Syntax: Introduction

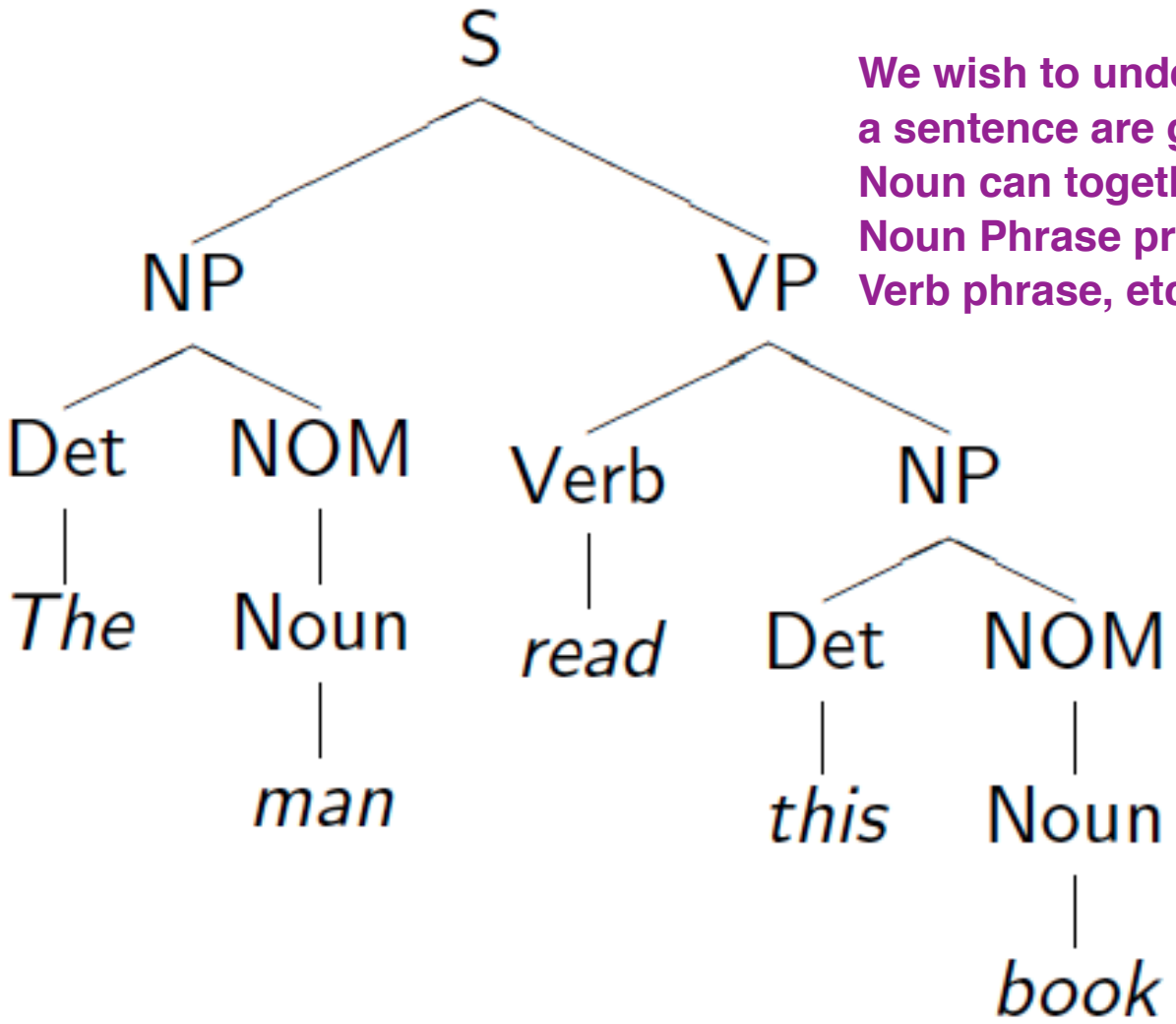
Till now, we have discussed:
Language modeling — understanding ordering of words
POS tagging — understanding roles of words

Now we will discuss more complex notions, such as grammatical relations among words

What is Syntax?

