

Does the parser exclusively use structure-sensitive search in reflexives? Evidence from Mandarin Chinese

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Outline

1 Introduction

2 Experiment

3 Modeling

4 Conclusions

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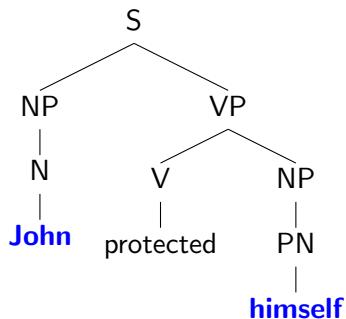
1 Introduction

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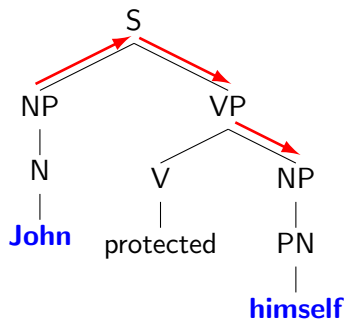
4 Conclusions

Parse a sentence ...



The human parser is sensitive to **structural constraints** in real time.

Parse a sentence ...



Structural-sensitive search

In anaphoric dependencies, the antecedent *c-commands* the reflexive. (Chomsky, 1981; Reinhart, 1981)

Structure-sensitive search: recent evidence

Xiang, Dillon, and Phillips (2009)

1. The tough **soldier** [that **Katie** treated in the military hospital] introduced **herself** to all the nurses.

Gender: Katie = herself

2. The tough **soldier** [that **Fred** treated in the military hospital] introduced **herself** to all the nurses.

Gender: Fred \neq herself

see also Sturt (2003)

(Exclusive) structure-sensitive search

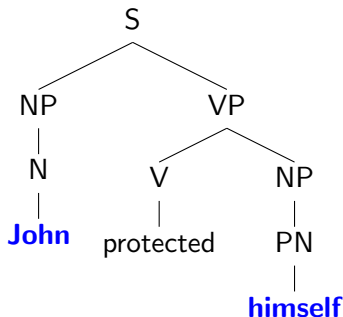
Phillips, Wagers, and Lau (to appear)

“we tentatively suggest that argument reflexives are immune to interference from structurally inaccessible antecedents because antecedents are retrieved using only structural cues.”

“we are suggesting that the person, gender, and number features of reflexives like himself, herself, and themselves play no role in the search for antecedents.”

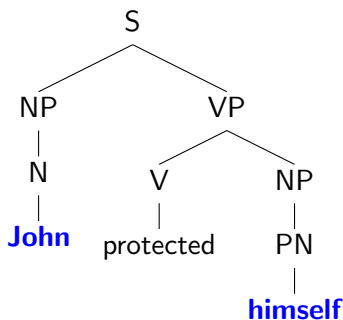
Cue-based retrieval

Lewis and Vasishth (2005); Lewis, Vasishth, and Van Dyke (2006)



Cue-based retrieval

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$$\left[\begin{array}{l} \text{cat} : S \\ \text{num} : \textit{sing} \\ \text{spec} : NP \\ \text{comp} : VP \\ \text{tense} : \textit{past} \end{array} \right]$$

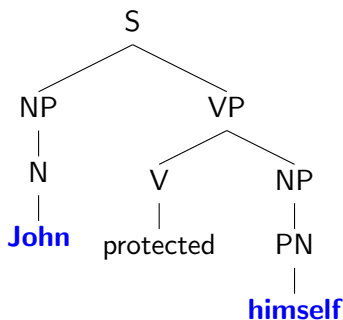
$$\left[\begin{array}{l} \text{cat} : VP \\ \text{num} : \textit{sing/pl} \\ \text{tense} : \textit{past} \\ \text{comp} : NP \\ \text{head} : \textit{protected} \end{array} \right]$$

$$\left[\begin{array}{l} \text{cat} : NP \\ \text{num} : \textit{sing} \\ \text{case} : \textit{nom} \\ \text{gender} : M \\ \text{head} : \textit{John} \end{array} \right]$$

$$\left[\begin{array}{l} \text{cat} : NP \\ \text{num} : \textit{sing} \\ \text{case} : \textit{acc} \\ \text{gender} : M \\ \text{head} : \textit{himself} \end{array} \right]$$

Cue-based retrieval

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$$\left[\begin{array}{l} \text{cat} : S \\ \text{num} : \textit{sing} \\ \text{spec} : NP \\ \text{comp} : VP \\ \text{tense} : \textit{past} \end{array} \right]$$

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Similarity-based interference (SBI)

high SBI

1. The tough **soldier** that **Katie** treated in the military hospital introduced **herself** to all the nurses.

low SBI

2. The tough **soldier** that **Fred** treated in the military hospital introduced **herself** to all the nurses.

Xiang et al. (2009)

Research questions

Research questions

What searching strategy does the parser employ in building anaphoric dependencies?

