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Treebank Grammars and Parser Evaluation

Syntactic analysis (5LN455)

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Based on slides from Marco Kuhlmann

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Recap: Probabilistic parsing

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Probabilistic context-free grammars

A probabilistic context-free grammar (PCFG) is a context-free grammar where

- each rule *r* has been assigned a probability $p(r)$ between 0 and 1
- the probabilities of rules with the same left-hand side sum up to 1

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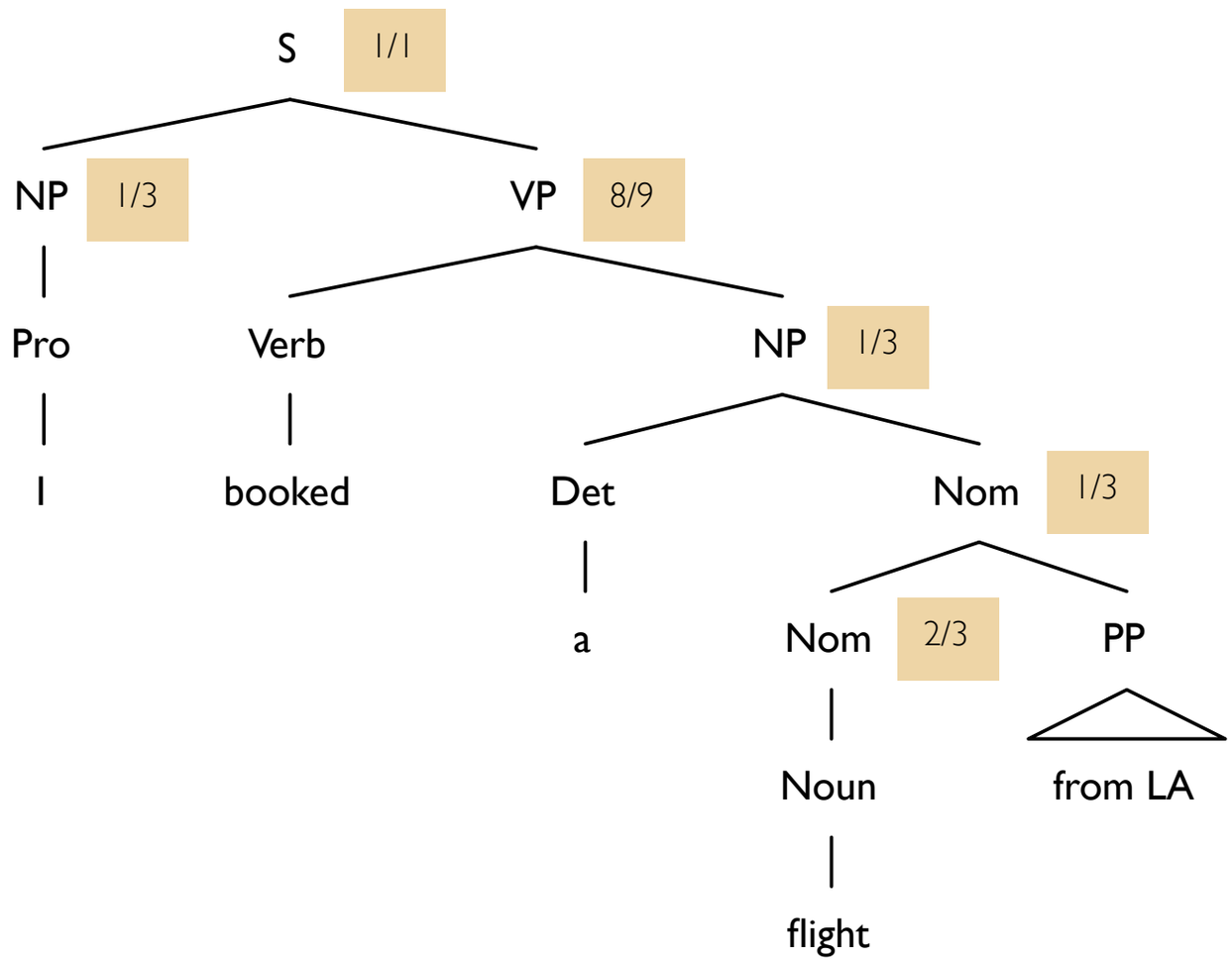
Probability of a parse tree



