

EEG Study of Effortful Listening

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Disclaimers

- VA salaried employee
 - The views of this presentation do not represent those of the Department of Veterans Affairs or the US government.
- ETSU academic appointment
- Duke unpaid fellowship appointment

Listeners with Hearing Loss

- Common complaint is difficulty understanding speech, especially in noisy background
- Still common complaint with hearing aids
- Additional mental effort (Listening Effort) required -> Mental fatigue
- Current clinical measures of Listening Effort:
 - Word/Speech recognition in noise
 - Self-report assessment of function
- Cognitive measures (e.g., pupillometry & EEG)
 - Neurological underpinnings of effortful listening
 - Aid in development of a clinical measure

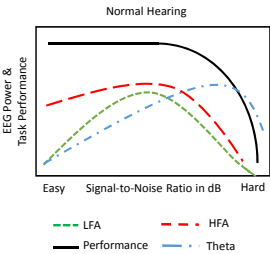
Electroencephalography (EEG)

- Frequency & Cognition:
 1. Low-frequency alpha (8-10Hz, parietal lobe) reflects cognitive inhibition, working memory
Klimesch, 1999; Klimech et al., 2007
 2. High-frequency alpha (11-13Hz, parietal lobe) reflects cognitive demand
↓ high-frequency alpha = ↑ cognitive demand
Klimesch, 1999; Klimech et al., 2007
 3. Theta (4-8Hz, frontal lobe) reflects cognitive control, cingulo-opercular network
Wisniewski et al., 2015; Vaden et al. 2013; Eckert et al., 2016; Clayton et al., 2015
- Goal: Evaluate an EEG-based method to assess cognitive states of listening effort

Hypotheses

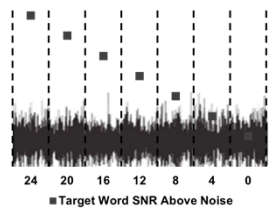
1. Low-frequency alpha (LFA) Cognitive Inhibition
2. High-frequency alpha (HFA) Cognitive Demand
3. Theta Cognitive Control

Each will have an inverted U-shape curve reflecting the maximum cognitive inhibition, demand, and control



Methods

- 20 participants (11 female) with normal hearing, 2 left-handed, mean age = 25.5 years, SD = 3.5 years
- Words – In – Noise (WIN) task
 - Seven signal-to-noise ratios (SNR) of 24 to 0 dB SNR in 4-dB SNR decrements
 - “Say the word cool”
 - Target word SNR decreased
 - Five words in each SNR
 - Background held constant



Methods

- Words – In – Noise (WIN) task
 - Five lists each containing 35 words (NU-6) in multi-talker babble
 - One list as practice (excluded)
 - Two lists in descending order
 - Two lists in random order
 - Counter-balanced

Methods – cont.

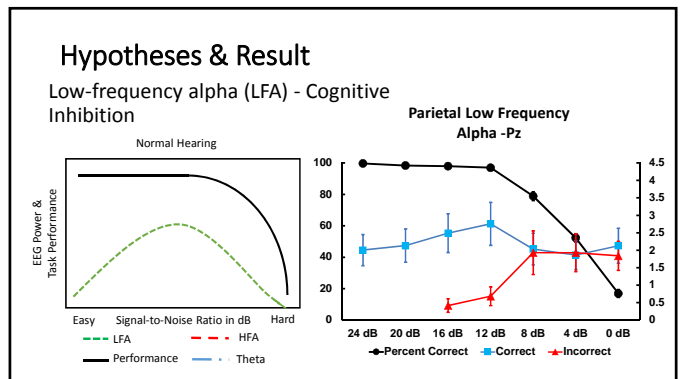
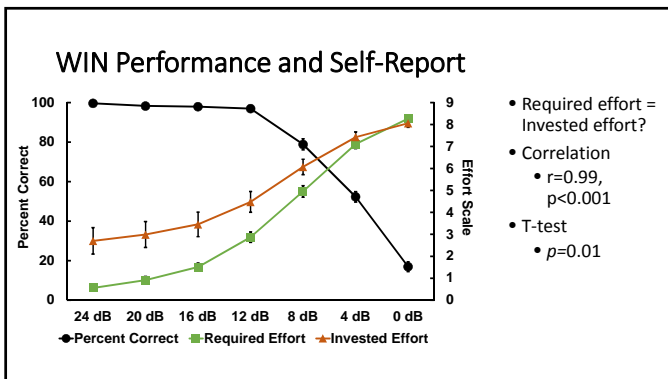
- Unaided
- Sound field
- Seated 1 m, 0° loudspeaker
- 70 dB SPL –
 - Background Babble
- Participants rated the effort of each SNR