Is the structure-sensitive search exclusive?

Can interference effect surface under a stronger statistical power?

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Test memory access using *ziji*

Our work was motivated by Dillon et al. (submitted).

Mandarin reflexive *ziji*:

local / long-distance binding.
completely retrospective.

Test memory access using *ziji*

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Structural constraints

The antecedent c-commands *ziji*

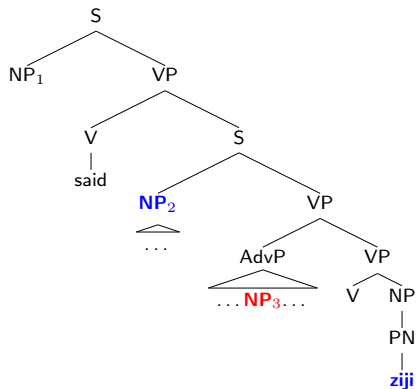
The antecedent locates in the subject position.

Non-structural constraints

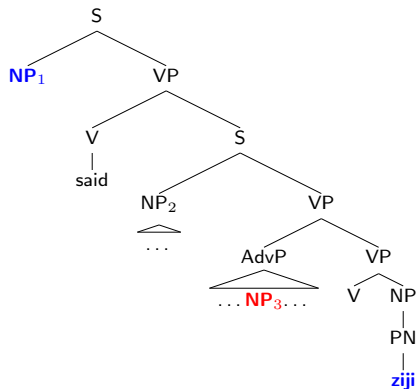
The antecedent is animate and sentient.

cf. Huang and Liu (2001); Huang, Cole, and Hermon (2006)

Test memory access using *ziji*: locality



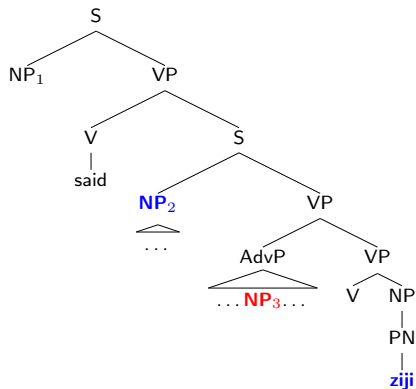
(1) Local



(2) Non-local

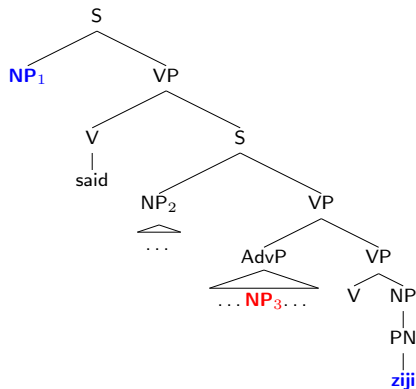
c.f. Liu (2009); Li and Zhou (2010); Dillon et al. (submitted)

Test memory access using *ziji*: interference effect



(1) Local

(a) Non-Interfering (b) Interfering



(2) Non-local

(c) Non-Interfering (d) Interfering

A self-paced reading experiment:

- 2×2 factorial design: Locality \times Interference
- 24 sets of conditions; 70 fillers
- 120 Mandarin-speaking undergraduate subjects in China.
- A yes-no comprehension question after the stimulus sentence.

Experiment conditions

a: *Non-local; Non-interfering*

反对派领袖 表示 [这个声明 [在 抗议 失控 的时候]_{AdvP}
 opposition-leader say the-statement at protest lose-control time
 告诫了 自己的 党员]_S
 warned ziji 's party member

'The opposition leader said that this statement warned his party members when the protest got out of control.'

b: *Non-local; Interfering*

反对派领袖 表示 [这个声明 [在 抗议者 失控 的时候]_{AdvP}
 opposition-leader say the-statement at protester lose-control time
 告诫了 自己的 党员]_S
 warned ziji 's party member

'The opposition leader said that this statement warned his party members when protesters got out of control.'

