Explanation coherence inside sentences, but only offline

Runyi Yao, Kelsey Sasaki, Daniel Altshuler and E. Matthew Husband

Faculty of Linguistics, Philology, and Phonetics, University of Oxford

FACULTY OF LINGUISTICS, PHILOLOGY AND PHONETICS

Coherence in Sentence Processing

A crucial task for comprehenders to understand discourse is determining **coherence** relations between linguistic units:

- Comprehenders can **generate expectations** about **coherence relations** between sentences [1][2][3] and relative clauses [4], reflected in, e.g., **faster processing** when text matches coherence expectations.
- E.g., *The boss <u>fired</u> the employee who was* [*late*]$_{causal-faster}$/[*tall*]$_{neutral-slower}$.

<u>Intra-sentential coherence</u> has also been observed but not explored experimentally:

- E.g., *A jogger/teacher was hit by a car* ⤳ 'hit while jogging/*teaching' [5]

★ **QUESTION**

Will **intra-sentential explanation coherence driven by resultative adjectives** (e.g., *broken, injured*) affect sentence processing?
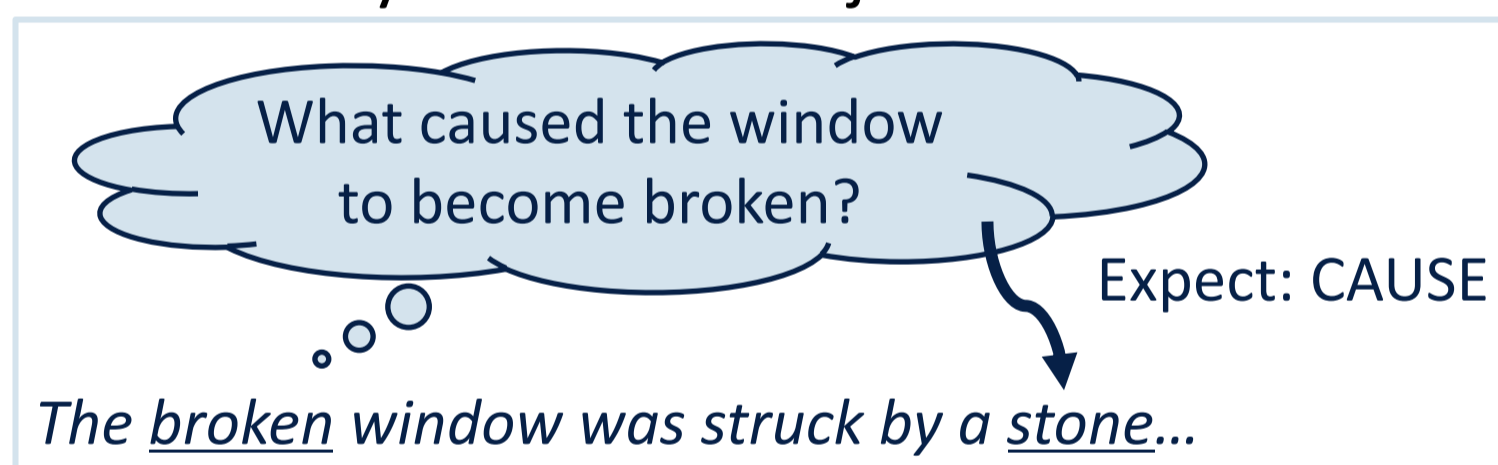
Causality, Temporal Relation and Topichood

Causal relations depend on <u>temporal relations</u>:

- To permit an explanation relation between the resultative adjective (e.g., *broken*) and the verb (e.g., *struck*), the NP (e.g., *the broken window*) needs to be **temporally independent**.
- **Topics** can be interpreted outside the scope of an event quantifier [6], while subjecthood and definiteness modulate whether the NP can be the topic of the sentence; i.e., **Definite** NPs are presuppositional and can serve as topics when they are **subjects** [7][8]. E.g., sentences in the **Passive-Definite** condition may be interpreted as (a) while others may be interpreted as (b):

