Beyond the brain: the rhythmic inner ear and its involvement in selective listening

Moritz H. A. Köhler[12] & Nathan Weisz[123]

1. Centre for Cognitive Neuroscience, University of Salzburg, 5020 Salzburg, Austria
2. Department of Psychology, University of Salzburg, 5020 Salzburg, Austria
3. Neuroscience Institute, Christian Doppler University Hospital, Paracelsus Medical University Salzburg, Austria

PARIS LODRON UNIVERSITY SALZBURG

Auditory Neuroscience Group
Salzburg Brain Dynamics Lab

CCNS Centre for Cognitive Neuroscience

ÖAW ÖSTERREICHISCHE AKADEMIE DER WISSENSCHAFTEN

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Did you ever intensely focus your attention on something you looked at (e.g., a painting in a gallery)? What does happen in this situation when someone tries to speak to you? Exactly, it takes some time until you notice that someone is talking to you. This is some desired behavior of your brain to help you to get not distracted by disturbing stimulation of other sensory modalities than the one you are focusing on. In case of our visual sense, we can simply open/close the eye lids to regulate theamount of visual stimulation. For our sense of hearing, we are not able to open/close our pinnae. Here, the outer hair cells (OHC) inside the cochlea accomplish the task to amplify/attenuate sounds that reach the ear. We already know how the OHCs alter the acoustic properties of the cochlea. We also know that there are neural connections originating in the primary auditory cortex and eventually innervating the OHCs.

But what is the missing functional link that exercises control on the OHCs?

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The What

In a pilot study for this project, it could be demonstrated that the activity of the OHCs was rhythmically modulated in the frequency range of the brain's theta-rhythm (4-7 Hz). Moreover, the power of the OHCs' activity at these frequencies was reduced when attention was directed to the visual modality and elevated when focusing on the auditory modality, respectively. So, the brain's theta rhythm is the transmitter for inhibiting distracting auditory stimulation while focusing on visual stimulation and vice versa. These findings are in line with previous literature in the visual domain showing that during visual scene analyses visual input is sampled at frequencies of the brain's theta-rhythm.

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The Question: How do cortical attention processes exert control on the cochlea?

As the pilot study has shown in the context of intermodal attention the OHCs' activity is theta-rhythmically modulated. However, there is nothing known about other challenging attention situations.

Research question: How is this theta-rhythmic modulation altered during interaural attention, attention to pitch, predictions, during resting-state, and is the primary auditory cortex the origin of these modulations?

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The Project's Experiments

In total there are five experiments planned. Each point of the research question will be investigated in its own study. Wherever feasible the experimental design will be kept as close as possible to the one from the pilot study. Figure 1 demonstrates the framework of the project and the aims of each individual study. Studies 1-3 will investigate how amplitude and phase of the cochlear theta rhythmicity are modulated during interaural attention, attention to pitch (intraaural attention), and predictions. Studies 4 & 5 will explore how cortical and cochlear activities interact with each other during resting-state and attention processes, respectively. Furthermore, they will resolve the question, if the primary auditory cortex is the causal starting point of this interaction.

For more details, please contact: moritz.koehler@sbg.ac.at

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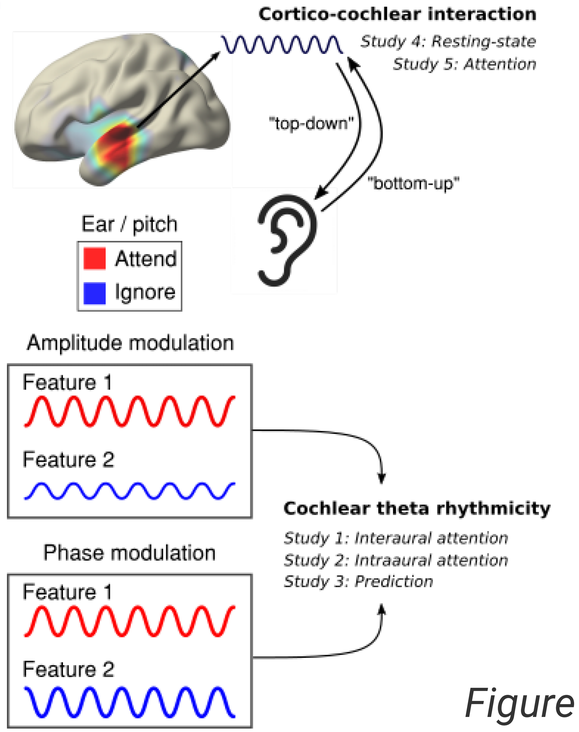

Figure 1

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Significance

This project will valuably contribute to advance questions about how cortico-cochlear interactions occur and underlying large-scale systems that control them in the service of auditory perception by conceptually and methodologically integrating the cochlear and cortical research line.