

# **Top-Down and Bottom-Up Parsing**

Natalie Parde

UIC CS 421

**There are many ways to generate parse trees.**

### Top-Down Parsing:

- Goal-driven
- Builds parse tree from the start symbol down to the terminal nodes

### Bottom-Up Parsing:

- Data-driven
- Builds parse tree from the terminal nodes up to the start symbol

**Naïve approach:**  
Enumerate all possible  
solutions

**Dynamic programming  
approach:** Save partial  
solutions in a table, and  
use this information to  
reduce search time

**These approaches can be implemented naïvely,  
or using more advanced techniques.**

# Top-Down Parsing

- Assume that the input can be derived by the designated start symbol **S**
- Find the tops of all trees that can start with **S**
  - Look for all production rules with **S** on the left-hand side
- Find the tops of all trees that can start with those constituents
- (Repeat recursively until terminal nodes are reached)
- Trees whose leaves fail to match all words in the input sentence can be rejected, leaving behind trees that represent successful parses

# Top-Down Parsing: Example

## Input Sentence:

Book that flight.

## Grammar:

S → NP VP  
S → Aux NP VP  
S → VP  
NP → Pronoun  
NP → Proper-Noun  
NP → Det Nominal  
Nominal → Noun  
Nominal → Nominal Noun  
Nominal → Nominal PP  
VP → Verb  
VP → Verb NP  
VP → Verb NP PP  
VP → Verb PP  
VP → VP PP  
PP → Preposition NP

## Lexicon:

Det → that | this | a  
Noun → book | flight | meal | money  
Verb → book | include | prefer  
Pronoun → I | she | me  
Proper-Noun → Houston | NWA  
Aux → does  
Preposition → from | to | on | near | through

# Top-Down Parsing: Example

Book that flight.

S

S

S

$S \rightarrow NP VP$

$S \rightarrow Aux NP VP$

$S \rightarrow VP$

$NP \rightarrow Pronoun$

$NP \rightarrow Proper-Noun$

$NP \rightarrow Det Nominal$

$Nominal \rightarrow Noun$

$Nominal \rightarrow Nominal Noun$

$Nominal \rightarrow Nominal PP$

$VP \rightarrow Verb$

$VP \rightarrow Verb NP$

$VP \rightarrow Verb NP PP$

$VP \rightarrow Verb PP$

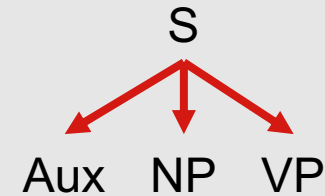
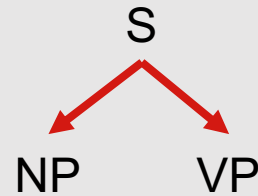
$VP \rightarrow VP PP$

