Token and Type Constraints for Cross-Lingual Part-of-Speech Tagging

Oscar Täckström
Dipanjan Das, Slav Petrov, Ryan McDonald & Joakim Nivre

UPPSALA UNIVERSITET

SWEDISH ICT SICS

.	ADJ	ADP
ADV	CONJ	DET
NOUN	NUM	PRON
PRT	VERB	X

.	ADJ	ADP
ADV	CONJ	DET
NOUN	NUM	PRON
PRT	VERB	X

Wiktionary

…	…
var	ADV, CONJ, DET, NOUN, VERB
vara	NOUN, VERB
varade	VERB
…	…

.	ADJ	ADP
ADV	CONJ	DET
NOUN	NUM	PRON
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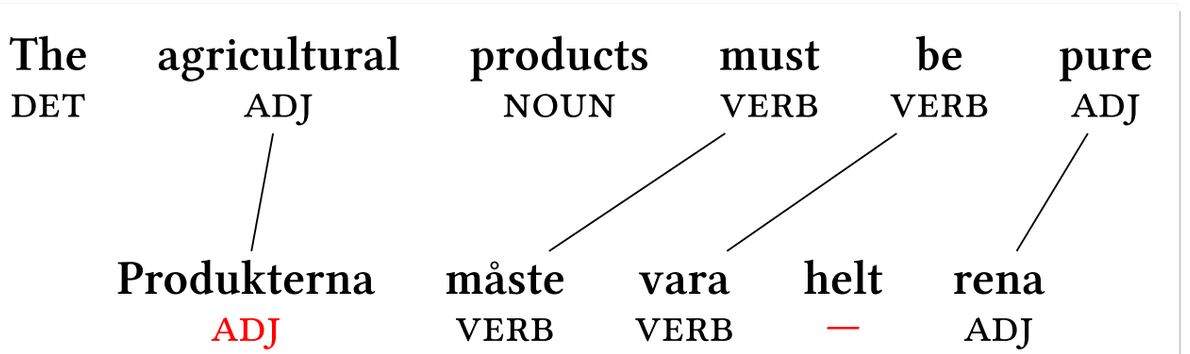

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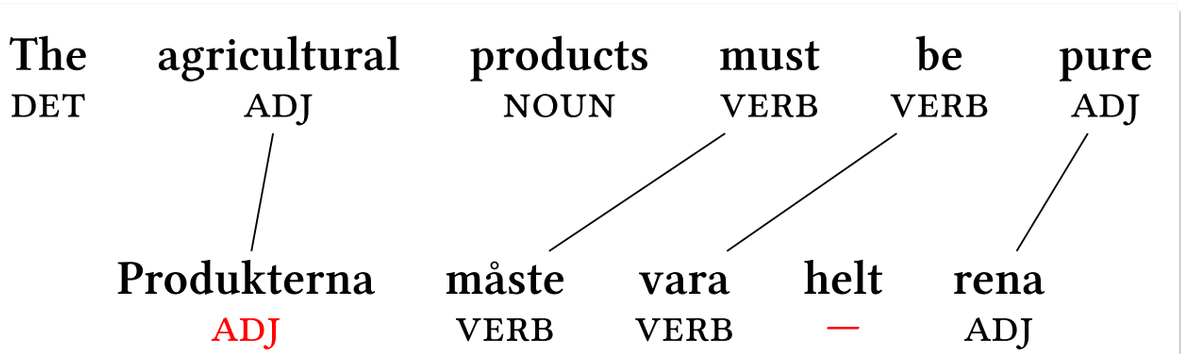

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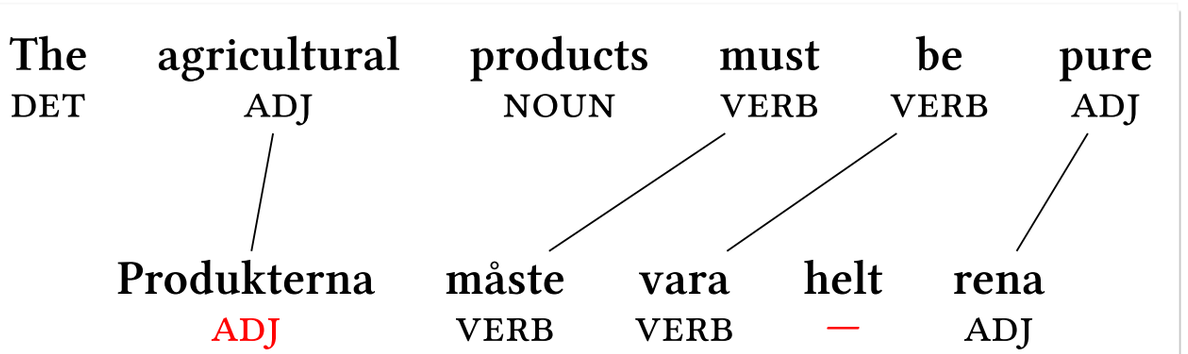

Latent variable CRF model

.	ADJ	ADP
ADV	CONJ	DET
NOUN	NUM	PRON
PRT	VERB	X

Wiktionary

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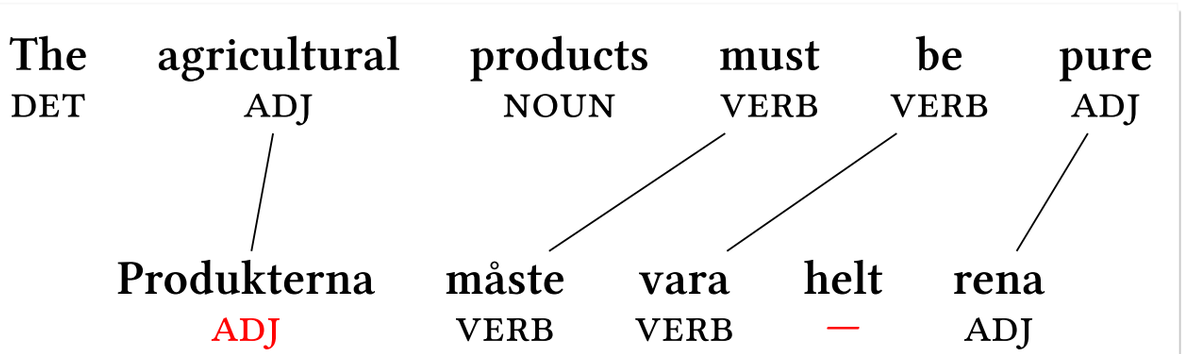

Latent variable CRF model

>25% error reduction over state of the art

Part-of-Speech Tagging

Is	this	the	future	of	chamber	music	?

Part-of-Speech Tagging

Is	this	the	future	of	chamber	music	?
VBZ	DT	DT	NN	IN	NN	NN	?

Part-of-Speech Tagging

Is	this	the	future	of	chamber	music	?
VBZ	DT	DT	NN	IN	NN	NN	?

Måste	en	familj	ha	just	den	uppbyggnaden	?
MV	EN	NN	HV	AB	PO	NN	I?

Всеки	има	право	на	живот	.
PC	VPI	NC	R	NC	PUNCT

...

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...

Supervised accuracies:

~95% in-domain (Petrov et al., 2012)

<90% out of domain (Blitzer et al., 2006)

Coarse "Universal" Tags

Is	this	the	future	of	chamber	music	?
VBZ	DT	DT	NN	IN	NN	NN	?

Måste	en	familj	ha	just	den	uppbyggnaden	?
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Naseem et al., 2009; **Petrov et al., 2012**

Coarse "Universal" Tags

Is	this	the	future	of	chamber	music	?
VBZ	DT	DT	NN	IN	NN	NN	?
VERB	DET	DET	NOUN	ADP	NOUN	NOUN	.

Måste	en	familj	ha	just	den	uppbyggnaden	?
MV	EN	NN	HV	AB	PO	NN	I?
VERB	NUM	NOUN	VERB	ADV	PRON	NOUN	.

Всеки	има	право	на	живот	.
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PRON	VERB	NOUN	ADP	NOUN	.

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Is	this	the	future	of	chamber	music	?
VBZ	DT	DT	NN	IN	NN	NN	?
VERB	DET	DET	NOUN	ADP	NOUN	NOUN	.

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VERB	NUM	NOUN	VERB	ADV	PRON	NOUN	.

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Naseem et al., 2009; **Petrov et al., 2012**

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Is	this	the	future	of	chamber	music	?
VBZ	DT	DT	NN	IN	NN	NN	?
VERB	DET	DET	NOUN	ADP	NOUN	NOUN	.

Måste	en	familj	ha	just	den	uppbyggnaden	?
MV	EN	NN	HV	AB	PO	NN	I?
VERB	NUM	NOUN	VERB	ADV	PRON	NOUN	.

Всеки	има	право	на	живот	.
PC	VPI	NC	R	NC	PUNCT
PRON	VERB	NOUN	ADP	NOUN	.

Naseem et al., 2009; **Petrov et al., 2012**

Coarse "Universal" Tags

Is	this	the	future	of	chamber	music	?
VERB	DET	DET	NOUN	ADP	NOUN	NOUN	.

Måste	en	familj	ha	just	den	uppbyggnaden	?
VERB	NUM	NOUN	VERB	ADV	PRON	NOUN	.

Всеки	има	право	на	живот	.
PRON	VERB	NOUN	ADP	NOUN	.

Cross-lingual tagging (Das & Petrov, 2011)

Cross-lingual parsing (Zeman & Resnick, 2008; ...)

Constraints

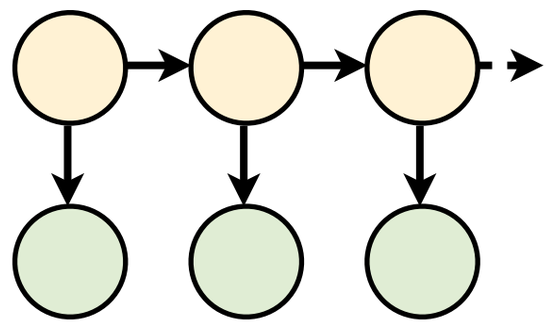
1. Token constraints
2. Type constraints
3. Coupled token and type constraints

Models

Models

1. Log-linear ("feature-based") HMM

(Berg-Kirkpatrick et al., 2010; ...)



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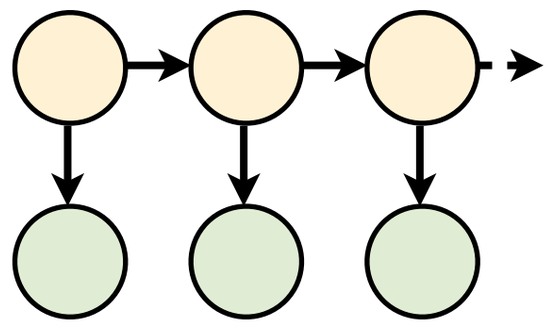
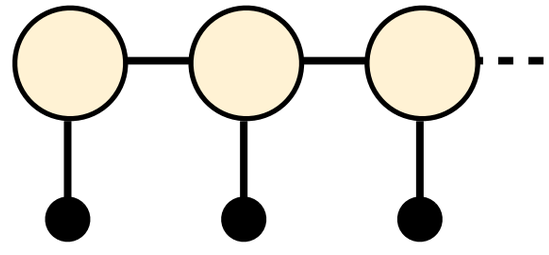


2. Latent variable CRF



Complete Token Supervision

Produkterna	**måste**	**vara**	**helt**	**rena**
(The products)	(must)	(be)	(completely)	(pure)
NOUN	VERB	VERB	ADV	ADJ

En	**dyrbar**	**vara**
(An)	(expensive)	(commodity)
DET	ADJ	NOUN

...

Full disambiguation *in context*

Complete Token Supervision

Produkterna (The products) NOUN	**måste** (must) VERB	**vara** (be) VERB	**helt** (completely) ADV	**rena** (pure) ADJ

En (An) DET	**dyrbar** (expensive) ADJ	**vara** (commodity) NOUN

...

Full disambiguation *in context*

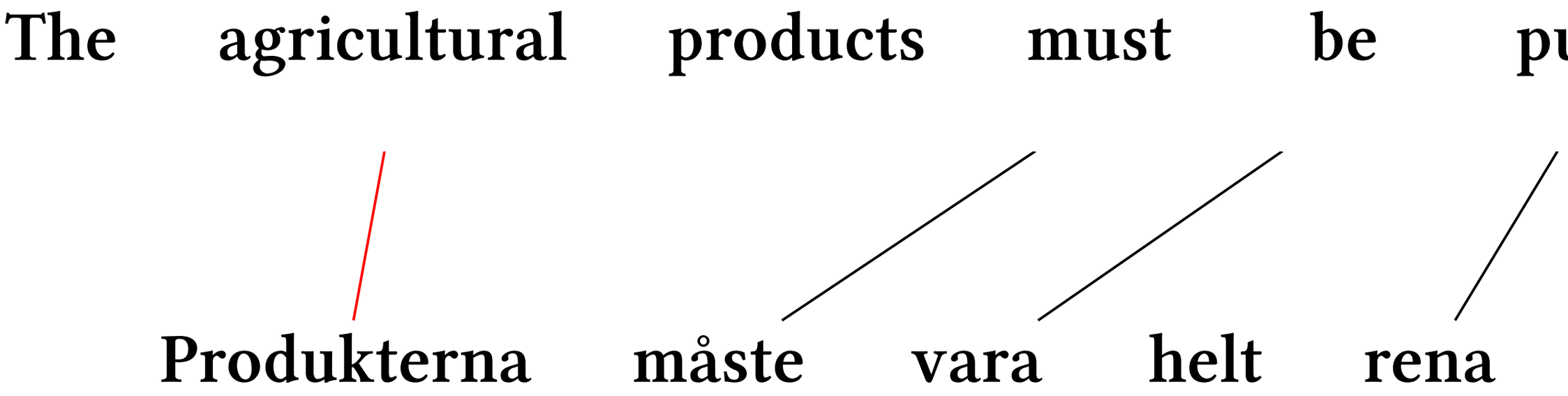
Projected Token Constraints

The agricultural products must be pure

Produkterna måste vara helt rena

Yarowsky & Ngai, 2001; ...

