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Society for Education, Music and Psychology Research

Article

Psychology of Music
2021, Vol. 49(3) 513–528

DOI: 10.1177/0305735619880288
journals.sagepub.com/home/pom
SAGE

All or nothing: The interaction of musical and spatial atmosphere

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Abstract

Atmosphere can be defined as the affective quality of an environment. Prior research has shown that music can influence how an environment is affectively perceived. In the current study, we systematically examined in three experiments how musical and spatial atmosphere interact and influence the overall valence of the atmosphere. In Experiments 1a ($n=50$) and 1b ($n=136$), we identified two rooms and two musical pieces that strongly contrast in the valence of perceived atmosphere. In Experiments 2 and 3, 32 participants each were exposed to the four combinations of rooms and music for 10-min periods on two different days. Perceived overall atmosphere was assessed. Musical and spatial valence both significantly affected the experienced overall valence of atmosphere. A significant interaction between music and room showed that making one aspect of a perfectly pleasant overall atmosphere negative had a much stronger effect than making one aspect positive in a totally unpleasant atmosphere. This suggests that pleasant atmospheres are particularly vulnerable, which might be explained by an attentional bias toward negative information. Future research should focus on examining fundamental psychological mechanisms underlying the constitution of perceived atmosphere.

Keywords

multisensory integration, valence, perception, interaction, atmosphere

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Atmospheres fill spaces. (Böhme, 2017, p. 25)

The term "atmosphere" derives from meteorology. However, when used in the sense of ambiance, atmosphere can be defined as the aesthetic and affective quality of the environment an individual is placed in. Atmospheres appear in the interaction of subject and object and have the potential to communicate feelings to the subject (Böhme, 2017). Assuming a bipolarity of affective space (Russell, 1979), Russell and Pratt (1980) defined valence and arousal as the relevant dimensions that can, in their combination, exhaustively describe the affective impact of an environment. In earlier literature (e.g., Mehrabian & Russell, 1974) and also more recently (Bakker, van der Voordt, Vink, & de Boon, 2014), dominance is suggested as a third dimension required to describe environments. However, it is still debated whether dominance represents an affective, cognitive, or even a conative indicator (Bakker et al., 2014).

Atmospheres can be associated with multiple aspects of an environment such as sounds, architecture, and light (see Böhme, 2017, for a detailed theoretical description). In consumer research, the manipulation of various atmospheric stimuli like light and color is analyzed in its potential to increase shopping behavior (for review, see Turley & Milliman, 2000). Especially for (background) music, effects on the perception of restaurants (Wilson, 2003), bars, and banks (North, Hargreaves, & McKendrick, 2000) can be shown. In both studies, it was found that the rating of music correlates positively with the environment and music can increase the purchase intention. Environmental psychology, another area of applied atmosphere research, concentrates on the atmospheric impact of natural and built environments. The typical finding is that the restorative quality of natural environments can reduce stress and increase relaxation compared to urban environments (e.g., Hartig, Mang, & Evans, 1991). Research in the psychology of architecture has shown that a change of atmosphere, for example, by different window views, can influence the physical perception of spaciousness as well as the emotional response in terms of room satisfaction (Ozdemir, 2010). This leads to an important distinction in empirical approaches to atmosphere: On one hand, the perception of atmosphere can be studied. Do participants recognize, for example, the valence of a certain scenario? On the other hand, the emotions evoked by an atmosphere can be studied. Does a certain atmosphere actually make a participant experience the corresponding emotion? It is important to note here that perception of an atmosphere does not automatically lead to inducing the corresponding emotion. One can recognize that a fair has a happy atmosphere yet still feel sad (e.g., from personal loss). The same distinction holds true for the emotion perception and experience. Sad participants can recognize happy faces (see Juslin & Laukka, 2004, for a detailed discussion of this distinction in musical emotion). Gabrielsson (2001) discusses examples of positive, negative, no systematic, and no relations between perception of emotion and emotional reaction to music.

The present study focused exclusively on the perception of atmosphere. Musical atmosphere similar to spatial atmosphere can also be described according to the dimensions of valence and arousal. Especially for ambiguous affective qualities, this dimensional model proved to be better than a discrete model (Eerola & Vuoskoski, 2011). Through music, specific emotions (e.g., sadness and happiness) can be communicated with an accuracy approximately as high as in facial and vocal expression (Juslin & Laukka, 2004).

How spatial and musical atmosphere interact is so far largely unknown. One of the few studies conducted in this area, by Yamasaki, Yamada, and Laukka (2015), examined the effects of music on perceptions of the environment in terms of valence and activation. In a field study, participants rated their perception of four different environments either with no music or after listening to one of four different musical pieces. They found that the evaluation of the environment was influenced by the direction of the music characteristics. This effect was stronger when the characteristics of the music and the environment were incongruent (Yamasaki et al., 2015). However, this study only investigated the unilateral effect of music on the perception of the spatial environment, as perceived overall atmosphere was not accessed.

In contrast, we investigated the influence of spatial and musical surroundings on the perception of the overall atmosphere by systematically manipulating the combination of two spatial surroundings and two pieces of music, while both pairs strongly differed in their valence. We expected that the valence of the music as well as of the spatial surroundings would influence the rating of the overall perceived atmosphere. Concerning the interaction, two options would be plausible: either that this effect of musical and spatial surroundings on the overall atmosphere would be independent or an interaction of the two sources of atmosphere.

