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Introduction

Syntactic parsing (5LN713)

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Partly based on slides from Marco Kuhlmann

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Today

- Introduction to syntactic analysis
- Course information
- Exercises

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What is syntax?

- Syntax addresses the question of how sentences are constructed in particular languages.
- The English (and Swedish) word *syntax* comes from the Ancient Greek word *sýntaxis* ‘arrangement’.

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What is syntax not?

Syntax does not answer questions about …

… how speech is articulated and perceived (phonetics, phonology)

… how words are formed (morphology)

… how utterances are interpreted in context (semantics, pragmatics)

simplified

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Why should you care about syntax?

- Syntax describes the distinction between well-formed and ill-formed sentences.
- Syntactic structure can serve as the basis for semantic interpretation and can be used for
  - Machine translation
  - Information extraction and retrieval
  - Question answering
  - ...

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Why should you care about syntax?

- Syntactic structure can be useful for analysing large text materials
- Research in digital humanities
- Economic analysis

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Parsing

The automatic analysis of a sentence
with respect to its syntactic structure.

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Theoretical frameworks

- Generative syntax

  Noam Chomsky (1928–)

- Categorial syntax

  Kazimierz Ajdukiewicz (1890–1963)

- Dependency syntax

  Lucien Tesnière (1893–1954)

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Theoretical frameworks

Chomsky

Ajdukiewicz

Tesnière

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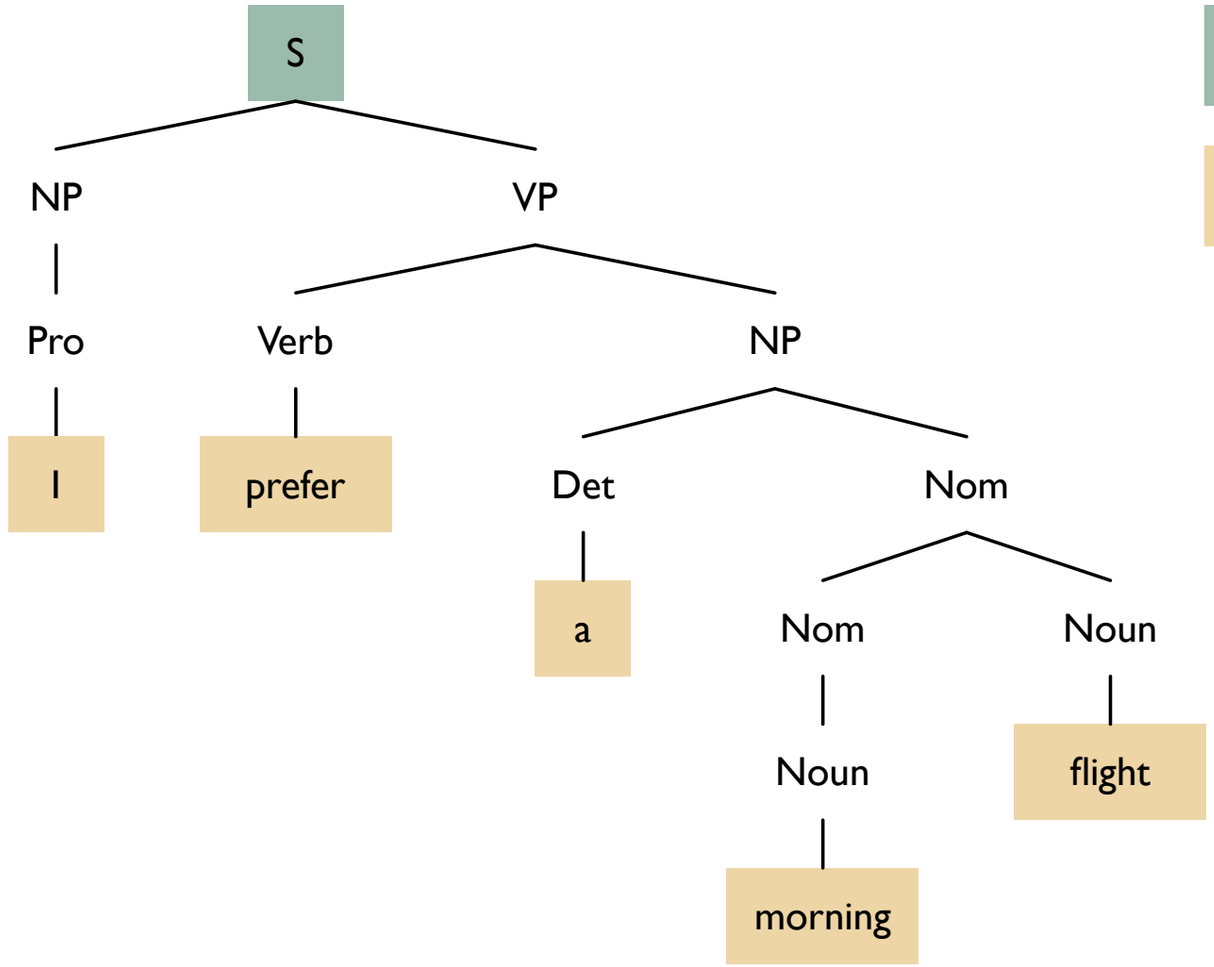
Phrase structure trees



