



# Cortical tracking of Mandarin structures

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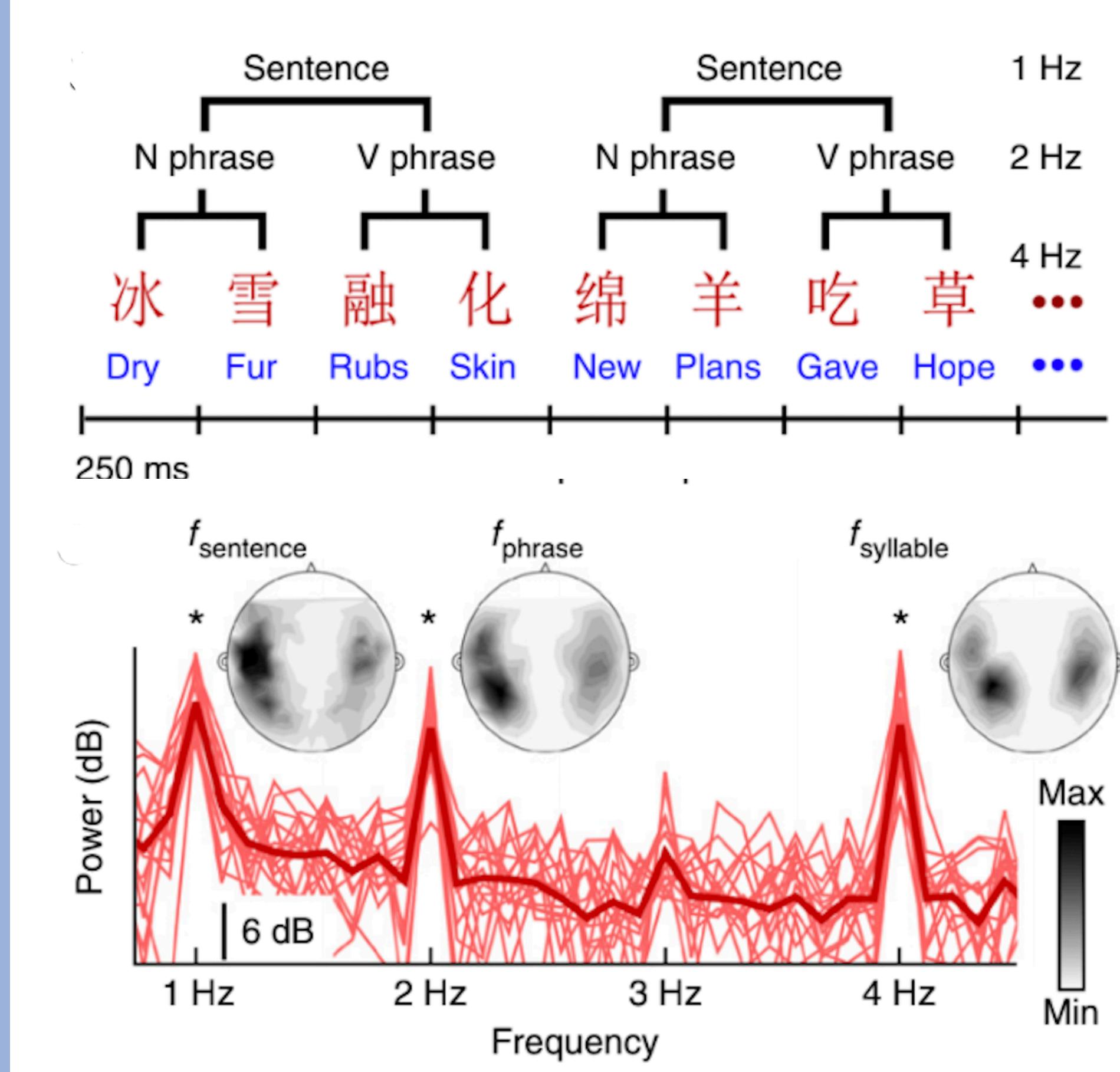
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## Introduction

- 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

- However, Frank & Yang (2018) suggest that these results may follow from the tracking of lexical and/or part-of-speech sequence information, not phrasal structure. For example, verbs occur at a frequency of 1 Hz while nouns occur at a 2 Hz rate.

We aim to replicate Ding et al's results using Mandarin stimuli with EEG and also test whether the results reflect lexical sequence or hierarchical information.

## EEG Methods

**Participants:** N=31 native speakers of Mandarin Chinese listened to 320 trials consisting of ten 4-syllable sentences.

**Procedure:** Participants were instructed to listen carefully to each trial and judge whether it included a plausible sentence or phrase.

