Grammars and Parsing: Part 2

Three concepts

- Constituency
  - Noun phrases like "a thoroughly entertaining movie"

- Grammatical Relations
  - Subject-object relations

- Subcategorization and Dependency Relations
  - "I *want* to fly to Detroit" : but *find* cannot be followed by an infinitive

A brief history of parse trees
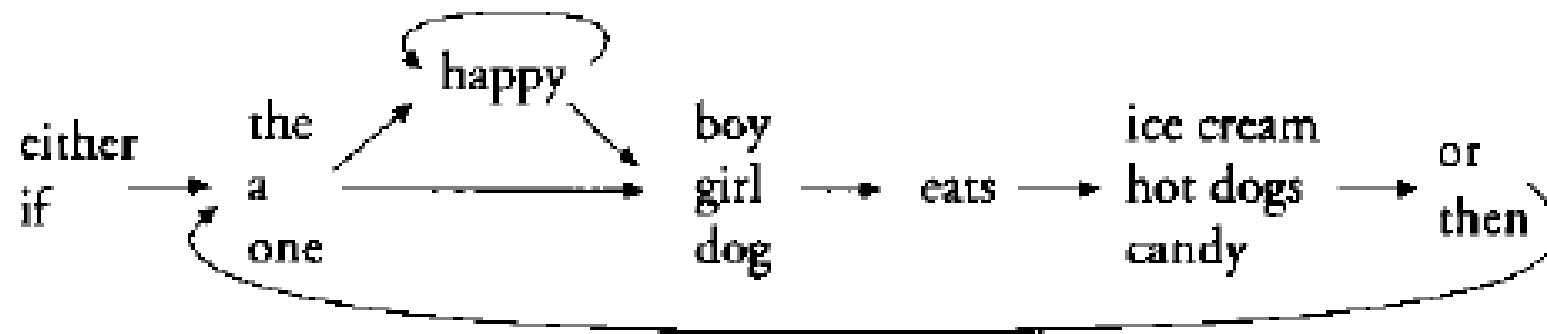
Refer Chapter from Pinker's book

Will anything simpler than a CFG work?

