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SOUND QUALITY AND ACTIVITY: SHARPNESS AND BANDWIDTH ANNOYANCE ON READING

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1. INTRODUCTION

In the presence of high levels of noise, hearing loss and interference in communication are the main effects observed. With moderate sound pressure levels (SPL), when such effects are not important, and annoyance is the main concern, other aspects of soundscape come into play [4]. Noise **quality**, which is not entirely accessed by sound energy indicators, becomes important [7][9].

Annoyance, like other environmental aspects, must be related to a whole situation [1]. The activity of the potentially annoyed subjects must be considered in annoyance evaluations. There are studies relating effects of high SPL noise and specific tasks [3][5], but much has still to be done considering annoyance and activity.

An experiment is here reported, to examine the relation of a pair of noise qualities and annoyance during intelectual activity.

2. MOTIVATION AND BACKGROUND

Sharpness is defined as the first moment of the **loudness** distribution [2], and doubtless is important in annoyance evaluation. Nevertheless, noises with the same sharpness have different annoying capacities. Surely, there are other qualities in such similar signals that should be defined and studied. Here, the degree of energy concentration in

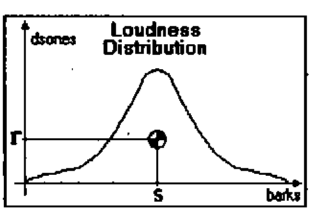

Fig. 1 - Sharpness (**S**) and Γ

frequency will be considered, for a single-hill loudness distribution, the ordinate Γ of its center of area being proposed as such an indicator (Fig. 1).

Loudness is an important subjective parameter, so it was chosen for normalizing purposes. Loudness summation was done accordingly to [6] and [8]. The analysis bands were those defined in [10] because of their properties. Due to this, sharpness is given in **barks** and the quality Γ measured in decimals of **sones**.

3. EXPERIMENT

Stimuli

Nine noise signals were obtained by white noise filtering and were divided into three sets. Each set presents three noises with same sharpness, but distinct values of Γ. The total loudness was nearly the same for all noises. Tab. 1 shows noise measurement. The sets will be represented by S_6, S_{12} and S_{18}, respectively.

Tab. 1 - Noise measurements

NOISE	#1	#2	#3	#4	#5	#6	#7	#8	#9
Loud (sones)	6.0	5.9	6.1	6.0	6.1	6.0	6.1	5.9	6.1
Sharp (barks)	6.0	6.0	6.6	12.1	12.1	12.0	18.1	18.1	17.8
Γ (dsones)	30.0	27.9	22.3	30.1	27.8	20.5	28.8	23.2	19.1
SPL (dB)	66.5	72.0	70.5	69.9	75.2	69.2	67.8	71.8	73.0
SPL (dBA)	61.9	59.6	57.3	70.5	75.8	69.8	67.8	71.5	72.3

Noises were stored digitally in 10 seconds .WAV files. They were played in loop using a sound card, an amplifier and loudspeakers with 30 Hz to 20 kHz operating range

Subjects

The subject group consisted in 13 volunteers (8 males and 5 females, 20 to 29 years), all students at the authors' university, with normal hearing. None of them had participated in psychoacoustics tests before. The group was divided into nine sessions, each with one or two subjects.

Procedure

The experiment was elaborated to access the influence of Γ on annoyance during an intelectual task (reading comprehension of literary texts). A whole session took less than one. The subjects were asked to estimate the perceived annoyance in a free-number magnitude estimation, with a suggested range from 0 to 100. Before the first noise, a reference situation was presented (room background only - never more than 54 dB or 43 dBA), which might be considered the best to perform the task. The noises were played in different orders in each session to avoid bias, so all noises were evaluated with all texts.

The test-room was sound treated to simulate a good office. A work desk was positioned 2m from the loudspeakers. The SPL was measured there, with and without the subjects (all the sessions), and the maximum difference from Tab. 1 was less than 2 dB.

4. RESULTS

Figures 1 and 2 show the results from the subjective tests. The first group of results (Fig. 2) is relative to the three noise sets (S_6, S_{12} and S_{18}). They have their annoyance evaluation represented by the ordinate (in normalized units of measurement). The abscissa represents the values of Γ, in decimals of sones. The vertical lines in the experimental points consist of the interquartile range of subjective evaluation of each noise.

