Lists with and without syntax: Neural correlates of syntactic structure

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1 INTRODUCTION

- In the neurobiology of language, a fundamental challenge is de-confounding syntax from semantics
- A novel design: embedding the same noun lists in longer lists (without structure) and in sentences (with structure)

List-in-list: forks, pen, toilet, rodeo, lamps, dolls, guitars...

same (lack of) conceptual combination, same lexical materials, different structure

List-in-sentence: The eccentric man hoarded lamps, dolls, guitars...

- We thus controlled word meaning and local semantic composition (e.g. '*lamps*' and '*dolls*' don't form a phrase) better than prior research

Question: Of the putative language-related areas, which (if any) would show sensitivity to structure independent of word meaning and local semantic composition?

2 METHODS

- 16 participants read stimuli word-by-word
- Memory probe task at end of each trial
- Trial order fully randomised
- KIT 208 channel MEG system
- Varied word association (cosine similarity among content word vectors) among words 1-7

2×2

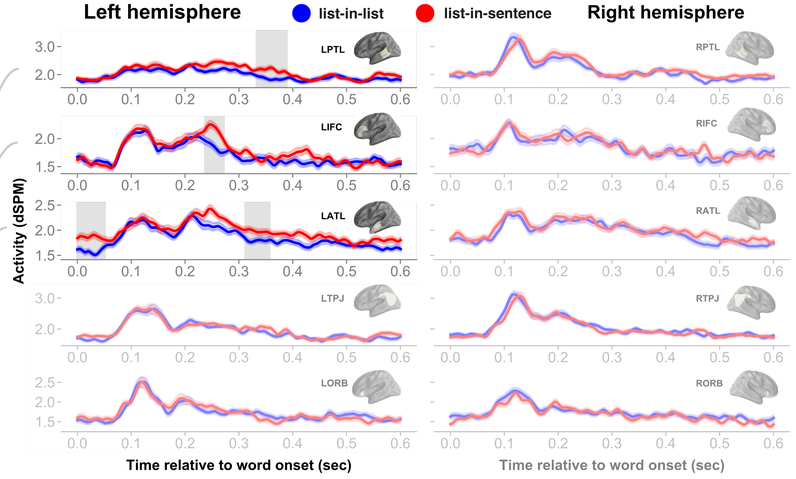
Structure	Assoc	Words 1-4	Words 5-7	Words 8-10
List-in-list	Low	forks pen toilet rodeo	lamps dolls guitar	wood symbols straps
List-in-sent	Low	The eccentric man hoarded	lamps dolls guitar	watches and shoes.
List-in-list	High	theater graves drums mulch	pianos violins guitars	crats knuckle cocoa
List-in-sent	High	The music store sells	pianos violins guitars	drums and clarinets.

ANALYSIS

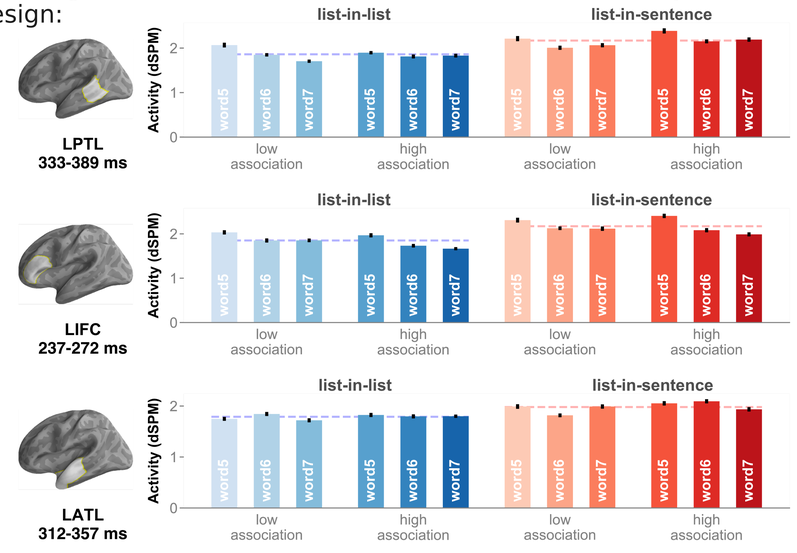
- (generalised) linear mixed models on reaction times and accuracy
  - ➔ list-in-sentence reduced RTs (χ^2=44.73***) & improved accuracy (χ^2=20.24***)
- Cluster-based permutation tests[1] on regions of interest activity across words 5-7 (i.e. word position as factor)
  - ➔ 2×2×3 (structure by association by position) repeated-measures analysis of variance at each time sample

