Ling 566
Oct 16, 2007

How the Grammar Works

Overview

- What we're trying to do
- The pieces of our grammar
- Two extended examples
- Reflection on what we've done, what we still have to do

What We're Trying To Do

- Objectives
  - Develop a theory of knowledge of language
  - Represent linguistic information explicitly enough to distinguish well-formed from ill-formed expressions
  - Be parsimonious, capturing linguistically significant generalizations.
- Why Formalize?
  - To formulate testable predictions
  - To check for consistency
  - To make it possible to get a computer to do it for us

How We Construct Sentences

- The Components of Our Grammar
  - Grammar rules
  - Lexical entries
  - Principles
  - Type hierarchy (very preliminary, so far)
  - Initial symbol (S, for now)
- We combine constraints from these components.

Q: *What says we have to combine them?*

A: The definition of well-formed structure

An Example

A cat slept.

- Can we build this with our tools?
- Given the constraints our grammar puts on well-formed sentences, is this one?

Lexical Entry for *a*

$$\left\langle \text{a} \;, \left[\begin{array}{ll} \textit{word} & \\ \text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \left[\begin{array}{ll} \textit{det} & \\ \text{AGR} & \textit{3sing} \\ \text{COUNT} & + \end{array}\right] \\ \text{VAL} & \left[\begin{array}{ll} \text{COMPS} & \langle\ \rangle \\ \text{SPR} & \langle\ \rangle \\ \text{MOD} & \langle\ \rangle \end{array}\right] \end{array}\right] \\ \text{SEM} & \left[\begin{array}{ll} \text{MODE} & \text{none} \\ \text{INDEX} & j \\ \text{RESTR} & \left\langle \left[\begin{array}{ll} \text{RELN} & \text{a} \\ \text{BV} & j \end{array}\right] \right\rangle \end{array}\right] \end{array}\right] \right\rangle$$

- Is this a fully specified description?
- What features are unspecified?
- How many word structures can this entry license?

Lexical Entry for *cat*

$$\left\langle \text{cat} , \left[\begin{array}{l} \textit{word} \\ \text{SYN} \left[\begin{array}{ll} \text{HEAD} & \left[\begin{array}{ll} \textit{noun} & \\ \text{AGR} & \left[\begin{array}{ll} \textit{3sing} & \\ \text{GEND} & \text{neut} \end{array} \right] \end{array} \right] \\ \text{VAL} & \left[\begin{array}{ll} \text{SPR} & \left\langle \left[\begin{array}{ll} \text{D} & \\ \text{COUNT} & + \\ \text{INDEX} & k \end{array} \right] \right\rangle \\ \text{COMPS} & \langle\,\rangle \\ \text{MOD} & \langle\,\rangle \end{array} \right] \end{array} \right] \\ \text{SEM} \left[\begin{array}{ll} \text{MODE} & \text{ref} \\ \text{INDEX} & k \\ \text{RESTR} & \left\langle \left[\begin{array}{ll} \text{RELN} & \text{cat} \\ \text{INSTANCE} & k \end{array} \right] \right\rangle \end{array} \right] \end{array} \right] \right\rangle$$

- Which feature paths are abbreviated?
- Is this a fully specified description?
- What features are unspecified?
- How many word structures can this entry license?

Effect of Principles: the SHAC

$$\left\langle \text{cat} \;,\; \left[\begin{array}{ll} \textit{word} & \\ \text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \left[\begin{array}{ll} \textit{noun} & \\ \text{AGR} & \boxed{2}\left[\begin{array}{ll} \textit{3sing} & \\ \text{GEND} & \text{neut} \end{array}\right] \end{array}\right] \\ \text{VAL} & \left[\begin{array}{ll} \text{SPR} & \left\langle \left[\begin{array}{ll} \text{AGR} & \boxed{2} \\ \text{COUNT} & + \\ \text{INDEX} & k \end{array}\right] \right\rangle_{\text{D}} \\ \text{COMPS} & \langle\,\rangle \\ \text{MOD} & \langle\,\rangle \end{array}\right] \end{array}\right] \\ \text{SEM} & \left[\begin{array}{ll} \text{MODE} & \text{ref} \\ \text{INDEX} & k \\ \text{RESTR} & \left\langle \left[\begin{array}{ll} \text{RELN} & \text{cat} \\ \text{INSTANCE} & k \end{array}\right] \right\rangle \end{array}\right] \end{array}\right] \right\rangle$$

Description of Word Structures for *cat*

$$
\begin{bmatrix}
word & \\
\text{SYN} & \begin{bmatrix}
\text{HEAD} & \begin{bmatrix} noun & \\ \text{AGR} & \boxed{2}\begin{bmatrix} 3sing & \\ \text{GEND} & \text{neut} \end{bmatrix} \end{bmatrix} \\
\text{VAL} & \begin{bmatrix}
\text{SPR} & \left\langle \begin{bmatrix} \text{AGR} & \boxed{2} \\ \text{COUNT} & + \\ \text{INDEX} & k \end{bmatrix}_{\text{D}} \right\rangle \\
\text{COMPS} & \langle\ \rangle \\
\text{MOD} & \langle\ \rangle
\end{bmatrix}
\end{bmatrix} \\
\text{SEM} & \begin{bmatrix}
\text{MODE} & \text{ref} \\
\text{INDEX} & k \\
\text{RESTR} & \left\langle \begin{bmatrix} \text{RELN} & \text{cat} \\ \text{INSTANCE} & k \end{bmatrix} \right\rangle
\end{bmatrix}
\end{bmatrix}
$$

cat

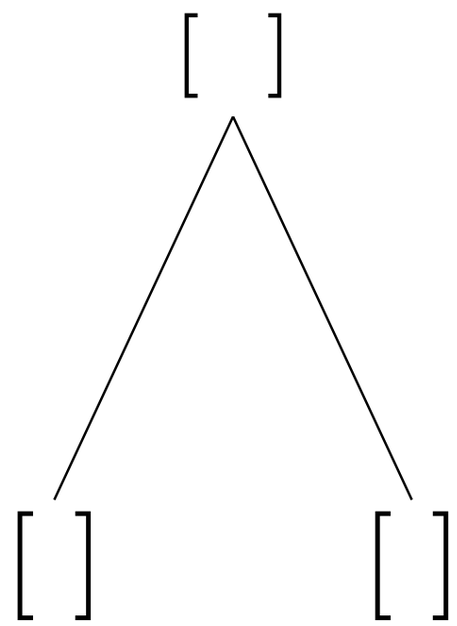
Description of Word Structures for *a*

$$\begin{bmatrix} word \\ \text{SYN} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} det \\ \text{AGR} & 3sing \\ \text{COUNT} & + \end{bmatrix} \\ \text{VAL} & \begin{bmatrix} \text{COMPS} & \langle\,\rangle \\ \text{SPR} & \langle\,\rangle \\ \text{MOD} & \langle\,\rangle \end{bmatrix} \end{bmatrix} \\ \text{SEM} & \begin{bmatrix} \text{MODE} & \text{none} \\ \text{INDEX} & j \\ \text{RESTR} & \left\langle \begin{bmatrix} \text{RELN} & \text{a} \\ \text{BV} & j \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix}$$

