

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

**Zhong Chen**

Department of Linguistics  
Cornell University, USA  
zc77@cornell.edu



**Shravan Vasishth**

Department of Linguistics  
Universität Potsdam, Germany  
vasishth@uni-potsdam.de



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# Outline

**1** Introduction

**2** Experiment

**3** Modeling

**4** Conclusions

# Outline

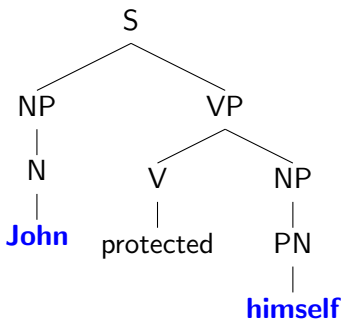
**1** Introduction

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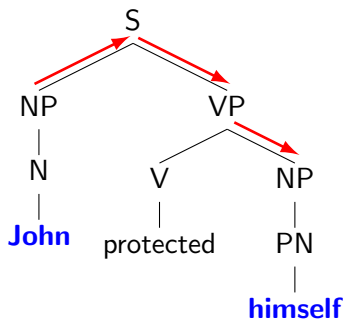
4 Conclusions

## 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

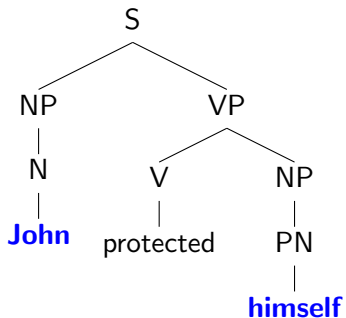
Phillips, Wagers, and Lau (to appear)

*“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

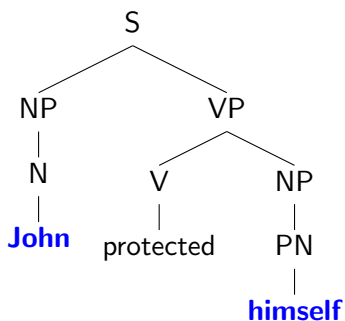
Lewis and Vasishth (2005); Lewis, Vasishth, and Van Dyke (2006)





# Cue-based retrieval

Lewis and Vasishth (2005); Lewis et al. (2006)



[ cat : *S*  
 num : *sing*  
 spec : *NP*  
 comp : *VP*  
 tense : *past* ]

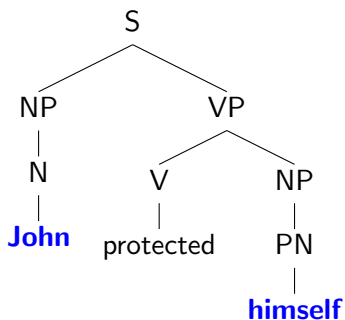
[ cat : *VP*  
 num : *sing/pl*  
 tense : *past*  
 comp : *NP*  
 head : *protected* ]

[ cat : *NP*  
 num : *sing*  
 case : *nom*  
 gender : *M*  
 head : *John* ]

[ cat : *NP*  
 num : *sing*  
 case : *acc*  
 gender : *M*  
 head : *himself* ]

# Cue-based retrieval

Lewis and Vasishth (2005); Lewis et al. (2006)



[ cat : *S*  
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 head : *himself* ]

## 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.  
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*Structural constraints*

The antecedent c-commands *ziji*

The antecedent locates in the subject position.

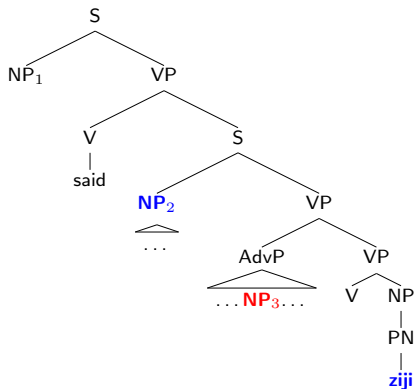
*Non-structural constraints*

The antecedent is animate and sentient.

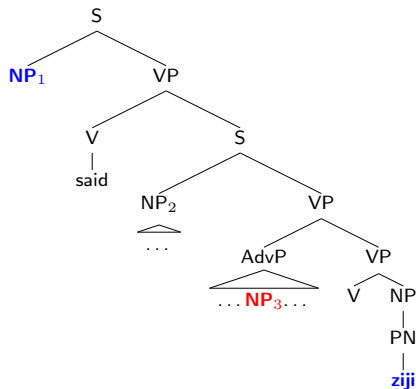
cf. Huang and Liu (2001); Huang, Cole, and Hermon (2006)