the
a
one

happy

boy
girl
dog

eats

ice cream
hot dogs
candy
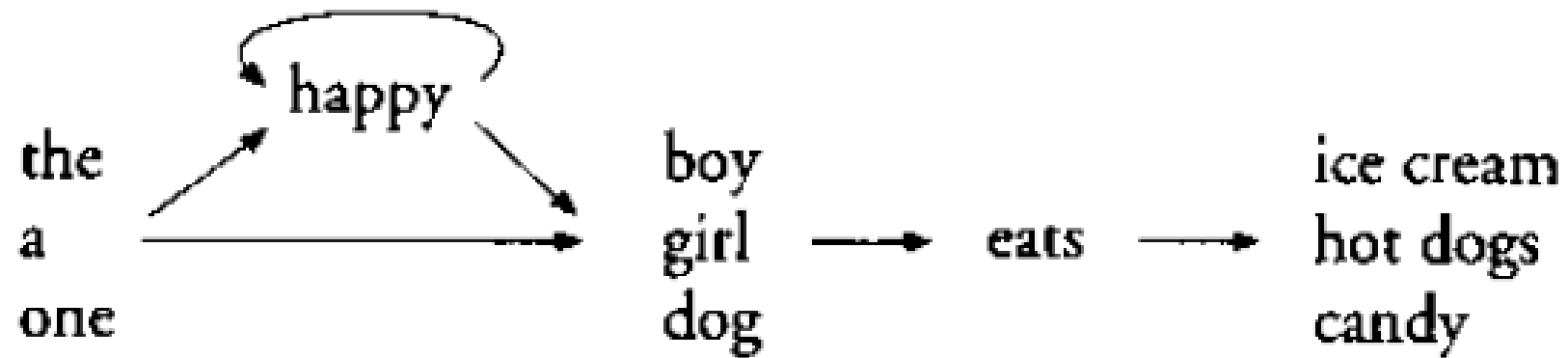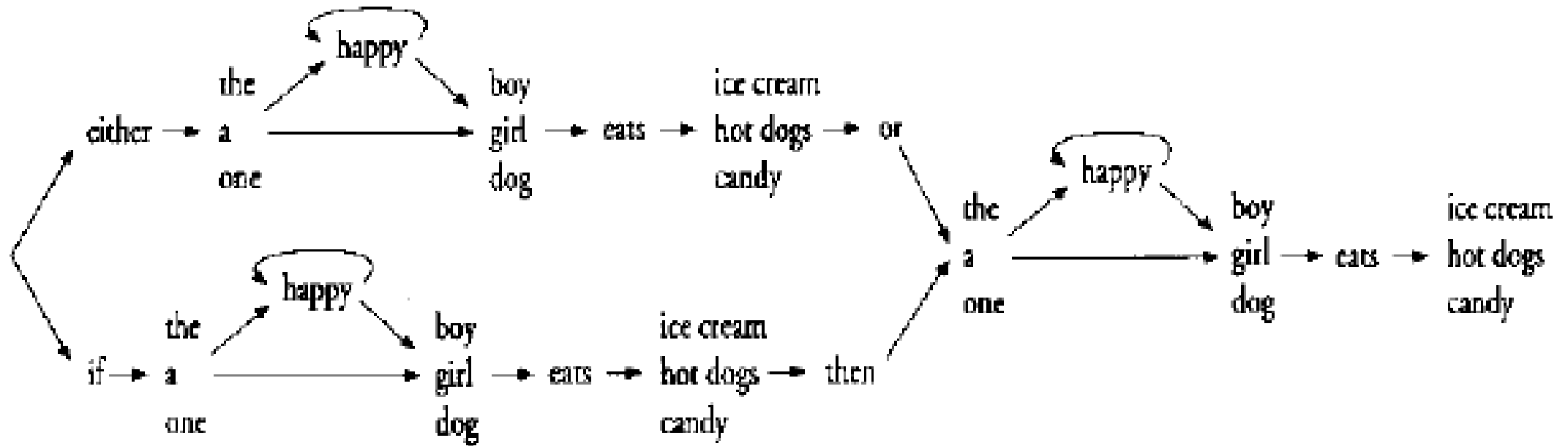
Refer Chapter from Pinker's book

Will anything simpler than a CFG work?

Either the girl eats ice cream, or the girl eats candy.
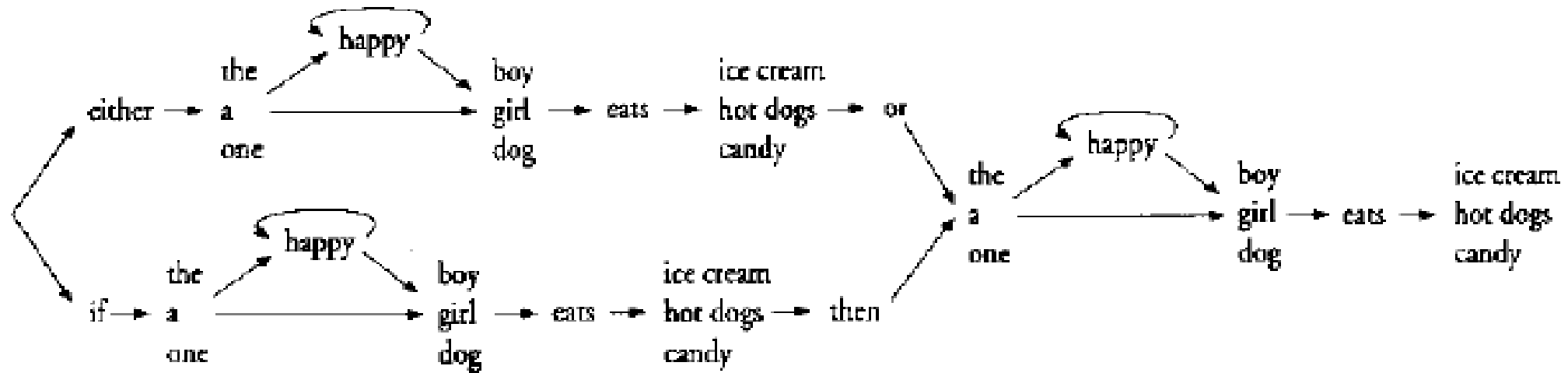If the girl eats ice cream, then the boy eats hot dogs.