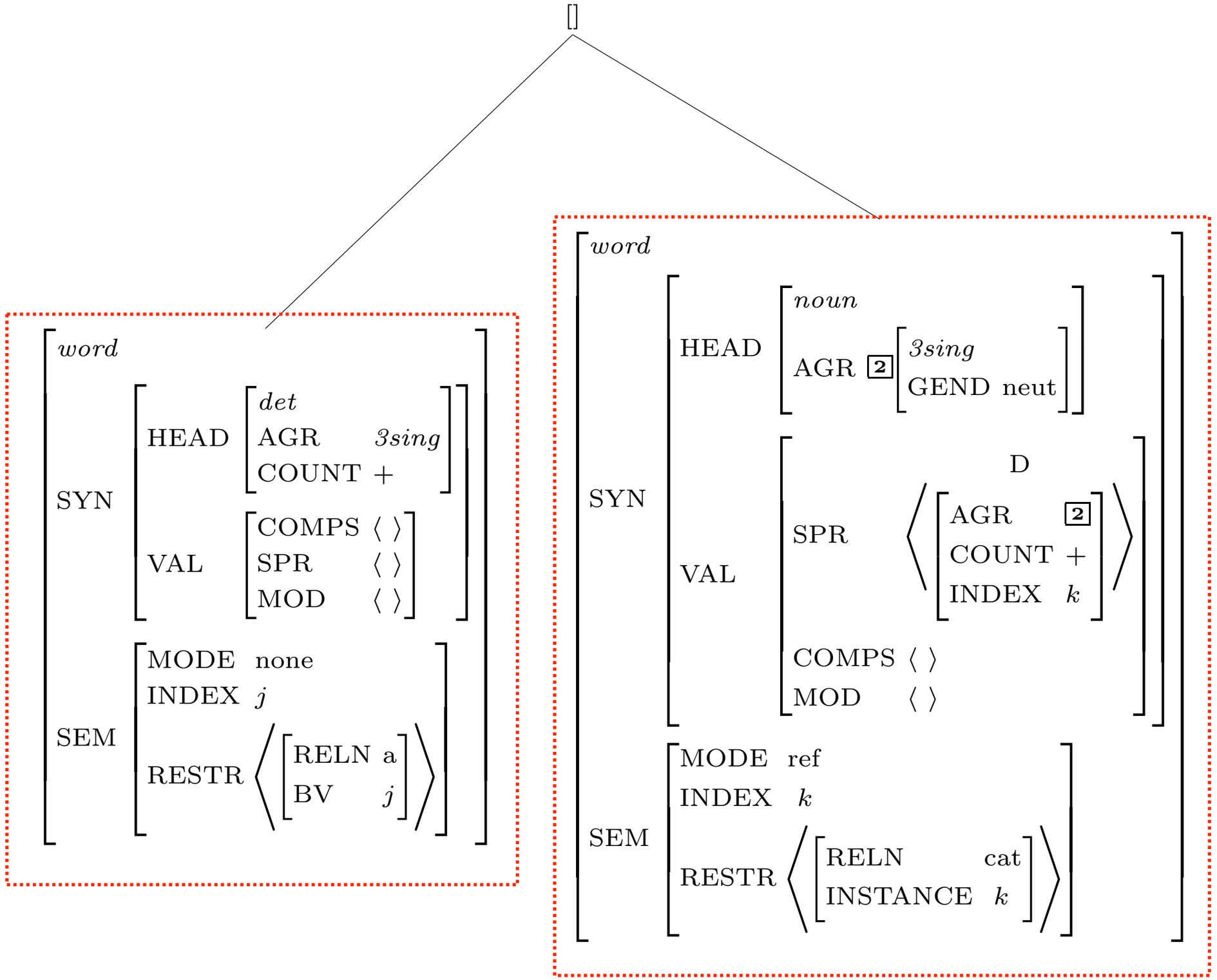
|

a

Building a Phrase



Constraints Contributed by Daughter Subtrees



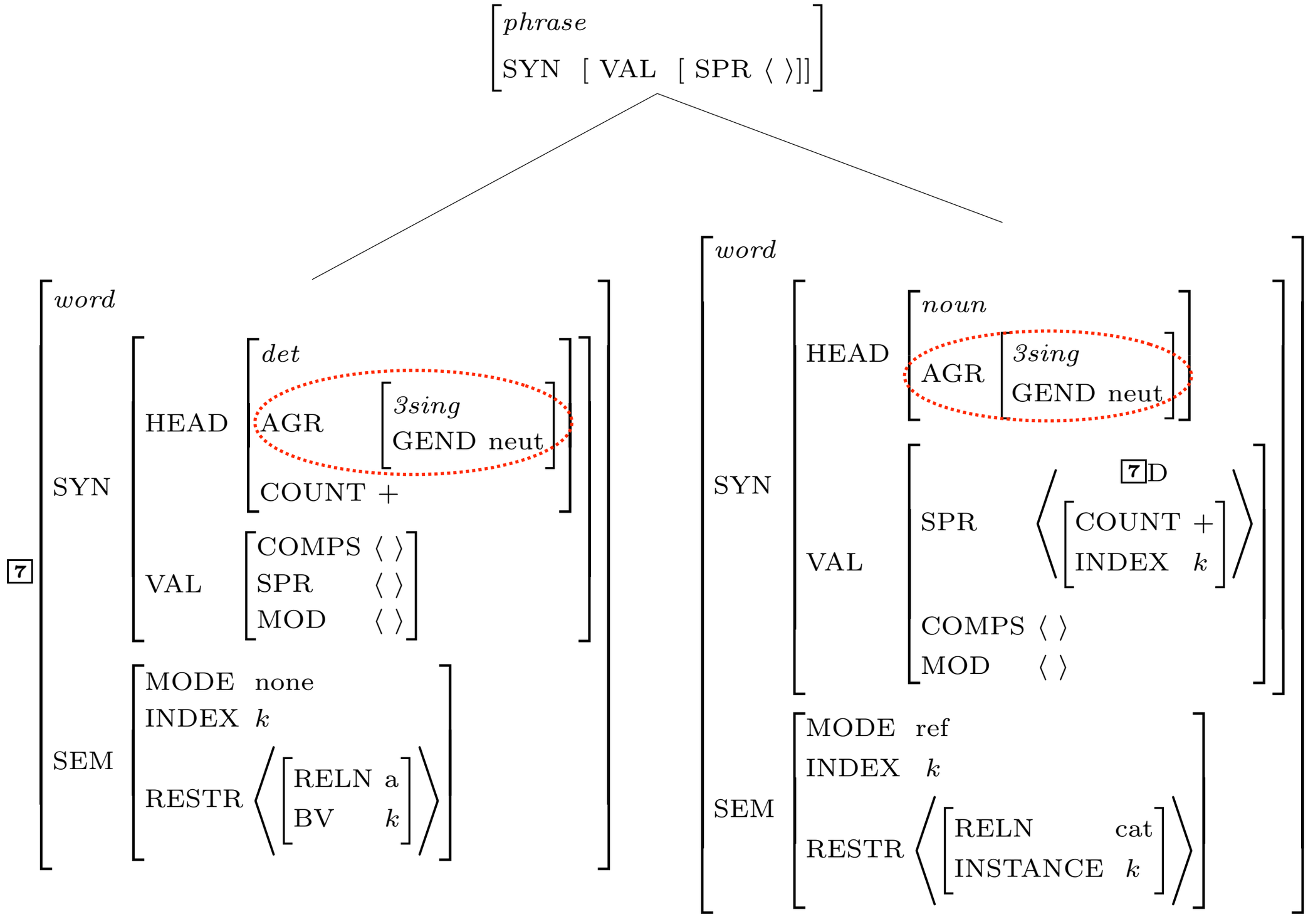
Constraints Contributed by the Grammar Rule

$$\begin{bmatrix} phrase \\ \text{SYN} \;\; [\,\text{VAL} \;\; [\,\text{SPR} \;\langle\,\rangle]] \end{bmatrix}$$

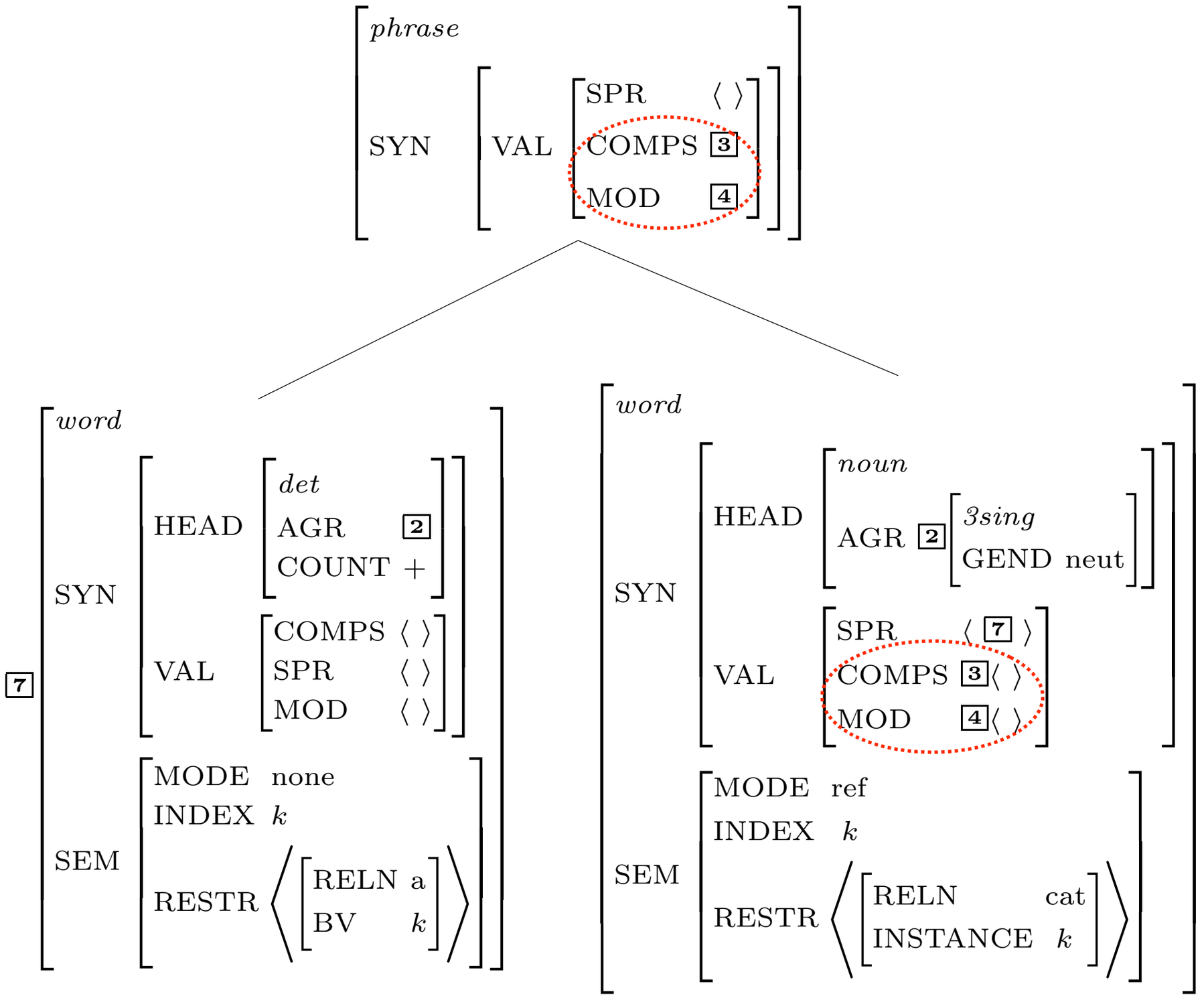
$$\begin{bmatrix} word \\ \boxed{7} \\ \text{SYN} \;\; \begin{bmatrix} \text{HEAD} \;\; \begin{bmatrix} det \\ \text{AGR} \;\; \begin{bmatrix} 3sing \\ \text{GEND} \;\; neut \end{bmatrix} \\ \text{COUNT} \;\; + \end{bmatrix} \\ \text{VAL} \;\; \begin{bmatrix} \text{COMPS} \;\langle\,\rangle \\ \text{SPR} \;\langle\,\rangle \\ \text{MOD} \;\langle\,\rangle \end{bmatrix} \end{bmatrix} \\ \text{SEM} \;\; \begin{bmatrix} \text{MODE} \;\; \text{none} \\ \text{INDEX} \;\; k \\ \text{RESTR} \;\left\langle \begin{bmatrix} \text{RELN} \;\; \text{a} \\ \text{BV} \;\; k \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix}$$

$$\begin{bmatrix} word \\ \text{SYN} \;\; \begin{bmatrix} \text{HEAD} \;\; \begin{bmatrix} noun \\ \text{AGR} \;\; \begin{bmatrix} 3sing \\ \text{GEND} \;\; neut \end{bmatrix} \end{bmatrix} \\ \text{VAL} \;\; \begin{bmatrix} \text{SPR} \;\left\langle \boxed{7}\,\text{D} \right\rangle \\ \text{COMPS} \;\langle\,\rangle \\ \text{MOD} \;\langle\,\rangle \end{bmatrix} \end{bmatrix} \\ \text{SEM} \;\; \begin{bmatrix} \text{MODE} \;\; \text{ref} \\ \text{INDEX} \;\; k \\ \text{RESTR} \;\left\langle \begin{bmatrix} \text{RELN} \;\; \text{cat} \\ \text{INSTANCE} \;\; k \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix}$$

