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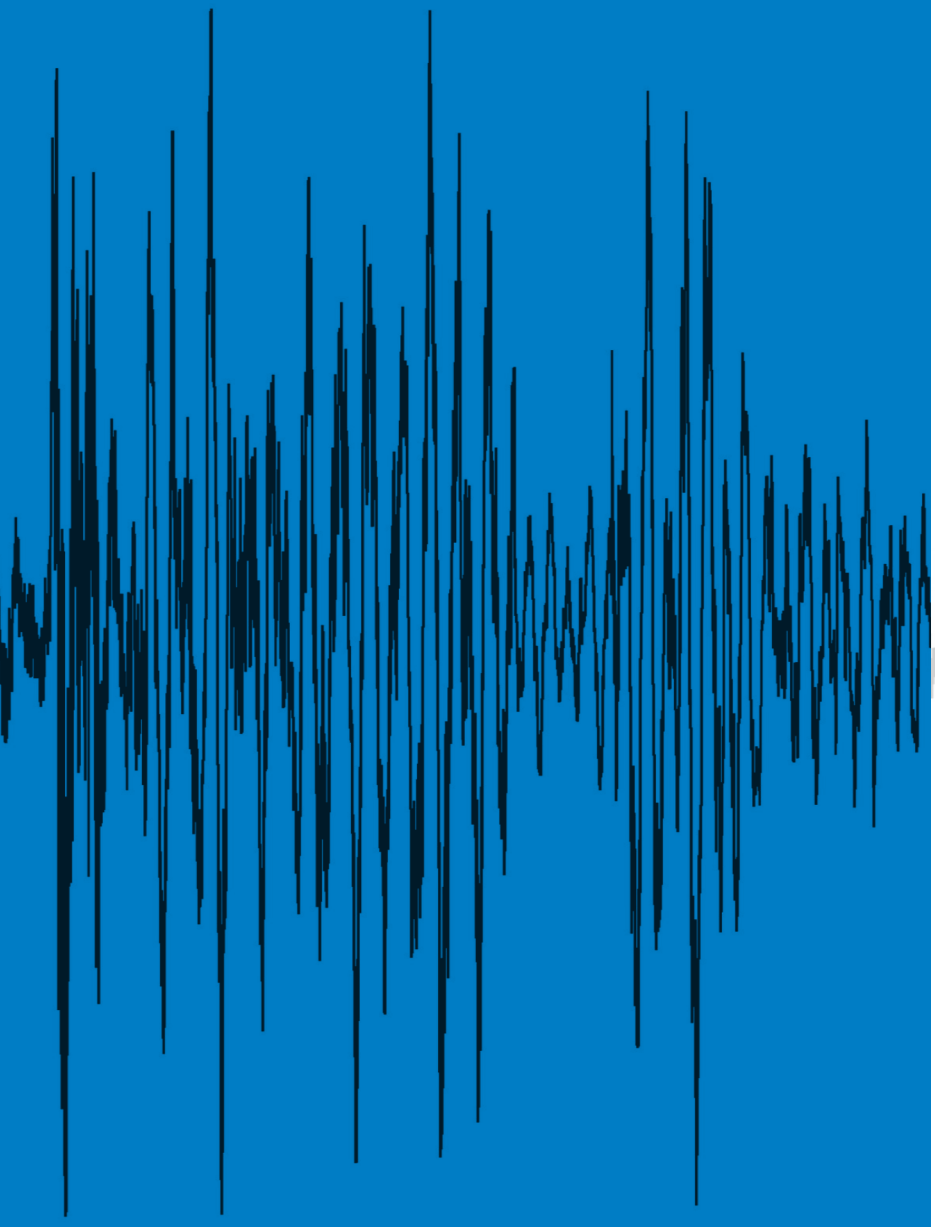

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The association of noise sensitivity with music listening, training, and aptitude

