

**NRSC 4433**  
Neural Basis of Auditory Perception  
and Cognition  
Fall 2023  
Tuesday 12:00-3:00

**Course Faculty**

Instructor: Judith McLean, Ph.D.

Office: 467 Levin

Email: [jmclean@sas.upenn.edu](mailto:jmclean@sas.upenn.edu)

Office Hours: By appointment

**Synopsis:**

This seminar will focus on the neural basis of auditory perception and cognition. We will examine auditory processing in animal ‘specialists’ to understand how sounds are processed in parallel pathways for identification and localization. We will also examine auditory cortical mechanisms for cognitive functions including attention, decision making, speech comprehension, and working memory. Emphasis will be placed on the analysis of primary literature. Students will be required to orally present journal articles from the primary literature, participate in the article discussions, write peer-reviews, and write a final “News and Views”-style paper.

**Specific Learning Objectives:**

By the end of the course, students will:

- Understand the physics and neurobiology of audition
- Understand the physiological and anatomical specializations in the auditory periphery and central auditory systems for sound localization
- Understand mechanisms of plasticity and learning in auditory systems
- Understand the functional and anatomical organization of the auditory cortex
- Describe the neural bases of auditory perception and cognition
- Acquire the skills needed to evaluate, critique, and present primary research articles from leading academic journals

**Pre-Requisites**

**NRSC 1110: Introduction to Brain and Behavior** is a *pre-requisite* for the course. The course will assume that students have a basic background in neuroscience

**Canvas**

Lecture slides, course materials, and announcements will be posted on this site.

### **Weekly Readings:**

The assigned papers are to be read *prior to class*. All reading material will be posted on the Canvas site. You must complete the assigned readings so that you are well-prepared for the discussions during class. Please do **all** of the required readings as they are assigned.

### **Assessment**

- You will have the potential to earn 100 points during the semester.
  - Participation (earned each class period)                      25 points
  - Two oral paper presentations    20 points each
  - Peer reviews (two)    15 points
  - News and Views Article    20 points

### **Essential Course Policies**

- There is no textbook for the course--all weekly readings will be on Canvas.

### **Attendance and Participation**

25% of your grade will come from Attendance and Participation. Attendance is **required** for this course. Anyone who misses **more than three class periods** because of unexcused absences will automatically fail the course. For each class period, you may earn up to three points for Attendance and Participation; one point will be earned automatically for showing up to class; two additional points can be earned for participating in the paper discussions. I am interested in questions that show you read the paper with a critical eye. Simply asking a question that requires a regurgitation of facts from the paper is not enough to warrant full credit.

### **Peer Reviews**

One of the requirements for this course (15% of total grade) is to complete **two** peer reviews of your fellow classmates' presentations. These reviews are to be thorough (~1-2 pages in length—see example provided in Canvas) and should provide significant feedback on the nature and quality of the presentation.

Peer reviews of student presentations will be due by **Sunday at 11:59 pm following the class period of the presentation**. I will provide a template by which to complete the assignment.

### **Oral Presentations:**

A majority of the course will consist of student presentations of primary research articles from the biomedical literature. Each paper will be divided into **two parts**, with each part delivered by a **different student**: 1) Introduction and the first half of the Results (with the associated Methods for those Results); and 2) second half of the Results (with the associated Methods for those Results) and Discussion. You are only responsible for presenting the figures in the print version of the paper; **you are NOT responsible for presenting supplementary data**. However, you should understand the relevance of the

supplementary data to the paper. Each section of the paper will be presented in ~20-25 minutes, for a total of 40-50 minutes per paper. **THOUGH YOU ARE ONLY PRESENTING HALF OF THE PAPER, YOU ARE RESPONSIBLE FOR KNOWING ALL OF INFORMATION WITHIN THE ENTIRE PAPER.** There will then be a ~20-30 minute discussion following the paper presentation during which all students are free to participate (to earn discussion points).

During the semester, each student will be *required* to do **two** presentations: one First Half (Introduction and the first half of the Results with the associated Methods) and one Second Half (second half of the Results with the associated Methods and Discussion). For papers with odd numbers of figures, the two presenters will split the middle figure accordingly. You will be graded separately for each of the two presentations.

### **“News and Views” Assignment**

For the one of the papers that you present, you will write an ~1000 word (two to three pages, single-spaced) “News and Views” article in the spirit of the journal *Nature*. The details of the assignment are described later in the syllabus.

### **Office Hours/Email Policy:**

You are encouraged to make an appointment with me if you have any questions about the content of the course. Please only e-mail me if you have a question that can be answered in a few sentences or less. If you have a question that requires a longer response, please come to my office hours.

### **Academic Integrity:**

Please note that Penn has strict rules on academic integrity (see [www.upenn.edu/academicintegrity](http://www.upenn.edu/academicintegrity)). Any violation of the rules will be reported to the Office of Student Conduct and will likely result in automatic failure of the course.

