Modeling priming effect with distributional semantics

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Background

Despite **access to word meaning** has been attested with subliminal stimuli, it is unclear what type of semantic information is grasped **unconsciously** [1].

According to **distributional semantics**, meaning similarity between linguistic units can be described in terms of **statistical patterns** detectable over large textual database [2].

- At the **local** level, words may be used together more often than would be expected by chance. Through **Pointwise Mutual Information** (PMI) is it possible to assess how the presence of one word informs about the likelihood that the other one will follow closely.

$$\mathrm{PMI}(w_1,w_2) = \log_2 \frac{p(w_1,w_2)}{p(w_1)p(w_2)}$$

- At the **distributed** level, words may share contextual similarity. This approach is typically based on linear algebra: words are modeled as co-occurrence vectors and **cosine proximity** indexes the similarity between word vectors.

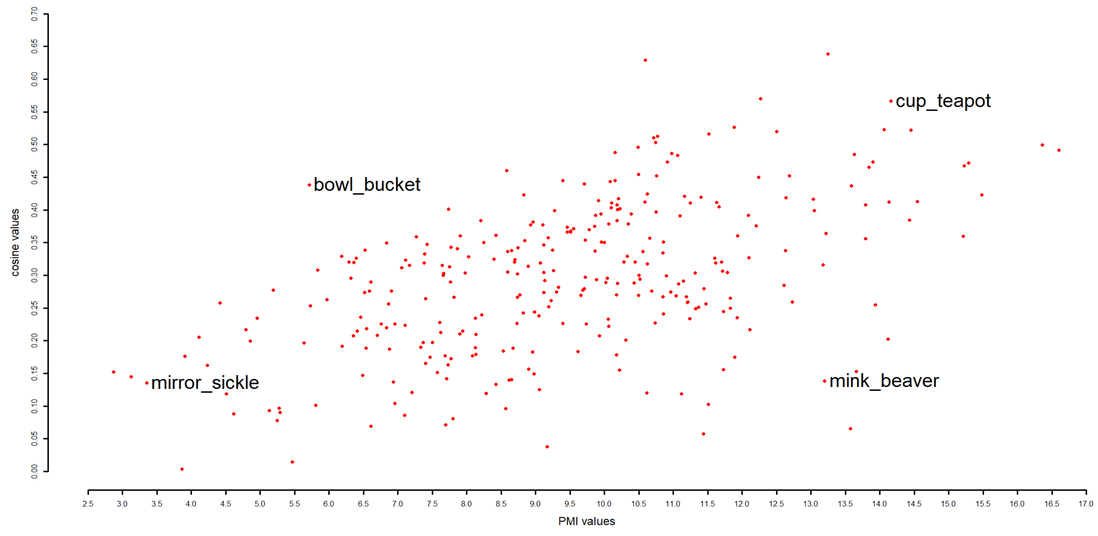
$$\cos(\theta) = \frac{\vec{a}\cdot\vec{b}}{||a||\cdot||b||}$$

Our study

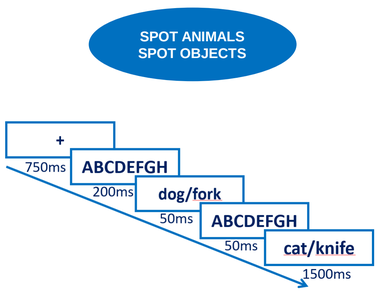
- **Research Question:** what kind of semantic information is processed out of awareness?
- **Hypothesis:** Unconscious word processing is mostly driven by local associative relationships. Conscious processing relies more on distributed information.

M&M

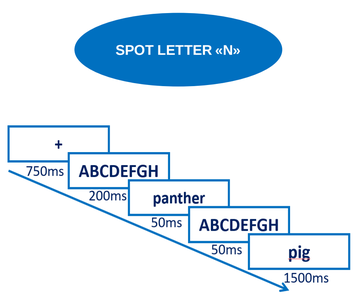
- 300 unique prime-target pairs (150 animal-animal, 150 tool-tool)
- Frequency counts extracted from the ItWac corpus [3].
- Word vectors obtained training a word2vec model [4] on ItWac.