$PP \rightarrow Preposition NP$

# Top-Down Parsing: Example

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$VP \rightarrow Verb$

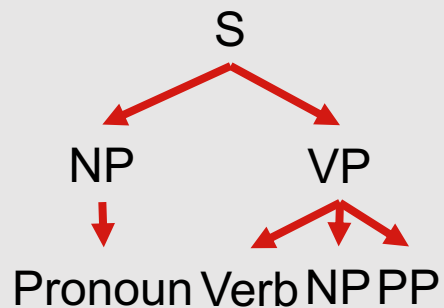
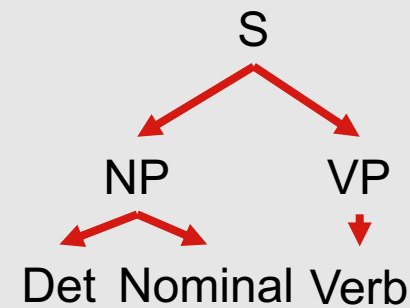
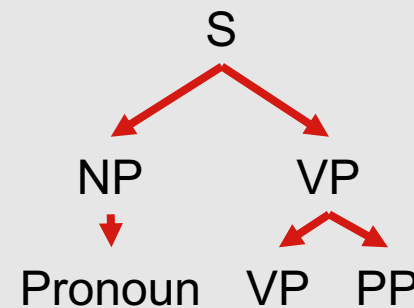
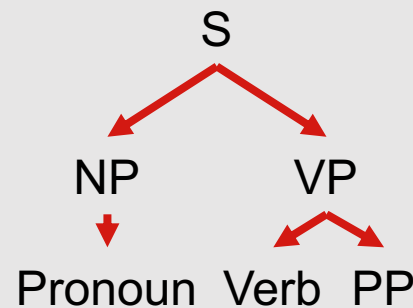
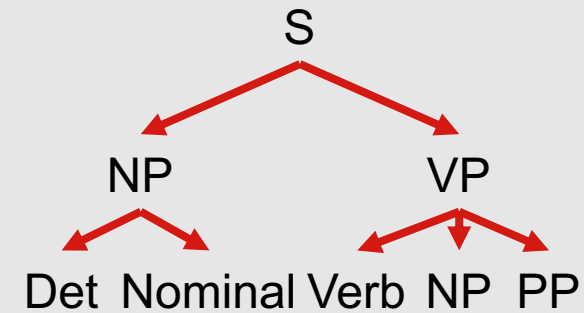
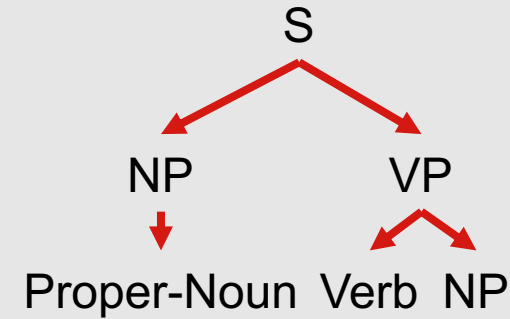
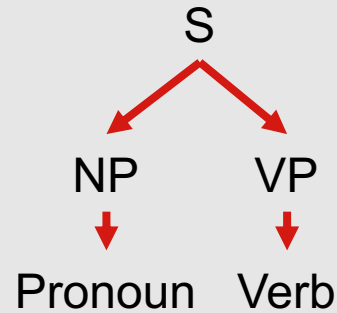
$VP \rightarrow Verb NP$

$VP \rightarrow Verb NP PP$

$VP \rightarrow Verb PP$

$VP \rightarrow VP PP$

$PP \rightarrow Preposition NP$



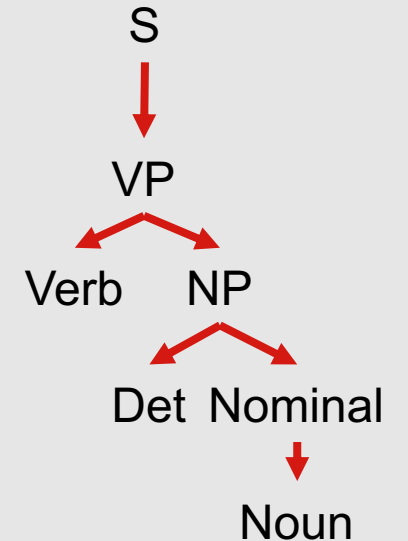
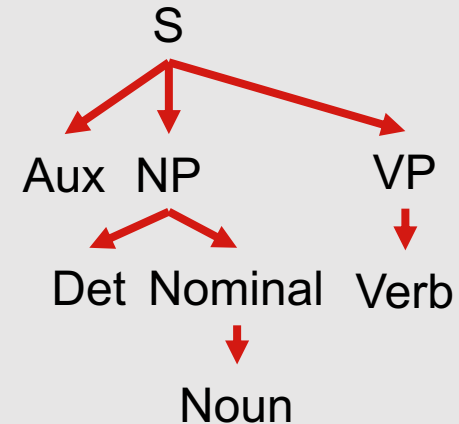
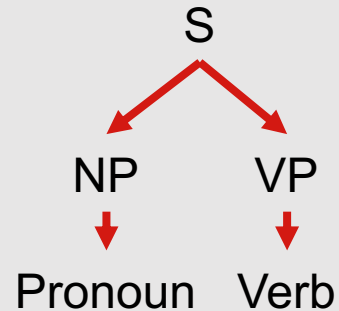
...and many more!



# Top-Down Parsing: Example

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...and many, many more not shown!

