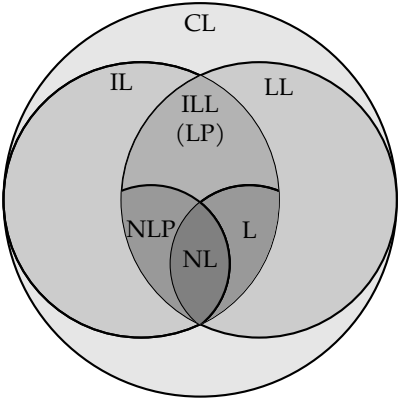
Dependency as Modality, Parsing as Permutation

A Neurosymbolic Perspective on Categorial Grammars

Konstantinos Kogkalidis

ESSLLI, August 2024, Leuven

The (Very) Big Picture



CL (folklore)

IL no double negation elim, no excluded middle
Heyting, 1930s

LL no erasure, no duplication
Girard, 1987

L non-commutative ILL
Lambek, 1958

NL non-associative L
Lambek, 1961

NLP non-associative ILL
Abrusci, 1990; van Benthem, 1991

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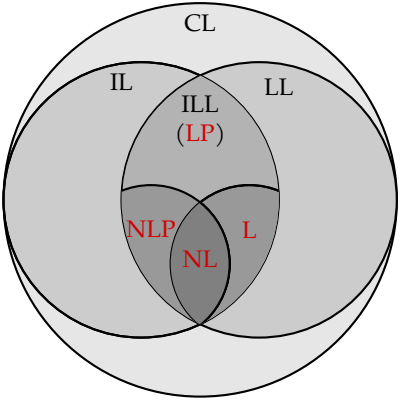

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(N)L(P): *Grammar Logics*

The (Slightly Less) Big Picture

LLC

the (well-typed) categorial perspective

Language	**Logic**	**Computation**
grammar	substructural logic	λ-calculus
grammatical category	proposition	type
phrasal composition	inference rule	computation step
grammaticality	derivability	type inhabitation
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The (Slightly Less) Big Picture

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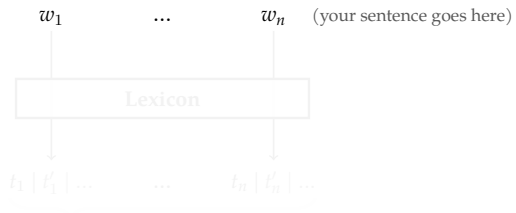
sentence	proof	program

How (idealized)



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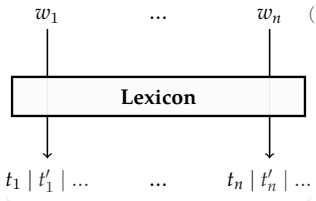

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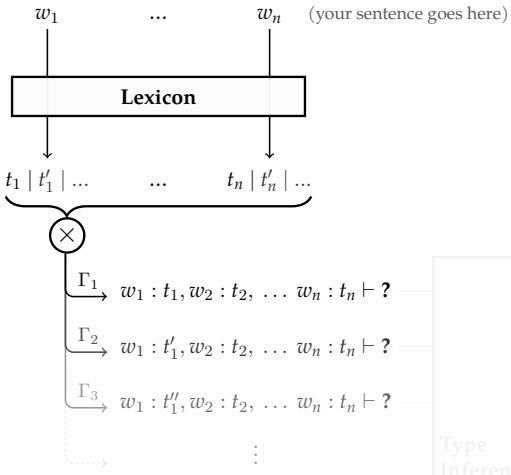

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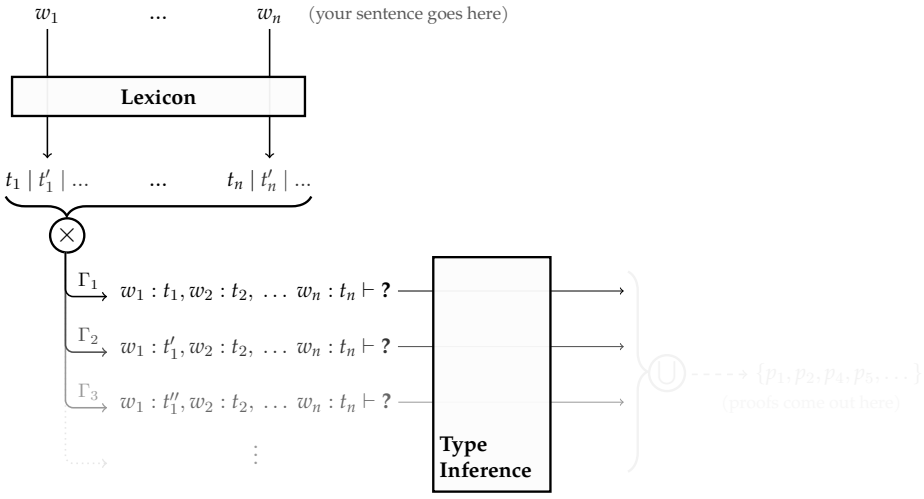

