CORTICAL AUDITORY PROCESSING AND SPEECH UNDERSTANDING FROM CHILDHOOD TO ADULTHOOD

Binaural Hearing and Speech Laboratory

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INTRODUCTION

Auditory maturation

- The auditory system gradually matures from birth to adulthood.
- Developmental changes are observed in brain function and behavior.

Development of cortical auditory processing

- Cortical auditory evoked potentials (CAEPs, Figure 1) are objective measures of cortical activity in response to sound.[1]
- Amplitudes and latencies of CAEP obligatory components (P1, and N1) index auditory maturational changes.[2,3]
  - P1 amplitude and latency decrease with development.
  - N1 amplitude increases and N1 latency decreases with development.

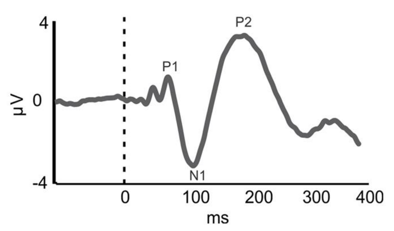

Figure 1 : Typical CAEP waveform in adults

Development of speech understanding ability

- Speech understanding in quiet and in noise develops gradually.[4]
- Speech reception thresholds improve with age.[5]

Questions

- Are there frequency specific differences in cortical auditory maturation?
- How is cortical maturation associated with speech understanding?

Study goals

- Investigate auditory development from childhood to young adulthood
  - CAEPs in response to high- and low-frequency speech sounds.
  - Speech understanding in quiet and in noisy conditions.
  - Association between CAEPs and speech understanding.

METHODS

Study Design and Participants

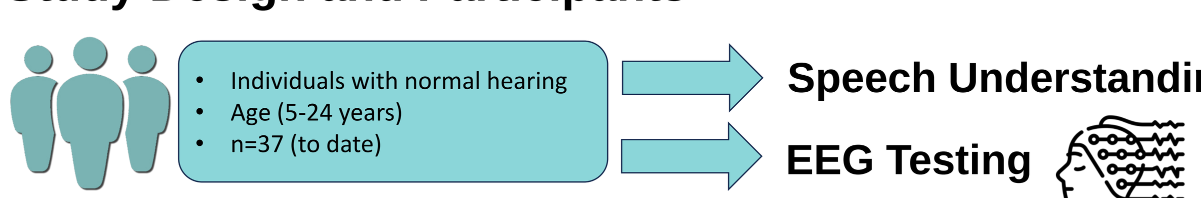

Figure 2: Study Design

Speech Understanding

- Four-alternative-forced choice task[6]
- Speech reception threshold (SRT): point on psychometric function at 79.4% performance

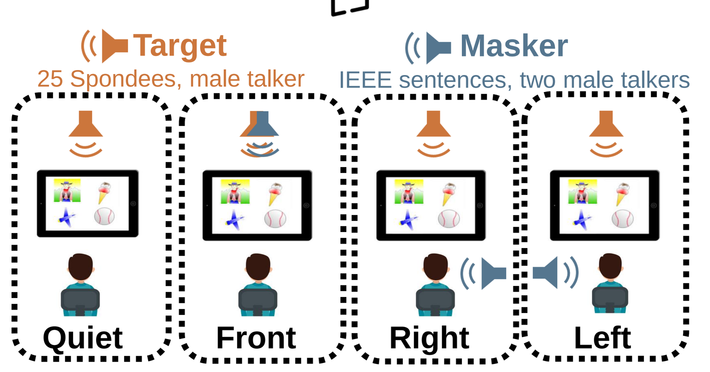

Figure 3: Children's Realistic Index for Speech Perception (CRISP)

EEG Testing

- CAEPs collected during passive listening
- Stimuli
  - naturally spoken /m/ & /s/ phonemes
  - Monaural, 65 dB SPL
  - 80ms duration
  - 150 trials each
  - ISI:1000-2000ms

