The microphone and artificial head sound pressure measurement

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Introduction

A frequent question that emerges in psychoacoustic research is the selection of suitable methods for recording sound signals to be used as stimuli in psychoacoustic tests. An appropriate measure of naturalness is required (realism requirements) according to the aim of the recording. In order to have a faithful reproduction (more difficult to achieve with capacious natural sound sources and with recordings made in a normal echoic room) the signal should retain without distortion the spatial and timbral sound character in the location of recording; given the properties of the reproduction chain, the reproduced sound should evoke in the listener the same sound percepts as the original.

The compatibility of reproduction and recording methods has previously been studied [e.g. 1]. Whenever someone listens to a sound the resulting listening percept is influenced by the ear's acoustic properties; the spatial and timbral sound image is created together with directional properties of the head (including the body), pinna and ear canal. Although microphone signals from the same spatial positions, where the entrance of the auditory canal is located during listening, do not possess these properties, head-and-torso simulators (HATS) are being developed and improved based on results of measuring on human heads. HATSs are usually constructed to have a frequency response function ($U_{head\ out}(f)/\ U_{mic\ ref}(f)$) similar to that measured on the tympanic membrane ($SPL_{eardrum}(f)/\ SPL_{ref}\ (f)$). This type of head-related transfer function has its reference point midway between the ears, and the type of incident sound field can be as free (progressive) as diffuse. In order to restrict the influence of the listening space and increase repeatability, recorded stimuli used in psychoacoustic tests are generally reproduced using headphones or loudspeakers in an acoustically adapted room. The properties of the auditory canal and pinna in a natural way influence the percept during listening, and if these are already included in recordings (HATS recordings) the percept is influenced by them twofold. (Influences and differences in the case of headphone and loudspeaker reproductions; see also in [1]). In such cases it is useful to use a head simulator whose output signal follows sound pressure changes at the entrance of the auditory canal.

This contribution summarizes results of measured frequency response functions for three head simulators and one studio recording microphone.

Methods and Results

Measurements were made in an anechoic room, using: a MLSSA system [3], 2-way Yamaha MSP5 loudspeaker box (L), B&K 4165 reference microphone (M_{ref}), Sennheiser ME62 omnidirectional studio microphone (M), Cortex Instrument C1/ T01 binaural recording head with manikin (C), Georg Neumann KU100dummy head (N), and Schoeps KFM360 (S) surround microphone system.

The values of spectra of MLSSA impulse response were averaged in critical bands (Bark). The space-frequency transfer functions presented below were obtained by subtracting the value of the reference loudspeaker response function from the value of measured responses in 23 Barks (the value of the lowest Bark was excluded). The reference point was at the entrance position of the left ear, around which the head and microphone corpus were rotated. [See loudspeaker positions and direction of rotation in Fig. 1].

