PSYC 4265 Auditory Perception Spring 2026

Dr. Sarah M. N. Woolley

Day/Time: Thursdays, 4:10 to 6 PM

Location: 828 Uris Hall

Office Hours: Thursdays, 3 to 4 PM, 806 Uris Hall

and zoom or in the Zuckerman Institute by appointment

Email: sw2277@columbia.edu

Introduction

How does the human brain make sense of the acoustic world? What properties of sound are important for the discrimination and recognition of sounds with specific meaning? 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? What's special about music? We will address these questions and more by studying the basics of auditory perception in textbook chapters, classic and current literature. Our reading of the literature will be critical, with a focus on good scientific design.

This course systematically reviews the main topics of auditory perception such as relationships between acoustics and perception, how the ear and brain encode sound, and how we perceive speech and music. We will read and discuss classic and current literature on humans and other animals.

Course requirements

Professor Woolley's permission to join the class is required. Each week, class time is devoted to the presentation and discussion of journal articles. The background reading provides information on the relevant topics, prepares students for reading and discussing the research papers, and serves as a stimulus for discussion. Two students lead the discussion each week, with my help. Each student takes the midterm exam and writes a paper on a chosen research topic at the end of the semester.

Course material

Book chapters and review papers are background reading for understanding the data papers that we discuss in class. Data papers on weekly topics are read by all students before class and presented by 1 to 2 students each week, with help from Professor Woolley. All of the reading material is posted on the course website. There are no textbooks to buy.

Grading

One exam is taken at the end of the first month (20% of final grade). Each student leads class discussions of the assigned papers (40% of final grade). All students participate in weekly discussion of assigned papers (40% of final grade).

Reading list and weekly schedule

Week 1 Jan 22 – Course overview and organization
I will introduce the course goals, content and structure

Week 2 Jan 29 - Introduction to sound and the auditory system

Background reading
Pickles ch 1 The physics and analysis of sound
PNS ch 30 The inner ear
Pickles Auditory pathways: anatomy and physiology In: Handbook of Clinical Neurology
PNS ch 31 The auditory central nervous system

I will present on the fundamental principles of sound, hearing and auditory function

Week 3 Feb 5 – Sound intensity and loudness perception

Background reading
Yost ch 13 Loudness
Moore ch 4 The perception of loudness
Schreiner, C, Mallone, BJ (2015) Representations of loudness in the auditory cortex. In: Handbook of Clinical Neurology

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

Dean, I, Harper, NS, McAlpine, D (2005) Neural population coding of sound level adapts to stimulus statistics. *Nature Neurosci* **8**:1684-1689.
Presenter: Hutton Saunders

Week 4 Feb 12 - Frequency representation

Background reading
Pickles ch 1 The physics and analysis of sound
PNS ch 31 The auditory central nervous system
Pickles Frequency resolution
Moore ch 4

Papers
Han, YK, Kover, H, Insanally, MN, Semerdjian, JH, Bao, S (2007) Early experience impairs perceptual discrimination. *Nature Neurosci* **10**:1191-1197.
Presenter: Jessica Li

Bitterman et al., (2008) Ultra-fine frequency tuning revealed in single neurons of human auditory cortex. *Nature* **451:** 197-201.
Presenter: Hope Trygstad

Week 5 Feb 19 - Temporal processing

Background reading
Pickles ch 1 The physics and analysis of sound
PNS ch 31 The auditory central nervous system
Moore ch 5 Temporal processing in the auditory system
Arnal et al (2015) Temporal coding in the auditory cortex. In: Handbook of Clinical Neurology.

Papers
Lu, T, Liang, L, Wang, X (2001) Temporal and rate representations of time-varying signals in the auditory cortex of awake primates. *Nature Neurosci* **4**:1131-1138
Presenter: Anuraag Pandhi

Boemio et al. (2005) Hierarchical and asymmetric temporal sensitivity in human auditory cortices. *Nat Neurosci* **8:** 389-395.
Presenter: Sophia Roeseler

Week 6 Feb 26 - Sound localization

Background reading
Middlebrooks, J (2015) Sound localization In: Handbook of Clinical Neurology
Pickles ch 7.3 Cortical processing of sound location
McAlpine, D (2005) Creating a sense of auditory space. *J Physiol* **566**: 21-28.