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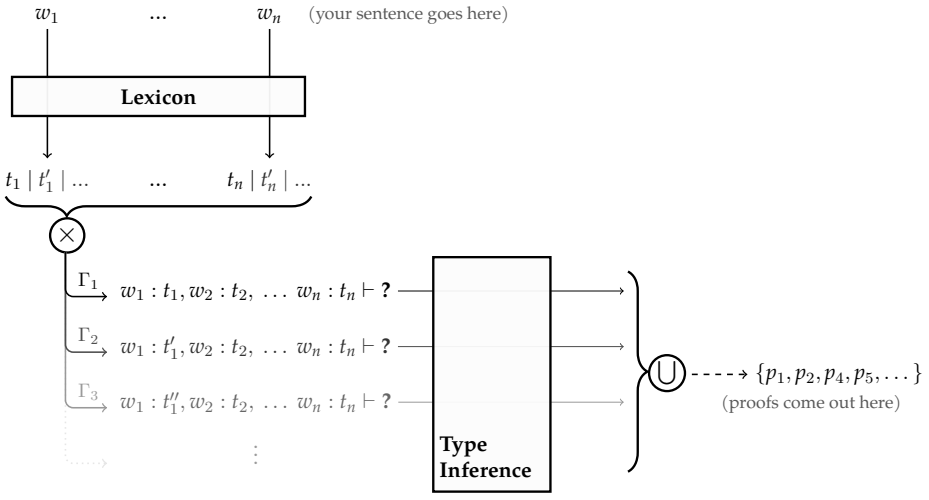

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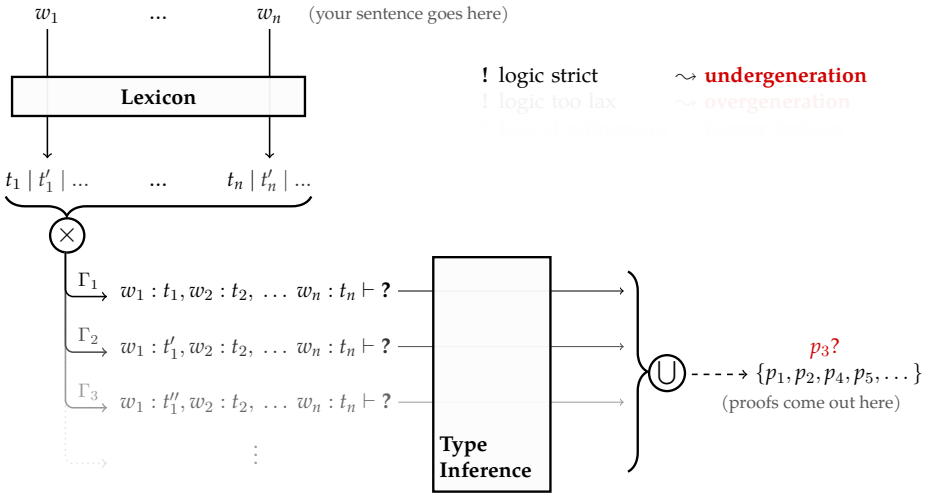

! logic strict ⇝ **undergeneration**

! logic too lax ⇝ **overgeneration**

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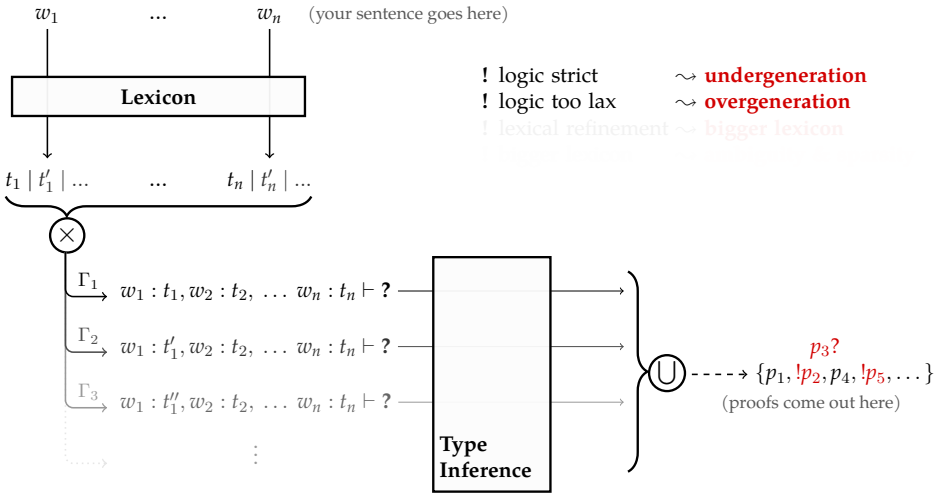

