Neural Oscillations in Language Processing: Tracking and Predicting

Lorenzo Titone[1] , Sanne ten Oever[2,3,4], Andrea E. Martin[2,3], Vadim V. Nikulin[1], & Lars Meyer[1,5]

[1]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, DE · [2]Max Planck Institute for Psycholinguistics, Nijmegen, NL · [3]Donders Centre for Cognitive Neiroimaging, Nijmegen, NL · [4]Maastricht University, NL · [5]Clinic for Phoniatrics and Pedaudiology, University Hospital Münster, DE

titone@cbs.mpg.de

Introduction

Oscillations in Language

- *Neural oscillations* = rhythmic cycles of neural activity
- Neural oscillations support language processing by:
  1. Tracking exogenous acoustic units (e.g. syllables) and suprasegmental acoustic cues (e.g. prosody)
  2. Predicting the *when and* what of forthcoming events

Neural Tracking and Chunking

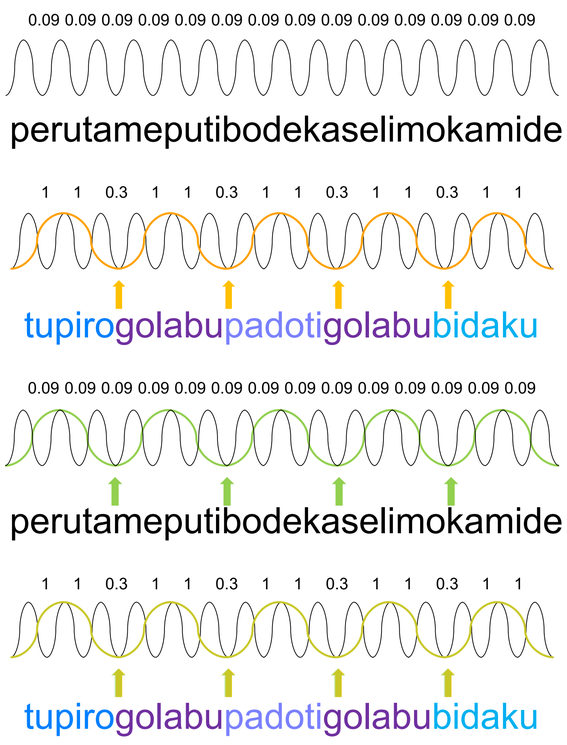
- Word learning relies on statistical regularities in speech
- Neural tacking of prosody and of transitional probabilities (TPs) between syllables enables chunking and learning
- **Experiment 1: Which neural circuits are involved in the tracking of prosodic and statistical cues?**

Neural Entrainment and Predictions

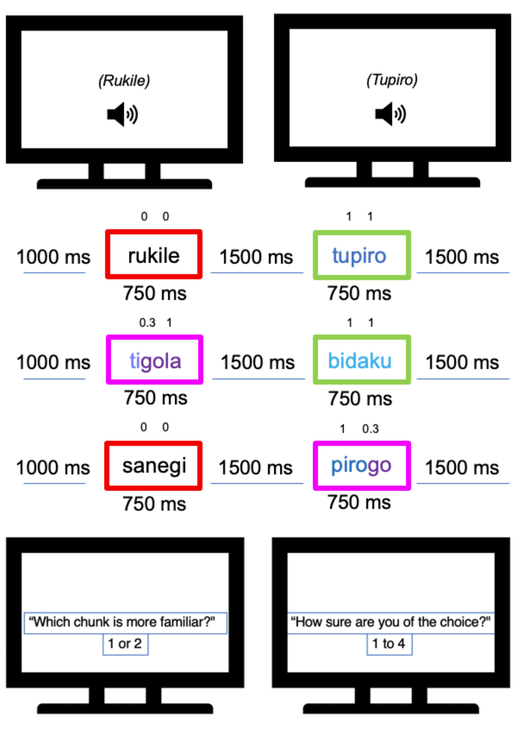
- *Entrainment* = neural inheritance of contextual rhythms that drives temporal—*when*—predictions
- *Internal language models* = set of linguistic knowledge that drives content—*what*—predictions
- **Experiment 2: How do oscillations help predictions?**