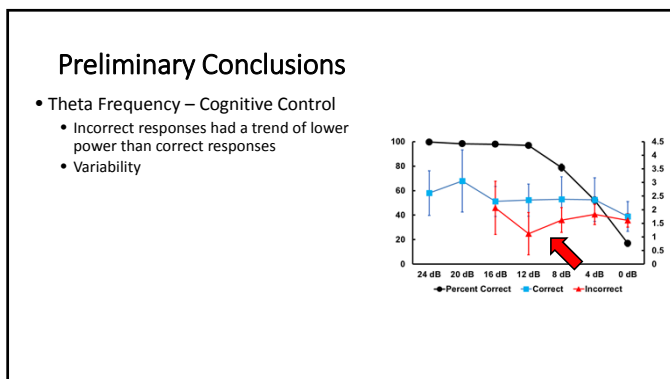
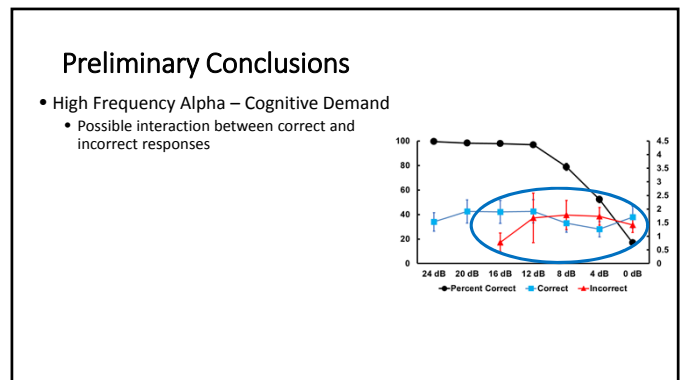
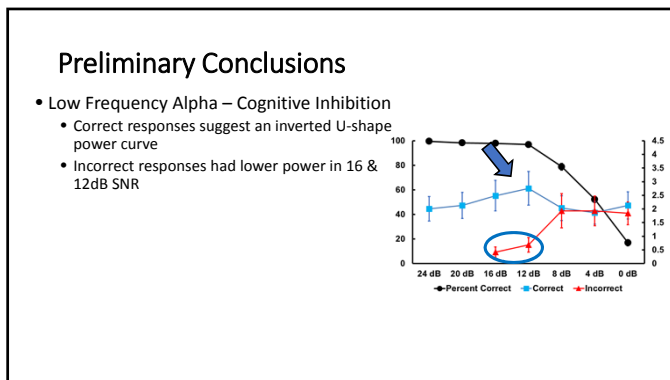
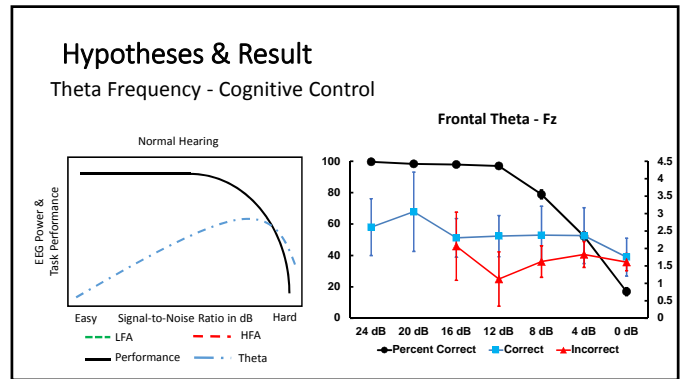
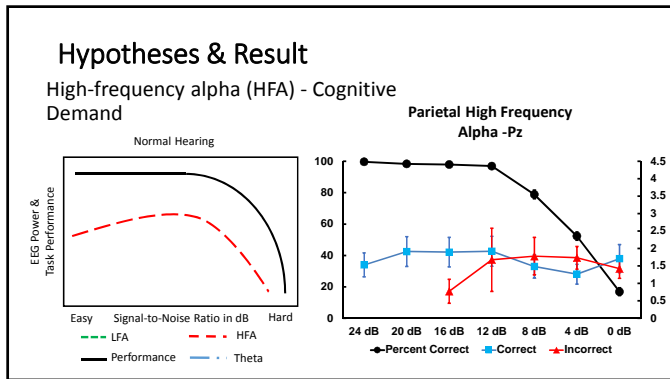
Methods: EEG

- 64- Channel Neuroscan system
- MATLAB & EEGLAB
- Independent component analysis (ICA)
 - Artifact Rejection (e.g., eye blinks)
- Frequency Analysis
 - Theta – Frontal (Fz, Blue)
 - High/Low Alpha – Parietal (Pz, Red)
- EEG data epoch:
 - Target Word “cool”

Methods: EEG – cont.

EEG data collapsed across all four lists then sorted by condition and response type:





Further Analysis

- Examine additional frequency bands (e.g., gamma)
- Group regions of electrodes for surface analysis
- Dipole source analysis - shows promise
- Examine order effects and descending vs. random effects
- Expand to other types of auditory stimuli and tasks (e.g., phonemes, sentences)
- Acknowledgements:
 - Mentors - Sherri Smith, Kim Schairer, Eric Sellers, & Mark Eckert
 - Hearing and Balance Research Program, James H. Quillen VA, Mountain Home
 - Lab Assistants – Marissa, Michelle, & Lucia
 - Participants