Ling 566
Oct 16, 2007

How the Grammar Works

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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

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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

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How We Construct Sentences

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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)

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How We Construct Sentences

- The Components of Our Grammar
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- We combine constraints from these components.

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How We Construct Sentences

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

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How We Construct Sentences

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- We combine constraints from these components.

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

A: The definition of well-formed structure

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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?

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Lexical Entry for *a*

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

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

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Lexical Entry for *cat*

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

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

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Effect of Principles: the SHAC

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

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Description of Word Structures for *cat*

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

cat

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Description of Word Structures for *a*

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

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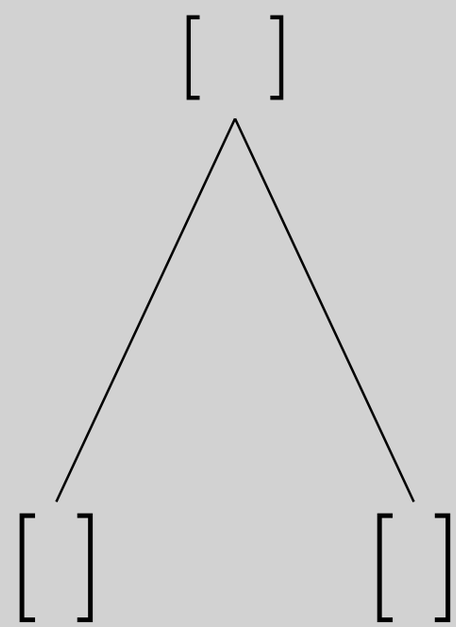
Building a Phrase



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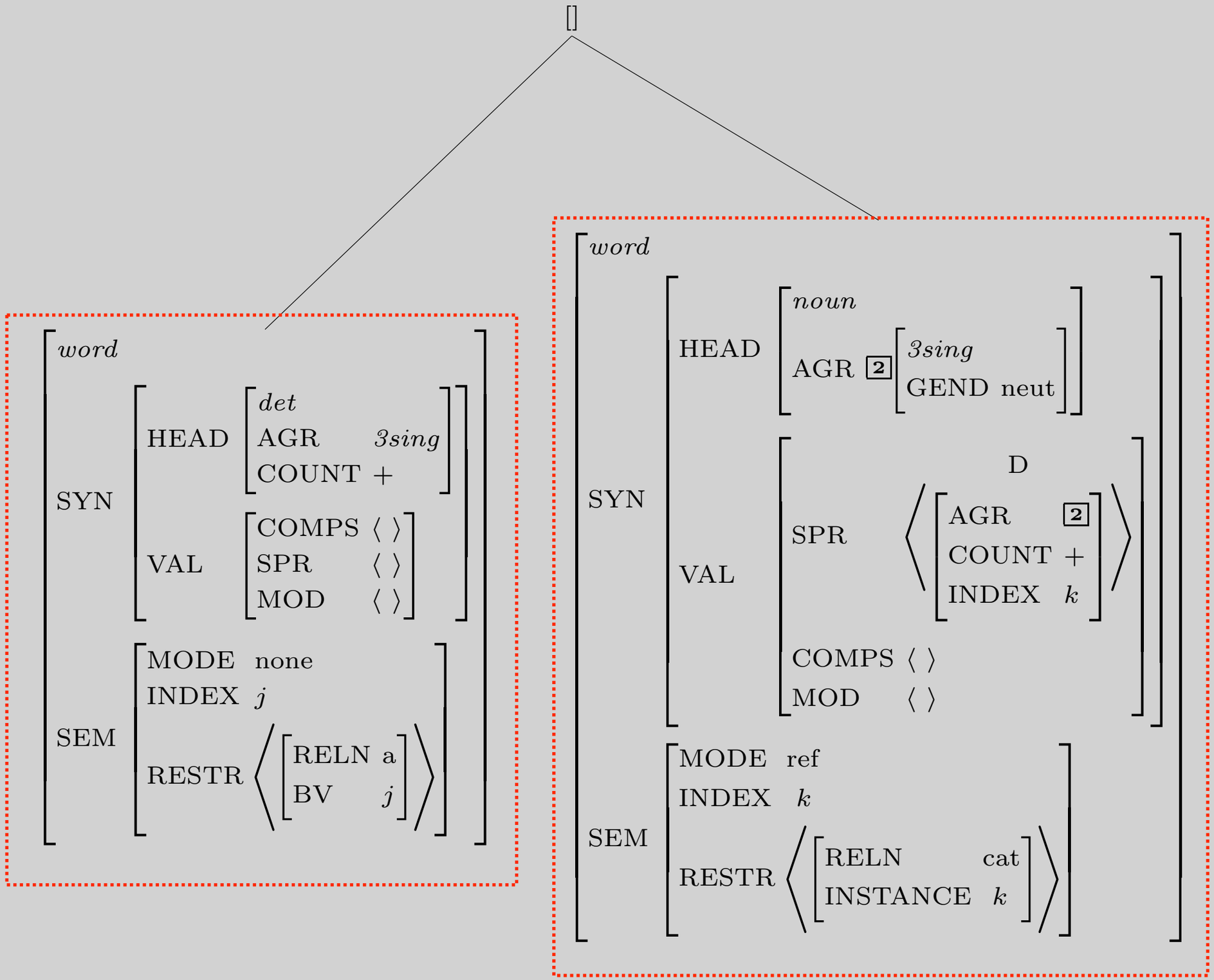
Constraints Contributed by Daughter Subtrees



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Constraints Contributed by the Grammar Rule

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

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A Constraint Involving the SHAC

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

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

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Effects of the Valence Principle

$$\begin{bmatrix} \textit{phrase} & \\ \text{SYN} & \begin{bmatrix} \text{VAL} & \begin{bmatrix} \text{SPR} & \langle\ \rangle \\ \text{COMPS} & \boxed{3} \\ \text{MOD} & \boxed{4} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

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

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

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Effects of the Head Feature Principle

$$\begin{bmatrix} \textit{phrase} & \\ \text{SYN} & \begin{bmatrix} \text{HEAD} & \boxed{6} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & \langle\ \rangle \\ \text{COMPS} & \boxed{3} \\ \text{MOD} & \boxed{4} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

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

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

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Effects of the Semantic Inheritance Principle

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

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

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

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Effects of the Semantic Compositionality Principle

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

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

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

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Is the Mother Node Now Completely Specified?

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

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

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

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Lexical Entry for *slept*

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

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Another Head-Specifier Phrase

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

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

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

Key

- HSR
- SHAC
- Val Prin
- HFP
- SIP
- SCP

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

Key

- HSR
- SHAC
- Val Prin
- HFP
- SIP
- SCP

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

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

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

Key

- HSR
- SHAC
- Val Prin
- HFP
- SIP
- SCP

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

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

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

Key

	HSR
	SHAC
	Val Prin
	HFP
	SIP
	SCP

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

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

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

Key

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

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

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

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

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

Key

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Another Head-Specifier Phrase

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

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

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

Key

- HSR
- SHAC
- Val Prin
- HFP
- SIP
- SCP

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Is this description fully specified?

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

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

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

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Does the top node satisfy the initial symbol?

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

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

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

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Initial Symbol (Ch 6 version)

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

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RESTR of the S node

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

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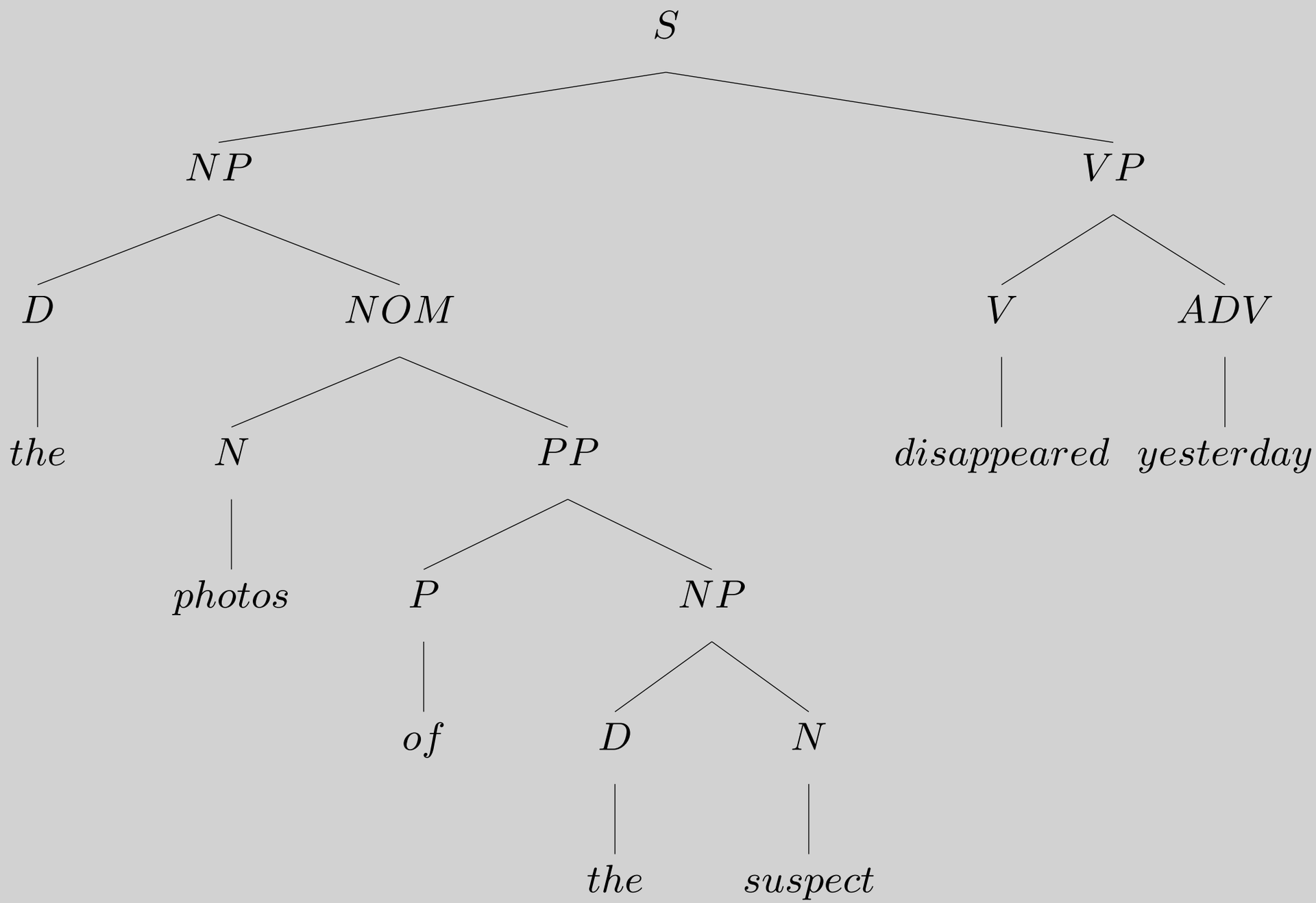
Another Example



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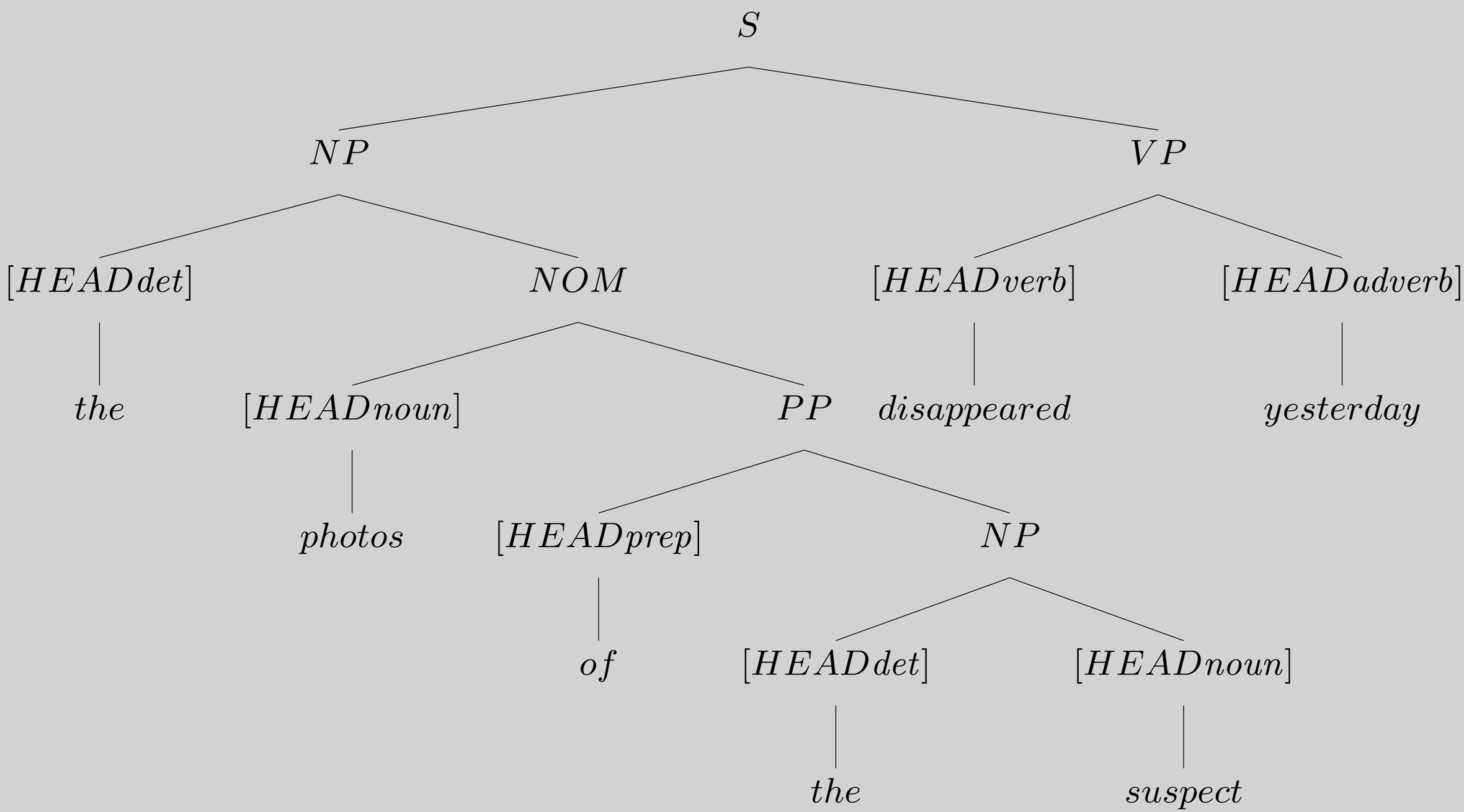

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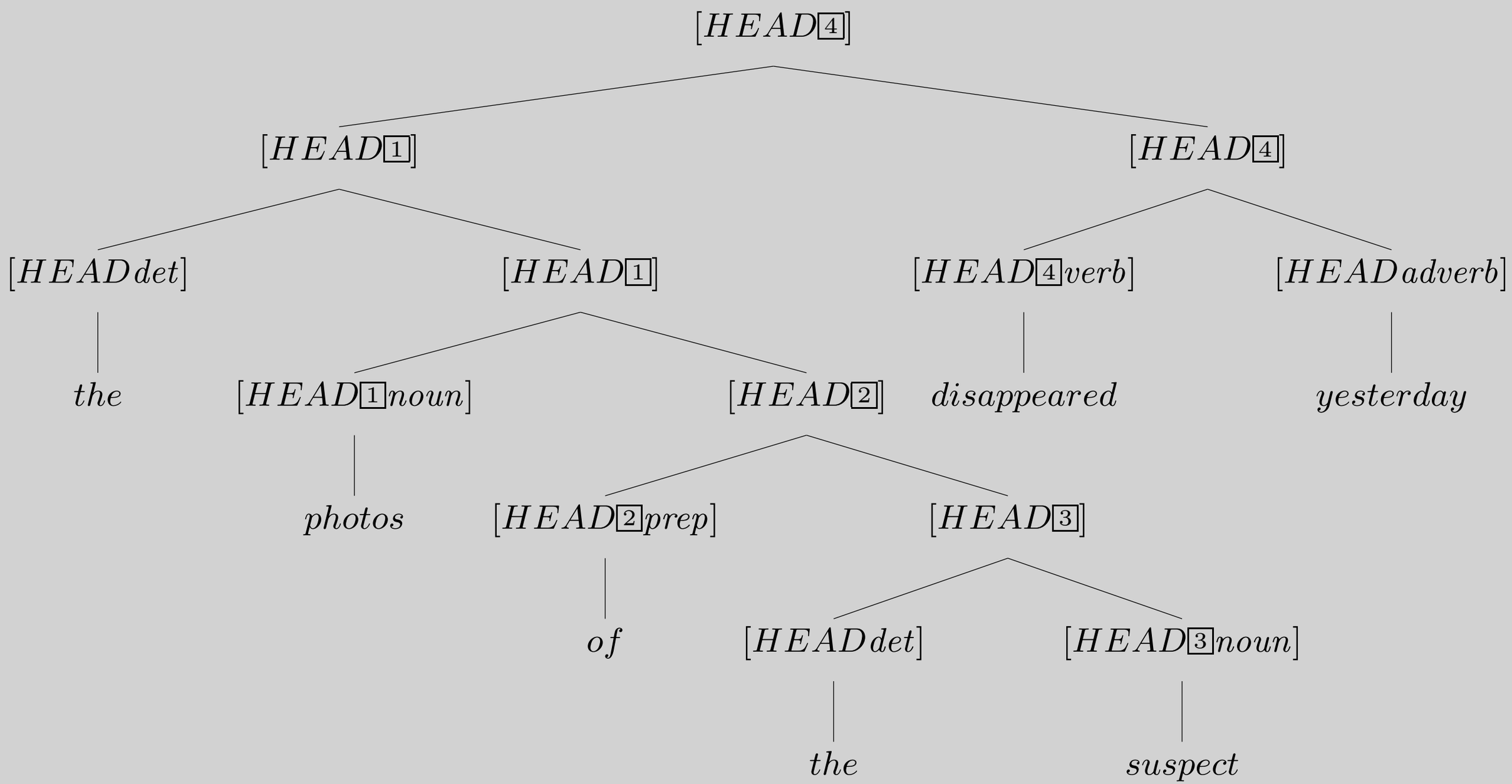
Head Features from Lexical Entries, plus HFP