Probability: 16/729

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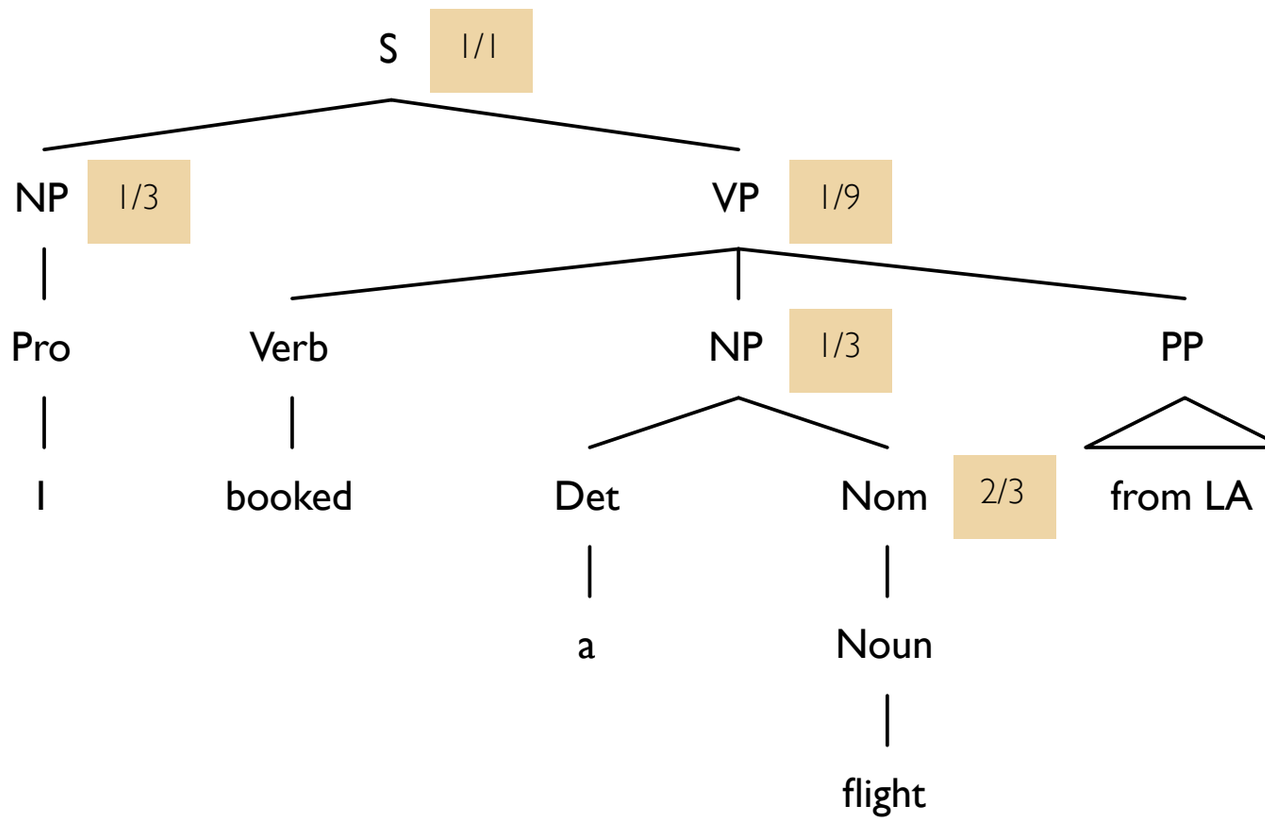
Probability of a parse tree



Probability: 6/729

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Computing the most probable tree

```
for each max from 2 to n
  for each min from max - 2 down to 0
    for each syntactic category C
      double best = undefined
      for each binary rule C -> C1 C2
        for each mid from min + 1 to max - 1
          double t1 = chart[min][mid][C1]
          double t2 = chart[mid][max][C2]
          double candidate = t1 * t2 * p(C -> C1 C2)
          if candidate > best then
            best = candidate
      chart[min][max][C] = best
```

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Backpointers

```
double best = undefined

Backpointer backpointer = undefined

...

if candidate > best then
  best = candidate

  // We found a better tree; update the backpointer!

  Backpointer bp1 = backpointerChart[min][mid][C1]

  Backpointer bp2 = backpointerChart[mid][max][C2]

  backpointer = new Backpointer(C -> C1 C2, bp1, bp2)

...

chart[min][max][C] = best

backpointerChart[min][max][C] = backpointer
```

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Treebank grammars

Treebanks

- Treebanks are corpora in which each sentence has been annotated with a syntactic analysis.
- The annotation process requires detailed guidelines and measures for quality control.
- Producing a high-quality treebank is both time-consuming and expensive.

The Penn Treebank

- One of the most widely known treebanks is the Penn TreeBank (PTB).
- The PTB was compiled at the University of Pennsylvania; the latest release was in 1999.
- Most well known is the Wall Street Journal section of the Penn Treebank.
- This section contains 1 million tokens from the Wall Street Journal (1987–1989).

