A new view on information processing in the auditory cortex by means of computational modelling

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Abstract

Sound waves are transduced in the cochlea into electric signals, which then propagate up the auditory pathway to the auditory cortex (AC) via several intermediate, subcortical stations in the brainstem and the midbrain. In AC, sounds are represented in several tonotopically organized fields. Magnetoencephalography (MEG) with its high temporal resolution of milliseconds makes it an important tool to study signal processing in the human AC by measuring the magnetic fields caused by the response of AC to acoustic stimulation. Responses to tones measured by MEG are called event-related fields (ERFs) which appear as series of waves with different amplitudes and latencies; the most prominent deflection is the N1m which occurs about 100 ms after stimulus onset. Despite decades of research, there is an ongoing debate about the generation mechanisms of ERFs and what they signify. Here, I briefly review potential generation mechanisms of ERFs and offer new views on ERF generation. For this, I use a computational model of AC which accounts for auditory ERFs and is based on the serial core-belt-parabelt network structure of AC, one of the basic principles of mammalian AC. The computational units of the model are simplified cortical columns consisting of a mean-field excitatory and a mean-field inhibitory cell populations which are represented by their own state variables in coupled first-order differential equations. Both populations are characterized by nonlinear firing rates and, additionally, coupled to dynamics of short-term synaptic depression (STSD) which is governed by its own first-order differential equation. The excitatory and inhibitory cell populations are connected to each other and are organized according to the AC network structure. Instead of using numerical solvers, the dynamics of the model are analysed by linearizing the function of firing rates and solving the STSD equation by time-scale separation. In so doing, dynamics of AC are characterized by damped harmonic oscillators, i.e., normal modes. Unlike the prevailing view where ERFs arise out of the linear combination of activity in discrete sources (i.e., equivalent current dipoles which are pointlike sources), in the normal mode view each deflection of an ERF waveform is the result of the constructive or destructive interference pattern of superimposed normal modes. Also, I show that the reduction of ERF magnitude due to stimulus repetition is the result of modulation of normal mode properties rather than the reduction of activity in discrete sources.

About the presenter

I am a Ph.D. student, completing my studies at the Leibniz Institute for Neurobiology in Germany. I have backgrounds in physics and neuroscience. I am interested in understanding how sounds are processed and represented in our brain. In order to investigate this, I combine MEG signals from auditory cortex of humans with computational models.