

# HuMaze – Testing Hungarian relative clause processing in the Maze-task

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# Relative clause processing asymmetry

## Subject relative clause (Subject RC)

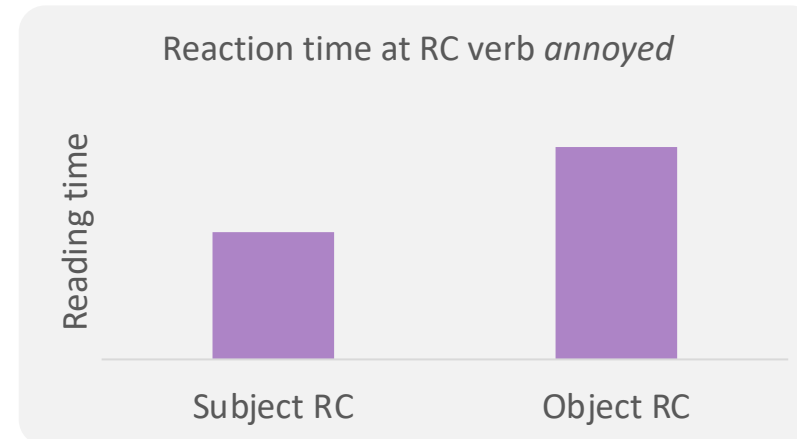
The engineer [who **annoyed** the analyst] wrote a report about the project.

## Object relative clause (Object RC)

The engineer [who the analyst **annoyed**] wrote a report about the project.

Object RC is **harder to process**

(i.a., Gibson, 1998, 2000; King & Just, 1991; Staub, 2010; Staub et al., 2017; Traxler et al., 2002)



# Two families of accounts

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## 1. **Expectation-based accounts** (i.a., Hale, 2001; Levy, 2008)

Evidence: i.a., Carreiras et al., 2010; Holmes & O'Regan, 1981; Cohen & Mehler, 1996; Hsiao & Gibson, 2003; Gibson & Wu, 2013

## 2. **Memory-based accounts** (i.a., Gibson, 1998; Lewis & Vasishth, 2005)

Evidence: i.a., Vasishth & Lewis, 2006; Konieczny, 2000; Levy & Keller, 2013; Nakatani & Gibson, 2008; Ueno & Garnsey, 2008; Kwon et al., 2010; Jäger et al., 2015; Wu et al., 2017

# Expectation-based account

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Comprehenders **predict upcoming structure** based on previous experience

**The more expected** a word is in its context, **the easier** it is to process

$$\text{difficulty} \propto -\log P(w_i | w_{1 \dots i-1}, \text{CONTEXT})$$

Surprisal

Estimated based on corpus frequencies

English **Subject RCs are more frequent** than Object RCs

→ captures processing asymmetry

# Memory-based account

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Syntactic **structure is built incrementally**

Integrating new words requires working **memory resources**

Subject RC: **The engineer** [who **annoyed** the analyst] wrote a report.



Object RC: **The engineer** [who the analyst **annoyed**] wrote a report.

