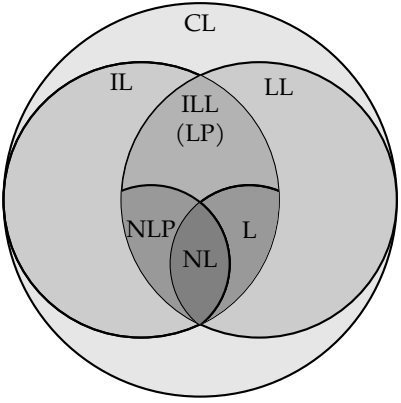
Dependency as Modality, Parsing as Permutation

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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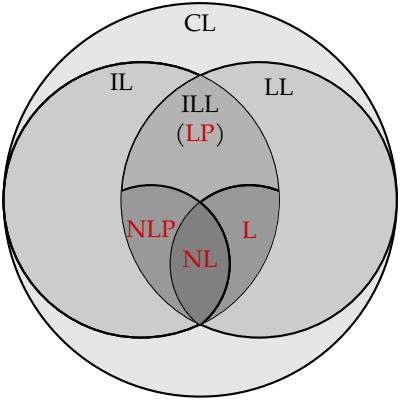

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(N)L(P): *Grammar Logics*

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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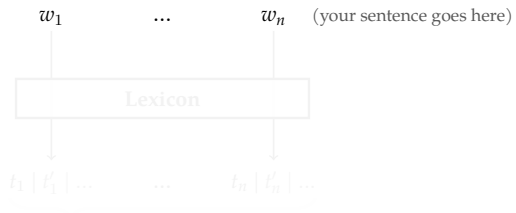
sentence	proof	program

How (idealized)



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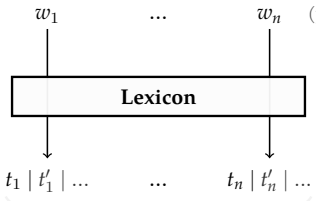

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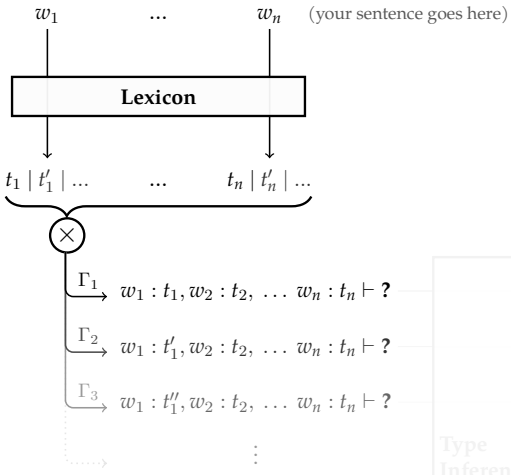

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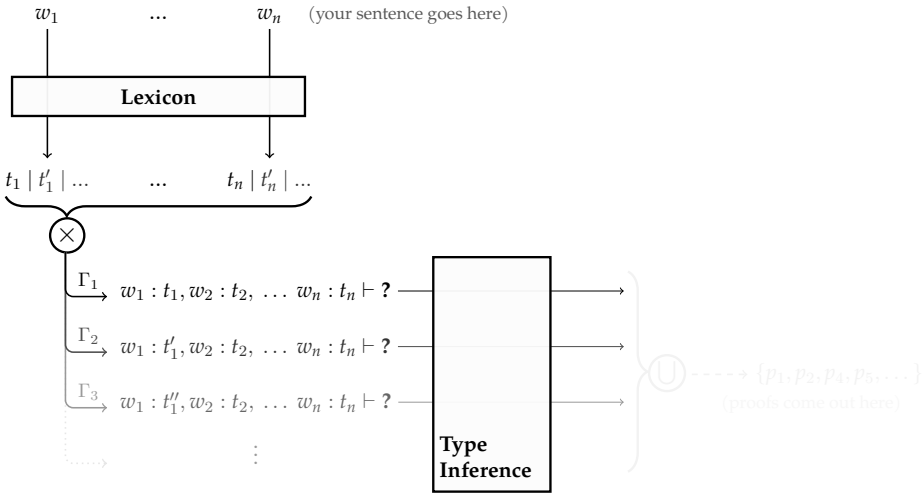

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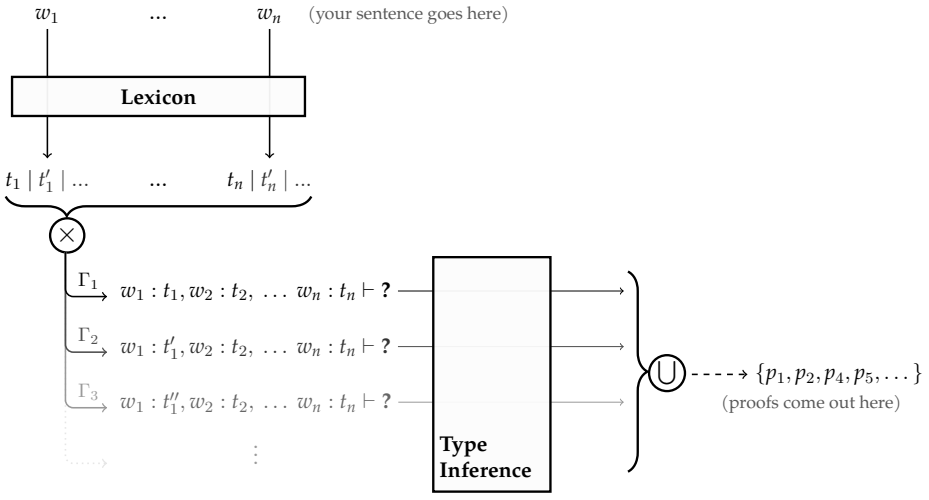