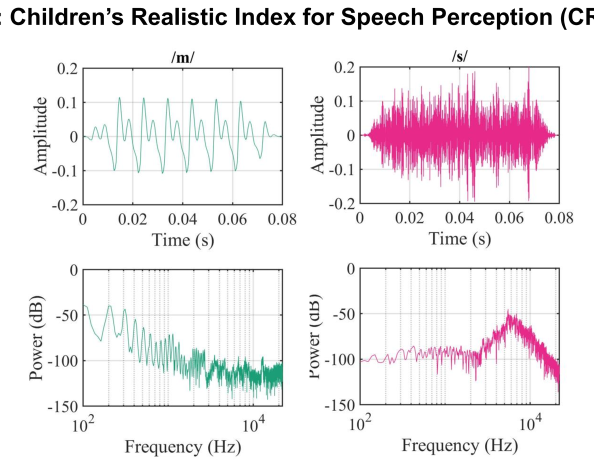

Figure 4: Waveforms and power spectra of /m/ and /s/ stimuli

Analysis approach

- N1 and P1 peak amplitudes and latencies and SRTs in quiet and noise were examined
- Analyses were done with age as a continuous variable
- Participants were also grouped in the following categories for comparison
  - Ages 5-8, N=5
  - Ages 9-12, N=13
  - Ages 13-17, N=11
  - Ages 18-24, N=8

RESULTS

Development in speech CAEPs

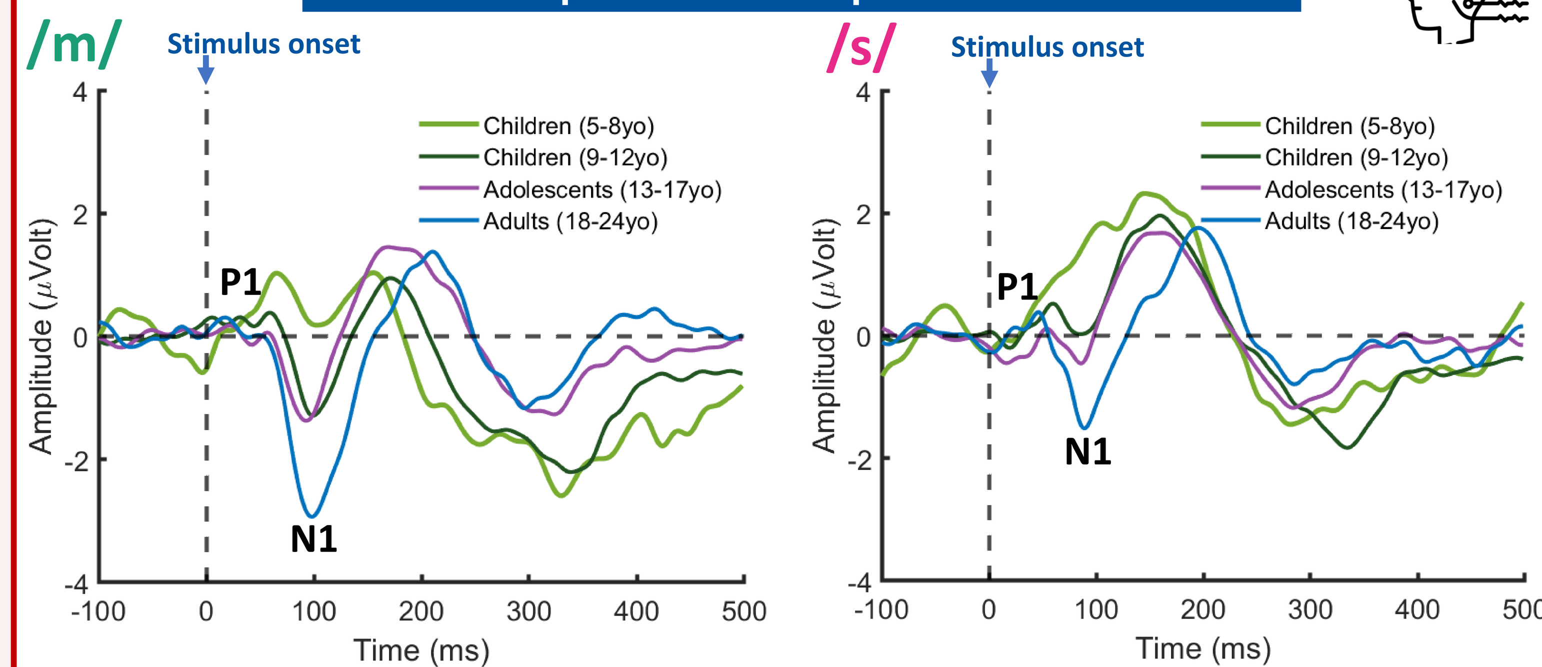

Figure 5 : Grand average CAEP waveforms at Cz for /m/ and /s/ stimuli (combined for both ears)

