

Cognitive control effects on the kindergarten path: Separating correlation from causation



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Background

Two properties of young children's real-time language comprehension:

- They incrementally use probabilistic cues to guide parsing decisions.¹
- Often fail to revise initial interpretations that conflict with late-arriving linguistic cues.²

Cognitive control modulates *adults'* ability to revise erroneous interpretations

- Improvement following cognitive control training predicts better sentence revision.³
- Real-time cognitive control engagement accelerates recovery from syntactic misanalysis.⁴

Cognitive control *may* play a role in children's syntactic revision

- Late maturation of prefrontal cortex means decreased cognitive control.
- Child-to-child variation in cognitive control tasks correlates with syntactic revision ability.
- Unclear whether effects are specific to cognitive control or broader individual differences.

Research Questions

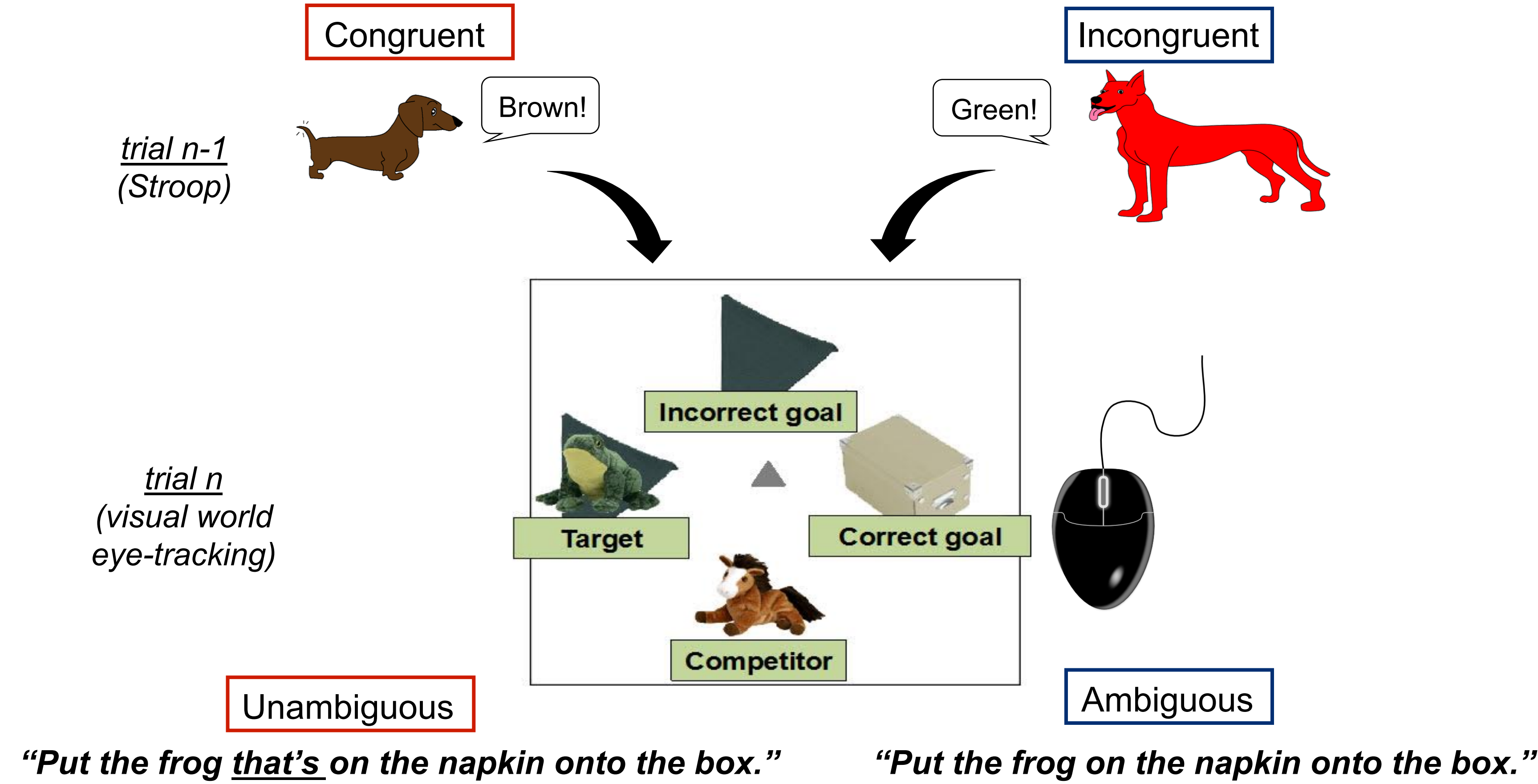
1. Are children's failure with syntactic revision *causally* linked to cognitive control?
2. If so, are effects of cognitive control continuous throughout development?

