Effects of Background Music on Risk-Taking and General Player Experience

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ABSTRACT
Music affects our emotions and behaviour in real life, yet despite its prevalence in games, we have a limited understanding of its potential as a tool to explicitly influence player experience and behaviour in games. In this work, we investigate whether we can affect players' risk-taking behaviour through the presence and attributes of background music. We built a game that operationalizes risk behaviour by repeatedly giving players the choice between a safe but less rewarding course, and a risky but potentially more rewarding course. In a mixed-design user study (N=60), we explored the impact of music presence, tempo, and affective inflection on players' in-game risk behaviour and overall player experience. We found an effect of music presence on risk behaviour in the first playthrough, i.e., in the absence of other prior knowledge about the game. Further, music affect and tempo affected player immersion, as well as experienced mastery and challenge. Based on these findings, we discuss implications for game design and future research directions.

Author Keywords
music; game audio; risk-taking; player behaviour; player experience; immersion.

CCS Concepts
•**Software and its engineering** → **Interactive games;** •**Applied computing** → **Sound and music computing; Computer games;**

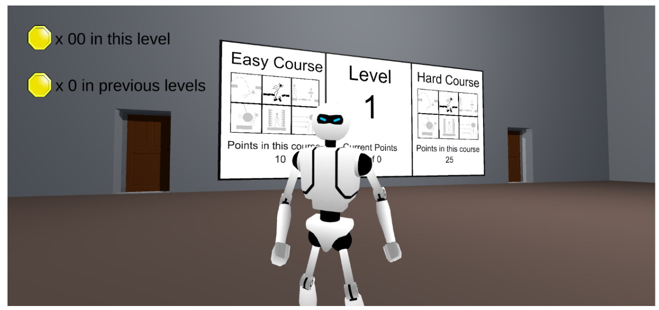

Figure 1: Players repeatedly chose between an easy, safe level and a hard but potentially more rewarding level.

INTRODUCTION
For many people, music is ubiquitous in our everyday lives and activities, affecting our emotions, habits, and behaviour. These effects are used in stores to influence purchase decisions or duration of stay [26, 42, 43], by influencing consumers' emotions and satisfaction in service settings [38]. A meta-analysis has shown that generally the presence of music improves experiences in consumer settings [49]. Further, the effects of music on emotions are often leveraged by individuals explicitly for that purpose, i.e., for self-regulation of emotions such as stress relief [31, 50, 60]. It has also been employed in therapeutic contexts to augment depression treatment or to facilitate pain relief [4, 37], emphasizing the substantial potential of music in providing an influencing factor on our emotions and decisions.

In games, there is evidence that music can impact performance, although the nature of this impact varies, likely because of cognitive distraction that arises in certain combinations of game task and musical attributes [9, 56]. Further, the strong link between music and emotional responses in real life also has been reported for players' emotions in games [15, 21]. Through this link between music and emotions, the literature indicates that music can also affect players' risk-averseness, by making players progress through a game more cautiously or more brashly [62]. This prompted us to investigate whether background music in games can be used to influence players' risk-taking and decisions.

Being able to nudge player decisions towards or away from risky choices would constitute an interesting tool in game design. It could be used to make nervous or novice players more likely to try out risky options in specific game segments, for example in tutorials or scaffolding segments. This could facilitate their learning progress by trying more difficult/riskier levels earlier than they might otherwise. Further, making players more likely to try riskier options could be an interesting addition to difficulty adjustment in games. Using music to nudge players towards a riskier, more difficult gameplay choice could be used as a first, subtle factor in adjusting difficulty. For example, it could provide distraction to make gameplay more difficult. It could also encourage players to combat a more difficult enemy/level of their own volition.

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Music is often perceived subconsciously or peripherally [3]. This subtlety means it could be used to increase perceived difficulty prior to more noticeable approaches like adjusting the number of enemies. Potentially it could then avoid acceptance issues or diminished feelings of achievement, which can be side effects of highly visible difficulty adjustment [40, 47]. This could be applied both as an addition to static game difficulty, and an additive factor in dynamic difficulty adjustment.

To explore the potential role of music in risk-based player behaviour, we built a platform game in which players choose between an easy, safe course and a hard but potentially more rewarding course in every level. We conducted a mixed-design user study (N=60) to investigate the impact of the presence of music, as well as tempo and affective inflection of music, on players' risk behaviour and overall player experience.

Our findings show that contrary to our expectations, music decreased risk-taking in the first playthrough, but had no effect subsequently once players had become acquainted with the game's difficulty progression. Further, we found effects of music affect and tempo on player immersion, and perceived challenge and mastery. This paper thus contributes a first exploration of whether and how music can be used to impact players' risk-taking in games. Our results highlight the potential of novel, explicit applications of background music and specific musical attributes in game design. We discuss and contribute potential future research directions towards a deeper understanding of the role of music in facilitating immersion and affective experiences in player-game interaction.

BACKGROUND

Outside of games, music has a long history of inducing stress relief, eliciting emotions, and facilitating an experience of flow [13, 15, 21, 60], i.e., a state in which people feel neither overwhelmed nor bored [12, 13, 61]. Low-arousal music has been shown to have a sedative effect on listeners, which is beneficial during low-intensity exercise [29].

In interactive media, background music affects users peripherally, particularly compared to visual cues, but its influence is nevertheless noticeable, and there are occasions of auditory dominance [3, 57]. In games, its presence affects both players experience and perception of the game [33]. Music has strong ties to immersion, by inducing emotions, and mediating players' emotional responses to storytelling [15]. It also generally supports dissociation [16]. However despite the theoretical substantiation of the link between music and immersion, there are still relatively few empirical studies that show that music leads to immersion. Even fewer explore how it does so, e.g., which attributes of music can leverage this effect. Nacke & Grimshaw showed that music facilitates engagement and immersion—and through these, flow and presence [39]. Another user study by Zhang & Fu showed that background music increased immersion in a game, however in this study background music was conflated with sound effects [63]. Sound effects have a different role in game audio, as they are more closely tied to immediate feedback functionality [3, 44, 48].

