

Objectives

Use the **flexible word order of Hungarian** to tease apart **expectation-based** vs. **memory-based accounts** of relative clause (RC) processing.

Background

- Important case study in the processing of syntactic complexity: RCs.
 - Asymmetry between the English subject-extracted RC (1a) and object-extracted RC (1b): **ORC is harder to process than SRC**.
- (1) a. The engineer [RC who _ annoyed the analyst] wrote a report about the project.
b. The engineer [RC who the analyst annoyed_] wrote a report about the project.

Competing classes of accounts:

- Memory-based accounts: predict general locality preference – **shorter filler-gap dependencies are preferred** (Gibson, 1998; Lewis & Vasishth, 2005).
- Expectation-based accounts: attribute **greater processing cost to less expected structures** (e.g. surprisal, Hale, 2001; Levy, 2008).

In English, the predictions of both accounts converge, since English SRCs instantiate a shorter filler-gap dependency than ORCs, and they are also more frequent.

Experiment 1: extraction site × locality

In Hungarian, **extraction site and locality** (i.e. the length of the relevant filler-verb dependency) can be **varied independently**.

SRCs: either VO = local (2a) or OV = non-local (2b). Cf. English VO.

- (2) a. A mérnök, aki idegesítette az elemző...
the engineer.NOM who.NOM annoyed the analyst.ACC
b. A mérnök, aki az elemzőt idegesítette...
the engineer.NOM who.NOM the analyst.ACC annoyed...
Both: "The engineer who annoyed the analyst... (wrote a report...)"

ORCs: either VS = local (3a) or SV = non-local (3b). Cf. English SV.

- (3) a. A mérnök, akit idegesített az elemző...
the engineer.NOM who.ACC annoyed the analyst.NOM...
b. A mérnök, akit az elemző idegesített...
the engineer.NOM who.ACC the analyst.NOM annoyed...
Both: "The engineer who the analyst annoyed... (wrote a report...)"

Self-paced reading: extraction site (SRC vs. ORC) × locality (local vs. non-local).

- 81 monolingual speakers of Hungarian (aged 18-35).
- Item N=32. Filler N=38. Latin Square.
- A comprehension question followed each sentence.
- In order to avoid an event plausibility confound, nouns (e.g. *engineer*, *analyst*) were counterbalanced to occur both in head NP and RC NP positions.

Levy et al. (2013), in a similar manipulation in Russian, found an advantage for local sentences at RC verb. Memory and Expectation have the same prediction for Russian.

References

- Gibson. 1998. Linguistic complexity: locality of syntactic dependencies. *Cognition*. // Gibson & Wu. 2013. Processing Chinese relative clauses in context. *Language and Cognitive Processes*. // Hale. 2001. A probabilistic early parser as a psycholinguistic model. // Levy. 2008. Expectation-based syntactic comprehension. *Cognition*. // Levy, et al. 2013. The syntactic complexity of Russian relative clauses. *JML*. // Lewis & Vasishth. 2005. An activation-based model of sentence processing as skilled memory retrieval. *Cognitive Science*. // Oravecz, et al. 2014. The Hungarian Gigaword Corpus.