**Recording and statistics:** EEG data were recorded at 500 Hz from 61 active electrodes (band-pass filter 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 a common average. For each condition, we compute **Evoked Power**, **Induced Power** and **Inter-trial Phase Coherence** from 0.5 to 10 Hz in increments of 0.111 Hz. Conditions were compared via one-way ANOVA for each measure at each frequency of interest.

## Stimuli

### Condition 1: Four-syllable sentence (ABCD)

綿 羊 吃 草  
mian2 yan2 chi1 cau3  
Cotton sheep eat grass  
'Sheep eat grass.'

### Condition 3: Two-syllable phrase (ABAB)

老 牛 青 草  
lau3 niu2 qing1 cau3  
Old cattle green grass

### Condition 2: Semantically-mismatched sentence

軍 孩 奔 草  
jun1 hai2 ben1 cau3  
Soldier child run grass

### Condition 4: Reversed phrase (BADC)

羊 棉 草 吃  
yan2 mian2 cau3  
Sheep cotton grass

8 blocks, 40 trials per block (20 **normal**, 20 **outlier**), 10 items in a trial

## Conclusions

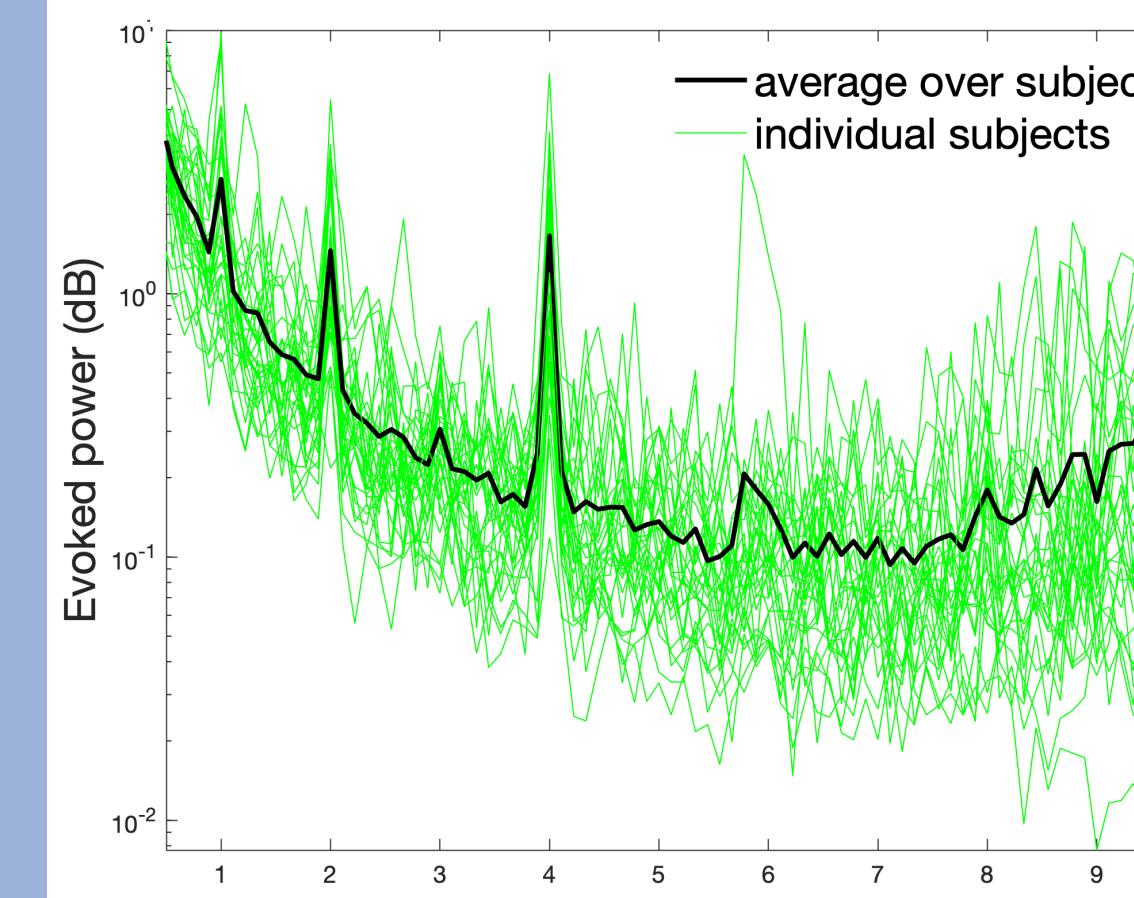
- 4 Hz Syllable-level peaks were shown in all conditions.
- 2 Hz "Phrases" peak found only for well-formed sentences (Condition 1) and phrases (Condition 3).
- 1 Hz "Sentences" peak found only for well-formed sentences (Condition 1).
- No evidence of a 2 Hz or 1 Hz peak when words occur in a regular, but not grammatical, lexical sequence, controlling for semantic relatedness (Condition 4).
- Results confirm that oscillatory synchronization can be modulated by linguistic hierarchical structures, not just word-sequences.

