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ON THE INFLUENCE OF INTERAURAL CORRELATION ON BINAURAL LOUDNESS FOR BROADBAND NOISE

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ABSTRACT

The influence of the interaural crosscorrelation factor of broad band noise on the binaural loudness is investigated for pink noise and broad band filtered white noise. An adaptive staircase method is used to compare the loudness of eleven different dichotic signals with the loudness of a diotic reference. The sound pressure level and the spectral shape of right and left ear signals are identical for all signals compared. No influence of the interaural crosscorrelation factor on the loudness can be found despite of the different spaceousness of the sound images produced by different correlation coefficients.

INTRODUCTION

Natural noises recorded with an artificial head frequently show interaural correlation coefficients different from the unity. However, binaural loudness models do not take into account this parameter [1]. Our interest in this study is to investigate the influence of the interaural correlation factor on the loudness perception.
DUBROVSKIJ/CHERNYAK [2] investigated the binaural loudness summation by finding out points of subjective equalness (PSE) of the loudness of monaural, diotic ($r = 1$) and dichotic ($-1 \leq r < 1$) signals. In a first experiment they compared monaural signals to uncorrelated ($r = 0$) diotic signals as references, in a second experiment dichotic signals were compared to diotic signals as a reference. Dubrovskij/Chernyak used the method of constant stimuli. The stimuli were white noises in the frequency band from 20 up to 5000 Hz, with levels of 79, 83, 89, 92 dB, generated according to LICKLIDER [3]. The dichotic signals were composed from three different noises with interaural crosscorrelation $r = 0$, 0.2, 0.4 and 0.85, according to JEFFRESS/ROBINSON [4]. Both experiments showed no dependence of the loudness perception on the correlation coefficient.
Experimental methods have been improved since this examination. LEVITT [5]

showed that adaptive methods are faster and cause less bias. JAESTEDT [6] showed that psychoacoustical measurement can be done by stimulus comparison. In our experiment we investigate the influence of the crosscorrelation coefficient using a different and new designed experiment with the same and new stimuli, a more precise scale division and a broader range of interaural correlation levels and a broader SPL range.

EXPERIMENT

The binaural loudness of dichotic stimuli are compared to that of a diotic reference. Used stimuli are pink noise from 20 Hz up to 20000 Hz and white noise from 20 up to 5000 Hz, generated with interaural crosscorrelation factors $r = -1, -0.85, -0.6, -0.4, -0.2, 0, 0.2, 0.4, 0.6, 0.85$ and 1. The reference diotic signals ($r = 1$) are generated completely uncorrelated to the test signals. The stimuli are presented through Stax-earphones in a soundproof cabin. Each signal has 700 ms duration and is Hanning-windowed on 25 ms at its beginning and end. A presentation is composed of reference signal and test signal sequentially presented in randomized order. Between the signals is a pause of 500 ms. The TPs are asked to decide, whether the first or second signal is the loudest one.

For the loudness comparison a transformed up-down-forced-choice method is employed using a staircase-method beginning with steps of 2 dB. After two reversals the step size is halved, until the trial is finished after four revesals with a step size of 0.25 dB. The PSE is calculated as median of the last four reversals. Trials are presented in statisticaly randomized order.

Six series of tests with different experimental conditions (see table 1) are conducted: the number of TPs ranges from 7 to 10 per test, pink noise or filtered white noise are used and the SPL of the test signal is varied from 63 dB up to 83 dB.

series of tests	a	b	c	d	e	f
number of TP	9	8	9	8	10	7
noise	pink	pink	pink	pink	white	white
SPL of test signal	63 dB	63 dB	68 dB	68 dB	78 dB	83 dB
first level difference	-1 dB	+9 dB	-1 dB	+5 dB	+5 dB	-1 dB

Table 1: The experimental conditions for each of the six tests

Seventeen TPs (6 female, aged 23 – 30; 11 male, aged 25 – 48) take part in the experiment, each absolves three different series. All TPs are audiologically normal (i.e. maximum -15dB loss in one band, tested by Békésy - tracking).