(a) $\exists x[window(x) \& \exists s[broken(s) \& In(s,x)] \& \exists e[strike\text{-}with\text{-}a\text{-}stone(e) \& Theme(e,x)]] \rightsquigarrow e_s = e$

(b) $\exists e[strike\text{-}with\text{-}a\text{-}stone(e) \& \exists x[Theme(e,x) \& window(x) \& \exists s[broken(s) \& In(s,x)]]] \vDash e_s \prec e$

Hypotheses

Main Hypothesis: Grammatical cues can guide both online and offline processing of intra-sentential explanation coherence driven by resultative adjectives.

H1: Resultative adjectives can give rise to intra-sentential causal coherence relations, perhaps by raising the sub-QUD, 'What event caused this state?'

> What caused the window to become broken?
> Expect: CAUSE
> *The <u>broken</u> window was struck by a <u>stone</u>…*

H2: Explanation coherence is governed in part by the grammatical cues of Structure (Passive/Active) and Definiteness (Definite/Indefinite) related to topichood.

H3: The resultative adjective may trigger an expectation for an upcoming explanation. Therefore, like inter-sentential coherence, intra-sentential explanation coherence can also facilitate online processing via an expectation-based mechanism.

Sample Experimental Item

Structure	Definiteness	Coherence (expected)	Sentence
Passive	*Definite*	Yes	The broken window was struck by a <u>stone</u> from the sidewalk next to the building.
Passive	Indefinite	No	A broken window was struck by a <u>stone</u> from the sidewalk next to the building.
Active	*Definite*	No	Bethany struck the broken window with a <u>stone</u> from the sidewalk next to the building.
Active	Indefinite	No	Bethany struck a broken window with a <u>stone</u> from the sidewalk next to the building.
Question			Was the window broken because of the stone?

Exp1: Offline Processing

Comprehension Task

- Written and hosted on PCIbex Farm.
- 48 Prolific-recruited native English speakers, 40 experimental items and 40 fillers.
- 7-point Likert scale, where 1 = definitely yes, 7 = definitely no.
- Prediction: The **Passive-Definite** condition would receive **lower** scores than others.