**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.; Frank, S. L., and Yang, J. (2018). *PLoS ONE* 13(5): e0197304.

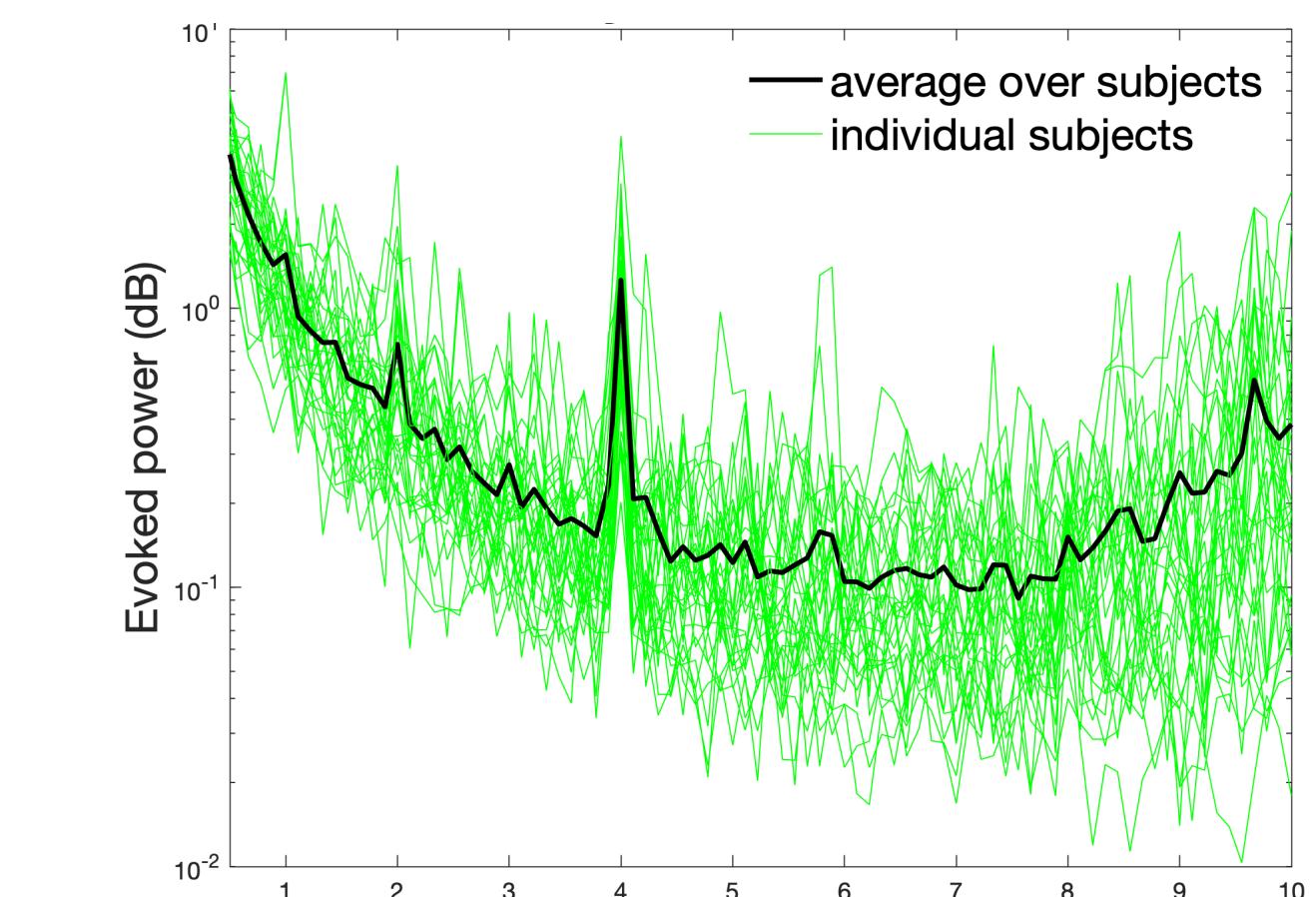
## Results

### Evoked Power