Refer Chapter from Pinker's book

Will anything simpler than a CFG work?

Will anything simpler than a CFG work?

If either the girl eats ice cream or the girl eats candy, then the boy eats hot dogs.
Either if the girl eats ice cream then the boy eats ice cream, or if the girl eats ice cream then the boy eats candy.

An infinite number of FSAs?

Refer Chapter from Pinker's book

From this insight to CFG rules and parse trees

- Self study

Long range dependencies: An example sentence

How Ann Salisbury can claim that Pam Dawber's anger at not receiving her fair share of acclaim for *Mork and Mindy*'s success derives from a fragile ego escapes me.

Refer Chapter from Pinker's book

Centre-embedding

The mouse ate the corn.
The mouse that the snake ate ate the corn.
The mouse that the snake that the hawk ate ate ate the corn

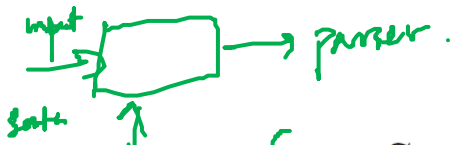CFG rules: S → NP ate NP; NP → NP RC; RC → that NP ate

Find out more about centre-embedding using more examples
Is centre-embedding related to the handling of arithmetic expressions in formal languages?
Reference: http://pages.cs.wisc.edu/~fischer/cs536.s08/course.hold/html/NOTES/3.CFG.html

Interesting: Check this out: https://web.stanford.edu/class/archive/cs/cs103/cs103.1156/tools/cfg/

Parsing for Disambiguation: Recap

Deepa ate noodles with chopsticks

input → parser .

soln

Grammar rules

S ⟶ NP VP	NP ⟶ NP PP	V ⟶ ate
VP ⟶ V NP	NP ⟶ Deepa	PREP ⟶ with
VP ⟶ VP PP	NP ⟶ noodles	
PP ⟶ PREP NP	NP ⟶ chopsticks	
	NP ⟶ spoons	

recursion

Prep NP PP

ketchup

I₁:

```
              S
            /   \
          NP     VP
          |     /  \
        Deepa  V    NP
               |   /  \
              ate NP   PP
                  |   /  \
               noodles PREP  NP
                        |    |
                       with chopsticks
```

I₂:

```
              S
            /   \
          NP     VP
          |    /    \
        Deepa VP      PP
             / \     /  \
            V   NP  PREP  NP
            |   |    |    |
           ate noodles with chopsticks
```