Experiment conditions

c: *Local; Non-interfering*

这个声明 表示 [反对派领袖 [在 抗议 失控 的时候]_{AdvP}
 this-statement say **opposition-leader** at **protest** lose-control time
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 warned **ziji** 's party member

'This statement said that the opposition leader warned his party members when
the protest got out of control.'

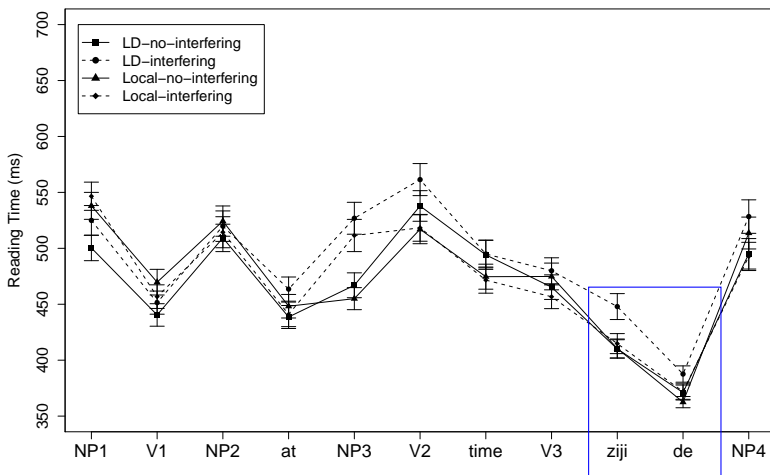
d: *Local; Interfering*

这个声明 表示 [反对派领袖 [在 抗议者 失控 的时候]_{AdvP}
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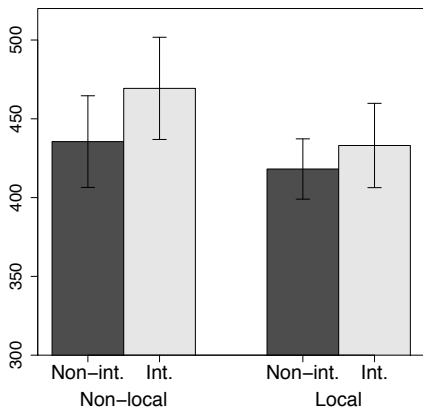
Mean reading times for each condition

6.08% data (RT > 2000 ms) were removed.

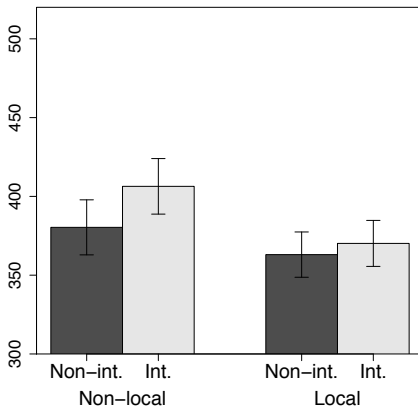


Mean RTs at critical and spillover regions

Reading Time (ms) at 'ziji', 95% CI



Reading Time (ms) at 'ziji+1', 95% CI



Statistical analyses

Results from the linear mixed model

Region	Contrast	Coefficient	Std. Error	t-value
<i>ziji</i>	Locality	-0.026	0.013	-1.92
	Interference	0.027	0.013	2.03
	Loc. \times Interf.	-0.026	0.013	-1.97
<i>ziji</i> + 1	Locality	-0.024	0.010	-2.26
	Interference	0.023	0.010	2.25
	Loc. \times Interf.	-0.001	0.010	-0.94

Note: We used orthogonal contrast coding ($\pm\frac{1}{2}$ for each factor).
RTs were log-transformed.

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Sentence processing as memory retrieval

Boston, Hale, Vasishth, and Kliegl (2011)

implements the cue-based retrieval (Lewis & Vasishth, 2005) in a dependency parser and includes some key assumptions of the general cognitive architecture ACT-R. (Anderson & Lebiere, 1998)

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$$A_i = B_i + \sum_j W_j S_{ji}$$

Activation value



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Activation value

Baseline activation

Similarity-based interference

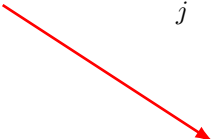
Sentence processing as memory retrieval

Boston et al. (2011)

