Welcome and Introduction

**5:00 pm**

**Name** Jonathon Whitton  
**Lab** Lab Eaton Peabody Lab, Neural Plasticity Unit  
**Advisor** Daniel Polley, Ph.D.  
**Title** Immersive audiomotor game play enhances neural and perceptual salience of weak signals in noise  

**Abstract** All sensory systems face the fundamental challenge of encoding weak signals in noisy backgrounds. Though perceptual abilities can improve with practice, these benefits rarely generalize to untrained stimulus dimensions. Inspired by recent findings that action videogame training can impart a broader spectrum of benefits than traditional perceptual learning paradigms, we trained adult humans and mice in an immersive audiogame that challenged them to forage for hidden auditory targets in a two-dimensional soundscape. Both species learned to modulate their angular search vectors and target approach speeds based on real time changes in the level of a weak tone embedded in broadband noise. In humans, mastery of this tone in noise task generalized to an improved ability to recognize sentences in speech babble noise. Auditory cortex units in trained mice exhibited an improved coding of low-intensity sounds at the training frequency with an enhanced resistance to masking noise. These findings highlight the potential to improve the neural and perceptual salience of degraded sensory stimuli through immersive computerized games.

**5:15 pm**

**Name** Kevin Woods  
**Lab** Department of Brain and Cognitive Sciences, MIT  
**Advisor** Josh McDermott  
**Title** Tracking one of many similar sources in multidimensional feature space  

**Abstract** Auditory scenes are often encountered in which just one of many competing sources is of interest, and must be selected out for further processing. This problem is made more difficult when competing sources are similar in the ranges of time-varying values they can take along feature dimensions used for selection (such as location, pitch, or loudness). For example, two speakers of the same gender may have pitch ranges which overlap. In such a case, pitch alone cannot reliably index a target speaker. Further, these competing sources may occasionally take the same pitch at the same time, resulting in ambiguity. Any single feature thus quickly fails to unambiguously index a target source among similar competing sources. By referencing several features in conjunction, however, source separation can in principle be maintained in a multidimensional feature space. Despite this, it is not clear that human listeners in fact use conjunctions of time-varying features to select a source of interest from among similar competing sources. Tokens of simple voices (synthesized continuous phonation) had f0, f1 and f2 trajectories independently drawn from low-passed noise. Participants were cued to attend to one of two such voices in a mixture. Following the mixture, the tail end of one voice was used as a probe to determine if the cued voice had been successfully tracked through the mixture. Trajectories for the two voices in a mixture were required to cross each other in every single feature dimension, but never crossed in all dimensions at once. Thus, the two voices in a mixture could not be tracked on the basis of any one feature alone, yet had unique
trajectories in multidimensional feature space. Pilot results to date suggest that (1) multiple dynamic features can be used in concert to selectively follow a target sound, where either feature alone will not suffice, and that (2) performance increases with the global minimum distance between trajectories in multidimensional space.

5:30 pm
Name Ariel Edward Hight
Lab ABI Lab
Advisor Chris Brown, Dan Lee
Title Optically-Evoked Auditory Brainstem Responses (oABR)
Abstract Since its discovery in 2005, optogenetic tools, consisting of genetically-modified neurons that can be stimulated with high selectivity and temporal precision, have become a popular and useful technique for studying neural circuits. Advantages of optogenetic control in neural prostheses include increased spatial selectivity, physiological selectivity, and reduction of recording artifact. In order to explore the possibility of using optogenetic methods as a new approach to auditory prosthetics such as the auditory brainstem implant (ABI), a justification is needed for using optogenetic tools over electrical neurostimulators. To induce light sensitivity in the mouse auditory system, a 1.5 L dose of Adeno-Associated Virus (AAV) containing genetic information for encoding light sensitive proteins channelrhodopsin-2 (ChR2) or chromos is injected into the cochlear nucleus. Three weeks after injection, we stimulate the re-exposed brainstem with blue light. The blue light stimuli is presented through an optical fiber whose end is placed directly on the surface of the brainstem. As a quick and noninvasive indication of neural activation, optically-evoked Auditory Brainstem Responses (oABR) are recorded. These recordings show as many as five identifiable peaks, peak amplitudes ranging from 0-50 V, and peak latencies early as 2 ms and late as 6 ms. Immediately after the recording, the brainstem of these mice are prepared for histological examination. Currently, we are combining multi-unit recordings of upstream neurons in the Inferior Colliculus (IC) with these histological preparations of fluorescently-marked ChR2 and Chronos to confirm optogenetic control of the auditory system and potentially provide indications of oABR peak generators. Future experiments will include multi-unit recordings in the IC to monitor the activation of neurons upstream in the auditory system in addition to providing an approximation of tonotopic selectivity of neural activation.