### **Course Absence Report:**

The Course Absence Report (CAR) system has been designed to provide a consistent way for students to notify course instructors of short-term absences for one or more courses. It also provides a method for advising offices to track absences and coordinate support for students who miss classes. The submission of a CAR does not excuse you from your course obligations; students are still responsible for following up with each instructor directly and adhering to course policies and procedures as outlined in the course syllabus. All students enrolled in a class can submit a CAR during the current term using Penn InTouch.

All notifications of class absences must be sent to the instructor through the CAR *only*. If you will be absent for more than five days as a result of a University-approved excuse, please contact a CaseNet advisor with the College Office, who will notify your instructors directly.

<b><i>Week</i></b>	<b><i>Dates</i></b>	<b><i><u>Lecture Topic</u></i></b>	<b><i><u>Readings</u></i></b>	<b><i><u>Assignments Due</u></i></b>
<b>1</b>	<b>8/29</b>	<b>Course Introduction</b>		
<b>2</b>	<b>9/5</b>	<b>Physics of Sound Fourier theory Spectrograms</b>	<i>Mather Ch.4</i>	
<b>3</b>	<b>9/12</b>	<b>Physiology of Peripheral Auditory System  The cochlea as a frequency analyzer</b>		<b>Paper Preferences Due</b>
<b>4</b>	<b>9/19</b>	<b>Physiology of Central Auditory System  Perception of Sound Loudness, Pitch Auditory Scene analysis</b>	<i>Plack Barker Hall 2014 Aizenberg Natan</i>	
<b>5</b>	<b>9/26</b>	<b>Perception of Speech and Music</b>		

6	10/3	Hearing Dysfunction	<p><b>Movie:</b> <i>Sound of Metal</i></p>	
7	10/10	<p><b>Sound Localization: Bat</b> Student Presentations</p>	<p><b>Review : Wenstrup and Portfors, 2011 Neuweiler, G. (2003)</b></p> <p><b>Suga, N. (1990, 2018)</b></p> <p><i>Model Systems:</i> <i>Bat</i></p>	
8	10/17	<p><b>Sound Localization: Barn Owl</b> Student Presentations</p>	<p><b>Review: Konishi, 2006</b></p> <p><i>Model System:</i> <i>Barn Owl</i></p> <p><i>Wagner et al 1987</i> <i>Cazettes et al 2014</i></p>	
9	10/24	<p><b>Plasticity and Learning: Barn Owl</b> Student Presentations</p>	<p><b>Review: Knudsen, 2002</b></p> <p><i>Model System</i> <i>Barn Owl</i></p>	
10	10/31	<p><b>Plasticity and Learning: Birdsong</b> Student Presentations</p>	<p><b>Review: Mooney, 2009</b> <b>Burke and Schmidt, 2020</b></p> <p><i>Model System</i> <i>Zebra Finch</i> <i>Vallentin et al 2016</i></p>	
11	11/7	<p><b>Auditory Cortex: Parallel Processing What and Where</b> Student Presentations</p>	<p><b>Review: King et al., 2018</b></p> <p><i>What and where</i> <i>(Lomber and Malhotra)</i></p>	

12	11/14	<b>Auditory Cortex: Music</b>  Student Presentations	<i>Review: King et al., 2018</i>  <i>Music and speech (Norman Haignere et al.)</i>	
13	11/21	<i>No Class: Thanksgiving</i>		
14	11/28	<b>Auditory Cortex: Speech/pathology Attention</b>  Student Presentations	<i>Speech (Pasley et al.)</i>  <i>Attention (Atiani et al.)</i>	
15	12/5	<b>Auditory Cortex: Decision Making Working Memory</b>  Dr. Yale Cohen guides Student Presentations	<i>Decision making (Tsunada et al.)</i>  <i>Working Memory (Plakke et al.)</i>	<b>NEWS AND VIEWS DUE</b>

### **Review Papers for background:**

- Neuweiler, G. (2003) Evolutionary aspects of bat echolocation. *J Comp Physiol A* 189: 245-256
- Suga, N. (2018) Specialization of the auditory system for the processing of bio-sonar information in the frequency domain: Mustached bats. *Hearing Research*. 361: 1-22
- Wenstrup, J.J. and Portfors, C.V. (2011) Neural processing of target distance by echolocating bats: Functional roles of the auditory midbrain. *Neuroscience and Biobehavioral Reviews*. 35: 2073-2083
- Konishi, M. (2006) Listening with two ears. *Scientific American*. Special Editions 16, 3s, 28-35
- Mooney, R. (2009) Neural mechanisms for learned birdsong. *Learning & Memory* (Cold Spring Harbor, N.Y.) 16(11):655-69
- Burke J. and M. F. Schmidt, M. F. (2020) Neural control of birdsong (2.0). In: *Encyclopedia of Life Sciences*. Chichester: John Wiley and Sons.
- Knudsen, E.I. (2002) Instructed learning in the auditory localization pathway of the barn owl
- Suga, N. (1990) Biosonar and neural computation in bats. *Scientific America*, Vol 262:6, p. 60-68
- King, (2018) Recent advances in understanding the auditory cortex. *F1000Research* 2018, 7(F1000 Faculty Rev):1555 Last updated: 27 SEP 2018

