23 Natural sounds and our auditory system

- Reconsidering our auditory system under natural environments -

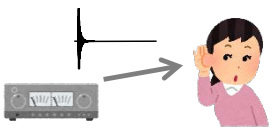
Abstract

Our everyday life is coloured by natural sound textures. How does our brain transform them to a rich repertoire of our hearing experiences? For studying this, it is insufficient to simply use synthetic sounds in artificial conditions. Here, we introduce some of our attempts to deepen our understanding of the auditory system through carefully studying natural sound signals that arrive at our ears in the natural environment (outside the experiment rooms). Specifically, we focus on binaural recordings that include effects of natural head movements and natural reverberations coming from walls, trees, etc. Our study revealed how we adapt to a reverberating environment and called for reconsidering some of the established theories of auditory research. If we can precisely understand what underpins our perception of sound textures, we will be able not only to transfer the content of a sound but also to manipulate its fine texture.

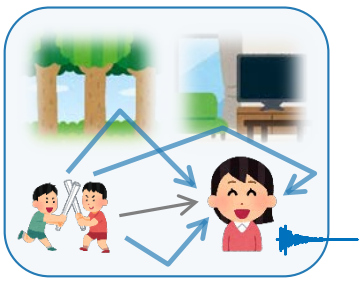
Is our audition optimized to natural sounds?

Auditory researches often use synthetic simple sounds in an anechoic room. But it is not those sounds but natural sounds that our auditory system is optimized to process, an emerging theory says. We are trying to understand how natural sounds are perceived by carefully studying what sound signals arrive at our ears in the natural environments.

Synthetic, monaural, direct

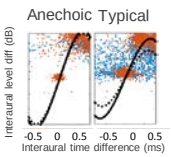


Natural, binaural, reverbs



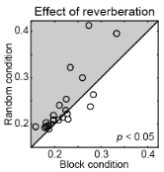
What cue matters? [1]

- Localization of a sound is done by integrating several cues (interaural time/level difference).
- Found that the cues are less reliable in natural environment.
- Need to reconsider how our binaural system has developed.



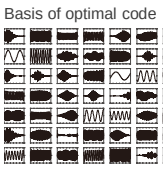
What material is hit? [2]

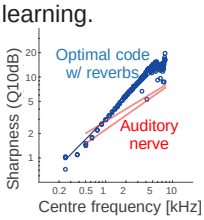
- Decay of impact sound is a cue of material perception.
- Room reverbs affect decay. → Changes in perception?
- Found that we adapt to reverbs to reduce their effects.



Unsupervised learning?

- Sparse codes of natural sounds match auditory nerve filters.
- Found that they get unmatched if considering natural reverbs.
- Unlikely to be simple unsupervised learning.





We process natural sounds in a more complicated way than previously thought.

Reference

[1] S. Furukawa, "Natural Combinations of Interaural Time and Level Differences in Realistic Auditory Scenes," in *Proc. 39th Annual Midwinter Meeting of the Association for Research in Otolaryngology*, 2016.

[2] T. Koumura, S. Furukawa, "Effect of Reverberation and Its Presentation Context on Material Perception Based on Impact Sounds," in *Proc. 40th Annual Midwinter Meeting of the Association for Research in Otolaryngology*, 2017.

Contact

Hiroki Terashima Sensory Resonance Research Group, Human Information Science Laboratory
Email : terashima.hiroki(at)lab.ntt.co.jp