root (top)

leaves (bottom)

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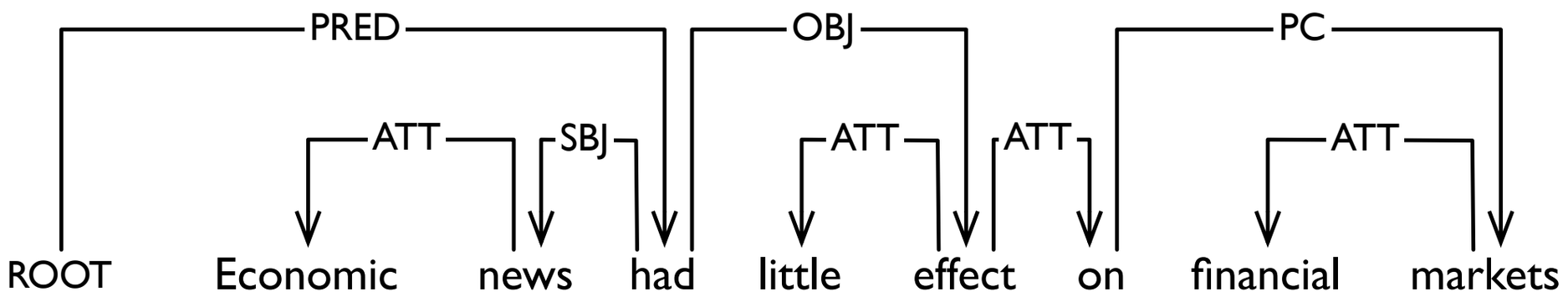
Dependency trees