### **Papers for student presentation:**

- Mark Aizenberg<sup>1</sup>, Laetitia Mwilambwe-Tshilobo<sup>1</sup>, John J. Briguglio<sup>2</sup>, Ryan G. Natan<sup>1</sup>, Maria N. Geffen<sup>1\*</sup> (2015) Bidirectional Regulation of Innate and Learned Behaviors That Rely on Frequency Discrimination by Cortical Inhibitory Neurons. *PLOS Biology* | DOI:10.1371/journal.pbio.1002308
- Ryan G Natan<sup>1</sup>, John J Briguglio<sup>1</sup>, Laetitia Mwilambwe-Tshilobo<sup>1</sup>, Sara I Jones<sup>1</sup>, Mark Aizenberg<sup>1</sup>, Ethan M Goldberg<sup>2,3</sup>, Maria Neimark Geffen<sup>1\*</sup> (2015) Complementary control of sensory adaptation by two types of cortical interneurons. *eLife* 2015;4:e09868. DOI: 10.7554/eLife.09868
- Smotherman, M., Zhang, S. and Metzner, W. (2003) A Neural Basis for Auditory Feedback Control of Vocal Pitch. *J. Neurosci.* 23:1464-1477
- Wagner, H., Takahashi, T. and Konishi, M. (!987). Representation of Interaural Time Difference in the Central Nucleus of the Barn Owl's Inferior Colliculus. *J. Neurosci.* 7:3105-3116
- Cazettes, F., Fischer, B.J., Pena, J.L. (2014). Spatial cue reliability drives frequency tuning in the barn Owl's midbrain. *eLife* 2014;3:e04854. DOI: 10.7554/eLife.04854

Winkowski, D.E. and E.I. Knudsen (2006) Top-down gain control of the auditory space map by gaze control circuitry in the barn owl. *Nature*. 439: 336-339

Bergen, J.F., Ro, P., Ro, D. and Knudsen, E.I. (2005) Hunting Increases Adaptive Auditory Map Plasticity in Adult Barn Owls. *J. Neurosci*. 25:9816-9820.

Hyde, P.S. and Knudsen, E.I. (2001) A Topographic Instructive Signal Guides the Adjustment of the Auditory Space Map in the Optic Tectum. *J. Neurosci*. 21:8586-8593.

Linkenhoker, B.A., von der Ohe, C.G. and Knudsen, E.I. (2005) Anatomical traces of juvenile learning in auditory system of adult barn owls. *Nature Neuroscience*. 8:93-98.

London, S.E. and Clayton, D.F. (2008) Functional identification of sensory mechanisms required for developmental song learning. *Nature Neuroscience*. 11:579-586

Vallentin, D. Kosche, G., Lipkind, D. Long, M.A. (2016) Inhibition protects acquired song segments during vocal learning in zebra finches. *Science*. 351:267-271

Lomber, S.G. and Malhotra, S. (2008) Double dissociation of ‘what’ and ‘where’ processing in auditory cortex. *Nature Neuroscience*. 11: 609-616

Norman-Haignere, S., Kanwisher, N.G. and McDermott, J.H. (2015). Distinct Cortical Pathways for Music and Speech Revealed by Hypothesis-Free Voxel Decomposition. *Neuron*. 88: 1281–1296

Pasley, B.N., David, S.V., Mesgarani, N., Flinker, A., Shamma, S.A., Crone, N.E., Robert T. Knight, R.T., Chang, E.F. (2012). Reconstructing Speech from Human Auditory Cortex. *PLoS Biol* 10(1): e1001251. doi:10.1371/journal.pbio.1001251

Mesgarani, N and Chang, E. F. (2012). Selective cortical representation of attended speaker in multi-talker speech perception. *Nature*. 485: 233-237

Tsunada, J., Liu, A.S.K., Gold, J.I., and Cohen, Y. (2016). Causal contribution of primate auditory cortex to auditory perceptual decision-making. *Nature Neuroscience*. 19:135-142

Atiani, S., David, S.V., Elgueda, D., Loastro, M., Radtke-Schuller, S., Shamma, S.A., and Fritz, S.G. (2014). Emergent Selectivity for Task-Relevant Stimuli in Higher-Order Auditory Cortex. *Neuron*. 82:486-499

Plakke, B., Hwang, J. and Romanski, L.M. (2015) Inactivation of Primate Prefrontal Cortex Impairs Auditory and Audiovisual Working Memory

## **NEWS AND VIEWS ASSIGNMENT**

News and Views articles are brief and aim to introduce a scientist to significant new research in other fields. The goal of this assignment is to write an article about a specific

topic that can be understood by a general scientific audience (e.g., one of your classmates); what you write needs to avoid specialized technical jargon. The basic template of an article is as follows:

**Title:** A short, snappy and relevant title to get the reader's attention.

**Statement of the News:** 1-2 sentences and  $\leq 20$  words

- summarizes the major finding(s) of the paper by emphasizing its relevance and impact on the field.