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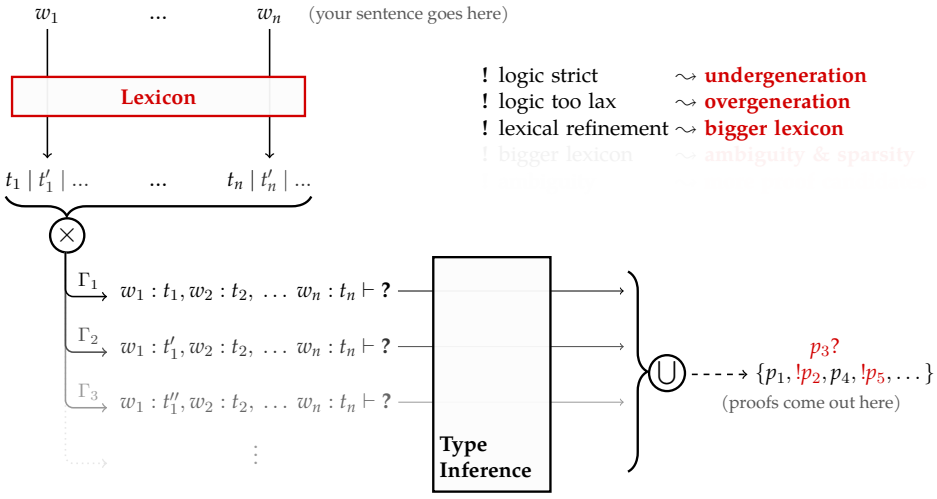

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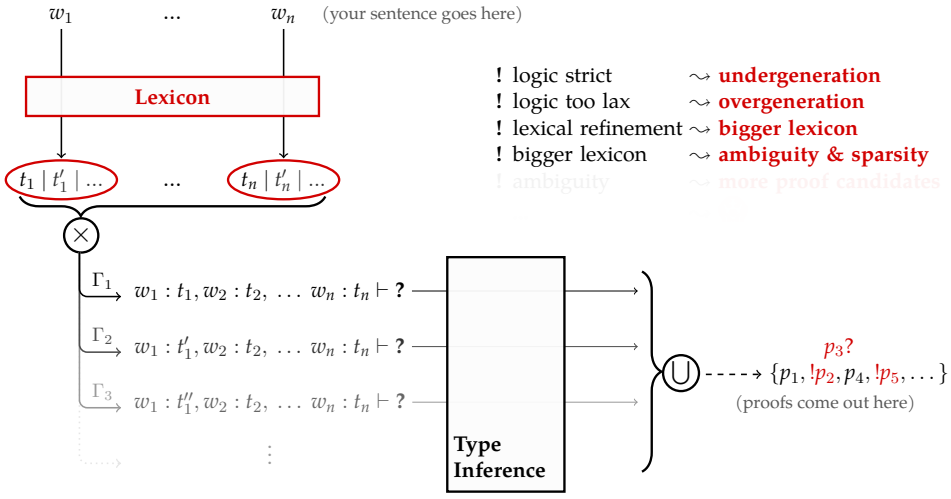

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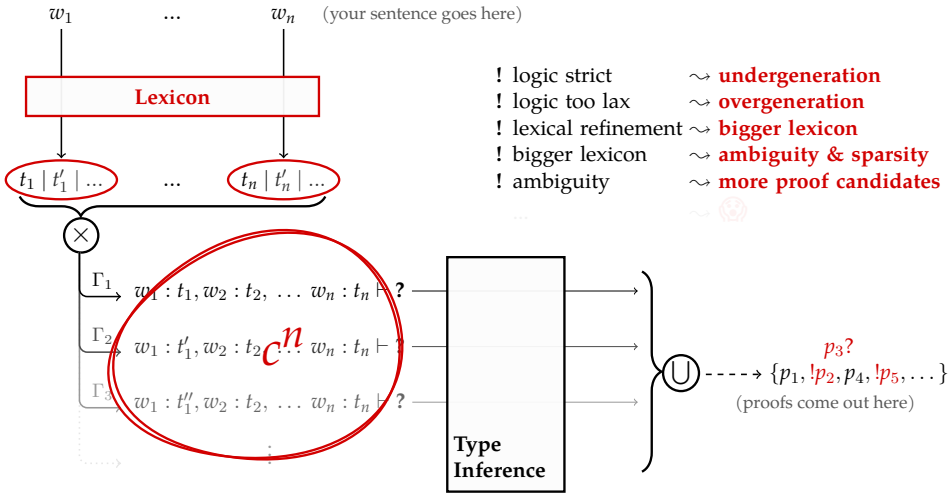

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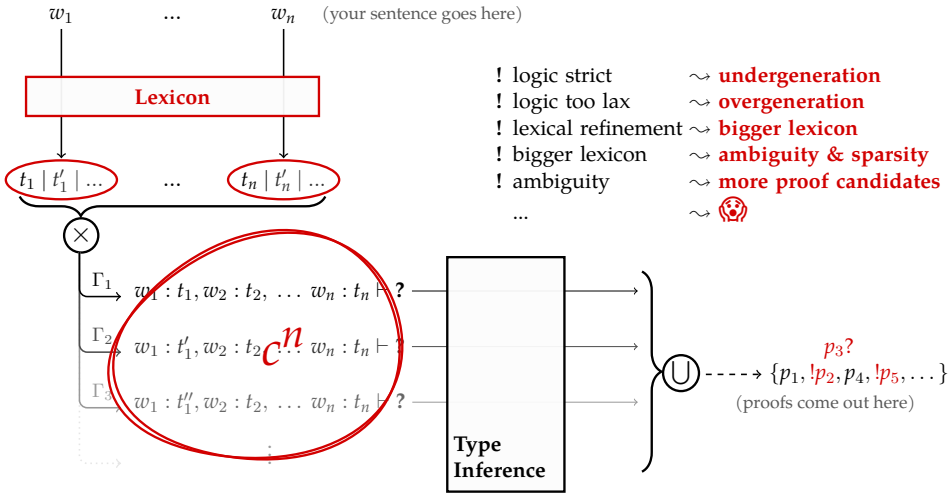

