

Hearing & Communication Neuroscience Core Course

Instructors

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*Course coordinator

Locations: HNB 120 on UPC, **ARC 302 (Auditory Research Center Conference Room)** on HSC

Time: Tuesdays and Thursdays, 10-11:50am

Units: 4

Course Description

This course is intended to provide graduate students with a basic grounding in broad aspects of the neuroscience of hearing and vocal communication (e.g., development, structure and function of the inner ear, neural circuitry for transmission and analysis of auditory information, audiology, psychophysics, vocal perception and production, language, etc). This course serves as the graduate core course for our Training Program in Hearing & Communication Neuroscience (HCN).

Grading

Evaluation will be based on scores on six take-home exams and participation in class discussions. The course is divided into 6 modules: (1) Cochlear Amplification and Physiology (classes 1–4,6), (2) Physiology and the Auditory CNS (classes 7–12), (3) Development and Genetics (classes 13–18), (4) Speech Communication (classes 19–24), (5) Auditory Perception (classes 25–26), and (6) Assessment and Disorders (classes 27–30). Each module will give a take-home assignment which will be scored. The score for each module will be weighted according to the number of classes in that module.

Course Materials

Course materials (syllabus, readings, lecture figures, etc.) will be available on Blackboard: <https://blackboard.usc.edu>. Be sure to check this site frequently. Many important announcements will appear first on Blackboard. Pre-requisite: BISC 421 or NEUR 524 or permission of the instructors.

Students with Disabilities

Students requesting academic accommodations based on a disability are required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP when adequate documentation is filed. Please be sure the letter is delivered to one of the instructors as early in the semester as possible. Disability Services and Programs is located in Student Union 301 and their phone number is (213) 740-0776.

Statement on Academic Integrity

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. Scampus, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A:

<http://www.usc.edu/dept/publications/SCAMPUS/gov/>.

Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: <http://www.usc.edu/student-affairs/SJACS/>.

Schedule of Classes

Module 1: Cochlear Amplification and Physiology (classes 1–4,6; Shera)

1. **Tuesday, Jan 14:** *Waves and Resonances* ([Charaziak](#))
Waves and wavenumbers, impedance, reflection, standing waves, resonances in tubes and sitting rooms
2. **Thursday, Jan 16:** *Cochlear Traveling Waves and Amplification* ([Charaziak](#))
Basilar-membrane traveling waves, dispersion, the cochlear amplifier, spontaneous and evoked otoacoustic emissions
3. **Tuesday, Jan 21:** *Hair Cells and Transduction* ([Kalluri](#))
Type I and Type II hair cells, stereocilia and electromechanical transduction, endolymphatic potential and driving force, electromechanical filtering and synaptic transmission
4. **Thursday, Jan 23:** *Getting the Signal to and from the Brain: Cochlear Innervation* ([Kalluri](#))
Type 1 and type 2 afferent neurons, lateral and crossed efferent neurons; synaptic patterns on inner and outer hair cells; synapse dynamics and auditory nerve responses
5. **Tuesday, Jan 28:** *No Class*
See you at ARO in San Jose!
6. **Thursday, Jan 30:** *Paper Discussion* ([Shera](#), [Kalluri](#), [Abdala](#), [Charaziak](#))
Classic papers by Gold and Pumphrey predicting the existence of cochlear amplification from behavioral measurements.

Module 2: Physiology and the Auditory CNS (classes 7–12; Bottjer)

7. **Tuesday, Feb 4:** *Boot Camp: Neural Physiology* ([Bottjer](#))
Electrical properties of excitable cells: current clamp and voltage clamp; local potentials, reversal potentials; passive electrical properties; action potentials; synaptic transmission
8. **Thursday, Feb 6:** *Auditory Circuits of the Brain I: Auditory Brainstem* ([Bottjer](#))
CNS circuitry; tonotopic organization, parallel processing, feature detection, hierarchical processing; role of inhibition & intrinsic conductances in mediating neural response patterns
9. **Tuesday, Feb 11:** *Auditory Circuits of the Brain II: Auditory Localization* ([Bottjer](#))
Barn owls as a model system for spatial localization of sounds; developmental aspects, the role of NMDA receptors in aligning auditory and visual spatial localization
10. **Thursday, Feb 13:** *Auditory Circuits of the Brain III: Cortex* ([Bottjer](#))
Functional circuits for auditory processing in thalamus and cortex; role of inhibition in frequency tuning; representation of complex sounds, streaming
11. **Tuesday, Feb 18:** *Paper Discussion* ([Bottjer](#))
Cortical mechanisms for pitch perception; recent papers by Bendor, Osmanski, Wang
12. **Thursday, Feb 20:** *Brain Specializations for Speech and Language* ([Aziz-Zadeh](#))
Brain regions important for language, aphasias, laterality, embodied semantics, and relationships between language and other modes of higher cognitive functioning

