Mean-field model of auditory cortex explains the differences in neuromagnetic fields evoked by dissonant and consonant dyads

Alejandro Tabas*[1], Martin Andermann*[2], Valeria Sebold[2], André Rupp+[2], and Emili Balaguer-Ballester+[13]

[1]Faculty of Science and Technology, Bournemouth University, UK
[2]Heidelberg University, Germany
[3]Bernstein Center for Computational Neuroscience, Germany
*equal contribution
+joint last author

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Pitch is a fundamental attribute of auditory sensation. A dyad is a sound presenting two simultaneous pitches; it is one of the most common perceptual scenarios in human auditory soundscape. However, the neuronal mechanisms underlying the perception of dyads are poorly understood.

Dyads evoke a strong percept related to the ratio between the fundamental frequencies of the two sounds. Simple ratios (e.g. 3:2) evoke a consonant, pleasant sensation while complex (e.g 16:15) ratios evoke a more dissonant percept. The N100m is a transient neuromagnetic response of the auditory evoked fields observed in MEY recordings, sensitive to fundamental auditory properties such as pitch or timbre. The N100m is associated with activity in the antero-lateral Heschl's gyrus (alHG) in human auditory cortex (AC).

First, we studied the effect of consonance and dissonance on the dynamics of the N100m using six different dyads built from two iterated rippled noise (IRN). We found a strong and significant correlation between the dissonance percept reported by human listeners (Fig. A, grey dashed lines) and the latency of the N100m (Fig. A, blue lines).

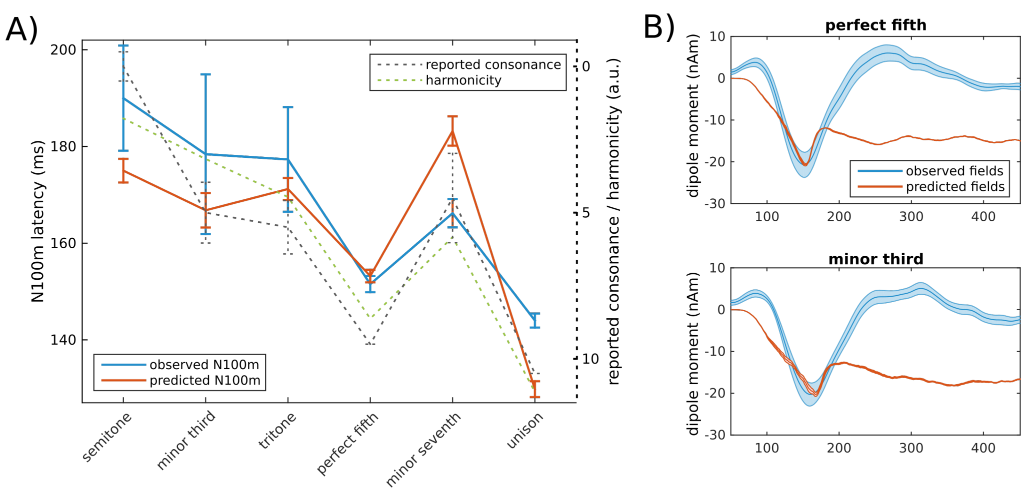

Figure 1: A) Observed (blue) and predicted (red) N100m latencies, reported consonance (grey), and harmonicity (green; measured as the similarity of the subcortical harmonic patterns separately elicited by the two notes of the dyad). B) Observed (blue) and predicted (red) early auditory fields for two dyads.

The major goal of this study was to understand this correlation on the basis of the competitive dynamics of a cortical excitatory and inhibitory network of neural ensembles, endowing realistic neural and synaptic parameters. Excitatory populations encode the pitch value, and receive direct inputs from an idealised model of subcortical processing, based on a well established model of the auditory periphery. In accordance with recent findings on the organisation of the mammal AC, inhibitory-to-excitatory connectivities follow a harmonic pattern that is crucial for cortical processing of pitch.

The model was able to simultaneously decode the two single pitch values present within the stimuli, and to predict the latencies of the N100m evoked by the dyads (Fig. A, red lines; Fig. B compares field predictions and observations).

The model output suggests that the correlation of the N100m latency with consonance perception stems from the harmonic connectivity structure in AC. Simple frequency ratios (consonant dyads) preserve a greater harmonic relationship than more complex ratios (see green dashed lines in Fig. A), and thus are naturally faster to decode in cortex, eliciting an earlier N100m.

In conclusion, our results suggest that the simulated competition dynamics in alHG provide a mechanistic explanation of consonance perception.

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