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Contributions: TL;DR

1. dependency labeling with $\Diamond$, $\Box$ modalities
2. $\sim$65 000 proof-derivations for written Dutch
3. fast & accurate wide-coverage parsing using
   (a) an inductive neural lexicon
   (b) neural proof search as subtype permutation

Dependency as Modality

A boring, old, monochromatic parse

$$\dfrac{\dfrac{}{\text{this} : np}\,\mathcal{L}ex \quad \dfrac{\dfrac{}{\text{makes} \vdash np \multimap np \multimap s}\,\mathcal{L}ex \quad \dfrac{\dfrac{}{\text{some} : np \multimap np}\,\mathcal{L}ex \quad \dfrac{}{\text{sense} : np}\,\mathcal{L}ex}{\text{some, sense} \vdash np}\multimap E}{\text{makes, some, sense} \vdash np \multimap s}\multimap E}{\text{this, makes, some, sense} \vdash s}\multimap E$$

Dependency as Modality

Fancy colored rules

$$\frac{\Gamma \vdash A}{\langle \Gamma \rangle^{c} \vdash \Diamond^{c} A}\ \Diamond^{c} I \qquad \frac{\Gamma \vdash \Box^{\alpha} A}{\langle \Gamma \rangle^{\alpha} \vdash A}\ \Box^{\alpha} E$$

α an adjunct

a structurally dispensable word/phrase

c a complement

a necessary argument of a syntactic predicate

$\Diamond, \Box \sim$ refinement!

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$\Diamond, \Box \sim$ refinement$^\uparrow$

Dependency as Modality

Glorious new parse

$$\dfrac{\dfrac{\dfrac{}{\text{this} : np}\,\mathcal{L}ex}{\langle \text{this} \rangle^{su} \vdash \Diamond^{su} np}\,\Diamond^{su} I \qquad \dfrac{\dfrac{\dfrac{\dfrac{}{\text{no} : \Box^{mod}(np \multimap np)}\,\mathcal{L}ex}{\langle \text{no} \rangle^{mod} \vdash np \multimap np}\,\Box^{mod} E \qquad \dfrac{}{\text{sense} : np}\,\mathcal{L}ex}{\langle \text{no} \rangle^{mod}, \text{sense} \vdash np}\,\multimap E}{\langle \langle \text{no} \rangle^{mod}, \text{sense} \rangle^{obj} \vdash \Diamond^{obj} np}\,\Diamond^{obj} I \qquad \dfrac{}{\text{makes} \vdash \Diamond^{obj} np \multimap \Diamond^{su} np \multimap s}\,\mathcal{L}ex}{\text{makes}, \langle \langle \text{no} \rangle^{mod}, \text{sense} \rangle^{obj} \vdash \Diamond^{su} np \multimap s}\,\multimap E}{\langle \text{this} \rangle^{su}, \text{makes}, \langle \langle \text{no} \rangle^{mod}, \text{sense} \rangle^{obj} \vdash s}\,\multimap E$$

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$$\langle \text{this} \rangle^{su}, \text{makes}, \langle \langle \text{no} \rangle^{mod}, \text{sense} \rangle^{obj} \vdash s$$

Dependency as Modality

Glorious new parse

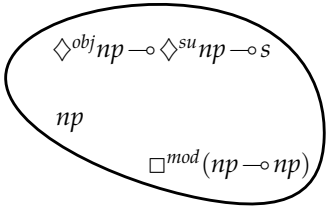
$$\langle \text{this} \rangle^{su}, \text{makes}, \langle \langle \text{no} \rangle^{mod}, \text{sense} \rangle^{obj} \vdash s$$

su

mod

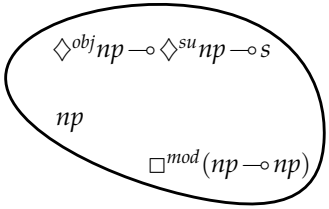
obj

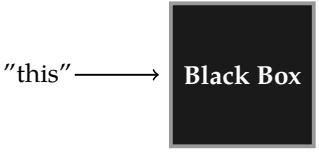
The Neural Lexicon



Black Box

The Neural Lexicon





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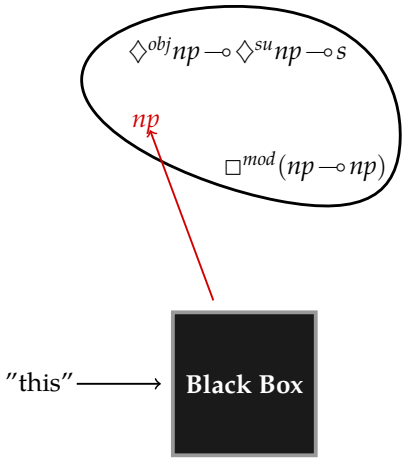

