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

• 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: Barber & Bale (2002). Chomsky (to appear), Marantz (1997)

Stimuli Variables

<table>
<thead>
<tr>
<th>Lexical Variables</th>
<th>Combinatoric Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Derivational entropy</strong></td>
<td><strong>Noun/Verb entropy</strong></td>
</tr>
<tr>
<td>hammer... → -able 0.6</td>
<td>hammer... → -ØV 0.33</td>
</tr>
<tr>
<td>hammer... → -er 0.2</td>
<td>hammer... → -ØN 0.67</td>
</tr>
<tr>
<td>hammer... → -ize 0.2</td>
<td><strong>Inflectional entropy</strong></td>
</tr>
<tr>
<td>Number of senses (polysenes):</td>
<td>hammer... → -s 0.3</td>
</tr>
<tr>
<td>power hammer → mallet</td>
<td>hammer... → -ing 0.3</td>
</tr>
<tr>
<td>cock hammer → pounding hammering</td>
<td>hammer... → -ed 0.4</td>
</tr>
<tr>
<td>Number of distinct meanings (homographs):</td>
<td>Example N/V entropy</td>
</tr>
<tr>
<td>bank (institution or river)</td>
<td>words &gt;0.67</td>
</tr>
<tr>
<td>bat (animal or sports object)</td>
<td></td>
</tr>
<tr>
<td>row (line or paddle)</td>
<td>joke, heat, blur</td>
</tr>
<tr>
<td>Noun/Verb entropy is given by:</td>
<td></td>
</tr>
<tr>
<td>$H_{\text{noun/verb}} = -P_{\text{verb}} \log P_{\text{verb}} - P_{\text{noun}} \log P_{\text{noun}}$</td>
<td></td>
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</tbody>
</table>

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)**

- Noun/Verb entropy
- Derivational entropy
- Number of senses
- Inflectional entropy

**Behavioral Results (RT)**

- Word frequency
- Derivational entropy
- Noun/Verb entropy
- Number of senses
- Inflectional entropy
- Number of meanings

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)


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