# Structural Ambiguity

How different parse trees may be produced from the same sentence or phrase

- Attachment ambiguity: where a constituent may attach to the rest of the tree
  - I saw a man with a telescope
- Coordination ambiguity: How to group the arguments of a conjunction
  - Spicy rice and apples
- *Disambiguation* relies on applying additional knowledge
  - Of language, e.g., what verbs and nouns or prepositions go together
  - Of the real world
  - Of the context, such as prior sentences or conversations

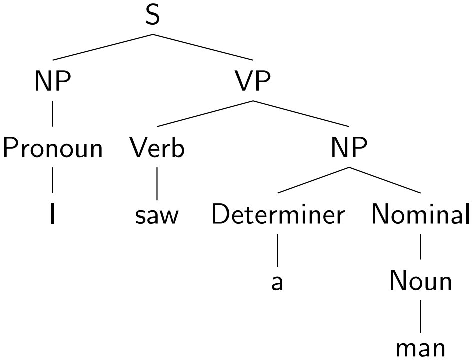
# Jurafsky's Miniature Grammar, $\mathscr{L}_1$

## Omitting the lexicon

$$
\begin{array}{rcl}
\text{S} & \longrightarrow & \text{NP VP} \\
\text{S} & \longrightarrow & \text{Auxiliary-Verb NP VP} \\
\text{S} & \longrightarrow & \text{VP} \\
\text{NP} & \longrightarrow & \text{Pronoun} \\
\text{NP} & \longrightarrow & \text{Proper-Noun} \\
\text{NP} & \longrightarrow & \text{Determiner Nominal} \\
\text{Nominal} & \longrightarrow & \text{Noun} \\
\text{Nominal} & \longrightarrow & \text{Nominal Noun} \\
\text{Nominal} & \longrightarrow & \text{Nominal PP} \\
\text{VP} & \longrightarrow & \text{Verb} \\
\text{VP} & \longrightarrow & \text{Verb NP} \\
\text{VP} & \longrightarrow & \text{Verb NP PP} \\
\text{VP} & \longrightarrow & \text{Verb PP} \\
\text{VP} & \longrightarrow & \text{VP PP} \\
\text{PP} & \longrightarrow & \text{Preposition NP}
\end{array}
$$

