L2: Syntax I - POS and Phrase structure

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Outline

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- Natural language syntax and syntax of programming languages

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  George saw ___.
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- Similar kinds of sentences where units appear “displaced”.
  Lydia bought some violets.
  The violets were bought by Lydia.

Some history

- Writing grammars of natural languages (of any kind) has a long tradition.
- Attempts of formal accounts of grammar: Pāṇini, 4th century BC.
- Generative Grammar: Noam Chomsky. Syntactic Structures. 1957.

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1 accepted widely today; 2 has been criticised.

Formal grammars

Formal grammar

A formal grammar consists of:

- a finite set of terminal symbols: a, b, ϵ (empty string);
- a finite set of non-terminal symbols: A, B;
- a finite set of production rules: $A \rightarrow aB$, $B \rightarrow b$, $aB \rightarrow A$;
- a start symbol: $S \rightarrow AB$.

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Derivation: start with S and apply the sequence of rules by replacing symbols on the LHS with those on the RHS; stop when all symbols are non-terminal.

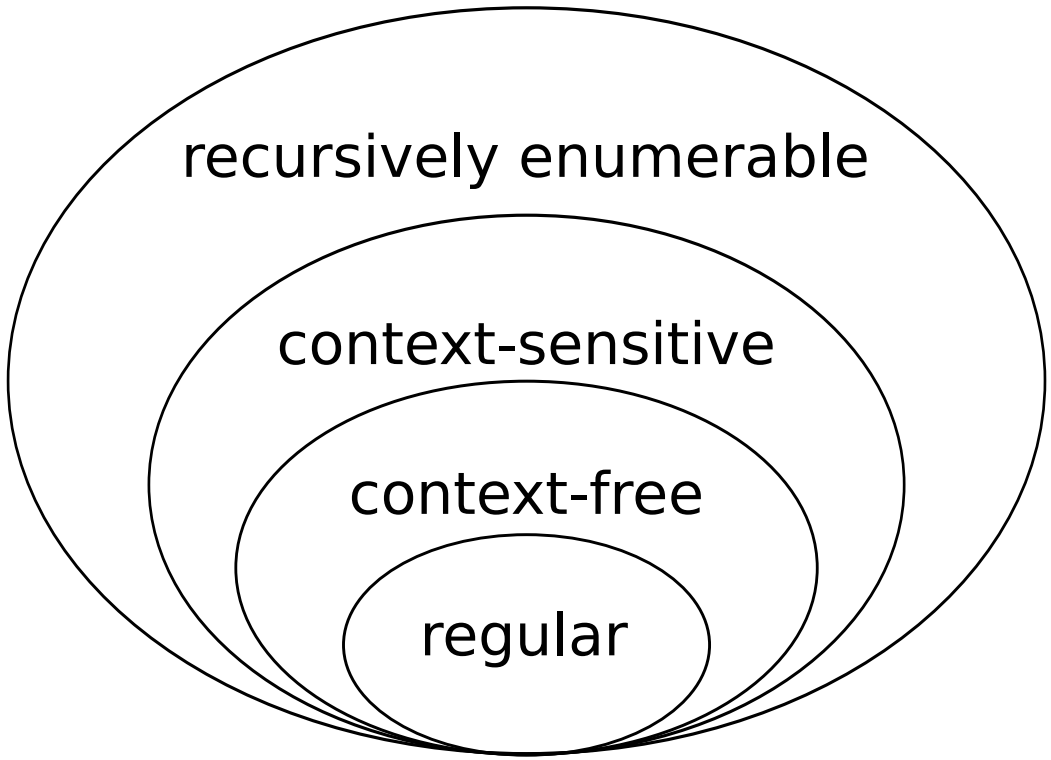
A comparison of formal grammars

Increasing the power of production rules generates different kinds of formal grammars. . .

