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The effect of cochlear nonlinearities on binaural masking level differences

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Background

The binaural masking level difference (BMLD) has been shown to be constant (10−15dB) for masker spectrum levels from 70dB/Hz down to 30−40dB/Hz and to gradually decrease with lower levels (McFadden, 1968; Hall and Harvey, 1984). The decrease at low levels was larger in an asymmetric condition where the masker was attenuated in only one ear. McFadden predicted the data by assuming that an external and an internal noise would interaurally decorrelate the internal representations of the stimuli. In the present study, the role of nonlinear cochlear processing and asymmetric masker level on the BMLD was investigated using an equalization−cancelation (EC) based binaural model framework.

Methods

The BMLD was measured for 500−Hz target tones presented in 3−kHz−wide maskers. BMLDs were obtained as a function of masker level in one symmetric and two asymmetric masker conditions: (i) NoSπ: thresholds were measured for masker spectrum levels between 50 and -10dB/Hz, with the same level at both ears; (ii) No′Sπ′50: same as first condition but the masker was attenuated in one ear only and fixed at 50dB/Hz in the non−attenuated ear; (iii) No′SΠ′20: same as second condition but with a masker level of 20dB/Hz in the non−attenuated ear. An EC based binaural model with a frontend including nonlinear peripheral processing (Jepsen et al., 2011) was used to predict these results.

Results

The BMLD obtained in the No′Sπ′50 condition was smaller than that obtained in the NoSπ condition at all masker levels between 50 and -10dB/Hz. The difference in BMLD between the two conditions gradually increased with decreasing masker level from 50 to 20dB/Hz and remained constant between 20 and -10dB/Hz. The proposed model could account for these data. A model analysis suggested that the increase in BMLD difference between the No′Sπ′50 and NoSπ conditions results from a decrease in interaural correlation at the output of the periphery, and is a consequence of the cochlear nonlinearity at levels between 20 and 50dB/Hz. For levels below 20dB/Hz, cochlear processing becomes linear and the model predicts that the difference in BMLD between the symmetric and the two asymmetric conditions is constant, in line with the experimental data.

Conclusion

A model was proposed to account for the effect of level asymmetry on BMLD. The modeling results suggest that cochlear nonlinearites affect the analysis of binaural cues at higher processing stages such that signals carrying interaural level differences can become interaurally decorrelated.