Syntactic Adaptation Effects Do Not Transfer Across Tasks

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Expectations in Language Comprehension

‣ Constantly generating expectations about upcoming input during language processing

The defendant examined…the evidence
the pictures
the documents

examined = main verb

by the lawyer turned out to

examined = reduced relative

(Ferreira & Clifton 1986)

Probabilistic Parsing

▸ Parsing decisions are based on probabilities derived from distributional information (e.g., surprisal theory, entropy reduction)

▸ Structural expectations reflect distribution of structures

1 sentence   *10 sentences*   *100 sentences*   *Stable Distribution*

(Jurafsky 1996; Hale 2001; Levy 2008)
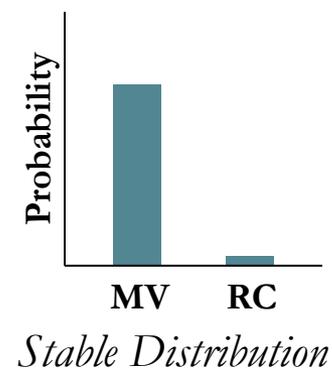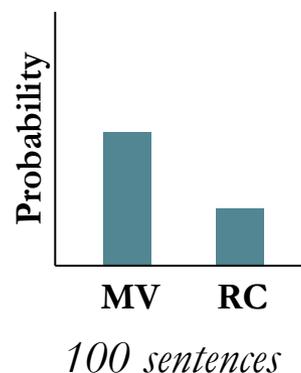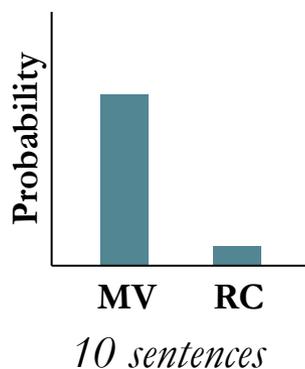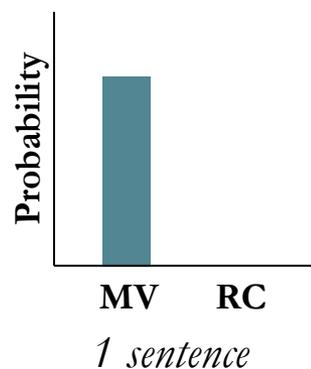
Syntactic Adaptation

▸ Biases in ambiguity resolution can be altered by manipulating probability of competing structures

  ▸ Exposure to *a priori* improbable structure increases expectation for that structure

Stable Distribution

(Fine et al. 2013; Fine & Jaeger 2013 ; Jaeger & Snider 2013; Linzen & Jaeger 2015)
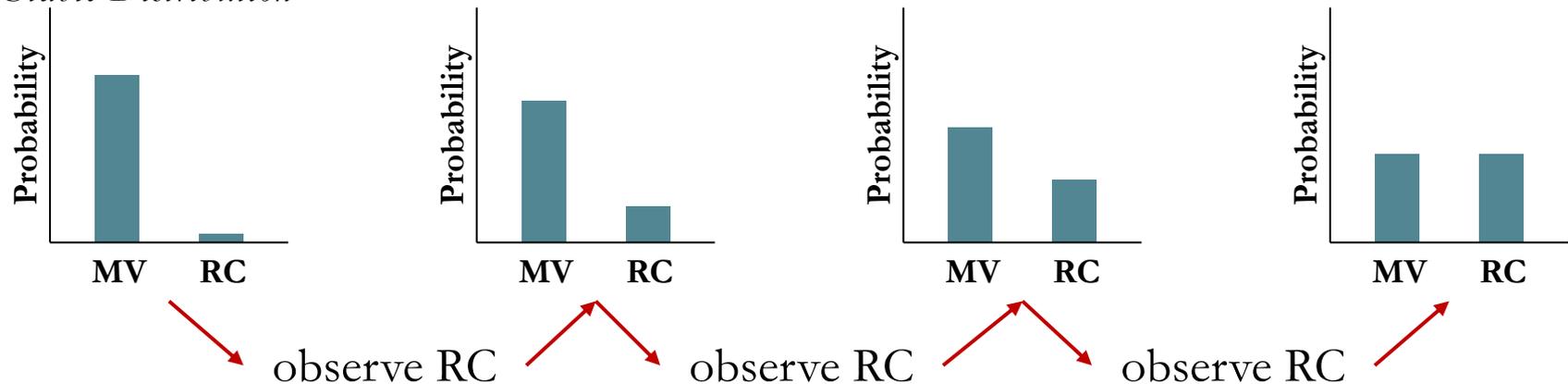
Hypothesis About Syntactic Adaptation

‣ Instance of general statistical learning (Fine & Jaeger 2013, Jaeger & Snider 2010)

  ‣ Should find evidence for robust generalizations beyond the local task

‣ Lab-specific phenomenon

  ‣ Participants infer the intent of the experimenters & adjust their structural expectations accordingly

Today: Examine the generality of syntactic adaptation by presenting distributional information & parsing test as separate tasks

Roadmap

- Filler-gap dependencies

- Background experiment: Atkinson & Omaki 2016
    - Participants adapt their gap position expectations

- Adaptation across tasks
    - Experiment 1: Filled gap effect
    - Experiment 2: Plausibility mismatch effect

Why Filler-Gap Dependencies?

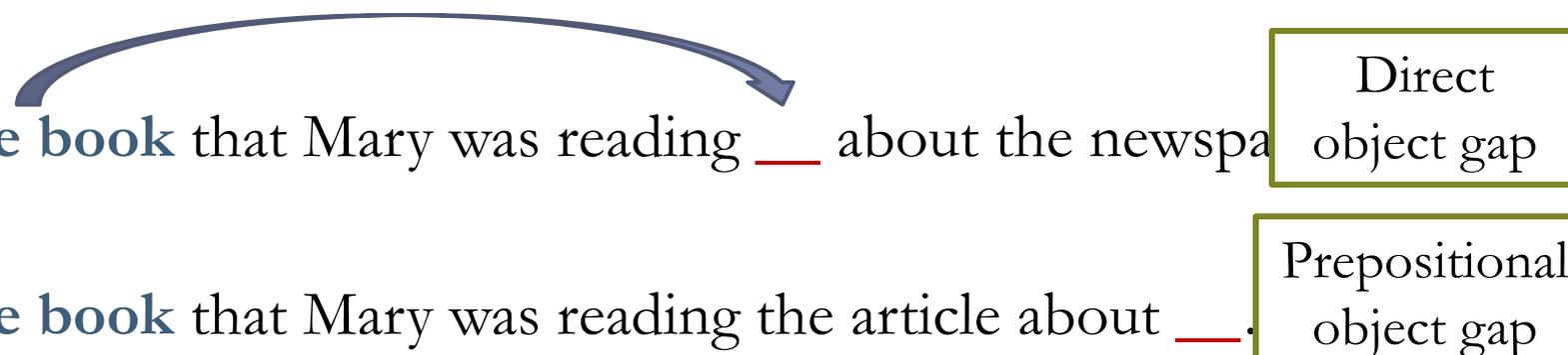- Part of a larger investigation comparing syntactic adaptation mechanisms in adults & children (Atkinson et al. in press; Atkinson 2016)

  - Need a structure that is familiar to children & provides a good testing ground for syntactic adaptation

- Can embed in narratives with a variety of structures without affecting the distribution of critical structural options