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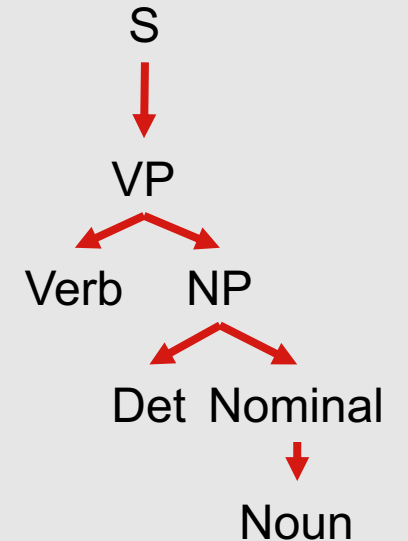
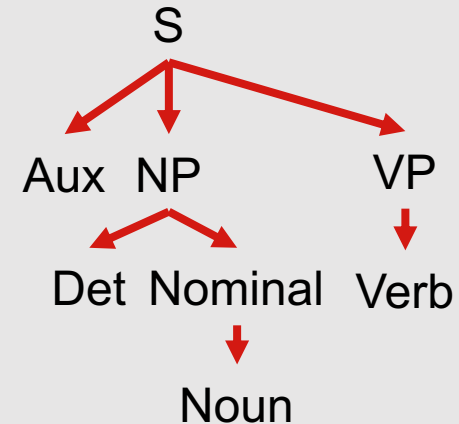
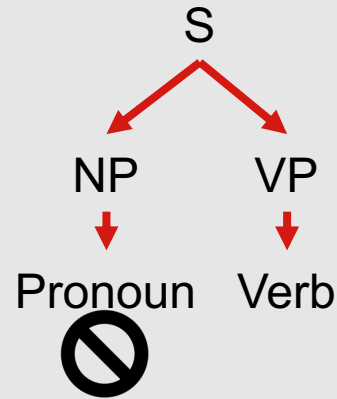
$VP \rightarrow Verb NP$

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$VP \rightarrow VP PP$

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$Det \rightarrow that \mid this \mid a$

$Noun \rightarrow book \mid flight \mid meal \mid money$

$Verb \rightarrow \text{book} \mid include \mid prefer$

$Pronoun \rightarrow I \mid she \mid me$

$Proper-Noun \rightarrow Houston \mid NWA$

$Aux \rightarrow does$

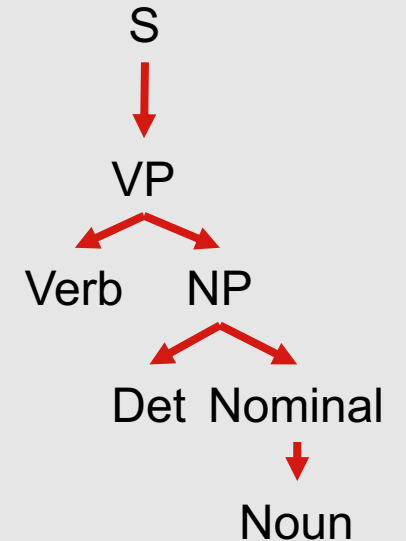
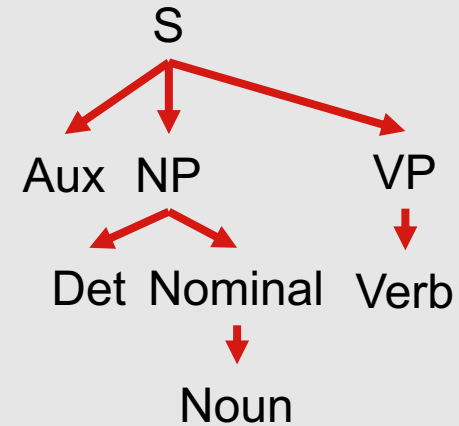
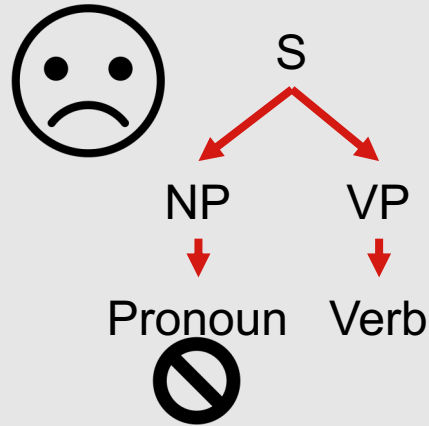
$Preposition \rightarrow from \mid to \mid on \mid near \mid through$

...and many, many more not shown!

