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SIMULATION OF TRAM NOISE ABATEMENT PROCEDURES IN THE PSYCHOACOUSTIC LABORATORY: A PILOT STUDY

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1. INTRODUCTION

In the South of Duesseldorf, a citizens committee has been founded to combat traffic noise. The persons concerned are living at a nearly 1000 m straight of the Benrather Schlossallee. This street is a section of the federal highway B8. Tram tracks for each direction are placed in the cobble-stone paved centre of the street. Since the peripheral lanes are mostly used by parking cars, car and lorry traffic in each direction is mainly single-tracked too, and uses - like the tram - the cobble-stone paved section. The speed limit is set to 50 km/h; however, the broad and straight street certainly induces violations. Sound level measurements in the early evening hours (5.40 to 7.30 p.m.) resulted in 1-minute Leq´s ranging from 49-64 dB(A), which averaged at 59 dB(A).

The residents are mainly complaining about noise and vibrations produced by the rather old tram cars and the traffic noise due to the cobble-stone pavement. They demand the street degraded to a lower status, the cobble-stone pavement replaced by asphalt and the tram replaced by busses.

The public transport organisation suggests to replace the old tram tracks and cars by a modern low-level tram (LLT) transport system.

A laboratory experiment was designed in order to simulate the current noise situation and the two proposals and to compare their effects.

2. METHOD

Recordings. The noise of the street was recorded on digital audio tapes. One microphone was placed before and one behind an opened bottom-hung window of a room at ground floor level, which was made available by the citizens committee. The distance of the outdoor microphone to the passing trams was 7 m. From the four hour indoor recording, one undisturbed tram passage could be isolated. It lasted 27 s with Lmax=73.4 and Leq=61.1 dB(A).

In comparable streets in Duesseldorf and Bonn, which allowed the same recording distances, but had no cobble-stone pavement, the passages of a bus (23 s) and an LLT (27 s) were recorded outdoors.

Transmission Function. In an attempt to simulate the indoor noise scenarios, the outdoor recordings of the bus and the LLT had to be adjusted to the indoor recording of the tram. For this purpose, linear third-levels were determined for the general traffic noise on the outdoor and indoor tape. The outdoor-indoor difference for each third-level made the transmission function through the open window. The overall difference averaged out at 10 dB. Using a 16-bit-filter, each third of the bus recording was attenuated by the same amount, the transmission through the open window attenuated the broad band traffic noise. The LLT noise underwent the same procedure. The objective was to approximate - as close as possible - the indoor noise, which would be heard, if either proposal may be put into practice.

Lmax of the simulated bus noise was 72.8, Leq 62.2 dB(A). The corresponding values for LLT were 68.3 and 59.8 dB(A), respectively.

Experimental Tapes. A 1-minute quiet period was isolated from the indoor recording (Lmax=35.7, Leq=31.7 dB(A)). The tram passage was digitally faded into this background with a 5-second delay. The length of the tapes was set to 27 min. Down to the early evening hours, the tram shuttles in 10-minute intervals. Since the direction can be neglected due to the spatial nearness of the two tracks, this results in 27:10x2=5.4 passages in 27 min. Therefore, in order to simulate the frequency of events, five copies of the tram-on-background-minute were pasted onto the tape (1st, 7.5th, 14th, 20.5th, 27th min). Pauses were filled with background. In the same way, the bus and LLT scenarios were produced.

Experimental Cubicle. The tapes were played back via loudspeakers in a 4.36x3.64 m experimental cubicle within a psychoacoustic laboratory. For moderate sound-proofing, the cubicle was rested on elastic pedestals and the punched sandwich front walls were filled with sound-proofing material. To prevent reflexions between the side walls, these were slightly disparallel. In order to create a living room atmosphere, the cubicle was furnished and carpet was fitted on the ground. Two windows in the cubicle directly in front of the windows of the surrounding room allowed outdoor view.

Experimental Protocol. The subject was seated in an arm-chair facing the windows in 3.25 m distance to the loud speakers. In a 20-minute quiet period, a questionnaire obtaining control variables (e.g. noise sensitivity, hearing etc.) was answered and the subject was allowed to relax and read magazines. During the following 27-minute exposure period, the subject was also allowed to read, in order to simulate a leisure time atmosphere. After exposure, loudness, annoyance, threat and interference of the noise with reading was rated in a questionnaire. Moreover, subjects were asked to imagine the experimental noise being present daily at home. A list of 19 domestic interference items followed (e.g. „must increase volume of radio and TV) and subjects answered on 5-point category scales, how often they would expect each interference to occur. Usually, factor analysis of those items results in one main component [1], [2]. Therefore, the ratings of expected interferences were averaged for each person and tape, before group means were calculated.

