BACKGROUND & SIGNIFICANCE

- Even with the widespread adoption of newborn hearing screening and Early Hearing Detection and Intervention systems, infants who are hard-of-hearing (HH) remain at increased risk for poor or delayed development of auditory and speech perception skills.
- The development of speech perception, including speech discrimination, depends partially or entirely on experience with highly salient and behaviorally relevant acoustic inputs.
- We have demonstrated that the speech-evoked mismatch response (MMR) is modulated by the neural encoding of speech and may be useful in predicting later behavioral outcomes in infants.
- Speech perception is positively correlated with better auditory development on functional auditory skills and a variety of language outcomes.
- There is wide variability in discrimination outcomes that may affect the utility of MMR as a biomarker, for example, the absence of a response may not be an accurate indicator of discrimination but may reflect the still developing neural generators for engaging in and completing the task.
- Perceptual attenuation—or “narrowing”—is a model of perceptual learning positing that perceptual abilities are shaped by environmental experiences over the first year of life.
- Here we describe our adapted EEG methods to examine the development of infant speech perception to study periods of perceptual attunement between HH and infants with normal hearing (NH).

OBJECTIVE

The objective of this study was to examine developmental changes in spectral-temporal features of the MMR, which may provide insight into neurophysiological processes underlying perceptual attunement in both HH and NH populations. The data presented here represent preliminary results (N = 57) of an ongoing, longitudinal study of ~240 infants to be completed in 2023.

METHODS

Participants

- Time 1: Age = 3 Months
  - N = 35 (17 female, 3 HH)
  - Mean age = 3.26 months
  - SD age = 0.37 months

- Time 2: Age = 6 Months
  - N = 22 (14 female, 4 HH)
  - Mean age = 6.36 months
  - SD age = 0.54 months

Time 3: Age = 12 Months

  *Data collection for Time 3 (6 mo) is now in progress.

Electroencephalography

- Continuous EEG was recorded during sleep throughout the session.
- 11 electrode montage
- Nasal (N) reference during acquisition
- Average reference for analysis
- Ocular activity (EOG) was monitored for wakefulness & eye movement

EEG Analysis

- EEG Data were epoched around the onset of each target stimulus (see Figure 2); the number of Standard trials (N) were randomly selected to match the number of Deviant trials.
- The continuous waveform transform (CWT) was used to compute inter-trial spectral-temporal coherence estimates for each condition (S12 at spaced Morlet wavelet scales).
- References contain links to detailed CWT methods.

SPECTRAL-TEMPORAL FEATURE IDENTIFICATION

To determine the spectral-temporal features for classifying discrimination responses, we first analyzed the grand averaged responses of all contrasts for both Standard and Deviant sequences separately for Time 1 and Time 2 (Figure 1). For those analyses, we included a wide range of masking from -2.25 to 2.10 seconds around the onset of the target window. This large analysis window allowed us to verify response repetition and verify that changes in the response to a Deviant stimulus were not attributed artifact or other sources of variance.

In order to narrow the spectral and temporal regions of interest, we computed the temporal envelopes of the grand mean responses. We sought to determine the time range of increased magnitudes when a Deviant response was present; that range was determined to be approximately 0 to 0.7 seconds from stimulus onset. Next, using only the time window in the target range, we computed the spectral envelopes for both Standard and Deviant responses in order to determine the spectral bands that contributed to a change detection (i.e., a discrimination response). We identified two different spectral bands with consistently larger magnitudes in the Deviant than in the Standard conditions: Theta-1 (~2.2 - 4.4 Hz) and Theta-2 (~4.8 - 9.8 Hz). While other activity at higher frequency bands (e.g., Beta and Gamma) was detected, we limited the remaining analyses to the two Theta bands with observable magnitude differences for a stimulus change.

To test whether magnitude differences were present for each of the four contrasts, we computed the mean spectral activations separately for the Theta-1 and Theta-2 bands at each of the two time points.

The grand average of the spectral activation (as measured in dB) was computed for each participant across the two time points. For the HH groups, we tested the hypothesis that band activations in the Deviant stimulus were greater than activations to a Standard stimulus by performing a series of one-sided, paired t-tests. Activations with significant effects are noted in Figure 3a and 3b (left). We did not perform hypothesis testing in the HH groups due to the small sample size.

ACKNOWLEDGMENTS & REFERENCES


DISCUSSION

- Neural encoding represented in the low-frequency Theta band corresponds with detection of a change in stimulus features; that is, responses reflect the discrimination of two speech sounds.
- We observed discrimination responses in two separate Theta ranges, Theta-1 (~2.2 - 4.4 Hz) and Theta-2 (~4.8 - 9.8 Hz), that differ with age.
- The lower frequency Theta-1 response was dominant in the younger age group (3 mo), while the older age group (6 mo) showed both Theta-1 and Theta-2 discrimination responses.
- Oscillatory EEG of infants while listening to speech sounds can provide valuable information about the neural encoding of speech features important for language development.