Filler-Gap Dependencies

‣ **Filler** – fronted element

‣ **Gap** – filler's thematic position

(1) **The book** that Mary was reading ___ about the newspa... | Direct object gap

(2) **The book** that Mary was reading the article about ___. | Prepositional object gap

‣ **Active Gap Filling** – Parser actively associates the filler with a direct object gap

  ‣ Probabilistic account: direct object gaps expected because they are the most frequent

(e.g., Stowe 1986, Frazier 1987, Garnsey et al. 1989, Traxler & Pickering 1996)

Gap Position Corpus Analysis

▸ Selections from 2 corpora of natural conversations

▸ Limited to post-verbal argument gap positions

   ▸ Argument *wh*-questions (*who*, *what*, *which*, *whose*) & relative clauses

Corpus	# Lines	Direct Object Gaps	Prepositional Object Gaps	Total
CallHome	28,967	1,790	612	2,402
Switchboard	44,696	1,159	226	1,385
	73,663	2,949 **(77.9%)**	838 **(22.1%)**	3,787

(Atkinson 2016; LDC: Kingsbury et al. 1997; Marcus et al. 1999)

Atkinson & Omaki 2016

▸ Are gap position expectations subject to syntactic adaptation effects?

▸ Blocked adaptation:

  ▸ Exposure block = manipulation of gap positions

  ▸ Experimental block = test of active gap filling

▸ Eye tracking during reading

▸ Based on Experiment 2 from Fine et al. (2013)

Atkinson & Omaki 2016: Design

▸ ***Filled gap effect:*** slowdown on direct object region when a direct object gap is expected

(3) The suitcase that the thief stole **the precious jewels** from __ …

(e.g., Lee 2004; Stowe 1986; Wagers & Phillips 2014)

Atkinson & Omaki 2016: Design

▸ **Filled gap effect:** slowdown on direct object region when a direct object gap is expected

▸ **NP-fronting** (ambiguous)

The suitcase *that* the stealthy, wanted thief stole the precious jewels from __ was full of sentimental items.

▸ **PP-fronting** (unambiguous)

The suitcase *from which* the stealthy, wanted thief stole the precious jewels __ was full of sentimental items.

▸ Filled gap effect: NP-fronting > PP-fronting

(e.g., Lee 2004; Stowe 1986; Wagers & Phillips 2014)

Atkinson & Omaki 2016: Design

Exposure Type	Exposure Block
Prepositional object gaps	24 PO gap sentences

- ***Prepositional Object (PO) Gap***

  The suitcase that the stealthy, wanted thief stole <u>the precious jewels</u> from <u>__</u> was full of sentimental items.

Atkinson & Omaki 2016: Design

Exposure Type	Exposure Block
Prepositional object gaps	24 PO gap sentences
Direct object gaps	24 DO gap sentences

▸ **Prepositional Object (PO) Gap**

The suitcase that the stealthy, wanted thief stole <u>the precious jewels</u> from __ was full of sentimental items.

▸ **Direct Object (DO) Gap**

The painting that the infamously successful burglar stole __ from the museum was well guarded.

▸

Atkinson & Omaki 2016: Design

Exposure Type	Exposure Block
Prepositional object gaps	24 PO gap sentences
Direct object gaps	24 DO gap sentences
Fillers	24 fillers

- ***Prepositional Object (PO) Gap***

  The suitcase that the stealthy, wanted thief stole <u>the precious jewels</u> from __ was full of sentimental items.

- ***Direct Object (DO) Gap***

  The painting that the infamously successful burglar stole __ from the museum was well guarded.

Atkinson & Omaki 2016: Design

| Exposure Type	Exposure Block	Experimental Block
Prepositional object gaps	24 PO gap sentences	24 filled gap targets + 48 fillers
Direct object gaps	24 DO gap sentences	
Fillers	24 fillers	

- ***NP-fronting*** (ambiguous)

  The suitcase *that* the stealthy, wanted thief stole <u>the precious jewels</u> from <u>__</u> was full of sentimental items.

- ***PP-fronting*** (unambiguous)

  The suitcase *from which* the stealthy, wanted thief stole <u>the precious jewels</u> <u>__</u> was full of sentimental items.

(e.g., Lee 2004; Stowe 1986; Wagers & Phillips 2014)

Atkinson & Omaki 2016: Filled Gap Region

▶ No significant effects on first fixation duration or first pass time
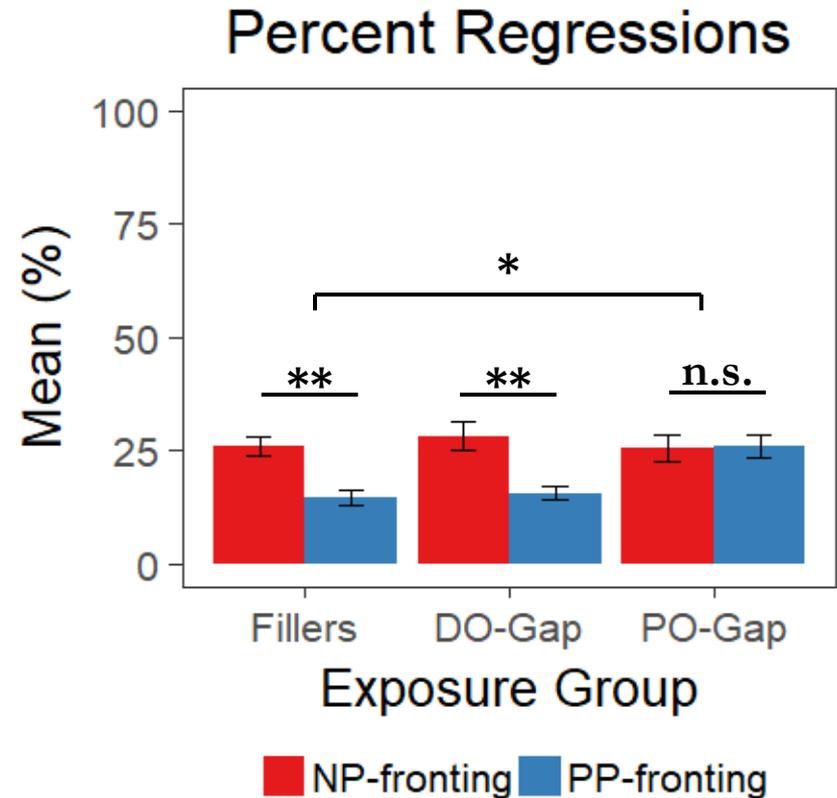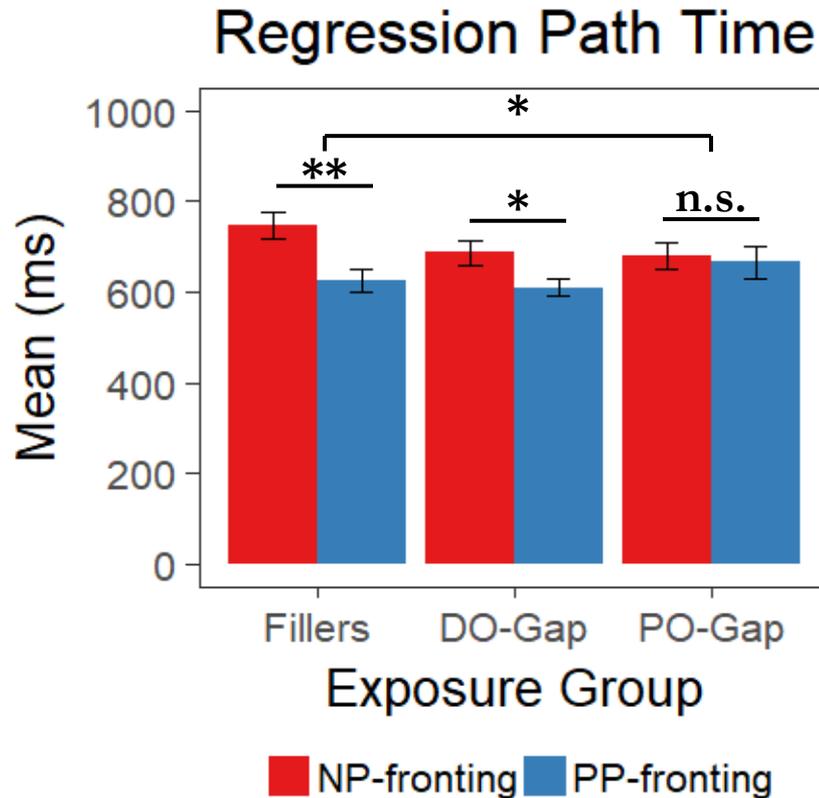
▶ DO gap expectations <u>suppressed</u> in PO gap exposure group

Syntactic Adaptation Across Tasks

▸ Atkinson & Omaki (2016) demonstrates that participants <u>do adapt</u> their gap positions expectations

> ***Research Question:*** Are syntactic adaptation effects the result of general adaptation of parsing biases?

▸ Experiments consist of 2 parts:

  1) Sentence recognition task

     ▸ Exposure to gap positions within short narratives

  2) Eye tracking during reading task

Experiment 1: Filled Gap Effect

‣ 48 native English speaking University of Washington undergraduates

‣ 2 exposure groups (between-participants) – Filled gap effect
  ‣ DO gap sentences presented within narratives
  ‣ PO gap sentences presented within narratives

‣ Test sentences – Filled gap effect
  ‣ Same as Atkinson & Omaki (2016) experimental block

Experiment 1: Design

Exposure Type	Sentence Recognition Task	Eye Tracking Task
		24 filled gap targets + 48 fillers
		Identical to Atkinson & Omaki (2016)

▸ ***NP-fronting***

The suitcase ***that*** the stealthy, wanted thief stole <u>the precious jewels</u> from <u>__</u> was full of sentimental items.

▸ ***PP-fronting***

The suitcase ***from which*** the stealthy, wanted thief stole <u>the precious jewels</u> <u>__</u> was full of sentimental items.

(e.g., Lee 2004; Stowe 1986; Wagers & Phillips 2014)

Experiment 1: Design

Exposure Type	Sentence Recognition Task	Eye Tracking Task
Prepositional object gaps	48 PO gap sentences	24 filled gap targets + 48 fillers

▸ ***PO Gap***

The newspaper article that their friend wrote <u>the blog post</u> about __ gave great tips…

Experiment 1: Design

Exposure Type	Sentence Recognition Task	Eye Tracking Task
Prepositional object gaps	48 PO gap sentences	24 filled gap targets + 48 fillers
Direct object gaps	48 DO gap sentences	

▸ ***PO Gap***

The newspaper article that their friend wrote <u>the blog post</u> about __ gave great tips…

▸ ***DO Gap***

The blog post that their friend wrote __ about the newspaper article gave great tips…

Experiment 1: Example PO Gap Narrative

Jill and Justin planned to spend a day exploring New York City. Over the past few weeks, they had been reading all the information they could find about things to do there. **The newspaper article that their friend wrote the blog post about __ gave great tips about the most popular attractions in the city.** They decided that they definitely wanted to go shopping in Times Square and that, in the evening, they would see a Broadway play. They left on the train the next morning. After they arrived in New York, they made their way to Times Square. **The shops that they encountered the crowds in __ were enormous.** They looked around for a while, but decided not to buy anything so that they would not have to carry bags with them the rest of the day. After all of their time in the crowds, Jill and Justin were exhausted and they decided to find a place where they could eat lunch. **The deli's menu that Jill discovered the delicious sandwich on __ was much more expensive than she expected.** The couple decided to splurge, though, since it was their first time in the city. Then, they walked through Central Park until it was time for them to take their seats for the show. **The musical that the couple watched the famous actress in __ made them want to come back and see a Broadway performance again.** Jill and Justin were sad to leave after such an exciting day.

Experiment 1: Sentence Recognition Task

▸ 48 critical sentences → 12 narratives x 4 filler-gap dependencies

  ▸ Crucially, remaining sentences did not contain filler-gap dependencies

▸ Was this sentence in the passage you just read?

  ▸ *Matching sentence*

    Jill and Justin were sad to leave after such an exciting day.

  ▸ *Mismatching sentence*

    Jill and Justin were <u>happy</u> to leave after such an exciting day.

▸

Experiment 1: Recognition Accuracy

Exposure Type	Accuracy	SE
DO gap sentences	69.6%	6.6%
PO gap sentences	67.9%	6.7%

▸ No significant difference in accuracy

Experiment 1: Filled Gap Region

▸ No significant effects on first fixation duration or first pass time

Regression Path Time — Bar chart showing Mean (ms) on y-axis (0 to 1000), Exposure Group (DO-gap, PO-gap) on x-axis. "n.s." bracket. Box labeled "Main effect of fronting type". Legend: NP-fronting (red), PP-fronting (blue).

Percent Regressions — Bar chart showing Mean (%) on y-axis (0 to 100), Exposure Group (DO-gap, PO-gap) on x-axis. Box labeled "Main effect of fronting type". "n.s." bracket. Legend: NP-fronting (red), PP-fronting (blue).
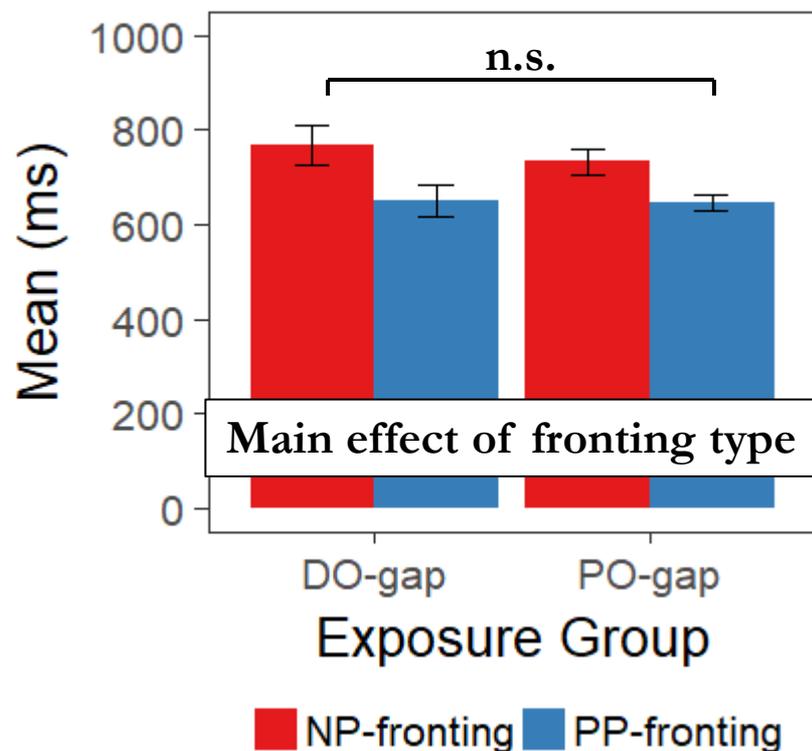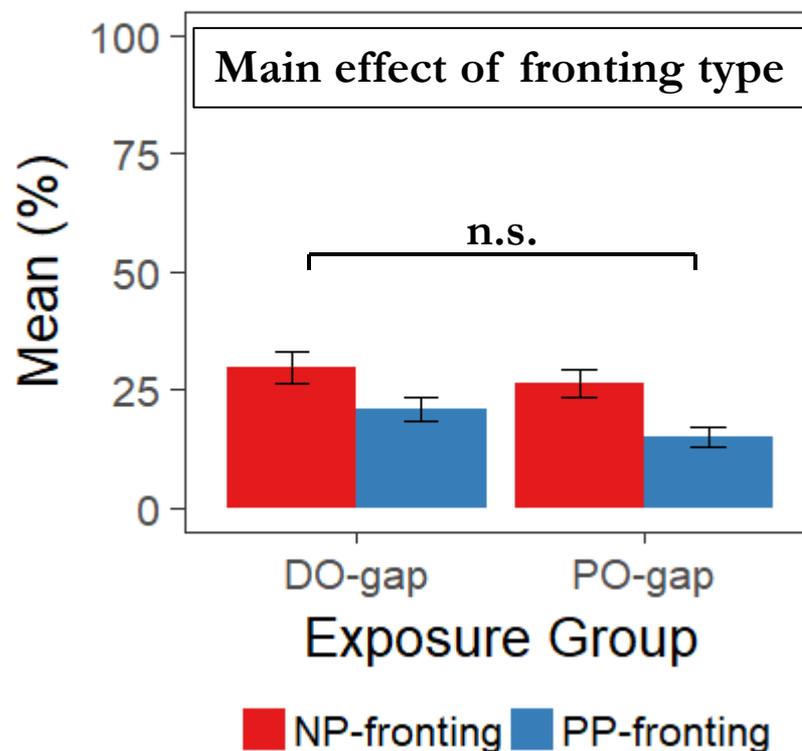
▸ PO gap exposure group <u>doesn't adapt</u> their gap expectations

Experiment 1: Summary

▸ Unlike in blocked adaptation (Atkinson & Omaki 2016), DO gap expectation persists

  ▸ PO gap exposure group demonstrates filled gap effect

▸ Adaptation of gap expectations (in the form of reduced active DO gap filling) does not transfer across tasks

  ▸ Both tasks performed in the same room with the same experimenter

▸

Experiment 2: Plausibility Mismatch Effect

‣ Distribution of gap positions should transfer across test sentence types

  ‣ Utilize different measures of active gap filling in each task

‣ 47 native English speaking Johns Hopkins University undergraduates

‣ 2 exposure groups (between-participants) – Filled gap effect

  ‣ DO gap sentences presented within narratives
  ‣ PO gap sentences presented within narratives

‣ Test sentences – Plausibility mismatch effect

‣

Experiment 2: Design

Exposure Type	Sentence Recognition Task
Prepositional object gaps	48 PO gap sentences
Direct object gaps	48 DO gap sentences
Identical to Experiment 1	

▸ ***PO Gap***

The newspaper article that their friend wrote <u>the blog post</u> about __ gave great tips…

▸ ***DO Gap***

The blog post that their friend wrote __ about the newspaper article gave great tips…

▸

Experiment 2: Design

▸ ***Plausibility mismatch effect:*** slowdown on verb (or spillover) when filler is not a semantically plausible direct object of the verb

▸ ***Plausible Filler***

The book that the author <u>wrote</u> thoughtfully about __ was named for an explorer.

▸ ***Implausible Filler***

The city that the author <u>wrote</u> thoughtfully about __ was named for an explorer.
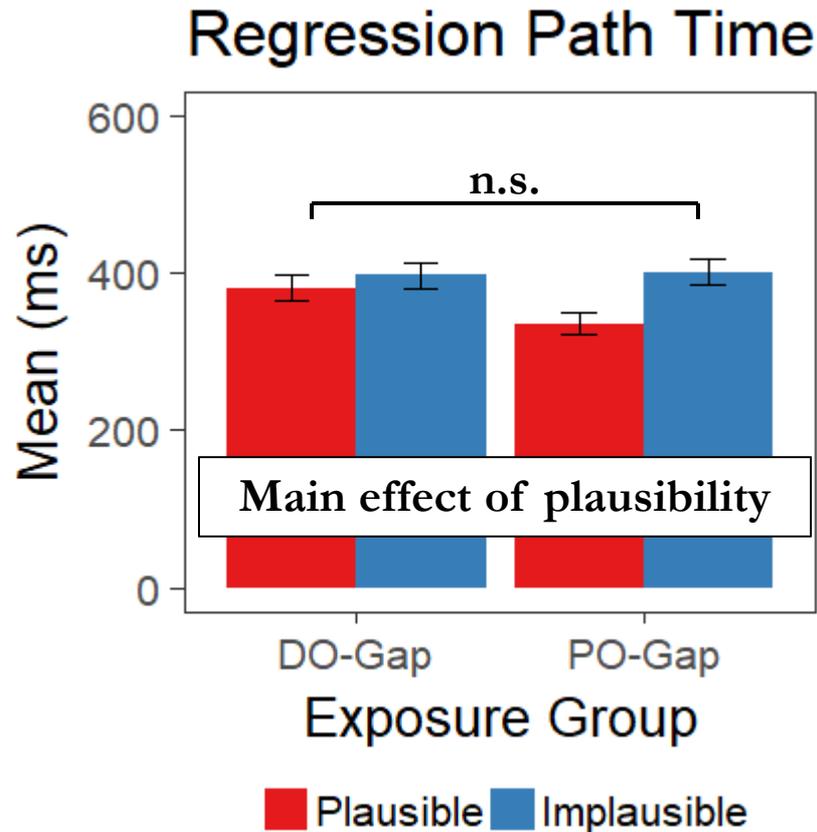
Experiment 2: Design

Exposure Type	Sentence Recognition Task	Eye Tracking Task
Prepositional object gaps	48 PO gap sentences	24 plausibility mismatch targets + 48 fillers
Direct object gaps	48 DO gap sentences	

▸ *Plausible Filler*

The book that the author <u>wrote</u> thoughtfully about __ was named for an explorer.

▸ *Implausible Filler*

The city that the author <u>wrote</u> thoughtfully about __ was named for an explorer.

