«***Proposal A*** *focuses on the mediation of language through acoustics.*
Proposal B *focuses on the basic cognitive aspects of language processing.»*

Goals

Language is one of the most complicated phenomena in everyday life, and by far the most common means by which human beings interact with each other. Viewed as a dynamical system, it is fascinating that spatial (written) and temporal (spoken) patterns can couple brain states so effectively! Our goal in this project is **to model how neural states can be coupled physically by acoustic transmission to model how changing neural states representing interpreted phonemes can create complex information structures in cortex**.

Plan

We will begin by developing a computer simulation of the basilar membrane of the cochlea, the organ responsible for mechanical spectral analysis of incoming auditory stimulation[5, 6]. The basilar membrane can be approximated as a series of coupled mass-spring oscillators with different resonant properties [1, 4]. We will test this simulation by coupling the boundary conditions with recordings of actual speech. Time permitting, we will develop a neural model of phoneme classification [3], which will be coupled to the output of the basilar membrane model. We may even go so far as to attempt a mechanical cochlea [1, 2]. We will attempt to develop a simulated dynamical system which exhibits highly specific sequence dependence, so that many differences in presented input patterns are essentially abolished in the output, but specific differences of comparable magnitude reliably produce dramatically different results.

References

[1] F. Chen, H. I. Cohen, T. G. Bifano, J. Castle, J. Fortin, C. Kapusta, D. C. Mountain, A. Zosuls, and A. E. Hubbard. A hydromechanical biomimetic cochlea: experiments and models. *Journal of the Acoustical Society of America*, 119(1):394–405, 2006. doi: 10.1121/1.2141296.

[2] R. M. Keolian. A demonstration apparatus of the cochlea. *Journal of the Acoustical Society of America*, 101(2): 1199–1201, 1997. doi: 10.1121/1.419497.

[3] N. Mesgarani, S. V. David, J. B. Fritz, and S. A. Shamma. Phoneme representation and classification in primary auditory cortex. *Journal of the Acoustical Society of America*, 123(2):899–909, Feb. 2008.

[4] D. C. Mountain and A. E. Hubbard. Analysis and synthesis of cochlear mechanical function using models. In *Auditory Computation*, volume 6, pages 62–120. Springer-Verlag, New York, 1996.

[5] K. E. Nilsen and I. J. Russell. Timing of cochlear feedback: a spatial and temporal representation of a tone across the basilar membrane. *Nature Neuroscience*, 2:642–648, 1999. doi: 10.1038/10197.

[6] M. A. Ruggero, N. C. Rich, A. Recio, S. S. Narayan, and L. Robles. Basilar membrane responses to tones at the base of the chinchilla cochlea. *Journal of the Acoustical Society of America*, 101(4):2151–2163, 1997. doi: 10.1121/1.418265.