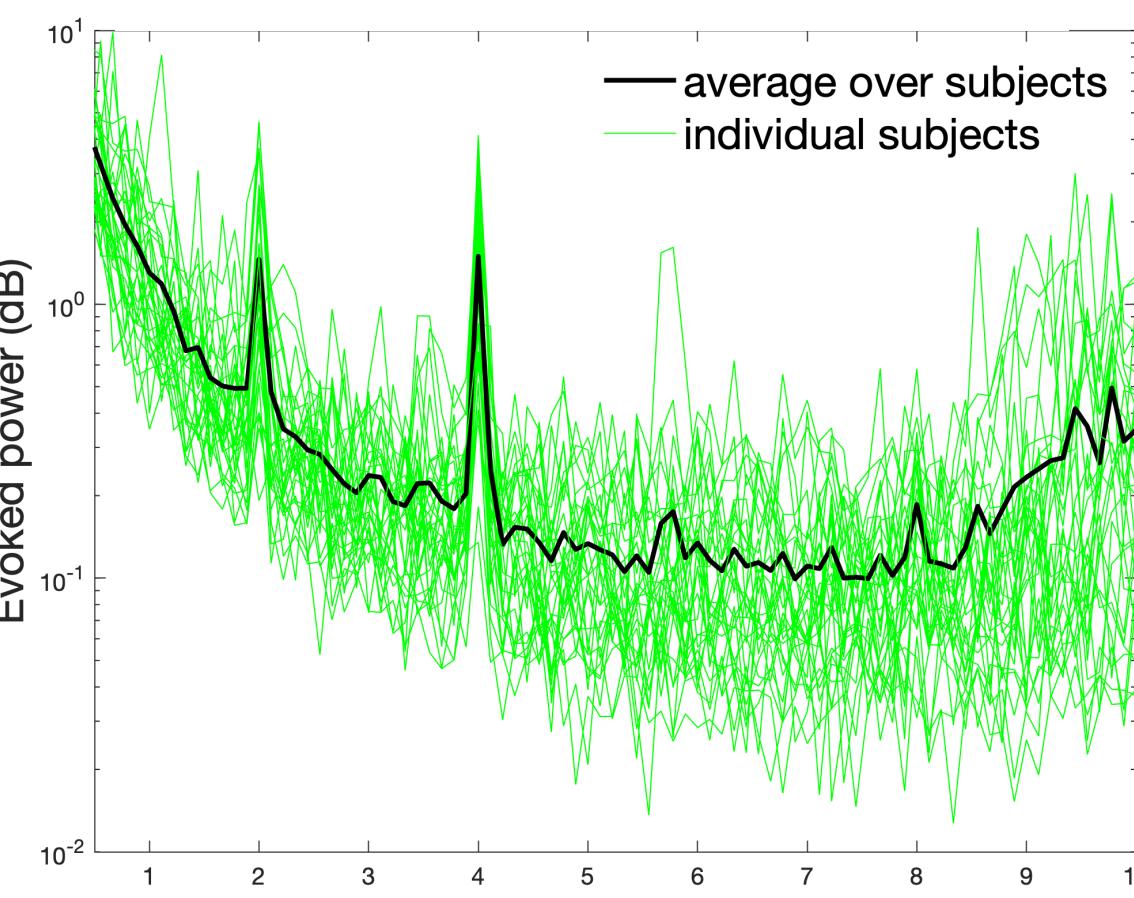
#### (1) Four-syllable sentence



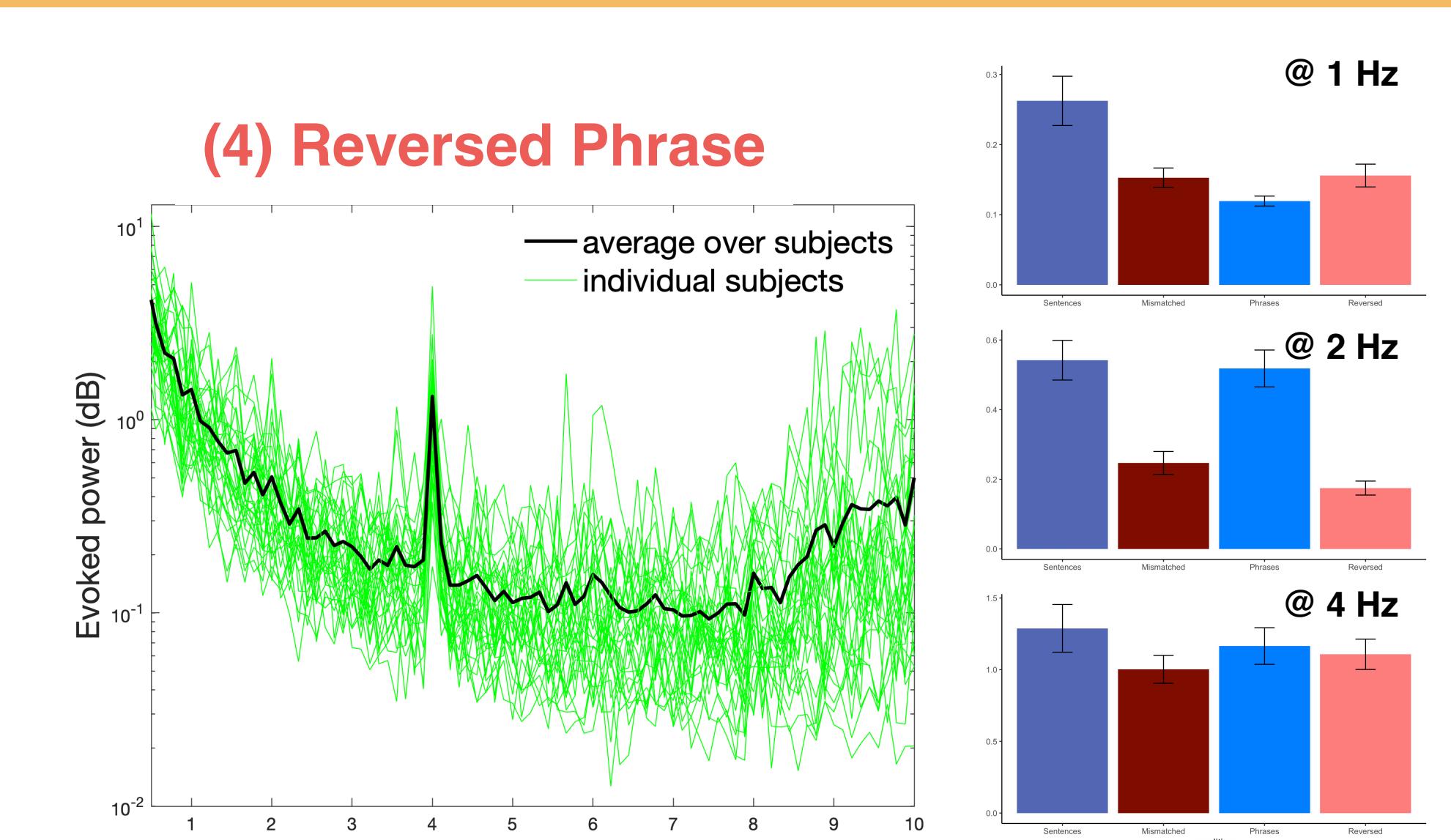