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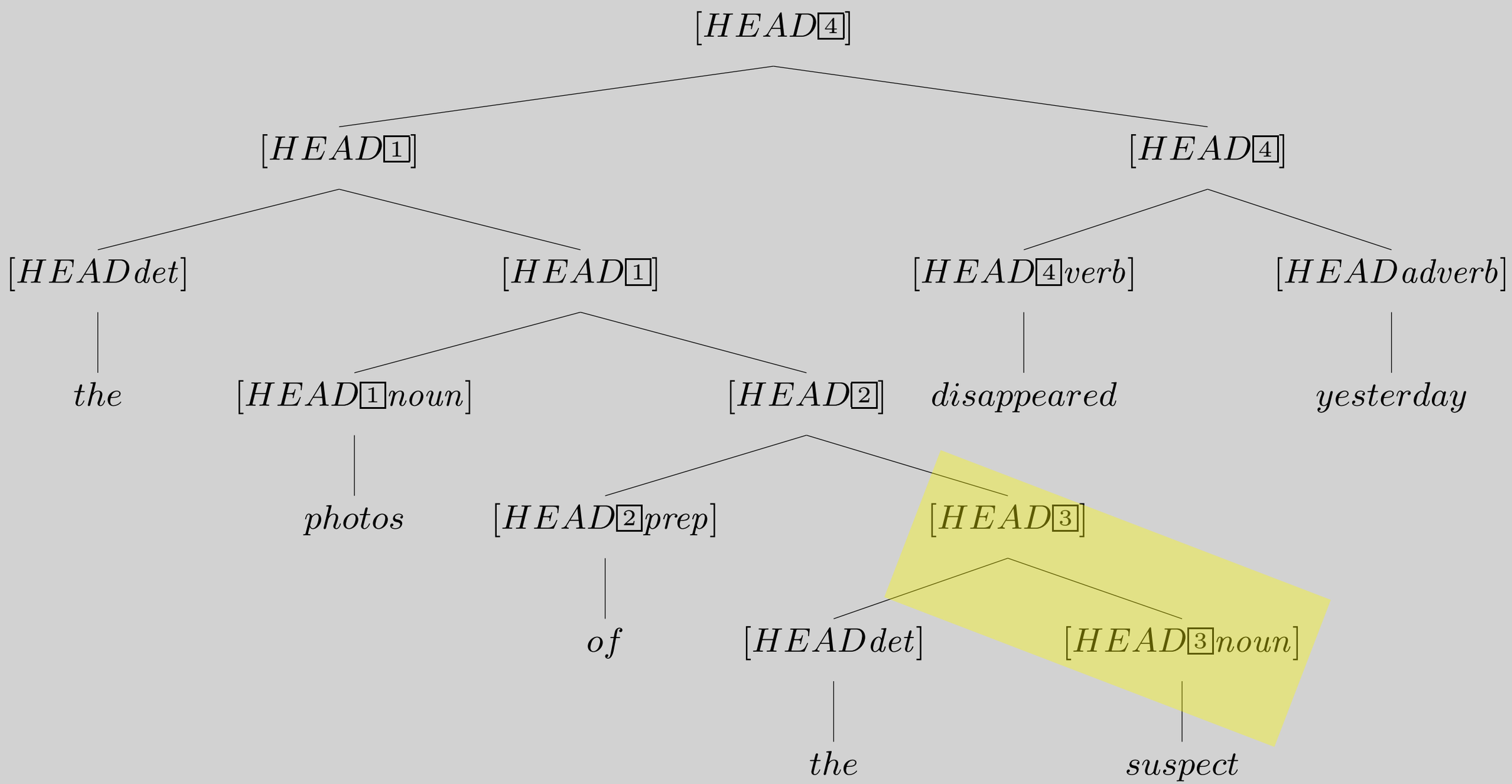

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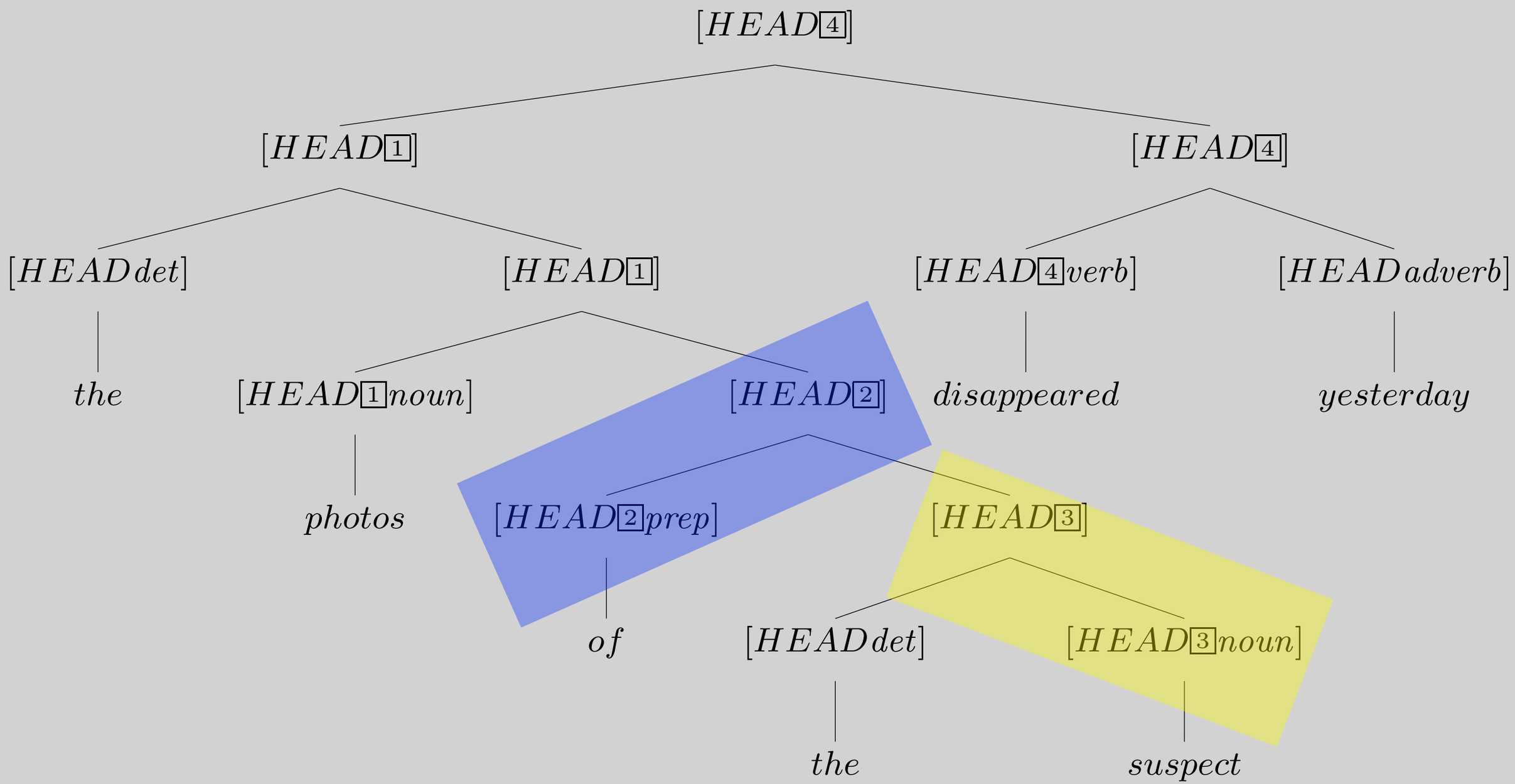

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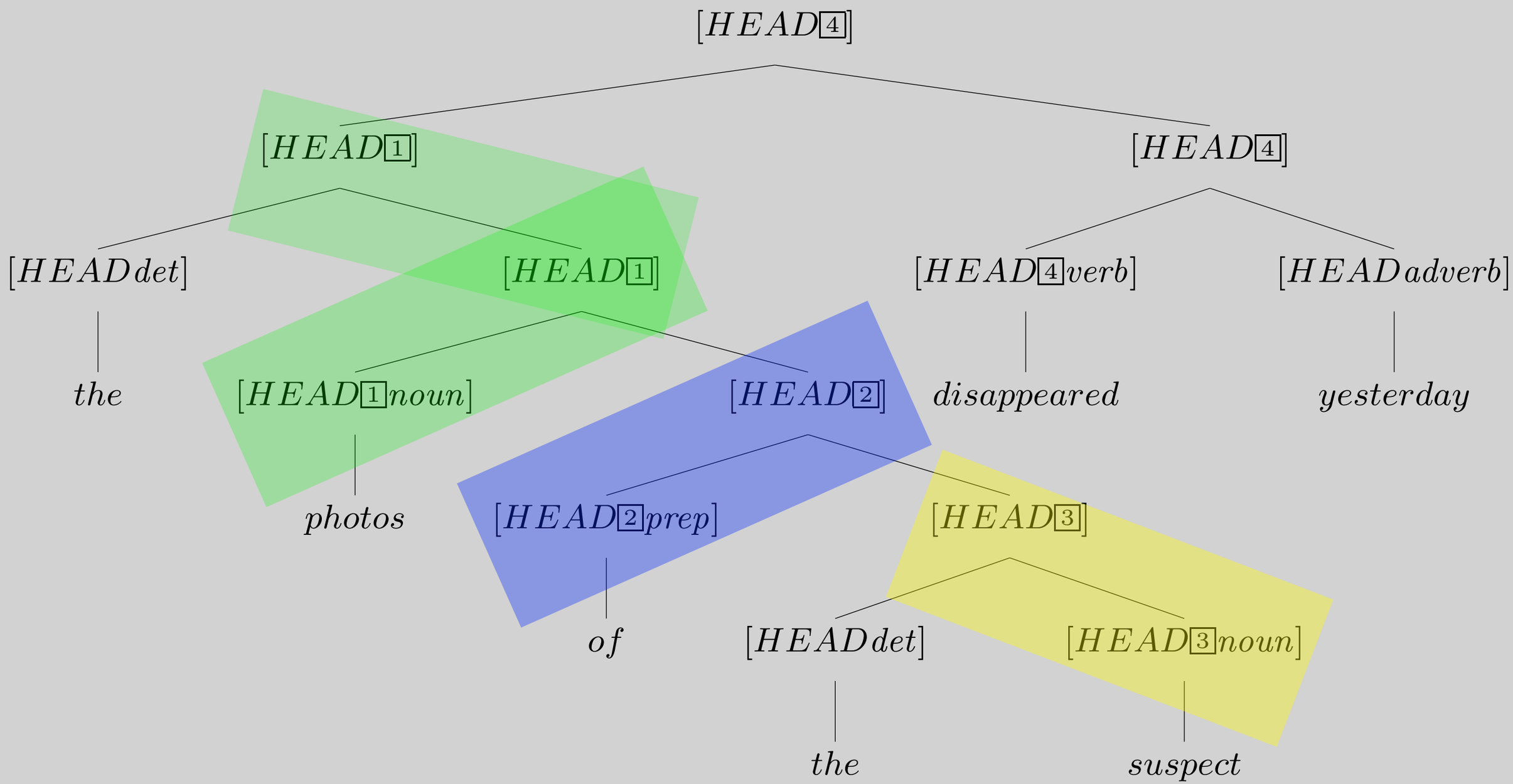

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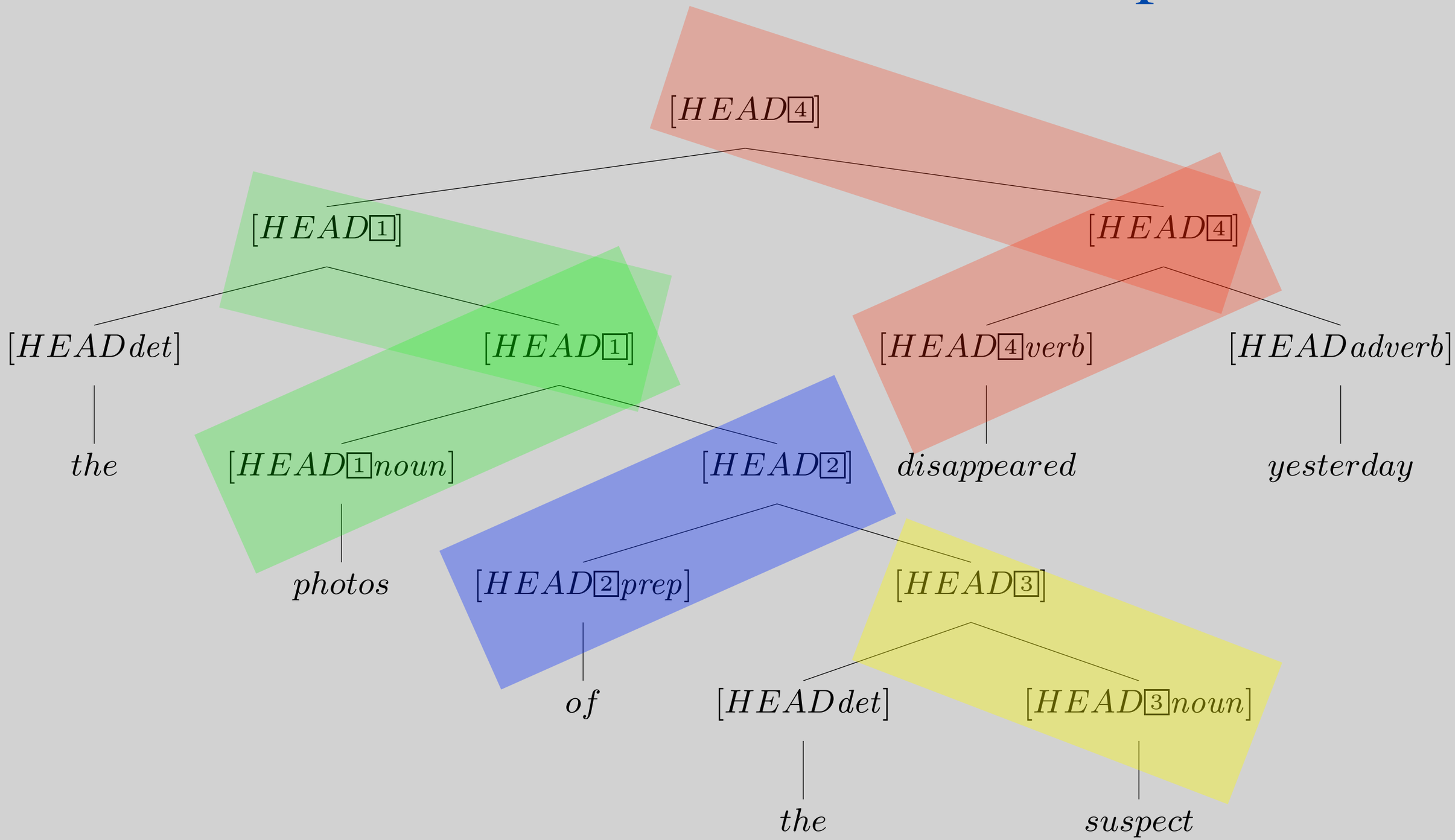

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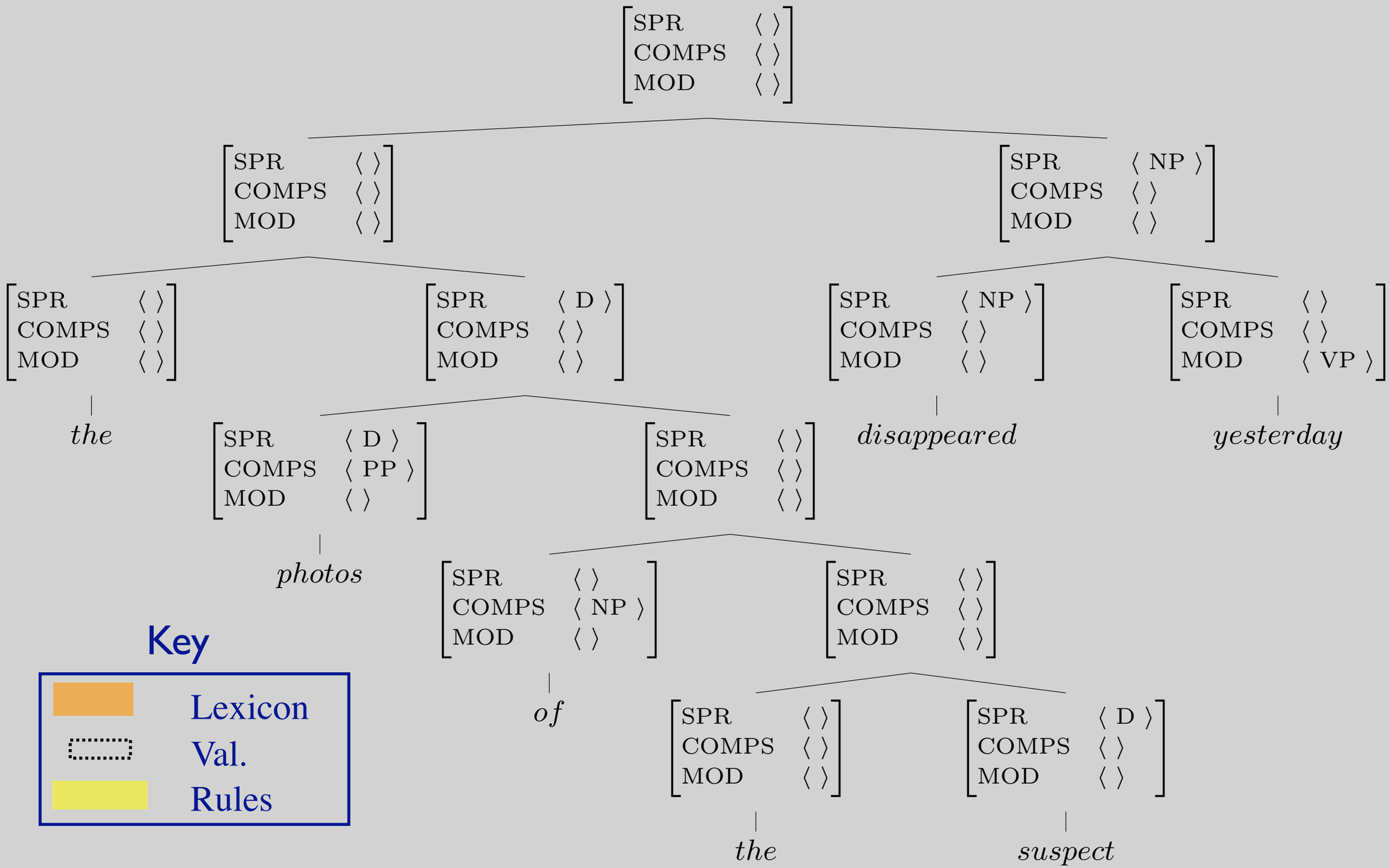

