

A decorative border in the top-left corner of the slide, composed of a grid of small orange squares and rectangles, creating a geometric pattern.

Ling 566

Oct 15, 2024

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

Why does this matter to NLP?

- Understand how language works => better positioned to build technology that works with language
- For some applications, grammar engineering is a valuable component directly
- Grammar engineering can also support extremely detailed annotation

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?

The Definition of Well-Formed Structures

(39) **Well-Formed Tree Structure:**

Φ is a Well-Formed Tree Structure according to G if and only if:

1. Φ is a tree structure,
2. the label of Φ 's root node satisfies S ,¹⁷ and
3. each local subtree within Φ is either phrasally licensed or lexically licensed.

(40) **Lexical Licensing:**

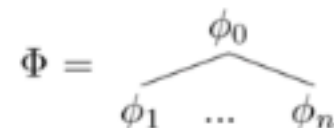
A word structure of the form:



is licensed if and only if G contains a lexical entry $\langle d_1, d_2 \rangle$, where ω satisfies d_1 and ϕ satisfies d_2 .

(41) **Phrasal Licensing:**

A grammar rule $\rho = d_0 \rightarrow d_1 \dots d_n$ licenses a local subtree:



if and only if:

1. for each $i, 0 \leq i \leq n$, ϕ_i is of¹⁸ the type *expression*,
2. there is some assignment function g under which the sequence $\langle \phi_0, \phi_1, \dots, \phi_n \rangle$ satisfies the description sequence $\langle d_0, d_1, \dots, d_n \rangle$,¹⁹
3. Φ satisfies the Semantic Compositionality Principle, and
4. if ρ is a headed rule, then Φ satisfies the Head Feature Principle, the Valence Principle and the Semantic Inheritance Principle, with respect to ρ .

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*

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

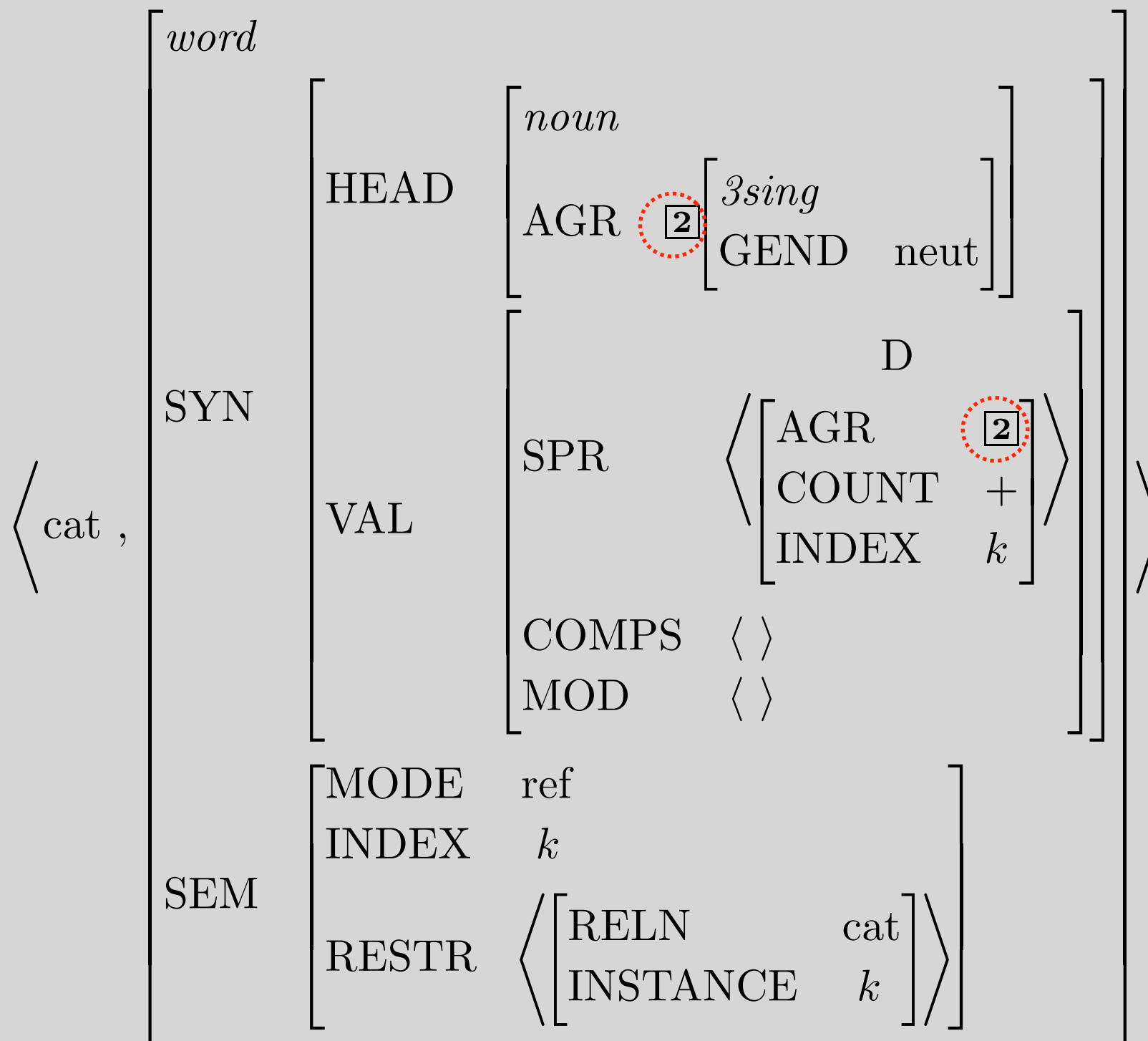
- Is this a fully specified (resolved) description?
- What features are unspecified?
- How many word structures can this entry license?

Lexical Entry for *cat*

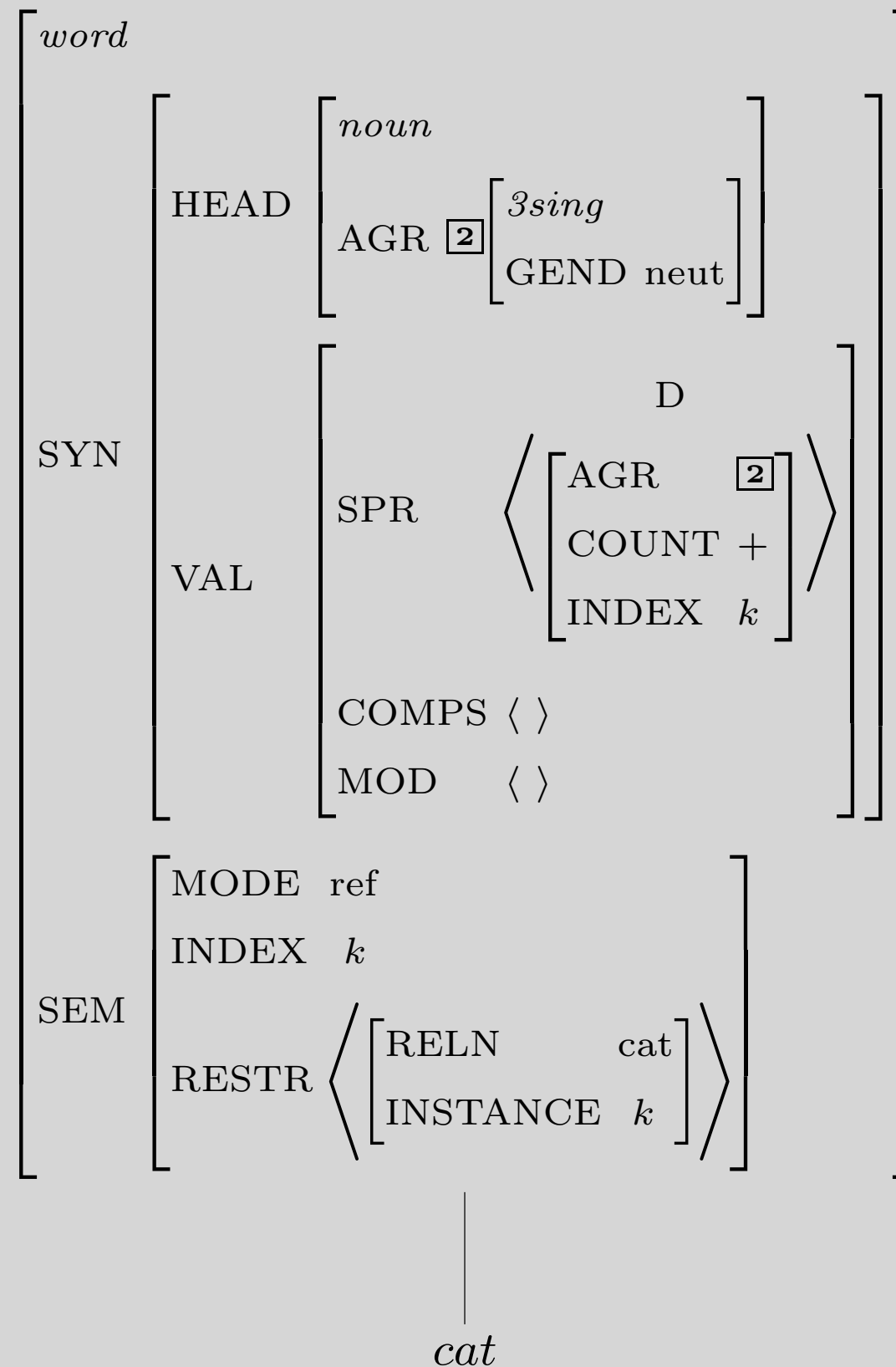
$\langle \text{cat} ,$	$\left[\begin{array}{c} \text{word} \\ \\ \end{array} \right]$	
	SYN	$\left[\begin{array}{c} \text{HEAD} \left[\begin{array}{c} \text{noun} \\ \text{AGR} \left[\begin{array}{c} 3\text{sing} \\ \text{GEND} \quad \text{neut} \end{array} \end{array} \right] \end{array} \right]$ $\text{VAL}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

- 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



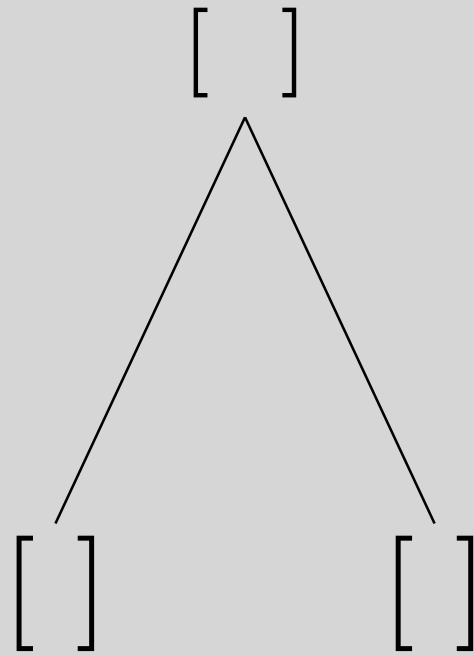
Description of Word Structures for *cat*