After every test session all TPs are asked for their general impressions, especially whether it is possible for them to concentrate upon loudness for the whole time, and whether the experiment is too long. Further the TPs are asked to describe their perception of the noises, especially the width, sharpness, sensory unpleasantness and lateralization.

RESULTS

Medians and quartiles of the PSEs are calculated for the different cross correlation factors whithin each of the test series a-f separately. Nearly all medians are within the range of the just-noticeable-difference (JND) which is given by ZWICKER/FASTL [7] as ± 0.75 dB for white noise at levels > 40 dB. The median for the uncorrelated (r=0) white noise (serie f) is slightly less than the lower JND limit. All results for the diotic pink noises are summarized in Fig. 1 whereas results for the bandpass filtered white noise are represented in Fig. 2. Although very different intracranial noise images are reported by TPs, no influence on loudness judgement can be noticed.

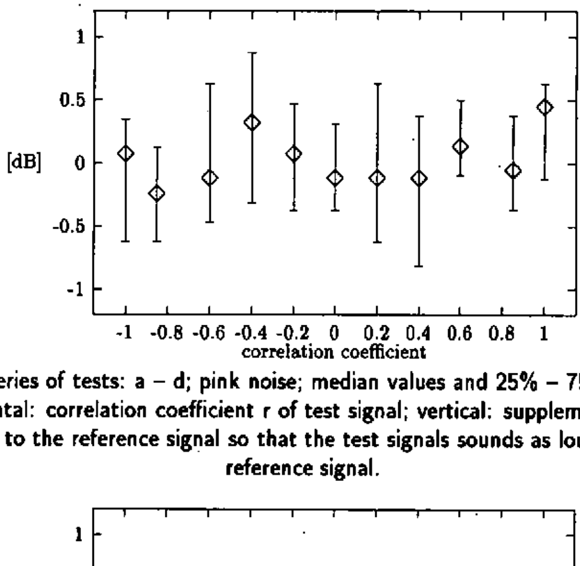

Fig. 1:series of tests: a – d; pink noise; median values and 25% – 75% quartiles horizontal: correlation coefficient r of test signal; vertical: supplement to be added to the reference signal so that the test signals sounds as loud as the reference signal.

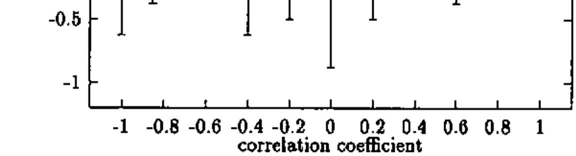

Fig. 2:series of tests: e – f; band noise 20 – 5000 Hz; median values and 25% – 75% quartiles; horizontal and vertical same as in Fig. 1.

Grouping the data according to the sex of TPs, to their experience with psychoacoustical tests or to their perceived lateralization of intracranial noise images of the signals doesn't lead to any statisticaly significant influence of these parameters on loudness perception. All medians are in the range of the JND and all quartiles are within a range of reference SPL ± 1.1 dB.
However, TPs report about their perception clear differences among the stimuli. All TPs perceive a focused centered noise image for diotic signals. As the correlation coefficient decreases, the lateralization gets wider and for half of the TPs splits into two images attached to the ears. Uncorrelated signals are perceived as focused to the ears (same results are reported by DUBROVSKIJ/CHERNYAK [8]). The other half of the TPs gets wideness sensations for signals with low correlation factors, but does not hear independent noise image components.
Also the TPs report that their estimation of sharpness and pitch increases with decreasing correlation coefficients.

CONCLUSION

In this study we consider the influence of interaural correlation on loudness for band pass and broad band noises ranging from 63 to 83 dB SPL. Despite of different noise perceptions due to different interaural correlation factors, no influence on the loudness perception is found. Thus the results support the assumption of energywise summation of binaural loudness [2] for a wider range of sound pressure and stimuli types.

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