PSYC GU4265
Auditory Perception Spring 2017
Mondays 4.10-6PM, Schermerhorn 405
Instructor: Helen Brew, PhD
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Office hours: Wednesday 3-5pm, Schermerhorn 356

Course description

How does the human brain make sense of the acoustic world? What aspects of auditory perception do humans share with other animals? How does the brain perform the computations necessary for skills such as sound localization? How do we focus our auditory attention on one voice in a crowd? What acoustic cues are important for speech perception? How is music perceived? These are the types of questions we will address by studying the basics of auditory perception from textbook readings and reviews, and reading classic and current literature to understand scientific progress in the field today.

Course overview

This course will systematically review the main topics of auditory perception such as: 1) the physics of sound; 2) the anatomy and physiological functioning of the auditory system; 3) perception of loudness; 4) frequency selectivity and discrimination; 5) sound source localization; 6) perceptual phenomena such as forward and backward masking; 7) temporal processing; 8) pitch and timbre perception in simple and complex sounds; 9) scene analysis; 10) speech and music perception. We will focus in on aspects of these topics using examples from the current literature.

Prerequisites: Mind Brain and Behavior (PSYC UN1010) or equivalent biological knowledge is required. Dr. Brew's permission to join the class is required in order to register. As usual for classes at the 3000-level and above, it is expected that you will have some knowledge of research methods and statistics.

Course objectives: This course fulfills the Seminar Requirement and the Group II – Psychobiology and Neuroscience Distribution Requirement for the Psychology Major and for the Psychology Post-Baccalaureate Certificate Program, and the Advanced Psychology Seminar Requirement for the Neuroscience and Behavior Major. This course could also be used to fulfill one of the three seminar requirements for the M.A., provided the graduate student consults with his/her advisor and obtains permission from the Director of Graduate Studies.

The goals of this course are:

- to gain an understanding of auditory perception in humans and animals
- to gain an understanding of the neural mechanisms underlying auditory perception
- to gain an understanding of current auditory research by reading primary scientific literature
- to read, understand and orally present primary scientific literature from psychology and neuroscience journals
- to be able to critically evaluate published research and discuss its merits, caveats and alternative interpretations
- to develop a review commentary on an auditory topic by reading and evaluating published research

Course requirements and grade percentages

Weekly readings/assignment and participation (15%): You will be expected to carefully **read two or three scientific research papers each week**. The chosen papers are primary research reports from seminal findings on the topic of the week. Some basic background knowledge of each topic is expected, which will be attained from

the **textbook chapters or reviews cited in the assigned reading**. Everyone will **post a substantial comment, thought or question on the week's papers before class** on the Discussion Board of Courseworks, which will serve as a basis for discussion during class.

Presentation of two papers (40%): Every week, 2 student leaders will each present one of the assigned readings in an approximately 25 minute slide presentation and initiate a short discussion of the paper. Each student will **present 2 papers** during the semester. Written feedback will be provided one week following the presentation. Ideally, obtain help with your presentation from Dr. Brew well before class, e.g. during Wednesday office hours.

Mid-term (10%): The students take a one-hour long **written midterm exam** with mini-essay questions covering the material in the textbook, the papers and the class discussions. This will take place on Monday 6th March, and will be open book, open notes.

Research review paper (30%): A **term project** will be required, on a topic of your choosing from material covered during the seminar (~10-15pg). Guidelines for this will be given at the start of the course. (There is an option to write a research proposal instead.) The project will require that you meet individually with the instructor to get approval on the topic and outline. Outline due by week 10, April 3rd. Completed paper (or research proposal) due by May 1st, the final day of class.

Short presentation based on term paper (5%): Each student will give a **ten minute presentation** of an interesting aspect of their term project paper on May 1st, the final day of class.

Class policies

Attendance: You are expected to come to class each week prepared to discuss the assigned papers. Your unexcused absence will be noted and reflected in your participation grade. In the case of excused absences for which you obtain pre-approval from Dr. Brew, make-up 'participation' will be arranged on an individual basis.

Assignments: Paper presentations are assigned based on solicited preferences during the first week of the semester and once assigned may not be changed. In the case of a documented medical or family emergency, alternate arrangements will be made to present the paper individually during office hours. The due date for the term paper is firm, and as such, one letter grade will be deducted for each day it is late.

