Discourse and Coreference

LING 571 — Deep Processing Methods in NLP

November 23, 2021

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Announcements

- HW6 grades delayed due to technical issues; will be up relatively soon
- No class Wednesday!
  - HW7 due dates: b/c holiday, late submissions open until Monday Nov 29
  - No homework this week; HW8 out Dec 1
- Please name readme.{txtlpdf}
  - All lower-case, no spaces, etc etc

HW7 Notes

- thanks for Canvas usage!
- File name must be argument, but still specified with width and weighting keys
- Punctuation: leave *only* alphanumeric characters (as tokens, and within tokens)
  - “\w”: match a single alphanumeric
  - “\W”: match a single non-alphanumeric
- Be careful with 0s
  - Might help to use logarithm rules
- Updated correlation in example_similarity_output.txt

Roadmap

- Introduction to Discourse
- Coreference Resolution
  - Phenomena
  - Pronominal Anaphora Resolution
  - Hobbs' Algorithm

Introduction to Discourse

What is Discourse?

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- Discourse is language ***in situ***
  - rather than synthetic, isolated sentences.
  - language use *toward a goal*

Different Parameters of Discourse

- **Number of participants**
  - Single author/voice → Monologue
  - Multiple participants → Dialogue

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- **Modality**
  - Spoken vs. Written
- **Goals**
  - Transactional (message passing) vs. Interactional (relations, attitudes)
  - Cooperative task-oriented rational interaction

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- Understanding depends on context
  - Word sense — *plant*
  - Intention — *Do you have the time?*
  - Referring expressions — *it*, *that*, *the screen*
  - Domain restriction — “All of the students read the announcement.”

Why Discourse?

- Applications: Discourse in NLP
  - Question-Answering
  - Information Retrieval
  - Summarization
  - Dialogue / Conversational AI
  - Automatic Essay Grading

Reference Resolution

User: Where is ***A Bug's Life*** playing in ***Summit***?

System: A Bug's Life is playing at the Summit Theater.

User: When is ***it*** playing ***there***?

System: It's playing at 2PM, 5PM, and 8PM.

User: I'd like 1 ***adult*** and 2 ***children*** for ***the first show***. How much would ***that*** cost?

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From Carpenter and Chu-Carroll, Tutorial on Spoken Dialogue Systems, ACL '99

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- Summary:
  - *First Union President John R. Georgius is planning to announce his retirement tomorrow.*
- Inter-sentence coherence relations:
  - **Second sentence**: main concept (nucleus)
  - **First sentence**: background

Coherence Relations

John hid Bill's car keys. He was drunk.

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- **Assumption**
  - Segments of discourse should have meaningful connection.
  - Establish through ***coherence relations***

Discourse: Looking Ahead

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Coreference

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Coreference

Cohesion

Discourse: Looking Ahead

Coreference

Cohesion

Coherence

Discourse: Looking Ahead

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Structure / Segmentation

Coreference Resolution

Reference: Terminology

Queen Elizabeth set about transforming **her husband**, **King George VI**, into **a viable monarch**. **Logue**, **a renowned speech therapist**, was summoned to help **the King** overcome **his speech impediment**.

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    - *Queen Elizabeth, her, the Queen*
    - *Logue, a renowned speech therapist*
  - Entities in **purple** do not corefer to anything.

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- ***Antecedent:***
  - An expression that introduces an item to the discourse for other items to refer back to
  - Queen Elizabeth… her

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*Not all anaphora is referential! e.g. "*No dancer hurt their knee.*"

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Referring Expressions

- Many forms:
  - *Queen Elizabeth*
  - *she/her*
  - *the Queen*
  - *HRM*
  - *the British Monarch*

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    (…i.e. likely a different interpretation during a RPDR viewing party.)

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- Correct interpretation of reference requires **Discourse Model**
  - Entities referred to in the discourse
  - Relationships of these entities

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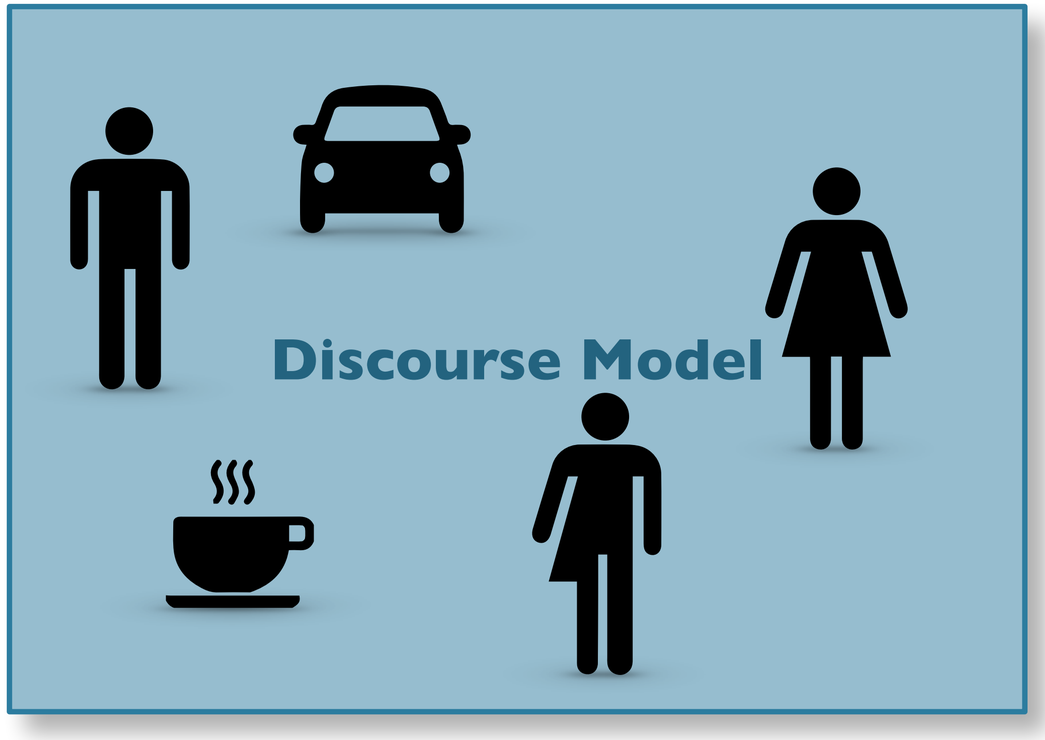
    - [“introduces a discourse referent (dref)”]
  - Subsequent mentions **access** entity *from* the model.

Reference and Model



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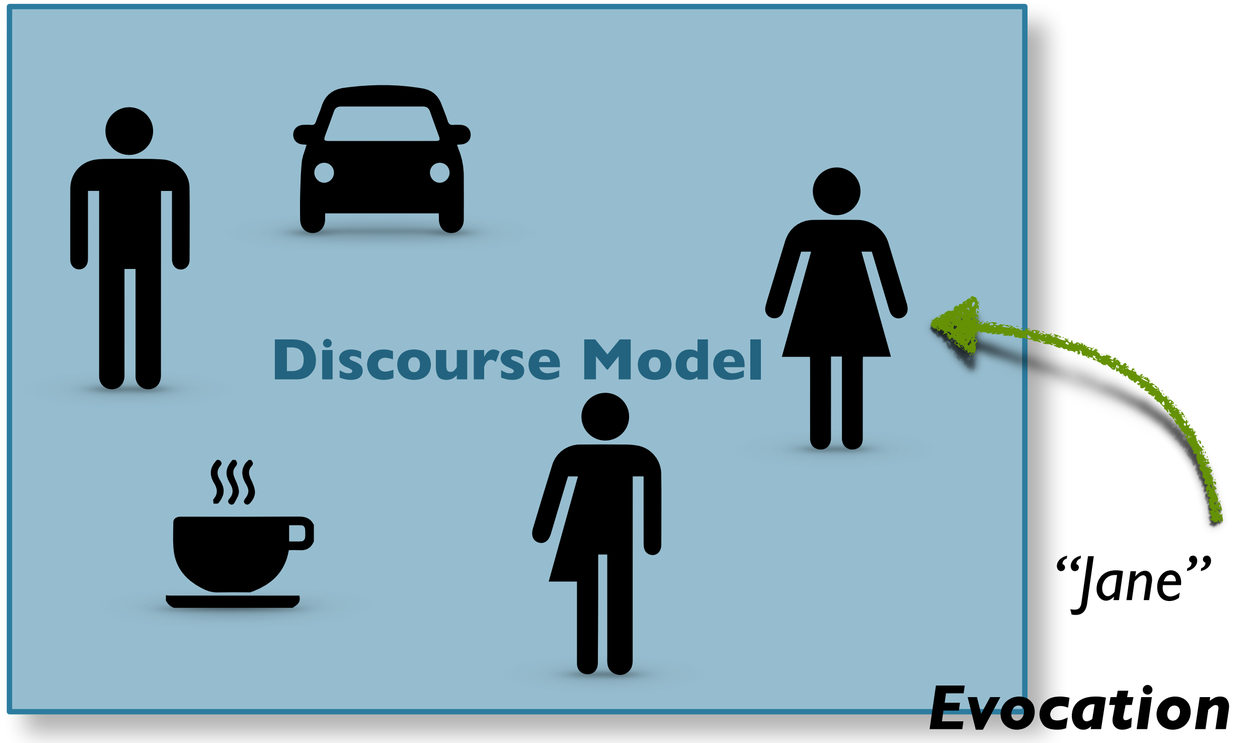

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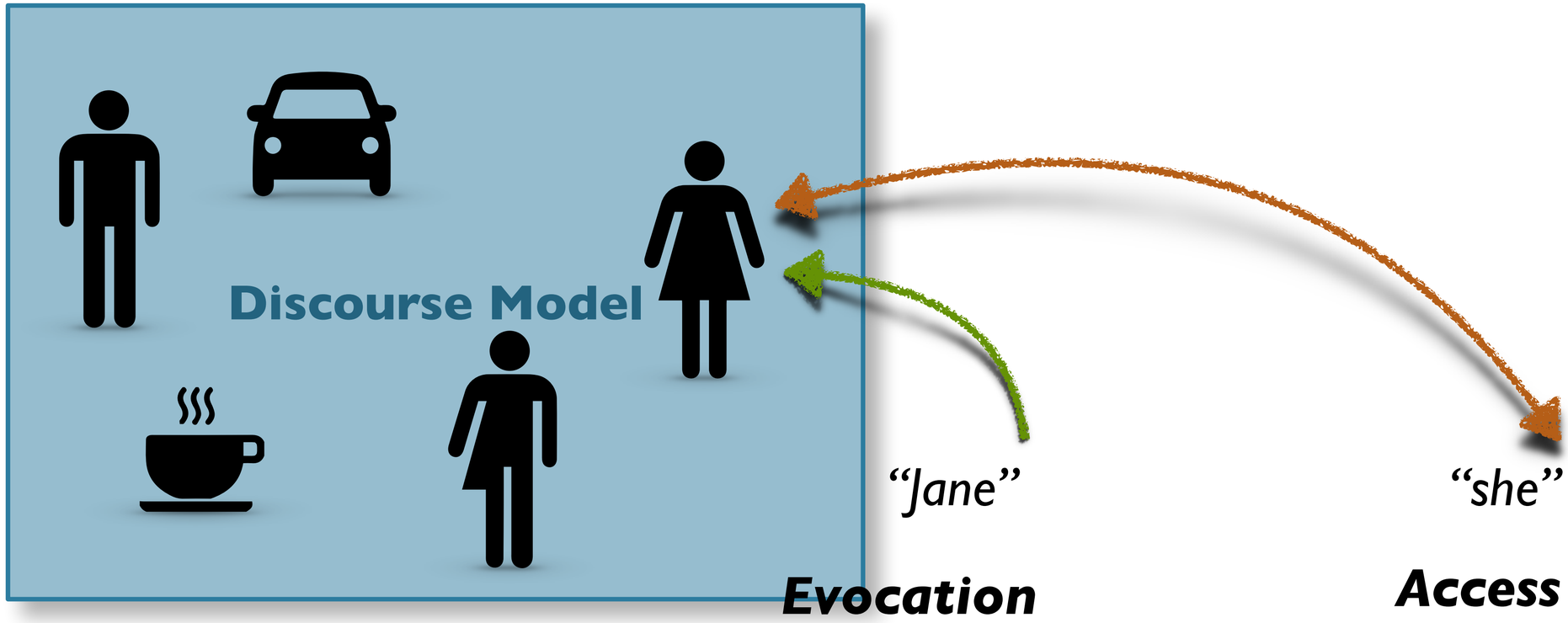

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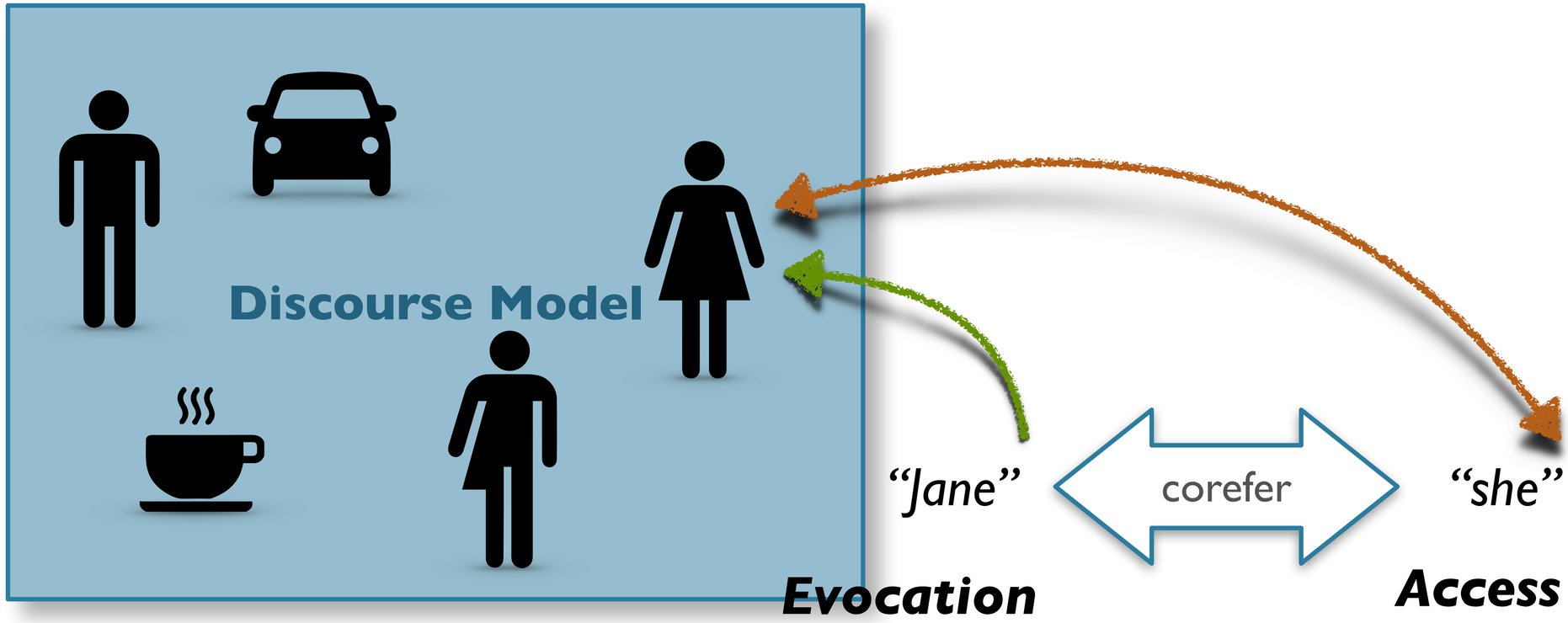

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- **Pronomial anaphora resolution*:***
  - Find antecedent for a single pronoun.
  - Subtask of coreference resolution

Pronominal Anaphora Resolution

Reference Phenomena

Expression Type	Examples	Constraints
Indefinite NP	"*a cat*", "*some geese*"	Introduces new entity to context
Definite NP	"*the dog*"	Refers to entity identifiable by hearer in context
Pronouns	"*he*," "*them*," "*they*"	Refers to entity, must be "***salient***"
Demonstratives	"this," "that"	Refers to entity, sense of distance (literal/figurative)
Names	"*Dr. Woodhouse*," "*IBM*"	New or old entities

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- e) is acceptable because the definite NP has a further range for salience.

