Weakly-Supervised Grammar-Informed Bayesian CCG Parser Learning

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Motivation

Annotating parse trees *by hand* is extremely difficult.

Motivation

Can we learn new parsers cheaply?

Motivation

Can we learn new parsers cheaply?

(cheaper = less supervision)

Motivation

When supervision is ***scarce***,
we have to be ***smarter*** about data.

Type-Level Supervision

Type-Level Supervision

- Unannotated text

- Incomplete tag dictionary: word ↦ {tags}

Type-Level Supervision

Used for part-of-speech tagging for 20+ years

[Kupiec, 1992]
[Merialdo, 1994]

Type-Level Supervision

Good tagger performance
even with low supervision

[Ravi & Knight, 2009]
[Das & Petrov, 2011]
[Garrette & Baldridge, 2013]
[Garrette *et al.*, 2013]

Combinatory Categorial Grammar (CCG)

CCG

[Steedman, 2000]
[Steedman and Baldridge, 2011]

CCG

Every word token is associated with a **category**

[Steedman, 2000]
[Steedman and Baldridge, 2011]

CCG

Every word token is associated with a **category**

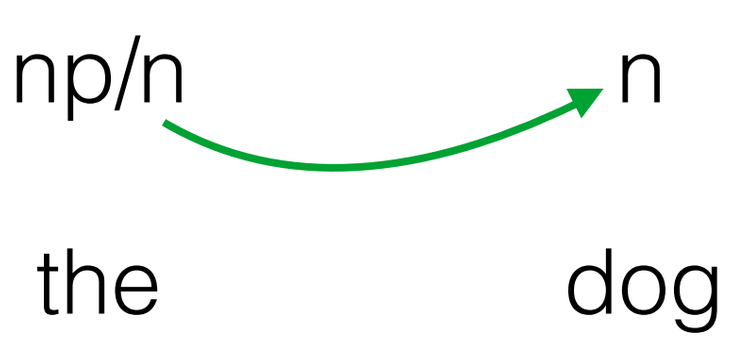
Categories **combine** to form categories of larger constituents

[Steedman, 2000]
[Steedman and Baldridge, 2011]

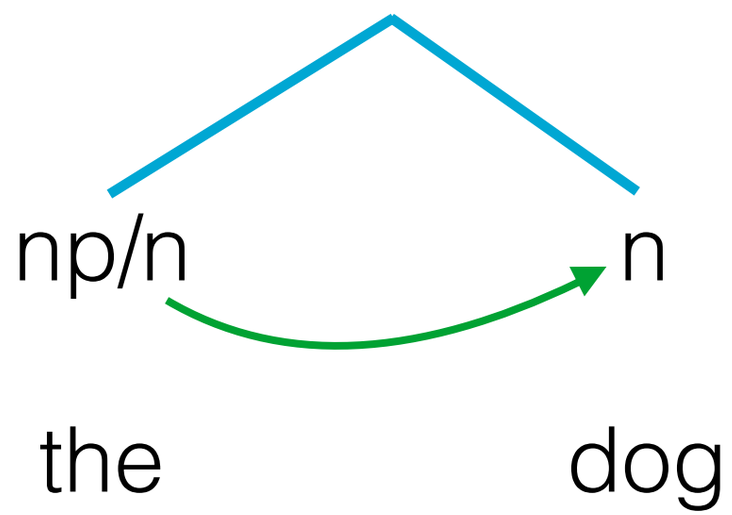
CCG

np/n	n
the	dog

CCG



CCG



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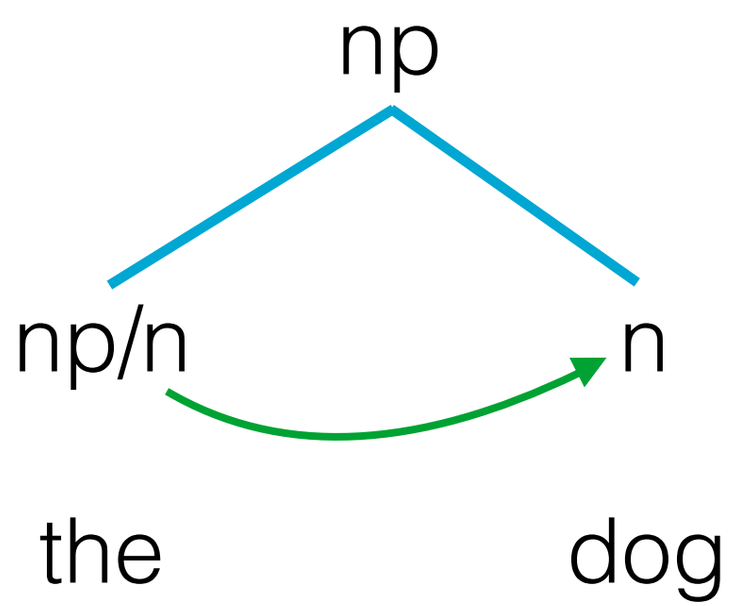
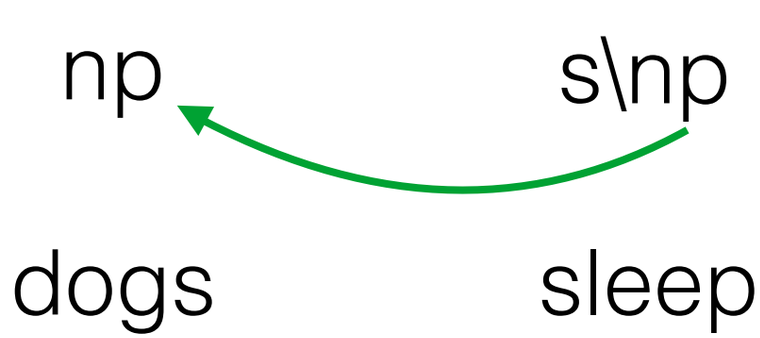


CCG

np s\np

dogs sleep

CCG



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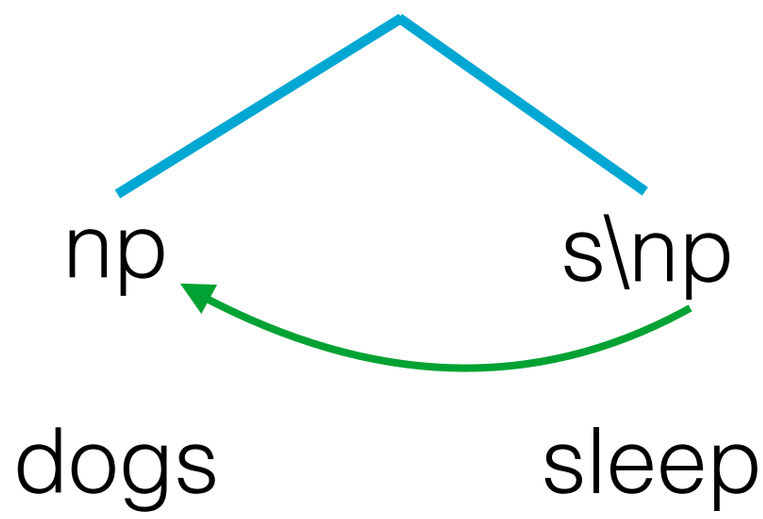

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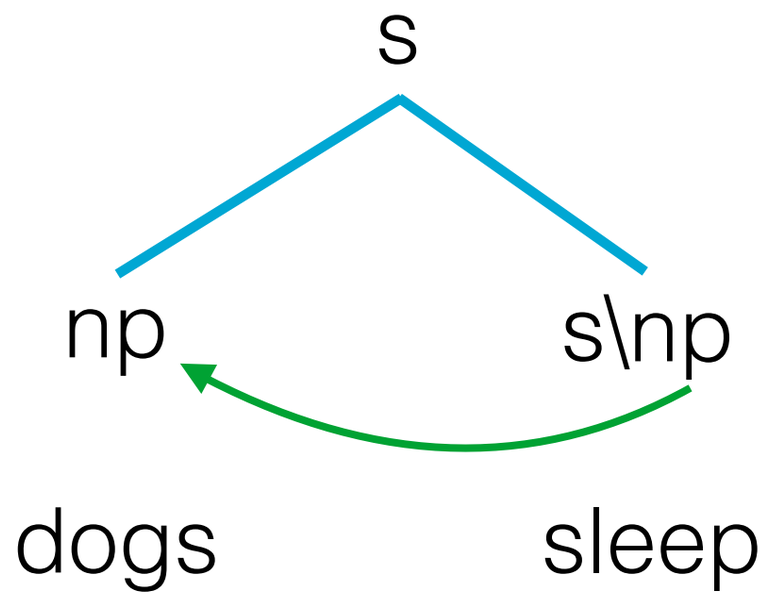


Type-Supervised CCG

the **lazy** **dogs** **wander**

Type-Supervised CCG

the	**lazy**	**dogs**	**wander**
np/n			

Type-Supervised CCG

the	**lazy**	**dogs**	**wander**
np/n	n/n		
	np		

Type-Supervised CCG

the	**lazy**	**dogs**	**wander**
np/n	n/n	n	
	np	np	
		(s\np)/np	

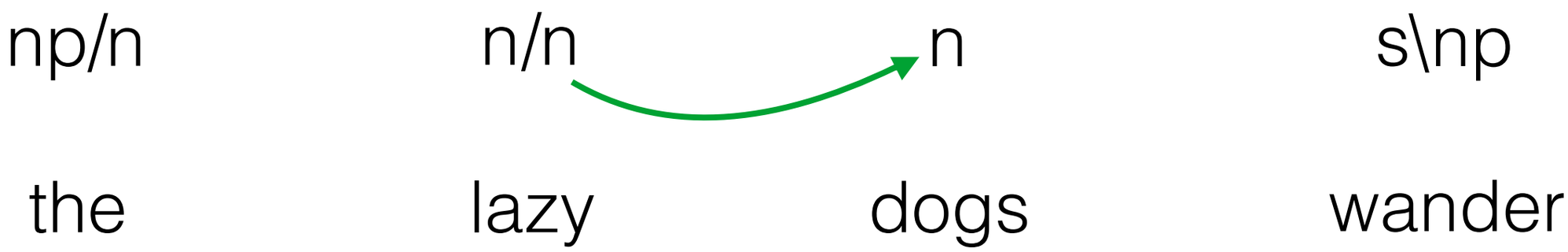
Type-Supervised CCG

the	**lazy**	**dogs**	**wander**
np/n	n/n	n	n
	np	np	n/n
		(s\np)/np	np/n
			s\np
			...

CCG Parsing

np/n	n/n	n	s\np
the	lazy	dogs	wander

CCG Parsing



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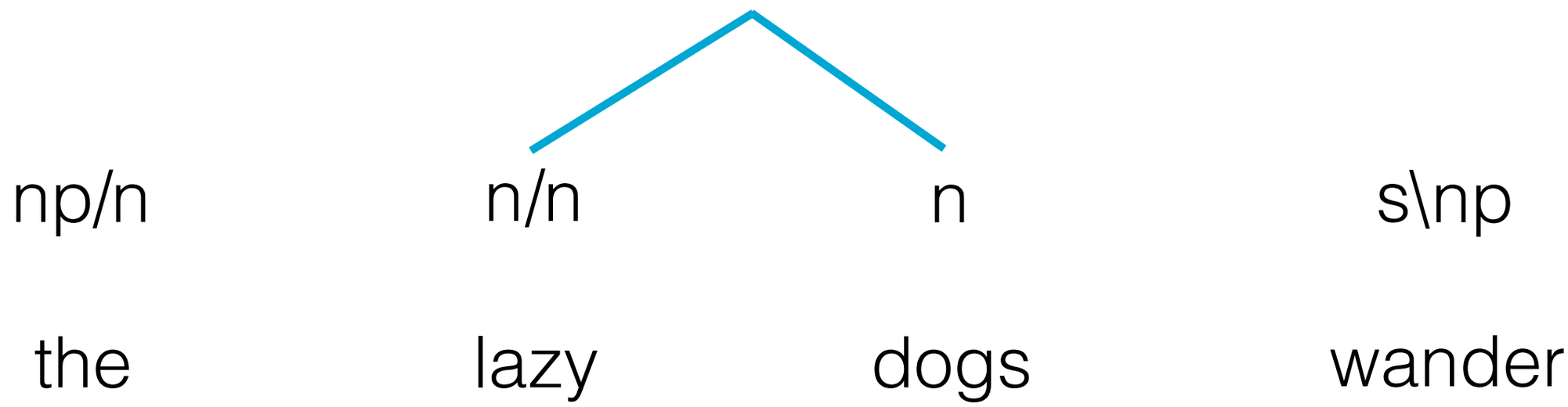

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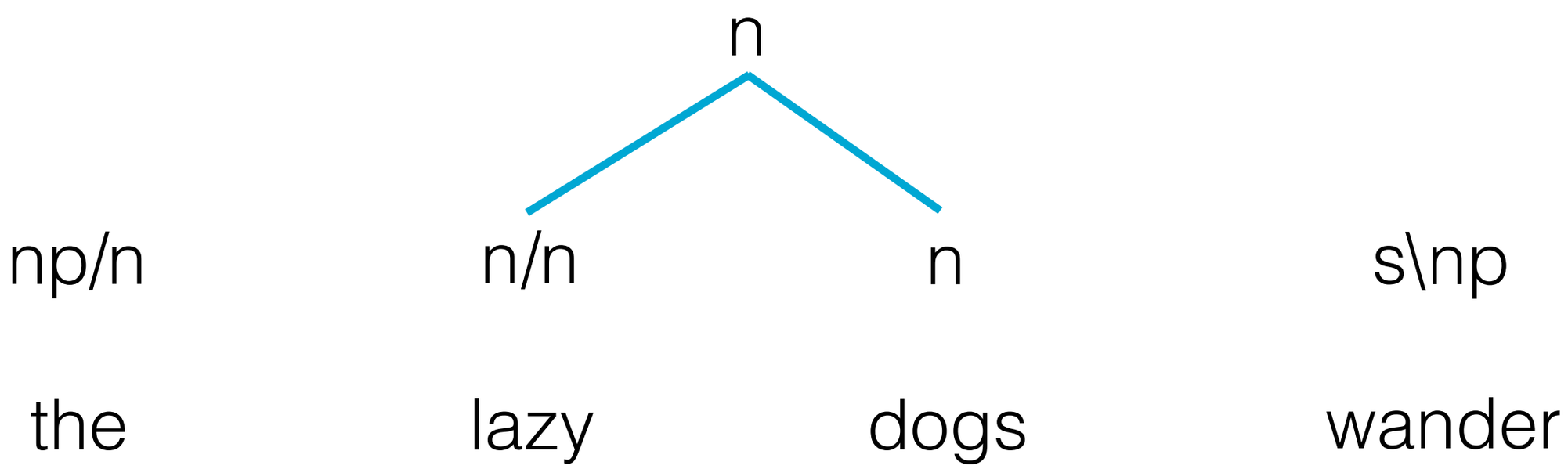

