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A NEW METHOD OF LOUDNESS DETERMINATION - THE CONTINUOUS JUDGEMENT OF TIME VARIABLE SOUND ON AN «ANALOG» CATEGORY SCALE

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INTRODUCTION

Loudness is supposed to be the most important acoustical factor contributing to the annoyance of disagreeable sounds /1/. As to the difference between both sensational entities the loudness is usually taken as a neutral property of the object, whereas the annoyance should depend, to a higher degree, on individual subjective factors. Even such a distinction between loudness and annoyance does not guarantee that the loudness of a given sound is evaluated equally by different subjects, as there may be individual differences concerning the sensory system as well as differences in the individual learning process where loudness categories are associated with sounds.

In everyday life often category judgements in terms of *soft* and *loud* are used to characterize the loudness of sounds and noise. These evaluations are absolute jugdements and from psychology it is known that these judgements are made on the basis of an relational system /2/.

Here the loudness sensation of traffic sounds with a varying sound pressure is measured with a newly developed category scale under laboratory conditions, and the acoustical and non-acoustical influences on the loudness judgement process are investigated (see also /3/). In this paper mainly the method of obtaining the loudness judgements and some individual responses will be discussed.

The feeling of loudness is assumed to change continuously in the *soft* - *loud* dimension of sensation and so the discrete categories as e.g. *very soft, loud, very loud etc.* are a rather coarse instrument for describing the loudness perception. Each category covers a more or less large range of the loudness feeling according to the categories employed. In music where composers want the performers to play their instruments at prescribed intensities about seven different categories ranging from *ppp* (*p* - *piano*) to *fff* (*f* - *forte*) are used. The category *ffff* appears only seldom. When categories are applied to classify the sensation of loudness, the originally analog character of the loudness vanishes and it is rather difficult to describe small changes of the sensation in terms of a categorical system.

THE ANALOG SCALE OF THE DISCRETE CATEGORIES

The subjects are asked to give their loudness judgements with the aid of a category scale on a response box. The five loudness categories *very soft, soft, medium, loud* and *very loud* are equidistantly arranged along a vertical straight line in increasing order and the limits between the categories are marked by horizontal lines. The length of the whole scale covers 10 cm, and there is an answer-button, which can be moved manually into any position along the scale by the subjects according to the momentarily perceived loudness of the sound.

The response knob belongs to the sliding contact of a longitudinal linear potentiometer of 10 kOhms. So its position can easily be controlled throughout the experiment by permanently measuring the voltage at the sliding contact.

This combination of the originally *discrete* categories with a continuous *analog* scale enables the subjects to give very fast loudness judgements. The cognitive decision of whether a perceived loudness change is distinct enough to change the actual category is no longer necessary, and so even minor loudness changes within a category can easily be expressed by shifting the response knob only a slight amount apart. Also differently quick changes of the perceived loudness can be transposed immediately into an adequate movement of the response-knob. The categories along the scale give a convenient orientation for the answers.

So this way of describing a continuously changing perception turns out to be very appropriate. Of course, this method is also well suited for other gradual perceptional phenomena. The scale of the response box can easily be changed and by a redefinition of the meaning of the knob's position other qualities can be measured.

THE EXPERIMENTAL SET-UP AND THE PROCEDURE.

For the experiment a series of different traffic noises from cars, lorries and trains are presented to the subject. The whole presentation takes about half an hour.

The sound fields. In order to present a sound field as natural as possible, artificial head recordings are used. For sound reproduction in the big unechoic room of the acoustic's group in Oldenburg two loudspeaker boxes are positioned such that they give an optimal spatial impression of the sounds recorded.

The instruction. The subject is asked to continuously give absolute judgements on the actually perceived loudness of road traffic noise.

As most of the subject are not familiar with the laboratory environment, especially with the unechoic room, we take great care to prepare the subject for the task they have to perform. After the familiarization period the subject is instructed as follows.

"You will hear some traffic noises and you are asked to judge the momentary loudness of these noises. For your answer you can shift this answering button to a position on this scale, which you feel is the most adequate. If you think your answer is not quite right you may correct it whenever you like to. For this test we assume that you know from your experience what is loud or soft or very loud etc. and you are asked to use your everyday experience in giving the judgement on the loudness."

After the experiment the subject is asked about the experience during the test. These interviews as well as the preparation of the subject for the task and the correlatation of the answers to the answers measured are detailed in another lecture /4/.

Recorded data. During the presentation of the noises the actual A-weighted sound pressure level of a monitor microphone and the voltage from the potentiometer which represents the actual loudness judgement of the subject are recorded.

THE RESULTS

Fig 1 shows the A-weighted sound pressure level of traffic noise (cars passing by) and the corresponding answer of a subject as a function of time. The histogram of the different level-answer combinations is given in Fig. 2 for the entire experiment (about 85000 pairs for one session) for the same subject.