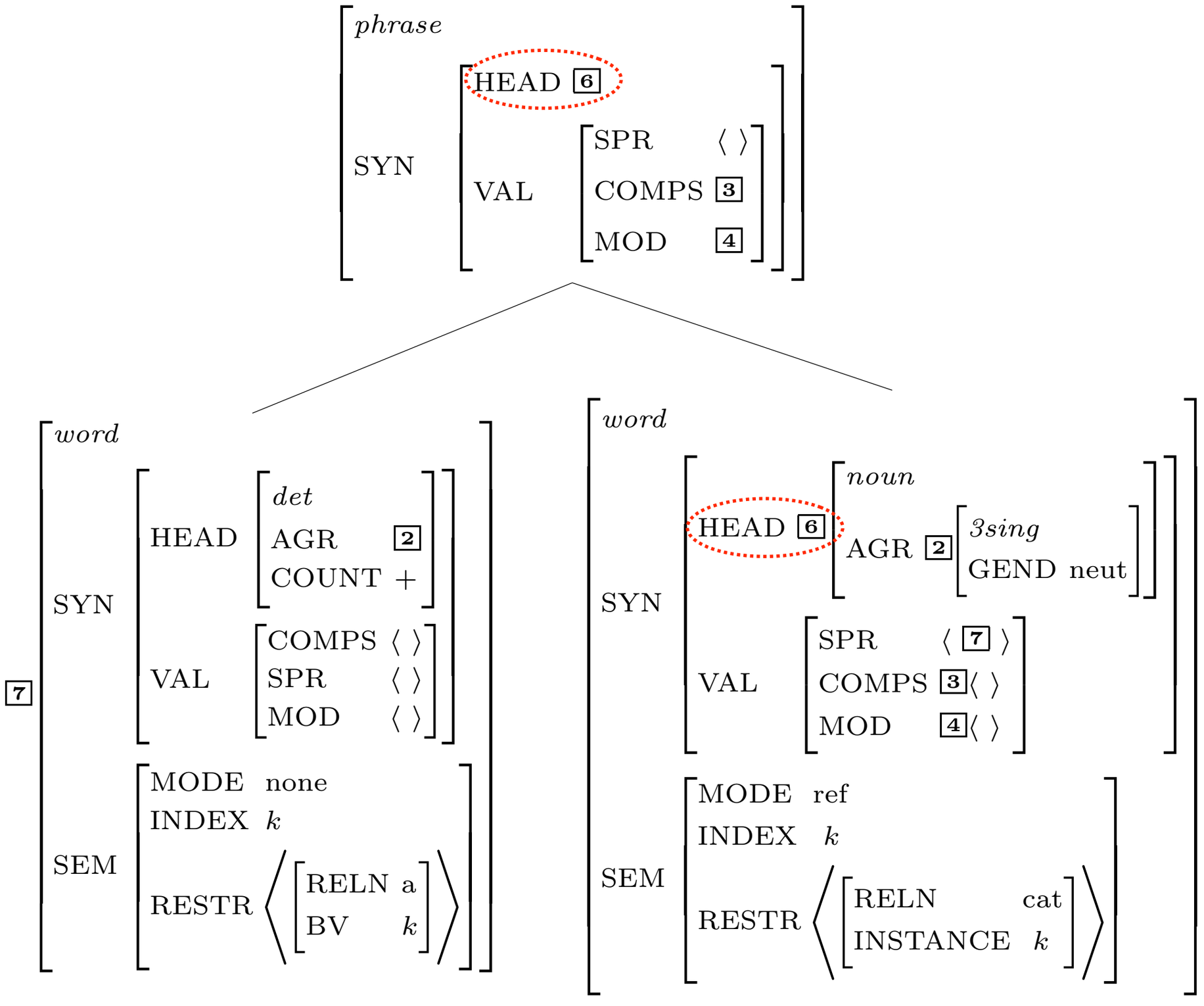
A Constraint Involving the SHAC



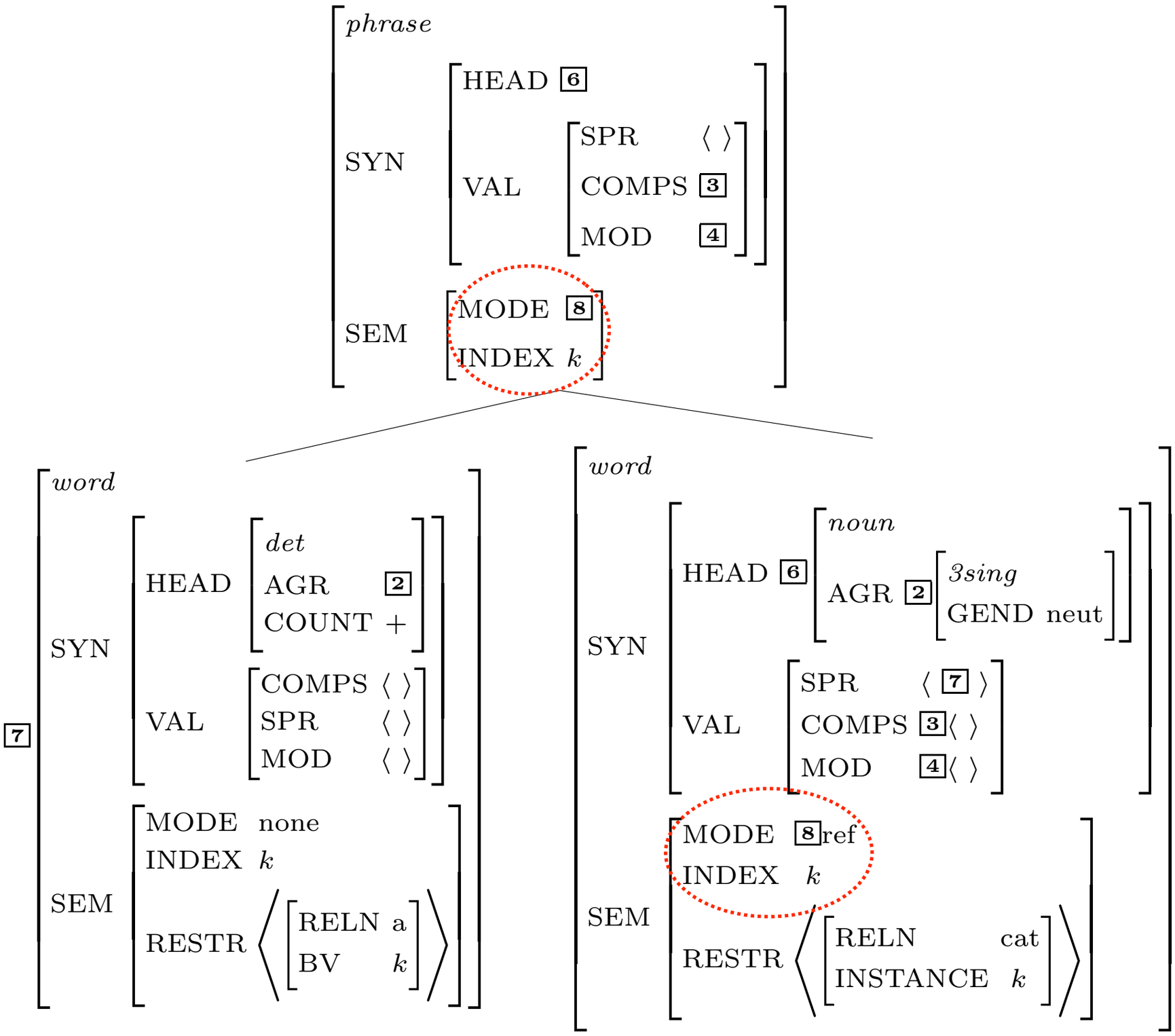
Effects of the Valence Principle



Effects of the Head Feature Principle



Effects of the Semantic Inheritance Principle



Effects of the Semantic Compositionality Principle

$$\left[\begin{array}{ll} \textit{phrase} & \\ \text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \boxed{6} \\ \text{VAL} & \left[\begin{array}{ll} \text{SPR} & \langle\ \rangle \\ \text{COMPS} & \boxed{3} \\ \text{MOD} & \boxed{4} \end{array}\right] \end{array}\right] \\ \text{SEM} & \left[\begin{array}{ll} \text{MODE} & \boxed{8} \\ \text{INDEX} & k \\ \text{RESTR} & \boxed{A} \oplus \boxed{B} \end{array}\right] \end{array}\right]$$

$$\boxed{7}\left[\begin{array}{ll} \textit{word} & \\ \text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \left[\begin{array}{ll} \textit{det} & \\ \text{AGR} & \boxed{2} \\ \text{COUNT} & + \end{array}\right] \\ \text{VAL} & \left[\begin{array}{ll} \text{COMPS} & \langle\ \rangle \\ \text{SPR} & \langle\ \rangle \\ \text{MOD} & \langle\ \rangle \end{array}\right] \end{array}\right] \\ \text{SEM} & \left[\begin{array}{ll} \text{MODE} & \text{none} \\ \text{INDEX} & k \\ \text{RESTR} & \boxed{A}\left\langle \left[\begin{array}{ll} \text{RELN} & \text{a} \\ \text{BV} & k \end{array}\right] \right\rangle \end{array}\right] \end{array}\right]$$

$$\left[\begin{array}{ll} \textit{word} & \\ \text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \boxed{6}\left[\begin{array}{ll} \textit{noun} & \\ \text{AGR} & \boxed{2}\left[\begin{array}{ll} \textit{3sing} & \\ \text{GEND} & \text{neut} \end{array}\right] \end{array}\right] \\ \text{VAL} & \left[\begin{array}{ll} \text{SPR} & \langle\ \boxed{7}\ \rangle \\ \text{COMPS} & \boxed{3}\langle\ \rangle \\ \text{MOD} & \boxed{4}\langle\ \rangle \end{array}\right] \end{array}\right] \\ \text{SEM} & \left[\begin{array}{ll} \text{MODE} & \boxed{8}\text{ref} \\ \text{INDEX} & k \\ \text{RESTR} & \boxed{B}\left\langle \left[\begin{array}{ll} \text{RELN} & \text{cat} \\ \text{INSTANCE} & k \end{array}\right] \right\rangle \end{array}\right] \end{array}\right]$$

Is the Mother Node Now Completely Specified?

$$\begin{bmatrix} \textit{phrase} \\ \text{SYN} & \begin{bmatrix} \text{HEAD} & \boxed{6} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & \langle\ \rangle \\ \text{COMPS} & \boxed{3} \\ \text{MOD} & \boxed{4} \end{bmatrix} \end{bmatrix} \\ \text{SEM} & \begin{bmatrix} \text{MODE} & \boxed{8} \\ \text{INDEX} & k \\ \text{RESTR} & \boxed{A} \oplus \boxed{B} \end{bmatrix} \end{bmatrix}$$

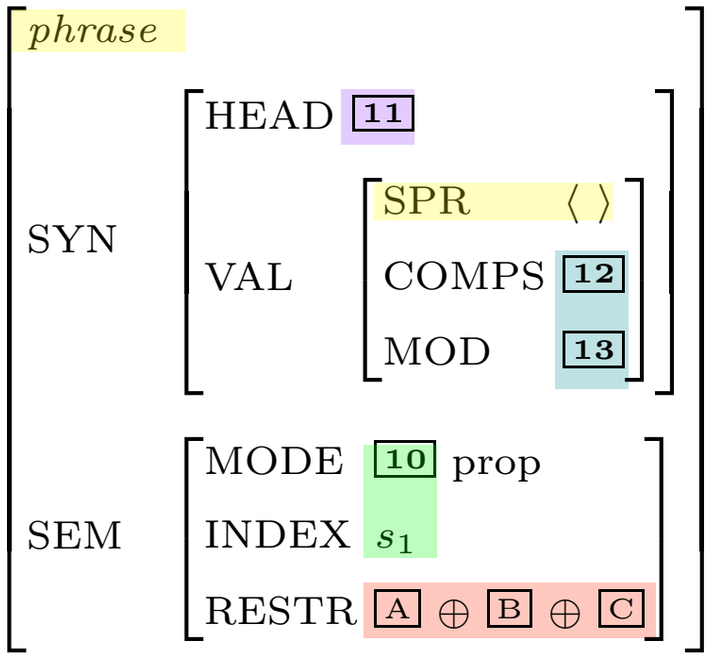
$$\boxed{7}\begin{bmatrix} \textit{word} \\ \text{SYN} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \textit{det} \\ \text{AGR} & \boxed{2} \\ \text{COUNT} & + \end{bmatrix} \\ \text{VAL} & \begin{bmatrix} \text{COMPS} & \langle\ \rangle \\ \text{SPR} & \langle\ \rangle \\ \text{MOD} & \langle\ \rangle \end{bmatrix} \end{bmatrix} \\ \text{SEM} & \begin{bmatrix} \text{MODE} & \text{none} \\ \text{INDEX} & k \\ \text{RESTR} & \boxed{A}\left\langle \begin{bmatrix} \text{RELN} & \text{a} \\ \text{BV} & k \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix}$$