# Top-Down Parsing: Example

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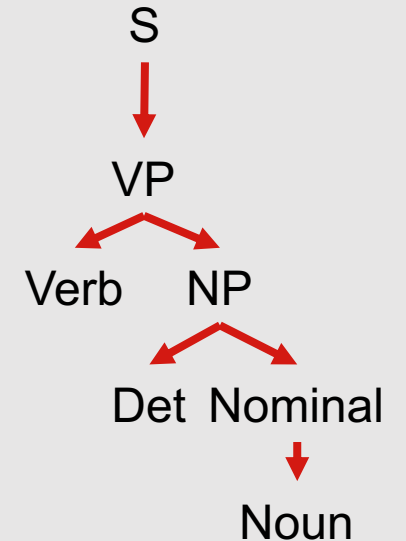
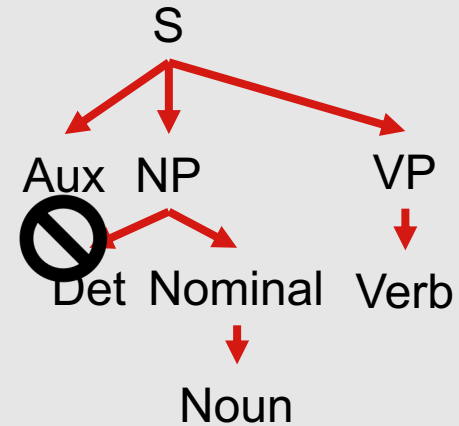
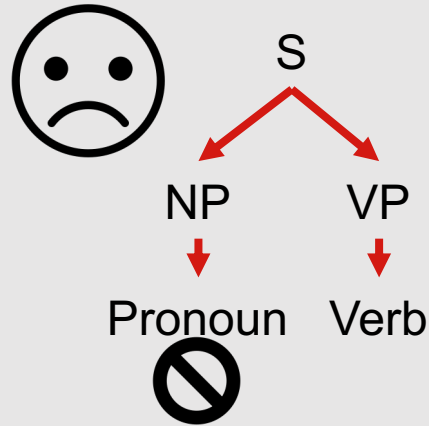
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# Top-Down Parsing: Example

