Music influences the perception of our acoustic and visual environment

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ABSTRACT
While many sounds in our environment may cause annoyance to people, music is well-known to positively affect our thoughts, emotions, and behaviors. Within a longitudinal study, we explored how music influences the perception of our acoustic and visual environment. Thirty-two participants were prompted by a smartphone app 10 times per day over the course of one week. They rated the soundscape and the visual environment and reported on the predominant sound source(s) occurring in the soundscape in addition to other situational variables. Upon completion of the study, participants also filled out a battery of standard personality questionnaires. Results reveal that during musical episodes, participants perceive their acoustic and visual environment as more pleasant, pay more attention to the soundscape, and report better mood states compared to non-musical episodes. These effects are robust only in the context of the home environment of the participants, where most of the music was consumed. Moreover, two interaction terms were found to be significantly correlated with the prevalence of musical episodes. This study therefore provides insight on how people actively "design" their environment with music, and how the motives for doing so depend on person-related and situational factors.

Keywords: Soundscapes, Music, Evaluation, Environment
I-INCE Classification of Subjects Number(s): 56.3

1. INTRODUCTION

Music is an important part of our everyday acoustic environment. While many sounds in our everyday environment may cause people to become annoyed ("noise", according to some definitions), music is the canonical example of a sound source that can enhance mood states (1) and support everyday activities like sport and exercise (2). The motivation of a person to listen to music and the actual use of music is dependent upon situation (3). Juslin et al. (2008) studied music listening in its natural context by comparing musical and non-musical episodes in everyday life situations (4). The authors observed differences in the prevalence (relative frequency of occurrence) of certain emotions such as happiness, nostalgia (more frequent in musical episodes), anger, and anxiety (more frequent in non-musical episodes).

The effect of single sound sources on the overall quality of acoustic environments has been investigated in several studies (5). According to De Coensel et al. (2011), the sound quality of acoustic environments dominated by road traffic sounds is evaluated as more pleasant when adding sounds of natural origin, e.g. bird songs or water sounds (6). Moreover, public spaces with fountains were shown to be improved compared to acoustic environments only consisting of road traffic sound. Nilsson et al. (2009) stated that sounds of fountains may reduce the perceived loudness of traffic sounds in public parks, and thus enhance the overall sound quality of the acoustical environment (7). Moreover, sounds of birds lead to an enhancement of both the overall pleasantness and eventfulness (6). These examples illustrate that adding sounds to the acoustical environment indeed can improve its overall quality. It further explains why sound quality cannot only be described by sound pressure levels and psychoacoustic metrics.

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Compared to other environmental sounds, the question how music effects the perception of our environment has received scant attention. In the course of several interview studies, Bull (2001) described how people use music to spatially and conceptually reorganize their experience by means of music (8). Recent quantitative research by Yamasaki et al. (2015) indicates that when exposed to music, people give more positive judgments of their environment, both in terms of sonic and visual aspects (9). Several mechanisms underlying the "aestheticing" effect of music have been proposed but have not been systematically investigated. Initial mood for example is hypothesized to mediate the effect of music listening on general judgment processes (10). Second, music is assumed to modulate attention processes and to help people focus on or ignore certain properties of their surroundings, e.g. noise (11).

Furthermore, the use of and response to music is well-known to be related to certain personality traits such as Openness to Experience. This factor is associated to a high frequency of aesthetic chills and excitement in response to art (12). Chamorro-Premuzic et al. (2009) were able to show that Openness to Experience particularly predicted cognitive use of music (e.g. intellectual stimulation through music) while individuals scoring high in Neuroticism were more likely to use music for emotional regulation (13). One personality trait predicting evaluations of the acoustic environment is noise sensitivity. It can be defined as ''*the internal states (be they physiological, psychological [including attitudinal], or related to life style or activities conducted) of any individual which increase their degree of reactivity to noise in general*'' (14, p. 59).

