Effects of different kinds of traffic noise on reading and attention performance in elementary school children

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Introduction

Most of the tasks children have to do during their school day require many different cognitive skills (e.g. speech comprehension, working memory, attention and concentration). To investigate these skills in our study on effects of noise in elementary school children, three different sets of experiments are carried out. In the first set we investigated the influence of different kinds of acute traffic noise on attention and reading performance.

Attention and concentration skills, among other things, belong to the cognitive abilities that are necessary for coping successfully with everyday tasks at school, for example arithmetic or reading exercises. It is known that noise can have negative effects on single cognitive functions and/or complex abilities like reading [1]. Concerning reading ability, distinct findings mainly result from studies which investigated the effects of chronic noise exposure [2]. So far less is known about the influence of acute noise exposure on reading ability. The aims of this part of the study can be described as follows: (1) In contrast to the other set of experiments in the accompanying paper [3] it was of special interest to investigate the effects of **acute** traffic sounds on **visually presented** tasks. (2) The task should be realised in a way that is of high ecological validity for children. (3) Road traffic sounds at a moderate level should be used as sound conditions, since moderate sounds happen to be relevant for very many people.

Methods

Subjects

The participants were 103 children (52 girls, 51 boys) from five elementary schools in Oldenburg. The children were in the third grade (aged from 8 years 5 months to 11 years 4 months).

Tasks

In this part of the experiment, three different kinds of procedures were used:

A) Attention and concentration were measured with a modified version of the "KLT-R Konzentrations-Leistungs-Test" [4]. The test requires the solution of simple arithmetical problems and the storage of provisional results in short-term memory.

B) In order to assess the reading ability the first author developed a new reading test. The test's main idea is to find mistakes in written sentences. In this test, participants have to silently read sentences presented on prepared sheets. For each sentence they have to decide if the sentence is correct or incorrect and subsequently mark this decision in a defined way. If they decide for "incorrect" they are instructed to also mark the wrong word in the sentence. One test form consists of 48 items: 36 items contain one mistake, 12 are correct. The children do not know the number of incorrect sentences.

C) The third task was a noise assessment task. The children had to judge short segments of sounds (duration: 30 seconds) according to their disturbing and humming character. The children were asked: (1) *Please imagine you are doing your homework. How disturbing would this sound be to you?* (2) *How humming ("brummig") do you feel this sound is?* The participants had to mark their judgements on two rulers (one for each question) as a stroke at a number between zero and one hundred (Disturbance: zero = not at all disturbing; 100 = very disturbing).

Sounds

Performance in the arithmetic test and the reading test was analysed under conditions of four different experimental sounds and one control sound. The control sound was a simulated motorway noise from 200 meters distance at a level of 37 dB(A), to avoid the unnatural quietness in our lab. The four experimental sounds were traffic noise sounds which varied on two dimensions: traffic density and attenuation at frequencies lower than 500 Hz (see Table 1). Traffic density was realised by the number of passing vehicles per hour and the attenuation by a filtering procedure.

		Traffic density (TD)	
		500 vehicles	**2000 vehicles**
Filter	**0 dB**	500_0 / 51 dB(A)	2000_0 / 57 dB(A)
	12 dB	500_12 / 49 dB(A)	2000_12 / 55 dB(A)

Table 1: Sound conditions and sound levels ($L_{eq/10min}$).

For the noise assessment task we added one more step along each described dimension: 100 vehicles per hour and a 6 dB filter. Therefore, there were nine experimental sounds. Each child listened to three sounds at different traffic densities for one filter setting. Additionally all groups listened to the control sound. All sounds in all tasks were presented under free-field conditions using two speakers and a subwoofer located at the front of the room.

Procedures

All children did the arithmetic test and the reading test in a "control condition", that means under the control sound. The children also completed a parallel test form of both tests under one of the four experimental sounds. We therefore had four sub-groups with different experimental conditions. This design allows to test for a general difference in performance between the control and the experimental conditions and also whether the four sounds have a different effect on performance. Both the control and the experimental condition were carried out in the same session. The experimental order was controlled: 50% started with the control and 50% with the experimental condition. At the end of the test session all children did the noise assessment task. The entire investigation took place in a sound insulated lab, with a maximum of six children in one session. For all tasks examples and practice items were given.