Projected Token Constraints



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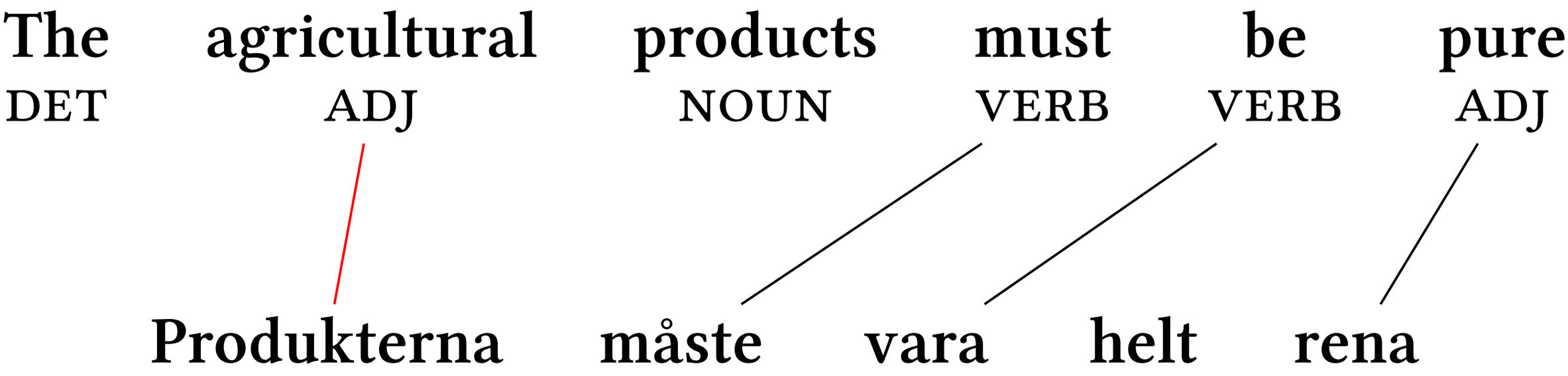
Projected Token Constraints



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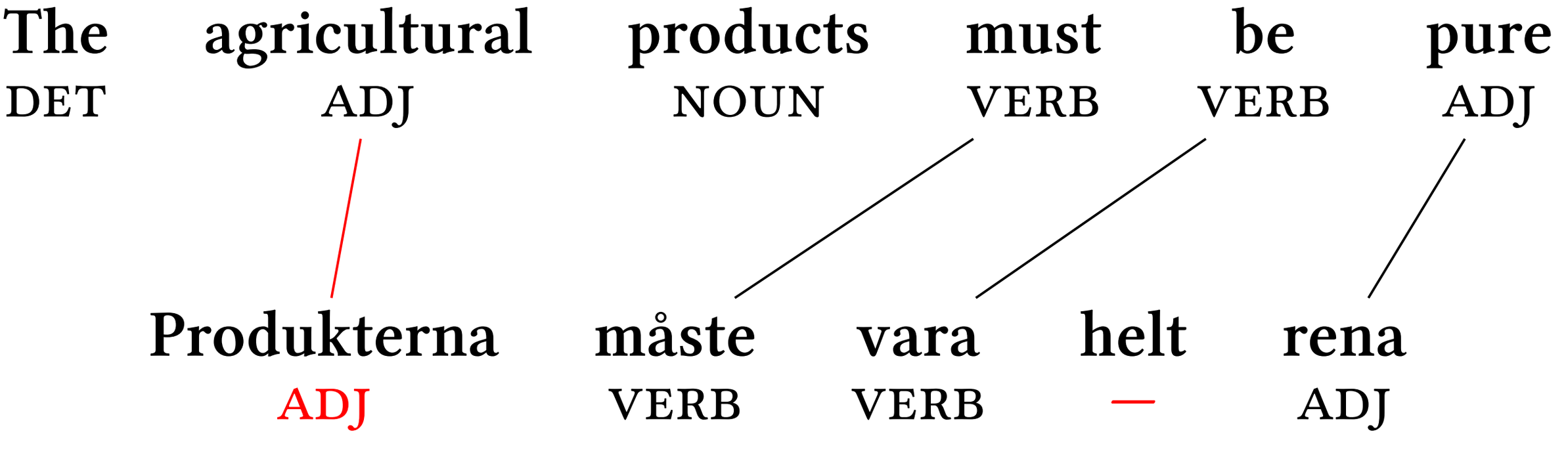

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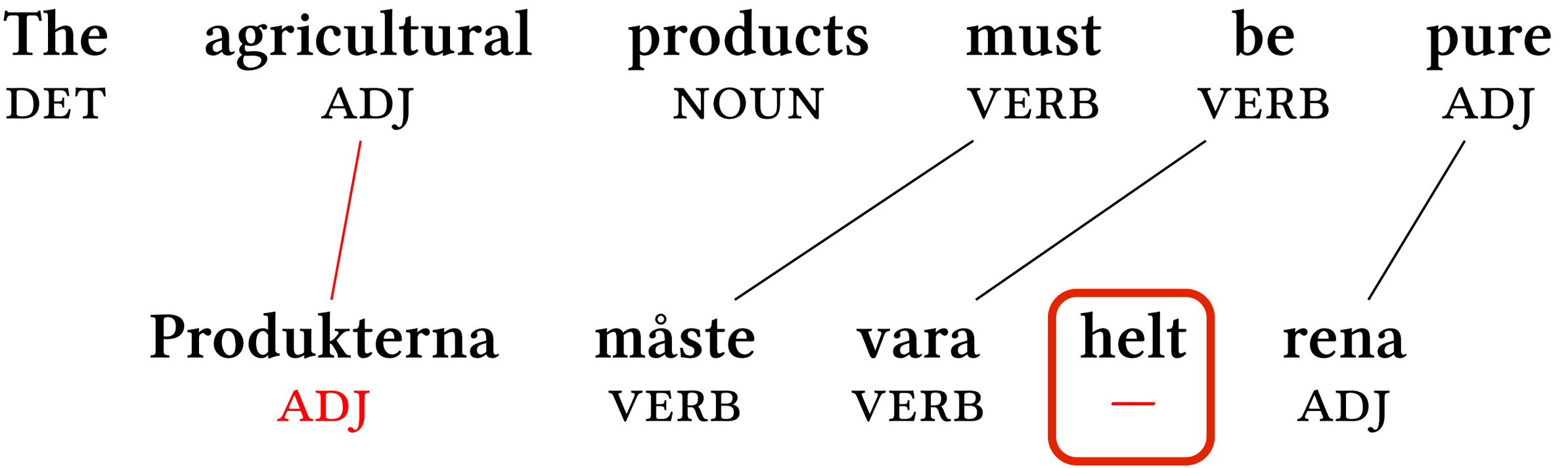

Incomplete

Yarowsky & Ngai, 2001; ...

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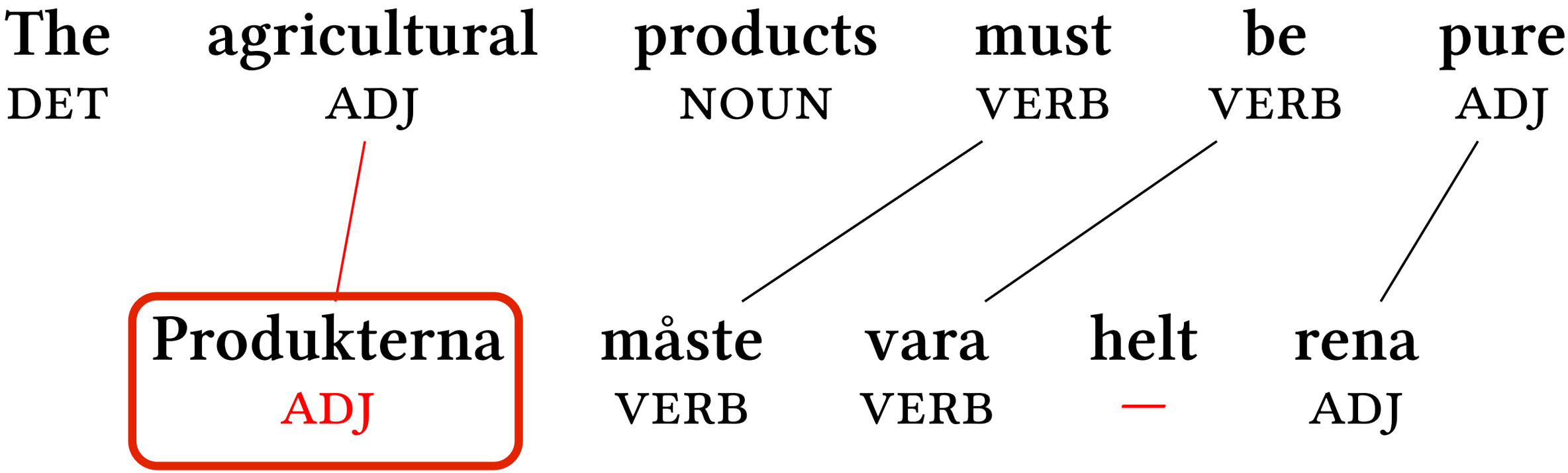
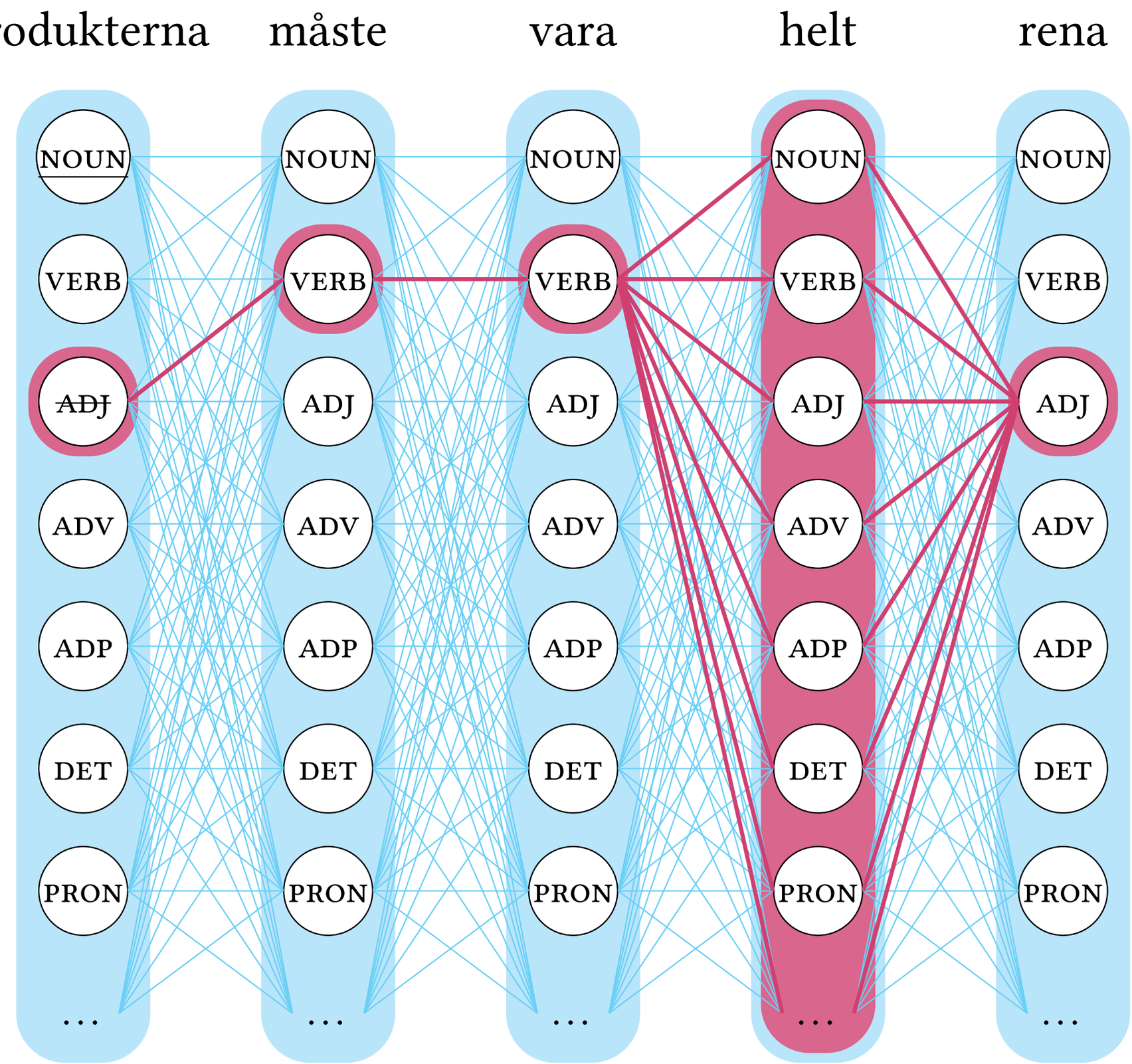


Incomplete

Noisy (systematic)

Yarowsky & Ngai, 2001; ...