Grammar	Language	Production rules allowed
Type-0	Recursively enumerable	$\alpha \rightarrow \beta$ (unrestricted)
Type-1	Context sensitive	$\alpha \mathrm{A} \beta \rightarrow \alpha \gamma \beta$
Type 2	Context-free	$\mathrm{A} \rightarrow \gamma$
Type-3	Regular	$\mathrm{A} \rightarrow$ a and $\mathrm{A} \rightarrow$ aB

A: non-terminal symbol; a: terminal symbol; α, β, γ: terminal or non-terminal symbols

Chomsky hierarchy



From Wikipedia

Terminal symbols: words

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b. They frequently phone each other.

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Not very useful.

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(9) a. The . . . became popular in the second half of the 19th century: (photography, ¬to).

b. Peter was eager to . . . : (leave, ¬green).

Types of POS

Open and closed class

(10) a. I googled their name: V.

b. *The chair is to the nearleft of the table: P or Adv.

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Lexical and functional categories: semantic content vs grammatical function

(13) Many/D managers/N could/Mod be/Aux sacked/V by/P the/D board/N.

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- Nouns (N): John, apple, grass
  proper vs. common, countable vs. mass
- Verbs (V): rains, kisses, give
  intransitive, transitive, and ditransitive
- Adjectives (A): new, surprising
- Adverbs (Adv): quickly, honestly
- Pronouns and anaphora (N or Pron): he, her, which, itself
- Determiners (D): a, an, the, this, every, none, no, three, your, which
- Prepositions (P): in, on, at
- Complenetisers (C): that, for, if, whether
- Conjunctions (Conj): and, or, nor, either, neither
- Negation (Neg): not, non
- Auxiliaries (Aux): is, do, have, to
- Modal verbs (Mod): will, would, shall, should, can, could

The Penn Treebank set of POS

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- Finer distinctions:
  - VB: Verb, base form: take
  - VBD: Verb, past tense: took
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- Tagging guide

Why do POSs matter for NLP?

The POS of a word (tagging) tells us

- how the word fits with other words to make a sentence (parsing);
- gives us some semantic information.

(14) a. Flying/A planes/N can/Mod be/Aux dangerous/A.

b. Flying/V planes/N can/Mod be/Aux dangerous/A.

POS tagging and context

The most likely POS for an ambiguous word can be resolved from the context.

(15) a. They/N can/Aux fish/N in/P the/D lake/N.

b. They/N can/V fish/N at/P the/D factory/N.

Non-terminal symbols: phrases

Constituent/phrase structure

Words associate with certain other words and form units.

(16) a. Peter kicked [the cat].

b. *Peter [kicked the] cat.

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(18) a. Peter kicked [the cat].

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(19) a. [Jane] loves [his new book on syntax].

b. [Bill] hates [his annoying colleague from work].

Tests for constituency: replacement

Similar units can be replaced.

(20) a. [The man with an umbrella] [read] [the book with the green cover].

b. [He] [wrote] [it].

c. [They] [ran].

Tests for constituency: sentence fragment

(21) a. What did Peter do yesterday?

b. Read the book with the green cover.

c. *Read the.

Tests for constituency: coordination

Only similar items can be conjoined.

(22) a. Peter [[read the book] and [washed the dishes yesterday]].

b. Peter [[read the book] and [ran]].

c. [[Peter] and [his wife]] [read the book].

Tests for constituency: displacement

(23) a. John looked up a word.

b. John looked up a tree.

c. The word/the tree, John looked up.

d. *Up the word, John looked.

e. Up the tree, John looked.