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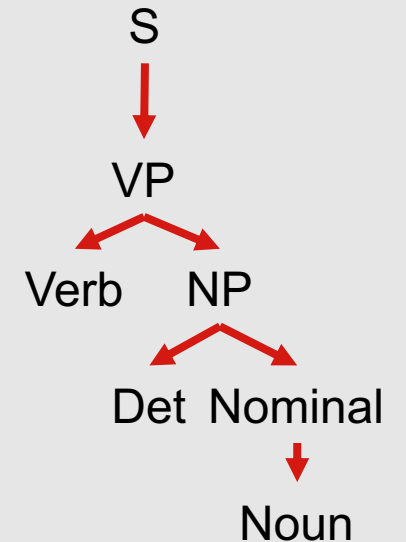
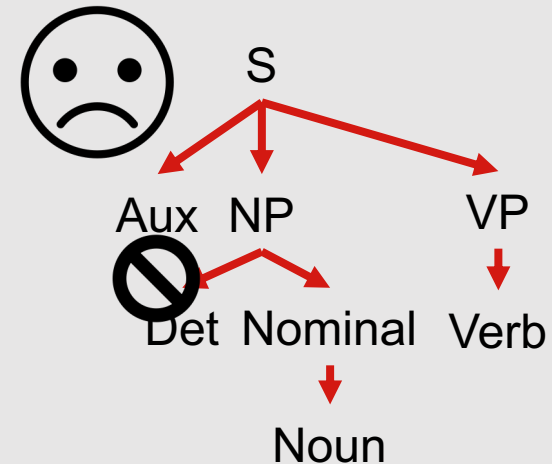
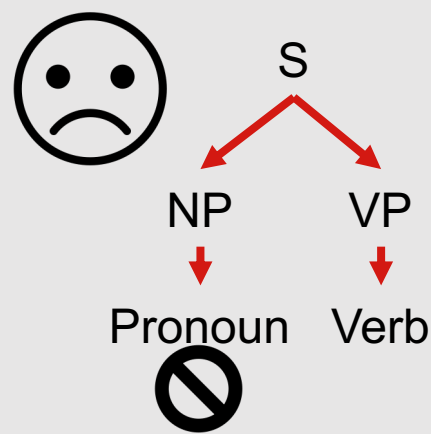
Det  $\rightarrow$  **that** | this | a  
Noun  $\rightarrow$  book | **flight** | meal | money  
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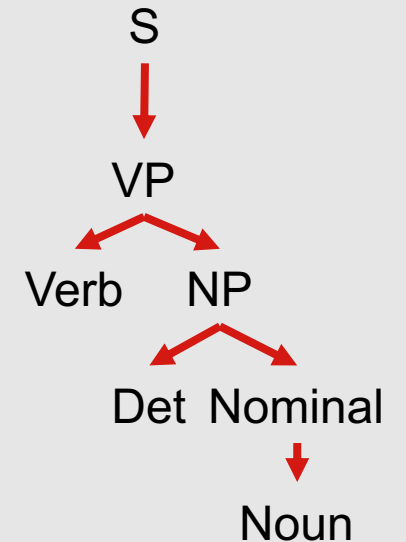
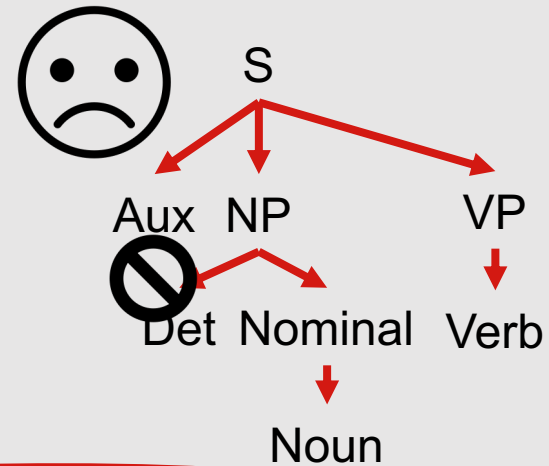
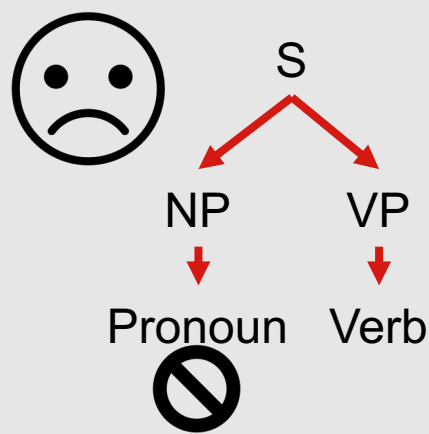
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# Top-Down Parsing: Example

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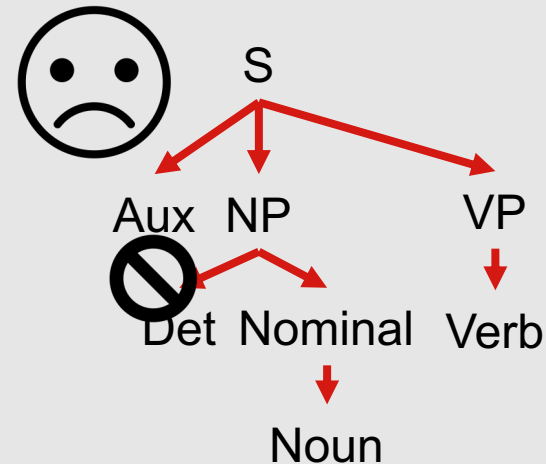
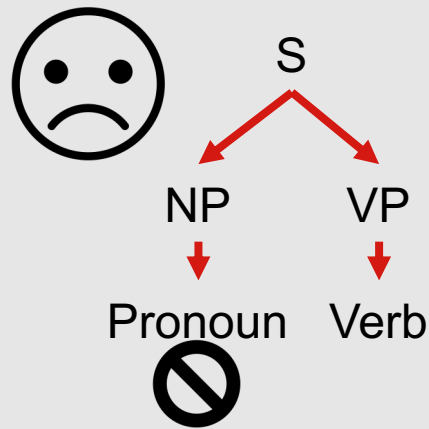
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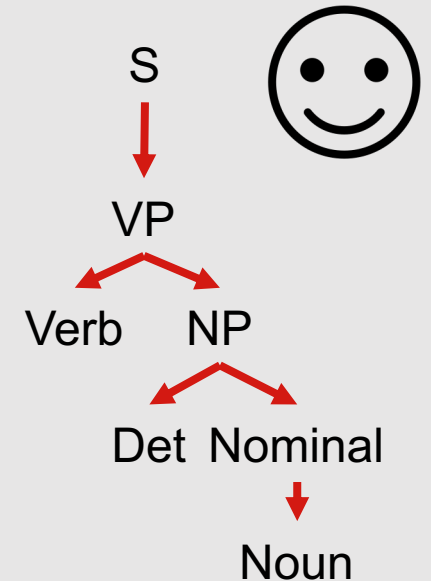
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...and many, many more not shown!