However, there are also some mixed results for the effects of music in games. In a qualitative study, Wharton & Collins found that music could both facilitate and detract from immersion [62]. Similarly, studies by Sanders & Cairns empirically showed that the presence of music sometimes decreased immersion and sometimes increased it, depending on players' music preferences [51]. Another study by Cassidy & MacDonald showed the importance of self-selected (i.e., familiar and liked) music for enjoyment and to easy tension and anxiety in a game [9]. A user study by Jørgensen showed that taking away music in-game decreases control, but can also facilitate concentration, depending on genre [27]. Unexpectedly, a study exploring effects of game audio in virtual reality showed that there was no difference in immersion or affective state whether background music was present or not [48]. It is difficult to compare these studies, as effects of music in games are dependent on genre, medium of display, and the individual; moreover musical attributes such as tempo, arousal, and dynamics also appear to have different effects [11, 41, 48]. For instance, we have shown that audio is perceived differently depending on whether the game is played in virtual reality or on a PC [48]. Further, dynamic music has been shown to lead to greater immersion than non-dynamic music, while low-arousal non-dynamic music led to a more pronounced flow experience (perhaps because music potentially overshadowed sound effects) [20]. However, this study employed a questionnaire with a factor structure that has not held up to scrutiny [32]. Cassidy & MacDonald showed that higher-arousal music increased players' tension/anxiety and distraction [9], while low-arousal music has been shown to be soothing during exercise, and is generally preferred in relaxing contexts [29, 41].

Effect of Music on (Player) Behaviour

In non-gaming contexts, music affects emotional responses: through psychological arousal (linked to decreasing inhibitions) but also through relaxation (which reduces anxiety and can also focus attention) [4, 14, 31, 42, 53]. While there are many mediating factors (i.e., musical attributes and individual differences), the connection of music to individuals' emotional state yields effects on individuals' behaviour—sometimes this includes risk taking (cf. [7, 24]). For example music affects our behaviour in restaurants in terms of the amount of money we spend and how much time we spend there [8, 35]. Music can also affect gambling behaviour, with the presence of music, and particularly faster music effecting faster bets—however it did not impact the amount of money that was bet [14, 52]. Meta-analyses have concluded that music can have a small negative impact on concentration and memory (e.g., disturbing reading), but overall has positive effects on emotional responses and exercise performance [28, 42]. In a driving simulator study, Brodsky showed that music speed correlated with driving speed and the number of driving errors [7].

In games, music is said to affect player decisions through their interactivity; by changing over time, it can influence upcoming choices, as well as comment on choices already made [3]. This is confirmed anecdotally in horror games, wherein changes in music impact where players go in the game (e.g., to avoid or seek out scary parts) [48]. The effects of music tempo on listeners' activities that is evident in real-world activities [42], has also been shown to apply to player performance in racing games: Cassidy & MacDonald showed that higher-arousal

Song	Tempo Variant	Arousal M	Arousal SD	Valence M	Valence SD	Joy M	Joy SD
BI	80 bpm	5.24	1.13	3.75	0.96	4.80	0.92
	120 bpm	5.74	1.01	4.49	1.33	5.46	0.92
	both (avg.)	5.52	1.08	4.16	1.23	5.17	0.97
FFS	80 bpm	3.25	1.10	4.99	1.01	3.43	1.05
	120 bpm	3.67	1.06	5.40	1.17	4.17	0.67
	both (avg.)	3.49	1.09	5.22	1.11	3.84	0.92

Table 1: Survey respondents perceived song BI as activating, pleasant, and happy. FFS was rated as less activating and more neutral, but still pleasant.

music also correlated with higher driving speed and greater number of errors, in comparison with low-arousal music and no music [9, 10]. A study by Tan et al. showed that players in a role-playing game performed best for some measures when music was present compared to when it was absent [56]. Music unrelated to gameplay led to the best performance, while adaptive music that conveyed gameplay information led to worse performance, possibly due to the greater cognitive focus. Further, in a small qualitative study by Wharton & Collins, players reported differences in their degree of caution, activity, and aggression during gameplay depending on background music [62]: upbeat music was reported to "*propel*" players but also distract them. Depending on the song, music was described as making their play style "*less cautious, more aggressive*" or "*less active and nonaggressive*" [62]. All of these effects could impact risk-taking behaviour depending on game mechanics. Overall the literature shows that music can affect player behaviour by increasing immersion or distraction, but also hints at the potential for music to impact risk behaviour.

In games research, this connection—between music, emotional state, and behaviour, including risk taking—has not been a focus of empirical study, even though the interactivity of games constitutes a highly interesting scenario to explore risk taking due to ties to player modelling and performance. Given the variables, tempo and affective inflection are particularly worth exploring in more depth as mediating factors.

RESEARCH QUESTION

The literature indicates that background music in games has an effect on player experience, particularly on players' immersion and emotional state. In real-life activities, the presence of music and its specific attributes can affect our decisions and behaviour. In this paper, we contribute to the literature on whether these effect occurs in games too. In particular, we were interested in effects on players' in-game risk-taking behaviour. Our research gap focuses on this theoretical connection within games, to explore whether music can be used to en-/discourage players to take certain actions. With a more informed understanding of how music in games impacts player choices, game designers and developers could use this as a subtle tool to influence players, i.e., to go to a certain place in the game, or perform a certain action. This could then be used for difficulty adjustment or scaffolding as described earlier. As music, and audio in general, are often unconsciously perceived, there is potential to influence players while upholding their sense of agency and control.