Projected Token Constraints



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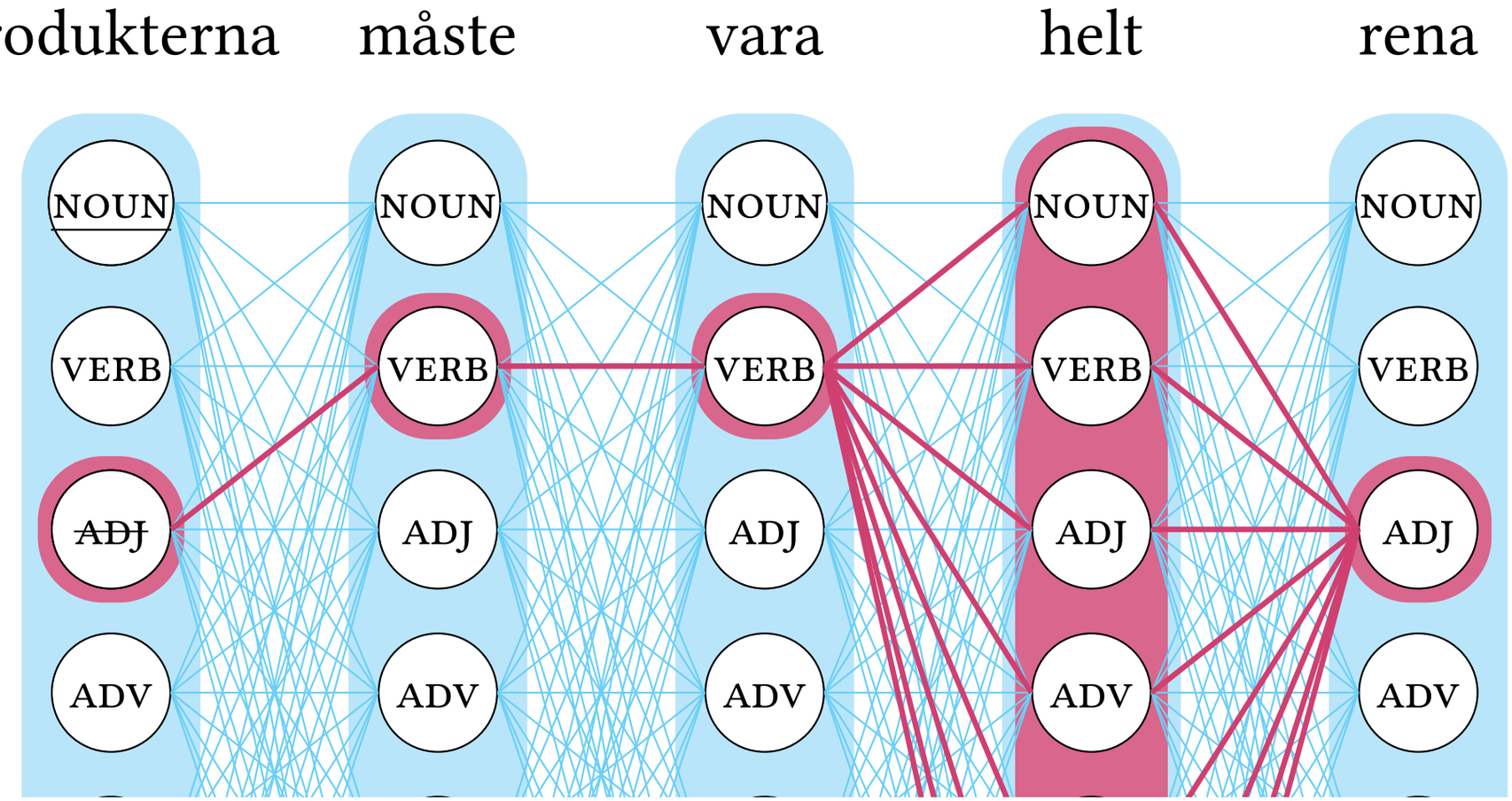
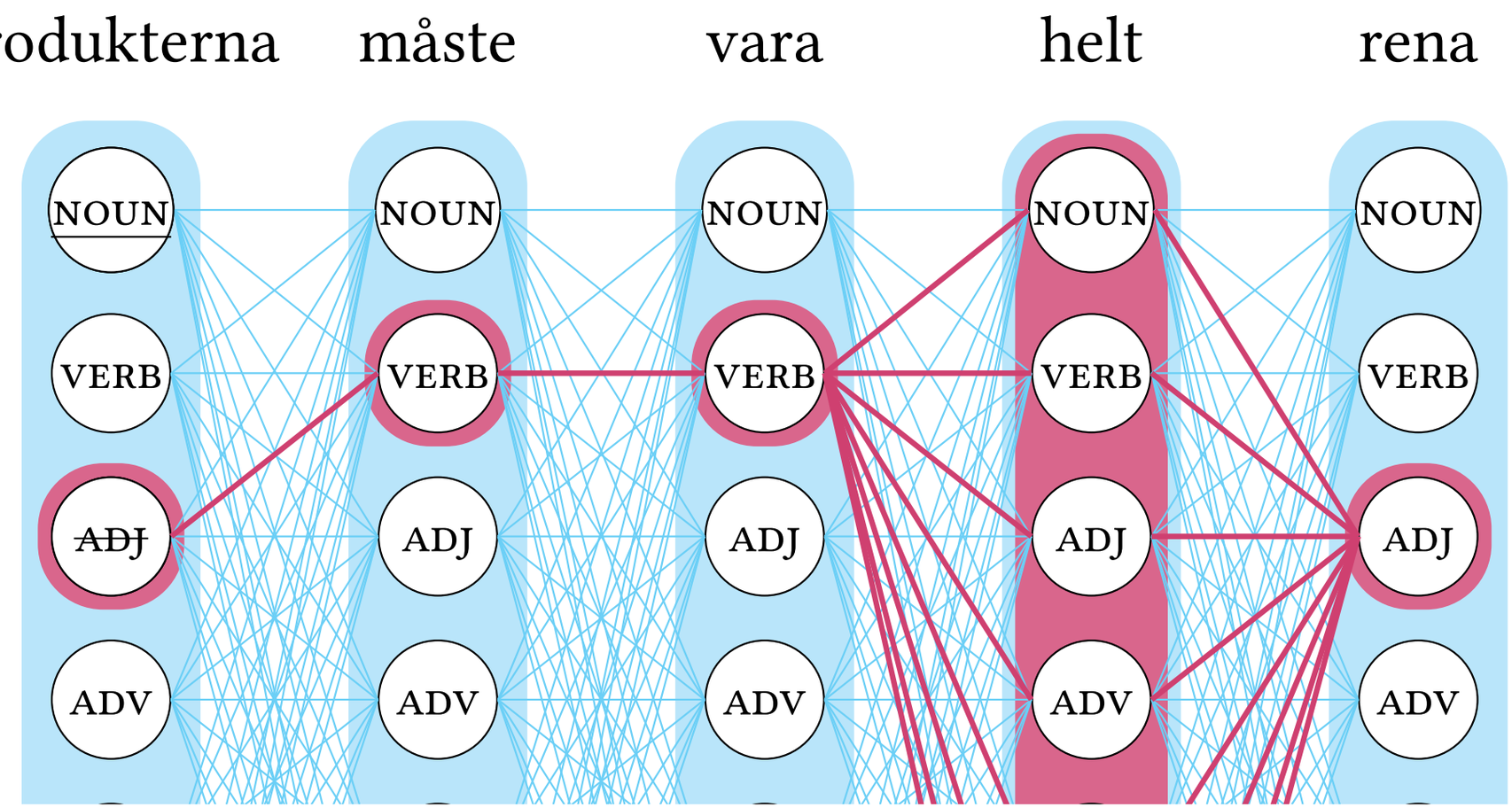


Marginal conditional likelihood

$$p_\theta(\tilde{\mathbf{y}} \mid x) = \frac{\sum_{y \in \tilde{\mathbf{y}}} \exp\left\{\theta^\top \Phi(x, y)\right\}}{\sum_{y' \in \mathcal{Y}(x)} \exp\left\{\theta^\top \Phi(x, y')\right\}}$$

Projected Token Constraints



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Type Constraints

…	…
var	ADV, CONJ, DET, NOUN, VERB
vara	NOUN (commodity), VERB (to be)
varade	VERB
…	…

(~1.4 tags / token)

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Cross-lingual projection (Das & Petrov, 2011)

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“2 hours of annotation” (Garrette et al., 2013)

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Cross-lingual projection (Das & Petrov, 2011)

Wiktionary (Li et al., 2012)

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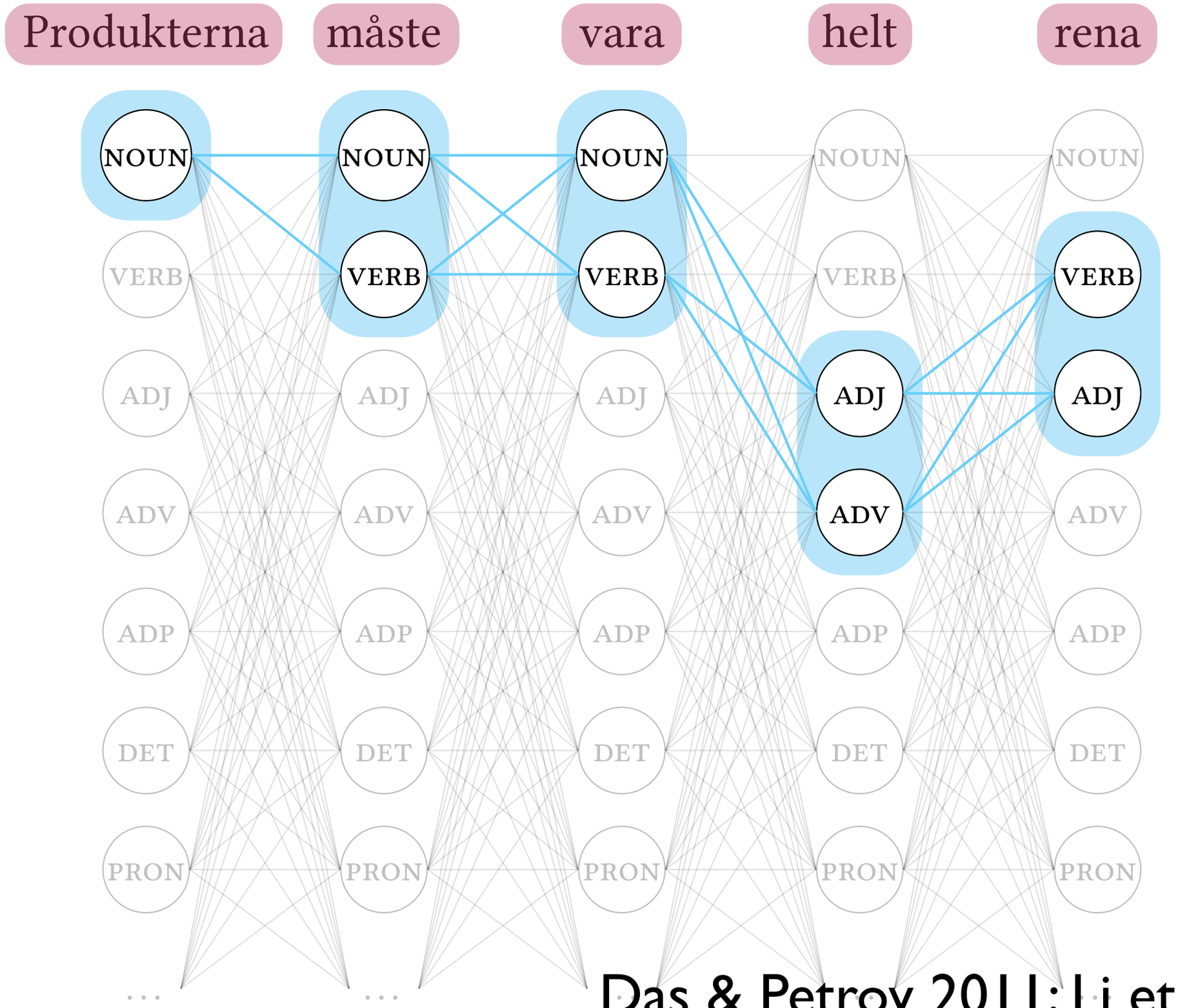
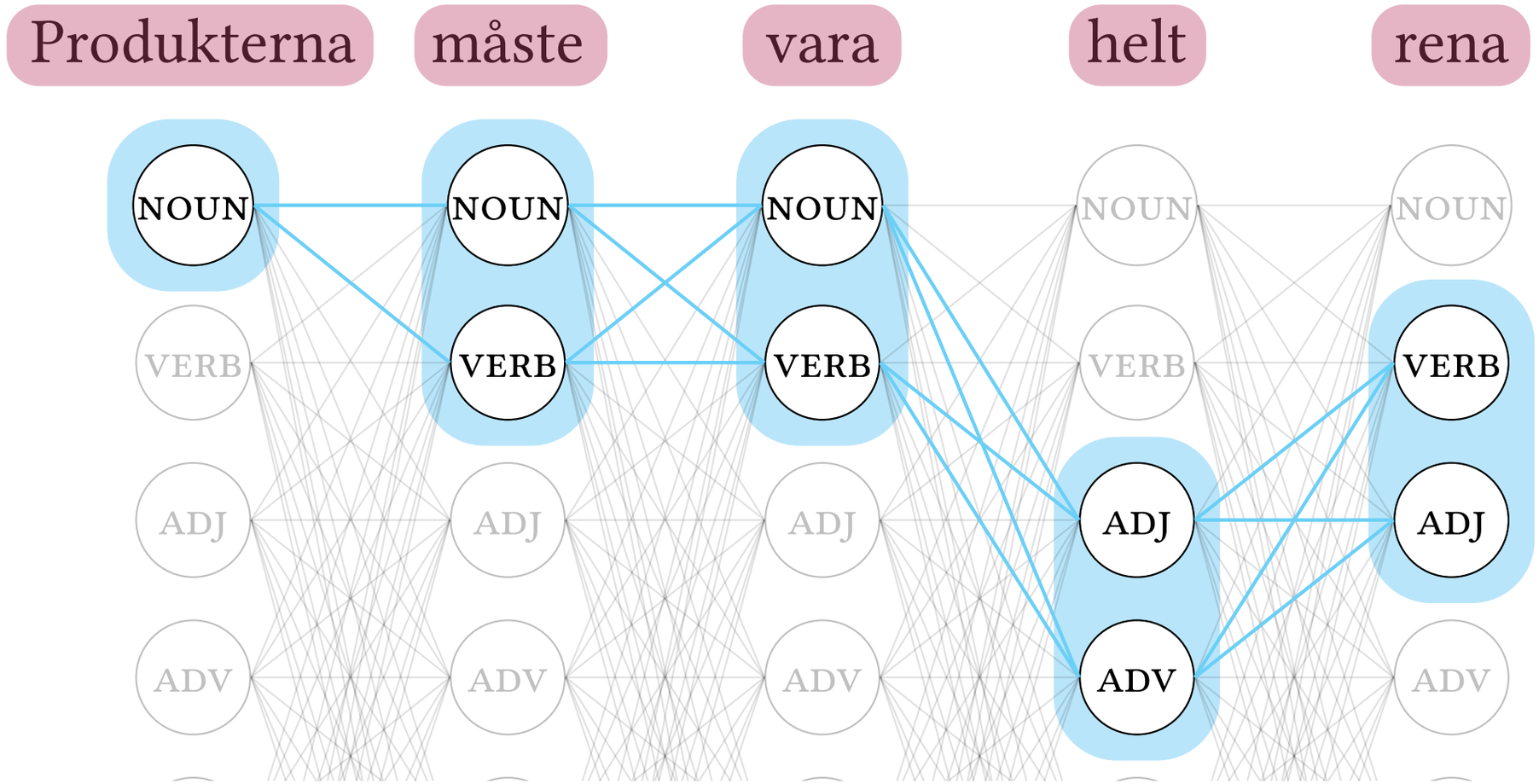
Only partial disambiguation

Type Constraints (HMM)



Das & Petrov 2011; Li et al., 2012

Type Constraints (HMM)



