

Why or what next? Eye movements reveal expectations about discourse direction

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Dependencies

Arthur scolded Patricia. She had put thumbtacks on the teacher's chair.



- Dependencies within sentence and between sentences
- Dependencies between-sentences affect dependencies within (Crain & Steedman 1985; Altmann & Steedman 1988; Van Berkum, Brown, & Hagoort 1999; Arnold 2001; Sedivy 2002; Kehler, Kertz, Rohde, & Elman 2008; Rohde, Levy, Kehler 2008; Kaiser 2009, and others)
- This talk: discourse coherence relations which capture a sentence's role relative to other sentences (Hobbs 1979; Kehler 2002)

Arthur scolded Patricia. She likes spinach.



Discourse dependencies

- Coherence relations (Kehler 2002, Mann and Thomson 1987, Asher 1993)
- Questions under discussion (Roberts 1996)
- This talk: WHY / WHAT NEXT (Explanation / Occasion)

Arthur scolded Patricia. She had put thumbtacks on the teacher's chair. **WHY**

Heidi shipped Eric a package. He wrote her a thank-you note. **WHAT NEXT**

- **WHY/WHAT NEXT relations reflect verb-driven biases**
(story completions reported in Rohde et al. 2006; Kehler et al. 2008; see other IC work in Garvey & Caramazza 1974; Brown & Fish 1983; Au 1986; McKoon, Greene, & Ratcliff 1993)
 - Implicit Causality verbs ('scold', 'frighten', 'adore') bias towards WHY
 - Transfer verbs ('ship', 'hand', 'pass') bias towards WHAT NEXT

Identifying discourse relations

- Does identification of operative coherence relation require complete clauses as per Clausal Integration?
(Garnham, Traxler, Oakhill, & Gernsbacher 1996; Stewart, Pickering, & Sanford 2000)
- Or do comprehenders anticipate relations?

Goal: Use anticipatory looking to test for expectations about upcoming discourse continuations

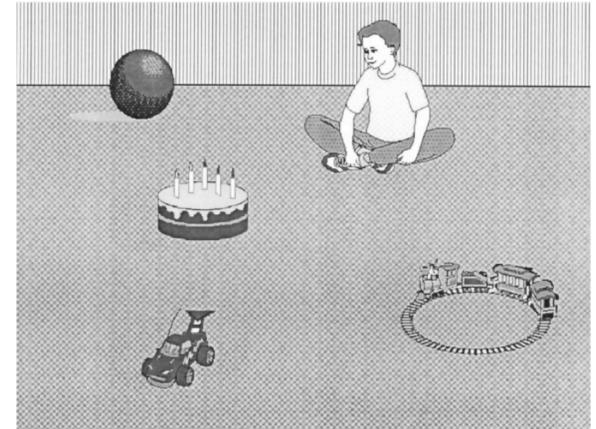
We find: Comprehenders identify likely coherence relations soon after coherence-biasing verb, before complete clauses are available.

Anticipatory looking

- Verbs restrict subsequent reference
(Altmann & Kamide 1999)

The boy will move/eat the cake.

→ With 'eat', look to cake before 'cake'



- Implicit causality verbs induce next-mention biases
(Pyykkönen & Järvikivi 2009)

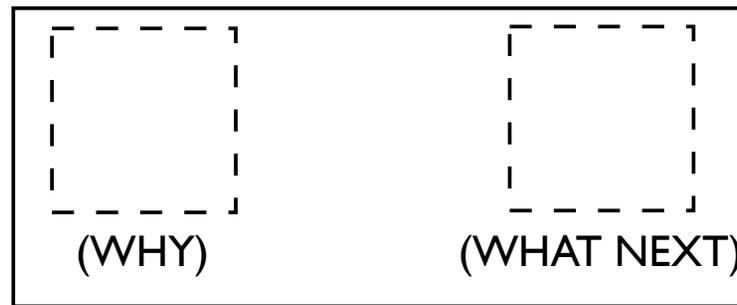
The butler frightened the guitarist in the dining room because he ...

→ Look to butler before 'he'

→ How to test expectations about discourse relations?