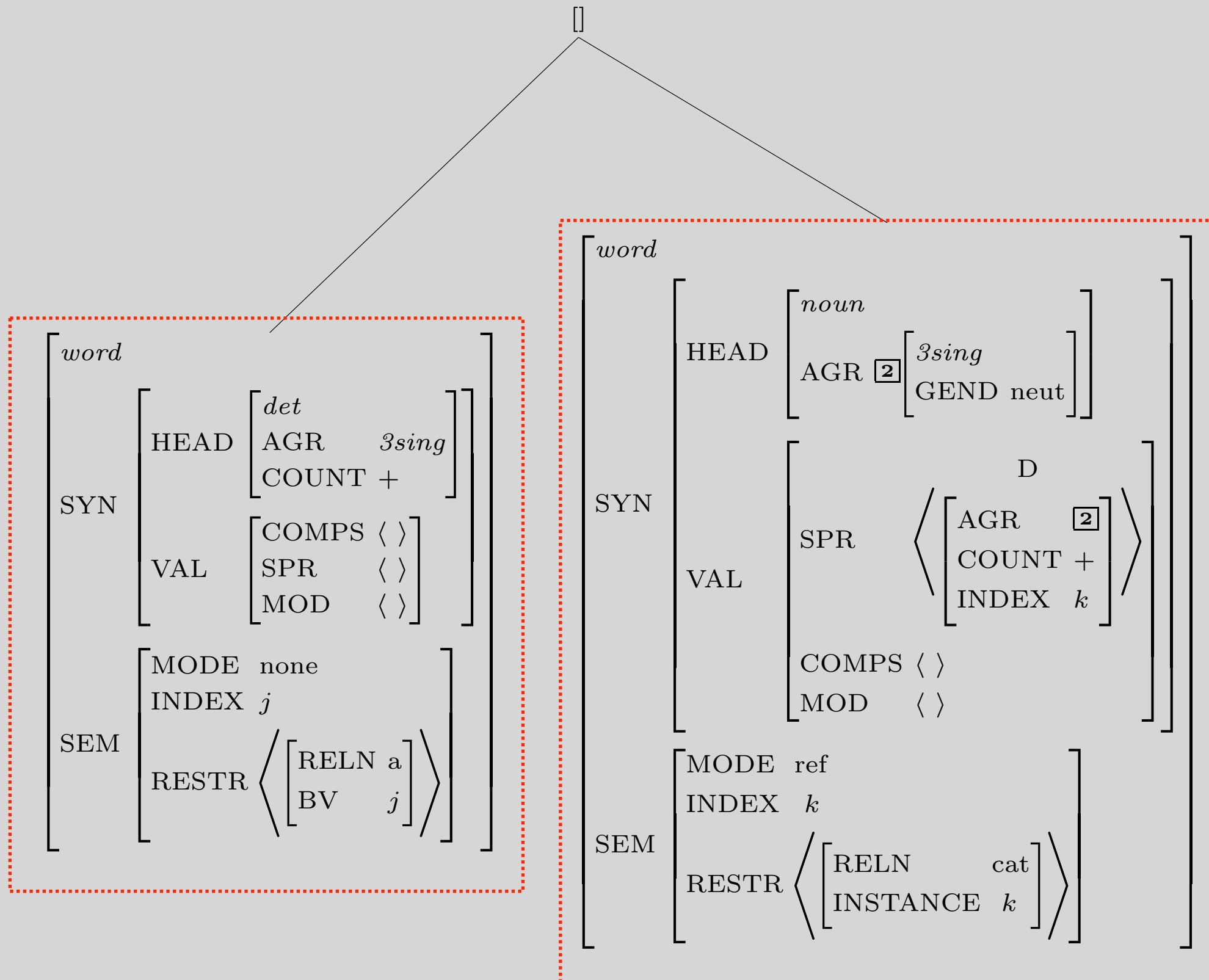
Description of Word Structures for a

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

Building a Phrase



Constraints Contributed by Daughter Subtrees



Constraints Contributed by the Grammar Rule

(56) Head-Specifier Rule

$$\left[\begin{array}{c} \textit{phrase} \\ \text{SYN} \left[\text{VAL} \left[\text{SPR} \langle \rangle \rangle \right] \right] \end{array} \right] \rightarrow \boxed{7} \text{ H} \left[\text{SYN} \left[\text{VAL} \left[\begin{array}{c} \text{SPR} \langle \boxed{7} \rangle \\ \text{COMPS} \langle \rangle \end{array} \right] \right] \right]$$

A phrase can consist of a (lexical or phrasal) head preceded by its specifier.

$$\left[\begin{array}{c} \textit{phrase} \\ \text{SYN} \left[\text{VAL} \left[\text{SPR} \langle \rangle \rangle \right] \right] \end{array} \right]$$

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

$$\left[\begin{array}{c} \textit{word} \\ \text{SYN} \left[\begin{array}{c} \text{HEAD} \left[\begin{array}{c} \textit{noun} \\ \text{AGR} \left[\begin{array}{c} 3\textit{sing} \\ \text{GEND neut} \end{array} \right] \end{array} \right] \\ \text{VAL} \left[\begin{array}{c} \text{SPR} \left\langle \left[\begin{array}{c} \boxed{7} \text{D} \\ \text{COUNT} + \\ \text{INDEX } k \end{array} \right] \right\rangle \\ \text{COMPS} \langle \rangle \\ \text{MOD} \langle \rangle \end{array} \right] \\ \text{SEM} \left[\begin{array}{c} \text{MODE ref} \\ \text{INDEX } k \\ \text{RESTR} \left\langle \left[\begin{array}{c} \text{RELN cat} \\ \text{INSTANCE } k \end{array} \right] \right\rangle \end{array} \right] \end{array} \right]$$

A Constraint Involving the SHAC

(62) Specifier-Head Agreement Constraint (SHAC)
Verbs and common nouns must be specified as:

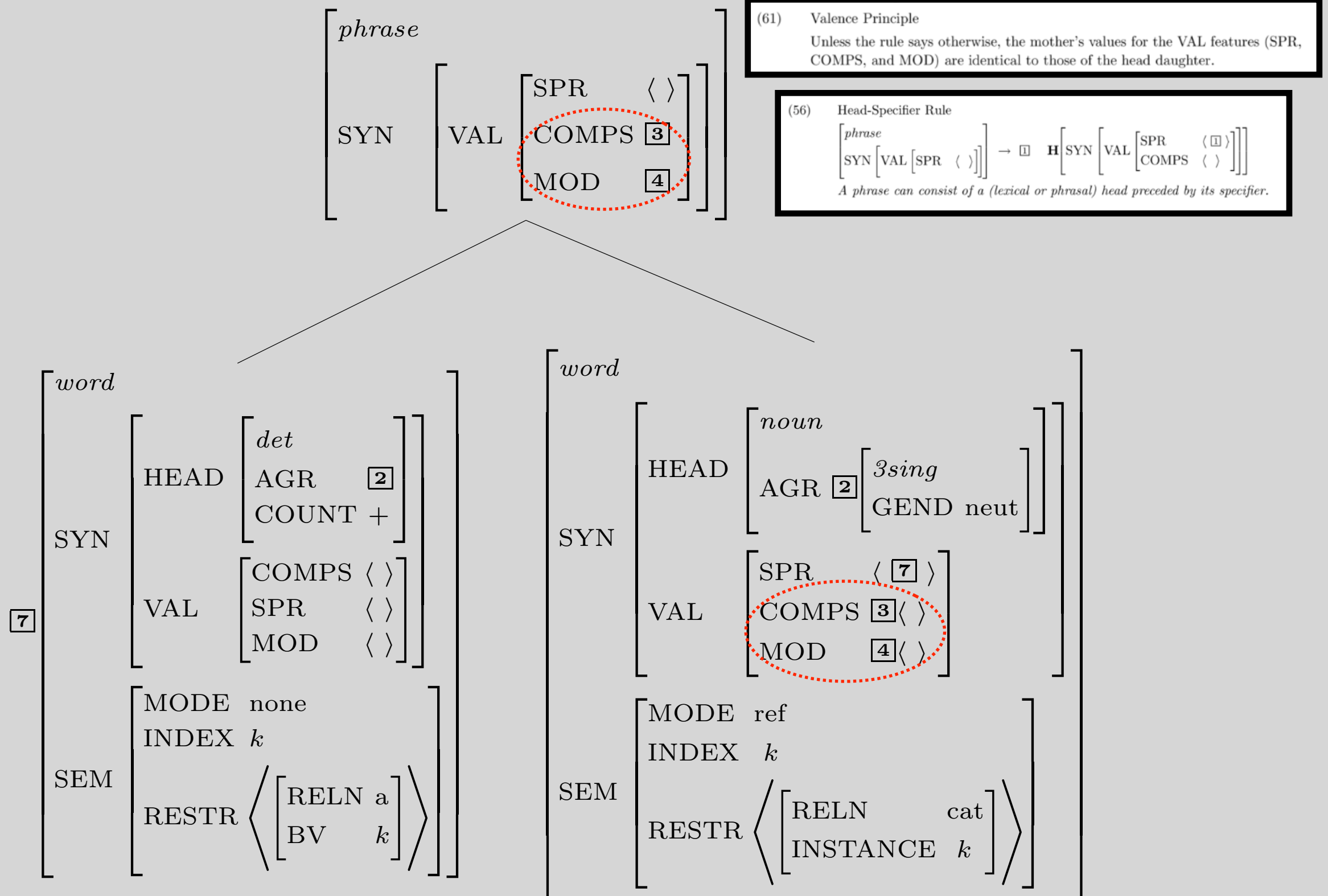
$$\left[\begin{array}{c} \text{HEAD} \left[\text{AGR } \boxed{1} \right] \\ \text{VAL} \left[\text{SPR } \langle \left[\text{AGR } \boxed{1} \right] \rangle \right] \end{array} \right]$$

$$\left[\begin{array}{c} \text{phrase} \\ \text{SYN } [\text{VAL } [\text{SPR } \langle \rangle]] \end{array} \right]$$

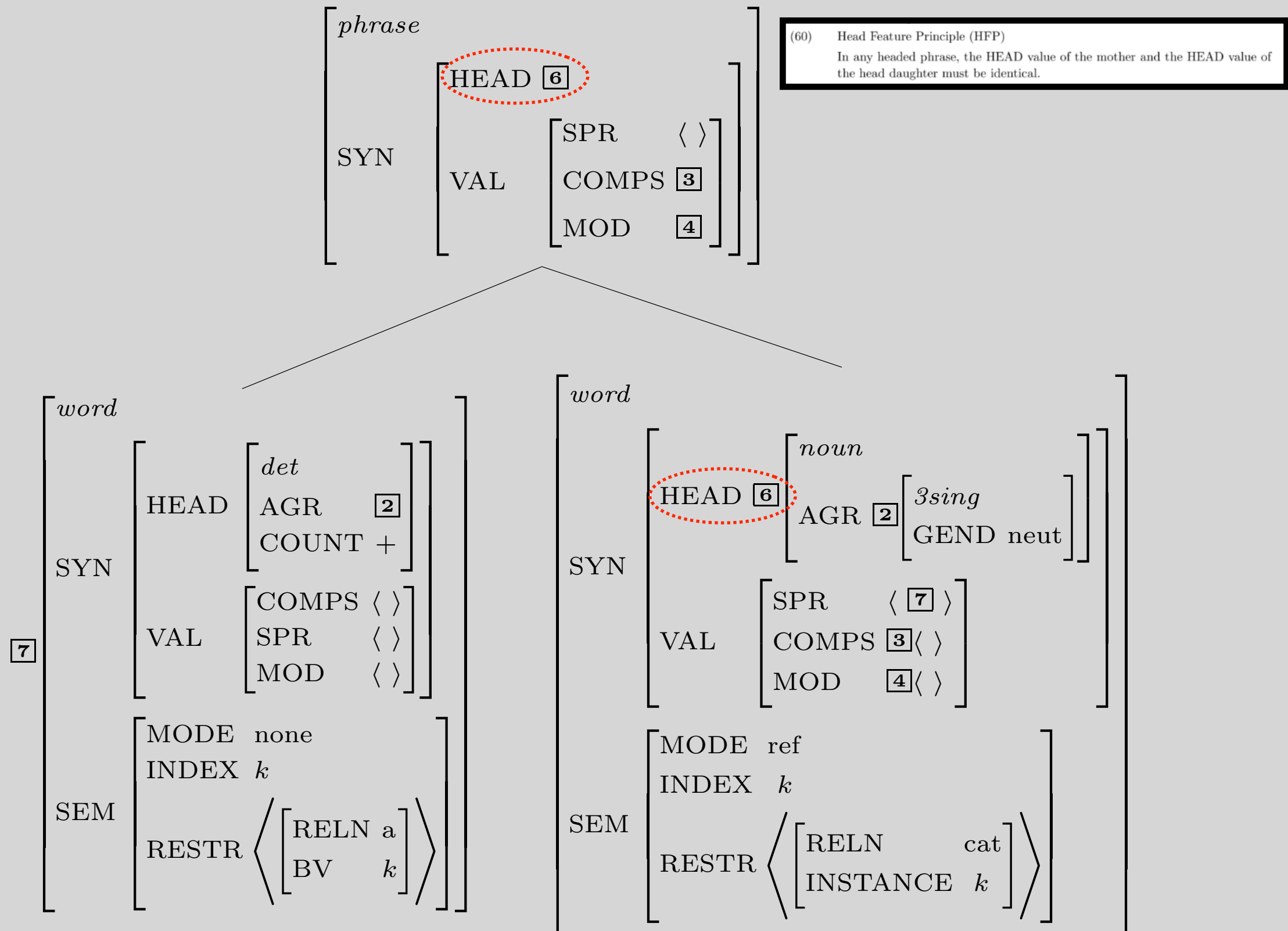
$$\boxed{7} \left[\begin{array}{c} \text{word} \\ \text{SYN} \left[\begin{array}{c} \text{HEAD} \left[\begin{array}{c} \text{det} \\ \text{AGR } \left[\begin{array}{c} 3\text{sing} \\ \text{GEND neut} \end{array} \right] \\ \text{COUNT } + \end{array} \right] \\ \text{VAL} \left[\begin{array}{c} \text{COMPS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

