Neural circuits for selective auditory filtering

Aims and key research questions

To facilitate sensory processing in complex environments, the brain can selectively filter auditory input to enhance neural responses to relevant sounds and suppress responses to background distractors. Because different sounds may be relevant at different times, this filtering must be dynamic such that the brain's internal representation of the same auditory scene can vary depending on behavioral demands. Neural correlates of selective filtering have been observed in auditory cortex (AC), but the underlying circuitry has not yet been identified.

A synthesis of existing results and our preliminary data suggests that selective auditory filtering arises through interactions between AC and two thalamic structures: the medial geniculate body (MGB), which sends direct excitatory input to AC and receives direct excitatory feedback from AC, and the thalamic reticular nucleus (TRN), which relays indirect inhibitory feedback from AC to MGB (figure 1). Based on this hypothesis, we propose a program of research to answer three key questions:

Q1: Are selective spectral and temporal filtering evident in the auditory thalamus?

We predict that selective filtering similar to that observed in AC will also be evident in MGB and TRN, with both spectral filtering that alters frequency tuning and temporal filtering that aligns ongoing fluctuations in excitability with the expected timing of sound onsets (figure 2).

Q2: How do thalamocortical interactions contribute to spectral and temporal filtering?

We hypothesize that filtering arises through thalamocortical interactions; MGB responses to relevant sounds are enhanced by direct excitatory feedback from AC, while MGB responses to distractors are suppressed by indirect inhibitory feedback from AC via TRN.

Q3: How does attention modulate spectral and temporal filtering?

We expect that spectral and temporal filtering can enhance responses to an isolated sound source even during passive listening, while selective enhancement of responses to one of several sound sources requires attention to specific acoustic features.

To answer these key questions, we will carry out experiments to record and manipulate thalamic and cortical activity during passive listening and the performance an auditory task. We will use mice as an animal model to take advantage of tools for selective manipulation of thalamocortical interactions that are not available for other species.