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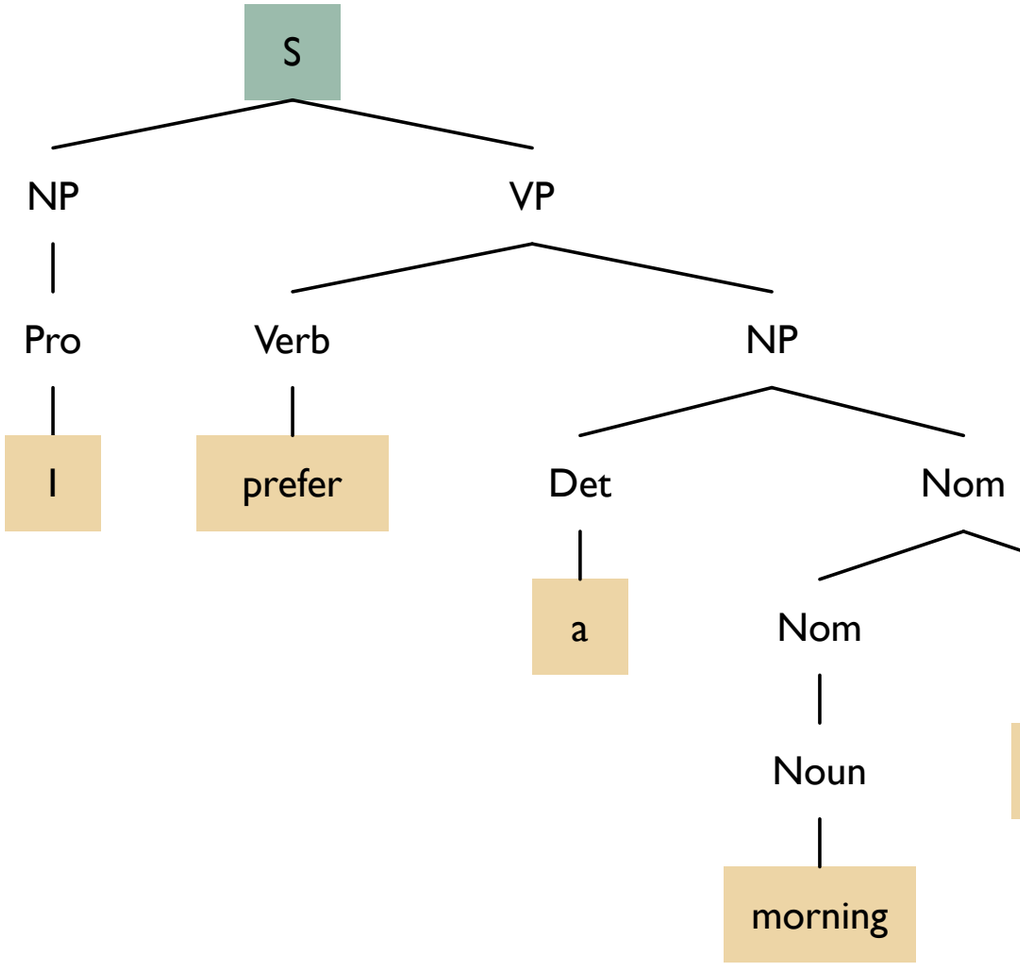
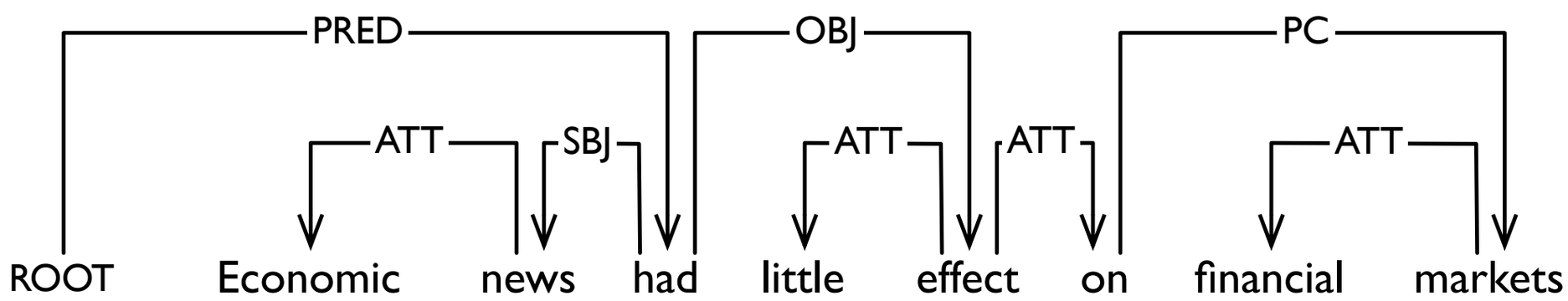
Phrase structure vs dependency trees





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Ambiguity

I booked a flight from LA.

- This sentence is ambiguous. In what way?
- What should happen if we parse the sentence?

