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 90° interaural phase difference is in a binaural 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 2, the decrease is larger when the masker is attenuated in one ear only. Thresholds for monaural and binaural detection are illustrated in the middle and right panels. In the right panel, the interaural phase difference (ILD) is 90° with a 20 dB (blue circles) or 40 dB (red circles) masker. The reference condition for the monaural condition is shown in the left panel. For the noise spectrum level (No) 30 dB/Hz, the interaural correlation measured at the output of the peripheral processor for masker signals as a function of the ILD.

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

Two binaural models were investigated to test this hypothesis: (i) The equalization cancellation (EC) binaural model proposed by Breebaart et al. (2001) which includes a linear-gamma filterbank. (ii) An extension of the model proposed by Breebaart et al. (2001) with nonlinear peripheral processing, which includes a dual resonance-nonlinear filterbank peripheral (DRNL filterbank: Lopez-Parra and Plack, 2003). Model predictions obtained with the two models were compared to test whether the nonlinear cochlear processing in the DRNL filterbank is necessary and sufficient to account for the effect of the interaural masker level differences on the BMLD. Model predictions obtained with the extended nonlinear model are consistent with the experimental data.

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?

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The non-linear cochlear response is modeled by the DRNL filterbank. It is characterized by a low-pass level dependent non-linearity filter bandwidth. A nonlinear input-matrix function. The response of the DRNL in the present model was fitted to temporal masking curve data (Jespersen et al., 2011). The input-output response has three distinct phases.

- Linear response for input levels < 50 dB SPL
- Compensative response with a ratio of 0.25 for input levels between 50 and 80 dB SPL
- Linear response for input levels > 80 dB SPL

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