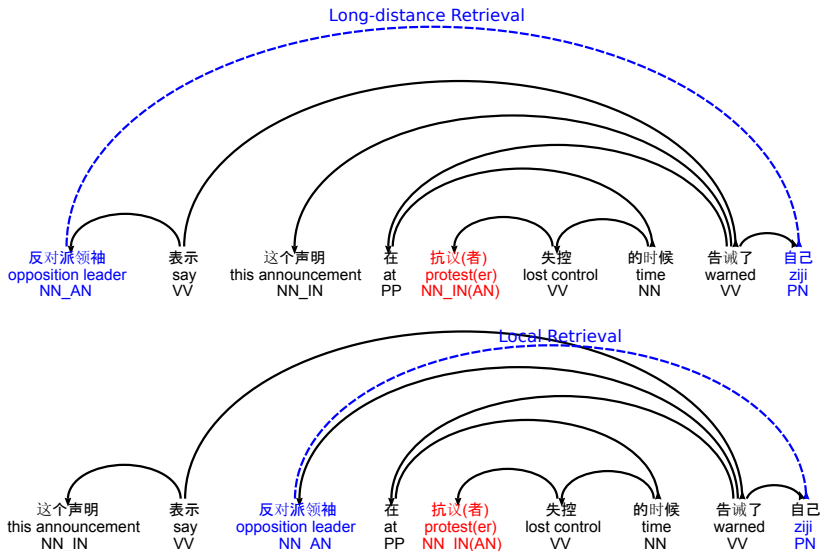
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$$A_i = B_i + \sum_j W_j S_{ji}$$

Retrieval time:

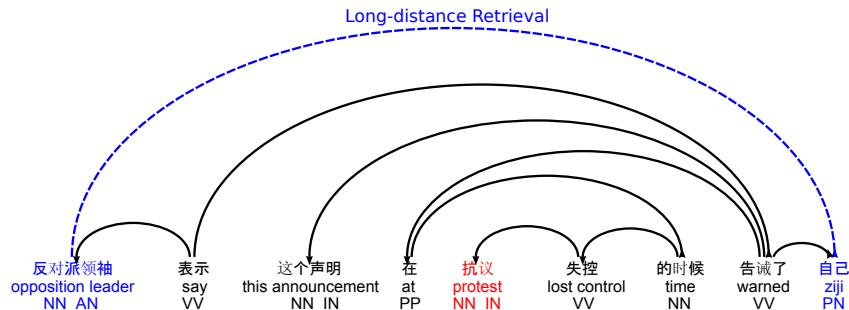

$$T_i = F e^{-A_i}$$

Dependencies



Caculating the retrieval latencies...

a: *Non-local; Non-interfering*

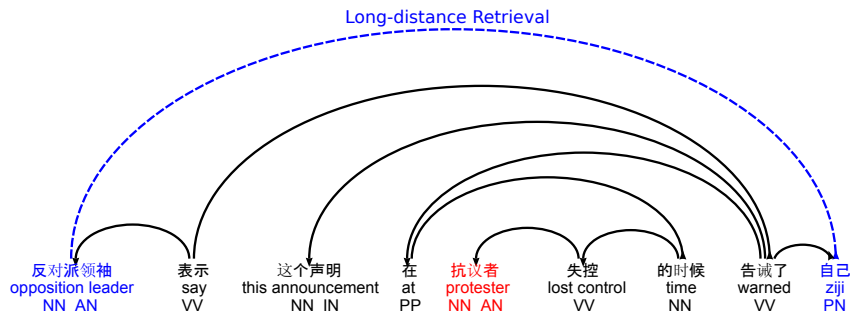


$$A = -3.17$$

$$T = 334 \text{ ms}$$

Caculating the retrieval latencies...

b: *Non-local; Interfering*

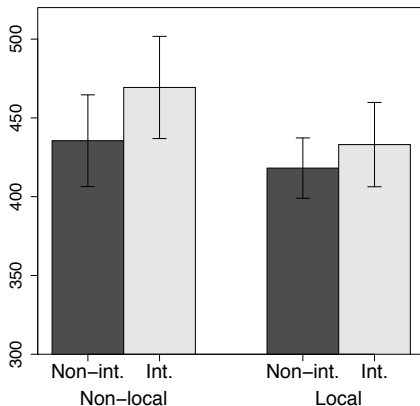


$$A = -3.58$$

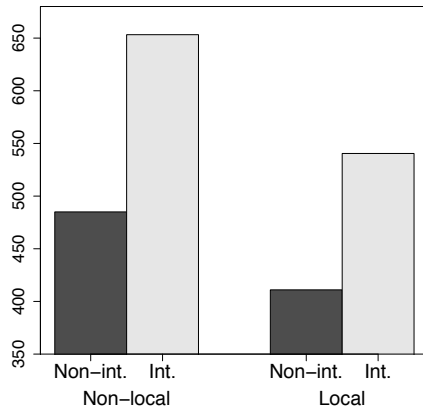
$$T = 502 \text{ ms}$$

Modeling results

Reading Time (ms) at 'ziji', 95% CI



Predicted Reading Time (ms) at 'ziji'



