Incremental interpretation of clause-internal coherence: Evidence from the Maze

THE UNIVERSITY of EDINBURGH

KELSEY **SASAKI***   DANIEL **ALTSHULER***   HANNAH **ROHDE**†

daniel.altshuler@ling-phil.ox.ac.uk | *University of Oxford †University of Edinburgh | XPRAG 2025

UNIVERSITY of OXFORD

Background: Coherence inferences

- Coherence theories largely focus on cross-clausal inferences [1,2].

- Less is known about clause-internal coherence (**CIC**) inferences (see (b)) [3,4], but adjectives may participate in CIC inferences with verbs [5,6].

  (a) Alice fell. Betty pushed her.   (b) A scared mouse was chased by a cat.

- Nouns can also participate in CIC inferences [7]:

  (c) Alice congratulated a {winner / champion}.   = Explanation
  (d) Alice congratulated a {reader / bookworm}.   = Background

How incremental is clause-internal coherence interpretation?

Comprehenders can draw clause-internal coherence (CIC) inferences offline:

- e.g., *The scared mouse was chased by the cat.* ➡ the mouse was scared because the cat chased it

  Do comprehenders build CIC inferences online? If so, when?

Insights from psycholinguistic data

Sentence-internal coherence inferences can be built incrementally [8, 9]

Explanations can be rapidly inferred between matrix and relative clauses:

Causal RC	Diane fired the guy from the London office who was embezzling money {because / and so} astoundingly he hired a stripper for the Christmas party.
Non-causal RC	Diane fired the guy from the London office who was here last month {because / and so} astoundingly he hired a stripper for the Christmas party.

Incremental processing advantage for causal coherence inferences [8, 9, 10]

Causal RC	She voted for the candidate **that has a progressive platform**, Pat Mirabella.
Non-causal RC	She voted for the candidate **that has a big mustache**, Pat Mirabella.

❖ **What happens within a single clause (verb~noun CIC)?**

Testing incremental verb~noun CIC inferences

❖ Are causal CIC inferences (e.g., Explanation) easier than Background?
❖ Are CIC inferences integrated at the noun?
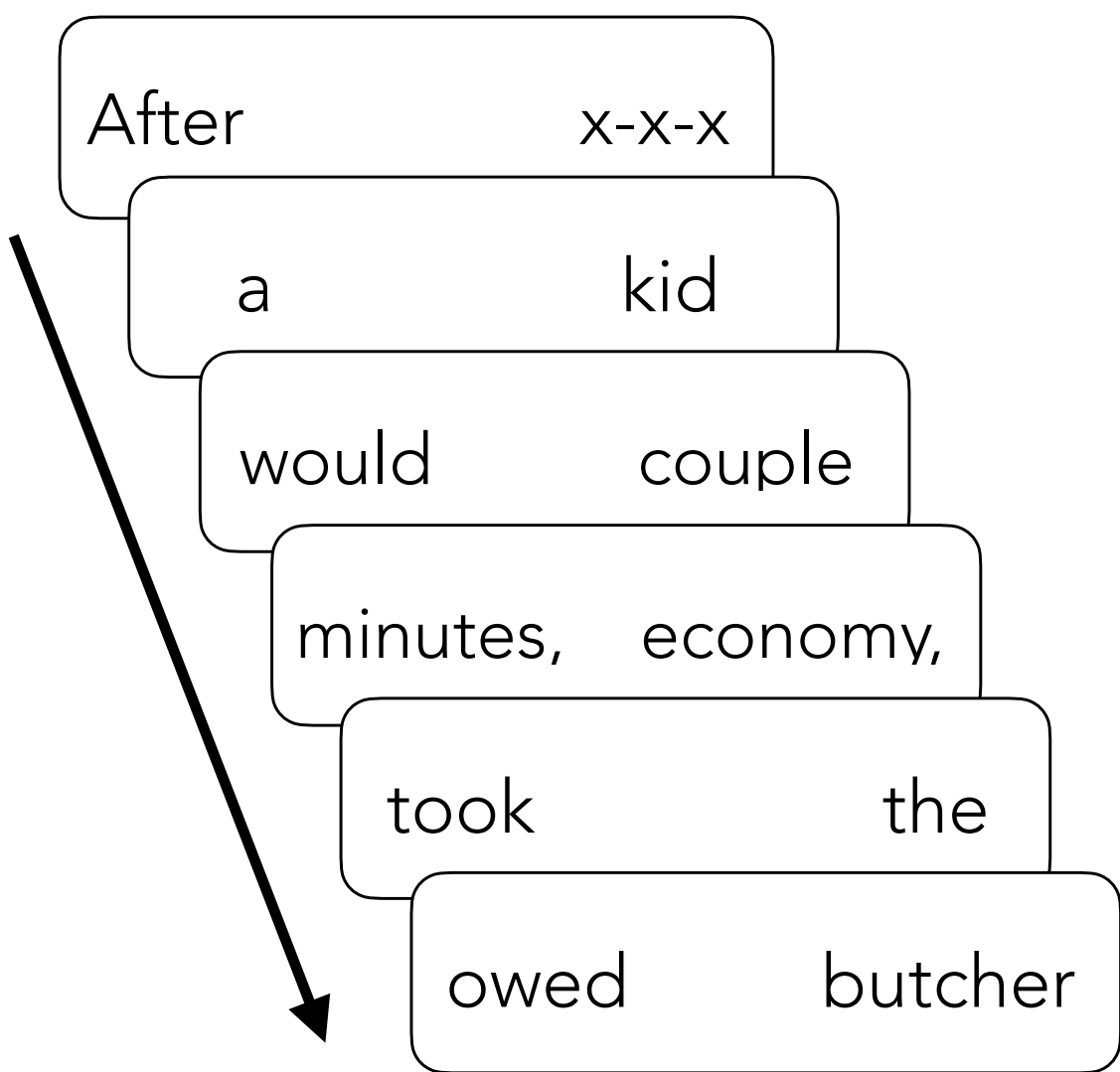❖ Does noun type matter (deverbal vs non-deverbal)? [5, 7]

