

# Planning production: Morphological, semantic and syntactic representations

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## Introduction

- Lexical, morphological, and phonological processing are viewed as separate processing levels in most models, yet their spatial and/or temporal characterization is under-specified.
- Invasive intracranial electrophysiology recordings have revealed selectivity for morphological processing in time and space during production.<sup>1,2</sup>
- Given its spatial and temporal sensitivity and non-invasive nature, MEG is an ideal method for studying the stages of linguistic processing leading up to production in healthy brains.

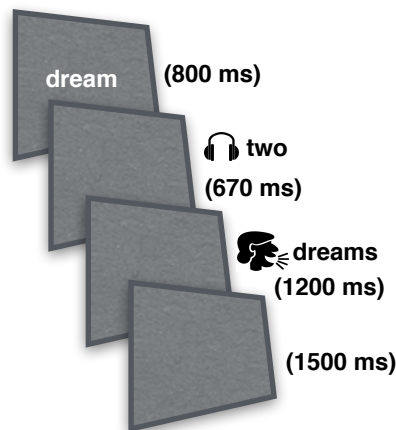
## Research questions

- Do we observe an effect of abstract inflection, regardless of differences in phonology?
- Do we observe differences in activity based on syntactic category, independent of semantic properties and inflectional status?
- How are representations of inflectional, semantic, and syntactic features encoded in the brain over time?

## Task: Phrase Completion

**Task instruction:** Complete the phrase with the appropriate form of the **noun / verb**

	prompt	cue	target	condition
Inflect (modify)	dreams	one / I	dream	no -s
	dream	two / he	dreams	+s
Inflect (same)	dream	one / I	dream	no -s
	dreams	two / he	dreams	+s
Repeat	dream	say	dream	no -s
	dreams	say	dreams	+s



24 right-handed native English speakers, 1080 trials

## Design and Materials

3 inflection x 3 semantic x 3 syntactic

		Noun	Verb	Ambiguous
<b>Inflect (modify)</b> IN context + change the form of the	<b>Abstract</b> no physical referent	trait	adapt	dream
<b>Inflect (same)</b> IN context + no change to seen word	<b>Movement</b> non-manipulable motion	tornado	kneel	leap
<b>Repeat</b> NO context + no change to seen word	<b>Manipulable</b> manipulation by humans	sword	carve	hammer

## Analysis

- Acquisition recording band 0-200Hz, sampling rate of 1000 Hz
- Epochs from 0 (cue offset) to 500 ms (average production)

### Spatiotemporal, Non-Parametric Permutation Tests

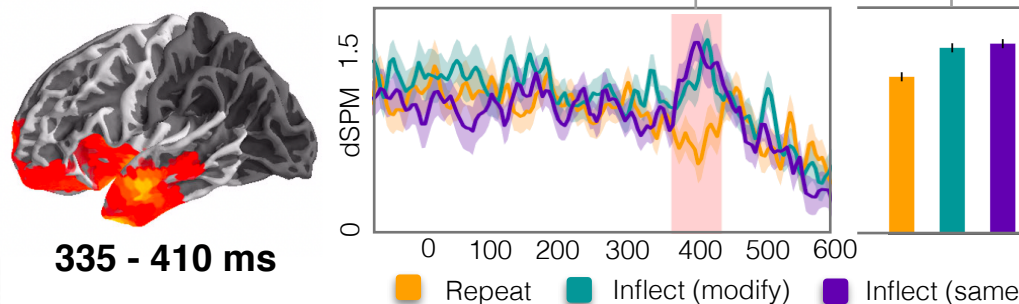
- Non-parametric cluster permutation ANOVAs performed from 100 to 500 ms across a left hemisphere mask,  $p < 0.05$

### Representational Similarity Analysis (RSA)

- Searchlight analysis through time (50 ms sliding windows) and space (10 mm of cortex around each source)
- Whole left hemisphere (0 - 500 ms),  $p < 0.05$ , FDR correction

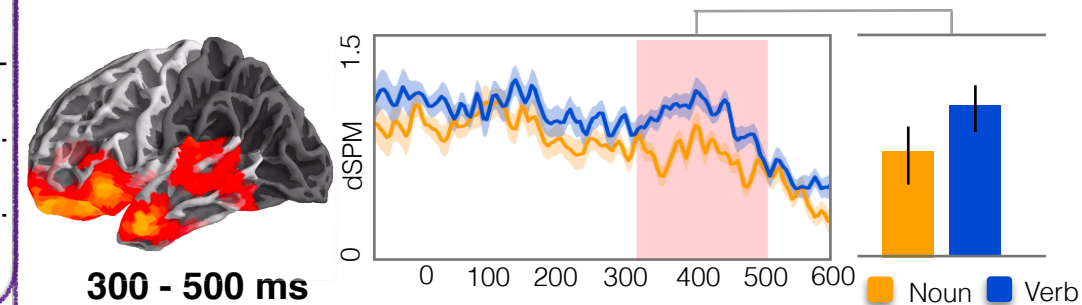
## Results

### a) Effect of abstract inflection (independent of phonology) in 300-500 ms window\*



\* no significant interactions with semantic or syntactic features

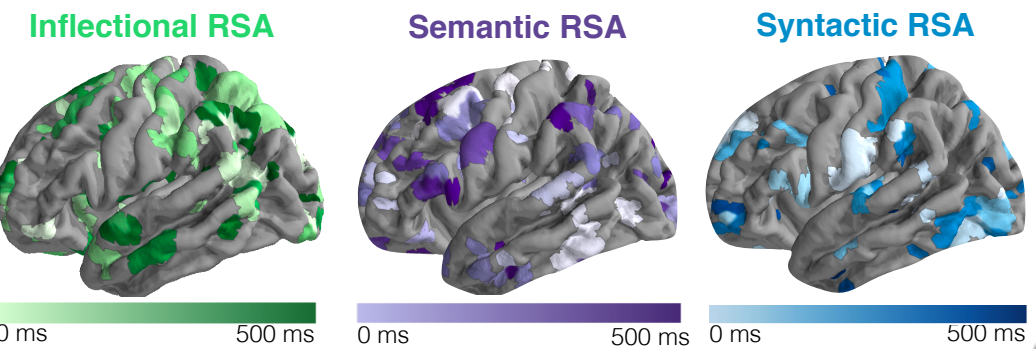
### b) Difference in activity based on syntactic category<sup>3,4,5</sup> regardless of other linguistic features (300 - 500 ms window)



\* no significant interactions with semantic features or inflectional status

### c) Representations of inflectional, semantic, and syntactic features encoded in the left hemisphere over time

Significant correlation with model matrix (extending for at least 25 consecutive ms) throughout the left hemisphere



## Conclusions

1. We find evidence of abstract grammatical inflection during production in frontal and frontotemporal regions.
2. This effect is consistent across syntactic category, person/number and lexico-semantic properties, suggesting the existence of a unified inflectional system.
3. Detailed neural representations of inflectional, semantic, and syntactic properties can be probed using multivariate analyses at different time-scales over distinct anatomical regions.

### References

<sup>1</sup> Sahin et al., 2009; <sup>2</sup> Lee et al., 2018; <sup>3</sup> Shapiro, Moo, & Caramazza, 2006; <sup>4</sup> Bedny et al., 2008; <sup>5</sup> Bedny & Thompson-Schill, 2006