The Penn Treebank

```
( (S
    (NP-SBJ
      (NP (NNP Pierre) (NNP Vinken) )
      (, ,)
      (ADJP
        (NP (CD 61) (NNS years) )
        (JJ old) )
      (, ,) )
    (VP (MD will)
      (VP (VB join)
        (NP (DT the) (NN board) )
        (PP-CLR (IN as)
          (NP (DT a) (JJ nonexecutive) (NN director) ))
        (NP-TMP (NNP Nov.) (CD 29) )))
    (. .) ))
```

PTB bracket labels

Word	Description
NNP	Proper noun
CD	Cardinal number
NNS	Noun, plural
JJ	Adjective
MD	Modal
VB	Verb, base form
DT	Determiner
NN	Noun, singular
IN	Preposition
…	…

Phrase	Description
S	Declarative clause
NP	Noun phrase
ADJP	Adjective phrase
VP	Verb phrase
PP	Prepositional
ADVP	Adverb phrase
RRC	Reduced relative
WHNP	*Wh*-noun phrase
NAC	Not a constituent
…	…

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Reading rules off the trees

Given a treebank, we can construct a grammar by reading rules off the phrase structure trees.

Sample grammar rule	Span
S → NP-SBJ VP .	Pierre Vinken … Nov. 29.
NP-SBJ → NP , ADJP ,	Pierre Vinken, 61 years old,
VP → MD VP	will join the board …
NP → DT NN	the board

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The Penn Treebank

```
( (S
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      (, ,)
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        (NP (CD 61) (NNS years) )
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    (. .) ))
```

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Treebank grammars

The Penn Treebank

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        (NP-TMP (NNP Nov.) (CD 29) )))
    (. .) ))
```

S → NP-SBJ VP .

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The Penn Treebank

```
( (S
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      (NP (NNP Pierre) (NNP Vinken) )
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    (. .) ))
```

NP-SBJ → NP , ADJP ,

The Penn Treebank

```
( (S
    (NP-SBJ
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      (, ,)
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        (JJ old) )
      (, ,) )
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    (. .) ))
```

ADJP → NP JJ

The Penn Treebank

```
( (S
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      (, ,)
      (ADJP
        (NP (CD 61) (NNS years) )
        (JJ old) )
      (, ,) )
    (VP (MD will)
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        (NP-TMP (NNP Nov.) (CD 29) )))
    (. .) ))
```

NP → CD NNS

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Treebank grammars

The Penn Treebank

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( (S
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      (NP (NNP Pierre) (NNP Vinken) )
      (, ,)
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    (. .) ))
```

NP → NNP NNP

Coverage of treebank grammars

- A treebank grammar will account for all analyses in the treebank.
- It can also be used to derive sentences that were not observed in the treebank.

Properties of treebank grammars

- Treebank grammars are typically rather flat.
  Annotators tend to avoid deeply nested structures.
- Grammar transformations.
  In order to be useful in practice, treebank grammars need to be transformed in various ways.
- Treebank grammars are large.
  The vanilla PTB grammar has 29,846 rules.

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Estimating rule probabilities

- The simplest way to obtain rule probabilities is relative frequency estimation.
- Step 1: Count the number of occurrences of each rule in the treebank.
- Step 2: Divide this number by the total number of rule occurrences for the same left-hand side.
- The grammar that you use in the assignment is produced in this way.

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Parser evaluation

Different types of evaluation

- Intrinsic versus extrinsic evaluation.
  Evaluate relative to some gold standard vs. evaluate in the context of some specific task
- Automatic versus manual evaluation.
  Evaluate relative to some predefined measure vs. evaluate by humans.

Standard evaluation in parsing

- Intrinsic and automatic
- Parsers based on treebank grammars are evaluated by comparing their output to some gold standard.
- For this purpose, the treebank is customarily split into three sections: *training*, *tuning*, and *testing*.
- The parser is developed on *training* and *tuning*; final performance is reported on *testing*.

Bracket score

- The standard measure to evaluate phrase structure parsers is bracket score.
- Bracket: [min, max, category]
- One compares the brackets found by the parser to the brackets in the gold standard tree.
- Performance is reported in terms of precision, recall, and F-score.

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Bracket score

- The standard measure to evaluate phrase structure parsers is bracket score.
- Bracket: [min, max, category]

signature!

- One compares the brackets found by the parser to the brackets in the gold standard tree.
- Performance is reported in terms of precision, recall, and F-score.

Evaluation measure

- Precision:
  Out of all brackets found by the parser,
  how many are also present in the gold standard?

- Recall:
  Out of all brackets in the gold standard,
  how many are also found by the parser?