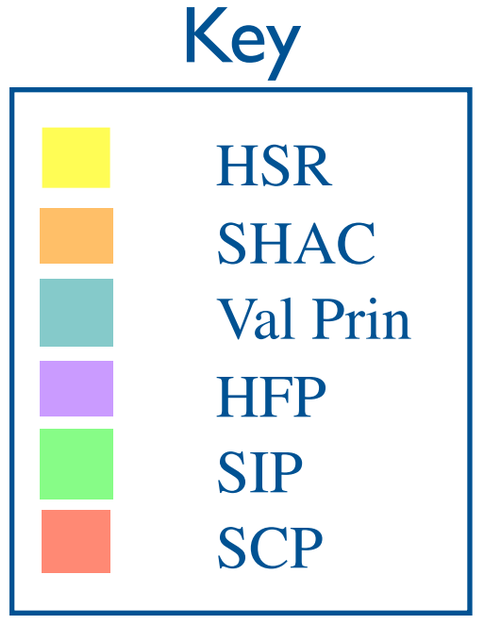
$$\begin{bmatrix} \textit{word} \\ \text{SYN} & \begin{bmatrix} \text{HEAD} & \boxed{6}\begin{bmatrix} \textit{noun} \\ \text{AGR} & \boxed{2}\begin{bmatrix} \textit{3sing} \\ \text{GEND} & \text{neut} \end{bmatrix} \end{bmatrix} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & \langle\ \boxed{7}\ \rangle \\ \text{COMPS} & \boxed{3}\langle\ \rangle \\ \text{MOD} & \boxed{4}\langle\ \rangle \end{bmatrix} \end{bmatrix} \\ \text{SEM} & \begin{bmatrix} \text{MODE} & \boxed{8}\text{ref} \\ \text{INDEX} & k \\ \text{RESTR} & \boxed{B}\left\langle \begin{bmatrix} \text{RELN} & \text{cat} \\ \text{INSTANCE} & k \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix}$$

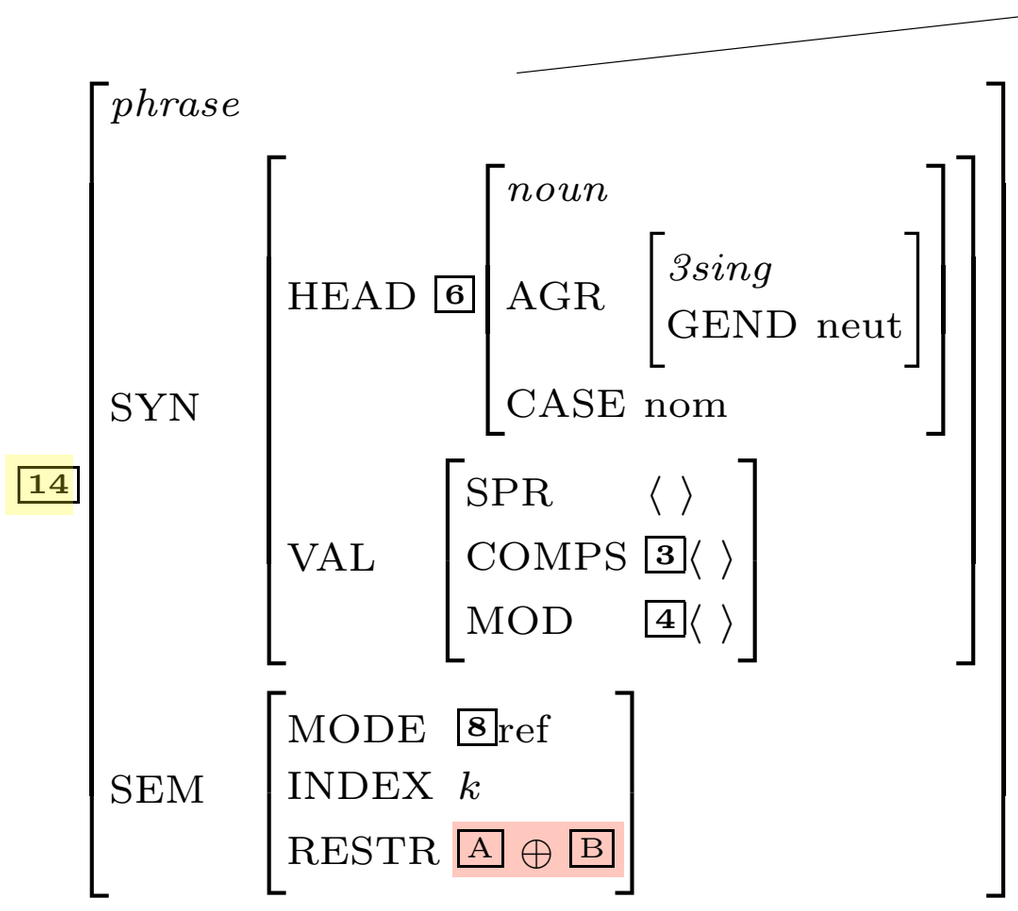
Lexical Entry for *slept*

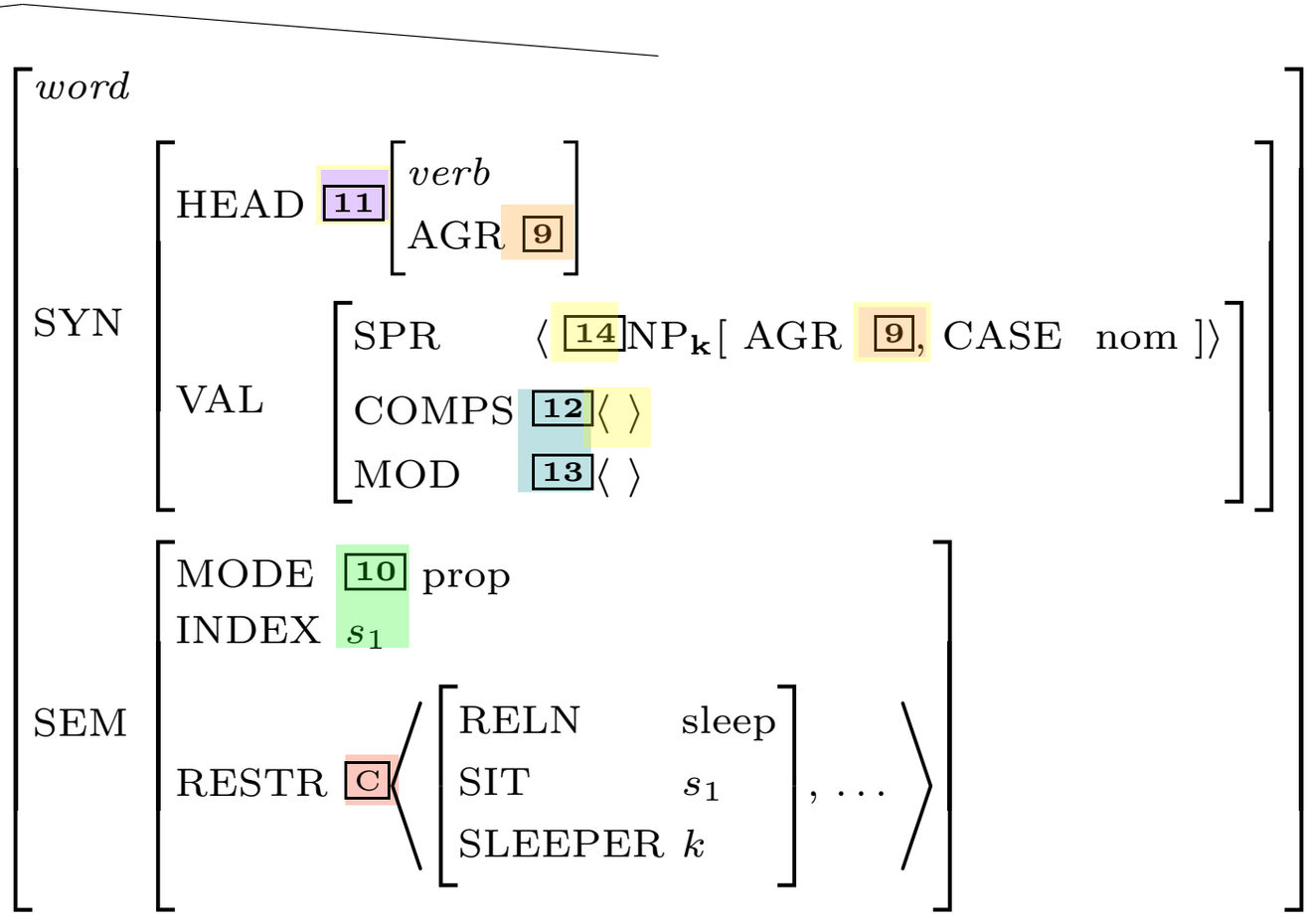
$$\left\langle \text{slept}, \left[\begin{array}{l} \textit{word} \\ \text{SYN} \left[\begin{array}{ll} \text{HEAD} & \textit{verb} \\ \text{VAL} & \left[\begin{array}{ll} \text{SPR} & \left\langle \left[\begin{array}{ll} \text{AGR} & \boxed{9} \\ \text{CASE} & \text{nom} \end{array}\right] \right\rangle_{\text{NP}_m} \\ \text{COMPS} & \langle\,\rangle \\ \text{MOD} & \langle\,\rangle \end{array}\right] \end{array}\right] \\ \text{SEM} \left[\begin{array}{ll} \text{INDEX} & s_1 \\ \text{MODE} & \text{prop} \\ \text{RESTR} & \left\langle \left[\begin{array}{ll} \text{RELN} & \text{sleep} \\ \text{SIT} & s_1 \\ \text{SLEEPER} & m \end{array}\right], \ldots \right\rangle \end{array}\right] \end{array}\right] \right\rangle$$

Another Head-Specifier Phrase









Is this description fully specified?

$$\left[\begin{array}{ll} \textit{phrase} & \\ \text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \boxed{11} \\ \text{VAL} & \left[\begin{array}{ll} \text{SPR} & \langle\,\rangle \\ \text{COMPS} & \boxed{12} \\ \text{MOD} & \boxed{13} \end{array}\right] \end{array}\right] \\ \text{SEM} & \left[\begin{array}{ll} \text{MODE} & \boxed{10}\ \text{prop} \\ \text{INDEX} & s_1 \\ \text{RESTR} & \boxed{\text{A}} \oplus \boxed{\text{B}} \oplus \boxed{\text{C}} \end{array}\right] \end{array}\right]$$

$$\boxed{14}\left[\begin{array}{ll} \textit{phrase} & \\ \text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \boxed{6}\left[\begin{array}{ll} \textit{noun} & \\ \text{AGR} & \left[\begin{array}{ll} \textit{3sing} & \\ \text{GEND} & \text{neut} \end{array}\right] \\ \text{CASE} & \text{nom} \end{array}\right] \\ \text{VAL} & \left[\begin{array}{ll} \text{SPR} & \langle\,\rangle \\ \text{COMPS} & \boxed{3}\langle\,\rangle \\ \text{MOD} & \boxed{4}\langle\,\rangle \end{array}\right] \end{array}\right] \\ \text{SEM} & \left[\begin{array}{ll} \text{MODE} & \boxed{8}\text{ref} \\ \text{INDEX} & k \\ \text{RESTR} & \boxed{\text{A}} \oplus \boxed{\text{B}} \end{array}\right] \end{array}\right]$$

$$\left[\begin{array}{ll} \textit{word} & \\ \text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \boxed{11}\left[\begin{array}{ll} \textit{verb} & \\ \text{AGR} & \boxed{9} \end{array}\right] \\ \text{VAL} & \left[\begin{array}{ll} \text{SPR} & \langle\,\boxed{14}\text{NP}_{\mathbf{k}}[\ \text{AGR}\ \boxed{9},\ \text{CASE}\ \ \text{nom}\ ]\rangle \\ \text{COMPS} & \boxed{12}\langle\,\rangle \\ \text{MOD} & \boxed{13}\langle\,\rangle \end{array}\right] \end{array}\right] \\ \text{SEM} & \left[\begin{array}{ll} \text{MODE} & \boxed{10}\ \text{prop} \\ \text{INDEX} & s_1 \\ \text{RESTR} & \boxed{\text{C}}\left\langle\left[\begin{array}{ll} \text{RELN} & \text{sleep} \\ \text{SIT} & s_1 \\ \text{SLEEPER} & k \end{array}\right], \ldots\right\rangle \end{array}\right] \end{array}\right]$$