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5. very quickly: AdvP $\rightarrow$ (AdvP) Adv

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   VP $\rightarrow$ (AdvP+) V (NP) (NP) (AdvP+)
8. Alex gave a present quietly to Lydia in the garden yesterday.
   VP $\rightarrow$ (AdvP+) V (NP) (NP) (AdvP+) (PP+) (AdvP+)

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10. Alex has scared the ducks. Alex may leave.
    TP $\rightarrow$ NP (T) VP
11. Lydia said that Alex scared the ducks.
    Lydia asked George if Alex scared the ducks.
    CP $\rightarrow$ (C) TP
    VP $\rightarrow$ (AdvP+) V (NP) ({NP/CP}) (AdvP+) (PP+) (AdvP+)

Phrase structure

Representing phrase structure

Bracketing

[$_{TP}$ [$_{NP}$ [$_{N}$ Alex]] [$_{VP}$ [$_{V}$ gave] [$_{NP}$ [$_{N}$ Lydia]] [$_{NP}$ [$_{D}$ a] [$_{N}$ present]] [$_{AdvP}$ [$_{Adv}$ yesterday]]]]

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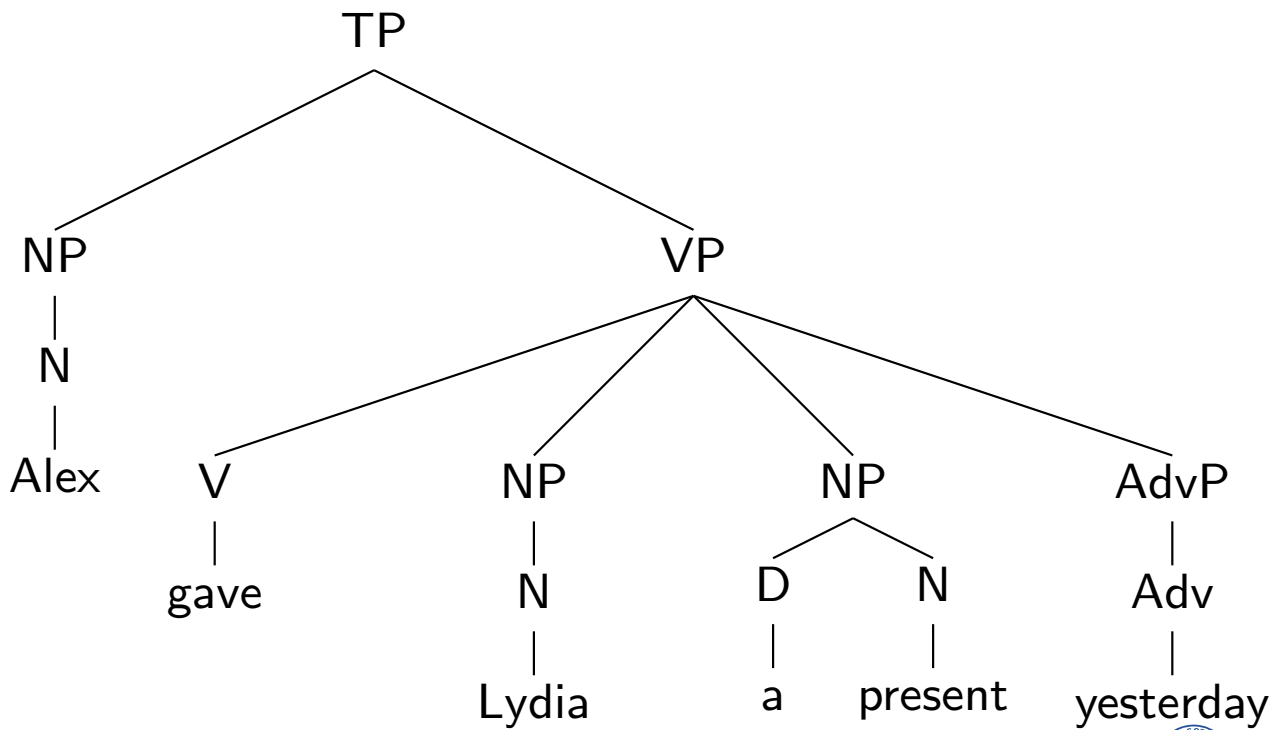
Trees



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5. Recursive application of rules is allowed: XP $\rightarrow$ Y XP

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5. Sentence meaning: The tree climbed up Alex.