Academic Integrity: "The intellectual venture in which we are all engaged requires of faculty and students alike the highest level of personal and academic integrity. As members of an academic community, each one of us bears the responsibility to participate in scholarly discourse and research in a manner characterized by intellectual honesty and scholarly integrity. . . . In practical terms, this means that, as students, you must be responsible for the full citations of others' ideas in all of your research papers and projects; you must be scrupulously honest when taking your examinations; you must always submit your own work and not that of another student, scholar, or internet agent." From the Faculty Statement on Academic Integrity - www.college.columbia.edu/academics/integrity-statement. Cheating on assignments or exams and plagiarism are very serious violations within the academic community. Students are expected to do their own work on all tests and assignments for this class. You are expected to always act in accordance with the Columbia honor code. Any student found cheating or plagiarizing in this class will be reported to Columbia's Office of Judicial Affairs and Community Standards for evaluation and academic discipline. If you have questions about any aspect of academic integrity at Columbia, please refer to the following link: www.college.columbia.edu/academics/integrity and if you have specific questions about the judicial process, please see www.college.columbia.edu/academics/disciplinaryprocess.

Reading materials

ALL the necessary reading materials to be read, digested and commented-on before each week's class will be posted on CourseWorks. When it comes to your term paper, you will need to read around and find some more original papers to include, with help from me. The background reading selections will usually total 30 pages per week, and the original research papers are usually 5-10 pages long, but very information-dense.

FYI, much of the background reading will be from the textbooks listed below which are referred to by these acronyms, within the schedule.
PONS = Principles of Neural Science by Kandel et al, 5th edition
IPH = An Introduction to the Psychology of Hearing, by Brian Moore.
FOH = Fundamentals of Hearing, 5th edition, by William Yost

Course schedule

Week 1 - Monday January 23. The physics of sound, the ear, auditory neuroanatomy and neurophysiology.
Thresholds, input-output functions, tuning curves, audiograms, post-stimulus time histograms.

Background reading: from chapter 30 of PONS, and chapter 1 of IPH
Students will select their two presentation topics today. Please choose one paper from weeks 2-8, the other from weeks 9-13.

Week 2 - Jan 30. Sound intensity and loudness perception.

Background reading: selections from chapter 31 of PONS and chapters 2 and 4 of IPH

Neural population coding of sound level adapts to stimulus statistics. Dean I, Harper NS, McAlpine D. (2005) Nat Neurosci. Dec;8(12):1684-9.

Loudness adaptation and excitation patterns: Effects of frequency and level. Hellman, R, Miskiewicz, A, Scharf, B (1997) *JASA* **101**:2176-2185.

Week 3 - Feb 6. Frequency representation
Place theory, pure tones, amplitude modulation, frequency modulation

Background reading: selections from chapter 31 of PONS and chapter 3 of IPH.

Ultra-fine frequency tuning revealed in single neurons of human auditory cortex. Bitterman Y, Mukamel R, Malach R, Fried I, Nelken I. (2008) Nature. Jan 10;451(7175):197-201.

Dichotomy of functional organization in the mouse auditory cortex.

Bandyopadhyay S, Shamma SA, Kanold PO. (2010) Nat Neurosci. Mar;13(3):361-8.

Week 4 – Feb 13. Temporal processing in the auditory system.

Gap detection, forward and backward masking, phase-locking

Background reading: selections from chapter 31 of PONS and chapter 5 of IPH

Gap detection with sinusoids and noise in normal, impaired, and electrically stimulated ears. Moore BC, Glasberg BR. (1988) J Acoust Soc Am. Mar;83(3):1093-101.

Hierarchical and asymmetric temporal sensitivity in human auditory cortices. Boemio A, Fromm S, Braun A, Poeppel D. (2005) Nat Neurosci. Mar;8(3):389-95.

Week 5 – Feb 20. Sound localization

Interaural differences, minimum audible angle, delay lines

Background reading: Chapter 12 of FOH; review "On hearing with more than one ear: lessons from evolution" Schnupp JW, Carr CE. (2009) Nat Neurosci. Jun;12(6):692-7; review Konishi, M (2003) Coding of auditory space. *Annu Rev Neurosci* 26:31-55.

A neural map of auditory space in the owl. Knudsen, EI, Konishi, M (1978). *Science* 200: 795-7.

Slow Temporal Integration Enables Robust Neural Coding and Perception of a Cue to Sound Source Location. Brown AD, Tollin DJ. **(2016)** J Neurosci. 2016 Sep 21;36(38):9908-21.

Week 6 – Feb 27. Complex sounds and scene analysis.

Cocktail party effect, stream segregation.

Background reading: Chapter 4 of FOH; review Carlyon, RP (2004) How the brain separates sounds. *Trends Cog Sci* 8:465-471.

Tuning for spectro-temporal modulations as a mechanism for auditory discrimination of natural sounds. Woolley SM, Fremouw TE, Hsu A, Theunissen FE. (2005) Nat Neurosci. Oct;8(10):1371-9.

