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Effects of transportation noise and attitudes on noise annoyance and task performance

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In this study, effects on task performance and annoyance by aircraft and road traffic noise and attitudes towards these noise sources were addressed in a lab-setting. On day 1 of the study, participants performed a 3-back working memory task in silence and with noise samples played over a headphone at four different loudness levels. On day 2, they filled out questionnaires on aircraft/road traffic-related attitudes and noise sensitivity. We hypothesized that attitudes would only affect task response times for noise samples with recognizable sources. For this reason unrecognizable noise samples were generated from the sound characteristics of an Airbus320 flyover and of a road traffic recording and were used next to the original noise samples. Preliminary results showed no differences of attitudes on annoyance. For participants with negative attitudes towards the noise source, response times were rising with increasing loudness levels during recognizable samples, whereas response times decreased during unrecognizable samples when loudness levels rose. For the group with positive attitudes towards the noise source, reaction times seemed fairly stable across conditions. These results indicate that attitudes towards noise sources may mediate the effect of noise on cognitive tasks.

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1 INTRODUCTION

People's attitudes towards noise sources are often mentioned as one of the non-acoustic variables influencing responses to different kinds of noise. In several papers, a relation between noise annoyance and attitudes towards the noise source have been reported[1-3] (the more negative the attitudes, the higher the annoyance).

According to Guski[3], the evaluation of the source of the noise within a social community leads to common beliefs that certain noise sources are more valuable or harmful than others. Kroesen et al.[4,5] state that people's opinions and attitudes on noise related subjects are largely shaped by policy about these matters, and lead to more or less coherent social 'frames of mind'[4,5]. These social frames do not cause annoyance directly, but they do provide boundaries about how to feel in what circumstances. According to their theory, personal variables can be explained in a cause-effect model, which partly determines what 'frame of mind' a person will adopt about noise related issues[5].

Fields and Walker[6] concluded in their review paper that the fact that railway noise is perceived as less annoying than aircraft noise with the same loudness level, could not be explained by positive attitudes towards railways. However, taking negative attitudes such as fear and preventability into consideration led to a 5-20% attenuation of the gap in noise annoyance responses between aircraft and railway noise[6]. 'Fear of an aircraft crash', 'beliefs that aircraft noise could and should be prevented' and 'noise sensitivity' (regarded as an attitude by the authors) are associated with noise annoyance in over 70% of the surveys reviewed by Fields[7]. In only 18% of the relevant reviewed studies a correlation was found between noise annoyance and negative feeling about other nuisances caused by the noise source, such as dirt and the emissions of fumes. Positive feelings and beliefs about economic importance of an airport for the community were associated with less annoyance in three out of four surveys[7]. Frequency of usage of the noise source showed to have little to no correlation with noise annoyance and for the perceived safety of aircraft very small positive correlations with noise annoyance were found[8].

Different types of attitudes have thus been shown to be related to annoyance, but results are inconsistent and there is no clear consensus of which attitudes are relevant in this matter. Moreover, to our knowledge no studies show that attitudes actually have a causal effect on noise annoyance and task performance.

If listeners hear a sound, they will try to identify the source of the sound or guess what the source could be[9]. When the source of a sound is not identifiable, listeners will not be able to access a preset of opinions on the source. Therefore, the only possible way attitudes towards noise sources can exert a causal influence on the way noise is perceived, the annoyance it causes, and the manner in which it affects performance, is if sources of sounds are recognizable.

The aim of this study was to find out to what extent attitudes influence responses to noise, by having participants perform a task and rate their annoyance levels whilst listening to recognizable and unrecognizable aircraft and road traffic samples. It was expected that people with negative opinions on aircraft and road traffic noise would report higher noise annoyance levels and perform less well in a cognitive task compared to people with positive opinions on these transport (and noise) sources.

2 METHODS

2.1 Participants

Forty-eight participants (after exclusion of one participant who performed at chance level for more than 10 minutes of which at least 5 minutes in a row, 39 women, mean age = 21.9, SD = 7.05) volunteered for this lab study. All participants received either a monetary award or credits in the psychology curriculum at the VU University Amsterdam. Ethical approval for the study was obtained from the local ethics and research committee.