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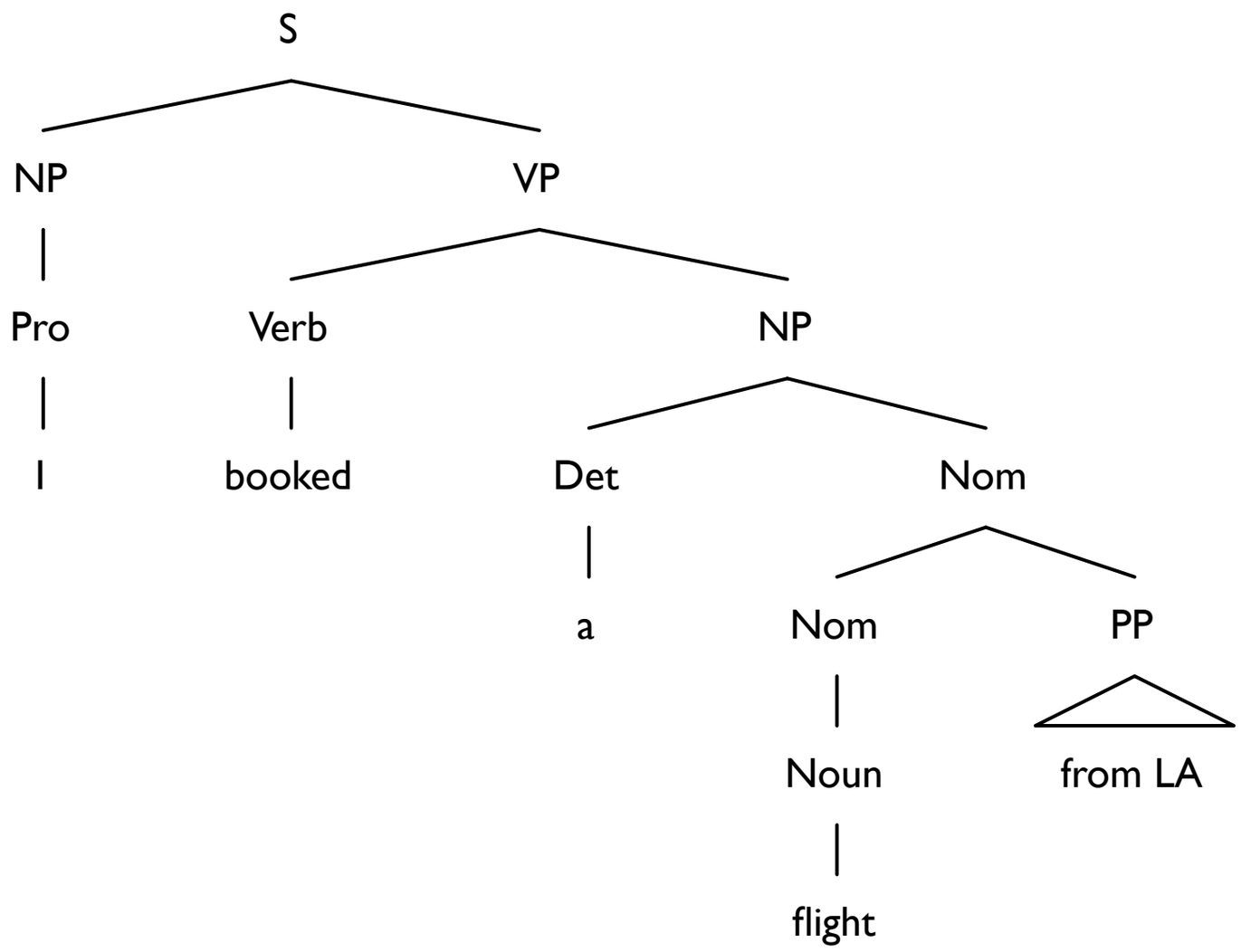
Ambiguity



