Testing temporal boundaries of composition in low-frequency neural oscillations

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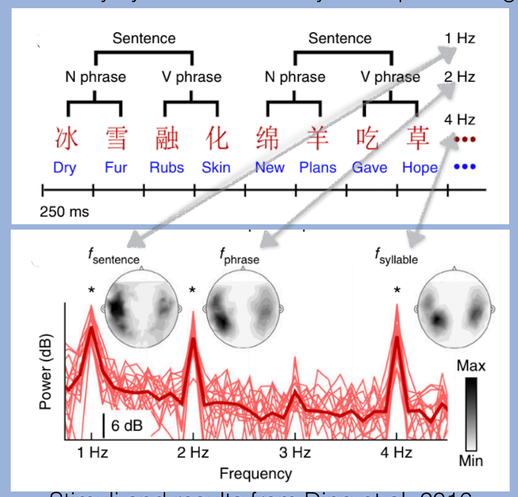
Introduction

- Neural responses can be entrained to linguistic structures (Ding et al., 2016, 2017). Ding and colleagues (2016) observed cortical tracking of linguistic structures at evoked frequencies corresponding to phrasal (2 Hz) and sentence structure (1 Hz) levels of Mandarin structures in continuous isochronic speech. Non-Mandarin speakers show only syllable effects only when processing the same stimuli.



Stimuli and results from Ding et al. 2016

- Question 1: Are low-frequency oscillations driven by the integration of information (i.e. oscillation-based model, Greenberg and Ghitza 2009) or the evoked response for each event (i.e. evoked-response model, Nourski et al., 2009)?
- Question 2: What is the relationship between language comprehension and delta brainwaves?
- Question 3: Does rhythmicity at the phrasal level affect the processing of composition (Ghitza, 2017)?

We aim to investigate the temporal dynamics of information integration reflected in low-frequency delta oscillations (0.5-3 Hz) by manipulating temporal properties of stimuli.

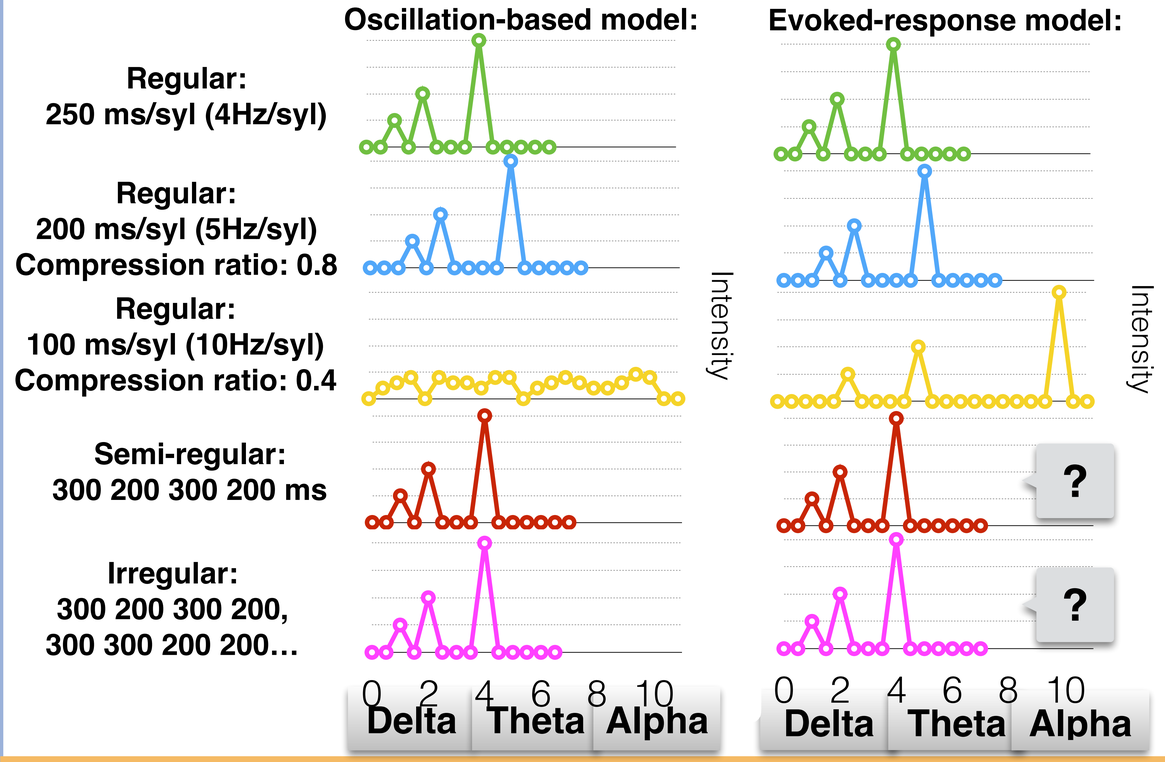
EEG Methods

Participant: N=27 native speakers of Mandarin Chinese listened to 300 trials consisting of ten 4-syllable sentences.

Procedure: Participants were instructed to listen carefully to each trial and judge whether the trial they just heard includes plausible sentence/ phrase or not, following the paradigm in Ding et al. (2016).

Recording and statistics: EEG data were recorded at 500 Hz from 61 active electrodes (band-pass filtered at acquisition: 0.01-200 Hz). The first sentence from each trial was excluded to avoid potential EEG responses to sound onset (Ding et al. 2017). Data were manually cleaned of artifacts, filtered from 0.1-25 Hz, and re-referenced offline to common average. For each condition, we compute **Evoked Power** and **Inter-trial phase coherence** from 0.1 to 20 Hz in increments of 0.1 Hz and a Hanning taper was applied after adding 10 seconds of zero-padding to each condition. Conditions were compared via one-way ANOVA for each measure in each frequency of interest.

Experimental conditions and predictions



Conclusions

- As a baseline, we replicated the findings in Ding et al. (2016, 2017): peaks at the sentence, phrase, and syllable rate were observed in the regular 250ms/syl.
- Peaks were shown in the 200 ms/syl but not in the 100 ms/syl. The results support the oscillation-based model, suggesting that delta entrainments represent the integration of information and the sufficient decoding time is necessary for the synchronization with information.
- The high accuracy of comprehension with the absence of cortical tracking in the 100 ms/syl might raise the possibility of late comprehension.
- Peaks were also observed in the semi-regular and the irregular conditions, suggesting that delta oscillators are flexible to accommodate rhythmicity in speech.

References

Ding, N., Melloni, L., Zhang, H., Tian, X., and Poeppel, D. (2016). *Nat. Neurosci.* 19, 158–164.; Ding, N., Melloni L., Yang A., Wang Y., Zhang W., and Poeppel D. (2017). *Front. Hum. Sci.* 11, 481.; Ghitza, O. (2017). *Lang, Cogn Neurosci*, 32(5):545–561.; Ghitza, O. and Greenberg, S. (2009). *Phonetica*, 66(1-2):113–126.; Nourski, K. V., Reale, R. A., Oya, H., Kawasaki, H., Kovach, C. K., Chen, H., Matthew A. Howard, I., and Brugge, J. F. (2009). *J. Neurosci. Res.*, 29(49):15564–15574.

Results

Inter-trial phase coherence