The Neuroscience of Hearing and Its Disorders: Research at NEOMED

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https://www.neomed.edu/research/hearing/
Hearing disorders of many types begin in the inner ear, but they have long-term effects in the brain. The Hearing Research Group at NEOMED is interested in how the central nervous system functions in association with hearing and vocal communication, how it is affected by hearing disorders, and how interventions of the peripheral and central nervous systems may ameliorate hearing disorders.

**Jeffrey Wenstrup, Ph.D. (Director)**

Dr. Wenstrup's team studies how emotional centers in the brain interact with the auditory system to establish the meaning of speech and other vocal communication sounds. The interpretation of social vocalizations depends on information about acoustic structure, other sensory stimuli, and internal state. The laboratory examines the mechanisms acting within the basolateral amygdala that integrate across these information sources. Dr. Wenstrup's team seeks to relate these mechanisms to disorders that result in an altered emotional response to speech, such as schizophrenia, autism, and some forms of post-traumatic stress disorder.

**Jianxin Bao, Ph.D.**

Dr. Bao's group focuses on developing new drug and gene therapies for hearing disorders such as hearing loss and tinnitus. The prevalence of age-related hearing loss is 63 percent for those 70 years of age and above. Approximately 15 percent of Americans between the ages of 20 and 69—or 26 million Americans—have noise-induced hearing loss. Tinnitus is highly associated with hearing loss. There are no medications against these disorders. The group conducts studies to prevent hearing loss and tinnitus through development of new technology platforms. In addition, the group is developing advanced hearing and molecular tests to better identify subtle cellular and synaptic changes in the cochlea that will provide a better time window for medical intervention.

**Alexander Galazyuk, Ph.D.**

Dr. Galazyuk's laboratory studies tinnitus—the perception of sound in the ears or head when no external source is present. The American Tinnitus Association estimates that 50 million Americans experience tinnitus to some degree, with 16 million patients requiring tinnitus treatment. Tinnitus is the most prevalent disability among active military personnel and veterans. Dr. Galazyuk's group is working to identify underlying brain mechanisms responsible for the development of tinnitus, as well as potential therapies for tinnitus.
Hearing Research Focus Group

• 10 labs with 12 faculty studying the auditory system, from the ear to the brain

• Research topics include:
  • Hearing loss (age-related, noise-induced, developmental)
  • Auditory processing disorder
  • Tinnitus
  • Emotional disorders
  • Much more!

• Wide variety of biomedical research techniques
Hearing Research Focus Group

Rich training environment:

• Access to all faculty in the group – collaboration is the norm

• History of successful training. Over the past ~7 years:
  • 24 medical students
  • 11 graduate students
  • 7 postdoctoral trainees
Hearing Research Focus Group

Rich training environment:

• Weekly journal clubs
• Seminars, with a chance to meet experts in the field
• Regular attendance at national and international conferences
Hearing Research Focus Group

- Our labs receive funding through the National Institutes of Health (NIH)
  - Across 10 labs: 6 R01s, 1 R41, 1 R21, 1 R15

- History of pre-doctoral NIH fellowships for PhD students
  - 4 since 2012
Hearing Research Focus Group

Access to state-of-the-art techniques & resources

- Behavioral assessments: operant conditioning, acoustic startle responses, vocal communication
- Imaging and microscopy: optogenetics, transmission electron microscopy, multiphoton imaging
- Neurophysiological recording: brain slice recording, in vivo recording in behaving animals, voltage-sensitive measurement
NEOMED

Founded in 1973

3 Colleges: Medicine, Pharmacy, Graduate Studies

“NEOMED harnesses diversity, innovation and collaboration to create transformative leaders and improve health through education, discovery and service.”
NEOMED

• Located in Rootstown, OH

• Rural area; on-campus living, dining, and fitness center are available

• Graduate students, pharmacy students, medical students, postdoctoral fellows
Just down the road from Kent, OH

• Home to Kent State University
• Shopping, dining, music, events, outdoor recreation
Also near...