Module 3: Development and Genetics (classes 13–18; Segil, Gnedeva)

13. **Tuesday, Feb 25:** *Introduction to Developmental Biology and Regenerative Medicine*
Part 1: Introduction to modern developmental biology and regenerative medicine. Part 2: From germ layer to the otic placode, with a nod to gastrulation.
14. **Thursday, Feb 27:** *How the Ear Develops I*
Otic placode regionalization, otocyst formation, neurogenesis and the formation of the spiral ganglia, early innervation of the sensory system.
15. **Tuesday, Mar 3:** *How the Ear Develops II*
Cochlear outgrowth, morphogenesis of the inner ear, formation of the sensory primordium, the nascent organ of Corti.
16. **Thursday, Mar 5:** *How the Ear Develops III*
Patterning the organ of Corti and the vestibular system, sculpting the bony labyrinth.
17. **Tuesday, Mar 10:** *Genetics of Hearing Loss and Other Hot Topics*
Part 1: Genetics of hearing loss. Part 2: Hot topics – Regenerative medicine, stem cells, gene therapy, inner ear organoids, epigenetic reprogramming, and disease modeling.
18. **Thursday, Mar 12:** *Evolution and Development of the Middle Ear (Crump)*
Evolution and development of the bones of the middle ear - From outside in: Transducing sound to the inner ear.

USC Spring Break, Mar 15–22

Module 4: Speech Communication (classes 19–24; Goldstein)

19. **Tuesday, Mar 24:** *Speech Production (Byrd)*
Vocal tract anatomy and articulation, linguistic contrast, co-articulation and parallel transmission, gestural units in speech production, source-filter theory, spectrograms, instrumental techniques for articulation research
20. **Thursday, Mar 26:** *Songbirds as a Model System for Vocal Learning and Behavior (Bottjer)*
Neural mechanisms underlying acquisition of learned vocal behavior in juvenile songbirds; control of vocal motor output in adult songbirds; vocal plasticity and mirror neurons
21. **Tuesday, Mar 31:** *Speech Perception and Sound Patterns in Language (Walker)*
Typology of sound patterns in language, perception of consonants and vowels, syllable structures and speech perception
22. **Thursday, Apr 2:** *Development of Speech Perception (Mintz)*
Descriptive and theoretical accounts of learning phonetic categories from birth to 12 months; mechanisms for segmenting words from fluent speech; methods for testing infant speech perception
23. **Tuesday Apr 7:** *Development of Speech Production (Goldstein)*
Emergence of phonological structure, self-organization models, sensorimotor abilities of young infants, onset and structure of babbling, attunement of vocal actions to the ambient language, phonetic and phonological structure of early words
24. **Thursday, Apr 9:** *Signal Processing of Speech (Narayanan)*
Representations and models of speech signal from time, frequency, homomorphic and linear prediction domains; applications

Module 5: Auditory Perception (classes 25–26; Goldsworthy)

25. Tuesday, Apr 14: Auditory Perception I (Goldsworthy)

The limits of auditory detection and discrimination for simple sounds such as sinusoids in the context of how these sounds are encoded in auditory-nerve firing patterns

26. Thursday, Apr 16: Auditory Perception II (Goldsworthy)

Auditory detection and discrimination for increasingly complex sounds, including musical notes and phonemes

Module 6: Assessment and Disorders (classes 27–30; Eisenberg)

27. Tuesday, Apr 21: Behavioral and Objective Methods of Hearing Assessment (Abdala)

Behavioral and objective tests used by clinical audiologists to assess hearing in adults and children; conventional audiograms and their limitations; alternative forms of assessment that do not require a volitional response; applications to assess the integrity of the peripheral and central auditory systems

28. Thursday, Apr 23: Development of Speech Perception in Children with Hearing Loss (Eisenberg)

Basic effects of hearing loss on communication; audiological indications of different pathologies affecting the auditory system, and the influence of auditory sensory devices on the development of speech perception, speech production, and spoken language

29. Tuesday, Apr 28: Prosthetic Hearing (Goldsworthy)

Past, present, and future of cochlear and auditory brainstem implants

30. Thursday Apr 30: Speech Pattern Recognition and Adaptation (Goldsworthy)

Acoustic representations of speech and how alterations of these representations affect perception; the roles of plasticity and rehabilitation

HCN Retreat on Santa Catalina Island, May 4–5