# Bottom-Up Parsing

- Earliest known parsing algorithm!
- Starts with the words in the input sentence, and tries to build trees from those words up by applying rules from the grammar one at a time
  - Looks for places in the in-progress parse where the righthand side of a production rule might fit
- Success = parser builds a tree rooted in the start symbol **S** that covers all of the input words



# Bottom-Up Parsing: Example

## Input Sentence:

Book that flight.

## Grammar:

S  $\rightarrow$  NP VP  
S  $\rightarrow$  Aux NP VP  
S  $\rightarrow$  VP  
NP  $\rightarrow$  Pronoun  
NP  $\rightarrow$  Proper-Noun  
NP  $\rightarrow$  Det Nominal  
Nominal  $\rightarrow$  Noun  
Nominal  $\rightarrow$  Nominal Noun  
Nominal  $\rightarrow$  Nominal PP  
VP  $\rightarrow$  Verb  
VP  $\rightarrow$  Verb NP  
VP  $\rightarrow$  Verb NP PP  
VP  $\rightarrow$  Verb PP  
VP  $\rightarrow$  VP PP  
PP  $\rightarrow$  Preposition NP

## Lexicon:

Det  $\rightarrow$  that | this | a  
Noun  $\rightarrow$  book | flight | meal | money  
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Aux  $\rightarrow$  does  
Preposition  $\rightarrow$  from | to | on | near | through

# Bottom-Up Parsing: Example

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Noun → book | flight | meal | money  
Verb → book | include | prefer  
Pronoun → I | she | me  
Proper-Noun → Houston | NWA  
Aux → does  
Preposition → from | to | on | near | through

Noun	Det	Noun
↓	↓	↓
book	that	flight

Verb	Det	Noun
↓	↓	↓
book	that	flight

# Bottom-Up Parsing: Example

Book that flight.

$S \rightarrow NP VP$   
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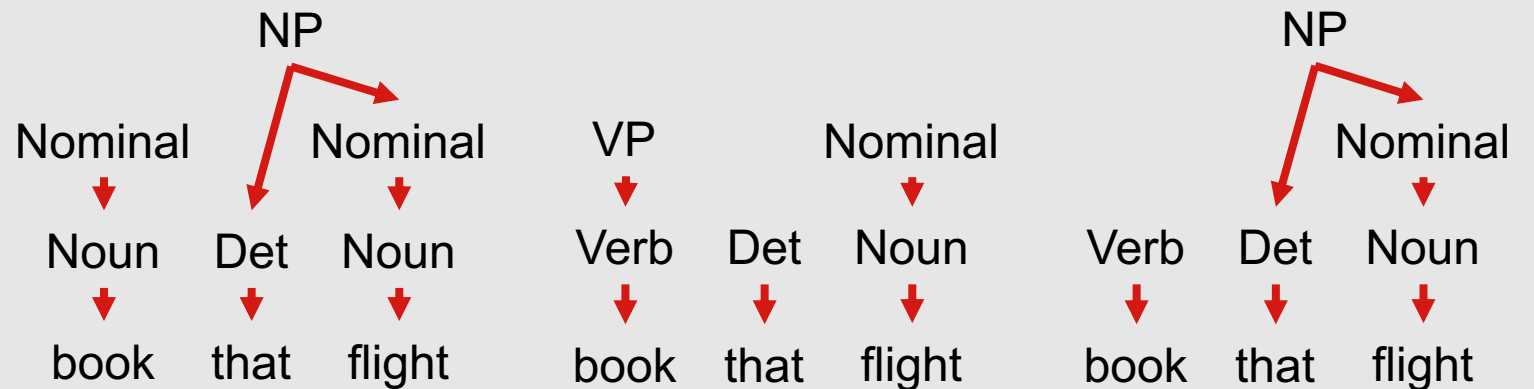
Nominal		Nominal
↓		↓
Noun	Det	Noun
↓	↓	↓
book	that	flight

		Nominal
		↓
Verb	Det	Noun
↓	↓	↓
book	that	flight

# Bottom-Up Parsing: Example

Book that flight.