# Attachment Ambiguity: Setting the Stage

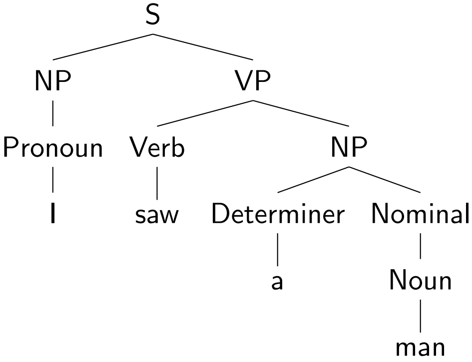
I saw a man



# Attachment Ambiguity: Example

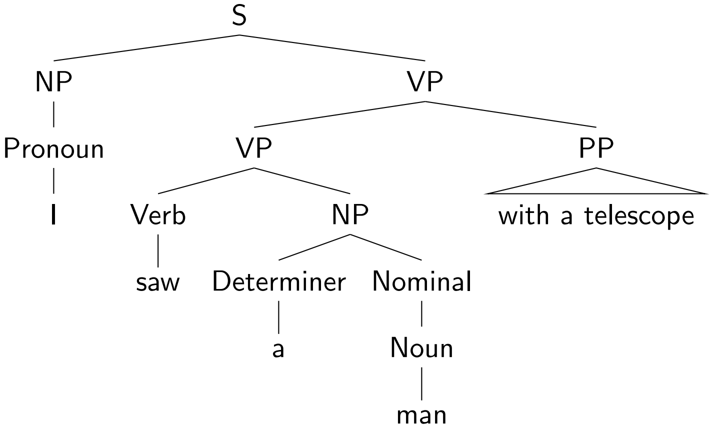
I saw a man with a telescope

Modify the following tree for the above sentence



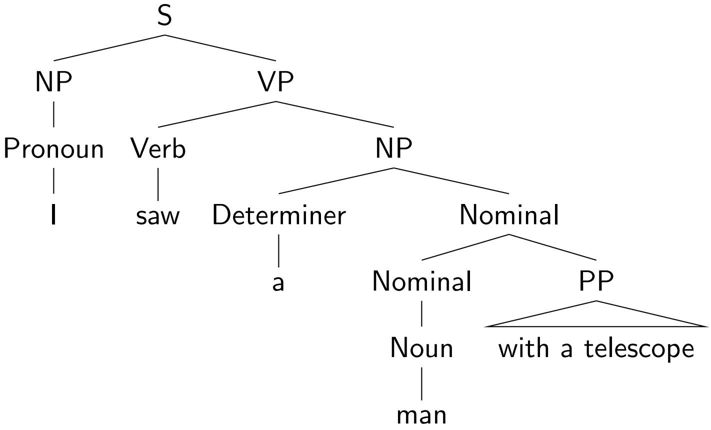
# Attachment Ambiguity: 1

I saw a man with a telescope



# Attachment Ambiguity: 2

I saw a man with a telescope



# Simple Coordination Productions

## Add these to the earlier grammar

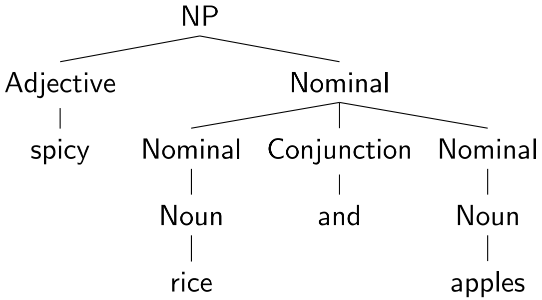
$$\begin{array}{rcl} \text{NP} & \longrightarrow & \text{NP Conjunction NP} \\ \text{Nominal} & \longrightarrow & \text{Nominal Conjunction Nominal} \\ \text{VP} & \longrightarrow & \text{VP Conjunction VP} \\ \text{PP} & \longrightarrow & \text{PP Conjunction PP} \end{array}$$

Also, for adjectives include

$$\text{NP} \quad \longrightarrow \quad \text{Adjective Nominal}$$

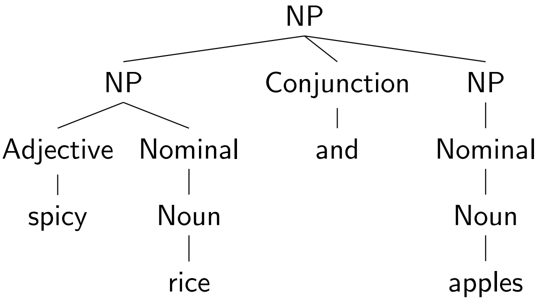
# Coordination Ambiguity: 1

## Spicy rice and apples



# Coordination Ambiguity: 2

## Spicy rice and apples



# Sentences in Practice

## A. A. Milne, Winnie the Pooh

### Eeyore's take on writing

"This writing business. Pencils and what-not. Over-rated, if you ask me. Silly stuff. Nothing in it."

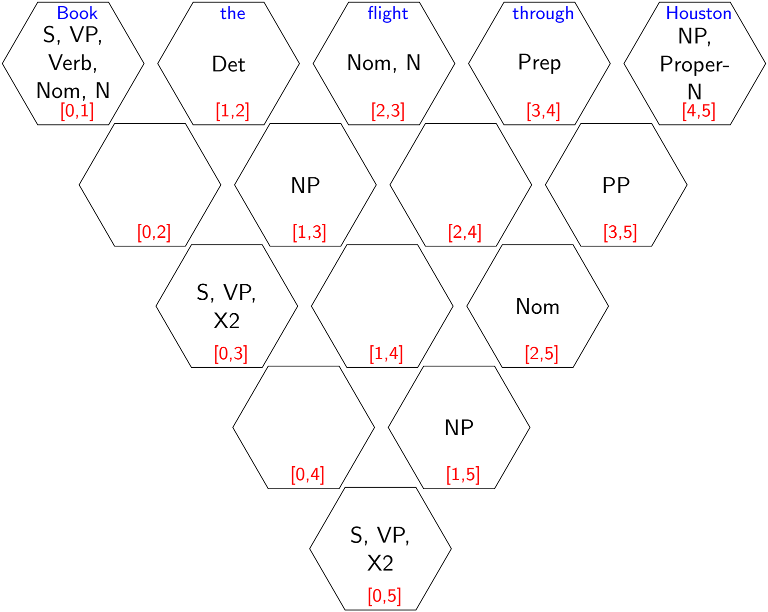
- Five sentences
- Do you identify verbs in them?
- What grammar would generate these sentences?