Norming study (n = 36)

To ensure *because* serves as a reliable Explanation cue, we selected our test items by norming 41 2-sentence narratives adapted from our prior offline studies [7]:

△ For Causal CIC	Alice congratulated Bob. He had broken a world record.
○ For Non-causal CIC	Alice congratulated Bob. He had finished reading ten long book chapters.

How likely do you think it is that Alice congratulated Bob because he had {broken a world record / finished reading ten long book chapters}?

The Maze Task [11]

- Advance by choosing valid continuation
- Choosing foil terminates trial
- Success requires fully incremental processing
- Foils auto-generated [12], then manually revised

After	x-x-x
a	kid
would	couple
minutes,	economy,
took	the
owed	butcher

References [1] Asher, N. & A. Lascarides (2003). *Logics of conversation.* CUP. [2] Kehler, A. (2002). *Coherence, reference, and the theory of grammar.* CSLI. [3] Hobbs, J. (2010). *Constraints in Discourse, 2.* [4] Cohen, J. & A. Kehler. (2021). *Philosophers' Imprint, 21.* [5] Sasaki, K. & D. Altshuler. (2023). *Proceedings of SuB 27.* [6] Yao, R., E.M. Husband, & D. Altshuler. (2024). *Proceedings of SuB 28.* [7] Sasaki, K., H. Rohde & D. Altshuler. (to appear). *Proceedings of SuB 29.* [8] Hoek, J., H. Rohde, J. Evers-Vermeul & T.J.M. Sanders. (2021a). *Cognition,* 210. [9] Duff, J. (2023). Doctoral dissertation, UC Santa Cruz. [10] Hoek, J., H. Rohde, J. Evers-Vermeul & T.J.M. Sanders. (2021b). *Language, Cognition & Neuroscience* 36:3. [11] Forster, Kenneth I., Christine Guerrera, & Lisa Elliot. (2009). *Behavior Research Methods 41(1).* [12] Boyce, Veronica, Richard Futrell, & Roger Levy. (2020). *Journal of Memory and Language, 111.* [13] Duff, J., D. Altshuler & K. Sasaki. (to appear). *Proceedings of SALT 35.*

Our contribution:

Maze study on causal clause-internal coherence inferences involving nouns:
- Advantage for nouns that form a plausible clause-internal Explanation (α because β) with verb over nouns that do not
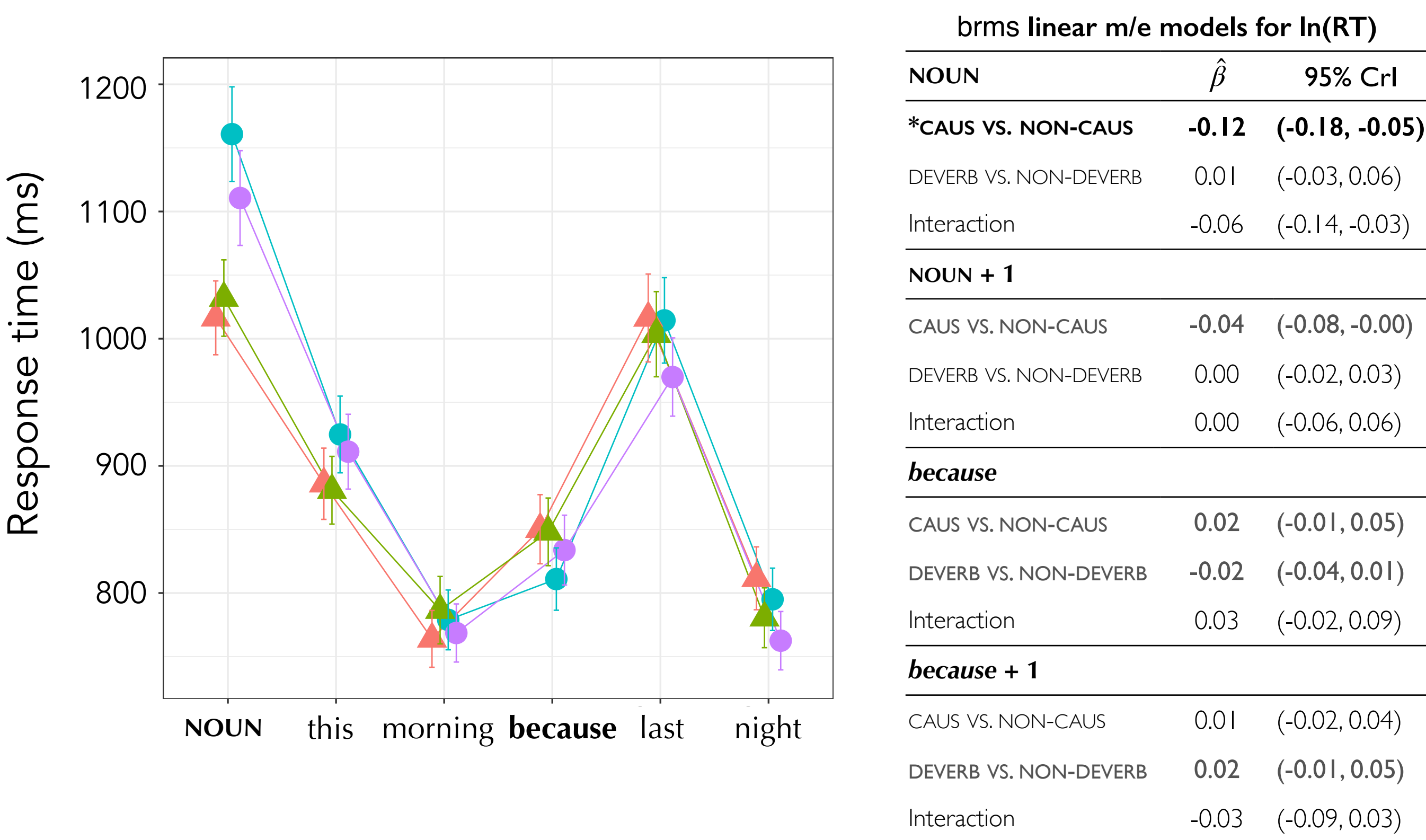- Results compatible with rapid commitment to clause-internal Explanation

CIC inferences are built incrementally in at least some cases.

Experiment (n = 57)

Best 32 narratives from norming study: strongest Explanation inference

Causal CIC Deverbal	Alice congratulated two **winners** this morning **because** last night they each broke a world record.
Non-causal CIC Deverbal	Alice congratulated two **readers** this morning **because** last night they each finished ten long chapters.
Causal CIC Non-deverbal	Alice congratulated two **champions** this morning **because** last night they each broke a world record.
Non-causal CIC Non-deverbal	Alice congratulated two **bookworms** this morning **because** last night they each finished ten long chapters.
Foils	x-x-x heterogeneous door **crowding** goal anymore **biggest** are worry say solution fund is hates movies.

brms linear m/e models for ln(RT)

NOUN	$\hat{\beta}$	95% CrI
*CAUS VS. NON-CAUS	-0.12	(-0.18, -0.05)
DEVERB VS. NON-DEVERB	0.01	(-0.03, 0.06)
Interaction	-0.06	(-0.14, -0.03)
NOUN + 1		
CAUS VS. NON-CAUS	-0.04	(-0.08, -0.00)
DEVERB VS. NON-DEVERB	0.00	(-0.02, 0.03)
Interaction	0.00	(-0.06, 0.06)
because		
CAUS VS. NON-CAUS	0.02	(-0.01, 0.05)
DEVERB VS. NON-DEVERB	-0.02	(-0.04, 0.01)
Interaction	0.03	(-0.02, 0.09)
***because* + 1**		
CAUS VS. NON-CAUS	0.01	(-0.02, 0.04)
DEVERB VS. NON-DEVERB	0.02	(-0.01, 0.05)
Interaction	-0.03	(-0.09, 0.03)

- Slowdown for Non-causal CIC at noun, in line with rapid CIC selection + causal advantage
- Marginal slowdown for Causal CIC at *because*, in line with rapid CIC selection

Discussion

Why only a marginal effect at *because*?
- Mixed findings on multiple Explanations in previous studies [8, 9]
- Previous findings suggest that discourse update/coherence interpretation is non-monotonic [13]—CIC interpretations may be relatively easy to reanalyze (vs. cross-clausal interpretations)

Could effect at noun be explained by verb-noun collocation frequency?
- Possibly, but question then arises as to why collocation frequencies would pattern that way in the first place
- Cognitive privilege for causal coherence ➡ higher collocation frequency for, e.g., *congratulate ~ winner/champion* vs. *congratulate vs. reader/bookworm*?

Next studies: Other CIC relations

Disentangling CIC effects from collocation frequency effects:
- Violated Expectation: *Alice congratulated the loser.*

What other CIC relations are possible? Are they built incrementally?
- Narration/Occasion: *The jogger was hit by a car.*
- Result: *The risk-taker was bitten by a crocodile.*
- Contrast: *The sprinter also jogs.*