- Refers to the way words are arranged together, and the relationship between then.

Syntax Tree: Example



Sentence: The man read this book

We wish to understand how different words in a sentence are grouped, e.g., a Det and a Noun can together give a Noun Phrase, a Noun Phrase preceded by a verb can give a Verb phrase, etc.

Our final goal:
How to construct a syntax tree for a given sentence?

Defining the notions: Constituency

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Part of Speech - "Substitution Test"

The {sad, intelligent, green, fat, ...} one is in the corner.

Different words having the same POS (here, adjective) can be used as a substitute for each other.

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Constituency: Noun Phrase

- *Kermit the frog*
- *they*
- *December twenty-sixth*
- *the reason he is running for president*

Similarly, different word-sequences (phrases) can be used as a substitute for each other. E.g., noun phrases

Constituent Phrases

How are constituent phrases usually named?

Usually named based on the word that heads the constituent:

the man from Amherst	is a Noun Phrase (NP) because the head man is a noun
extremely clever	is an Adjective Phrase (AP) because the head clever is an adjective
down the river	is a Prepositional Phrase (PP) because the head down is a preposition
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Compare with: *The man from Amherst grew beautiful russet potatoes*.

Joe appears in a place that a larger noun phrase could have been.

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Kermit the frog comes on stage
They come to Massachusetts every summer
December twenty-sixth comes after Christmas
The reason he is running for president comes out only now.

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Consituent = Prepositional phrase: *On December twenty-sixth*
On December twenty-sixth I'd like to fly to Florida.
I'd like to fly on December twenty-sixth to Florida.
I'd like to fly to Florida on December twenty-sixth.
But not split apart
**On December I'd like to fly twenty-sixth to Florida.*
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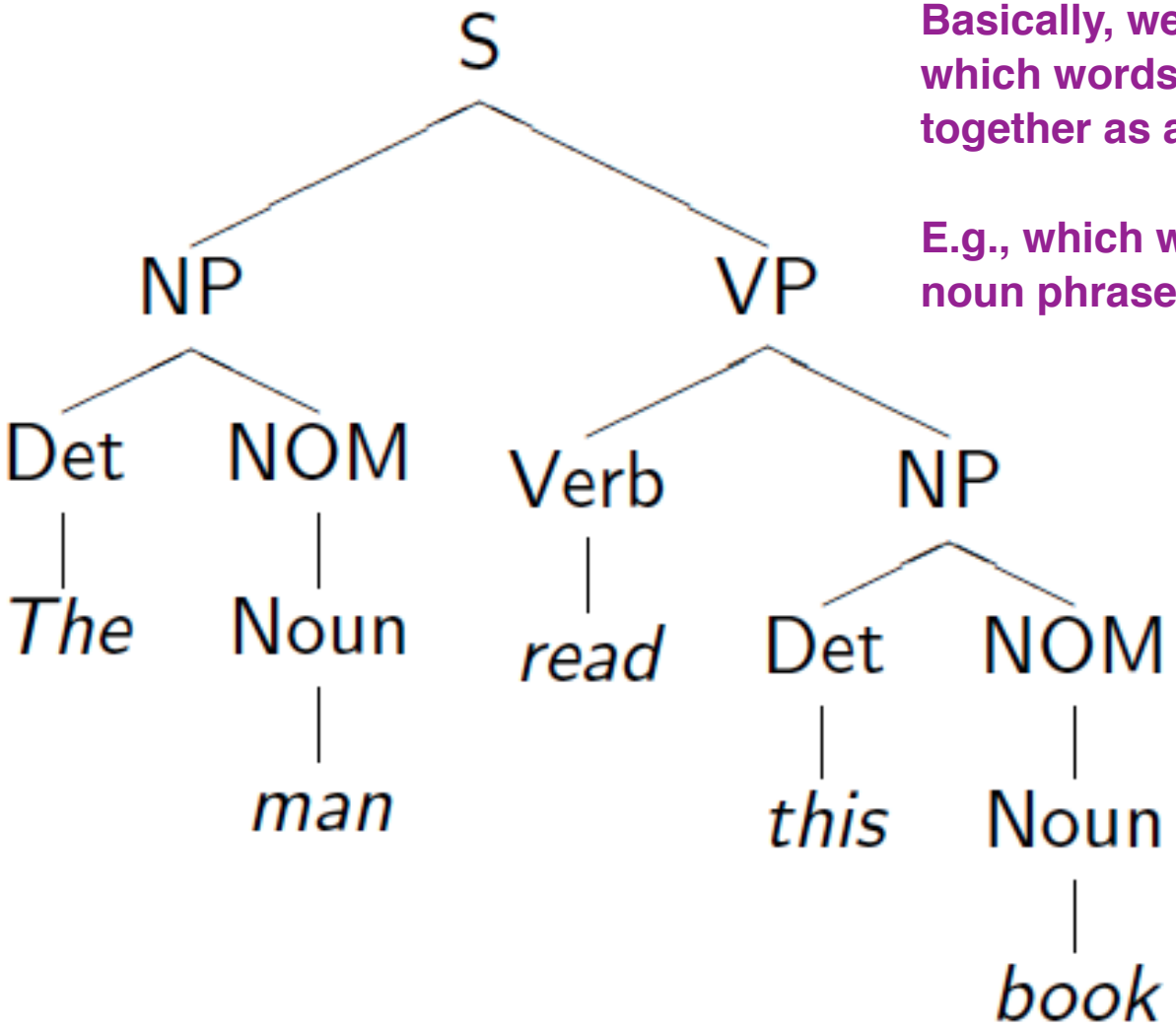
Modeling Constituency: what tool do we need?