In addition, we investigated time perception as an abstract cognitive aspect of the overall situation, in order to determine whether possible interaction effects are specific to the atmosphere, or if the results can be transferred to other abstract aspects of the overall situation.

Overview of the experiments

In Experiment 1a and 1b, we determined two rooms and two pieces of music that strongly differed in their valence. The rooms and pieces of music were required to evoke specific spatial and musical atmospheres in Experiments 2 and 3. In Experiment 2, we examined the interaction of the musical and spatial atmosphere by combining each of the musical pieces with each of the rooms in a 2×2 within-subjects design. The music was played via loudspeakers in order to facilitate the impression of an overall atmosphere. In Experiment 3, we tried to replicate our results of Experiment 2 under less integrative circumstances by using earphones, thus separating the spatial from the musical atmosphere.

Experiment 1a

The purpose of Experiment 1a was to select and evaluate two rooms that highly differed in their perceived valence of atmosphere.

Method

Participants. Fifty German speaking persons ($M_{age} = 25.92$, $SD_{age} = 5.52$; 72% female) participated in the study. Of the participants, 94% were students (eight psychology students). Participants signed an informed consent and received 5 euros for their participation. Four students received course extra credit instead.

Material. We selected two rooms from the Psychological Institute of the University of Freiburg that based on the authors' intuition differed extremely in the valence of their atmosphere, and tested how these rooms were perceived by the participants (Figure 1). The room that was supposed to evoke a positive spatial atmosphere was a conference room on the sixth floor of the building, with an open view all over Freiburg. To evoke a negative atmosphere, a room in the basement was chosen. There is hardly any daylight, but the room has bright artificial light. To make participants' seating in the basement room comparable to the conference room, we equipped it with a table and a chair, exactly matching the ones in the conference room.

Atmosphere was operationalized by a German translation of the questionnaire on affective qualities of the environment by Russell and Pratt (1980). The perception of the affective qualities of the environment were assessed on an 8-point scale (1 = *extremely inaccurate*; 8 = *extremely accurate*) measuring the underlying dimensions of *valence* and *arousal* on the four bipolar scales

Figure 1. The conference room (left) used in order to evoke a positive room atmosphere and the basement room (right) used to evoke a negative atmosphere.

pleasant–unpleasant, arousing–sleepy, exciting–gloomy, distressing–relaxing. The 40 items of the questionnaire were forwardbackward translated from English into German (for a full list of adjectives, see Appendix A in Supplemental Materials online). It was also found that listeners agreed on the affective qualities of music more for emotions like happiness and sadness than for others, such as jealousy (Juslin & Laukka, 2004). Therefore, in this study, we only focused on the valence of atmosphere as the relevant dimension.

To investigate time, we asked participants to estimate their waiting time in the room in minutes. Following Wearden (2015), participants also assessed their subjective experience of time by rating felt time in minutes ("How long did the time feel that you have spent in the room?") and on a visual analogue scale the passage of time ("How fast or slow did the time feel?" lengths = 14 cm, slower [left] to faster [right] than normal), and awareness of time ("How much attention did you pay to the time?" lengths = 14 cm, less [left] to more [right] than normal). For all questions, please see Appendix F in Supplemental Materials online.

Procedure. All participants spent 6 min alone in each of the rooms. The order was counterbalanced. At the beginning of the session, the participants handed over all timers (clocks, smartphones, etc.). In order to control for any misattribution effects of physical exercise (Schwarz & Clore, 2007), both rooms were accessed by elevator. During the waiting time, it was left entirely to the participants how they would spend the time while the door of the room was closed. After 6 min, the participants rated the spatial atmosphere as well as their temporal experience on a paper questionnaire before leaving the room. Then the experimenter took the participant to the second room where the procedure was according to the first room.

Results

In the current study, only the results of the rated valence of the spatial atmosphere of this experiment were relevant. Please see Appendix B in Supplemental Materials online for detailed results of all measured variables. We created the valence scale by recoding the values of the unpleasant scale and calculated one mean for pleasant and unpleasant items. Results show that the

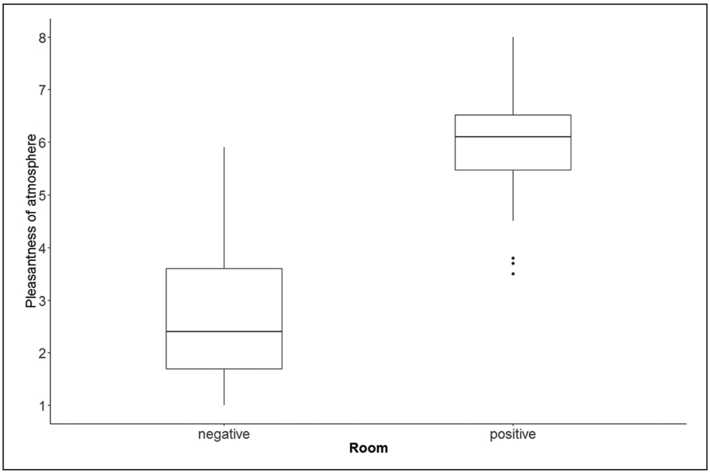

Figure 2. Sample means of perceived pleasantness of overall atmosphere comparing the conference room (positive room) and the basement room (negative room) in Experiment 1a. Valence was rated on an 8-point scale. Error bars represent 1 standard error of the mean.

conference room ($M = 5.92$, $SD = 0.16$) was perceived as more pleasant by the participants than the basement room ($M = 2.75$, $SD = 0.18$), $t(49) = 12.62$, $p < .001$, $d = 18.67$ (Figure 2).