Testing discourse expectations

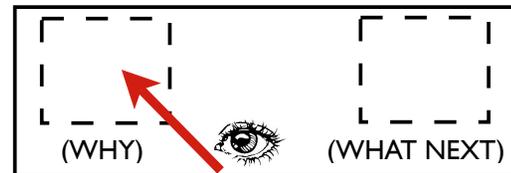
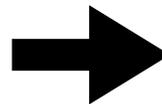
- Train participants to associate visual regions with WHY/WHAT-NEXT relations



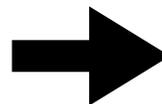
- Test whether verb influences expectations about relation between current sentence and next



... scold ...

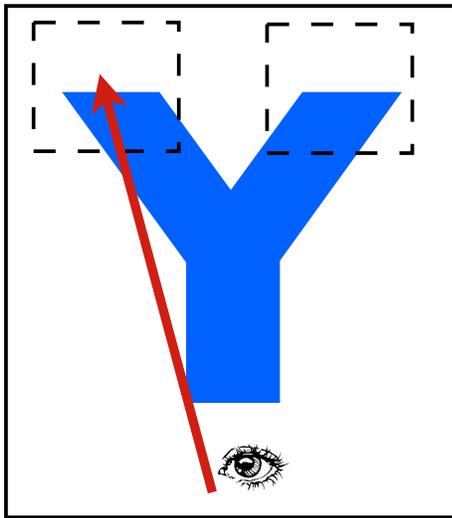


... ship ...



Paradigm: visual regions ~ categories

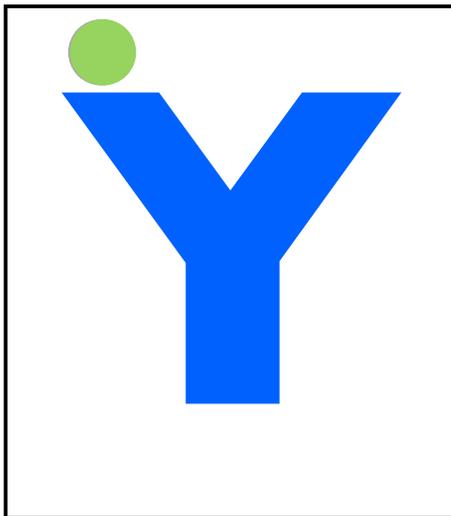
- Measure categorization through eye movements
 - McMurray & Aslin (2004) introduce occlusion-based displays to test infants' visual and auditory categories



- Babies see shapes disappear behind occluder
- Shapes reemerge left/right based on category
 - ■ → left
 - X → right
- Novel items test category generalization
 - X → ?? (infants use color)

Implicit learning training phase

- Goal: Train participants to associate visual regions with WHY/WHAT NEXT categories



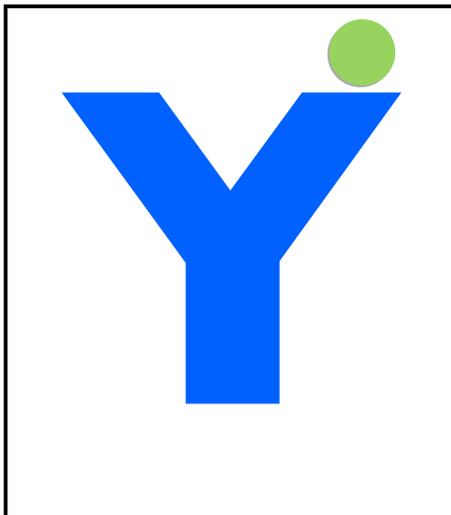
- Task: Figure out how tube is categorizing stories
 - left : WHY
 - right : WHAT NEXT
- Click ball to hear two-sentence passage
- Guess left or right
- Get category feedback when ball re-emerges



(WHY) Leo takes the bus to work. He doesn't have a car.

Implicit learning training phase

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(WHY) Leo takes the bus to work. He doesn't have a car.



(WHAT NEXT) Melissa ran towards Trevor. They embraced.

