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THE EFFECT OF COCHLEAR NONLINEARITIES ON BINAURAL MASKING LEVEL DIFFERENCES

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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 180° interaural phase difference in a silent 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 commonly 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 lower masker levels. As shown in Fig. 1, the decrease is larger when the masker is lower. The masker levels. As shown in Fig. 1, the decrease is larger when the masker is lower. The masker levels. As shown in Fig. 1, the decrease is larger when the masker is lower.

Two binaural models were considered. Both were signal-driven bottom-up processes used as artificial observers. Both implementations assume two sources of internal noise, one to limit sensitivity (BMLD) in the peripheral processor, and one to define the internal biasary. The two models implemented differ in the filterbank properties.

Research Tools:

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

Model

Two model implementations were considered. Both were signal-driven bottom-up processes used as artificial observers. Both implementations assume two sources of internal noise, one to limit sensitivity (BMLD) in the peripheral processor, and one to define the internal biasary. The two model implementations differ 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 turn would reduce the efficiency of the detection process.

In this study, the BMLD was measured for 500-Hz tones in 3-kHz-wide maskers with a level between 10 and 50 dB/Hz. As an N0S/0 dB/Hz stimulus, the masker was attenuated in one ear only, with two ears. For attenuation in one ear only, thresholds were measured for four masker levels in the non-attenuated ear (reference level of either 20 or 50 dB/Hz).

The nonlinear cochlear response is modeled by the DRNL filterbank. It is characterized by three distinct frequency bands. The response of the DRNL in the present model was fitted to proposed macaque data (Ishiyama et al., 2011). The input-output response has three distinct frequency bands. The response of the DRNL in the present model was fitted to proposed macaque data (Ishiyama et al., 2011).

The auditory filter bandwidth of the DRNL filterbank is similar to those of 4th order gammatone filters at low levels and increases for higher input levels.

Research Questions:

Are the nonlinearities in the cochlea necessary and sufficient to explain the effect of interaural masker level differences on tone-in-noise detection?

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 adaptive adjustment of the level of the tone

Illusory correlation (IC) is almost-zero-effect on BMLD and is equal to 0 dB/Hz. IC increases for lower levels (internal noise).

The BMLD for NoS/50 dB/Hz is less than the BMLD for NoS/20 dB/Hz at corresponding masker levels.

Discussion

Linear peripheral processor:

• Detection is limited by the auditory filter bandwidth to the frequency of the masker.

Nonlinear peripheral processor:

• Detection is limited by the auditory filter bandwidth to the frequency of the masker (e.g., lower than the BMLD for NoS/50 dB/Hz). IC increases for lower levels (internal noise).

Effect of IC 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.

References:


