Structured Access in Comprehension

Brian Dillon
Linguistics

Cognitive Brown Bag
October 5, 2011
The man who kicked John hurt himself
Memory access

The man who kicked John hurt himself

Tuesday, October 4, 11
The man who kicked John hurt himself
Today

Claim: syntactic parsing operations rely on *structured memory access* for retrieval of information.
Pt. 1, English reflexives: feature content of distractor should not result in incorrect retrieval.

Pt. 2, Mandarin reflexives: feature mismatched targets should be retrieved based solely on syntactic position.
The man who hurt himself

Target

The man who saw John

Distractor
Interference

When a sentence has...

- Multiple proper names
- Multiple descriptive NPs
- Multiple animate nouns
- Multiple subjects
- Multiple NPs with identical case
- Multiple nationality nouns
- Multiple job nouns

... it is more difficult (slower) to understand.

Interference

When a sentence has...

- ungrammatical agreement but a feature-matched distractor
- ungrammatical NPI dependency but a feature-matched distractor

... it is less difficult (faster) to understand.

Agreement attraction

*The key[-PL] to the cabinet[-PL] definitely are[+PL] rusty.

*The key[-PL] to the cabinets[+PL] definitely are[+PL] rusty.
Agreement attraction

*The key to the **cabinet** were on the table.

*The key to the **cabinets** were on the table.

figure from Wagers, Lau & Phillips 2009
The key to the cabinets definitely are ...
Agreement attraction

The key to the cabinets definitely are ...

McElree, Foraker and Dyer 2003; Lewis and Vasishth 2005; Lewis, Vasishth and Van Dyke 2006
Agreement attraction

Data

Model

Judgment model: Direct access agreement

figure from Wagers, Lau & Phillips 2009

from ACT-R parser

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Broken agreement

[The key to the cabinet] definitely was...

[The key to the cabinets] definitely was...

*[The key to the cabinet] definitely were...

*[The key to the cabinets] definitely were...

↑ target

↑ distractor

Pearlmutter, Garnsey & Bock 1999; Wagers, Lau & Phillips 2009; (also Bock & Miller 1991)
Summary of interference effects in Pearlmutter et al 1999

-150 -100 -50 0 50 100 150

Interference effect (ms)

[The key to cabinets were...] - [The key to the cabinet were]

Summary of interference effects in Wagers et al 2009

-60 -40 -20 0 20 40 60

Interference effect (ms)

[The key to cabinets was...] - [The key to the cabinet was]
So: agreement retrievals are content-addressable. Item information, rather than structure, provides the ‘index’ or ‘cue’ to retrieval. Agreement attraction results.
Agreement attraction results from incorrect retrieval, initiated only when bottom-up input clashes with predicted features!

Wagers 2008; Wagers, Lau & Phillips 2009
This reflects the normal workings of the parser. Syntactic parsing relies on skilled memory retrieval using a variety of cues... leading to occasional error.

Lewis & Vasishth 2005; Lewis, Vasishth & Van Dyke 2006; Vasishth et al 2008; Chen et al 2010; Patil et al 2011
The man[-PL] with the kids[+PL] hurt themselves[+PL]
Reflexives

Cross-modal priming: Nicol & Swinney 1989


Eye-tracking: Sturt 2003

ERP: Xiang, Dillon & Phillips 2009
Reflexives

The **surgeon** who treated **Bruce** pricked **her/himself** with a used needle.

The **surgeon** who treated **Jennifer** pricked **her/himself** with a used needle.
Summary of interference effects in Sturt 2003

Summary of interference effects in Wagers et al 2009

Agreement attraction pattern.
The key to the cabinets definitely were...

The surgeon who treated Mary pricked herself...

target
distractor
[The surgeon who treated the girl(s)] totally was/were...

[The surgeon who treated the girl(s)] totally pricked him/themselves...

↑

target
distractor
Offline judgments

Agreement.

Reflexives.

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Overview

Summary of interference effects in Experiments 1-3

- Agr: Exp 1
- Agr: Exp 2
- Ref: Exp 1
- Ref: Exp 3
Critical region first pass reading time in Experiment 1

- [+]gram, [-]intr
- [-]gram, [+]intr
- [-]gram, [-]intr
- [-]gram, [+]intr

First-pass
Total reading times

Critical region total reading time in Experiment 1

- Agreement
  - [+gram],[-intr]
  - [-gram],[+intr]
  - [-gram],[-intr]
  - [-gram],[+intr]