Implicit learning details

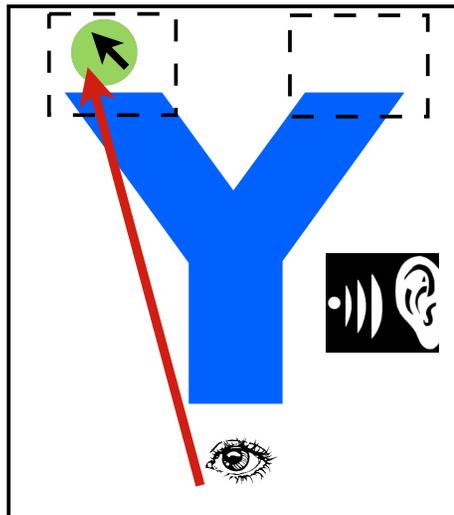
- Participants: 24 native English speakers
- Task: listen to two-sentence passages (10 correct in a row or listen to all items)
- Materials
 - 30 WHY, 30 WHAT-NEXT
 - No coherence-biasing verbs from main experiment
 - Left/right mapping balanced across participants
- Post-training quiz: 30 items with no feedback

Implicit learning results

- Post-training quiz: 7 of 24 participants were above chance
- No debriefing after training phase
- Comments about categories after main experiment:
 - Common responses: "no idea", "male/female?", "positive/negative?"
(including a few above-chance participants)
 - One category: "explains", "tells cause", "could use because"
 - Other category: "what happened after", "result"

Main experiment

- Measure anticipatory looks before second sentence (speeded task where participant must click ball to hear each sentence)



- Same categories, new task
- Click ball to hear Sentence1
- Sentence1 plays
- Eye tracking during Sentence1
- Ball re-emerges to signal continuation type
- Click re-emerging ball to hear Sentence2



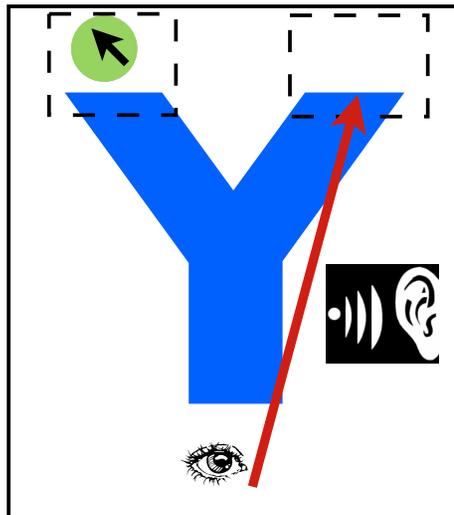
Sentence1: Arthur scolded Patricia in the hallway. (IC → WHY)

Sentence2 (WHY): She had put thumbtacks on the teacher's chair.

Sentence2 (WHAT NEXT): He then sent her to the principal's office.

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- Click ball to hear Sentence1
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Sentence1: Arthur scolded Patricia in the hallway. (IC → WHY)

Sentence2 (WHY): She had put thumbtacks on the teacher's chair.

Sentence2 (WHAT NEXT): He then sent her to the principal's office.



Sentence1: Heidi shipped Eric a package. (Transfer → WHAT NEXT)

Sentence2 (WHY): She thought he'd like some cookies from home.

Sentence2 (WHAT NEXT): He wrote her a thank you note.

Main experiment details

■ Materials:

- 40 sentence1 with IC verbs (20/20 sentence2 WHY/WHAT-NEXT)
- 40 sentence1 with transfer verbs (20/20 sentence2 WHY/WHAT-NEXT)
- 80 fillers with no IC/transfer verbs (40/40 sentence2 WHY/WHAT-NEXT)

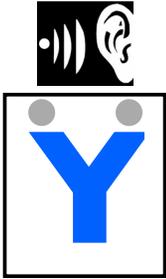
■ Analysis:

- Compare overall looks to WHY/WHAT NEXT regions after verb offset
- Consider timecourse of looks after verb offset

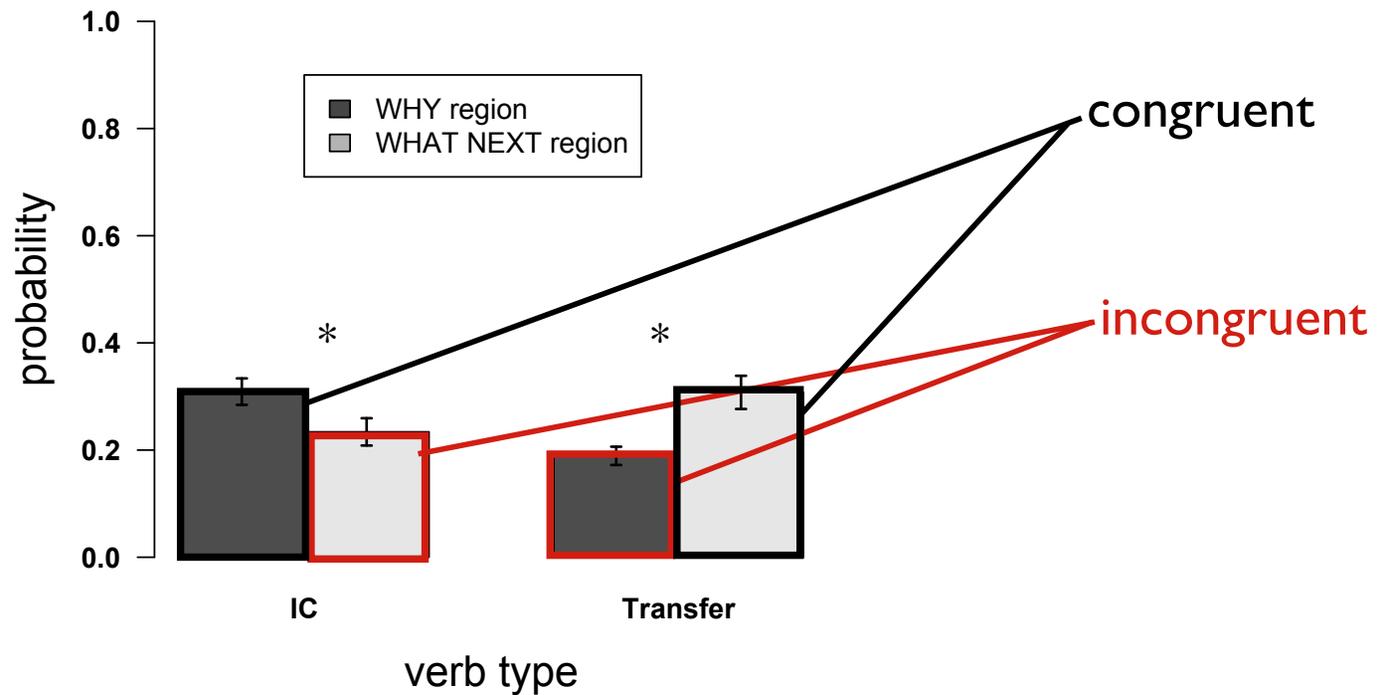
■ Predicted interaction:

- IC verbs → looks to WHY region
- Transfer verbs → looks to WHAT NEXT region

Results: anticipatory looks



Fixation Proportions for All Participants
(from verb offset for 3200msec)