Conflict adaptation assesses dynamic engagement of cognitive control

- Adults: conflict detection engages cognitive control, which facilitates later syntactic revision.
- Children: conflict adaptation found *within* cognitive-control tasks (e.g., Stroop).
- If cognitive control is a *causal* factor in children's inability to revise, then engagement of cognitive control should influence their moment-by-moment (re)interpretations.

Method and Procedure

We monitored children's eye-movements as they completed a cross-task conflict adaptation paradigm that pseudorandomly interleaved Stroop-like trials with sentence-comprehension trials:

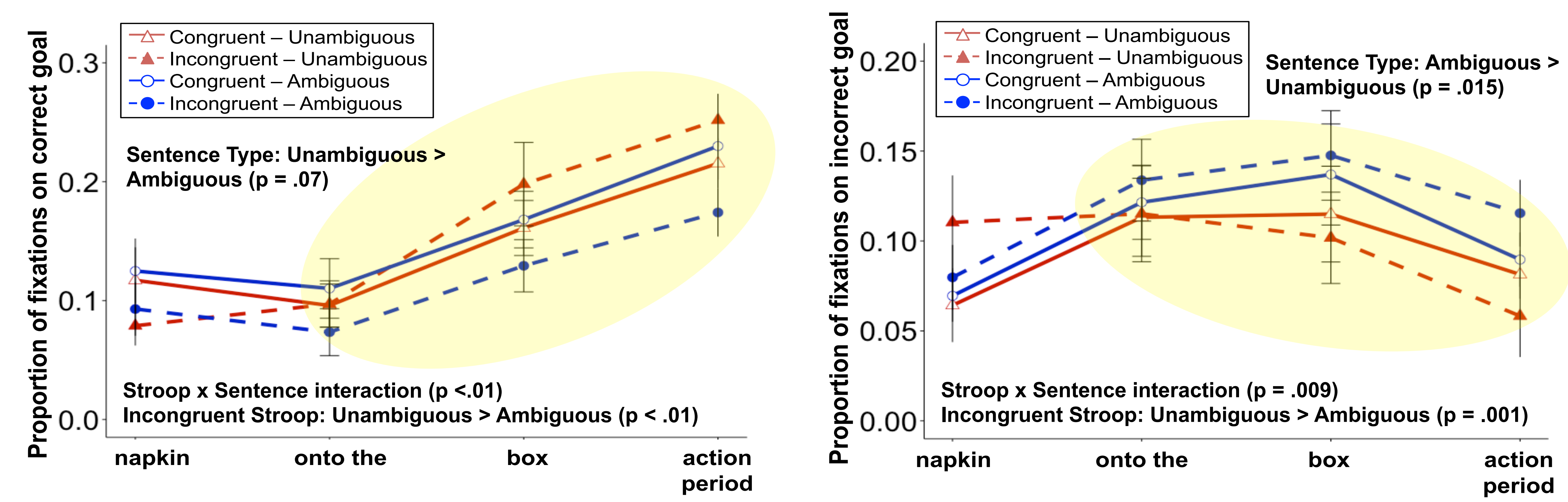


	16 critical Stroop-sentence pairs		Congruent Stroop	Incongruent Stroop
	Unambiguous sentence	Ambiguous sentence	4 trials	4 trials
n = 33				
ages 4;0 = 5;9				
20 filler sentences and 44 additional Stroop trials prevent kids from predicting upcoming task/trial type.				
Beforehand, children performed a block of Stroop-only trials and were familiarized with objects.				