2.1 Material

2.1.1 Samples and playback method

Four noise samples with a 45s duration were used in this study. Two of these were original recordings of respectively an Airbus A320 aircraft[10] and road traffic noise[11]. From each of the original samples an artificial unidentifiable sample was generated, which matches the long-term average frequency spectrum, SEL(A) level and envelope of the original recording, but does not share the recognizability of the original sample. The artificial samples were produced by calculating the power of the frequency bands of the complete original sample, then taking the envelope of the original sample and filling this envelope with noise. In order to create versions that can be reproduced over headphones but nevertheless sound natural, all samples were played back through TANNOY REVEAL loudspeakers and recorded with a Brüel & Kjær head and torso simulator (HATS) Type 4100D equipped with ears Type 4189A-022 and Type 4189 microphones in the ears. The HATS was placed 3 meters in front of the loudspeaker in a semi-echoic environment. The samples were presented to the participants through Sennheiser HD600 headphones. Level calibration was performed by placing the headphones on the HATS and by equating the SEL(A) levels measured in this way to the levels obtained during loudspeaker presentation. The playback levels are equivalent free-field levels measured at the position of the center of the head.

2.1.2 Task

A 3-back task[12] was used for measuring continuous performance. This task is considered to be a difficult working memory task and was chosen for this study to ensure that all participants were engaged as much as possible. Letters (lower- and upper-case) were presented on screen one at a time with a duration of 500 ms. Participants had to press one response key if the letter on screen was the same as three letters back or a second response key when this was not the case. The task consisted of 40 blocks with 20 letters each. During 32 of these blocks a samples was played to the participant at one of four possible loudness levels (45, 55, 65 and 75 SEL(A)), so all four noise samples were played twice at every loudness level. The remaining 8 blocks were performed in silence. After every block a noise annoyance question was presented, which had to be answered on a 0-9 scale: ‘To what extent would the noise you just heard annoy you, if you were to hear it outside in for instance a garden for a longer period of time’. The task was performed in a sound-isolated room.

All task stimuli were presented in OpenSesame version 0.25[13].

2.1.3 Questionnaires

The following questionnaires were administered:

- A scale on attitudes about aircraft derived from a large survey by the RIVM about living close to Schiphol Airport in the Netherlands[14]. This attitudes scale consisted of questions about feelings of safety, health and stress, environmental and policy related issues. A similar scale was constructed for road traffic noise. Range of the complete attitude scale (aircraft + road traffic noise) was 31 – 149 (very negative – very positive attitude).
- Noise Sensitivity Questionnaire (NoiSeQ[15]). A self report 35 item scale on noise sensitivity (answered on a 0-4 Likert scale, range 0-105, low to high noise sensitive) with subscales on communication, sleep, spending free time, being at home and being at work.

2.2 Procedure

Participants were recruited via a subject pool website of the VU University Amsterdam. Before starting with the experiment, they were told that this study was divided in an experimental and a questionnaire part.
After arriving, participants filled out an informed consent form and a short questionnaire about their demographics. After completion, they practiced the 3-back task for 4.5 minutes without background noise. Feedback about accuracy and reaction times was offered every 90 seconds during the practice session. After finishing the practice session, it was explained that background noise was going to be played frequently during the task, but that the samples would never be extremely loud or painful. After every block, participants rated their annoyance level on a single question described above. Once in every 5 blocks feedback on response times and accuracy performance was given to motivate the participant to perform even better. The whole experiment lasted approximately one hour.
The day after participating in the task, the subjects received an e-mail with a link to the questionnaires, which could be filled out online, and were asked complete the questionnaires in one session. After completion of the questionnaires, a debriefing form was sent to them by e-mail.

3 RESULTS

Reliability measures of the new attitude scale (aircraft and road traffic noise) were high: Cronbach’s $\alpha = .91$.

The mean score on the attitude scale was 108.15 ($SD = 16.71$). The range of this scale was 31 to 149 (very negative attitude towards transport vehicles - very positive attitude), so this sample of participants is on the positive side of the scale.
The participant sample was divided in 2 groups based on a median split on the scores on the attitude questionnaire. Because the 33 out of 48 people either liked (positive group) or disliked (negative group) both noise sources, it was decided to analyze the effects of the original sounds vs. the artificial sounds. Means on the attitude scale were 96.00 ($SD = 14.25$) for the negative group and 120.29 ($SD = 7.74$) for the positive group.