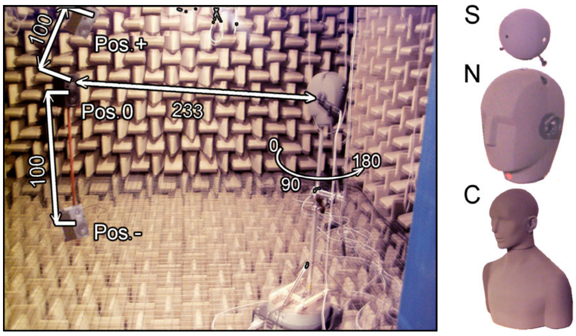
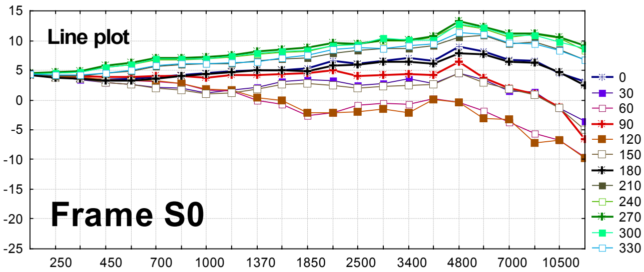
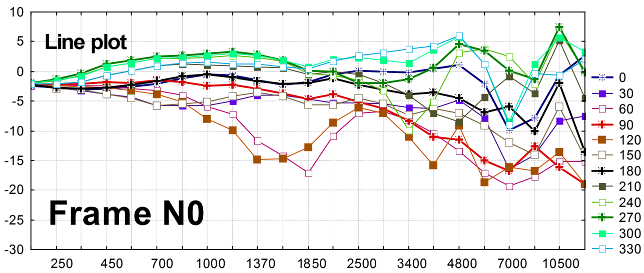
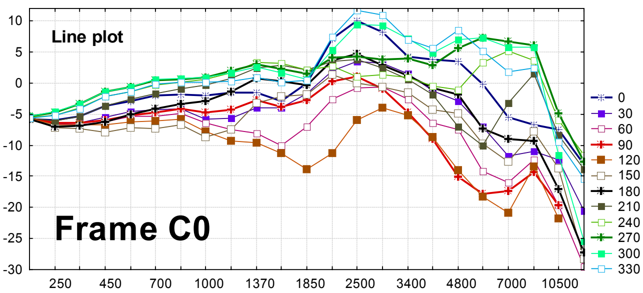
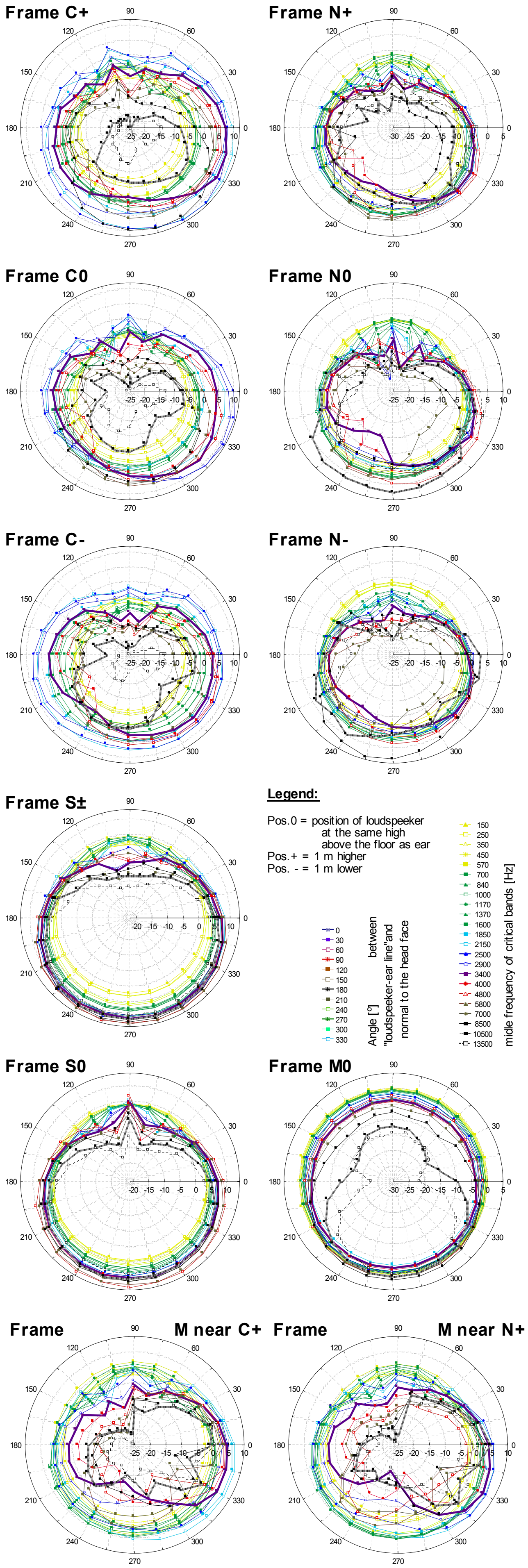


Figure 1: Experiment setup and used head simulators.









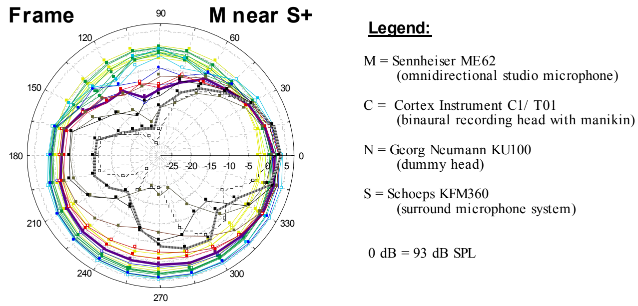


Figure 1: Space-frequency transfer functions of used microphone and head simulators at three loudspeaker positions (line plots and polar plots).

Discussion

Visible in all graphs [Frames in Fig. 2] is a decrease of SPL where the microphone was positioned on the side of the head turned away from the source (at an angle close to 90 degrees). This influence of acoustic shadow of the head's corpus is applicable from a level of 500 Hz and higher (compare results for only the omnidirectional microphone in Frame M0 and for the omnidirectional microphone in head simulator in Frames M). The effect of the shadow on the reverse side is lower when the imagined "microphone-source" line goes through the corpus's symmetrical axis (best observed in Frame S0 for 90 degrees). This effect is less pronounced for loudspeaker positions + and –. SPLs are higher for angles 270-330 due to the opposite effect of progressive wave flow, also according to head shape (or pinna). Very pronounced is increasing SPL due to resonance of the auditory canal at frequencies 2 – 4 kHz (Frames C) and also at 7 – 8 kHz (Frames C and N). Shadow and canal resonance also similarly influenced the sound field in close proximity to the head (see Frames M near C/N/S, where microphone M was close to the ear entrance). For these reasons, use of the head simulator S is in most cases better than use of two microphones; the head N is more applicable for recording in a diffuse-like sound field, while the head C yields an aurally adequate signal in free fields applicable in analysis but not in reproduction.

Acknowledgement

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References

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