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 intellectual 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 Ω](image-url)
frequency will be considered, for a single-hill loudness distribution, the ordinate $\Gamma$ 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 $\Gamma$ 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 $\Gamma$. The total loudness was nearly the same for all noises. Tab. 1 shows noise measurement. The sets will be represented by $S_9$, $S_{17}$, and $S_{18}$, respectively.

<table>
<thead>
<tr>
<th>Tab. 1 - Noise measurements</th>
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<tbody>
<tr>
<td>NOISE</td>
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<tr>
<td>---------------</td>
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<tr>
<td>Loud (sones)</td>
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<tr>
<td>Sharp (barks)</td>
</tr>
<tr>
<td>$\Gamma$ (dsones)</td>
</tr>
<tr>
<td>SPL (dB)</td>
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<td>SPL (dBA)</td>
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</table>

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 $\Gamma$ on annoyance during an intelectual task (reading comprehension of literary texts). A whole session took less than one. The subject was 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 (S6, S12 and S18). They
have their annoyance evaluation represented by the ordinate (in
normalized units of measurement). The abscissa represents the values of $\Gamma$, in
decimals of sones. The vertical lines in the experimental points consist of the interquartile range
of subjective evaluation of each noise.

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 $\Gamma$ are
considered less annoying than those with intermediate values. In
general, to increase $\Gamma$ from median values may bring a reduction in
perceived annoyance. The last set of noises (S18) has a slight difference,
in the evaluation of the low $\Gamma$ noise. Low values of $\Gamma$ 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 F
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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