Marginal joint likelihood

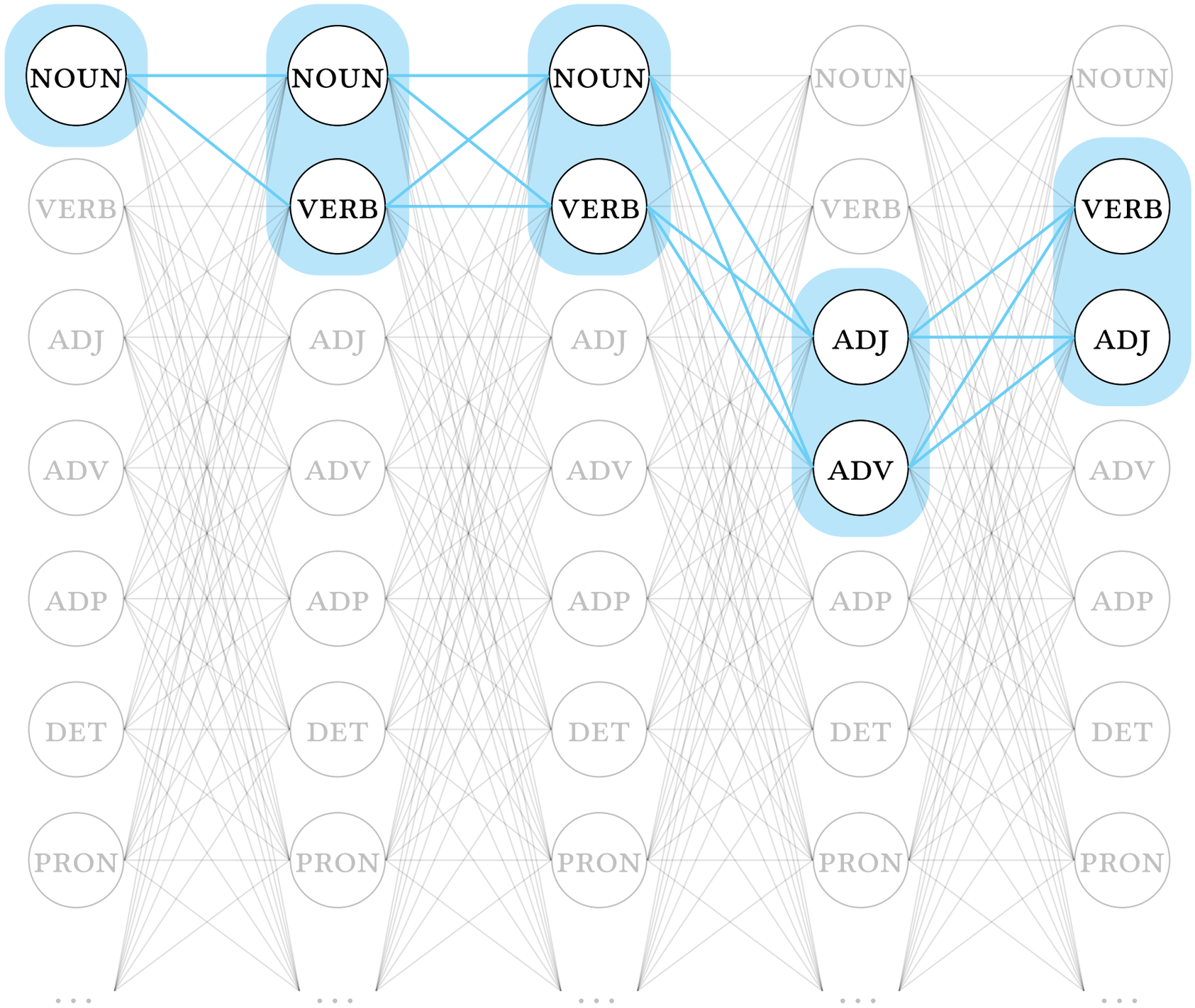
$$p_\beta(x) = \sum_{y \in \mathcal{Y}(x)} \prod_{i=1}^{|x|} \underbrace{p_\beta(x_i \mid y_i)}_{\text{emission}} \underbrace{p_\beta(y_i \mid y_{i-1})}_{\text{transition}}$$

Das & Petrov 2011, Li et al., 2012

Token and Type Constraints

Produkterna måste vara helt rena

1.
2.
3.



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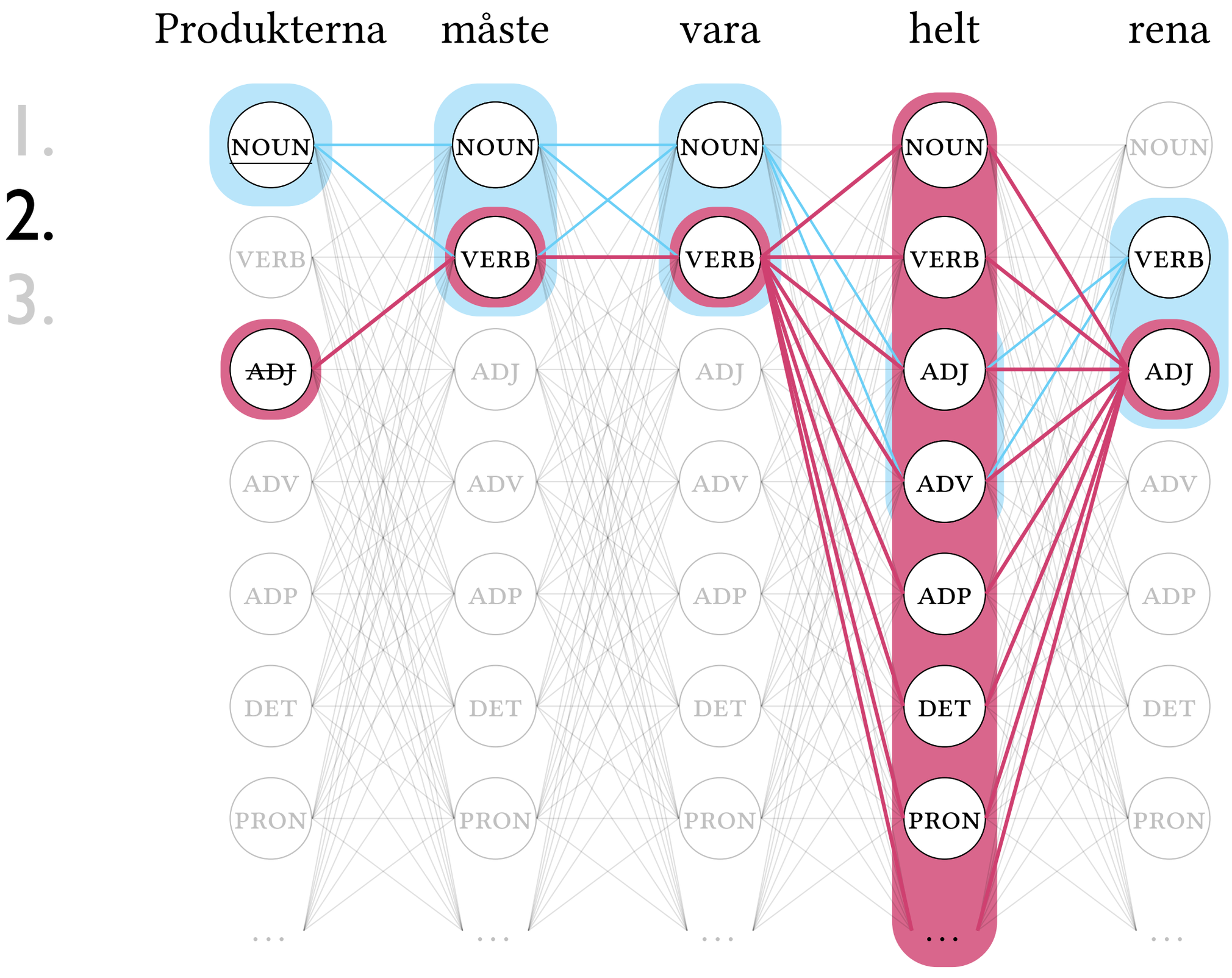

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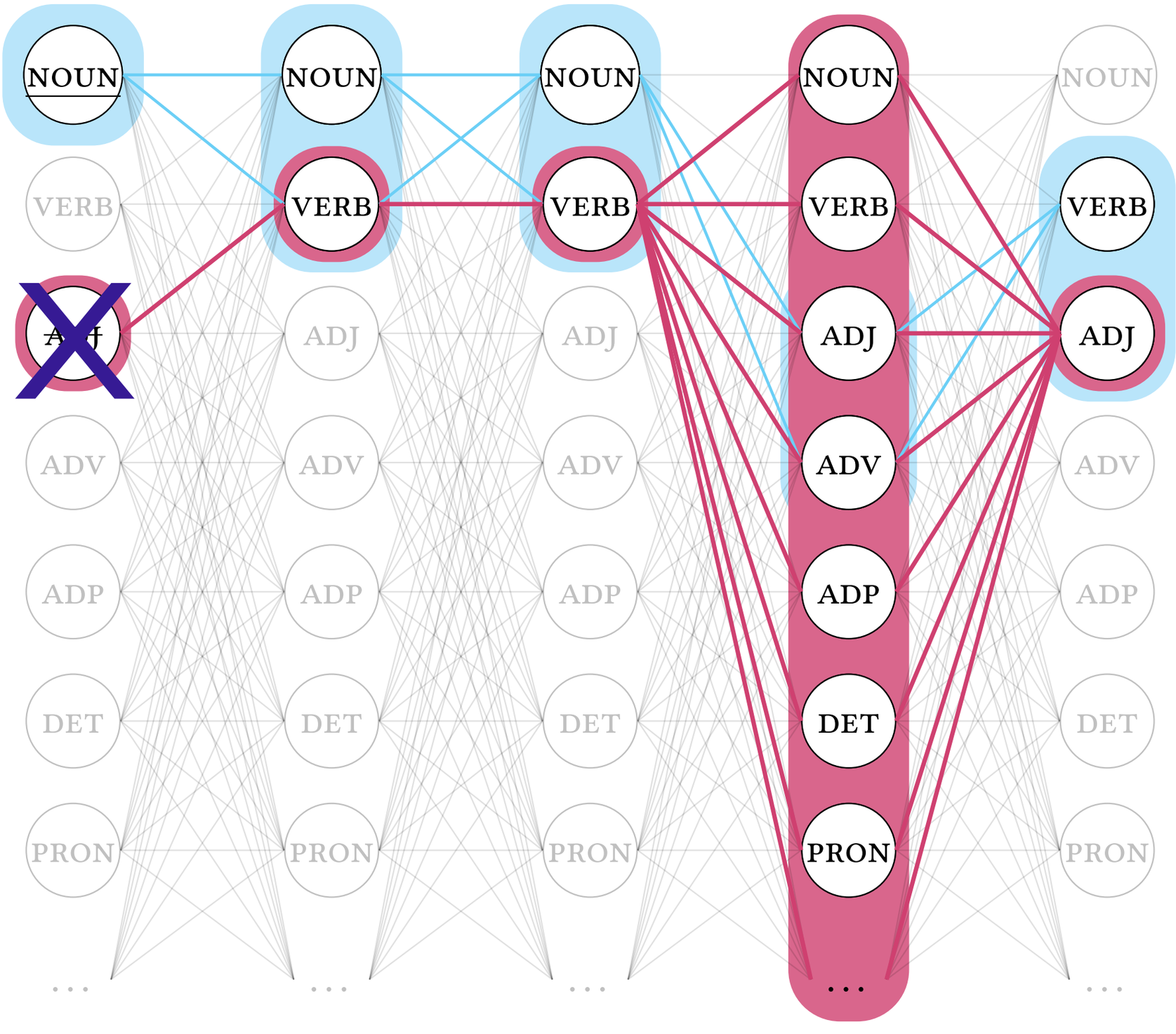

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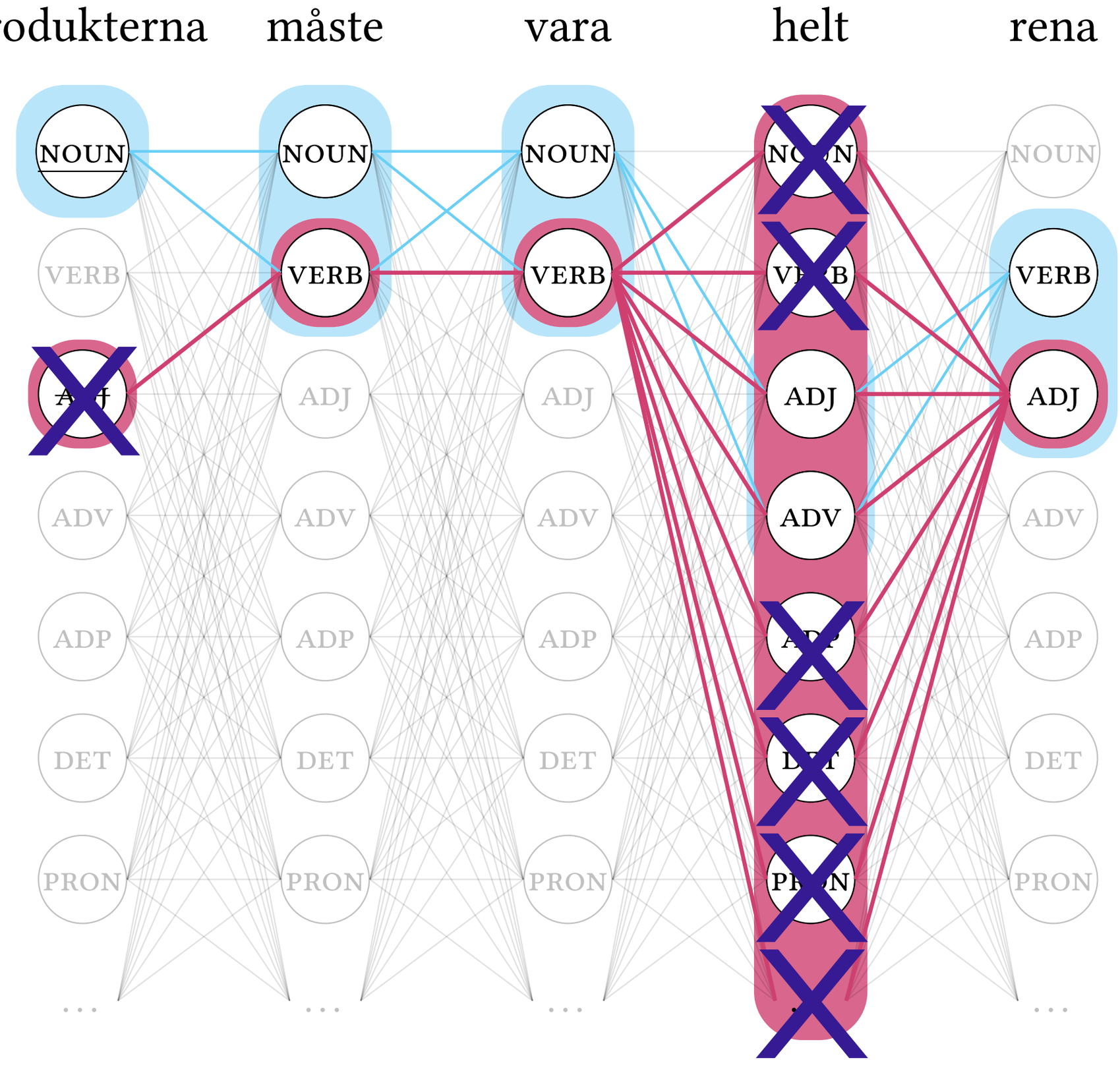