5:45 pm
Name Brian Buechel
Lab Neural coding group at EPL
Advisor Bertrand Delgutte
Title New strategy for improving ITD coding with cochlear implants at high stimulation rates
Abstract Bilateral cochlear implant users, when compared with normal hearing listeners, show reduced sensitivity to interaural time differences (ITD), instead relying primarily on interaural level differences to localize sounds (Seeber and Fastl, J. Acoust. Soc. Am. 123: 1030). This degraded ITD sensitivity is particularly prominent with high-rate periodic pulse trains, which are used in most clinical sound processors. Perceptual ITD sensitivity can be improved by introducing binaurally coherent jitter into the inter-pulse timings of pulse trains (Laback and Madjak, Proc. Natl. Acad. Sci. 105: 814). Neural correlates of this effect have been found in inferior colliculus neurons where jitter increased sustained firing rates and restored ITD tuning at high pulse rates (Hancock et al., J. Neurophysiol. 108: 714). Sustained activity during these high-rate jittered pulse trains was shown to occur after short inter-pulse intervals. This suggests a novel sound processing strategy in which intermittent extra pulses are inserted so as to create short intervals in an otherwise periodic pulse train. To test this idea with stimuli that resemble those produced by clinical sound processors with natural speech inputs, a speech corpus processed by a continuous interleaved sampling processor was analyzed to characterize envelope statistics such as fundamental frequency (F0), attack slope, and depth of F0 modulations. These statistics were used to synthesize a pseudo-syllable modulated pulse train stimulus in which the locations of extra pulses can be systematically manipulated. These stimuli were presented to a bilaterally-implanted awake rabbit while recording from single units of the inferior colliculus. Of the six neurons studied with pseudosyllable stimuli, two showed increased firing rates when extra pulses were inserted near the local maxima of
F0 modulations, consistent with the hypothesis. In one of these neurons, ITD sensitivity was improved by the addition of extra pulses. Additional data are needed to determine the extent to which ITD coding is affected by this strategy.

6:00 pm
Name Andrew Ayoob
Lab Draper Laboratory- biomedical engineering center, MIT-Langer Lab
Advisor Jeff Borenstein, Robert Langer
Title Biodegradable controlled release membranes
Abstract Drug delivery to the inner ear spaces remains a challenge in the treatment of many otologic disorders. The blood-cochlea barrier impedes entry of systemically administered therapeutic molecules into the cochlea1. Intratympanic delivery of drug solution increases therapeutic concentration in the perilymph, but rapid clearance precludes maintenance of therapeutic levels in the inner ear fluids2. Additionally, repeated injections cause damage to the tympanic membrane. Single transtympanic injection poloxamer gels reduce the need for repeated injections, but lack an on-demand delivery mechanism that could be utilized for treatment of fluctuating otologic disorders such as Menieres Disease3. My research is focused on the synthesis and characterization of polymeric membranes for long-term encapsulation and enzymatically triggered release of therapeutic agents. The poly(ester amide)s, including poly[glycerol sebacate] (PGS), and poly[1,3-diamino-2-hydroxypropane-co-polyol sebacate] (APS), are a class of non-porous elastomers that are biochemically degradable with biocompatible degradation products4. APS pre-polymers of varying molecular composition were synthesized via step-growth polymerization and cured under high vacuum and high temperature to produce an infinite network polymer membrane. The APS membranes were investigated for mechanical properties, passive solute diffusion rates, hydrolytic stability, and rate of enzymatically triggered degradation. Drug release studies were carried out in laminated planar encapsulation devices with lidocaine as a surrogate therapeutic and lipase (porcine pancreas) as an enzyme trigger. Aliquots of receiver solution are currently being analyzed with liquid chromatography-mass spectrometry (LC-MS) and ultraviolet-visible light spectroscopy (UV-VIS) to determine lidocaine release as a function of time. Preliminary results indicate that tuning the APS molecular composition, specifically ratio of amide to ester linkages, allows for control over the rate of passive solute diffusion, hydrolytic stability, and tunable enzyme degradation kinetics. Optimized APS polymer films may be useful for the development of an implantable, fully resorbable drug delivery device capable of metering drugs into the auditory system on an on-demand basis over a sustained period without subsequent surgical intervention.