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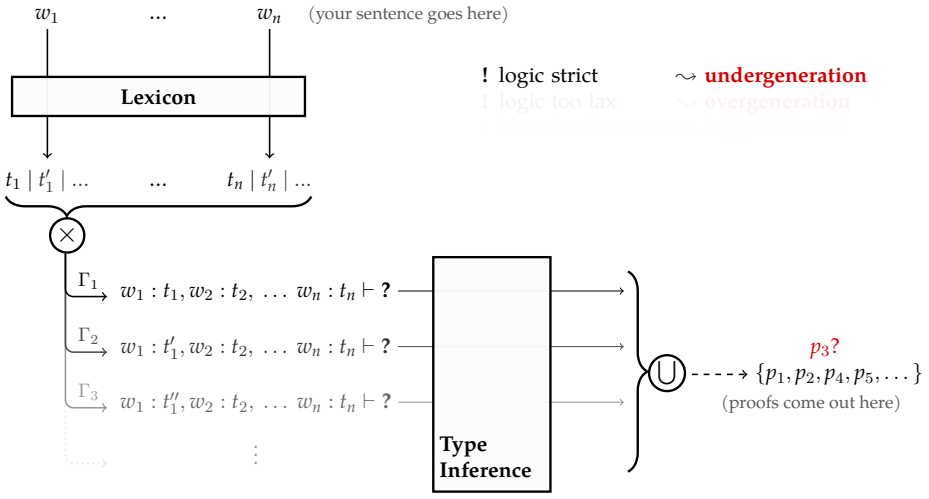

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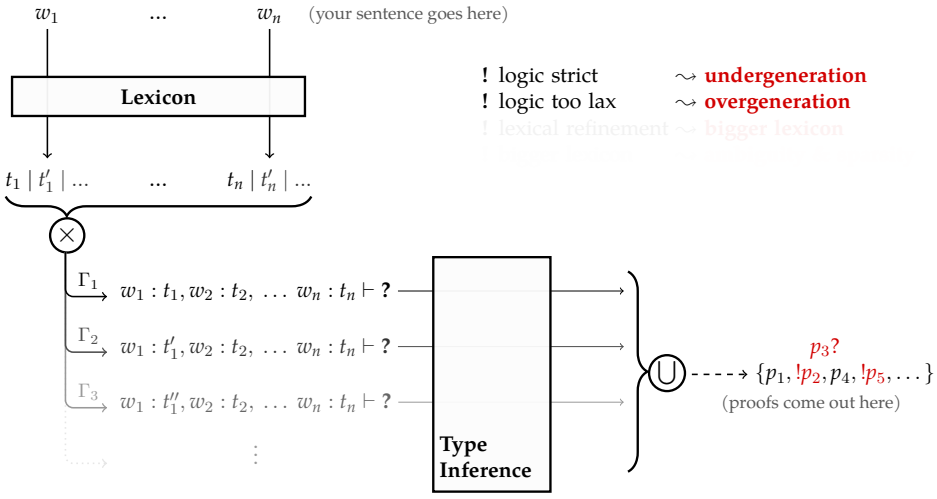

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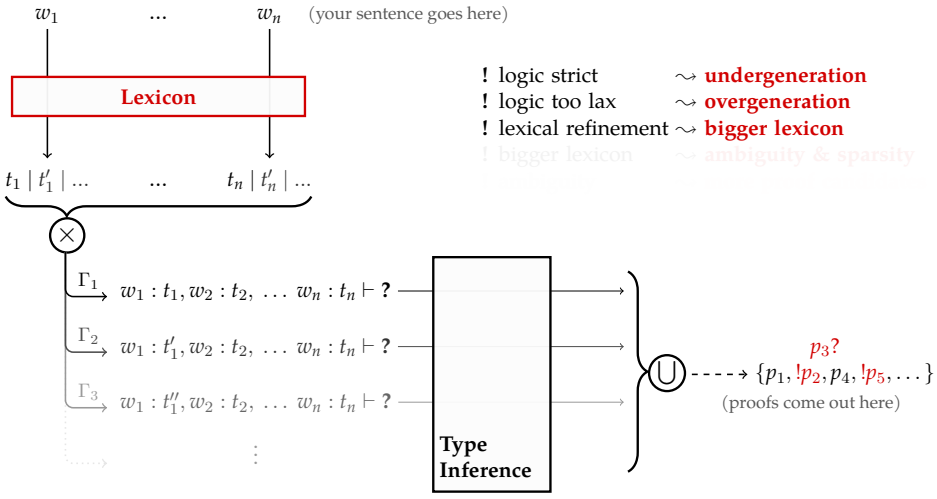

