Neural Tracking of Rhythmically Presented Morpheme Structure

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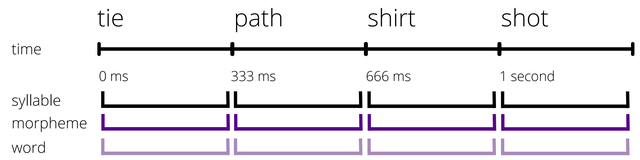
INTRODUCTION

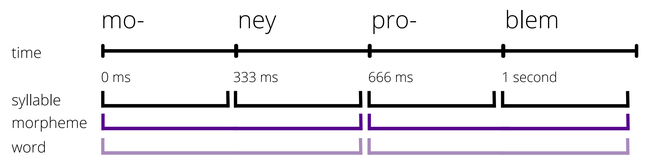
Understanding speech requires the brain to parse a continuous signal into a hierarchical structure of discrete units of meetings. Previous work [1, 2] has shown neural tracking of linguistic structure in low frequency bands (delta). **This study aims to assess the tracking of morphemes** (the smallest meaningful parts of language) **when disassociated from word and syllable boundaries in rhythmic auditory presentation**.

METHOD

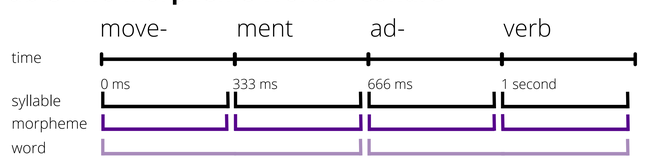
One Syllable Words - Cond. 1



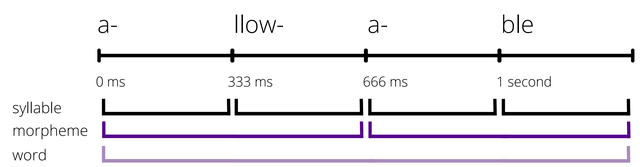
Two Syllable One Morpheme Words - Cond. 2



Two Syllable Two Morpheme Words - Cond. 3



Four Syllable Two Morpheme Words - Cond. 4



Stimuli → Each syllable was generated separately using IBM Watson's Text to Speech. Each syllable was shortened to fit into the 333 ms window. Each block consisted of 200 syllables (66 seconds), to which participants were instructed to listen to without a task.
Participants → 13 Native English Speakers
Acquisition → Brain data were recorded on a 208 Channel MEG system.

ANALYSIS

Preprocessing
Environmental Filtering

Sensor-Space Analysis
Filtering & ICA → Epoching → Denoising Source Separation (keep top 6 components) [3] → Fourier Transform

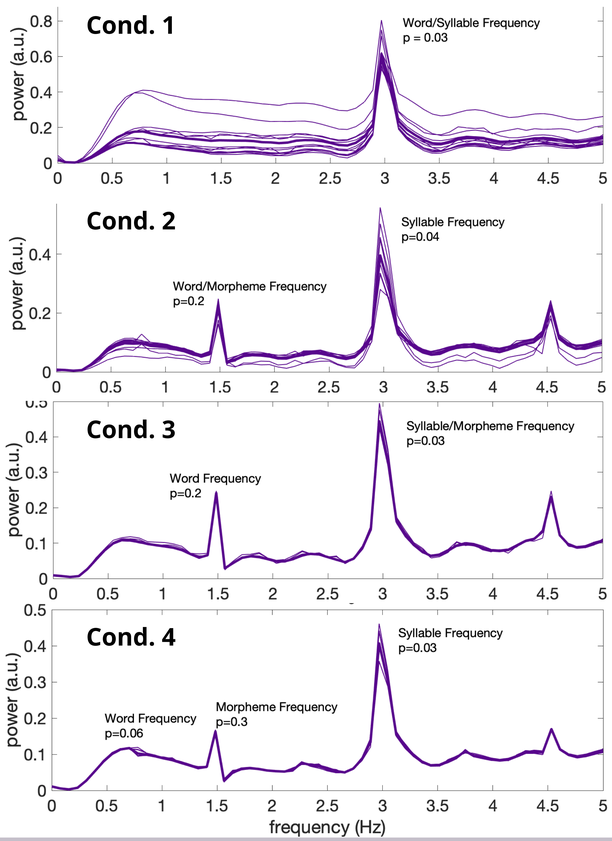
Source-Space Analysis
Power Spectral Density of inverse solution (dSPM)

Analysis Notes

- Sensor-Space significance for peaks is one-sided t-test based on the average of the two adjoining bins following [1]. However, this method is influenced by the location of contours and cutoffs from the FIR filter (band pass between 0.5 and 5 hz)

RESULTS

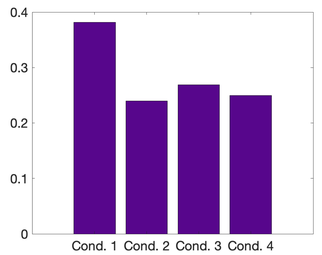
SENSOR-SPACE ANALYSIS



- Strong Syllable-rate 3-hz peak is present across frequencies
- FIR filtering at 0.5 Hz induces visible variation in a.u.
- Peaks at 1.5 Hz fail to reach significance, 0.75 Hz in Cond. 4 significant possibly due to filter cutoff slope

Analysis of 3 Hz Power

- Strong correlation was found between number of oscillators at a frequency and the power in a.u. (r=0.9414, p=0.058)
- Possible confound between syllable transition surprisal (single syllable words vs 2 syllable words) and number of oscillators. When excluding Cond. 1 (highest surprisal), r=0.94 and p=0.2

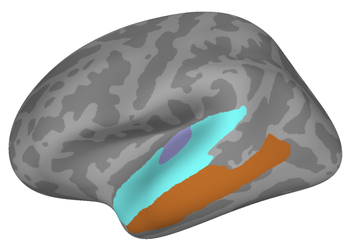


Power at 3 Hz by Condition

PLANNED SOURCE ANALYSIS

- ROIs include Heschl's Gyrus, Superior Temporal Gyrus (STG), and Middle Temporal Gyrus (MTG).

Prediction → Significant differences in power at MTG at 3 Hz between Conditions 2 and 3 due to morphemic processing



DISCUSSION & NEXT STEPS

- Results show tentative evidence for moprpheme-level tracking in speech.
- Further work is needed to fully decorrelate word/morpheme/syllable boundaries and surprisal values in stimuli.
- Different significance testing strategy is needed, to remove effects from filtering

CITATIONS

[1] - Ding, N., Melloni, L., Zhang, H., Tian, X., & Poeppel, D. (2016). Cortical tracking of hierarchical linguistic structures in connected speech. Nat Neurosci, 19(1), 158–164. https://doi.org/10.1038/nn.4186
[2] - Lu, Y., Jin, P., Pan, X., & Ding, N. (2022). Delta-band neural activity primarily tracks sentences instead of semantic properties of words. NeuroImage, 251, 118979. https://doi.org/10.1016/j.neuroimage.2022.118979
[3] - de Cheveigné, A., & Simon, J. Z. (2008). Denoising based on spatial filtering. Journal of Neuroscience Methods, 171(2), 331–339. https://doi.org/10.1016/j.jneumeth.2008.03.015