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Abstract

After intensive, long-term musical training, the auditory system of a musician is specifically tuned to perceive musical sounds. We wished to find out whether a musician's auditory system also develops increased sensitivity to any sound of everyday life, experiencing them as noise. For this purpose, an online survey, including questionnaires on noise sensitivity, musical background, and listening tests for assessing musical aptitude, was administered to 197 participants in Finland and Italy. Subjective noise sensitivity (assessed with the Weinstein's Noise Sensitivity Scale) was analyzed for associations with musicianship, musical aptitude, weekly time spent listening to music, and the importance of music in each person's life (or music importance). Subjects were divided into three groups according to their musical expertise: Nonmusicians ($N = 103$), amateur musicians ($N = 44$), and professional musicians ($N = 50$). The results showed that noise sensitivity did not depend on musical expertise or performance on musicality tests or the amount of active (attentive) listening to music. In contrast, it was associated with daily passive listening to music, so that individuals with higher noise sensitivity spent less time in passive (background) listening to music than those with lower sensitivity to noise. Furthermore, noise-sensitive respondents rated music as less important in their life than did individuals with lower sensitivity to noise. The results demonstrate that the special sensitivity of the auditory system derived from musical training does not lead to increased irritability from unwanted sounds. However, the disposition to tolerate contingent musical backgrounds in everyday life depends on the individual's noise sensitivity.

Keywords: Musical aptitude, musical expertise, music listening, noise sensitivity

Introduction

Unwanted sounds in the environment interfering with task performance or communication and evoking disturbance and annoyance are typically considered as noise.[1] Although acoustically noisy sounds are identified by high values in specific features, such as loudness, roughness, spectral entropy, and inharmonicity, even sounds low in those features can be experienced as noise.[2,3] Hence, perception of sounds as noise is subjective and may vary from person to person. A personal attitude toward the sounds of the environment represents an individual's noise sensitivity.[4]

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Noise sensitivity refers to physiological and psychological internal states that increase the degree of reactivity to noise,[5] and is a predictor of noise annoyance.[6,7] Noise-sensitive individuals display stronger affective reactions to noise.[7] No strong evidence for an auditory component at threshold levels in noise sensitivity has been found, as it has not been related to auditory acuity.[4,7] Noise sensitivity aggregates in families, and the estimate of heritability is 36%.[8]

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The study of noise sensitivity is relevant for medical science, as high sensitivity may reduce quality of sleep,[9] have negative effects on cognitive performance in noisy environments,[10] and even increase the harmful cardiovascular health effects of noise.[11,12] Noise may prevent individuals with high noise sensitivity from achieving the same work results compared to less sensitive individuals, leading to psychosomatic, neurotic, and other difficulties, whereas individuals with lower noise sensitivity may better adapt to noise during mental performance.[10] Self-reported impaired health and noise exposure have been shown to be correlated in noise-sensitive individuals, but not in nonsensitive ones.[13]

Musical training can alter perceptual sensitivity to the incoming auditory information. Musicians often begin their instrument and ear training in early childhood and subsequently undergo intensive musical practice for many years. Such training results in functional adaptations of the central auditory system for fine-grained perception of musical sound components, such as pitch, timbre, and timing.[14-20] Furthermore, it is now well documented that musical training has an effect on the perception of not only music, but also other sounds rich in spectrum, such as speech prosody or second-language phonemes.[21,22] The increased perceptual skills in musicians are observed even when speech is masked by background noise. Parbery-Clark *et al*.[22] compared subcortical neurophysiological responses to speech in quiet and noise in a group of highly trained musicians and nonmusician controls. They found that in background noise, the musicians demonstrated earlier onset and transition response timing, better stimulus-to-response and quiet-to-noise correlations, and greater neural representation of the stimulus harmonics than did the nonmusicians. Earlier response timing as well as a better stimulus-to-response correlation in the noise condition was associated with better speech perception in noise. Thus, musical expertise results in a more robust subcortical (brainstem) representation of speech in the presence of background noise, which may contribute to musicians' behavioral advantage in speech-in-noise perception.[22,23]