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	that				
	***this* N**				

Information Status

- ***Accessibility scale***: (Ariel, 2001)
  - More salient elements easier to call up, can be shorter
  - correlates with length: more accessible, shorter refexp

Full name+modifier
↓full name
↓long definite description
↓short definite description
↓last name
↓first name
↓distal demonstrative+modifier
↓proximate demonstrative+modifier
↓distal demonstrative+NP
↓proximate demonstrative+NP
↓distal demonstrative(-NP)
↓proximate demonstrative (-NP)
↓stressed pronoun+gesture
↓stressed pronoun
↓unstressed pronoun
↓cliticized pronoun
↓verbal person inflections
↓∅

Complicating Factors

- ***Inferrables***
  - refexp refers to inferentially related entity:
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- ***Non-referential cases***:
  - ***It's** raining.* (Pleonasm)
  - ***It** was good that Frodo carried the ring.* (Extraposition)

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  - *Anjali has a Corvette.* **They are red.* *It is red.*
- **Person**:
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- **Gender**:
  - ***Janae** plays **the guitar**.* ***She** sounds great.*
  - ***Janae** plays **the guitar**.* ***It** sounds great.*

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    - *He_1 said that he_2 bought Willie a new car.* [He_1 ≠ Willie, he_2 ≠ Willie]

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  - Pronoun/Def. NP: can't corefer with subject of clause
    - Reflexives do corefer with subject of containing clause

Features for Anaphora Resolution: Preferences

- **Recency**:
  - Prefer closer antecedents.
  - *The doctor found* ***an old map*** *in the captain's chest. Jim found* ***an even older map*** *on the shelf.* ***It*** *described an island.*

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- **Grammatical role**:
  - Saliency hierarchy of roles
  - e.g. ***Subj > Object > Ind. Object > Oblique > AdvP***
    - ***Billy Bones** went to the bar with **Jim Hawkins**. **He** called for a glass of rum.*
    - ***Jim Hawkins** went to the bar with **Billy Bones**. **He** called for a glass of rum.*

Features for Anaphora Resolution: Preferences

- **Repeated Mention**:
  - Once entity is focused, likely to continue to be focused → more likely pronomialized.
    - ***Billy Bones*** *had been thinking of a glass of rum.* ***He*** *hobbled over to the bar.* ***Jim Hawkins*** *went with him.* ***He*** *called for a glass of rum.*

Features for Anaphora Resolution: Preferences

- **Repeated Mention**:
  - Once entity is focused, likely to continue to be focused → more likely pronomialized.
    - ***Billy Bones*** *had been thinking of a glass of rum.* ***He*** *hobbled over to the bar.* ***Jim Hawkins*** *went with him.* ***He*** *called for a glass of rum.*

- **Parallelism**:
  - Prefer entity in same role.
  - ***Silver*** *went with* ***Jim*** *to the bar.* ***Billy Bones*** *went with* ***him*** *to the inn.*

Features for Anaphora Resolution: Preferences

- **Verb Semantics**
  - Some verbs semantically bias for one of their argument positions.

John ***telephoned*** ***Bill***. ***He*** *had lost the laptop.*

John ***criticized*** ***Bill***. ***He*** *had lost the laptop.*

Features for Anaphora Resolution: Preferences

- **Verb Semantics**
  - Some verbs semantically bias for one of their argument positions.

    John ***telephoned*** ***Bill***. ***He*** *had lost the laptop.*

    John ***criticized*** ***Bill***. ***He*** *had lost the laptop.*

- **Selectional Restrictions**
  - Other kinds of semantic knowledge
    - *John parked* ***his car*** *in* ***the garage*** *after driving* ***it*** *around for hours.*
      - Understood that a car has the ability to ***drive*** whereas garage does not.

Reference Resolution Approaches

- Common features:
  - Use of a “Discourse Model”
    - Referents evoked in discourse, available for reference
    - Structure indicating relative salience
  - Syntactic & Semantic Constraints
  - Syntactic & Semantic Preferences
- Differences:
  - Which constraints/preferences? How to combine? Rank?

Hobbs' Algorithm

Hobbs' Resolution Algorithm

- **Requires**:
  - Syntactic parser
  - Gender & number checker
- **Input**:
  - Pronoun
  - Parse of current and previous sentences
- **Captures**:
  - Preferences: Recency, grammatical role
  - Constraints: binding theory, gender, person, number

Hobbs Algorithm

- Summary:
  - English-centric, rule-based algorithm.
  - Exploits English features of:
    - Agreement
    - Right-branching
    - SOV order
  - Inter-sententially, exploits notions of recency.

Hobbs Algorithm Detail (Hobbs, 1978)

1. Begin at the noun phrase (NP) node immediately dominating the pronoun
2. Go up the tree to the first NP or sentence (S) node encountered. Call this node **X**, and call the path used to reach it *p.*
3. Traverse all branches below node **X** to the left of path *p* in a left-to-right, breadth-first fashion. Propose as the antecedent any encountered NP node that has an NP or S node between it and **X**.
4. If node **X** is the highest S node in the sentence, traverse the surface parse trees of previous sentences in the text in order of recency, the most recent first; each tree is traversed in a left-to-right, breadth-first manner, and when an NP node is encountered, it is proposed as antecedent. If X is not the highest S node in the sentence, continue to step 5.

Hobbs Algorithm Detail (Hobbs, 1978)

5. From node **X**, go up the tree to the first NP or S node encountered. Call this new node **X**, and call the path traversed to reach it *p*.

6. If **X** is an NP node and if the path *p* to **X** did not pass through the Nominal node that **X** immediately dominates, propose **X** as the antecedent.

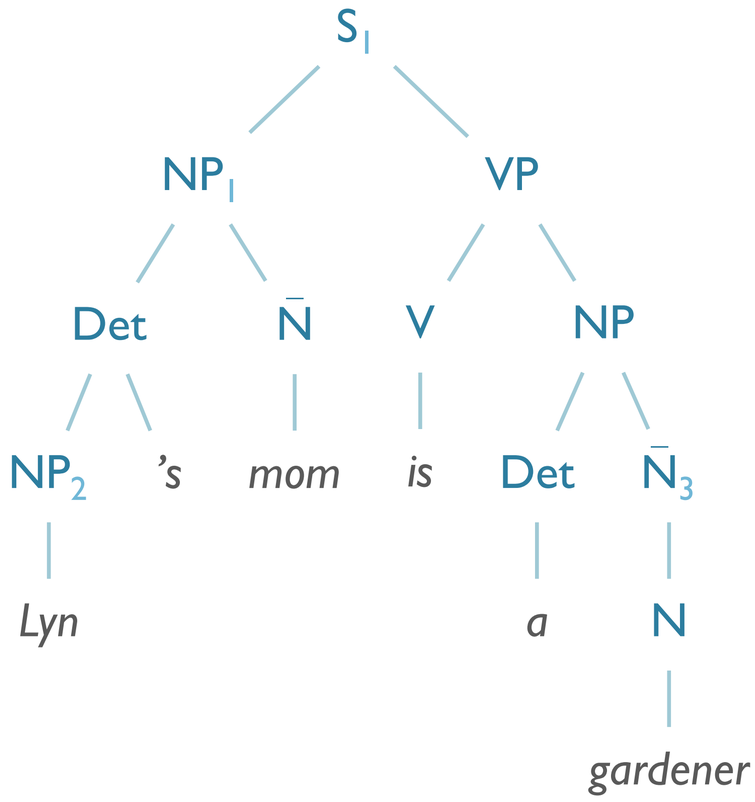
7. Traverse all branches below node **X** to the *left* of path *p* in a left-to-right, breadth-first manner. Propose any NP node encountered as the antecedent.

8. If **X** is an S node, traverse all branches of node **X** to the *right* of path *p* in a left-to-right, breadth-first manner, but do not go below any NP or S node encountered. Propose any NP node encountered as the antecedent.

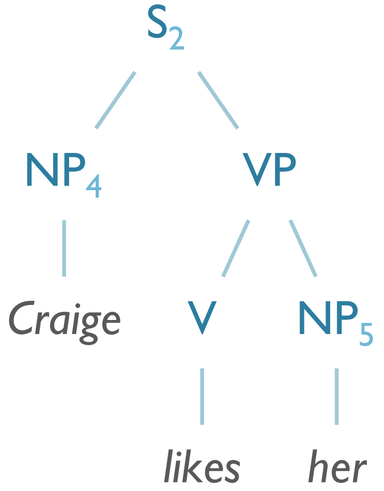
9. Go to step 4.

Hobbs Example

Lyn's mom is a gardener.



*Craige likes **her**.*



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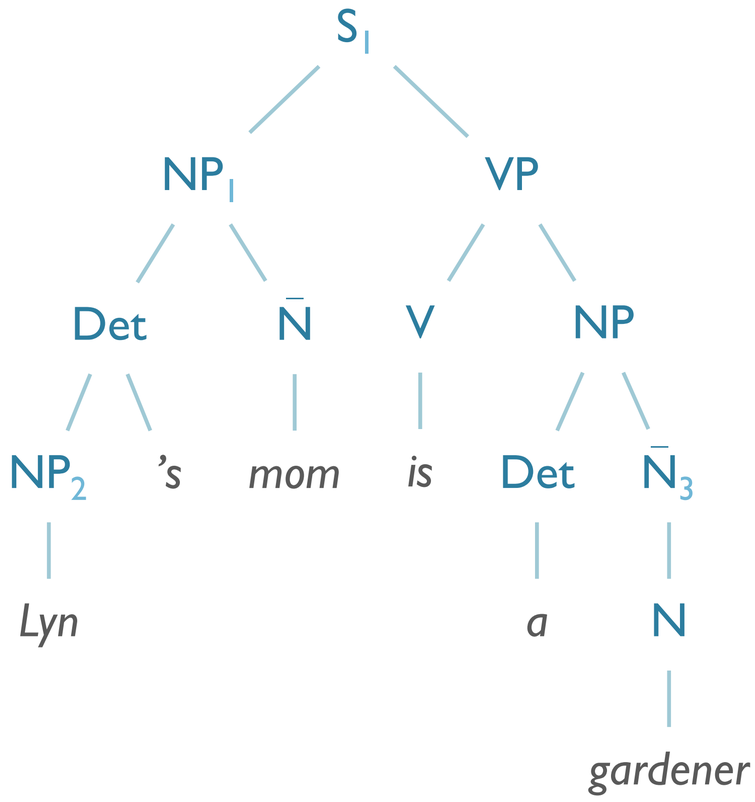

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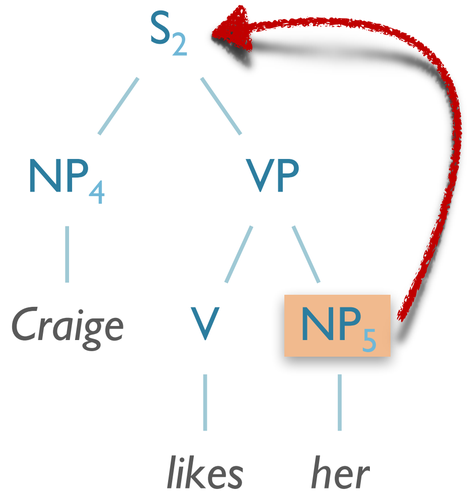

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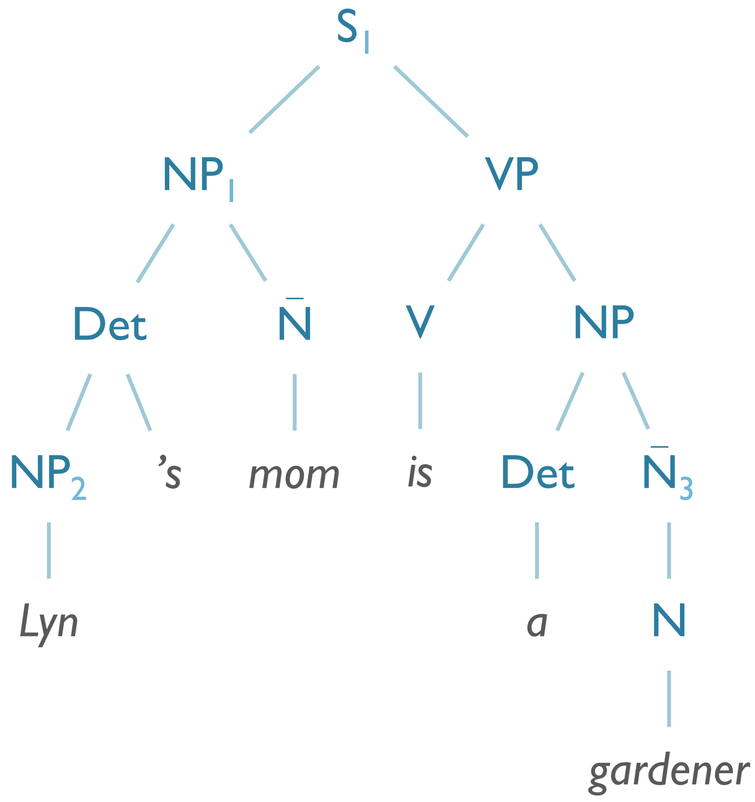

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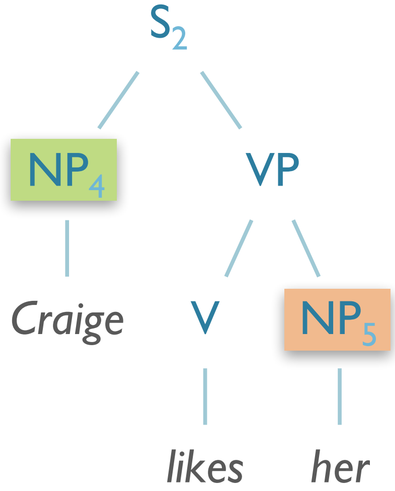

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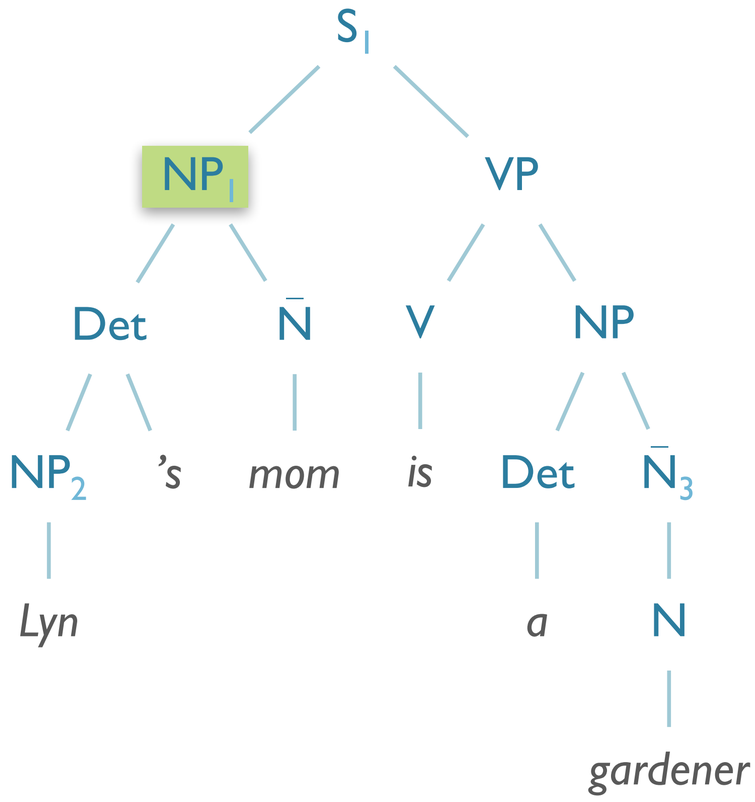

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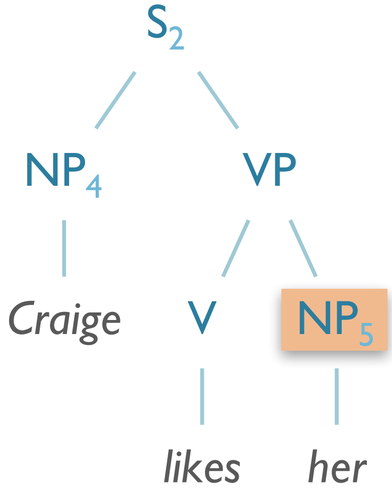
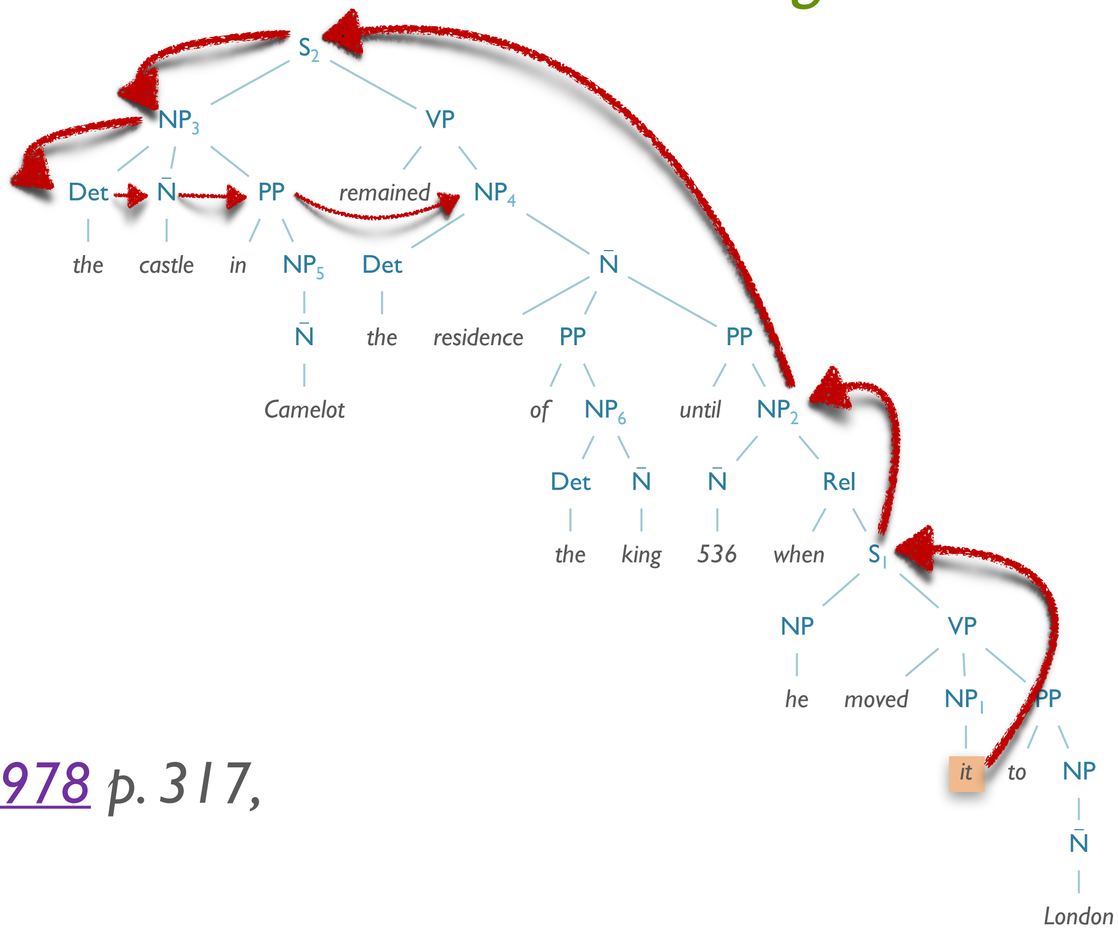


Another Hobbs Example

*…the castle in Camelot remained the residence of the king until 536 when he moved **it** to London.*



for full walkthrough see Hobbs, 1978 p. 317, and the end of today's slides

Hobbs Algorithm

- Results: 88% Accuracy; 90% intrasentential
  - …on perfect, manually parsed sentences
- Useful ***baseline*** for evaluating pronomial anaphora
- Issues:
  - **Parsing**:
    - Not all languages have parsers
    - Parsers not always accurate
  - **Constraints/Preferences:**
    - Captures: Binding theory, grammatical role, recency
    - But not: parallelism, repetition, verb semantics, selection

Hobbs Algorithm

- Other issue: does not implement world knowledge
  - *The city council refused the women a permit because they feared violence.*
  - *The city council refused the women a permit because they advocated violence.*

  (Winograd, 1972)*

  *more on this later

- Get this reading by knowledge of city councils and permitting, and reasons why permits would be refused.