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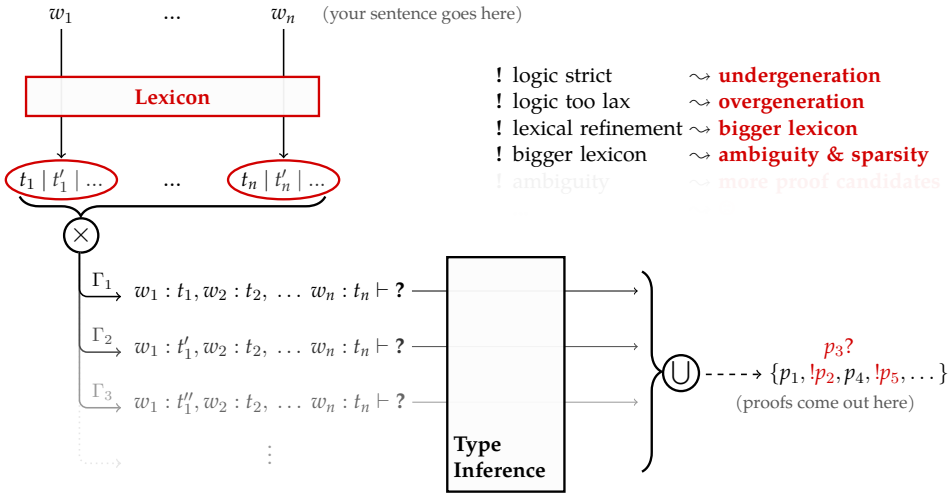

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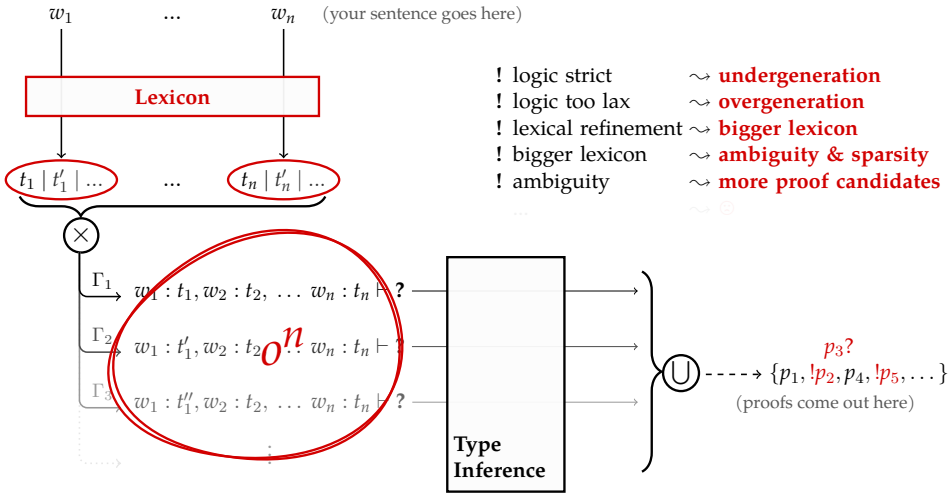

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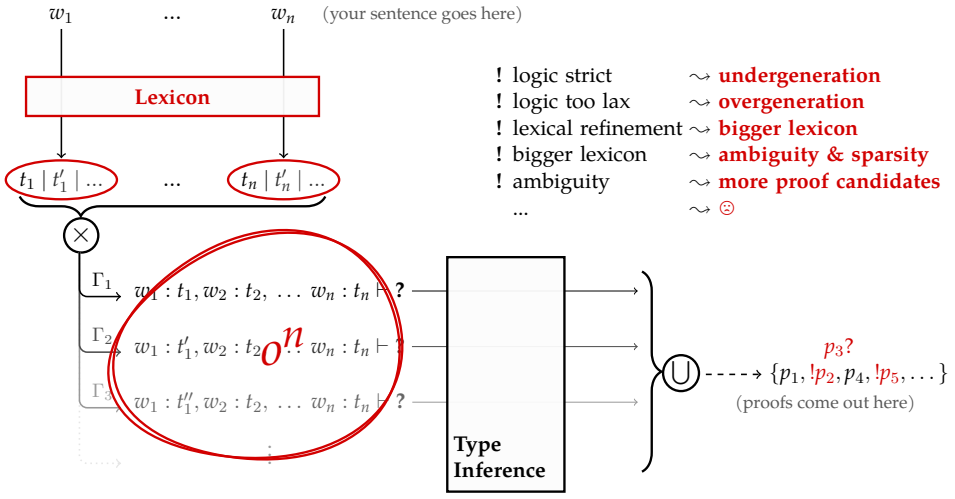

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... ⇝ ☹

(1) Dependency as Modality

A boring, old, monochromatic parse

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

(1) 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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Glorious new parse