#### (2) Semantic-mismatch sentence



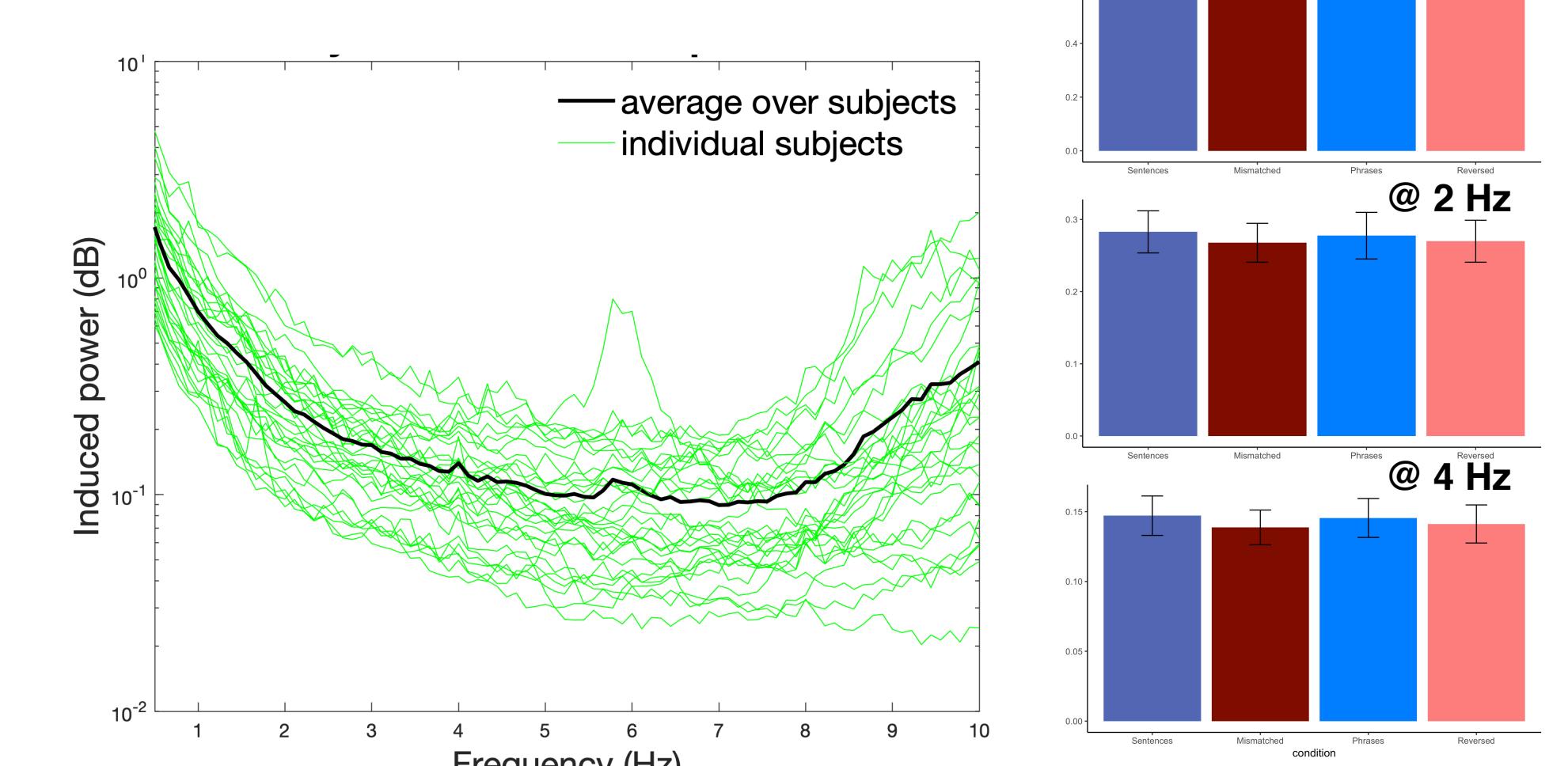
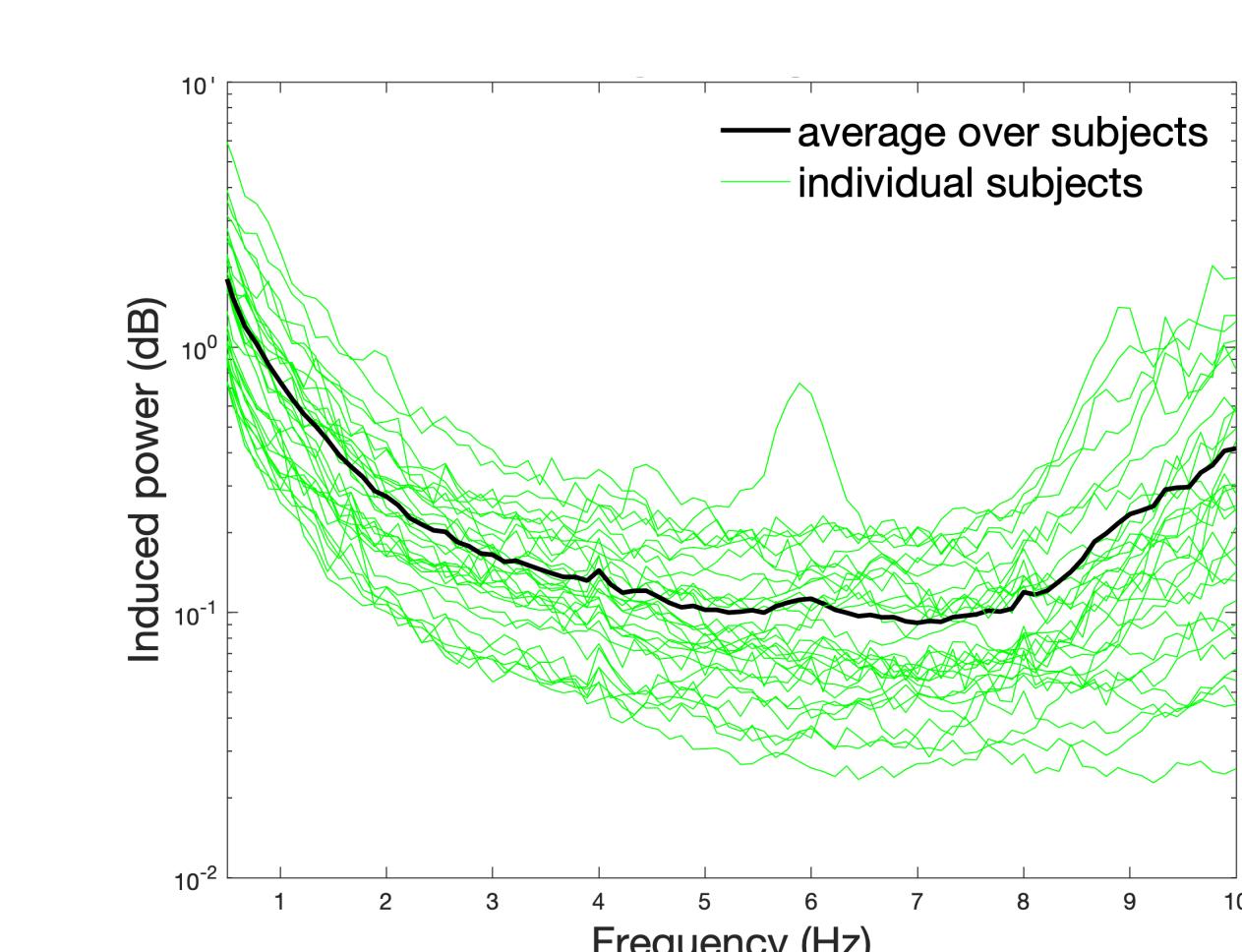