Basically, we want tools to understand which words (in a given text) come together as a unit.

E.g., which words together make up a noun phrase?

Modeling Constituency

Context-free grammar

The most common way of modeling constituency

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$NP \rightarrow$ Det Nominal

$NP \rightarrow$ ProperNoun

$Nominal \rightarrow$ Noun | Noun Nominal

CFG for Languages

CFG: $G = (T, N, S, R)$

- T: set of terminals
- N: set of non-terminals
  - For NLP, we distinguish out a set $P \subset N$ of pre-terminals, which always rewrite as terminals
- S : start symbol
- R: Rules/productions of the form $X \rightarrow \gamma$, $X \in N$ and $\gamma \in (T \cup N)*$

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Terminals and pre-terminals

Terminals mainly correspond to words in the language while pre-terminals mainly correspond to POS categories

CFG for Languages

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$NP \rightarrow$ Det Nominal

$NP \rightarrow$ ProperNoun

$Nominal \rightarrow$ Noun | Noun Nominal

"Noun", "ProperNoun", "Det" are pre-terminals.

But we cannot generate any string with these rules, since there is no terminal.

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$Det \rightarrow$ a

$Det \rightarrow$ the

$Noun \rightarrow$ flight

Terminals: "a", "the", "flight"
Pre-terminals: "Det", "Noun", "ProperNoun"
Non-terminals: "NP", "Nominal"

CFG as a generator

$NP \rightarrow$ Det Nominal
$NP \rightarrow$ ProperNoun
$Nominal \rightarrow$ Noun | Noun Nominal
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- Thus a CFG can be used to randomly generate a series of strings

CFGs and Recursion

A CFG can contain recursive rules.
E.g., the rule for a Prepositional Phrase (PP)

Recursive Definition

- PP → Prep NP
- NP → Noun PP

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start of a NP start of a NP

Example Sentence

[$_S$The mailman ate his [$_{NP}$ lunch [$_{PP}$ with his friend [$_{PP}$ from the cleaning staff [$_{PP}$ of the building [$_{PP}$ at the intersection [$_{PP}$ on the north end [$_{PP}$ of town]]]]]]].

start of a NP start of a NP start of a NP

CFGs and Grammaticality

A CFG defines a formal language = set of all sentences (string of words) that can be derived by the grammar

- Sentences in this set are said to be **grammatical**
- Sentences outside this set are said to be **ungrammatical**