Predictions

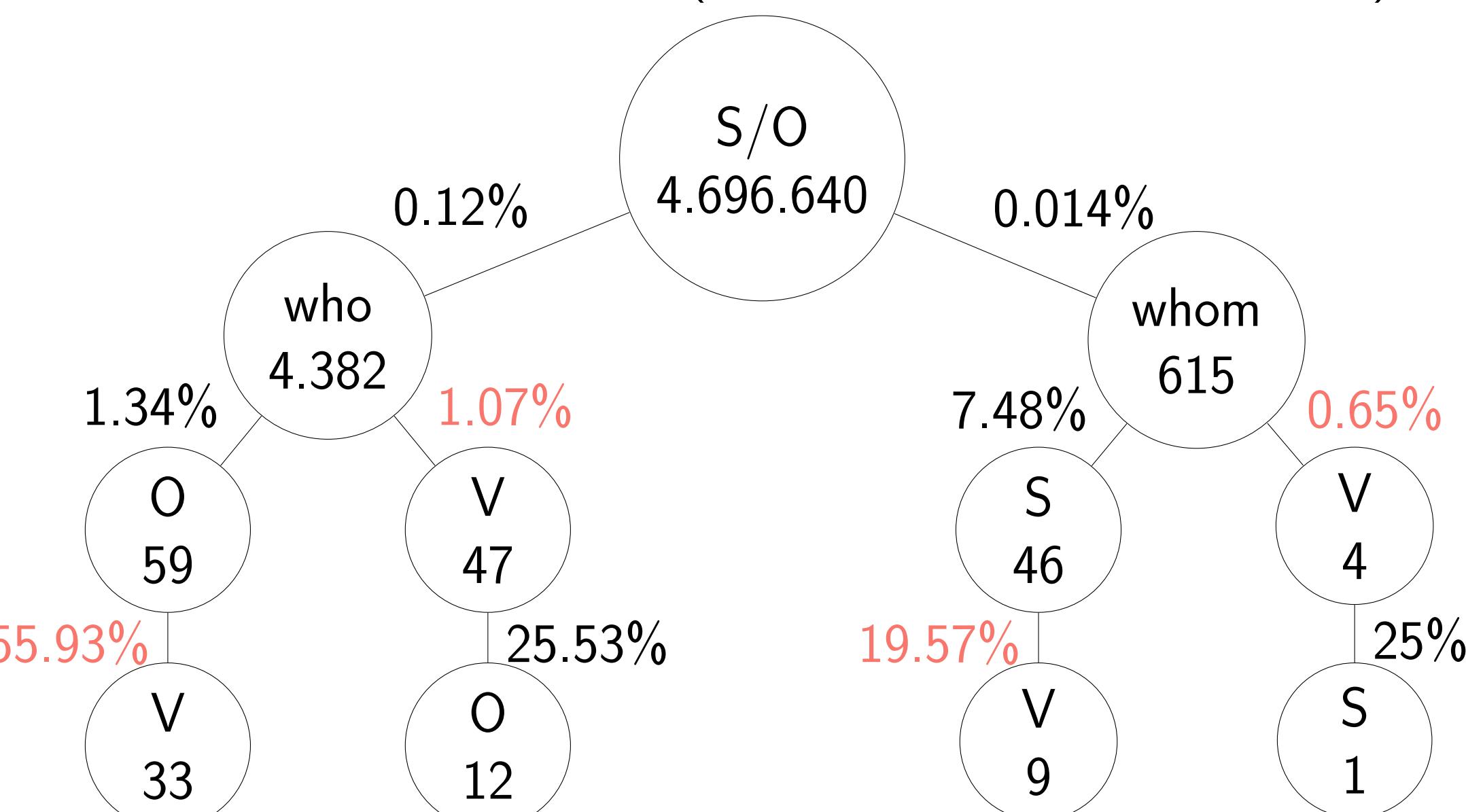
- Memory: Word orders with **local**/shorter filler-verb dependencies **less costly** (2a, 3a) than non-local ones (2b, 3b), irrespective of SRC/ORC. → RC verb
- Expectation: Different predictions, based on probability estimates.
 - Local structures more costly** to process. → RC verb
 - General advantage for SRCs. → relative pronoun

- ① Overall frequency: from Hungarian National Corpus (Oravecz, et al. 2014).

Structure	Count	Searches
SRC, local	44	(Det) N.nom (,) Rel.Pronoun.nom V.3sg (Det) N.acc
SRC, non-local	466	(Det) N.nom (,) Rel.Pronoun.nom (Det) N.acc V.3sg
ORC, local	26	(Det) N.nom (,) Rel.Pronoun.acc V.3sg (Det) N.nom
ORC, non-local	50	(Det) N.nom (,) Rel.Pronoun.acc (Det) N.nom V.3sg