Does the top node satisfy the initial symbol?

$$\left[\begin{array}{ll} \textit{phrase} & \\ \text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \boxed{11} \\ \text{VAL} & \left[\begin{array}{ll} \text{SPR} & \langle\,\rangle \\ \text{COMPS} & \boxed{12} \\ \text{MOD} & \boxed{13} \end{array}\right] \end{array}\right] \\ \text{SEM} & \left[\begin{array}{ll} \text{MODE} & \boxed{10}\ \text{prop} \\ \text{INDEX} & s_1 \\ \text{RESTR} & \boxed{\text{A}} \oplus \boxed{\text{B}} \oplus \boxed{\text{C}} \end{array}\right] \end{array}\right]$$

$$\boxed{14}\left[\begin{array}{ll} \textit{phrase} & \\ \text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \boxed{6}\left[\begin{array}{ll} \textit{noun} & \\ \text{AGR} & \left[\begin{array}{ll} \textit{3sing} & \\ \text{GEND} & \text{neut} \end{array}\right] \\ \text{CASE} & \text{nom} \end{array}\right] \\ \text{VAL} & \left[\begin{array}{ll} \text{SPR} & \langle\,\rangle \\ \text{COMPS} & \boxed{3}\langle\,\rangle \\ \text{MOD} & \boxed{4}\langle\,\rangle \end{array}\right] \end{array}\right] \\ \text{SEM} & \left[\begin{array}{ll} \text{MODE} & \boxed{8}\text{ref} \\ \text{INDEX} & k \\ \text{RESTR} & \boxed{\text{A}} \oplus \boxed{\text{B}} \end{array}\right] \end{array}\right]$$

$$\left[\begin{array}{ll} \textit{word} & \\ \text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \boxed{11}\left[\begin{array}{ll} \textit{verb} & \\ \text{AGR} & \boxed{9} \end{array}\right] \\ \text{VAL} & \left[\begin{array}{ll} \text{SPR} & \langle\,\boxed{14}\text{NP}_{\mathbf{k}}[\ \text{AGR}\ \boxed{9},\ \text{CASE}\ \ \text{nom}\ ]\rangle \\ \text{COMPS} & \boxed{12}\langle\,\rangle \\ \text{MOD} & \boxed{13}\langle\,\rangle \end{array}\right] \end{array}\right] \\ \text{SEM} & \left[\begin{array}{ll} \text{MODE} & \boxed{10}\ \text{prop} \\ \text{INDEX} & s_1 \\ \text{RESTR} & \boxed{\text{C}}\left\langle\left[\begin{array}{ll} \text{RELN} & \text{sleep} \\ \text{SIT} & s_1 \\ \text{SLEEPER} & k \end{array}\right], \ldots\right\rangle \end{array}\right] \end{array}\right]$$

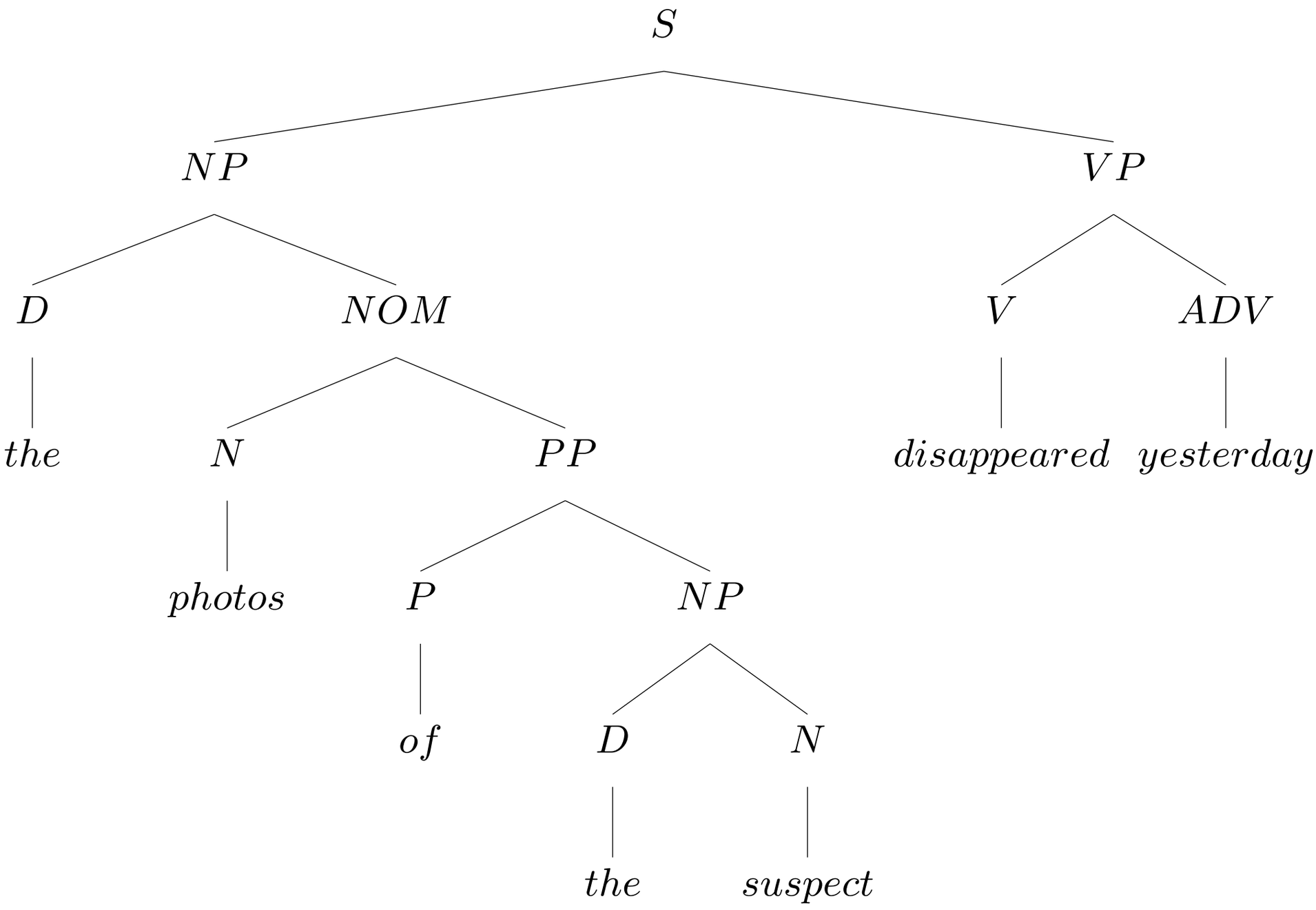
Initial Symbol (Ch 6 version)

$$\begin{bmatrix} \text{SYN} & \begin{bmatrix} \text{HEAD} & \textit{verb} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & \langle\ \rangle \\ \text{COMPS} & \langle\ \rangle \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

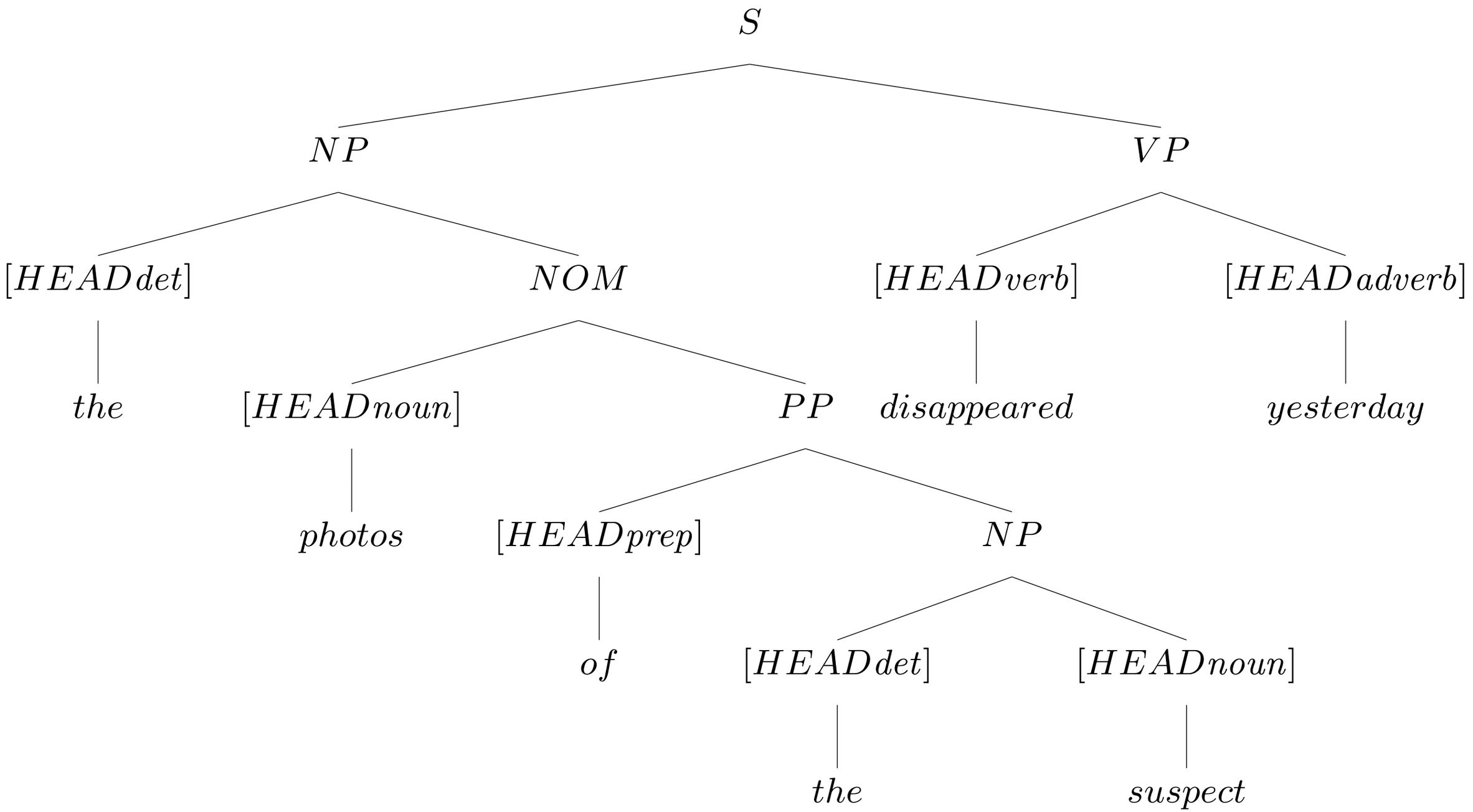
RESTR of the S node

$$\left\langle \begin{bmatrix} \text{RELN} & \text{a} \\ \text{BV} & k \end{bmatrix}, \begin{bmatrix} \text{RELN} & \text{cat} \\ \text{INST} & k \end{bmatrix}, \begin{bmatrix} \text{RELN} & \text{sleep} \\ \text{SIT} & s_1 \\ \text{SLEEPER} & k \end{bmatrix}, \ldots \right\rangle$$