Discussion

The perceived atmosphere of the conference room, which was intended to be the more pleasant one, was indeed perceived as more pleasant compared to the more unpleasant basement room. Therefore, our assumptions concerning the spatial atmosphere were confirmed.

Experiment 1b

In order to select two pieces of music that strongly differed in the valence of their atmosphere on a level comparable to the two rooms from Experiment 1b, we conducted an online study in which each participant listened either to a pair of unpleasant or a pair of pleasant musical pieces, and, subsequently, rated the musical atmosphere.

Method

Participants. 136 German-speaking participants ($n = 136$; $M_{age} = 26.23$, $SD_{age} = 8.58$; 74% female) took part in the online study. Eighty percent of the participants were students (39 psychology students). Seventy percent described themselves as very interested or extremely interested in music. With regard to the knowledge about music in general, 38% had an average knowledge, only 10% in total had very much knowledge or no knowledge at all. Before testing, they agreed to the informed consent and received 2 euros for their participation. Eight students received course extra credit instead.

Material. We visited the rooms and recorded our own associations toward the spatial atmosphere. Based on this information, we selected four instrumental musical pieces that matched in our view the unpleasant atmosphere of the basement room and four instrumental musical pieces matching the more pleasant conference room in its atmospheric valence. We decided to choose music examples from instrumental Western art music of the last three centuries, because we expected cultural codifications regarding this genre to be relatively stable (see "General discussion" below). There were, however, some exclusion criteria on a more formal level: Many examples from Western art music are based on principles of contrast and development. Accordingly, affective qualities often vary widely over a relatively short period of time, which makes it hard to determine positive or negative valence on one dimension. Therefore, we chose musical examples that are relatively consistent with regard to harmony, timbre, and affective qualities over an extended period of time. Pieces from the late Romantic and the early Modern periods (Debussy, Wagner, Grieg) seemed to be particularly promising for a relatively consistent positive mood and avant-garde music from the 1960s and 1970s (Crumb, Penderecki) for a relatively consistent negative mood. In addition, we selected two more pieces, one from the late Baroque era (Bach) and one from contemporary electronic music (Monolake) for expected positive and negative valence, respectively.

For positive valence, the pieces "Morning Mood" (Grieg, 1888), "Arabesque No. 1" (Debussy, 1888–1891), "Rheingold Prelude" (Wagner, 1869), and "Goldberg Variations Aria" (Bach, 1741) were chosen. These examples show an either bright (Bach, Grieg) or dark (Wagner: low brass and strings) but always warm and balanced timbre; they avoid abrupt events in favor of gradient, flowing development; they either propose a prominent and clear melodic figure or display an even and plain texture; and they are in large parts based on the sonic material of major triads (Debussy, Grieg) or the harmonic series of overtones (Wagner). To evoke an unpleasant musical atmosphere, "Makrokosmos I, Part One: Primeval Sounds Genesis I Cancer" (Crumb, 1972), "Threnody for the Victims of Hiroshima" (Penderecki, 1960), "The Dream of Jacob" (Penderecki, 1974), and "Toku" (Monolake, 2012, track 2) were used. All these pieces are characterized by a high degree of dissonant tension, a tendency for low register and droning, noise-like sounds or especially sharp-colored high pitches (Pendercki, "Threnody for the Victims of Hiroshima"), and sudden and unpredictable changes, for example, regarding dynamic, timbral, or spatial qualities.

In line with Experiment 1a, atmosphere was assessed via the affective qualities of the environment questionnaire (Russell & Pratt, 1980), and subjective time experience (passage of time and awareness of time) was also rated. In addition, we measured liking, familiarity (7-point scales), and associations with the music as well as interest and knowledge about music in general (5-point scales). The online survey was provided by Enterprise Feedback Suite (EFS)-Survey (Questback, 2017).

Procedure. Each participant listened to either a pair of pleasant or a pair of unpleasant pieces in a randomized order. They were instructed to close their eyes while listening to the music to minimize the influence of spatial atmosphere. It was not possible to go to the next page until they had listened to the entire piece of music. After listening to the first piece, they completed questionnaires on the affective qualities, the temporal experience, and additional information (see "Material" section). The procedure for the second piece of music was in accordance to the first.