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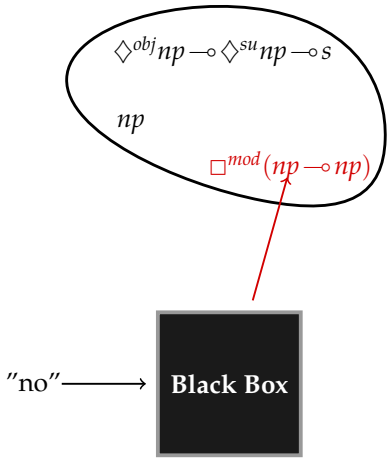

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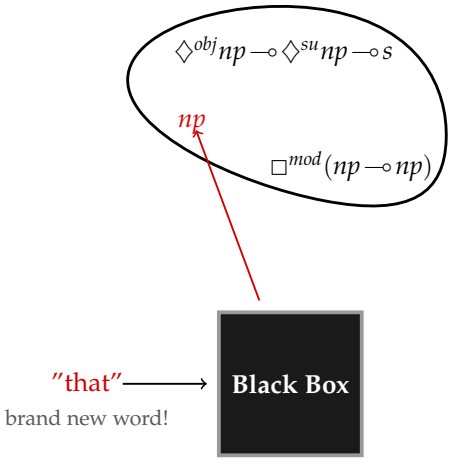

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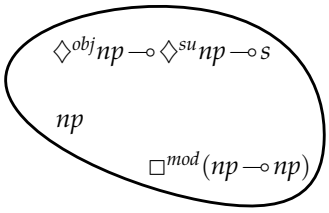

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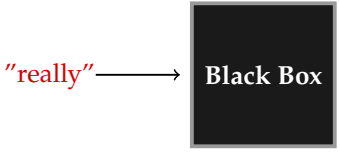
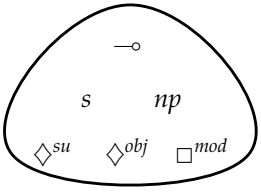
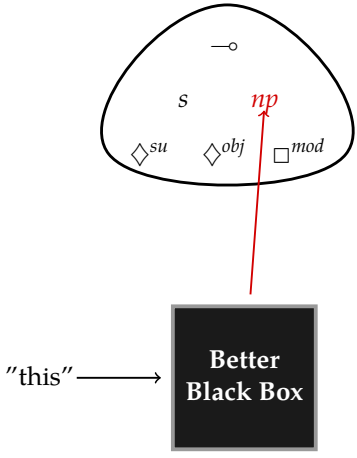


The Neural Lexicon – take # 2



Better Black Box

The Neural Lexicon – take # 2



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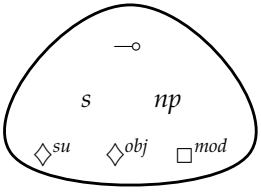

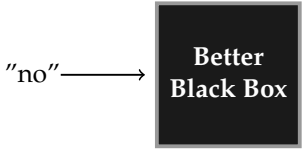

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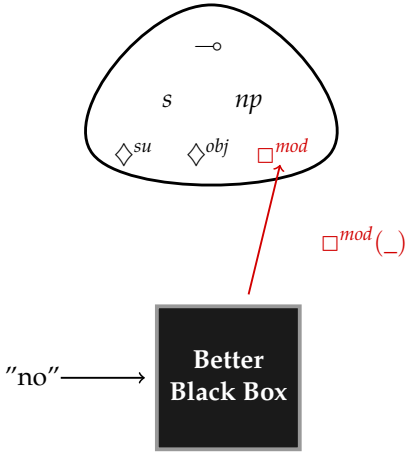

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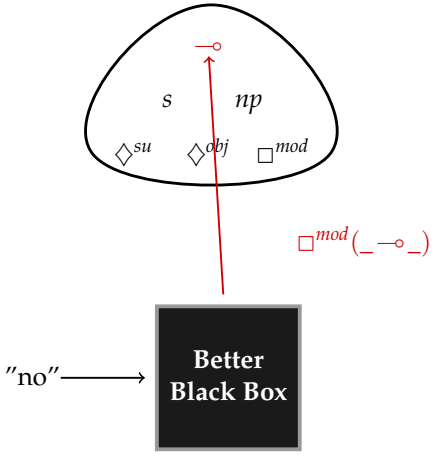

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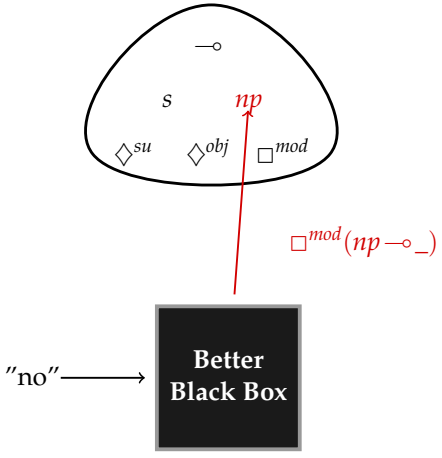