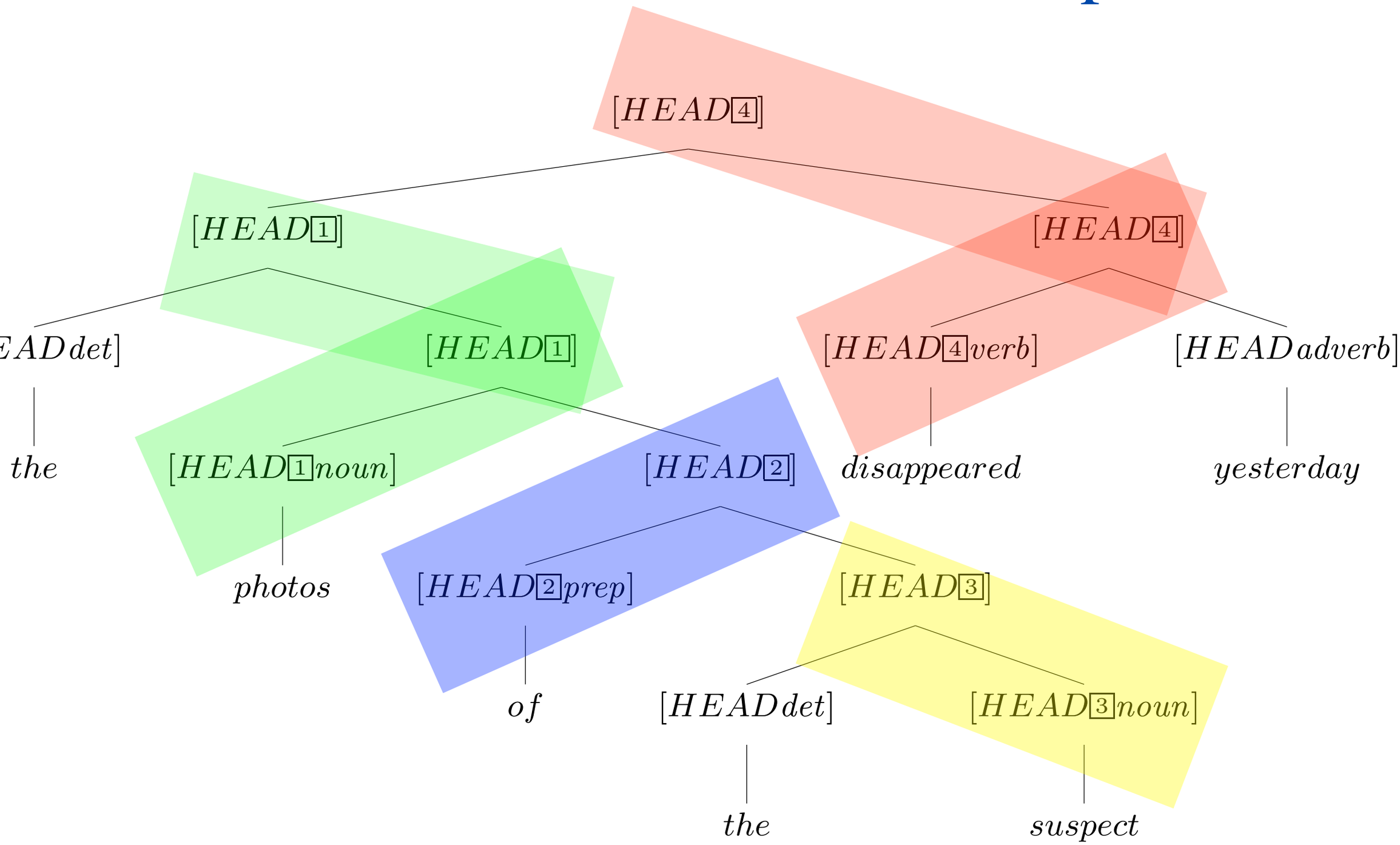
Another Example



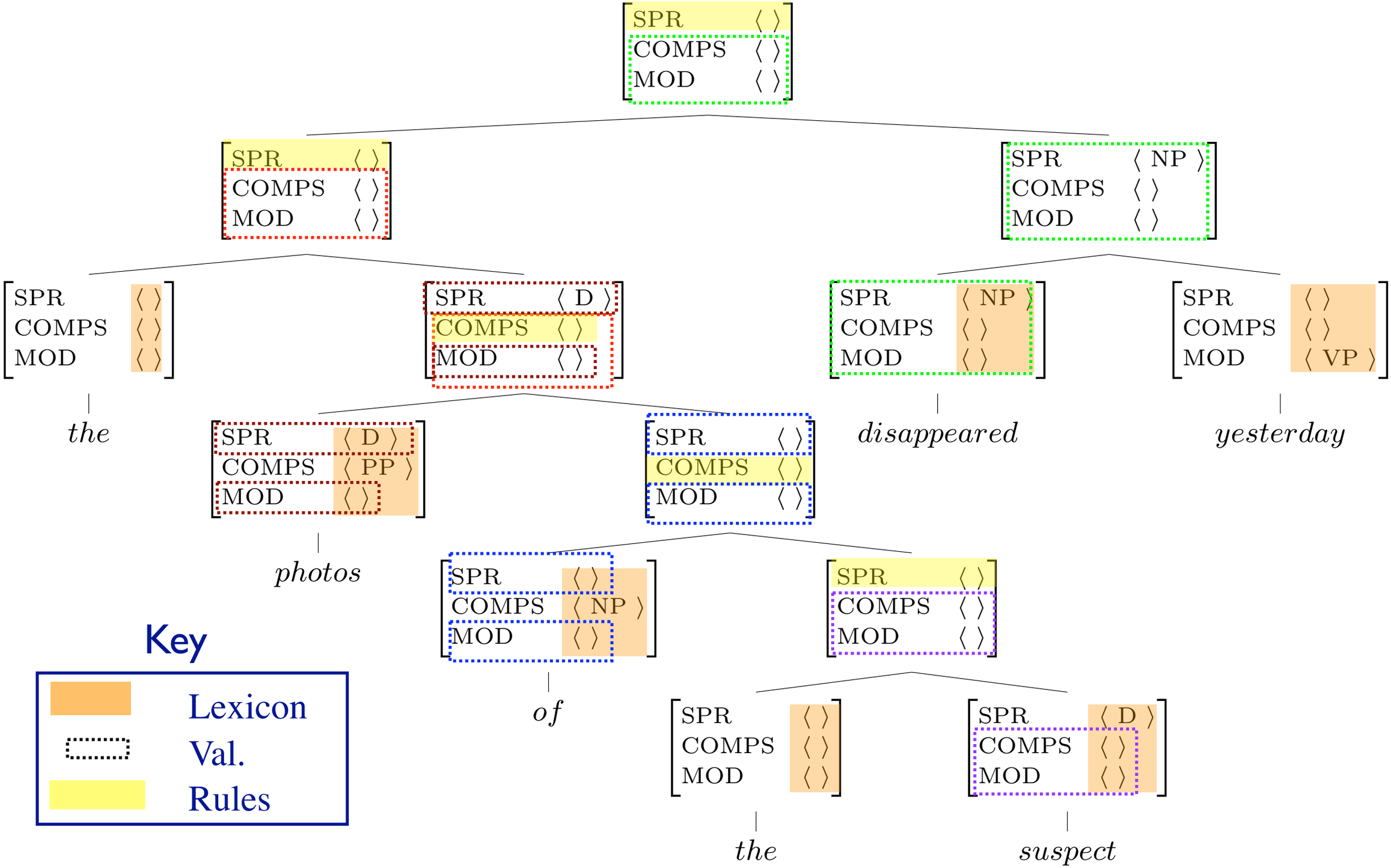
Head Features from Lexical Entries



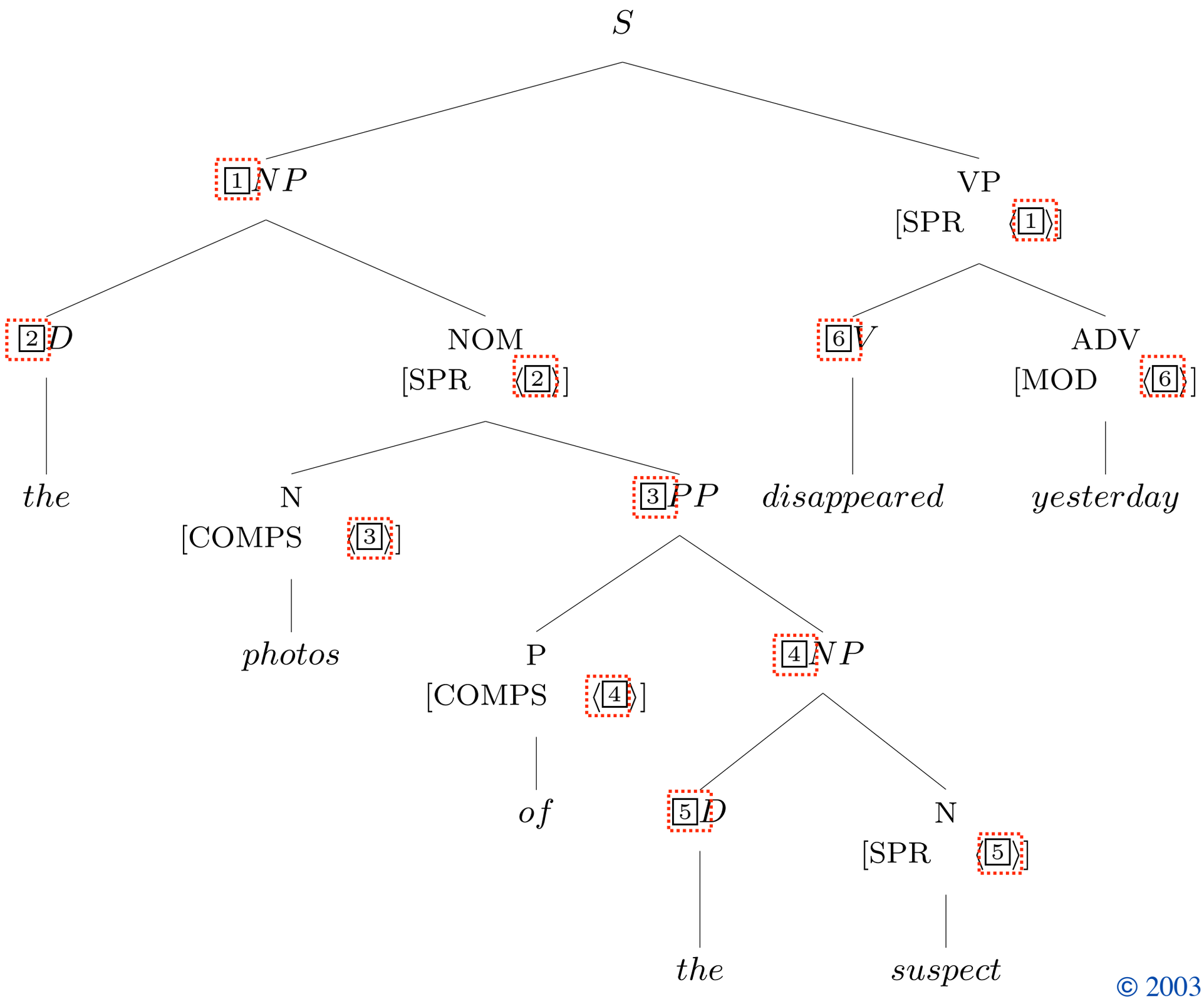
Head Features from Lexical Entries, plus HFP