Investigations on the influence of situational variables and personality traits on soundscape on the one hand and music perception on the other have predominantly been done by researchers belonging to different research areas, despite the overlapping contexts and relevance of findings. Thus, the main aim of our study is to bridge gaps between both disciplines and to investigate how music contributes to our perception of soundscape, or the "acoustic environment as perceived or experienced and/or understood by a person or people, in context" (soundscape as defined by the ISO working group TC43 SC1 WG 54). We present here the findings obtained with the Experience Sampling Method (ESM), where we compared episodes in which music dominated the soundscape with non-musical episodes with regard to peoples' perception of their environment. The ESM refers to a method of data collection in which people periodically make momentary judgments over the course of the day while going about their everyday activities (15). In contrast to laboratory experiments, the ESM can provide quantitative and qualitative "in-situ" data - valuable perceptual data of people actually experiencing real acoustic environments.

2. METHOD

2.1 Participants

32 participants, 17 women and 15 men, with a mean age of 28.8 (SD=5.6) participated in the study. They were recruited via a departmental mailing list for current students, postdocs, faculty and staff and also via Craigslist. Each received $30 CAD for their participation and were naive with regard to the hypotheses under test. All but one participant were residents in Montreal. 80.8% of them were students, and the rest (19.1%) had a job outside the university. One participant reported hearing problems, and none discontinued participation in the study once they began.

Participants were recruited on the basis of having an Android smartphone that they regularly carried with them. Those who did not have an Android phone but who wished to take the study were given an appropriate phone provided by McGill, which they kept with them for the course of the study week.

2.2 Materials and apparatus

Participants were invited to the Multimodal Interaction Laboratory (MIL) at McGill for an entrance interview and training session. At the interview, they were guided through the installation of the smartphone app that would administer the study over the following week. The app was persistent in the background unless the phone was completely turned off, and they were encouraged to uninstall it after participating.

Participants were asked to provide a 12-hour time frame of their typical day where these alarms would prompt them while they were "awake and active". As training, participants were given a practice alarm and questionnaire that they filled out while seated next to the researcher. This process was repeated if further clarification was required. Participants began the full test study week within two days of their training, depending on their availability.

Participants were instructed that the app would cause their phone to ring at 10 random points throughout the day (momentary judgments) once at a fixed time in the evening (daily summary), and once on the last night of the study (weekly summary). At these points they would conduct a one-minute questionnaire.

At the end of the week-long study, participants were also asked to return to the MIL to fill out exit questionnaires and have an exit interview with one of the investigators where they could also give feedback regarding the study.

2.3 Measures and Design

The electronic questionnaires were designed by means of a web-based administration interface in combination with an Android application specifically designed for Experience Sampling (Movisens XS, Germany). In total, three different questionnaires were presented in this study (momentary, daily summary, and weekly summary), of which only the "momentary form" was used to analyze the relationship between music and the evaluation of the audio-visual environment. This form was designed to report momentary judgments of the soundscape over the course of the day and occurred 10 times per day. Amongst others, it contained questions on the soundscape pleasantness ("How do you rate the pleasantness of the soundscape?"), eventfulness, and familiarity. This question had to be answered on a 7-step Likert scale ranging from unpleasant (1) to pleasant (7), not eventful (1) to very eventful (7), and unfamiliar (1) to familiar (7). Additionally, the participants were requested to report on the predominant sound source in the soundscapes. In this paper, episodes in which music was reported the predominant sound source, are named "musical episodes" and labelled with the index *music*. We only considered music as part of the soundscape when played live or via loudspeakers, not when played by headphones in public settings. We therefore instructed participants to remove their headphones and evaluate the "natural" soundscape if they were listening to music in public. Moreover, participants reported on the pleasantness of the visual environment and situational factors such as the location, the degree of attention paid to the soundscape, current mood, and activity-at-hand. Lastly, participants were asked to indicate whether they were: "alone"; "around others", such as on a bus or in a library, but not interacting; and "interacting with others".