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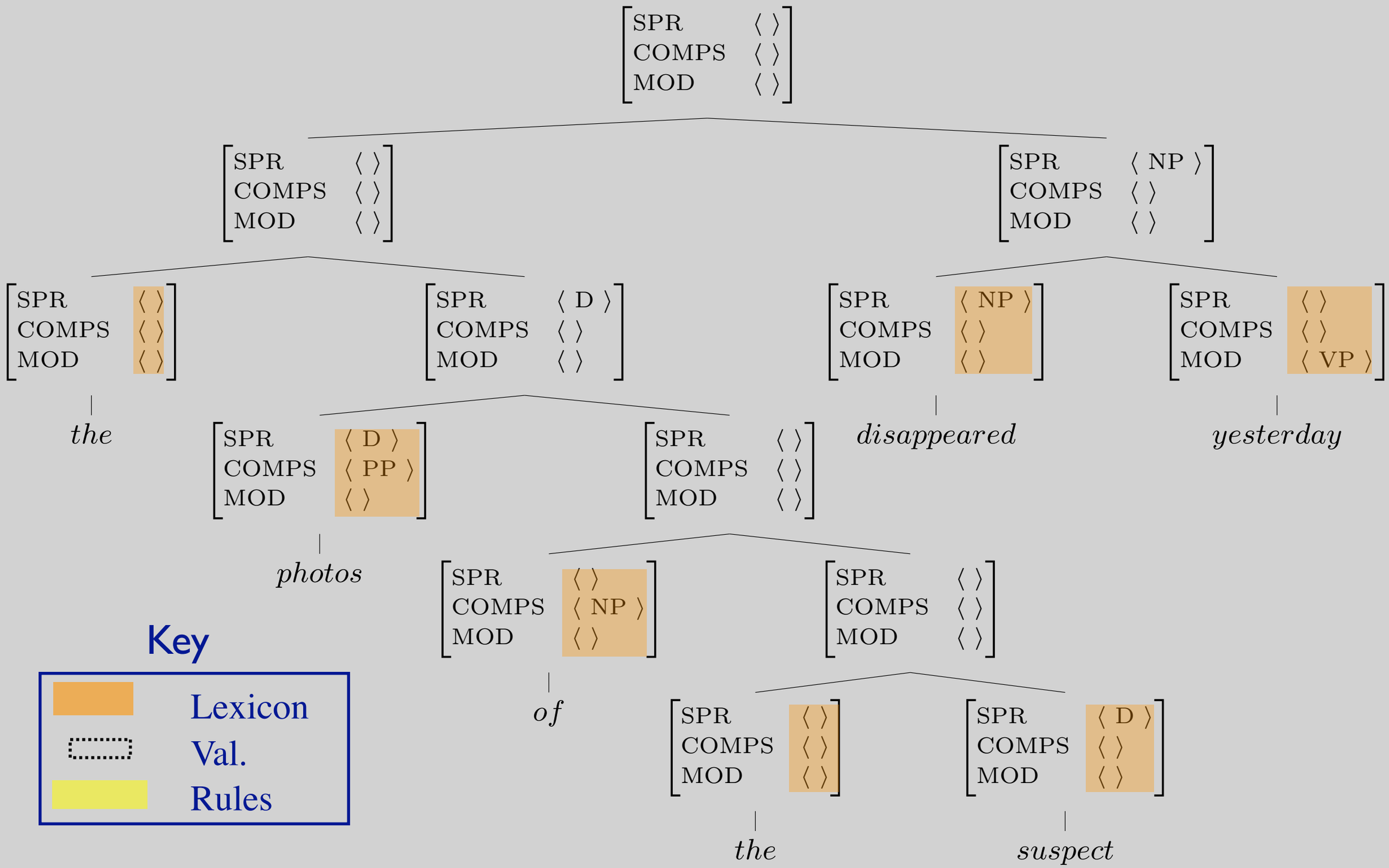

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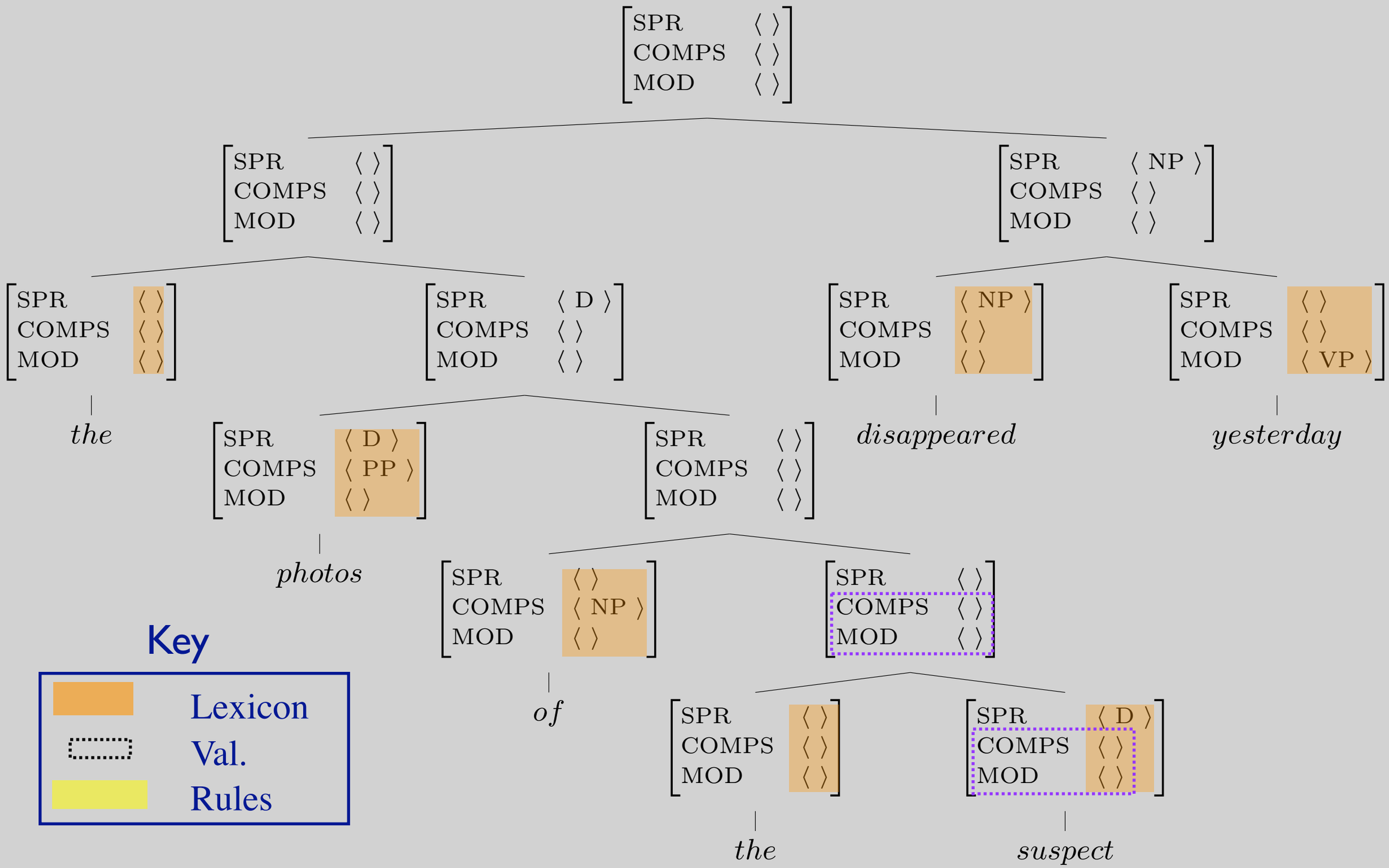

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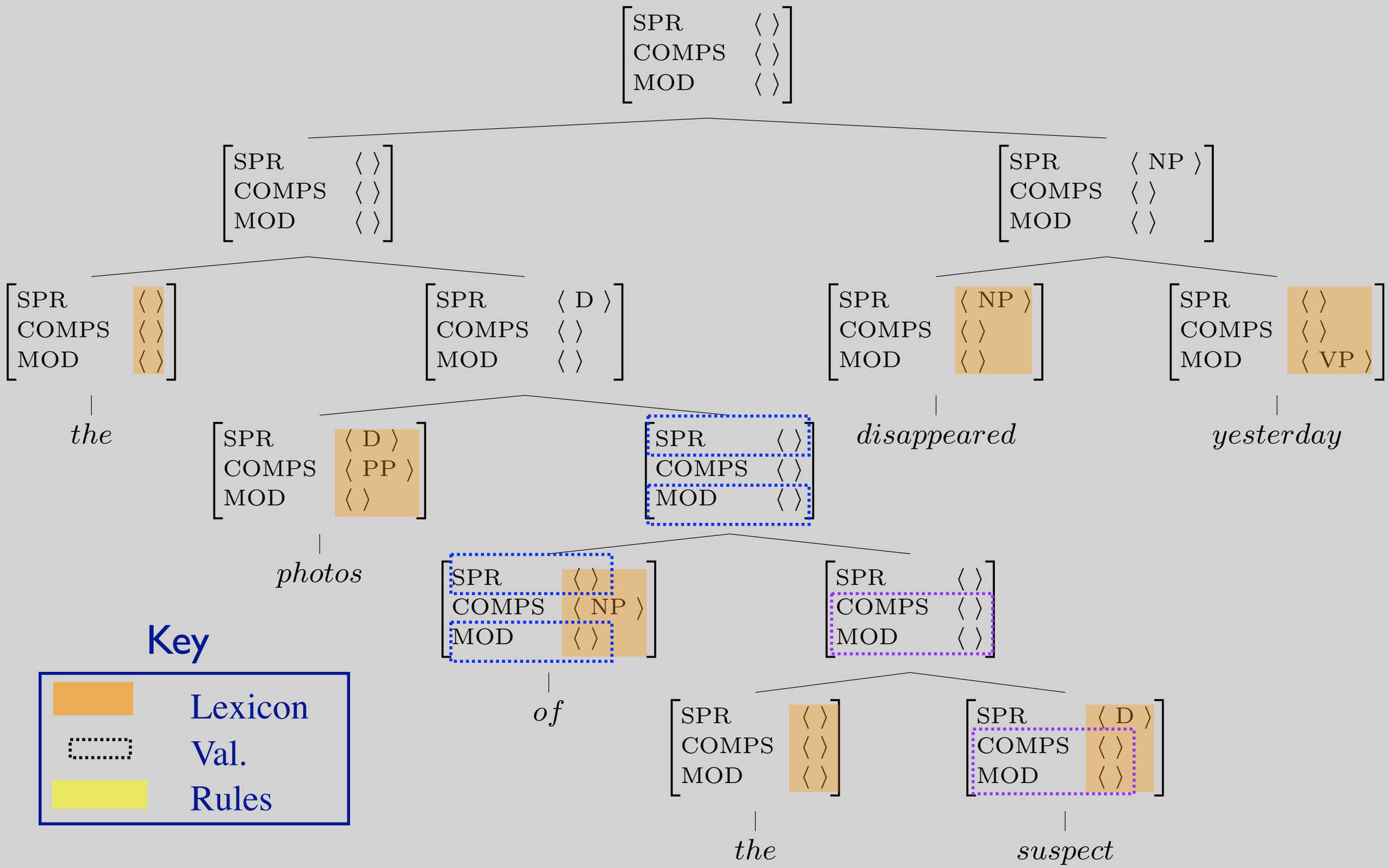

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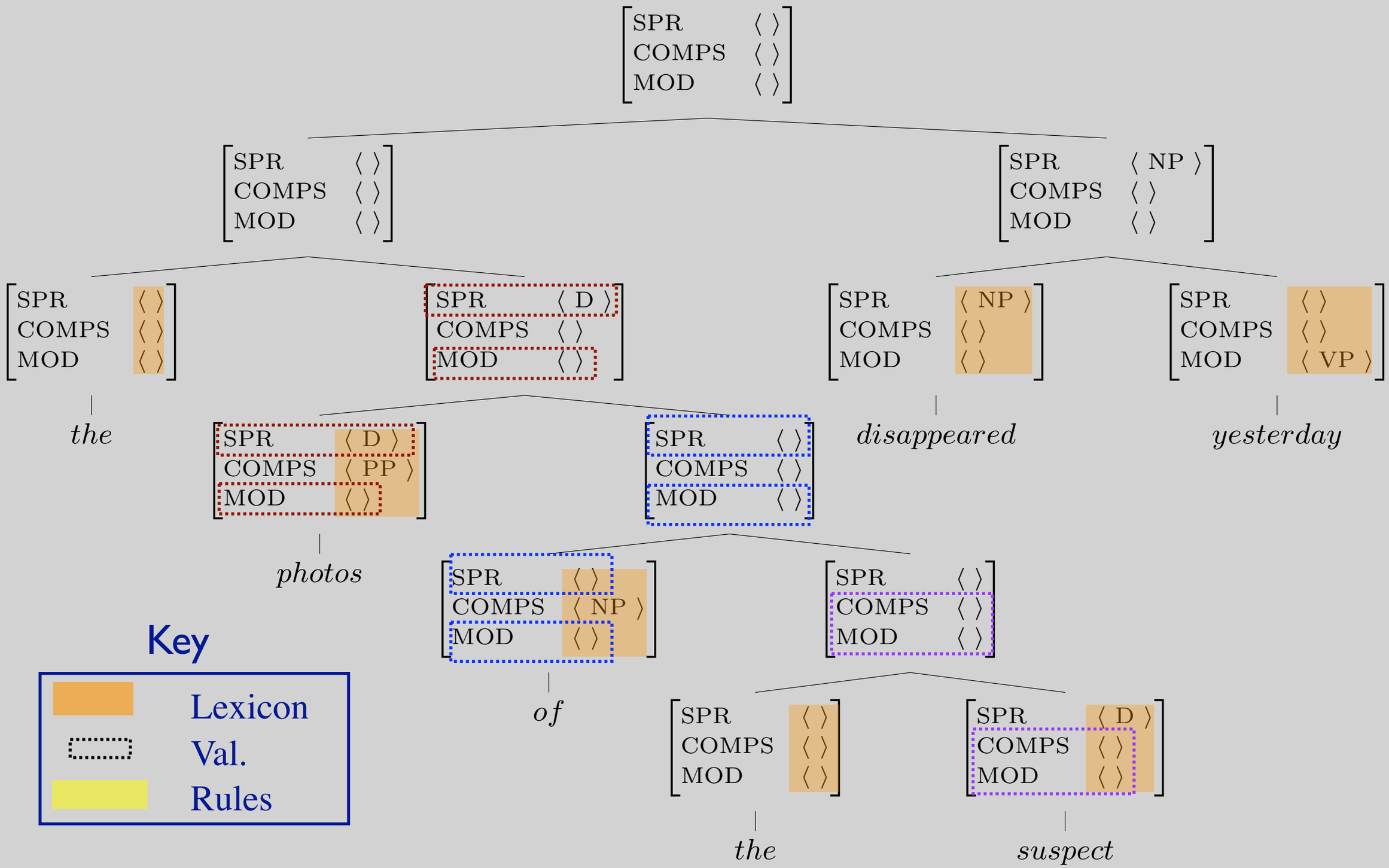

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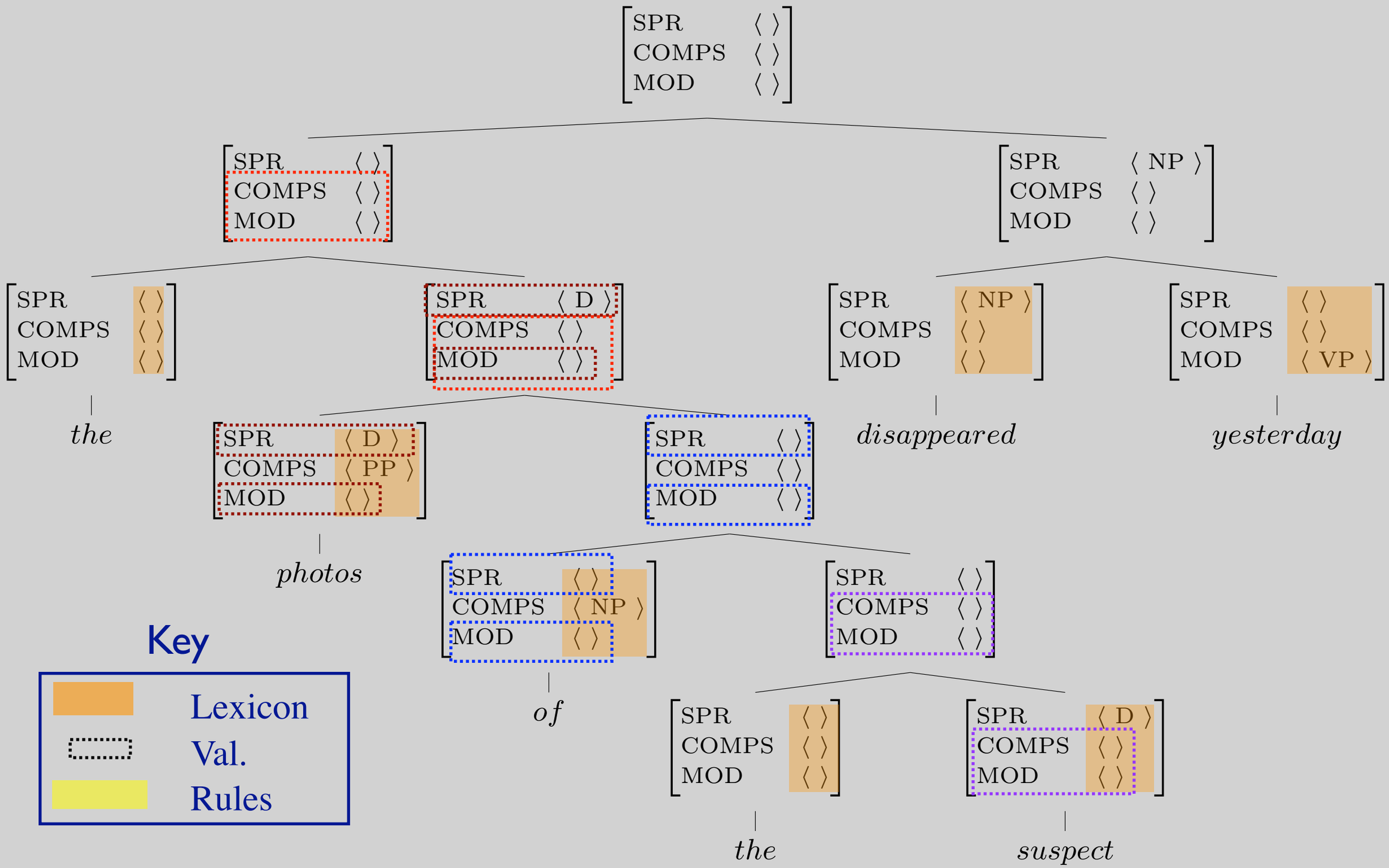

