Auditory model-based selection of the most informative experimental conditions

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Abstract

For improving the diagnosis of hearing impaired patients one recent focus has been on measuring comprehensive test-batteries, i.e. on obtaining quantitative data, such as tone detection thresholds or amplitudes from various objective measures. However, generalizing how a patient with a certain test result is best aided, fitted, or treated remains extremely challenging. Computer models of all kinds have been employed to try to make such a relation but physiological models require too many parameters to be confined whereas very abstract or black-box models do not offer the causal insights both clinicians and researchers are often looking for. Functional models of the auditory system that often have about 3-10 parameters, such as filter bandwidth or an accuracy limiting internal noise parameter, appear to be a good compromise but still require hours of data collection prior to model fitting. An open question is therefore how to confine the parameters of a functional model in the most time efficient way. In other words: which experiment needs to be conducted and which experimental conditions need to be measured to learn the most about the model parameters characterizing a patient. In a preceding study (Herrmann and Dietz, Acta Acustica, 5, 51, 2021) a likelihood-based measurement algorithm has been developed but has only been tested with artificial patients simulated on a computer. The algorithm was capable of running in parallel to the measurement. In the present study we used the measurement algorithm to obtain the four parameters that a binaural model requires for a full characterization of a subject's 250-Hz frequency channel. The experiment was binaural tone-in-noise detection, where the algorithm could vary the interaural correlation of the masker, the interaural phase difference of the tone, and the tone level. At this stage, three normal-hearing subjects were tested. Within 500 alternative-force choice trials (about 30 min) all parameters were determined with relative standard deviations of 25% on average, but no more than 40% for any parameter. For comparison: the estimated parameters differed by a similar order of magnitude between the three subjects, despite similar age and audiograms. The duration to obtain a similar model parameter accuracy with a conventional adaptive stair-case procedure depends on how smart and confined the experimenter chooses the conditions but was multiple times longer in all our cases. The measurement procedure is not limited to psychophysics but can be used with all types of experiments. The conference contribution will focus on the analysis of the advantages, challenges, and limitations of model-steered experiments and on the analysis of which stimulus conditions the algorithm actually chooses, because they offer new perspectives for the design of diagnostic models and experiments.

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