(e.g., Traxler & Pickering 1996)

Experiment 2: Recognition Accuracy

Exposure Type	Accuracy	SE
DO gap sentences	71.2%	6.5%
PO gap sentences	73.8%	6.4%

▸ No significant difference in accuracy

Experiment 2: Spillover Region

▸ No significant effects on first fixation duration or first pass time

Regression Path Time — Mean (ms) vs Exposure Group (DO-Gap, PO-Gap); n.s.; **Main effect of plausibility**; legend: Plausible (red), Implausible (blue)

Percent Regressions — Mean (%) vs Exposure Group (DO-Gap, PO-Gap); **Main effect of plausibility**; n.s.; legend: Plausible (red), Implausible (blue)
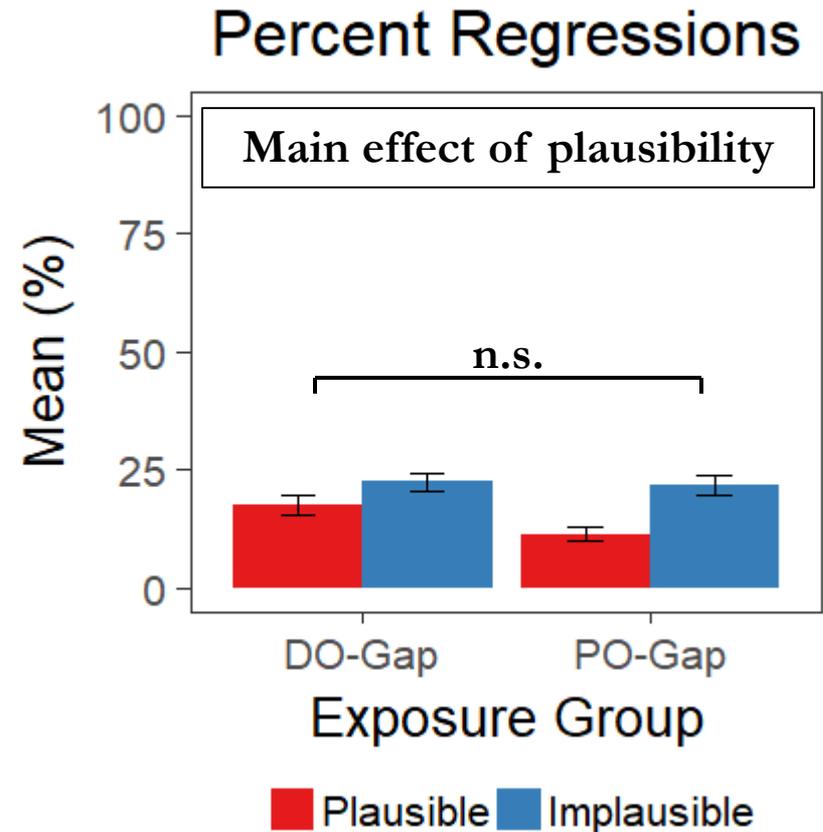
▸ PO gap exposure group <u>doesn't adapt</u> their gap expectations

Experiment 2: Summary

▸ As in Experiment 1, DO gap expectation persists

  ▸ PO gap exposure group demonstrates plausibility mismatch effect

▸ Adaptation of gap position expectations (again) does not transfer across tasks

Discussion

▸ Syntactic adaptation: general statistical learning or lab-specific phenomenon?

  ▸ Lack of cross-task adaptation suggests participants adjusting syntactic expectations after inferring the experimenter's goals

▸ Active gap filling bias may not reflect the input distribution

  ▸ May demonstrate parser's bias towards shorter dependencies to minimize memory costs (e.g., Chen et al. 2005, Fiebach et al. 2002, Gibson 1998, Grodner & Gibson 2005)

Future Directions

‣ What constitutes a single experiment / task?

  ‣ A clear break between blocks (contra Atkinson & Omaki 2016)

  ‣ Tasks presented on the same computer

  ‣ Is there such a thing as a "task" in non-laboratory language comprehension situations?

‣ If syntactic adaptation is restricted to local tasks, how do parsing biases emerge in the course of development?

  ‣ 5-year-olds do not demonstrate active gap filling (Atkinson et al. in press)

  ‣ Processing system primed by effortful production (Atkinson 2016)

Thank you!

‣ Thanks to the many people that have helped with this project:

  ‣ Colin Wilson, Barbara Landau, Steven Gross, & Kevin Duh

  ‣ Melinh K. Lai

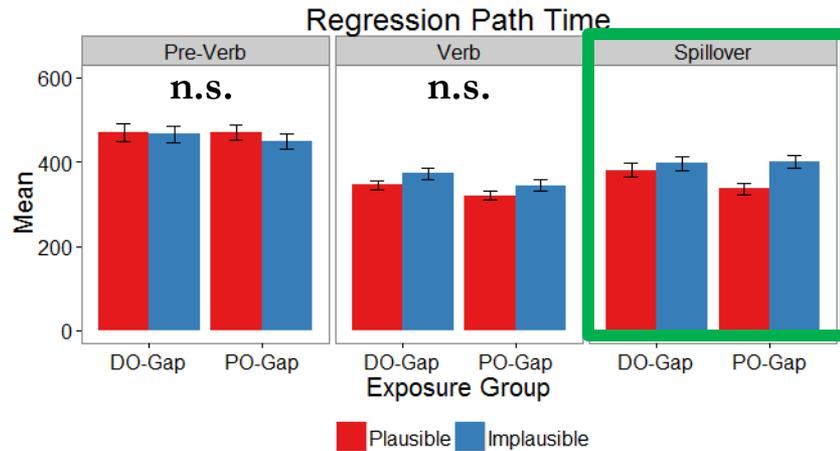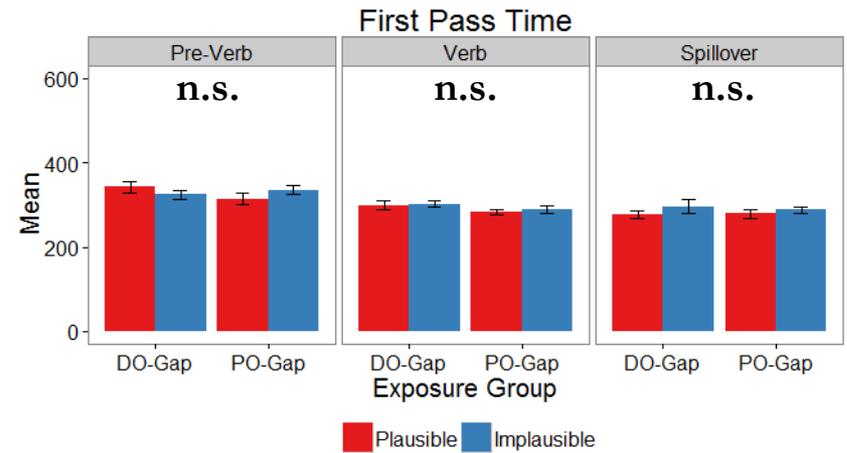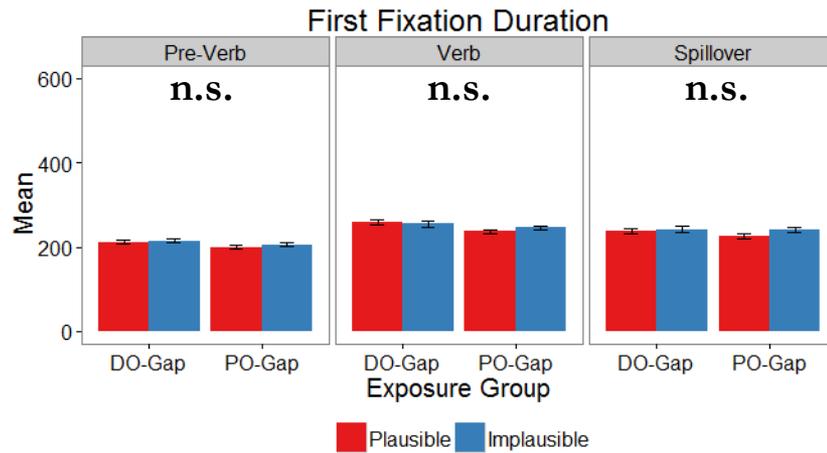 ‣ Psycholinguistics & SynSem Groups at the University of Michigan

Questions?