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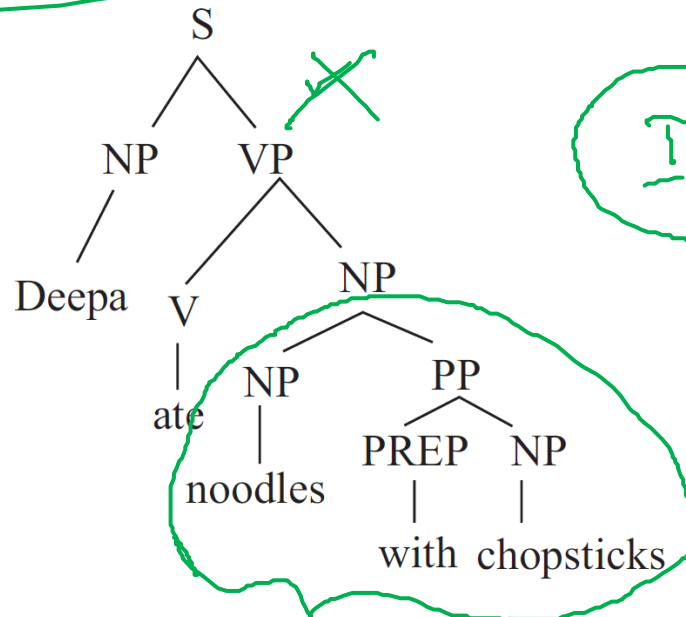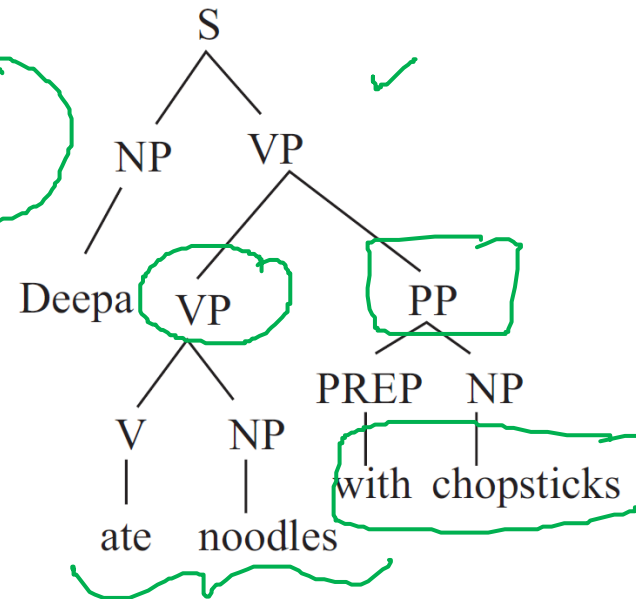
Homework

- Draw parse trees corresponding to the sentence "I saw a man in the forest", and make sure you understand the interpretations associated with each parse tree

- What about "I saw a man in the forest with a telescope"?

Parsing As Search

- Search space:
    - A set of trees consistent with a given grammar

- Goal:

    - Find a single tree whose root is S

    and whose fringe is the sentence

Parsing As Search

- Search space:
    - A set of trees consistent with a given grammar

- Goal:
    - Find $\left\{ \begin{array}{l} \text{all trees} \\ \text{a single tree} \\ \text{the best tree} \end{array} \right\}$ whose root is S

    and whose fringe is the sentence

- There are two extreme ways of specifying the search space (and many variants in between)
    - Top Down – constrained by grammar
    - Bottom Up -- constrained by data

Rules of Grammar

$S \rightarrow NP\ VP$	$Det \rightarrow that \mid this \mid a$
$S \rightarrow Aux\ NP\ VP$	$Noun \rightarrow book \mid flight \mid meal \mid money$
$S \rightarrow VP$	$Verb \rightarrow book \mid include \mid prefer$
$NP \rightarrow Det\ Nominal$	$Aux \rightarrow does$
$Nominal \rightarrow Noun$	
$Nominal \rightarrow Noun\ Nominal$	$Prep \rightarrow from \mid to \mid on$
$NP \rightarrow Proper\text{-}Noun$	$Proper\text{-}Noun \rightarrow Houston \mid TWA$
$VP \rightarrow Verb$	
$VP \rightarrow Verb\ NP$	$Nominal \rightarrow Nominal\ PP$

Refer J&M Chapter 10 (shared)

Top Down Parsing

$S \rightarrow NP\ VP$	$Det \rightarrow that \mid this \mid a$
$S \rightarrow Aux\ NP\ VP$	$Noun \rightarrow book \mid flight \mid meal \mid money$
$S \rightarrow VP$	$Verb \rightarrow book \mid include \mid prefer$
$NP \rightarrow Det\ Nominal$	$Aux \rightarrow does$
$Nominal \rightarrow Noun$	
$Nominal \rightarrow Noun\ Nominal$	$Prep \rightarrow from \mid to \mid on$
$NP \rightarrow Proper\text{-}Noun$	$Proper\text{-}Noun \rightarrow Houston \mid TWA$
$VP \rightarrow Verb$	
$VP \rightarrow Verb\ NP$	$Nominal \rightarrow Nominal\ PP$

Input Sentence : Book that flight.