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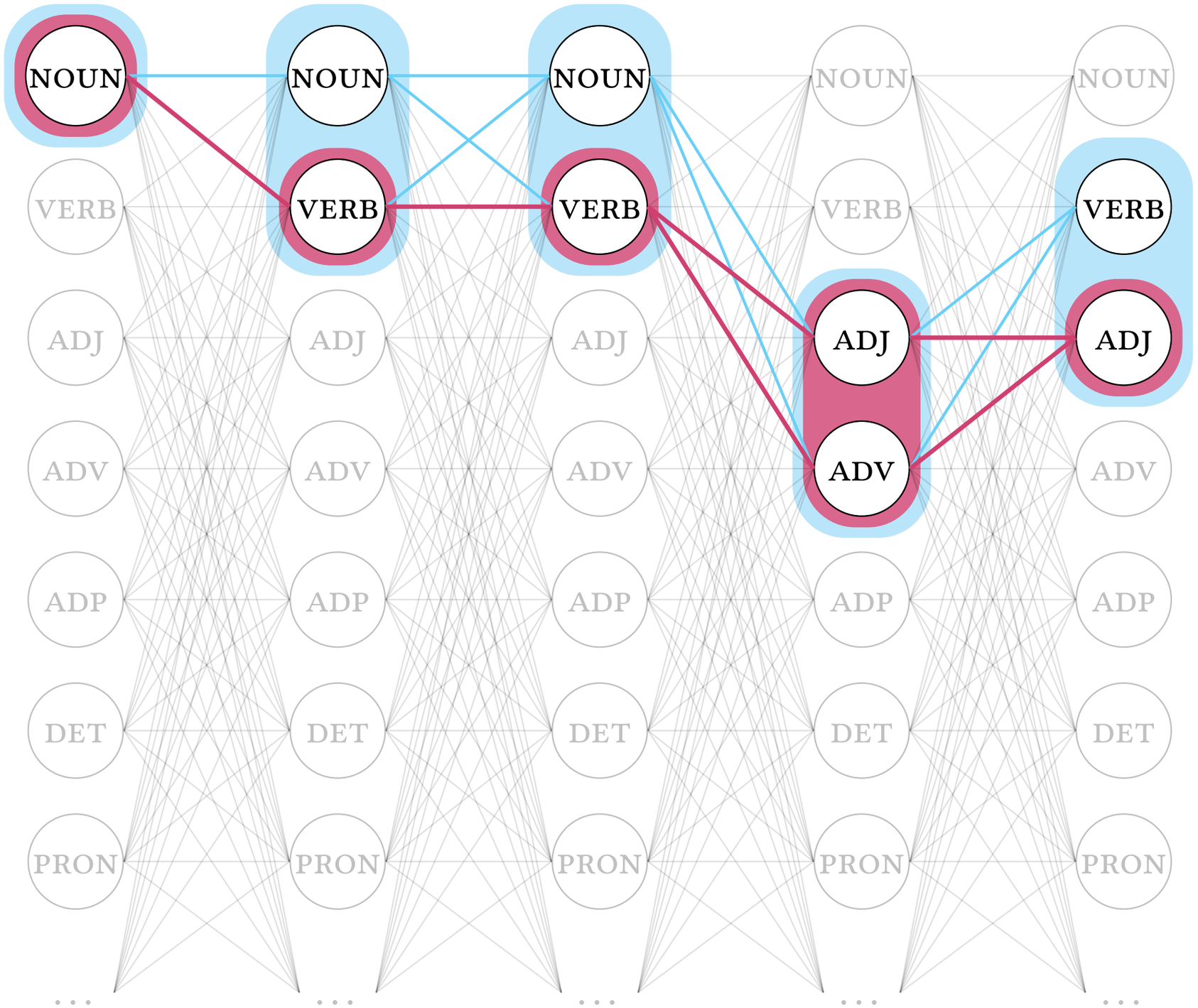

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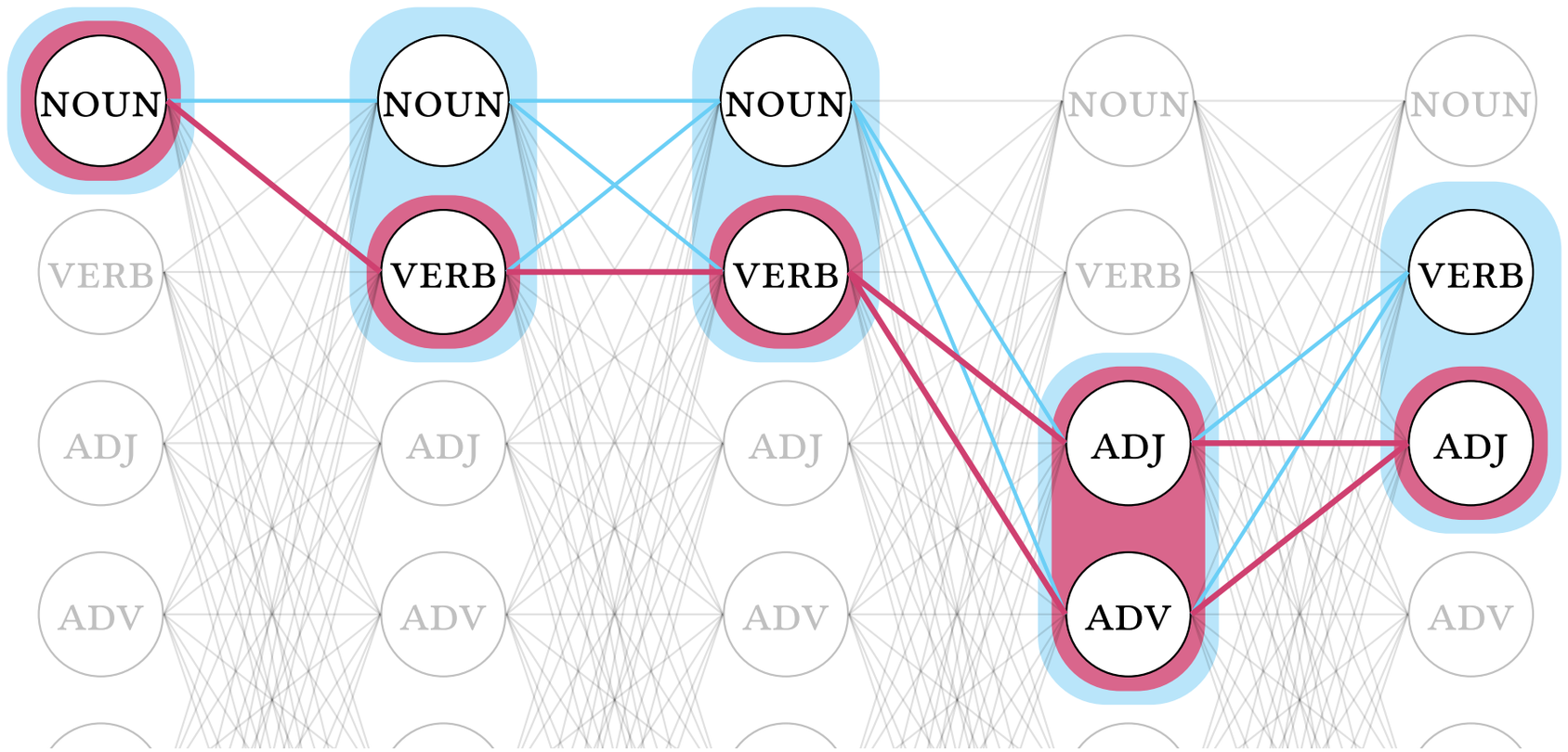


Marginal conditional likelihood

$$p_\theta(\widehat{\mathcal{Y}}(x, \tilde{\mathbf{y}}) \mid x) = \frac{\sum_{y \in \widehat{\mathcal{Y}}(x,\tilde{\mathbf{y}})} \exp\left\{\theta^\top \Phi(x, y)\right\}}{\sum_{y' \in \mathcal{Y}(x)} \exp\left\{\theta^\top \Phi(x, y')\right\}}$$

Token and Type Results

Type
(Wik)

Type
(Proj)

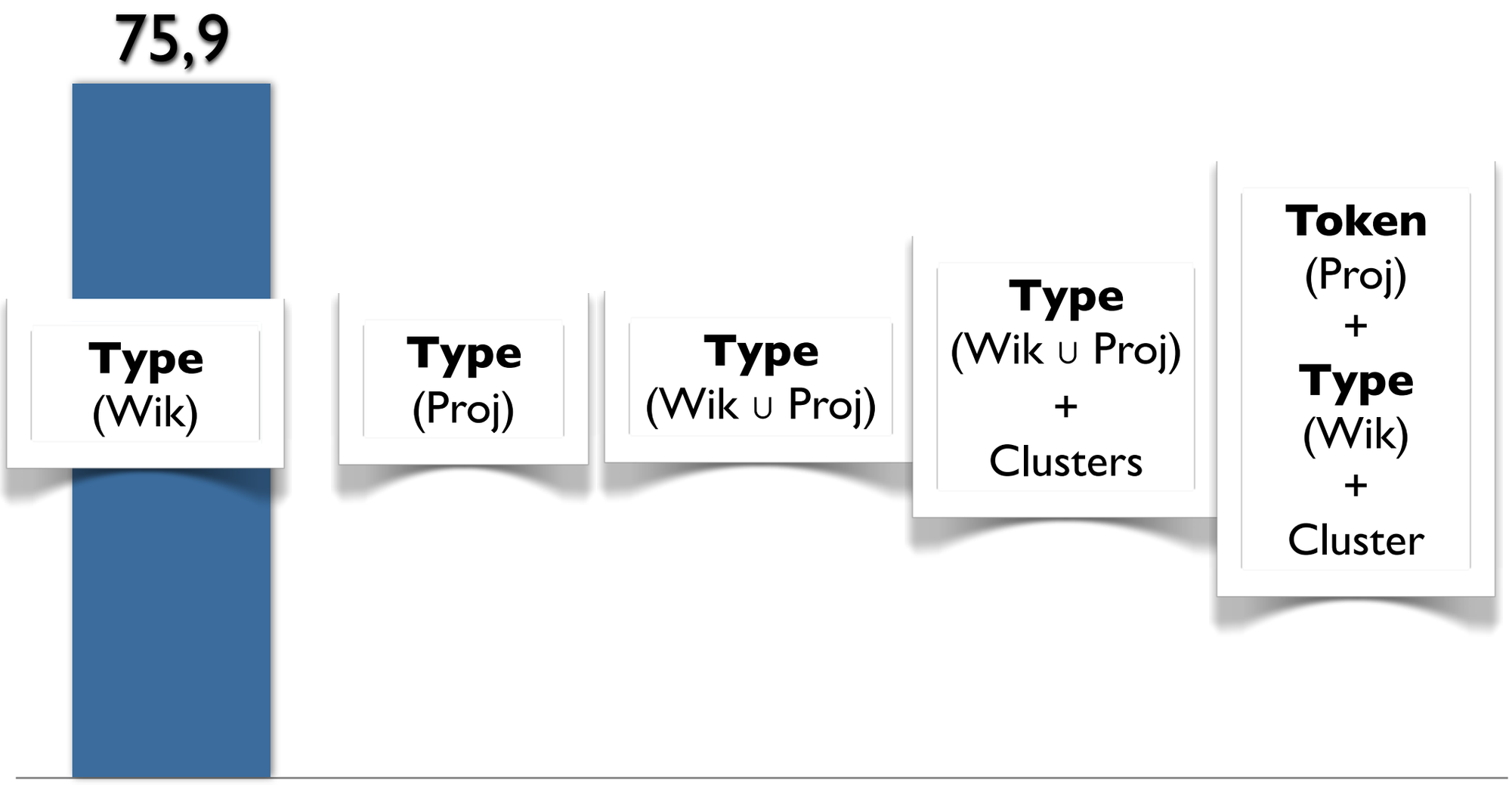
Type
(Wik ∪ Proj)