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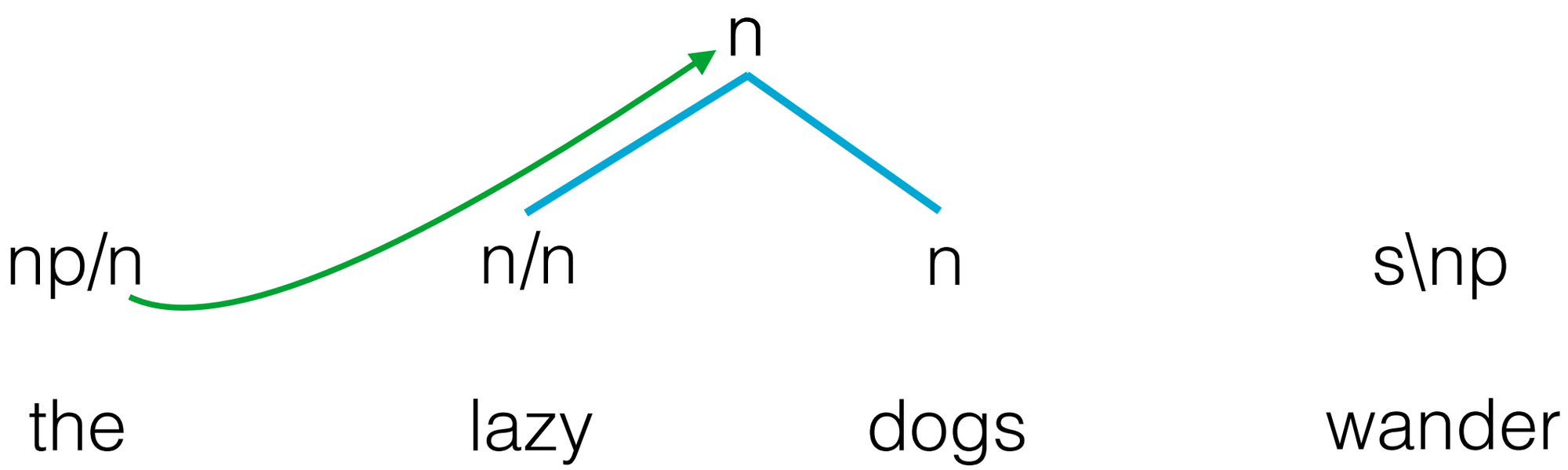

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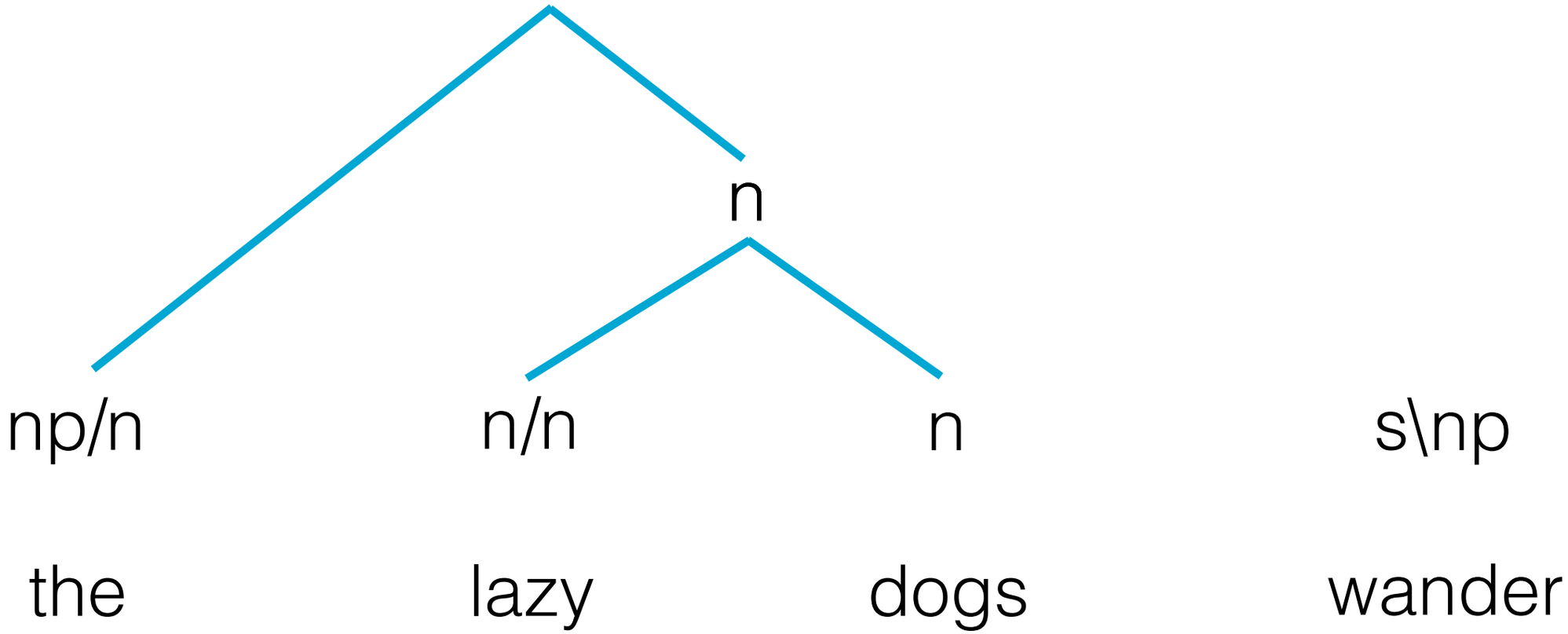

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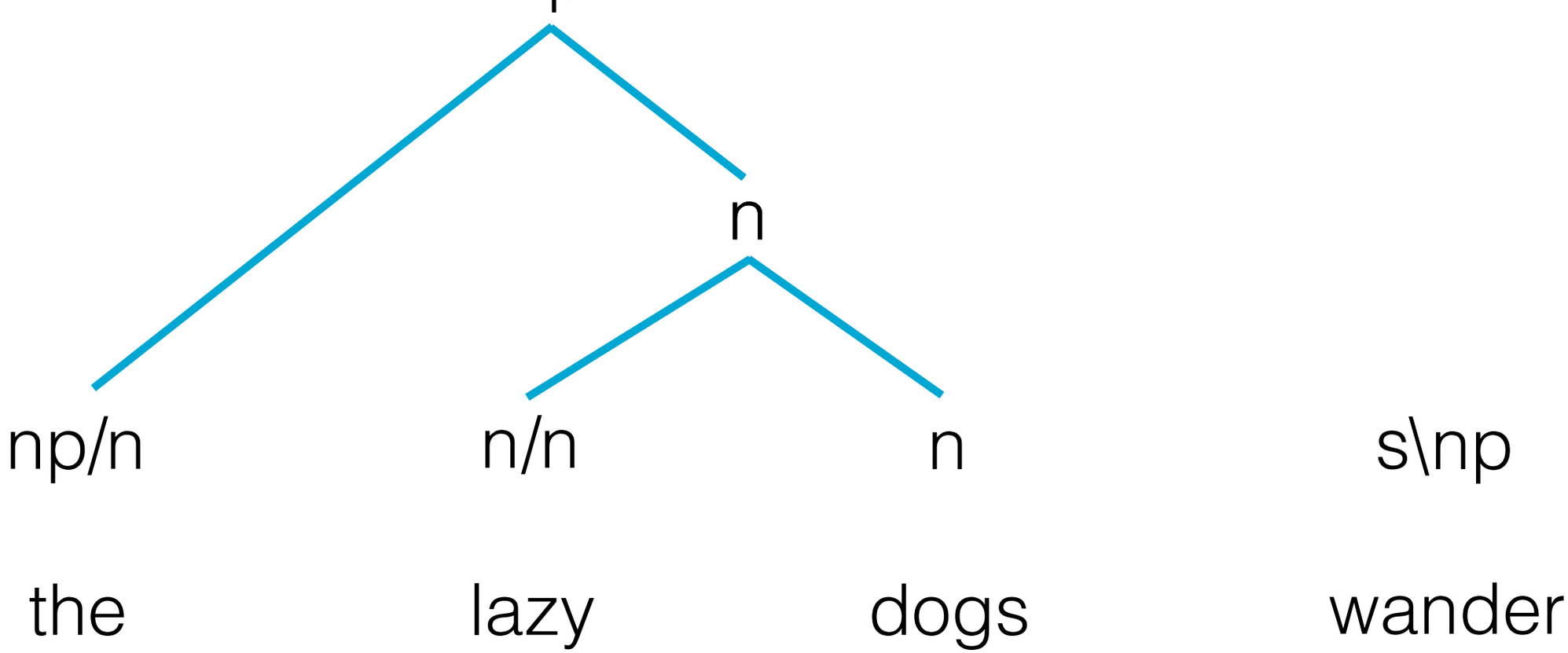

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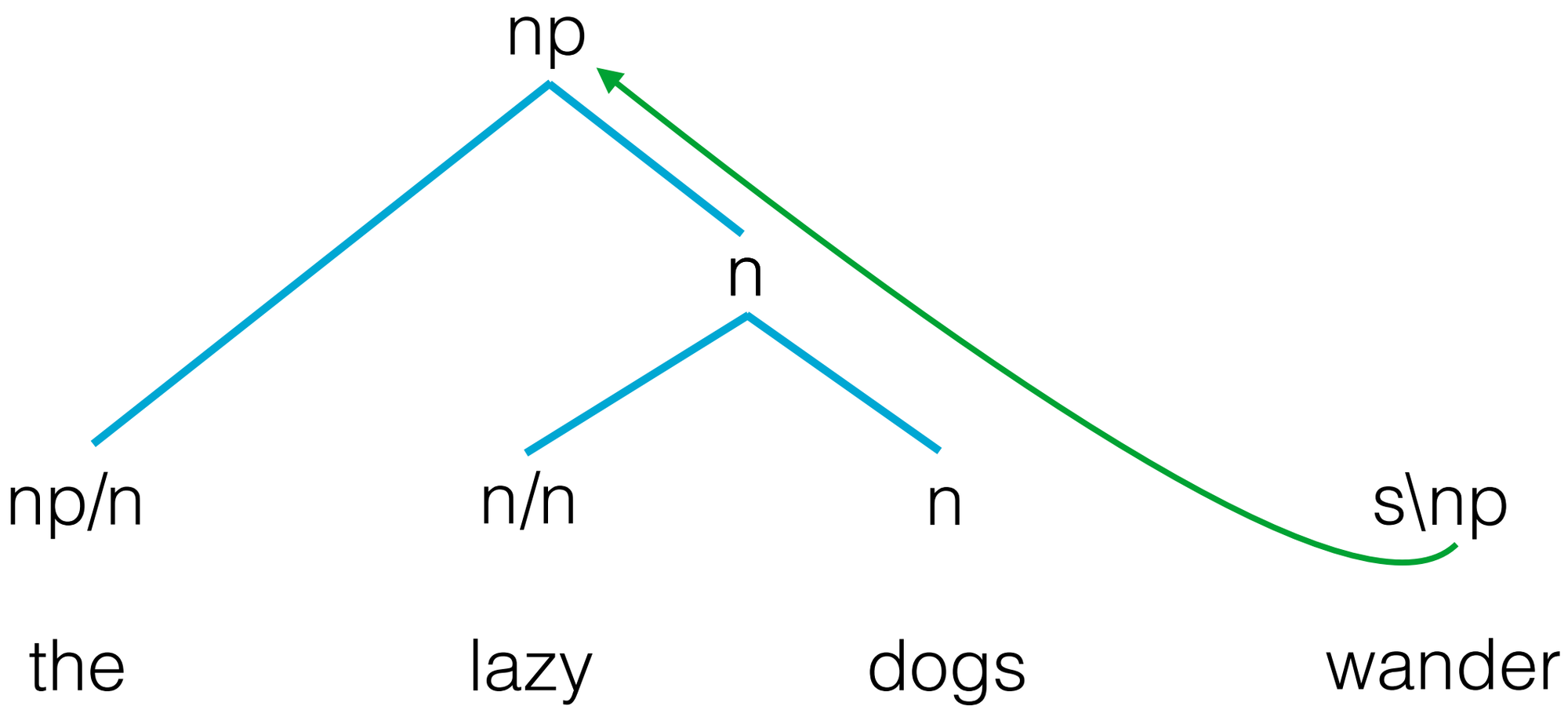