- Reflexive
Critical region $P(\text{regression})$ in Experiment 1

- Agreement
- Reflexive

Legend:
- $[+\text{gram}],[+\text{intr}]$
- $[+\text{gram}],[+\text{intr}]$
- $[+\text{gram}],[+\text{intr}]$
- $[+\text{gram}],[+\text{intr}]$

RT

- Agreement
- Reflexive

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Activation of constituent $i$:

$$A_i = B_i + \sum_{j=1}^{m} W_j S_{ji} + \sum_{k=1}^{p} PM_{ki} + \epsilon$$
*The new executive who t oversaw the middle managers definitely were ....
*The new executive who oversaw the middle managers apparently doubted themselves*
Retrieval Model: Results

Predicted % of incorrect retrievals

- Reflexives: % retrieval of distractor NP

- Feature-based access:
  - +Gram,-Intr
  - +Gram,+Intr
  - -Gram,-Intr
  - -Gram,+Intr

- Structured access:
  - +Gram,-Intr
  - +Gram,+Intr
  - -Gram,-Intr
  - -Gram,+Intr

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Predicted and observed reflexive interference effects

- Model: Grammatical
- Model: Ungrammatical
- Empirical: Grammatical
- Empirical: Ungrammatical

Feature-based access vs. Structured access
- English reflexives do not pattern like English agreement.

- No evidence that comprehenders retrieve incorrect antecedent for reflexives; suggests that the structural position controls memory retrieval.
Pt. 1, English reflexives: feature content of distractor should not result in incorrect retrieval.

Pt. 2, Mandarin reflexives: feature mismatched targets should be retrieved based solely on syntactic position.
“Lisi says that Xiaoming harmed her/herself.”
Lisi  shuo fengbao  hai-le  ziji

LD:  
Lisi  says  storm  harm-PERF  self
“Fenqin says that the storm harmed her.”

Xiaoshuo  shuo  Lisi  hai-le  ziji

Local:  
Novel  says  Lisi  harm-PERF  self
“The novel says Lisi harmed herself.”
Mandarin ziji

Local:

```
S
  NP
    Novel
  VP
    V
      say
      NP
        Lisi
        VP
          V
            harm
            NP
              ziji
```

LD:

```
S
  NP
    Lisi
  VP
    V
      say
      NP
        storm
        VP
          V
            harm
            NP
              ziji
```

**Time Course: Expt 6**

- S
- NP: Novel
- VP: say NP Lisi VP harm ziji
- S
- NP: Lisi
- VP: say NP storm VP harm ziji

+subject +c-command

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Time course of retrieval

Constant access time:

- Cross-sentential anaphora
- VP ellipsis
- Wh-filler retrieval
- Clefted filler retrieval
- Subject-verb integration

\[ d' = \lambda(1 - e^{-\beta(t-\delta)}) \quad \text{for} \quad t > \delta \]

张教练 表明 那篇报导 [在 团队 未能 发挥 水准 的时候] 低估了 自己
Coach Zhang say [that report [when team not perform well time] underestimate ziji]
“Coach Zhang says that that report underestimated self when the team was doing poorly.”

回忆录 表明 张教练 [在 团队 未能 发挥 水准 的时候] 低估了 自己
Auto-biography say [coach Zhang [when team not perform well time] underestimate ziji]
“The auto-biography says that coach Zhang underestimated self when the team was doing poorly.”

张教练 表明 那篇报导 [在 团队 未能 发挥 水准 的时候] 低估了 那位击球手
Coach Zhang say [that report [when team not perform well time] underestimate that batsman]
“Coach Zhang says that that report underestimated the batsman when the team was doing poorly.”

回忆录 表明 张教练 [在 团队 未能 发挥 水准 的时候] 低估了 那位击球手
Auto-biography say [coach Zhang [when team not perform well time] underestimate that batsman]
“The auto-biography says that coach Zhang underestimated the batsman when the team was doing poorly.”

Local control:
Control SAT functions

Proportion of asymptotic accuracy vs. Processing time (ms)

- **Long-distance control**
- **Local control**

Difference = -6 ms
Mandarin *ziji* SAT functions

![Graph showing the time course of Expt 6 for Mandarin *ziji* SAT functions. The graph compares local and long-distance antecedent processing times, with a difference of 56 ms.](image)

Proportion of asymptotic accuracy

Processing time (ms)

- Long-distance antecedent
- Local antecedent

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Average rate $\beta$ for ziji and control conditions

Average asymptotic accuracy $\lambda$ for ziji and control conditions

![Bar chart showing speed and accuracy for ziji and control conditions.](chart.png)
LD binding
厨師表示 [油鍋 曾经烫伤了 自己]， 所以 辞职了。
Chef say [deep-fryer scalded ziji], so (pro) resigned.
“The chef said the deep fryer scalded him, so he resigned.”