6:15 pm
Break

6:30 pm
Name Sonam Dilwali
Lab EPL
Advisor Konstantina Stankovic
Title Understanding the Mechanism of Sporadic Vestibular Schwannoma-Associated Sensorineural Hearing Loss
Abstract Vestibular schwannomas (VS) are the most common tumors of the cerebellopontine angle. They have a clinical incidence of 1:10,000 and a histological incidence of approximately 1:100. Interestingly, although occurring on the vestibular nerve, VS cause sensorineural hearing loss (SNHL) in 95% of patients. VS tumor size correlates poorly with the degree of SNHL, suggesting the etiology to be more complex than simply mechanical compression of the adjacent auditory nerve. We hypothesize that VS secretion of proteins with ototoxic or otoprotective potential influences hearing status of VS patients. In previous work, we identified a known otoprotective protein fibroblast growth factor 2 (FGF2) to be secreted at higher levels from VS that do not cause significant SNHL. We aim to investigate the role of FGF2 and other candidate proteins in VS-associated SNHL using a murine cochlear organotypic culture model. We apply human VS secretions, collected by incubating freshly resected tumor specimens in media, as well as specific candidate proteins onto the cochlear cultures. Post-incubation, we assess cell death rates in hair cells and spiral ganglion neurons as these cell types are
known to be lost in VS-associated SNHL. Our study can provide mechanistic insight into the pathobiology of VS-associated SNHL, identifying targets for pre-emptive and therapeutic treatments to minimize SNHL due to VS.

6:45 pm
Name Koeun Lim
Lab Jenks Vestibular Physiology Laboratory, Massachusetts Eye and Ear Infirmary, Boston MA.
Advisor Maria-Carolina Bermudez, Daniel M. Merfeld
Title Visual fixation of a head-fixed target alters the dynamics of rotational perception
Abstract The vestibular system provides information about self-motion and orientation in space. Its pathways are widely parallel, each pathway performing a unique transformation that is tailored for its purpose. Although the dynamics of vestibular afferent signals is initially determined by the dynamics of the sensory organ (e.g., high-pass filter with a time constant of 6 sec), the upper stream dynamics can change substantially depending on further transformation. Such differences in dynamics in vestibular system were earlier demonstrated in the studies investigating perception thresholds and compensatory eye movements called the vestibulo-ocular reflex (VOR), which are both driven primarily by vestibular signals. These studies reported that the time constant of the VOR was prolonged (15 sec) whereas the time constant for direction-recognition motion perception thresholds in the dark was shortened (0.7 sec). In this study, we measured vestibular perception thresholds in human subjects in the dark and with a visual fixation target in order to investigate how the VOR, can affect perception. Specifically, we suppressed the VOR by providing a visual fixation point that moved with the human subjects body and head. In this condition, subjects sometimes experienced an illusion that the visual target was moving, which is called the oculogyral illusion (OGI). To study response dynamics, we presented yaw rotation motion stimuli at 6 different frequencies (0.15, 0.2, 0.5, 1, 2, and 5Hz). For the 4 subjects we tested, the mean OGI perception thresholds were lower by half at 0.15, 0.2, 0.5, and 1Hz than when the thresholds were measured without a visual fixation target (dark). At higher frequencies, the mean thresholds converged with and without a visual fixation target. This result implies that the VOR signal, when suppressed, adds information to direction-recognition perception, which reduces direction-recognition thresholds primarily at lower frequencies.

7:00 pm
Name Jennifer Zuk
Lab The Gaab Laboratory, Laboratories of Cognitive Neuroscience - Division of Developmental Medicine - Boston Childrens Hospital and Harvard Medical School
Advisor Dr. Nadine Gaab
Title Altered functional connectivity during phonological processing in young children with familial risk for dyslexia prior to and during reading acquisition
Abstract Developmental dyslexia (DD) is a specific reading disorder characterized by impairments in word recognition and decoding. Longitudinal studies in children identified phonological processing, the ability to manipulate speech sounds, to be a key predictor of DD. Functional Magnetic Resonance Imaging (fMRI) studies reported that children and adults with DD exhibited reduced activation in left-hemispheric tempo-occipital and tempo-parietal cortical regions during phonological processing compared to typically developing individuals. Additionally, hypoactivation in similar left-hemispheric posterior regions during phonological processing has been shown in children with a family history of DD prior to reading onset. To date, the functional connectivity between these brain regions and other left-hemispheric regions typically implicated in language processing has not been investigated at a young age during reading acquisition. The present analysis explored functional connectivity during phonological processing with seed-based cross-correlation. 38 children with (FHD+, n=18) and without a family history of DD (FHD-, n=20) completed fMRI investigation at two time points: initially prior to reading onset, and then following one year of kindergarten. We hypothesized (i) that functional connectivity during phonological processing would change following the onset of reading instruction and (ii) that functional connectivity would differ in FHD+ and FHD- children. Functional connectivity was determined by the bivariate correlation of the time course
for BOLD activation within each left-hemispheric posterior seed region. Results indicate that in pre-reading children, FHD- children exhibited increased functional connectivity between left-hemispheric temporoparietal regions and frontal areas compared to FHD+ children. After one year, FHD- children demonstrated increased functional connectivity between left-hemispheric temporoparietal regions and temporo-occipital regions compared to FHD+ children. These preliminary findings suggest that functional connectivity during phonological processing changes in response to reading instruction differentially based on family history. Further longitudinal investigation is needed to determine the developmental trajectory of the neural networks involved in phonological processing.

