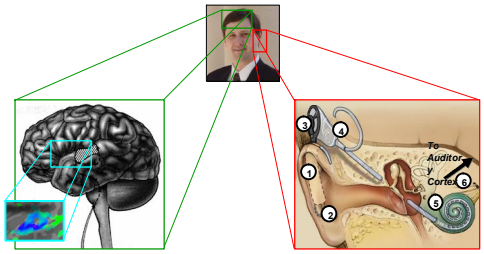
Thomas M. Talavage, PhD

- Associate Professor, Electrical and Computer Engineering, Biomedical Engineering
- Adjunct Associate Professor, Dept. of Radiology, Indiana University School of Medicine (IUSM)
- tmt@purdue.edu

PURDUE UNIVERSITY

School of Electrical and Computer Engineering
Weldon School of Biomedical Engineering

Enhancing Speech Perception in Auditory Impairment and Rehabilitation Scenarios



Central Auditory System:
fMRI of Auditory Neurophysiology
fMRI of Impaired/Rehabilitated Speech Perception
Techniques for Auditory fMRI

Peripheral Auditory System:
Acoustic Simulation of Impairment/Rehabilitation
Computational Models of Impairment/Rehabilitation
Novel Hardware/Processing for Rehabilitation

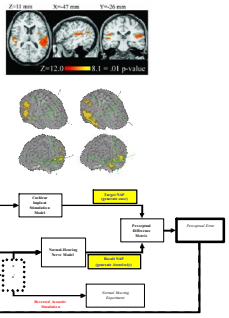
PURDUE UNIVERSITY

School of Electrical and Computer Engineering
Weldon School of Biomedical Engineering

Current Research Areas

Central Auditory System

- Improved fMRI measurement of responses to acoustic stimulation (R01EB003990)
  - Compare/compensate for activation across experimental environments
- Auditory neuroscience: adapatation to degraded speech stimuli
  - Longitudinal "learning" of degraded speech stimuli



Peripheral Auditory System

- Rethink acoustic simulations of CI electrical stimulation
  - Optimize acoustic CI simulators based on induced peripheral activation
- Alternative models for exciting the auditory nerve
  - Are discrete electrodes the only answer?

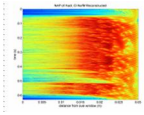
PURDUE UNIVERSITY

School of Electrical and Computer Engineering
Weldon School of Biomedical Engineering

Methodologies

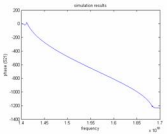
Central Auditory System

- Acute and longitudinal studies of normal-hearing listeners
- fMRI conducted at both 1.5T and 3.0T
  - InnerVision Medical imaging (Lafayette, IN) [1.5T]
  - IU School of Medicine (Indianapolis, IN) [1.5T, 3.0T]
  - Medical College of Wisconsin (Milwaukee, WI) [1.5T]
  - *??? (West Lafayette, IN) [3.0T] ???*



Peripheral Auditory System

- Behavioral studies of normal-hearing listeners compared with data collected from CI users
  - Data are analyzed as a function of
    - Stimulus characteristics (frequency shift, frequency resolution)
    - Phonemic content (manner, place, voicing)
    - Listener characteristics (age, hearing status)
- Computational models of nerve activity (e.g., Heinz et al., 2001)
- Device development using microstrips with left- and right-handed materials
  - Dispersion curve can produce variable frequency-velocity relationship



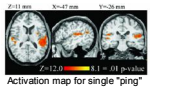
PURDUE UNIVERSITY

School of Electrical and Computer Engineering
Weldon School of Biomedical Engineering

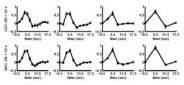
Recent Results

Central Auditory System

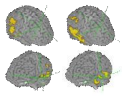
- Cortical responses to acoustic noise associated with fMRI persist up to 10s
- Integration window for alteration of responses in auditory cortex is at least 12s in length
- Different cortical pathways used to process normal (dorsal) and degraded (ventral) speech after 15 hours of training.



Activation map for single "ping"



fMRI Response as function of TR/ISI



Normal Degraded

Peripheral Auditory System

- Acoustic CI simulations produce a perceptual task of equivalent complexity to speech perception in CI users, but the nature of the complexity is different....
- Proof-of-concept waveguide-like device constructed to operate and produce focusable external electric fields.
  - Goal is waveguide application of findings of C.P. Richter (Northwestern) re: 2.12 μm wavelength excitation

PURDUE UNIVERSITY

School of Electrical and Computer Engineering
Weldon School of Biomedical Engineering

Future Directions

Central Auditory System

- Improved evaluation of speech perception pathway selection
  - Augment training and rate of fMRI observations
  - Attempt to achieve "chronic" stimulation state
    - Long-term wearable simulator?
    - Opportunity for patient to adapt to degraded form of own speech
  - Evaluate time-course and extent of brainstem involvement in the observed alternative pathways
- Improved auditory fMRI techniques
  - Post-acquisition compensation
  - Active noise cancellation?

Peripheral Auditory System

- Enhanced simulations of auditory rehabilitation
  - Develop (pseudo-)inverse of neural activity model to create stimuli for delivery to normal-hearing listeners
- Alternative cochlear implant design
  - Validate new microstrip design for ability to localize excitation
  - Apply microstrip in (*ex vivo*) animal model to evaluate excitation vs. heating

PURDUE UNIVERSITY

School of Electrical and Computer Engineering
Weldon School of Biomedical Engineering