Local binding
医疗报告 表示 [厨师 曾经烫伤了 自己]， 所以 辞职了。
Medical report say [chef scalded ziji], so (pro) resigned.
“The medical report said the chef scalded himself, so he resigned.”

No binding
*/?医疗报告 表示 [油锅 曾经烫伤了 自己]， 所以 辞职了。
*/?Medical report say [deep-fryer scalded ziji], so (pro) resigned.
*/? “The medical report says that the deep fryer scalded self, so he/she/I resigned.”
ERP

LD ziji

Local ziji

Long-distance antecedent

Local antecedent

No antecedent
- Long-distance binding is slower to process (SAT) and temporarily treated as a feature mismatch (ERP)... despite the fact that it is the preferred interpretation!

- Suggests that comprehenders retrieve the local subject, despite its feature mismatch. **Structural position determines retrieval**, not semantic features.
Wrapping up

Pt. 1, English reflexives: feature content of distractor did not cause syntactically illicit retrieval.

Pt. 2, Mandarin reflexives: feature mismatched distractors were retrieved if they were in a syntactically licit position.
For parsing-related retrievals, comprehenders engage a structured access mechanism: syntactic position rather than feature content determines what we retrieve in online parsing.
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Average processing speed $\delta + \beta^{-1}$ for ziji and control conditions

- **Local condition**
- **LD condition**

**Processing speed (ms)**

**Ziji**

**Control**

**Speed (delta+beta^{-1})**
Interference

Sample Sentence

- The banker that the barber praised climbed the mountain
- The banker that praised the barber climbed the mountain
- The banker that you praised climbed the mountain
- The banker that you climbed the mountain

Gordon et al 2001
Interference

[The banker who the barber praised] climbed...

[the banker]

Gordon et al 2001
[The banker who the barber praised] climbed...
Interference

[The banker who the barber praised] climbed...

feature over-writing inhibits subsequent retrieval.

Nairne 1988, 1990
SAT estimates

Dynamics advantage for local antecedents

Dynamics advantage for local control condition

Participants

Participants
Expt 1

Agreement Conditions: Regions 5–6

First Pass Time

Total Reading Time

...were reluctant

to work long shifts.

...were reluctant

to work long shifts.
Expt 1

Reflexive Conditions: Regions 5–6

First Pass Time

Total Reading Time

...themselves with a used syringe.

Reflexive Conditions: Regions 5–6

First Pass Time

Total Reading Time

...themselves with a used syringe.

Reflexive Conditions: Regions 5–6

First Pass Time

Total Reading Time

...themselves with a used syringe.

Reflexive Conditions: Regions 5–6

First Pass Time

Total Reading Time

...themselves with a used syringe.
Experiment 2: Agreement
First Pass and Total Reading Times in Region 5

<table>
<thead>
<tr>
<th>Singular Subject</th>
<th>Plural Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First Pass Time</strong></td>
<td><strong>First Pass Time</strong></td>
</tr>
<tr>
<td><strong>Total Reading Time</strong></td>
<td><strong>Total Reading Time</strong></td>
</tr>
</tbody>
</table>

- Singular Subject
- Plural Subject
- +Gram, −Intr
- +Gram, +Intr
- −Gram, −Intr
- −Gram, +Intr
Experiment 3: Reflexives
First Pass and Total Reading Times in Region 5

**Ssingular Subject**

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>+Gram,−Intr</td>
<td></td>
<td></td>
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<tr>
<td>+Gram,+Intr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>−Gram,−Intr</td>
<td></td>
<td></td>
</tr>
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<td>−Gram,+Intr</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Plural Subject**

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</tr>
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<td>−Gram,−Intr</td>
<td></td>
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</tr>
<tr>
<td>−Gram,+Intr</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Model error rates

Predicted % of incorrect retrievals

- +Gram,-Intr
- +Gram,+Intr
- -Gram,-Intr
- -Gram,+Intr

% retrieval of interfering noun

Agreement  Feature-based reflexives  Structural reflexives

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Model comparison

\[
\frac{L(M_1 \mid D)}{L(M_2 \mid D)}; \quad L(M \mid D) = \int L(\theta \mid D) p(\theta \mid M) d\theta
\]
From experiment to model

Predicted interference: Grammatical conditions

- Agreement
- Feature-based reflexives
- Structural reflexives

Empirical likelihood for agreement interference
Empirical likelihood for reflexive interference

Predicted interference: Ungrammatical conditions

- Agreement
- Feature-based reflexives
- Structural reflexives

Empirical likelihood for agreement interference
Empirical likelihood for reflexive interference