Noun/Verb Entropy: an MEG Study of Word-level Syntactic Category Ambiguity

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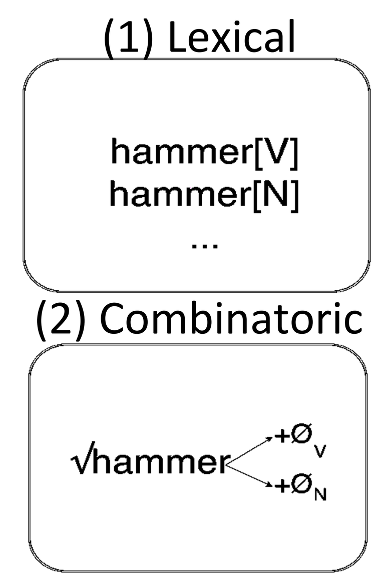
Introduction

- How are grammatical categories such as *noun* and *verb* computed during word recognition? At least two options (for review, see: Vigliocco et al. 2011):

(1) Lexical: category is a feature of the representation of each word, with distinct representations for each category

(2) Combinatoric: lexical category is assigned to a category-neutral root via affixation[1]

- Lexical category as a feature of distinct words predicts category ambiguity correlations with 300ms MTL (middle temporal lobe) activity (see: e.g., meaning entropy effects for distinct meanings in Simon et al. 2012)
- Lexical category as a product of combinatoric processes predicts earlier (before 300ms) LATL (left anterior temporal lobe) activity correlated with category ambiguity (see: verb subcategorization frame effect in Linzen et al. 2013 and cf. Bemis & Pylkkänen 2013)
- Does the brain response to category ambiguity of null-inflected words support (1) or (2)?



[1]For linguistic support of (2), see: Barner & Bale (2002), Chomsky (to appear), Marantz (1997)

Stimuli Variables

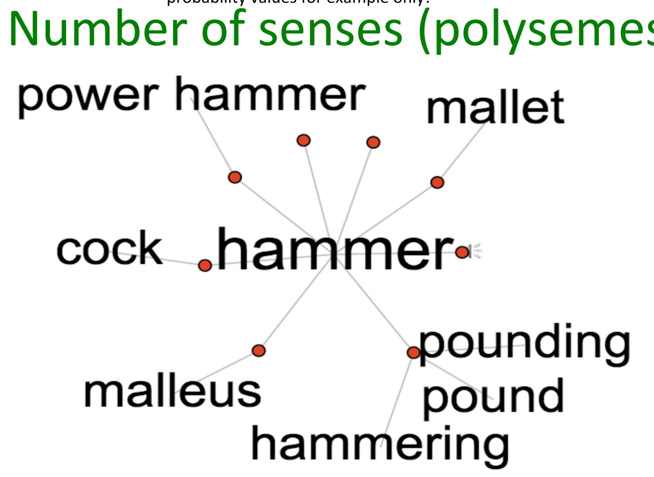
Lexical Variables

- Derivational entropy;

$$hammer...\left\{\begin{array}{ll} -able & 0.6 \\ -er & 0.2 \\ -ize & 0.2 \end{array}\right.$$

probability values for example only!

- Number of senses (polysemes);



- Number of distinct meanings (homographs);
  - *bank* (institution or river)
  - *bat* (animal or sports object)
  - *row* (line or paddle)

Combinatoric Variables

- Noun/Verb entropy;

$$hammer...\left\{\begin{array}{ll} -\varnothing V & 0.33 \\ -\varnothing N & 0.67 \end{array}\right.$$

- Inflectional entropy;

$$hammer...\left\{\begin{array}{ll} -s & 0.3 \\ -ing & 0.3 \\ -ed & 0.4 \end{array}\right.$$

