Previously Triggered Dependency Search Overrides Local Coherence Effects

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The Question

Does online long-distance dependency formation resolve local ambiguity?
Road Map

1. Introduction
   - Local Attachment
   - Active Search
   - Competition for the parser’s “attention”

2. Eye-tracking Study
   - Early measures
   - Late measures
   - A possible conflict?

3. Discussion
Local Attachment

As the parser encounters a string, attempts to form a coherent analysis:

* one possible structure-building method
Local Attachment

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[CP Whenever [IP he hums]]

[VP hums]] [IP [NP Annie’s song] …]

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Local Attachment

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* Intransitive or Transitive?

* one possible structure-building method
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[CP Whenever [IP he **hums Annie's song**]]

*one possible structure-building method*
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Local Attachment

As the parser encounters a string, it attempts to form a coherent analysis:

\[ \text{[VP hums [NP Annie's song] ...]} \]

\[ \text{[CP Whenever [IP he hums Annie's song] ...]} \]

*one possible structure-building method

e.g., Tabor & Hutchins (2004); Tabor, Galantucci & Richardson (2004)
The parser also seems to attempt to complete dependencies as early as possible
(e.g., van Gompel & Liversedge 2003, Kazanina et al. 2007)

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Active Search

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[CP Whenever he hums, [IP Annie’s song...]

No!!
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[CP Whenever he hums, [IP Annie’s song... ]]

GMME
Active Search

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But only when the grammar allows.

[CP Whenever he [VP hums [NP Annie’s song ……}
The parser also seems to attempt to complete dependencies as early as possible
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But only when the grammar allows.

[CP Whenever he [VP hums [NP Annie’s song ……

The NP is c-commanded by the pronoun (thus coreference violates Condition C) (Chomsky 1981)
Active Search

As the parser encounters a string, it must attempt to form a coherent analysis:

\[ \text{[CP Whenever [IP he \textbf{hums Annie's song}]} \]

\[ \text{[VP hums [NP Annie's song] ...]} \]

\[ \text{[VP hums] [IP [NP Annie's song] ...]} \]

*one possible structure-building method*
As the parser encounters a string, it must attempt to form a coherent analysis:

\[ \text{Whenever he hums Annie's song} \]

*one possible structure-building method*

e.g., Kazanina et al. (2007)
What is at stake?

Whenever *he* hums *Annie’s* song ....

- Local Attachment biases the parser to analyze “Annie’s song” as the embedded object
What is at stake?

Whenever *he* hums *Annie’s* song ......

- Local Attachment biases the parser to analyze “Annie’s song” as the embedded object.
- Active Search biases the parser to complete the dependency as early as possible, with Annie’s song analyzed as a matrix subject.
What is at stake?

Whenever *he* hums *Annie’s* song ……

- Local Attachment biases the parser to analyze “Annie’s song” as the embedded object
- Active Search biases the parser to complete the dependency as early as possible, with Annie’s song analyzed as a matrix subject
- These two biases pull the parser in different directions
What is at stake?

Whenever he hums Annie’s song ......

- Local Attachment biases the parser to analyze “Annie’s song” as the embedded object
- Active Search biases the parser to complete the dependency as early as possible, with Annie’s song analyzed as a matrix subject
- These two biases pull the parser in different directions
- Does the parser prioritize one?
Previous studies

Kwon & Sturt (2014)

- Before PRO running, Martin had breakfast.
- Before PRO washing the kids ...
1. Introduction
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   - Competing pressures

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### Predictions

<table>
<thead>
<tr>
<th>Hypothesis #1: Parser prioritizes</th>
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<td>Local Attachment</td>
<td>Dependency Formation</td>
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Whenever he hums Annie’s song

**Hypothesis #1**

The parser prioritizes forming a local attachment
Hypothesis #1
The parser prioritizes forming a local attachment

Whenever he hums Annie’s song ambiguous
Whenever he *hums Annie’s song*

Hypothesis #1

The parser prioritizes forming a local attachment
Whenever he hums Annie’s song

Hypothesis #1
The parser prioritizes forming a local attachment

Matrix subject
Requires non-local resolution

Embedded Object
Can have local resolution
Whenever he hums Annie’s song

Hypothesis #1
The parser prioritizes forming a local attachment
Whenever he hums Annie’s song is ….

Hypothesis #1
The parser prioritizes forming a local attachment
## Predictions

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Whenever he hums Annie’s song ambiguous

Hypothesis #2
The parser prioritizes forming a coreference dependency
Hypothesis #2
The parser prioritizes forming a coreference dependency.