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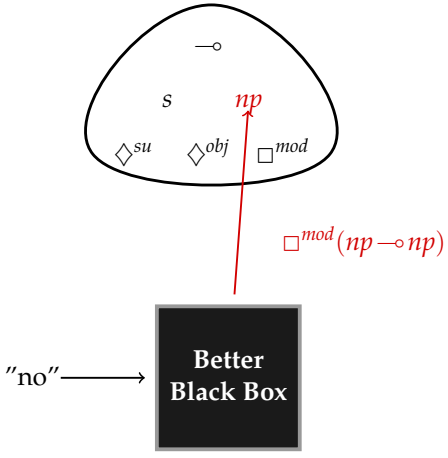

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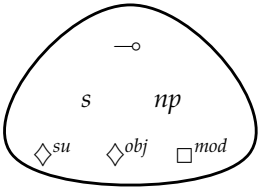

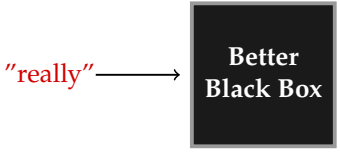

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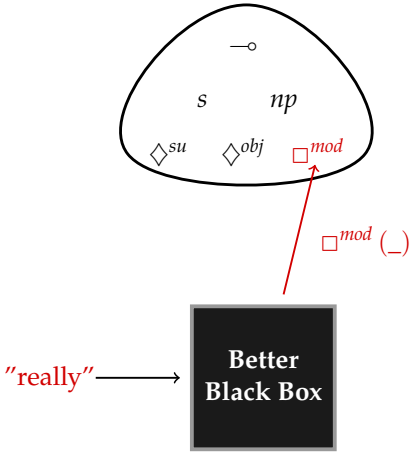

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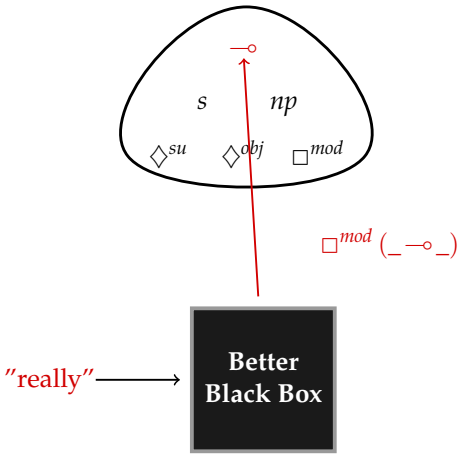

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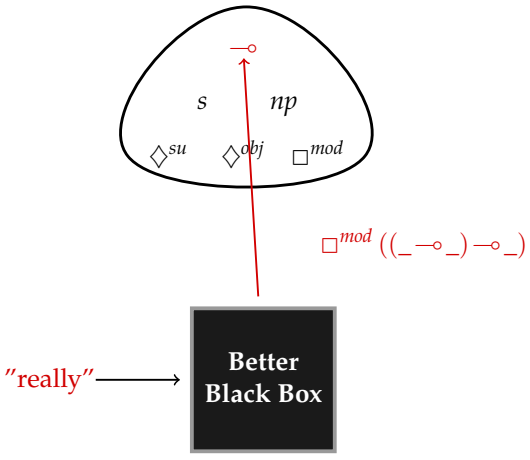

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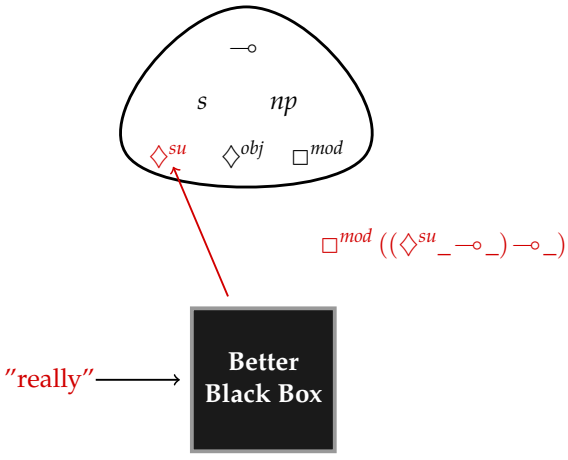

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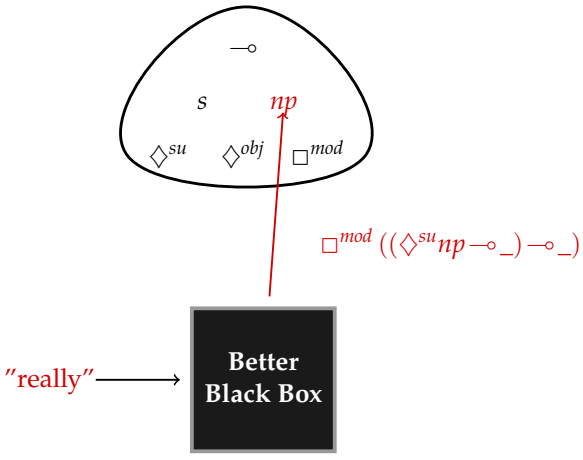