Some examples CFG cannot handle

Agreement is context sensitive

(24) a. John sleeps.

b. They sleep.

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Discontinuous and overlapping phrases

(27) a. John bought and Mary sold a car.

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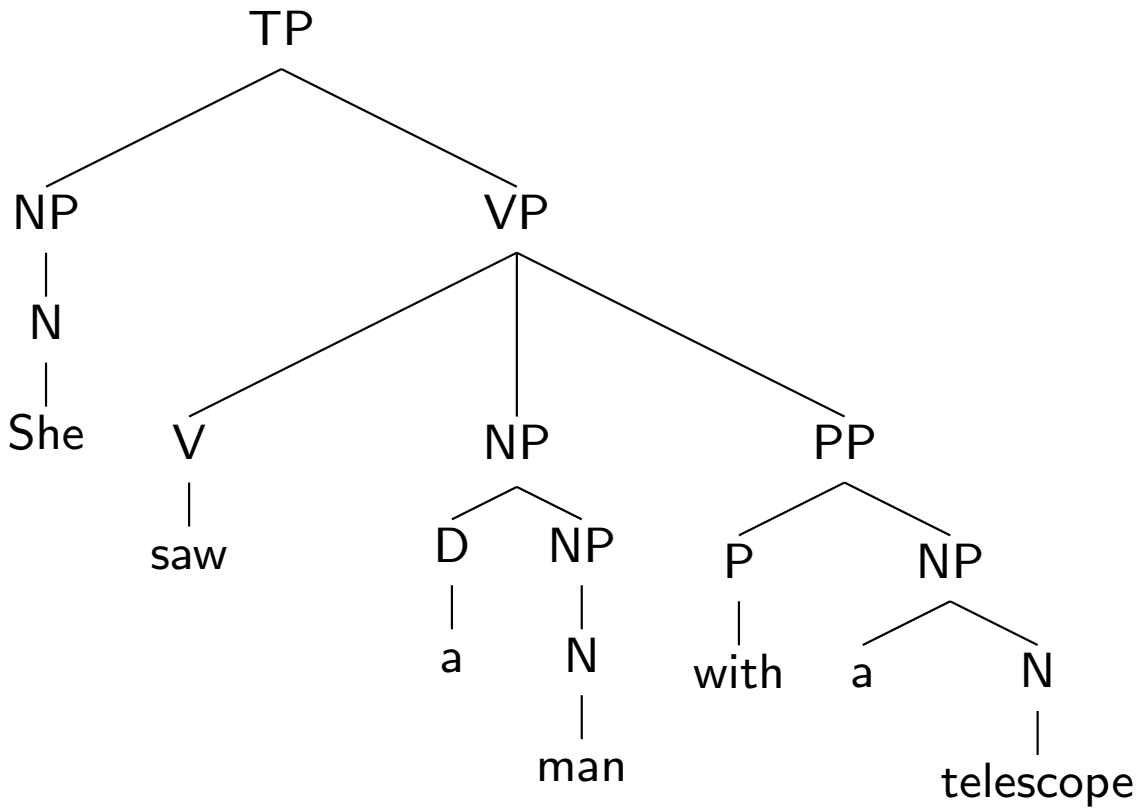
Sufficient to describe most human languages.
(NB: Swiss German, Bambara)

Syntactic ambiguity

(30) [$_{TP}$ [$_{NP}$ [$_{N}$ She]] [$_{VP}$ [$_{V}$ saw] [$_{NP}$ [$_{D}$ a] [$_{NP}$ [$_{N}$ man]]] [$_{PP}$ [$_{P}$ with] [$_{NP}$ a [$_{N}$ telescope]]]]]