To our knowledge, only one study has investigated the relationship between noise sensitivity, musical background, and experience. Franek[24] found that individuals who played any musical instrument or had played in the past had slightly higher levels of noise sensitivity than people who never played a musical instrument but who liked to listen to music. In that study, subjects who did not listen to background music very frequently and those who preferred complex and reflective musical genres had slightly higher levels of noise sensitivity.[24] However, listening to music and instrumental training/practice are different components of musical behavior; hence, they may or may not relate to noise sensitivity independently from each other. Musical behavior as a complex phenomenon should be studied by investigating several main components of it, such as the importance of music, musical aptitude, amount of training/practice, and listening to music, which can also be viewed as time spent in passive (background) and active (attentive) music listening. Taking into consideration various details of musical behavior may bring forth new evidence on the relationship between individual noise sensitivity and musical behavior. Hence, this study aims to investigate whether music listening, training, and aptitude increase general sensitivity to environmental sounds, resulting in altered noise sensitivity in musicians compared to nonmusicians, and overall whether and how musical behavior and attitude relate to noise sensitivity.

Methods

Subjects

In Finland, subjects were recruited around the Helsinki area using email lists. The majority were students and alumni of the University of Helsinki, Sibelius Academy, and other Finnish universities. In Italy the subjects were Psychology students of the University of Foggia recruited during a Psychology course. A total of 197 participants were recruited in two countries (Finland: N = 91; 44 men, 47 women; and Italy: N = 106; 10 men, 96 women). The age range was 19-56 years [mean (M) = 28.57, standard deviation (SD) = 7.93 for Finland; M = 24.71, SD = 8.01 for Italy]. The recruited subjects also participated in other studies on brain determinants of music perception and appreciation (Finland), and language learning (Italy). The results of these studies will be reported elsewhere. The subjects were classified into three groups according to their musical expertise, similar to previous studies (e.g., Tervaniemi *et al*. 2006; Brattico *et al*. 2009; Vuust *et al*. 2012): Nonmusicians (N = 103), amateurs (N = 44), and professional musicians (N = 50).[25,26] Nonmusicians were the individuals who never played any music outside regular school, or had a little practice that was not recent. Amateur musicians were musically trained individuals who were self-taught or did not graduate from a music school, and had weekly practice. Professional musicians had attended music lessons for more than 5 years, practiced an instrument or sang regularly, and earned money from music teaching and/or performance. The study was approved by the local Ethical Committees at the University of Helsinki and the University of Foggia and it conformed to the Declaration of Helsinki. Written informed consent was obtained from all subjects. The Finnish subjects were not paid for their participation in the study but a small compensation was provided for the time spent, or travel expenses were offered in the form of culture passes (value of €15). For the Italian subjects, participation in the study was part of the study credits for the Psychology curriculum.

Procedures

Subjects were invited to fill in the Helsinki Inventory of Music and Affective Behaviors (HIMAB) online.[27] The HIMAB is an Internet-based test battery that includes listening tests

for the evaluation of individual musical aptitude; questions assessing training history; level of musical training; yearly and weekly amount of musical practice; weekly music listening; and noise sensitivity. HIMAB was provided in Finnish, Italian, and English, to be filled in depending on the language preferred by each individual subject. The test included a list of questions and links. The links directed participants to sound tracks or an external website where they could fill in online musical aptitude tests. In Finland, after recruitment, and upon informed consent, subjects were sent an email containing instructions and link to the online form that they could fill in at home or in the lab, as they wished. When subjects filled in the HIMAB at home, they were given the telephone number of a research assistant who would guide them in case any technical issues arose during the experimental session. In Italy, informed consent was collected from the participants during a Psychology course. Students were invited to fill in the HIMAB in the lab of the Department on different days.

