Electrophysiological responses to change in spectral ripple envelope phase in normal-hearing infants

David Horn, Max Walter, Jay Rubinstein, Bonnie K. Lau

University of Washington, Department of Otolaryngology-Head & Neck Surgery

Laboratory for Auditory Neuroscience and Development

Virginia Merrill Bloedel Hearing Research Center

UW LAND Lab

Spectral resolution is important for speech understanding in noisy real-world environments.

Spectral ripple discrimination is one method used to measure spectral resolution.

Spectral ripple discrimination has been shown to correlate with open-set speech understanding in adults and children who use cochlear implants[1].

Behavioral measures of spectral ripple discrimination in infants is time consuming.

This is a preliminary feasibility study asking: Can we obtain an electrophysiological measure of spectral ripple discrimination in very young infants?

We measured an EEG acoustic change response (ACR) to a suprathreshold[2] spectral ripple envelope inversion.

METHODS

Participants were six 2- to 4-month-old infants

- Infants were healthy, born full term, passed newborn hearing screening, showed no risk factors for hearing loss, passed otoacoustic screen on all test dates
- Data from 15 additional infants were excluded from this analysis due to not enough trials, noisy data, infant fell asleep, or equipment error

EEG Pre-Processing (using MNE-Python software)

- 32-channel recording at 1 kHz sampling rate from Brainvision ActiCAP slim EEG system
- Down sampled at 128 Hz, bandpass filtered [1,40] Hz, then set to average reference
- Standard ICA applied for artifact removal - MNE-python parameters (fastica, n_comp = 3, random_state = 95, max_iter = 1000)
- Data epoched to stimulus onset. If any channel was dropped >20% of epochs, it was removed
- ACR was identified automatically with MNE-python algorithm that checked for local maxima in global field power. Fitted peaks within the expected time window for infants of this age (1.18 – 2.28 s) were then visually confirmed.

