A Signal Detection Theory Model of Binaural Cue Reweighting

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Background:

Normal-hearing listeners weight binaural localization cues depending on the sound's frequency content. Interaural time differences (ITDs) dominate at low frequencies, and interaural level differences (ILDs) dominate at high frequencies. However, the relative weighting of the cues used by the listeners can be sub-optimal, resulting in poorer localization in many scenarios, e. g., in reverberation. Previous studies showed that various training protocols can be used to induce a binaural cue reweighting both to increase the ILD weight and to increase the ITD weight. These studies used various measures to determine the ILD/ITD weight, making it difficult to compare the effectiveness of the different training protocols, as well as to compare the weights obtained in these studies to the standard "trading ratio". E.g., in our previous study using discrimination training, the proportion of discrimination responses following the ILD (P_{ILD}) was used as the relative weight measure [Singhal et al. (2023) ARO Abstract #SU44]. Here, the goal is to develop a signal-detection-theory (SDT) model, based on which a measure of the ILD/ITD weight can be estimated that is independent of the task and conditions used in each study.

Methods:

The model is based on the standard SDT model for the 2-Intervals–2-Alternative-Forced-Choice discrimination task, as used in our previous study. It uses several simplifying assumptions, the main one being that the responses are unbiased. And, it derives w_{LT}, a d-prime-like measure of the relative weight per unit of azimuthal shift in cues.

Results:

The derived relative weight estimate w_{LT}, when applied to our previous results, shows that the effectiveness of the training was approximately equal for both ITD training and ILD training. Also, the measure is more robust to noise and less affected by outliers, compared to the P_{ILD} measure used originally.

Conclusion:

A STD-model-based measure of relative weight provides a reliable and location-independent estimate of the binaural cue weighting. Applied to our experimental data, it shows that a simple adaptive discrimination training without visual signals can induce binaural reweighting in both directions. Next steps are to extend the model to localization-based estimates of relative weight and to studies estimating the "trading ratio". This will allow us to compare the effectiveness of different training procedures, like visually guided training and training in reverberant environments.

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