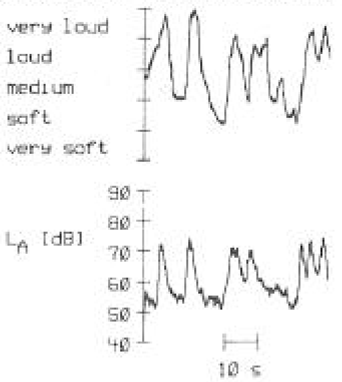


Fig. 1: The A-weighted SPL of car traffic and the absolute judgement of a subject as a function of time

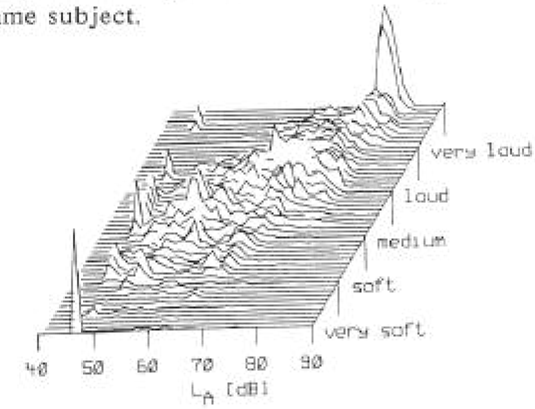
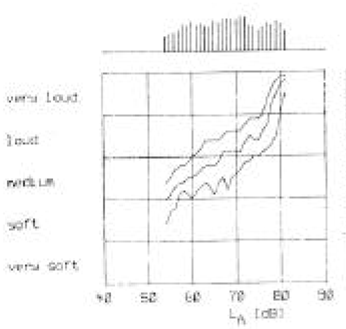


Fig. 2: The compound level-answer-histogram for the whole experiment for the same subject

These histograms are an important basis for the extraction of characteristic distribution parameters. Fig.3 shows the answer for a given dBA-level in terms of percentiles of the corresponding loudness distribution, which can be derived from Fig.2. The lower one of the three curves represents the 25%-value, the middle curve the 50%- and the upper curve the 75%-value of the answers for a given level. The answers in Figs. 2 and 3 are given by the most loudness sensitive of our 14 participants and for a comparison Fig.4 gives the answers in the same manner as Fig.3 for the least sensitive subject.



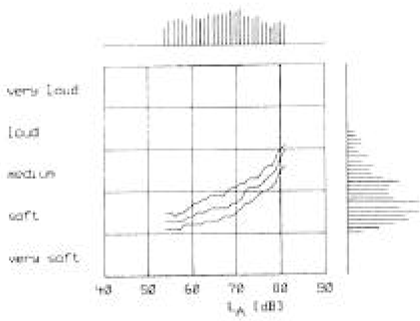


Fig.3: Most loudness sensitive *Fig.4: Least loudness sensitive*

The 25%-(lowest curve), the 50%-(middle curve) and the 75%-value(upper curve) of the distribution of the answers for a given level for the two extremes of loudness sensitivity. Half of the given absolute judgements are found between the outer curves.

The differences between these two subjects are illustrated in a further representation (Fig.5). It shows the cumulative distribution of all the given answers during a session of both subjects the left curve belonging to the least loudness sensitive and the right one to the most sensitive subject.

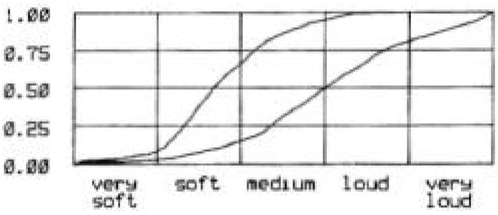


Fig.5: Cumulative frequency distributions of the answers obtained from the less sensitive (left curve) and the most sensitive subject (right curve)

Of course, the special shape of the curve depends on the distribution of the stimuli offered, but the difference between the curves may be interpreted in terms of different loudness sensibility. From the different slopes of the curves it can further be concluded that the more sensitive subject also responds more sensitivly to level differences as the offered stimulus distribution is the same in both cases.

CONCLUSIONS

i. The loudness response of the subjects shows a reasonable relation to physical sound field parameters. The application of the "analog" category scale is successful for the representation of the perceived loudness.

ii. The relationship between the judgements and the level exhibits different individual sensitivities. These differences concerns the overall sensibility as well as the differential sensibility to level changes.

Detailed results of the absolute loudness response on different traffic noises will be given in further lectures /4,5/.

Further aspects. The measured data allow crosscorrelation calculations between the level and the subject's answer which will exhibit the time lag and the degree of linear correlation between the stimulus and the judgement. The combination of the momentary judgement with an overall judgement will give the basis for the development of an integration rule for time varying sounds.

It is also possible to study psychometric properties as time series effects or the frequency and range /6/, which play an important role in absolute judgement experiments.

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