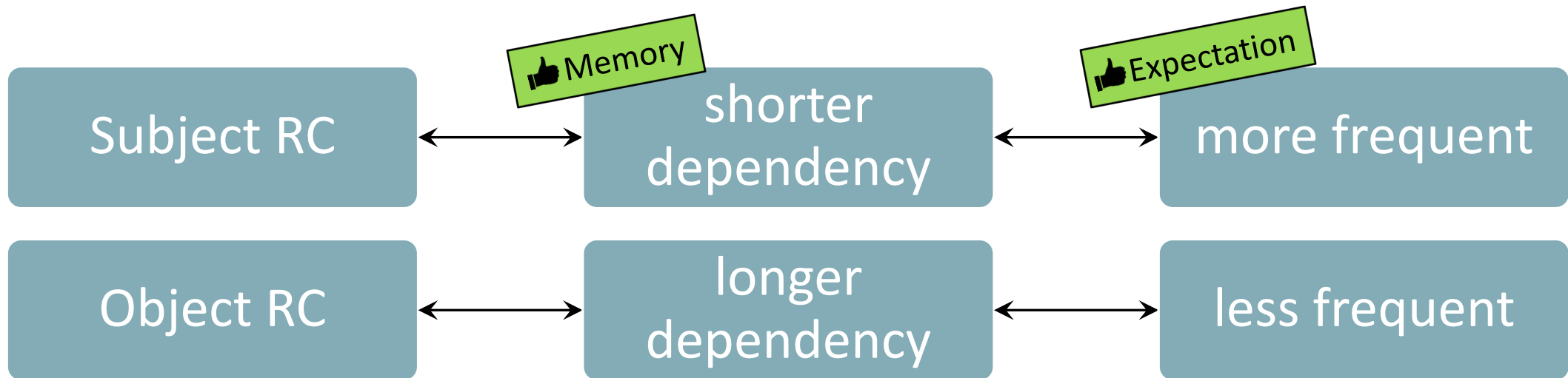


Object RC requires a **longer dependency** → captures processing asymmetry

**Cost:** retrieval, storage, integration, similarity-based interference

# Converging predictions in English


Memory- and expectation-based accounts both capture the English asymmetry



# Hungarian: flexible word order

## Subject RCs with short and long dependencies

A mérnök [aki idegesítette az elemzőt ] beszámolt a projektről.  
The engineer [who.NOM annoyed the analyst.ACC ] reported the project-on



A mérnök [aki az elemzőt idegesítette ] beszámolt a projektről.  
The engineer [who.NOM the analyst.ACC annoyed ] reported the project-on




**Both:** 'The engineer who annoyed the analyst wrote a report about the project.'

# Hungarian: flexible word order

## Object RCs with short and long dependencies

A mérnök [akit idegesített az elemző ] beszámolt a projektről.  
The engineer [who.ACC annoyed the analyst.NOM ] reported the project-on



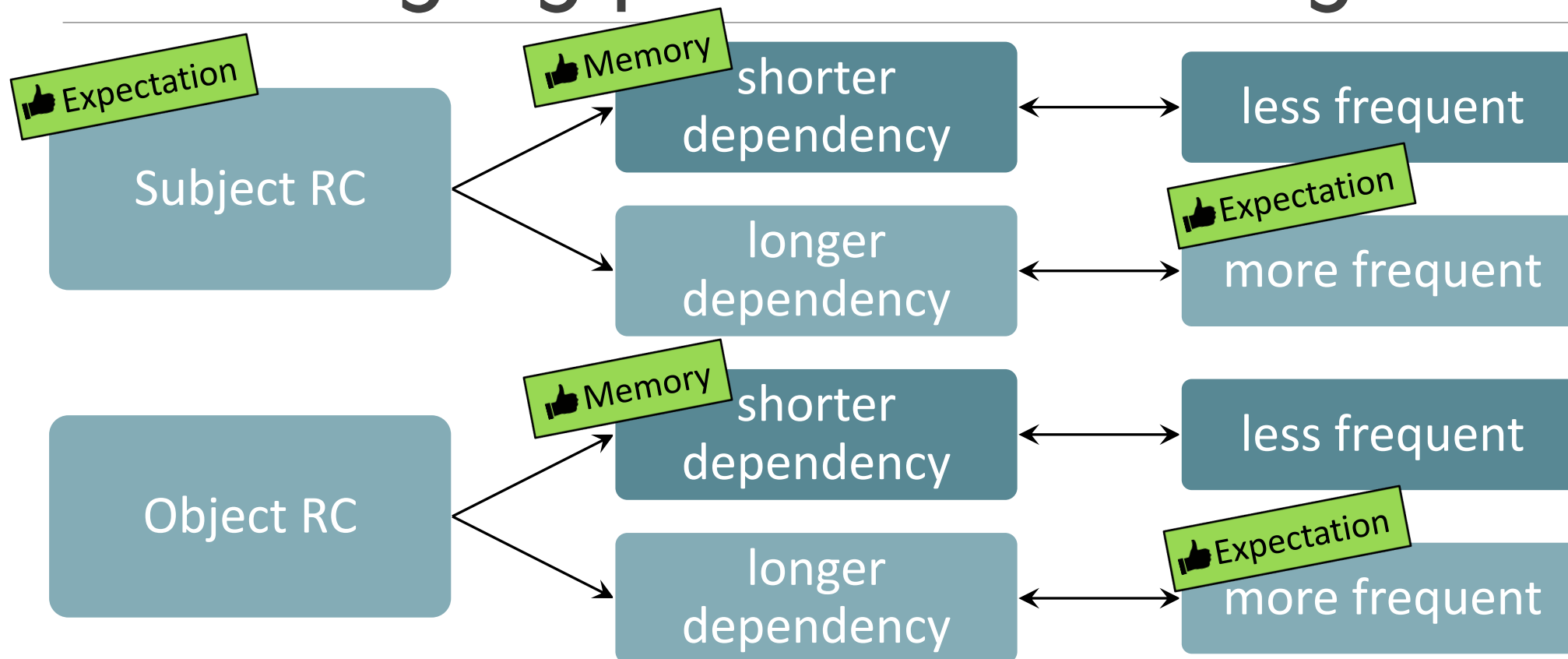
A mérnök [akit az elemző idegesített ] beszámolt a projektről.  
The engineer [who.ACC the analyst.NOM annoyed ] reported the project-on