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

Effects of the Valence Principle

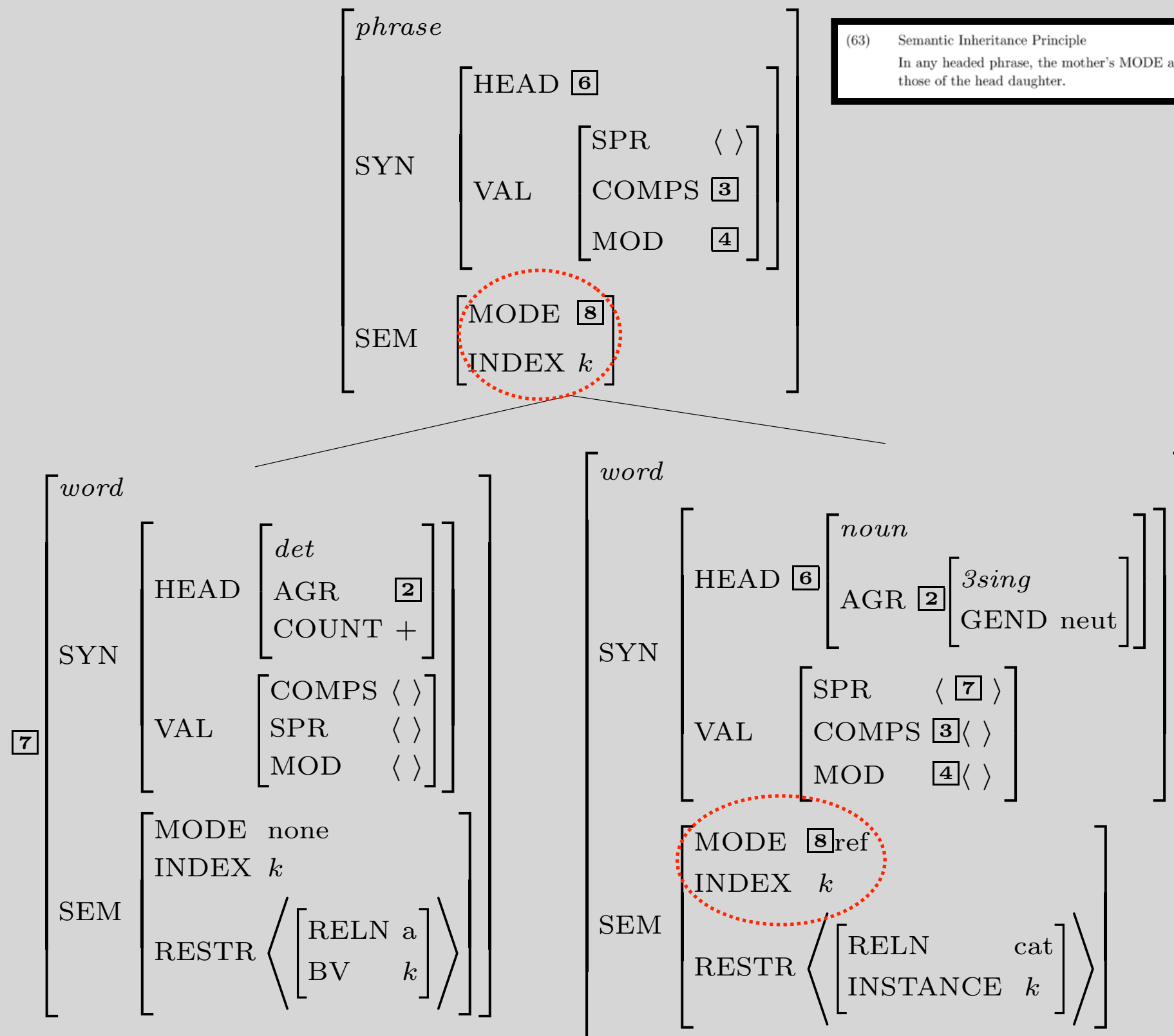


Effects of the Head Feature Principle



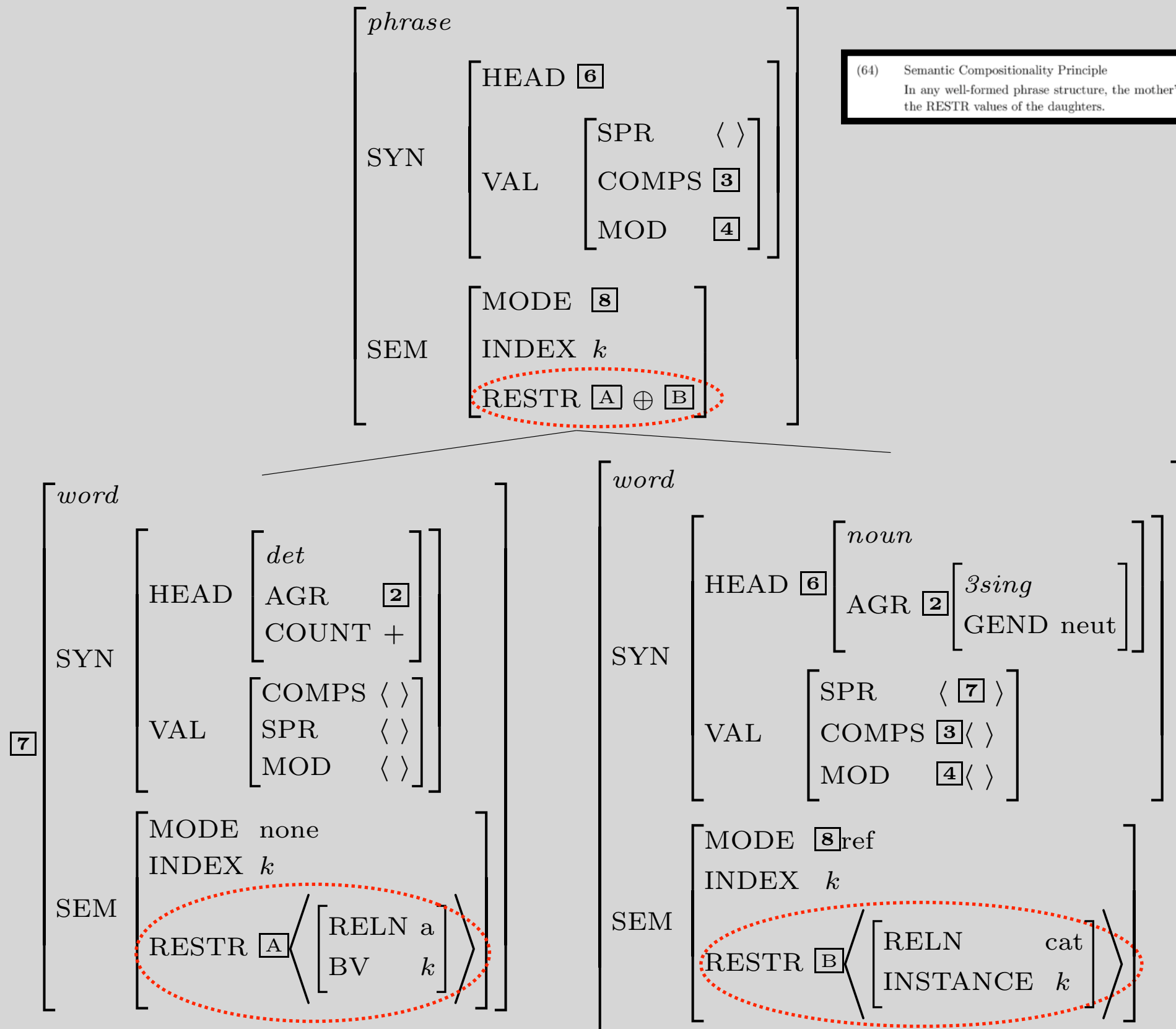
Effects of the Semantic Inheritance Principle

(63) Semantic Inheritance Principle
In any headed phrase, the mother's MODE and INDEX values are identical to those of the head daughter.

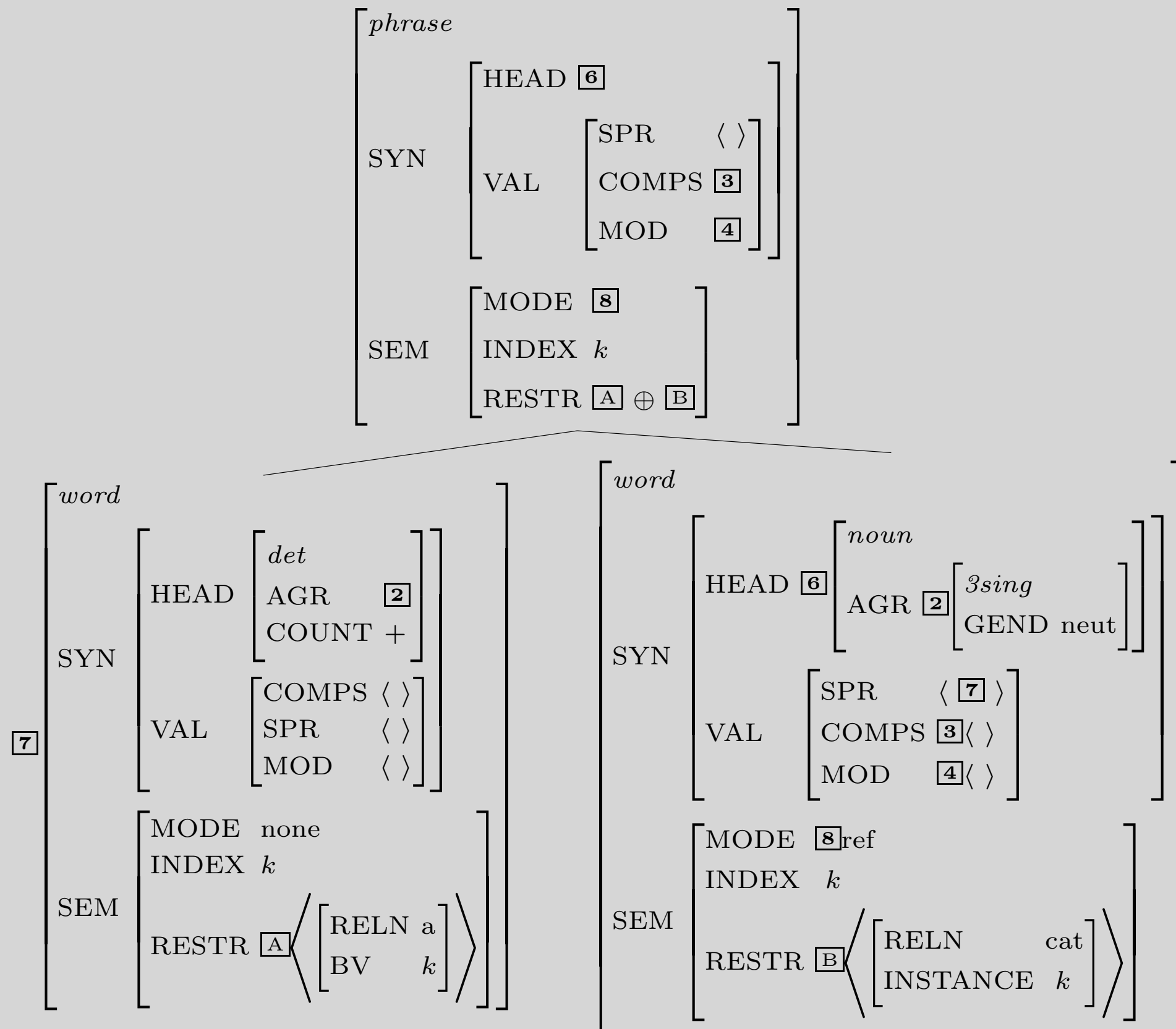


Effects of the Semantic Compositionality Principle

(64) Semantic Compositionality Principle
In any well-formed phrase structure, the mother's RESTR value is the sum of the RESTR values of the daughters.