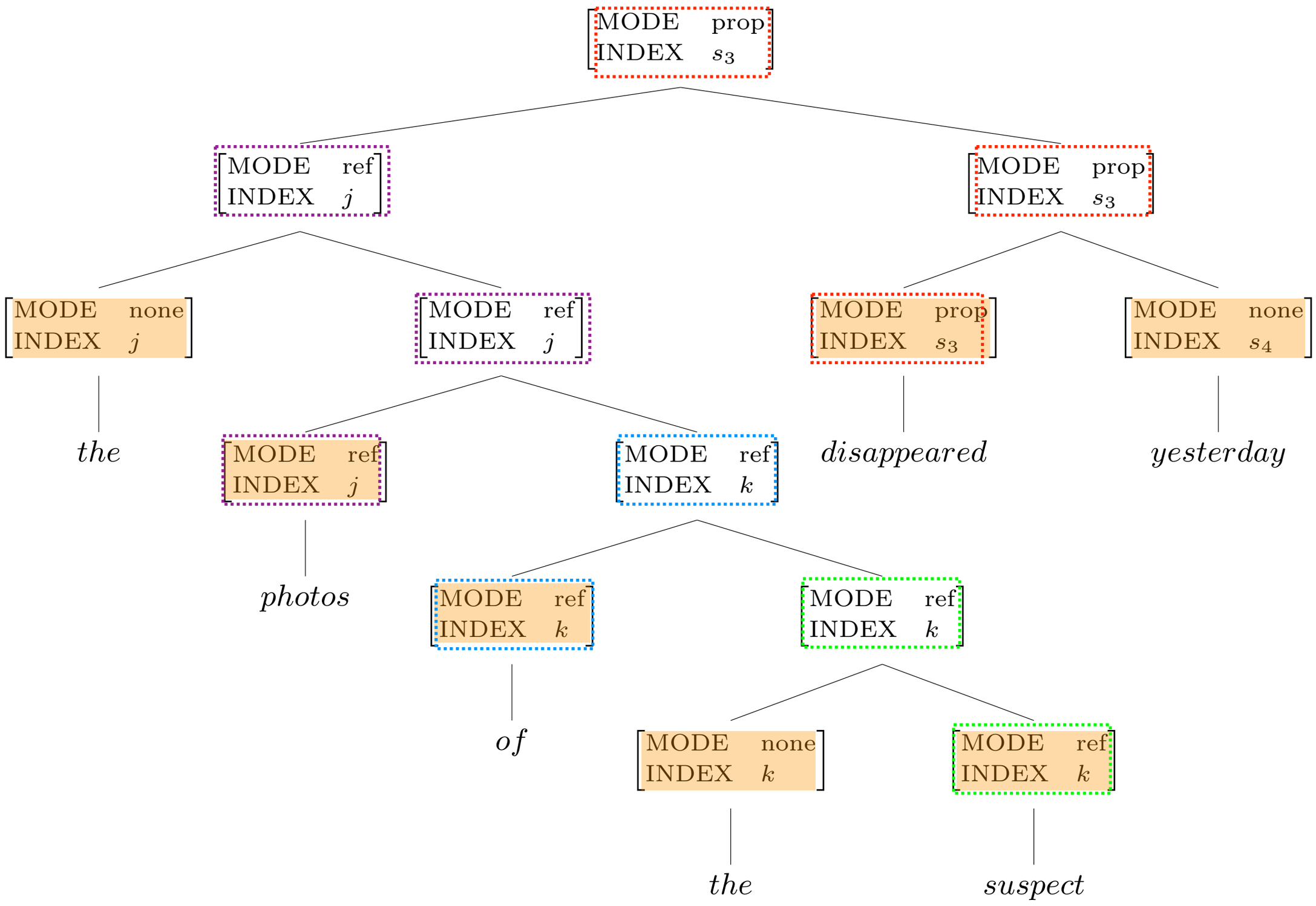
Valence Features: Lexicon, Rules, and the Valence Principle



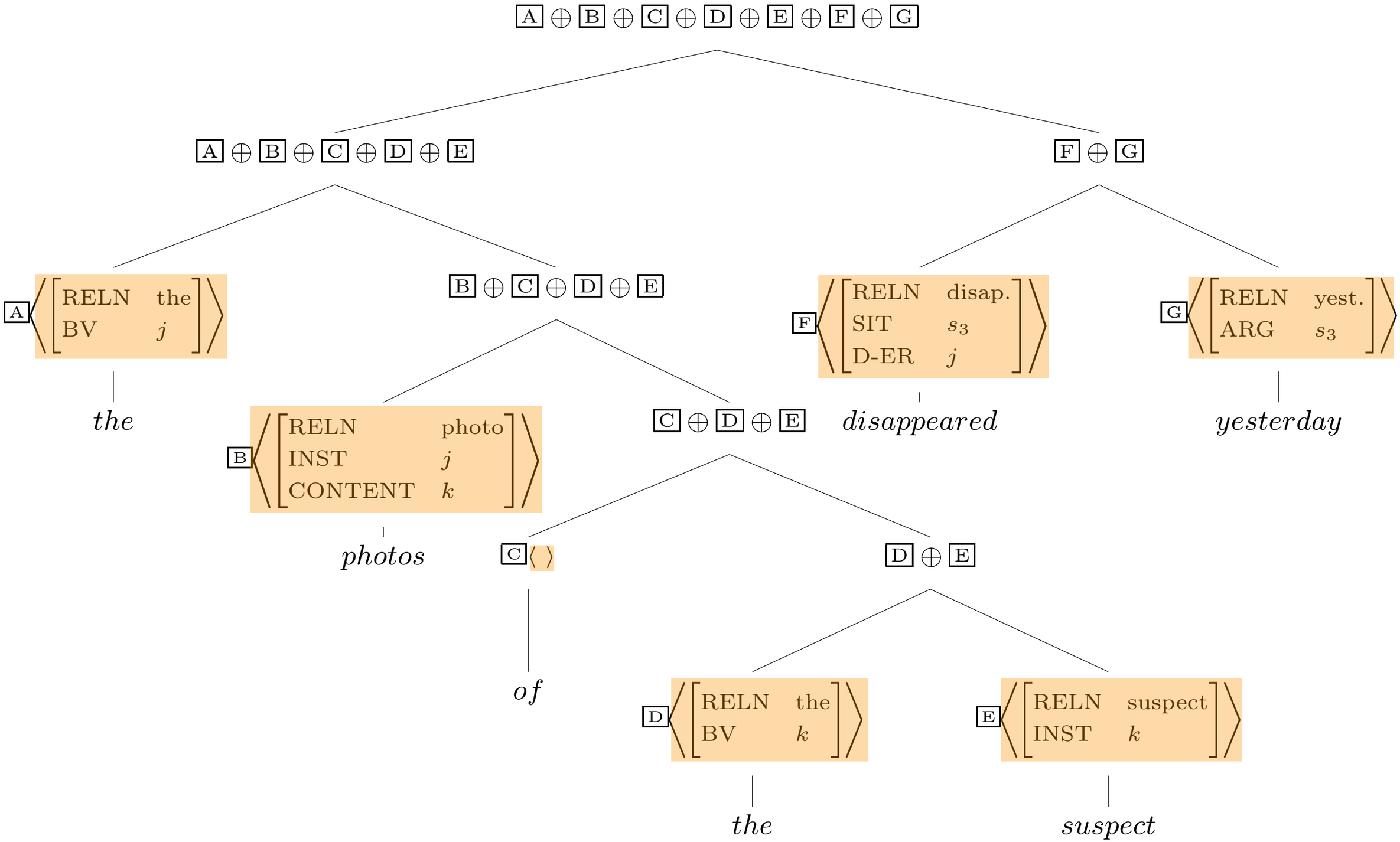
Required Identities: Grammar Rules



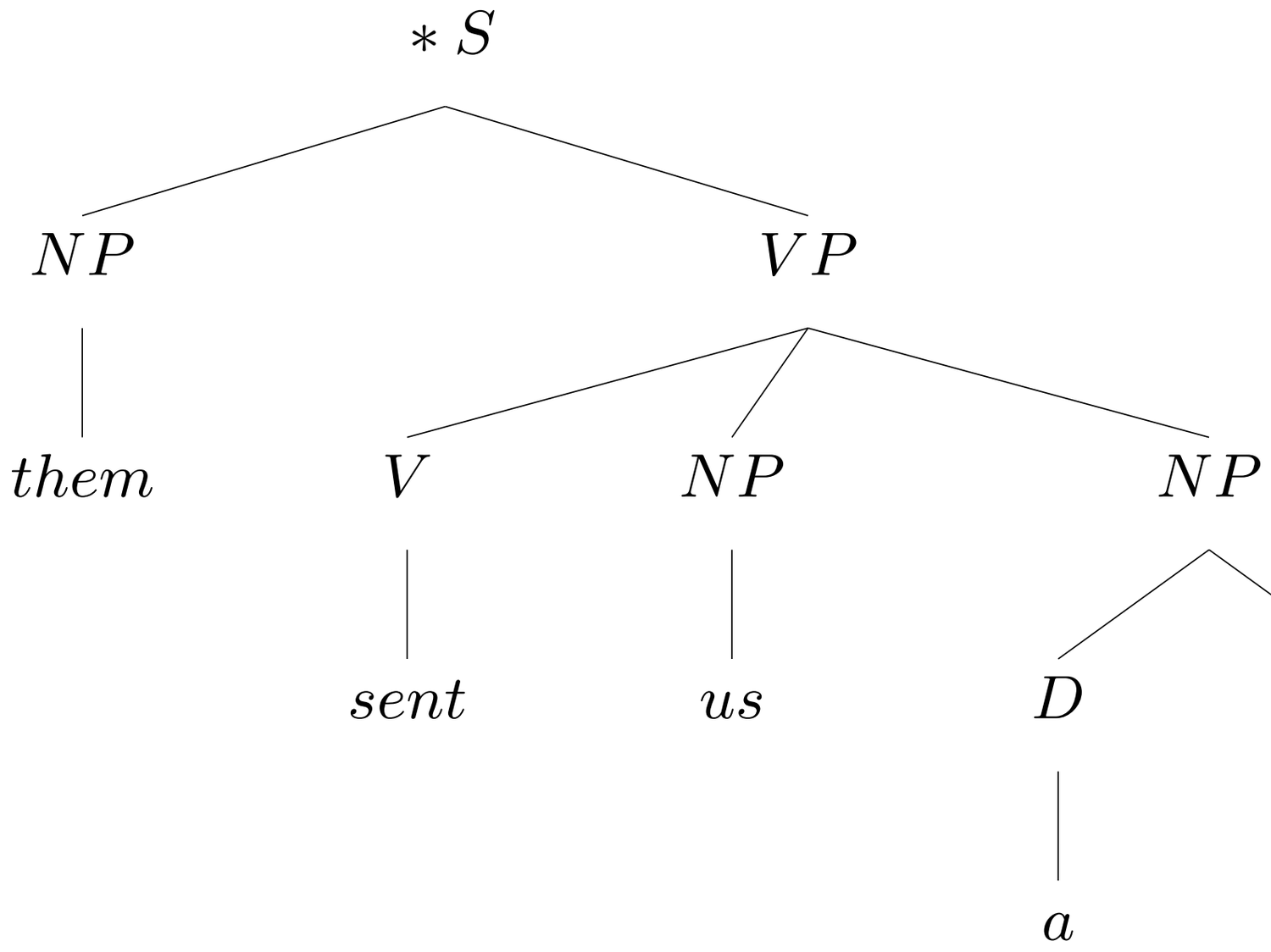
Two Semantic Features: the Lexicon & SIP