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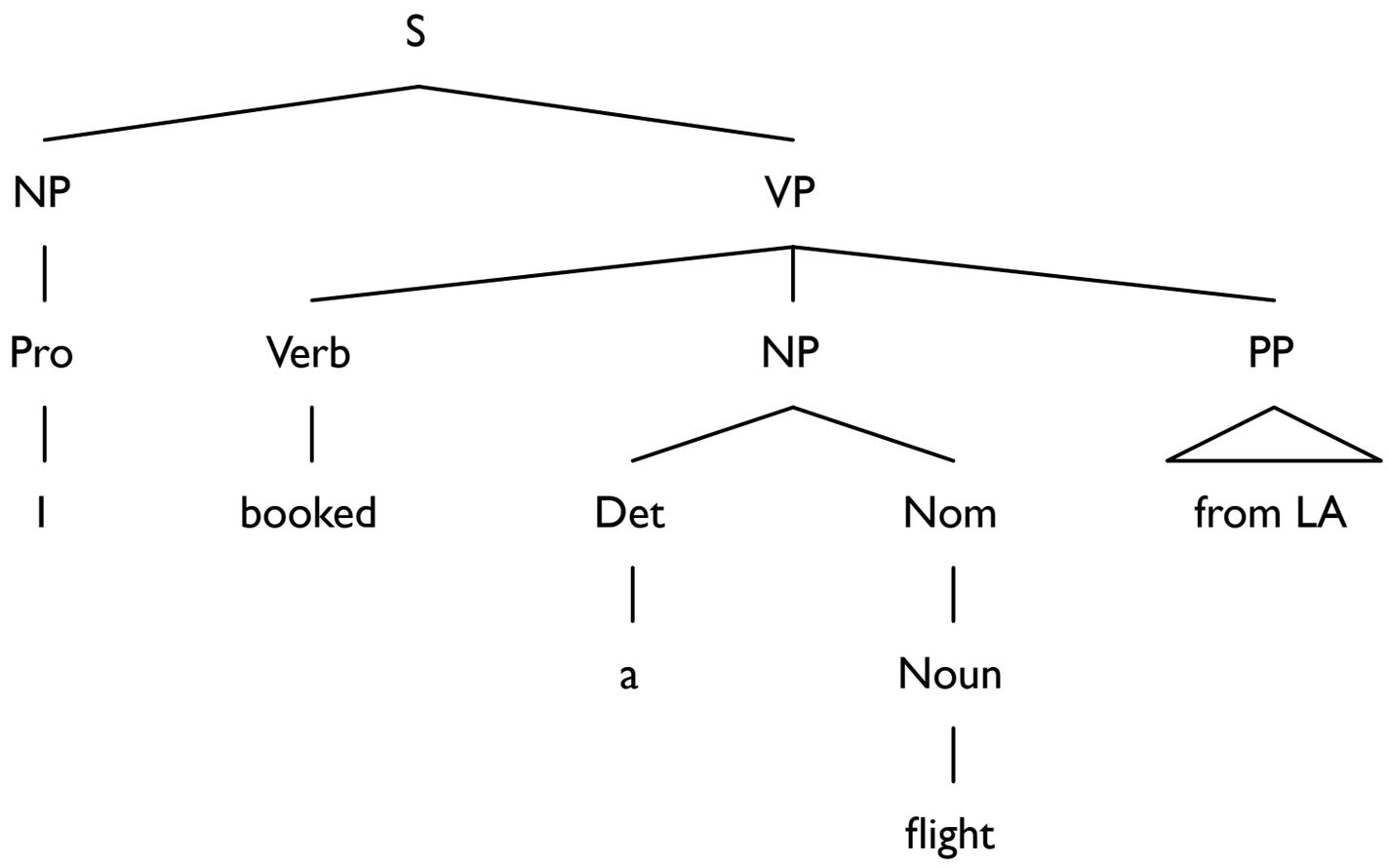
Ambiguity



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Interesting questions

- Is there any parse tree at all?
  - *Recognition*
- What is the best parse tree?
  - *Parsing*

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Parsing as search

- Parsing as search:
  Search through all possible parse trees for a given sentence.
- In order to search through all parse trees we have to ‘build’ them.

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Top–down and bottom–up

top–down

only build trees that are rooted at *S*

may produce trees that do not match the input

bottom–up

only build trees that match the input

may produce trees that are not rooted at *S*

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Dynamic programming (DP)

- Divide and conquer:
  In order to solve a problem, split it into subproblems, solve each subproblem, and combine the solutions.
- Dynamic programming (DP) (bottom up):
  Solve each subproblem only once and save the solution in order to use it as a partial solution in a larger subproblem.
- Memoisation (top down):
  Solve only the necessary subproblems and store their solutions for reuse in solving other subproblems.

