Auditory Neuroscience of Speech Perception & Vocal Communication

Winter Quarter
2019-2020 ACADEMIC YEAR
January 2 – March 20, 2020

SYLLABUS

Professor: Mark Tramo, MD PhD
Lectures: Thursdays, 6:30P – 8:30P
Sections: Thursdays, 8:30 – 9:30P
Location: Mathematical Sciences Building (MS), Rm 5233

UPPER DIVISION COURSES
NEUROSCI/IBP. Auditory Neuroscience of Speech Perception & Vocal Communication (4)

Lectures = 2 hrs/week, 1 hour each. Sections = 1 hr/wk 1 hr each. Outside study = 9 hours per week.

Do you hear yourself reading this sentence? There is no sound in your brain, only neural representations of sound that are automatically associated with the words you’re reading. How does the brain transform sound waves into auditory percepts and store them in memory? What parts of the brain are necessary to understand speech, distinguish laughing from crying, detect a foreign accent, and recognize your mother’s voice? When do auditory-perceptual capacities critical to human language acquisition develop? Are the brains of people who speak tonal languages different from the brains of people who speak non-tonal languages? Do the brains of bilingual adults differ from those fluent in one language? What happens to someone’s speech and other communication abilities when a disease damages the underlying neural substrate? How do bionic devices called "cochlear implants" help deaf patients hear?

This course takes an interdisciplinary approach to addressing these questions with the goal of understanding how humans and other animals communicate emotion, meaning, and information using sound. Topics cover active research areas in the disciplines of systems neuroscience, cognitive neuroscience, psychoacoustics, and psycholinguistics. Fundamental principles in neurophysiology, neuroanatomy, neuroimaging, audiology, psychology, and neurology are emphasized. Students are taught basic tenets of signal processing and learn how to use digital sound synthesis and analysis software. Students present key papers from professional journals on topics of their choosing. The mid-term examination and final examination are take-home. Letter grading is based on attendance (30%), participation/presentation (20%), mid-term exam (10-20%), and final exam (30-40%).
Pre-requisites
M101A or PS107

Faculty
Mark Tramo, MD, PhD
Dept of Integrative Biology & Physiology, UCLA College of Letters & Science
Dept of Neurology, David Geffen School of Medicine at UCLA
Dept of Musicology, UCLA Herb Alpert School of Music
Co-Director, University of California Multi-Campus Music Experience Research Initiative (UC MERCI)
Director, The Institute for Music & Brain Science
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URL: http://www.BrainMusic.org

Teaching Assistant
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Enrollment
• Open to all UCLA undergraduates who meet one of the prerequisites listed above.
• PTEs – to be discussed after the first seminar

Learning Outcomes
By the end of this course, students will have learned:
• Experimental methods and research opportunities available to scientists and clinicians working on speech perception and vocal communication
• How to identify and name anatomical structures in the auditory nervous system of humans and other animals
• The basics of acoustic signal processing and neural coding in the auditory nervous system
• How to find, read, understand, and critically evaluate papers published in professional peer-reviewed journals
• How to critically evaluate claims made in the media and on the internet about speech, prosody, and voice perception.
• Oral presentation skills that are broadly relevant to career development with guidance in a supportive group environment.

How your learning will be assessed
• ATTENDANCE/PARTICIPATION
  - Attendance Score = 1 point/class x 3 classes/wk x 10 wk/quarter = 30 points per quarter
  - Participation
    - eye contact
    - questions
- active participation in class discussions
- slide presentation of 1-2 professional journal articles
- Absences are not excused unless Professor Tramo receives an email from a dean, faculty member, or health professional ≥24 hours before class starts

• READING
  • Textbooks (see below)
  • Class notes
  - Course website announcements, PDFs
    - Articles assigned from professional science, medicine, and audiology journals for oral presentations and assigned reading:
      -> UCLA electronic library -> search e-journals using the name of the journal the paper was published in
      - inside the journal search the title and or author of the paper
      - download a PDF of the paper of interest

• PRESENTATION
  - One Powerpoint presentation of a professional journal publication

• FINAL EXAMINATION
  - Take-home, open-book, takes 2-3 hours to complete
  - Posted on the course website at 2P on Tuesday March 19th of Final Examination week
  - Must be completed independently by each student and emailed to Professor Tramo at mtramo@ucla.edu by 5P

Required Book

Recommended Books
• Speech Physiology, Speech Perception, and Acoustic Phonetics. Phillip Lieberman & Sheila Blumstein, 1988
• Science of Sound, 3rd edition, Thomas Rossing et al.
• The Auditory Cortex. Jeffrey Winer & Christopher Schreiner (Eds), 2011
• The Human Auditory Cortex. David Poeppel et al. (Eds), 2012
• The Mammalian Auditory Pathways. Douglas Oliver et al. (Eds), 2017
• Neural Correlates of Auditory Cognition. Yale Cohen et al. (Eds), 2012

Important notes

• Students needing academic accommodations based on a disability should contact the Center for Accessible Education (CAE) at (310)825-1501 or in person at Murphy Hall A255. In order to ensure accommodations, students need to contact the CAE within the first two weeks of the term.
• Please read the Student Code of Conduct (https://www.deanofstudents.ucla.edu/studentconductcode). According to Senate Regulation A-306 (https://senate.ucla.edu/regulations/chapter1#bootstrap-fieldgroup-accordion-item--section-4-grades-3), faculty and TAs are required to report suspected acts of academic dishonesty to the Office of Student Conduct (https://www.deanofstudents.ucla.edu/Contact-Us).

