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ZARAGOZA '89
ENVIRONMENTAL ACOUSTICS

8º SYMPOSIUM FASE'89
«ACUSTICA AMBIENTAL»
Zaragoza, Abril 1989

CONTINUOUS CATEGORICAL LOUDNESS EVALUATION OF TRAFFIC NOISE LOUDNESS

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INTRODUCTION

For the development of a *subjective noise evaluation system* which can be used in free field conditions, some preliminary experiments are carried out under laboratory conditions. One intention is to approximate the natural situation in certain respects.

Different traffic noises are used for the investigation, mainly road traffic noise. In order to simulate the original sound field the noises are recorded with the aid of an artificial head. For the correct sound reproduction by headphones it would have been necessary to use an individual frequency response equalization of the headphone- ear canal entrance - system. Otherwise confusion effects as front-back-reversals and sound elevation effects in the frontal hemisphere are to be expected. So loudspeakers are used for the reproduction. They are positioned in the big unechoic room such that they give an optimally realistic impression.

As absolute judgements are commonly used in expressing everyday sensations, categories are employed for the loudness evaluation. A particular feature of absolute judgements is the fact, that they are given on the basis of a relational system /1,2,3/. This relational system comprises all factors that influence the decision process. Especially there are not only acoustical factors, as an acoustician might wish, but a lot of non-acoustical factors, that play an important role in absolute loudness judgements. A description of relevant non-acoustical factors is given in another lecture /4/, whereas this lecture concentrates on acoustical effects.

EXPERIMENTS

As the loudness of different traffic noises shall be judged instantaneously, a rapid answering method is needed. For this purpose we use a newly developed "analog" category scale for answering (/5/, see also /6/). This method is quite appropriate for continuously expressing sensational variations and besides this, it also allows to reproduce small changes of the loudness, which normally cannot be denoted in a discrete category system because of its underlying coarseness.

Before the experiment is started we take care that, if necessary, the subject becomes familiar with the unusal and strange atmosphere in the unechoic room. The subject is instructed to judge the loudness of the sounds perceived with the aid of the analog category scale. The noises used in the experiments are given in table 1 according to the order of presentation. The experiment takes about half an hour and during that time, there is always a possibility to communicate with the subject, whenever necessary. After the experiments interviews are made with the subjects in which we try to obtain information about the variables which influence the decision making process. 14 subjects (22-49 years old) participate in the experiments.

To ensure that the presentation conditions are the same for all our subjects, the actual sound pressure level is monitored by a half inch condensor microphone, which is positioned near the subject's head. Besides the A-weighted sound pressure level, a voltage, which represents the actual loudness judgement of the subject, is digitized at a rate of 50 Hz per channel. This results in 85,000 data during 1,700 seconds for every entity.

SOME RESULTS

Subjects: Fig. 1 shows a typical time function of the dBA-level and the corresponding absolute loudness judgements of a subject for one noise. The subjects coped differently with the scale and most of the 14 subjects tried to follow their momentary perception of loudness in the direct and immediate movement of the response knob. A few of the subjects decided to judge the loudness in a more integral way. They waited for distinct changes in the loudness before they moved the knob.

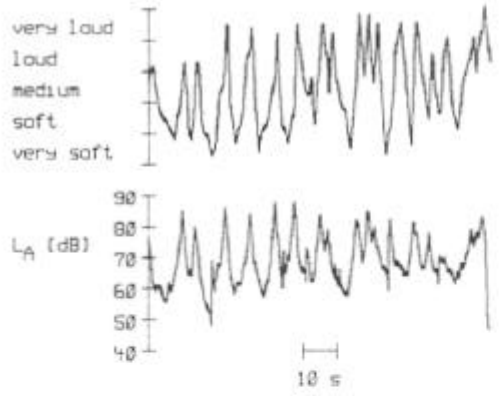

Fig. 1: Time function of the A-weighted sound pressure level and the corresponding answer of one subject.

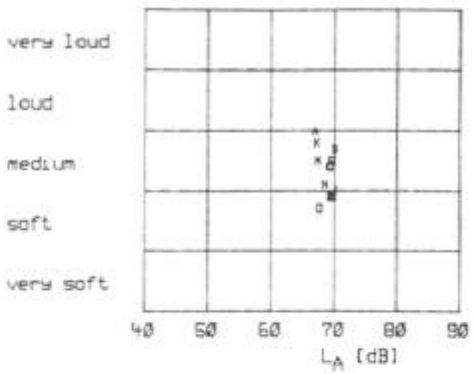

Fig. 2: The medians of the levels and the absolute judgements of the subjects for the whole presentation

From the distribution of the levels and the corresponding anwers recorded, the medians of the level and of the responses are calculated over the whole presentation period. The medians of the level are used as indicators for the levels presented. If they are the same, one can conclude that the subjects received the same levels during the different sessions.

