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Discrepancy in binaural tests and in measurements of sound field parameters

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Introduction

„Hearing research at the moment is a complicated interaction between physics, anatomy, physiology, and psychology. We cannot separate certain variables to the degree that is possible in physics. Furthermore, our measurements are not so precise, and the range of validity is not so well defined. Therefore, we often have to modify our earlier findings in light of the new, at least in the range of validity.

If we have a speaker in a normal living room and we listen to him monaurally or binaurally first from a distance of one meter and then from three meters, we notice hardly any difference except for a small drop in loudness at the greater distance. But if we have two identical microphones, one placed one meter away from the speaker and the second three meters away, then the recordings show two different sound pressure patterns over time. There is a small time delay for the lower trace which was recorded from the more distant microphone. It is difficult to understand how such different stimuli as the sound patterns in the upper and lower traces can product the same sensations. Much research was done to find the reasons why this is possible." [1].

Insufficiencies in binaural tests

Békésy's observed the difference between the „acoustical information" and the measurable parameters in the time space. Nowadays we are searching for the same answers to these questions in the frequency space.

The Head Related Transfer Functions (HRTF's) are complex transfer functions describing the transmission from the free-field sound source to the eardrums by different angle of incidence. They contain the effects of the things near to the ears, first of all the head, the outer ears, and the torso. *Theoretically,* if we know all the proper HRTF's from each direction we can synthesise binaural signals.

The binaural technique bases on the fact that by exactly recording of the sound pressure of the two eardrums we are able theoretically recreate the perfect soundfield during playback through headphones (create the full 3D spatial sound reproduction using only two channels). The recording must be done on real human head or using a head and torso simulator (dummy-head).

The torso imitates the real human head (and body) as good as possible. We can record with the built-in microphones or even at the entrance of the blocked earcanal (this recording contains full spatial information - showed by Moller [2]).

Some investigations for measuring the quality of the artificial heads showing that these simulators are not as good as recommended. The recording made on real human heads deliver better results (in front-back error probability) and sounds better [3],[4]. In our research we try to find which parameters are the most or even the non significant during measuring the HRTF's.

Measuring the influence of the every day life environment

The sound field in the every day life differs from the situations we usually measure in. Our purpose was to make changes on the torso which are natural in the every day life and in the real life observations (clothing, hair, glasses...etc.).

The torso is fasten on a turntable in the anachoic chamber. The loudspeaker distance is 2 m. the height and the orientation can be adjusted with strings. The exact position is controlled by a laser direction meter. The broadband noise input signal is presented periodically and a response average is calculated. The microphone signals are sampled by 50 kHz and a 4096 points FFT is used. The reference signal was recorded in the origo without the torso. The quotient of the response spectrum and the reference spectrum results in HRTF's. The average SNR is 85 dB [5].

Results

The HRTF's of the normal torso is the reference for each direction in the horizontal plane. Moreover we made some measurements with changes in the acoustical environment. We put caps, hair, glasses, sweater, coat...etc. on the torso.

Fig.1. shows an informative result using baseball cap on the torso. There is three separate domains where no influence (less than 1 dB) was detected. Three more where csillapítás and erõsítés occur. The response as the ear is on the other side of the head determines a noisy domain.

Clothes seem to have a sound absorbing effect. If we put sweater on the torso we see a little csillapítás (more than 1 dB) and smoothing in the 500-1500 Hz domain. The thicker the clothing is the more is the csillapítás. This effects mainly occur between ±60° in the horizontal plane.

Hair produces csillapítás as well. It is significant in the 3-6 kHz domain between 90° and 270° (Fig.2.).