Refer J&M Chapter 10 (shared)

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Bottom Up Parsing

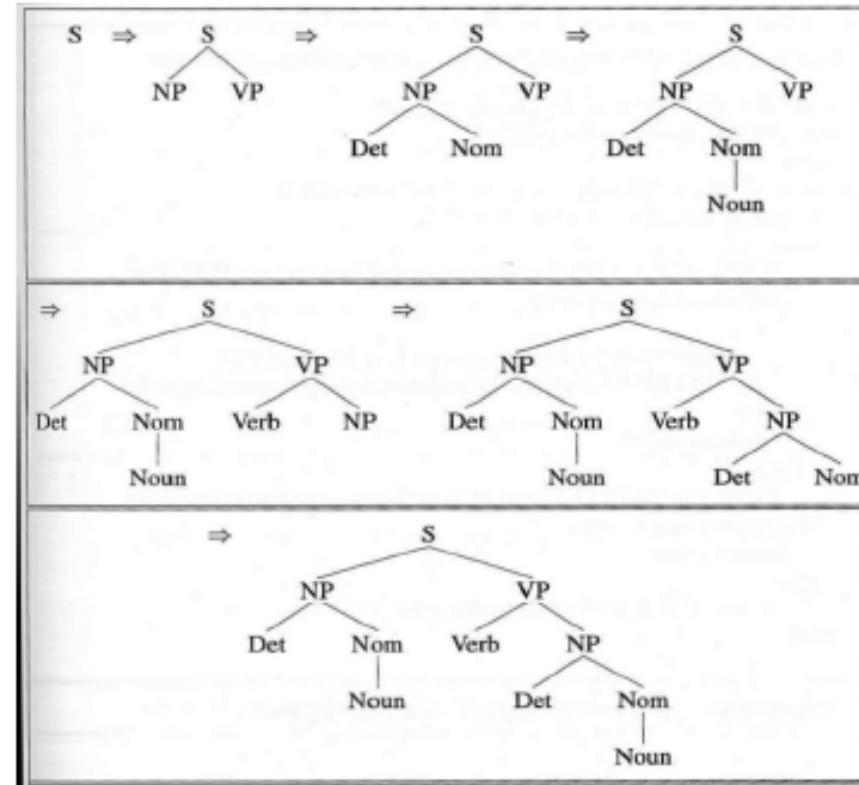|	
S → NP VP	Det → that | this | a
S → Aux NP VP	Noun → book | flight | meal | money
S → VP	Verb → book | include | prefer
NP → Det Nominal	Aux → does
Nominal → Noun	
Nominal → Noun Nominal	Prep → from | to | on
NP → Proper-Noun	Proper-Noun → Houston | TWA
VP → Verb	
VP → Verb NP	Nominal → Nominal PP

Input Sentence : Book that flight.