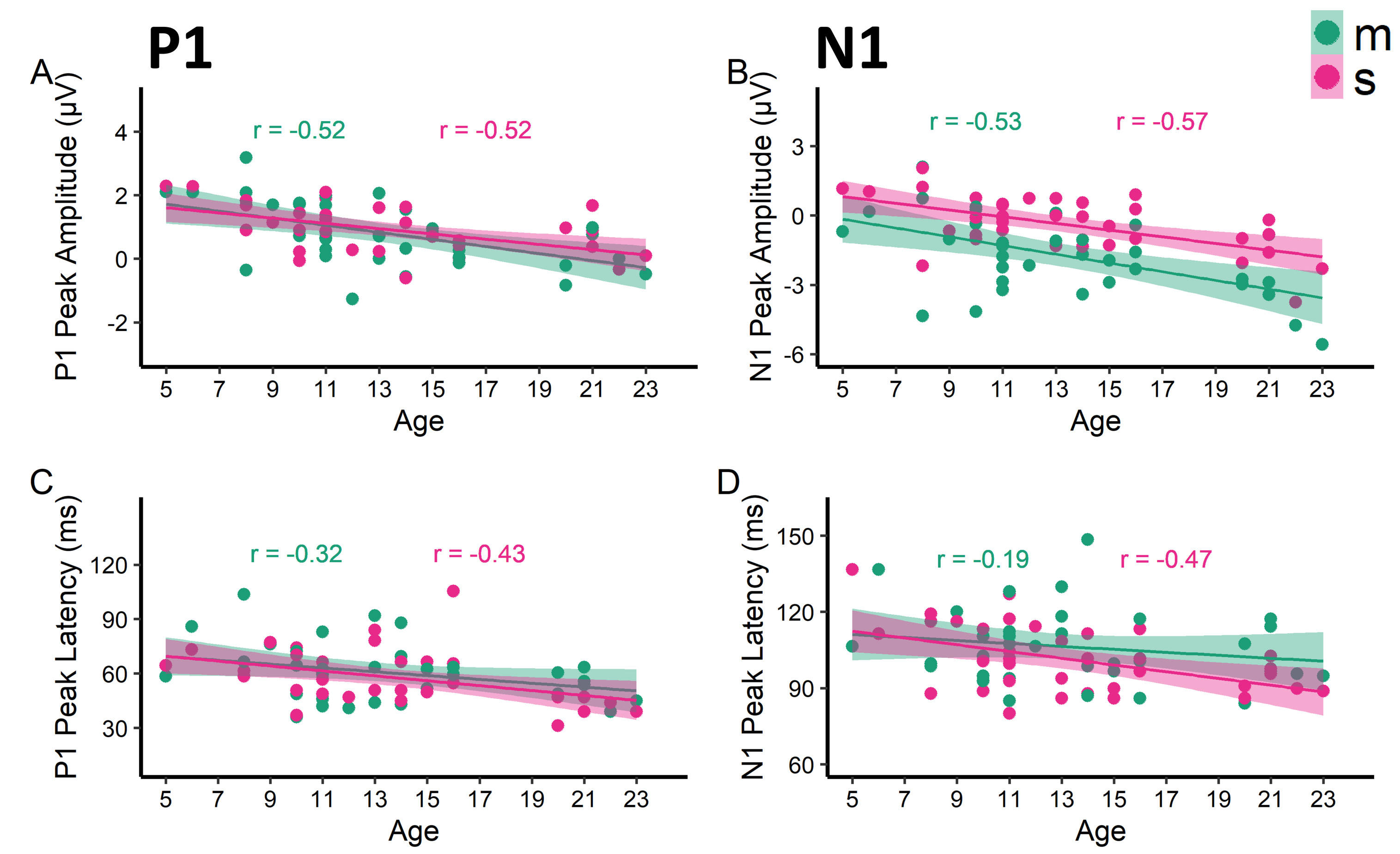

Figure 6: P1 and N1 peak amplitudes and latencies for /m/ and /s/ stimuli as a function of age

Development in Speech Reception Thresholds (SRTs)