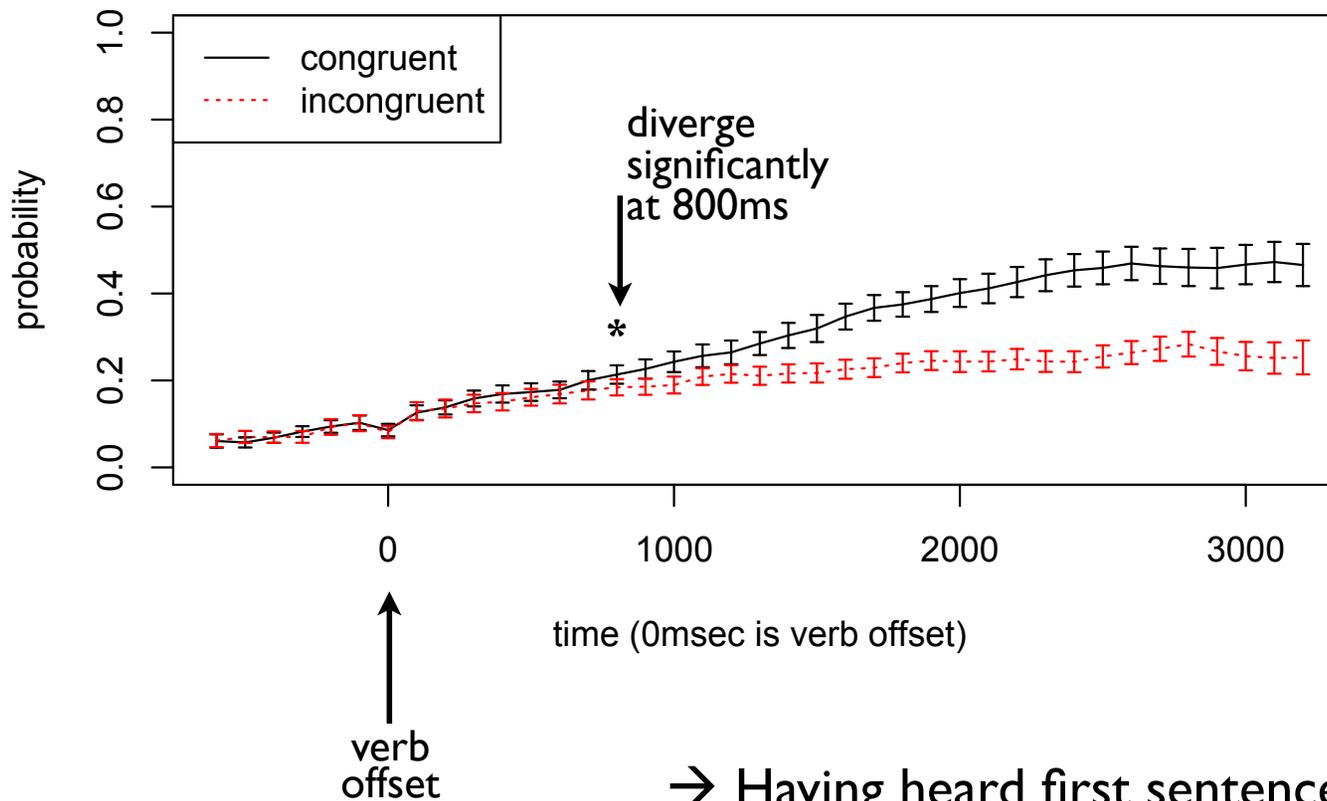


→ Predicted verbytype x category crossover interaction

Results: timecourse from verb offset

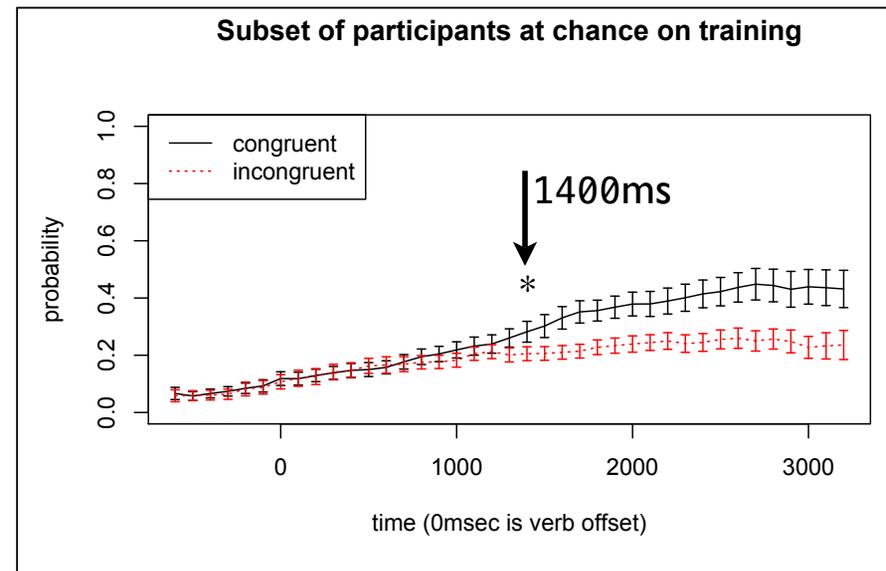
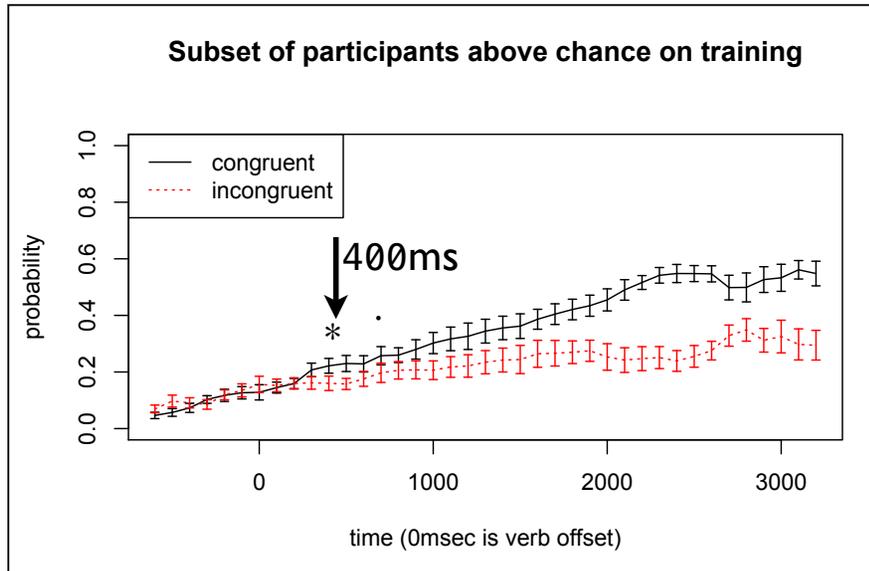