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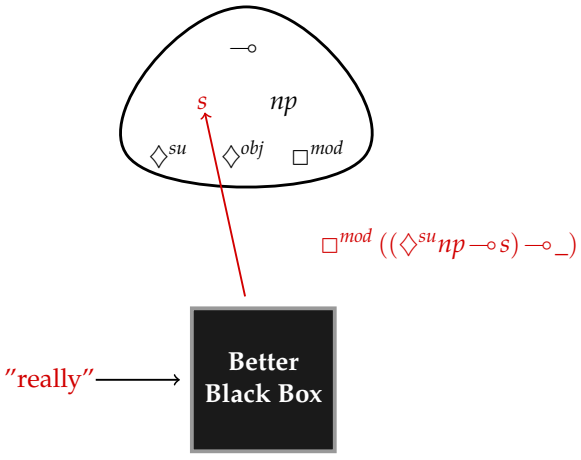

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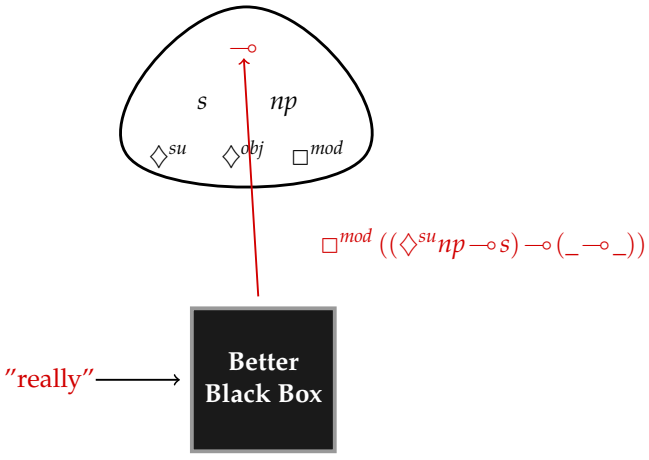

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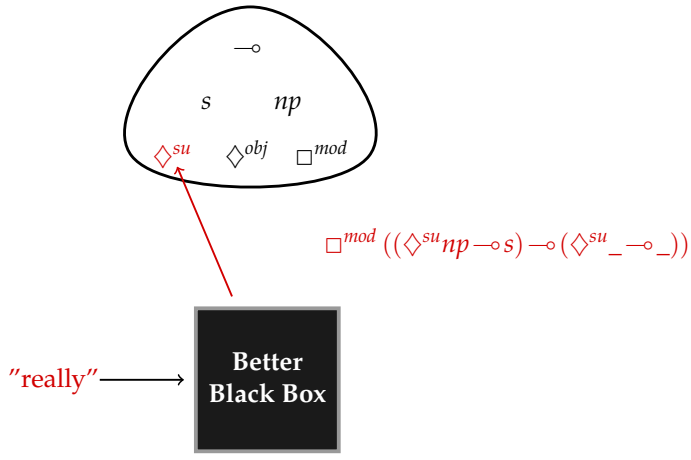

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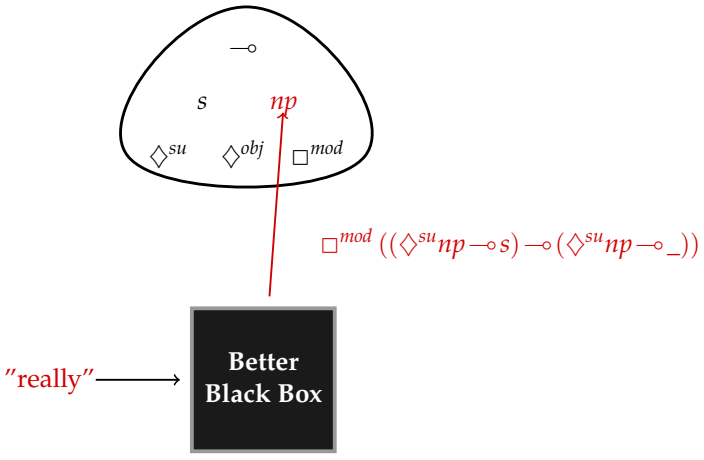