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

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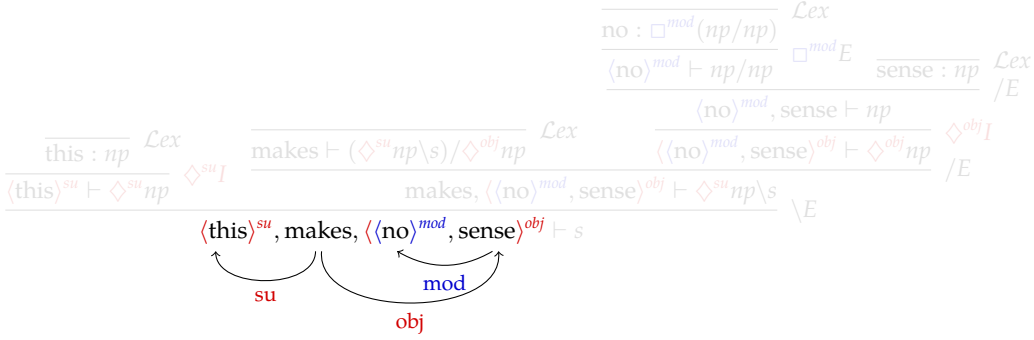
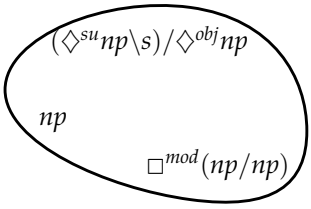


(2) The Neural Lexicon



Black Box

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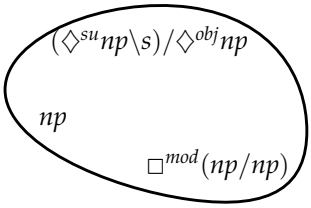

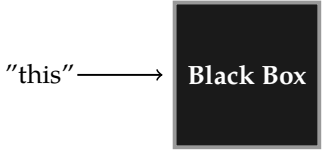

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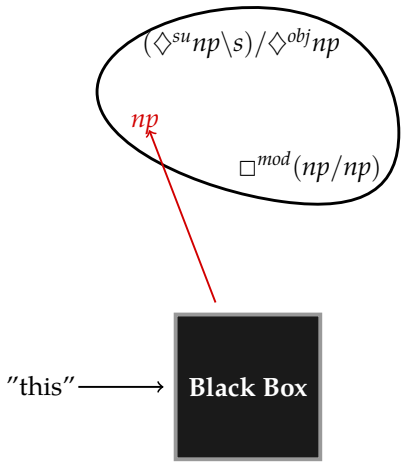

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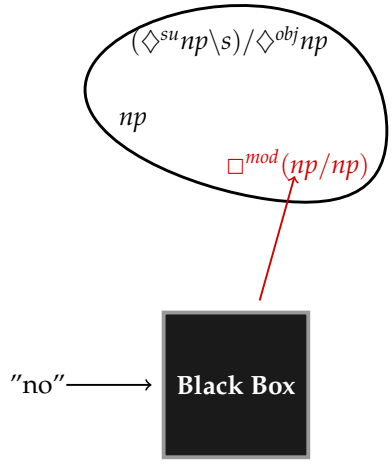

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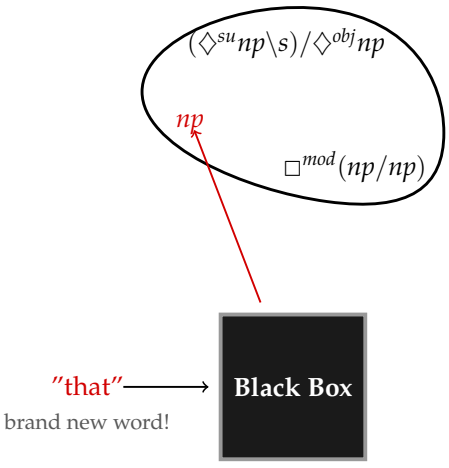

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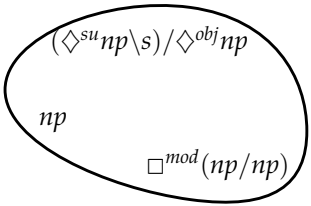

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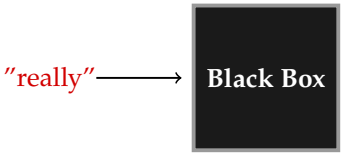

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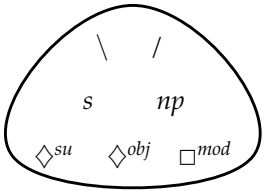

Better Black Box

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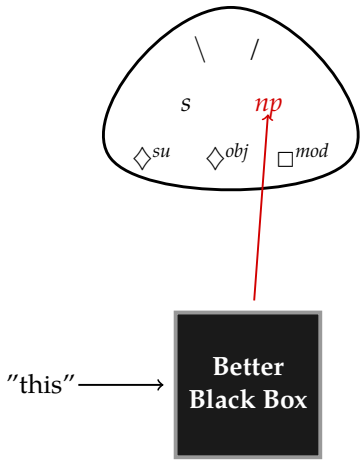

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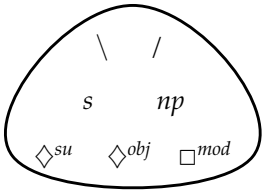

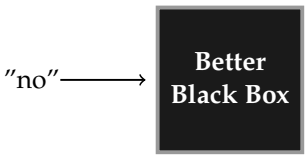

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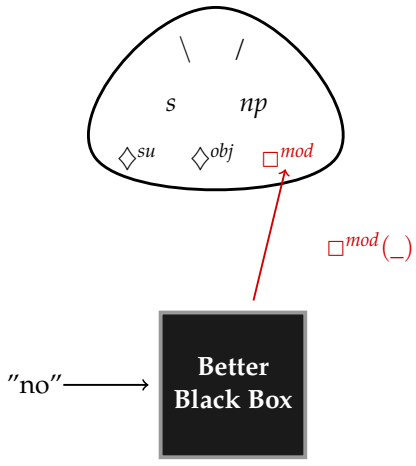