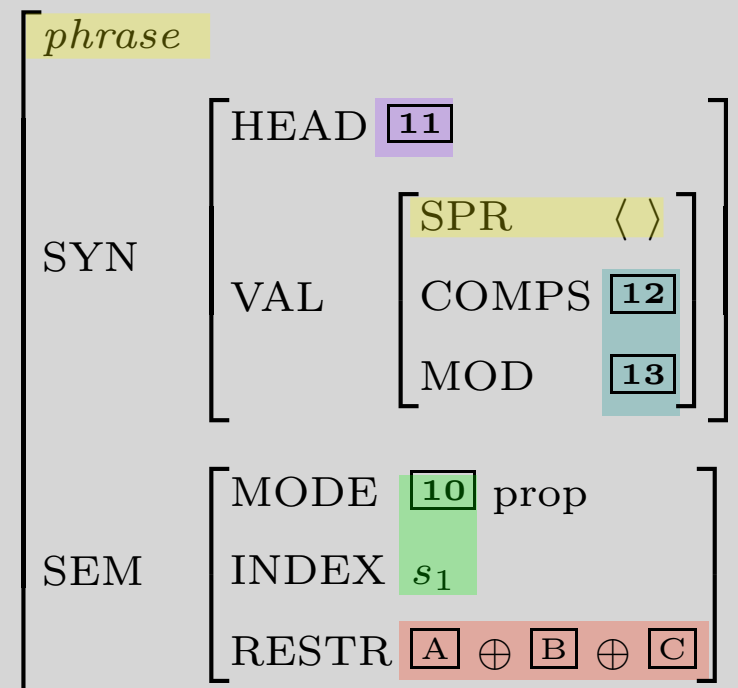
Is the Mother Node Now Completely Specified?



Lexical Entry for *slept*

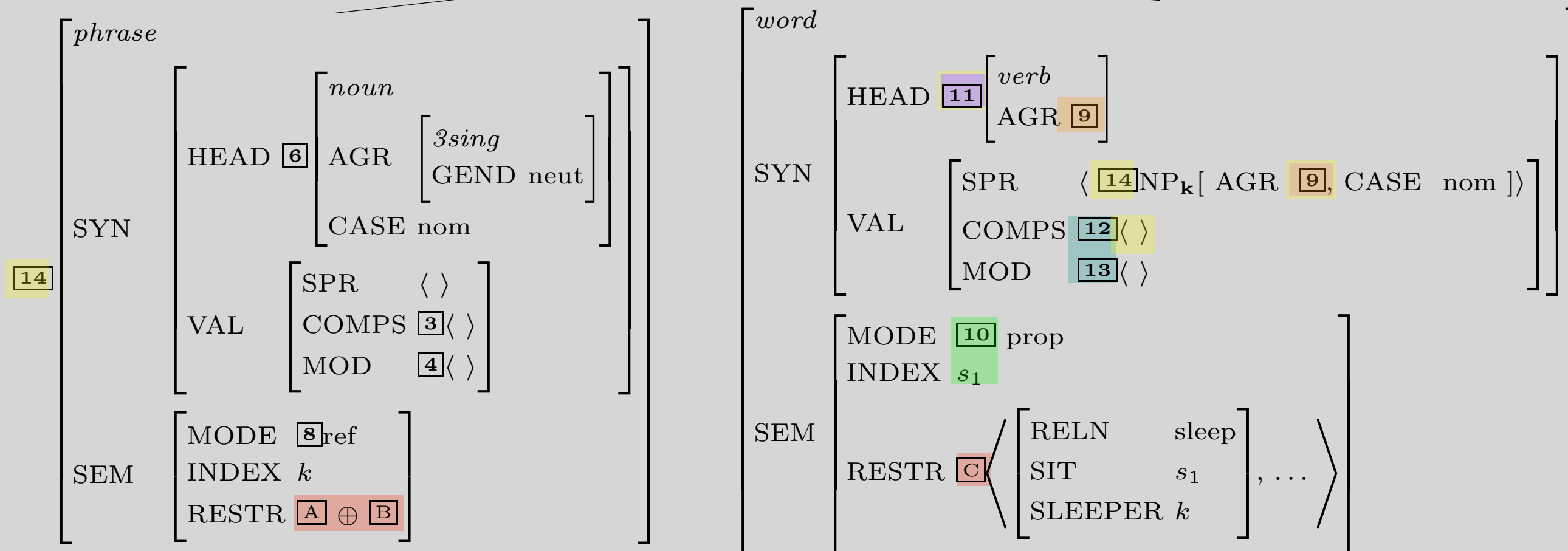
$\langle$ slept, $\rangle$	<i>word</i>			
	SYN	HEAD	<i>verb</i>	
		VAL	SPR	$\langle$ $\left[\begin{array}{cc} \text{AGR} & \boxed{9} \\ \text{CASE} & \text{nom} \end{array} \right] \rangle$
			COMPS	$\langle \rangle$
			MOD	$\langle \rangle$
	SEM	INDEX	s_1	
		MODE	prop	
		RESTR	$\langle$ $\left[\begin{array}{cc} \text{RELN} & \text{sleep} \\ \text{SIT} & s_1 \\ \text{SLEEPER} & m \end{array} \right], \dots \rangle$	

Another Head-Specifier Phrase

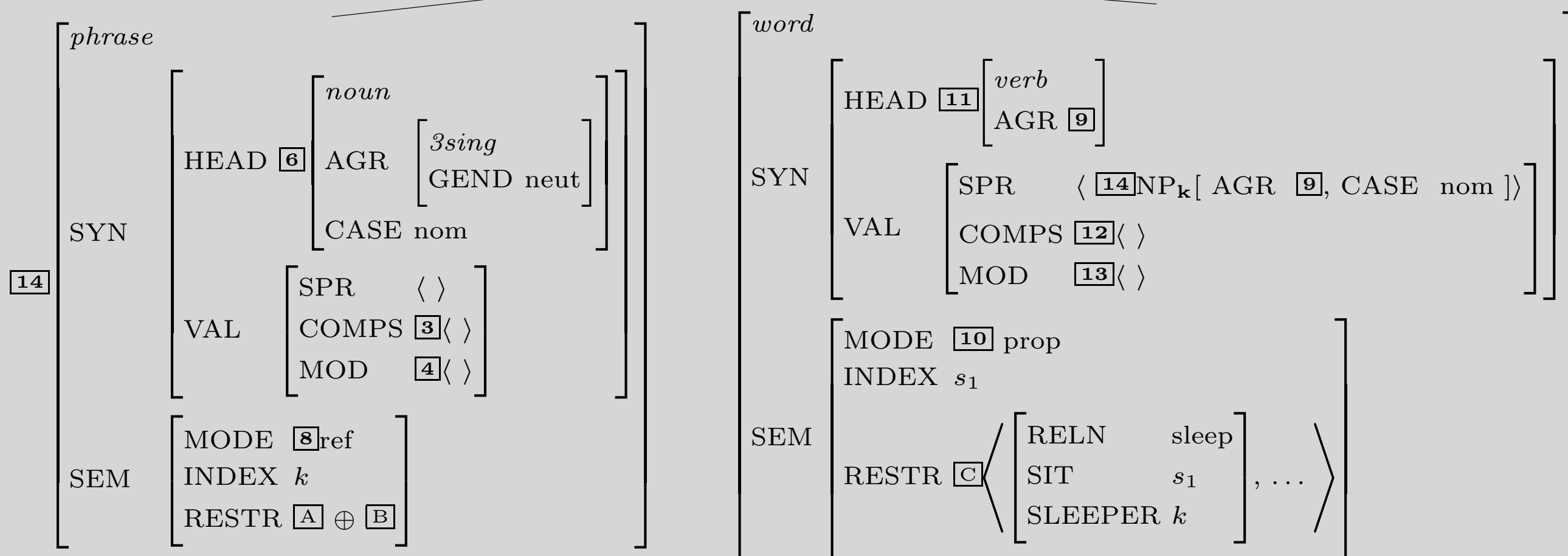
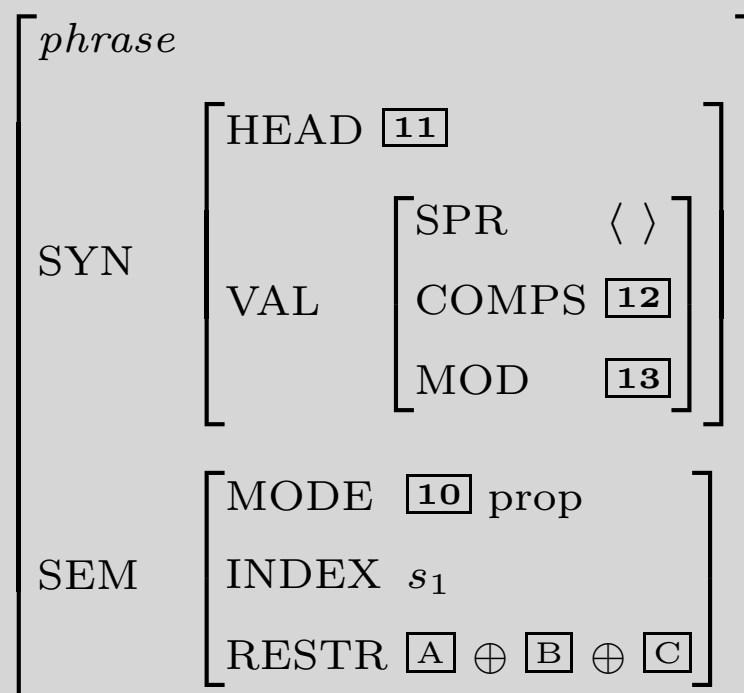


Key

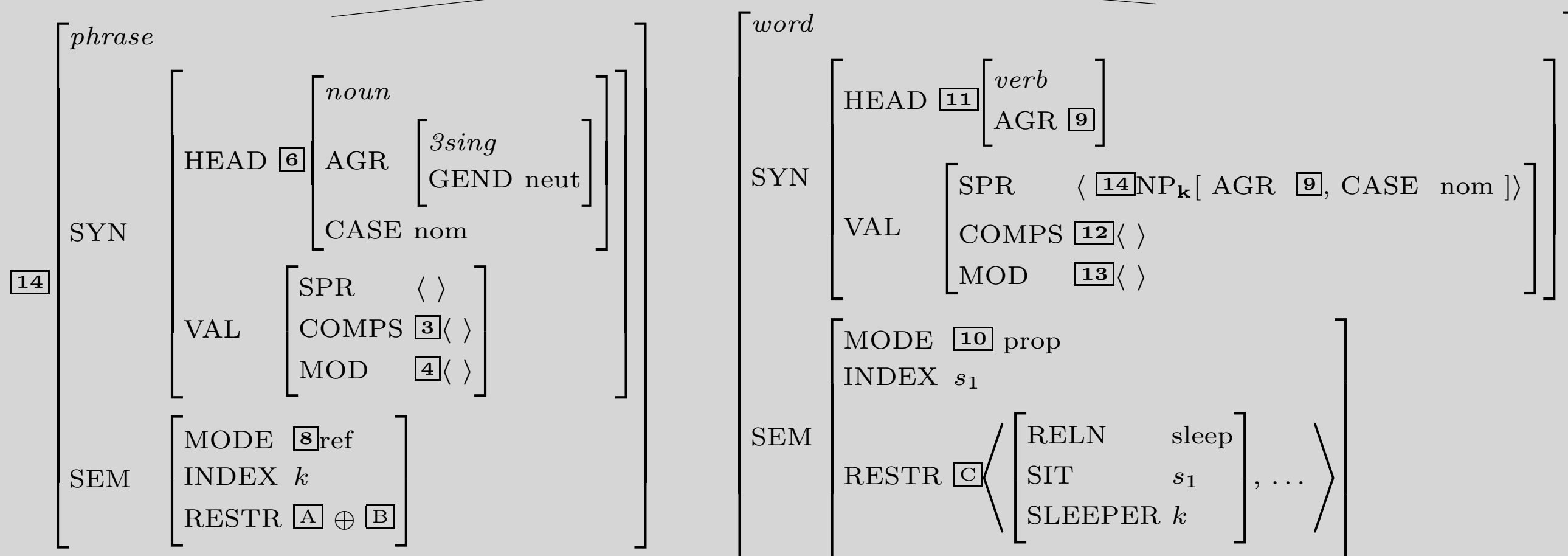
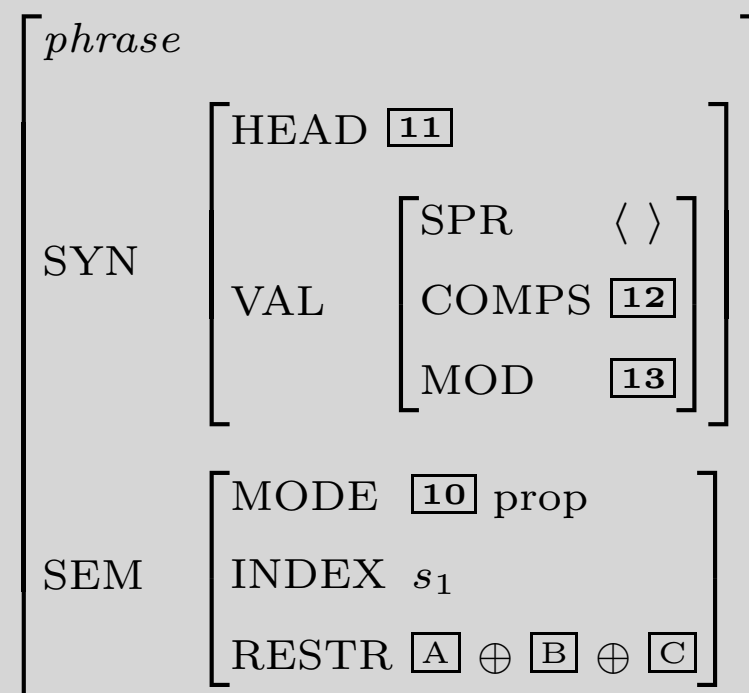
	HSR
	SHAC
	Val Prin
	HFP
	SIP
	SCP



Is this description fully specified?