# Parsing with a Context-Free Grammar

## Cocke-Kasami-Younger (CKY) algorithm

- Apply dynamic programming
  - Build up solutions incrementally
  - Reusing them in larger solutions
- Convert to Chomsky Normal Form
- Each constituent is based on
  - A single terminal
  - Two nonterminals (constituents)
- Compute and store all possible constituents for each cell in a matrix
  - Allow duplicates to accommodate ambiguity
  - Store provenance of each value
- When we arrive at a cell the cells it relies upon are already computed
- The nonterminal in the final cell represents the constituent for the entire input (if any)
- Reconstruct parse tree from the provenance

# Example of a CKY Parse



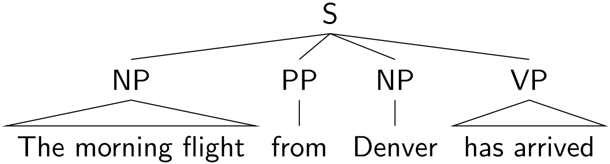
# Improving CKY for Practical Use

- Generalize to arbitrary grammars (not just Chomsky Normal Form)
  - Ensures parses produced reflect grammarians' intuitions
- In statistical parsing, accommodate probabilities to
  - Select likelier parses
  - Avoid exponentially many parses

# Partial or Shallow Parsing

## Applicable when we don't need a complete parse to produce a valuable product

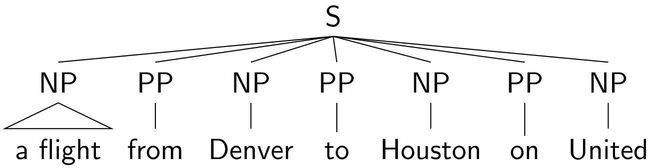
- Produce flat trees
  - Avoid decisions about nesting and ambiguity that a full parser must contend with
- *Chunking*: Identify constituents for nonoverlapping segments
- Exclude hierarchical structure (i.e., slightly above POS tagging)
  - [$_{\text{Pro}}$ I] [$_{\text{V}}$ saw] [$_{\text{NP}}$ a man] [$_{\text{PP}}$ with a telescope]



# Identifying Base Phrases

## Alternative to chunking

- A base phrase (some variation in definitions)
  - Doesn't (recursively) contain constituents of the same type
  - Includes the headword and any prehead modifiers (or any post-head material)
  - Excludes post-head modifiers (to avoid attachment ambiguity)
    - Can be difficult to use as a result since boundaries are less clear
    - Can yield outcomes where an NP or PP may contain nothing other than its head



# Machine Learning for Chunking

## An application of sequence learning

- Introduce $2n+1$ tags (given $n$ chunk types)
  - $B_k$: Beginning of chunk type $k$
  - $I_k$: Inside of chunk type $k$
  - $O$: Outside of all chunk types
  - No need for end of a chunk since the beginning of the next (or end of sentence) indicates its end
- Example of IOB chunking

| | | | | | | |
|---|---|---|---|---|---|---|
| I | saw | a | man | with | a | telescope |
| $B_{NP}$ | $B_{VP}$ | $B_{NP}$ | $I_{NP}$ | $B_{PP}$ | $I_{PP}$ | $I_{PP}$ |
| $[_{NP}$I] | $[_{VP}$saw] | $[_{NP}$a | man] | $[_{PP}$with | a | telescope] |

- Training data: from existing treebanks
  - Identify head words of a constituent
  - Include head and prehead words within the constituent
  - Exclude post-head words

# Evaluation Metrics for Chunking

- Correct chunk: whose tag (label) and segment are correct
- Metrics adopted from information retrieval

$$\text{Precision}, P = \frac{\text{Number of correct chunks identified}}{\text{Number of chunks identified}}$$

$$\text{Recall}, R = \frac{\text{Number of correct chunks identified}}{\text{Number of (correct) chunks existing}}$$

$$\text{F-measure}, F_\beta = \frac{(\beta^2 + 1)PR}{\beta^2 P + R}$$

$$\text{F}_1, F_1 = \frac{2PR}{P + R}$$

- F-measure trades off precision and recall
  - $\text{F}_1$ gives equal importance to precision and recall