Musical background and listening to music

HIMAB questions on musical background were adapted from the "Creativity in Music" questionnaire.[28] The questions assessed subjects' musical education, duration of musical training, age of musical training onset, and amount of weekly practice. These variables were collected to affiliate subjects to a musical group and were not analyzed for association with noise sensitivity. Another set of questions from the "Creativity in Music" questionnaire assessed the habits of listening to music at different age ranges. Listening to music was qualified in hours per week spent listening passively (e.g., background music) or actively (directed listening, without doing anything else). For this study, we analyzed only the amounts of listening to music at the subjects' current age. Another HIMAB question assessed music importance:[27] subjects were asked to evaluate the importance of music in their daily life on the scale from 1 (not at all important) to 7 (very important). In summary, we tested the following HIMAB variables for statistical association with noise sensitivity: Active listening to music, passive listening to music, and music importance.

Musical aptitude

Musical aptitude was tested with Seashore tests for pitch and time[29] and the Montreal Battery of Evaluation of Amusia (MBEA).[30] The Seashore pitch and timing discrimination subtests were used to evaluate tone and time discrimination. In the pitch tests, pairs of tones were presented. The task was to say whether the second tone was higher or lower than the first one in the pair. In the time tests, again a pair of tones was given to evaluate if the second tone was longer or shorter than the first one. MBEA was designed for the diagnosis of different types of amusia by assessing musical abilities related to the processing of pitch and beat in the musical context. The original MBEA consists of six scales evaluating music perception and memory, and it requires about 2 h to complete in the lab. For our study we used the online version of MBEA,[31] testing musical aptitude on three scales. We chose the online MBEA because it takes only 15-30 min and can be administrated remotely on the Internet without the assistance of a researcher. The test consists of short melodies, some of which include a tone altered in pitch, which is either mistuned (MBEA Scale) or does not belong to the key (MBEA Out-of-Key). Other melodies include a time-alternated tone (MBEA Beat).

Noise sensitivity

Noise sensitivity was studied using the Weinstein's Noise Sensitivity Scale administered online within HIMAB. It consisted of 21 items, which were presented on a six-point scale rating from "agree strongly" to "disagree strongly." Several items were scored in the opposite direction before the responses were summed.[32]

Data analysis

The differences in noise sensitivity between countries (Italy, Finland), genders (males, females), and groups classified according to musical expertise (musicians, amateurs, nonmusicians) were tested in separate one-way analyses of variance (ANOVAs). Spearman's rho coefficient was used to test the correlations between passive/active listening to music, music importance, musical aptitude, and noise sensitivity.

Results

Noise sensitivity scores were in the range of 25-121, with a mean of 81.07 (SD = 17.6). We did not find any differences in noise sensitivity between the two countries (P = .79) [Figure 1]. In addition, men and women did not differ in the level of noise sensitivity: Neither in the general sample of subjects (P = .08), nor in Finland (P = .15) or Italy (P = .26)

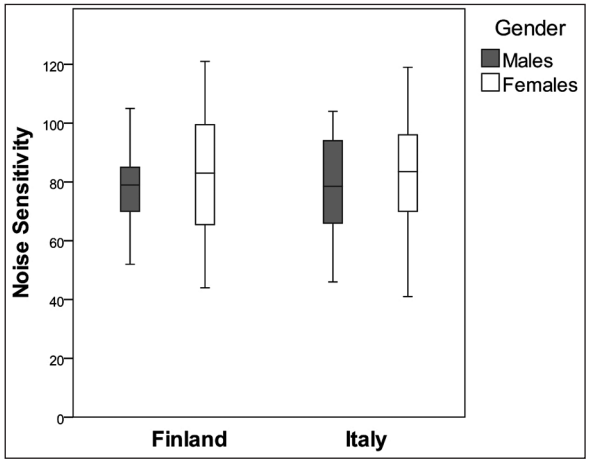

Figure 1: Histogram showing the means (bars stand for standard deviation) of noise sensitivity scores in Finland and in Italy among men and women

alone [Figure 1]. Considering this, we combined the Finnish and Italian samples for the following analyses of noise sensitivity in relation to musical expertise, musical aptitude, and listening to music.