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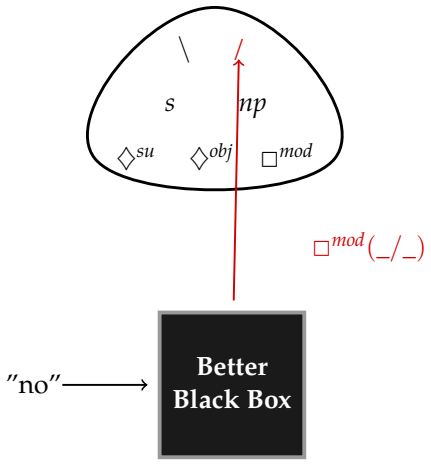

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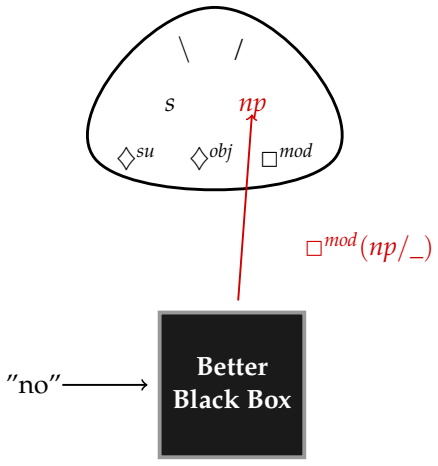

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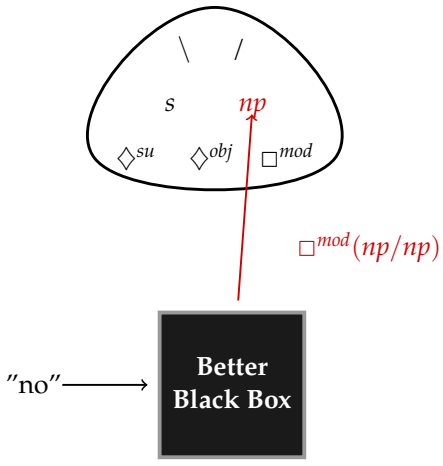

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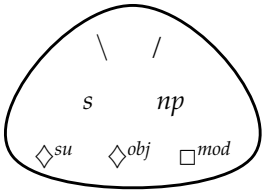

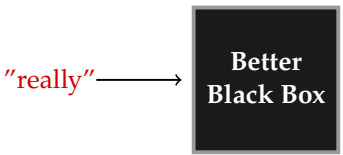

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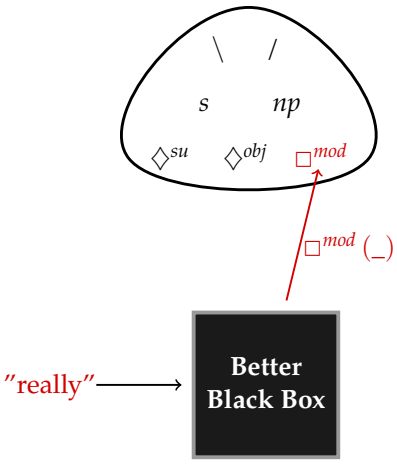

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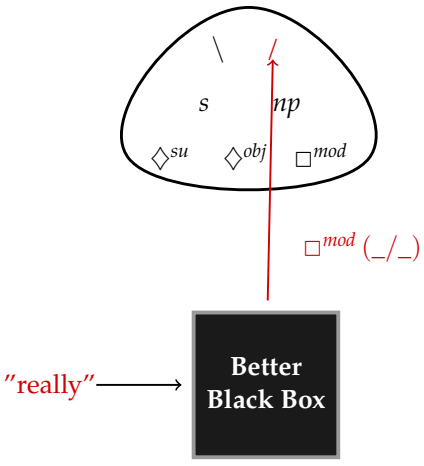

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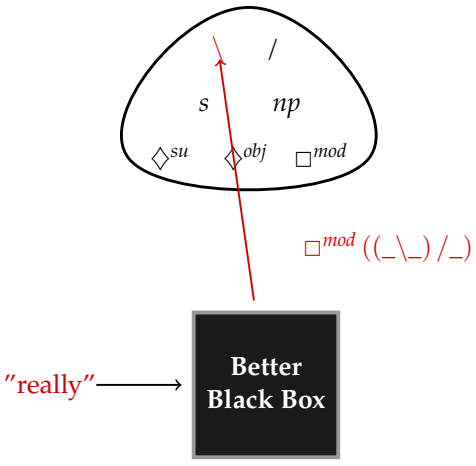