Hobbs Algorithm: A Parable

- Was actually one of the first instances in NLP where a researcher tried an informed, if "naïve" baseline
  - …found that (in 1972) no system he could build could beat it!
- "*the naïve approach is quite good. Computationally speaking, it will be a long time before a semantically based algorithm is sophisticated enough to perform as well, and these results set a very high standard for any other approach to aim for.*

  "Yet there is every reason to pursue a semantically based approach. The naïve algorithm does not work. Any one can think of examples where it fails. In these cases it not only fails; it gives no indication that it has failed and offers no help in finding the real antecedent." — Hobbs (1978), Lingua, p. 345

Coreference and World Knowledge

Coreference and World Knowledge

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- The trophy doesn't fit into the brown suitcase because it's too [small/large]. What is too [small/large]?

Coreference and World Knowledge

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  - Answers:The suitcase/the trophy.

Coreference and World Knowledge

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- Paul tried to call George on the phone, but he wasn't [successful/available]. Who was not [successful/available]?
  - Answers: Paul/George.
- The lawyer asked the witness a question, but he was reluctant to [answer/repeat] it . Who was reluctant to [answer/repeat] the question?

Coreference and World Knowledge

- The trophy doesn't fit into the brown suitcase because it's too [small/large]. What is too [small/large]?
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- Paul tried to call George on the phone, but he wasn't [successful/available]. Who was not [successful/available]?
  - Answers: Paul/George.
- The lawyer asked the witness a question, but he was reluctant to [answer/repeat] it . Who was reluctant to [answer/repeat] the question?
  - Answers: The witness/the lawyer.

Winograd Schema Challenge

- Still hard!
  - WSC
  - Winogrande

SuperGLUE GLUE | Paper </> Code | Tasks | Leaderboard | FAQ | Diagnostics | Submit

Leaderboard Version: **2.0**

Rank	Name	Model	URL	Score	BoolQ	CB	COPA	MultiRC	ReCoRD	RTE	WiC	WSC	AX-g	AX-b
1	SuperGLUE Human Baselines	SuperGLUE Human Baselines		89.8	89.0	95.8/98.9	100.0	81.8/51.9	91.7/91.3	93.6	80.0	100.0	99.3/99.7	76.6
2	T5 Team - Google	T5		88.9	91.0	93.0/96.4	94.8	88.2/62.3	93.3/92.5	92.5	76.1	93.8	92.7/91.9	65.6
3	Facebook AI	RoBERTa		84.6	87.1	90.5/95.2	90.6	84.4/52.5	90.6/90.0	88.2	69.9	89.0	91.0/78.1	57.9
4	IBM Research AI	BERT-mtl		73.5	84.8	89.6/94.0	73.8	73.2/30.5	74.6/74.0	84.1	66.2	61.0	97.8/57.3	29.6
5	SuperGLUE Baselines	BERT++		71.5	79.0	84.8/90.4	73.8	70.0/24.1	72.0/71.3	79.0	69.6	64.4	99.4/51.4	38.0
		BERT		69.0	77.4	75.7/83.6	70.6	70.0/24.1	72.0/71.3	71.7	69.6	64.4	97.8/51.7	23.0
		Most Frequent Class		47.1	62.3	21.7/48.4	50.0	61.1/0.3	33.4/32.5	50.3	50.0	65.11	00.0/50.0	0.0
		CBoW		44.5	62.2	49.0/71.2	51.6	0.0/0.5	14.0/13.6	49.7	53.1	65.11	00.0/50.0	-0.4
		Outside Best		-	80.4	-	84.4	70.4/24.5	74.8/73.0	82.7	-	-	-	-
-	Stanford Hazy Research	Snorkel [SuperGLUE v1.9]		-	-	88.6/93.2	76.2	76.4/36.3	-	78.9	72.1	72.6	-	47.6

Winograd Schema Challenge

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Heavily supervised

SuperGLUE GLUE Paper Code Tasks Leaderboard FAQ Diagnostics Submit

Leaderboard Version: **2.0**

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1	SuperGLUE Human Baselines	SuperGLUE Human Baselines		89.8	89.0	95.8/98.9	100.0	81.8/51.9	91.7/91.3	93.6	80.0	100.0	99.3/99.7	76.6
2	T5 Team - Google	T5		88.9	91.0	93.0/96.4	94.8	88.2/62.3	93.3/92.5	92.5	76.1	93.8	92.7/91.9	65.6
3	Facebook AI	RoBERTa		84.6	87.1	90.5/95.2	90.6	84.4/52.5	90.6/90.0	88.2	69.9	89.0	91.0/78.1	57.9
4	IBM Research AI	BERT-mtl		73.5	84.8	89.6/94.0	73.8	73.2/30.5	74.6/74.0	84.1	66.2	61.0	97.8/57.3	29.6
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		BERT		69.0	77.4	75.7/83.6	70.6	70.0/24.1	72.0/71.3	71.7	69.6	64.4	97.8/51.7	23.0
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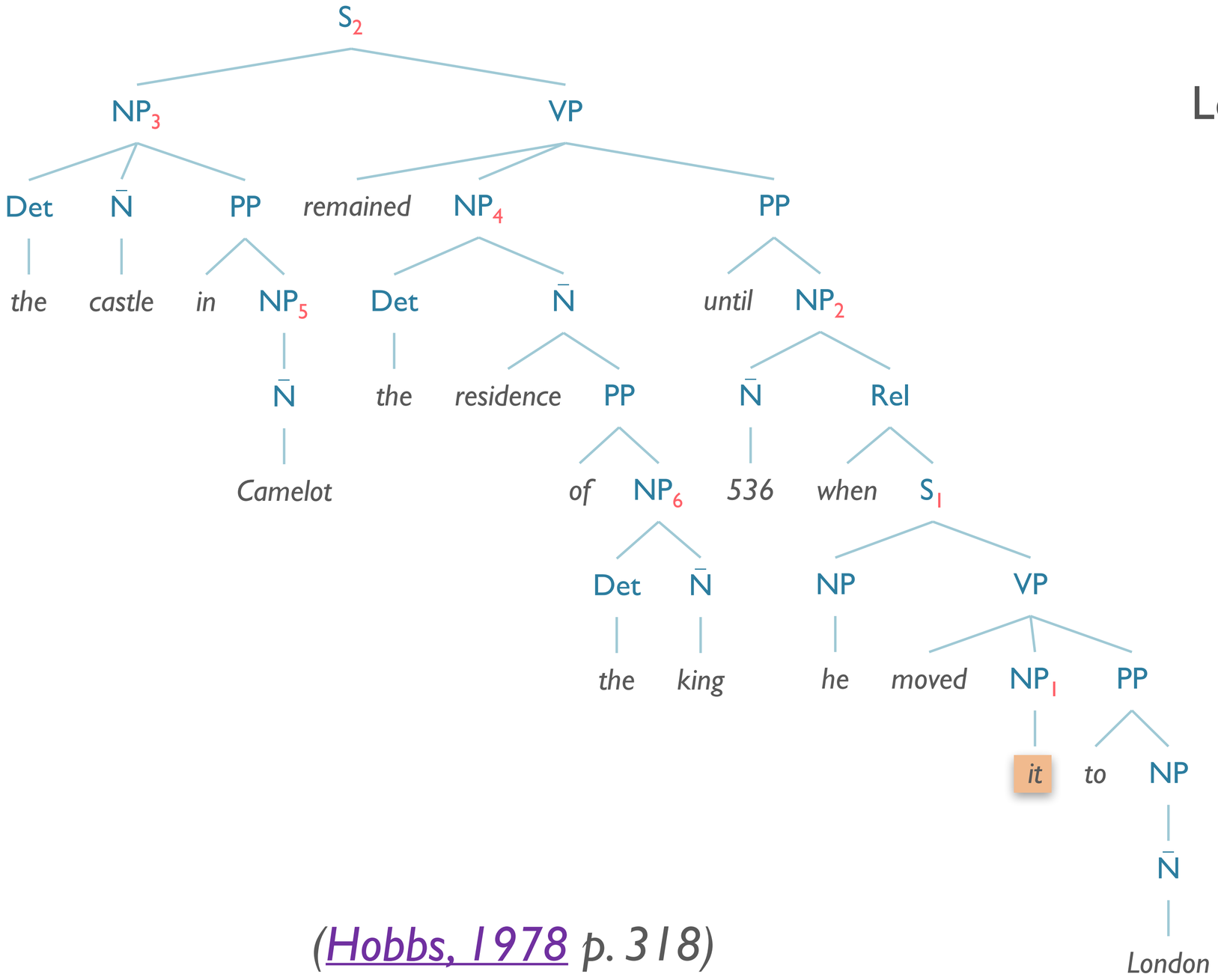
		CBoW		44.5	62.2	49.0/71.2	51.6	0.0/0.5	14.0/13.6	49.7	53.1	65.1	100.0/50.0	-0.4
		Outside Best		-	80.4	-	84.4	70.4/24.5	74.8/73.0	82.7	-	-	-	-
-	Stanford Hazy Research	Snorkel [SuperGLUE v1.9]		-	-	88.6/93.2	76.2	76.4/36.3	-	78.9	72.1	72.6	-	47.6

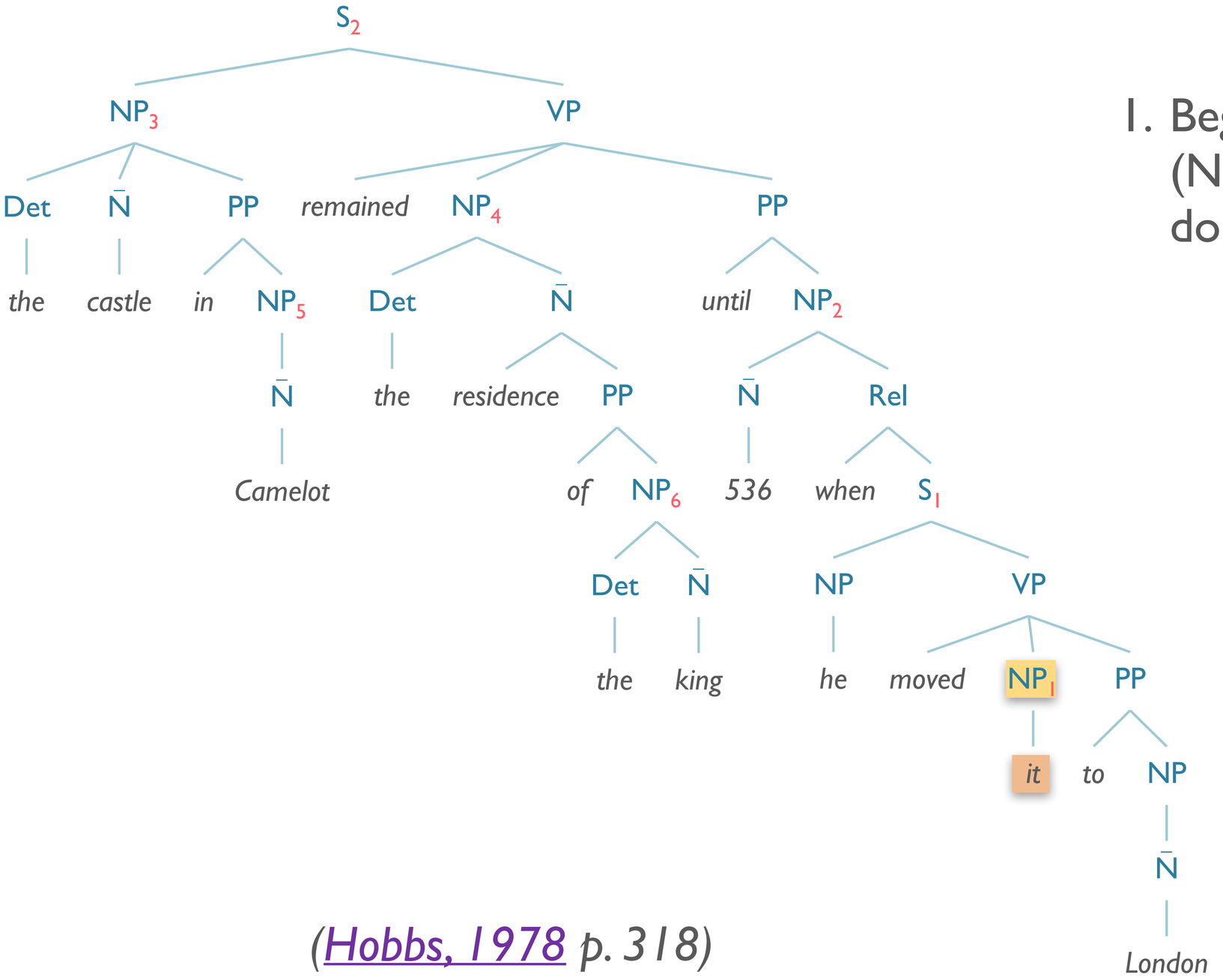
Hobbs Algorithm Walkthrough

(h/t Ryan Georgi)



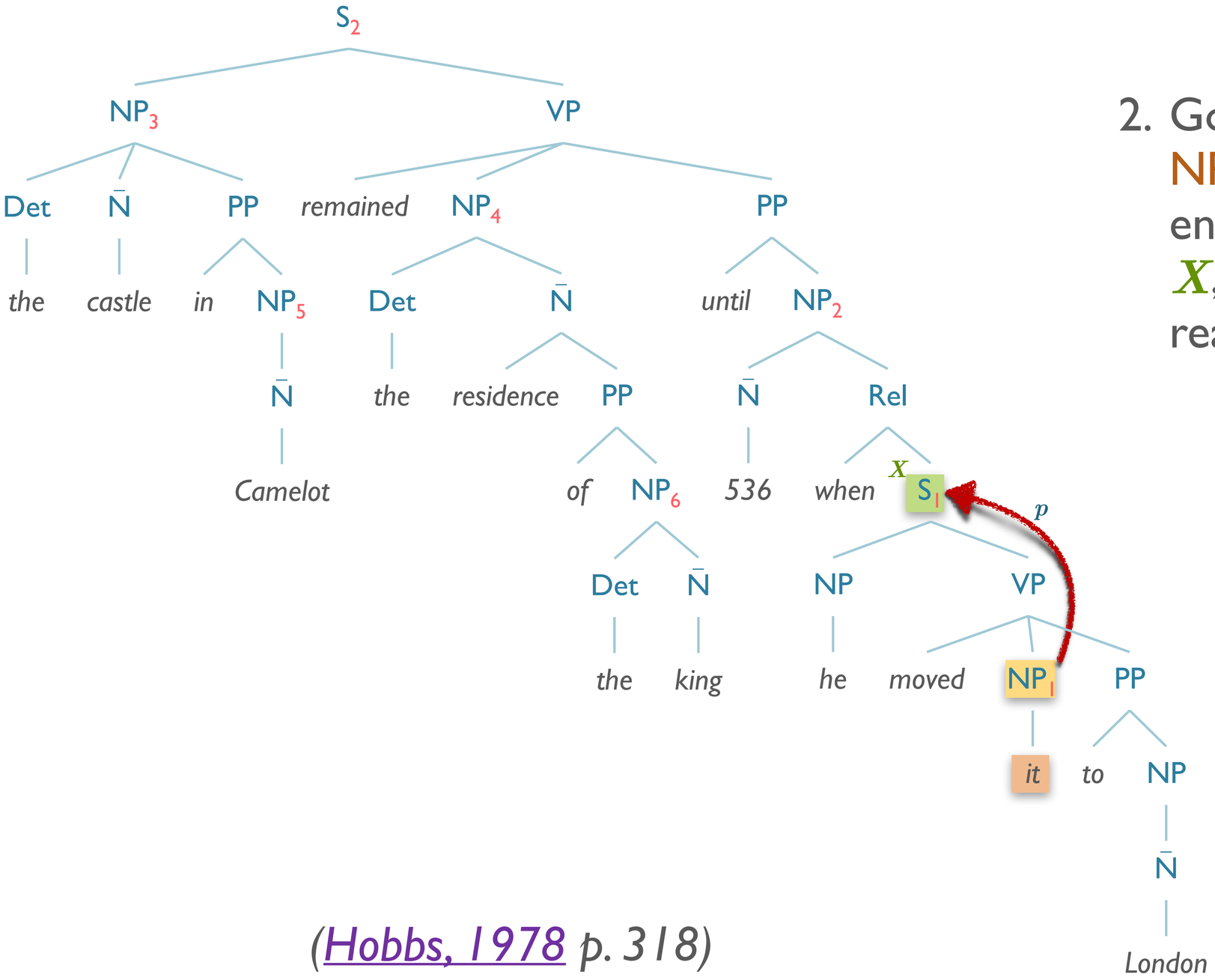
Let's figure out what the antecedent for "*it*" is