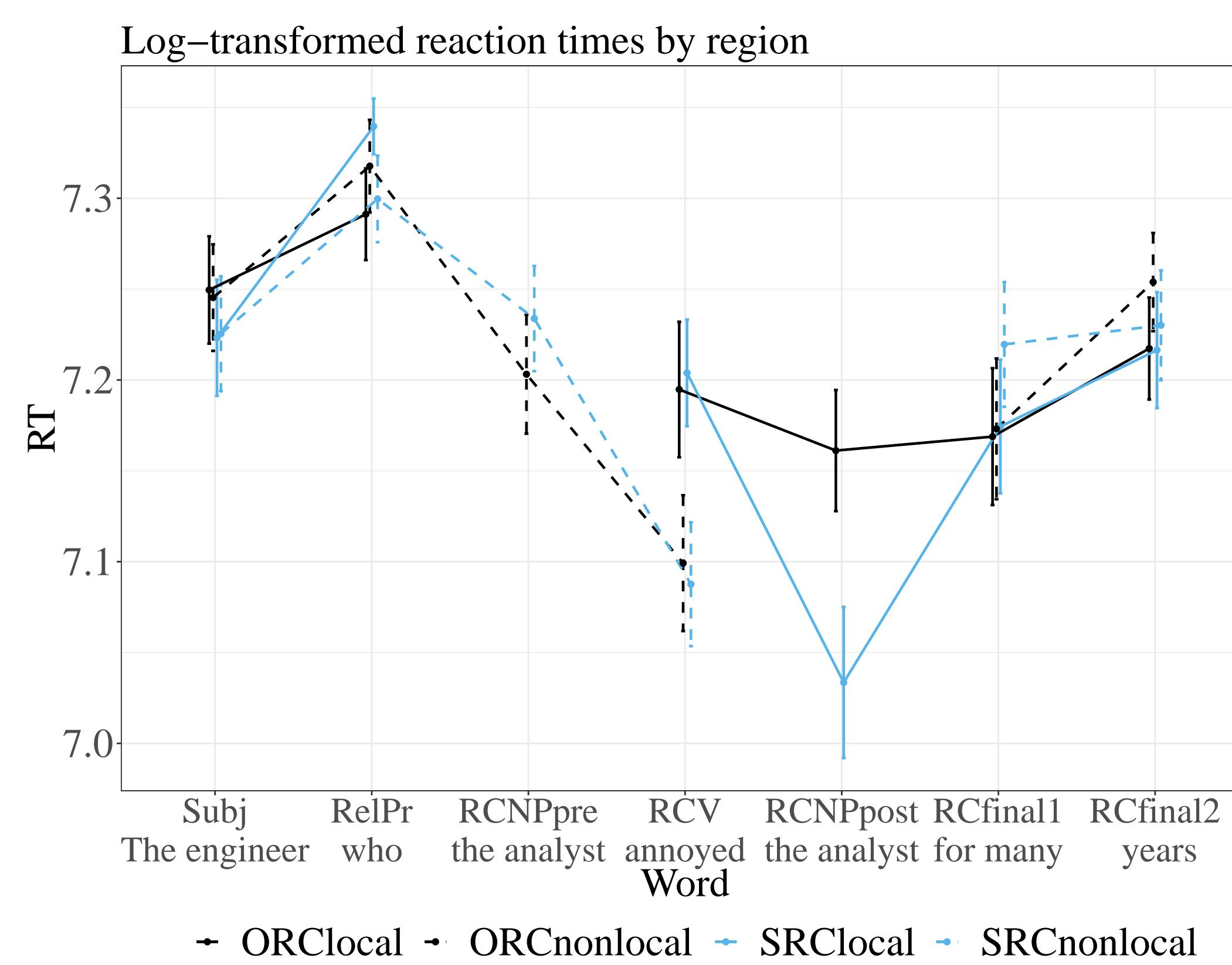
- ② RCs=syntactically constrained context; additional pre-V material helps sharpen expectations about the location and identity of V → facilitate processing of V.

- ③ Incremental counts and probabilities (based on Oravecz, et al. 2014).



Results of Exp. 1

- Trials with incorrectly answered comprehension questions were excluded.
- RCfinal regions represent PPs.
- RCNP appears pre- and post-verbally on the plot, depending on condition.



Predicting RT by RC status * locality, taking into account RT on previous word.

- RC verb region:** Effect of locality ($p<0.01$): **longer RT for local sentences**.
- RelPr region:** No effect, despite SRC-ORC disambiguation (RC status, $p=0.49$).

Supports the prediction of Expectation, but not Memory-based accounts.