GRAND MEAN AVERAGE

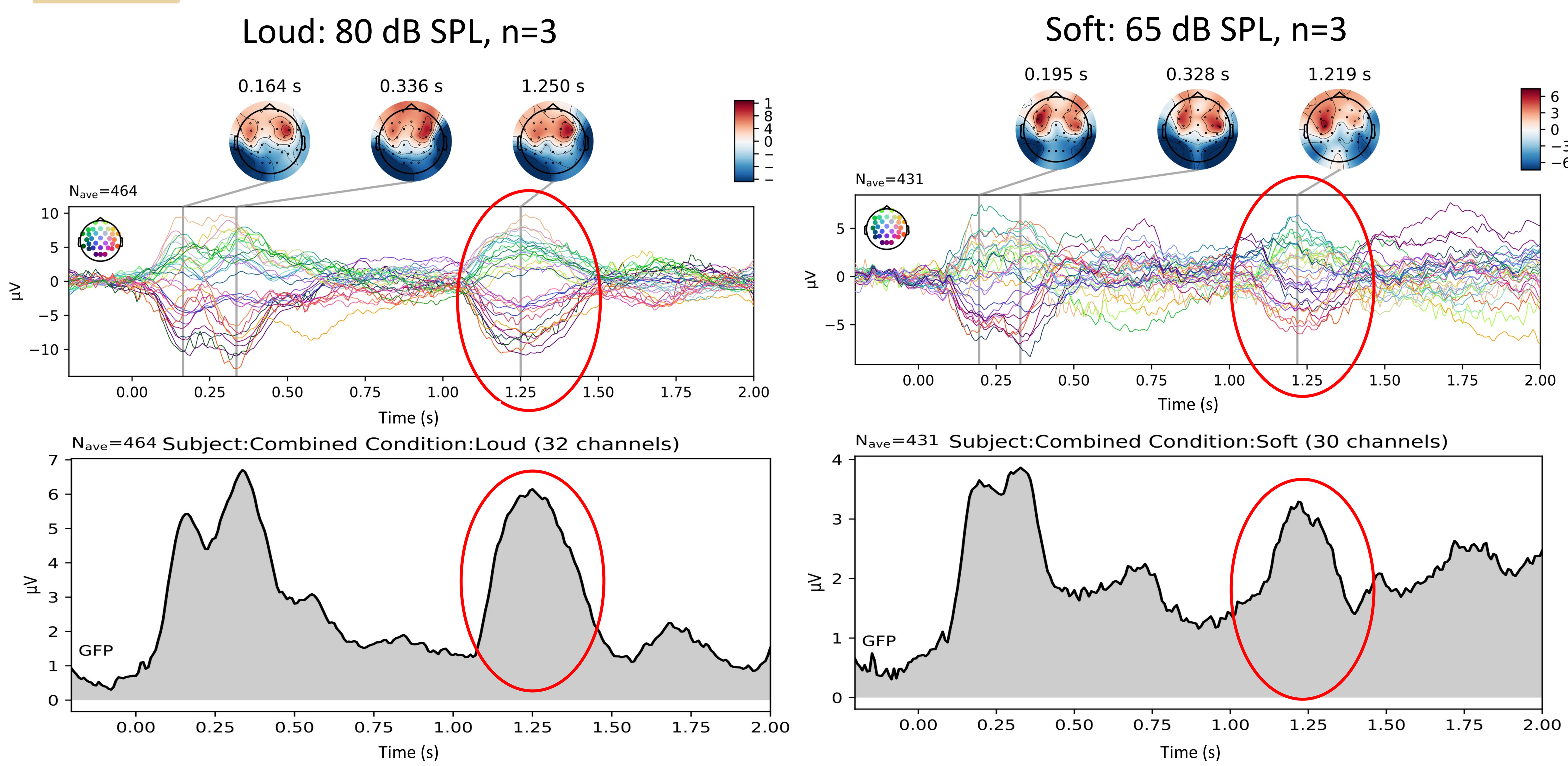


Fig 1. Grand averaged event-related potentials with topographic maps shown at the peak of the onset and the acoustic change response in the Loud (*left*) and Soft (*right*) conditions. Global field power, the standard deviation of the electrode values at each time point, is shown below in gray. Acoustic change responses to spectral ripple envelope inversion are circled in red.

INDIVIDUAL GLOBAL FIELD POWER

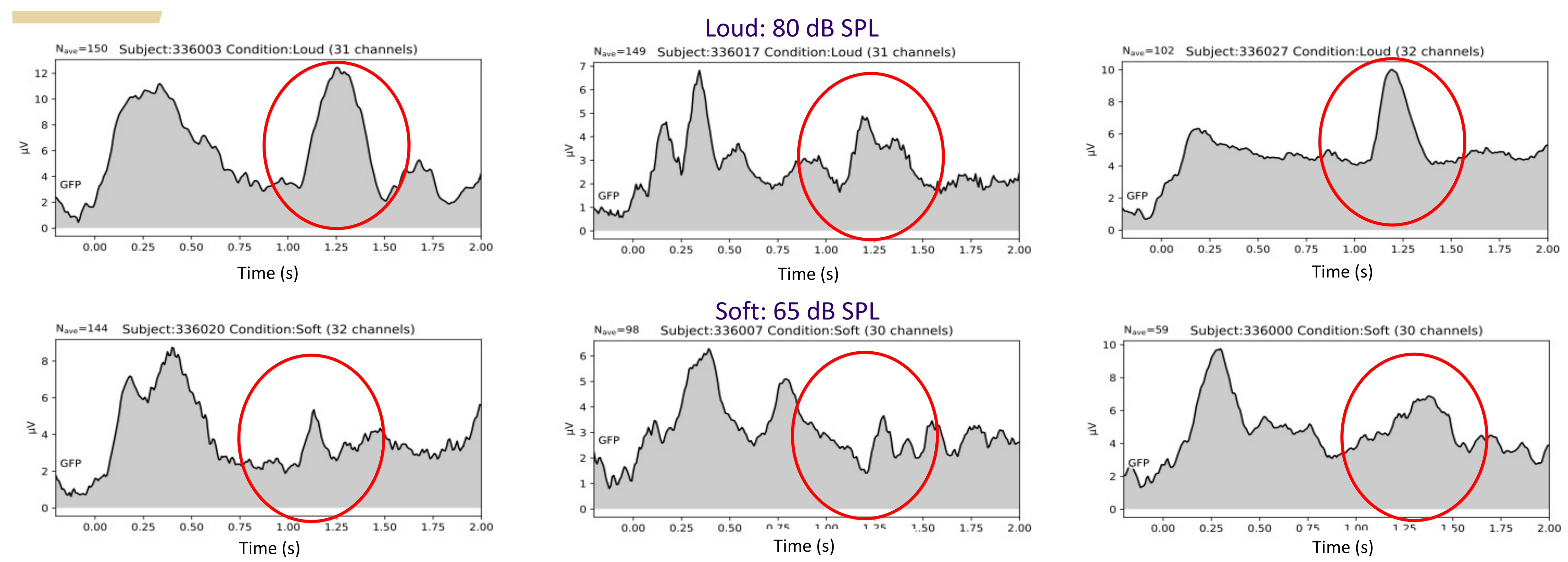
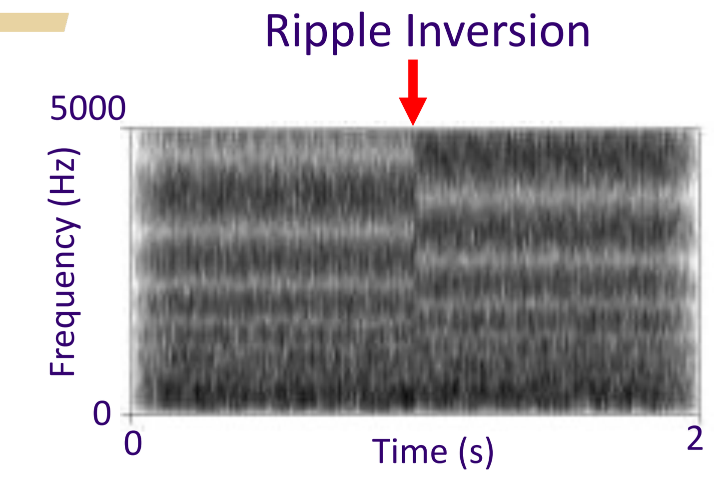