(*Hobbs, 1978 p. 318*)



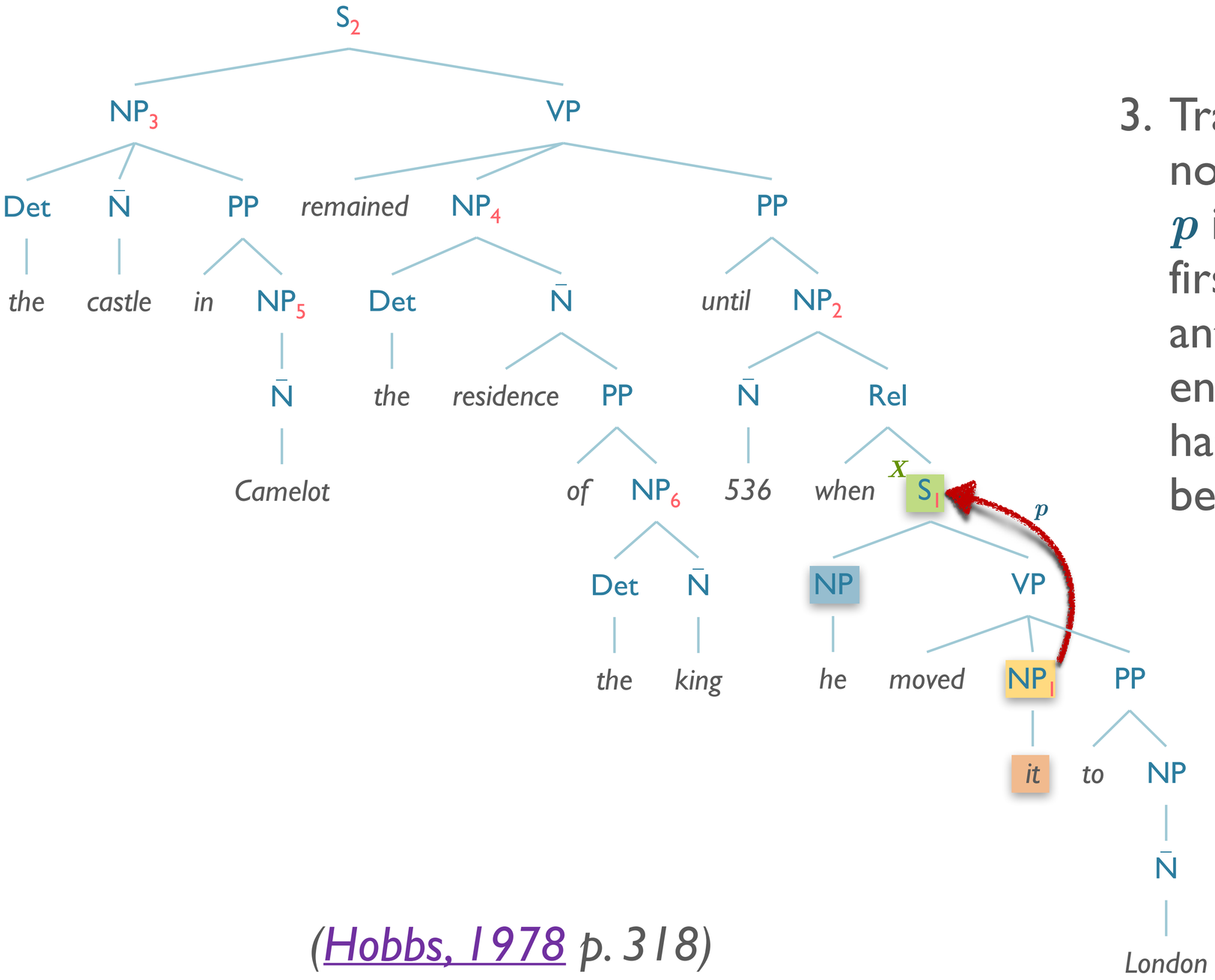
1. Begin at the noun phrase (NP) node immediately dominating the pronoun

(Hobbs, 1978 p. 318)



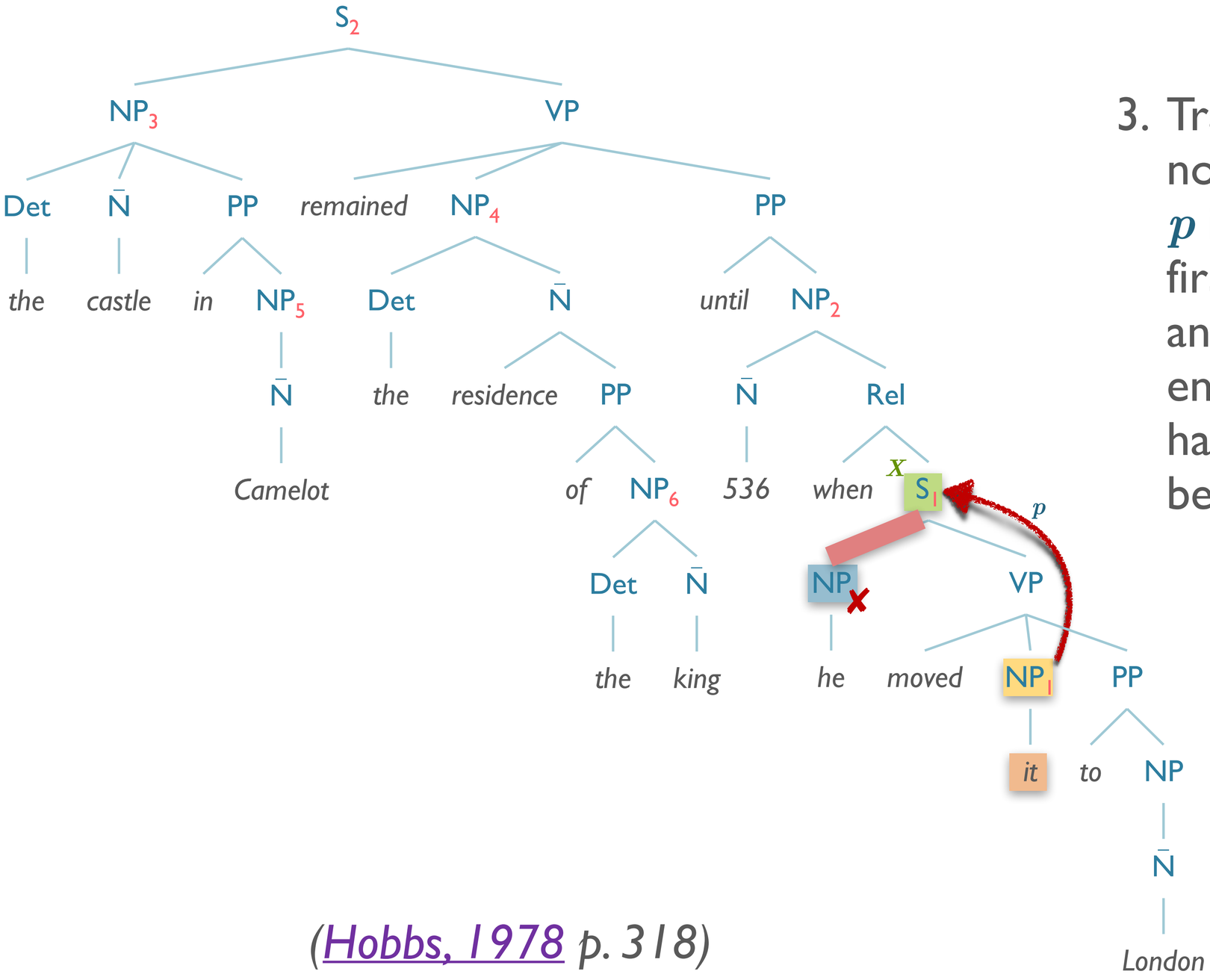
2. Go up the tree to the first NP or sentence (S) node encountered. Call this node X, and call the path used to reach it p.

(Hobbs, 1978 p. 318)



3. Traverse all branches below node X to the left of path p in a left-to-right, breadth-first fashion. Propose as the antecedent any encountered NP node that has an NP or S node between it and X.

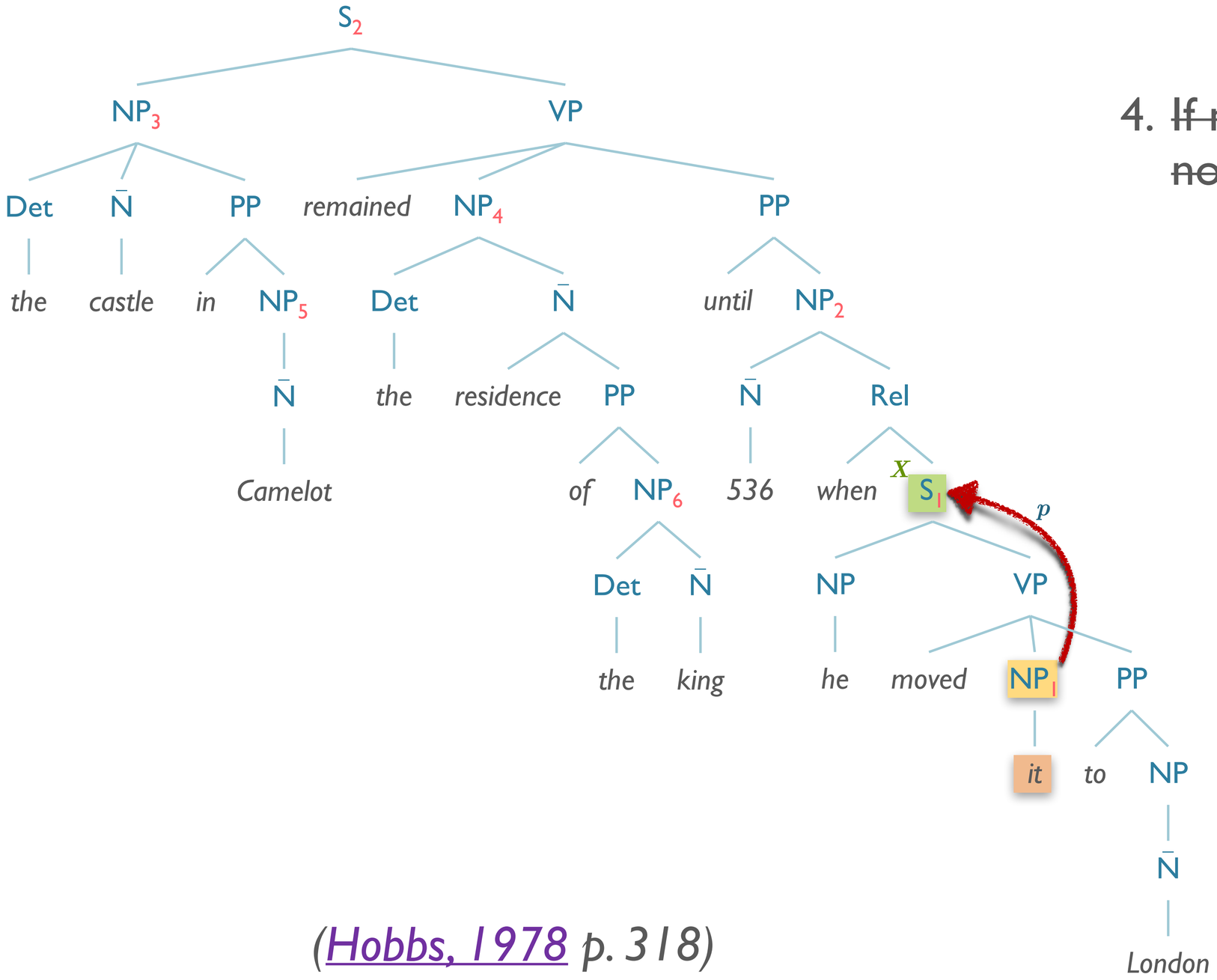
(Hobbs, 1978 p. 318)



3. Traverse all branches below node X to the left of path p in a left-to-right, breadth-first fashion. Propose as the antecedent any encountered NP node that has an NP or S node between it and X.

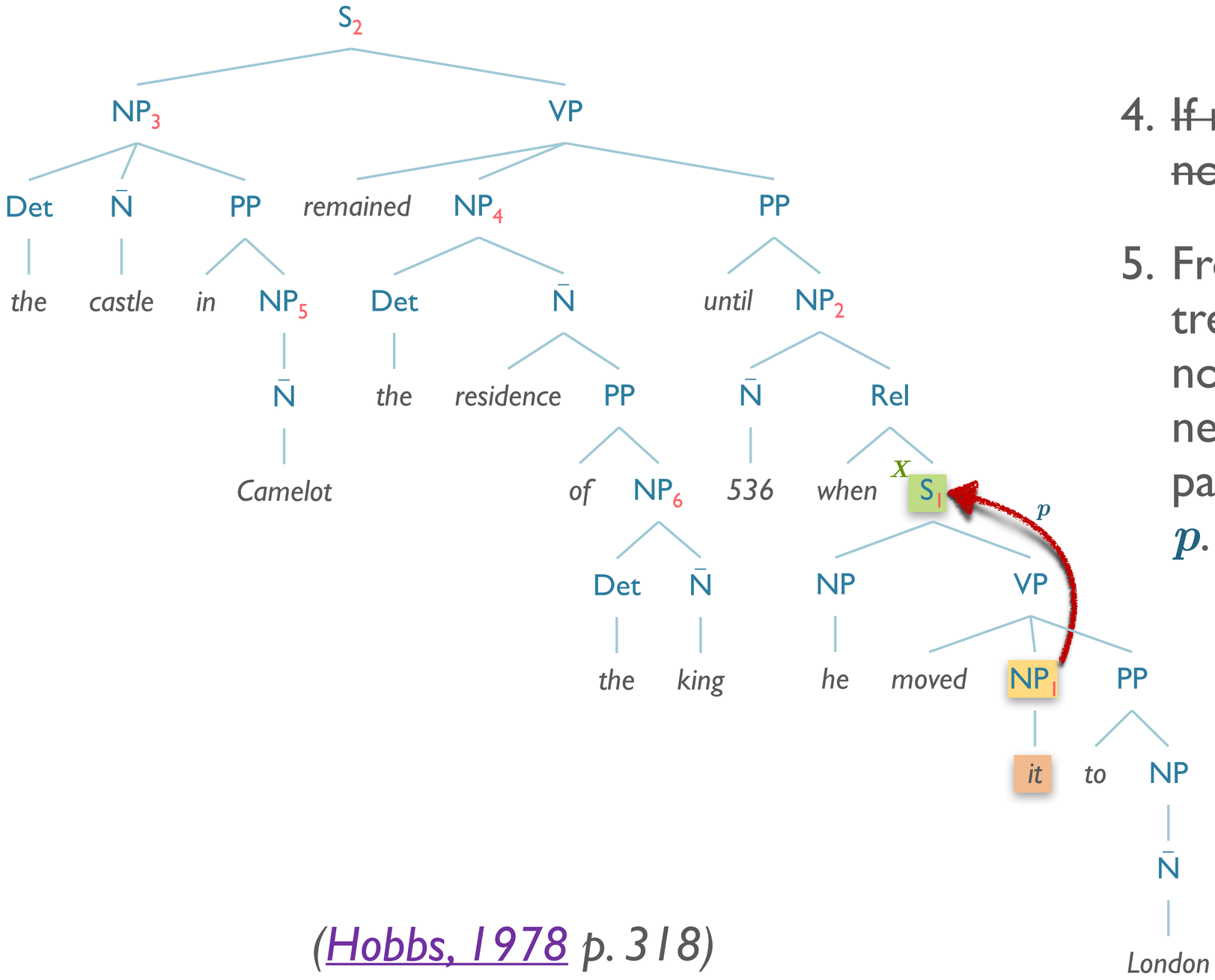
No NP or S between "he" NP and X

(Hobbs, 1978 p. 318)



4. ~~If node *X* is the highest S node in the sentence…~~

(*Hobbs, 1978 p. 318*)



