Title	方向性マスキング解除を説明する両耳聴モデルに関する研究
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Study on binaural model for spatial release from masking

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There are cases that target signal cannot be perceived in real environments because target signals are possibly masked by varieties of noises. For signal detection in the noisy environments, detectability of signals could be improved using directional information. This phenomenon is referred as to spatial release from masking (SRM). These phenomena play an important role to detect alarm signals. However, how these phenomena are occurred by ITD and ILD in auditory system is still an open question. The purpose of our study is to investigate a binaural hearing model accounting for masking release by the significant spatial cues and to clarify how SRM occurs using the ITD and ILD.

Durlack proposed the equalization-cancellation (EC) model to interpret on BMLD. The EC model assumed that the auditory system transforms a masker incoming one ear into that incoming other ear. Then, the equalized maskers cancel each other using ITD cues to eliminate the masker components. Signal-to-masker ratio with the cancelled maskers increases and then detectability of the target signals goes up.

The results described similar characteristics of the masking release occurred by ITD. The EC model could estimate the masking release occurred by ITD with high accuracy. However, when the input signals have ILD greatly, the accuracy of the simulations goes down. The phenomenon in which ILD yields the great SRM has not yet been considered to implement the model.

In this study, we propose a binaural hearing model that accounts for the spatial masking release using the ITD and ILD cues. The model is based on EC model. In human sound localization mechanism, ITD and ILD are detected by alternative organs. Then, we consider to implement ITD process and ILD process independently and in parallel.

Firstly, we discuss to compute amount of masking release occurred complex tone hearing. Complex tones have different ILDs on bands of frequency. Thus SRM is different among frequency bands. Our model divides the target signals and maskers incoming two ears into the frequency bands using a gammatone filter bank. The output of the filters are used to calculate ITDs and ILDs for each band.

We propose a method for calculating amounts of masking release occurred by ITDs and ILDs for each band. The calculating method is based on EC theory. In ITD process, the equalized maskers are cancelled each other using ITD cues to eliminate the maskers. To equalize the two maskers, delay τ is added one masker. The signal on the same side is added to the same delay. Then, the masker in one ear is cancelled by subtracting the masker in other ear. SRM is calculated using signal-to-masker ratio. In ILD process, target signals are enhanced using ILD cues to rise up to exceed the masker. To equalize the two maskers, enhancing power a is multiplied to one masker. The signals are enhanced to be the same power. Then, the masker in one ear is cancelled by subtracting the masker in other ear. SRM is calculated using signal-to-masker ratio. The two processes can compute amount of masking release occurred by ITD and ILD separately. The model can deals with the masking release from not only the effectiveness of ITDs but also the effectiveness of ILDs.

We consider to combine the outputs of two processes for the masking release occurred by ITD and ILD. As explained in the previous section, we defined ITD and ILD processes independently in our model. Therefore, the model needs a weight to mix effects of ITD and ILD at the frequency of the signal. Here, the model refers the relation between the characteristic frequency (CF) and synchronization index of auditory nerve in the acoustic system.

SRM is calculated for each band. The final output of the model is the largest masking release selected from all outputs of the subbands.

We simulate the SRM to evaluate the model. This simulation data is the same signals and maskers as used by Kuroda *et al.* The results of the simulation using the proposed model showed the same tendency as the empirical data by Kuroda *et al.* Consequently, our binaural hearing model could calculate the masking release occurred by ITD and ILD.

In this study, we proposed a binaural hearing model that accounts for the SRM. The model is implemented to base on assumption occurred the elimination of the maskers in the acoustic system. The results of the simulation show similar amount of the masking release to the empirical data. This finding suggest that our binaural hearing model can calculate the masking release occurred by ITD and ILD.