

## Probabilistic context-free grammars

### A. Overview

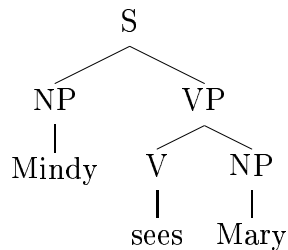
- (1)
  - a. CFGs
  - b. PCFGs
  - c. Sentence probabilities

### B. What is a CFG?

- (2)

|    |   |       |
|----|---|-------|
| S  | → | NP VP |
| VP | → | V     |
| VP | → | V NP  |
| V  | → | sees  |
| V  | → | helps |
| NP | → | Mindy |
| NP | → | Mary  |

(3)



### C. What is a PCFG?

- (4) A PCFG is a context-free grammar where each rule has an associated probability. In addition, the rules that expand any particular non-terminal  $A$  must exhibit a probability distribution, i.e. their probabilities must sum to one (Suppes 1970).

- (5)

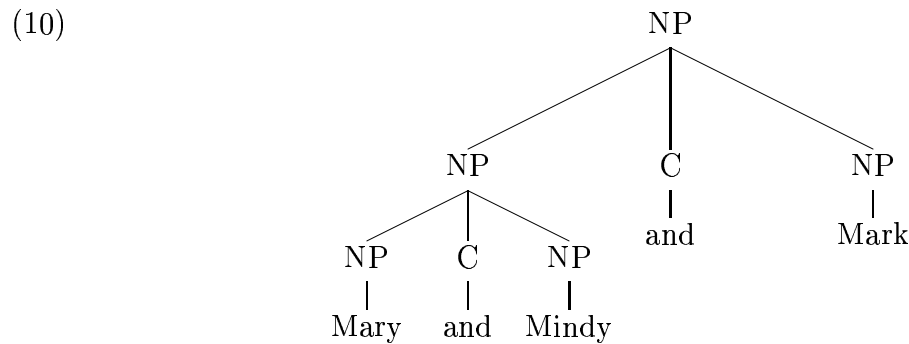
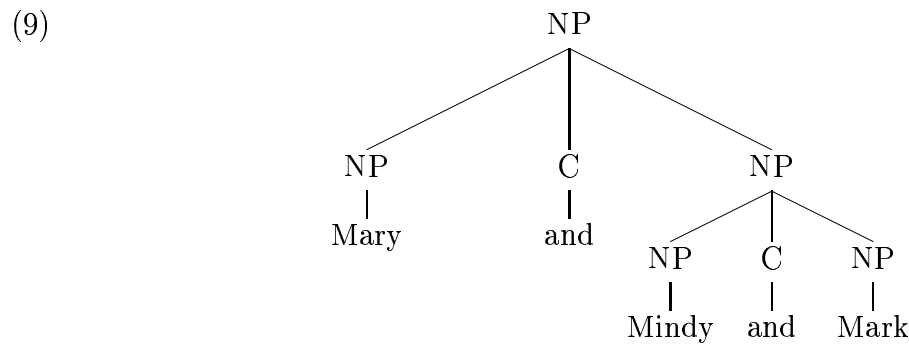
|    |   |       |    |
|----|---|-------|----|
| S  | → | NP VP | 1  |
| VP | → | V     | .3 |
| VP | → | V NP  | .7 |
| V  | → | sees  | .4 |
| V  | → | helps | .6 |
| NP | → | Mindy | .2 |
| NP | → | Mary  | .8 |

**D. What is a the probability of a sentence?**

(6)  $p(s) = \sum_j p(t_j)p(s|t_j)$

- (7)
- |    |   |         |    |
|----|---|---------|----|
| NP | → | NP C NP | .4 |
| NP | → | Mary    | .3 |
| NP | → | Mindy   | .2 |
| NP | → | Mark    | .1 |
| C  | → | and     | 1  |

(8) The probability of each parse is:  $.3 \times .2 \times .1 \times 1 \times 1 \times .4 \times .4 = .00096$ . The overall probability of the string is  $.00096 + .00096 = .00192$ .



**References**

CHARNIAK, EUGENE. 1993. *Statistical Language Learning*. Cambridge: MIT Press.

HAMMOND, MICHAEL, 2003. *Statistical natural language processing*. U. of Arizona.

SUPPES, PATRICK. 1970. Probabilistic grammars for natural languages. *Synthese* 22.95–116.