**Both:** 'The engineer who the analyst annoyed wrote a report about the project.'



# Disentangling predictions in Hungarian



frequencies extracted from the Hungarian National Corpus  
(Oravecz et al. 2014)

# More fine-grained predictions

## Memory accounts

longer dependencies harder

**local < non-local**

## Expectation accounts

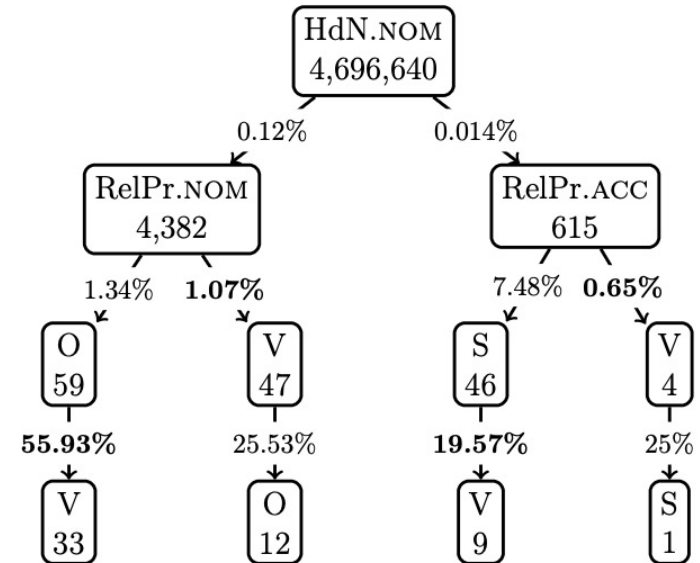
less frequent harder

**non-local < local**

## Location: **RC Verb**

- place of verb-argument integration

- anti-locality effect



: Incremental counts and probabilities (based on the Hungarian National Corpus)

(as reported by Ronai & Xiang, 2023)

# More fine-grained predictions

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Relative pronoun **case marking signals RC structure** (aki vs. akit)