Results

Responses for Experimental items / Responses for Filler items
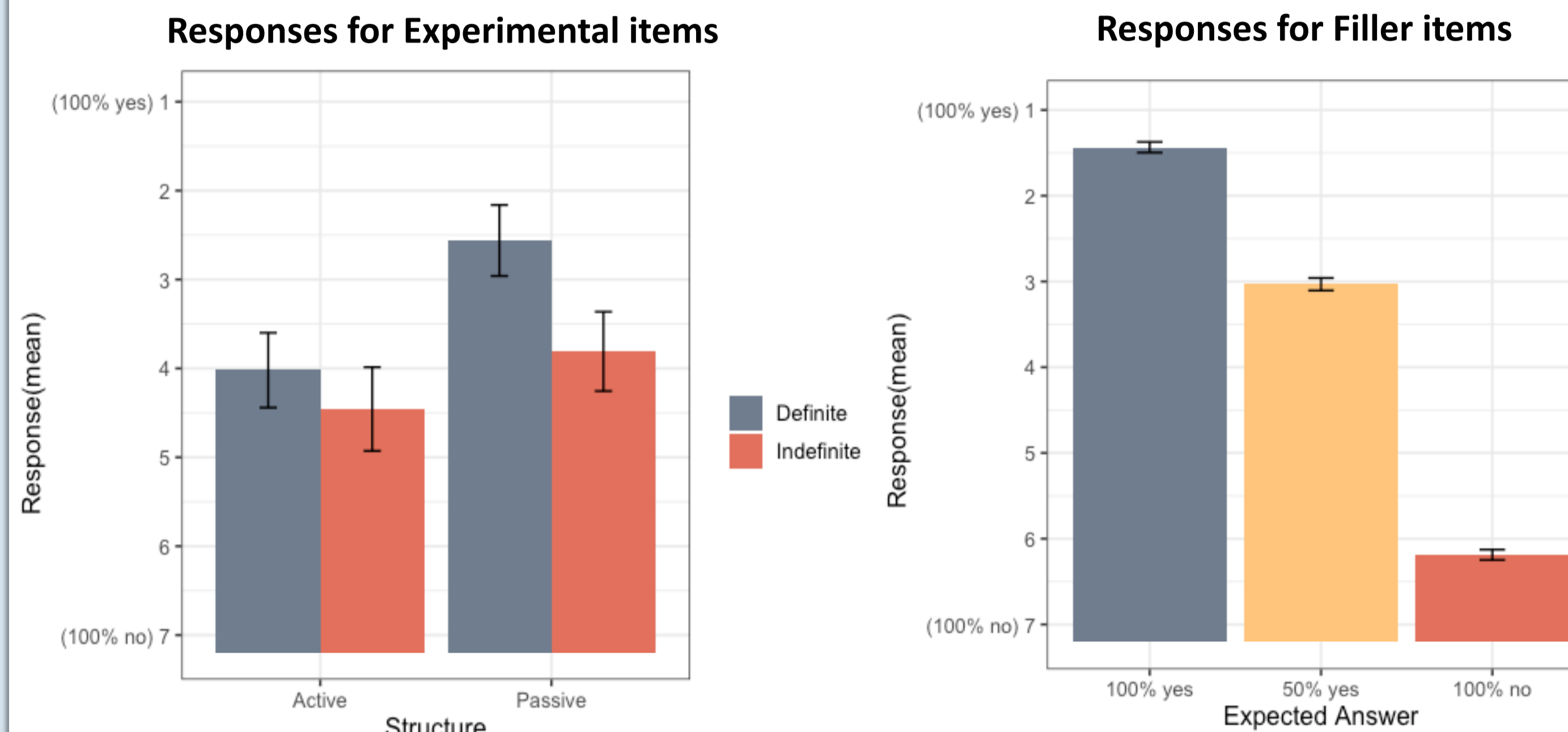
Fixed Effects in Cumulative Link Mixed Model

	Est	SE	z	Pr (> |t|)
Structure	-1.03	0.19	-5.43	<.001***
Definiteness	-0.80	0.14	-6.14	<.001***
Interaction	-0.83	0.26	-3.23	.0013**

Pairwise Comparisons

Contrast: Definite - Indefinite				
	Est	SE	z	Pr (> |t|)
Active	-0.44	0.15	-2.85	.0044**
Passive	-1.25	0.21	-5.86	<.001***

Results & Discussion

- Average ratings of experimental items across all conditions were **intermediate compared to that of fillers**, while the responses to the fillers demonstrated that participants made use of the full scale:
  > Evidence that, overall comprehenders tend to infer Explanation relations between resultative adjectives and associated instruments within sentences.
- Explanation inference was **strongest** in the **Passive-Definite** condition, as we predicted:
  > Suggests that comprehenders used Definiteness and Structure as cues when establishing Explanation relations in offline processing.

Sample Fillers in Exp1

Expected Answer	Sentence	Question
100% yes	Jenny had a delicious dinner last Friday with her best friend in an Italian restaurant.	*Did Jenny have dinner with her best friend last week?*
50% yes	Judy believed that she could be the best student in her class.	*Was Judy the best student in her class?*
100% no	The teacher scolded the naughty student.	*Was the student naughty because the teacher scolded him?*

Exp2: Online Processing

Word-by-word self-paced reading

- Written and hosted on PCIbex Farm.
- 101 Prolific-recruited native English speakers, 40 experimental items and 40 fillers.
- Critical words (CWs): the instruments (e.g., *stone*).
- Prediction: CWs or spillovers in the **Passive-Definite** condition would be read **faster**.