Conclusions

Using Mandarin *ziji*, we showed that:

- Building the anaphoric dependency is subject to **locality**. (confirms the results of Dillon et al. (submitted)).
- The retrieval of antecedent can suffer **interference** from elements that share non-structural cues, such as *animacy* (cf. Phillips et al. (to appear)).
- The parser does **not** seem to **exclusively** use structural cues for antecedent resolution of reflexives.

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谢谢!
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Absence of the interference effect

An example of statistical power:

In a two-sided paired t-test for self-paced reading data

$$\text{if } \left\{ \begin{array}{l} \Delta = 20 \text{ ms} \\ \text{s.d.} = 75 \text{ ms} \\ \text{power} = 0.8 \\ \text{sig.level} = 0.05 \end{array} \right\} \quad \text{We need } n = 112$$

to achieve a significant difference, if there were one in reality.

It is common to have a sample of 20. Given such difference of means and s.d., you only have a 20.4% chance of finding a significant effect if such effect does exist.

Comprehension-question response accuracies

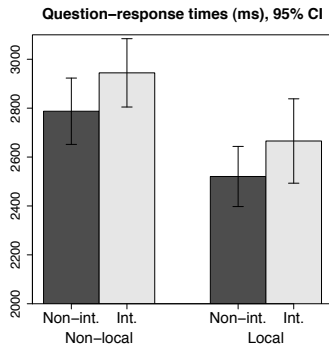
Table 1: Means and Std. Errors of response accuracies (%)

Non-local		Local	
No-interfere	Interfering	No-interfere	Interfering
85.6 (1.6)	79.8 (1.8)	87.1 (1.5)	88.5 (1.5)

Table 2: Statistical analysis of response accuracies

Contrast	Coefficient	Std. Error	z-score	p-value
Locality	0.49	0.14	3.45	< 0.001
Interference	-0.18	0.14	-1.23	n.s.
Loc. \times Interf.	0.32	0.14	2.24	< 0.05

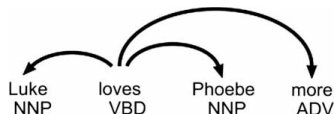
Comprehension-question response latencies



Contrast	Coefficient	Std. Error	t-value
Locality	-0.11	0.02	-6.10
Interference	0.04	0.02	2.14
Loc. \times Interf.	-0.03	0.02	-1.75

A dependency parser

Tesniere (1959)



Nivre (2004); Boston et al. (2011)

Table 3: How time is determined in the parser

<i>Transition</i>	<i>Time</i>
LEFT	50ms+50ms+retrieval time
RIGHT	50ms+50ms+retrieval time
SHIFT	50ms
REDUCE	0ms

ACT-R equations

Activation value

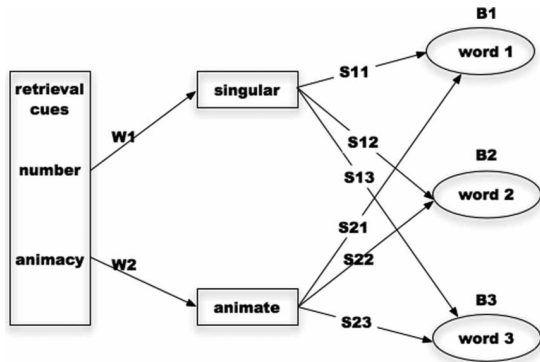
$$A_i = B_i + \sum_j W_j S_{ji}$$

Baseline activation

$$B_i = \ln\left(\sum_{j=1}^n t_j^{-d}\right)$$

Strength of association

$$S_{ji} = S_{\max} - \ln(\text{fan}_j)$$



(Boston et al., 2011, Figure B1)

Modeling steps

- Step 1 Prepare the gold-standard dependencies.
- Step 2 Treat the dependencies as training data; run the parser and convert these dependencies into a sequence of parser transitions.
- Step 3 Calculate retrieval while parsing based on the worked out parse sequence.