Probability of fixating congruent/incongruent region



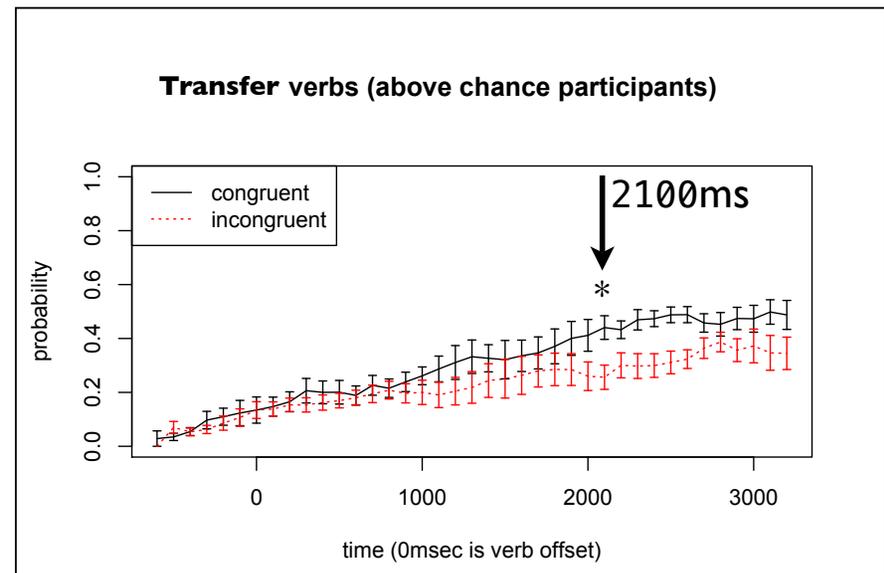
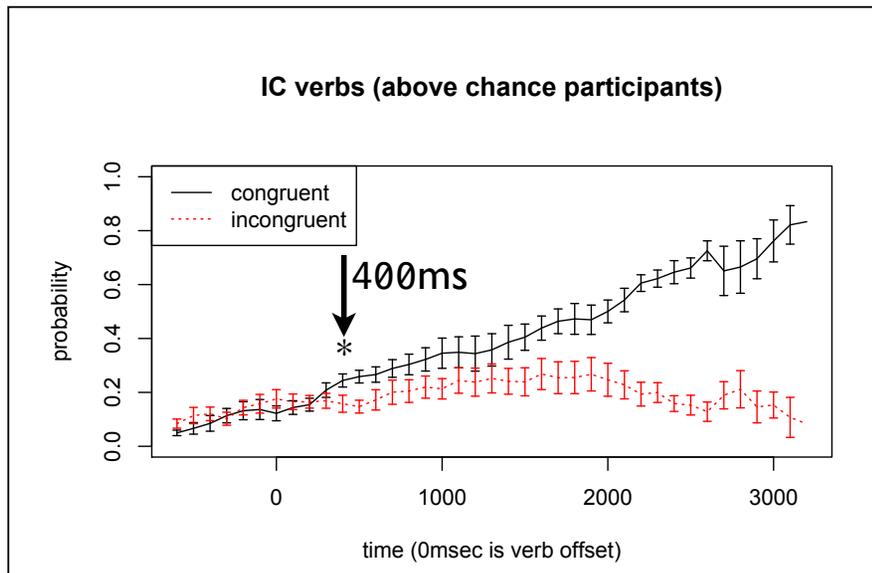
→ Having heard first sentence, participants anticipate upcoming continuation type