4. ~~If node X is the highest S node in the sentence…~~

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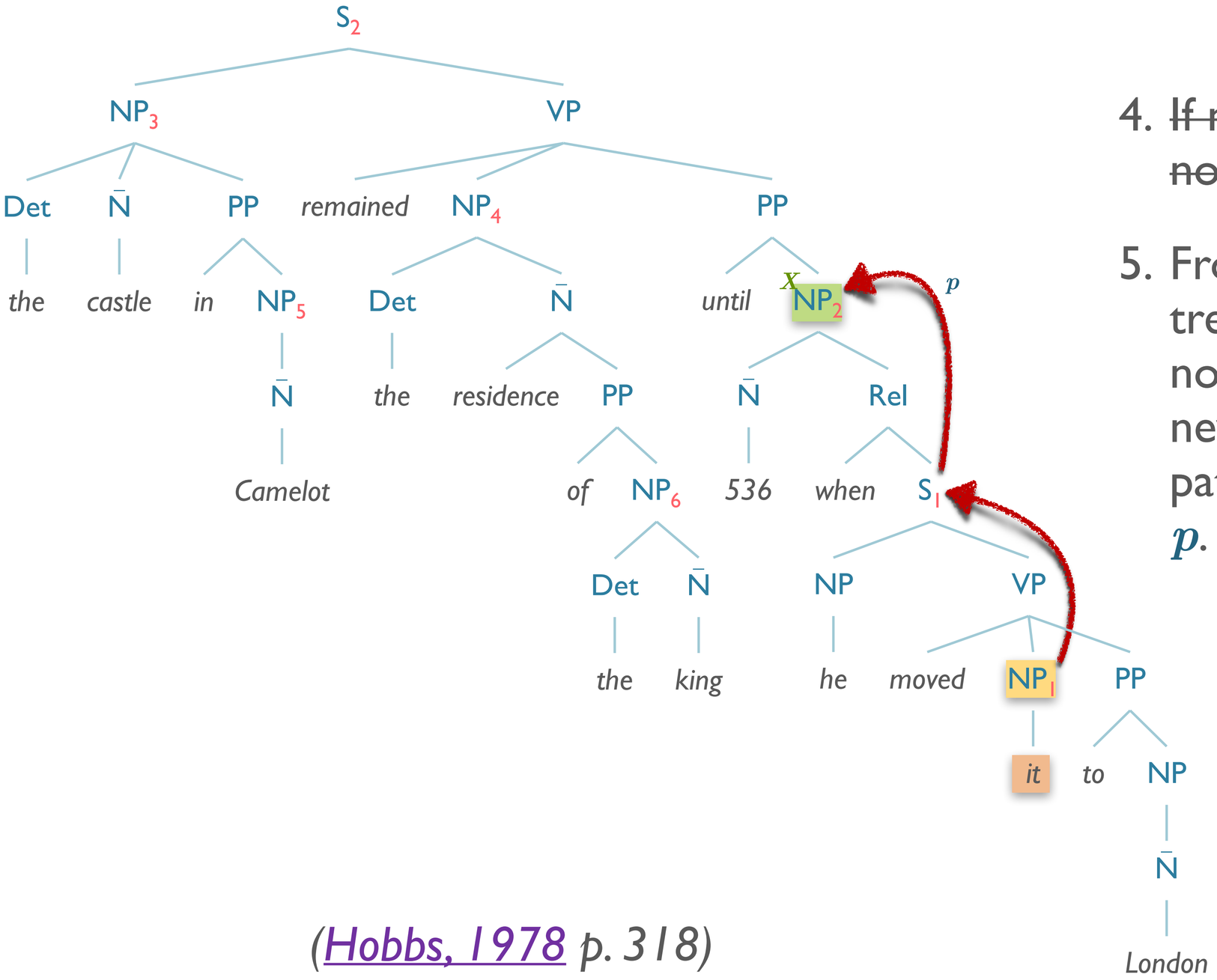
(Hobbs, 1978 p. 318)



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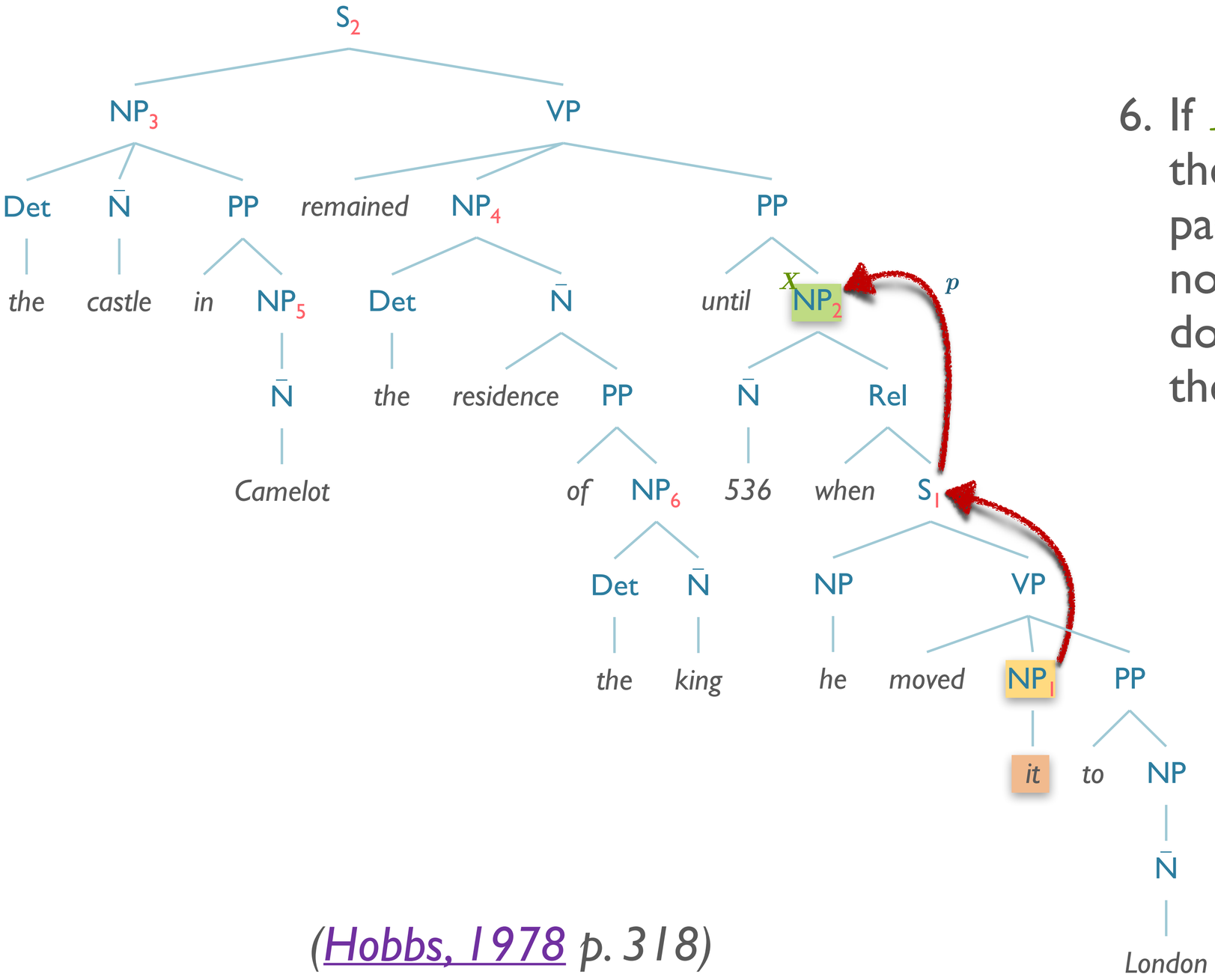
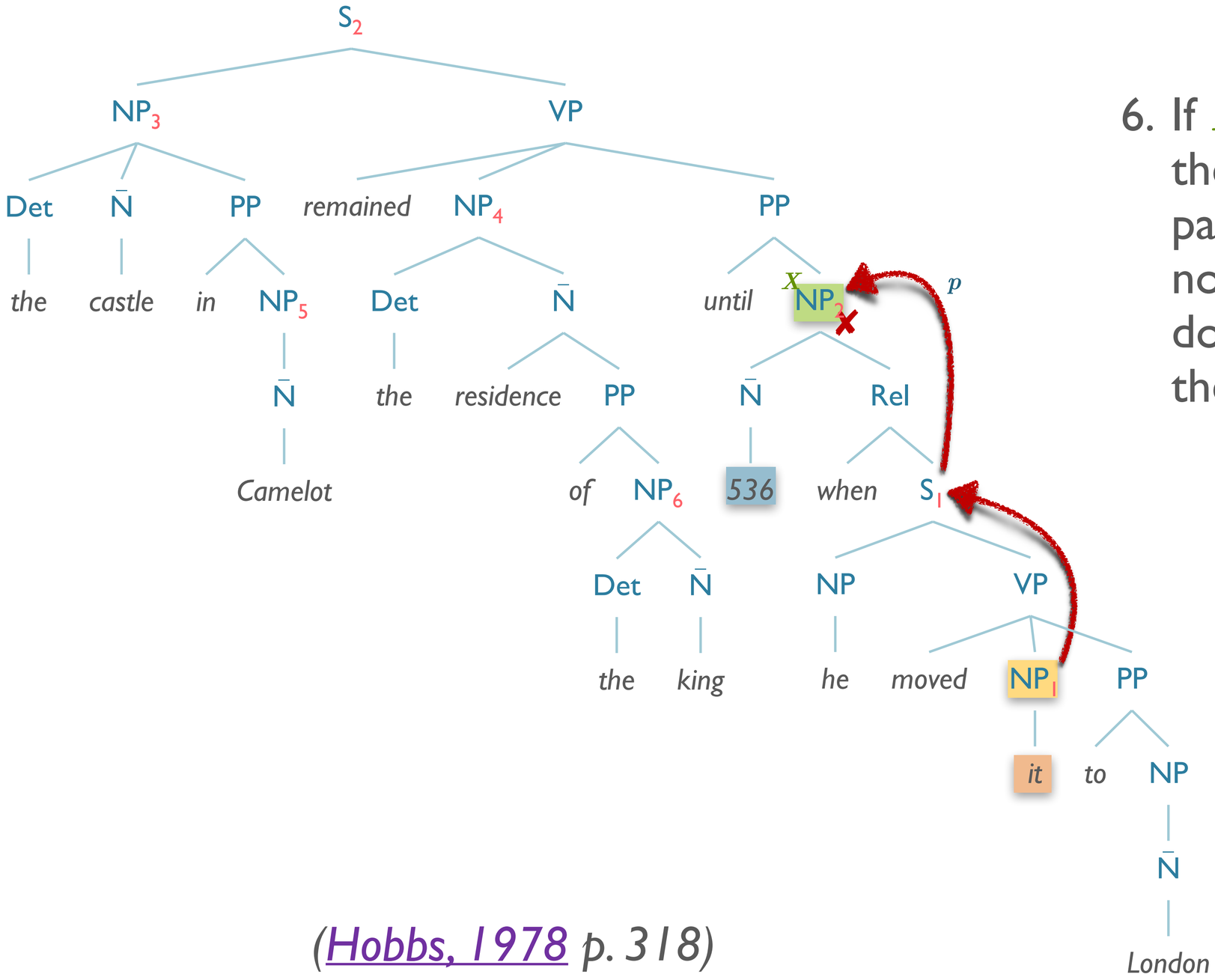


6. If X is an NP node and if the path p to X did not pass through the Nominal node that X immediately dominates, propose X as the antecedent.

(Hobbs, 1978 p. 318)



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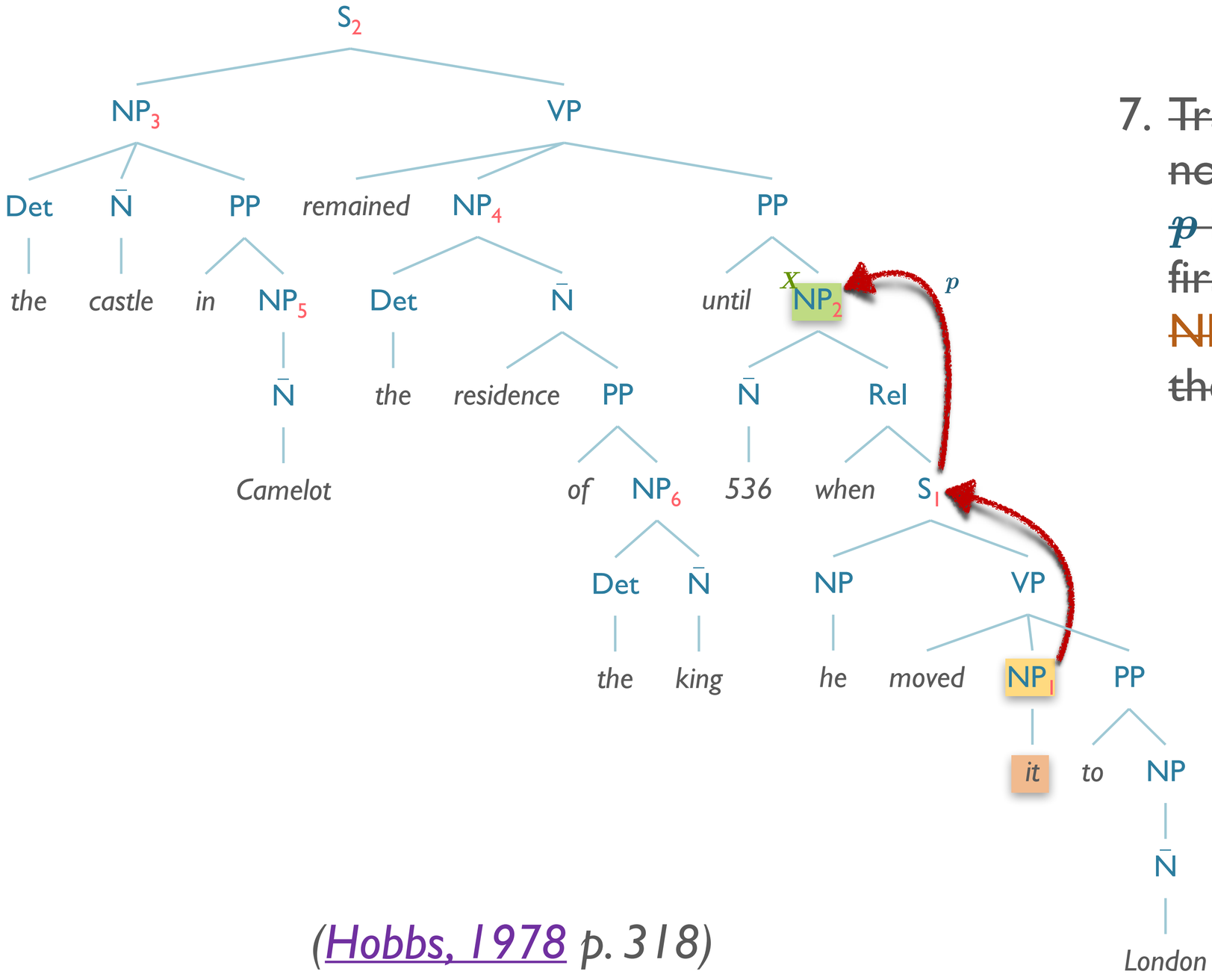
"536" can't be "moved"!

(Hobbs, 1978 p. 318)



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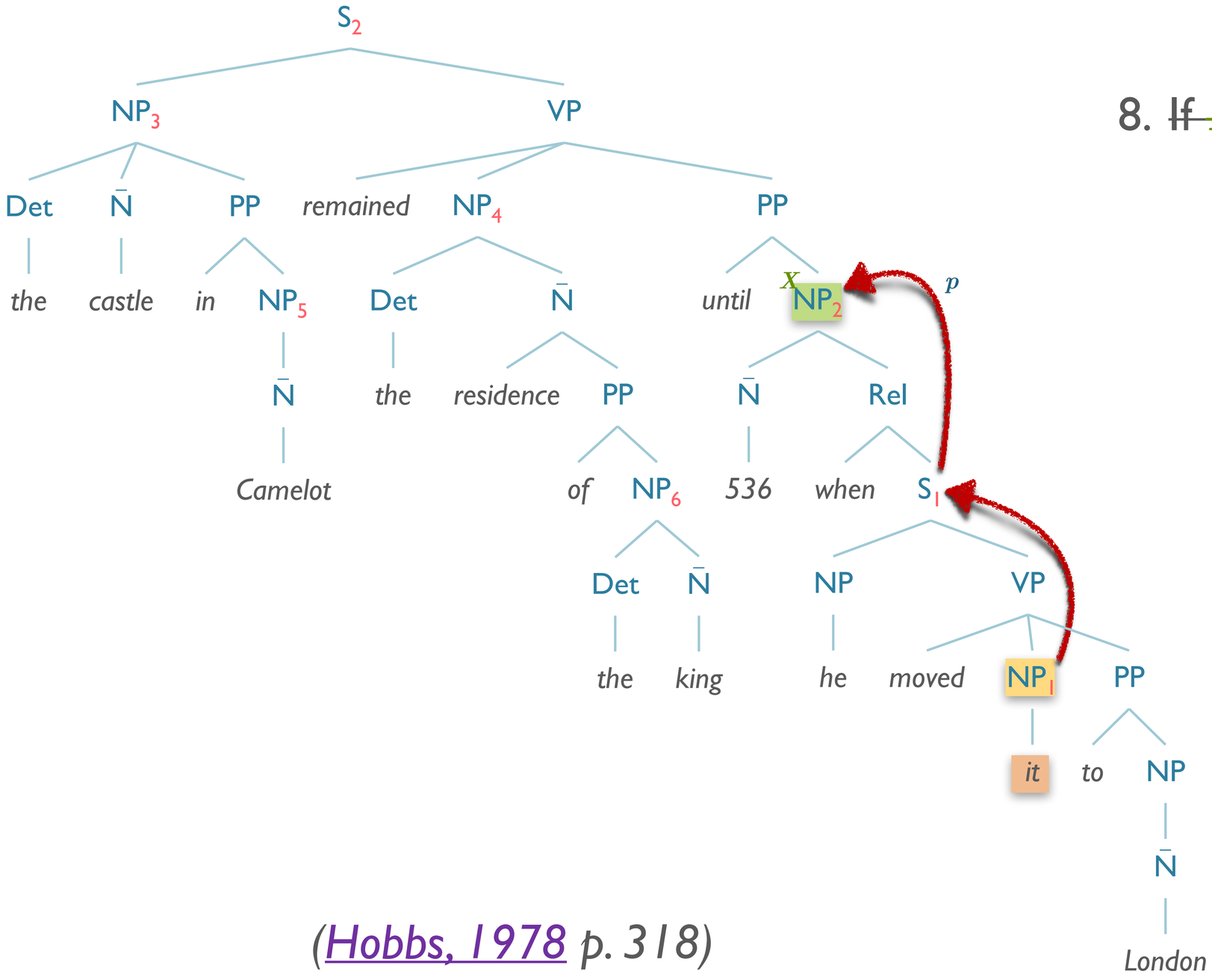