3 NEURAL EFFECTS OF STRUCTURE

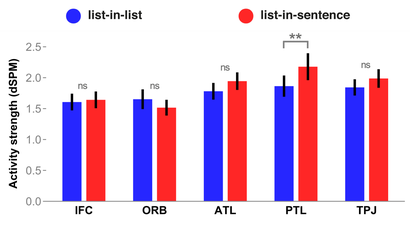
- Across word positions, lists-in-sentence increased activity in the left frontotemporal system at distinct time points



- Zooming in to structure effects in left PTL, IFC, and ATL by the full design:



- When including region as a factor, a structure by region interaction emerged: the observed difference between lists-in-lists and lists-in-sentences was largest in the left PTL at ~330-380 ms after stimulus onset



REFERENCES [1] Maris & Oostenveld (2007); **[2]** Kutas & Federmeier (2011); **[3]** Mollica et al. (2020) **[4]** Christiansen & Chater (2016); **[5]** Pallier, Devauchelle, & Dehaene (2011); **[6]** Fedorenko et al. (2016).

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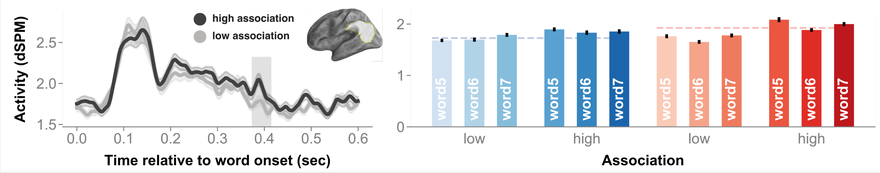
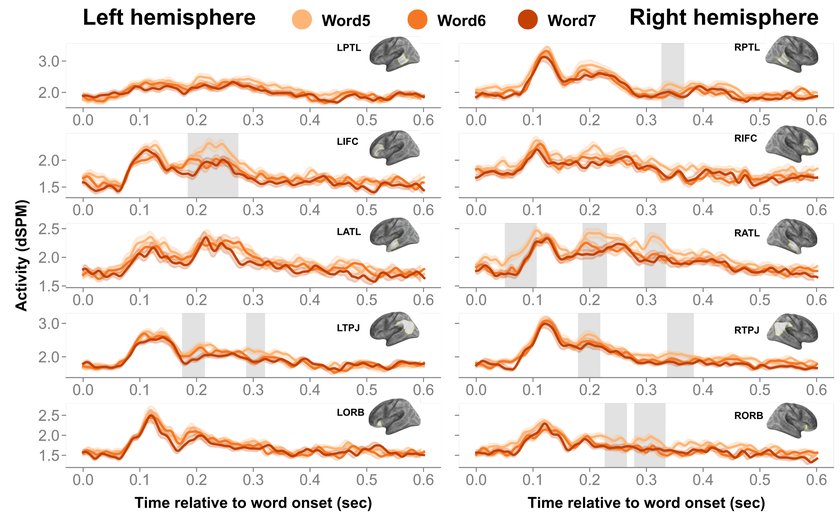
4 NEURAL EFFECTS OF ASSOCIATION

- Activity increased for more associative items in the left temporo-parietal junction at ~400 post word onset



5 NEURAL EFFECTS OF POSITION

- Word 5 increased cortical signals more so than words 6 and 7.



- Could the observed structure effects be driven by word 5?
  - ➔ after removing word 5 from the analyses, PTL and ATL effects remained, while the IFC effect became marginal but cluster extent remained (possibly due to reduced statistical power)

6 CONCLUSION

- The neural footprint of structure in the left PTL, ATL, and IFC cannot be attributed to contributions from word meaning and local semantic composition
- Association-based semantic relationships were reflected in the left TPJ: higher activity for more associative items[c.f. 2]
  - ➔ tentative hypothesis: the brain's attempt to 'making sense' out of the lists through composition[3] and/or 'chunking'[4]
- Position effects were widespread: increased activity for word 5 relative to words 6 & 7
  - ➔ this increase was not responsible for the structure effects
  - ➔ contra studies that showed activity increased as sentences progressed[5,6]