Musical expertise

Nonmusicians, amateurs, and musicians did not differ significantly from each other in their noise sensitivity scores ($P = .96$) [Figure 2].

Musical aptitude

The correlation between noise sensitivity and results on the pitch subscale approached significance (rho = –.147, $P = .06$) [Figure 3], while no significant relationship between noise sensitivity and performance on the Seashore test for time ($P = .85$) [Figure 3] was found. No significant correlations between noise sensitivity and MBEA scores on any of the test subscales were observed ($P = .92$ for MBEA Scale; $P = .57$ for MBEA Beat; $P = .81$ for MBEA Out-of-Key) [Figure 4].

Listening to music and music importance

Noise sensitivity was negatively correlated with the amount of passive music listening (rho = –.243, $P = .001$), meaning that subjects with higher noise sensitivity use music as a background more rarely than subjects with lower noise sensitivity [Figure 5]. However, there was no relation between noise sensitivity and the amount of active music listening in 1 week ($P = .50$) [Figure 5]. We also found that subjects with higher sensitivity to noise rated the importance of music in their life lower than those who were less sensitive to noise did [Figure 6], as was indicated by the significant negative correlation (rho = –.175, $P = .016$). We also found a strong positive correlation between the importance of music and amounts of passive and active listening to music (rho = .283, $P = .0001$ and rho = .445, $P < .0001$, respectively), meaning that individuals who reported music as being important in their everyday life spent more time listening to music both actively and passively.

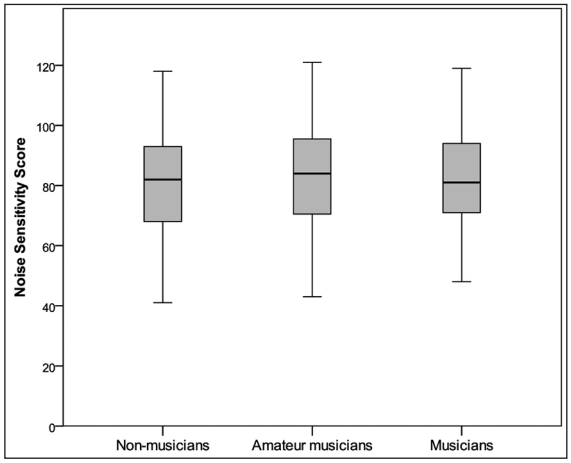

Figure 2: Histogram showing the means (bars stand for standard deviation) of noise sensitivity scores in nonmusicians, amateur musicians, and musicians

Discussion

Our aim was to investigate whether noise sensitivity is associated with music listening, training, and aptitude. The results show that cultural differences between Italy and Finland do not moderate noise sensitivity, and neither does gender of the adult participants. Furthermore, noise sensitivity does not differ significantly between nonmusicians, amateurs, and musicians. In the tests concerning musical aptitude, we did not find significant correlations between noise sensitivity and performance on the Seashore test for pitch and time. No correlations were found between noise sensitivity and MBEA scores on any of the scales. In contrast, significant correlation tests indicated that subjects with higher noise sensitivity use music as a background less often and rate the importance of music in their lives lower than those with lower noise sensitivity.