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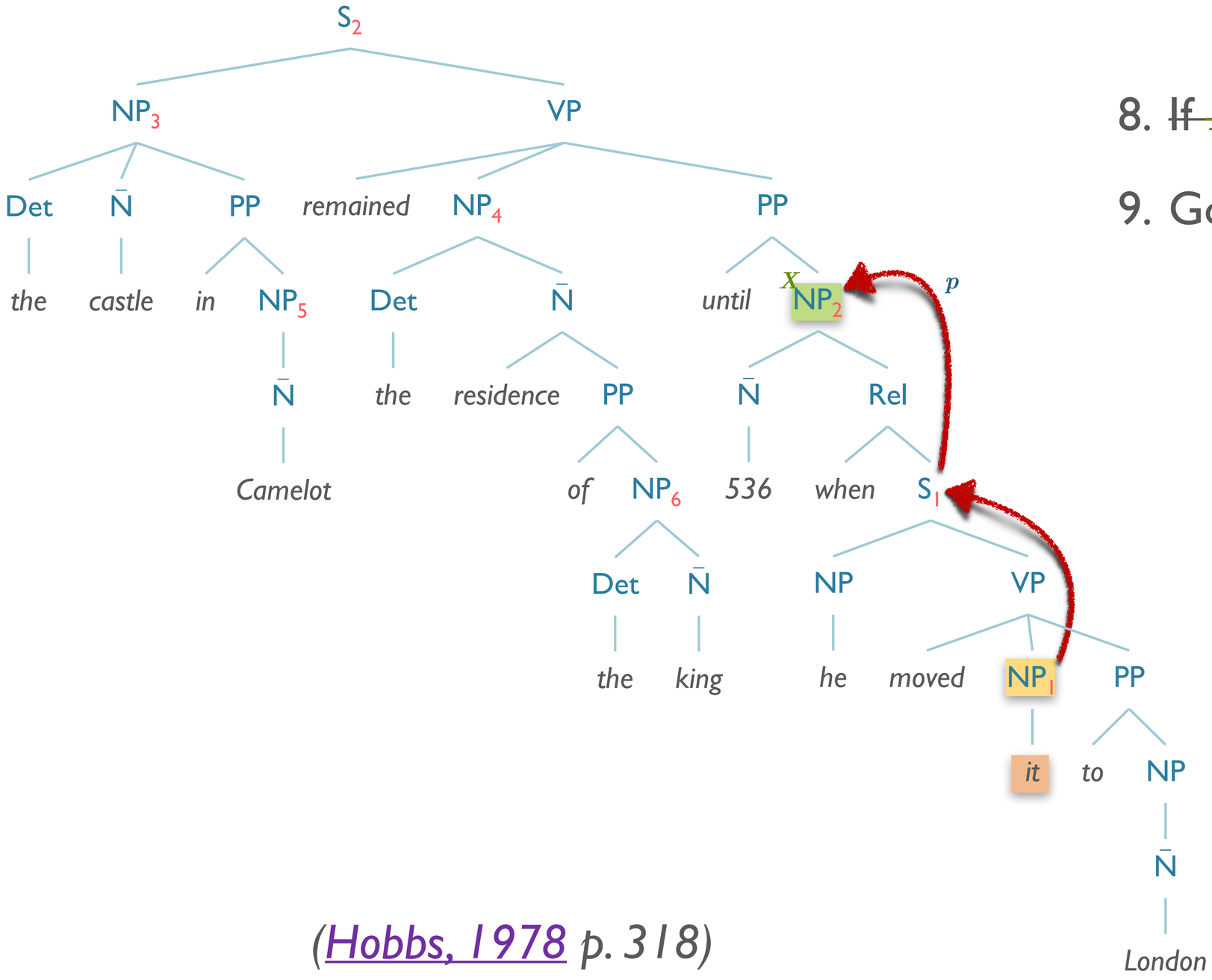
(*Hobbs, 1978 p. 318*)



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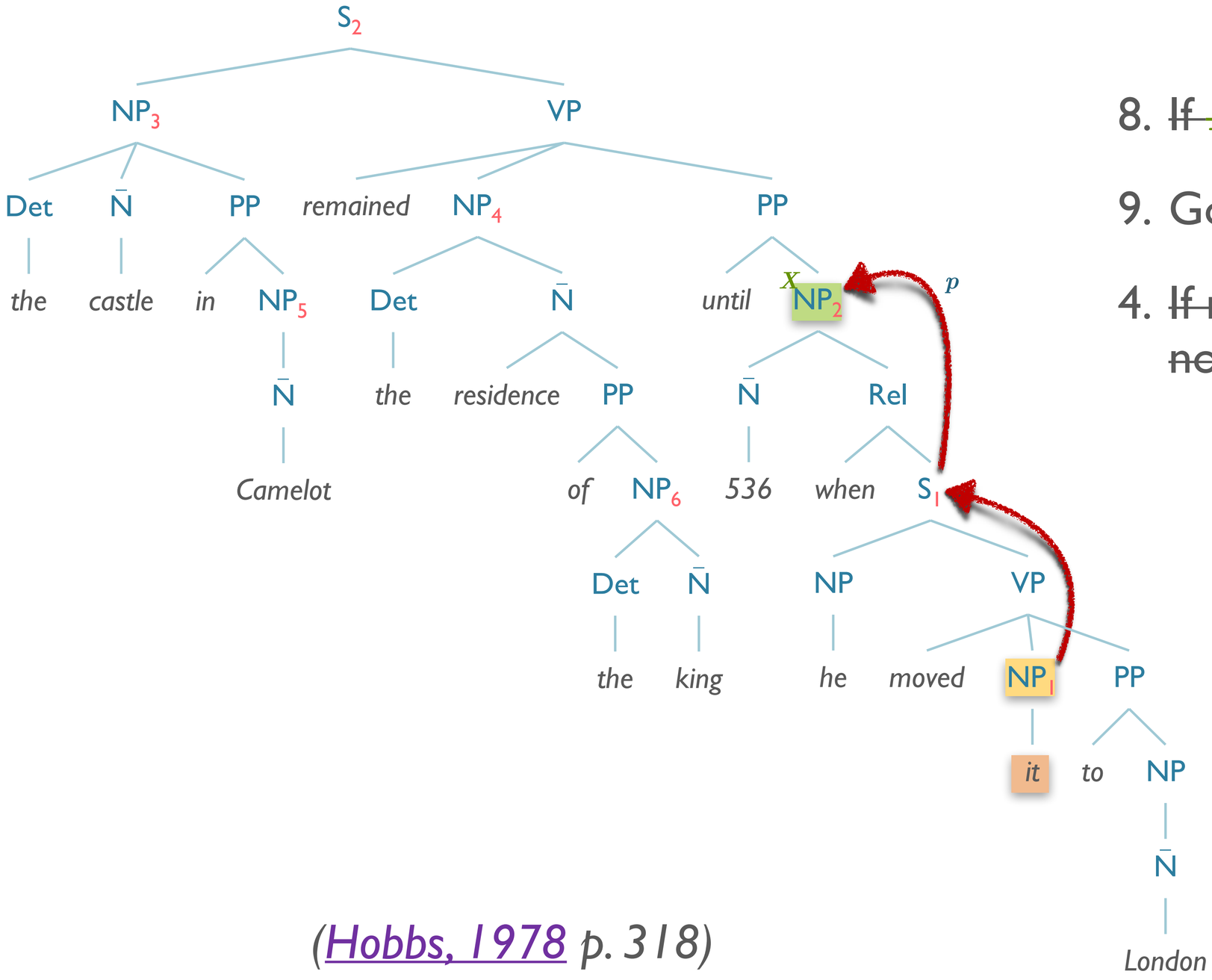
9. Go to step 4.

(*Hobbs, 1978 p. 318*)



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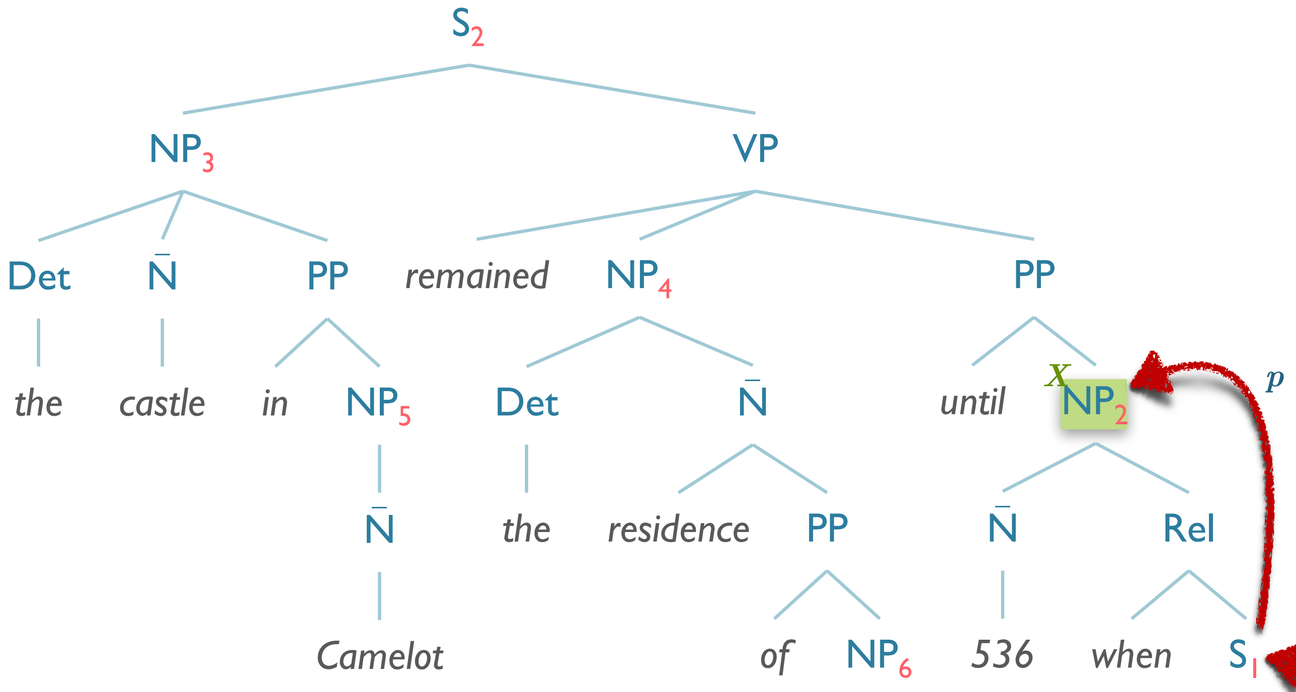
(Hobbs, 1978 p. 318)



(Hobbs, 1978 p. 318)

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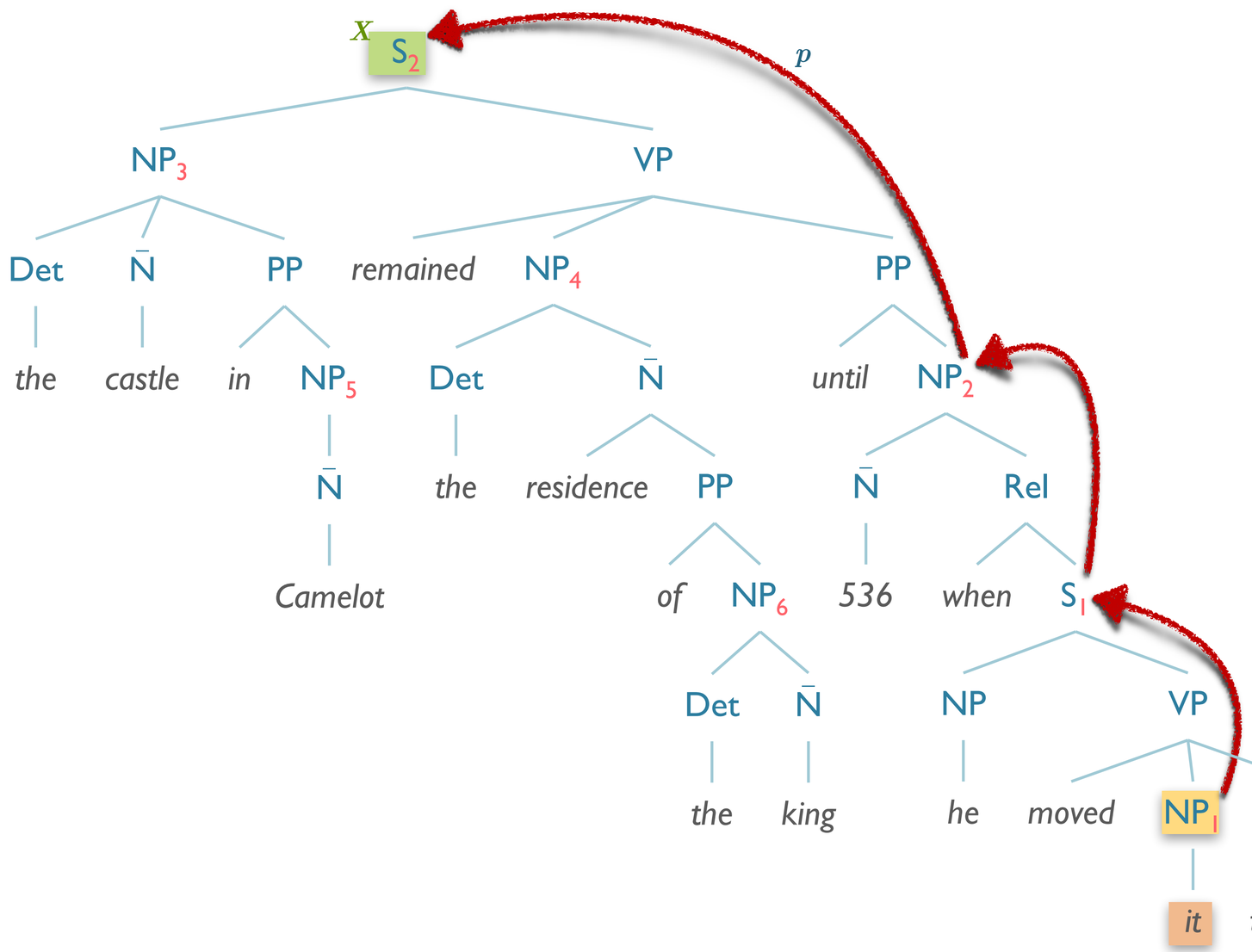
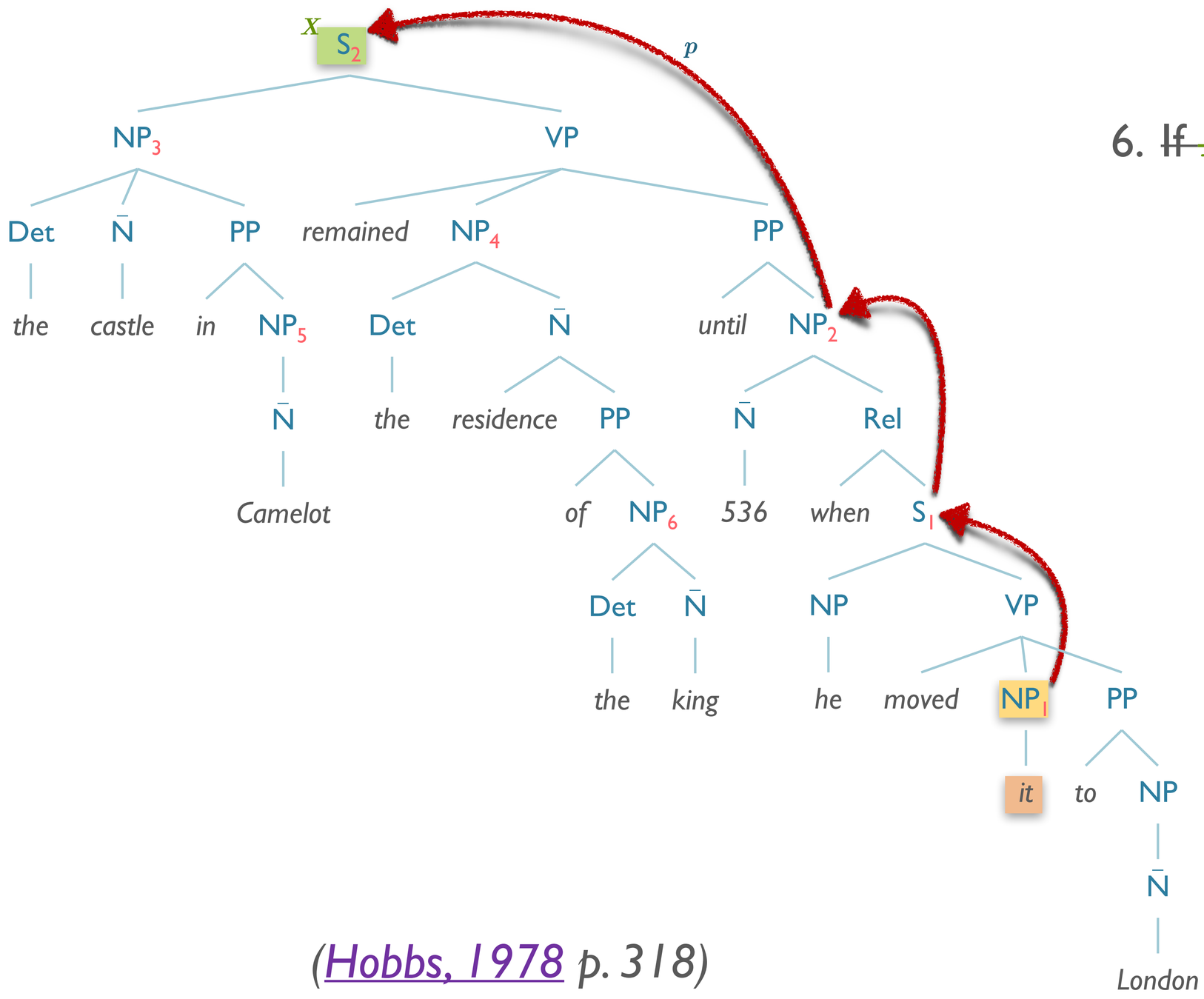
9. Go to step 4.
4. ~~If node *X* is the highest S node in the sentence…~~
5. From node ***X***, go up the tree to the first NP or S node encountered. Call this new node ***X***, and call the path traversed to reach it ***p***.