To explore the feasibility of this idea, our primary research question was therefore: ***RQ1a****: Can music presence affect risk-taking behaviour in games?* More specifically, we included musical attributes of tempo and perceived affective inflection in our investigation: ***RQ1b****: How do music affect and tempo influence risk-taking behaviour?* Based on our survey of the literature, we suspected that faster, more activating, and happier music might increase players' risk behaviour in games. Finally, as effects on the player due to music affect, tempo, and their interaction have not been explored in much detail in games, we formulated a secondary more general research question: ***RQ2****: How do affect and tempo of background music influence player experience?*

PRELIMINARY STUDY: MUSIC SELECTION

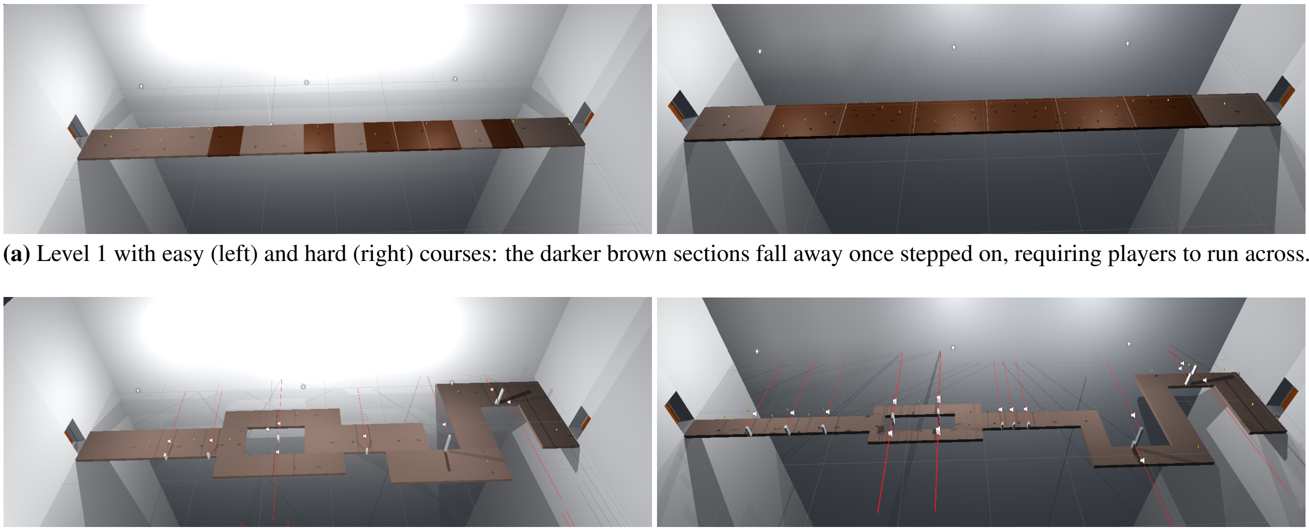
To explore our research questions, we required songs of different affective inflection, and in different tempo variants, for comparative purposes. We first pre-selected eleven pieces of free music from a larger online collection[1], based on two authors' independent estimation of affective inflection, considerations of song duration, suitability for looping, and maintenance of sound quality when modified to 80 and 120 bpm.

Three of these were then selected for online validation. One song was estimated to be activating and happy: song *Fresh Fallen Snow*[2] (FFS), Bb major, originally 116 bpm. The other was considered less activating and more neutral: song *Baby Instrumental*[3] (BI), E minor, originally 140 bpm. The third song was *Angel's Dream*[4] (AD), considered low arousal (originally 82 bpm). The authors' estimation of the songs' affective inflection (at both tempo variants) was then validated through an online survey as described below. The results finally led us to choose BI and FFS as the study's musical stimuli: We aimed for arousal as the main difference between songs in the study, yet AD differed from BI not only in arousal but also in valence more so than FFS. FFS was also longer, requiring less loops. We thus largely omit the third song from this paper due to scope, but its online survey results can be found in the supplementary material.

Survey Design and Measures

Each song was pitched to 80 and 120 bpm and then cut into three segments of 8 seconds (from the songs' beginning, middle, and end). The online survey was conducted with a between-subjects design, asking participants to listen to all segments of all songs in randomized order, but only a single tempo variant (either 80-bpm variants, or 120-bpm variants). Each participant listened to nine 8-second segments: (3 *songs* $\times$ 3 *segments*). Participants were then asked to rate each segment on 7-point scales for perceived arousal (1=*deactivating*; 7=*activating*), valence (1=*unpleasant*; 7=*pleasant*), and joy (1=*sad*; 7=*happy*). Prior to the music ratings, participants were asked to report demographic data as well as musical expertise. The survey took ~5 minutes; all participants were invited to enter in a draw for a 10 € Amazon voucher.

[1] Downloaded from the YouTube Audio Library and GameSound.xyz.
[2] By Chris Haugen, from YouTube Audio Library.
[3] By Antti Luode, GameSounds.xyz, CC 3.0.
[4] By Aakash Gandhi, from YouTube Audio Library



(a) Level 1 with easy (left) and hard (right) courses: the darker brown sections fall away once stepped on, requiring players to run across.

(b) Level 6 with easy (left) and hard (right) courses: players had to jump over the red lasers.

Figure 2: A bird's eye perspective of the layout of the easy and hard courses of the first (a) and sixth (b) level.

Survey Participants
A total of N=57 participants (37 female, 22 male) participated in the survey, recruited via university mailing lists and social media. The participants' age ranged from 16 to 77 (*M*=31.1, *SD*=11.3). Participants were randomly assigned to one of the two tempo variants. The 80-bpm variant was rated by 25 participants (13 female, 12 male), while the 120-bpm variant yielded 32 complete responses (22 female, 10 male). 32 participants reported playing an instrument, one participant stated to work in a music-related profession, and six participants reported to have experience in composition.

Music Ratings: Affective Inflection
The music ratings (reported in Table 1) roughly matched the pre-survey estimations; participants generally agreed that song BI was high arousal (i.e., activating), while FFS was seen as lower arousal. In terms of valence, all songs were overall rated positively, i.e., pleasant, although the 80-bpm variant of BI slipped to a slightly less than neutral valence. BI was rated as more happy than FFS.

USER STUDY
To explore our research questions on the influence of music on risk-taking (***RQ1a&b***) and player experience (***RQ2***), we conducted a user study with N=60 participants. The study followed a mixed design with two independent variables: *music tempo* as a between-subjects variable with two levels: fast (*120 bpm*) and slow (*80 bpm*). *Sound condition* was a within-subjects variable with three levels: the happy, high-arousal music (*HA*) of song BI and the more neutral, low-arousal music (*LA*) of song FFS. A no-music (*NM*) variant served as a baseline condition.