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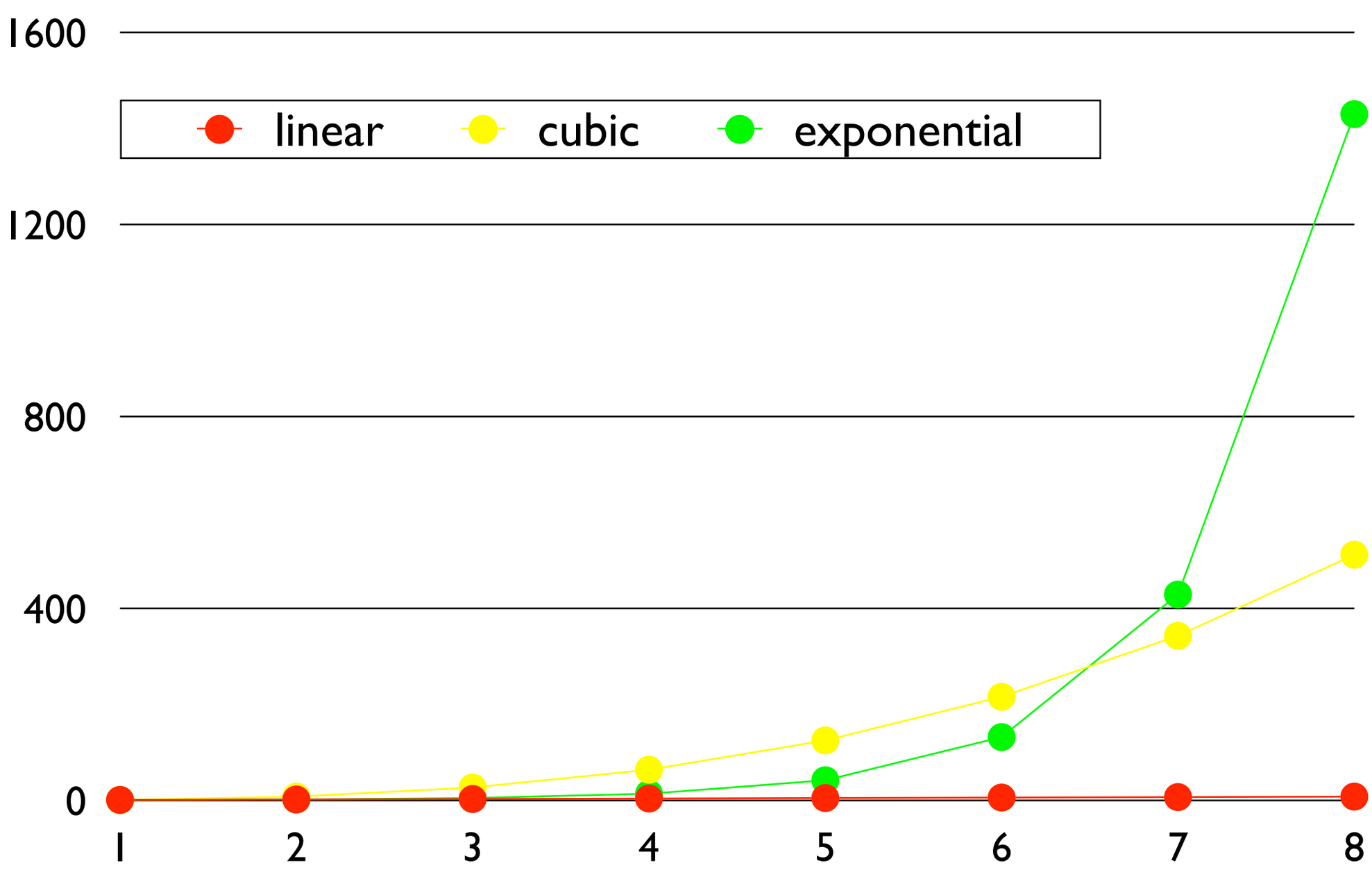
How many trees are there?