MEG Experiment 1: Paradigm

Exposure Phase

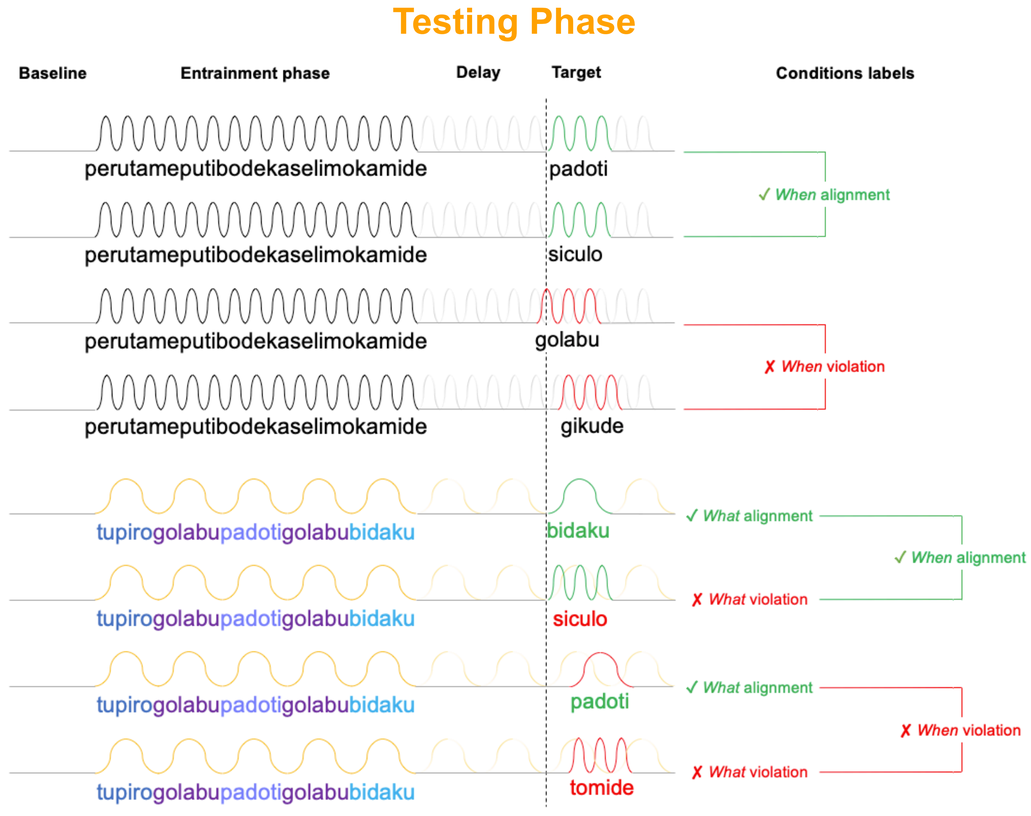


Testing Phase



MEG Experiment 2: Paradigm

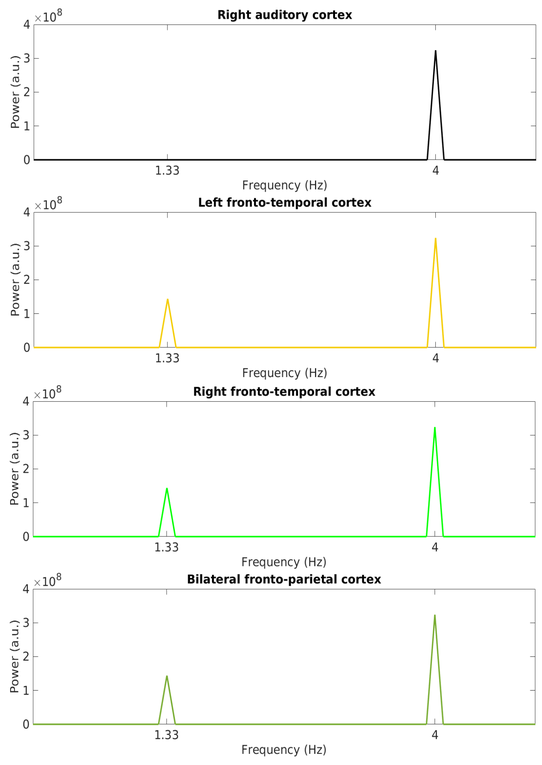
Testing Phase



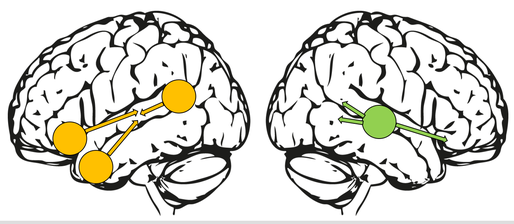
MEG Experiment 1: Expected Results

Exposure Phase

Frequency Analysis

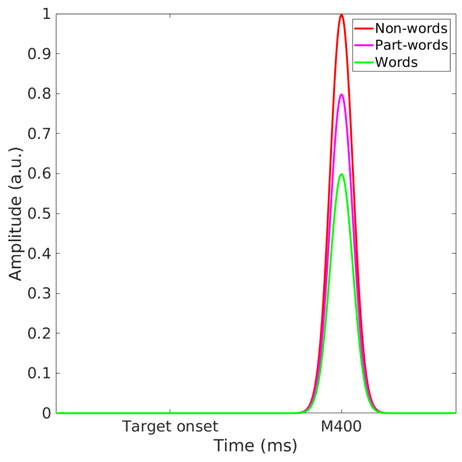


Connectivity Analysis

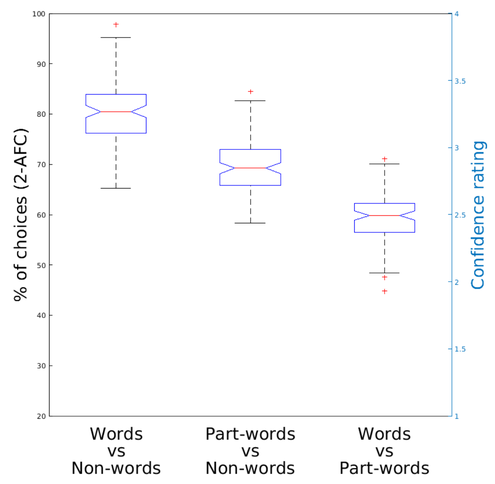


Testing Phase

Event Related Fields



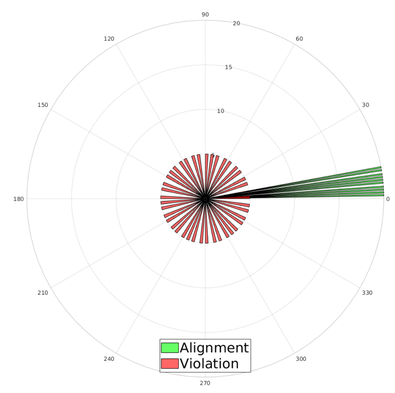
Behavioural Performance



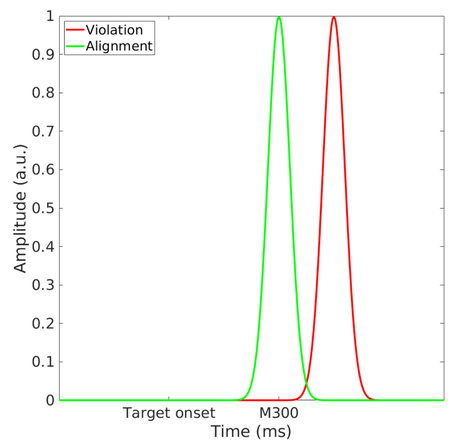
MEG Experiment 2: Expected Results

When Predictions

Pre-stimulus Phase Analysis

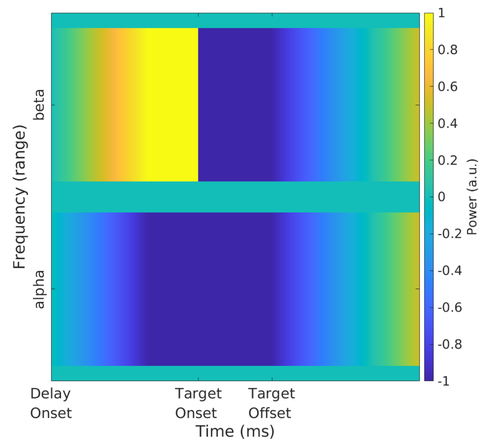


Event Related Fields

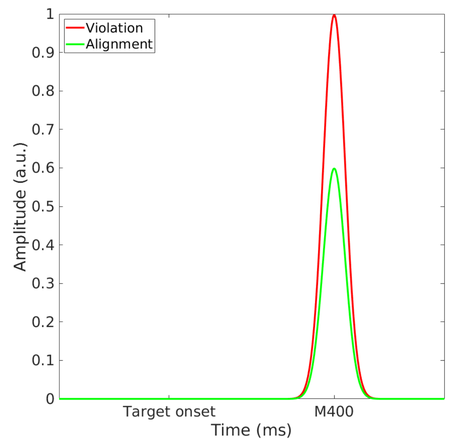


What Predictions

Time-Frequency Analysis



Event Related Fields



Hypotheses

Experiment 1

- Distinct neural circuits should display **periodicity** at the chunk rate when TPs and/or prosodic cues are rhythmic
- High-order regions sensitive to TPs should feedback **top-down** predictions of chunk boundaries, while acoustic as well as prosodic cues should be processed **bottom-up**
- **Evoked** responses (e.g. M400 amplitude) to test chunks should be larger for non-words compared to words
- **Neural tracking** of both statistical and prosodic rhythms should facilitate statistical learning of artificial words

Experiment 2

- Oscillations should carry predictions of ***when*** and ***what***
- ***When***: entrained oscillations carry temporal predictions (pre-target phase bias) that surface in faster processing of a downstream target that is aligned to an expected time point (post-target M300 latency reduction)
- ***What***: internal language models carry content predictions (alpha/beta power) that surface in facilitated processing of a downstream target that is part of the lexicon (post-target M400 amplitude reduction)

Implications

- Experiment 1 could reveal that **rhythmic processing** of **TPs** and **prosodic** cues embedded in a syllable stream:
  1. Is supported by distinct neural circuits
  2. Jointly impacts statistical learning of artificial words
- Experiment 2 could reveal that **neural oscillations** play a mechanistic role to **optimize sensory processing**:
  1. Entrainment supports temporal—*when*—predictions
  2. Internal models support content—*what*—predictions
  3. Oscillations impact downstream target processing

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