Results by training performance



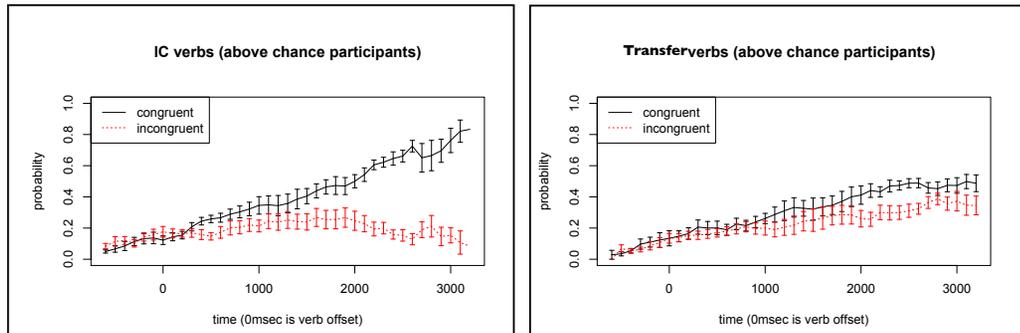
→ Participants (even those at chance on training) learned categories and anticipated upcoming continuations

Results: verb type differences



→ IC verbs yield earlier effects than Transfer verbs

Earlier effects with IC than Transfer



- Surprising because bias strength is similar (Kehler et al. 2008)
 $p(\text{WHY} | \text{IC}) \approx p(\text{WHAT NEXT} | \text{Transfer})$ in story completions

- Are participants waiting for direct object?

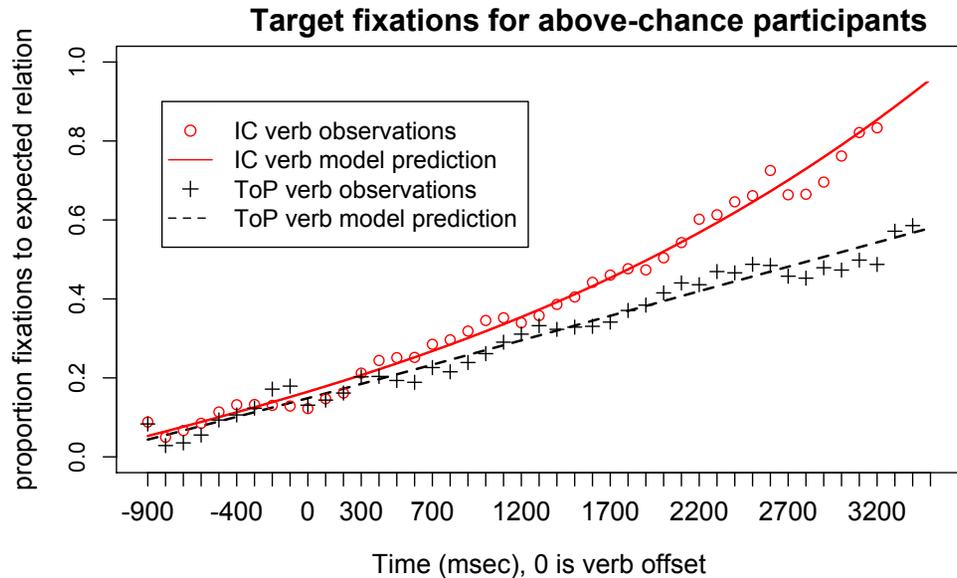
- Object expectedness influences coherence biases (Rohde, Kehler, & Elman 2007)

Normal object: John handed a book to Bob. He _____ \rightarrow WHAT-NEXT bias

Abnormal object: John handed a bloody meat cleaver to Bob. He _____ \rightarrow WHY

- How to capture verb differences?

Growth Curve Analysis (Mirman, Dixon, & Magnuson, 2008)



GCA: fit curves to observed data

- treat data as continuous
- avoid bin-by-bin repeated tests of dependent data

- Comprehenders look at target faster after IC verb (significant linear term) and with greater acceleration (significant quadratic term)
- Overall, the eyetracking results confirm hypothesis about expectation-driving processing and GCA quantifies verb type differences

Summary

- Novel paradigm for measuring comprehenders' expectations about discourse categories
- Results: anticipatory looks after coherence-biasing cue
 - In both above-chance and at-chance groups
 - Suggests that identifying discourse dependencies starts before both sentences are available (contra Clausal Integration)
 - for IC verbs, before first sentence is finished
- New perspective on known coherence-sensitive phenomena (coreference, ellipsis, syntactic attachment)
- Evidence of expectations beyond sound/words/syntax