Measures
We chose measures based on the above-described theoretical effects of music on players' immersion, emotional state, and thereby on behaviour and risk-taking. A post-gameplay questionnaire collected measures for participants' affective state, immersion, enjoyment, and difficulty experience. Affective state was operationalized through the self-assessment manikin (SAM) [6], which measures valence, arousal, and dominance on 9-point pictorial scales. For immersion, we employed the immersive experience questionnaire (IEQ) [25]: this questionnaire measures five subfactors of immersion (challenge, control, real-world dissociation, cognitive and emotional involvement) through 31 items on a 7-point scale (1=*not at all/very little*; 7=*a lot/very much so*). It also measures overall immersion as a sum score across the 31 items, as well as through a final single-item measure of immersion on a 10-point scale (1=*not at all immersed*; 10=*very immersed*). Finally, we employed subfactors of the player experience inventory (PXI) [59] to gather a quantitative measure of enjoyment (5 items), mastery (6 items), and (suitability of) challenge (5 items), each assessed on a 7-point Likert scale (1=*strongly disagree*; 7=*strongly agree*). At the end of the study, participants were also asked to fill in a demographic survey on their age, gender, and general playing habits. This final questionnaire also asked them to provide general feedback and rank the playthroughs with regards to perceived difficulty.

During the game, several metrics were logged to qualify in-game behaviour of players. The metrics consisted of risk choices, and performance measures: We collected the players' decisions in the lobby in favour of each difficulty level, as an operationalization of risk behaviour. Further, as performance measures, we collected players' final scores, how many times players failed the hard level, and the number of coins lost due to this event. These measures were added because if players choose the hard level but always successfully collect coins, the effect on player experience and future risk choices would likely differ compared to a scenario in which riskier choices led them to lose coins.

Stimuli

The stimuli consisted of a custom 3D jump'n'run PC game with a robot figure as the player's avatar. The player goal was to collect as many coins as possible across the game's six levels. Every level existed as an easy and a hard course layout, both consisting of the same general structure. The easy course offered players a level with reduced difficulty, with the chance to collect up to 10 coins. In case of in-game failure (e.g., falling off a platform), players could replay the easy level until successful completion of the course. In contrast, the hard course was designed to be more difficult; players could collect up to 25 coins, but in case of a failed level, all coins of that level were lost, and the level could not be replayed. Players were informed of the difficulty and the number of coins in each course prior to playing each level: players had to choose between the two courses by entering one of them through the corresponding door as shown in Figure 1.

To accommodate the study, the game was built in different versions: with background music (conditions *LA* and *HA*), as well as with no music (*NM*). All game versions contained sound effects for player actions (e.g., collecting coins). During the study, all participants wore over-ear headphones and controlled the game via keyboard and mouse. The in-game avatar could be moved with the `WASD` keys; sprinting (shift key) and jumping (space bar) were also enabled. The camera view direction could be panned via mouse.

A Note on Risk Operationalization and Player Investment

To ensure that players experienced a sense of losing something in the case of a failed hard level, the game continuously displayed the number of coins collected in the user interface (see Figure 1). When failing hard levels, players lost all coins collected in that level. The level choice thus operationalized risk: a choice between "*safe*" gain of coins vs. potentially no gain at all. In future work it may be interesting to raise stakes by taking away points gained in prior levels, adapting study compensation based on score, or adding time pressures.

Preliminary Studies: Difficulty Design

As mentioned, the easy and hard level courses were designed to vary in difficulty. Two preliminary playtesting sessions were conducted to evaluate the game design. The game was tested to balance difficulty (1) between the easy and hard courses, and (2) for increasing but manageable difficulty while progressing through the game's six levels. An example of the difference between balanced courses of the first and sixth (final) levels is shown in Figure 2: in this level, sections of the platform fall away once stepped on, requiring players to run across. In the easy course, players had to sprint less often and for shorter sections, while they had to sprint continuously while collecting coins in the hard course. In the final level, players had to jump to avoid laser beams; the easy course required fewer and shorter jumps compared to the hard course. The other levels included obstacles such as gaps in the platform, moving platforms and spiked walls, as well as wrecking balls.

The original prototype was designed in first-person perspective. In the first playtest, six participants (2 female, 4 male) were asked to play all levels in both difficulty versions. After each course, participants were asked to rate the course's difficulty based on obstacle design and coin placement, and invited to provide informal feedback. The informal feedback indicated that players had trouble with the camera perspective, e.g., difficulty gauging their exact distance to obstacles without a visible avatar. Based on this finding, the game was re-designed in third-person perspective, using a robot figure as the avatar (see Figure 1). The courses were re-arranged based on the recorded difficulty ratings.

Six participants were recruited for the second playtest using the same study design but with the redesigned game (3 female, 3 male). Two participants in this iteration had participated in the previous playtest; they were asked to additionally comment on the change to third-person perspective, which they considered an improvement. The playtest confirmed that each hard course was rated as more difficult than the corresponding easy course. The order of the levels one to six was also confirmed as following a slow progression regardless of which course players might choose.

Participants and Procedure

For the main user study, sessions began with a consent form and written introduction to the study and game. Participants were randomly distributed to tempo groups (*80 bpm* vs. *120 bpm*). All participants then played the game three times: one playthrough of all six levels for each sound condition (*NM*, *HA*, and *LA*). This within-subjects playing was counterbalanced (Latin Square). Each playthrough was followed by the post-game questionnaire. After all three conditions and subsequent questionnaires, participants were asked to fill in the final questionnaire that invited them to compare playthroughs in terms of perceived difficulty, and to provide demographic data and general feedback. Participants were rewarded with 5 € and a small chocolate bar. Each study session lasted ~40–50 minutes.

The sixty participants (48 male, 10 female, 2 something else) ranged in age from 16 to 51 (M=22, SD=4.5). The genders were roughly evenly divided in the *120 bpm* group (4 female, 26 male) and *80 bpm* group (6 female, 22 male, 2 something else). The majority of participants reported to generally play video games, averaging around Mdn=32 hours of play per month (IQR=15–50) among those who do play games.

