The effect of cochlear nonlinearities on binaural masking level differences

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**THE EFFECT OF COCHLEAR NONLINEARITIES ON BINONTAL 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 30° interaural phase difference 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 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 (top panel) than when it is attenuated at the two ears (bottom panel). The pressure levels (dB SPL) of the masker and noise were 70 dB SPL and 50 dB SPL, respectively. The two ear models are implemented only in the right ear.

In this study, the BMLD was measured for 500-Hz tones in 3-kHz-wide maskers with a level 0.7 dB SPL below masking level (ML). The BMLD for low- and high-frequency tones was measured in 60-s intervals for 20 masker levels in 3-kHz-wide maskers with a level 0.7 dB SPL below masking level (ML).

**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 internasal representations of the noise masker presented at different levels in the two ears, which in turn would reduce the efficiency of the detection process.

**Literature Relevance**

The nonlinearity of the cochlea is necessary and sufficient to explain the effect of interaural masker level differences on tone-in-noise detection.

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**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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**Research Tools**

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

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**Experiment**

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

**Detection of a 500-Hz tone (200 µV) in a 3-kHz-wide noise masker (300 µV) - 3 subjects - 3 repetitions per subject - 3-4 dB adaptive adjustment of the level of the tone.

**Results**

In the presence of a noise masker (left panel), BMLD is equal to the BMLD for which the noise masker is present (right panel).

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**Discussion**

**Model Predictions**

- Linear peripheral processor: BMLD for NoS is equal to the BMLD for NoS, which is equal to the BMLD for No SLM.
- Nonlinear peripheral processor: BMLD for NoS is larger than the BMLD for NoS, which is larger than the BMLD for No SLM.

**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.**

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**References**


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**Figures**

[Figure 1: Detection of a tone in noise is improved 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 30° interaural phase difference 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 commonly referred to as the binaural masking level difference (BMLD) and can be as large as 15 dB for broadband noise.]

[Figure 2: 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 (top panel) than when it is attenuated at the two ears (bottom panel). The pressure levels (dB SPL) of the masker and noise were 70 dB SPL and 50 dB SPL, respectively. The two ear models are implemented only in the right ear.

[Figure 3: In this study, the BMLD was measured for 500-Hz tones in 3-kHz-wide maskers with a level 0.7 dB SPL below masking level (ML). The BMLD for low- and high-frequency tones was measured in 60-s intervals for 20 masker levels in 3-kHz-wide maskers with a level 0.7 dB SPL below masking level (ML).

[Figure 4: The detection of a tone in noise is improved 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 30° interaural phase difference 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 commonly referred to as the binaural masking level difference (BMLD) and can be as large as 15 dB for broadband noise.]

[Figure 5: In this study, the BMLD was measured for 500-Hz tones in 3-kHz-wide maskers with a level 0.7 dB SPL below masking level (ML). The BMLD for low- and high-frequency tones was measured in 60-s intervals for 20 masker levels in 3-kHz-wide maskers with a level 0.7 dB SPL below masking level (ML).]