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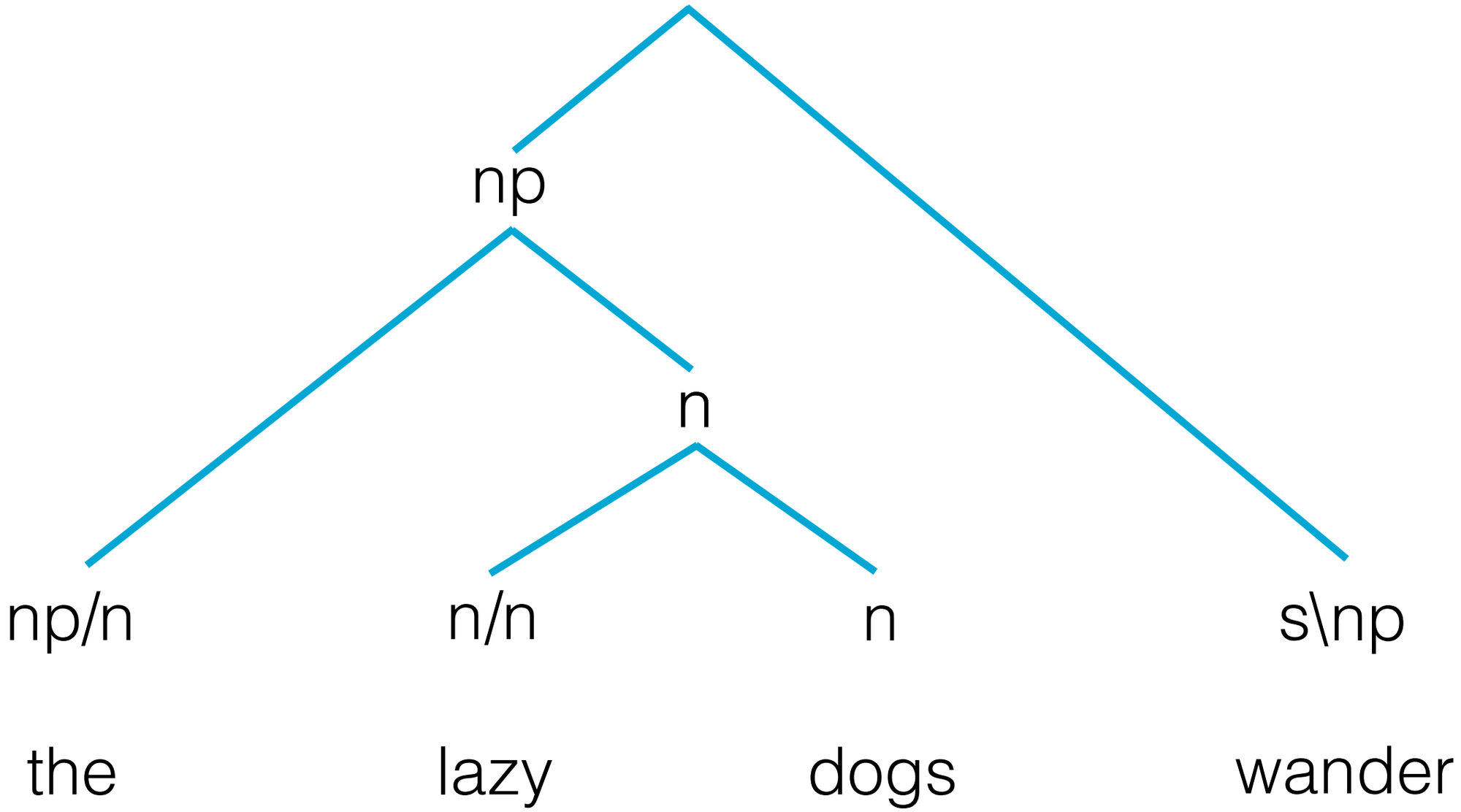

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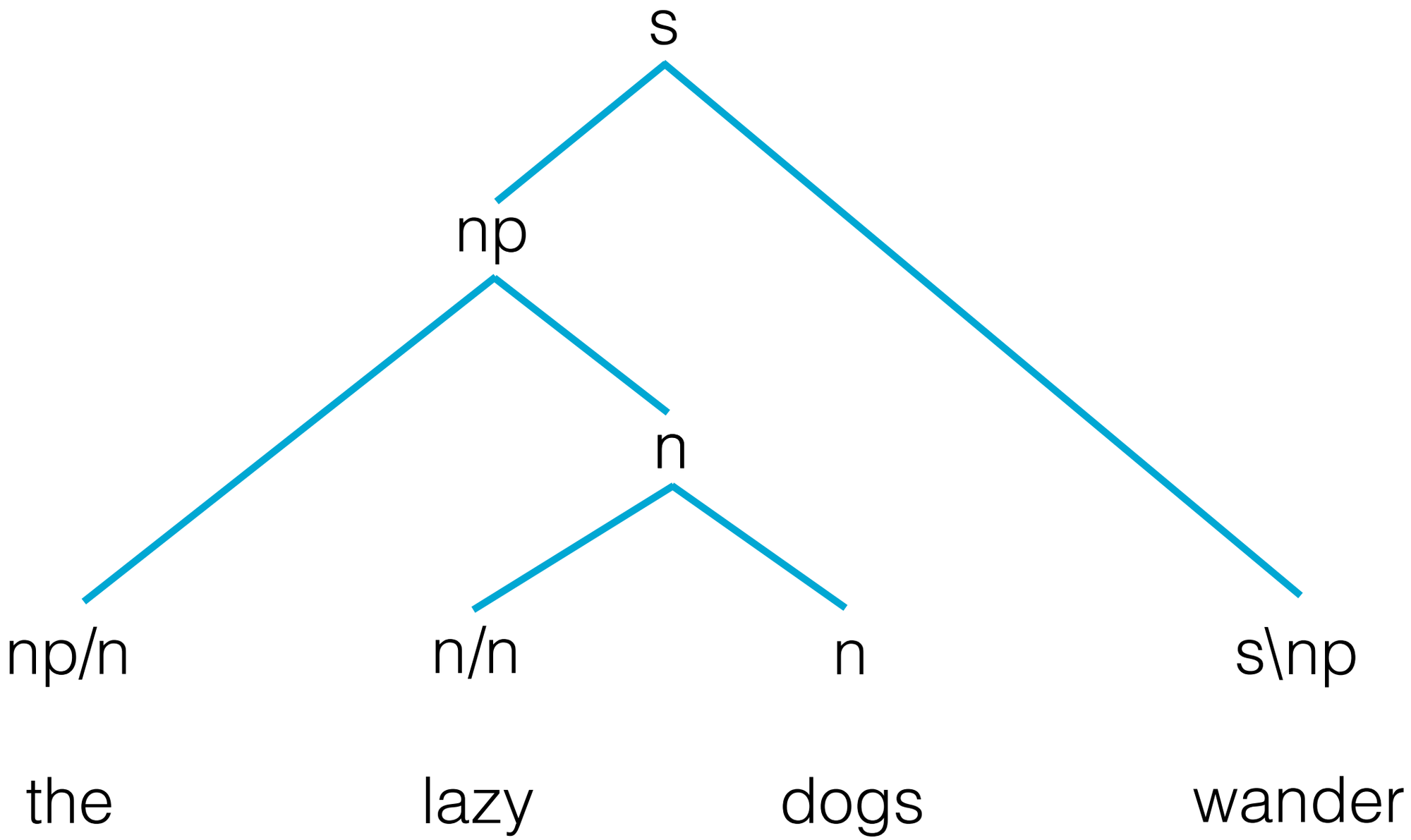

Why CCG?

Machine Translation

[Weese, Callison-Burch, and Lopez, 2012]

Semantic Parsing

[Zettlemoyer and Collins, 2005]

Type-Supervised CCG

Type-supervised learning for CCG
is highly *ambiguous*

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Penn Treebank
parts-of-speech

Type-Supervised CCG

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48 tags

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Penn Treebank
parts-of-speech

48 tags

CCGBank
Categories

Type-Supervised CCG

Type-supervised learning for CCG
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Penn Treebank
parts-of-speech

48 tags

CCGBank
Categories

1,300+ categories

Our Strategy

The grammar formalism *itself*
can be used to guide learning

Our Strategy

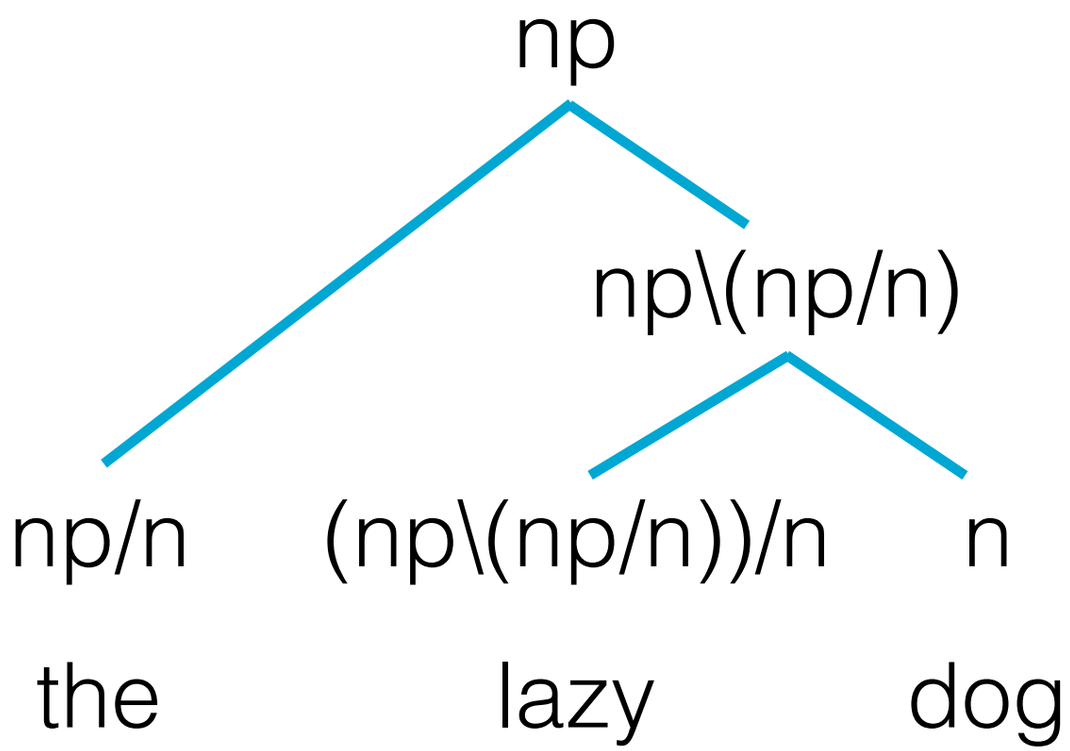
Incorporate *universal knowledge*
about grammar into learning

Universal Knowledge

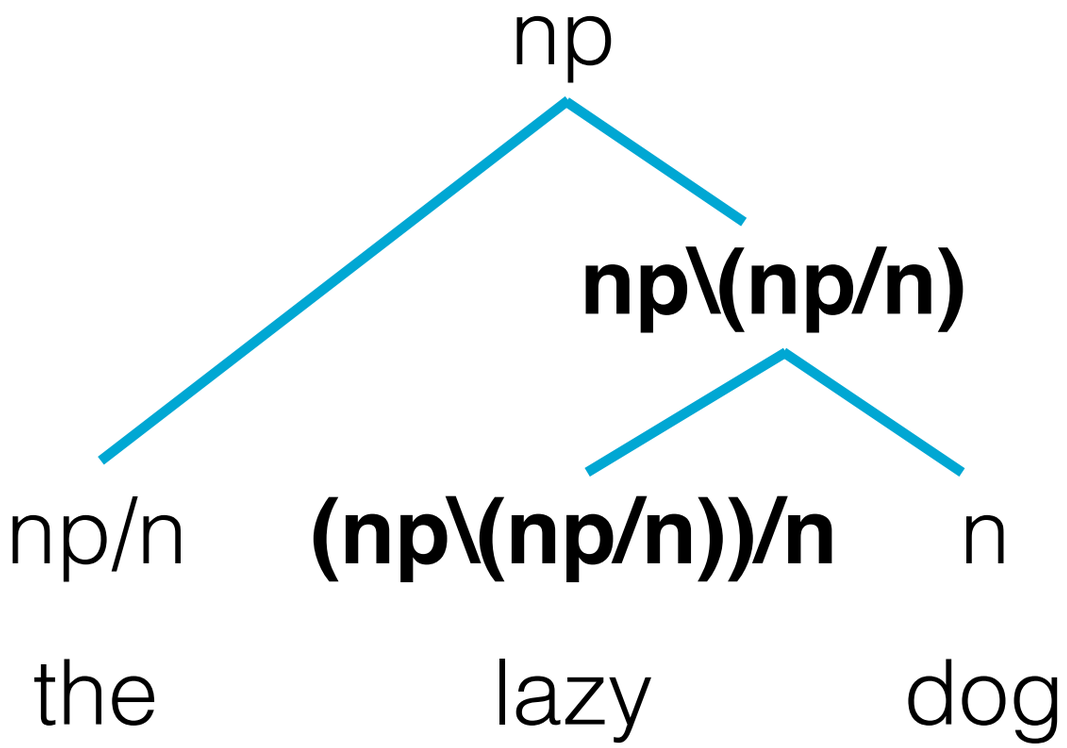
Prefer Simpler Categories

the lazy dog

Prefer Simpler Categories



Prefer Simpler Categories



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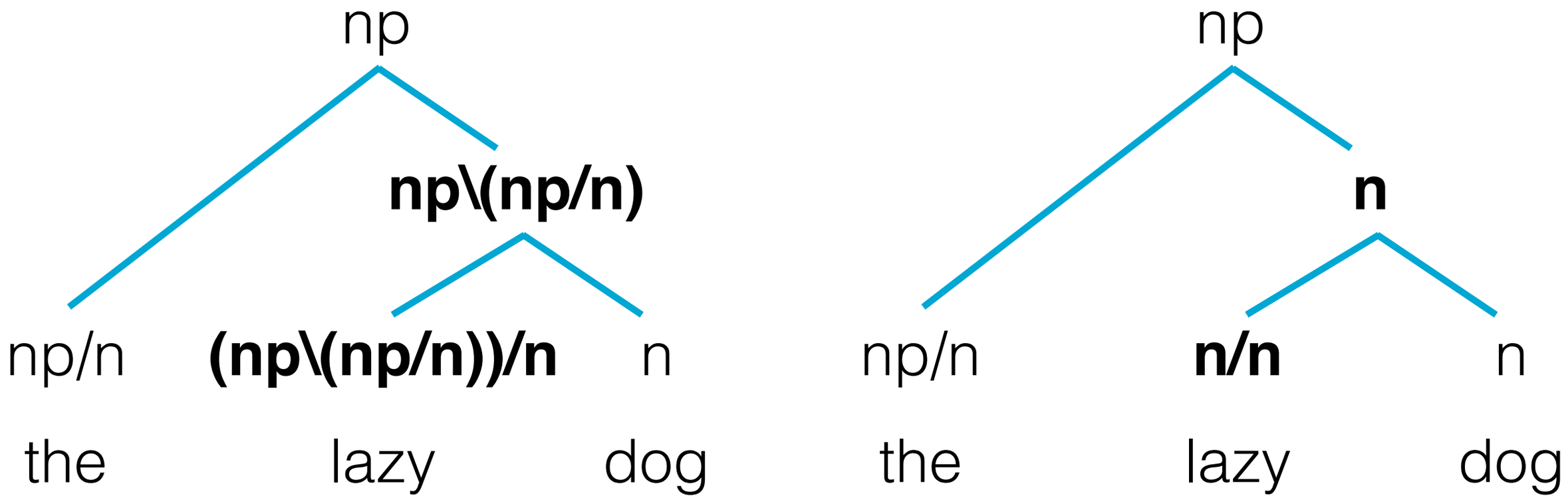