RESTR Values and the SCP

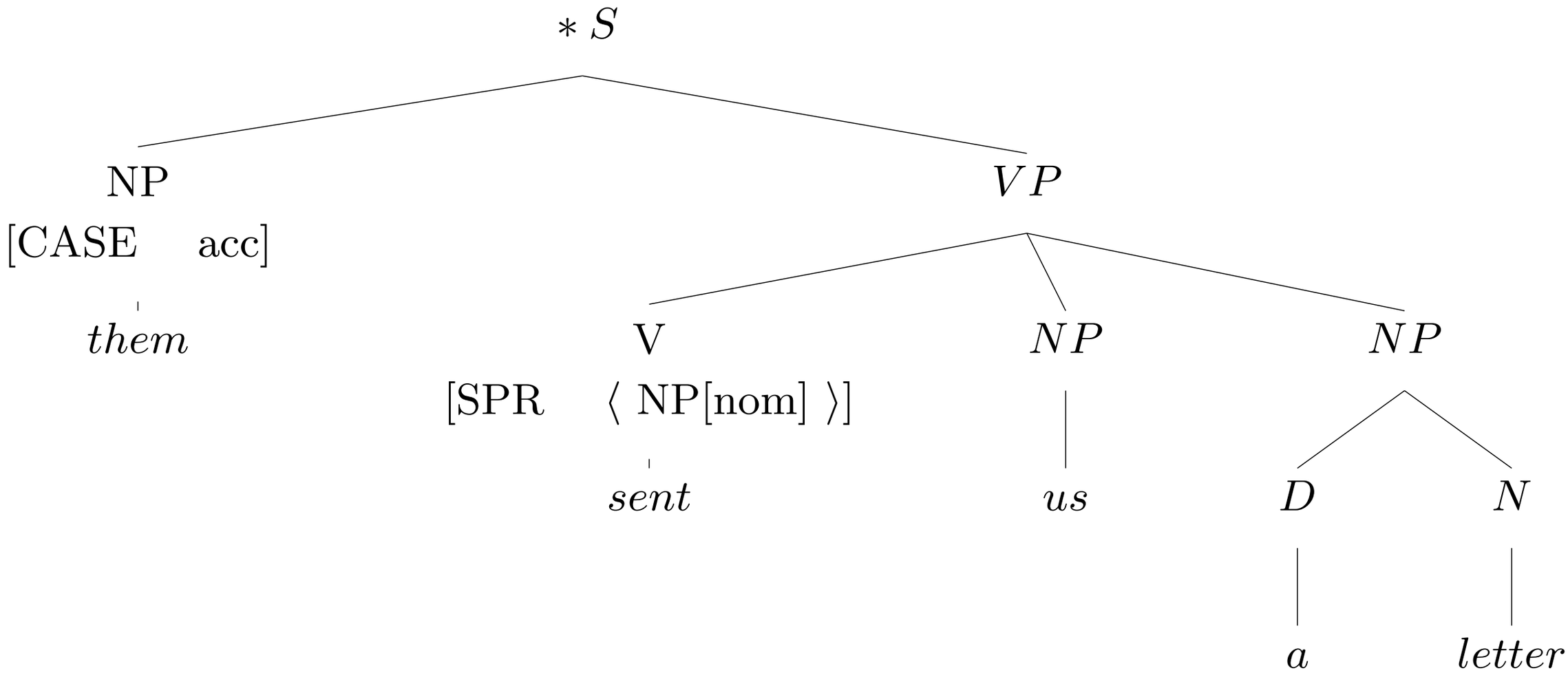


An Ungrammatical Example



What's wrong with this sentence?

An Ungrammatical Example

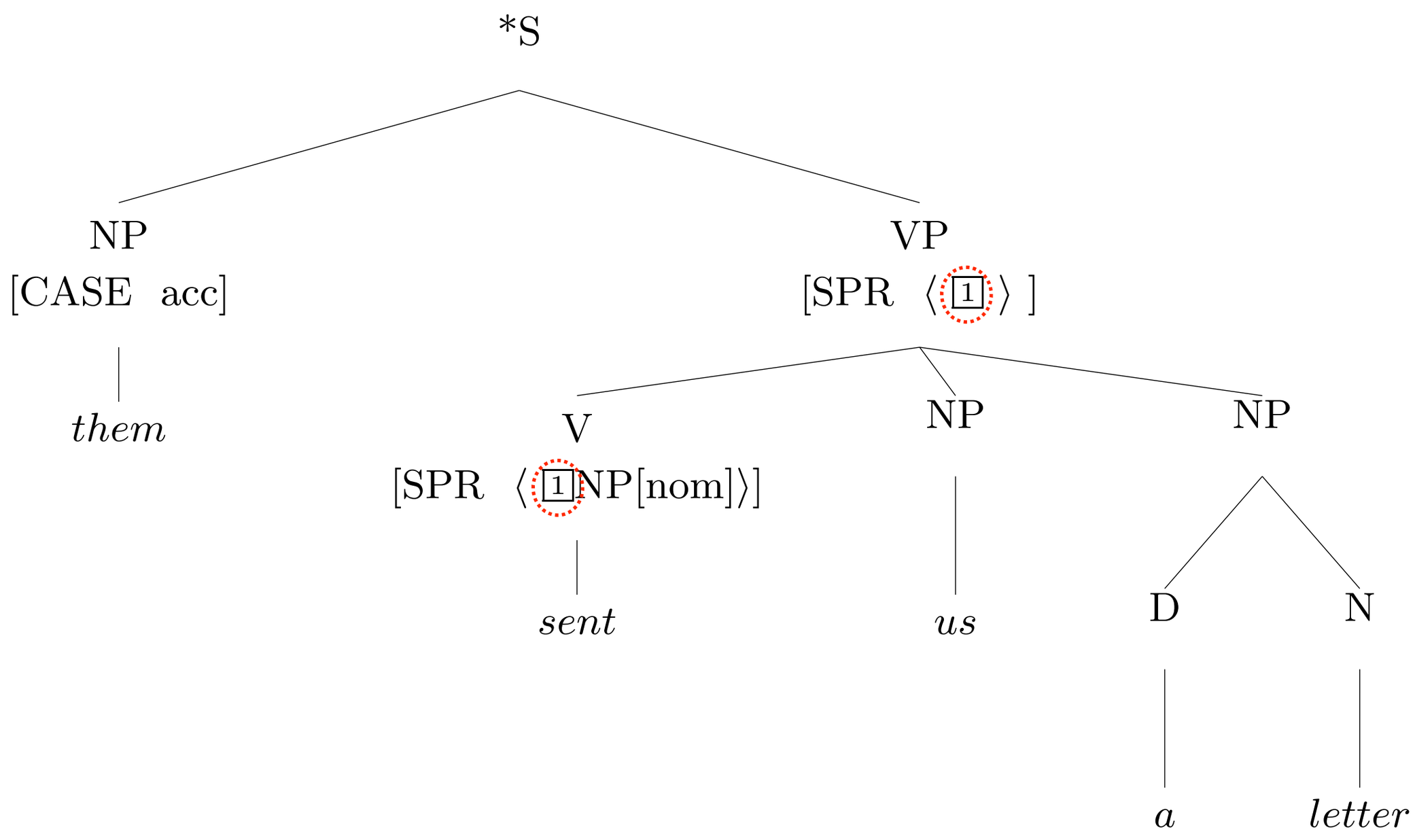


What's wrong with this sentence?

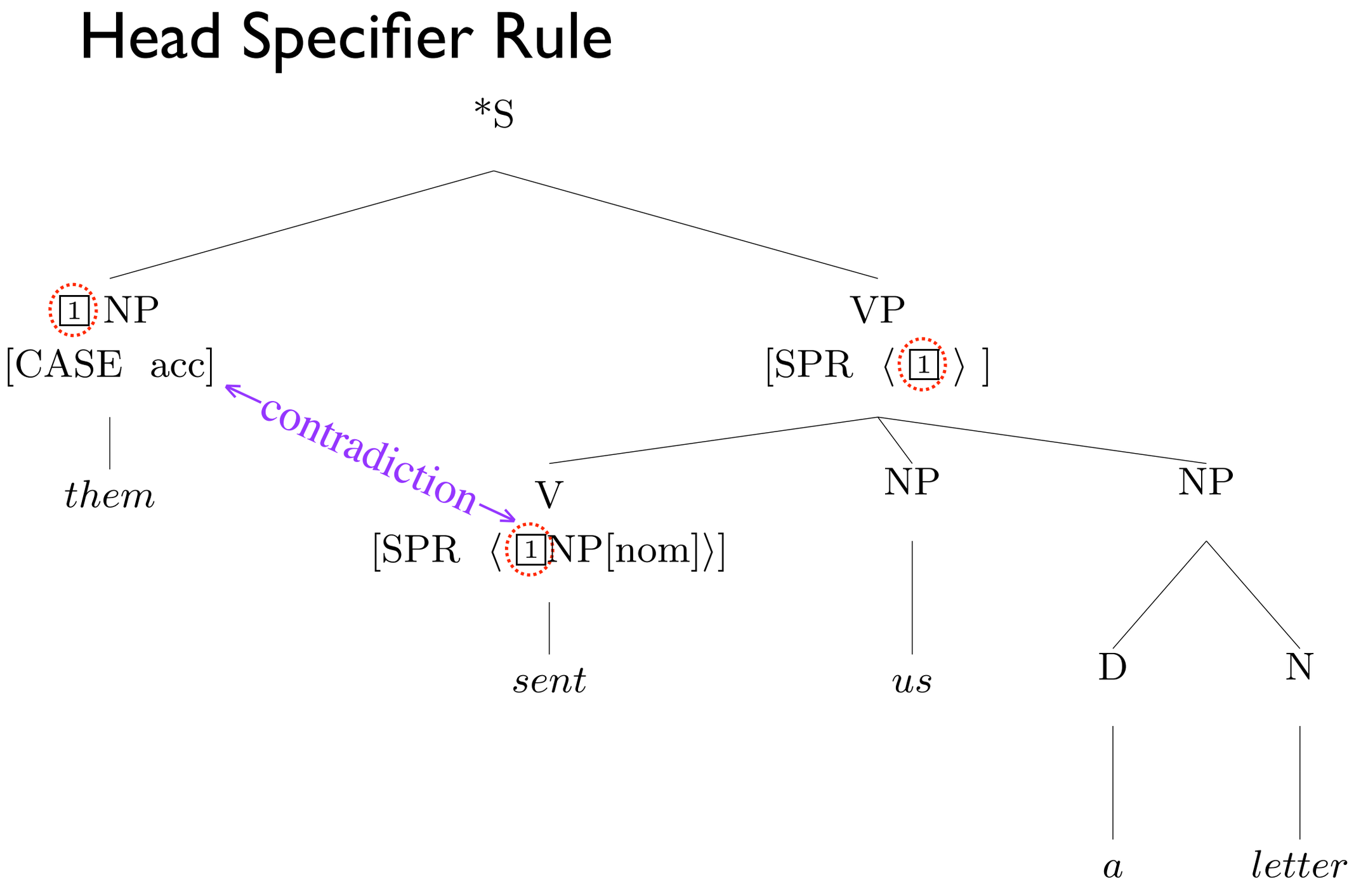
So what?

An Ungrammatical Example

The Valence Principle



An Ungrammatical Example



Exercise in Critical Thinking

- Our grammar has come a long way since Ch 2, as we've added ways of representing different kinds of information:
  - generalizations across categories
  - semantics
  - particular linguistic phenomena: valence, agreement, modification
- What else might we add? What facts about language are as yet unrepresented in our model?

Overview

- What we're trying to do
- The pieces of our grammar
- Two extended examples
- Reflection on what we've done, what we still have to do
- Next time: Review