Example N/V entropy words >0.67:

veil, **seat**, **risk**, **peel**, **joke**, **heat**, **blur**

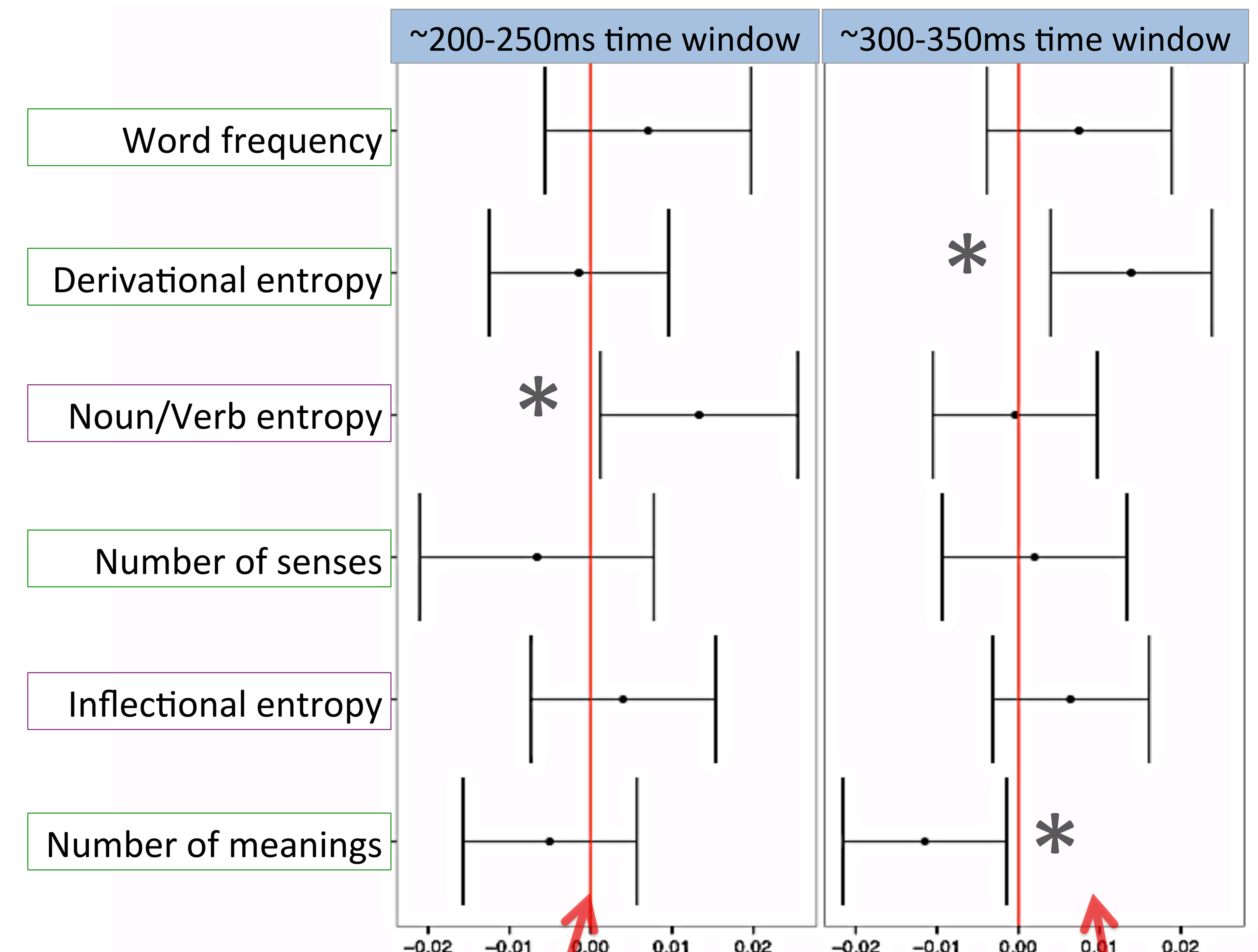
Noun/Verb entropy is given by:

