MODELLING OF MISMATCH NEGATIVITY RESPONSE AND NON-NATIVE STATISTICAL LEARNING

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Intro. Over the last several decades, a great deal of research has investigated the extent to which statistical learning can explain human listeners' linguistic knowledge (Maye, Weiss, & Aslin, 2008; McMurray, Aslin, & Toscano, 2009). Recent mismatch negativity (MMN) research suggests that statistical learning with the oddball paradigm can improve not only between-category discrimination, but also within-category acoustic cue perception (Nixon et al., 2018). To date, there have been very few quantitave models of MMN development during statistical learning of speech sounds. The present study uses Naive Discriminative Learning (NDL) to model trial-by-trial changes in EEG amplitude during statistical learning of non-native Cantonese lexical tones.

Method. EEG data from 19 native German speakers was recorded as they listened to stimuli. Stimuli were speech recordings manipulated into a 13-step pitch continuum from Cantonese mid-level to high-level tone with 0.14 semitones between steps. A sequence of four sounds was presented, sampled from one Gaussian (the standard, e.g. high tone) followed by one sampled from the other Gaussian (deviant, e.g. low tone) of a bimodal distribution.The input to the model was the auditory stimulus (continuum step) and the output was lexical tone (high or low). To model the continuous nature of the acoustic cues and sensitivity to pitch differences, three simulations used different cue-weight window sizes: 1) a single cue (one step), 2) one step either side or 3) two steps either side of the input cue.

Results. All simulations showed steeper learning for the standard in the first block. However, simulations predicted different learning effects depending on the window size of sensitivity to the pitch differences. With perfect discrimination of each stimulus (single input cue for each individual continuum step, i.e. window size = 1), connection weights followed a bimodal distribution after training. However, with larger window sizes, reflecting lower sensitivity, connection weights had a steep slope near the category boundary but then flattened out, reflecting 'categorical perception'. This pattern bears striking resemblance to offline data from two tasks: pitch estimation and discrimination. Pitch estimates were sensitive to single steps in the estimation task (high sensitivity) and developed a bimodal shape after training. Listeners seldom detected one-step differences in the discrimination task (low sensitivity), except near the category boundary. The disribution after training was almost flat, with a dip at the category boundary.

Discussion. Simulations showed steeper learning for cues sampled from the standard than the deviant distribution, as well as different trajectories for different continuum steps, reflecting the presentation frequency of the bimodal input distribution. Of particular interest is the effect of cue sensitivity, with bimodal representations emerging only when each continuum step could be discriminated (window size 1) and a relatively flat distribution with a dip at the boundary for lower sensitivity (window size 3). This predicts an effect of task on cue sensitivity, with lower sensitivity for category discrimination than for non-discrete estimation tasks. In light of the NDL simulation results, we will perform simulations using neural networks capable of representing past events as well as current input (namely LSTMs). Simulations of the two types of models will be compared for fit to behavioural and EEG data.

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