- Akron, OH (~20 minutes)
- Cuyahoga Valley National Park (~30 minutes)
- Cleveland, OH (~50 minutes)
Brain Health Research Institute

The HRG is part of a consortium of neuroscience research based at Kent State University

- Seminars on a broad range of topics in neuroscience
- Connections with scientists with expertise beyond the auditory system
- Career training opportunities

https://www.kent.edu/brainhealth
Our researchers:

- Dr. Merri Rosen
- Dr. Jianxin Bao
- Dr. Alex Galazyuk
- Dr. Julia Huyck
- Dr. Yong Lu
- Dr. Jeffrey Mellott
- Dr. Bruna Mussoi
- Dr. Brett Schofield
- Dr. Jeffrey Wenstrup
- Dr. Bradley Winters
- Dr. Sharad Shanbhag
- Dr. Nichole Beebe
Dr. Merri Rosen’s Laboratory:
Development of neural underpinnings of auditory perception

- Kids with **hearing loss** are at risk for later problems with speech perception.
- **Early life stress** increases the risk of long-term language deficits.
- RESEARCH GOAL: to understand the specific **perceptual** deficits, and the **neural changes** that cause these problems.
- This will allow us to design optimal **remediation** strategies.
Measuring perception and neural activity

Auditory perception: Operant conditioning

Auditory perception: Attenuation of acoustic startle

Neural recordings: Awake or anesthetized, behaving or passive
Dr. Alex Galazyuk’s Laboratory:
Tinnitus, Age-Related Hearing

**Tinnitus**
- Brain mechanisms and treatment

**Aging in bats?**
- Bats live very long lives with minimal signs of aging!!!
Dr. Bradley Winters’ Laboratory:
Cellular properties underlying sound localization circuits

Grothe, 2003
Dr. Bradley Winters’ Laboratory:
Cellular properties underlying sound localization circuits

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Dr. Brett Schofield’s Laboratory: Identifying brain circuits for the sense of hearing

Ascending pathways carry information to the “top” – auditory cortex – for perception.

Our focus: how do descending pathways allow auditory cortex to control what we hear?

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Red nerve fiber from auditory cortex… contacts a cell (*) in the arousal nucleus. The blue means the cell projects to the midbrain. The same cell “speaks” with the neurotransmitter acetylcholine.

Auditory cortex → Auditory auditory center → arousal nucleus → Midbrain auditory center

Schofield lab
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Premise: Older adults have more difficulty understanding speech in background noise, even without hearing loss.

Goals:
• To understand factors that contribute to difficulty with speech understanding in noise
• To explore factors that may counteract age-related difficulty with speech in noise

Methods:
• Behavioral and auditory electrophysiology testing
• Participants: human listeners with normal hearing or hearing loss; cochlear implant users
Dr. Jeffrey Mellott’s Laboratory:  
Neurotransmitter Changes in the Auditory System during Age-Related Hearing Loss

We use fluorescent immunohistochemistry...

3 mo  
21 mo

...to visualize changes in specific receptor subunits (magenta) that compensate for loss of neurotransmitters

Immuno electron microscopy...

...to visualize GABAergic synapses

Tract-tracing and reconstruction...

...to visualize changes in GABAergic input with age

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Dr. Jeffrey Wenstrup’s Laboratory: Acoustic Communication and Emotions

The Rationale:
The amygdala orchestrates emotional responses to sounds, e.g. speech

Our Goal:
• To understand how the amygdala contributes to acoustic communication
• To develop an understanding of brain mechanisms in psychological disorders that contribute to an altered emotional response to speech

Our approach:
Describe the acoustic features of social vocalizations
Relate the acoustics to internal state and behavioral contexts
Examine how amygdalar neurons respond to these signals across contexts

Big Brown Bat (Eptesicus fuscus)   CBA-CaJ Mouse

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Dr. Jianxin Bao’s Laboratory: Hearing Loss and Tinnitus

Translational Research

- Tinnitus
  - Novel tinnitus detection methods
  - Molecular markers

- Hearing loss
  - Functional assessments
  - Molecular markers

Clinical Research

- Hearing loss
  - Hidden hearing loss
  - Pharmacogenetics of Presbycusis

Auditory Brainstem Response

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Dr. Julia Huyck’s Laboratory: Perception, Learning, and Individual Differences (PLAID)

- Located at Kent State University (Speech Pathology and Audiology)
- Examine how adolescents and young adults perceive, and learn to perceive, speech and other sounds.
- Perform cognitive testing to better understand how cognition affects auditory processing

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Dr. Yong Lu’s Laboratory: Cellular Mechanisms of Auditory Processing

Research Interests:
• Cellular mechanisms of sound localization
• Development of auditory circuits
• Plasticity of auditory neurons in brain diseases

Research Methods:
• in vitro electrophysiology
• optical imaging
• immunohistochemistry
Opportunities for Neuroscience-Related Hearing Research at NEOMED

Email any of us (addresses on each of our slides) to learn more about our research opportunities

Hearing Research Group
https://www.neomedi.edu/research/hearing/

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