Results

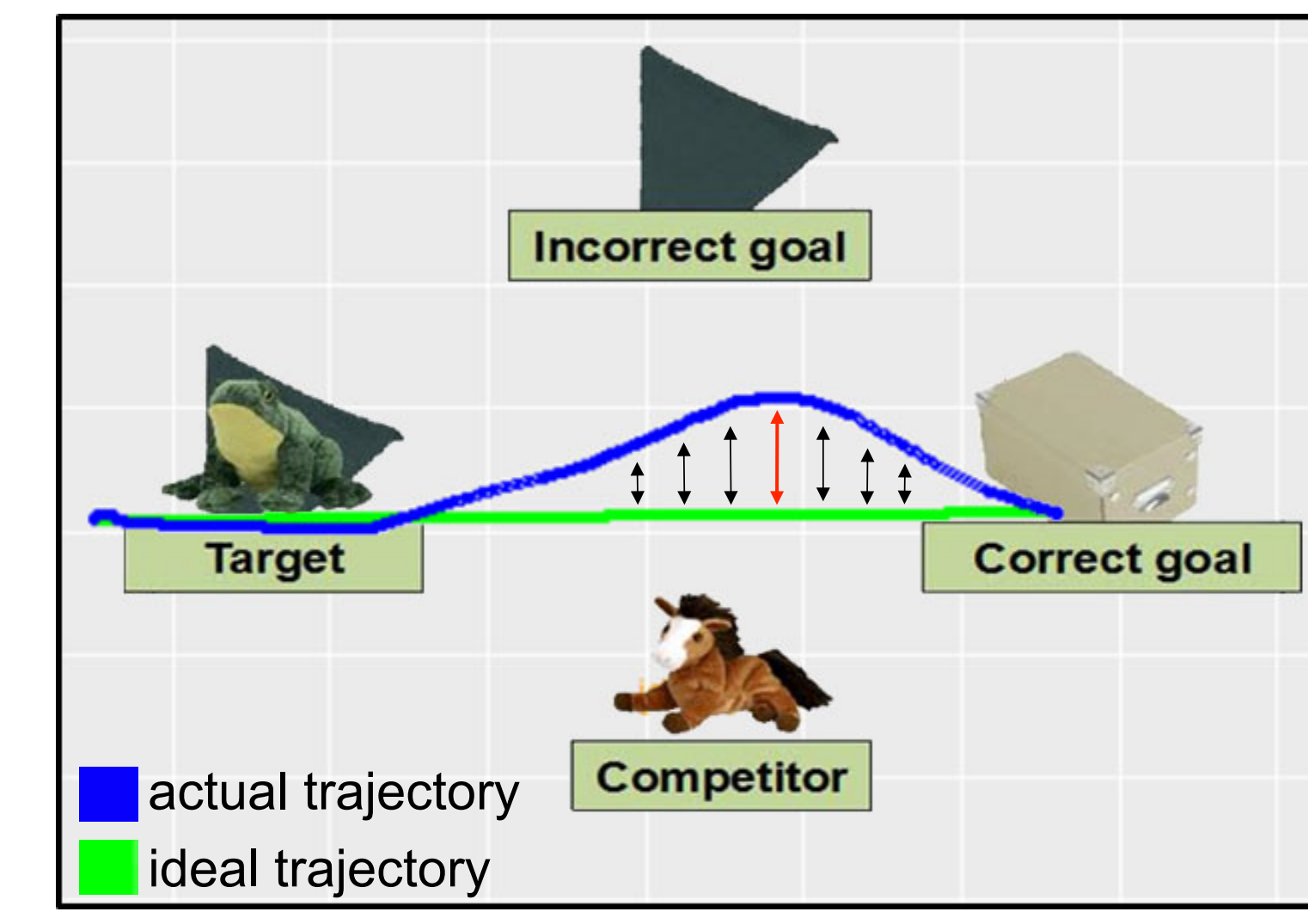
Prior cognitive control engagement increases developmental challenges with syntactic revision

- Stroop-conflict engages cognitive control: lower accuracy on incongruent (66%) vs. congruent (83%) trials.
- When ambiguous sentences followed incongruent vs. congruent Stroop trials, children looked *less* to correct goals (e.g., BOX – left panel) and *more* to incorrect goals (e.g., EMPTY NAPKIN – right panel).



