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 30 dB of interaural phase difference is in a 

Research Tools:
An equalization cancellation (EC) binaural model that includes
self-adaptive self-generating nonlinear (DRNL)
filterbank and a nonlinear adaptation stage.

Model
Two model implementations were considered. Both were signal driven, bottom-up processes used as artificial observer. Both implementations assume two sources of internal noise: one to limit sensitivity (DMLD) in the peripheral process, and one to limit the binaural adaptation.
The two model implementations 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.

Two binaural model implementations were tested in this hypothesis. I) The equalization cancellation (EC) binaural model proposed by Breebaart et al. (2001), which includes a linear-gammatone filterbank. II) An extension of the model proposed by Breebaart et al. (2001) with nonlinear peripheral processing, which includes a dual resonance nonlinear filterbank (DRNL) (Loizou and Meddis, 2001). Model predictions obtained with the two models were compared to test whether the nonlinear cochlear processing in the DRNL binaural model is necessary and sufficient to account for the effect of interaural masker level differences on the BMLD. Model predictions obtained with the extended nonlinear model are consistent with the experimental data.

Discussion

Experiment: Tone-in-noise detection as a function of the masker level
Detection of a 500 Hz tone (200 ms) in a 2 kHz wide noise masker (200 ms). 1 subjects – 3 repetitions per subject – 3-

Model Predictions
The nonlinear cochlear response is modeled by the DRNL filterbank. It is characterized by a nonlinear level-dependent auditory filter bandwidth. The non-linear input-output function is nonlinear. The response of the DRNL in the present model was fitted to improve masking curve data (Jepson et al., 2001). The input-output response has three distinct phases:

1. NMLD for NoS: Predictions for condition NoS=50dB/Hz & 0 ILD 30dB are predicted by the extended nonlinear model, while the Breebaart et al. (2001) model can only predict the BMLD for the masker level.

2. Nonlinear cochlear model account well for the data.

3. Both the Breebaart et al. (2001) model and the extended nonlinear model account well for the data.

Footnotes:

References:


Discussion

Effect of ILD on BMLD is accounted for by cochlear nonlinearities, which can cause a decrease in IC with the interaural level difference on the response of the masker level.