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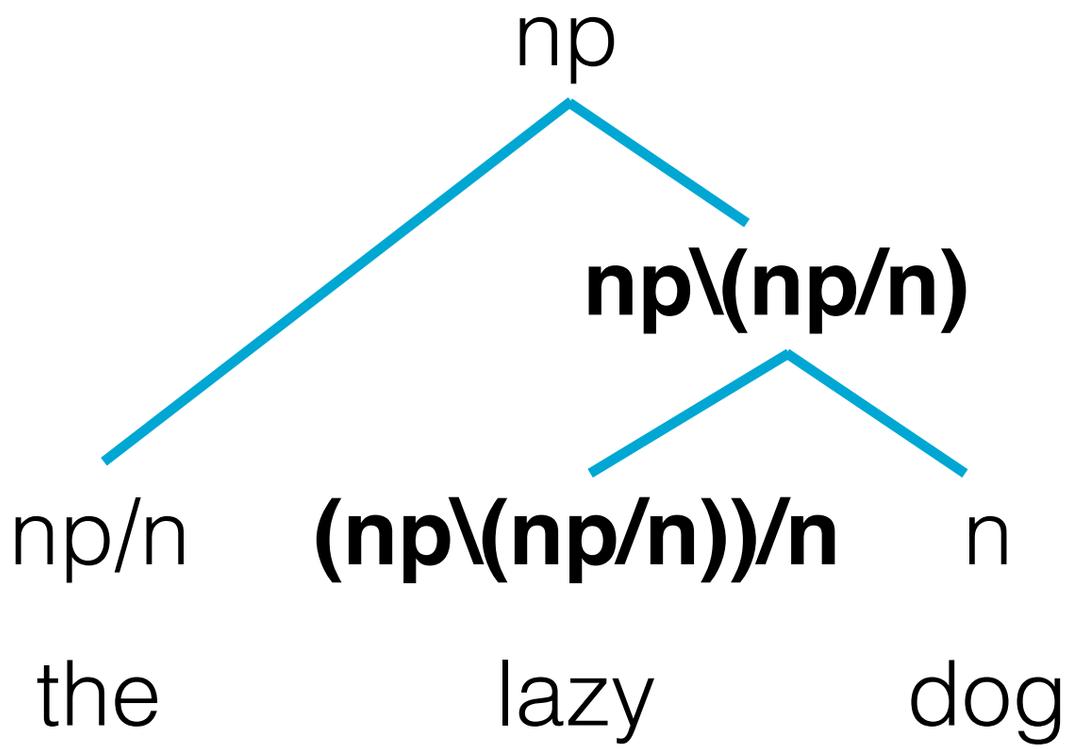

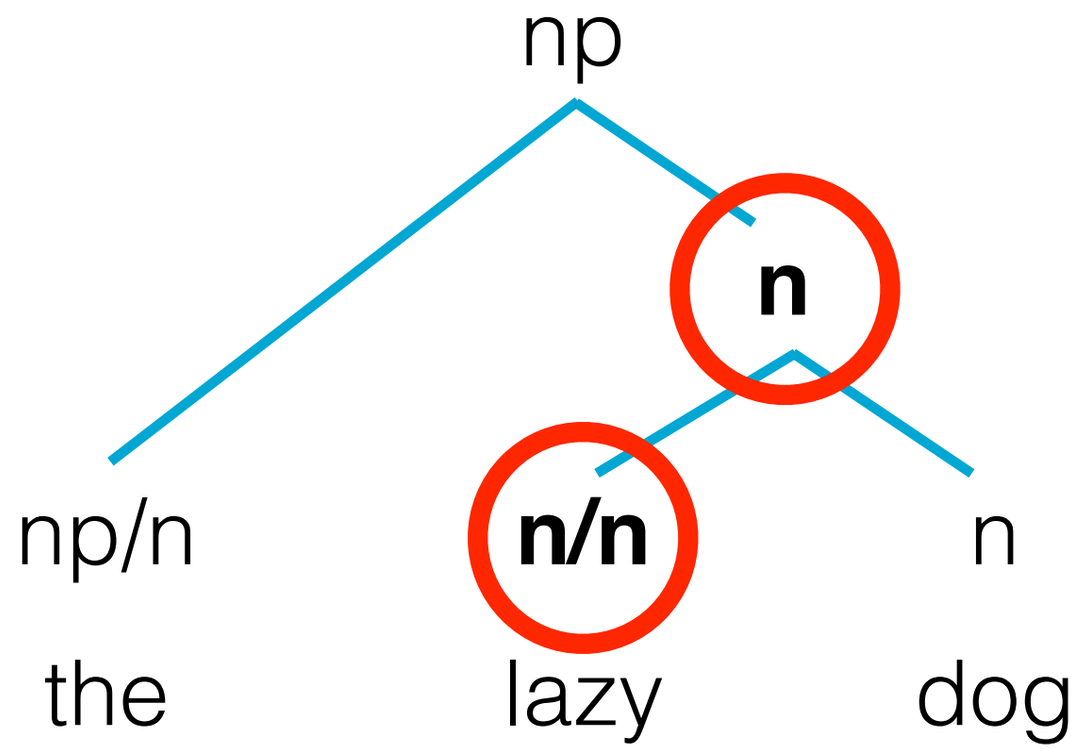

Prefer Simpler Categories

buy := $(s_b \backslash np)/np$

e.g. “Opponents don't **buy** such arguments.”

Prefer Simpler Categories

buy := $(s_b\backslash np)/np$ appears **342** times in CCGbank

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buy := $(((s_b\backslash np)/\mathbf{pp})/\mathbf{pp})/np$

“Tele-Communications agreed to **buy** half of Showtime Networks from Viacom (pp) for $ 225 million. (pp)”

Prefer Simpler Categories

buy := $(s_b\backslash np)/np$ appears **342** times in CCGbank

e.g. “Opponents don't **buy** such arguments.”

buy := $(((s_b\backslash np)/\mathbf{pp})/\mathbf{pp})/np$ appears **once**

“Tele-Communications agreed to **buy** half of Showtime Networks from Viacom (pp) for $ 225 million. (pp)”

Prefer Modifier Categories

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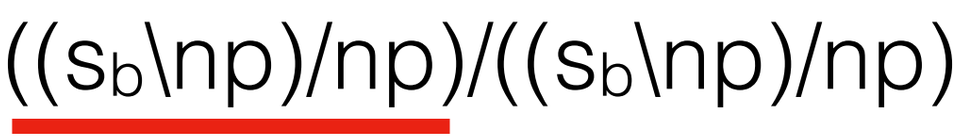
$((s_b\backslash np)/np)/((s_b\backslash np)/np)$

Prefer Modifier Categories



Prefer Modifier Categories

((s[b]\np)/np)/((s[b]\np)/np)

Prefer Modifier Categories

$(s_b\backslash np)/np$

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Prefer Modifier Categories

$(s_b\backslash np)/np$

transitive verb: (he) **hides** (the money)

$((s_b\backslash np)/np)/((s_b\backslash np)/np)$

Prefer Modifier Categories

$(s_b\backslash np)/np$

transitive verb: (he) **hides** (the money)

$((s_b\backslash np)/np)/((s_b\backslash np)/np)$

adverb: (he) **quickly** (hides) (the money)

Weighted Category Grammar

$a \longrightarrow$ {s, np, n,…}

$A \longrightarrow B / C$

$A \longrightarrow B \backslash C$

Weighted Category Grammar

$a \longrightarrow \{s, np, n, \ldots\} \qquad p_{atom}(a)$

$A \longrightarrow B \,/\, C$

$A \longrightarrow B \setminus C$

Weighted Category Grammar

$$a \longrightarrow \{s, np, n, \ldots\} \qquad p_{atom}(a) \times p_{term}$$

$$A \longrightarrow B \,/\, C$$

$$A \longrightarrow B \setminus C$$

Weighted Category Grammar

$a \longrightarrow \{s, np, n, \ldots\} \qquad p_{atom}(a) \times p_{term}$

$A \longrightarrow B \,/\, C \qquad \overline{p_{term}}$

$A \longrightarrow B \setminus C \qquad \overline{p_{term}}$

Weighted Category Grammar

$$a \longrightarrow \{s, np, n, \ldots\} \qquad p_{atom}(a) \times p_{term}$$

$$A \longrightarrow B \,/\, C \qquad \overline{p_{term}} \times p_{fwd}$$

$$A \longrightarrow B \setminus C \qquad \overline{p_{term}}$$

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$$A \longrightarrow B \setminus B \qquad \overline{p_{term}} \times \overline{p_{fwd}} \times p_{mod}$$

$$A \longrightarrow B \setminus C \qquad \overline{p_{term}} \times \overline{p_{fwd}}$$

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$$A \longrightarrow B \,\backslash\, B \qquad \overline{p_{term}} \times \overline{p_{fwd}} \times p_{mod}$$

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Weighted Category Grammar

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Weighted Category Grammar

$a \longrightarrow \{s, np, n, \ldots\} \qquad p_{atom}(a) \times p_{term}$

$A \longrightarrow B \,/\, B \qquad \overline{p_{term}} \times p_{fwd} \times p_{mod}$

$+$

$A \longrightarrow B \,/\, C \qquad \overline{p_{term}} \times p_{fwd} \times \overline{p_{mod}}$

$A \longrightarrow B \,\backslash\, B \qquad \overline{p_{term}} \times \overline{p_{fwd}} \times p_{mod}$

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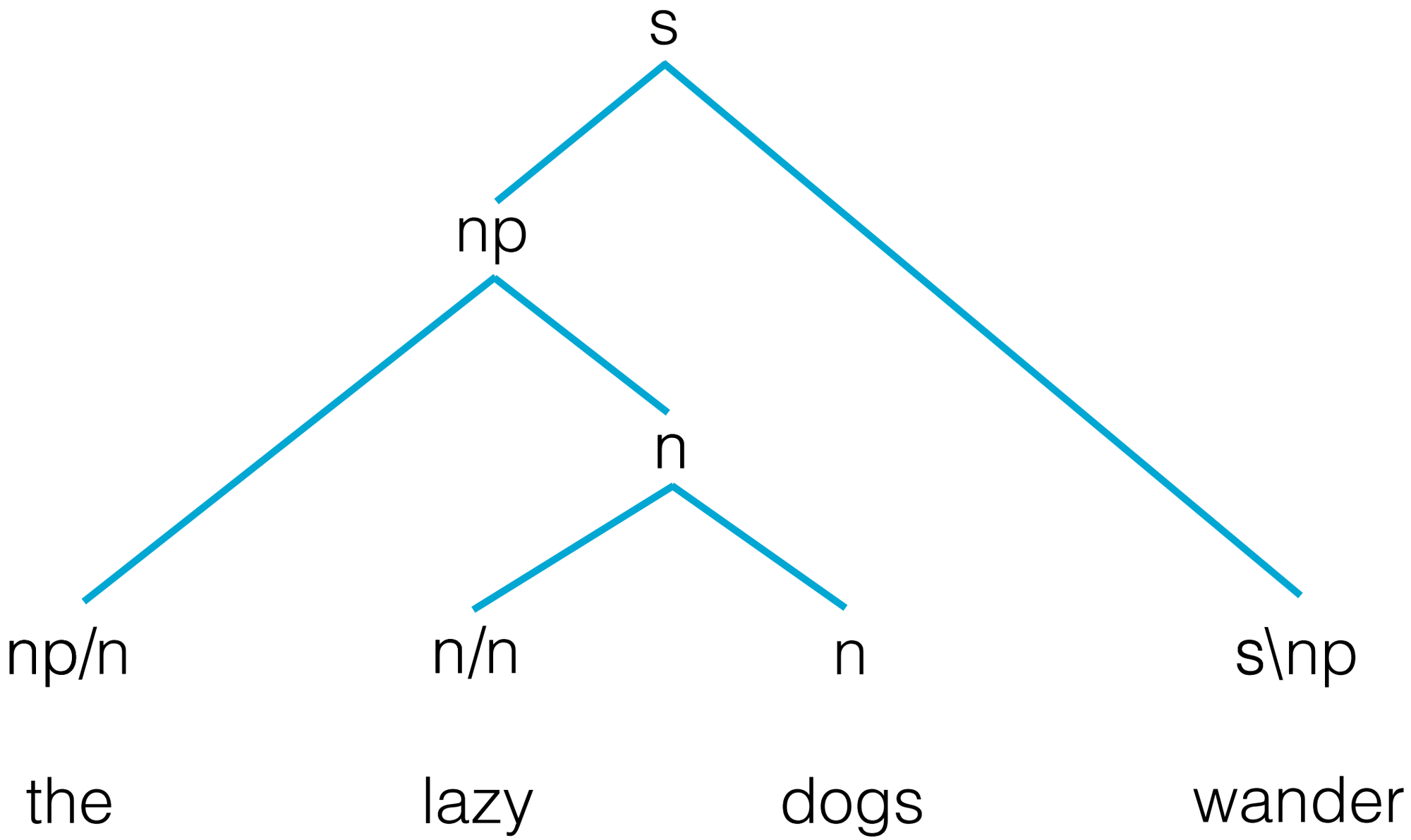
$A \longrightarrow B \,\backslash\, C \qquad \overline{p_{term}} \times \overline{p_{fwd}} \times \overline{p_{mod}}$

