



# The brain dissociates between different levels of prediction during language comprehension



Gina R. Kuperberg<sup>1,2,3,4</sup>, Edward W. Wlotko<sup>1,5</sup>, Simone J. Riley<sup>1</sup>, Margarita Zeitlin<sup>1</sup>, Maria Luiza Cuhna Lima<sup>1</sup>

<sup>1</sup>Department of Psychology, Tufts University; <sup>2</sup>MGH/MIT/HMS Athinoula A. Martinos Center for Biomedical Imaging;

<sup>3</sup>Department of Psychiatry, Massachusetts General Hospital and <sup>4</sup>Harvard Medical School; <sup>5</sup>Moss Rehabilitation Research Institute

## Introduction

Comprehenders continually generate probabilistic predictions at multiple levels of representation [1]

Here we asked whether and how predictions at different levels influence neural processing of incoming words

We recorded ERPs using a design in which target nouns fulfilled or violated contextual predictions at the level of *specific lexical items* and/or *verb-argument event structure*

## Design

Lexically constraining contexts (average constraint: 79%)

*The lifeguards received a report of sharks right near the beach. Their immediate concern was to prevent any incidents in the sea. Hence, they cautioned the....*

(1) **SWIMMERS** / (2) **TRAINEES** / (3) **DRAWER** ...

Target nouns were:

- (1) **Lexically Predictable**
- (2) **Lexical Prediction Violations**
- (3) **Lexical Prediction + Animacy Violations**

Lexically non-constraining contexts (average constraint: 26%)

*Eric and Grant received the news late in the day. They decided it was better to act sooner than later. Hence, they cautioned the....*

(4) **TRAINEES** / (5) **DRAWER** ...

Target nouns were:

- (4) **Lexically Unpredictable (non-violating)**
- (5) **Animacy Violations**

## Method

- 24 right-handed native English speaking volunteers participated
- Participants performed an acceptability judgment task
- Discourse contexts appeared in full; the third sentence appeared word-by-word w/ 450 ms duration and 100 ms ISI
- ERPs recorded with 32 Biosemi active electrodes, continuously sampled at 512 Hz with a bandpass filter of DC – 104 Hz

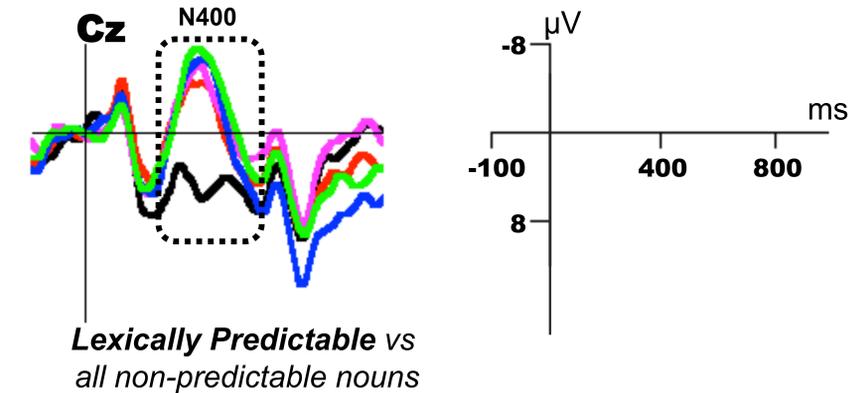
## Results and Discussion

### Semantic predictability

The amplitude of the N400 [2] was selectively reduced to the **Lexically Predictable** nouns compared to all other conditions

All non-predictable critical words (conds. 2-5) were matched on semantic relatedness to the contexts using Latent Semantic Analysis

Thus, the N400 primarily reflects the predictability of an incoming word's *semantic features*, rather than either its lexical predictability or its message-level coherence

