Improving auditory filter estimation with level-dependent cochlear noise floor

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Abstract

When developing models of human hearing for communication devices, it is important to have an accurate representation of auditory filter (AF) shape. AF shape has been traditionally estimated by the combination of notched-noise (NN) masking experiment and power spectrum model (PSM) of masking. AFs of hearing impaired (HI) listeners were sometimes estimated extremely broader than ones expected from physiological observation when NN thresholds rapidly converged onto the absolute threshold (AT) as notch width increases. The overestimation happened probably because the conventional PSM does not adequately include the effect of the cochlear noise floor associated with AT. This paper tried to clarify and solve the problem through NN measurements and a new formula of the PSM.
We measured a detailed set of NN threshold values for normal-hearing (NH) listeners, including low-level noises at four center frequencies (500, 1000, 2000, and 4000 Hz) to show how threshold converges onto the AT as notch width increases at low noise levels. We incorporated AT into the PSM for the AF shape estimation by introducing the level-dependent cochlear noise floor, $N_c^{(LD)}$, which is a function of the NN masker level from the base level directly calculated from the hearing level (HL) of 0 dB. We estimated the AF shapes for the four center frequencies simultaneously and compared the $N_c^{(LD)}$ model with a fixed noise floor model, $N_c^{(Fx)}$ and the conventional P_0 model in which an arbitrarily constant, P_0, had been introduced to represent the low-level threshold limit. The $N_c^{(LD)}$ model provided an excellent fit and a major reduction in the rms error of the AF shape estimation when comparing the P_0 and $N_c^{(Fx)}$ models. We also examined the frequency distribution of the cochlear noise floor in quiet, which provides the basis of the AT and AF shape estimation.
It was found that the frequency distribution associated with the HL of 0 dB was optimal regardless of the frequency dependency for the detector SNR, K, in the PSM. It implies that the AT can be explained by this noise floor in quiet.

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