Papers
Knudsen, EI, Konishi, M (1978) A neural map of auditory space in the owl. *Science* **200:** 795-797.
Presenter: Joelvi Garcia

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

Week 7 Mar 5 - Midterm exam

Week 8 Mar 12 - Auditory attention

Background reading
Yost ch 4 Complex sounds

Papers
Mesgarani, N, Chang, E (2012) Selective cortical representation of attended speaker in multi-talker speech perception. *Nature* **485:** 233-236.
Presenter: Noah Jung

Lesenfants, D, Francart, T (2020) The interplay of top-down focal attention and the cortical tracking of speech. *Sci Rep* **10:** 6922.
Presenter: Yinfu Lyu

Week 9 Mar 19 – spring break

Week 10 Mar 26 – Auditory scene analysis

Background reading
Yost ch 4 Complex sounds

Papers
Puuvada, KC, Simon, JZ (2017) Cortical representation of speech in a multitalker auditory scene. *J Neurosci* **37**: 9189-9196.
Presenter: Ciro Randazzo

Schneider, DM, Woolley, SMN (2013) Sparse and background-invariant coding of vocalizations in auditory scenes. *Neuron* **79**: 141-152.
Presenter: Jamie Woych

Week 11 Apr 2 - Speech Perception

Background reading
Litovsky, R (2015) Development of the auditory system. In: Handbook of Clinical Neurology PNS ch 60 Language
Diehl, RL, Lotto, AJ, Holt, LL (2004) Speech Perception. *Ann Rev Psychol* **55**: 149-79.
Saffran, J, Werker, J, Werner, L (2006) The Infant's Auditory World: Hearing, Speech and the Beginnings of Language.

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

Kuhl, PK, Feng-Ming Tsao, FM, Liu, HM (2003) Foreign-language experience in infancy: Effects of short-term exposure and social interaction on phonetic learning. *PNAS* **100:** 9096-9101.
Presenter: Dami Meiterman

Week 12 Apr 9 – Neural Basis of Speech Perception

Background reading
Koelsch, S, Siebel, WA (2005) Towards a neural basis of music perception. *TRENDS Cog Sci* **9:** 578-584.
Hickok, G, Poeppel, D (2015) Neural basis of speech perception. In: Handbook of Clinical Neurology

Kral, A (2013) Auditory critical periods: a review from system's perspective. *Neuroscience* **247**: 117-133.

Papers
Mesgarani, N, Cheung, C, Johnson, K, Chang, EF (2014) Phonetic feature encoding in human superior temporal gyrus. *Science* **343**: 1006-1010.
Presenter: Jason Bbosa

Albouy, P, Benjamin, L, Morillon, B and Zatorre, RJ (2020) Distinct sensitivity to spectrotemporal modulation supports brain asymmetry for speech and melody. *Science* **367**: 1043-1047.
Presenter: Anuraag Pandhi

Week 13 Apr 16 - Auditory communication in nonhuman animals

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

Papers
Moore, J, Woolley, SMN (2019) Emergent tuning for learned vocalizations in auditory cortex. *Nat Neuro* **22**: 14659-1476.
Presenter: Hope Trygstad

Takahashi, DY, Liao, DA, Ghazanfar, AA (2017) Vocal learning via social reinforcement by infant marmoset monkeys. *Curr Biol* **27:** 1844-1852.
Presenter: Sophia Roesler

Week 14 Apr 23 – Music Perception

Background reading
Zatorre, R, Samilpoor, V (2013) From perception to pleasure: music and its neural substrates. *PNAS* **10:** 10430-10437.
Koelsch, S, Siebel, W (2005) Toward a neural basis of music perception. *Trends Cog Sci* **9:** 578-584.

Papers
McDermott, J, Schultz, A, Undurraga, E, Godoy, R (2016) Indifference to dissonance in native Amazonians reveals cultural variation in music perception. *Nature* **535**: 547-550.
Presenter: Jessica Li

Fritz, T et al. (2009) Universal recognition of three basic emotions in music. *Curr Biol* **19:** 573-576.
Presenter: Mathew Mazero

Week 15 April 30 – Neural Basis of Music Perception

Background reading

Toader, C (2023) Cognitive Crescendo: How music shapes the brain's structure and function. *Brain Sci* **13:** 1390.

Janata, P (2015) Neural basis of music perception. In: Handbook of Clinical Neurology

Tervaniemi, M (2001) Musical Sound Processing in the Human Brain: Evidence from Electric and Magnetic Recordings. *Ann N Y Acad Sci* **930**:259-272.

Papers

Bellier, L, Llorens, A, et al. (2023) Music can be reconstructed from human auditory cortex activity using nonlinear decoding models. *PLoS Biol* **21**(8) e3002176.

Presenter: Jamie Woyche

Martin, S, Mikutta, C, Leonard, MK et al. (2018) Neural encoding of auditory features during music perception and imagery. *Cerebral Cortex* **28:** 4222-4233.

Presenter: Noah Jung