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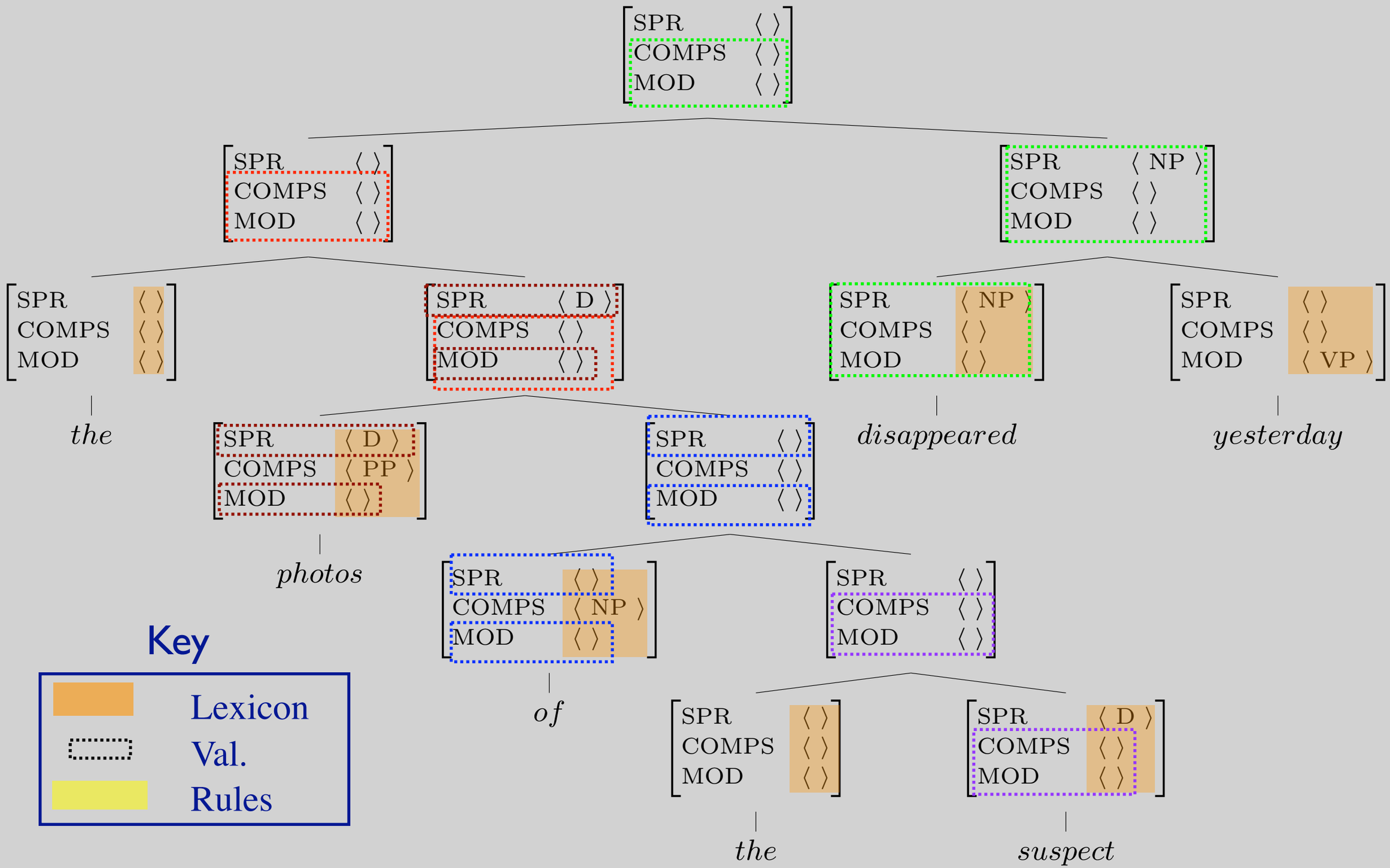

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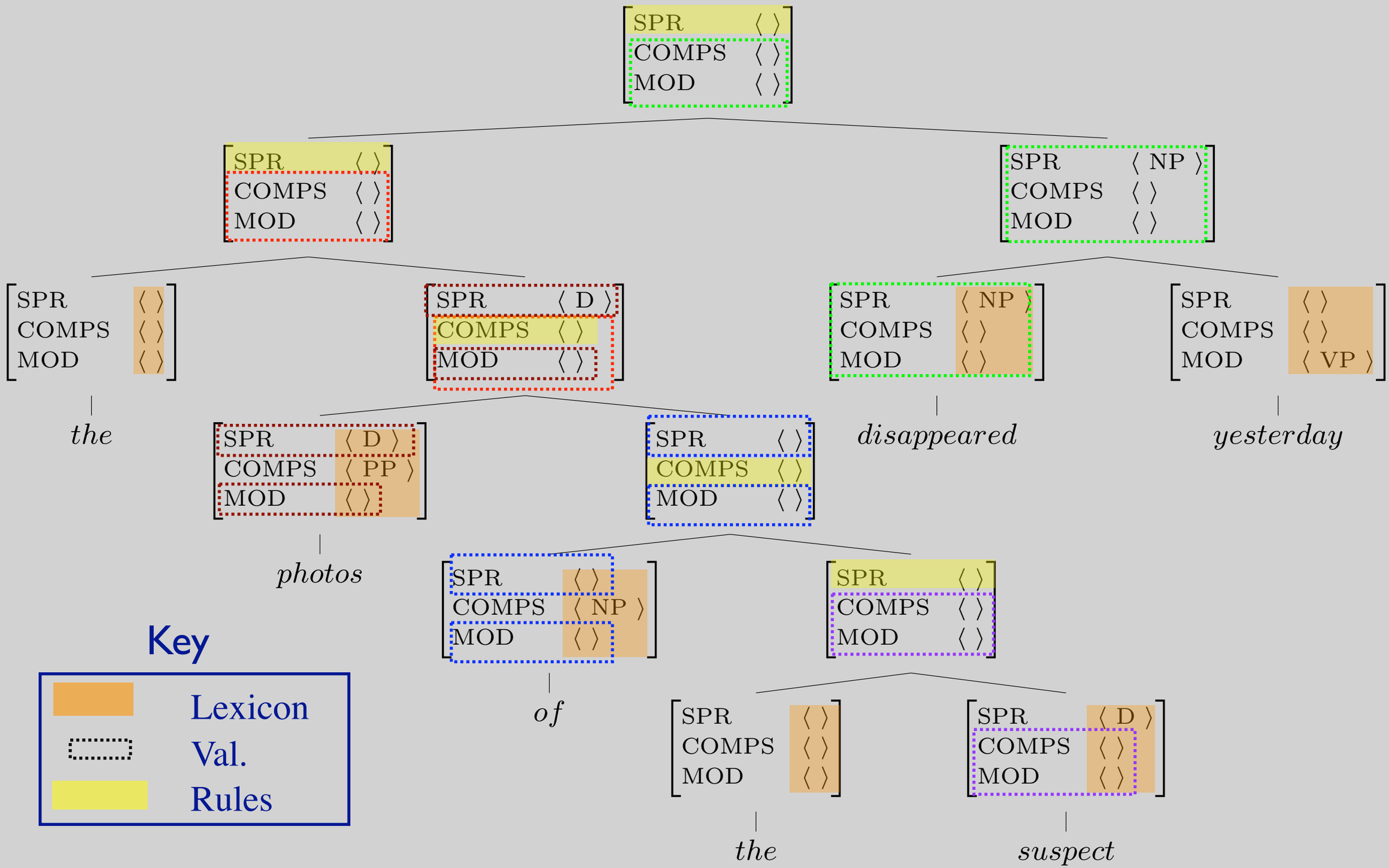

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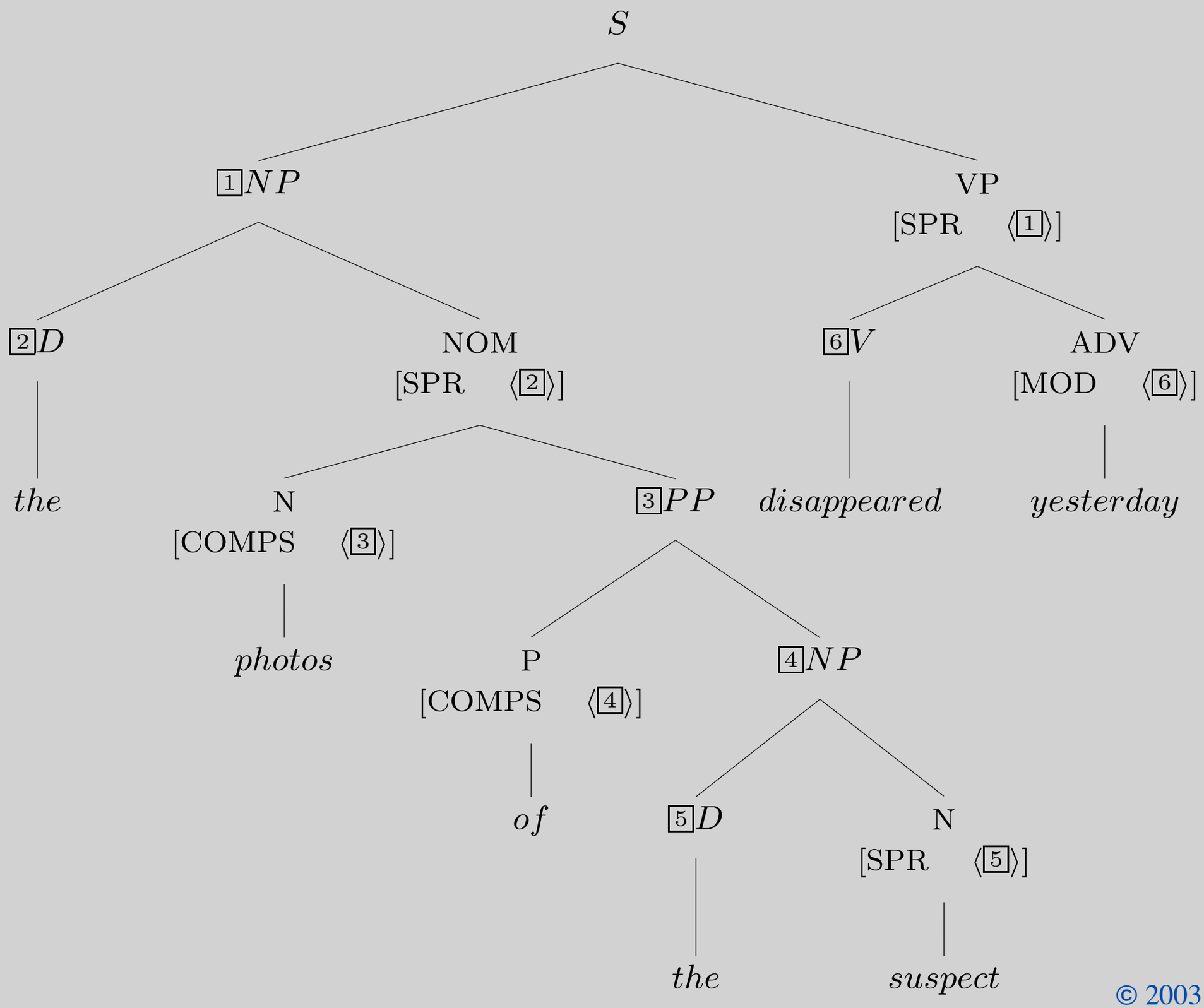

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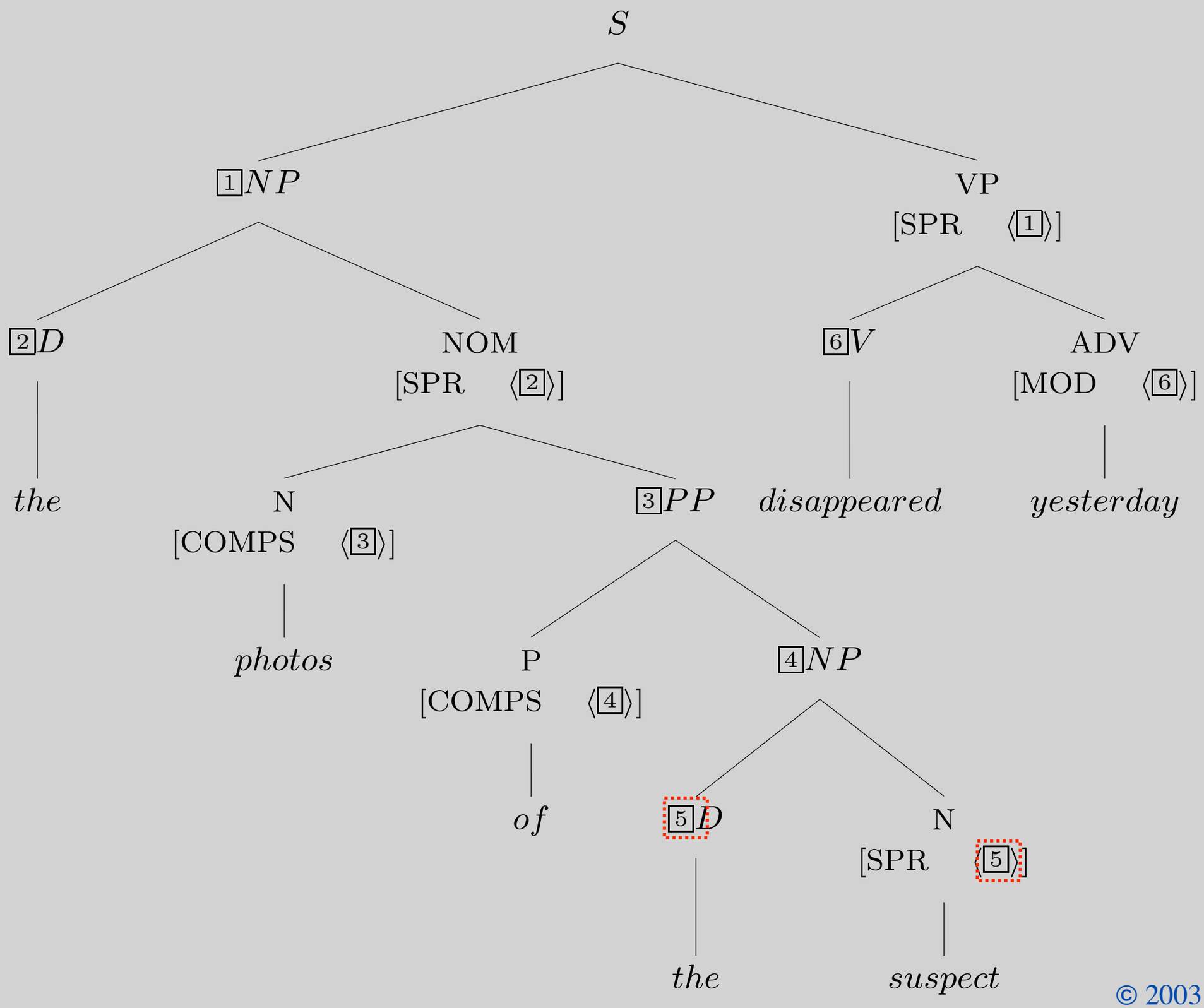

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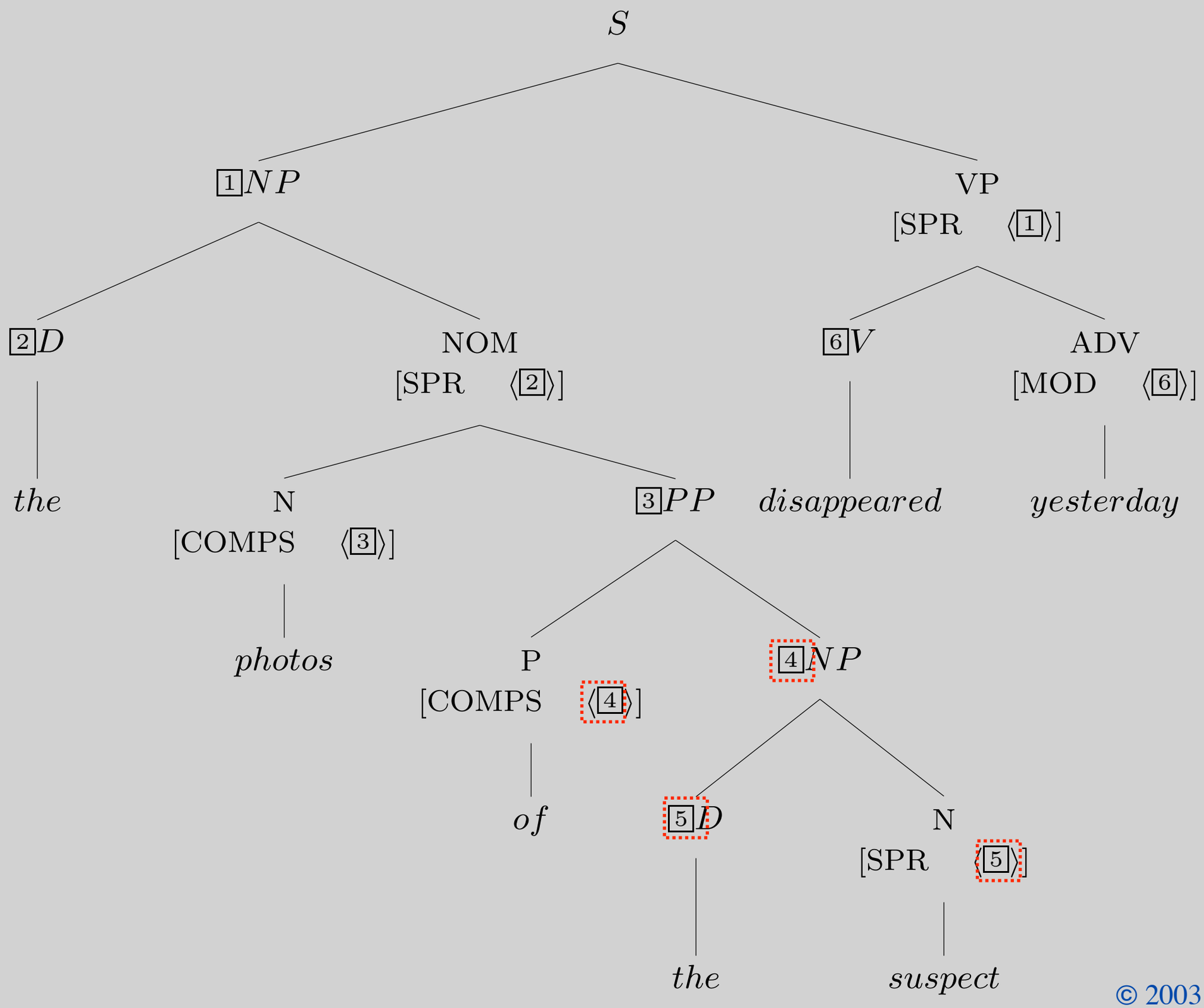