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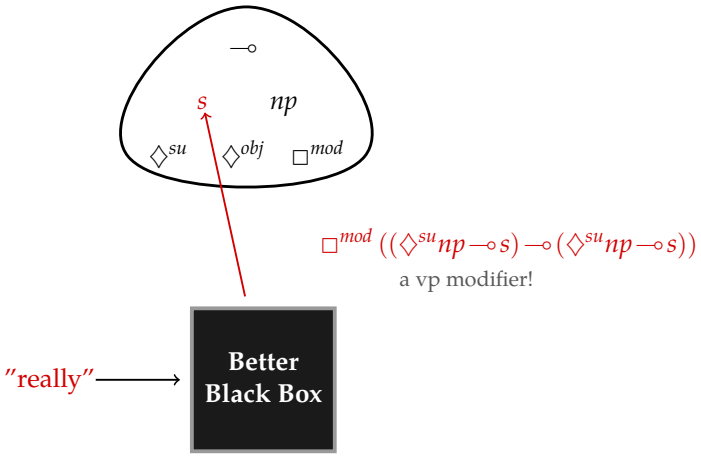
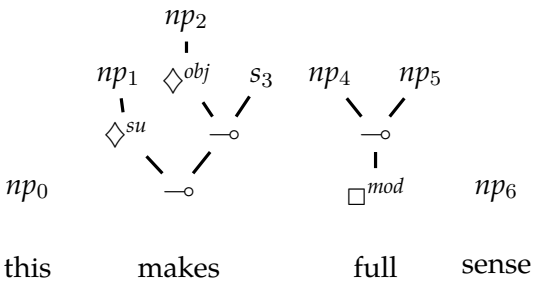
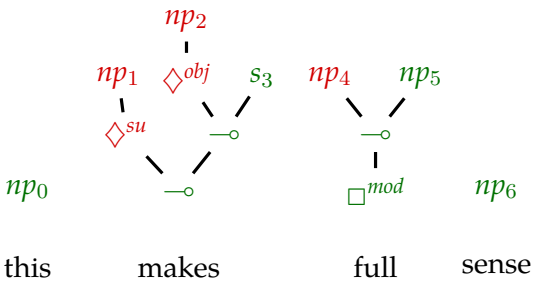


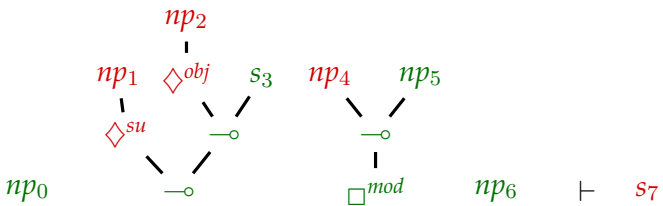
Parsing as Permutation



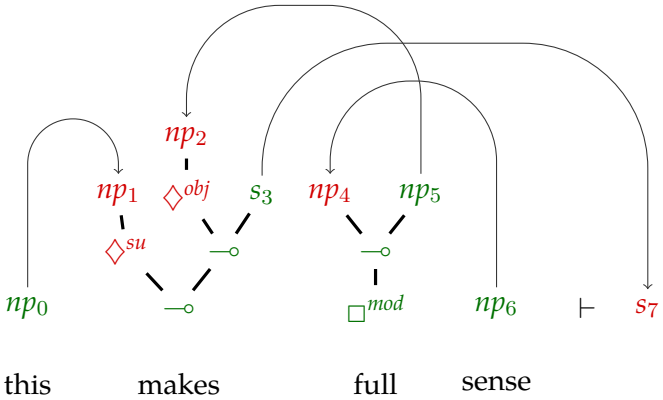
Parsing as Permutation



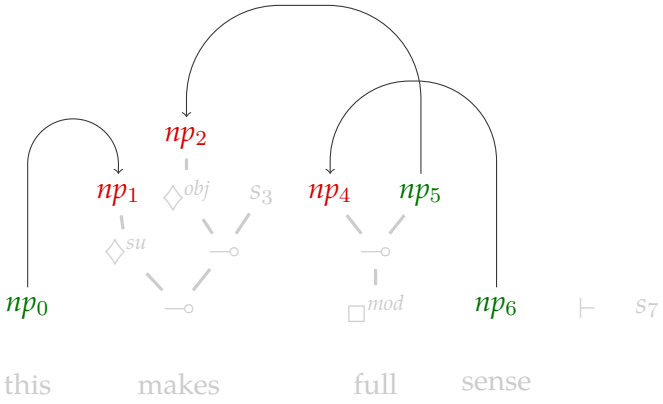
Parsing as Permutation



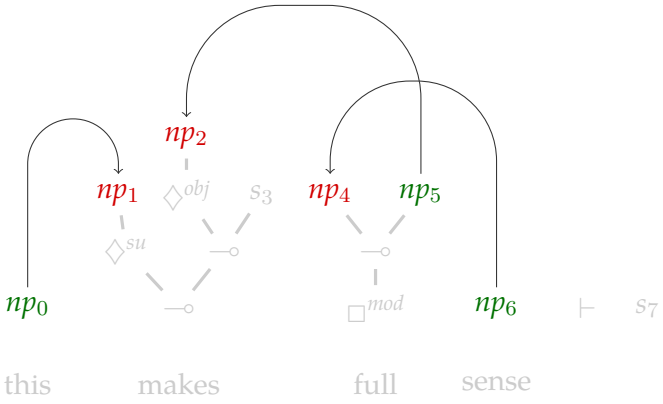
Parsing as Permutation



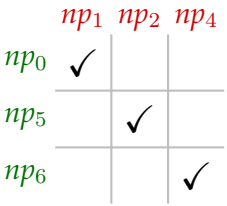
Parsing as Permutation



Parsing as Permutation



$\vdash$ s_7



Just out of time (hopefully)

- parser/resource (for Dutch) web API
  parseport.hum.uu.nl/spindle
- thesis, this presentation, *etc.*
  github.com/konstantinosKokos

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