## Expectation accounts

SRCs globally more frequent than ORCs

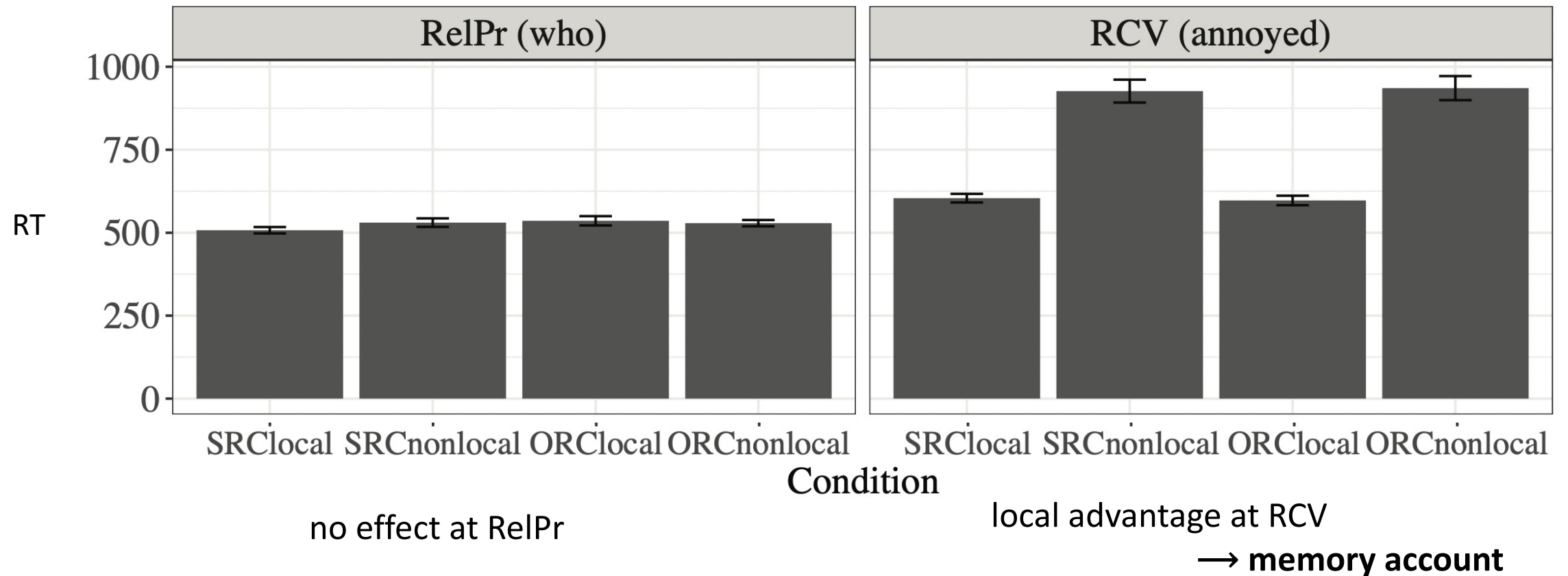
**Easier processing for SRCs at Rel. Pronoun**

## Memory accounts

**No difference at Rel. Pronoun**

# Prior work using self-paced reading

Ronai & Xiang's (2023) SPR experiments:



# Russian RCs in SPR vs. eye-tracking

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**Russian RCs** have very similar properties:

- Case-marking disambiguates SRC vs. ORC at relative pronoun
- Word order flexibility

**Relative pronoun:** SRC < ORC prediction

- No clear effect found in SPR (Levy et al., 2013; Price & Witzel, 2017)
- **Confirmed in eye-tracking** while reading (Price & Witzel, 2017)

# Lexical Maze-task

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Sentence presented as **series of lexical decisions**

## Effect localization & web reliability

Boyce, Futrell & Levy 2020; Vani, Wilcox & Levy 2021

hogy

e

katy

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## Replicates results found in **other methodologies**

Boyce, Futrell & Levy 2020; Forster, Guerra & Elliot 2009; Witzel, Witzel & Forster 2009

# Creating L-maze for Hungarian

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Custom language extension for Wuggy (Python Version)

Keuleers & Brysbaert 2010; <https://github.com/WuggyCode/wuggy>

Cleaned Hungarian Webcorpus

Halácsy et al., 2004; Kornai et al., 2006

Automated naïve syllable structures

Deployed in PCIBex

Boyce, Futrell & Levy 2020; Zehr & Schwarz 2022

# Experimental manipulation

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2-by-2 design: RC type (SRC vs. ORC) x word order (local vs. non-local)

(Levy et al., 2013; Ronai & Xiang, 2023)

(3) a. SRC, VO (local)

A mérnök, aki idegesítette az elemzőt...  
the engineer.NOM who.NOM annoyed the analyst.ACC

b. SRC, OV (non-local)

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...).’