Four dimensions
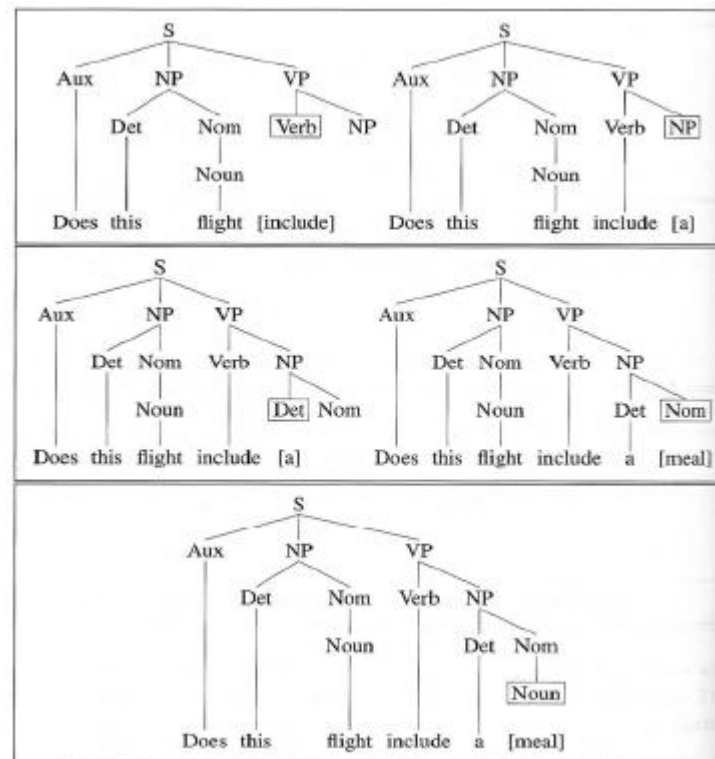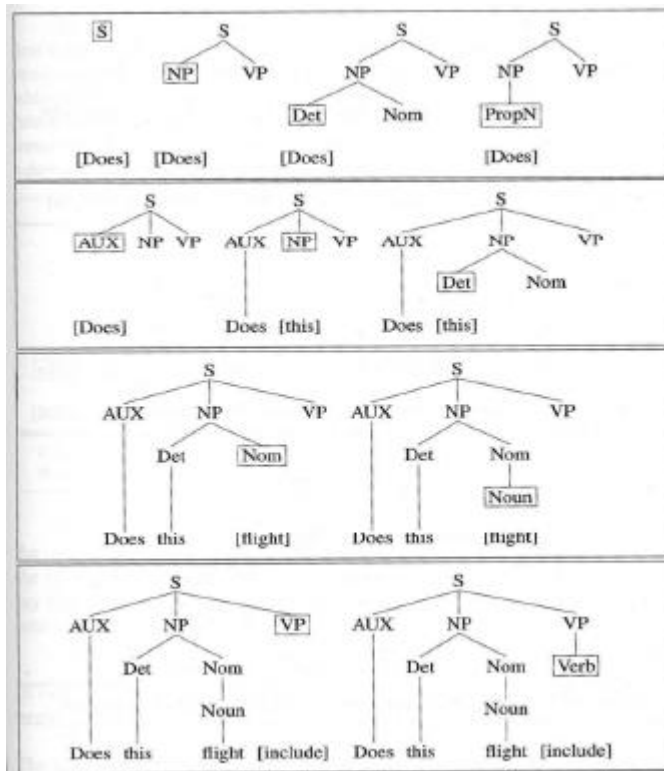
☐ A top-down depth-first derivation

- Choices
  - which leaf?
    left-to-right
  - which rule?
    top-to-down

Refer J&M Chapter 10 (shared)
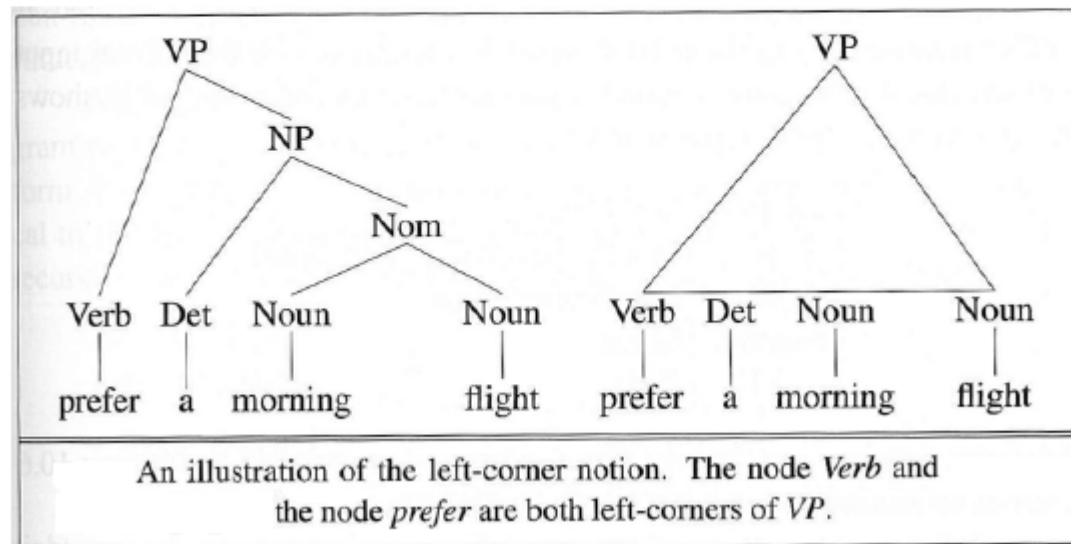
Top Down Parsing with Bottom Up Filtering

Refer J&M Chapter 10 (shared)

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The Concept of Left Corner

☐ Adding Bottom-Up Filtering

- Left-corner of a tree
  - the first word along the left edge of a derivation

An illustration of the left-corner notion. The node *Verb* and the node *prefer* are both left-corners of *VP*.