Results

For each musical piece, we calculated a coordinate according to Russell and Pratt (1980) by defining valence as the horizontal axis and arousal as the vertical axis, and using the following equations

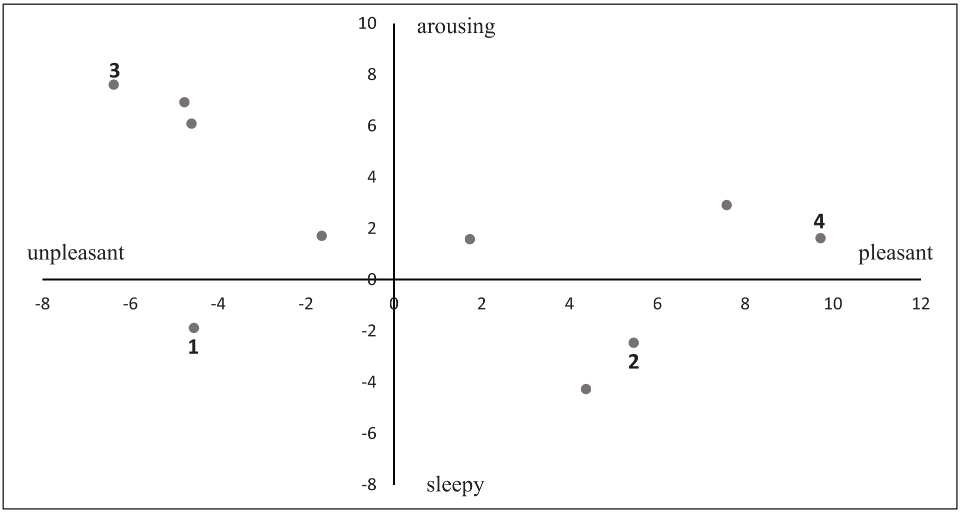

Figure 3. Coordinates calculated according to Russell and Pratt (1980) for all musical pieces and the negative (1) and positive (2) room of Experiment 1a. "Threnody for the Victims of Hiroshima" (3) was rated as the most unpleasant musical piece while "Morning Mood" (4) was rated as the most pleasant.

$$x = 1.00\,(\text{P-U}) + .707\,(\text{E-G}) - .707\,(\text{D-R}) \tag{1}$$

$$y = 1.00\,(\text{A-S}) + .707\,(\text{E-G}) + .707\,(\text{D-R}) \tag{2}$$

with P-U as the mean scores of pleasant–unpleasant, E-G as the mean scores of exciting–gloomy, D-R as the scores of distressing–relaxing, and A-S as scores of arousing–sleepy. Figure 3 shows the coordinates of all musical pieces and the two rooms of Experiment 1a. As valence was the relevant dimension for our study, we chose "Morning Mood" (Grieg, 1888) as the most pleasantly perceived piece of music and "Threnody for the Victims of Hiroshima" (Penderecki, 1960) as the most unpleasantly perceived piece of music. Comparing the means on the valence scale (for calculation, see Experiment 1a), there was a significant difference between the selected pleasant and the unpleasant musical pieces, $t(65) = 21.22$, $p < .001$, $d = 5.18$. Familiarity was higher for "Morning Mood" ($M = 6.70$, $SD = 0.68$) than for "Threnody for the Victims of Hiroshima" ($M = 2.59$, $SD = 1.69$), $t(65) = 13.06$, $p < .001$, $d = 3.19$. Liking was also higher for "Morning Mood" ($M = 6.42$, $SD = 0.90$) than for "Threnody for the Victims of Hiroshima" ($M = 2.76$, $SD = 1.69$), $t(65) = 11.01$, $p < .001$, $d = 2.69$. For detailed results of the other variables, please see Appendix C in Supplemental Materials online.

Discussion

When all scales are taken into account, "Morning Mood" was perceived as evoking the most pleasant musical atmosphere and "Threnody for the Victims of Hiroshima" as evoking the most unpleasant musical atmosphere. The results suggest that participants could differentiate between the pleasant and unpleasant affective qualities of the two pieces with a very high probability. There was a difference in the familiarity of the two pieces. As emotions are felt more intensely when musical pieces have higher familiarity (Swaminathan & Schellenberg, 2015), this might be confounding our results. Although familiarity is an important factor, for example, Schubert, Hargreaves, and North (2014) suggested that the influence might be decreased with respect to other determinants.

Experiment 2

In Experiment 2, we combined the selected rooms and pieces of music in a 2×2 within-subjects design according to the results of Experiments 1a and 1b, in order to examine the interaction of musical and spatial atmosphere.

Method

Participants. Assuming medium effect size, a power analysis was performed to determine the sample size. Thirty-two students ($M_{age} = 22.19$, $SD_{age} = 3.07$; 94% female) from the University of Freiburg participated in the study (78% psychology students). They all signed an informed consent and received 16 euros for their participation. Fourteen students received course extra credit instead. None of the participants took part in Experiment 1a and seven participated in Experiment 1b.

Material. In order to terminologically differentiate between, on one hand, the musical and spatial atmosphere induction as the independent variable and, on the other hand, the overall atmosphere perception as the dependent variable, the terms "positive/negative" refer to the atmosphere induction by rooms and music, and the terms "pleasant/unpleasant" refer to the perception of the overall atmosphere by participants. We evoked spatial atmosphere by using the conference room of Experiment 1a as the positive room and the basement room as the negative room. Musical atmosphere was evoked by the positively and negatively rated instrumental musical pieces selected in Experiment 1b, that is, "Morning Mood" (positive) and "Threnody for the Victims of Hiroshima" (negative). Since the recordings of both pieces were shorter than 10 min, they were repeated and then faded out after 10 min. By combining music and rooms, we created four conditions, two congruent (negative room/negative music, positive room/positive music) and two incongruent conditions (negative room/positive music, positive room/negative music). To facilitate the impression of an overall atmosphere, we played the music via loudspeakers at a comfortable volume.