(4) a. ORC, VS (local)

A mérnök, akit idegesített az elemző...  
the engineer.NOM who.ACC annoyed the analyst.NOM

b. ORC, SV (non-local)

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...).’

SRC (local): I mulnád, epi reedenítálye éz elegült náp súl áze, bagyágort ö kroluktród.

ORC (non-local): I mulnád, epit éz elegül reedenítály náp súl áze, bagyágort ö kroluktród.



# Recap of predictions

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## RC Verb Position

### Memory

local < non-local

### Expectation

non-local < local

## Rel. Pronoun

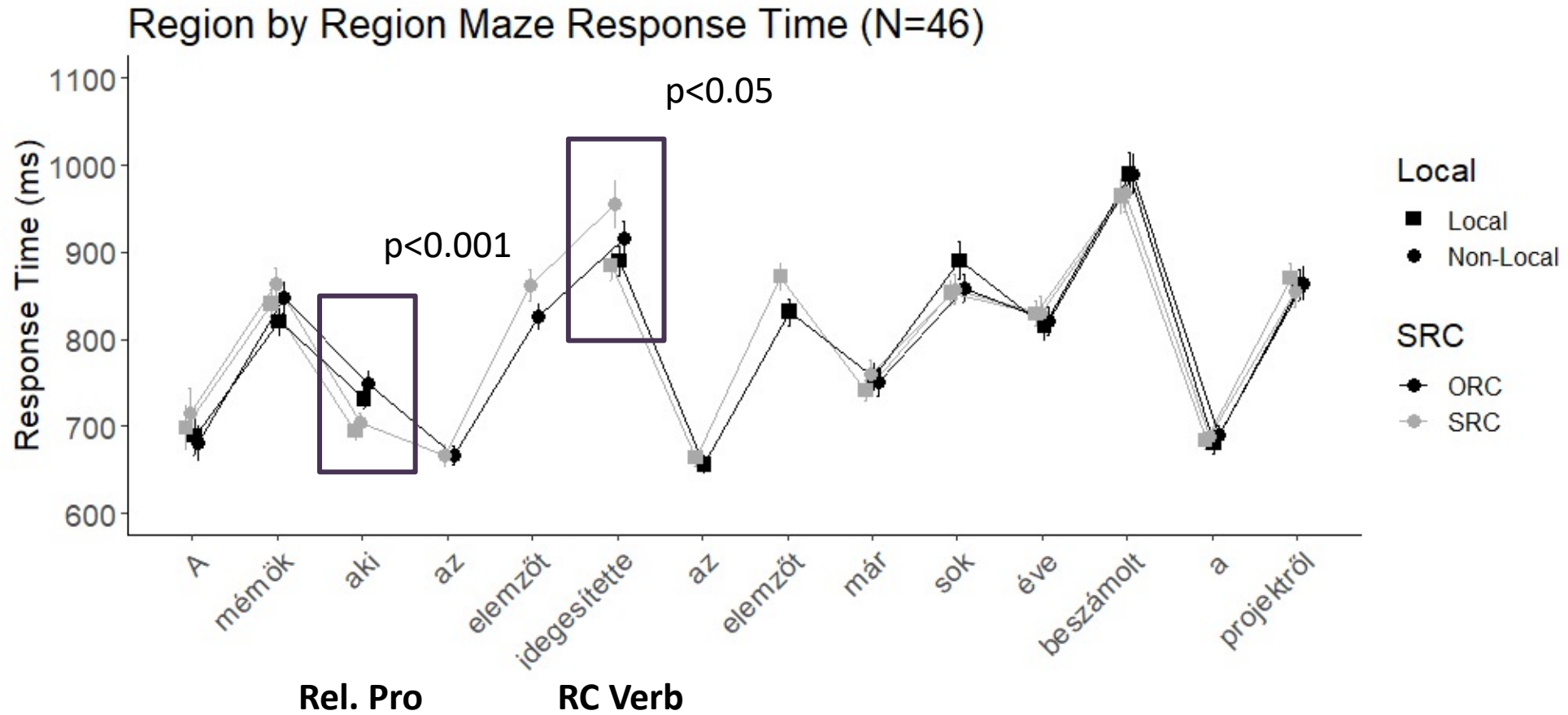
### Memory

No differences

### Expectation

SRCs < ORCs