A Left Corner Table

$S \rightarrow NP\ VP$	$Det \rightarrow that \mid this \mid a$
$S \rightarrow Aux\ NP\ VP$	$Noun \rightarrow book \mid flight \mid meal \mid money$
$S \rightarrow VP$	$Verb \rightarrow book \mid include \mid prefer$
$NP \rightarrow Det\ Nominal$	$Aux \rightarrow does$
$Nominal \rightarrow Noun$	
$Nominal \rightarrow Noun\ Nominal$	$Prep \rightarrow from \mid to \mid on$
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$VP \rightarrow Verb\ NP$	$Nominal \rightarrow Nominal\ PP$

- ◘ Adding Bottom-Up Filtering
  - A sample left-corner table

Category	Left Corners
S	Det, Proper-Noun, Aux, Verb
NP	Det, Proper-Noun
Nominal	Noun
VP	Verb

Refer J&M Chapter 10 (shared)

Repeated Parsing of Subtrees

No. of times major constituents are derived :

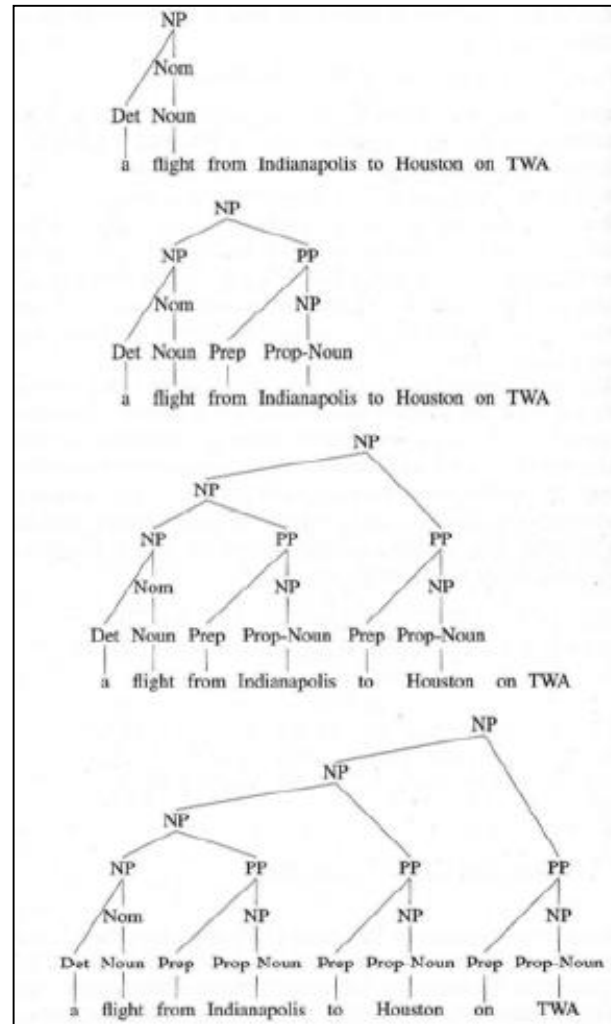"a flight" – 4 times
"from Indianapolis" – thrice
"to Houston" – twice
"on TWA" – once
"a flight from Indianapolis" – thrice
"a flight from Indianapolis to Houston" – twice
"a flight from Indianapolis to Houston on TWA" -- once

Refer J&M Chapter 10, page 373 (shared)

CYK Parsing

- A dynamic programming based bottom up parsing algorithm

Ignore for the moment

Parsers to try out

Link Parser : http://www.link.cs.cmu.edu/link/submit-sentence-4.html

Stanford Parser : http://nlp.stanford.edu:8080/parser/