Participants were asked to evaluate the perceived overall atmosphere with the *Scales of the Affective Quality Attributed to Places* (Russell & Pratt, 1980; for details, see Experiment 1a). Time experience was assessed by felt time judgments, passage of time judgments, and awareness of time judgments. In addition, we measured the emotional impact of the experiment by recording the emotional state before and after the experimental procedure. This change was of interest, as some authors have defined atmospheres as the potentiality of a surrounding to induce feelings (Löw, 2001). Participants rated their emotions on the 9-point Self-Assessment Manikin (SAM) scale (Bradley & Lang, 1994), picturing the dimensions *arousal* (calm/excited), *valence* (happy/unhappy), and *dominance* (controlled/uncontrolled). We also recorded temperature and weather as possible influencing variables, as these are non-architectural variables known to possibly affect emotional states (Denissen, Butalid, Penke, & van Aken, 2008).

Procedure. Before the first session, all participants signed the informed consent. As a baseline, they assessed their emotions in a neutral lab room. The experimenter then guided the

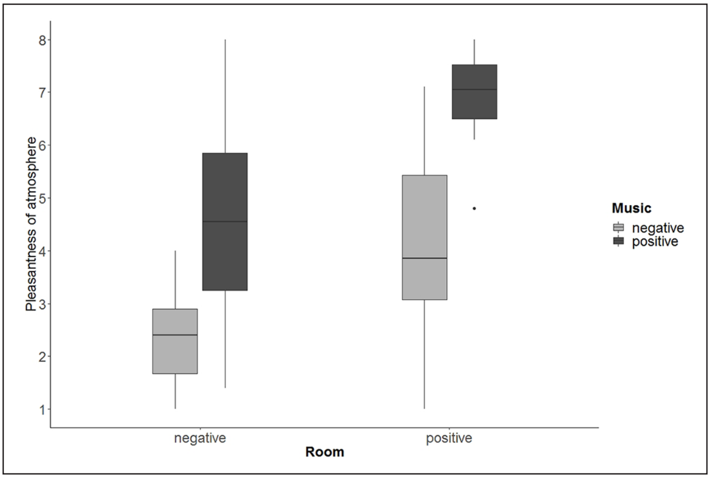

Figure 4. Interaction of music and room in Experiment 2. Figure shows mean pleasantness ratings for overall atmosphere. The terms positive/negative refer to the levels of the independent factors of atmosphere induction. Error bars represent 1 standard error of the mean.

participants to one of the rooms by elevator and turned on the music. Participants were instructed to stay in the room for 10 min while it was left to them how to spend the time, apart from changing the music or the volume. After 10 min, the experimenter entered the room and provided the questionnaires on atmosphere, time experience, and emotion. Then the same procedure was repeated in the second room with the second piece of music. Participants came for a second session on a different day between 1 and 7 days, proceeding according to the first session. In order to avoid repetition effects, in one session, they were exposed to the two congruent conditions, and in the other session, to the two incongruent conditions. The order was counterbalanced across all participants.

Results

Overall atmosphere. As in the previous experiments, we focused on the valence dimension of the perceived overall atmosphere (for additional results, please see Appendix D in Supplemental Materials online). Descriptively, the perceived atmosphere was rated most pleasant when music and room were both positive ($M = 7.00$, $SD = 0.70$) and most unpleasant when both were negative ($M = 2.32$, $SD = 0.86$). When the room was negative and the music positive ($M = 4.59$, $SD = 1.74$), the overall atmosphere was perceived as more pleasant than when the room was positive and the music negative ($M = 3.95$, $SD = 1.68$). A 2×2 repeated-measures analysis of variance (ANOVA) with the factors Room (positive vs. negative) and Music (positive vs. negative) was conducted for the dependent variable "perceived valence of the overall atmosphere" (Figure 4). There was a main effect for the factor Room, $F(1, 31) = 57.59$, $p < .001$, $\eta_p^2 = .650$, with the positive room being perceived as more pleasant than the negative room. There was also a main effect for Music, $F(1, 31) = 101.45$, $p < .001$, $\eta_p^2 = .766$, with the positive music being perceived as more pleasant than the negative music. The interaction between Room and Music was also significant, $F(1, 31) = 5.37$, $p = .027$, $\eta_p^2 = .148$. For positive music, the difference between the positive and negative room was larger ($M_{Diff} = 2.41$) than for the negative music ($M_{Diff} = 1.63$). Or put another way, for the positive room, the difference between the positive and negative music was larger (M_{Diff} = 3.05) than for the negative room (M_{Diff} = 2.27). In sum, the difference between the positive congruent condition and the incongruent conditions was larger than between the incongruent conditions and the negative congruent condition.

Time and emotion variables. There were no significant differences for any of the time variables.