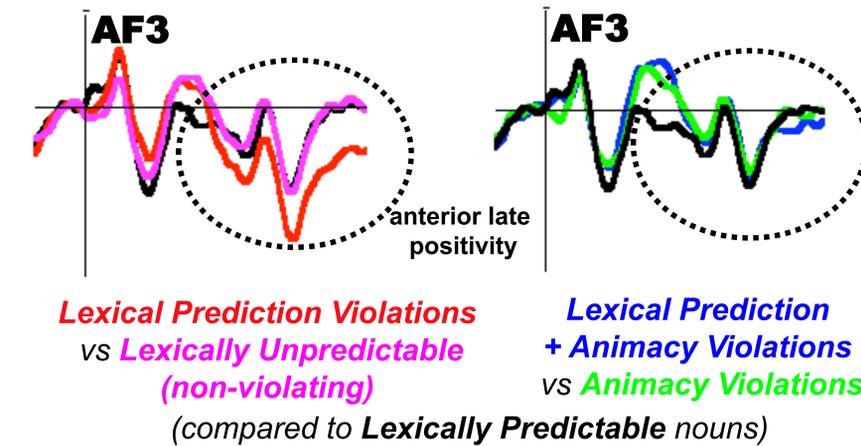


### Violations of lexical predictions

An anterior late positivity was selectively enhanced to unpredictable nouns that were **Lexical Prediction Violations** compared to **Lexically Unpredictable (non-violating)** nouns [cf. 3]

The anterior late positivity was not elicited by lexically violating nouns if these nouns were also **Animacy Violations**

The anterior late positivity effect likely reflects the violation of a *high certainty lexical prediction*, within a coherent meaning representation

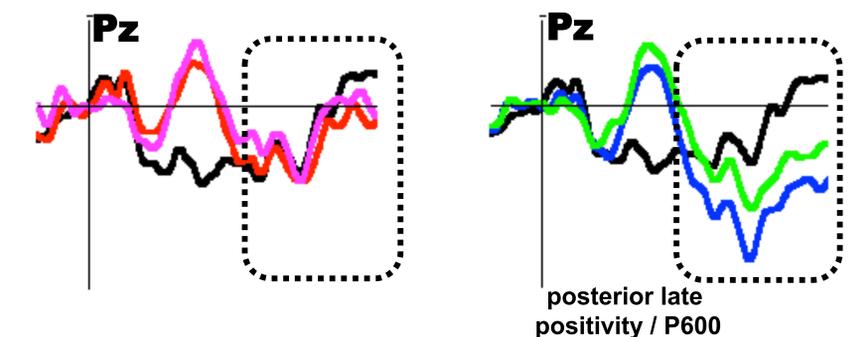


### Violations of event structure predictions

A posterior late positivity (the P600 effect [4,5]) was selectively enhanced to nouns that violated *event structure* based on animacy restrictions of the verb [cf. 6,7]

The amplitude of the P600 was larger for **Animacy Violations in constraining contexts** (violating lexical predictions) compared to **Animacy Violations in non-constraining contexts** (no violation of lexical predictions)

Neural processing of words that violate event structure predictions vs. strong lexical predictions involve *distinct but partially interacting networks*



## Conclusions

We observed clear dissociable neural signatures of *semantic facilitation*, *lexical prediction violations*, and *event structure prediction violations* in the same participants performing the same task

Taken together, these findings support a hierarchical generative architecture in which unfolding bottom-up evidence that has not already been predicted at a given level of representation manifests in the brain as *distinct spatiotemporal neural signatures*

## References & Acknowledgements

- [1] Kuperberg GR, Jaeger TF. *Lang Cog Neur.* 2016;31(1):32-59.
- [2] Kutas M, Federmeier KD. *Annual Review of Psychology.* 2011;62:621-647.
- [3] Federmeier KD et al. *Brain Research.* 2007;1146:75-84.
- [4] Kuperberg GR et al. *Cognitive Brain Research.* 2003;17(1):117-129.
- [5] Kuperberg GR. *Brain Research.* 2007;1146:23-49.
- [6] Paczynski M, Kuperberg G. *Lang Cog Processes.* 2011;26(9):1402-1456.
- [7] Paczynski M, Kuperberg G. *J Memory & Language.* 2012;67(4): 426-448.

We gratefully acknowledge support from NIH R01-HD082527, R01-MH071635, & K12-GM074869