Does the top node satisfy the initial symbol?



Does the top node satisfy the initial symbol?

(55)

$$S = \left[\text{SYN} \begin{bmatrix} \text{HEAD } \textit{verb} \\ \text{VAL} \begin{bmatrix} \text{COMPS } \langle \rangle \\ \text{SPR } \langle \rangle \end{bmatrix} \end{bmatrix} \right]$$

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

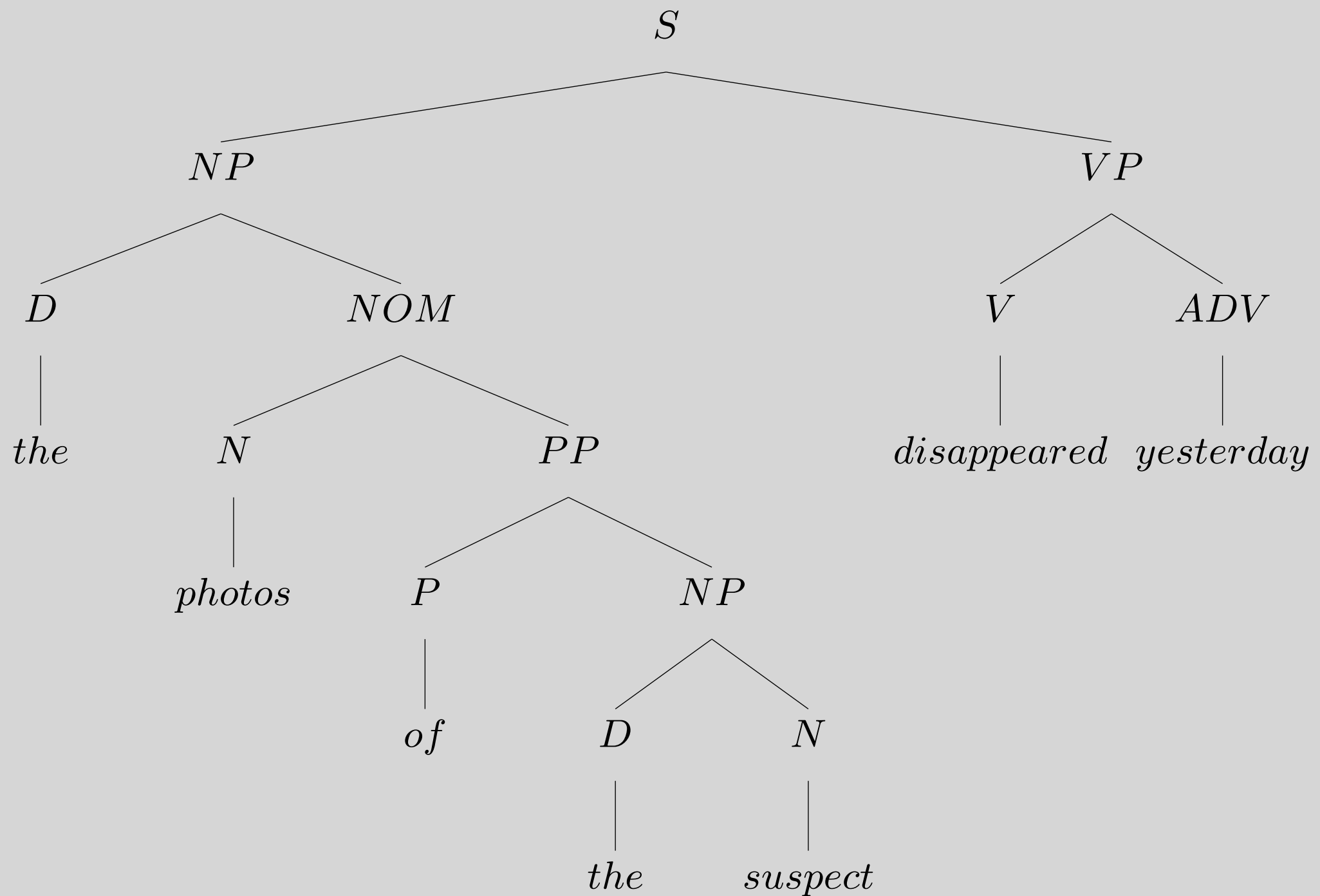
$$\boxed{14} \left[\begin{array}{l} \textit{phrase} \\ \text{SYN} \begin{bmatrix} \text{HEAD } \boxed{6} \begin{bmatrix} \textit{noun} \\ \text{AGR } \begin{bmatrix} 3\text{sing} \\ \text{GEND } \textit{neut} \end{bmatrix} \\ \text{CASE } \textit{nom} \end{bmatrix} \\ \text{VAL} \begin{bmatrix} \text{SPR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

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

RESTR of the S node

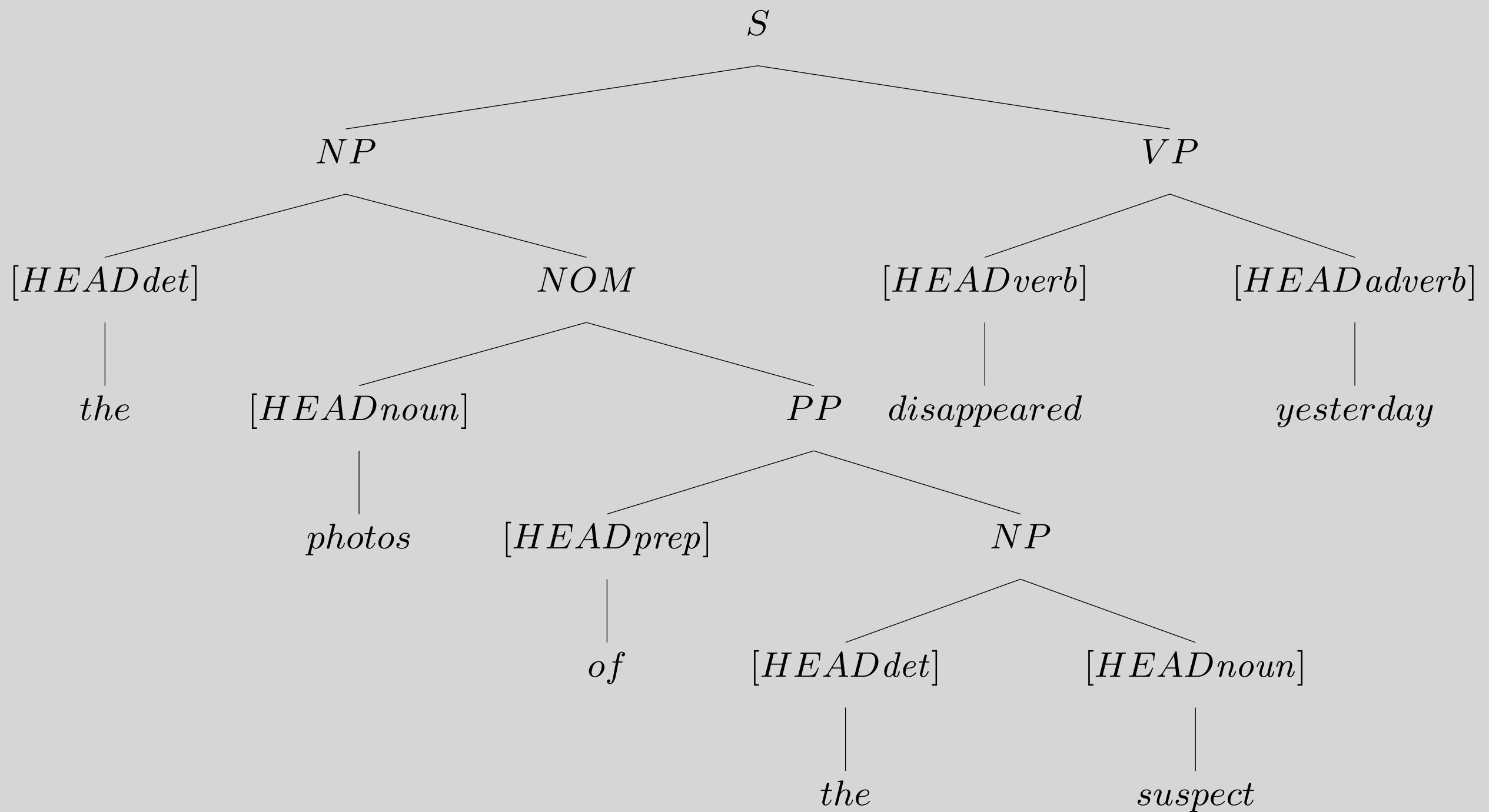
$$\left\langle \begin{bmatrix} \text{RELN} & a \\ \text{BV} & k \end{bmatrix}, \begin{bmatrix} \text{RELN} & \text{cat} \\ \text{INST} & k \end{bmatrix}, \begin{bmatrix} \text{RELN} & \text{sleep} \\ \text{SIT} & s_1 \\ \text{SLEEPER} & k \end{bmatrix}, \dots \right\rangle$$

Another Example

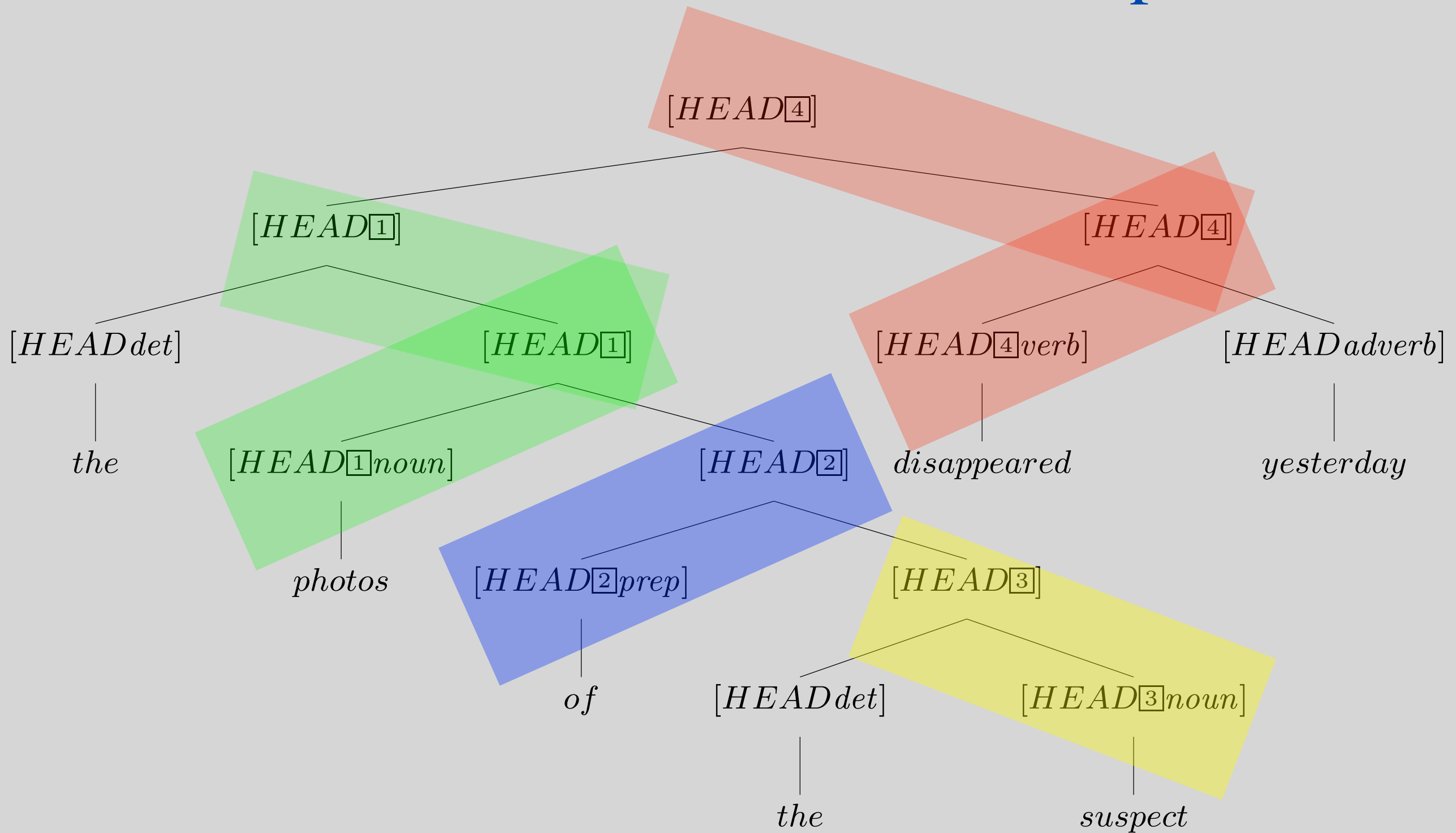


What rule builds each subtree?