Results

Detailed analyses were carried out for all procedures of this part of the study. In this paper just some of the most important results will be presented. In each of the three procedures the analyses were carried out for a different number of participants. That is because some children did not exactly follow the instructions. In the reading test some children with extremely poor results were excluded by a statistical procedure.

A) Arithmetic test (n = 99): The comparison between sound and control condition showed significant differences in performance. The number of "overall finished items" and the number of "correctly finished items" was reduced in the sound conditions ($p < 0{,}05$) (Figure 1).

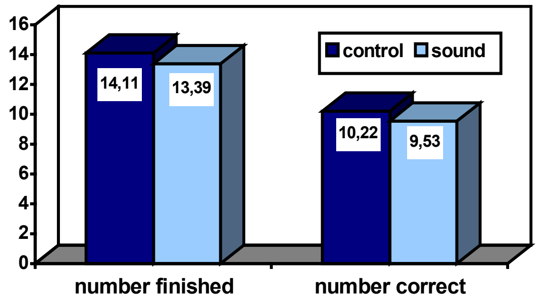

Figure 1: Effects of traffic noise on performance in the arithmetic test: comparison sound vs. control.

B) Reading test (n = 92): A significant difference between the sound conditions and the control condition could not be found. Also, we did not find such a difference in any of the four experimental groups. Regarding however the variable "percent error", the analysis of covariance (covariate: percent error in the control condition) showed a significant difference between the four experimental sounds [$F(3/87) = 2{,}712$, $p = 0{,}050$]. The post-hoc test revealed a significantly higher error percentage (representing the working accuracy) in the condition "2000_0" than in the condition "500_12" ($p < 0{,}05$).

C) Noise assessment task: For both assessments, significant results were found for the analysis of variance conducted for each group with a fixed filter. The post-hoc tests revealed that most experimental sounds were judged as more disturbing resp. humming than the control sound. The post-hoc test also brought up many significant results between other single sounds. All significant results showed higher disturbance or humming at higher traffic density. Concerning the humming judgement for the traffic density "2000", a significant effect of the between-subject factor "filter" was found [$F(2/98) = 3{,}220$, $p = 0{,}044$], with a higher amount of humming for the sounds with less filter attenuation at low frequencies.

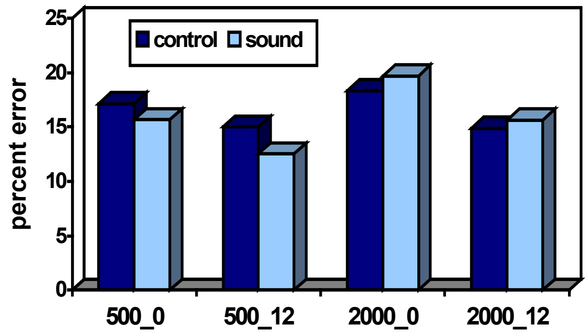

Figure 2: Effects of traffic noise on reading performance: percent error

Discussion

Although only traffic sounds with a moderate sound level were used, negative effects could still be demonstrated on performance in an arithmetic test and in a reading test. The adverse effects were most pronounced for sounds with higher traffic density and no attenuation at low frequencies. Thus, the importance of both dimensions as sound-relevant parameters was demonstrated. It can be assumed that these effects would be even more distinct if higher sound levels are used. The results of the noise assessment task clearly demonstrated that just small differences in sounds already cause significant effects in the judgements. Higher traffic density and less attenuation at low frequencies were judged as most disturbing and most humming. The direction of these results corresponds to the findings in the performance tests. Additionally, the results from the noise assessment task confirm that even young children are able to manage sound assessment tasks. This fact should be taken into account in future investigations mainly when decisions about the development concerning the reduction of traffic noise are planned.

Acknowledgments

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