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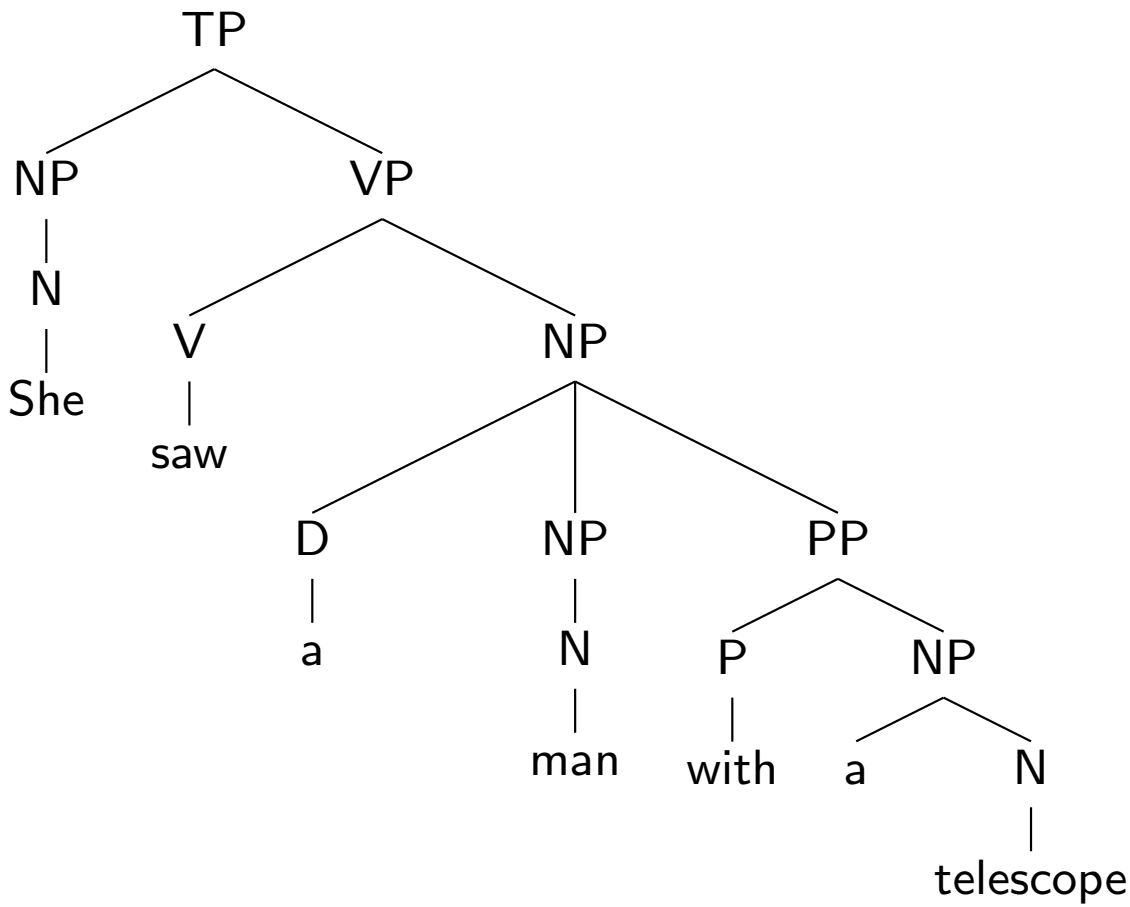

Further reading

(Allen, 1995) Chapter 2 (Linguistic background: an outline of English syntax)

(Jurafsky and Martin, 2009) Chapters 5.1: (Mostly) English word classes, 5.2 Tag-sets for English, Chapter 12: Formal grammars of English and Chapter 16: Language and Complexity

(Carnie, 2007) Chapters 2 (Parts of speech) and 3 (Constituency, trees and rules).

(Tallerman, 2011)

(Pinker, 1995) Chapters 4 to 7.

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