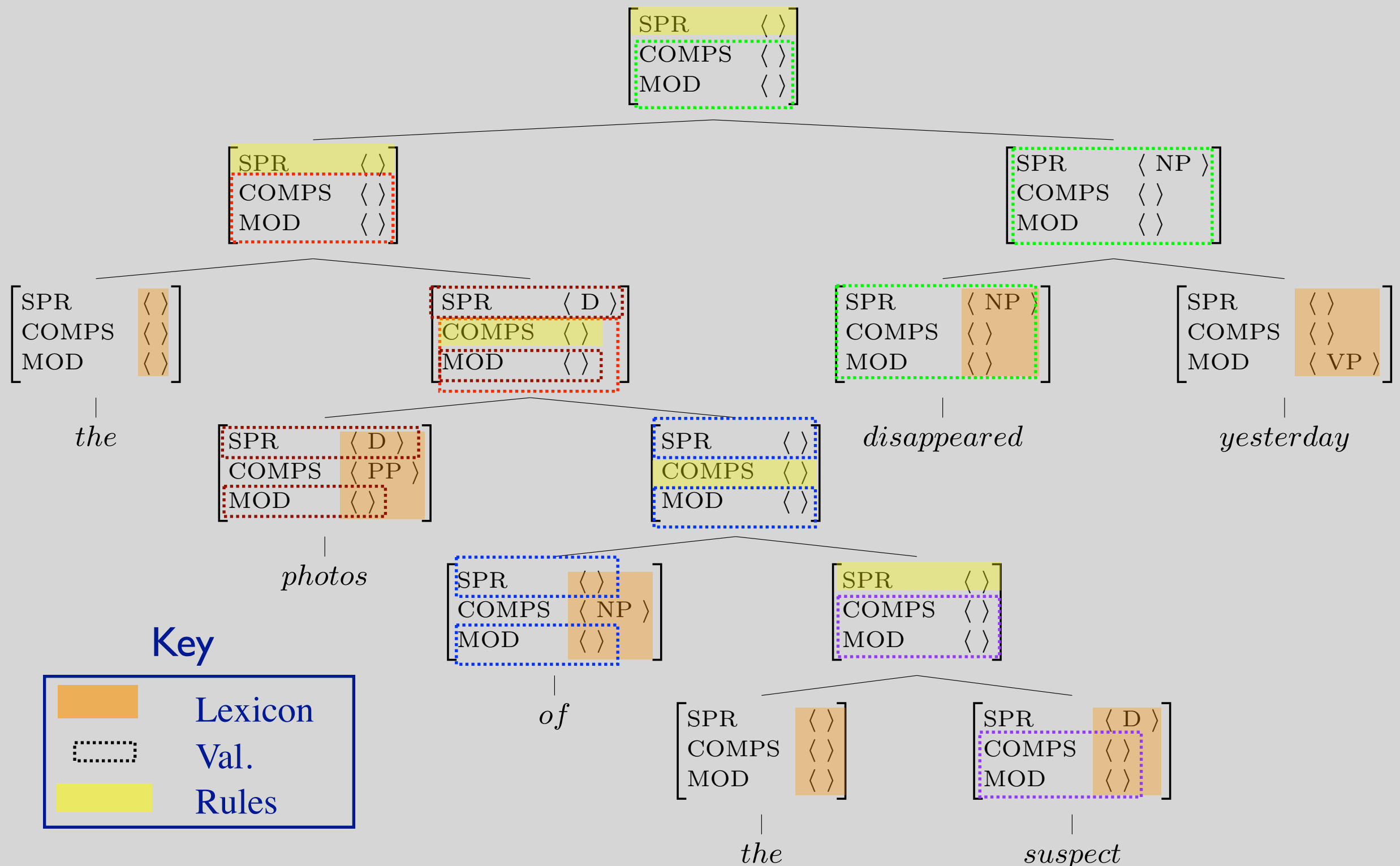
Head Features from Lexical Entries



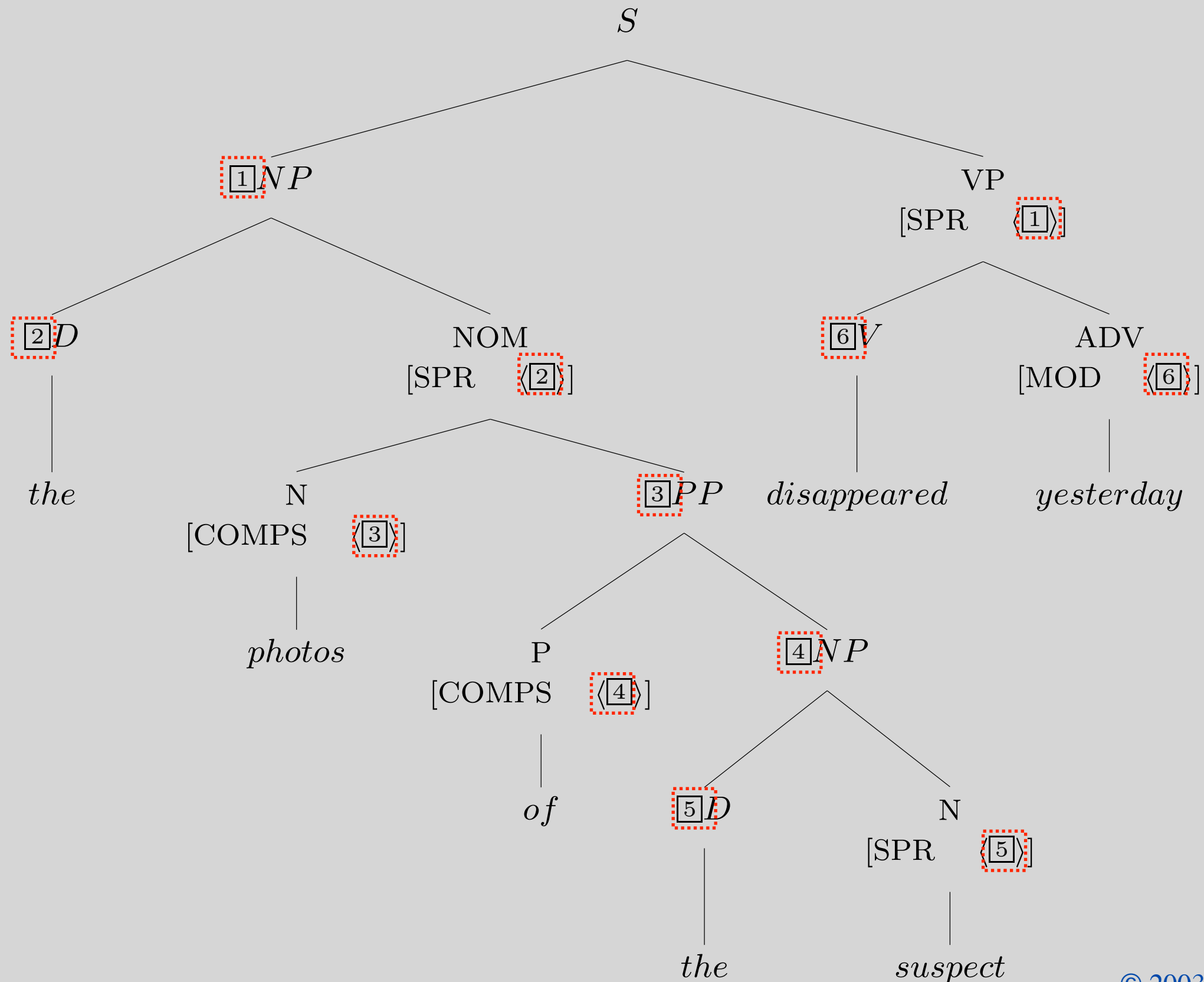
Head Features from Lexical Entries, plus HFP



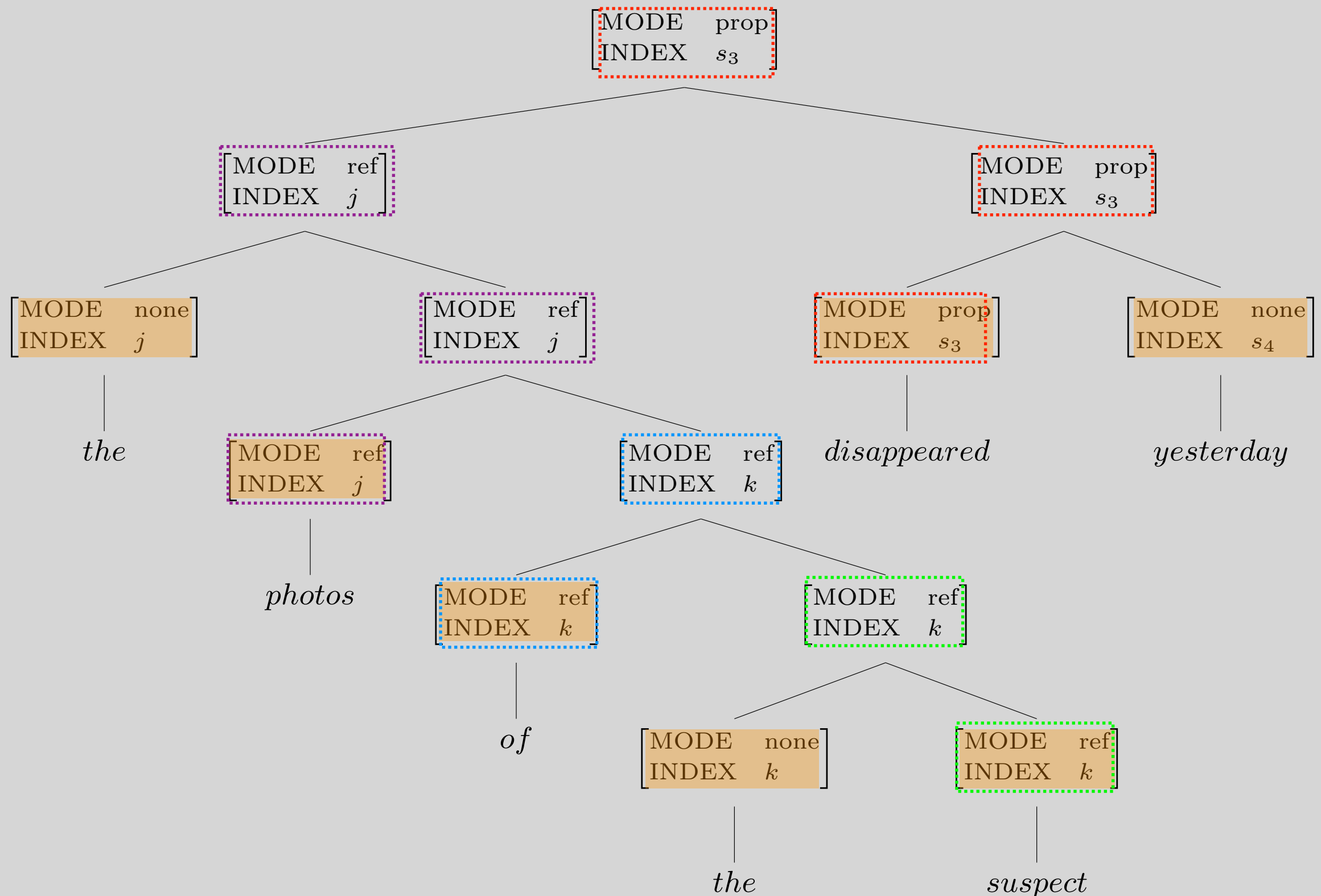
Valence Features: Lexicon, Rules, and the Valence Principle