Experiment 2: context manipulation

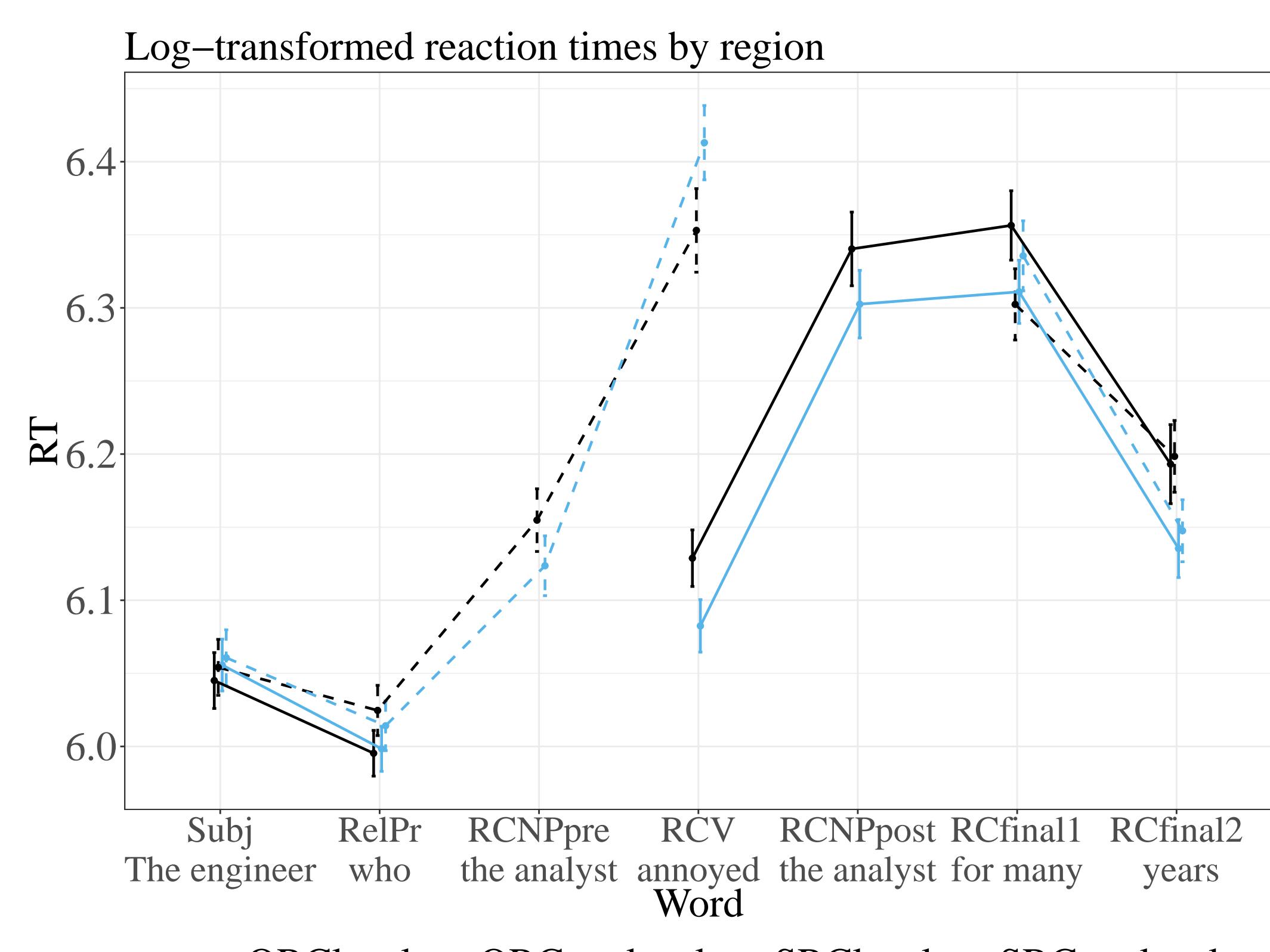
- No effect of expectation at RelPr: RCs are so infrequent that the surprisal of an RC parse obscures the SRC-ORC difference?
- Support: RT on RelPr was the highest in the whole sentence in Exp. 1.
- Prior research: RC-biasing contexts are known to **help avoid ambiguity with main clause** interpretation (see i.a. Gibson & Wu, 2013).

Context story: Mary is working together with two engineers on a project. She received a report on Sunday, but didn't know which engineer wrote it. She asked her secretary.

SPR: The secretary replied: The engineer who annoyed the analyst for many years was the one who wrote a report about the project.

Same experimental setup. 67 native monolingual participants.

Results of Exp. 2



- RC verb region:** Effect of locality ($p<0.001$): **longer RT for non-local sentences**. (Interaction also significant, $p<0.01$.)
- RelPr region:** Context seems to have reduced overall RT, but predicted SRC-ORC difference still does not arise (RC status, $p=0.76$).

Supports the prediction of Memory, rather than Expectation accounts.

Discussion

- When participants are already biased towards RC structures: shorter filler-gap dependencies are easier to process – **locality effect**.
- Otherwise, complexity is dominated by **incremental probabilistic update**.
- Two potential directions:
 - More fine-grained probability estimates under context are needed.
 - Another possibility is that online probabilistic update and online dependency building are two independent mechanisms.

Conclusion

- Hungarian RCs tease apart the predictions of Expectation and Memory accounts: both capture RC processing, but under different conditions.
- In the **absence of context**, Expectation prevails.
 - However, in **RC-biasing contexts**, Memory is supported.