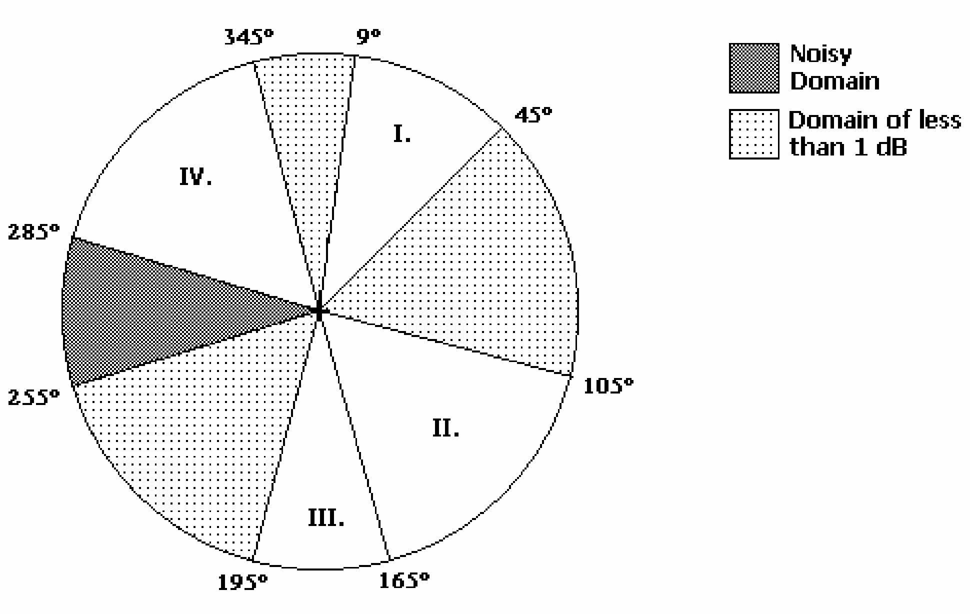

Fig. 1. Measurement in the horizontal plane using baseball cap. Domain I. contains 1 dB csillapítás as the frequency varies from 5-8 kHz up to 8-10 kHz. Domain II. contains 1 dB csillapítás at 5-7 kHz, and 1-4 dB erõsítés at 4-6 kHz. Domain III. only shows 1 dB csillapítás at 3-7 kHz. Domain IV. shows -2-3 dB at 3-6 kHz, and +5dB from 4 to 8 kHz.

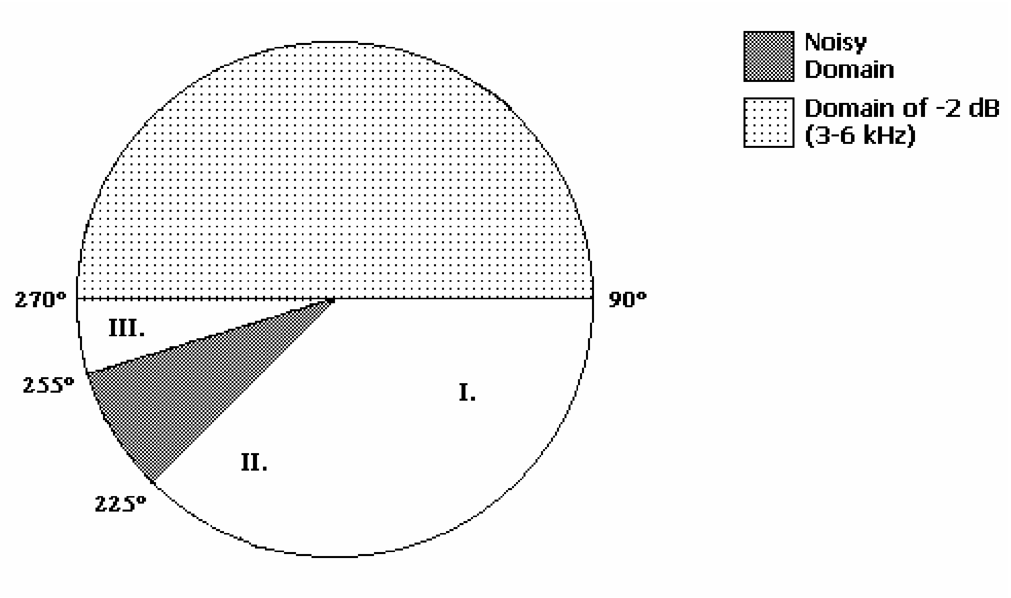

Fig. 2. Measurement in the horizontal plane using toupee. Domain I. contains increased csillapítás up to -4 dB at 3-6 kHz. This value decrease in Domain II. as the response is getting noisier. In Domain III a little csillapítás accurs as we come out from the noisy domain and getting closer to the frontal plane.

7.References

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