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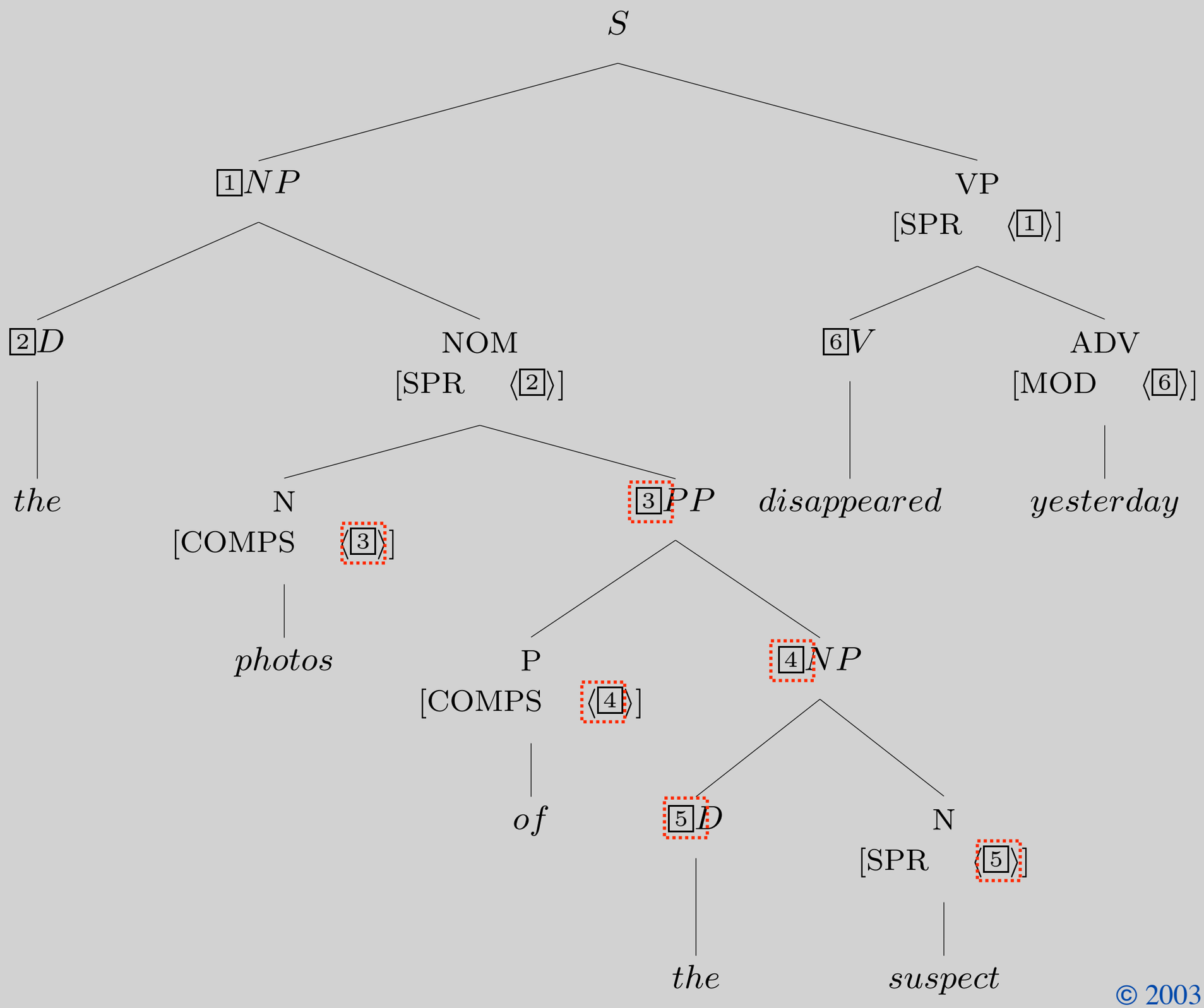

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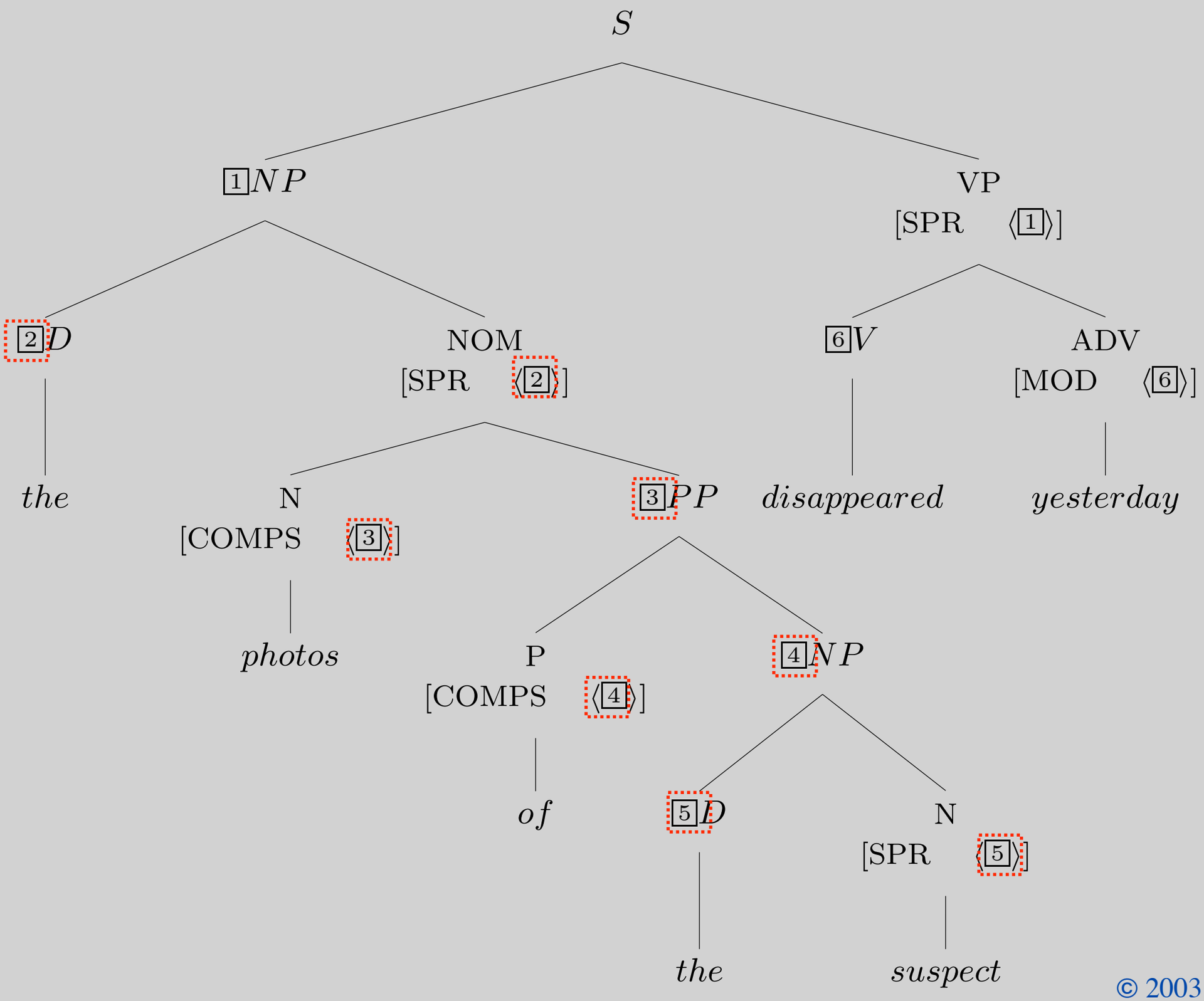

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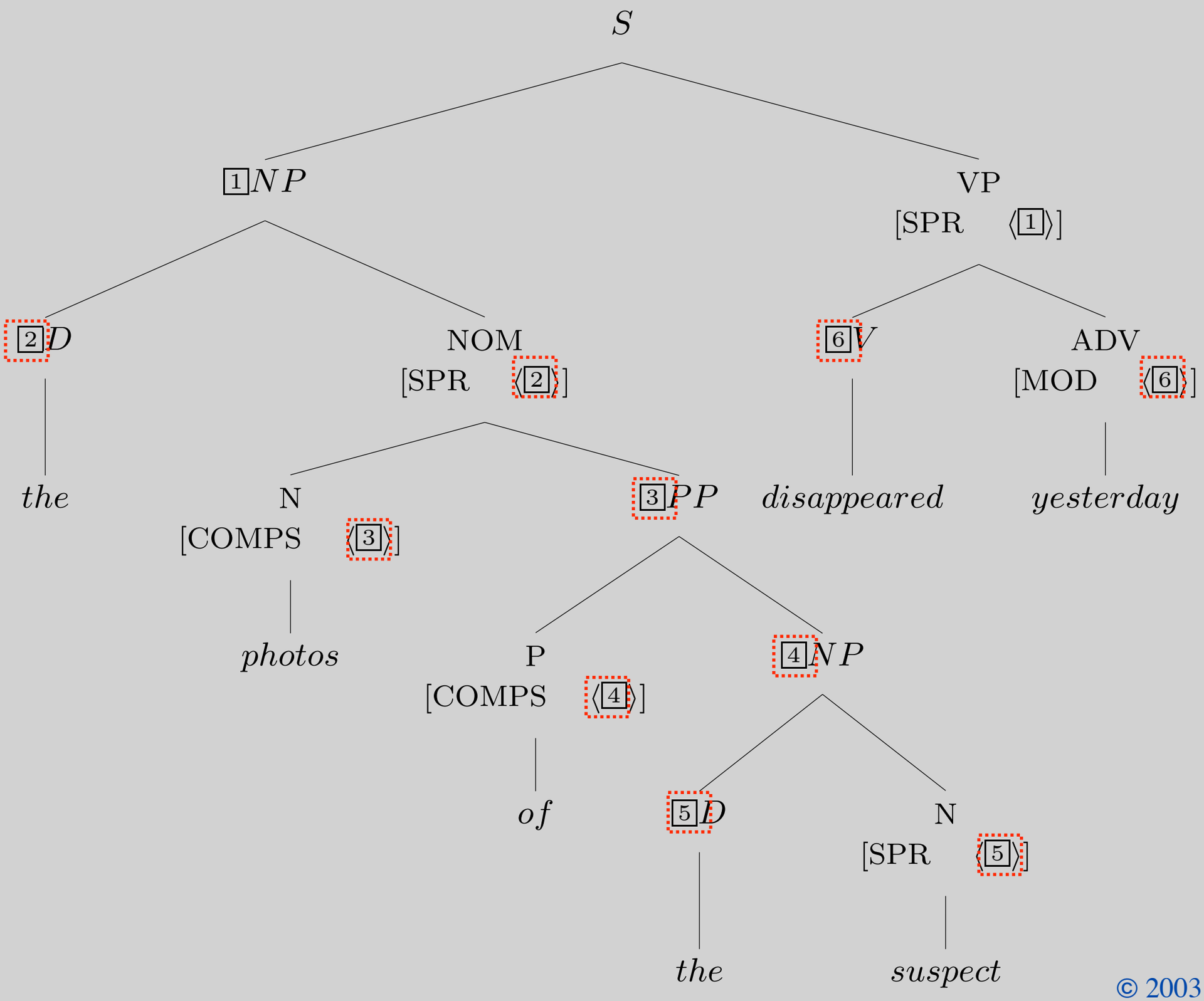

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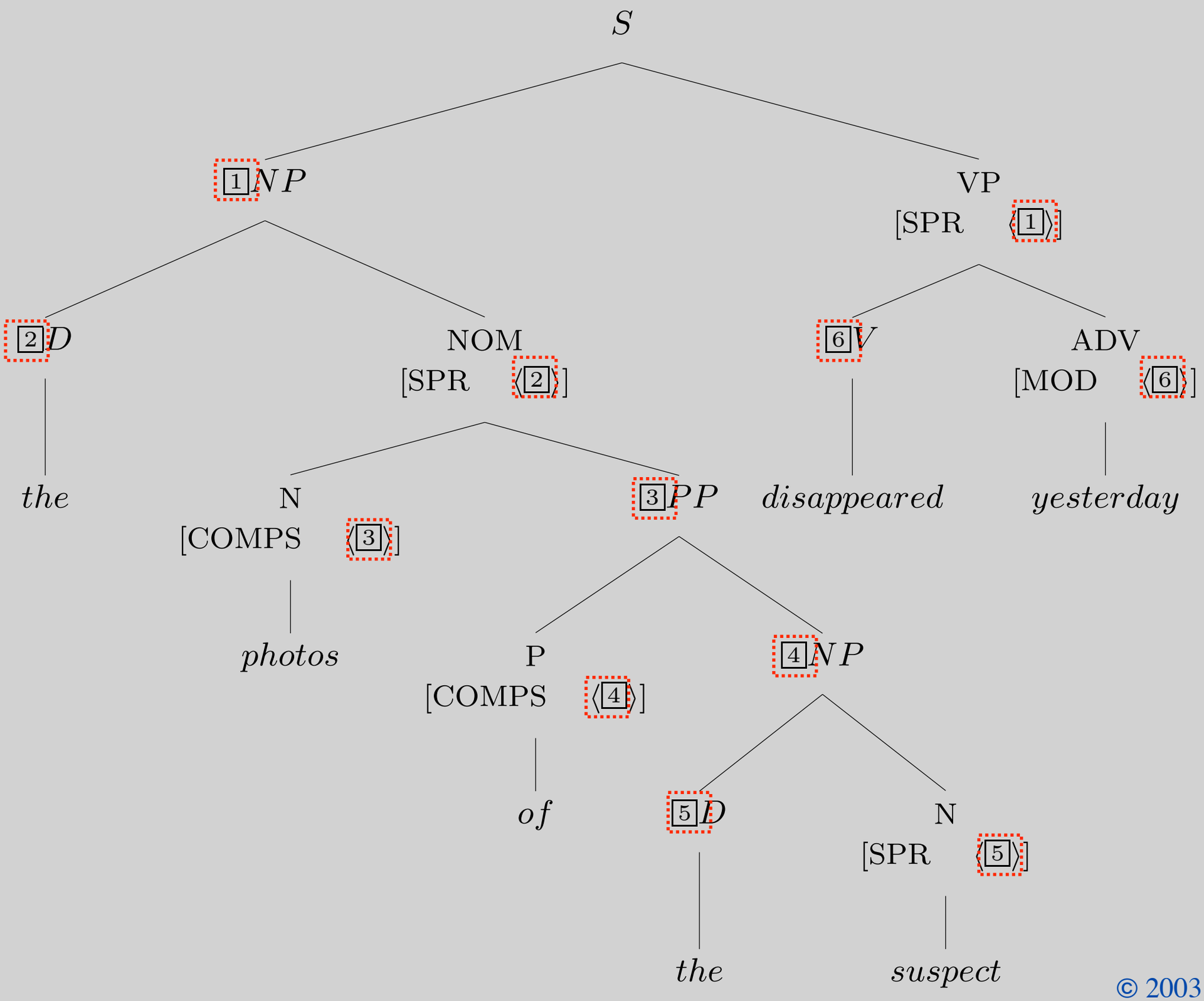

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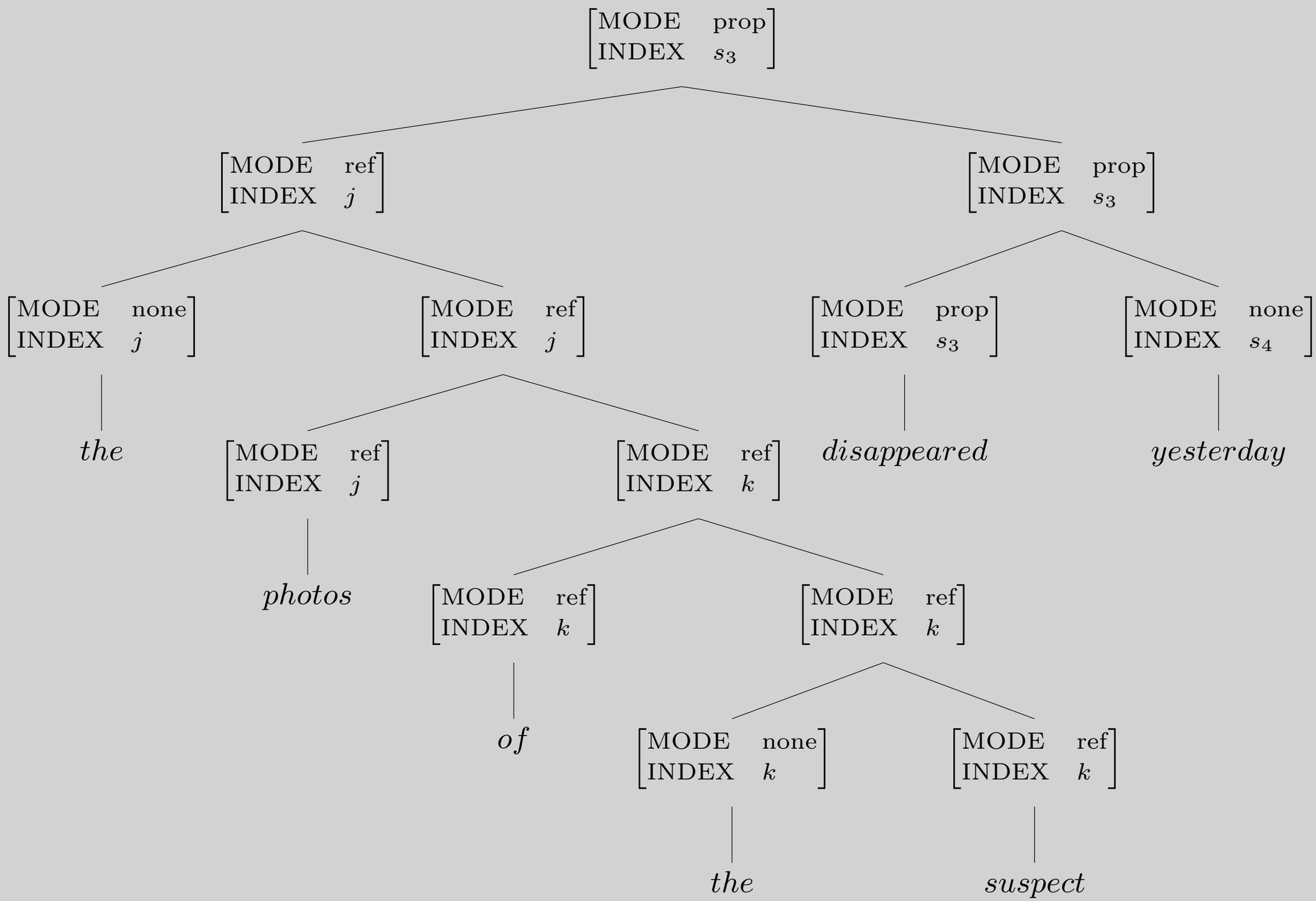