Results were analyzed with a mixed design ANOVA with 2 within variables (type of sound and loudness level) and 1 between variable (attitudes towards aircraft and road traffic). Analogous to several previous findings, higher loudness levels led to higher noise annoyance scores, $F(3,138) = 228.231$, $p < .001$, linear polynomial trend $F(1,46) = 301.029$, $p < .001$. Listening to artificial noise samples resulted in lower noise annoyance scores than hearing the original noise samples, $F(1,138) = 12.225$, $p = .001$. There was a significant interaction between sample type and loudness level on noise annoyance, $F(3,138) = 4.028$, $p = .009$. A linear polynomial contrast revealed the original noise samples to be more annoying at the lowest loudness levels, but since annoyance rose more sharply for the artificial samples both sample types reached the same noise annoyance ratings for the loudest level (see Figure 1), $F(1,46) = 9.408$, $p = .004$. No differences were found between attitude groups.

Figure 2 shows that for participants in the negative group response times on the 3-back task hardly differed between noise sample conditions, but responses of participants in the positive group were faster during presentation of artificial noise samples than during original samples, $F(1,138) = 4.670$, $p = .036$. Response times tended to become faster when loudness levels increased (Figure 3), linear polynomial contrast: $F(1,46) = 5.173$, $p = .028$. A 3-way interaction was found (Figure 4, linear polynomial contrast $F(1,46) = 5.360$, $p = .025$): with increasing loudness levels the negative group responded increasingly fast to task stimuli during the artificial sound samples, while response times became slightly slower during the original samples. In the positive group loudness levels exert no effect on response times for both types of sound samples.

No effects were found between groups, sample types and loudness levels on task performance accuracy.

Attitudes towards the noise sources and subjective noise sensitivity (measured by the NoiSeQ with a Cronbach's α of .82) correlated highly: *Spearman's* $\rho = .640$, $p < .01$.

4 DISCUSSION AND CONCLUSIONS

Before discussing the results it must be noted that overall scores on the attitude scale are very high in this sample of participants, indicating mostly positive attitudes towards the noise sources. The mean score of 96 for the negative group on a scale with a range of 31-149, is clearly on the high side. It is therefore possible that results would have turned out differently, had there been more participants with truly negative attitudes towards aircraft and road traffic.

Participants rated the unrecognizable noise samples as less annoying than the recognizable samples except when they were played at the loudest level. Against our expectations, no differences in annoyance ratings were found between attitude groups.

The finding that for more negative participants increasingly loud artificial sounds resulted in faster reaction times as opposed to slower performance during the original sounds at increasing loudness levels was somewhat surprising, as was the fact that the positive group did show a pattern with faster responses during the unrecognizable samples.

Differences in annoyance ratings for the original and artificial noise samples may have resulted from a lack of tonal components in the artificial noise samples. This possible confound is currently being addressed in a follow-up study.

The fact that the positive group showed faster responses to unrecognizable sounds could have been caused by a genuine interest in the recognizable sources, drawing attention away from the task at hand. This hypothesis can be tested by adding neutral samples to the design to see if differences between conditions and attitude groups disappear. An explanation for the pattern of the negative group could be: people with negative attitudes concerning noise may listen more carefully and actively. They are slowed down by trying to make sense of unrecognizable sounds at low loudness levels, but show the same speeding up pattern as people in the positive group when sounds are louder. At these levels the negative group is slowing down at the task and getting more annoyed.

Latent differences between the attitude groups cannot be ruled out when interpreting the task performance results. Salient is the high correlation between noise sensitivity and attitudes. Arousal regulation was found to differ between noise sensitive and non-noise sensitive participants[16]. In that study higher baseline arousal and differing physiological ways of coping with noise were found between groups. Since noise sensitivity correlates highly with attitudes towards the noise source in the present study, we will explore these latent differences between groups in future research.

It was found that attitudes on noise sources affect the way we perform when being exposed to noise by these sources. Since people are exposed to noise sources every day at home and in work environments these relations are worth exploring further.