When the questionnaire was completed, a 15-minute break followed. The experimental protocol then was repeated with a second tape. Every subject heard the original indoor tram scenario and either bus or LLT alternative. The sequence original-alternative was alternated.

Subjects. 200 written calls for subjects for a study on noise in general were distrubuted by the citizens committee. It was kept secret that design and purpose of the study was to test the alternative public transport scenarios. Finally, 18 (12 female and 6 male) residents volunteered. The age ranged from 25-60 years (mean±SD=40±12). The residents were divided in two groups of 9, one of which heard the bus and the other the LLT scenario as alternative.

Two age and sex matched control groups of people not living at the Benrather Schlossallee were recruited via anouncements.

3. RESULTS

Tram vs. Bus. The differences were not significant but consistent. The residents rated the bus scenario less loud, less annoying, less interfering with reading and also expected less domestic disturbances (e.g.Fig. 1-3).

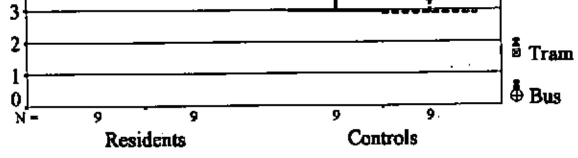

Fig. 1: Mean loudness± SE of 5 tram vs. bus passages. 0: not at all 9: extremely

As Fig. 2 shows, there was also a small tendency in the control group to judge the bus less interfering with magazine reading. With respect to all assessments, the controls responded on a lower level to any noise.

Tram vs. LLT. For both groups, most ratings differed less than 0.5 scale point. The direction of differences was not even consistent. Again, responses of the uneffected people tended to be smaller.

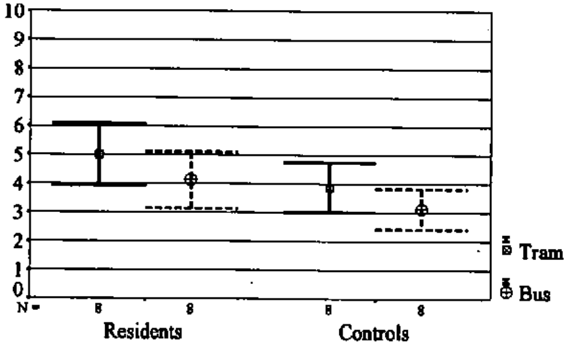

Fig. 2:
Mean interference of 5 tram vs. bus passages with reading.
0: not at all
10: unbearable

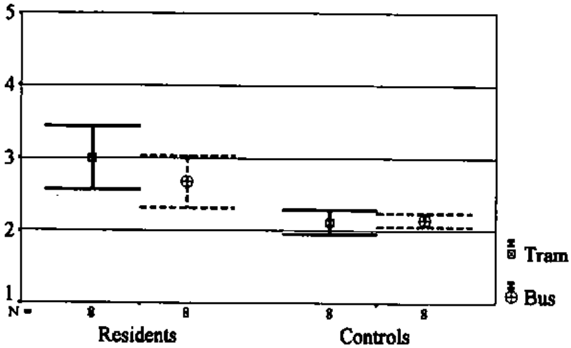

Fig. 3:
Mean expected frequency of domestic interferences ± SE for 5 tram vs. bus passages.
1: never
5: permanent

4. CONCLUSION

Although the LLT was the softest noise, the bus scenario tended to cause smaller responses in the residents group. Hence, if any conclusion can be drawn from the small differences, the bus alternative did better.

One may suspect that the residents identified their own bus proposal. However, when asked for the source of the bus noise, the most frequent answers were lorry and tram, while the controls identified lorry and car.

Finally, the inconsistent results for the controls suggest that there is no objective noise effect reduction. On the other hand, the residents are the population, which will respond to any traffic changes that may take place.

5. REFERENCES

[1] S. Leonard, P.N. Borsky, Proc. Noise as a Public Health Problem, 691-705 (1973).
[2] J. Vogt, K.-Th. Kalveram, J. Kastka, Proc. Inter-Noise, 251-254 (1994).

This study may be part of the first authors' thesis.