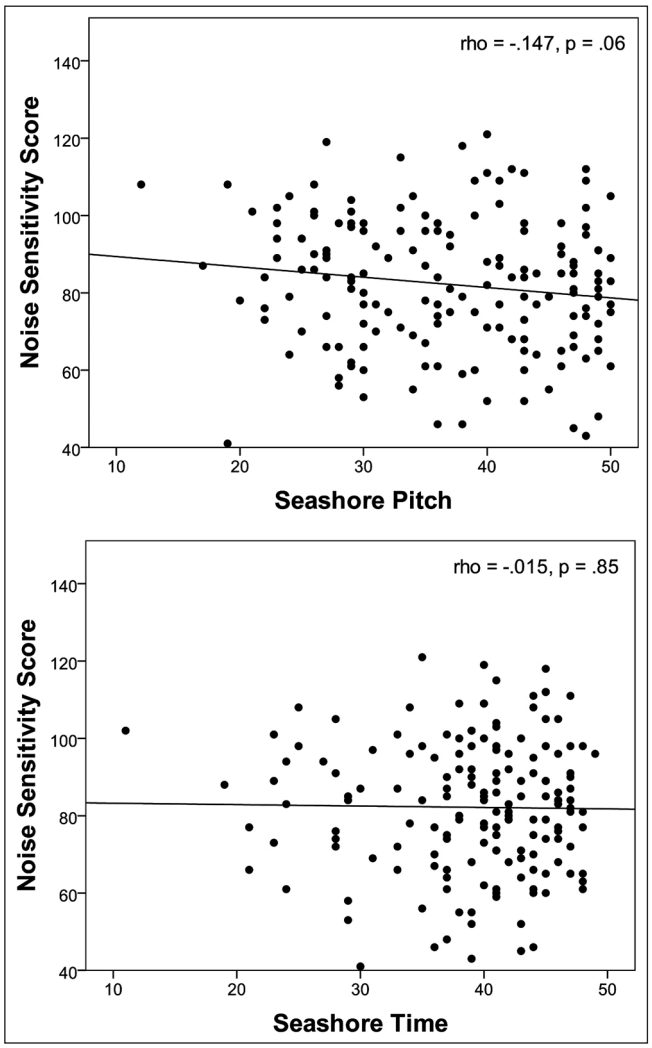

Figure 3: Scatterplots representing the relationship between noise sensitivity and performance in the Seashore test for pitch and time

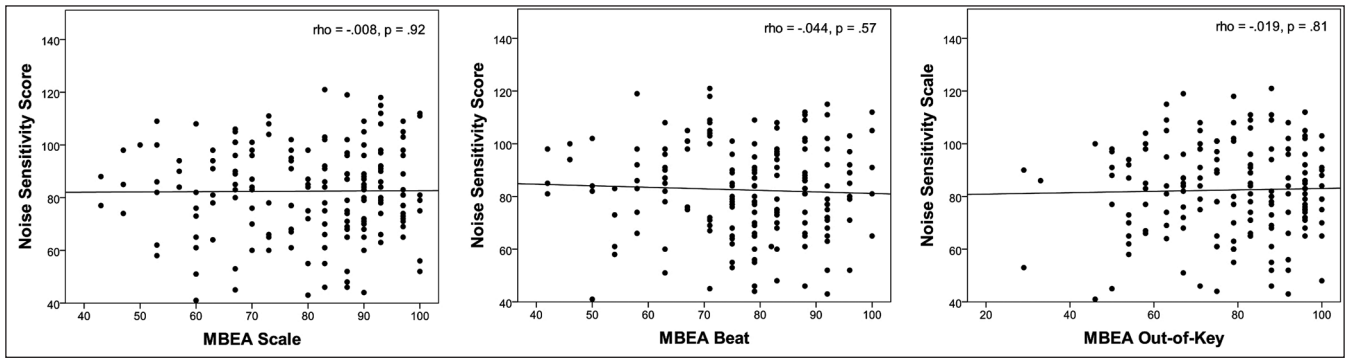

Figure 4: Scatterplots representing the relationship between noise sensitivity and performance in MBEA Scale, Beat, and Out-of-Key

In our study, noise sensitivity did not differ between participants recruited in Finland and Italy. We also did not observe differences in noise sensitivity between male and female participants. Previously, similar levels of noise sensitivity in different countries were found in a study conducted around three international airports in Amsterdam, Sydney, and London.[6] Gender effects on noise sensitivity were not consistent across studies, as some of them reported noise sensitivity to be independent of gender,[32,33] whereas in another case women were found to be a significant majority of individuals with high noise sensitivity.[4] As regards the results of our study, we note that the recruited participants might not be representative for the whole population in either Finland or Italy. First, the relatively young mean ages of subjects in the samples, their high level of education, and the prevalence of female Psychology students among the Italian participants limited the generalizability of our results. Second, recruitment from a single geographical point represented a single sample and might not be common for the general population.