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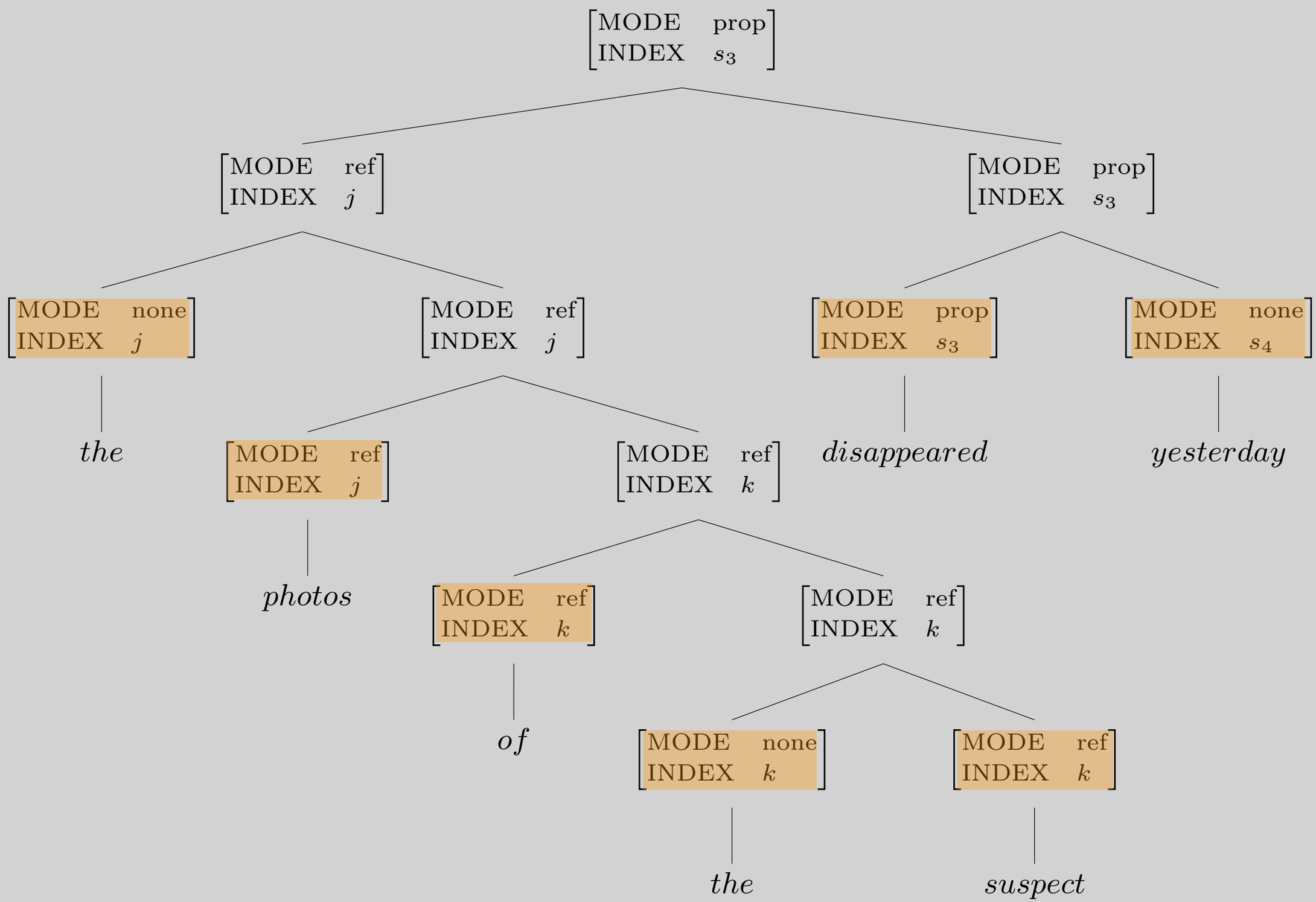

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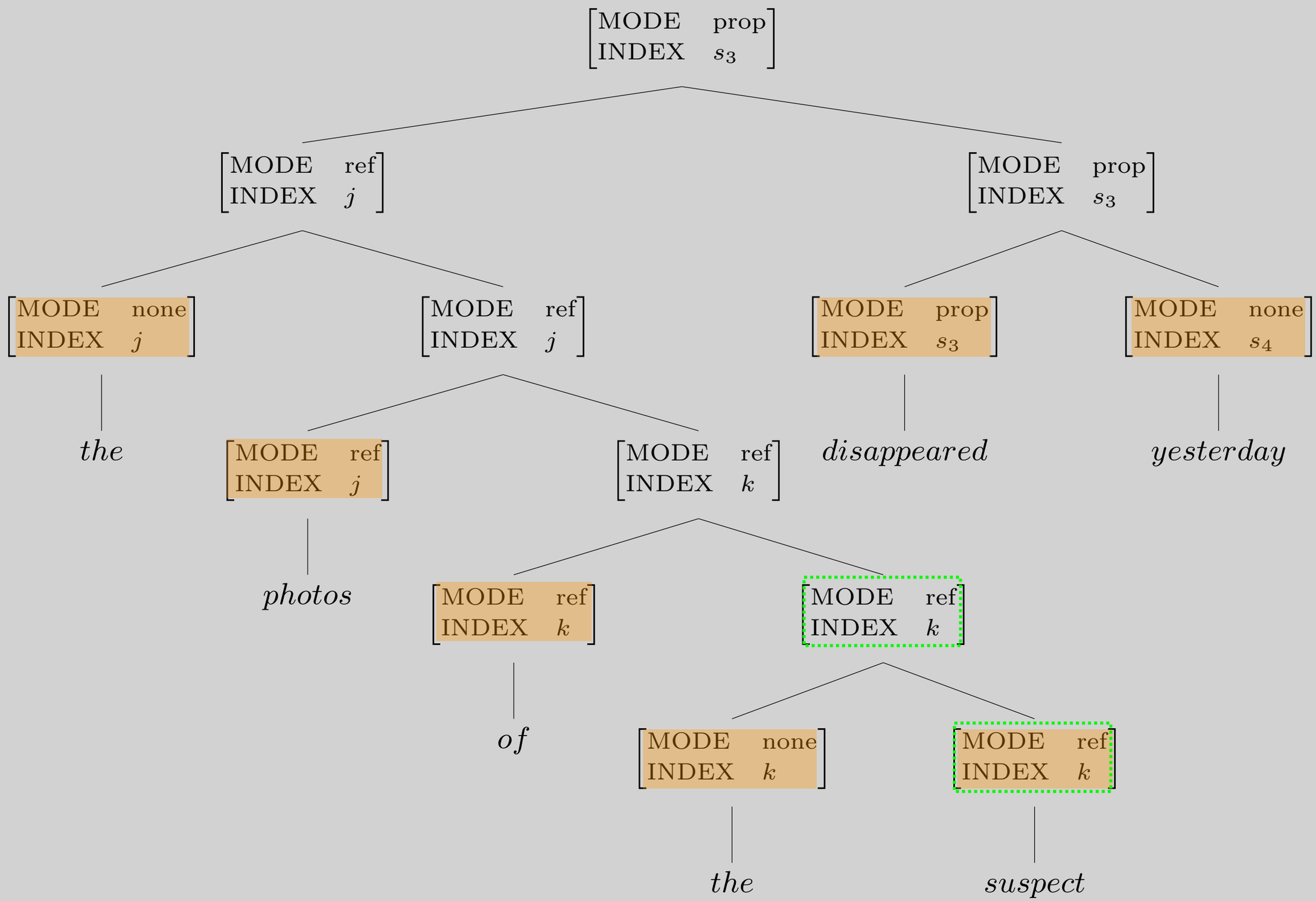

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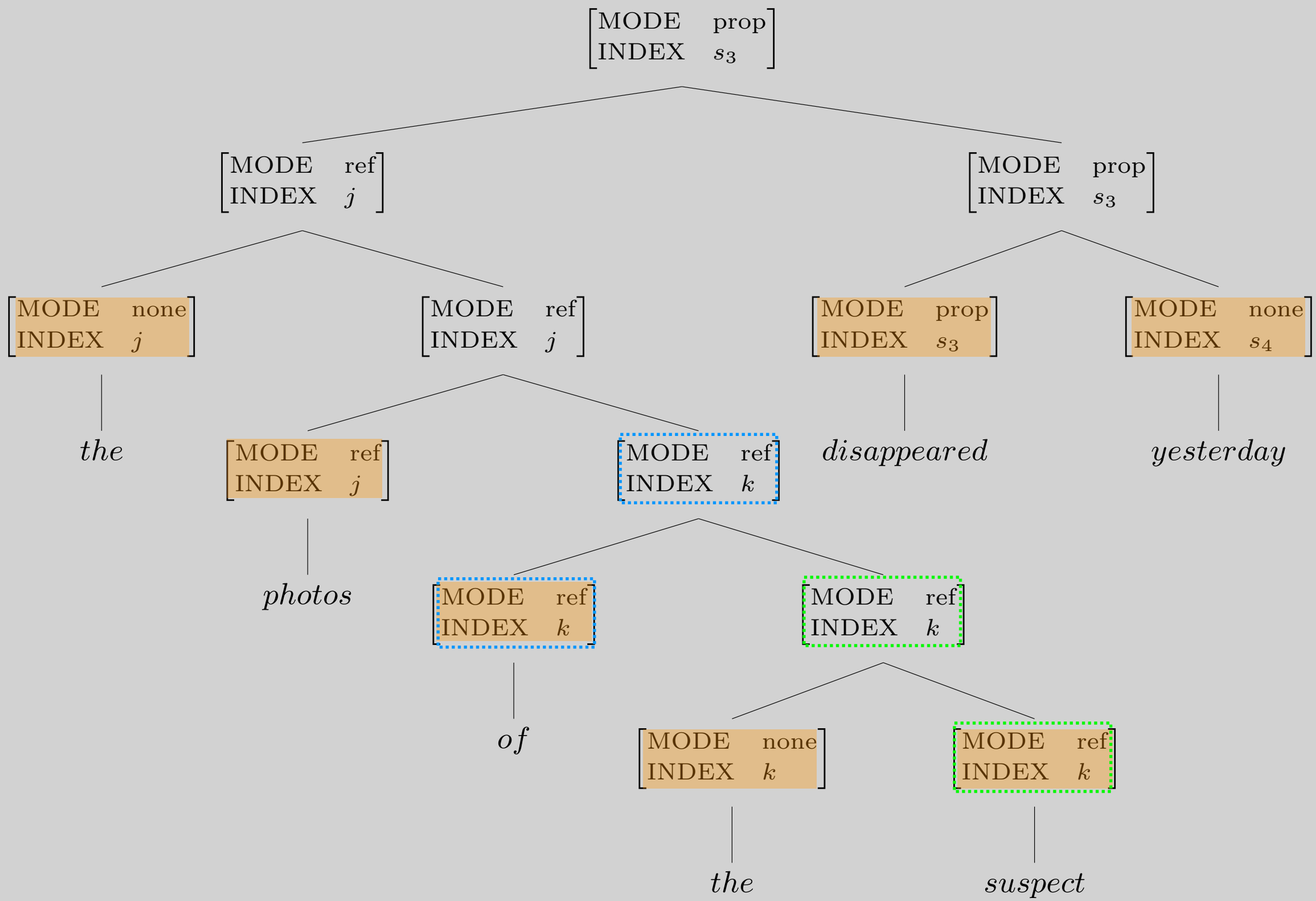

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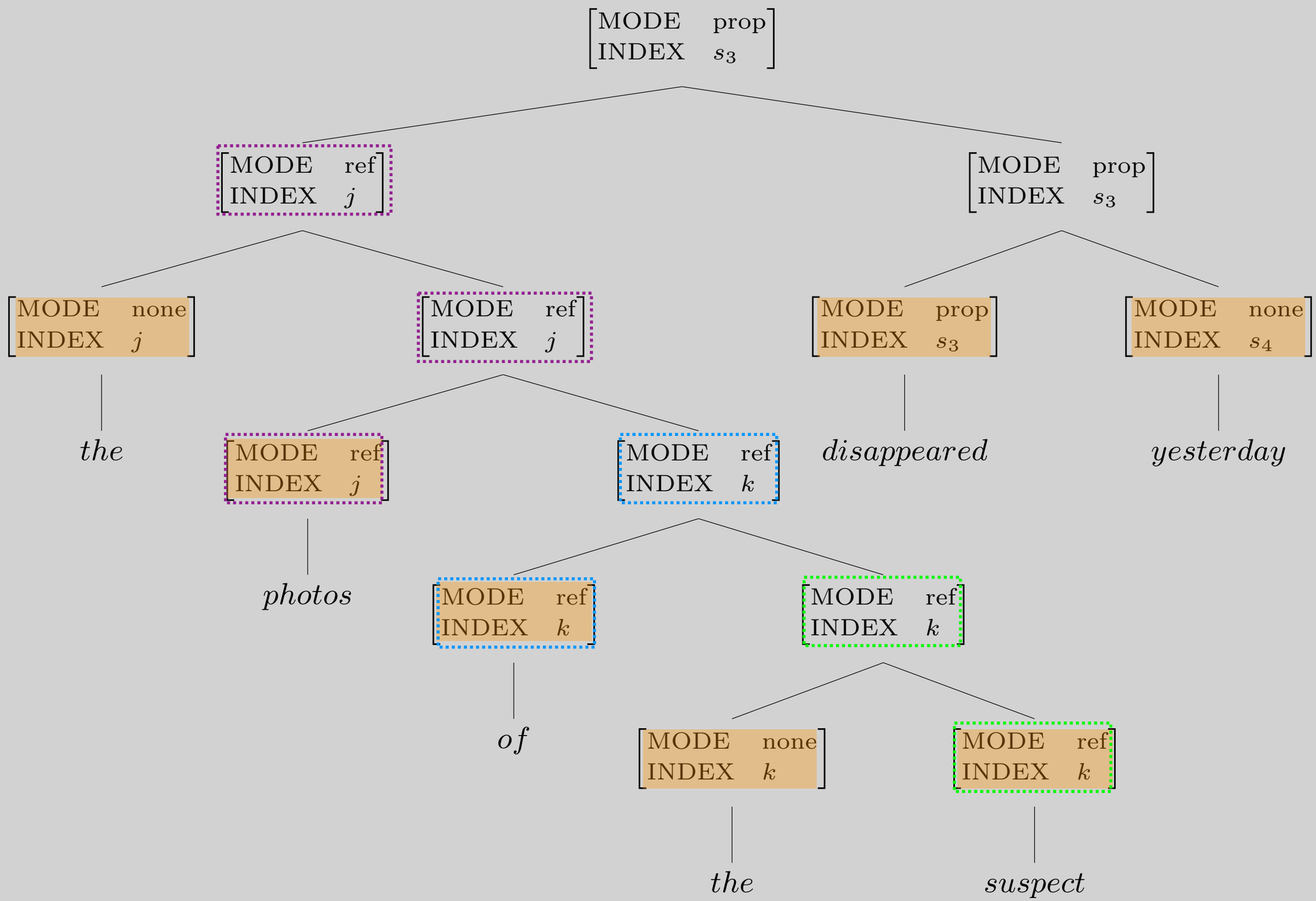

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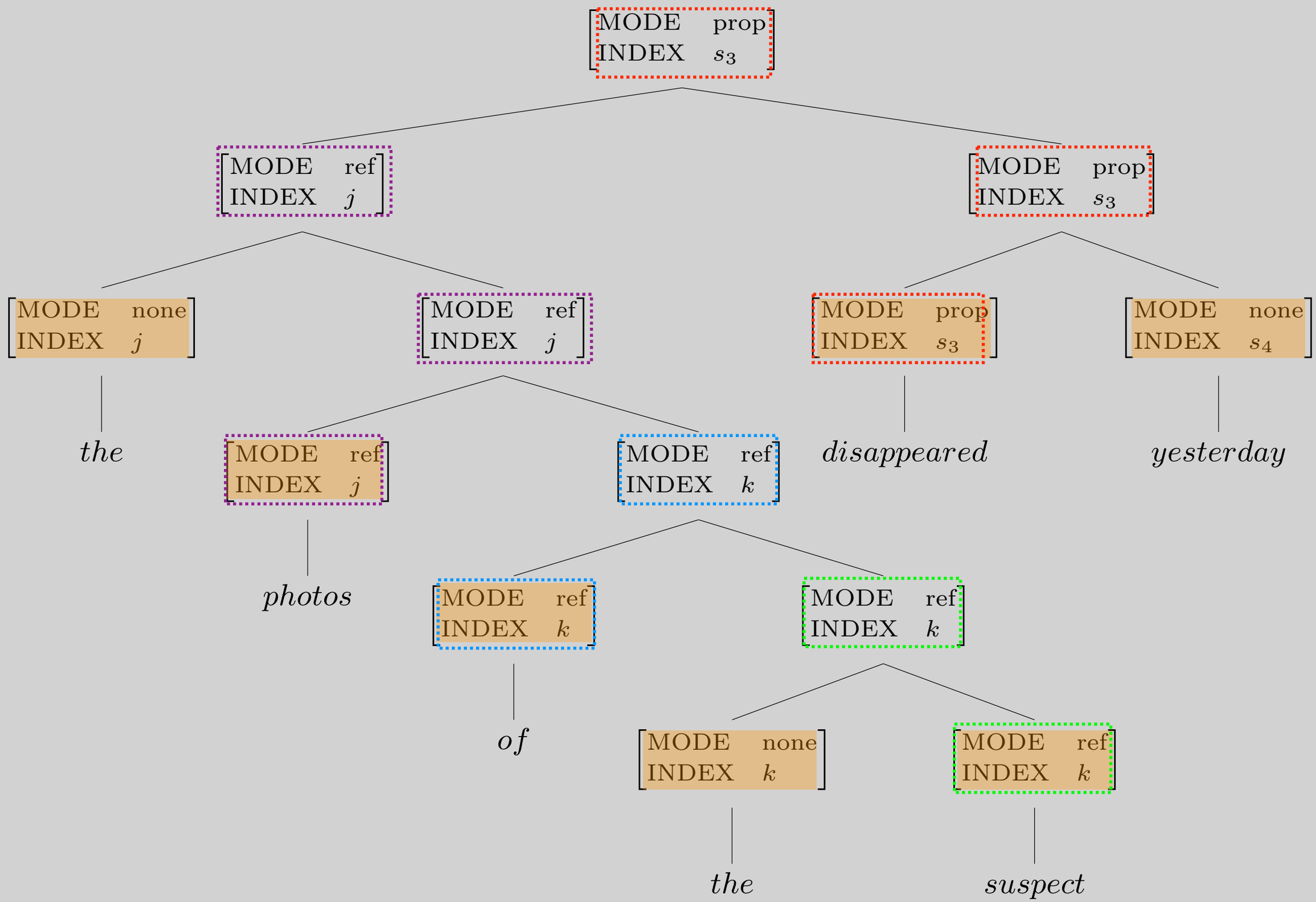