Type
(Wik ∪ Proj)
+
Clusters

Token
(Proj)
+
Type
(Wik)
+
Cluster

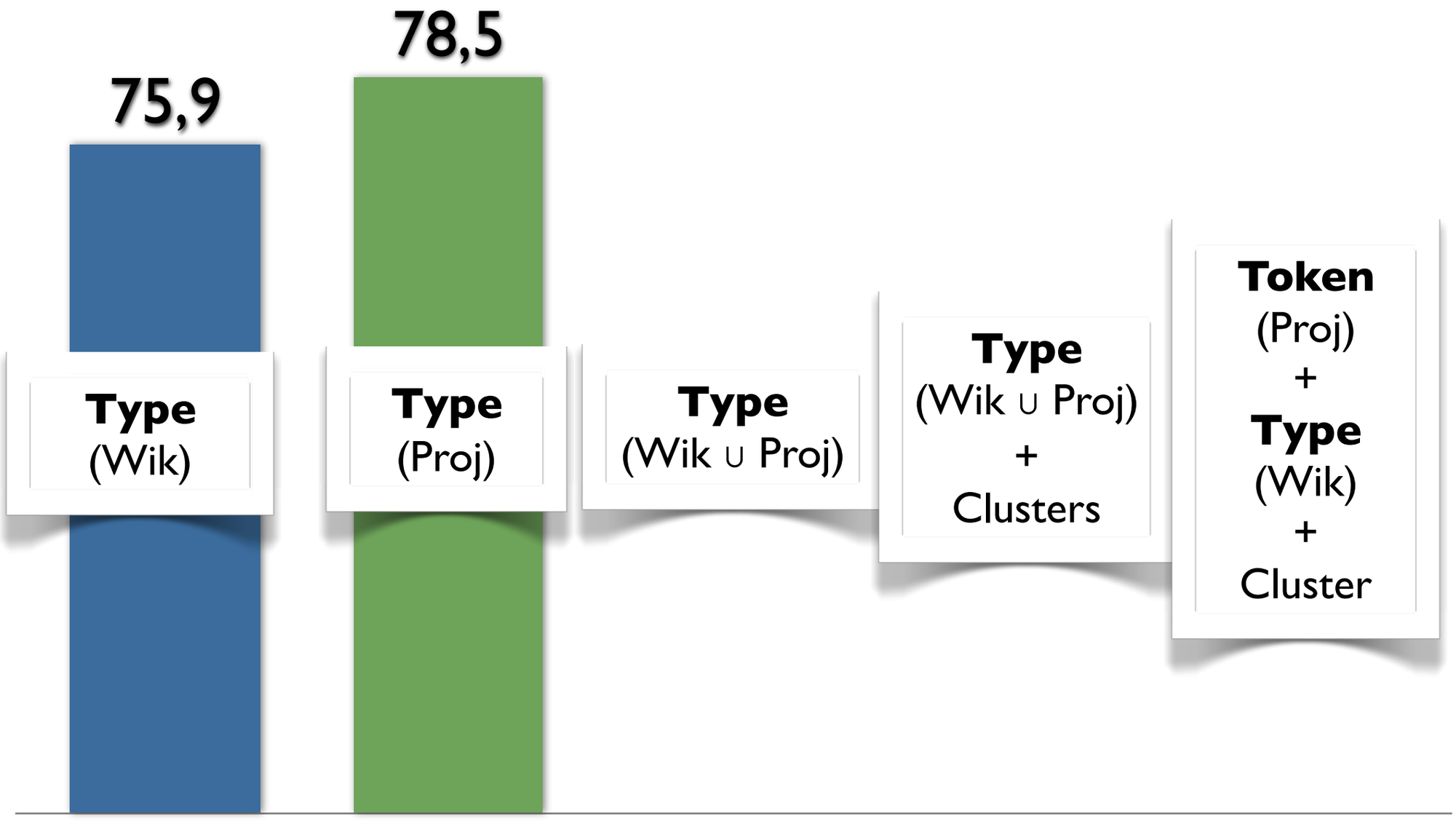
Average across 15 languages

Token and Type Results



Average across 15 languages

Token and Type Results



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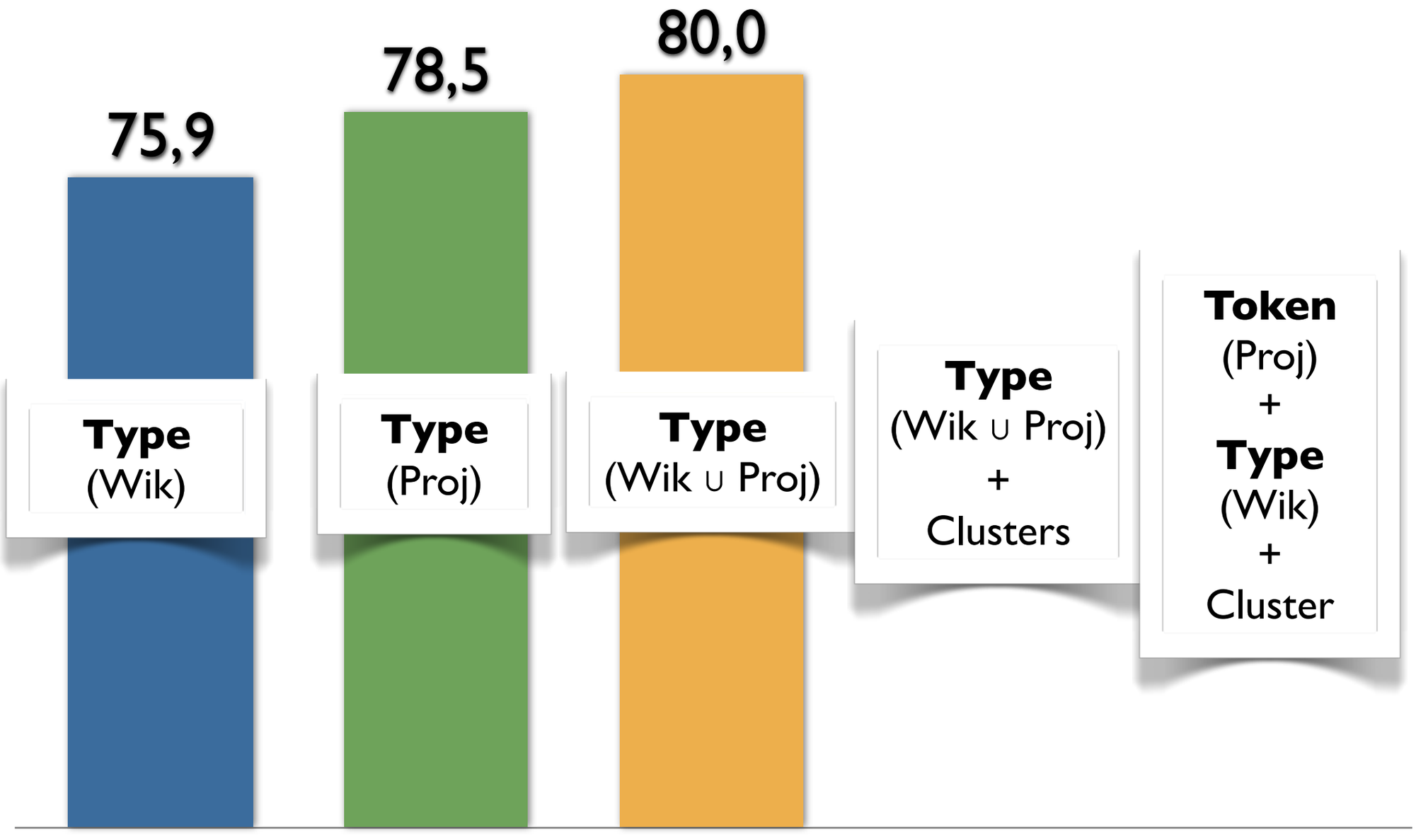
Token and Type Results



Average across 15 languages

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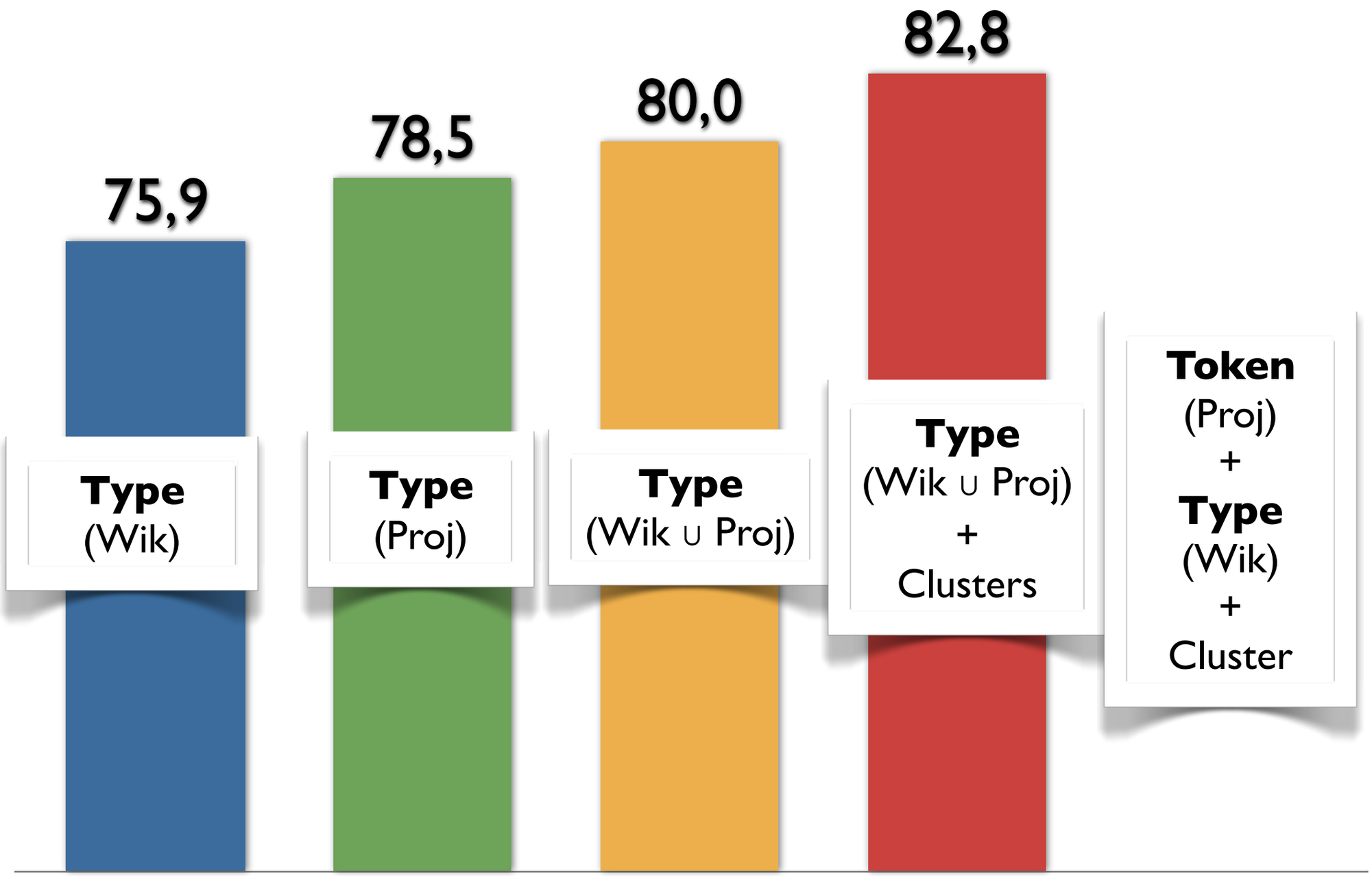

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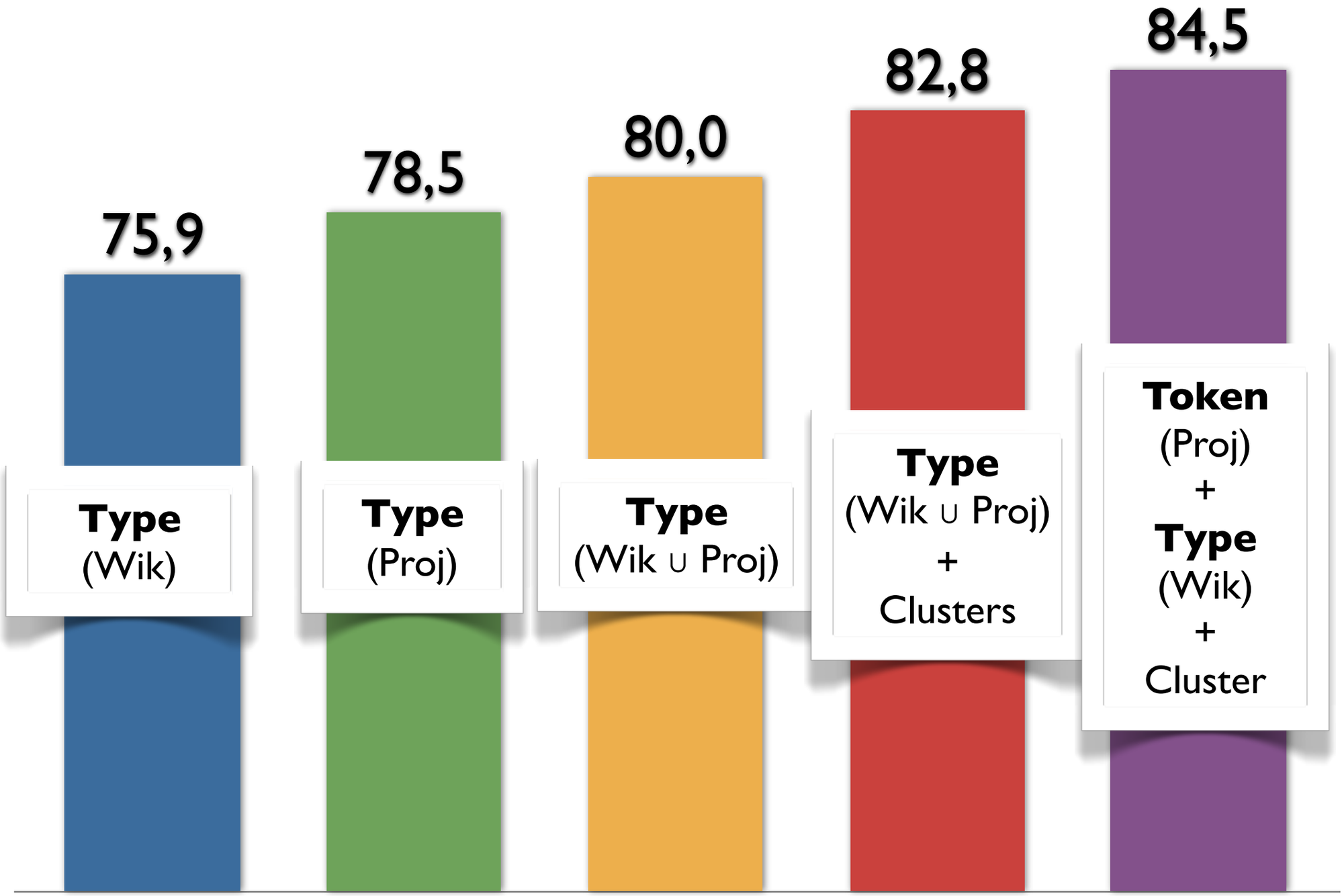