# Test memory access using *ziji*: locality



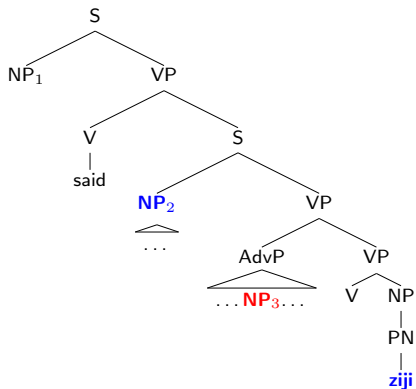
(1) Local



(2) Non-local

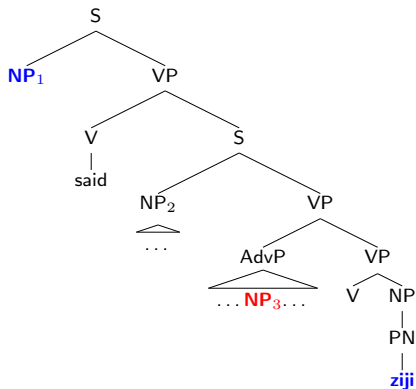
c.f. Liu (2009); Li and Zhou (2010); Dillon et al. (submitted)

# 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:

- $2 \times 2$  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]<sub>AdvP</sub>  
 opposition-leader say the-statement at protest lose-control time  
 告诫了 自己的 党员]<sub>S</sub>  
 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]<sub>AdvP</sub>  
 opposition-leader say the-statement at protester lose-control time  
 告诫了 自己的 党员]<sub>S</sub>  
 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]<sub>AdvP</sub>  
 this-statement say **opposition-leader** at **protest** lose-control time  
 告诫了 自己的 党员]<sub>S</sub>  
 warned **ziji** 's party member

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

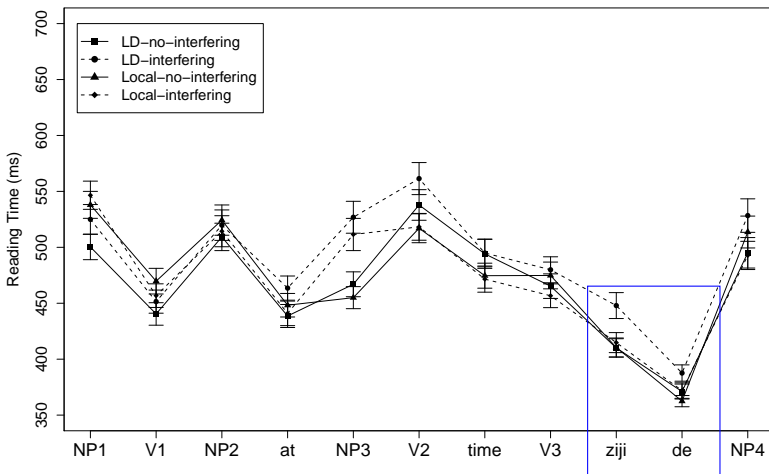
### d: *Local; Interfering*

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

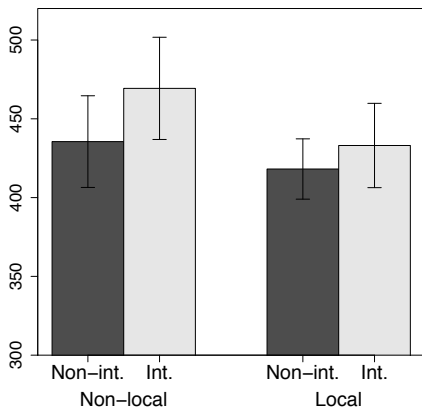
# Mean reading times for each condition

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

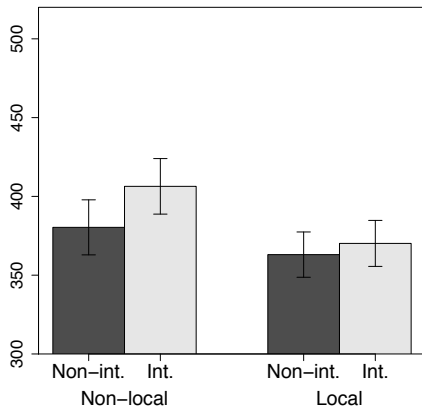


# Mean RTs at critical and spillover regions

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>z<sub>iji</sub></i>	Locality	-0.026	0.013	-1.92
	Interference	0.027	0.013	<b>2.03</b>
	Loc. × Interf.	-0.026	0.013	-1.97
<i>z<sub>iji</sub> + 1</i>	Locality	-0.024	0.010	<b>-2.26</b>
	Interference	0.023	0.010	<b>2.25</b>
	Loc. × 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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$$A_i = B_i + \sum_j W_j S_{ji}$$