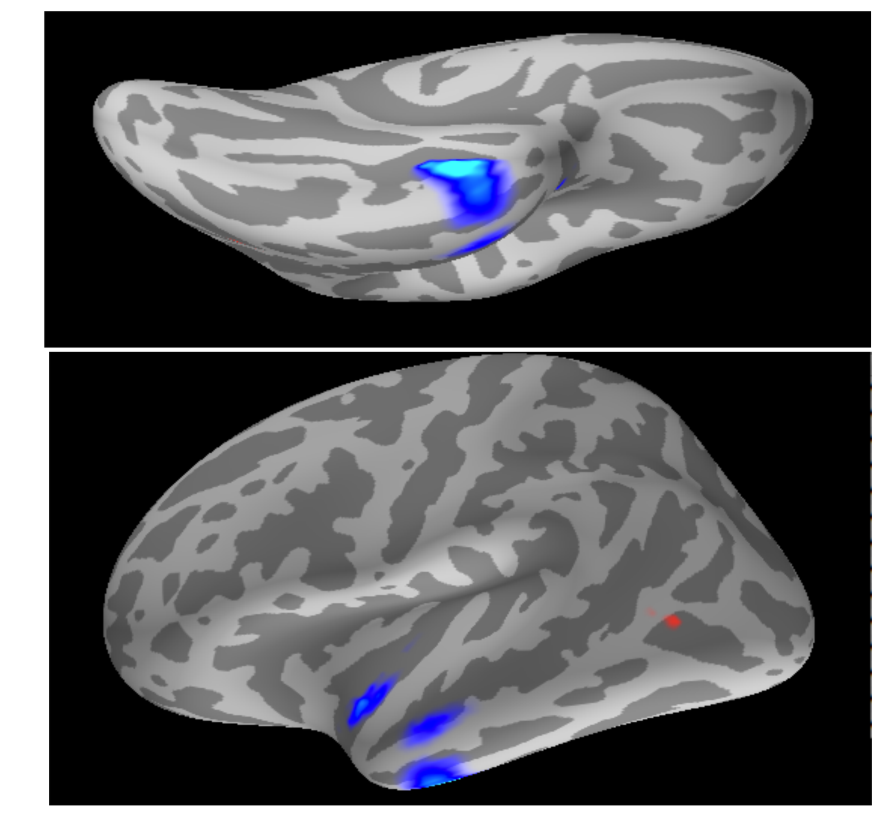
$$H_{noun/verb} = -p_{verb}\log_2 p_{verb} - p_{noun}\log_2 p_{noun}$$

Materials & Methods

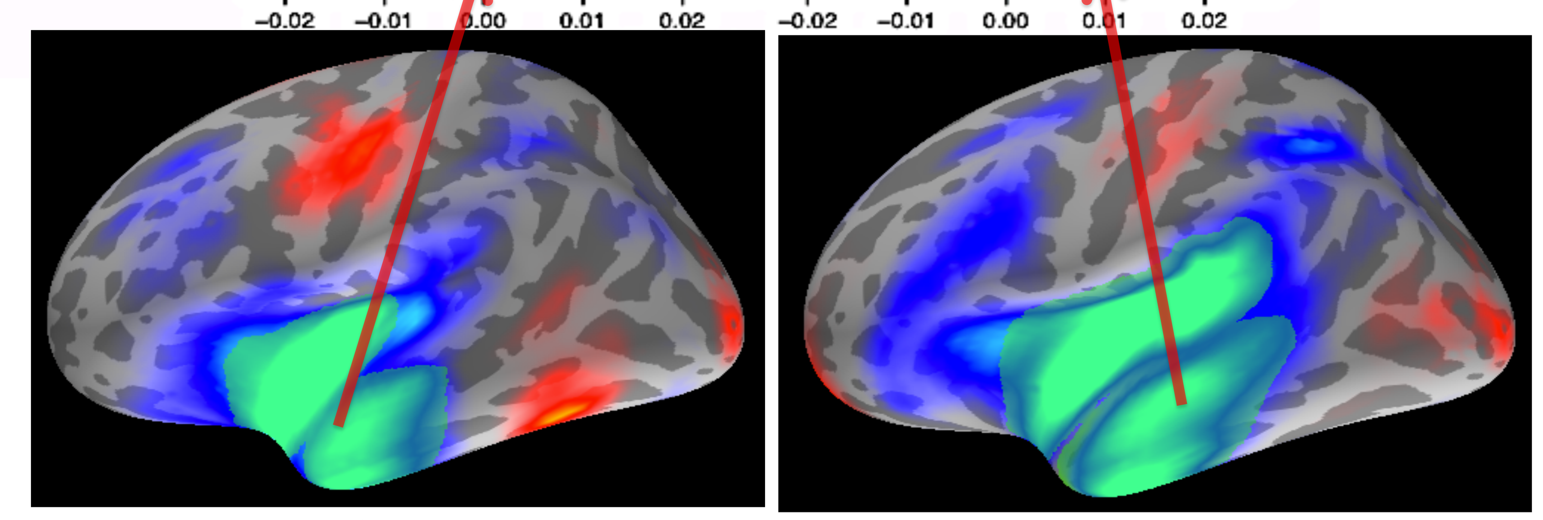
- Visual lexical decision experiment with concurrent MEG recording
- 12 right-handed native English speakers
- 208 sensor array
- Source solutions calculated with MNE (Gramfort et al. 2014)
- 313 words
- Effects of predictors were assessed using continuous linear mixed effects regression on single trial source activity