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Example: fibonacci numbers

Number series:

0 1 1 2 3 5 8 13 21 …

Formula:

F(n) = F(n-1) + F(n-2)

Base cases:

F(0) = 0, F(1) = 1

For n>1

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Example: fibonacci numbers

Naive implementation

```
def fib(n):
    if n <= 1:
        return n
    else:
        return fib(n-1) + fib(n-2)
```

Time complexity: $O(2^n)$

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Example: fibonacci numbers

Memoization (top down)

```
fibC = {0:0, 1:1}
def fibMem(n):
    if n <= 1:
        return n
    if not n in fibC:
        fibC[n] = fibMem(n-1) + fibMem(n-2)
    return fibC[n]
```

Time complexity: O(n)

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Example: fibonacci numbers

Dynamic programming (bottom up)

```
def fib_dp(n):
    fibV = [0,1]
    for i in range(2, n+1):
        fibV.append(fib[i-1] + fibV[i-2])
    return fibV[n]
```

Time complexity: O(n)

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Complexity

- Using DP we can (sometimes) search through all parsetrees in polynomial time.
- That is much better than to spend exponential time!
- But it may still be too expensive!
  In these cases one can use an approximative method such as greedy search or beam search.
  - Often possible in linear time

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Course information

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Intended learning outcomes 5LN713

At the end of the course, you should be able to

- explain the standard models and algorithms used in phrase structure and dependency parsing;
- implement and evaluate some of these techniques;
- critically evaluate scientific publications in the field of syntactic parsing,
- design, evaluate, or theoretically analyse the syntactic component of an NLP system

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Examination 5LN713

- Examination is continuous and distributed over three graded assignments, two literature seminars, and a graded project
  - 2 assignments are programming tasks where you implement (parts of) parsers.
  - 1 assignment where you run and evaluate a parser in a cross-lingual setting
  - Two literature seminars

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Assignments

- Assignment 1: PCFG
  - Implement conversion of treebank to CNF
  - Implement CKY algorithm
- Assignment 2: Dependency parsing
  - Implement an oracle for transition-based dependency parsing
  - Discuss issues with the implementation

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Assignments

- Assignment 3: Cross-lingual parsing
  - Use an existing dependency parser (UUparser)
  - Compare different transfer languages for a (simulated) low-resource language
  - Try different evaluation methods

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Literature seminars

- Read one given article for each seminar
- Prepare according to the instructions on the homepage
- Everyone is expected to be able to discuss the article and the questions about it
  - It should be clear that you have read and analyzed the article, but it is perfectly fine if there are parts that you find difficult and do not fully understand
- The seminars are obligatory
  - If you miss a seminar or are unprepared, you will have to hand in a written report and discuss it briefly with the teacher

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Project

- Can be done individually or in pairs:
  - To be self-organized by you!
- Suggestions for topics/themes will be on the web page
- Project activities:
  - Proposal: February 26
  - Discussion seminar: March 20 (may be changed)
  - Report: March 22

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Learning outcomes and examination

- explain the standard models and algorithms used in phrase structure and dependency parsing; all assignments and seminars
- implement and evaluate some of these techniques; assignments 1, 2, (project)
- critically evaluate scientific publications in the field of syntactic parsing, seminars, project
- design, evaluate, or theoretically analyze the syntactic component of an NLP system project, assignment 3

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Grading 5LN713

- The assignments and project are graded with G and VG
- G on the seminars if present, prepared and active. The seminars are obligatory, and not graded!
- To achieve G on the course:
  - G on all assignments, seminars and project
- To achieve VG on the course:
  - VG on the three assignments or
  - VG on the project and at least one assignment

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Teaching

- Lectures
  - Mainly:
    - Distributed as recordings
      - Followed by summary+exercise on Campus (+Zoom)
  - In a few cases standard lectures
- 2 seminars
  - On Campus in smaller groups
- Assignment and project supervision on Campus, plus on request by email

Lectures

- Lectures and course books cover basic parsing algorithms in detail
- They touch on more advanced material, but you will need to read up on that independently