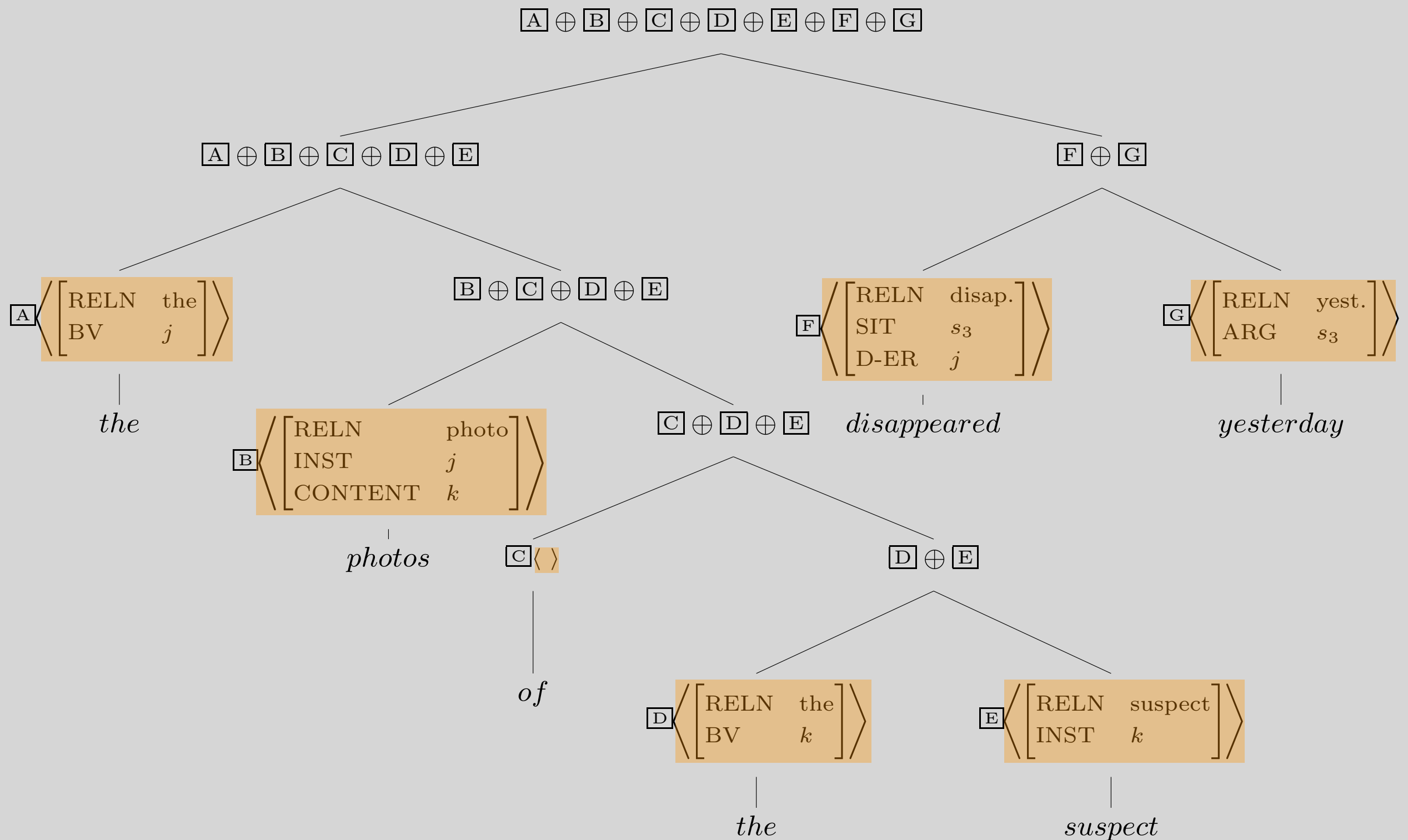
Required Identities: Grammar Rules



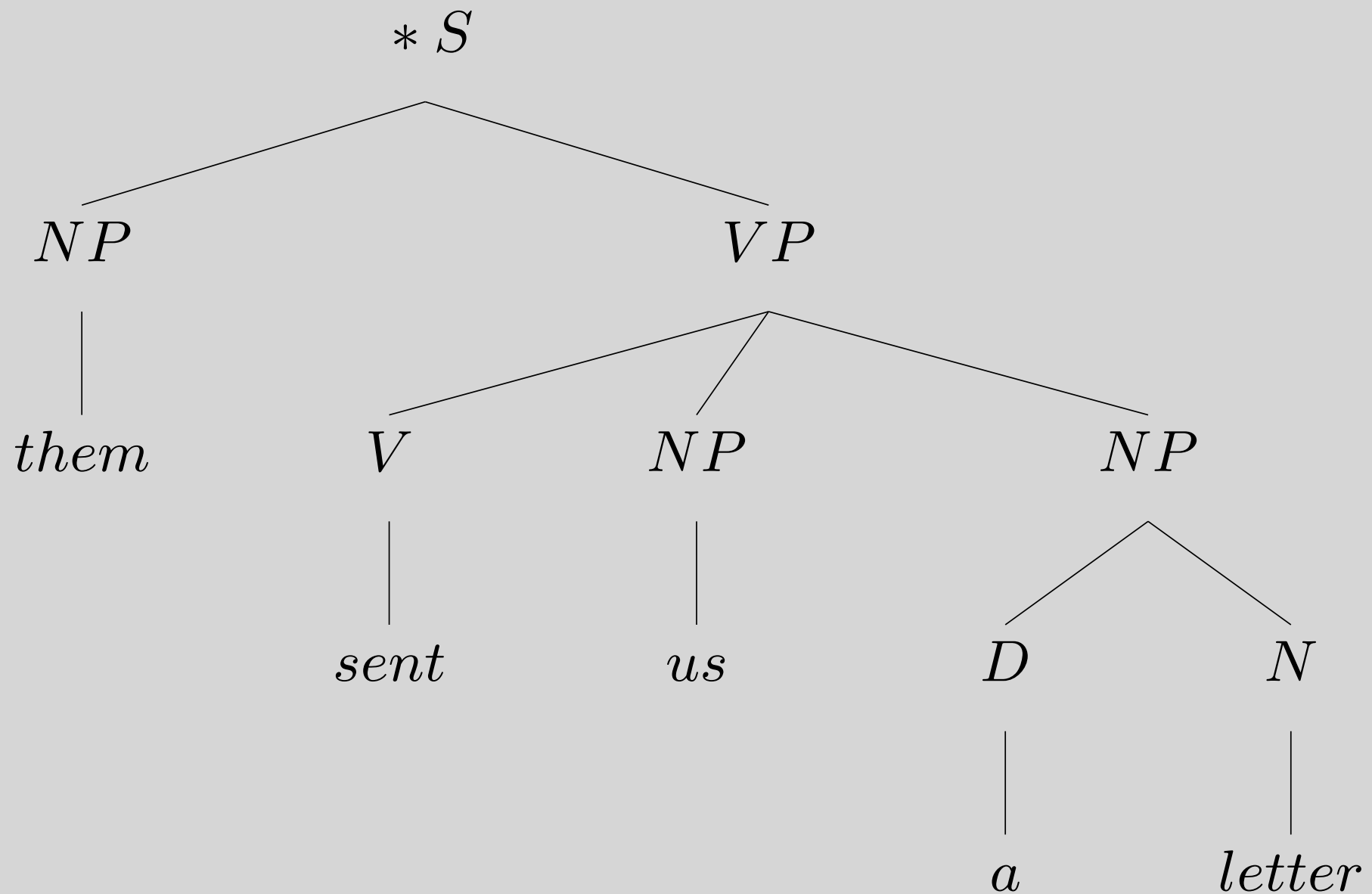
Two Semantic Features: the Lexicon & SIP



RESTR Values and the SCP

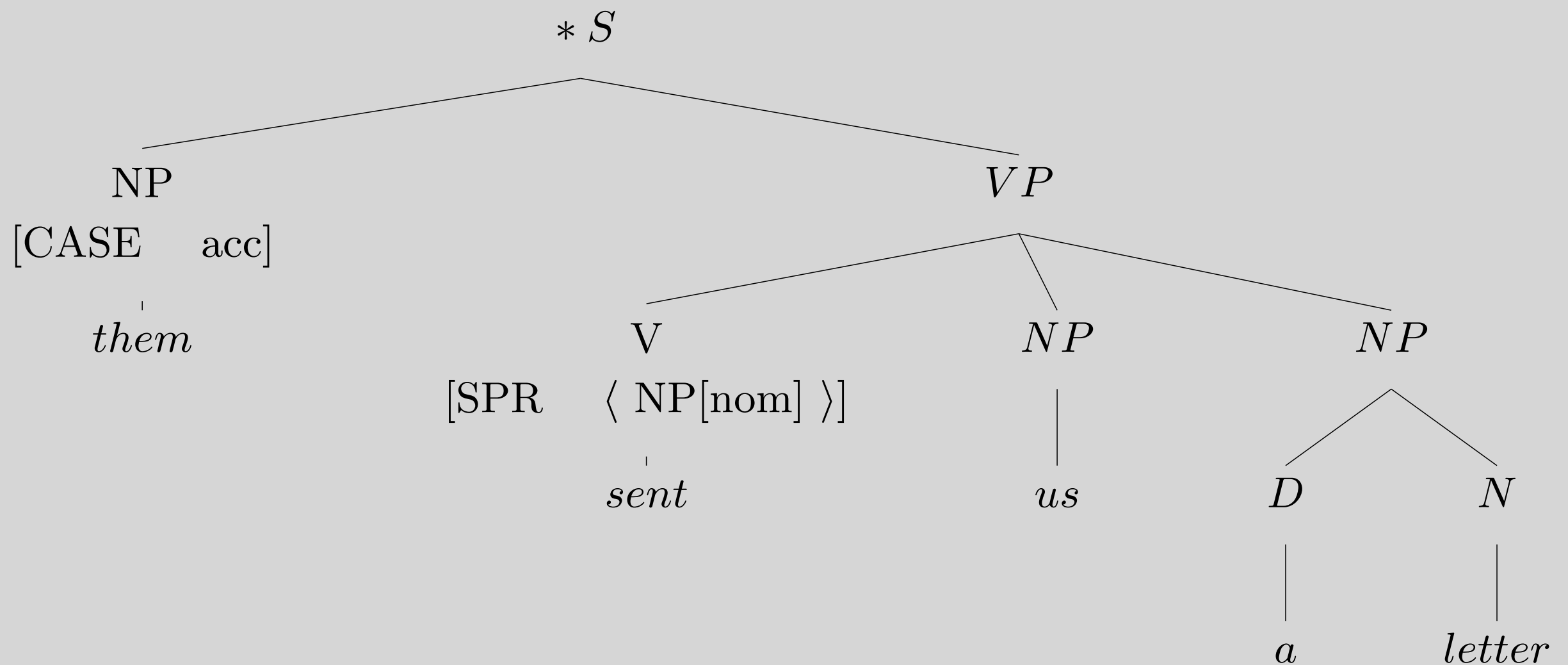


An Ungrammatical Example



What's wrong with this sentence?