For emotion variables, we analyzed the mean differences of pre- and post-test. For valence, there was a main effect for Music, $F(1, 31) = 34.87$, $p < .001$, $\eta_p^2 = .529$, as participants were less happy after a session with negative music ($M = 0.81$, $SD = 1.33$) than one with positive music ($M = –0.23$, $SD = 1.14$). Neither the factor Room nor the interaction between Music and Room reached significance. For arousal, we also found a main effect for Music, $F(1, 31) = 42.70$, $p < .001$, $\eta_p^2 = .579$. Participants were less aroused after a session with positive music ($M = 1.16$, $SD = 1.60$) than one with negative music ($M = –0.38$, $SD = 1.88$). There were no significant differences for Room or the interaction. For dominance, there was a significant interaction between Music and Room, $F(1, 31) = 5.00$, $p = .033$, $\eta_p^2 = .139$, with participants feeling less dominant after conditions in which Music and Room were incongruent ($M = –0.02$, $SD = 1.28$) compared to congruent conditions ($M = 0.61$, $SD = 1.37$). There were no main effects for Music or Room.

Other scales. The average temperature in the rooms was 19.27°C ($SD = 1.03$). The weather was in 20.3% of the testing sunny, in 28.1% sunny to cloudy, in 26.6% cloudy, in 20.3% cloudy to foggy, and in 4.7% rainy.

Discussion

Spatial and musical atmosphere both influenced the perception of the overall atmosphere in their characteristic direction of valence. This replicated our results of Experiments 1a and 1b, as the rooms and the music were explicitly chosen to affect the valence of the atmosphere. The interaction of spatial and musical atmosphere reveals that an atmosphere that is perceived to be perfectly pleasant is very vulnerable for a single negative influence. If there is only one disturbing factor, the whole atmosphere is massively reduced in perceived valence. An additional positive factor in a perfectly unpleasant environment, on the contrary, does not have that much impact to increase the pleasantness.

Experiment 3

Experiment 3 was a replication of Experiment 2, the only modification being that earphones instead of loudspeakers conveyed the music to the participants. We used loudspeakers in Experiment 2 in order to create an integrated impression of music and space so that both sources impacted the overall atmosphere to a roughly comparable degree. However, as Yamasaki et al. (2015) used earphones in their study, we aimed to make our design more comparable to theirs. We supposed that with earphones, the integration of spatial and musical atmosphere would be impeded.

Method

Participants. Thirty-two persons ($M_{age} = 25.06$, $SD_{age} = 7.13$; 59% female) participated in this study. Eighty-four percent of the participants were students (nine psychology students). They all signed an informed consent and received 16 euros for their participation. Eight students received course extra credit instead. None of the participants took part in Experiment 1a or 2, six participated in Experiment 1b.

Material and procedure. Experiment 3 was identical to Experiment 2, apart from using earphones instead of loudspeakers (for a detailed description of the method, please see the previous section).

Results

Overall atmosphere. Again we focused on the perceived valence dimension of atmosphere (for additional results of Experiment 3, please see Appendix E in Supplemental Materials online). In the condition where room and music were both positive, the atmosphere was perceived as most pleasant ($M = 6.84$, $SD = .83$). The atmosphere was rated most unpleasant when music and room were negative ($M = 2.75$, $SD = 1.17$). In the incongruent condition, when the music was positive and the room negative, the overall atmosphere was rated more pleasant ($M = 4.33$, $SD = 1.65$) than when the room was positive and the music negative ($M = 3.98$, $SD = 1.32$). The repeated-measures 2 × 2 ANOVA with the factors Music (positive vs. negative) and Room (positive vs. negative) revealed the same pattern as in Experiment 2 (Figure 5). We found a main effect for Room, $F(1, 31) = 49.06$, $p < .001$, $\eta_p^2 = .613$, and for Music, $F(1, 31) = 88.54$, $p < .001$, $\eta_p^2 = .741$, both with the positive factor level being perceived as more pleasant than the negative one. The interaction between Music and Room was also significant, $F(1, 31) = 23.42$, $p < .001$, $\eta_p^2 = .430$. Specifically, with positive music, the difference between the positive and negative room was larger ($M_{Diff} = 2.51$) than with negative music ($M_{Diff} = 1.23$). In other words, for the positive room, the difference between the positive and negative music was larger ($M_{Diff} = 2.86$) than for the negative room ($M_{Diff} = 1.58$). To conclude, the difference between the positive congruent condition and the incongruent conditions was larger than between the negative congruent condition and the incongruent conditions. The described interaction effect was numerically

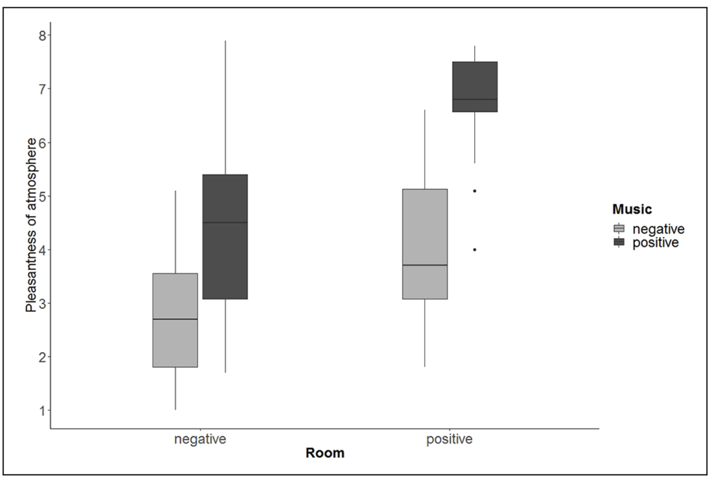

Figure 5. Interaction of music and room in Experiment 3. Figure shows mean pleasantness ratings for overall atmosphere. The terms positive/negative refer to the levels of the independent factors of atmosphere induction. Error bars represent 1 standard error of the mean.

