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THE PROBLEMS OF LEQ AS A MEASURE OF LOUDNESS OF VARIOUS KINDS OF NOISE

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INTRODUCTION

It is now examined to adopt Leq as a basic measure of environmental noise both in ISO (International Organization for Standardization) and JIS (Japanese Industrial Standard). A measure of noise is expected to show a good correspondence with subjective impression for various kinds of noises with different temporal structure and frequency components. Namely, it is desirable that the equal value of the measure always indicates equal subjective impression. Our previous experiments [1-11] using road traffic noise, music, speech, etc. suggest that the loudness of these fluctuating noises are approximated by Leq. These experiments, however, were conducted independently of one another and the stimulus series of each experiment consisted of a single noise source. Therefore the loudness of each noise source could not be compared with each other. In the present experiment a stimulus series which consisted of various noise sources were prepared and the propriety of Leq as a measure of various noise sources were examined by comparing the loudness of these noise sources.

EXPERIMENT

Stimuli

Nine kinds of noise sources were used as stimuli. They were aircraft noise, super express train noise, ordinary train noise, road traffic noise, speech, music, impulsive noise, artificial level-fluctuating noise and steady state pink noise. Four kinds of levels were used in each noise source, therefore a stimulus series consisted of 36 stimuli. The duration of these stimuli were about 10 sec except for impulsive noise, the duration of which was about 1 sec.

Apparatus

These stimuli were reproduced by a PCM tape recorder and presented to the subjects through an amplifier and a loudspeaker in a sound proof

room.

Procedure

The 36 stimuli were presented to the subjects in random order with about 30 sec silent intervals. The loudness of these stimuli were judged using magnitude estimation. Two trials were conducted after training.

Subjects

Sixty-seven male students aged between 18 and 21 participated as subjects in this experiment.

RESULTS

The data of two subjects who did not show significant correlation between two trials were excluded and geometric mean of 130 judgments by 65 subjects was regarded as the loudness of each stimulus. High correlation could be seen between Leq and the loudness in every noise source. Road traffic noise can be regarded as a representative environmental noise and its loudness usually shows good correspondence with Leq [8, 9]. Therefore the power function between Leq and the loudness of road traffic noise was used as a standard function to convert the loudness of each noise source into corresponding sound level, i.e. the point of subjective equality (abbreviated PSE).

DISCUSSION

The relation between Leq and PSE's is shown in Fig.1. High correlation between them suggests that Leq is a good measure of the loudness of various kinds of noises as a first approximation. Strictly speaking, however, there is a slight, but systematical deviation from Leq in PSE's of some noise sources. The reasons of this finding are examined from the following points of view.

Effects of frequency components

In order to examine the effects of frequency components, LLs, LLz and PNL were calculated. LLs and LLz are the loudness level based on Stevens' and Zwicker's methods [12, 13] and PNL was calculated on the basis of ISO/R507 [14]. These methods are based on the different frequency weighting from one another and from Leq. But there still exists the similar difference among the loudness of some noise sources. Moreover these methods are not always better measures of the loudness of noises than Leq considering their complicated calculation procedures.

Treatment of level-fluctuation

It is noted in Fig.1 that the loudness of impulsive noises are overestimated by Leq. This might be due to the difference of the duration. The duration of the stimuli in this experiment were about 10 sec except for the impulsive noises. Therefore it is probable that the subjective duration of impulsive noises were also 10 sec for the subjects, and modified Leq was tentatively calculated assuming the

duration of impulsive noises were 10 sec. This modified Leq was found to show a good correlation with the loudness of impulsive noises. This fact suggests that it will be more suitable to use an observation time period including some silent intervals in stead of actual duration of the noises in the calculation of Leq. Peak level measured by an impulse sound level meter is recommended by IEC [15] as a measure of impulsive noises. But it is not regarded as a good measure of the loudness of impulsive noises because it does not reflect the temporal loudness summation. This was also confirmed by this experiment.

Effects of subjective meaning of the noise sources

In order to examine the effects of subjective meaning of the noise sources, a questionnaire survey was conducted. As a result of this survey, aircraft noise was ranked first as a sound which is wanted to disappear and which people are severely suffering from, and last as an

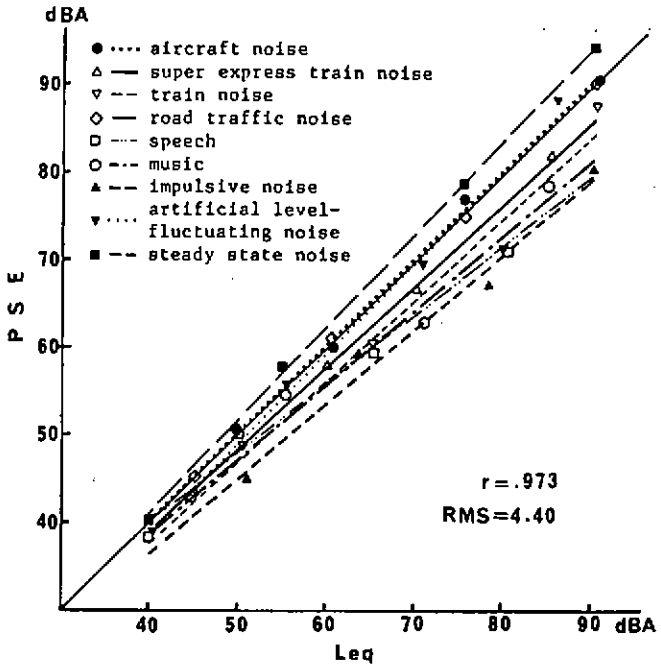

Fig.1

important sound in daily life. On the other hand, music and speech showed an opposite tendency to aircraft noise. These results agree with the results of the experiment, where the loudness of aircraft noise was overestimated and the loudness of music and speech were underestimated. These findings suggest that the subjective meaning of the noise sources may have a significant effect on the evaluation of the noises, though all the deviation from Leq found in Fig.1 are not interpreted.

CONCLUSION

As a result of experiment, it was found that Leq can be used as a good measure of the loudness of various noises as a first approximation. Leq has many advantages. It usually has a good correlation with loudness, it is easy to calculate, it can be adopted to various noise sources of any duration, and it is possible to predict future noise situation. The propriety of other noise measures were also examined in this experiment, but no other noise measures were found to be better than Leq. Strictly speaking, however, there was a slight, but systematical deviation from Leq in PSE's of some noise sources. This fact suggests that it would be better to adopt Leq as a basic measure and decide the permissible level of each noise source individually.

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