Atkinson & Omaki 2016: Results
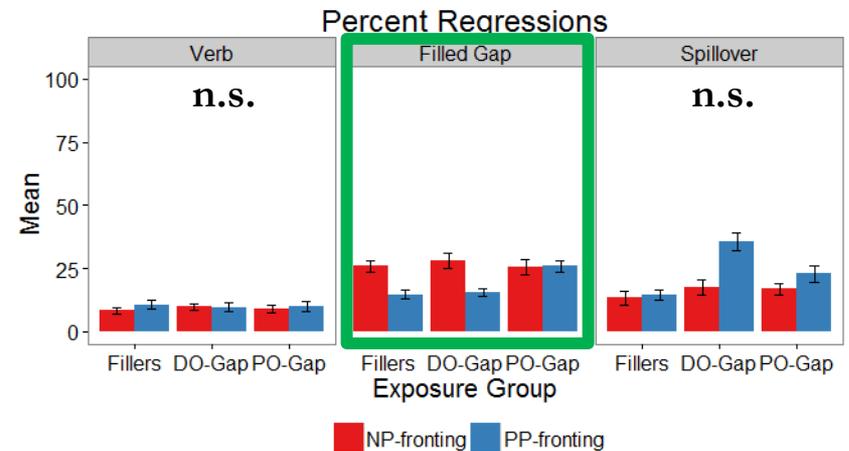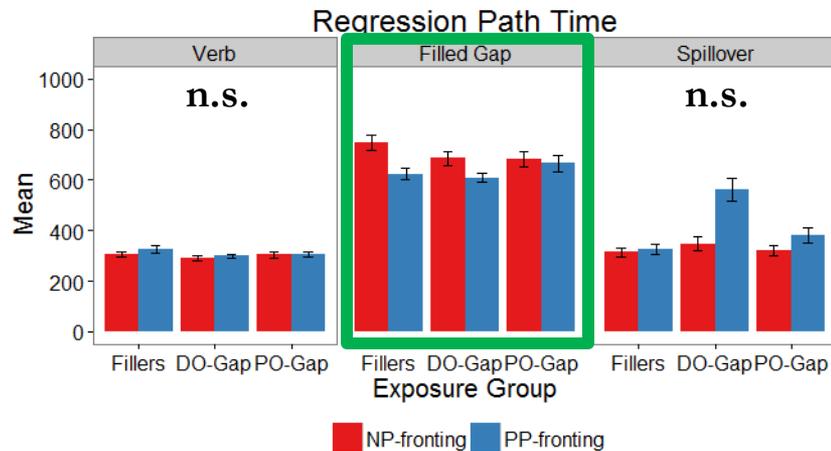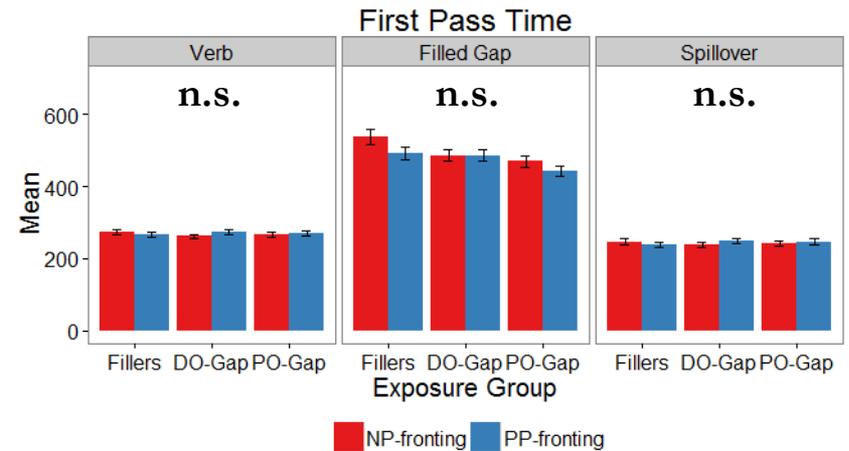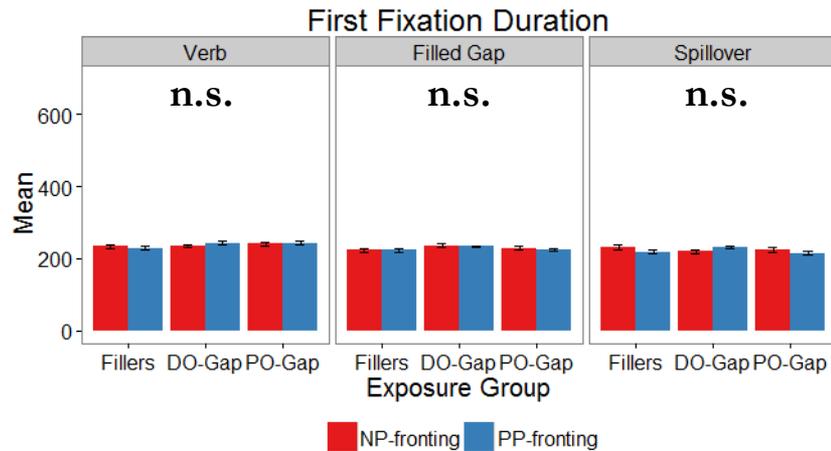
Experiment 1: Eye Tracking Results
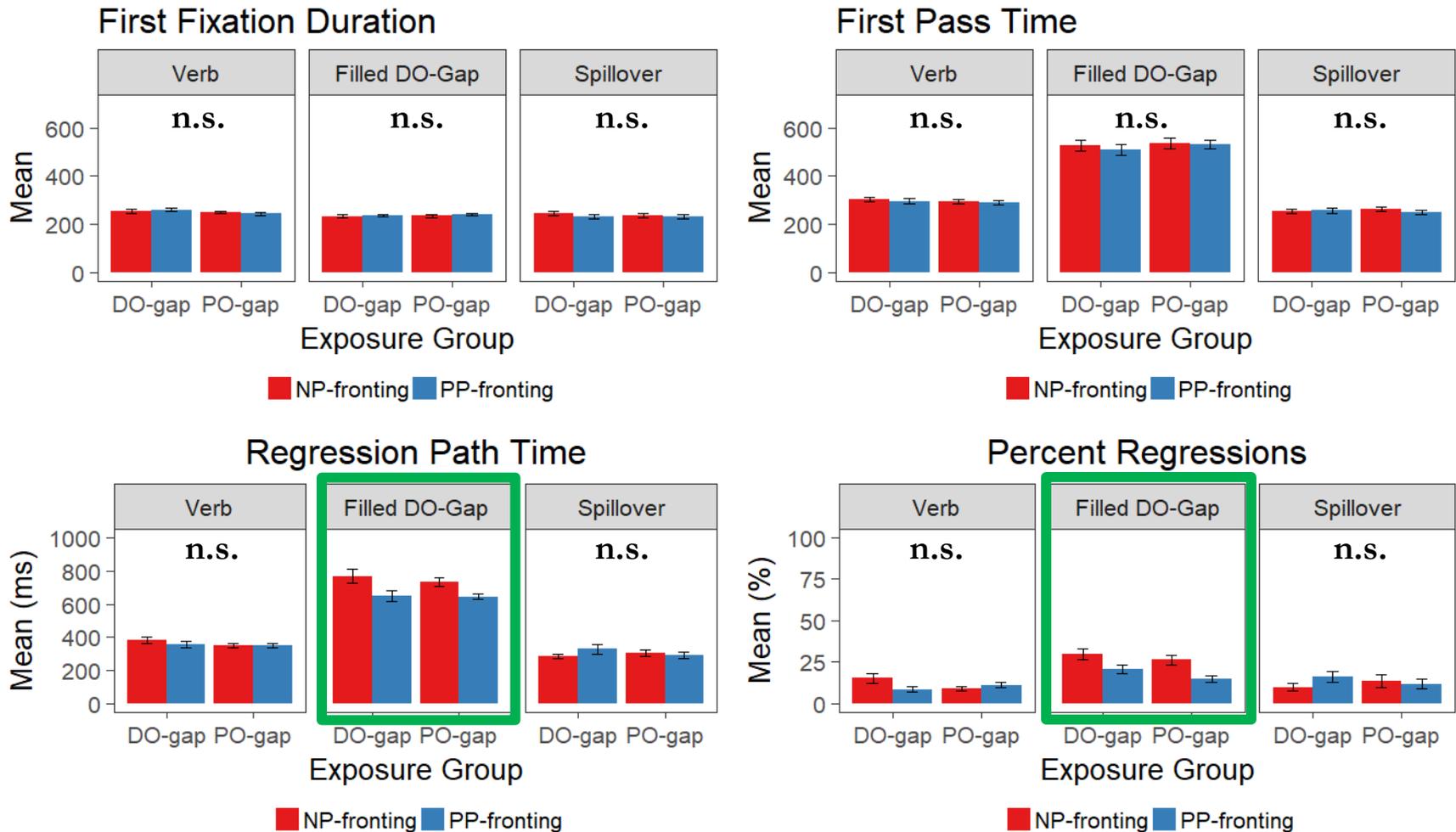
Experiment 2: Eye Tracking Results
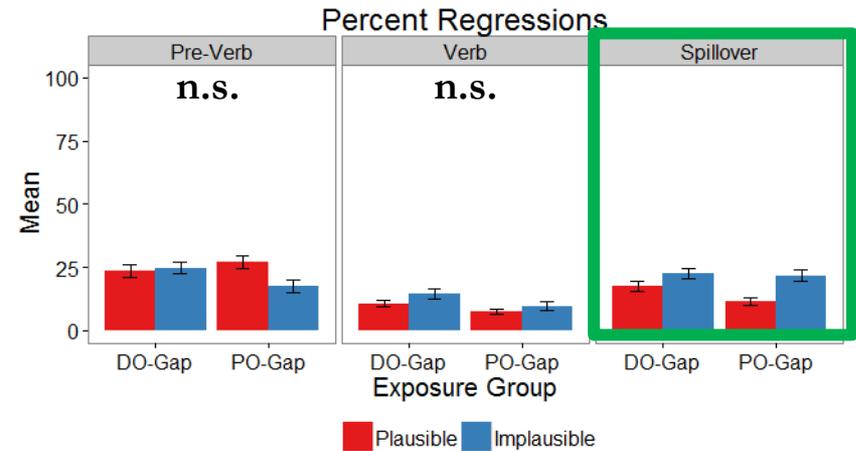
Blocked Adaptation: Filled PO Gap