Whenever he hums Annie’s song, the parser encounters an ambiguous coreference dependency: whenever he hums Annie’s song.

Diagram:
- Matrix subject: he
- Embedded Object: Annie’s song
- CP: whenever he hums
- IP: hums Annie’s song
- NP: Annie’s song
Hypothesis #2
The parser prioritizes forming a coreference dependency

Whenever he hums Annie’s song

ambiguous

Whenever he hums Annie’s song

Matrix subject
No c-command, Coreference possible

Embedded Object
C-command, Coreference impossible
Hypothesis #2
The parser prioritizes forming a coreference dependency.

Whenever he hums Annie’s song

[Diagram showing syntactic structure with annotations for 'whenever', 'he', 'hums', 'Annie’s song', 'Matrix subject', 'Embedded Object', 'No c-command, Coreference possible', 'C-command, Coreference impossible']
Hypothesis #2
The parser prioritizes forming a coreference dependency.

Whenever he hums Annie’s song is....
## Predictions

**Hypothesis #1: Parser prioritizes Local Attachment**

- Embedded object is c-commanded by cataphor
  - Thus cannot corefer
  - No slow-down predicted if gender mismatches
- Parser is surprised by the matrix verb
  - Slow-down predicted

**Hypothesis #2: Parser prioritizes Dependency Formation**

- Matrix subject is not c-commanded by cataphor
  - Thus can corefer
  - Slow-down at matrix subject if gender mismatches
- Parser expects the matrix verb
  - No slow-down predicted
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Eye-tracking methodology:
- 36 Northwestern undergrads
- 2 x 2 design, Gender Congruency vs Comma
- Presented in full sentences, one sentence at a time
- Comprehension questions after every sentence
- All results analyzed by Linear Mixed Effects Regressions (LMER)
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If local attachment:
- “Annie’s song” is misanalysed as an embedded object
- → RT slowdown at **matrix verb** in No Comma conditions
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If **dependency formation**: ‘Annie’s favorite song’ is analysed as a Matrix subject

→ RT slowdown in **Gender-mismatch conditions**
Matrix subject region:
- Gender Mismatch Effect
- Supports Hypothesis #2
  - Parser prioritizes forming a dependency early
  - Parser attempts to form a cataphoric dependency at matrix subject

Main effect of Gender: p<.03
Main effect of Comma: n.s.
Interaction (Gender vs Comma): n.s.
Matrix verb spillover region:
- Reading time slow-down
- Supports Hypothesis #1
  - Parser prioritizes forming a local attachment analysis
  - Parser is surprised by the intransitive verb

Main effect of Gender: n.s.
Main effect of Comma: p<.001
Interaction (Gender vs Comma) : n.s.
Matrix verb region:
- Reading time slow-down
- Supports Hypothesis #1
  - Parser prioritizes forming a local attachment analysis
  - Parser is surprised by the intransitive verb

Main effect of Gender: n.s.
Main effect of Comma: p<.02
Interaction (Gender vs Comma) : n.s.
Road Map

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Discussion

- Parser prioritizes cataphoric dependency formation (first-pass effects at the matrix subject)
  - Online formation of a cataphoric dependency affects local ambiguity resolution

- But it shows effects of a local attachment analysis (regression path & total time at the matrix verb)
Discussion

- **Multiple simultaneous representations**
  (e.g., Slattery et al. 2013, Gibson & Pearlmutter 2000, Pearlmutter & Mendelsohn 1999)
  - On each trial the parser maintains multiple representations
Discussion

- **Multiple non-simultaneous representations**
  (Kwon & Sturt 2014)
  - On a given trial the parser is guided by either Active Search or Local Attachment
  - Complementary subsets of trials showing a GMME at 'Annie's' vs. garden path at 'was'
Thank you!

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References


Slattery, Sturt, Christianson, Yoshida & Ferreira. (2013). Lingering misinterpretations of garden path sentences arise from competing syntactic representations. JML 69, 104–120.


Offline Forced-Coreference Acceptability

Scaled Likert Ratings for Forced Coreference Acceptability
Effect of Punctuation on Transitivity Bias

Use of EO and MS in forced-choice completions

- **Comma**
  - EO: 11.67%
  - MS: 88.33%

- **Nocomma**
  - EO: 63.33%
  - MS: 36.67%
Forced-Coreference Pilot for Eye-tracking

Likert Scale rating of Sentences with Line-break as a Factor

condition