DATA ANALYSIS AND RESULTS

We analyzed the results using a multilevel model approach in R with the `nmle` package [45], adding sound condition and tempo to the model as potential predictors of main effects, as well as two-way interaction effects. Contrasts were used as post-hoc analysis to compare the presence of music (*LA* and *HA* conditions) to its absence (*NM* condition), as well as between *HA* and *LA* conditions. A third contrast was used to compare *120 bpm* and *80 bpm* tempo groups.

In-Game Behaviour

Across the whole dataset, the multi-level model showed no significant effects on risk behaviour as defined by the number of hard-course choices per playthrough. Due to informal comments by participants that they had chosen based on different motivations in the first playthrough compared to later ones,

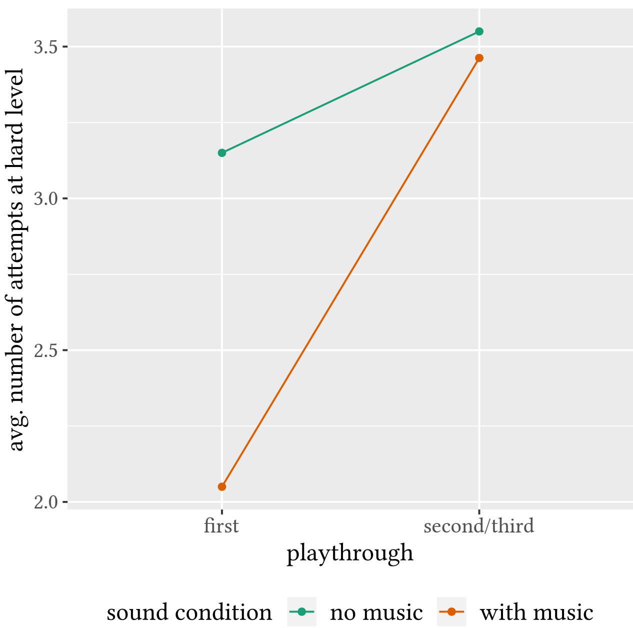


Figure 3: Players attempted the more difficult, higher-risk courses significantly more often when music was absent in the first playthrough. In subsequent playthroughs, music conditions had no effect on this choice.

Tempo	Sound Condition	Arousal M	Arousal SD	Valence M	Valence SD	Dominance M	Dominance SD
80 bpm	*HA*	4.40	1.52	5.03	1.35	4.50	1.38
	LA	3.57	1.52	5.10	1.32	4.67	1.56
	NM	3.67	1.21	4.90	1.35	4.60	1.52
120 bpm	*HA*	4.03	1.83	5.03	1.33	4.50	1.53
	LA	3.30	1.74	5.23	1.19	4.93	1.36
	NM	3.40	1.81	4.93	1.20	4.63	1.65

Table 2: Descriptive results of players' affective state.

we then split the dataset into the data collected during the first playthrough and that collected in the second and third playthroughs. Looking at only the first playthrough, there was a significant main effect of sound condition on risk behaviour, $\chi^2(2)=8.82$, $p<.05$. The contrast for absence vs. presence of music was significant, $b=-0.37$, $t(57)=-2.92$, $p<.01$, $r=0.36$ (see Figure 3). The descriptive data showed that participants playing without music in the first playthrough chose the hard course more often (*Mdn*=3, *IQR*=2–4, *95% CI* [2.42, 3.88]) than those playing with music (*Mdn*=2, *IQR*=1–3, *95% CI* [1.66, 2.44]), with *95% CI* [-1.92, -0.28] for the difference. In the later playthroughs, there were no significant effects on risk behaviour. Informal feedback indicated that they chose based on their skill or their prior choices in later playthroughs.

We ran another multi-level model for the total number of points scored in each playthrough. There was a main effect of sound condition on the final score, $\chi^2(2)=6.21$, $p<.05$. The contrast for high vs. low arousal was significant, $b=-2.40$, $t(118)=-2.03$, $p<.05$, $r=0.18$, showing that players were more successful in their final score in the *LA* condition (*Mdn*=38.5, *IQR*=30–51.2, *95% CI* [37.78, 44.42]) than the *HA* condition (*Mdn*=37.5, *IQR*=27.5–46.2, *95% CI* [32.73, 39.87]), albeit with *95% CI* [-0.47, 10.07] for the difference. There was no effect on points lost due to failing the hard course.

Player Experience

We divide these results into affective state as measured by SAM, immersion (IEQ), as well as enjoyment, mastery, and (perceived suitability of) challenge (PXI).

Affective State

There was no significant effect of condition or group on players' reported valence or dominance. For arousal, the mixed-effects linear model showed a significant main effect of the sound condition, $\chi^2(2)=14.97$, $p<.001$. The contrast for high vs. low arousal was significant, $b=0.39$, $t(118)=3.64$, $p<.001$, $r=0.32$, indicating that higher-arousal music coincided with higher affective arousal reports (*Mdn*=4, *IQR*=3–6, *95% CI* [3.88, 4.55]) compared to lower-arousal music (*Mdn*=3, *IQR*=2–5, *95% CI* [3.14, 3.73]), with *95% CI* [-1.22, -0.35] for the difference.

Immersion

Looking at the IEQ overall sum (across 31 items), the multilevel model showed a significant main effect of sound condition, $\chi^2(2)=13.88$, $p<.01$. The contrast of music absence vs. presence was significant, $b=2.48$, $t(118)=3.43$, $p<.001$, $r=0.30$, reflecting a higher sum immersion score for the with-music conditions (*Mdn*=139, *IQR*=123–156, *95% CI* [136.43, 142.07]) than for the no-music condition (*Mdn*=132, *IQR*=117–146, *95% CI* [127.49, 136.11]), with *95% CI* [0.23, 14.67] for the difference. There was also a significant main effect of tempo, $\chi^2(1)=4.04$, $p<.05$. The contrast for tempo was significant, $b=-5.03$, $t(58)=-2.02$, $p<.05$, $r=0.26$; the fast tempo group showed lower immersion (*Mdn*=132, *IQR*=117–148, *95% CI* [128.40, 139.50]) than the slow tempo group (*Mdn*=144, *IQR*=126–160, *95% CI* [138.93, 150.17]), with *95% CI* [2.62, 18.58] for the difference.