# Results



# Conclusion

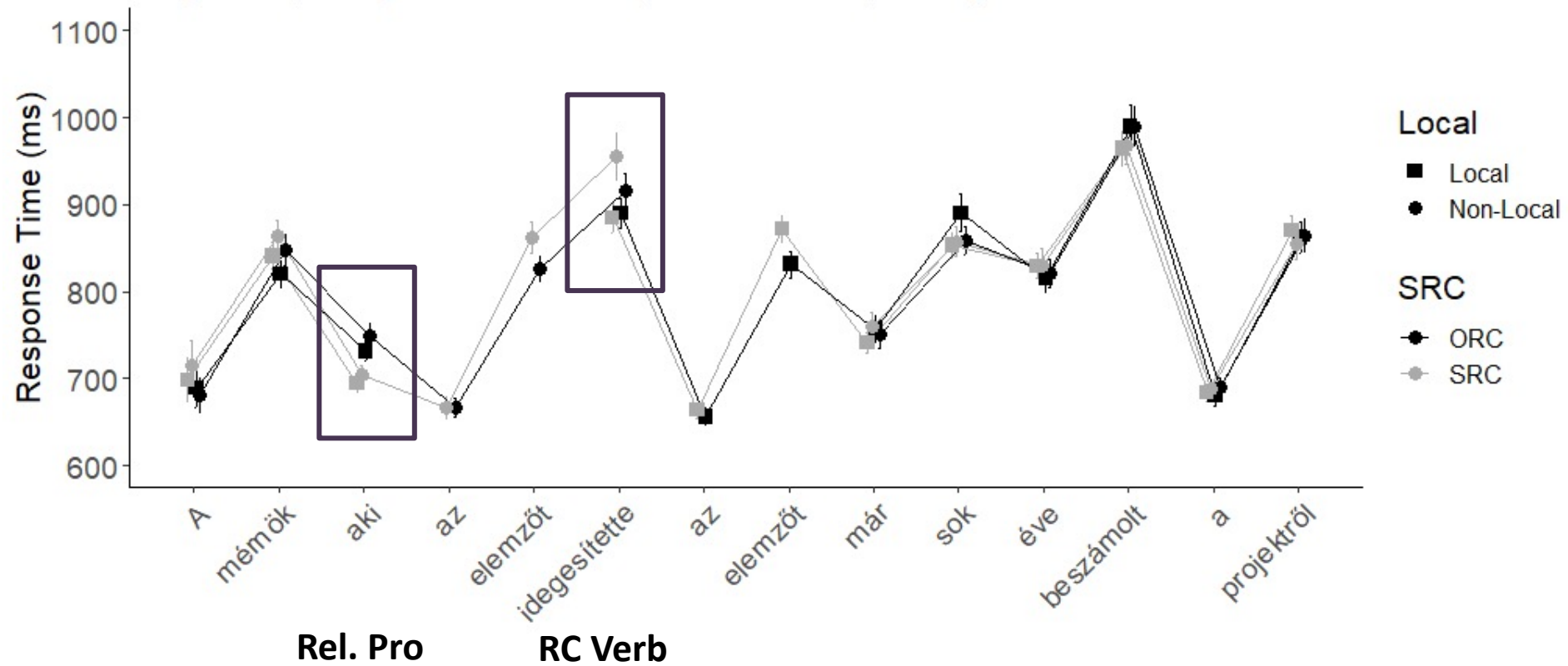
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Adaptation of **maze-task** to a **language understudied** in psycholinguistics

Captured predicted effects:

- **RC verb** → favors **memory** accounts
  - Replication of previous results from Hungarian SPR
- **Relative pronoun** → favors **expectation** accounts
  - Evidence for effect that has not been detected with Hungarian SPR
  - Lexical Maze can be useful method for capturing elusive effects

Region by Region Maze Response Time (N=46)



Thank you!

# Selected references

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