Results

Model Estimated Reading Times (msec)
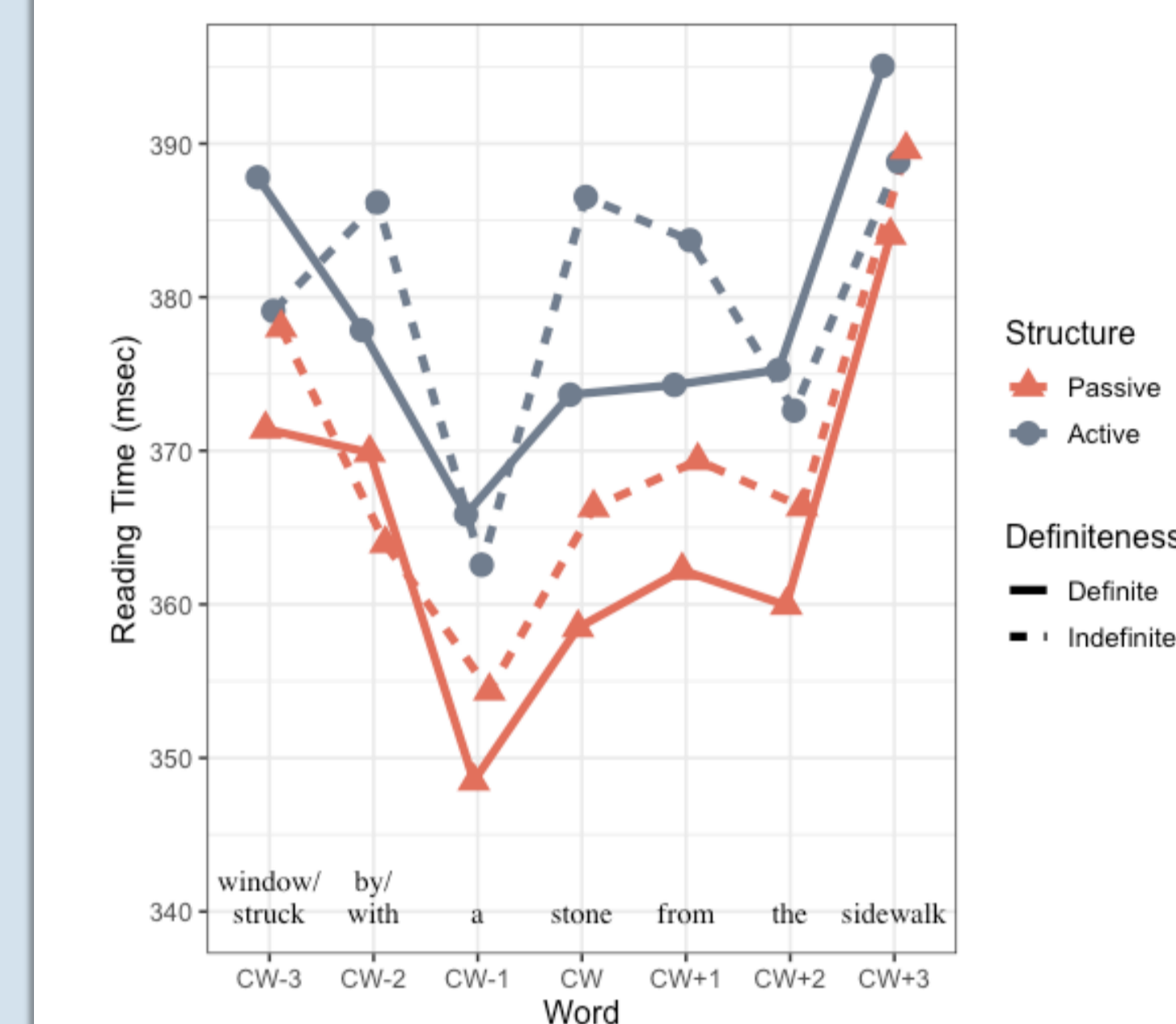
Fixed Effects in Linear Mixed Effects Model
Between CW-2 and CW+2