In the exit interview, participants were also asked to report on basic demographic information (birth year, gender, highest education, current job, and reported hearing problems) and to fill out four standardized personality questionnaires. The personality questionnaires were: a short version of the Big Five Inventory (BFI-10; (16)), Weinstein's noise sensitivity scale (WNS-6B; (17)), the "Rational-Experiential Inventory for Adolescents" (REI-A; (18)), and the Barratt Impulsiveness Scale (BIS-11; (19)).

2.4 Data analysis

The coding of the predominant sound source was based on a taxonomy proposed by Axelsson & Nilsson (20). The authors differentiate between three main categories: technological, human, and natural sounds. For this study, two more categories were established to account for the research question and the data at hand: Music and TV/Radio. The activity-at-hand was categorized based on a scheme by Jiang et al. (21), but adapted also based on the data at hand. Due to repeated measures obtained for each participant and thus violation of statistical independence assumptions, mixed model regression analyses were conducted to investigate whether music contribute to the momentary judgments of the audio-visual environment and to the psychological variables mood and attention (SPSS 23 for Windows). An advantage of mixed models compared to common linear models (e.g. ANOVA) is that datasets of participants are included in the calculation even if they are not complete, e.g. when participants missed single prompts (22). For all analyses, the significance level was set to $\alpha = .05$.

3. Results

3.1 Descriptive Statistics

Music was reported as the predominant sound source ("musical episodes") in 11.2 % of the questionnaires. Musical episodes primarily occurred when participants were at home (57.0 %) and/or when they were alone (54.5 %). These proportions are slightly higher for musical episodes compared to non-musical episodes (home: 45.0%; alone: 39.7%). Furthermore, participants reported musical episodes at high rates when they identified their activity as being work/study (36.0%) and personal business and home activities (29.2%). For comparison, in non-musical episodes these activities occur slightly less often (work/study: 32.3%, personal business and home activities: 27.9%).

3.2 Effect of music on dependent variables

To investigate the effect of music as the predominant sound source, several linear mixed-model analyses were performed (Type III test of fixed effects; repeated covariance type: compound symmetry, within-subject factor: time). These analyses reveal that in musical episodes, significantly higher ratings were reported for the soundscape factors pleasantness (M_{music} = 5.5, M_{others} = 4.6, F = 82.1, p < .001), and eventfulness (M_{music} = 3.8, M_{others} = 3.3, F = 13.6, p < .001). These effects can also be observed when the home environment is considered separately (pleasantness: M_{music} = 5.6, M_{others} = 5.0, F = 37.4; p < .001; eventfulness: M_{music} = 3.7, M_{others} = 2.9, F = 29.8, p < .001). The results further reveal that ratings of the visual environment are significantly higher in musical episodes (M_{music} = 5.2, M_{others} = 4.6, F = 16.0, p < .001). Even this effect can be found when only considering the participants' home environment (M_{music} = 5.5, M_{others} = 5.0, F = 10.7, p < .001). Moreover, as hypothesized, people reported better mood states in musical episodes (M_{music} = 5.5, M_{others} = 5.1, F = 16.1, p < .001) and higher attention paid to the soundscape (M_{music} = 4.1, M_{others} = 3.3, F = 42.7, p < .001).

3.3 Music listening and personality traits

We further explored whether the prevalence of situational variables (e.g. company of other people, certain activities), personality traits, and their interaction terms would predict the prevalence of musical episodes for each participant. Within this analysis, we did not find any main effects of situational factors or personality traits. However, we found two *Person X Situation* interactions which are significantly correlated with the prevalence of the musical episodes (using Pearson product-moment correlation coefficients). First, the interaction of percentage of time spent alone and the Big Five trait *Openness to Experience* (r = .40, p < .05). This means that time alone is a positive predictor for musical episodes in this study, if we consider participants scoring high on that personality trait. Second, the interaction of the prevalence of the activity "working on a task" and the noise sensitivity of a person (r = .43, p <.05) is positively correlated with the prevalence of musical episodes. That implies that participants scoring high on the Weinstein noise sensitivity scale and reporting a high proportion of working activities tended to report more musical episodes compared to less noise-sensitive and working participants. Lastly, the interaction of entertainment and recreational activities with noise sensitivity marginally misses the significance level (r = .39, p = .08).

