The Audiosphere - Thesis Project

Developing a Spatial Audio Platform for Naturalistic Auditory Categorization in Non-Human Animals, **Neuroscience/Physics**

Administrative Information

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Laboratories	CRNL (Lyon) & LMA (Marseille)
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Project Overview

The Audiosphere project establishes a new experimental and theoretical framework for studying how animals form and use auditory mental categories, with a focus on the brain circuits linking abstract acoustic features to behavioral responses. The project unfolds in three complementary phases: 1. Identify distinct auditory mental categories present in mice. 2. Characterize the neural circuits underlying auditory categorization. 3. Manipulate auditory mental categories to optimize behavioral flexibility.

This PhD project, at the interface between Physics and Neuroscience covers **Phase 1**, whose primary goal is to build an innovative spatial audio device and design the behavioral protocols required for auditory categorization studies. The **core technical goal** is to design a loudspeaker array capable of synthesizing fixed or moving sound sources in the half-space in front of a head-fixed mouse.

Five Missions

1. Spatial Audio Array Design Develop a loudspeaker array based on VBAP (Vector Base Amplitude Panning) synthesis, adapted to the constraints of animal experimentation.
2. Experimental Device Assembly Build the full system – mechanical structure, multi-channel audio chains, and control software – optimized for the 1–20 kHz range and ideally extendable to 40 kHz. The device must be portable for installation in a neuroscience laboratory.
3. Acoustic Characterization System Design and build a measurement system to validate the array's acoustic performance, starting with a mobile microphone compared against simulations, and evolving toward a fixed microphone array for more complete characterization.
4. Feasibility Study Explore advanced 3D sound reproduction techniques – Wave Field Synthesis (WFS), Higher-Order Ambisonics (HOA), and beamforming – as alternatives or complements to VBAP, evaluated both theoretically/numerically and experimentally from acoustic and/or behavioral perspectives.
5. Experimental Implementation Install and operate the array to conduct auditory categorization studies in mice. The audio system will be synchronized with high-density Neuropixels neural recording probes, requiring advanced acoustic and neural signal analysis methods.

Work Environment

The PhD is structured in two geographic phases: **Years 1–2 at LMA, Marseille** – Device design and construction, supervised by Renaud Côte with support from Vincent Roggerone and Sandrine Rakotonarivo. **Year 3 at CRNL, Lyon** – Live-animal experiments supervised by Pierre Le Merre.