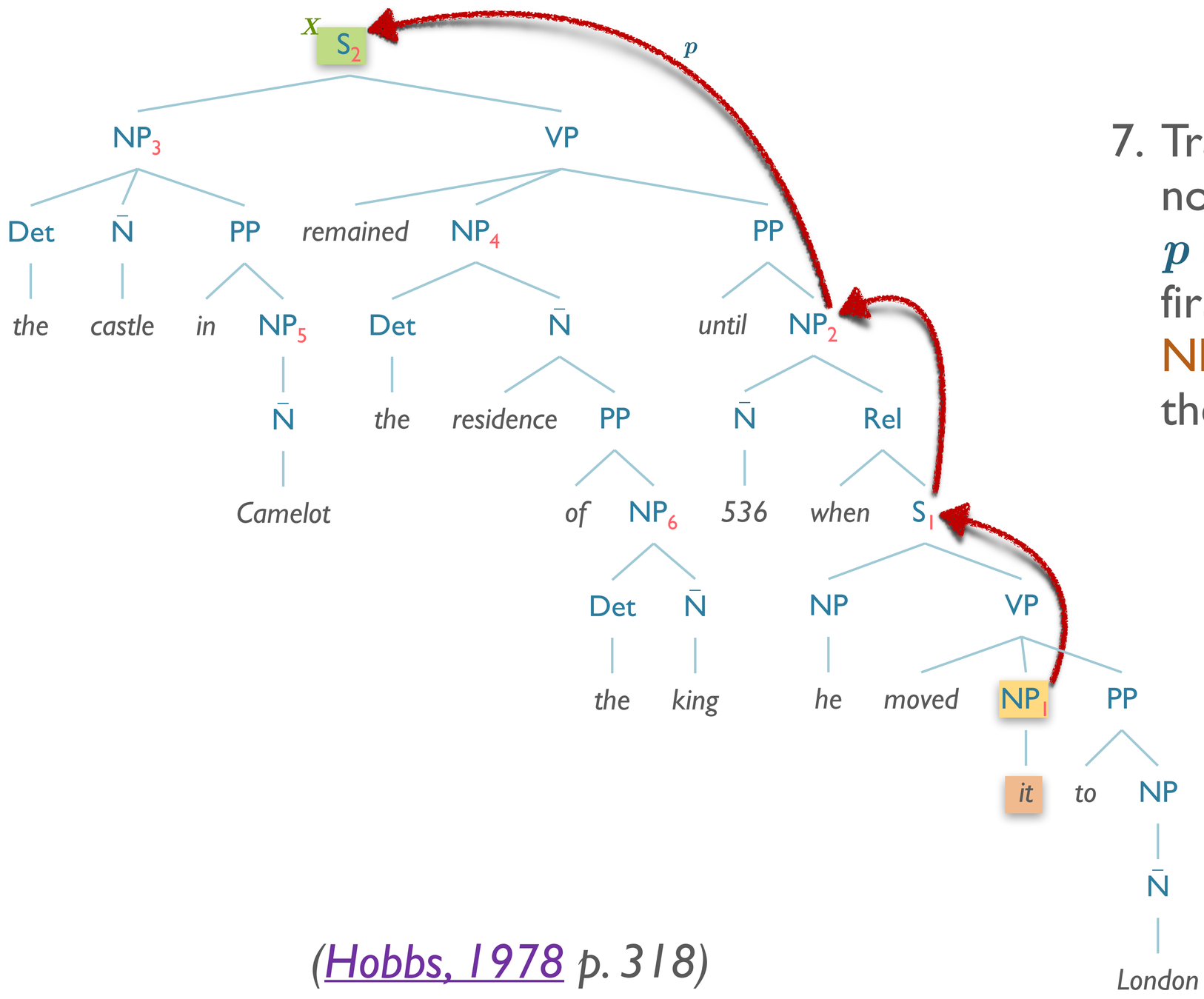
8. ~~If *X* is an S node…~~
9. Go to step 4.
4. ~~If node *X* is the highest S node in the sentence…~~
5. From node *X*, go up the tree to the first NP or S node encountered. Call this new node *X*, and call the path traversed to reach it *p*.

(Hobbs, 1978 p. 318)



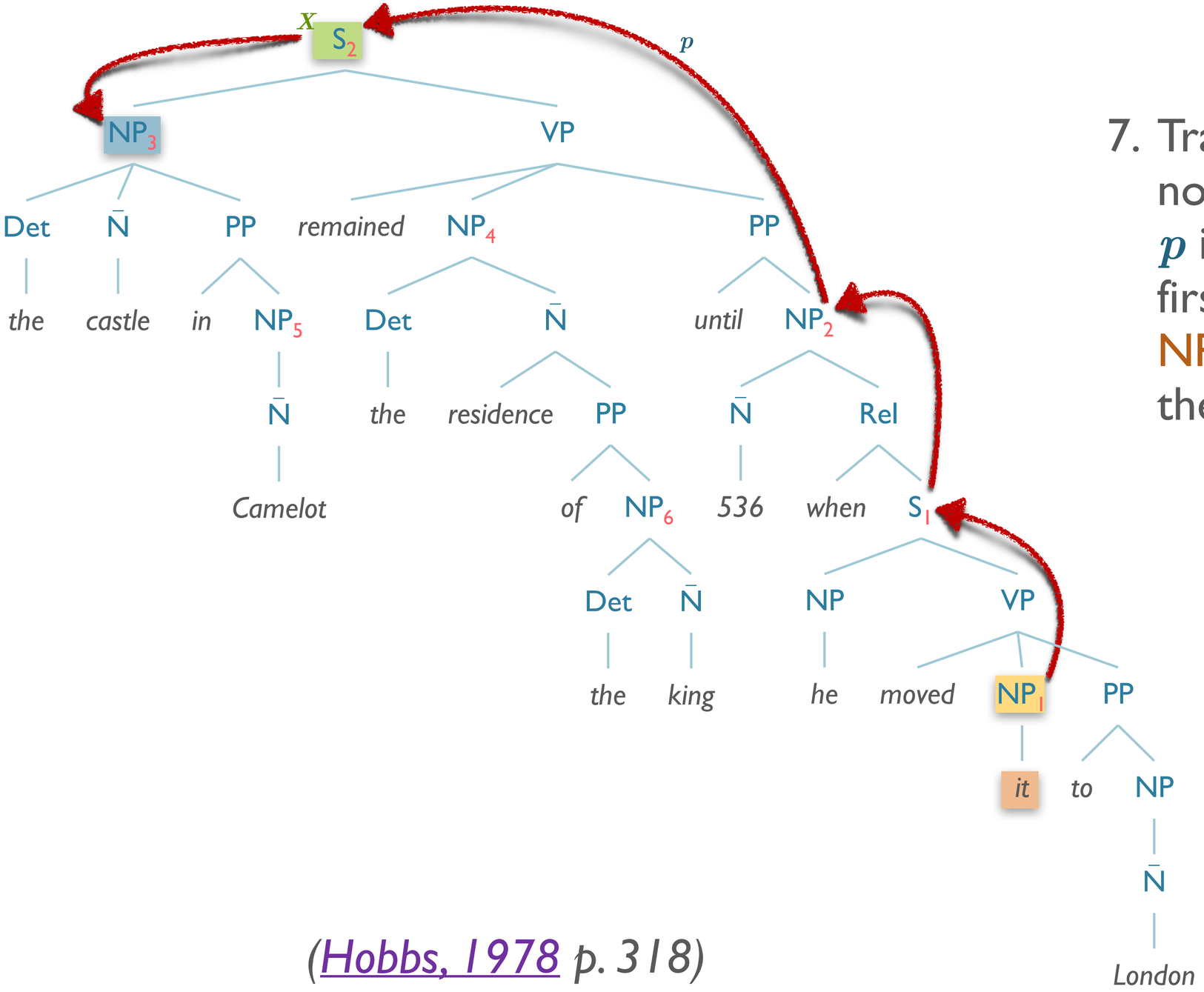
6. ~~If X is an NP node~~…

(Hobbs, 1978 p. 318)



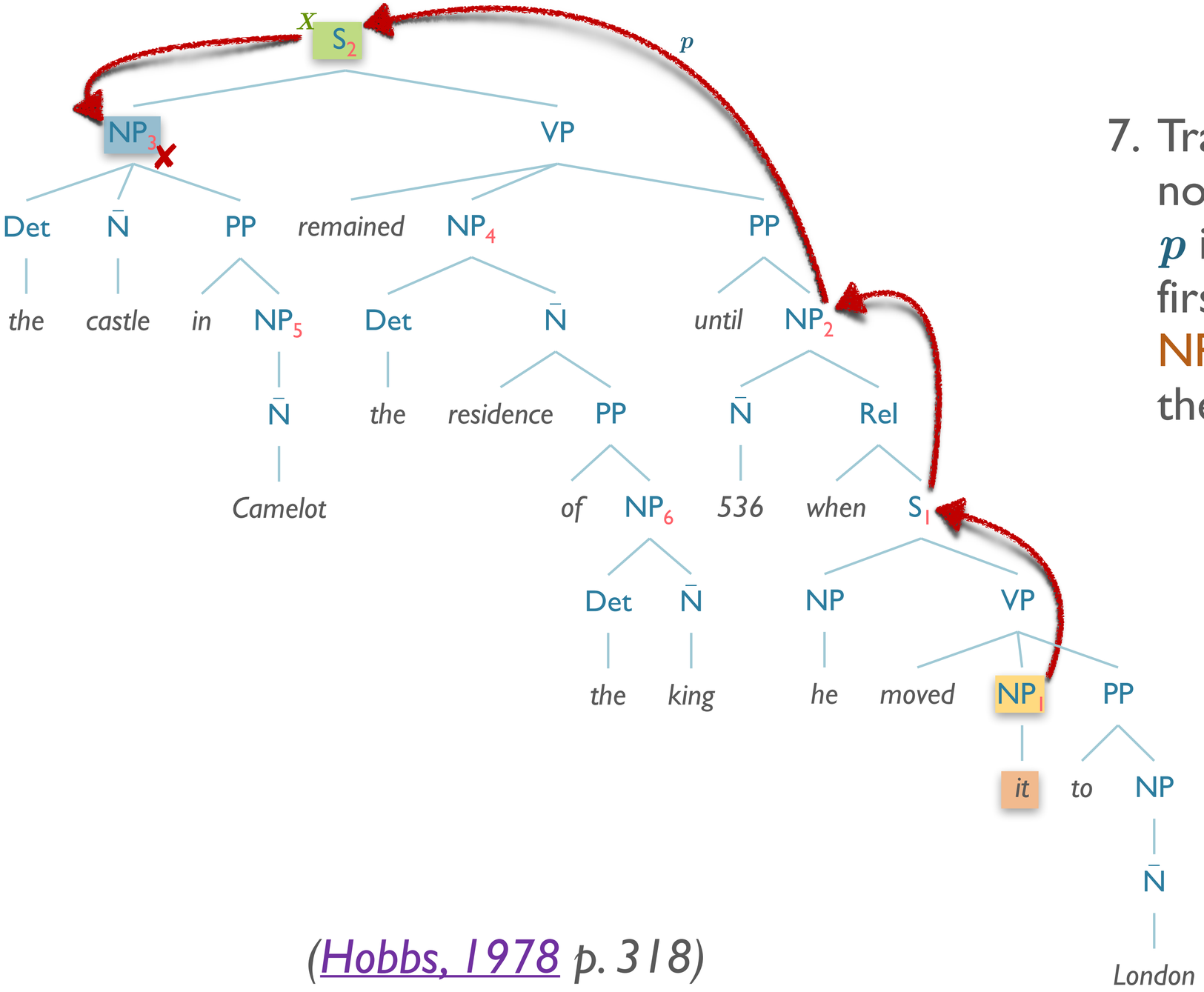
7. Traverse all branches below node X to the *left* of path p in a left-to-right, breadth-first manner. Propose any NP node encountered as the antecedent.

(Hobbs, 1978 p. 318)



7. Traverse all branches below node ***X*** to the *left* of path ***p*** in a left-to-right, breadth-first manner. Propose any NP node encountered as the antecedent.

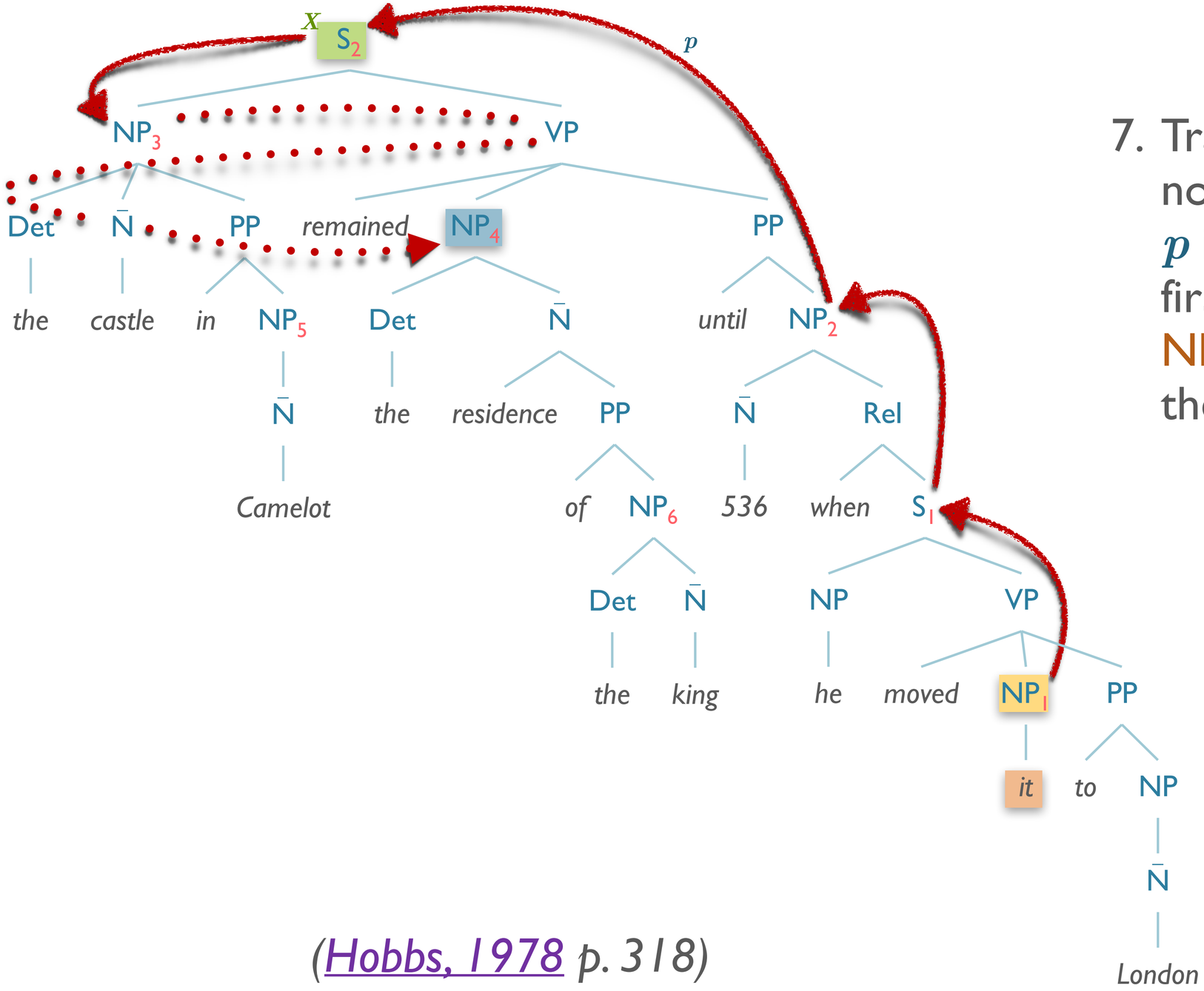
(Hobbs, 1978 p. 318)



7. Traverse all branches below node X to the *left* of path p in a left-to-right, breadth-first manner. Propose any NP node encountered as the antecedent.

