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Le Goff, Nicolas; Kohlrausch, Armin

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THE EFFECT OF COCHLEAR NONLINEARITIES ON BINARUAL MASKING LEVEL DIFFERENCES

Nicolas Le Goff1 and Armin Kohlrausch2,3
1. Technical University of Denmark, 2. Philips Research Europe, 3. Eindhoven University of Technology

Introduction

The detection of a tone in noise is impaired when the interaural phase difference of the signal at the two ears is not the same as that of the masker. The detection threshold of a tone presented with a 0° interaural phase difference is in a dichotic noise masker is typically lower than the detection threshold of a tone in a masker, both presented at one ear only. This difference between monaural and binaural detection thresholds is currently referred to as the binaural masking level difference (BMLD) and can be as large as 15 dB for broadband noise.

It is known that the BMLD decreases with higher masker levels. As shown in Fig. 1 the decrease is larger when the masker is attenuated in one ear only (top section) than when it is attenuated at the two ears (green line). The power of evidence increases that at lower masker levels, the cochlea is highly nonlinear and that the responses of both ears can be different, especially when both ears carry the same signal, but the signal at the two ears is not the same as that of the masker.

In this study, the BMLD was measured for S100 Hz tone in 3-kHz wide maskers with a level between 10 and 50 dBHL. As a nociflexor (1962) the masker was attenuated in either one or two ears. For attenuation in one ear only, thresholds were measured for two masker levels below the detection threshold of a tone in a masker, both presented at one ear only. This signal at the two ears is not the same as that of the masker. The detection threshold of a tone in noise is improved when the interaural phase difference of the tone and masker is reversed. This could therefore cause a reduction in interaural correlation between the left and right internal representations of the noise masker presented at different levels in the two ears, which in turn would reduce the efficiency of the detection process.

Two binaural model implementations were considered. Both were signal driven bottom-up processors used as artificial model. Both implementations assume two sources of internal noise: one to limit audibility (Dewald, 2001) in the peripheral processor, and one to limit binaural audibility. The two model implementations only differed in the filterbank properties.

Hypothesis

The response of the cochlea is level-dependent and nonlinear. Cochlear nonlinearities could therefore cause a reduction in interaural correlation between the left and right internal representations of the noise masker presented at different levels in the two ears, which in effect would reduce the efficiency of the detection process.

Research Tools:

An equalization cancellation (EC) binaural model that includes a gammatone dual-resonance nonlinear (DRNL) filterbank and a nonlinear adaptation stage.

Model

Two model implementations were considered. Both were signal driven bottom-up processors used as artificial model. Both implementations assume two sources of internal noise: one to limit audibility (Dewald, 2001) in the peripheral processor, and one to limit binaural audibility. The two model implementations only differed in the filterbank properties.

Detection of a 500-Hz tone (200 ms) in a 3-kHz-wide noise masker (300 ms) – 3 subjects – 3 repetitions per subject - 3-AFC

Experiment: Tone-in-noise detection as a function of the masker level

Detection of a 500-Hz tone (200 ms) in a 3-kHz-wide noise masker (300 ms) – 3 subjects – 3 repetitions per subject - 3-AFC

Model Predictions

Linear peripheral processor

Dependent on the ILD, the model predicts an increase in the masking level for ILD = 0° to 30°, which corresponds to a decrease in the masking level for ILD = 60° to 90°.

Nonlinear peripheral processor

The effect of ILD on BMLD is accounted for by cochlear nonlinearities, which can cause a decrease in IC in the internal representations of the masker, depending on the reference level of the masker.