

Competing models of retrieval in sentence processing: the case of aphasia

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1. Introduction

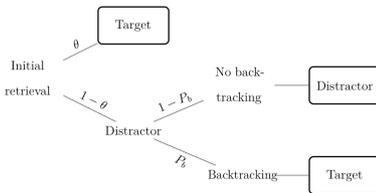
Cue-based theory explains syntactic dependency resolution in sentences like (1) by means of iterative retrievals from memory. At the retrieval point *kissed*, the parser starts a search in memory in order to recover a subject that fits the cues established by the verb.

- **1- Subject Relative:** The boy who hugged the girl chased the woman
- **2- Object Relative:** The brother who the sister followed kissed the woman

Two models are compatible with the cue-based theory: the computational model of sentence processing in Lewis and Vasishth (LV05) [2] and McElree's **direct-access model (DA)** presented in [3]. We implement them in a Bayesian framework and compare their relative fit to self-paced-listening data and picture selection accuracy [1] from 35 individuals with aphasia (IWAs) and 46 controls (subject and object relative clauses, see examples 1-2).

2. Direct-Access model (DA)

- Retrieval of an item takes an average time t_{da} , cues of the item always enable direct-access
- We follow [4] and implement DA as a Bayesian mixture-process model:



- Main parameters: probability of initial correct retrieval (θ), probability of backtracking (P_b)

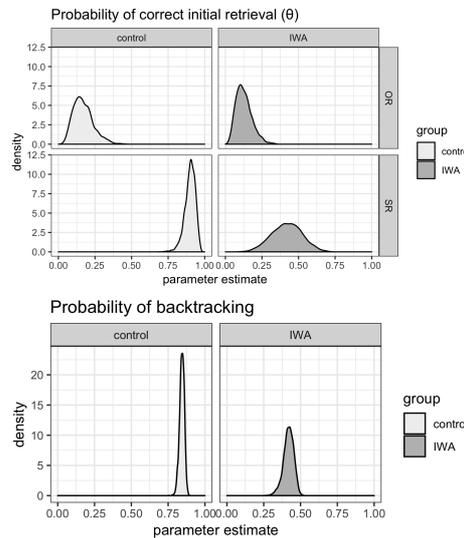


Figure 1. Posterior of the main parameters of DA

References

[1] Caplan, D., Michaud, J., & Hufford, R. (2015). Mechanisms underlying syntactic comprehension deficits in vascular aphasia: new evidence from self-paced listening. *Cognitive Neuropsychology*, 32(5), 283-313.
[2] Lewis, R. L., & Vasishth, S. (2005). An activation-based model of sentence processing as skilled memory retrieval. *Cognitive Science*, 29(3), 375-419.
[3] McElree, B. (2000). Sentence comprehension is mediated by content-addressable memory structures. *Journal of Psycholinguistic Research*, 29(2), 111-123.
[4] Nicenboim, B., & Vasishth, S. (2018). Models of retrieval in sentence comprehension: A computational evaluation using Bayesian hierarchical modeling. *Journal of Memory and Language*, 99, 1-34.

3. Activation-based model (LV05)

- Implemented as a **log-normal race of accumulators** with different variances [4]. Two accumulators of evidence, one for each possible interpretation: Subject/object relative clause.
- Accumulator with faster rate of accumulation fires, i.e. chosen interpretation.
- For each trial, the finishing time T of an interpretation i is sampled from a log-normal distribution with standard deviation σ_{group} :

$$T_i \sim \text{lognormal}(b - (\alpha_i + \beta_i * rc_{type}), \sigma_{group}) \quad (1)$$

where b is an arbitrary constant to constrain α_i to positive values.

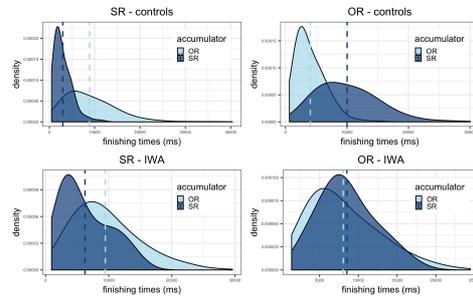


Figure 2. Distribution of finishing times of the two accumulators across conditions and groups

4. Posterior Predictive Checks

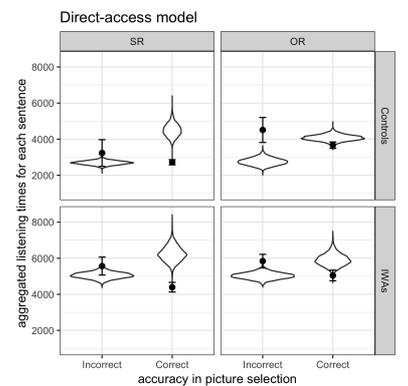
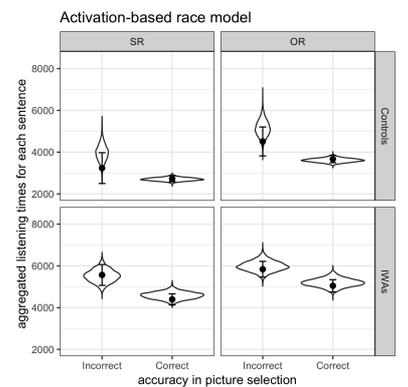


Figure 3. PPCs of both models. Dots and vertical bars indicate the mean and the 95% CI of the real data.

5. Model comparison: 10-fold cross-validation

LV05 provides a better quantitative fit, since it has a smaller elpd (a measure of distance between predicted and observed data): elpd DA = -28318, se 70, elpd LV05 = -28107, se 68.

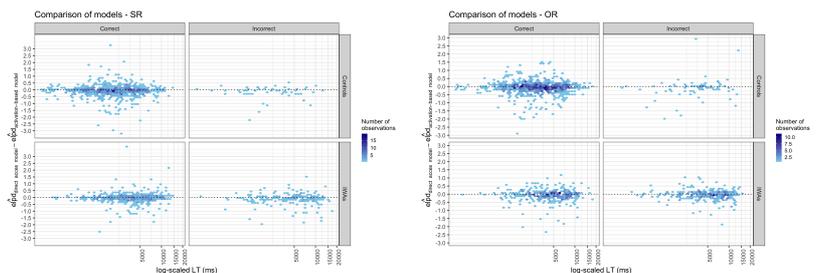


Figure 4. Predictive accuracy for each data point

6. Conclusion

The cross-validation and PPCs indicate that the activation-based model fits better our data: The PPCs show that DA underestimates the LT for incorrect trials and overestimates LT for correct trials. **Future directions for DA:** implementing a model that allows for reanalysis followed by a misretrieval. This could account for longer LTs in incorrect trials. Specially important for IWAs.