Average across 15 languages

Comparing with the State of the Art

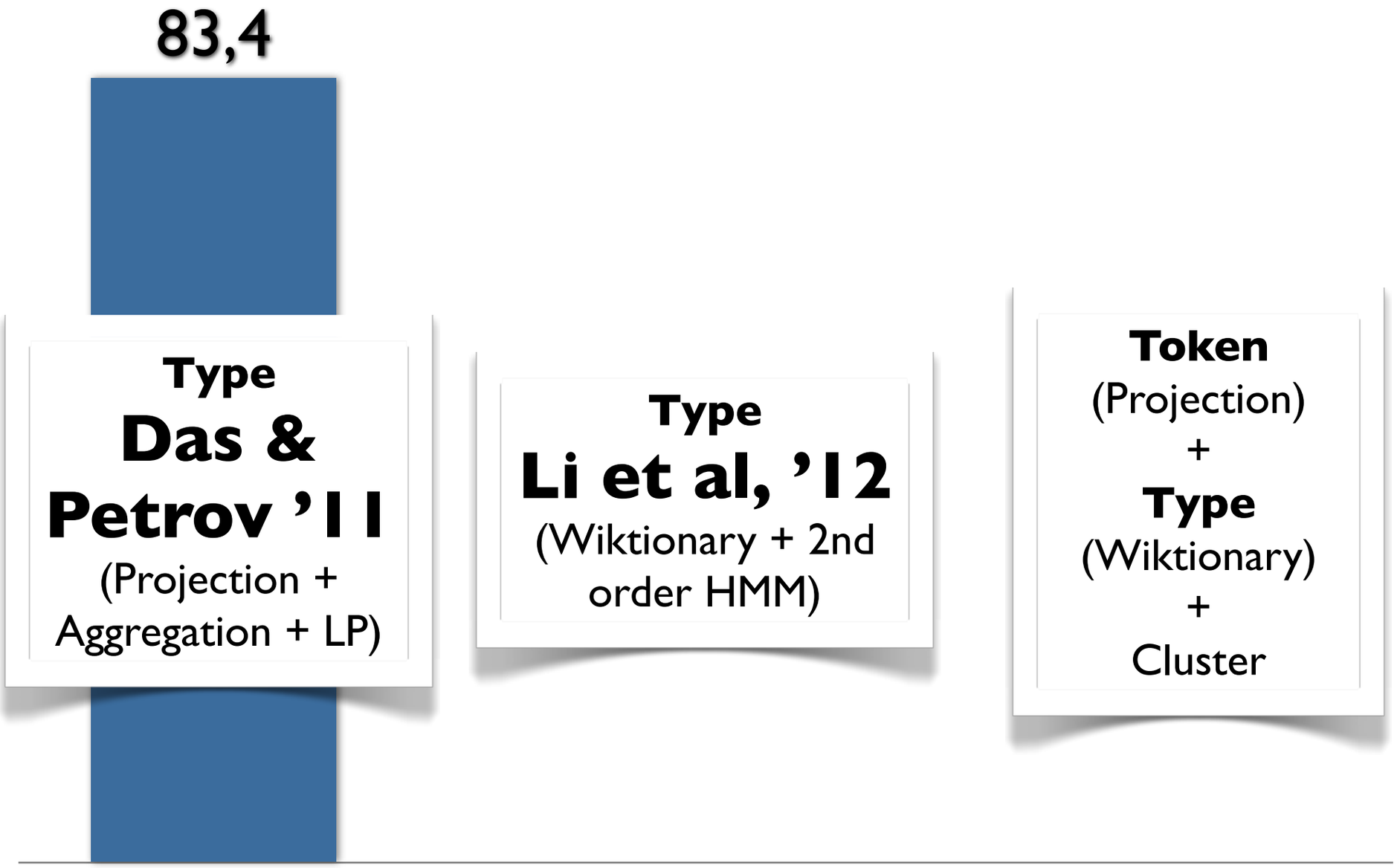
Type
Das & Petrov '11
(Projection + Aggregation + LP)

Type
Li et al, '12
(Wiktionary + 2nd order HMM)

Token
(Projection)
+
Type
(Wiktionary)
+
Cluster

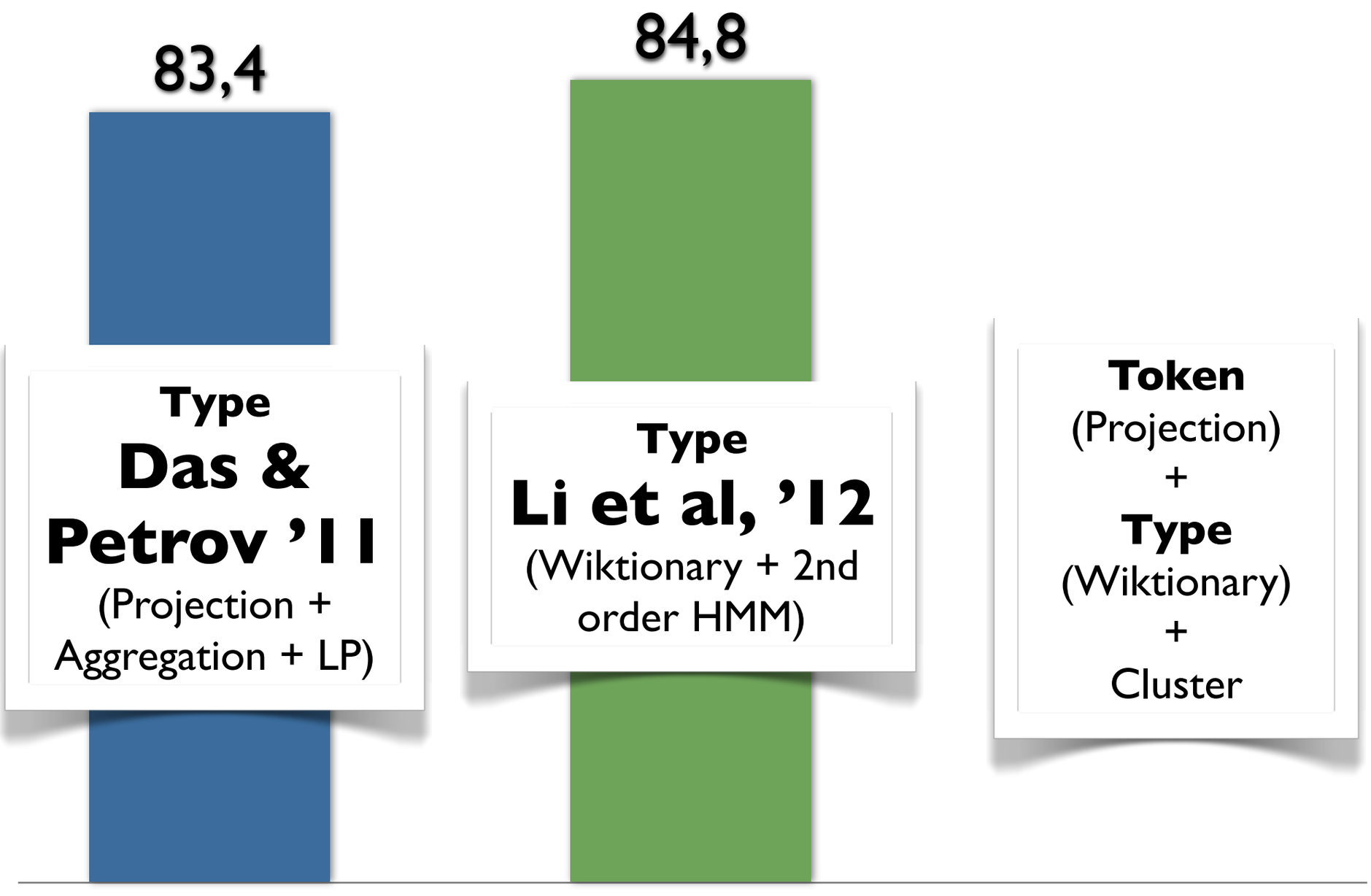
Average across 8 languages

Comparing with the State of the Art



Average across 8 languages

Comparing with the State of the Art



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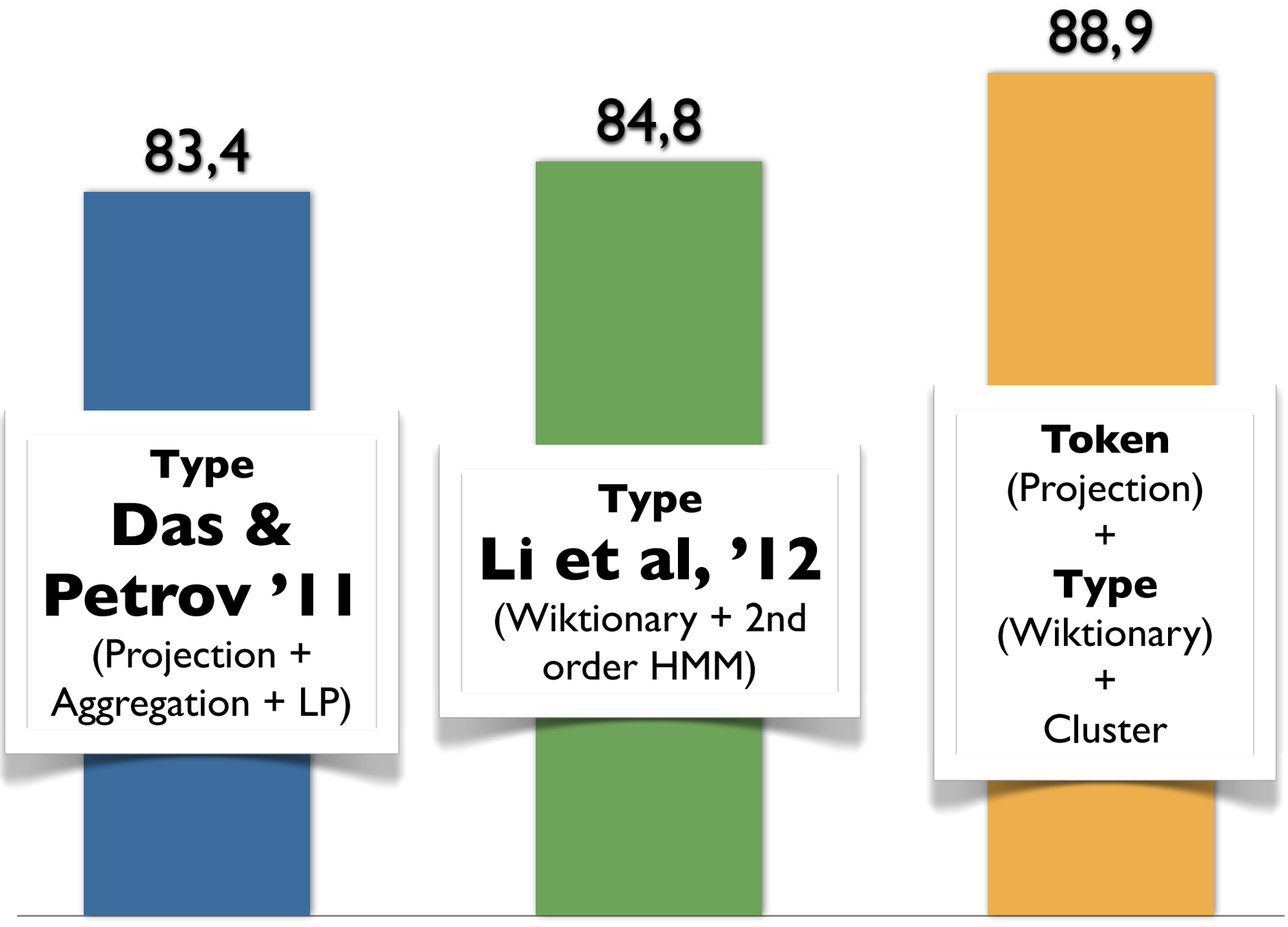
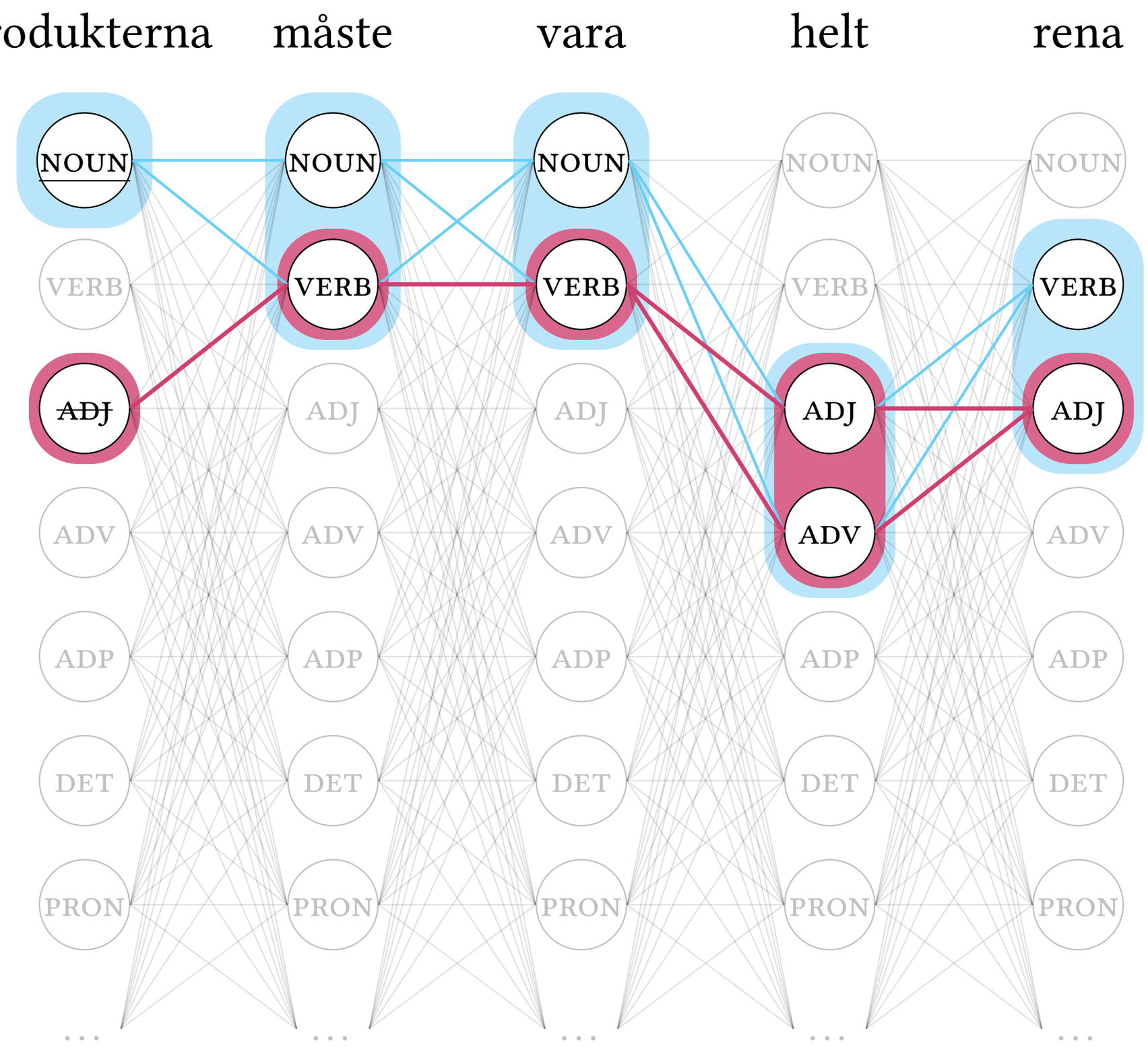