• Faculty and TAs are required under the UC Policy on Sexual Violence and Sexual Harassment to inform the Title IX Coordinator—A NON-CONFIDENTIAL RESOURCE—should they become aware that you or any other student has experienced sexual violence or sexual harassment.

LECTURE SCHEDULE

Thursday January 9
Introduction to Auditory Neuroscience
• Course Overview
• Learning Goals
• Learning Tools & Books
• Fields of Study in Auditory Neuroscience & Related Careers
  • Experiments of Nature: The Aphasias
  • Functional Organization of the Cerebral Cortex: Modality-Specific, Multi-Modal, & Supra-Modal Systems
  • Hemispheric Lateralization of Speech & Language: Split-Brain Experiments
• Classical Clinical Taxonomy of the Aphasias
• Classical Clinical Taxonomy of Cortical Auditory Disorders
• Professor Rounds: Michael Gazzaniga PhD; Norman Geschwind MD

Thursday January 16
Acoustical Phonetics
• Pictures of Sound:
  Time Domain vs. Spectral Domain
• Signals & Systems
• Acoustic Features & Perceptual Attributes
• Resonance & The Harmonic Series
  • The Human Vocal Apparatus
• The Source-Filter Model of Speech Production
• Intonation & Sound Symbolism
• Phonemes, Vowels, Consonants & Syllables

**Vowels: Acoustic Features & Classification I**
• Vowel Spectrograms
• Vocal Fold Vibrations, Glottal Pulses, & F0 Pitch
• Vocal Tract Resonances & Vowel Formants
  • Vowel Classification & Tongue Position:
    The Vowel Quadrilateral

*Friday JANUARY 17 - Study List Deadline (becomes official)*

**Thursday January 23**

**Vowels Acoustic Features & Classification II**
**Consonants & Syllables: Acoustic Features & Classification**
• Obstruent vs. Sonorant
• Voiced vs. Unvoiced
• Manner of Articulation
• Place of Articulation
  • Coarticulation, Formant Transitions, & Formant Loci of Origin

**Thursday January 30**

**Mid-Term Examination**
**The Peripheral Auditory System**
• External Ear
• Middle Ear
• Inner Ear & Cochlea
  • Organ of Corti
• Ohm’s Second Law & Fourier’s Theorem
• Basilar Membrane & Mechanical Tuning:
  Frequency Maps & Place Codes
  • Inner Hair Cells
• Radial Afferents & Pre-Synaptic Lateral Efferents
  • Outer Hair Cells
  • Spiral Afferents & Medial Efferents

**Neural Coding of Acoustic Information I**
• Tuning Curves
• Isorate Functions
• Isointensity Functions
• Spectrotemporal Receptive Fields
• Rate-Level Functions
• Spike Rasters
• Post-Stimulus Time Histograms
• First-Order & All-Order Interspike Interval Histograms
• Bionic Hearing: Cochlear Implants & Brain Chips

Thursday Feb 6

**Neural Coding of Acoustic Information II**

**Neural Coding of Vowels in the Auditory Nerve**
• Cariani & Delgutte’s Temporal Code for Vowel Pitch & Identity
• Sachs & Young’s Rate-Place Code for Vowel Identity
• Delgutte & Kiang’s Temporal Code for Vowel Identity

Thursday February 13

**Neural Representations of Consonants, Vocalizations, & Other Complex Sounds I**
• Discharge Patterns Evoked by Consonants in Cat Auditory Nerve & Rat Auditory Cortex
• Temporal Modulation of Frequency (FM) & Amplitude (AM) in Speech & Music
• Frequency Modulation (FM) & Direction Selectivity in Cat Auditory Cortex
• Amplitude Modulation (AM), Envelope Periodicity, & Temporal Modulation Selectivity in Cat Auditory Cortex
• Disarrangement of Tonotopy at Suprathreshold Tone Intensities

Thursday Feb 20

**Neural Representations of Consonants, Vocalizations, & Other Complex Sounds II**
• Representation of Consonant Voice Onset Time in Human Auditory Cortex
• Spectrograms of Rhesus Monkey & Pop Singer Vocalizations
• Discharge Patterns Evoked by Species-Specific Vocalizations in Marmoset Monkey Auditory Cortex
• Phonology & Semantics of Vervet Monkey Vocalizations
• Phonology & Semantics of Rhesus Monkey Vocalizations
• Discharge Patterns Evoked by Species-Specific Vocalizations in Rhesus Monkey Auditory Cortex

Thursday Feb 27
The Vocal Tract
Acoustical Phonetics of Singing
• Vocal Tract Resonances
• The Singer’s Formant
Evolution of Vocal Communication
• Comparative Anatomy of the Vocal Tract in Extant Humans & Apes
• Sociology of Group Communication
• Comparative Paleontology of the Skull in Hominids
• Comparative Anatomy of the Cerebral Cortex in Hominids
• Human Frontal Cortex & Supramodal-Future Processing

Thursday March 5
The Central Auditory Nervous System: Brainstem
• Serial & Parallel Processing in the Ascending Cochleotopic vs. Non-Cochleotopic Networks
  • Cochlear Nucleus
  • Inferior Colliculus
  • Medial Geniculate Body

Thursday March 12
The Central Auditory Nervous System: Auditory Cortex
Primary Auditory Cortex
Auditory Association Cortex
Intrinsic & Extrinsic Connections
Hemispheric Lateralization of Language Functions

Thursday March 19
Final Examination

Friday March 20 – Quarter ends