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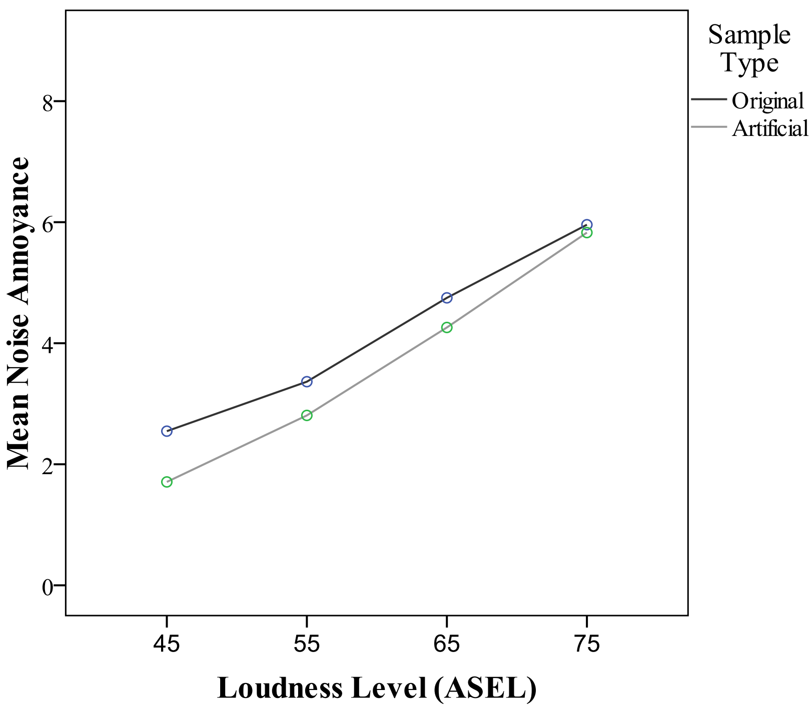

Fig. 1 – Mean noise annoyance ratings for the original and artificial noise samples at different loudness levels.

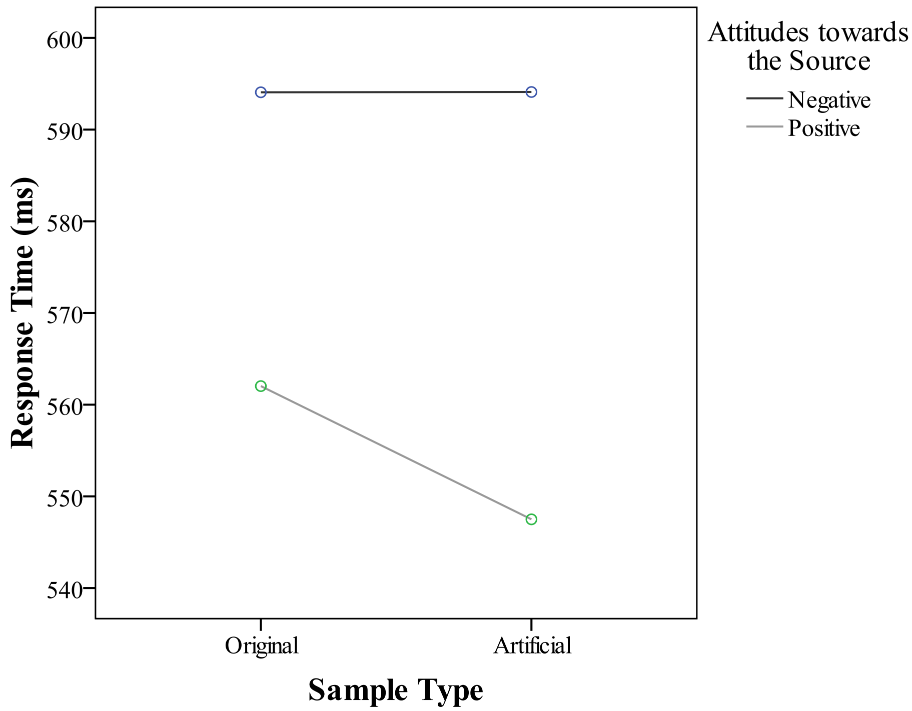

Fig. 2 – Mean response times (ms) on the 3-back task of participants in the negative and positive attitude groups during original and the artificial noise samples.