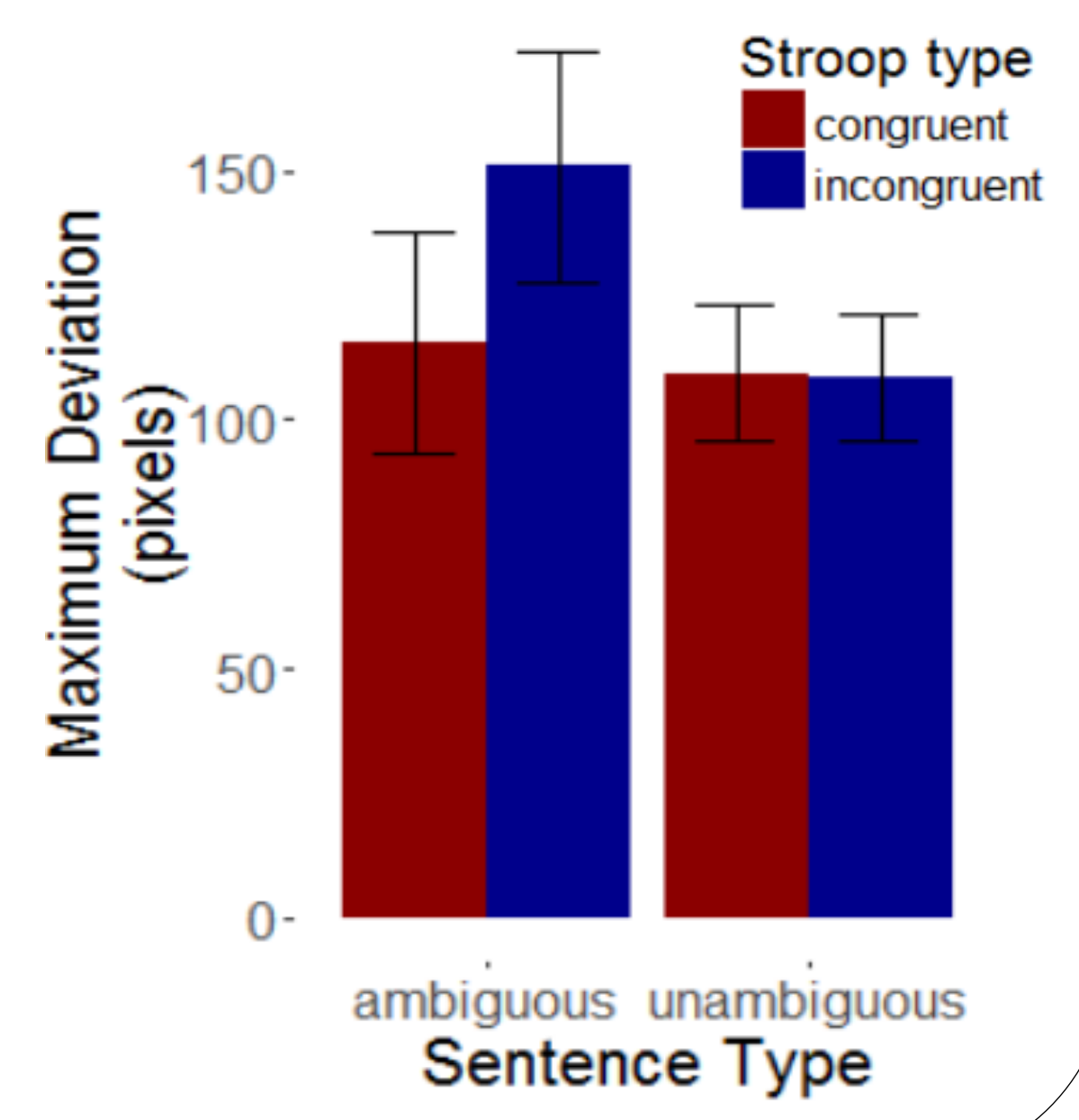
Prior cognitive control engagement also negatively impacts children's off-line interpretation

- Mouse-tracking⁵ reveals greater deviation towards incorrect goals when ambiguous sentences followed incongruent vs. congruent Stroop trials.



Calculating maximum deviation

- Only include trials involving correct goal
- Determine shortest distance at each time point between actual trajectory and ideal trajectory (i.e., straight line between target and correct goal)
- MAXIMUM DEVIATION = maximum distance between actual & ideal trajectories



Discussion

Cognitive control engagement is a causal factor in children's inability to revise syntactic misanalysis

- Prior Stroop type affects subsequent on-line and off-line interpretation of syntactically ambiguous sentences.
- Domain-general cognitive control procedures actively influence developmental sentence processing.

Developmental effects of cognitive control on sentence processing are strikingly different than adults

- While cognitive control *facilitates* adults' sentence re-interpretation,⁴ it *impedes* re-interpretation in children.
- Protracted prefrontal development means that children have limited ability to *sustain* cognitive control.
- This leads to failure to resolve syntactic ambiguity and recover from misinterpretation as input unfolds.

Remaining questions and future directions

- Is the depletion children exhibit due to immature cognitive control, or general fatigue due to task difficulty?
- How does limited cognitive-control ability interact with effects of language experience?
- What impacts does an immature system for language processing have on language learning?

References: ¹Trueswell et al., 1999, ²Choi & Trueswell, 2010, ³Novick et al., 2014, ⁴Hsu & Novick, in press, ⁵Anderson et al., 2011

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