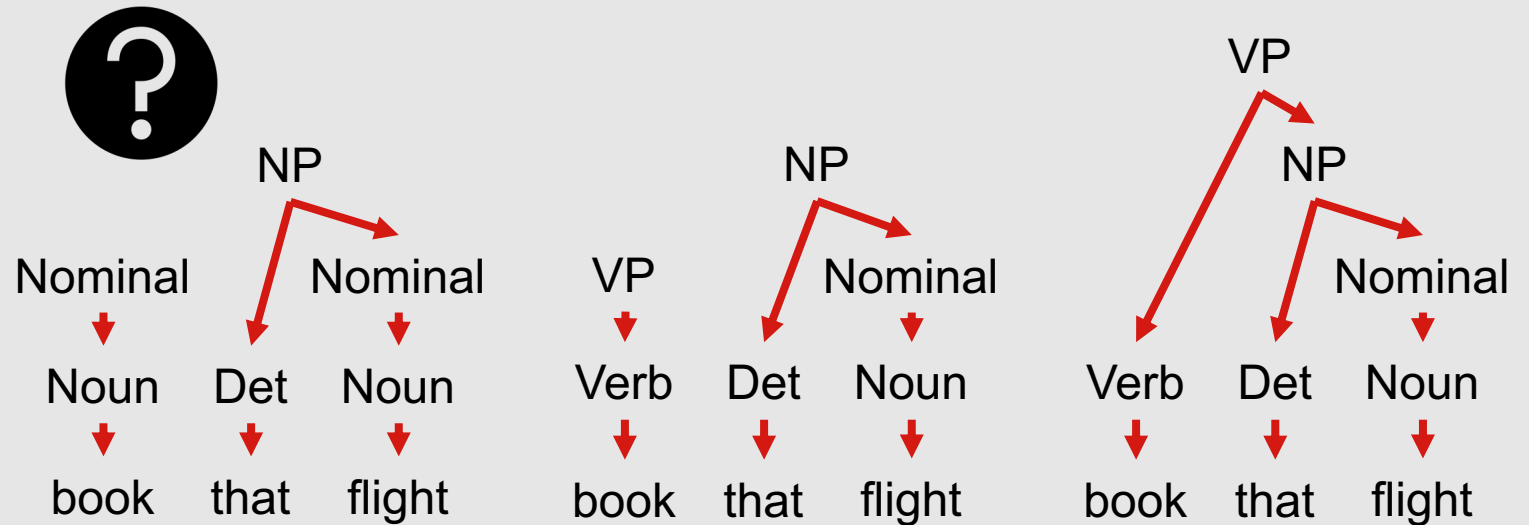
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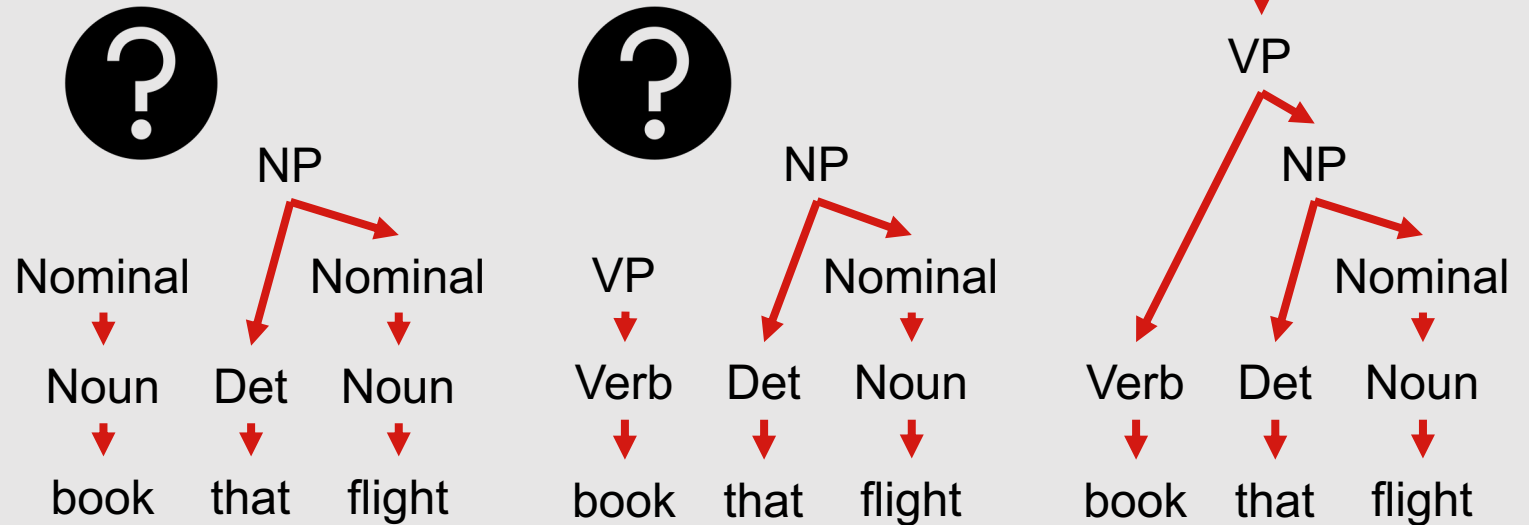
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# Bottom-Up Parsing: Example