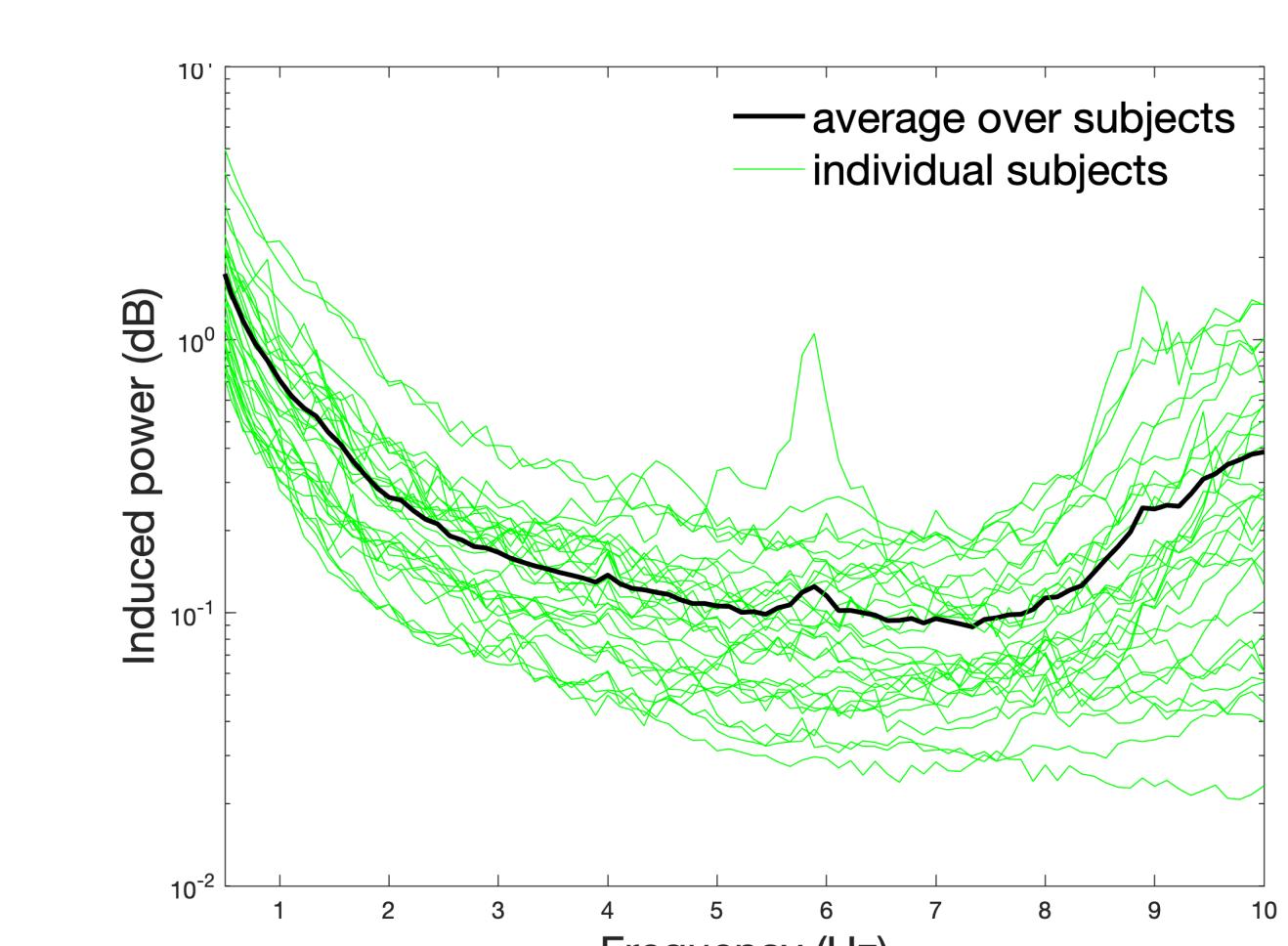
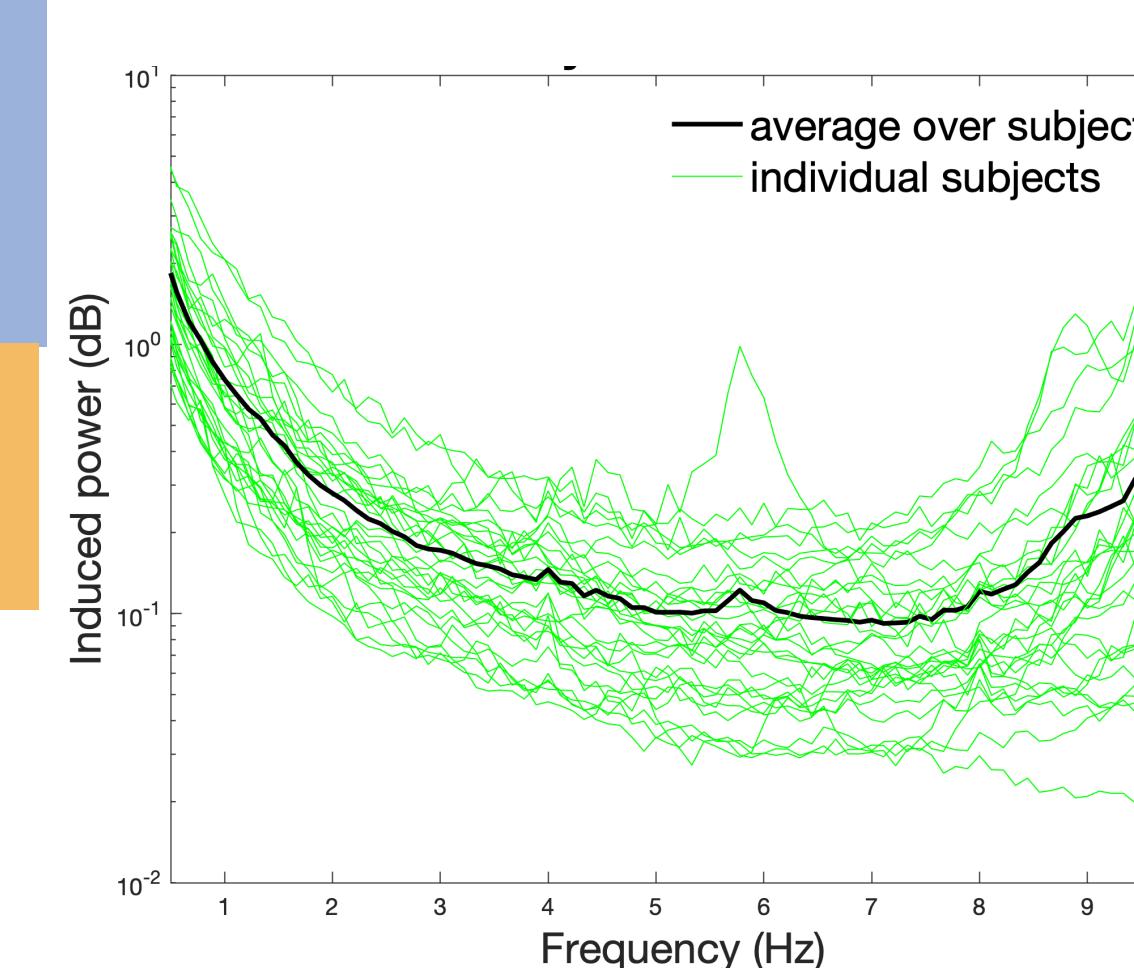
#### (3) Two-syllable phrase



#### (4) Reversed Phrase



### Induced Power



### Inter-trial Phase Coherence