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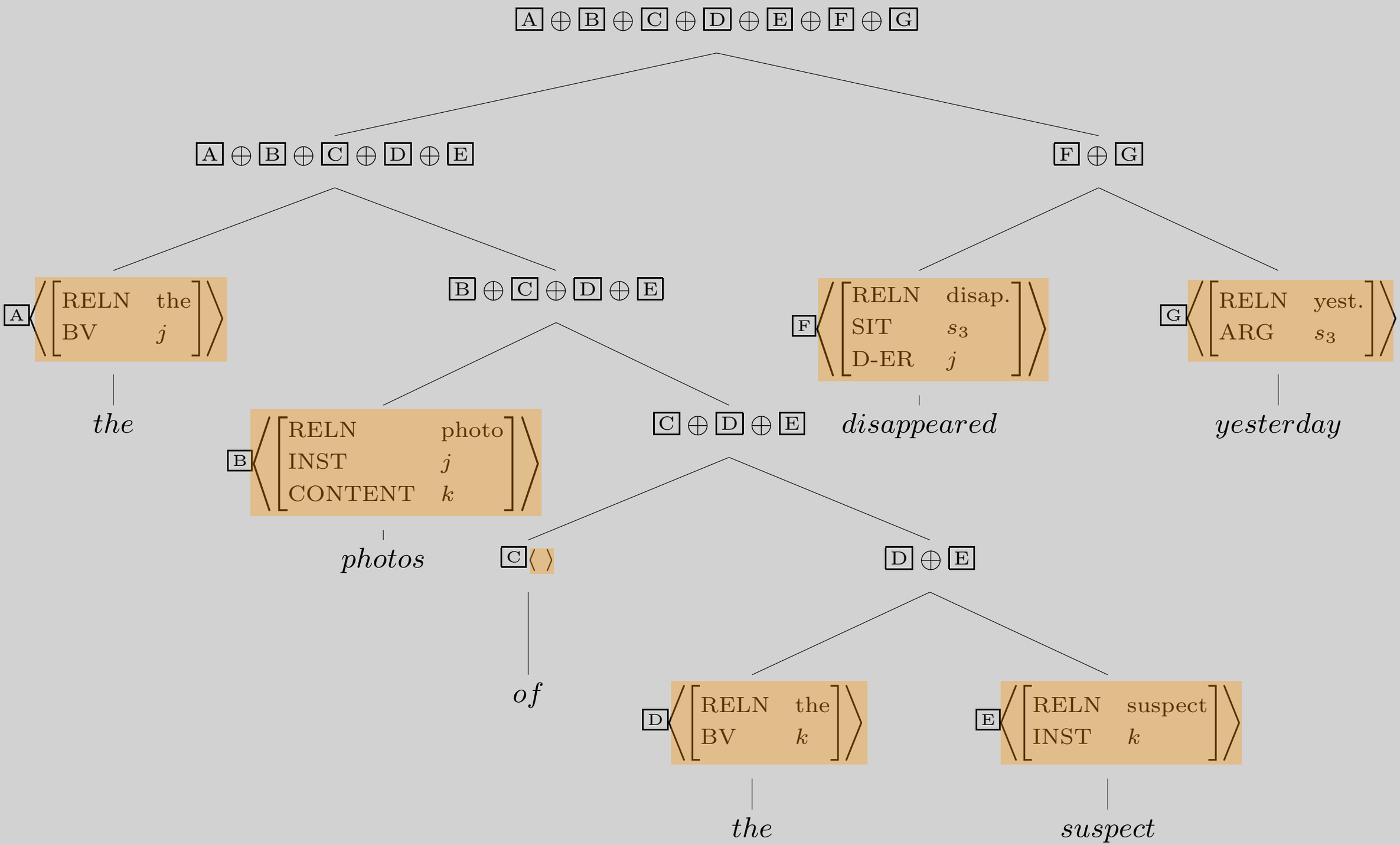
RESTR Values and the SCP



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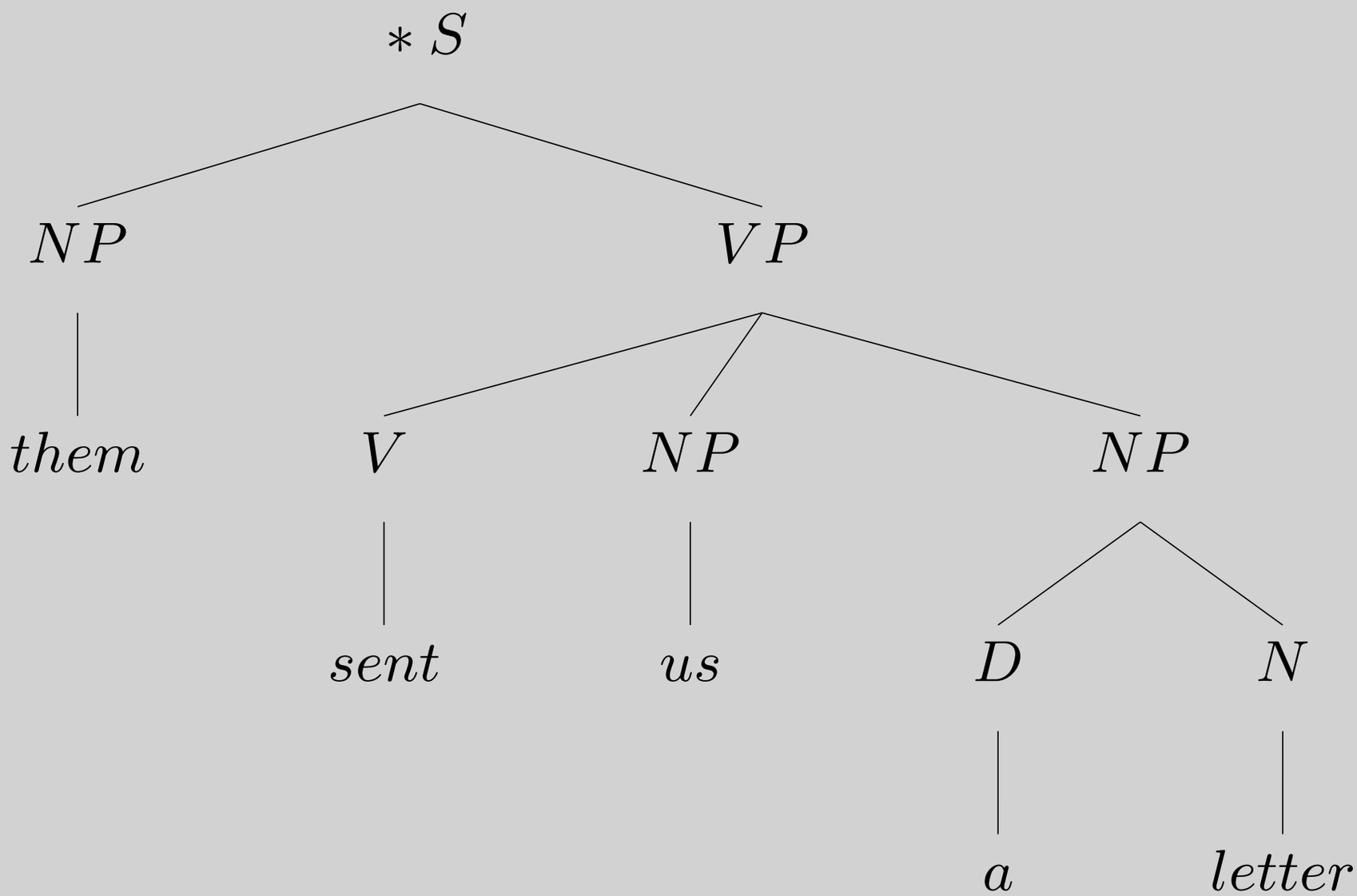

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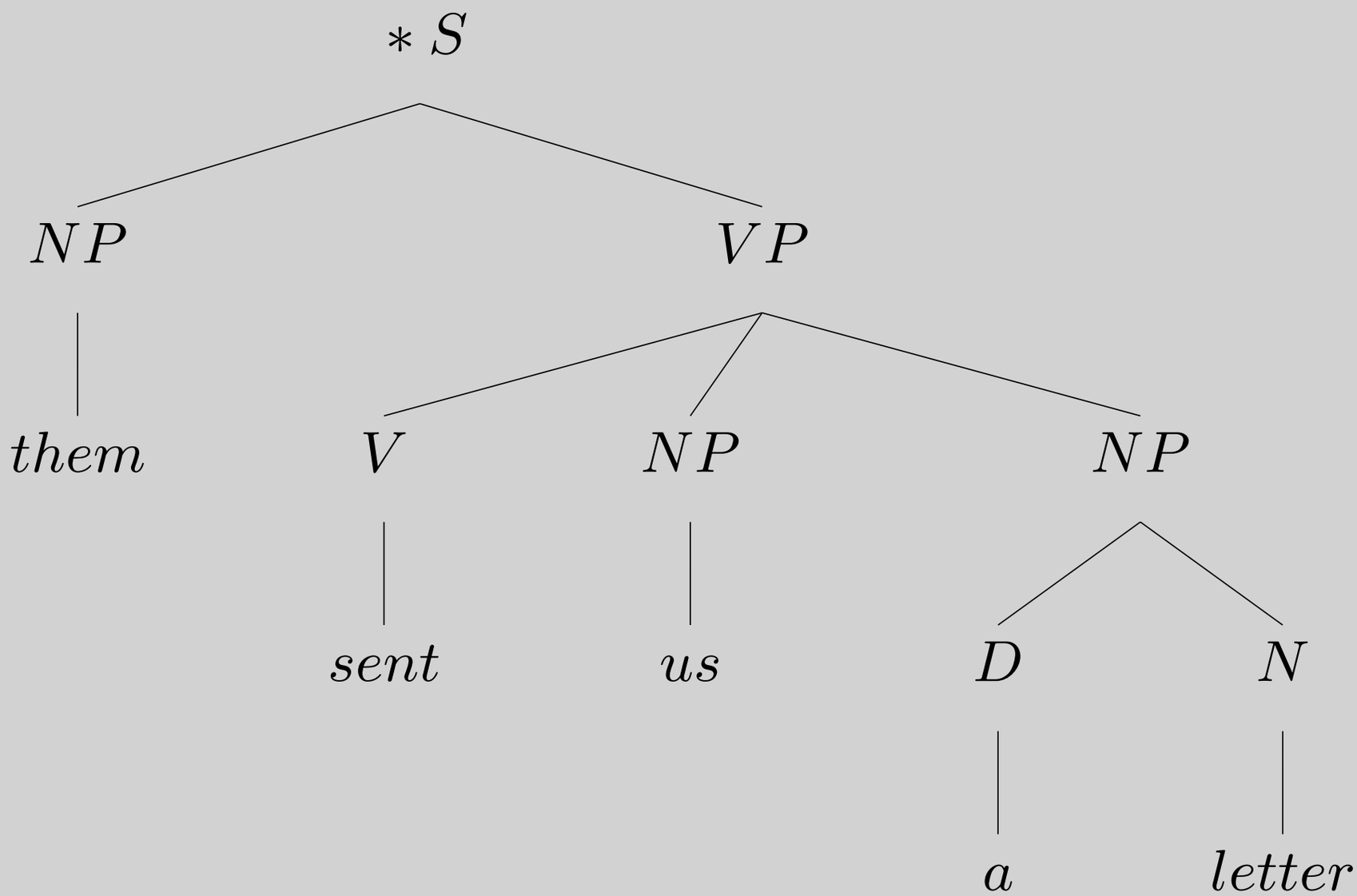

What's wrong with this sentence?

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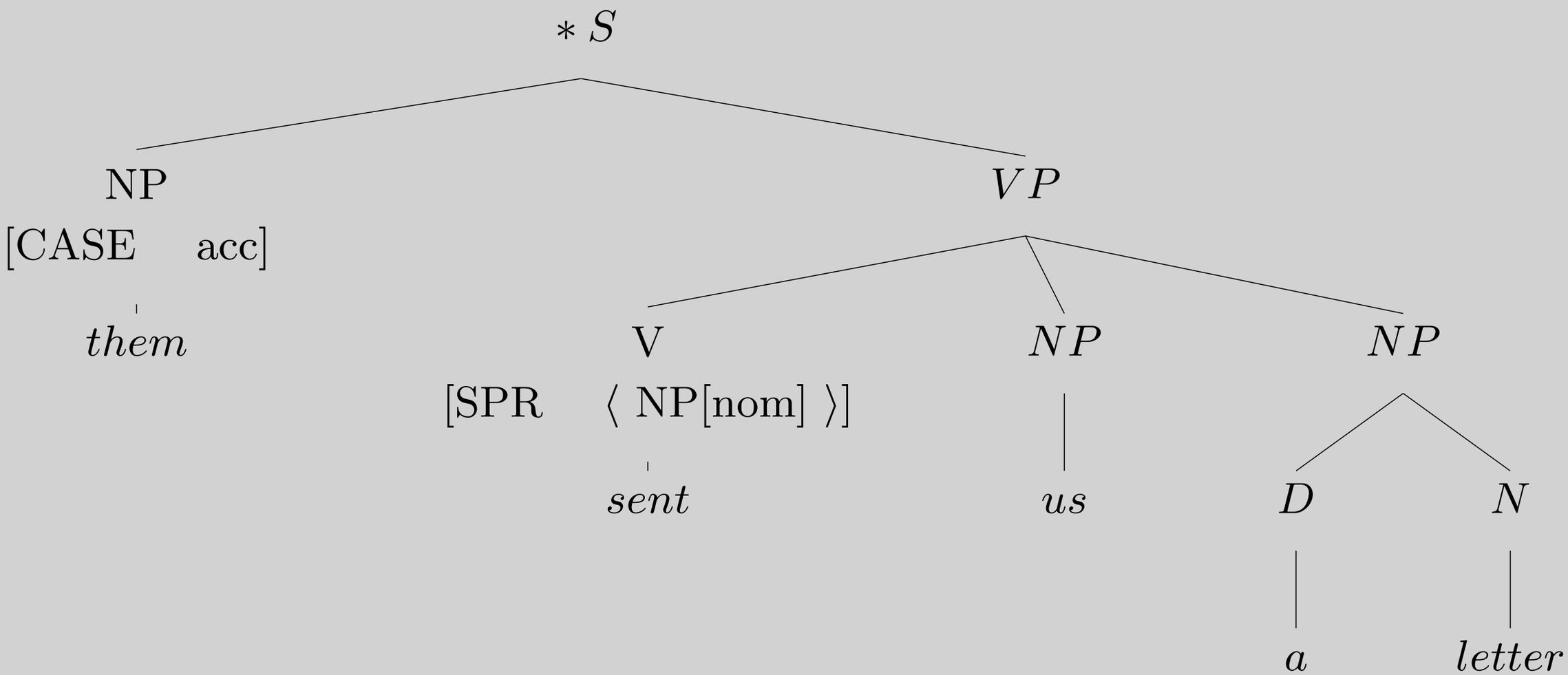

What's wrong with this sentence?

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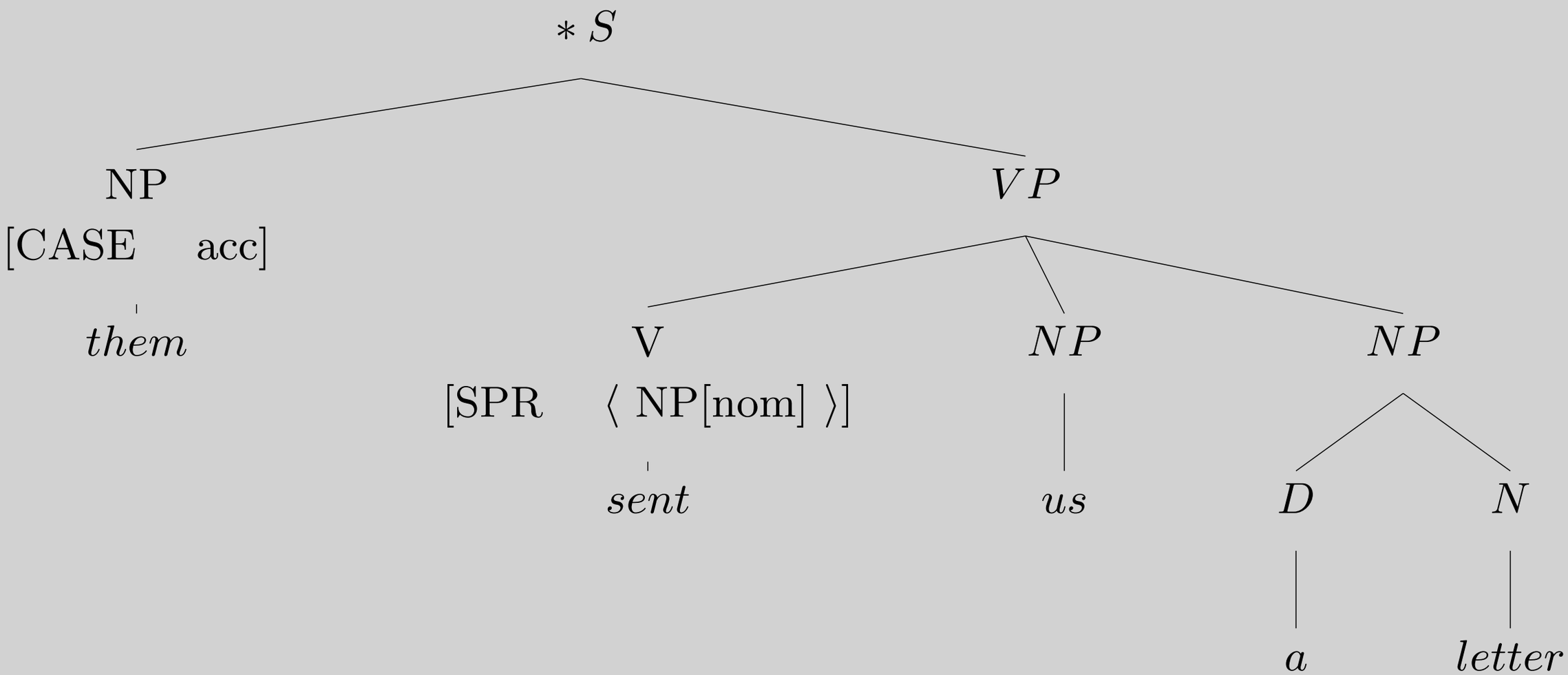

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So what?

