Background & Questions

- N400 is a negative-going ERP component that is sensitive to semantic expectation. (Kutas & Federmeier, 2011)
- Pre-nominal words reported to also elicit N400-like effect when incompatible with expected noun. (DeLong et al., 2005; Wicha et al., 2004)

Questions:
- What underlying processes lead to pre-nominal effects?
- What relevant measures should thus be expected to correlate with pre-nominal effects?

Task Analysis

- Common explanation for pre-nominal effect assume predictions at different levels of language processing.
- Unexpected information leads to large shift in predictions about the messages being conveyed (Kuperberg, 2016; Kuperberg & Jaeger, 2016; Rabovsky et al., submitted)

Bayesian Surprise

- Bayesian surprise: Relative entropy or Kullback-Leibler divergence between a prior and posterior distribution.
- Measures how much update occurs in the generative model after encountering new information.
- More unexpected pre-nominal information leads to larger change in expected event representation (see Figure 3 above).
- Offers an unified account of both N400 effect on content word (nouns) and corresponding effect on pre-nominal information.

Approximating Semantic Updating

- When pre-nominal information is deterministically predictive, e.g. gender. Bayesian surprise (BS) equals surprisal of the pre-nominal information.

$$BS = \sum_{i} p(NOUN_i | \text{masc, context}) \cdot \log \frac{p(NOUN_i | \text{masc, context})}{p(NOUN_i | \text{context})} = - \log p(\text{masc | context}) = \text{Surprisal of masc}$$

- When pre-nominal information is non-deterministically predictive, e.g. a/n ('an awesome kite'). Bayesian surprise does not equals surprisal.

$$BS = \sum_{i} p(NOUN_i | \text{a', context}) \cdot \log \frac{p(NOUN_i | \text{a',context})}{p(NOUN_i | \text{context})} = - \log p(\text{a'|context}) + f(p(\text{a'} | NOUN_i, \text{context})) < \text{Surprisal of a'}$$

Correlation between Bayesian Surprise and Surprisal in Language Use

- Figure 4. Correlation between the article's surprisal (log-transformed bi-gram probability) and the Bayesian surprise over the distribution of the upcoming noun incurred on the article.

- Figure 5. Correlation between the article's predictability (bi-gram probability) and the Bayesian surprise over the distribution of the upcoming noun incurred on the article.

Surprisal and Pre-nominal N400

- Figure 6. Re-analysis of the ERP data shared by Nieuwland et al. (2017). Surprisal of the article is a better linear predictor for N400 amplitude on the article (p < 0.016) than cloze probabilities of the articles (p < 0.13). The same holds for surprisal and N400 evoked by the noun (data not shown).
References:


For more details, see our draft on BioRxiv


Link: https://www.biorxiv.org/content/early/2017/05/30/143750