7:15 pm
Name Rachel R. Romeo
Lab McGovern Institute for Brain Research; MIT Department of Brain and Cognitive Sciences
Advisors Tyler Perrachione, PhD; John Gabrieli, PhD
Title Cortical modularity of phonological working memory in adults with dyslexia
Abstract Phonological working memory (PWM) is the mechanism by which speech sounds are maintained for a short period of time, and impairment is seen in many language disorders, including dyslexia. Skills are traditionally assessed by clinical tests of nonword repetition (NWR), in which individuals hear phonetically possible but non-existent words and repeat aloud. Though this has often been considered a pure working memory task free from higher-order language processing, recent fMRI investigations show that NWR is largely subserved by the canonical cortical language network. This suggests that speech sound maintenance might be achieved by the language system itself, rather than an independent WM system, and perhaps NWR impairments are not underlied by a deficit in some core WM module, but rather in a language-specific process such as orthographic-to-phonological recoding or productive phonological sequencing. To investigate, groups of language-normal and dyslexic adults heard and read both real and nonwords of 1 or 4 syllables before saying them aloud, yielding a 2x2x2x2 design, and sparse-sampling fMRI acquired whole-brain images before and after each word was said. In a second fMRI session, participants completed classic WM tasks of verbal digit (auditory) and dot location (visuospatial) sequencing, again at high and low loads (3 vs. 6 items). Pilot data for two control subjects confirm that both language tasks elicit activity in the STG, IFG, PMA, SMA, parietal regions, and auditory or visual cortices depending on modality, with nonwords eliciting greater fronto-parietal activity. Both sequencing tasks elicited activity in the DLPFC (site of executive function), as well as parietal and insular regions. Results from one dyslexic subject show similar patterns, though with hyperactivity on longer words and less deactivation on shorter ones, and much greater right hemisphere activity for visuospatial sequencing. Interestingly, this subject exhibited marked hypoactivity during repeating nonwords (as opposed to real words) in IFG and DLPFC. More subjects are needed to conclude how NWR relates to WM and language systems, and how this is disrupted in dyslexia.

7:30 pm
Name Jordan Whitlock
Lab Language Science Lab - Boston University, Sargent College of Health and Rehabilitation
Advisor David Caplan, MD, PhD
Title Language Comprehension and Memory: Preliminary Results from a Speed-Accuracy Trade-Off Study
Abstract Language is bursting with dependencies. As a simple example, the use of a pronoun (e.g. Peter rode his bike to school) requires access to its referent (his refers to Peter) for accurate comprehension. Thus, sentence comprehension inherently requires some memory component. The question then becomes what the nature of this memory component is. Research on memory for retrieval list items suggests two distinct memory types utilized: parallel, content-addressable search and serial search. Evidence suggests that much of sentence comprehension uses a content-addressable parallel search. One hypothesis is that given a sentence of adequate complexity and length, individuals will switch to a serial search mechanism to retrieve important information. In this talk, I present preliminary results of a study investigating the relationship between language comprehension and memory that utilizes a Speed-Accuracy Trade-off (SAT) procedure. This
task requires subjects make plausibility judgments for sentences presented phrase-by-phrase on a computer screen. Sentences vary with respect to sentence type, number of embedded clauses, ambiguity, closure location, and presence or absence of error. Sentences are designed so that the plausibility of each sentence cannot be determined until the final word of the sentence. This method provides a picture of how quickly subjects make a judgment about the plausibility of a sentence as well as how accurately they make these judgments. Results are plotted in regards to both speed and accuracy. Preliminary results suggest a main effect of number of embedded clauses closure on asymptotic accuracy. Best-fit lines for both individual subjects and averaged data suggest that even in the most complex of sentences, subjects tend to respond in a way consistent with parallel, content-addressable search.