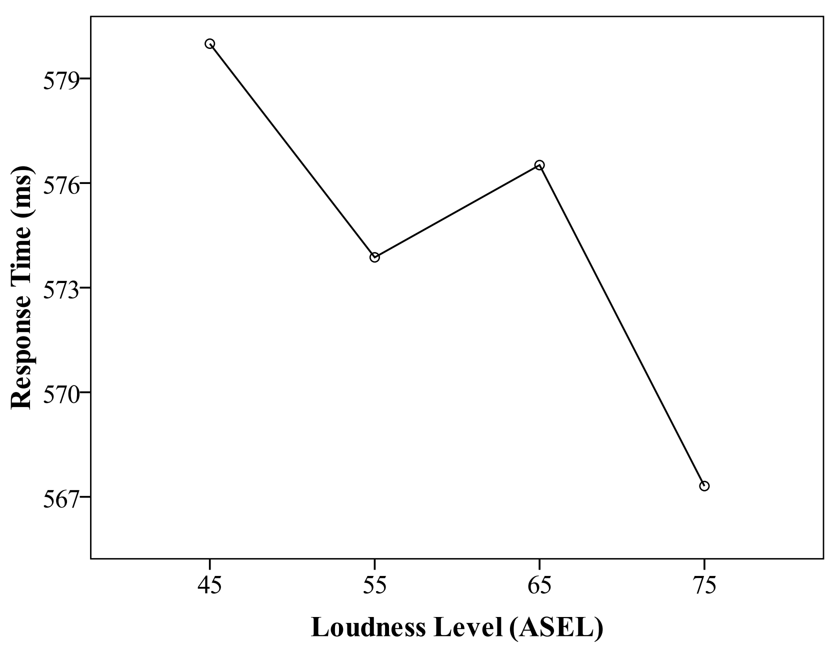

Fig. 3 – Mean response times (ms) on the 3-back task for the four loudness levels.

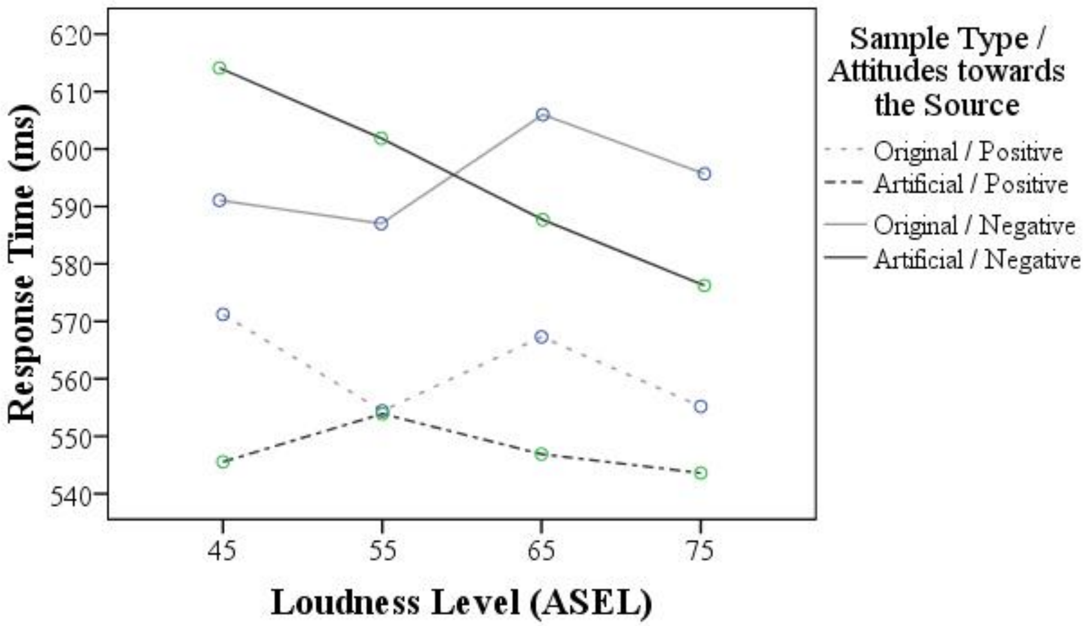

Fig. 4 – Mean response times (ms) of low and high attitude groups during the original and artificial noise samples at four loudness levels.