Role of Binaural Temporal Fine Structure and Envelope Cues in Cocktail-Party Listening. Swaminathan J, Mason CR, Streeter TM, Best V, Roverud E, Kidd G Jr. **(2016)** J Neurosci. Aug 3;36(31):8250-7.

Week 7 – March 6. Mid-term exam (plus short paper on auditory attention)

Selective attention reduces physiological noise in the external ear canals of humans. I: auditory attention. Walsh KP, Pasanen EG, McFadden D (2014) Hear Res. Jun; 312:143-59

Monday March 13th No class. Spring recess

Week 8 – Mar 20. Speech perception

Background reading: chapter 9 of IPH; review by Diehl, RL, Lotto, AJ, Holt, LL. (2004) Speech Perception. *Ann Rev Psychol* 55: 149-79.

Linguistic experience alters phonetic perception in infants by 6 months of age. Kuhl, PK, Williams, KA, Lacerda, F, Stevens, KN and Lindblom, B (1992) *Science* **255**: 606-608.

Foreign-language experience in infancy: Effects of short-term exposure and social interaction on phonetic learning. Kuhl, PK, Tsao, FM, Liu, HM (2003) PNAS **100:**9096-101.

Learning to recognize talkers from natural, sinewave and reversed speech samples. Sheffert, SM, Fellowes, JM, Pisoni, DB, Remez, RE (2002) J Exp Psych Human Percep Perform **28:**1447-69

Week 9 – Mar 27. Neural basis of speech perception

Background reading: selection from chapter 60 of PONS

Neural mechanisms for lexical processing in dogs. Andics A, Gábor A, Gácsi M, Faragó T, Szabó D, Miklósi Á (2016) Science. Sep 2;353(6303):1030-1032.

Phonetic feature encoding in human superior temporal gyrus.

Mesgarani N, Cheung C, Johnson K, Chang EF. (2014) Science. Feb 28;343(6174):1006-10.

Week 10 – April 3. Auditory communication in animals

Background reading: Review by Doupe, AJ, and Kuhl, PK (1999) Birdsong and human speech: common themes and mechanisms. *Annu Rev Neurosci* **22:** 567-631.

Risky ripples allow bats and frogs to eavesdrop on a multisensory sexual display. Halfwerk W, Jones PL, Taylor RC, Ryan MJ, Page RA. **(2014)** Science. Jan 24;343(6169):413-6.

Songbirds possess the spontaneous ability to discriminate syntactic rules.

Abe K, Watanabe D. (2011) Nat Neurosci. Jun 26;14(8):1067-74.

Week 11 – April 10. Music perception and pitch

Background reading: chapter 6 of IPH; brief selections from The Science of Musical Sound by John Pierce

Indifference to dissonance in native Amazonians reveals cultural variation in music perception. McDermott JH, Schultz AF, Undurraga EA, Godoy RA. (2016) Nature. Jul 28;535(7613):547-50.

Pitch perception and production in congenital amusia: Evidence from Cantonese speakers. Liu F, Chan AH, Ciocca V, Roquet C, Peretz I, Wong PC. **(2016)** J Acoust Soc Am. Jul;140(1):563.

Week 12 – April 17. Neural basis of music perception

Background reading: Review "Modularity of music processing" Peretz I, Coltheart M. (2003) Nat Neurosci. 2003 Jul;6(7):688-91.

The neuronal representation of pitch in primate auditory cortex.

Bendor D, Wang X. (2005) Nature. Aug 25;436(7054):1161-5.

Human pitch perception is reflected in the timing of stimulus-related cortical activity. Patel AD, Balaban E. (2001) Nat Neurosci. Aug;4(8):839-44.

Week 13 – April 24. The abnormal auditory system

Hearing loss and hearing abnormalities

Background reading: Chapter 16 in FOH; review "Sound strategies for hearing restoration". Géléoc GS, Holt JR (2014) Science. May 9;344(6184):1241062.

Interplay between singing and cortical processing of music: a longitudinal study in children with cochlear implants. Torppa R, Huotilainen M, Leminen M, Lipsanen J, Tervaniemi M (2014) Front Psychol. 5:1389

Specific disruption of thalamic inputs to the auditory cortex in schizophrenia models. Chun S, Westmoreland JJ, Bayazitov IT, Eddins D, Pani AK, Smeyne RJ, Yu J, Blundon JA, Zakharenko SS. **(2014)** Science. Jun 6;344(6188):1178-82.

Week 14 – May 1 (last week of class) Presentations based on your term papers.

Prepare a ten-minute slide presentation on the most interesting auditory finding included in your term paper. (Obviously not something the whole class has already seen and discussed).