Acknowledgements

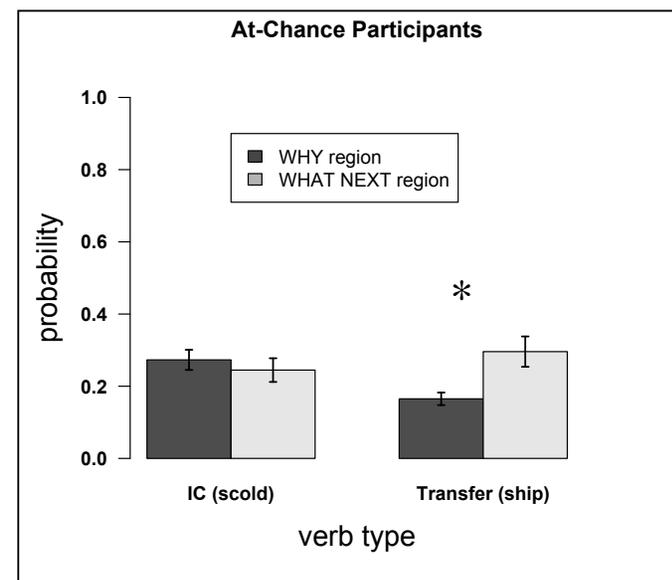
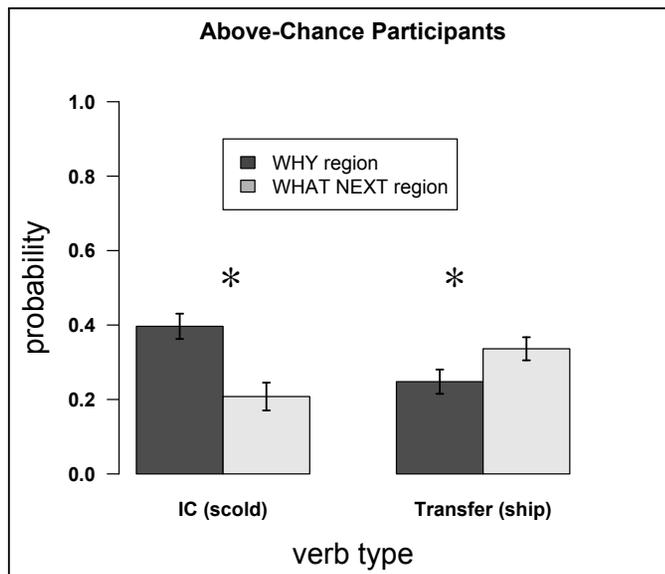
Thanks to Sudha Arunachalam, Brady Clark, Matt Goldrick, Elizabeth Mazzocco, Mike Tanenhaus, and Masaya Yoshida for helpful discussion.

Thanks also to research assistant Ronen Bay.

This work was supported in part by a Mellon postdoctoral fellowship to Hannah Rohde.

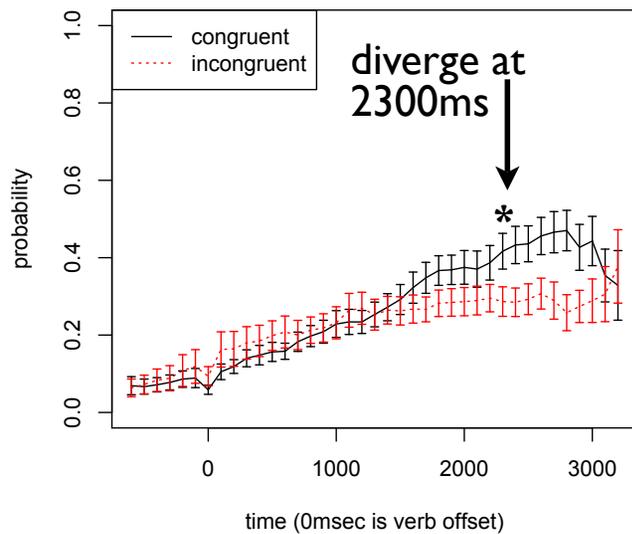
Thank you!

Overall means: training performance



Verb type (at-chance participants)

IC verbs (at chance participants)



TOP verbs (at chance participants)