The invariance of noise sensitivity between individuals with different musical backgrounds provides evidence for selectivity in the development of musicians' auditory skills. Compared to musically untrained individuals, musicians develop fine-grained skills for the perception of musical sounds[34-37] as well as more effective processing of speech sounds[38] and emotional sound components.[39] However, it has also been shown that musicians are sensitive to particular sound properties that carry some meaningful information about the sound. For example, musicians are especially sensitive to the sound quality of their own instrument[14] and to portions of vocalizations that contain emotional information.[39] In our study we observed that musicians did not have greater sensitivity to noise, perhaps due to the irrelevance of noise to musical training. These results support the notion that sound perception improvements in musicians, as a consequence of their regular long-term musical training, develop as adaptations for perceiving meaningful (salient) signals rather than as nonselective general sensitivity to perceive any sounds with higher accuracy.[40]

However, our results showing that nonmusicians, amateurs, and musicians do not differ significantly from each other in their noise sensitivity are at variance with previous results. A study by Franek[24] found that people who have played an instrument show slightly higher levels of noise sensitivity to certain noise dimensions than people who have no playing experience but like to listen to music. Yet one should keep in mind that there are methodological differences between this study and the study of Franek. First, we used general noise sensitivity without dividing it, as Franek did, into different subscales reflecting sensitivity to special types of environmental sounds. In the Franek study, musically active individuals and those who were not interested in music showed sensitivity to different sorts of noises. We could not observe a similar effect in general noise sensitivity. Second, musical groups were categorized using a different approach. In our study, we defined musical groups according to experience in playing a musical instrument or singing and formal musical training, whereas Franek considered musical practice and listening activity taken together when defining the groups. In both studies, music listening habits were significantly related to noise sensitivity. Therefore, Franek's use of music listening for classifying musical groups could be a reason for the positive result on the relationship between noise sensitivity and playing a musical instrument, which we did not observe. However, in Franek's study, individuals who were not interested in music were also slightly more noise-sensitive. Third, Franek's study[24] was obtained with subjects surveyed from a single geographical location and did not consider the variety of musicianship that can be typically encountered in a population, hence limiting the external validity of the findings.

Our results suggest that noise sensitivity affects only passive listening to music but does not relate to the amount of active listening to music (e.g., listening to music without doing anything else or attending musical performances). Along with that, noise sensitivity is negatively associated with the subjective importance of music in everyday life. However, the importance of music is strongly related to active listening to music as well as to passive listening to music. Taken together, the observed relationships indicate that