Table 1. Means and standard deviations of felt time (min), PoTJ (minimum = 0, maximum = 14), and awareness of time (minimum = 0, maximum = 14).

Condition	Felt time (min)		PoTJ		Awareness of time	
	M	*SD*	*M*	*SD*	*M*	*SD*
+ Room/+ Music	10.02	3.91	8.13	3.50	5.66	3.40
+ Room/– Music	12.59	4.54	5.33	2.54	8.20	2.97
– Room/+ Music	10.60	4.05	7.54	2.90	7.54	3.28
– Room/– Music	12.77	5.52	6.38	3.61	8.69	3.30

"+" and "–" represent the positive and negative valence of atmosphere, respectively. PoTJ: passage of time judgments.

larger in Experiment 3 compared to Experiment 2. Including *Experiment* as an additional between-subjects factor in the repeated-measures variance analysis showed no significant main effect for Experiment or any interaction effects with Music or Room.

Time and emotion variables. A 2 × 2 within-subjects ANOVA also revealed significant effects of spatial and musical atmosphere on the experience of time (Table 1). For felt time judgments, there was a significant main effect of Music, $F(1, 31) = 9.48$, $p = .004$, $\eta_p^2 = .234$, with negative music subjectively feeling as if it lasted longer than positive music. The main effect of Room as well as the interaction did not reach significance.

For passage of time judgments, we found a significant main effect for Music, $F(1, 31) = 9.83$, $p = .004$, $\eta_p^2 = .241$, as time felt slower when listening to negative than to the positive music. The results for passage of time also showed a significant interaction between Room and Music, $F(1, 31) = 5.80$, $p = .022$, $\eta_p^2 = .158$. Incongruent valence of atmosphere led to a slowing of passage of time compared to congruence.

Awareness of time increased when listening to negative music compared to positive music, $F(1, 31) = 12.47$, $p = .001$, $\eta_p^2 = .287$. There was also a main effect for Room, $F(1, 31) = 4.47$, $p = .043$, $\eta_p^2 = .126$, with the negative room obtaining a higher awareness of time than the positive room. The interaction between Music and Room did not reach significance.

For the emotional variables, we analyzed the differential values of pre- and post-test. For the valence, we found a main effect for Room, $F(1, 31) = 5.53$, $p = .025$, $\eta_p^2 = .151$, and for Music, $F(1, 31) = 33.11$, $p < .001$, $\eta_p^2 = .516$. Participants felt less happy after being exposed to the negative music ($M = 0.80$, $SD = 1.31$) than to the positive music ($M = –0.47$, $SD = 1.07$) and to the negative room ($M = 0.36$, $SD = 1.30$) than to positive room ($M = –0.03$, $SD = 1.08$). There was no significant interaction. For arousal, results only showed a main effect for Music, $F(1, 31) = 101.52$, $p < .001$, $\eta_p^2 = .766$. After a session with positive music, participants were less aroused than before ($M = 1.08$, $SD = 1.60$), compared to an exposure to negative music ($M = -1.13$, $SD = 1.70$). There were no significant differences for dominance.

Other scales. The average temperature in the rooms was 17.46°C ($SD = 0.53$). The weather was in 4.7% of the testing sunny, in 13.3% sunny to cloudy, in 53.1% cloudy, in 14.8% cloudy to foggy, in 4.7% rainy, and snowing in 9.4%.

Discussion

For the perceived overall atmosphere, the results were in accordance with Experiment 2 and we therefore replicated our finding. The results indicate that both musical and spatial atmosphere influence how one perceives the valence of the overall atmosphere. The interaction between spatial and musical atmosphere shows that, in particular, a pleasant atmosphere is highly susceptible to negative disturbing influences as adding one negative factor to a perfectly pleasant environment has a greater effect than adding one positive factor to a perfectly unpleasant environment. The found interaction was numerically stronger in Experiment 3 than in Experiment 2. As we did not find a difference between the Experiments or an interaction, we suggest that the two modes of listening to music were comparable with regard to atmosphere ratings.