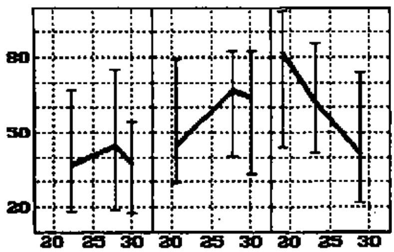

Fig. 2 - S_6, S_{12} and S_{18} mean annoyance evaluation

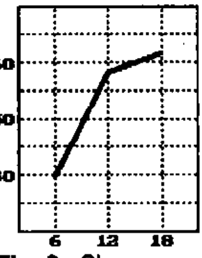

Fig. 3 - Sharpness and annoyance

The mean evaluated annoyance of each noise set is shown in Fig. 3. As in the first figure, the ordinate represents the normalized grades (mean). The abscissa is relative to the sharpness, accordingly to Tab. 1.

5. DISCUSSION

The shape of the curves on Fig. 2 are similar enough to draw the following conclusion: broad-band noises with low values of Γ are considered less annoying than those with intermediate values. In general, to increase Γ from median values may bring a reduction in perceived annoyance. The last set of noises (S_{18}) has a slight difference, in the evaluation of the low Γ noise. Low values of Γ and high sharpness make the noise spectral distribution similar to white noise, and very "hissy". So in this case, the isophonic weighting, included in the loudness evaluation, seems insufficient to enhance the annoying potential of high frequencies. Sharpness is related with annoyance in a way that fits very well what was initially supposed: high sharpness noises are more annoying than those with low sharpness. So, this quality consists in a good annoyance indicator. The quality represented by the parameter Γ can also be related with perceived annoyance of steady sounds, illustrating, by its considerable independence, the main point which the ongoing research aims at: to the adequate, however restrained to be objective, characterization of the annoyance potentially offered by a noisy environment, a vector of "qualitative quantifiers" should be measured. The kind of activity to be held in that environment should then originate the threshold criteria to qualify the environment.

To this end, the existing quantifiers seem to be insufficient, considerable effort being necessary to develop new ways to extract mathematically objective parameters to represent sound qualities. For non-stationary soundscapes, which may be very annoying even with steady, moderate SPL, time-frequency analysis may be a source for new parameters.

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References

[1] BERGLUND, B., BERGLUND, U., LINDVALL, T. (1975). ***Scalling Loudness, Noisiness, and Annoyance of Aircraft Noises***, J. of Acoust. Soc. of Am. **57**(4), pp 930-934.

[2] VON BISMARK, G. (1974). ***Sharpness as an Attribute of the Timbre of Steady Sounds***, Acustica **30**, pp 159-172.

[3] BROADBENT, D.E. (1958). ***Effect of Noise on an "Intelectual" Task***, J. of Acoust. Soc. of Am. **30**(9), pp 824-827.

[4] COSTA-FÉLIX, R.P.B. & ZINDELUK, M. (1995). ***Bancada Experimental para Avaliação de Incômodo Acústico*** (Experimental Bench for Acoustic Annoyance Evaluation), Proc. of the **16th Annual Meeting of the Brazilian Society of Acoustics (SOBRAC)**, São Paulo-SP, pp 117-121.

[5] JERISON, H.J. (1957). ***Performance on a Simple Vigilance Task in Noise and Quiet***, J. of Acoust. Soc. of Am. **29**(11), pp 1163-1165.

[6] ISO-532 (1975). ***Method for Calculating Loudness Level.***

[7] RONACHER, A. & STÜCKLSCHWAIGER, W. (1994). *"The Development of an Objective Assessment Scale for the Subjective Annoyance from Engine Noises"*, in ***Sound Engineering - Customer realted Acoustic Development in Vehicle Techniques*** (ed. Quang-Hue Vo, Renningem-Malmshein, Germany).

[8] STEVENS, S.S. (1956). ***Calculation of the Loudness of Complex Noise***, J. of Acoust. Soc. of Am. **28**(5), pp 807-832.

[9] ZINDELUK, M. (1995). ***On the Necessity of the Qualitative Dimension in the Evaluation of Annoyance***, Proc. of **15th ICA**, Trondheim-Norway, pp 306-310.

[10] ZWICKER, E., FLOTTORP, G., STEVENS, S.S. (1957). ***Critical Band Width in Loudness Summation***, J. of Acoust. Soc. of Am. **29**(5), pp 548-557.