For the IEQ subfactors, there was no significant main effect for cognitive or emotional involvement. However, there was a significant effect of sound condition on real-world dissociation, $\chi^2(2)=17.97$, $p<.001$. For this effect, both contrasts were significant. The contrast between absence and presence of music, $b=0.13$, $t(118)=2.00$, $p<.001$, $r=0.34$, reflected higher scores for the with-music conditions (*Mdn*=4.57, *IQR*=3.68–5.29, *95% CI* [4.40, 4.67]) than the no-music condition (*Mdn*=3.93, *IQR*=3.57–4.86, *95% CI* [3.93, 4.35]), with *95% CI* [0.06, 0.74] for the difference. The contrast between the two with-music conditions was also significant, $b=0.12$, $t(118)=2.00$, $p<.05$, $r=0.18$, indicating higher real-world dissociation for the higher-arousal music (*Mdn*=4.79, *IQR*=3.82–5.43, *95% CI* [4.48, 4.83]) than the lower-arousal music (*Mdn*=4.21, *IQR*=3.57–5.29, *95% CI* [4.27, 4.57]), although the difference was estimated at *95% CI* [-0.55, 0.07].

There was a second significant main effect of music tempo, $\chi^2(1)=8.22$, $p<.01$. The contrast between tempo groups was significant, $b=-0.34$, $t(58)=-2.94$, $p<.01$, $r=0.36$: real-world dissociation was higher for the slow tempo group (*Mdn*=4.71, *IQR*=3.86–5.43, *95% CI* [4.63, 5.15]) compared

TEMPO	SOUND CONDITION	IMMERSION (SUM) *M*	*SD*	REAL-WORLD DISSOC. *M*	*SD*	COG. INV. *M*	*SD*	EMOT. INV. *M*	*SD*	CHALLENGE *M*	*SD*	CONTROL *M*	*SD*
80 bpm	*HA*	148.40	21.72	5.11	0.91	5.29	0.84	4.36	1.18	4.89	0.74	4.92	1.04
	LA	140.70	22.35	4.67	1.09	5.05	0.92	4.14	1.20	4.67	0.77	4.82	0.84
	NM	136.30	23.34	4.47	0.89	4.88	1.03	3.96	1.28	4.65	0.75	4.73	0.96
120 bpm	*HA*	134.20	22.08	4.20	1.18	4.92	0.91	4.11	1.11	4.73	0.58	4.37	1.00
	LA	133.70	22.19	4.17	1.12	4.92	0.89	4.15	1.18	4.53	0.76	4.43	0.97
	NM	127.30	22.65	3.80	1.13	4.68	0.95	3.94	1.06	4.62	0.72	4.23	0.78

Table 3: Descriptive results of the immersive experience questionnaire.

TEMPO	SOUND CONDITION	ENJOYMENT *M*	*SD*	CHALLENGE *M*	*SD*	MASTERY *M*	*SD*
80 bpm	*HA*	5.35	1.41	4.81	1.03	4.49	1.04
	LA	5.41	1.23	5.07	1.03	4.74	1.21
	NM	5.17	1.42	4.99	1.11	4.57	1.14
120 bpm	*HA*	5.23	1.28	4.96	0.95	4.28	1.18
	LA	5.49	1.07	5.09	1.02	4.88	0.93
	NM	4.93	1.16	5.15	0.95	4.61	1.23

Table 4: Descriptive results of the player experience inventory.

to the fast tempo group (*Mdn*=3.86, *IQR*=3.32–4.96, *95% CI* [3.90, 4.48]), yielding a difference of *95% CI* [0.31, 1.09].

The multilevel model predicting IEQ's control factor showed a significant main effect of tempo, $\chi^2(3)$=4.80, $p<.05$. This was reflected in a significant contrast between tempo groups, *b*=-0.24, *t*(58)=-2.21, $p<.05$, *r*=0.28: The slow group (*Mdn*=4.8, *IQR*=4.2–5.4, *95% CI* [4.63, 5.11]) experienced higher control than the fast group (*Mdn*=4.5, *IQR*=3.8–5, *95% CI* [4.15, 4.65]), with *95% CI* [0.12, 0.82] for the difference.

For the challenge factor in immersion, the multilevel model found a main effect of sound condition, $\chi^2(2)$=6.41, $p<.05$. The contrast for high vs. low arousal was significant, *b*=0.11, *t*(118)=2.38, $p<.05$, *r*=0.21. In the higher-arousal music condition (*Mdn*=4.75, *IQR*=4.25–5.25, *95% CI* [4.67, 4.93]), participants reported higher challenge than in the lower-arousal music condition (*Mdn*=4.5, *IQR*=4–5.25, *95% CI* [4.46, 4.73]), with *95% CI* [-0.43, 0.00] for the difference.

Enjoyment, Mastery, and Challenge

As the PXI scale is not yet fully validated, we calculated Cronbach's alpha for its subscales as a measure of reliability. All subscales easily reached a range that generally indicates good internal consistency of items, with enjoyment: α=.95, mastery: α=.84, and challenge: α=0.84 [54].

There was a main effect of sound condition on enjoyment, $\chi^2(2)$=7.25, $p<.05$. The contrast for absence or presence of music was significant, *b*=0.11, *t*(118)=2.48, $p<.05$, *r*=0.22. Enjoyment was reported as higher with music (*Mdn*=5.8, *IQR*=5–6.2, *95% CI* [5.20, 5.54]) than without music (*Mdn*=5.2, *IQR*=4.6–6, *95% CI* [4.81, 5.29]), although with an estimated difference of *95% CI* [-0.08, 0.72].

No significant effects were found for (suitability of) challenge. However, there was a main effect of sound condition on reported mastery, $\chi^2(2)$=8.09, $p<.05$. The contrast between high and low arousal music was significant, *b*=-0.21, *t*(118)=-2.87, $p<.01$, *r*=0.26. Playthroughs with high-arousal music (*Mdn*=4.5, *IQR*=3.79–5.17, *95% CI* [4.20, 4.58]) yielded lower mastery scores than the low-arousal music (*Mdn*=4.83, *IQR*=4.33–5.38, *95% CI* [4.60, 5.03]), for a difference of *95% CI* [0.09, 0.76] (see Figure 4).