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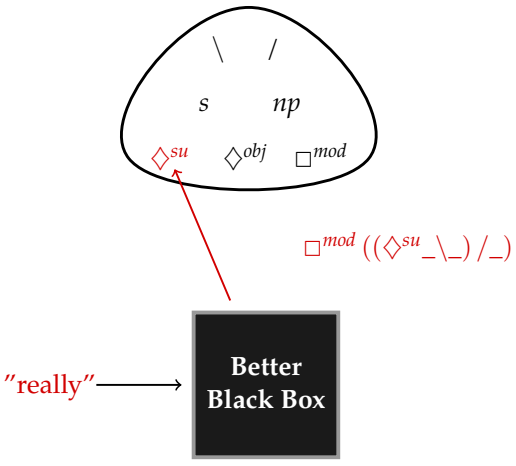

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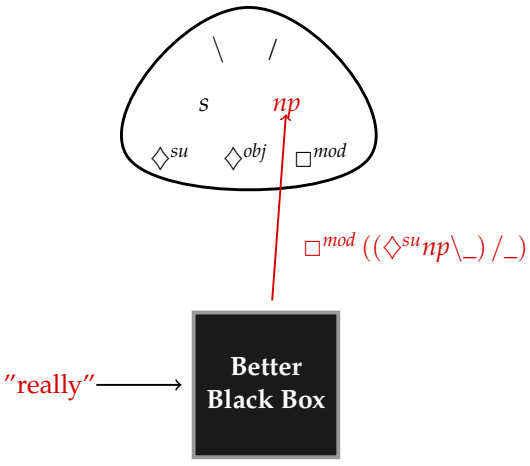

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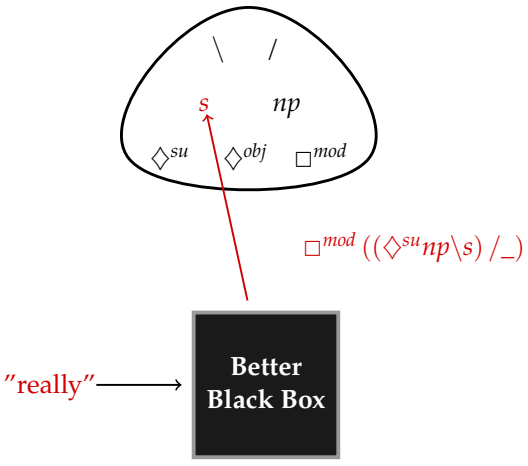
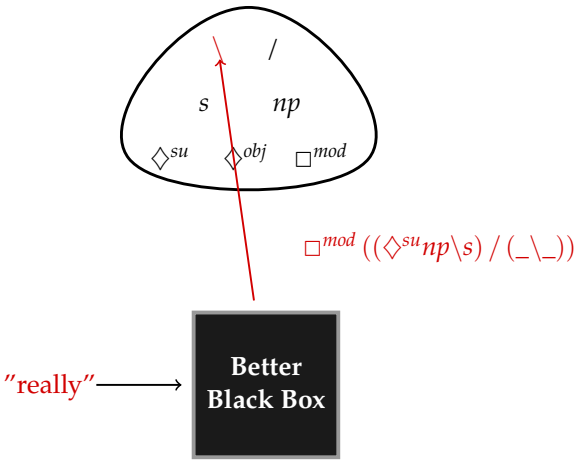
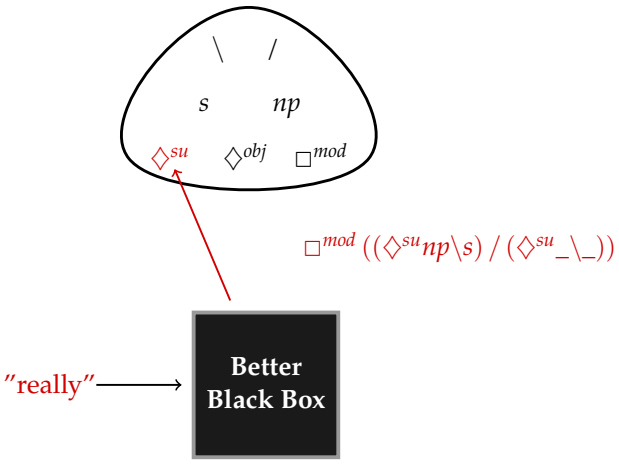