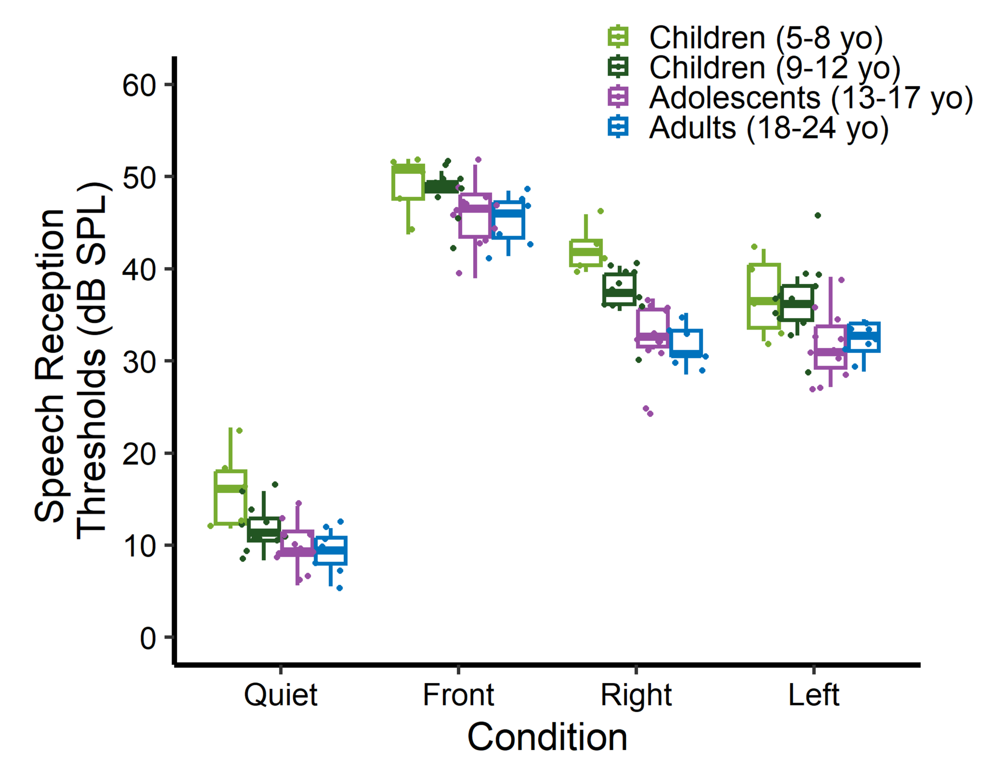

Figure 7: Speech reception thresholds in quiet and with maskers that are co-located (Front) or separated to either side.

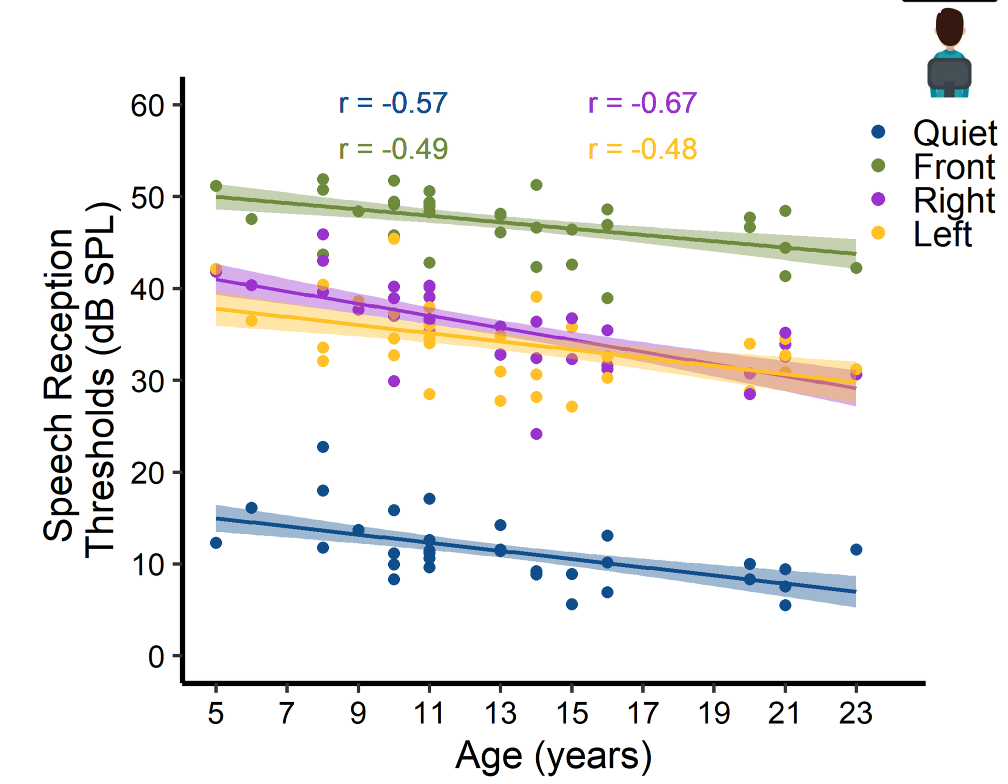

Figure 8: Speech reception thresholds as a function of age. 'r' values represent correlation coefficients.