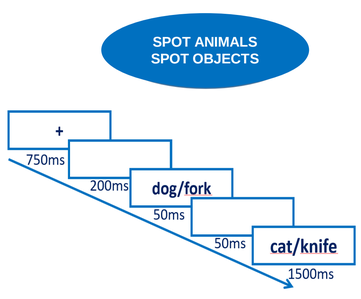
- Experiment 1:
  N = 102



- Experiment 1b:
  N = 102



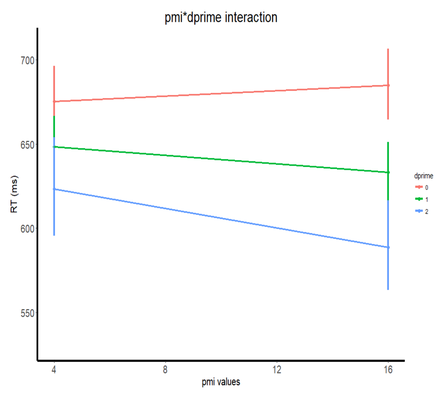
- Experiment 2:
  N = 102

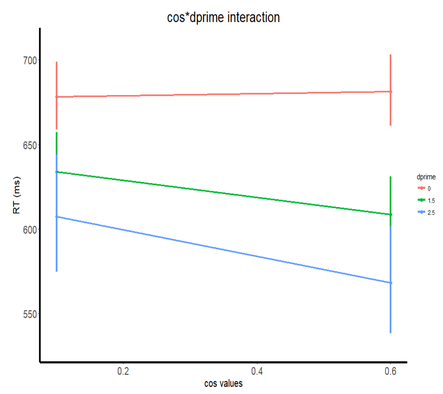


Results

Masked Semantic Classification

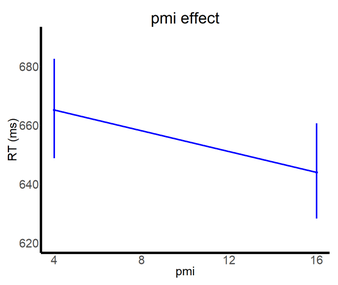
- No effect of semantic similarity
  pmi: $F(1, 9744)=1.0831$, $p= .298$
  cos: $F(1, 9747)=2.6152$, $p= .106$
- Prime visibility*semantic similarity interaction
  pmi*dprime: $F(1,9750)=13.7386$, $p= .0002$
  cos*dprime: $F(1,9749)=11.7786$, $p= .0006$

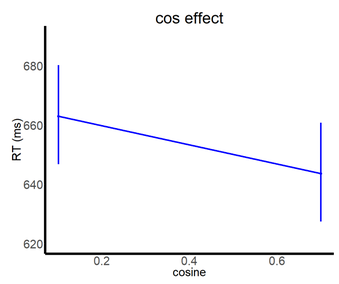




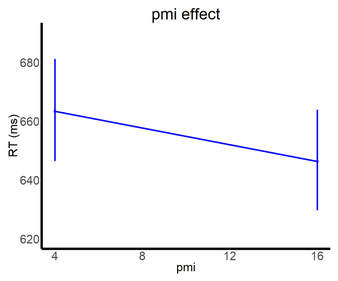
Unmasked Semantic Classification

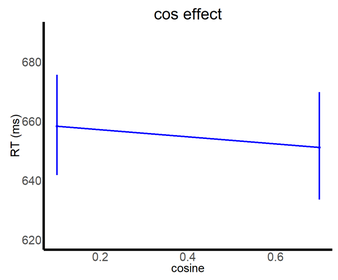
- Main effect of semantic similarity
  pmi: $F(1, 9774)=10.3641$, $p= .0013$
  cos: $F(1, 9747)=2.6152$, $p= .0058$





- Main effect of pmi when cos is considered in the same model
  pmi: $F(1, 9774)=10.3587$, $p= . 0013$
- No effect of cos when pmi is considered in the same model
  pmi: $F(1, 9774)=0.6022$, $p= .438$





Conclusions

- No semantic priming at the **subliminal level?**

1. None of the predictors has a main effect on RTs
2. All predictors interact with prime visibility, in a way that priming increases with participants' ability to detect the prime

- The **supraliminal effect** is mostly driven by **local association strength**, as only pmi significantly predicts priming if both the semantic indexes are tested in the same model.

References

[1] de Wit, B., & Kinoshita, S. (2015). The masked semantic priming effect is task dependent: Reconsidering the automatic spreading activation process. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *41*(4), 1062.
[2] Mandera, P., Keuleers, E., & Brysbaert, M. (2017). Explaining human performance in psycholinguistic tasks with models of semantic similarity based on prediction and counting: A review and empirical validation. *Journal of Memory and Language*, *92*, 57-78.
[3] Baroni, M., Bernardini, S., Ferraresi, A., & Zanchetta, E. (2009). The WaCky wide web: a collection of very large linguistically processed web-crawled corpora. *Language resources and evaluation*, *43*(3), 209-226
[4] Mikolov, T., Chen, K., Corrado, G., & Dean, J. (2013). Efficient estimation of word representations in vector space. *arXiv preprint arXiv:1301.3781*.

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