An Ungrammatical Example

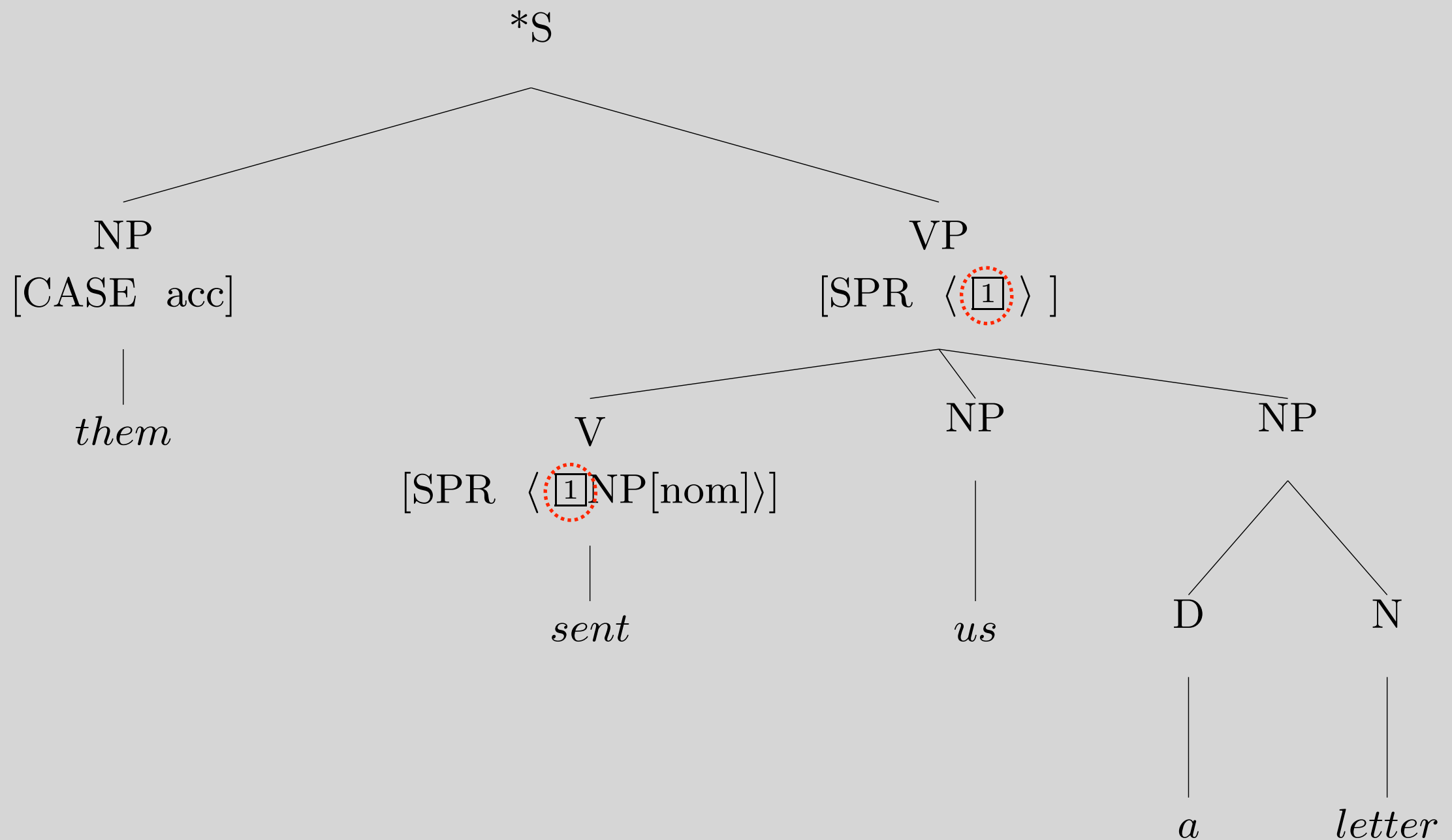


What's wrong with this sentence?

So what?

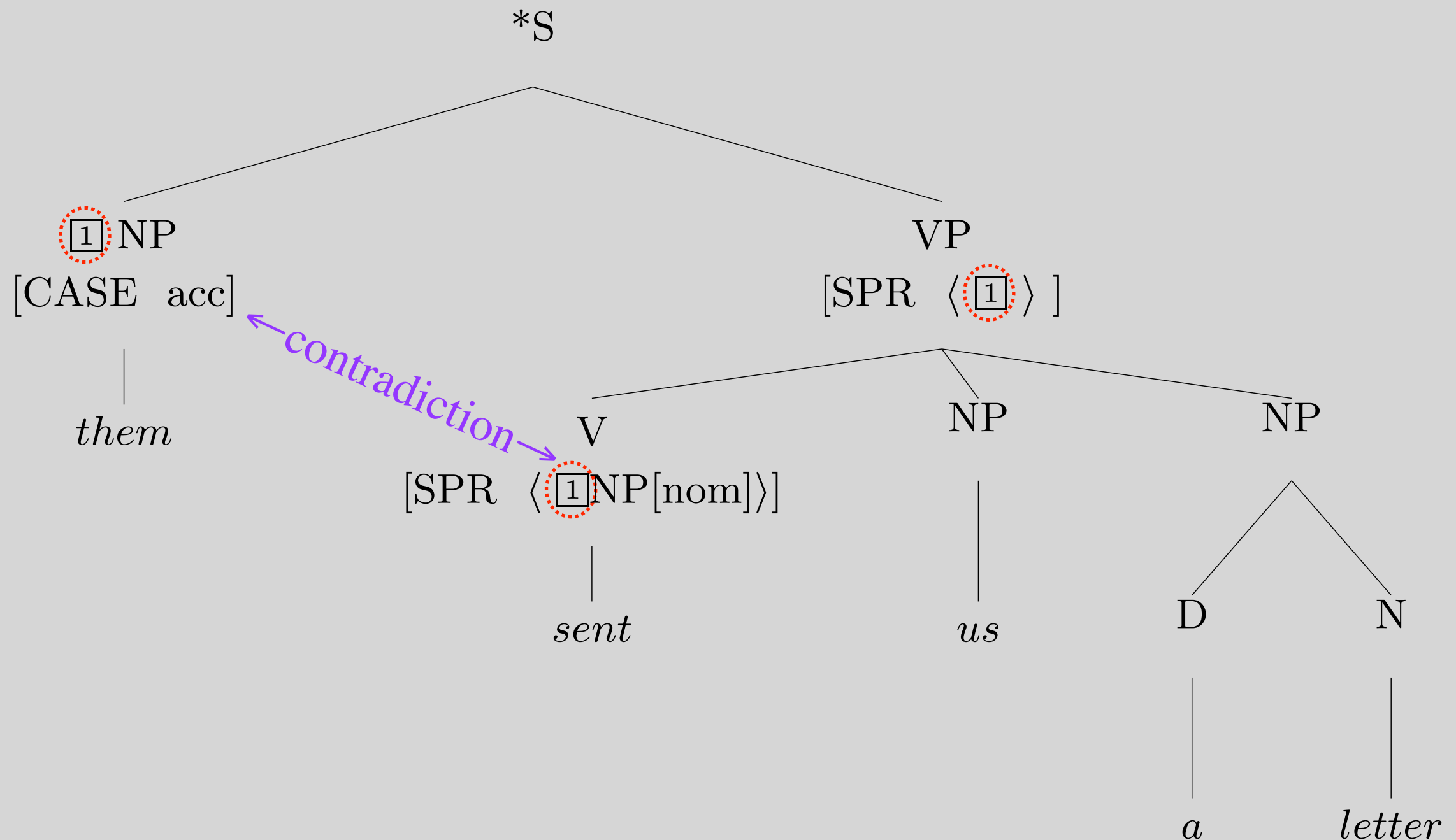
An Ungrammatical Example

The Valence Principle



An Ungrammatical Example

Head Specifier Rule



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

RQs: Licensing trees

- Is the difference between lexical entry and word structure whether it's in the context of a tree or not? I just want to make sure I have correct terminology.

RQs: Tag conventions

- When to use [A], [1], and *i*?

RQs: Unexpressed SENDEE/ADDRESSEE

- Is that okay? How does that work?
- Two interpretations of the sentence 'We send two letters to Lee' are discussed in Chapter 6. One is that Lee is the SENDEE but not the ADDRESSEE, and the other is that Lee is the ADDRESSEE but not the SENDEE. I wonder what the tree would look like in the situation where Lee is both the SENDEE and the ADDRESSEE. Would it look like (30) on page 189, but with a tag for the name predication where the NAMED value is the same for both SENDEE and ADDRESSEE?

RQs: Syntax-semantics interface

- What role does proximity play in word order when determining the roles of various NPs in a sentence (in English)? How far can an object be from the verb? Does this change when a preposition is present to mark their relationship?

RQs: BV

- Still need some clarification on BV. I've only seen this used to bind a det to its noun, but can it also be used elsewhere?

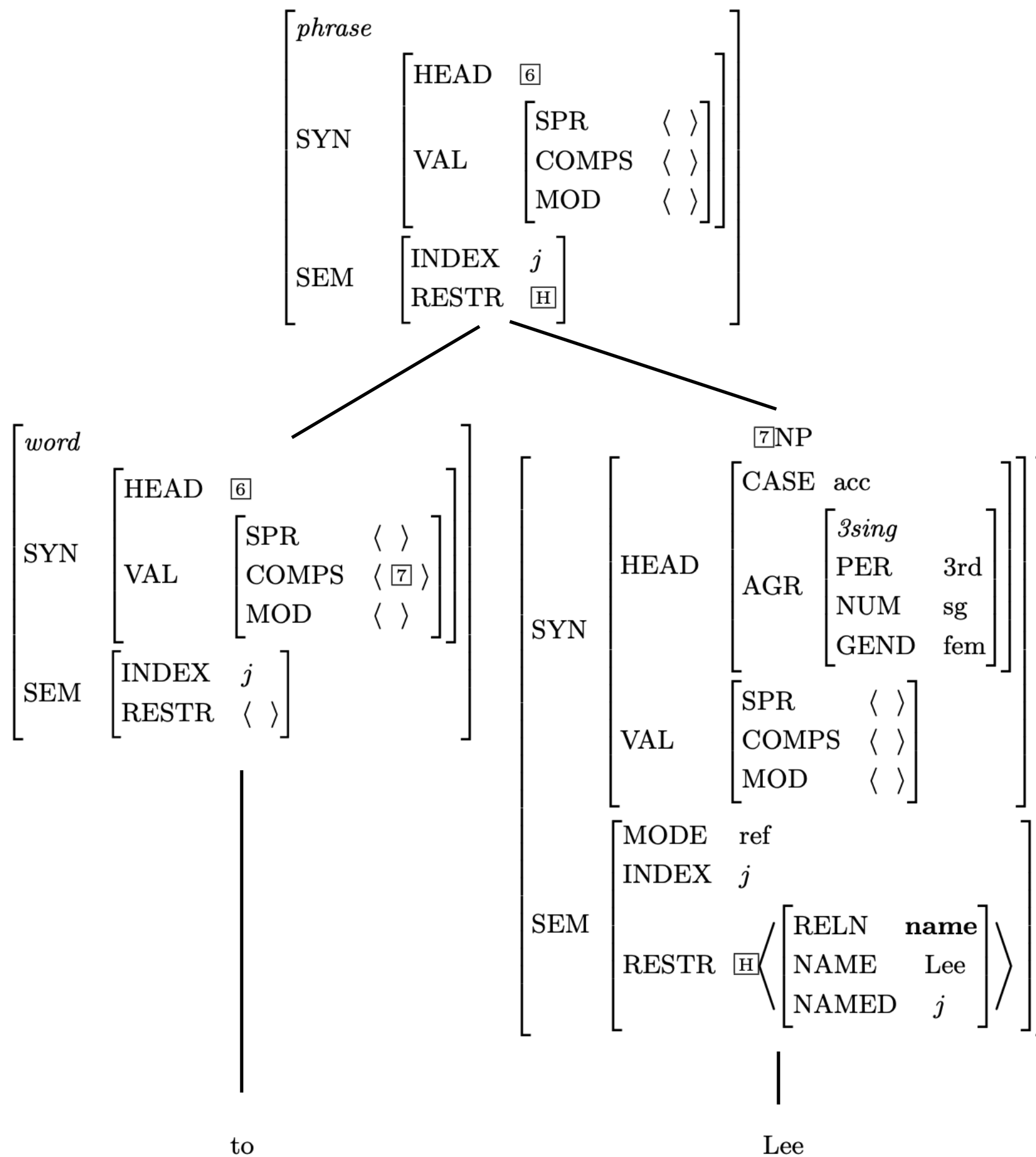
RQs: How to design grammars

- I'm wondering with all the first 6 chapter learnt, with the understanding of complex syntactic roles and feature-value pairs and considering this chapter as how the grammar works, I am wondering how do we effectively differentiate when specific syntactic features like BV or lexical entries should be utilized to maintain grammatical accuracy and coherence?

RQs: Semantically empty prepositions

- What's going on in the tree on p. 187?

(28)



RQs: CASE and AGR

- From some representations in this chapter and HW, I am curious about the interactions between case and agreement: should these two be treated as entirely distinct features, or is there theoretical flexibility to consider case as part of the agreement category in contexts where agreement with case features is observed?