Correlations between CAEPs and SRTs

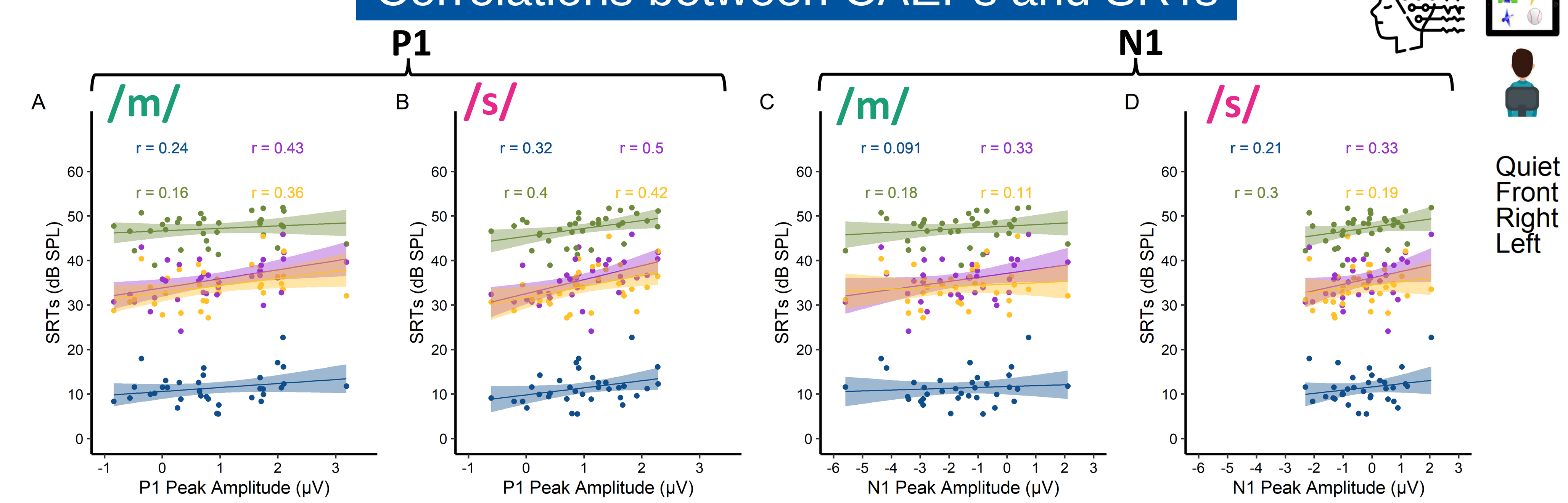

Figure 9: SRTs in CRISP task conditions as a function of P1 and N1 peak amplitudes for /m/ (Panels A & C) and /s/ (Panels B & D) stimuli. 'r' values represent correlation coefficients.

DISCUSSION

1. We replicate findings of improved speech understanding in both quiet and noisy conditions with age.[5,7]
2. Age-linked decrease in P1 amplitude, increase in N1 amplitude, and decreases in P1 and N1 latencies for /m/ and /s/ phonemes are in accordance with the literature using non-speech or other speech sounds.[8,9]
3. Weak to moderate correlations between behavioral measures (SRTs) and neural measures (CAEPs) provide evidence that basic speech processing might relate to speech understanding in both quiet and noisy conditions.
4. Correlations between CAEP measures and SRTs were stronger for /s/ as compared to /m/, possibly suggesting importance of higher frequencies in speech understanding.[10,11]
5. With ongoing data acquisition, we anticipate comprehensive understanding of the complex interplay between age, cortical auditory maturation, and speech understanding.

Maturational changes (reduced P1 and increased N1 amplitudes) were observed in cortical responses to both low- and high-frequency speech sounds

Speech cortical processing is moderately correlated with speech understanding in quiet and in noise

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