‣ Need a new paradigm to test whether participants are actively predicting PO Gaps

‣ ***Filled prepositional object gap effect:*** slowdown on complement of the preposition in non-island conditions compared to island conditions

   ‣ Previous work demonstrates gaps not predicted within islands

   (e.g., Stowe 1986; Traxler & Pickering 1996)

Design

Exposure Type	Exposure Block
Prepositional object gaps	24 PO gap sentences
Direct object gaps	24 DO gap sentences
Fillers	24 fillers
Identical to previous experiment	

▸ *PO Gap*

The suitcase that the stealthy, wanted thief stole <u>the precious jewels</u> from __ was full of sentimental items.

▸ *DO Gap*

The painting that the infamously successful burglar stole __ from the museum was well guarded.

Design

Exposure Type	Exposure Block	Experimental Block
Prepositional object gaps	24 PO gap sentences	24 filled prepositional object gap targets + 48 fillers
Direct object gaps	24 DO gap sentences	
Fillers	24 fillers	

▸ ***Non-Island***
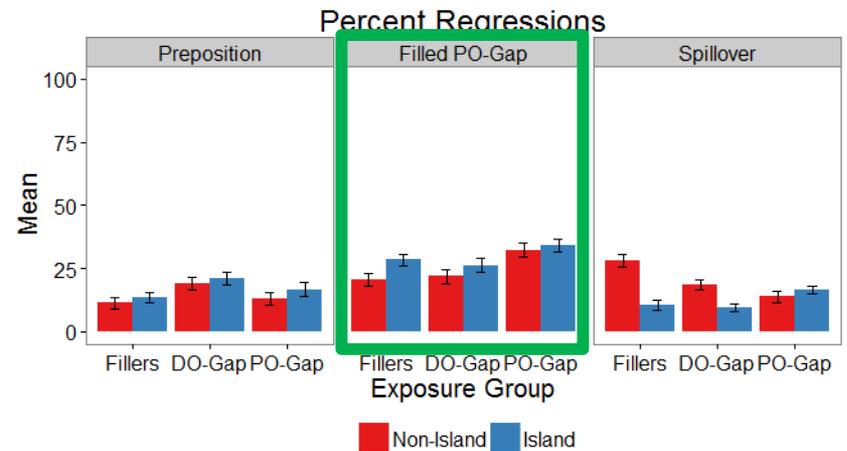
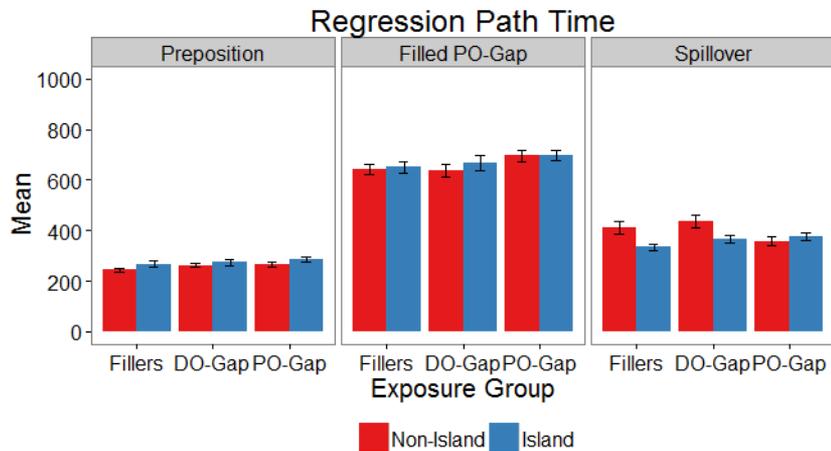**The carcass** that the large male lion ate __ by <u>the water's edge</u> was attracting scavengers.
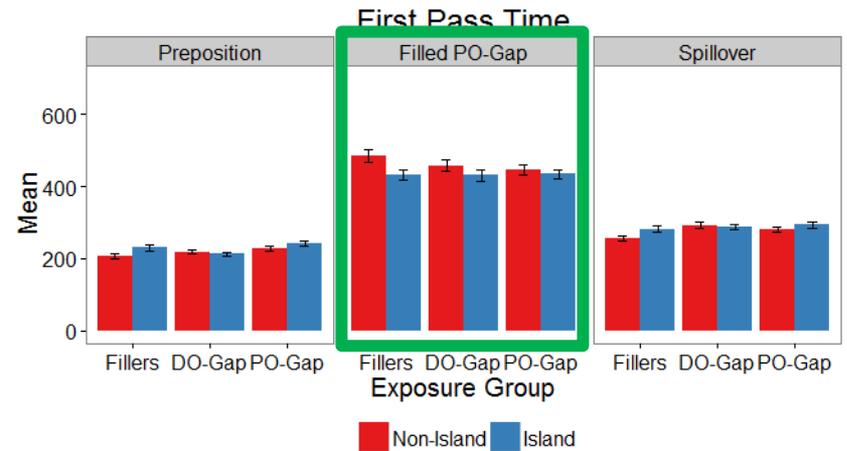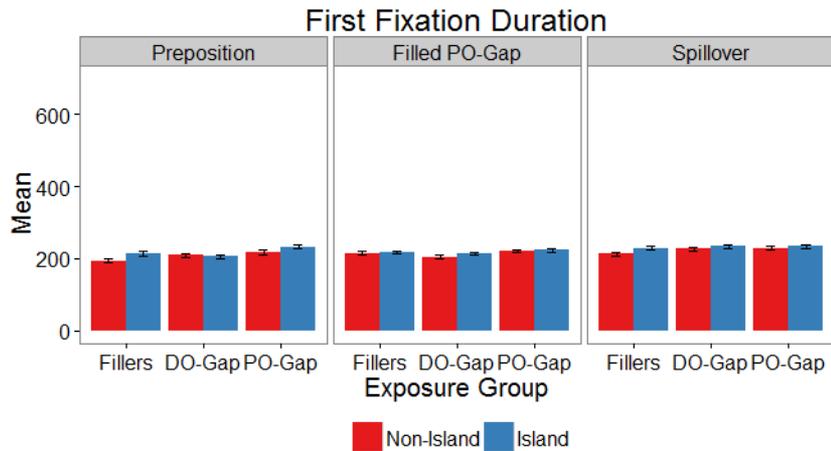
▸ ***Island***