Activation value

Baseline activation

Similarity-based interference

# Sentence processing as memory retrieval

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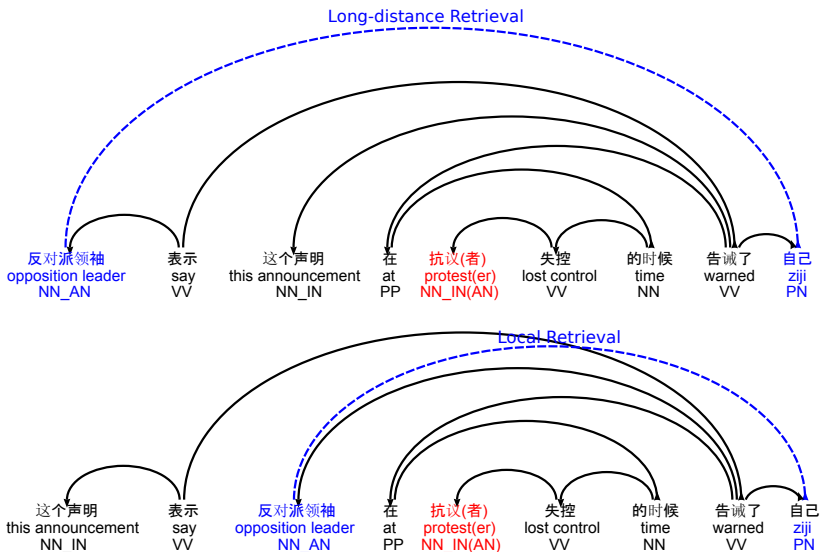
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$$A_i = B_i + \sum_j W_j S_{ji}$$

Retrieval time:

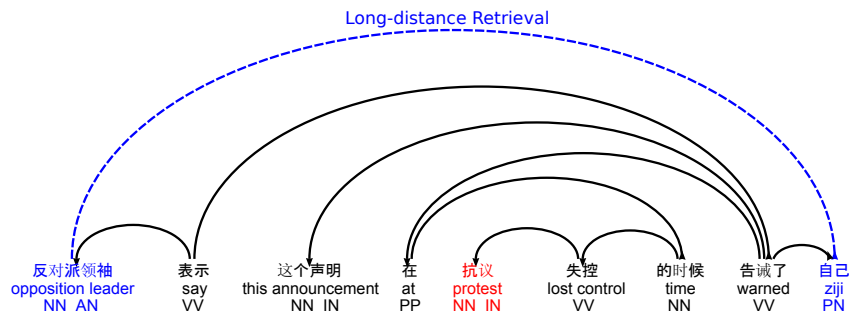
$$T_i = F e^{-A_i}$$

# Dependencies



# Calculating the retrieval latencies...

a: *Non-local; Non-interfering*

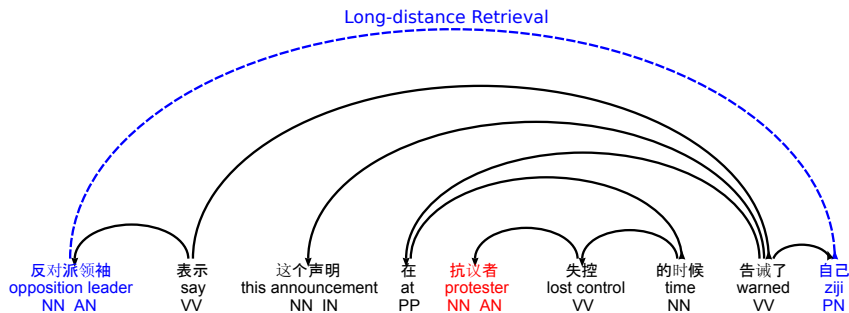


$$A = -3.17$$

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

# Calculating the retrieval latencies...

b: *Non-local; Interfering*



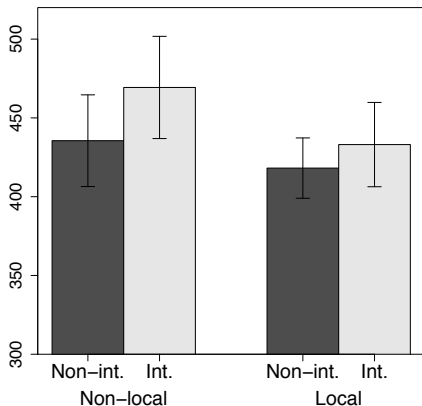
$$A = -3.58$$

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

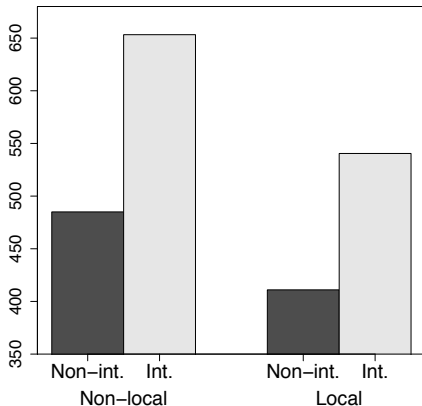


# Modeling results

### 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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