**1.Research in our lab:**

Our laboratory is interested in understanding the neural basis of auditory perception and vocal communication in a naturalistic environment. We are interested in revealing neural coding mechanisms operating in the cerebral cortex and how cortical representations of biologically important sounds emerge through development and learning. Perception and production of communication sounds (e.g. human speech and animal vocalizations) are among the most important behaviors of humans and many animal species. Because of the complexity and behavioral importance of communication sounds, understanding their neural representations in the cerebral cortex will help reveal computational principles that the brain uses to process a wide range of sounds we experience daily such as speech and music. Understanding how the brain processes such sounds will provide invaluable insights into neural mechanisms underlying human language perception as well as how the brain functions during social interactions. We use a combination of neurophysiological methods and state-of-the-art engineering and computational techniques to tackle our research questions.

**2. Current Research**

1)Neural basis of auditory perception:

- Neural coding of species-specific vocalizations in a naturalistic environment

- Cortical circuits and organization for processing pitch and harmonicity

- Spatial representation in auditory cortex; neural basis of cocktail-party effect

- Population coding studied with two-photon imaging technique

2)Neural mechanisms for vocal communication and social interaction:

- Neural circuits for vocal production and control in the brain

- Neural mechanisms underlying auditory-vocal interaction and feedback processing

- Brain functions during social interactions studied with wireless neural recording techniques

3)Cortical processing of cochlear implant stimulation:

- Neural representations of cochlear implant signals in auditory cortex

- Developmental and experience-dependent plasticity in cochlear implant usage

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| **Research direction** | **3. One sentence introduction** (displayed on home page, <32 words) | **4. A paragraph of summary**  (displayed on top of each section pages) |
| Review Articles | Good Introduction to prior work in the lab. |  |
| Neural Coding | Electrophysiology reveals various strategies of cortical coding of acoustic features. | We use electrophysiology methods (single-unit extracellular recording, intracellular recording, and population electrode array recording) to investigate some basic mechanisms of neural coding in the auditory cortex. We found neurons with various response properties to sounds, including synchronized temporal code, non-synchronized firing-rate code, fine tuning to pure tones, sensitivity to spectral contrast, and highly selectivity to complex sounds, etc. |
| Vocalization | Vocal production of marmoset, and neural mechanisms underlying auditory-vocal interaction. | We record vocalizations of marmosets in the colony, quantitatively characterize their vocalization repertoires and correlate with their behaviors, to understand how vocalizations of marmosets play an important role in their social interactions; We also use wireless recording electrode arrays to record neural activities in the auditory cortex and prefrontal cortex, in free-roaming condition, to study the neural mechanisms underlying vocal production, perception, and auditory-vocal interactions. |
| Pitch and Harmonics | Investigating the mechanisms underlying perception of music sounds, with behavioral and electrophysiological experiments. | Pitch and harmonic complex sounds are essential for music, speech, and auditory object grouping. We have shown that marmosets are able to perceive pitch in the same way as we humans do, and that there is a specialized region in the primary auditory cortex sensitive to pitch. We are currently investigating how the circuit in the auditory system enables these computations, and how the pitch-sensitive area emerges through development. |
| Sound Localization | Neural representation of the three-dimensional acoustic space in the auditory cortex. | We study how the location of sounds is represented and encoded in the auditory cortex of awake and behaving marmosets, through full free-field or close-field sound presentation, with electrophysiology techniques. |
| Cochlear Implant | Marmosets as a model for investigating cortical representation of cochlear implant stimulation. | We implant cochlear implants in one side of marmosets’ ears, and investigate neural representations of cochlear implant signals in auditory cortex, as well as developmental conditions and experience-dependent plasticity related to cochlear implant usage. |
| Behavior and Psychophysics | Auditory behaviors of marmosets; Auditory-tactile integrations in humans. | We trained marmosets with an operant conditioning behavioral paradigm on auditory tasks (tone detection, discrimination of vocalizations and pitch etc.) to study their basic auditory perception capacities and vocal behaviors. We also conduct human psychophysical experiments related to music perception and auditory-tactile integration. |
| Techniques | Electrophysiology, wireless recording, two-photon imaging, optogenetics, behavior... | We have developed multiple electrophysiology techniques to record from neural signals from awake marmosets, including single-unit extracellular and intracellular recording, wireless multi-channel electrode recording. We have also designed operant conditioning paradigm to study their auditory behaviors. Other techniques under development includes optogenetics and two-photon chronic imaging in awake marmosets... |