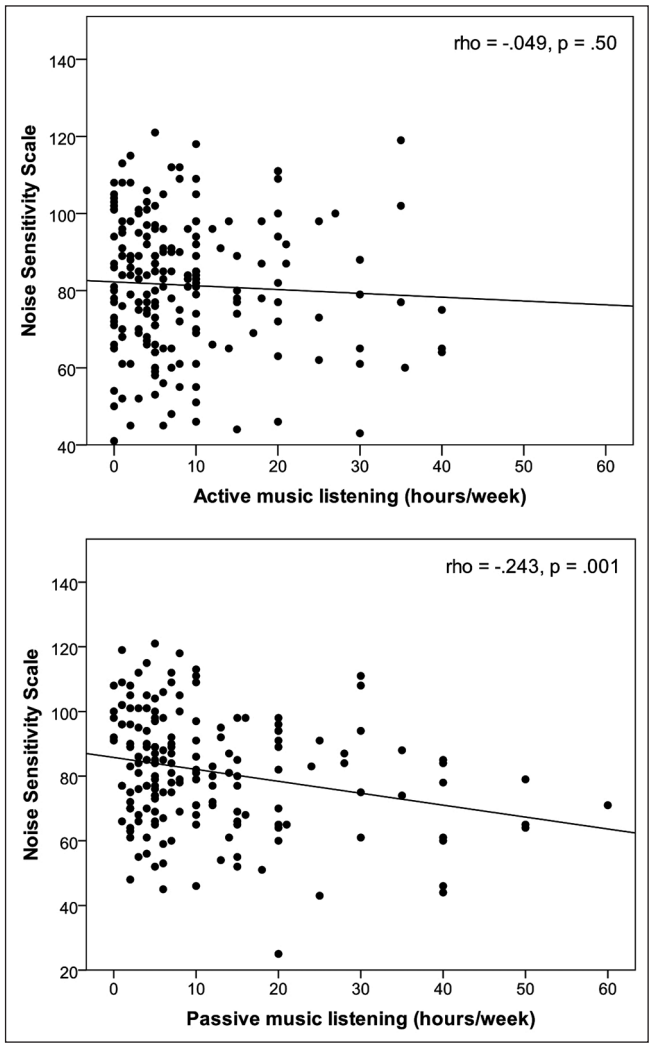

Figure 5: The relationship between passive listening to music, active listening to music, and noise sensitivity

noise sensitivity is specifically related to habits for passive listening to music, whereas reduced music importance in noise-sensitive individuals seems thus to be a consequence of lowered tolerance to background music. Listening to music is especially important compared to other leisure activities, as it serves a variety of personal needs.[41] In the investigation by Lonsdale and North[41] on the reasons for listening to music, participants mentioned regulating mood, performing musical activities, recalling memories, enjoying the sound of music, interacting socially, and accompanying other activities. These reasons imply an emphasis on individuals' free will in listening to music. However, a considerable quantity of the music heard in everyday life is not chosen.[42] When music is unwanted but still present in the environment, it might meet for certain individuals the definition of noise, thus causing negative effects, depending on individual noise sensitivity.

Noise sensitivity is related to individual traits such as a desire for privacy[32] and introversion.[43] In a noisy condition, introverts have reported more concentration problems

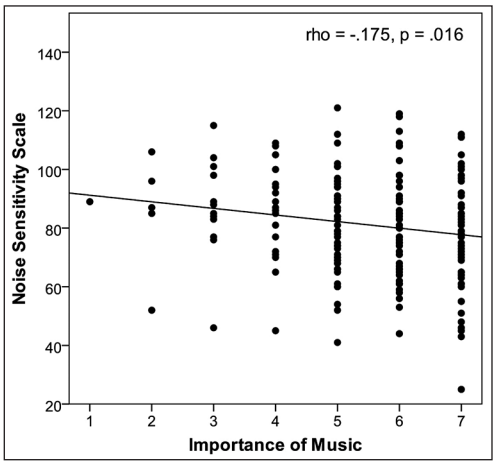

Figure 6: The relationship between noise sensitivity and importance of music in daily life

and fatigue during mental processing, and are slower than extroverts.[43] For a reading comprehension task, introverts were more negatively affected by music than extroverts, and introverts were also more negatively affected by noise.[44] Furthermore, the performance of introverts on complex cognitive tasks, such as the Stroop test, was found to be especially worsened by noise and background music with high arousal.[45] In the future, understanding noise sensitivity will require finding the underlying neural mechanisms that cause one individual to be more sensitive to noise than another.

Conclusions

Nonmusicians, amateurs, and musicians did not differ significantly from each other in noise sensitivity. We did not find a clear relationship between musical aptitude, assessed by listening tests, and noise sensitivity. However, we found that noise sensitivity is associated with daily musical behavior, such as passive listening to music and the importance given to music in everyday life. Individuals with higher noise sensitivity spent less time on passive (background) listening to music than people with lower sensitivity to noise. Noise sensitivity does not correlate with the amount of active (attentive) listening to music.

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Conflicts of interest

This research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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