**Opening paragraph geared to non-expert that:**

- Briefly states motivation for the paper (1-2 sentences)
- Explicitly cites the study and topic
- States primary finding
- Briefly summarizes the implications

**Paragraph(s) on background**

**Paragraph(s) on method (avoid being too technical)**

**Paragraph(s) on results**

**Final paragraph on the significance/implications of the work and future research directions**

**References:** at least **5** (one can be the paper you are presenting)

**One figures** (one created by you that captures the relevance/significance of the paper) with a caption written by you.

A total length of ~1000 words (1200 max).

# Guidelines for *Nature* News & Views articles

<http://ridl.cfd.rit.edu/products/press/nature/Nature%202014/N&V%20Guidelines%20ANA%20LOPES.pdf>

examples:

<https://www.nature.com/nature/articles?type=news-and-views>

*Nature's* News & Views section provides a forum in which scientific news can be communicated to a wide audience spanning the disciplines from astronomy to zoology.

News & Views articles are short (usually 800–900 words), and have as much in common with journalistic news reports as the formal scientific literature. They should therefore make clear the advance being discussed, and communicate a sense of excitement, yet provide a critical evaluation of the research concerned.

Please ask someone from an entirely different discipline to comment on a draft article before submission to *Nature*. It is essential that the article is written with such readers in mind rather than just for specialist colleagues.

## 1. How to write it

The 'news' should be highlighted in a brief opening paragraph to attract the attention of those who are not experts in the field. This paragraph should explicitly refer to the paper under discussion and touch on the general significance of the work. More detail, background and explanation should follow, including your own 'views'. The text is often best rounded off with comment on the limitations and implications of the new work, and on future research directions. Authors should avoid referring to their own work, except in passing.

## 2. Diagrams

Diagrams can be used to explain the new points made or the background science. *Nature's* art department can turn authors' sketches into publication-quality graphics, as long as the sketches are clear. Draft diagrams can be faxed (the number is given under 'Contact details') or sent electronically. Captions should be succinct but self-contained; readers like the main message of an article to be repeated briefly in the caption. Suggestions of other illustrative material, black-and-white or colour, informative or decorative, are welcome.

## 3. Titles

Titles for articles are open to discussion. They should be short and contain no punctuation marks or abbreviations. News & Views articles also carry a 'subject strapline' of one or two words to define the general subject area of the article, and a 'standfirst', a short item in larger type that precedes the main text and is intended to entice readers to read on.

## 4. References

References should be kept to a minimum, ideally fewer than ten. They should be given superscript numbers and cited sequentially in the text. Please do not use EndNote or a similar program. If the News & Views article is to accompany a paper in the same issue of *Nature*, the paper should be given a formal reference listed at the end of the article, and the first and last page numbers of cited papers should be included. If there are six or more authors to a reference, the first author only should be listed, followed by *et al.*

## 5. Acknowledgements and authorship

Acknowledgements are not allowed, nor are grant numbers. There should be no more than two authors.

## 6. Fees

A modest fee is paid for all News & Views articles published.

## 7. Sending the article

Articles should be delivered by e-mail, preferably as a Word attachment though plain ASCII text will do. If you are to be away during the month after submission, please also include a note of how you can be contacted.

## 8. Editing and corrections

Articles are on occasion heavily edited. But authors are given every opportunity to ensure accuracy by being sent an edited version of the text to correct (usually as a Word attachment). The corrected text is then seen by a *Nature* subeditor, who creates a typeset proof that is sent to the author as a pdf for a further check. Diagrams produced by the *Nature* art department are sent to authors as jpeg files for checking.

## What readers say

News & Views is a very popular section of *Nature*. But surveys of readers show that they struggle with unfamiliar jargon or concepts, even in disciplines close to their own. Overuse of abbreviations or acronyms is a particular problem in some subjects. All News & Views authors want to ensure that their article is technically correct and thought-provoking for those in the field concerned. This is indeed essential — the reader surveys show that one strength of News & Views is its authoritativeness. But the surveys also show that when care is taken to identify difficult terms or concepts, and then to avoid or explain them as appropriate, articles can meet that aim yet appeal to a much wider audience.