohesive-music (**CM**) condition could itself have contained a degree of dissonance, as the game was not designed to employ the soundtrack in this order during gameplay. However we emphasize the iterative stimuli pre-testing used to arrange the soundtrack pieces to match the level outline, and that the soundtrack was composed to match the game's general tone. Further, given that this condition was perceived as having the highest thematic fit as well as highest atmospheric rating (Figure 1), unintended dissonance seems unlikely. In the comparison between the cohesive-music and the dissonant-music conditions, we point out that players' subjective perception of music may vary, i.e., their perception of *Bloodborne*'s soundtrack as well as the happy music could impact results. However, we also point out that the *Bloodborne* soundtrack pieces share a kind of "tonality" or theme, and the tonality or thematic fit of the happy music seems clearly dissonant to it. This is also substantiated by the lower ratings of thematic fit for the dissonant-music condition.

As mentioned previously, it appears that atmosphere may constitute an important, but also highly nuanced, potentially subjective, and subtle experience. It is possible that the sample sizes were unable to display the qualitative effects of atmosphere on player experience. Further, there has been some indication that game genre — and specifically, fast-paced gameplay — could distract players from noticing audio explicitly [17, 71, 84]. However, we point out that

a fast pace need not impact subconscious effects of audio, aesthetics, and atmosphere; there is no indication that fast-paced games cannot be atmospheric just as commonly as slow-paced games (Bioshock [26] and Bastion [27] are great examples of fast-paced games renowned for their atmosphere).

Participants were predominantly male in both studies. There is some evidence of gender differences in music processing and preferences [47, 53], so this may have had an effect on our results, and will have to be explored in a more balanced study in the future. Further, while the online survey asked participants to rate some game aspects on their impact on game atmosphere, this was not a comprehensive list, and therefore could be further developed in the future. The likelihood that this list may have influenced participants' expectations of what atmosphere could consist of however is nonexistent, as this was the last question asked.

7 CONCLUSION

This work explored the concept of video game atmosphere, a topic for which empirical research is particularly sparse, despite it being a quality of importance for players. Our experiments have formalized a definition of atmosphere and empirically validated that players rate audio-visually cohesive conditions as more atmospheric than audio-visually dissonant conditions. This should provide a starting point in research and facilitate conversations about the topic which are often fraught with subjective statements. Further, the online experiment showed that players consider video game atmosphere to be a factor in games' quality and in their own purchasing decisions. This emphasizes the importance of working towards a better understanding of what constitutes the thus far nebulous concept of game atmosphere, and how designers can achieve it.

Unexpectedly, exposing players to a game with thematic dissonance ("breaking" the atmosphere) did not negatively impact PX, showing only a significant effect of dissonant music on brow event intensity. These effects of thematic cohesion/dissonance on PX indicate that further work is required; future investigations of atmosphere should focus on exploring the thematic cohesion between interactive elements such as level/narrative design and further audiovisual aspects, especially interactive ones like sound effects.

Drawing on the definition of atmosphere and the factors affecting it provided in this work, we can now take further steps to study its effects on PX. We provide empirically validated support that atmosphere is tied to audiovisual thematic fit, and starting points for future research on further associated factors, allowing for more objective conversations about this topic in the future. Games user researchers can make use of these results by furthering the study of atmosphere, and effects of atmosphere variation on PX. Players reportedly like atmospheric games, and include this quality as a factor in deciding which games to buy. Further, the study of dissonant player experiences is important because identifying the factors which influence negative mismatches between player expectation and game actuality allows us to avoid these pitfalls in the games we design. It also helps us to understand how player experience is potentially altered by simultaneously consuming additional media, e.g., podcasts or Twitch streams. All of this can aid in the creation of more enjoyable PX resulting in more pleasure derived from the exploration of atmospheric crafted worlds.

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