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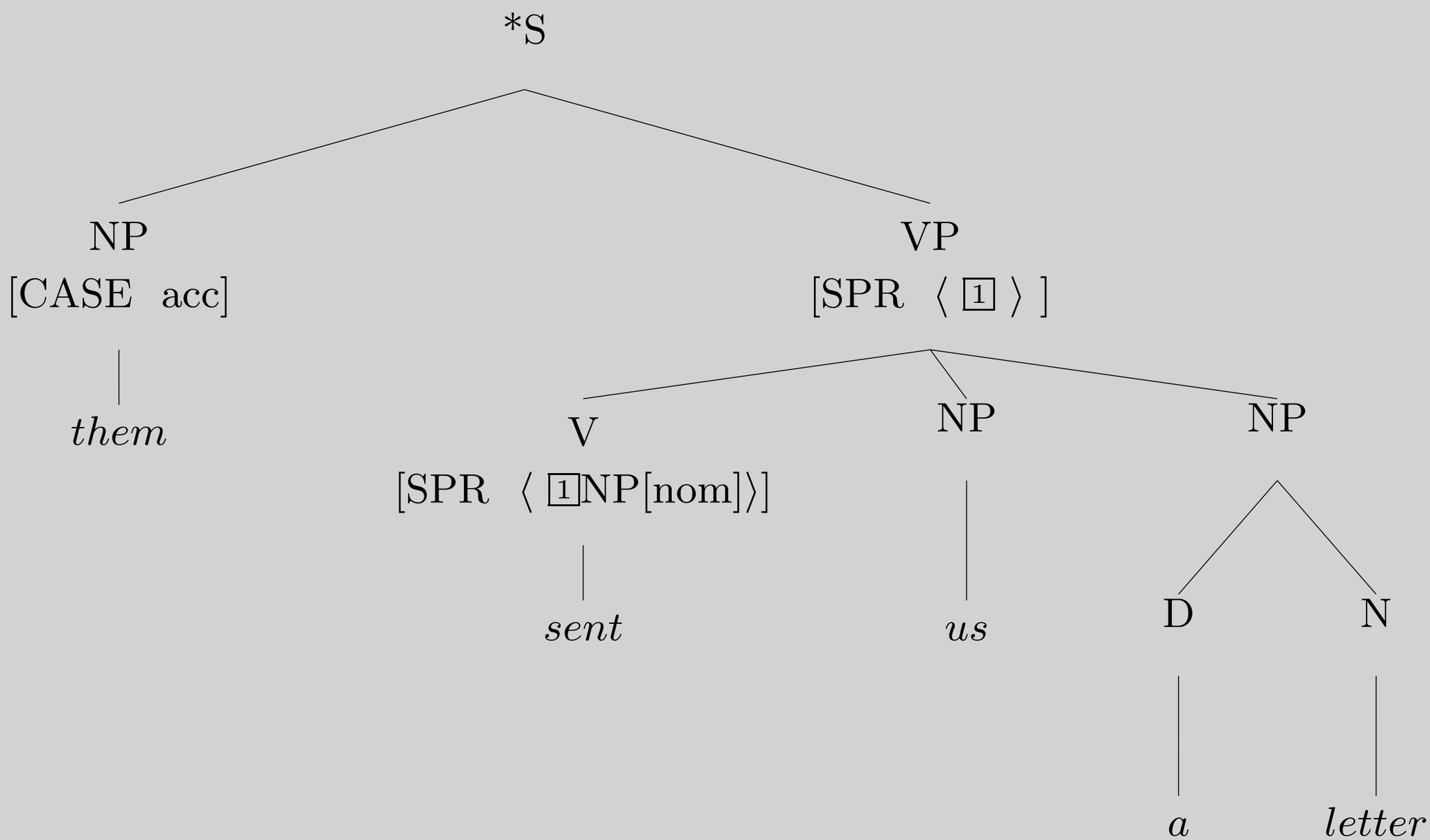
An Ungrammatical Example

The Valence Principle



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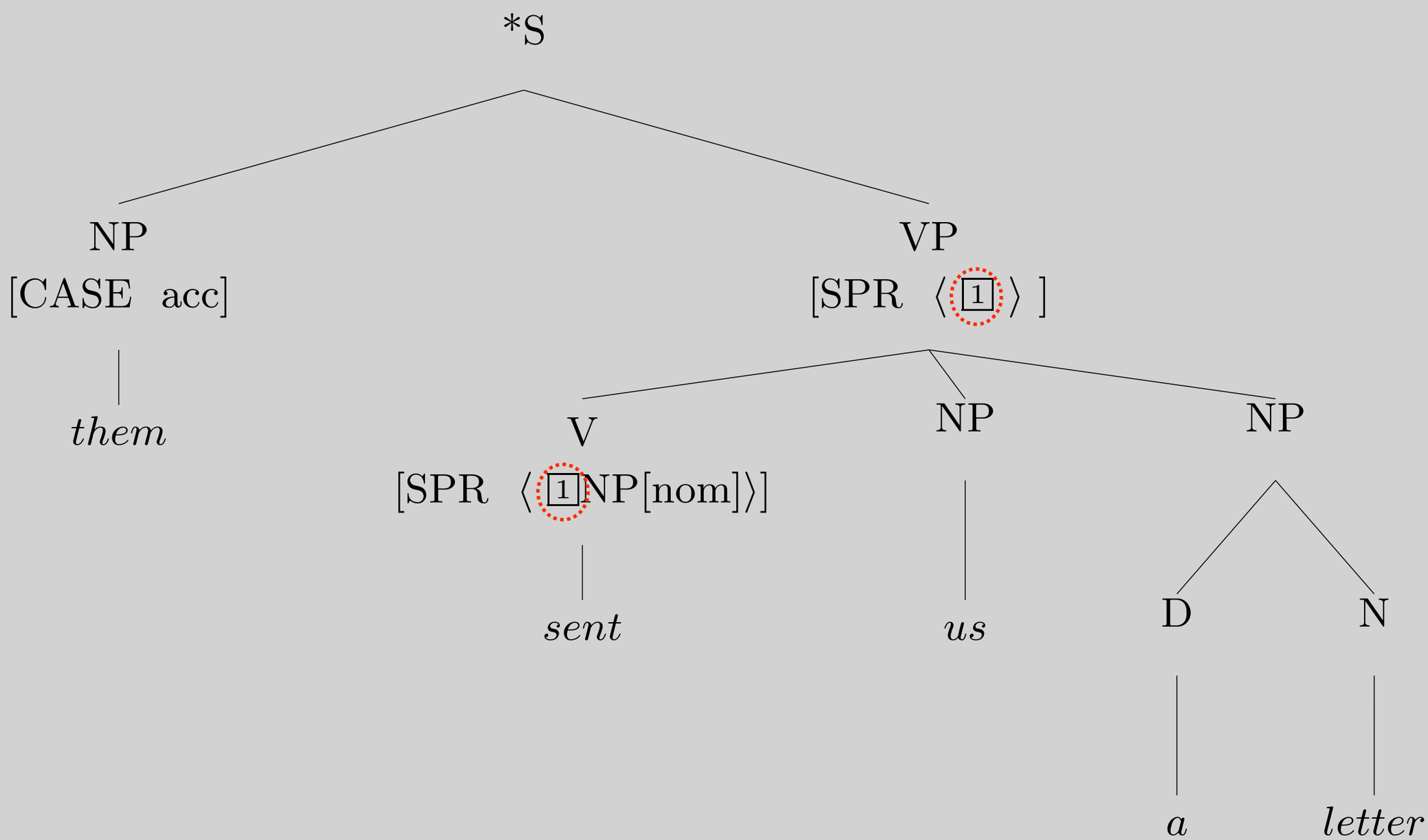
An Ungrammatical Example

The Valence Principle



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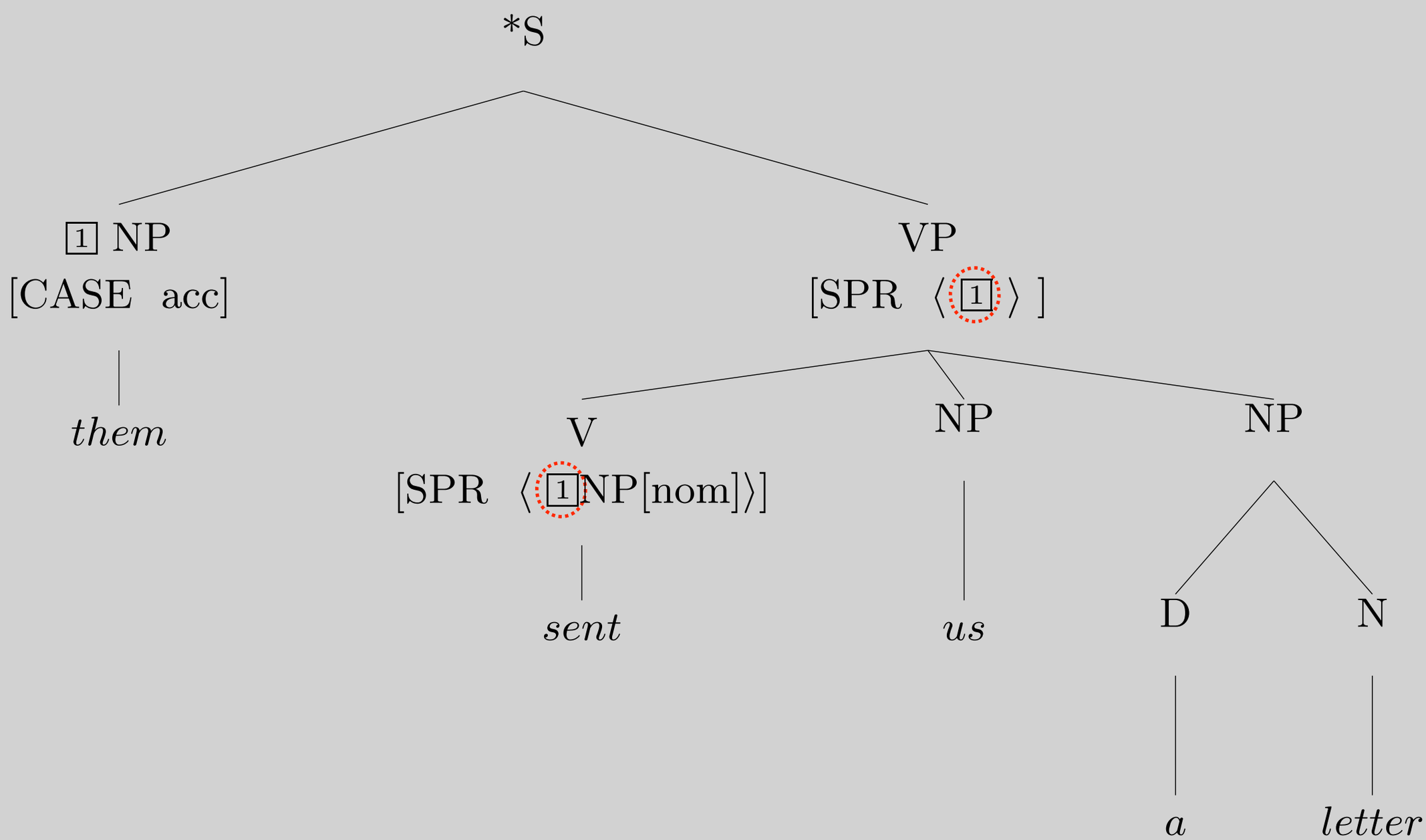
An Ungrammatical Example

Head Specifier Rule



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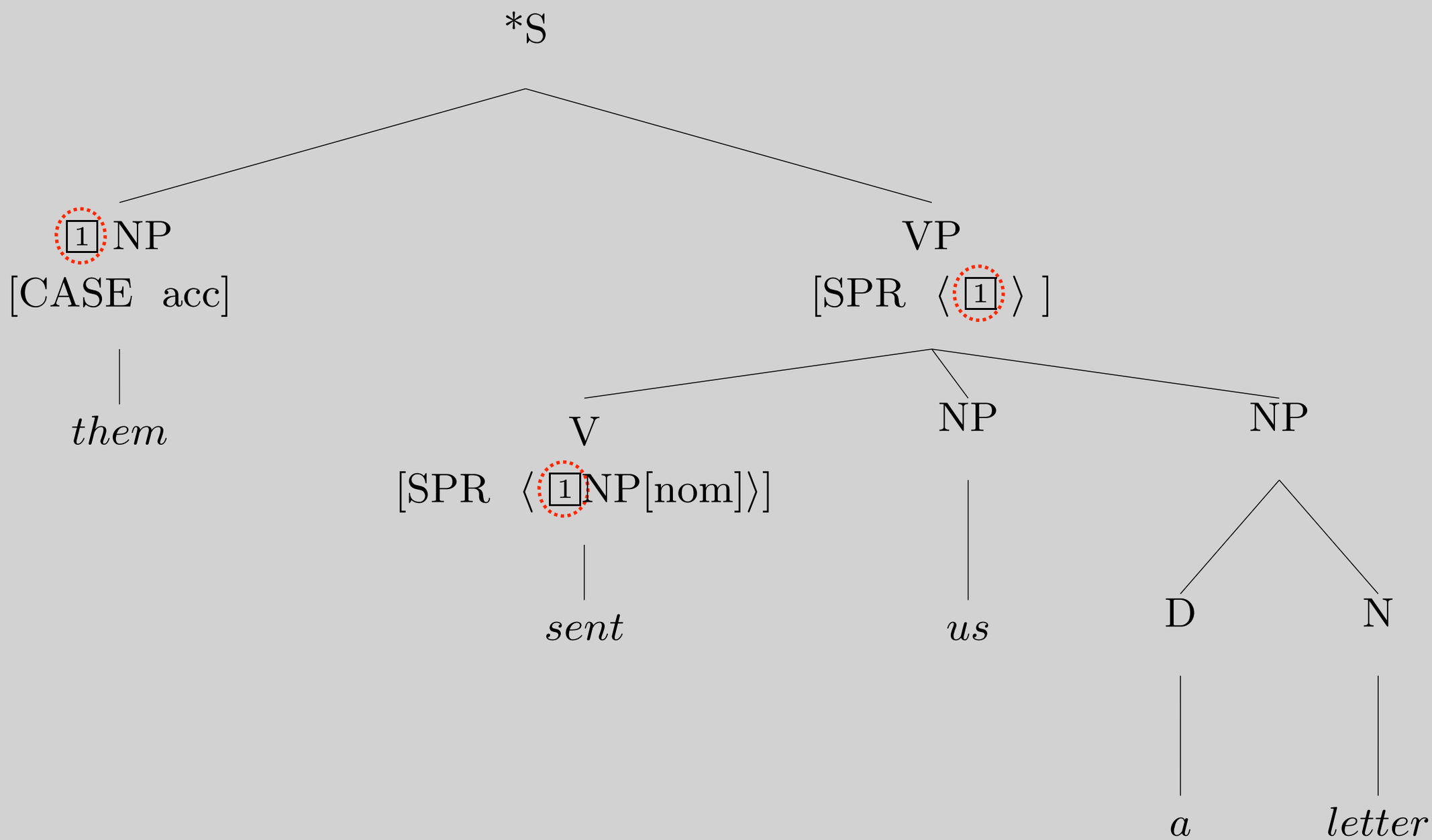
An Ungrammatical Example

Head Specifier Rule



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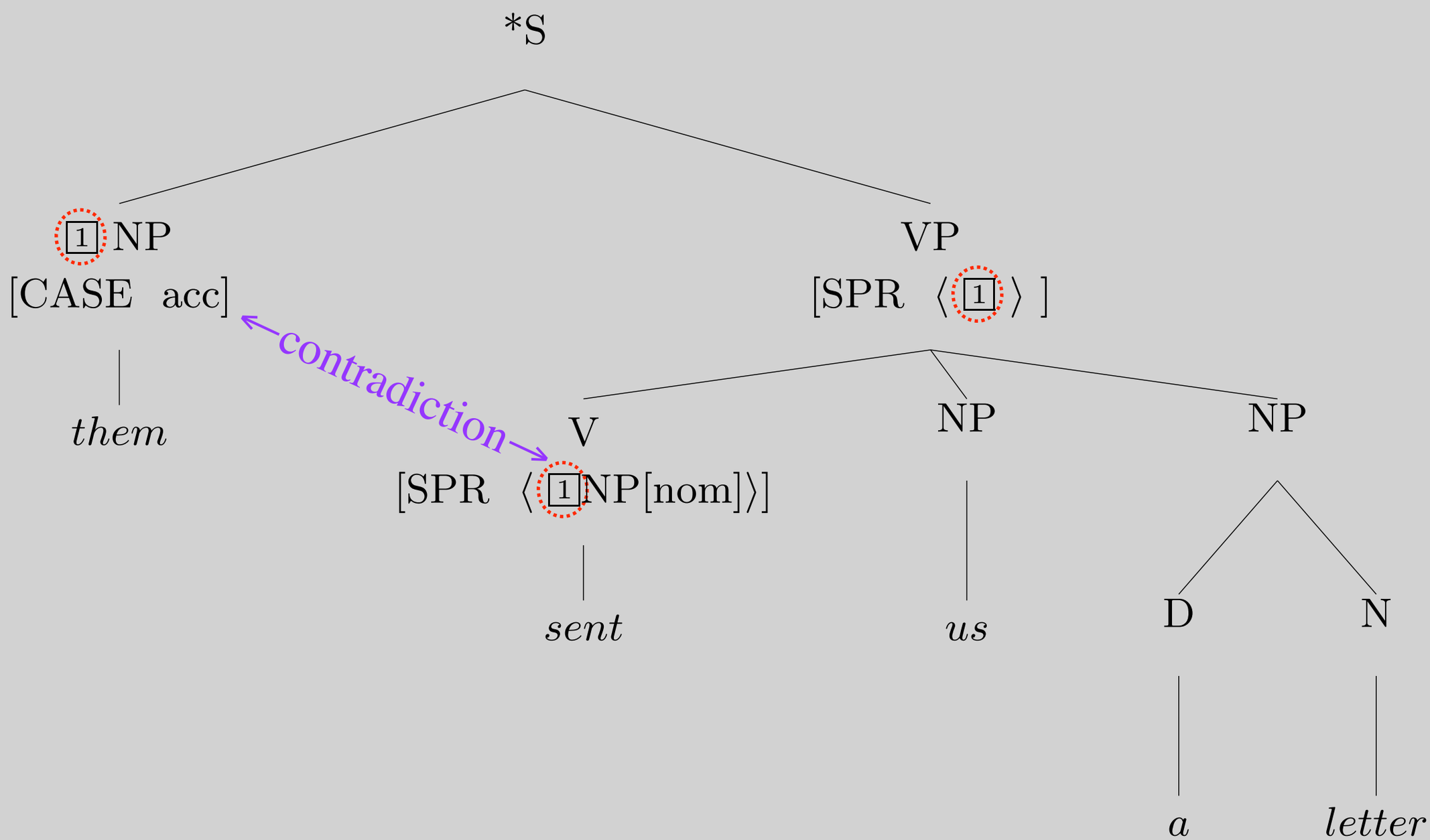
An Ungrammatical Example

Head Specifier Rule



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Exercise in Critical Thinking

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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

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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?

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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

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