Prefer Likely Categories

np/n	n/n	n	s\np
the	lazy	dogs	wander

Prefer Likely Categories



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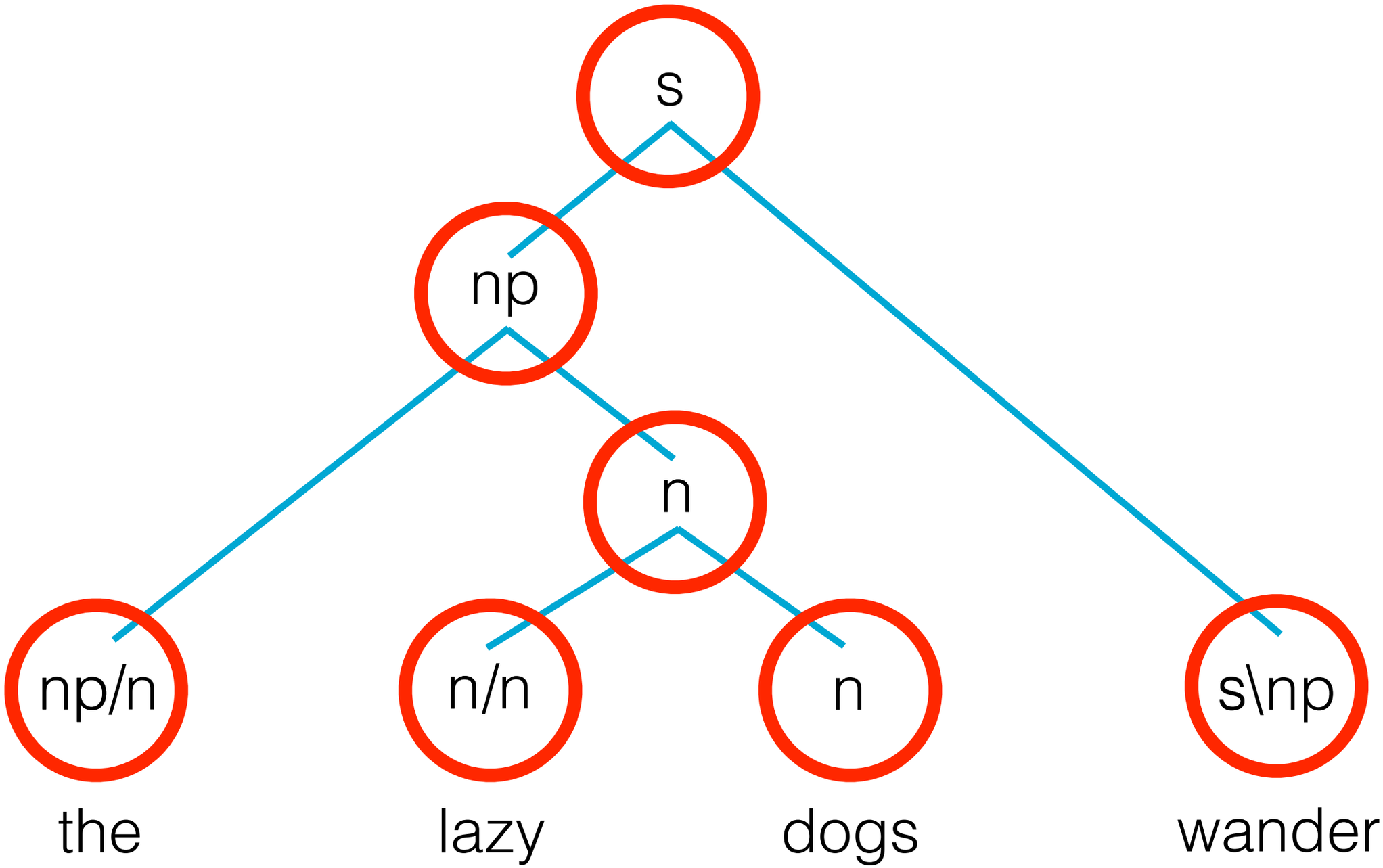


Type-Supervised Learning

unlabeled corpus

tag dictionary

Type-Supervised Learning

unlabeled corpus

tag dictionary

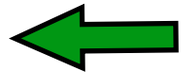
same as
POS tagging

Type-Supervised Learning

unlabeled corpus

tag dictionary

same as
POS tagging

universal properties of the CCG formalism 

Posterior Inference

[Johnson, Griffiths, and Goldwater, 2007]

Posterior Inference

PCFG

Posterior Inference

Priors (simple is good)

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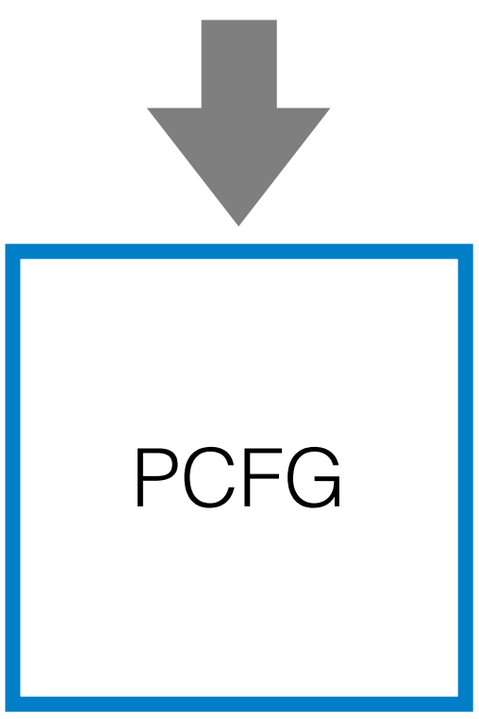
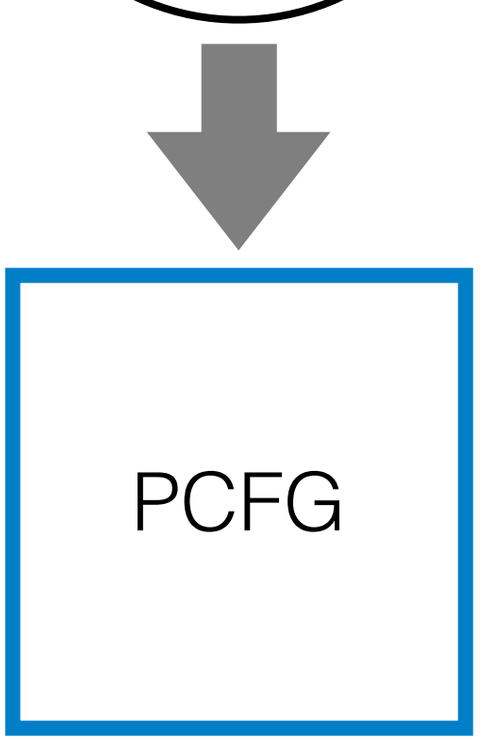


Posterior Inference

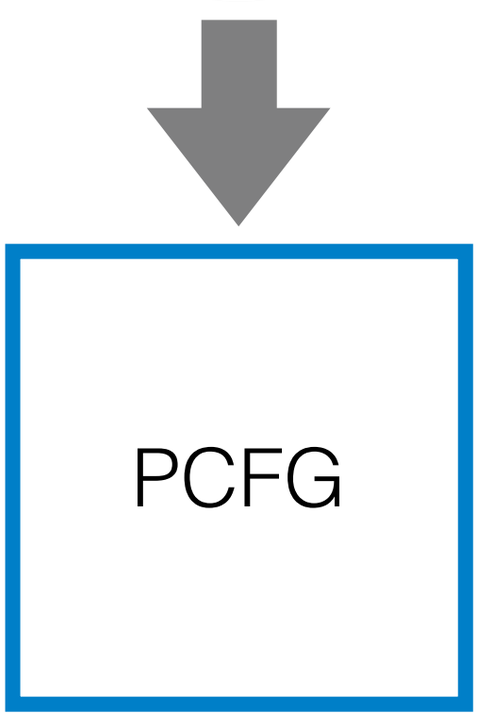
Priors (simple is good)



the lazy dogs wander

Posterior Inference

Priors (simple is good)

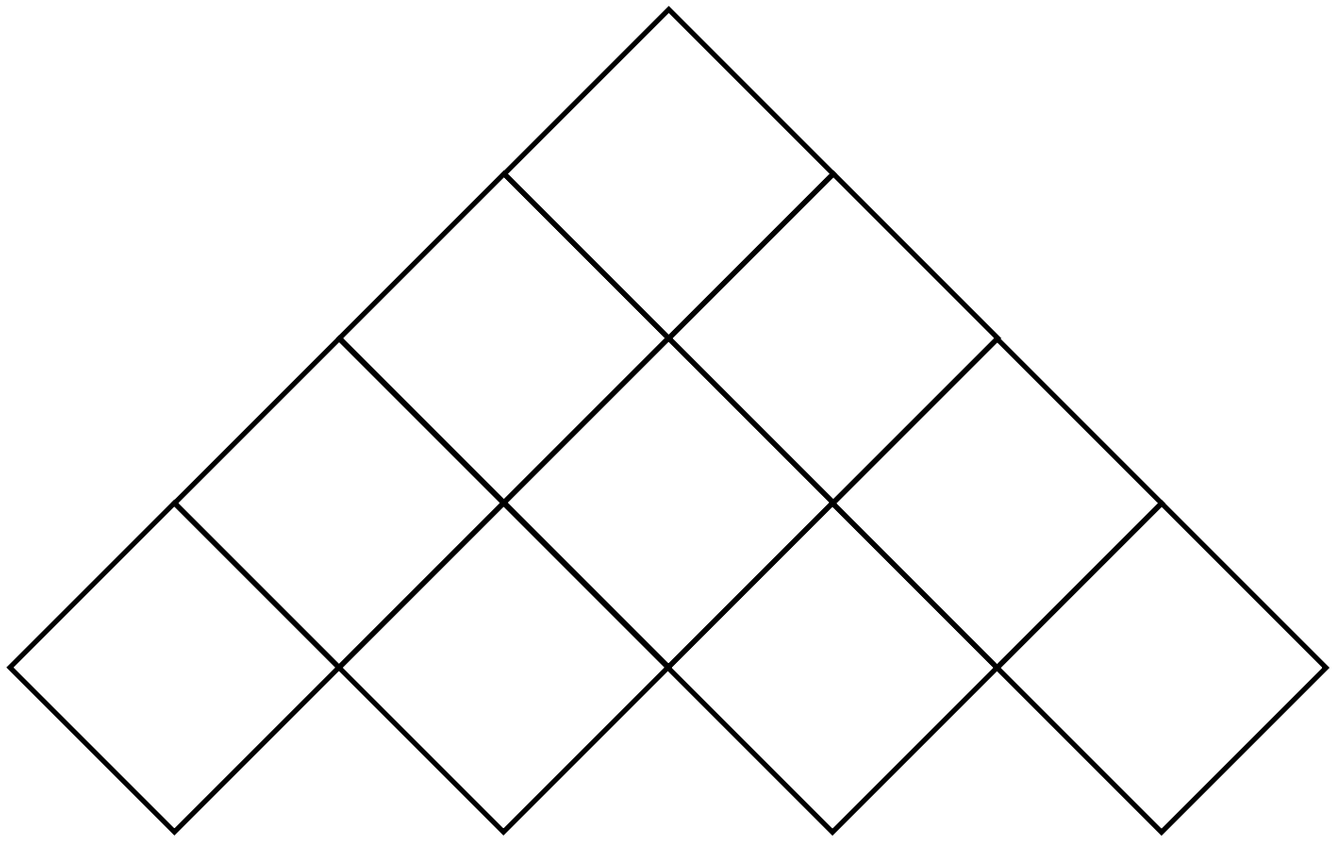


the	lazy	dogs	wander
np/n	n/n	n	n
	np	np	n/n
		(s\np)/np	np/n
			s\np
			...

Posterior Inference

Priors (simple is good)

PCFG



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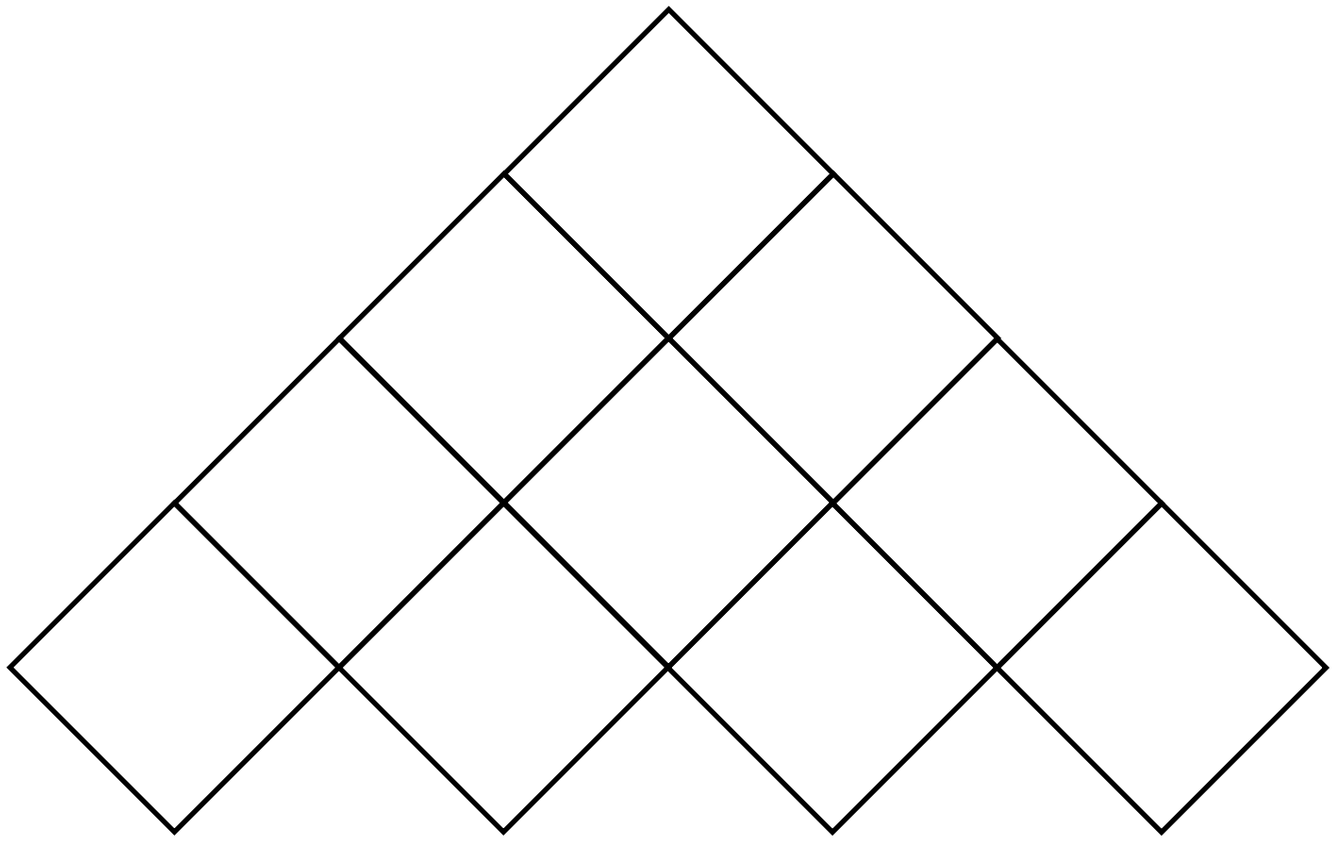

the	lazy	dogs	wander
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	np	np	n/n
		(s\np)/np	np/n
			s\np
			...