Fig 2. Global field power for individual participants in the Loud (*top*) and Soft (*bottom*) conditions. Acoustic change responses to spectral ripple envelope inversion are circled in red.

ACOUSTIC CHANGE RESPONSE



Stimuli were constructed from two concatenated 1-s noise carriers consisting of 2555 random phase pure tones between 100-5000 Hz, with a spectral envelope sinusoidally-modulated at 1-ripple-per-ocatave with peak-to-trough depth of 20 dB. The starting phase of the first half of the stimulus varied randomly while the starting phase of the second half was "inverted", shifted by 90-degrees, relative to the first.

INTERIM OBSERVATIONS

- Our preliminary analyses show that an acoustic change response (ACR) can be recorded in awake infants between 2 to 4 months of age in response to an inversion in the spectral ripple envelope (1-ripple-per-octave, 20 dB depth). This is consistent with EEG studies in adults[3] and behavioral data showing that infants discriminate this inversion[2].
- Prior research suggests that the ACR cannot be recorded while infants are asleep[4]. All infants in this preliminary study were awake throughout recording. However, many additional infants fell asleep during EEG sessions. Obtaining data from multiple ripple densities may be challenging, especially in younger infants who are more likely to fall asleep.
- ACR was obtained at both 65 and 80 dB. However, due to limited sample size, relationship between stimulus level and magnitude of ACR is unclear.
- 150 stimulus repetitions were presented to each infant although a different number of epochs were dropped during the pre-processing stage for each child. Further investigation required to determine the appropriate number of epochs for optimal signal-to-noise ratio.

References

1 Won, J. H., Drennan, W. R., & Rubinstein, J. T. (2007). Spectral-ripple resolution correlates with speech reception in noise in cochlear implant users. *JARO*, *8*(3), 384-392.

2 Horn, D. L., Won, J. H., Rubinstein, J. T., & Werner, L. A. (2017). Spectral ripple discrimination in normal hearing infants. *Ear and hearing*, *38*(2), 212.

3 Won, J. H., Clinard, C. G., Kwon, S., Dasika, V. K., Nie, K., Drennan, W. R., ... & Rubinstein, J. T. (2011). Relationship between behavioral and physiological spectral-ripple discrimination. *JARO*, *12*(3), 375-393.

4 Uhler, K. M., Hunter, S. K., Tierney, E., & Gilley, P. M. (2018). The relationship between mismatch response and the acoustic change complex in normal hearing infants. *Clinical Neurophysiology*, *129*(6), 1148-1160.

Please contact Bonnie Lau at blau@uw.edu or https://sites.uw.edu/landlab/ for further information.