The carcass that the large male lion [***who*** ate by <u>the water's edge</u>] found __ was attracting scavengers.

▸

Results
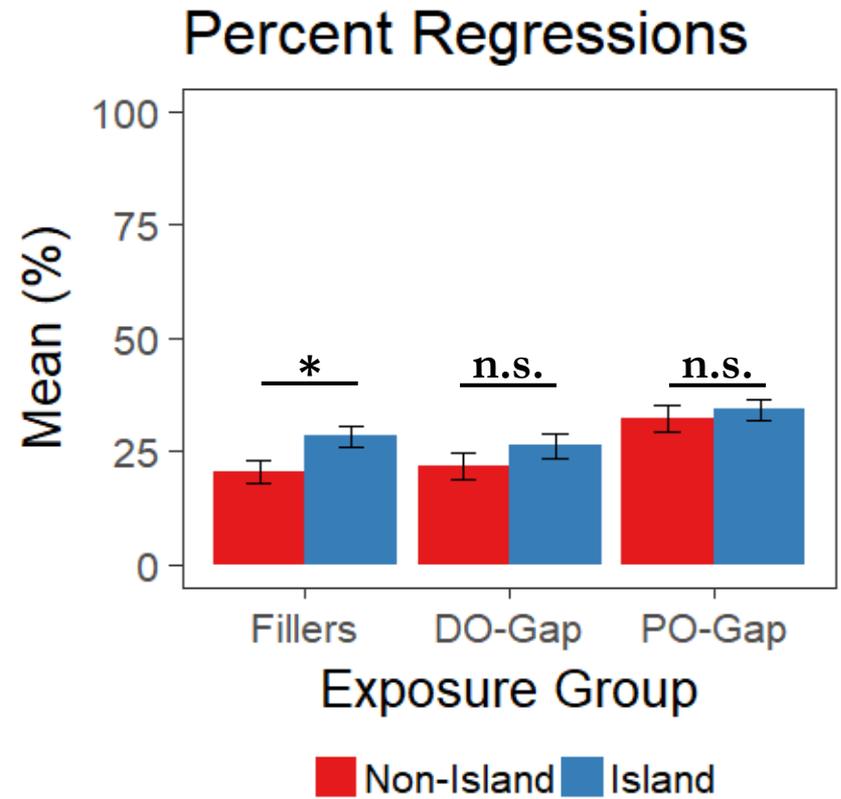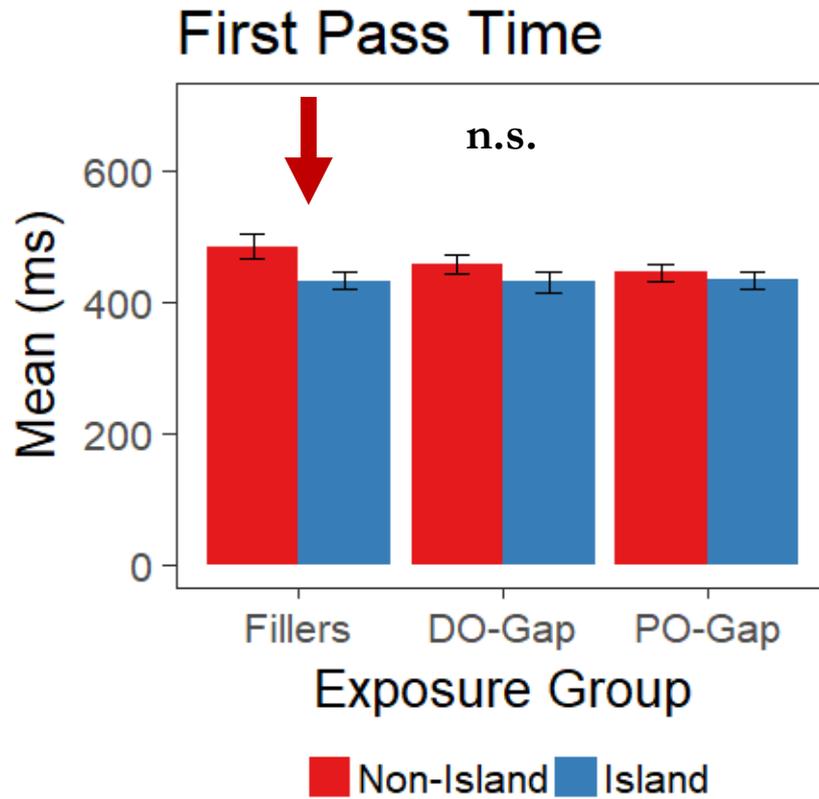
Filled PO Gap Region

First Pass Time and **Percent Regressions** bar charts by Exposure Group (Fillers, DO-Gap, PO-Gap), comparing Non-Island (red) and Island (blue). First Pass Time marked n.s.; Percent Regressions marked * for Fillers, n.s. for DO-Gap and PO-Gap.

▸ PO gap exposure group <u>not</u> actively predicting PO gaps

Summary

▸ Exposure to less predictable gap positions leads to general repression of (gap) predictions

▸ Taken together, blocked adaptation experiments not compatible with probabilistic parsing account
  ▸ Decrease in probability of one structure should lead to increase in probability of alternative structure

▸