Posterior Inference

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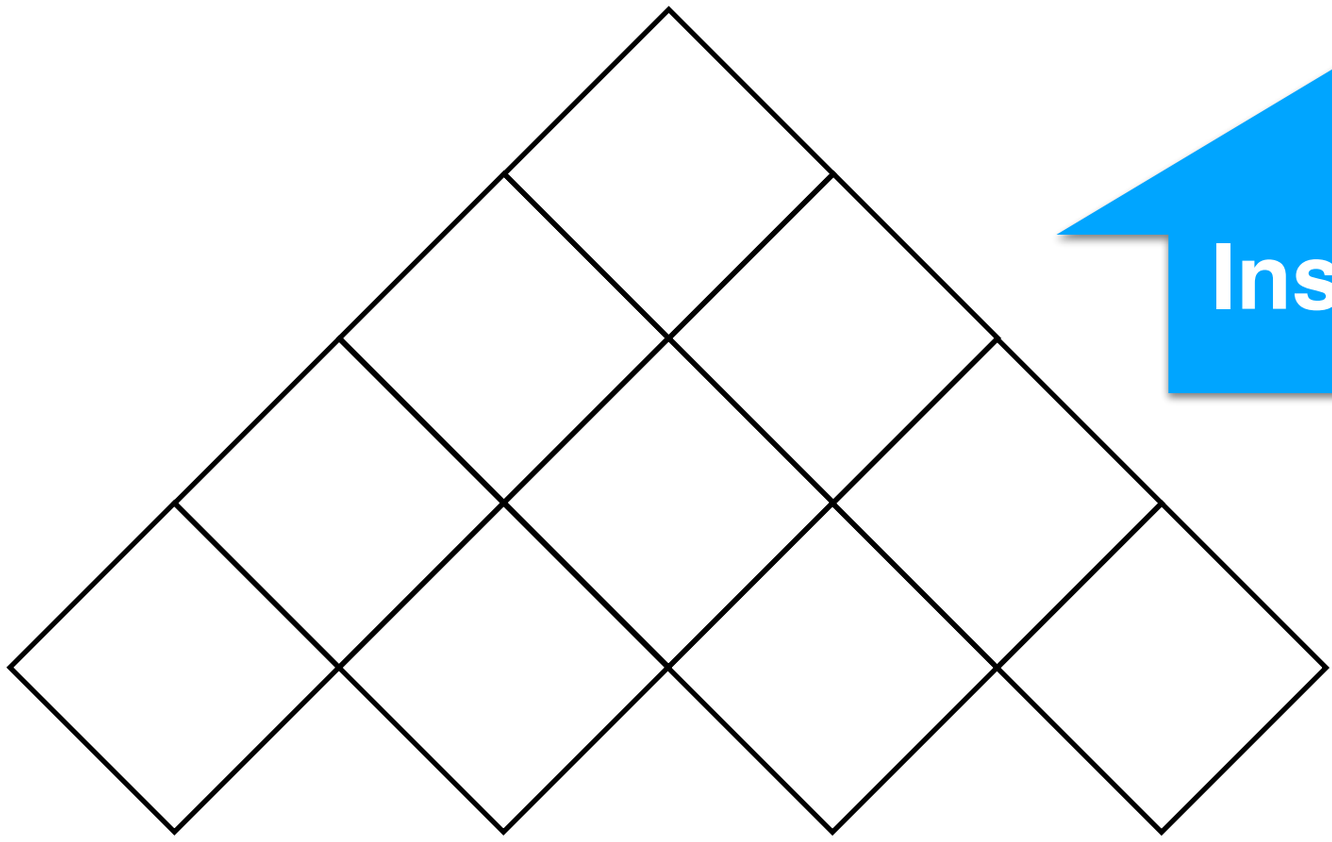

Inside

the	lazy	dogs	wander
np/n	n/n	n	n
	np	np	n/n
		(s\np)/np	np/n
			s\np
			...

Posterior Inference

Priors (simple is good)

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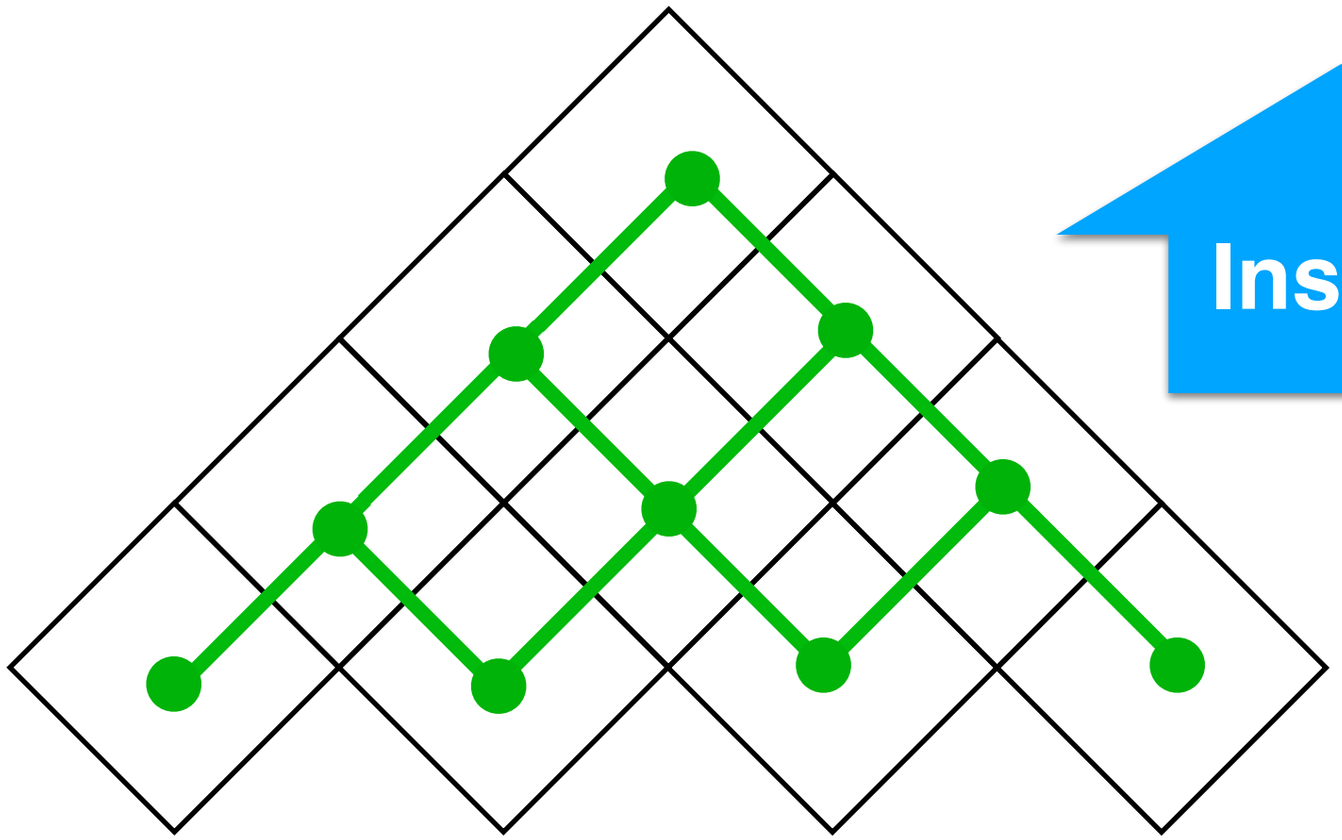

the	lazy	dogs	wander
np/n	n/n	n	n
	np	np	n/n
		(s\np)/np	np/n
			s\np
			...

Posterior Inference

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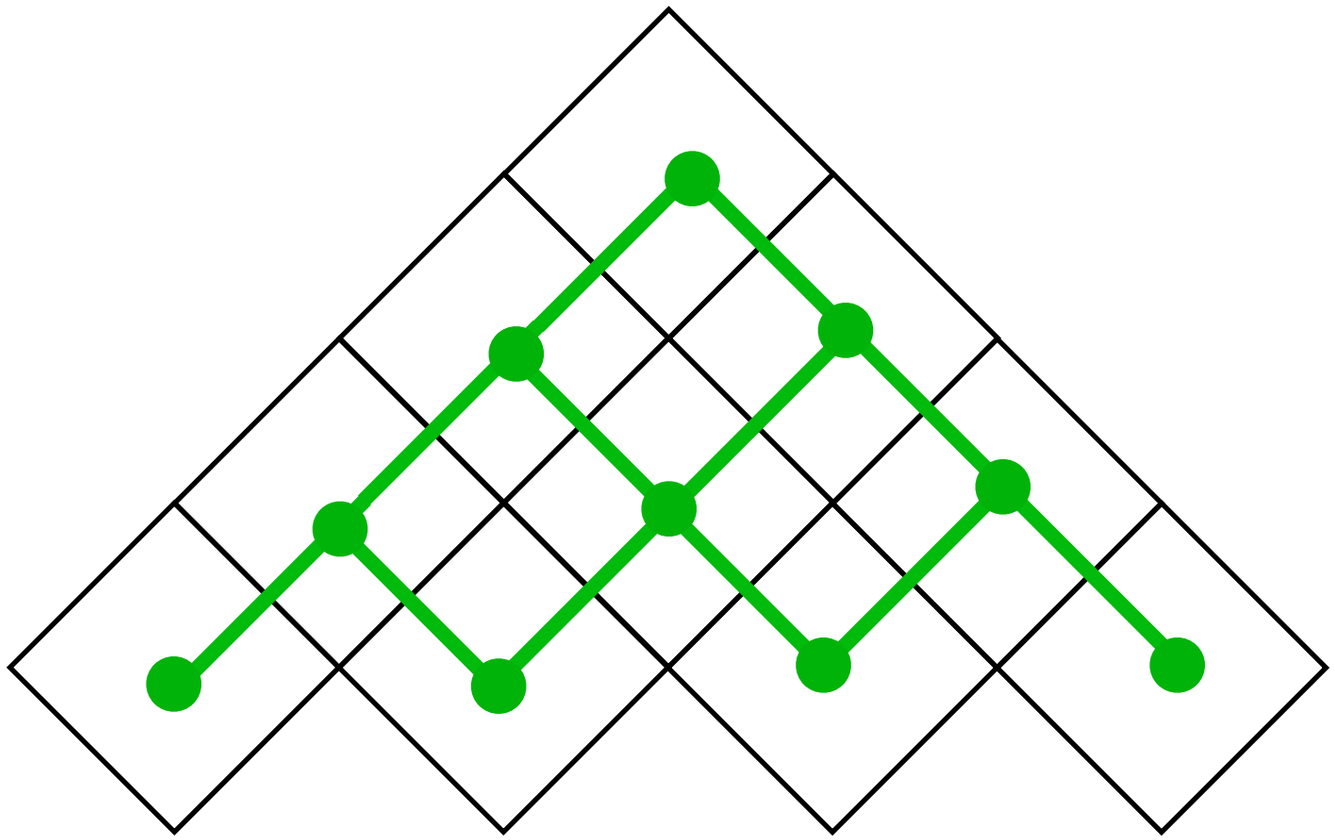

the	lazy	dogs	wander
np/n	n/n	n	n
	np	np	n/n
		(s\np)/np	np/n
			s\np
			...

Posterior Inference

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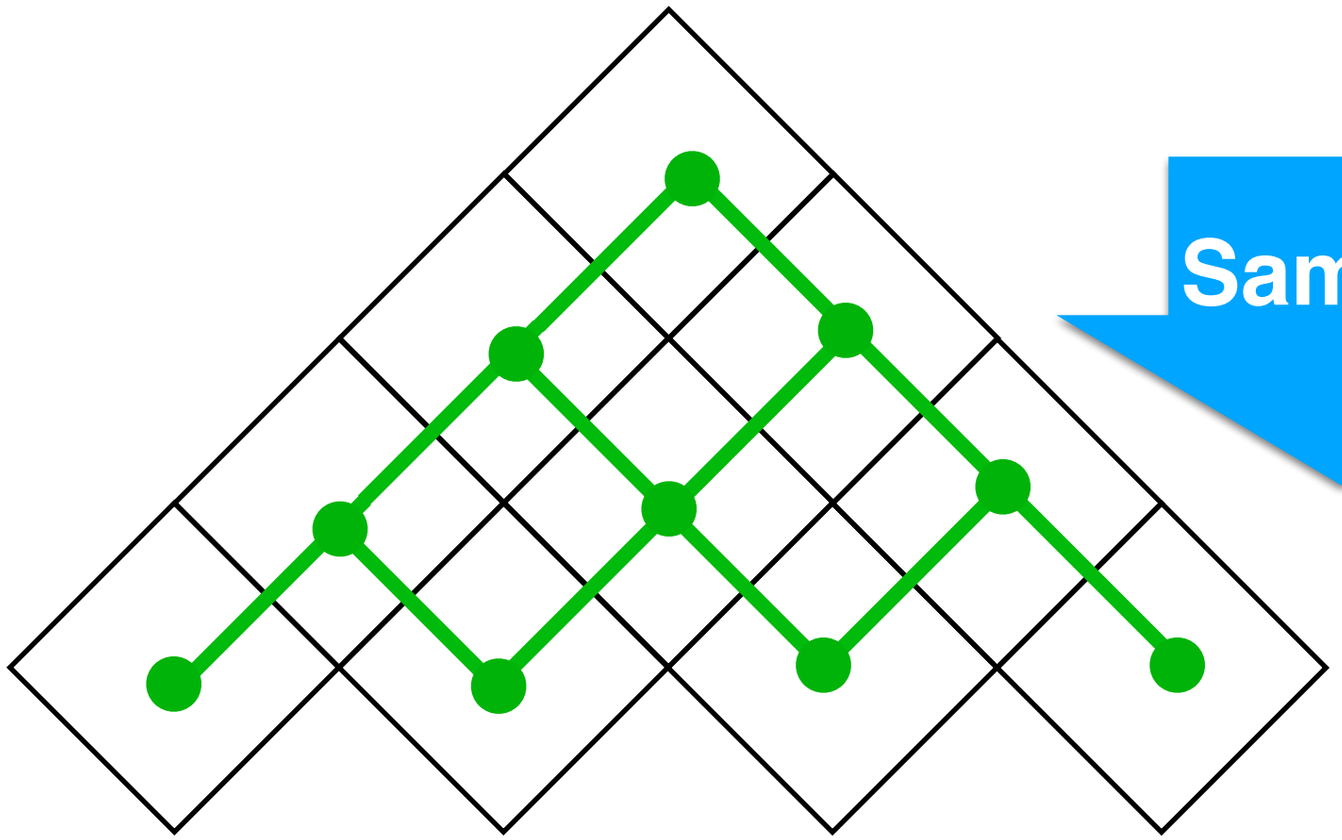