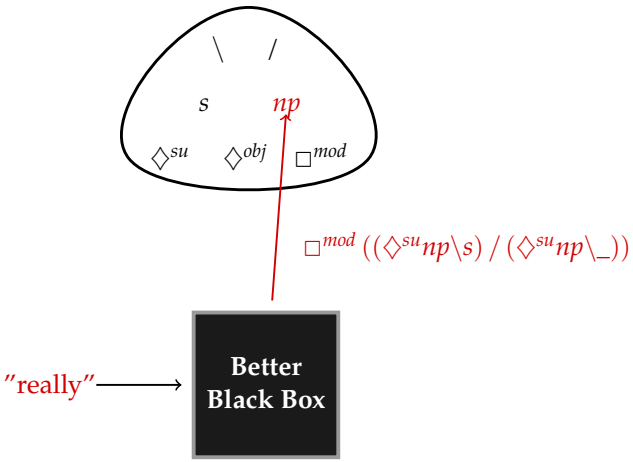
(2) The Neural Lexicon – take # 2



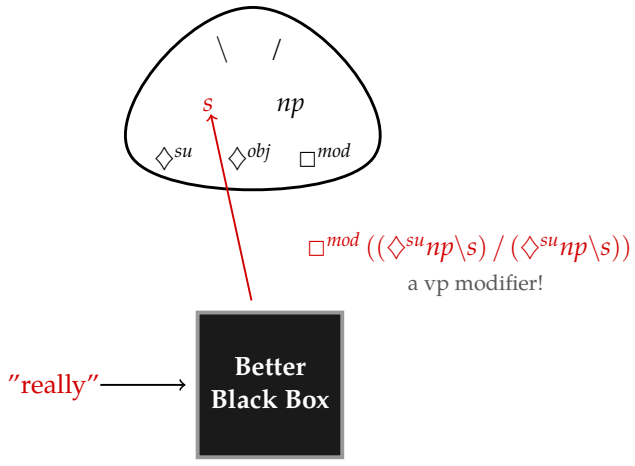
(2) The Neural Lexicon – take # 2



(2) The Neural Lexicon – take # 2

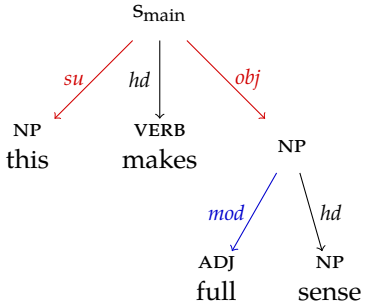


(2) The Neural Lexicon – take # 2



(3) Æthel

...from dependency graphs



(3) Æthel

...to $\mathrm{ILL}_{\Diamond,\Box}$ proofs

$$\dfrac{\dfrac{\dfrac{}{\text{this} : np}\,\mathcal{L}ex}{\langle \text{this} \rangle^{su} \vdash \Diamond^{su} np}\,\Diamond^{su} I \qquad \dfrac{\dfrac{}{\text{makes} \vdash (\Diamond^{su} np \multimap s)/\Diamond^{obj} np}\,\mathcal{L}ex \qquad \dfrac{\dfrac{\dfrac{\dfrac{}{\text{full} : \Box^{mod}(np \multimap np)}\,\mathcal{L}ex}{\langle \text{full} \rangle^{mod} \vdash np \multimap np}\,\Box^{mod} E \qquad \dfrac{}{\text{sense} : np}\,\mathcal{L}ex}{\langle \text{full} \rangle^{mod}, \text{sense} \vdash np}\,\multimap E}{\langle \langle \text{full} \rangle^{mod}, \text{sense} \rangle^{obj} \vdash \Diamond^{obj} np}\,\Diamond^{obj} I}{\text{makes}, \langle \langle \text{full} \rangle^{mod}, \text{sense} \rangle^{obj} \vdash \Diamond^{su} np \multimap s}\,\multimap E}{\langle \text{this} \rangle^{su}, \text{makes}, \langle \langle \text{full} \rangle^{mod}, \text{sense} \rangle^{obj} \vdash s}\,\multimap E$$

$\multimap \sim$ relaxation!

(3) Æthel

...to ILL$_{\Diamond,\Box}$ proofs

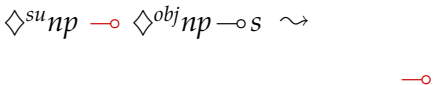
$$\dfrac{\dfrac{\dfrac{}{\text{this} : np}\,\mathcal{L}ex}{\langle \text{this} \rangle^{su} \vdash \Diamond^{su} np}\,\Diamond^{su} I \qquad \dfrac{}{\text{makes} \vdash (\Diamond^{su} np \multimap s)/\Diamond^{obj} np}\,\mathcal{L}ex \qquad \dfrac{\dfrac{\dfrac{\dfrac{}{\text{full} : \Box^{mod}(np \multimap np)}\,\mathcal{L}ex}{\langle \text{full} \rangle^{mod} \vdash np \multimap np}\,\Box^{mod} E \qquad \dfrac{}{\text{sense} : np}\,\mathcal{L}ex}{\langle \text{full} \rangle^{mod}, \text{sense} \vdash np}\,\multimap E}{\langle \langle \text{full} \rangle^{mod}, \text{sense} \rangle^{obj} \vdash \Diamond^{obj} np}\,\Diamond^{obj} I}{\text{makes}, \langle \langle \text{full} \rangle^{mod}, \text{sense} \rangle^{obj} \vdash \Diamond^{su} np \multimap s}\,\multimap E}{\langle \text{this} \rangle^{su}, \text{makes}, \langle \langle \text{full} \rangle^{mod}, \text{sense} \rangle^{obj} \vdash s}\,\multimap E$$

$\multimap \sim$ relaxation$^{\downarrow}$

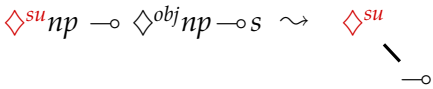
(4) Neural Proof Nets

$$\diamondsuit^{su} np \multimap \diamondsuit^{obj} np \multimap s \rightsquigarrow$$