3.4 Mediation analysis

A Multilevel Mediated Moderation analysis was applied to investigate whether the effect of music on visual pleasantness (b [Music = 0] = -0.653, SE = 0.136; p < .001) was mediated by the mood of a person. As already reported in Section 3.2, music was a significant predictor of mood, b (Music = 0) = -0.209, SE = 0.100, p < .05, and mood was a significant predictor of visual pleasantness, b = 0.531, SE = 0.037, p < .001. These results support the mediational hypothesis. The multilevel association between music and visual pleasantness slightly decreased after controlling for the mediator mood and integrate it in the model, b (Music = 0) = -0.545, SE = 0.126, p<.001, indicating partial mediation. The indirect effect thereafter was tested by means of a significance test against critical values of the standard normal distribution (23). These results indicate that the indirect coefficient was significant, b = 0.122, SE = 0.053, z = 2.31 (> 1.96).

4. Discussion

The results clearly show that music played live or via loudspeakers contributes positively to the pleasantness and eventfulness of a soundscape when the music is a predominant source. The findings further reveal that music influences psychological states such as the attention paid to the soundscape and (as already found by other authors) peoples' mood states. Music does not only seem to govern the perception of the soundscape, but also how we experience our visual environment. The results of this study demonstrate how listening to music affects the perceived pleasantness of our visual surroundings, e.g. of our home environment. This is in line with findings by Yamasaki et al. (2015) who also observed that music exposure resulted in more positive judgments of the sonic and visual surroundings. The mediation analysis indicates that the effect of music on visual pleasantness is partly mediated by an increased mood state. One can also assume that a halo effect might be at play in this evaluation process. This means that positive feelings associated to one area of the environment, namely the acoustical one, affects another one - in this case, the visual one. This hypothesis is corroborated by a rather high correlation between both pleasantness variables (r = .53, p < .001; not reported in the results section).

In addition, the results suggest that people actively design, modify, and "aestheticize" their soundscape by means of music, and that their reasons for doing so are dependent on personality traits and the situation. The data analysis, for example, indicates that participants scoring high on noise sensitivity tend to listen to music to support working and recreational activities. It may be assumed that noise-sensitive people use this strategy to also mask unwanted environmental sounds. Musical episodes were further reported more frequently by participants who score high on Openness to Experience and spend a lot of their time alone. It may further be assumed that the influence of this personality trait only manifest in certain situations where people have high autonomy (like home alone) and where they are most likely to modify the soundscape according to their particular needs.

Some limitations associated with the test design remain to be addressed. First, as in (almost) every study using the Experience Sampling Method, no definite conclusions about causal relationships can be drawn since no variables have been varied systematically. Second, potentially influencing variables such as the control over the music, the degree of liking for the music, as well as the music itself have not been measured. Third, the findings related to the frequency of musical episodes, personality traits, and situational factors are based on incidental results from a much broader study. Thus, a follow-up study should be conducted to replicate these findings, ideally using a larger sample to generate more robust findings. Furthermore, collecting short audio recordings would be appropriate. Such a study should, moreover, focus on motives for music listening (e.g. mood enhancement, masking environmental sound) to get a deeper insight into the strategies involved in people's aestheticization of the environment. Last but not least, this study should link properties of the environment to features of the music used in the course of musical and semantic analyses.

ACKNOWLEDGEMENTS

This research was funded by the German Research Foundation (GZ: STE 2331/1-1) and a grant from the Natural Sciences and Engineering Research Council of Canada (NSERC RGPIN 327392-13).

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