CW-2	Est	SE	t	Pr (> |t|)
Structure	-15.10	5.83	-2.59	.0124*
Definiteness	-1.20	4.76	-0.25	.8013
Interaction	14.24	10.45	1.27	.2107

CW-1	Est	SE	t	Pr (> |t|)
Structure	-12.78	5.17	-2.47	.0167*
Definiteness	-1.29	4.62	-0.28	.7806
Interaction	-9.15	10.45	-0.88	.3839

CW	Est	SE	t	Pr (> |t|)
Structure	-17.69	7.39	-2.39	.0198*
Definiteness	-10.35	5.81	-1.78	.0791.
Interaction	5.04	11.58	0.44	.6641

CW+1	Est	SE	t	Pr (> |t|)
Structure	-13.21	5.86	-2.25	.027*
Definiteness	-8.29	5.33	-1.55	.127
Interaction	2.28	11.60	0.20	.845

CW+2	Est	SE	t	Pr (> |t|)
Structure	-10.80	5.25	-2.06	.0435*
Definiteness	-1.88	5.64	-0.33	.7399
Interaction	-9.06	11.47	0.79	.4322

Results & Discussion

- **No interaction** was found between CW-3 and CW+3, contra our prediction :
  > Suggests establishing Explanation relation does not speed real-time processing.
  > May indicate that comprehenders do not establish—or at least do not leverage—intra-sentential coherence in online processing.
- The effects of Structure we found between CW-2 and CW+2 were perhaps due to **a higher expectation for prepositional phrases** in the passive conditions:
  > Passives might be **more frequently** followed by a PP.
  > Compare: *The broken window was struck (by a stone).* vs. *Bethany struck the broken window (with a stone).*

General Discussion

The **asymmetry** between the offline study and the online study suggests:

- Comprehenders can use Definiteness and Structure to guide Explanation Coherence between a resultative adjective and an instrument within a sentence, but **only in offline processing**.
- Perhaps comprehenders can only establish such relations when **cued by comprehension questions** that prime them to think about the **QUD**, as they were in Exp 1.
- It is also possible that there are some online effects, but **the SPR reading time may not be fine-grained enough** to capture them.

Future research

As prior research on inter-sentential coherence finds online effects in **rereading times** and/or **total reading times** [4][10], our ongoing study is using eye tracking to investigate **whether later eye movement measures reveal online processing effects of intra-sentential coherence**.

Selected References

[1] Rohde, H. (2008). *Coherence-driven effects in sentence and discourse processing*. University of California, San Diego. [2] Grüter, T., Takeda, A., Rohde, H. & Schafer, A. J. (2018). Intersentential coreference expectations reflect mental models of events. *Cognition*, 177, 172–176. [3] Hoek, J., Rohde, H., Evers-Vermeul, J. & Sanders, T. (2020). Scolding the child who threw the scissors: Shaping discourse expectations by restricting referents. *Language, cognition and neuroscience*. [4] Hoek, J., Rohde, H., Evers-Vermeul, J. & Sanders, T. J. (2021). Expectations from relative clauses: Real-time coherence updates in discourse processing. *Cognition*, 210(1), 104581. [5] Hobbs, J. R. (1990). *Literature and cognition* (No. 21). Center for the Study of Language (CSLI). [6] Herburger, E. (2000). *What counts: Focus and quantification*. MIT Press. [7] Musan, R. (1999). Temporal interpretation and information-status of noun phrases. *Linguistics and philosophy*, 621-661. [8] Gundel, J. K., & Fretheim, T. (2004). Topic and focus. *The handbook of pragmatics*, 175(196), 12. [9] Nedjalkov, V. P. (1988). *Typology of resultative constructions*. John Benjamins Publishing. [10] Scholman, M. C., Rohde, H. & Demberg, V. (2017). "on the one hand" as a cue to anticipate upcoming discourse structure. *Journal of Memory and Language*, 97, 47–60.

Contact: runyi.yao@ling-phil.ox.ac.uk