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 by the lawyer turned out to (Ferreira & Clifton 1986)

examined = main verb

examined = reduced relative
Probabilistic Parsing

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

- Structural expectations reflect distribution of structures

(Jurafsky 1996; Hale 2001; Levy 2008)
Biases in ambiguity resolution can be altered by manipulating probability of competing structures.

- Exposure to *a priori* improbable structure increases expectation for that structure.

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**Stable Distribution**

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 newspaper…

(2) The book that Mary was reading the article about __.

- **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

<table>
<thead>
<tr>
<th>Corpus</th>
<th># Lines</th>
<th>Direct Object Gaps</th>
<th>Prepositional Object Gaps</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>CallHome</td>
<td>28,967</td>
<td>1,790</td>
<td>612</td>
<td>2,402</td>
</tr>
<tr>
<td>Switchboard</td>
<td>44,696</td>
<td>1,159</td>
<td>226</td>
<td>1,385</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>73,663</strong></td>
<td><strong>2,949 (77.9%)</strong></td>
<td><strong>838 (22.1%)</strong></td>
<td><strong>3,787</strong></td>
</tr>
</tbody>
</table>

(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)
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)
Exposure Type | Exposure Block
---|---
Prepositional object gaps | 24 PO gap sentences

**Prepositional Object (PO) Gap**

*The suitcase* that the stealthy, wanted thief stole *the precious* jewels from ___ was full of sentimental items.
Atkinson & Omaki 2016: Design

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- **Prepositional Object (PO) Gap**
  
  The suitcase that the stealthy, wanted thief stole the precious jewels 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

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- **Prepositional Object (PO) Gap**

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

- **Direct Object (DO) Gap**

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

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Atkinson & Omaki 2016: Design

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(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 **suppressed** in PO gap exposure group
Syntactic Adaptation Across Tasks

- Atkinson & Omaki (2016) demonstrates that participants do adapt 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

<table>
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<th>Exposure Type</th>
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<td></td>
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<td><strong>Identical to Atkinson &amp; Omaki (2016)</strong></td>
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- **NP-fronting**
  
  The suitcase *that* the stealthy, wanted thief stole *the precious jewels* from __ was full of sentimental items.

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

(e.g., Lee 2004; Stowe 1986; Wagers & Phillips 2014)
**Experiment 1: Design**

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- **PO Gap**

The newspaper article that their friend wrote the blog post about ___ gave great tips…
Experiment 1: Design

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

- **DO Gap**
  - The blog post that their friend wrote ___ about the newspaper article gave great tips…
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 **happy** to leave after such an exciting day.
## Experiment 1: Recognition Accuracy

<table>
<thead>
<tr>
<th>Exposure Type</th>
<th>Accuracy</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO gap sentences</td>
<td>69.6%</td>
<td>6.6%</td>
</tr>
<tr>
<td>PO gap sentences</td>
<td>67.9%</td>
<td>6.7%</td>
</tr>
</tbody>
</table>

- No significant difference in accuracy
Experiment 1: Filled Gap Region

- No significant effects on first fixation duration or first pass time
- PO gap exposure group doesn’t adapt 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

<table>
<thead>
<tr>
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<th>Sentence Recognition Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepositional object gaps</td>
<td>48 PO gap sentences</td>
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<tr>
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Identical to Experiment 1

- **PO Gap**
  - The newspaper article that their friend wrote the blog post 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 wrote thoughtfully about __ was named for an explorer.

- **Implausible Filler**
  
  The city that the author wrote thoughtfully about __ was named for an explorer.

(e.g., Traxler & Pickering 1996)
Experiment 2: Design

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- **Plausible Filler**
  - The book that the author *wrote thoughtfully* about __ was named for an explorer.

- **Implausible Filler**
  - The city that the author *wrote thoughtfully* about __ was named for an explorer.

(e.g., Traxler & Pickering 1996)
### Experiment 2: Recognition Accuracy

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<tr>
<th>Exposure Type</th>
<th>Accuracy</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO gap sentences</td>
<td>71.2%</td>
<td>6.5%</td>
</tr>
<tr>
<td>PO gap sentences</td>
<td>73.8%</td>
<td>6.4%</td>
</tr>
</tbody>
</table>

- No significant difference in accuracy
No significant effects on first fixation duration or first pass time.

PO gap exposure group doesn’t adapt 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!

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- Colin Wilson, Barbara Landau, Steven Gross, & Kevin Duh
- Melinh K. Lai
- Psycholinguistics & SynSem Groups at the University of Michigan

Questions?

Contact: eeatkins@umich.edu

Slides available at http://emilyeatkinson.net
Atkinson & Omaki 2016: Results

First Fixation Duration

<table>
<thead>
<tr>
<th></th>
<th>Verb</th>
<th>Filled Gap</th>
<th>Spillover</th>
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<tbody>
<tr>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
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First Pass Time

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<tr>
<td>n.s.</td>
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Regression Path Time

<table>
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<th>Verb</th>
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<tbody>
<tr>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
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Percent Regressions

<table>
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<tr>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
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Experiment 1: Eye Tracking Results

**First Fixation Duration**

- Verb: n.s.
- Filled DO-Gap: n.s.
- Spillover: n.s.

**First Pass Time**

- Verb: n.s.
- Filled DO-Gap: n.s.
- Spillover: n.s.

**Regression Path Time**

- Verb: n.s.
- Filled DO-Gap: n.s.

**Percent Regressions**

- Verb: n.s.
- Filled DO-Gap: n.s.
- Spillover: n.s.
Experiment 2: Eye Tracking Results

First Fixation Duration

<table>
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<th>Pre-Verb</th>
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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

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**Identical to previous experiment**

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

- **DO Gap**
  - The painting that the infamously successful burglar stole __ from the museum was well guarded.
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- **Non-Island**
  
  The carcass that the large male lion ate __ by the water’s edge was attracting scavengers.

- **Island**
  
  The carcass that the large male lion [who ate by the water’s edge] found __ was attracting scavengers.
Results
PO gap exposure group **not** 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