Moving castles? 🤔

(Hobbs, 1978 p. 318)



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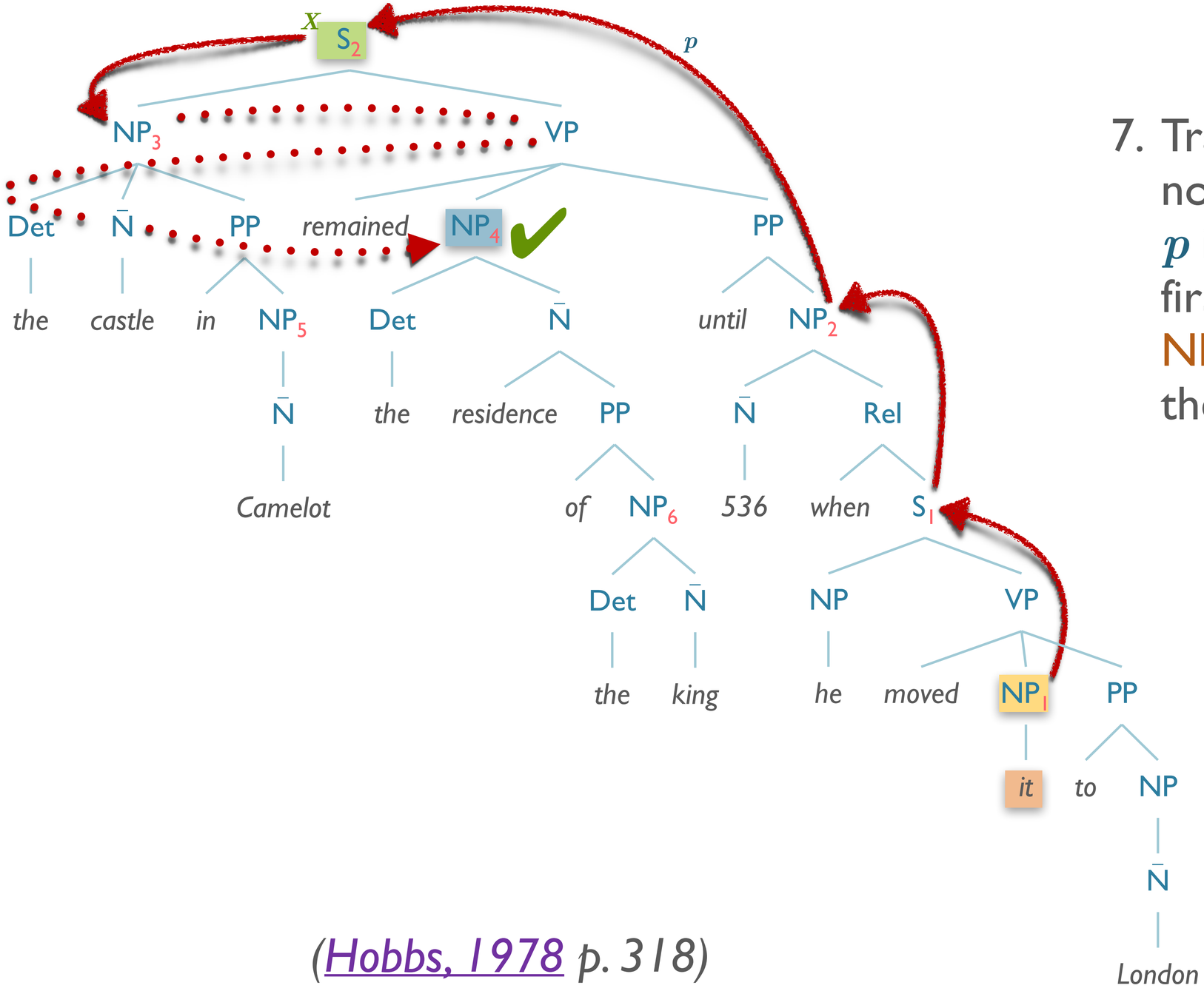


7. Traverse all branches below node X to the *left* of path p in a left-to-right, breadth-first manner. Propose any NP node encountered as the antecedent.

"the residence of the king"

(Hobbs, 1978 p. 318)

Hobbs Algorithm Detail (Hobbs, 1978)

1. Begin at the noun phrase (NP) node immediately dominating the pronoun
2. Go up the tree to the first NP or sentence (S) node encountered. Call this node X, and call the path used to reach it p.
3. Traverse all branches below node X to the left of path p in a left-to-right, breadth-first fashion. Propose as the antecedent any encountered NP node that has an NP or S node between it and X.
4. If node X is the highest S node in the sentence, traverse the surface parse trees of previous sentences in the text in order of recency, the most recent first; each tree is traversed in a left-to-right, breadth-first manner, and when an NP node is encountered, it is proposed as antecedent. If X is not the highest S node in the sentence, continue to step 5.

Hobbs Algorithm Detail (Hobbs, 1978)

5. From node X, go up the tree to the first NP or S node encountered. Call this new node X, and call the path traversed to reach it p.

6. If X is an NP node and if the path p to X did not pass through the Nominal node that X immediately dominates, propose X as the antecedent.

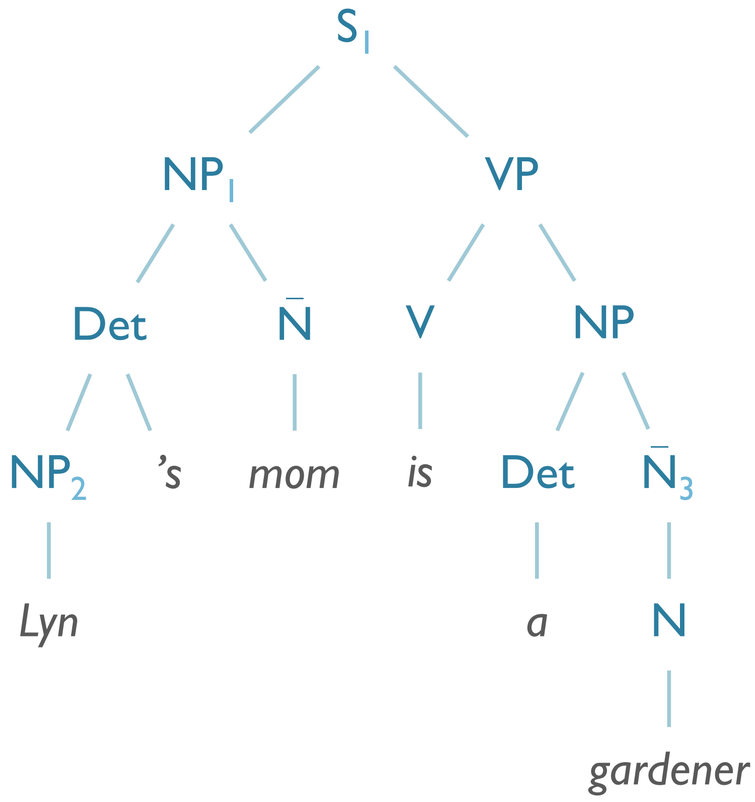
7. Traverse all branches below node X to the ***left*** of path p in a left-to-right, breadth-first manner. Propose any NP node encountered as the antecedent.

8. If X is an S node, traverse all branches of node X to the ***right*** of path p in a left-to-right, breadth-first manner, but do not go below any NP or S node encountered. Propose any NP node encountered as the antecedent.

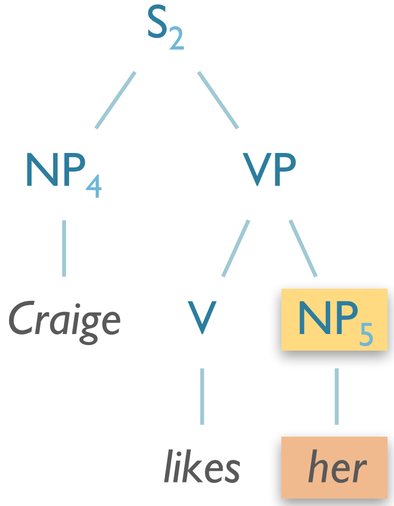
9. Go to step 4.

Hobbs Example

Lyn's mom is a gardener.



*Craige likes **her**.*



1. Begin at the noun phrase (NP) node immediately dominating the pronoun

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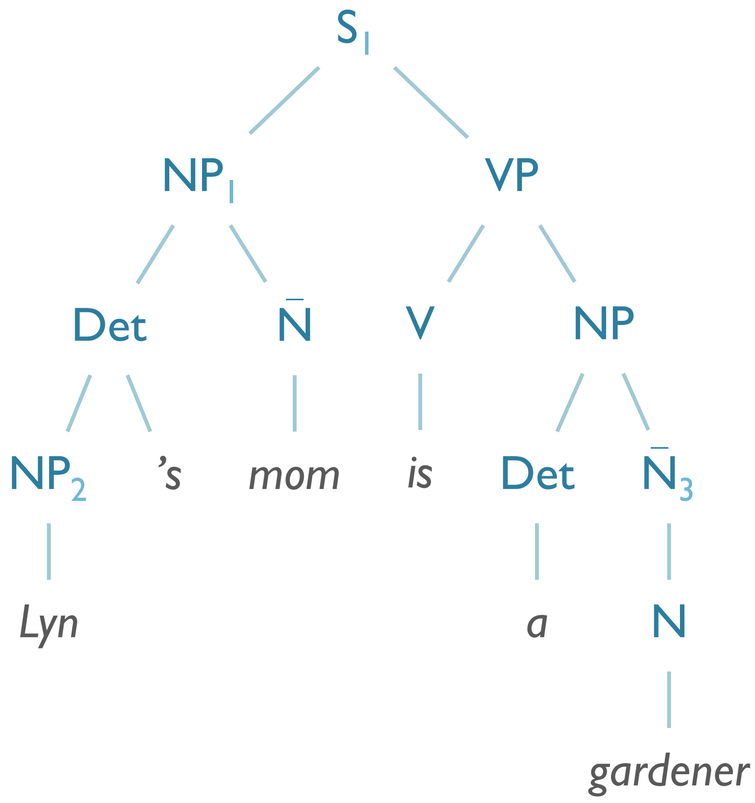

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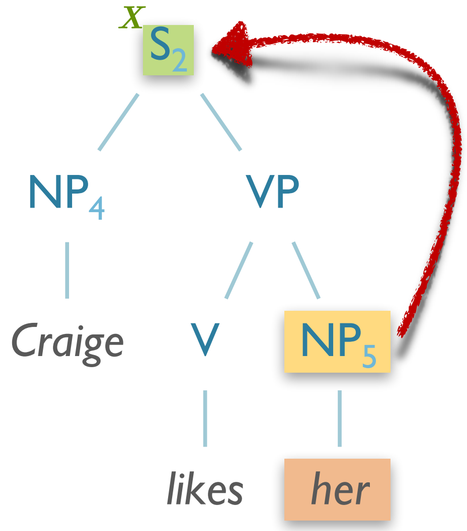
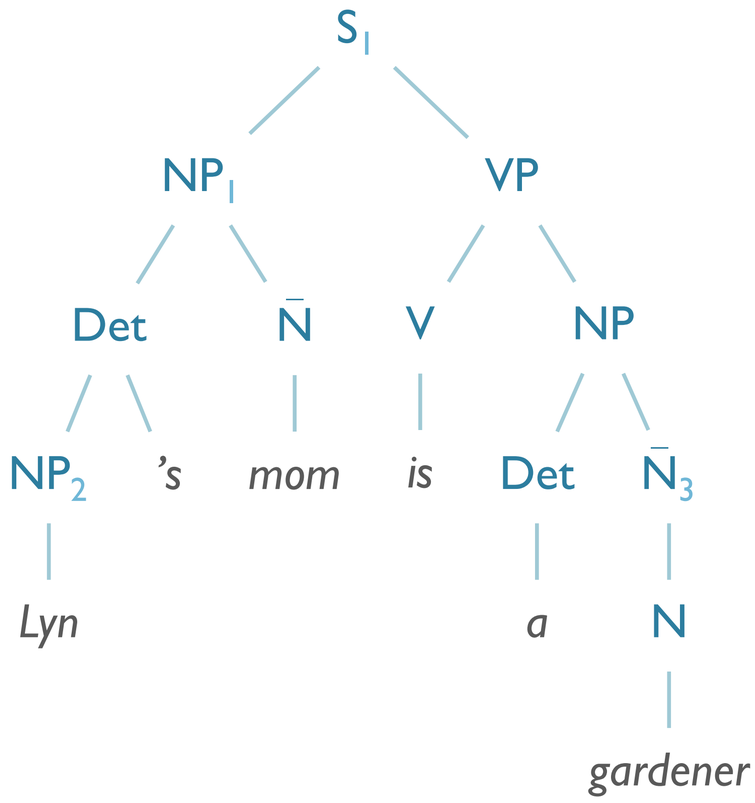


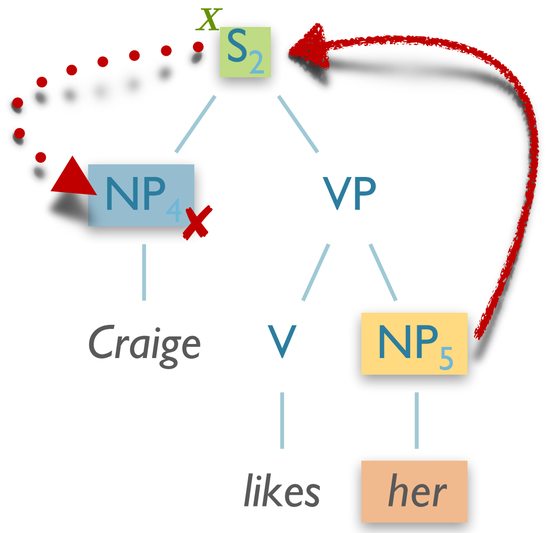
2. Go up the tree to the first NP or sentence (S) node encountered. Call this node ***X***, and call the path used to reach it ***p***.

Hobbs Example

Lyn's mom is a gardener.



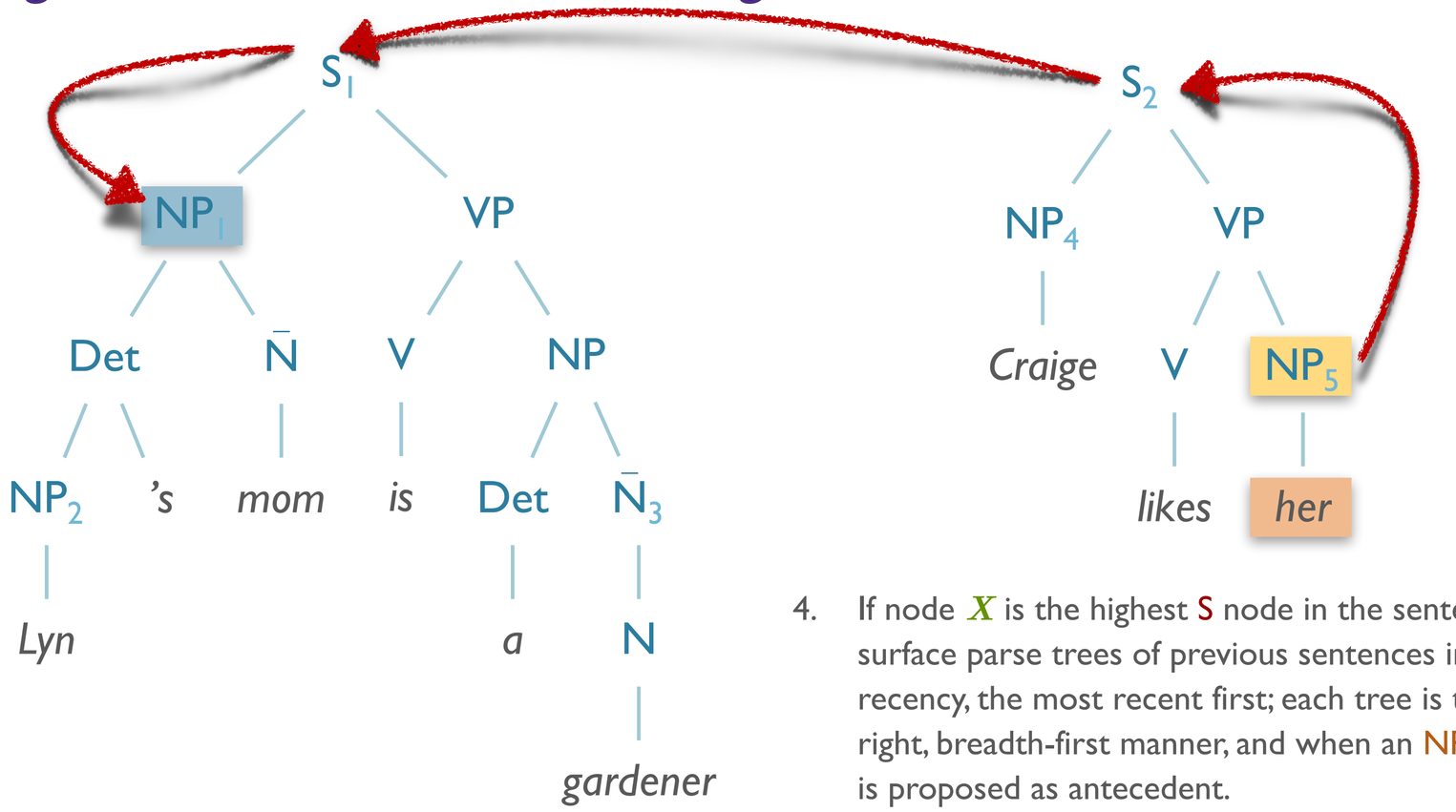
Craige likes her.



3. Traverse all branches below node X to the left of path p in a left-to-right, breadth-first fashion. Propose as the antecedent any encountered NP node that has an NP or S node between it and X.

Hobbs Example

Lyn's mom is a gardener. *Craige likes her.*



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Hobbs Example

- What about…?
  - *Lyn's mom ~~is~~ hired a gardener.*
  - *Craige likes her.*