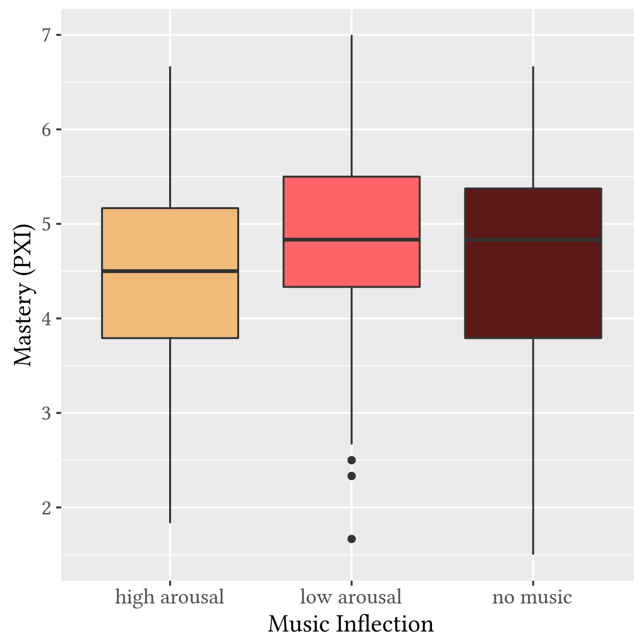


Figure 4: Players reported significantly lower mastery when playing with high-arousal compared to low-arousal music.

DISCUSSION

While our hypothesis regarding in-game behavioural effects of music attributes (affective inflection and/or tempo) did not hold up, our results do indicate that there is some effect of background music on in-game risk behaviour. Namely, the presence of music (regardless of affect or tempo) reduced risk behaviour: without music, players chose the riskier course significantly more often. This contrasts with a study by Cassidy & MacDonald wherein higher perceived arousal of music in a driving game correlated with increased driving speed and errors, compared to low-arousal and no-music conditions [9]. This also contrasts Brodsky's report that tempo increased driving speed and errors in a driving simulator [7]. Further, it is an interesting counterpoint to studies on risk behaviour in real-life gambling scenarios, where both the presence and speed of music significantly increased the pace of betting, but not the "risk per spin", i.e., how much money was bet [14, 52].

It should be noted that this effect only emerged in the first level—in subsequent playthroughs, music (neither its presence, nor its other attributes) had no effect on risk behaviour. Presumably, the effect of music presence on risk behaviour only occurs in the absence of other cues based on which players can choose their difficulty, i.e., knowing how their skill fares against the game's challenge. The direction of this effect, namely, that players chose the riskier option more often in the absence of music, was unexpected. We speculate that this may be due to an interaction between different types of immersion. Ermi & Mäyrä have proposed three flavours of immersion: sensory, challenge-based, and imaginative immersion [17]. The study showed that, in alignment with expectations based on the existing literature [16, 22, 39, 63], music facilitated immersion; the non-music condition yielded lower immersion scores. In the context of our findings, this could indicate that when the game provides less sensory immersion, players might seek out immersion through the part of the game which they can control, i.e., challenge-based immersion. Future work will have to explore this theory, yet overall, this finding implies that game audio design can potentially be used to influence players' risk behaviour in game tutorials and earlier segments of games. This design choice should be applied with some caution, as while no difference could be demonstrated for music presence impacting enjoyment, the confidence intervals suggests that it could be of practical importance. Further, music presence facilitated real-world dissociation with a medium effect size. This latter effect also matches a study by Tan et al. [56], who further showed that players in a role-playing game performed best with music compared to no music; whether this relates to different risk behaviour can only be speculated.

The higher-arousal music condition led to higher player arousal, indicating that participants' affective state was influenced by musical attributes. This has also previously been shown by Cassidy & Macdonald in their driving game [9], and emphasizes that the emotional responses to music evident in real life and other media [21, 60] also apply to player-game interaction in response to background music in games. There are however also counter examples in the literature where music arousal did not impact player arousal in games (e.g., [20]), and it has previously been noted that responses to and preferences regarding music are highly subjective [11, 41, 48]. Further, it should also be noted that arousal was not the only differing affective inflection of our music stimuli: in addition to being more activating, the higher-arousal music condition was also perceived as more happy, and more neutrally pleasant.

In our results, the higher-arousal music condition (more activating and happier) coincided with higher scores for real-world dissociation and perceived challenge, but the confidence intervals failed to demonstrate a clear difference. In contrast, playing in the lower-arousal music condition (less activating, more pleasant, neutrally happy) led to two interesting effects: first, players in this condition achieved higher scores (the confidence interval demonstrates no difference, but also implies that a difference could be of practical importance). Second, they reported significantly higher experienced mastery. There is some evidence that the presence of music can—depending on specific attributes that require further research—facilitate immersion but also negatively impact concentration [62]. Similarly, results by Cassidy & MacDonald also support that music—particularly high arousal and experimenter-selected—music can act as a distraction [9]. As such there is empirical precedence for high-arousal music increasing cognitive load, even though our own results are inconclusive. On the other end of the arousal spectrum, there is similar previous evidence that low-arousal music is preferred in a relaxing context [41], and can have a sedative effect in exercise contexts [29]. A study by Gasselseder [20] indicated that players experience a greater sense of flow with low-arousal, non-dynamic music compared to high-arousal music, however the factor structure of the questionnaire used has not held up to scrutiny (cf. [32]) and it is unclear which specific items were employed. Our results provide more empirical evidence for specific musical attributes factoring in these effects: the LA condition music may have helped participants achieve a flow-like state in which they were better able to master the game. The previously mentioned study by Tan et al. [56] provides another perspective on this aspect: in their comparison, players in a condition with unrelated music (without information conveyed through adaptive changes in the music) performed better than with the game's original adaptive soundtrack. This is further indication that unobtrusive music that demands little focus (i.e., the unrelated music in Tan et al.'s study, and the lower-arousal, more neutral music in ours) may be conducive to concentration, and thereby facilitate a better performance in players.