In Fig. 2 the medians of the levels and the reponses are drawn in the level-answer-plane and one can see that although the medians of the levels are essentially

the same, there is a considerable difference in the medians of the subjects. These differences in the subjective answers can be interpreted as different loudness sensibilities of the subjects /5,7/. For the given stimuli the medians of the most and the least sensitive subjects differ by about one and a third category. It is worth noting, that the least loudness sensitive subject is a pop musician.

Noises. Table 1 shows the noises in the order, in which they are presented. Their duration varies from 21 s to 209 s and their Leq ranges from 64.4 dB for the softest to 81.1 dB for the loudest one.

Table 1: The noises

No	*duration (s)*	*Leq (dB)*	*median of the loudness*	*description*
1	56	68.4	III-3	cars passing by
2	151	79.8	IV-6	trains passing by
3	99	75.1	III-9	cars passing by
4	33	75.9	III-9	cars passing by
5	151	75.1	IV-3	construction site traffic
6	209	76.8	IV-4	construction site traffic
7	79	64.9	II-10	cars passing by
8	117	74.7	IV-3	construction site traffic
9	120	72.1	III-6	cars passing by
10	21	78.5	III-5	small plane
11	137	64.8	III-2	cars passing by
12	116	71.9	III-7	cars passing by
13	95	74.3	IV-1	construction site traffic
14	114	65.1	III-2	cars passing by
15	167	66.9	III-3	cars passing by
16	35	81.1	III-6	police car with sirenes on

The categories are coded in Roman letters: I - very soft / II - soft / III - median / IV - loud / V - very loud. For a finer graduation the categories are subdivided into 10 parts and the Arabic number behind gives the exact position within the categories.

The noises can be divided into four different sets. The largest set includes the noises with the numbers 1, 3, 4, 7, 9, 11, 12, 14 and 15. These are different road traffic noises that have been picked up at various distances from the roads in free landscapes as well as from streets in a city. The second group comprises the noises 5,6,8 and to a smaller extent the noise 13, too. These are lorry noises, which are recorded near a construction site. In the third group one finds more transient noises of short duration: a small plane (10) and a police car with a working sirene (16). The noise number 2 has an extraordinary position among the other noises. It is radiated in a station by two trains passing.

(It should be noted, that Fig. 3 shows the median and not the Leq.)

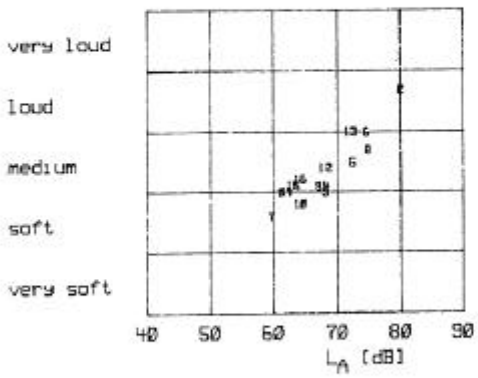

Fig. 3: The medians of the levels and of the judgements of 14 subjects related to the different noises

Fig. 3 shows, how the different noises are judged by the subjects. For every noise the medians of the levels and the medians of the judgements are plotted here as numbers (in agreement with Table 1) in the level-loudness-plane. The median of the subjects is taken from the judgements of all 14 subjects. The numbers which belong to the lowest median values represent noises from different streets with car noise only. The noises 5, 6, 8, and 13, which are found at higher levels, are caused by lorries and the extreme noise 2 comes from a running train in a station. The order of the noises in the level-loudness-plane shows a reasonable relationship between the level and the answers. As the A-weighted sound pressure level is not a good ear related measure, we assume that there will be still a better relation to the answers when using the phon or sone scale after Zwicker /8/.

CONCLUSION

The continuous judgement with the aid of the "analog" category scale gives an adequate description of the subjective sensation *loudness*. It reveals individual loudness sensitivities of the judging subjects and , as it is shown in another contribution, the given judgements correspond to the statements of the subjects in the interviews, which are carried out after the experimental session. These interviews show, that the *noise history* of the subjects plays an important role for the actual evaluations. Related to the different noises, the absolute judgements exhibit a reasonable relationship to objective intensities measures.

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