- F1-score:
  harmonic mean between precision and recall:
  2 × precision × recall / (precision + recall)

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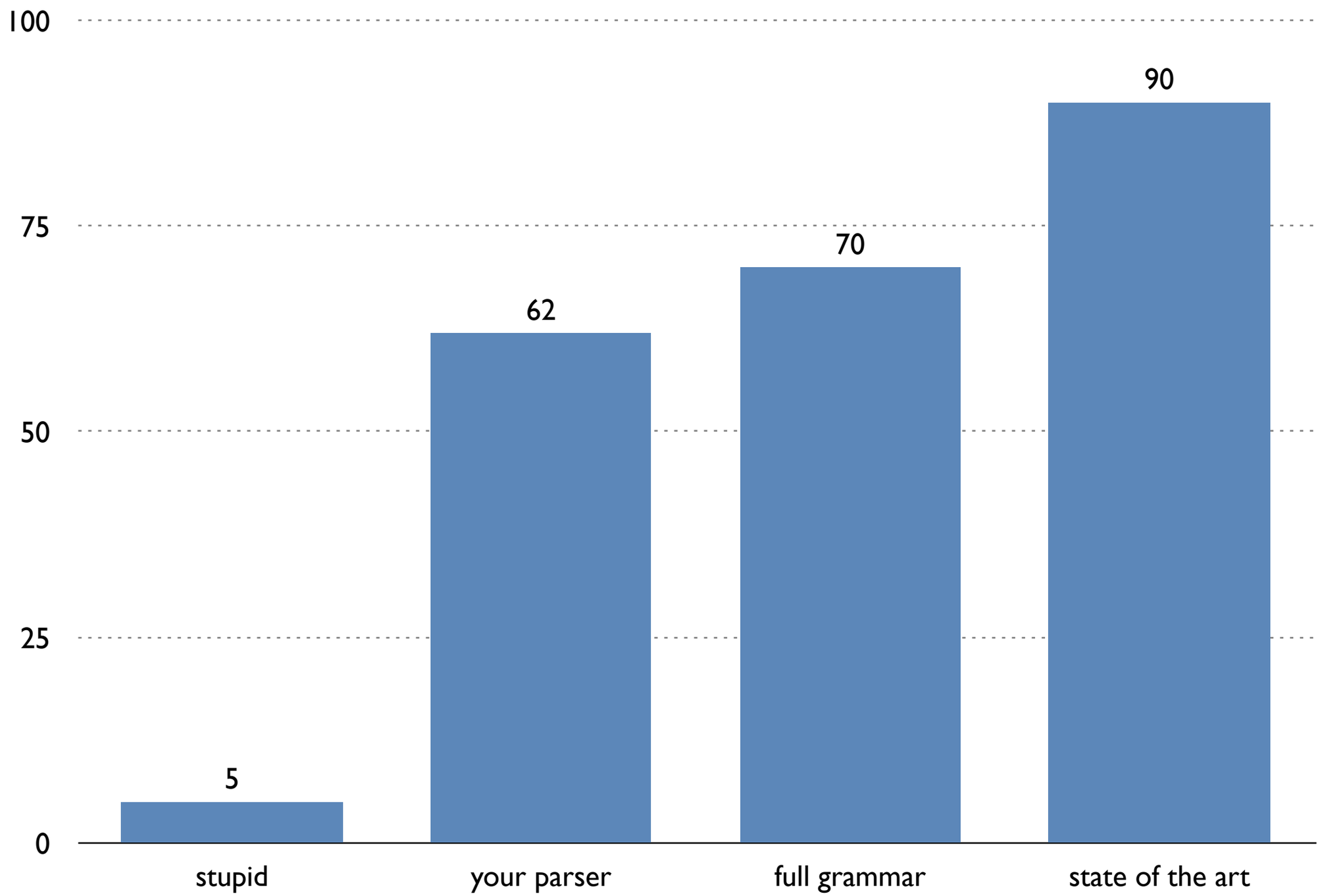
Parser evaluation

F1-scores for the WSJ



Domains and languages

- Most of the parsing research is performed for English on the Wall Street Journal part of Penn Treebank
- Results for other English domains and for other languages are often worse than English WSJ
- Possible reasons
  - Parsing methods developed for English tends to work best for English (WSJ)
  - Language differences
  - Annotation differences
  - Treebank size and quality
  - ...

Treebank types - examples

- Phrase-structure treebanks
  - Penn treebank (English, and Chinese, Arabic)
  - NEGRA (German)
- Dependency treebanks
  - Prague Dep. treebank (Czech, + other)
  - Danish Dep. treebank (Danish)
  - Converted phrase-structured treebanks (e.g. Penn)
- Other
  - CCGBank (CCG, English)
  - LinGO Redwoods (HPSG, English)

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Swedish Treebank

- Combination of two older treebanks which have been merged and harmonized:
  - SUC (Stockholm-Umeå Corpus)
  - Talbanken
- Size: ~350 000 tokens
- Phrase structure annotation with functional labels
- Converted to dependency annotation
- Some parts checked by humans, some annotated automatically

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Summary

- One can extract probabilistic context-free grammars from treebanks.
- Parsers can be evaluated by comparing their output against a gold standard.
- Reading: J&M 12.4, 14.3, 14.7