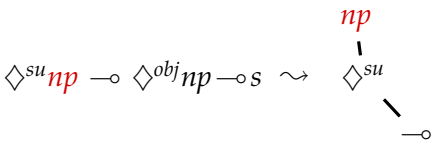
(4) Neural Proof Nets



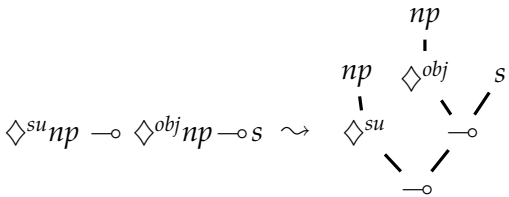
(4) Neural Proof Nets



(4) Neural Proof Nets



(4) Neural Proof Nets



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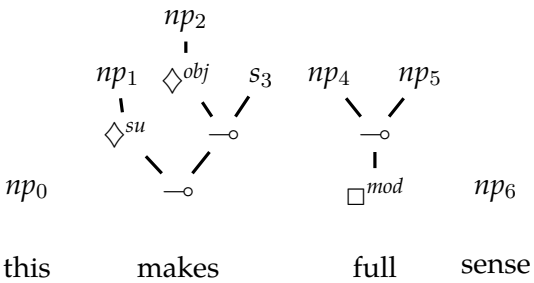
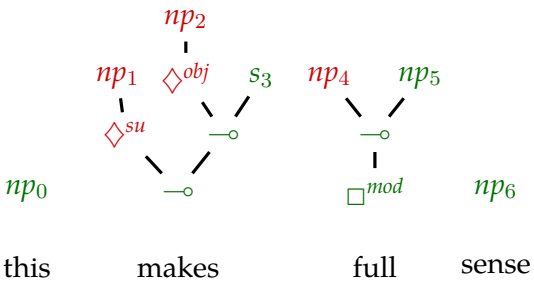
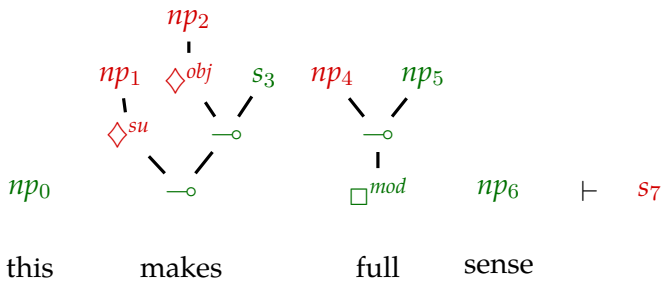


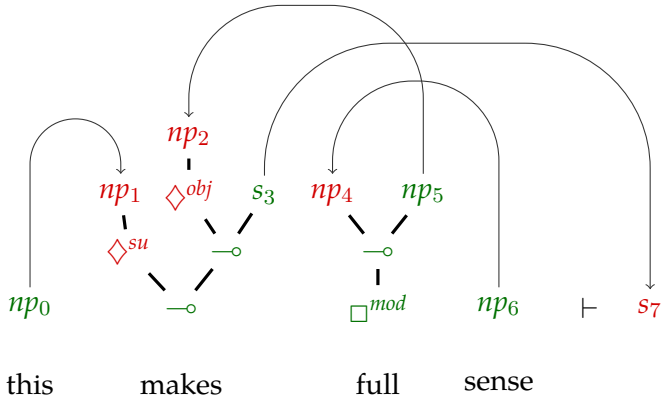
(4) Neural Proof Nets



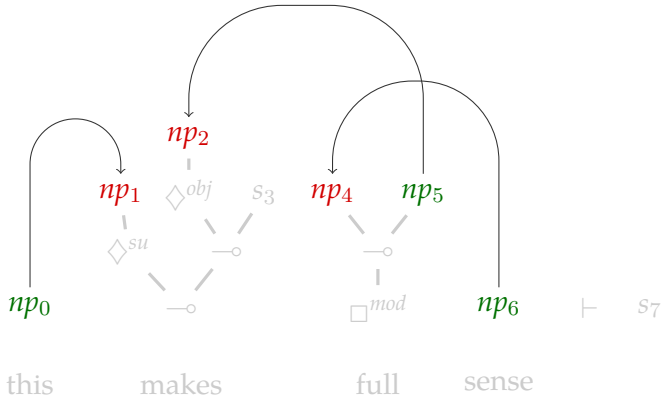
(4) Neural Proof Nets



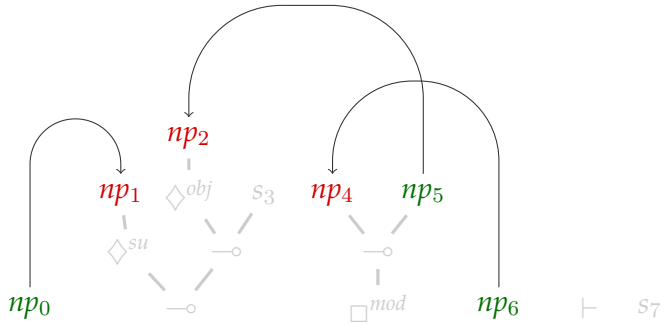
(4) Neural Proof Nets

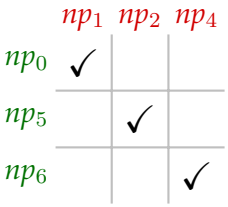


(4) Neural Proof Nets



(4) Neural Proof Nets





Just out of time (hopefully)

- parser/resource web API
  parseport.hum.uu.nl/spindle
- Dependency as Modality, Parsing as Permutation
  github.com/konstantinosKokos/phd-thesis
- this presentation

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