Results

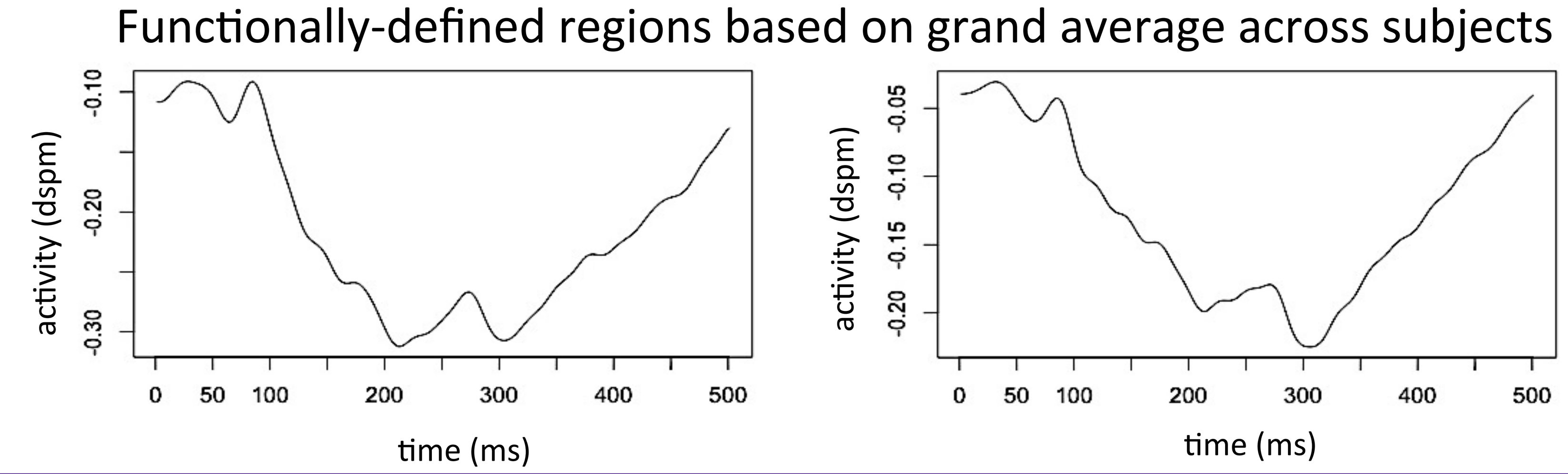


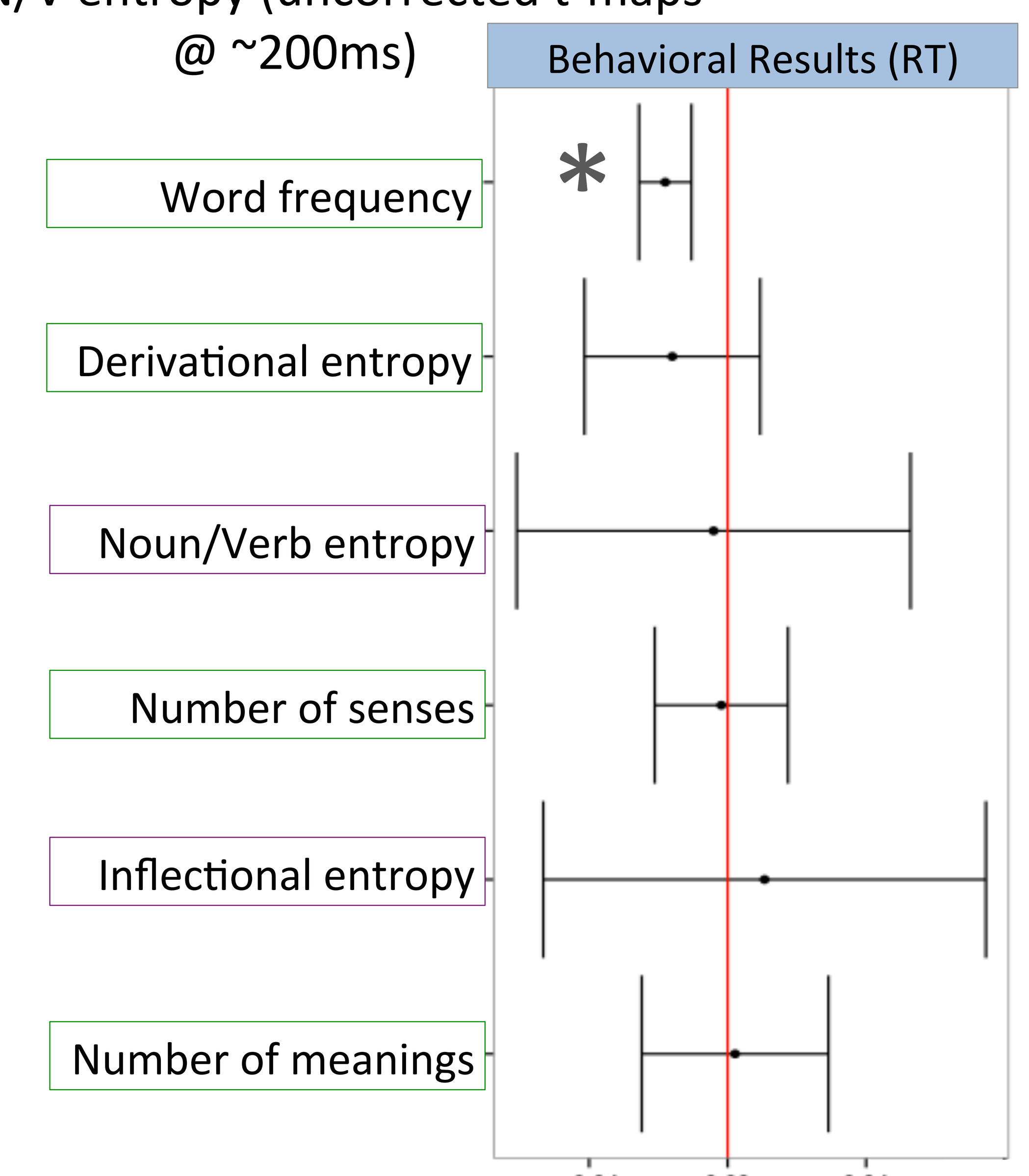


Correlations between neural activity and N/V entropy (uncorrected t-maps @ ~200ms)



Functionally-defined regions based on grand average across subjects





Conclusions

- No significant correlations were observed with number of senses or with inflectional entropy; however, stimuli were not selected optimally for observing the effects of these variables
- Number of meanings and derivational entropy correlate with activity in a broader temporal region and a later time window (~300-350ms), replicating experiments that associate these variables with lexical access
- As predicted by the combinatoric hypothesis, **N/V entropy correlates with activity in the LATL (left anterior temporal lobe) within the ~200-250ms time window**, parallel to the effects of subcategorization frame entropy for verbs when presented in isolation (Linzen et al. 2013)

References: Barner, D., & Bale, A. (2002). Lingua, 112, 771-791; Bemis, D., & Pylkkänen, L. (2013). PLoS ONE, 8(9), e73949; Gramfort, A., Luessi, D., Larson, E., Engemann, D., Strohmeier, D., Brodbeck, C., Parkkonen, L., & Hämäläinen, M. (2014). Neuroimage 86, 446-460; Linzen, T., Marantz, A., & Pylkkänen, L. (2013). The Mental Lexicon 8:2, 117-139; Marantz, A. (1997). University of Pennsylvania Working Papers in Linguistics 4.2: 201-225; Simon, D., Lewis, G., & Marantz, A. (2012). Language and Cognitive Processes, 27:2, 275-287; Vigliocco, G., Vinson, D., Druks, J., Barber, H., & Cappa, S. (2011). Neuroscience & Biobehavioral Reviews 35, 407-426.

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