**Science of Learning Institute**
**Funded Research Summary**

# Cortical dynamics of auditory perceptual learning, 2013 - 2015


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This project seeks to better understand the neural bases of auditory perceptual learning in the adult human brain. We will focus on learning-related changes in cortical auditory response dynamics as a function of repeat exposure to novel (non-native) speech sounds under attended (training) and unattended listening conditions. Our main hypothesis is that short-term auditory training modulates the temporal dynamics of cortical high-frequency responses (> 30 Hz), correlating with improved perceptual performance.

We will use a prospective repeated-measures design to study effects of short-term (one session) auditory discrimination training on cortical electrophysiological responses (spectral, evoked) to non-native speech sounds (Fig 1). Non-native speech sounds include: 1) voiced retroflex stop consonant (/ɖ/, Dravidian languages) and 2) lexical tones (risingTone2, falling Tone4, Mandarin Chinese).

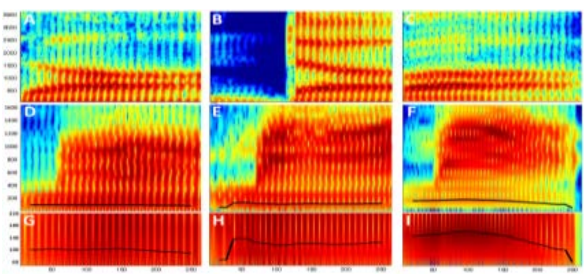

Figure 1. Spectrograms of six auditory stimuli: (A) English /da/; (B) Retroflex /ɖa/; (C) English /ba/; (D) English /ma/; (E) Mandarin /ma$^{Tone4}$/; (F) Mandarin /ma$^{Tone2}$/; Black lines in D-F trace pitch (f0) contour; Plots G-I show enlarged f0 contrast for plots D-F. Time (ms) is on the x-axis; Frequency (Hz) is on the y-axis. Color bar denotes intensity scale (red = greatest).

Intracranial electrocorticography recordings (ECoG) will be recorded directly from human cortex using electrode arrays implanted for surgical evaluation of intractable epilepsy. ECoG provides excellent temporal (1-2 ms), spectral (0-250 Hz), and spatial (≤10 mm) resolution and is ideally suited, therefore, for studying cortical dynamics (Fig 2). Behavioral and electrophysiology testing will be performed before (Study 1) and after auditory discrimination training (Study 2). Data collected under the same experimental conditions from patients who are native speakers of Mandarin Chinese will be analyzed through an ongoing collaboration with Tsinghua University School of Medicine in Beijing, China.

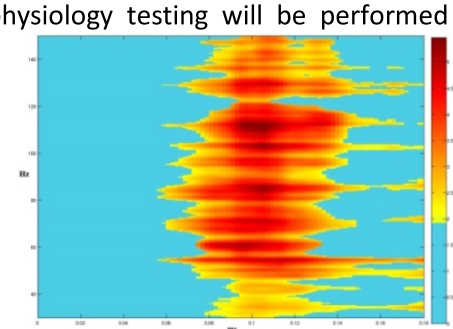

Figure 2. Example of a high-frequency, event-related auditory spectral response recorded from an intracranial electrode located on the left superior temporal gyrus of one patient. The response is color coded by size of power change (color bar; red greatest) and represents statistically significant ($p < 0.05$) changes from baseline (blue). Time is on the x-axis (0-180 ms), with stimulus onset at 0 ms; frequency is on the y-axis (30-150 Hz). (Adapted from Cervenka et al. 2013; *Clinical Neurophysiology*, 124(1):70-82, 2013).

Our interdisciplinary research team includes researchers from four Johns Hopkins Departments - Neurology, Cognitive Science, Biomedical Engineering and Neuroscience- as well researchers at Tsinghua University in Beijing, China. This project will also provide hands-on research training for undergraduate and graduate students interested in pursuing research in human auditory neuroscience. We anticipate that this project will yield new insights into the neural dynamics underlying human perceptual learning that may be useful for designing and evaluating auditory-based training programs, quantifying individual perceptual differences, and predicting treatment outcomes in clinical populations.


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