Book that flight.

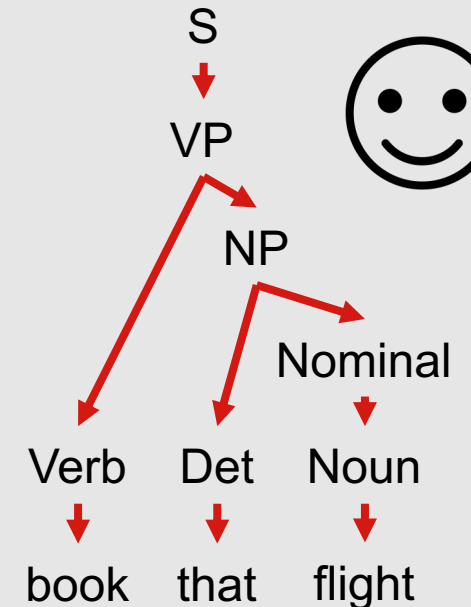
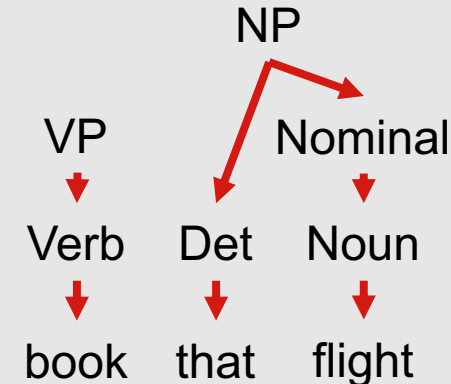
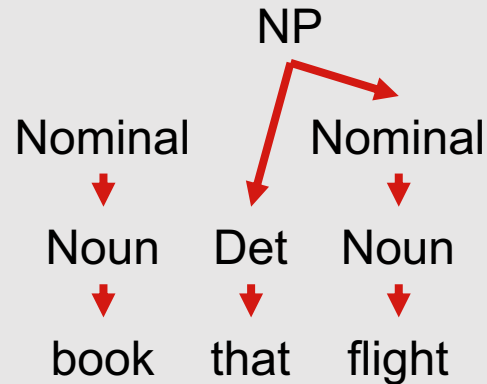
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# Top-Down vs. Bottom-Up Parsing

## Top-Down Parsing

- Pros:
  - Never wastes time exploring trees that cannot result in a sentence
  - Never explores subtrees that cannot fit into a larger valid (i.e., results in a sentence) tree
- Cons:
  - Spends considerable effort on trees that are not consistent with the input

## Bottom-Up Parsing

- Pros:
  - Never suggests trees that are inconsistent with the input
- Cons:
  - Generates many trees and subtrees that cannot result in a valid sentence (according to production rules specified by the grammar)