Music speed also affected immersion: slower music substantially facilitated immersion, and real-world dissociation in particular in comparison to the faster variants. This could relate to the previous thoughts on benefits of unobtrusive music. Overall, the slow-tempo, high-arousal music yielded the best immersion scores, although only tempo consistently demonstrated a difference in terms of the confidence intervals. Beyond this being an interesting indication of how to design background music in games to facilitate immersion, this emphasizes the need to always validate emotional perception of stimuli against a wider audience, as tempo itself does not immediately correspond to perceived arousal. Slower music also led to greater sense of control among participants; this matches prior results in the literature, e.g., in a driving simulator study, slow music resulted in less driving errors [7]. This similarly matches our thoughts on unobtrusive music: it seems likely that slow music is less cognitively taxing and distracting, resulting in a greater experience of control.

Limitations

The music conditions were validated as being perceived as high vs. low arousal, however the perceived arousal was not the only difference between these conditions. Future work will have to explore more specifically how or whether musically conveyed valence and joy affect risk behaviour. Further, as mentioned, music perception is highly individual, and we cannot guarantee that some participants may have differed in their emotional perception of the music [11, 41].

We must also address potential differences in how players perceived risk in our study scenario. It is possible that players did not perceive the risk of losing coins collected in the level as significant enough to affect their behaviour beyond what was found in the first playthrough. As mentioned, future work will have to explore the effects of further "*raising the stakes*".

In terms of procedure, we acknowledge that the majority of participants in the user study were male, while there was a majority of female participants in the music selection survey. There has been some evidence of a gender difference in the physiological response to the presence of music [39], while there is none in terms of time needed to come to an emotional judgement of musical stimuli [1]. However, we do not know if there are gender differences in terms of the emotional perception of musical stimuli. There are studies showing a gender difference for real-life risk behaviour, however these effects can often be mitigated or even disappear when controlling for social context and elicitation methods [5, 18, 46].

Finally, the player experience measures included the PXI. While the Cronbach's alpha indicated good internal consistency of items, the questionnaire is not yet fully validated.

Considerations for Game Design and Future Research

In the following, we discuss and summarize implications drawn from our findings as potential directions for future game design and research.

Turn Off Music to Increase Risk Taking

Our study indicated that the absence of music correlates with increased risk-taking in players in the early stages of playing. This finding provides context to all game studies exploring player behaviour in which risk is a potential factor, as part of player behaviour may depend on the game's auditory presentation in the beginning. Further, it raises the question of how this could be employed in games, particularly in tutorials, when players still know little about the game's level of challenge. Potentially, this could be used to increase player risk-taking for particularly nervous players (e.g., with little gaming experience). It also emphasizes the importance of reporting game audio when describing prototypes and commercial games used as stimuli, as the absence or presence of audio (music and/or sound effects) is often not reported.

Facilitate Immersion via Slow Music

Overall the combination of slow and high-arousal music (slow, activating, and happy) was best in facilitating immersion, although only the tempo yielded consistently significant results. This finding will need to be replicated in other games of varying genre and complexity, particularly as there are some studies in which music reportedly either did not affect or even decreased immersion [48, 62]. As this result is based on comparing 80 vs. 120 bpm music, future work will have to explore effects of other tempos. Nevertheless, it suggests that game sound designers should consider designing and validating background music in terms of tempo (and emotional inflection) to leverage immersive effects on players.

Music Attributes Affect Perceived Mastery

The low-arousal music condition yielded better performance and significantly higher experienced mastery. Given this tie to player perceptions of their own performance, background music may be an interesting additional factor in difficulty adjustment (dynamic or otherwise) [34, 58], by modifying perceived mastery via music arousal. This finding could also be used in game tutorials (and low-difficulty game settings) to facilitate a sense of mastery in novice players by providing low-arousal music. However, as a limitation to this potential application of music in game design, we must acknowledge that a substantial number of players turns background music off or replaces it. For players that turn off their games' music, attempts to adjust mastery via music may not be viable, although for players that replace it, games could consider selecting high or low-arousal music from players' curated playlists.

Sensory vs. Challenge-Based Immersion Trade-Off?

The higher risk-taking correlating with the absence of music was an unexpected finding in our study. We suggest that a lack of (sensory) immersion may lead players to seek out higher immersion in other forms. In many games, given largely fixed aesthetics, challenge-based immersion is an aspect which players have a degree of control over. This could make them seek out challenge-based immersion, and thus make more open to risky choices. This would in turn imply that players generally and actively seek out a highly immersive experience, raising interesting questions about how different types of immersion interact. We consider this an interesting direction for future research on the role of aesthetic factors in player-game interaction, and suggest exploring how player control over these types of immersion factors into player experience and behaviour.

How Can We Design For Affective Experiences?

Finally, the effects of music arousal on player arousal invites future research into how player affect matches musical affect in gameplay. Can high-arousal music elicit high player arousal across most games? Given the importance of players' affective state in gameplay [19, 23, 36, 55] and the strong (albeit often subjective [2]) emotional responses elicited by music [15, 21, 30, 60], the role of musical attributes in influencing players' affective experiences is of particular importance. Further, it makes emotional dissonance as a stylistic choice particularly interesting: how are players' emotional states affected when the emotions conveyed by a game's visuals and audio explicitly do not match? This aspect of games audio research has barely been explored, and we emphasize the potential of exploring background music effects in this context.

CONCLUSION

This work provides a first exploration into whether music can be used to impact players' risk-taking in games. In a mixed-design user study, we investigated the effect of music being present while players made choices of different degrees of risk, and further, the role of music attributes in terms of affective inflection and tempo. Unexpectedly, gameplay without background music correlated with higher risk-taking in players in the first playthrough. We also found effects of music attributes on immersion and mastery, yielding implications for the design of more immersive experiences, and towards purposefully affecting player perception of mastery. Finally, we highlight future research directions regarding the trade-offs between different types of immersion, and the role of player control over these types of immersion, as well as motivate more research into the role of background music in designing for specific affective experiences.

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