Unlike Experiment 2, the evoked atmosphere had an effect on the experience of time. Awareness of time was increased by a negative spatial atmosphere as well as by a negative musical atmosphere, indicating that both factors are relevant if a person pays attention to time. For the participants, time felt longer when listening to negative than when listening to the positive music. Accordingly, participants also reported that time was passing slower with the negative than with the positive music. This is in line with the finding that negative stimuli have an impact on time perception and can slow down the perceived passage of time (Droit-Volet & Wearden, 2015). An interaction between musical and spatial atmosphere showed that congruence of the valence of music and room led to a faster perceived passage of time than incongruent valence. This might be explained by an aversive reaction to incongruence (Dignath & Eder, 2015; Dreisbach & Fischer, 2015) that slows down the perceived passage of time because of the resolving negative affect (Droit-Volet & Wearden, 2015). One explanation for why this finding was only shown in Experiment 3 could be that music that is listened to by earphones is more immersive in the sense that the musical sphere is experienced as less connected to the spatial surrounding. This entails stronger cognitive demand for intermodal integration when one intends to holistically perceive an overall atmosphere, as was required in our experiment. This separation might enhance the experience of conflict-induced negative affect and thereby its effects on time perception.

General discussion

The current study investigated the interaction between musically and spatially evoked atmosphere. Musical pieces and rooms were combined in two atmospherically congruent conditions (positive room/positive music; negative room/negative music) and two atmospherically incongruent conditions (positive room/negative music; negative room/positive music). Music was played via either loudspeakers (Experiment 2) or earphones (Experiment 3). As dependent variables, the affective qualities of the atmosphere (Russell & Pratt, 1980) and the experience of time were measured, as were emotion, weather, and temperature. Here, only the results of the atmosphere ratings and the experience of time are discussed.

The results of Experiments 2 and 3 showed that both musical and spatial atmosphere have an influence on the perceived valence of the overall atmosphere. The consideration of spatial and musical information in the perception of the overall atmosphere is also in line with the literature as audio-visual information is generally integrated to perceive the environment, such as for object recognition (Suied, Bonneel, & Viaud-Delmon, 2009) and spatial localization (Battaglia, Jacobs, & Aslin, 2003). We also observed an interaction between musical and spatial atmosphere, pointing in the same direction in both experiments. The difference between the positive congruent condition and both incongruent conditions was larger than the difference between the negative congruent condition and both incongruent conditions.

This means that a positive environment can be severely impaired by only one negative source of information, whereas a negative atmosphere can be only moderately improved by one positive factor. A pleasant atmosphere seems to be very vulnerable and can be disturbed by changes to only one modality, while an entirely unpleasant atmosphere would require changes to all sources to reach a considerable improvement in pleasantness. As the current study was only a single study, this result must be confirmed with further research. The described pattern might be explained by an attentional bias toward threat information. As research in visual search suggests, emotional, particularly negative information can be detected faster and more efficiently than neutral information (Phelps, Ling, & Carrasco, 2006; Yiend, 2010). The attentional bias toward the negative music or room could have provoked enhanced information processing that resulted in a less pleasant perception of the atmosphere as soon as one of the factors was negative. Healthy participants show such an attentional bias toward processing negative input, especially when stimuli have a high intensity of valence (Yiend, 2010). We used music and rooms with an extremely positive and negative atmosphere which might have further enhanced the bias. For future research, it would be interesting to examine whether participants who are, for instance, more susceptible to disturbance by negative words in an emotional Stroop task are also more influenced by an unpleasant factor in an otherwise pleasant atmosphere.

What is experienced as the affective quality of music here measured in the two dimensions of valence and arousal is highly dependent on cultural codes. Therefore, the musical examples we selected for Experiment 1b were mostly pieces from Western art music of the last three centuries, which we found to be highly culturally conventionalized and to represent aesthetic and affective codes still valid today. These musical examples were all relatively consistent with regard to harmony, timbre, and affective qualities over an extended period of time, to avoid inconsistencies in the perceived valence.

Interestingly, the observed fragility of a positive atmosphere and that atmosphere's collapse in reaction to only one disturbing event has also been described in a historical context and on the basis of discursive sources with regard to the sacred atmosphere of Roman Catholic ceremonies in the late-18th century (Holzmüller, 2017). Travelers described not only how various factors like the play of light, the music, and the specific liturgy influenced their experience of sacred atmosphere but also how only one incongruent factor like chatting visitors or the sight of vendors destroyed the experienced atmosphere.

Conclusion

Both musical and spatial atmosphere can influence the valence of the perceived overall atmosphere. An interaction between musical and spatial atmosphere indicated that one negative factor reduces the valence of a very pleasant atmosphere more than an additional positive factor elevates a negative atmosphere. We conclude that the "perfect" atmosphere is rather vulnerable and can easily be disturbed by negative influences. One possible explanation for the effect could be an attentional bias toward negative information. Future research should try to elaborate further on the psychological mechanisms of the perception of atmosphere.

Acknowledgements

We thank Marie Fromm, Marie Heitfeld, Joana Post, and Jessica Gerstner for assistance and data collection. We thank Massimo Grassi and an anonymous reviewer for their valuable comments on a previous version of this manuscript. Raw data are available in Open Science osf.io/f9a7c/.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The study was funded by the German Research Foundation within the

Collaborative Research Center 1015 "Otium. Boundaries, Chronotopes, Practices" in project R5 "Waiting and Expecting in Spaces of Otium: An Empirical Study on the Connection Between Expectation, Atmosphere and Sense of Time" and project R1 "Otium and the Experience of Immersion in Music."

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Supplemental material

Supplemental material for this article is available online.

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