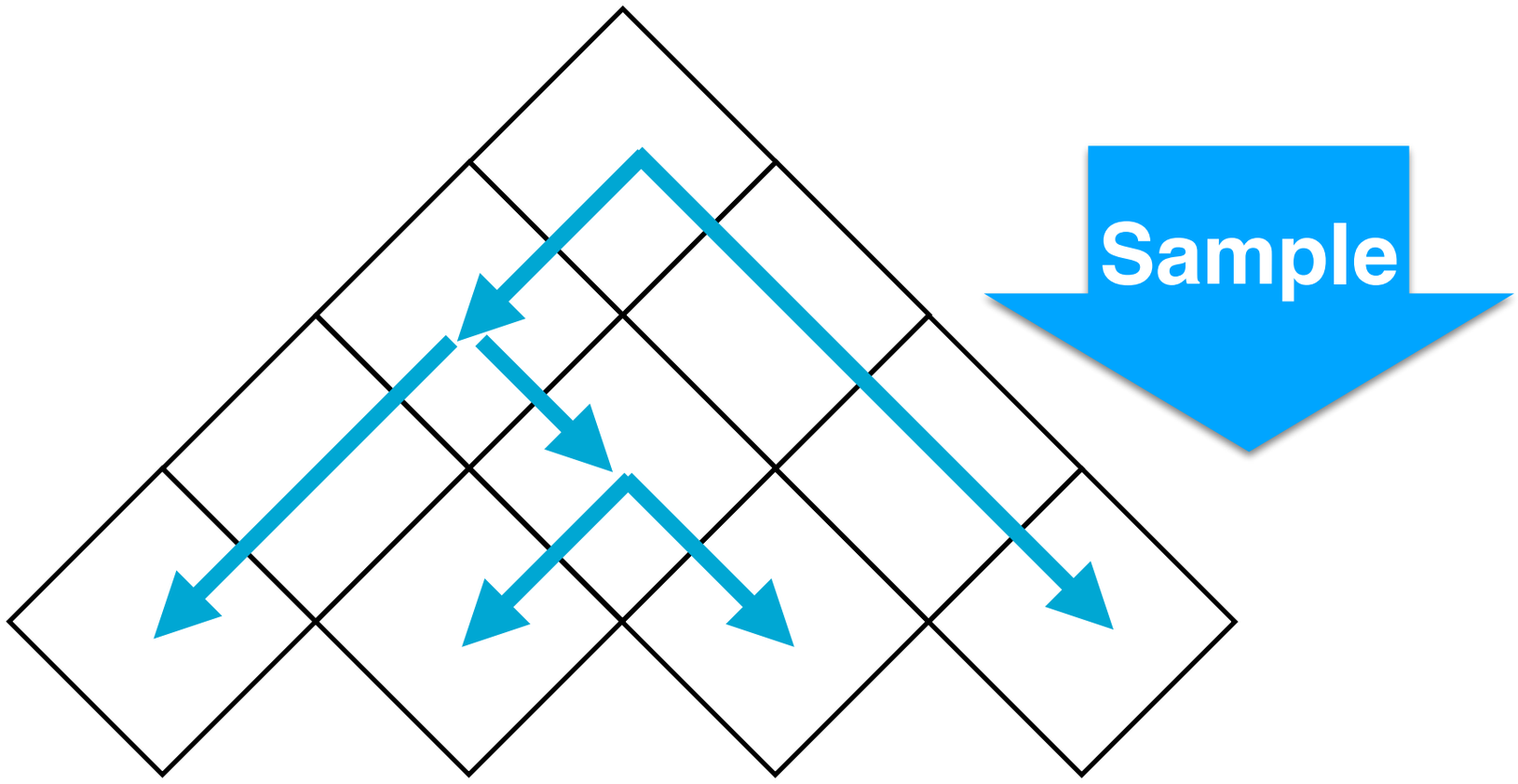
Sample

the	lazy	dogs	wander
np/n	n/n	n	n
	np	np	n/n
		(s\np)/np	np/n
			s\np
			...

Posterior Inference

Priors (simple is good)

PCFG

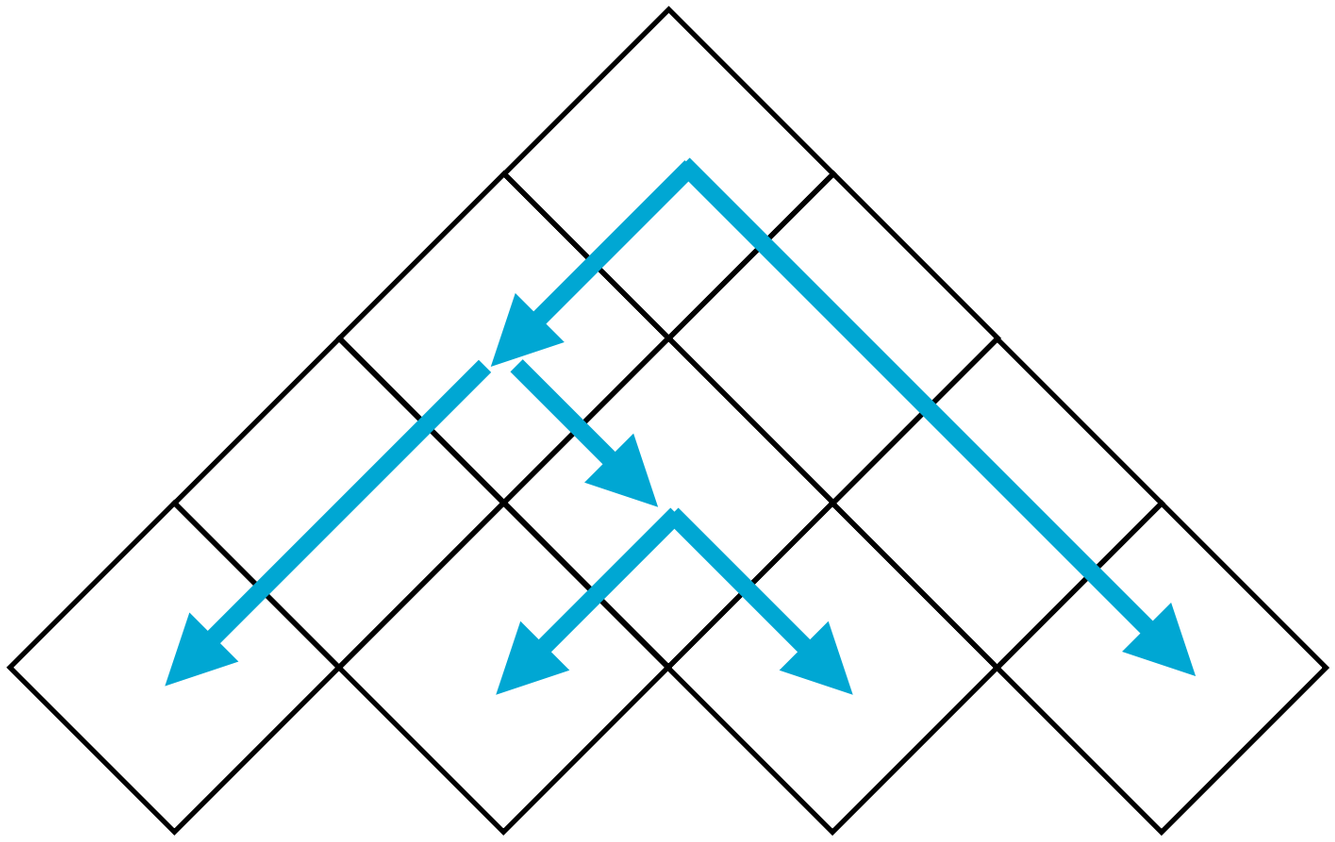


the	lazy	dogs	wander
np/n	n/n	n	n
	np	np	n/n
		(s\np)/np	np/n
			s\np
			...

Posterior Inference

Priors (simple is good)

PCFG

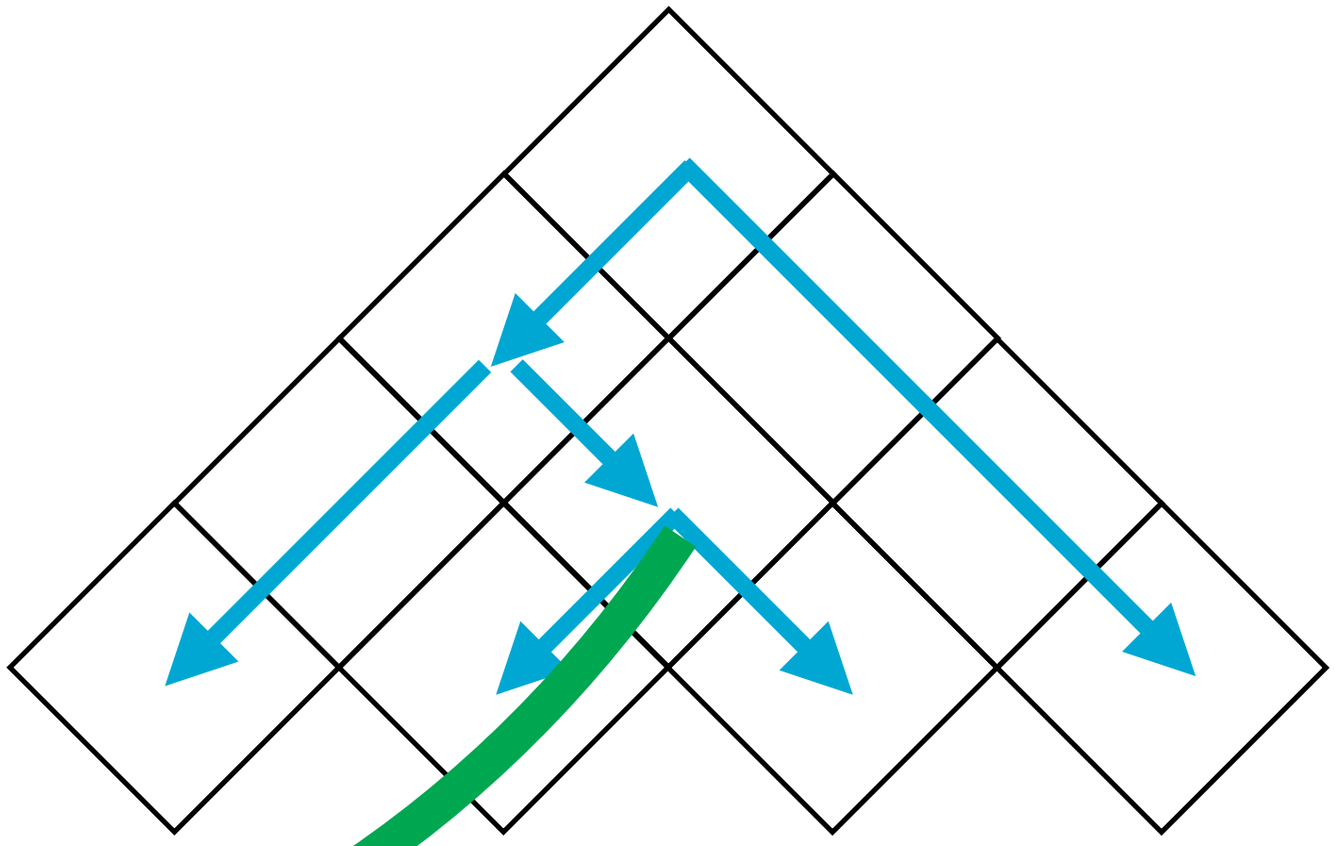


the	lazy	dogs	wander
np/n	n/n	n	n
	np	np	n/n
		(s\np)/np	np/n
			s\np
			...