Lecture organization

- Watch recorded lectures (slides+voice) on your own
- Read relevant course literature
- Work on given small exercises on your own
- This is followed by a summary session
  - Repetition of the most important concepts
  - Discussion of exercise + questions from recordings
  - Questions by students

Lecture recordings

- From 2020
  - Some comments may not be relevant (e.g. referring to the advanced programming course as finished). Time complexity, for instance, will be discussed in more detail during the classroom lectures
- Note that the order of lectures has also changed from previous years
  - Some references in the recordings may not be accurate, due to this
  - Please ask about anything that you find unclear!
  - Most obvious for the first lecture on dependency parsing

Course information

- Web page:
  - Course information
  - Assignments and project instructions
  - Annotated schedule
- Studium:
  - Zoom links
  - Recorded lectures and lecture materials
  - Hand in assignments

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Course workload 5LN713

- **7.5 hp means about 200 hours work:**
- ~ 40 h lectures (including preparation)
- 2 h seminars
- 13 h scheduled supervision
- 145 h work on your own
  - ~ 70 h assignment work (including reading)
  - ~ 10 h seminar preparation
  - ~ 65 h project work

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Deadlines

Assignment	Deadline	Backup
1: PCFG	Feb 9	April 1
2: Dependency	Feb 22	April 1
3: Cross-lingual	March 4	April 1
Project proposal	Feb 26	March 3
Project report	March 22	April 15
Missing seminar report	Feb 14/March 11	April 15

Seminar	Date
1	February 7
2	March 4
Project seminar	March 20

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Course status

- This course is given for the last time in 2024
- There will be three opportunities for reexamination after the end of the course, one per term, autumn 24, spring 25 and autumn 25.
  - Dates will be distributed on the course web page.
- There may have to be some changes to the schedule, due to traveling, possibly affecting the final seminar

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Reading: course books

- Daniel Jurafsky and James H. Martin. Speech and Language Processing. 3rd edition. 2023. Available online as pdf.
  Chapters 17-18.
- Sandra Kübler, Ryan McDonald, and Joakim Nivre. Dependency Parsing. Morgan and Claypool, 2009. Available online through UU.
  Chapters 1-4, 6.

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Reading: articles

- Seminar 1
  - Chris Dyer, Adhiguna Kuncoro, Miguel Ballesteros, Noah A. Smith. Recurrent Neural Network Grammars. NAACL 2016.
- Seminar 2
  - Eliyahu Kiperwasser and Yoav Goldberg. Simple and Accurate Dependency Parsing Using Bidirectional LSTM Feature Representations. TACL. Volume 4, 2016

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Reading: additional material

- Lecture notes by Joakim Nivre – in Studium
- Additional research articles
  - Especially for project and assignment 3

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Evaluation from previous years

- 2023: Overall score: 4.8/5
- Strengths (from recent years):
  - Implementation assignments were useful (but hard)
  - Good to combine the implementation of basic algorithms with discussions of more advanced topics
  - Freedom to choose a project, and to work in pairs
  - Good structure, assignments, and teacher
- Weaknesses:
  - Assignment 1 had too much time
    - Updated
  - Add more new material
    - Handled mainly by the literature seminar, and also by the renewed focus on cross-lingual parsing

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Recorded lectures

- Available in Studium (with automatic subtitles)
- Until you get access to Studium, you can find the first block of recorded lectures here:
  - https://www.youtube.com/playlist?list=PLH4LBlvRWr95-h6-g8R4P3hUF1wZK3sdh

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Work until Friday lecture

- Read J&M 17.1–17.5 (introduction)
- Read J&M 17.6 (CKY)
- Watch recorded lectures about CKY
- Read description of assignment 1: CKY
- Work on exercises (in Studium)

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Schedule changes

- Lecture January 31:
  - Will have to be moved, info coming shortly
- Final seminar
  - May have to be moved
  - Depending on me possibly presenting at a conference
  - Info will come next week!

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Exercise

- Try to come up with parse trees for all possible interpretations of the below example sentence:
  - Phrase-structure trees
  - Dependency trees

- ”Time flies like an arrow”