Posterior Inference

Priors (simple is good)

PCFG

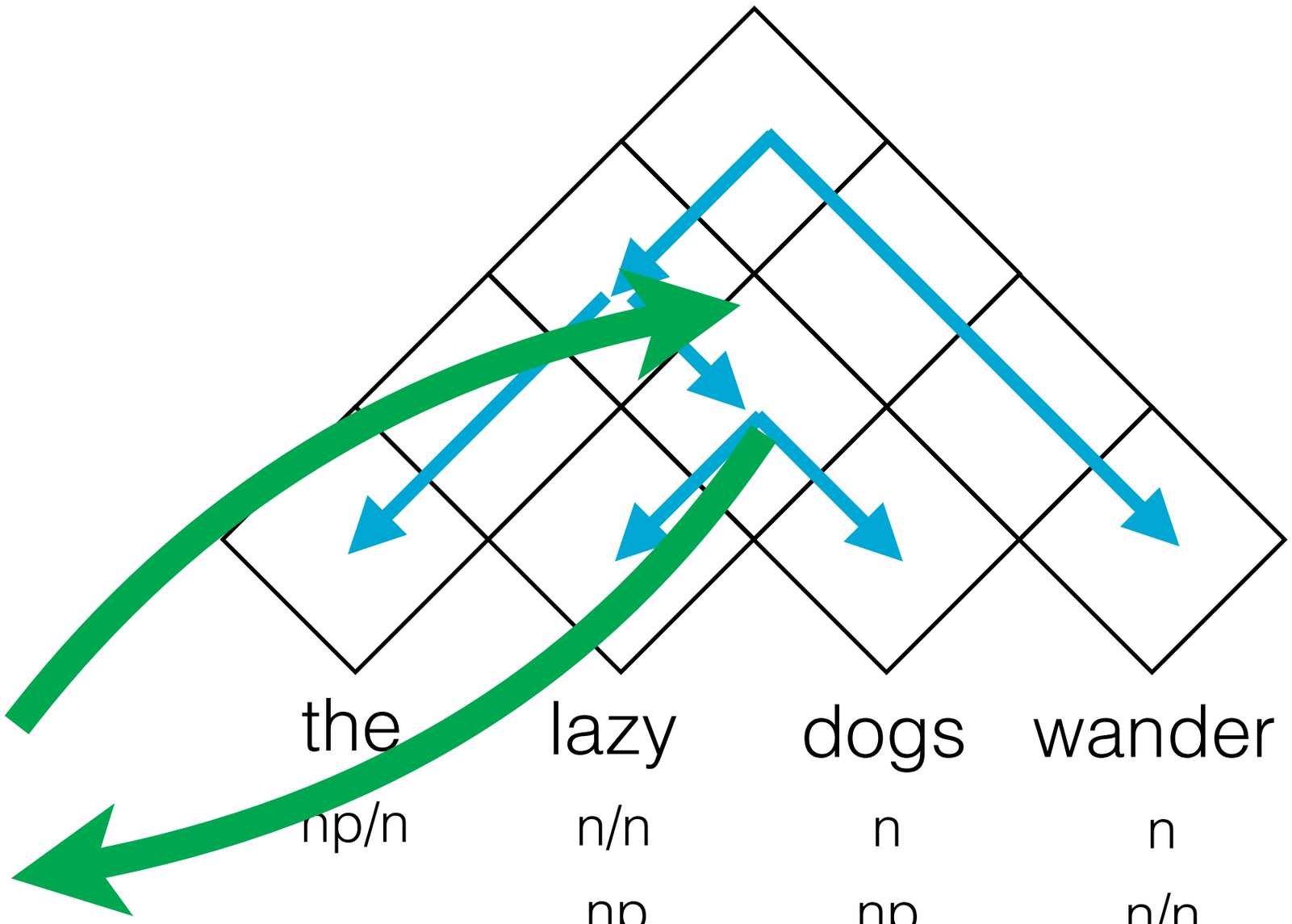


the	lazy	dogs	wander
np/n	n/n	n	n
	np	np	n/n
		(s\np)/np	np/n
			s\np
			...

Posterior Inference

Priors (simple is good)

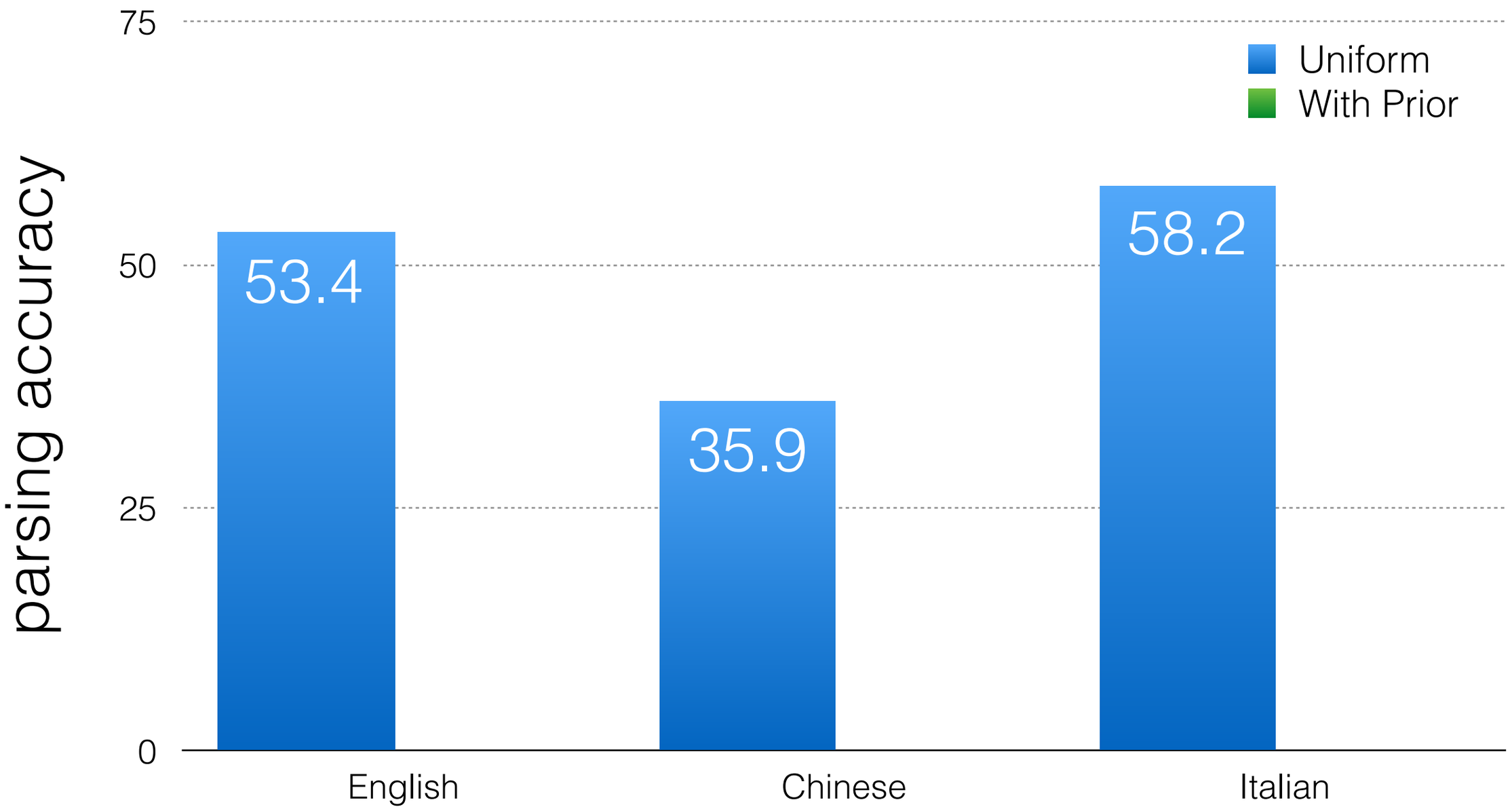
PCFG



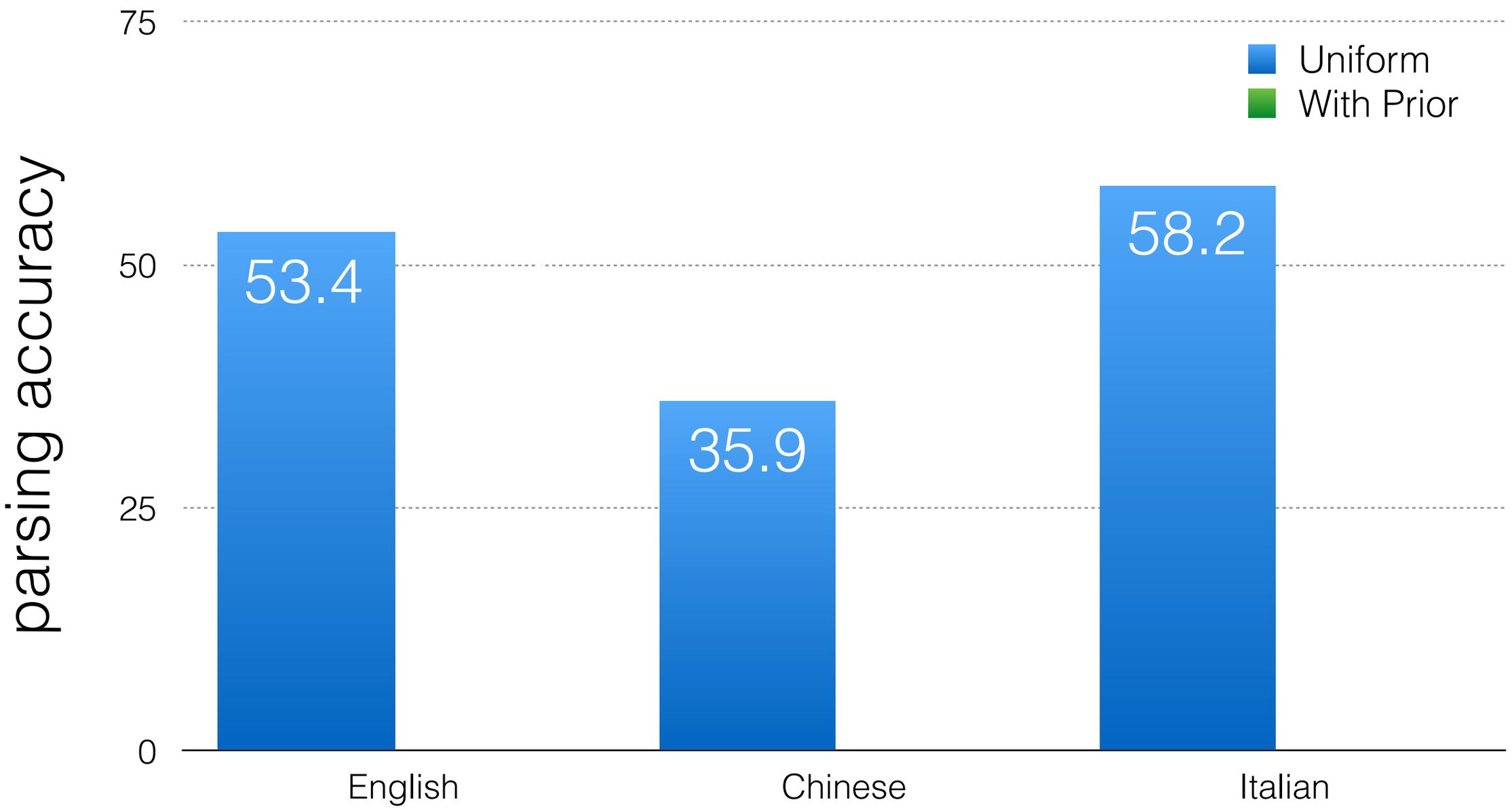
the	lazy	dogs	wander
np/n	n/n	n	n
	np	np	n/n
		(s\np)/np	np/n
			s\np
			...

Results

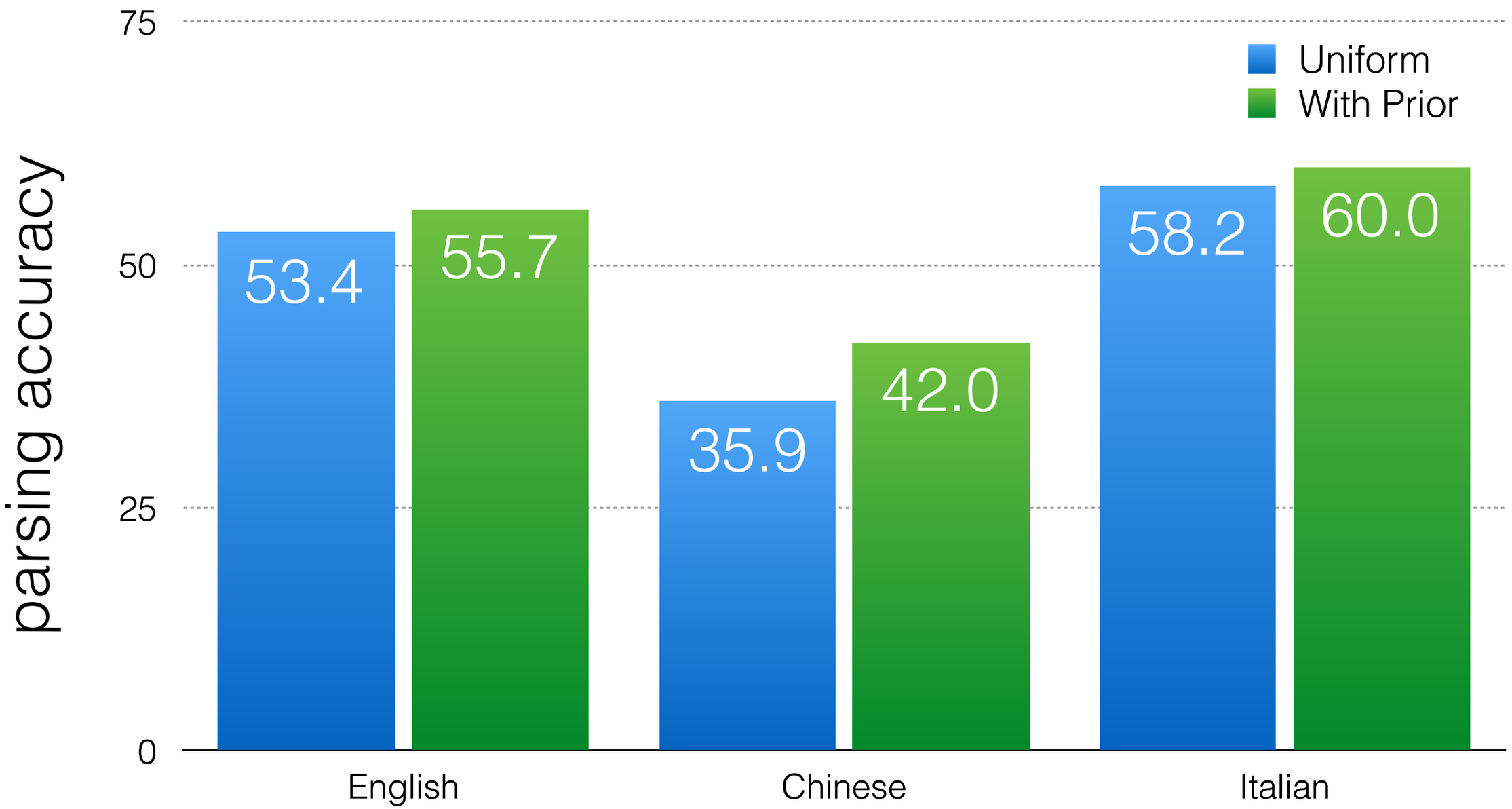
CCG Parsing Results



CCG Parsing Results



CCG Parsing Results



Conclusion

Using **universal grammatical knowledge**
can make better use of weak supervision