Average across 8 languages

Projection Errors



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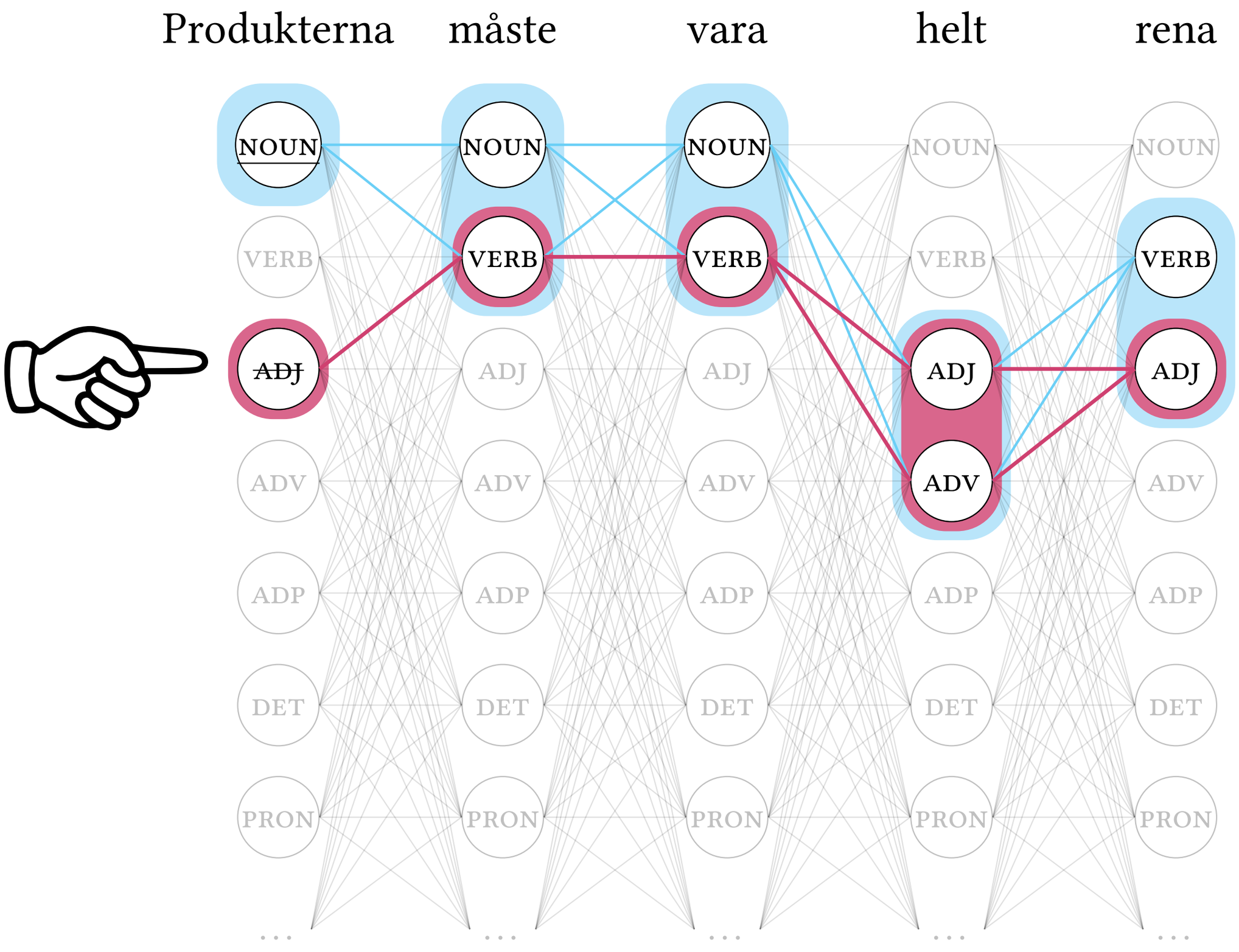

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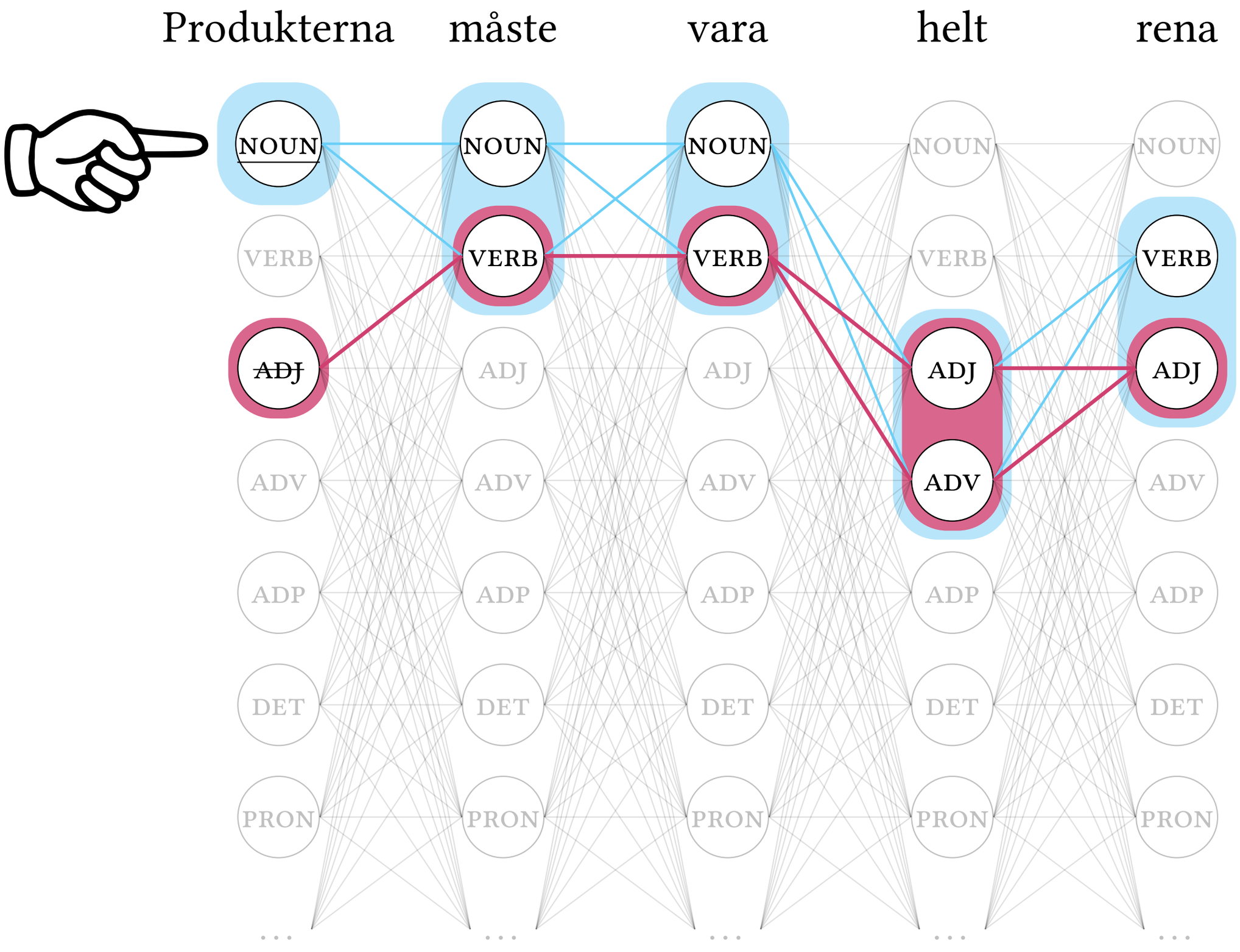
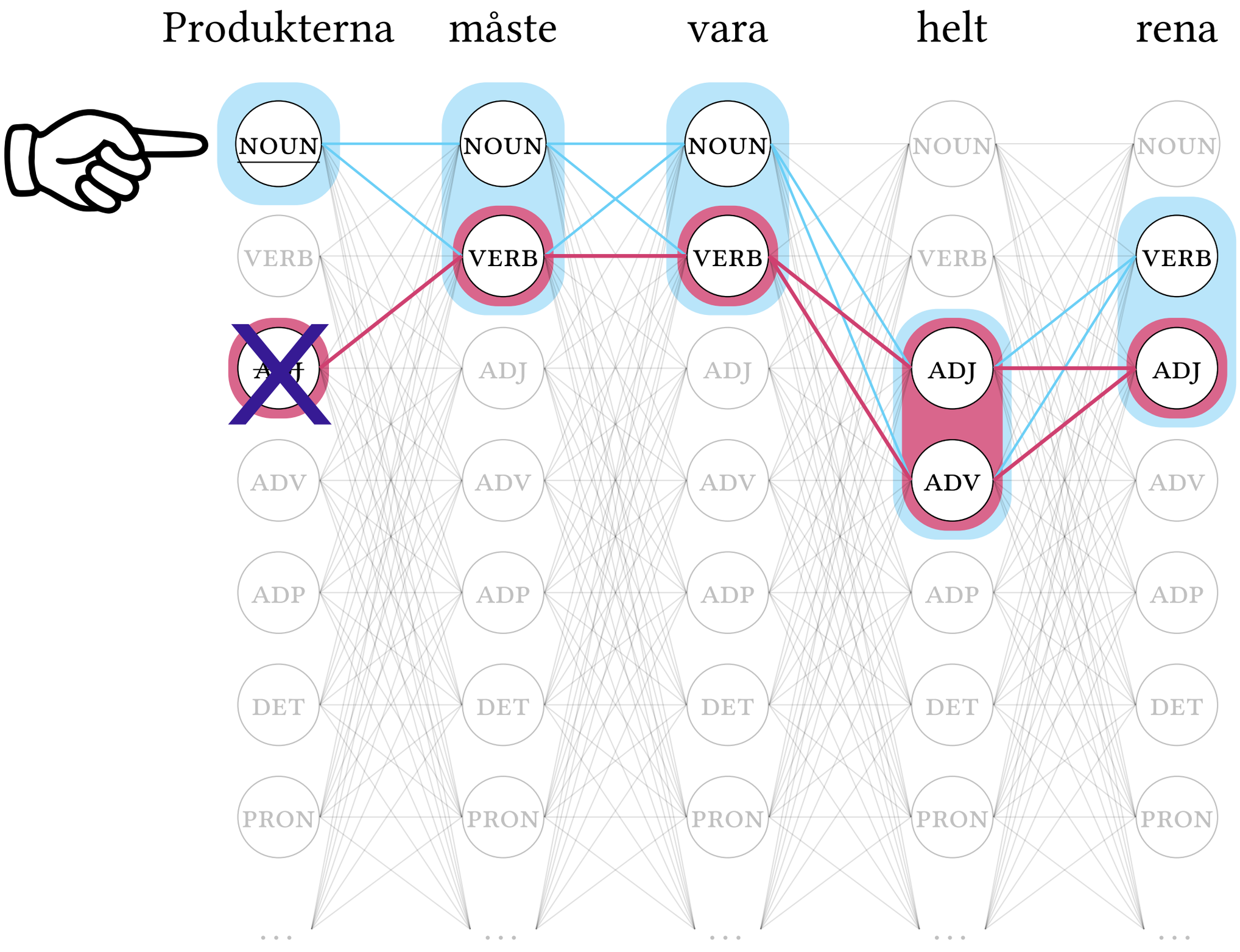


Projection Errors



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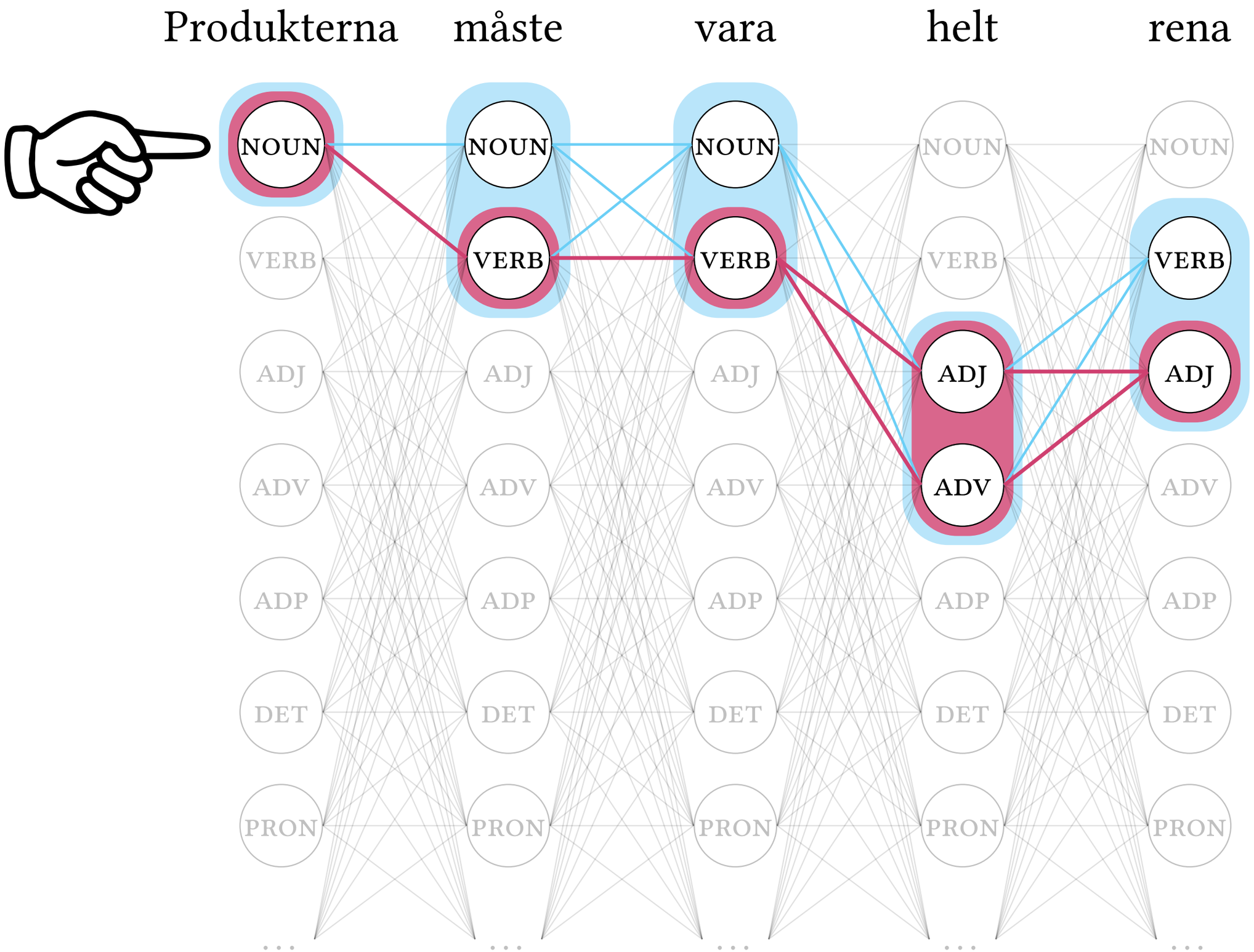

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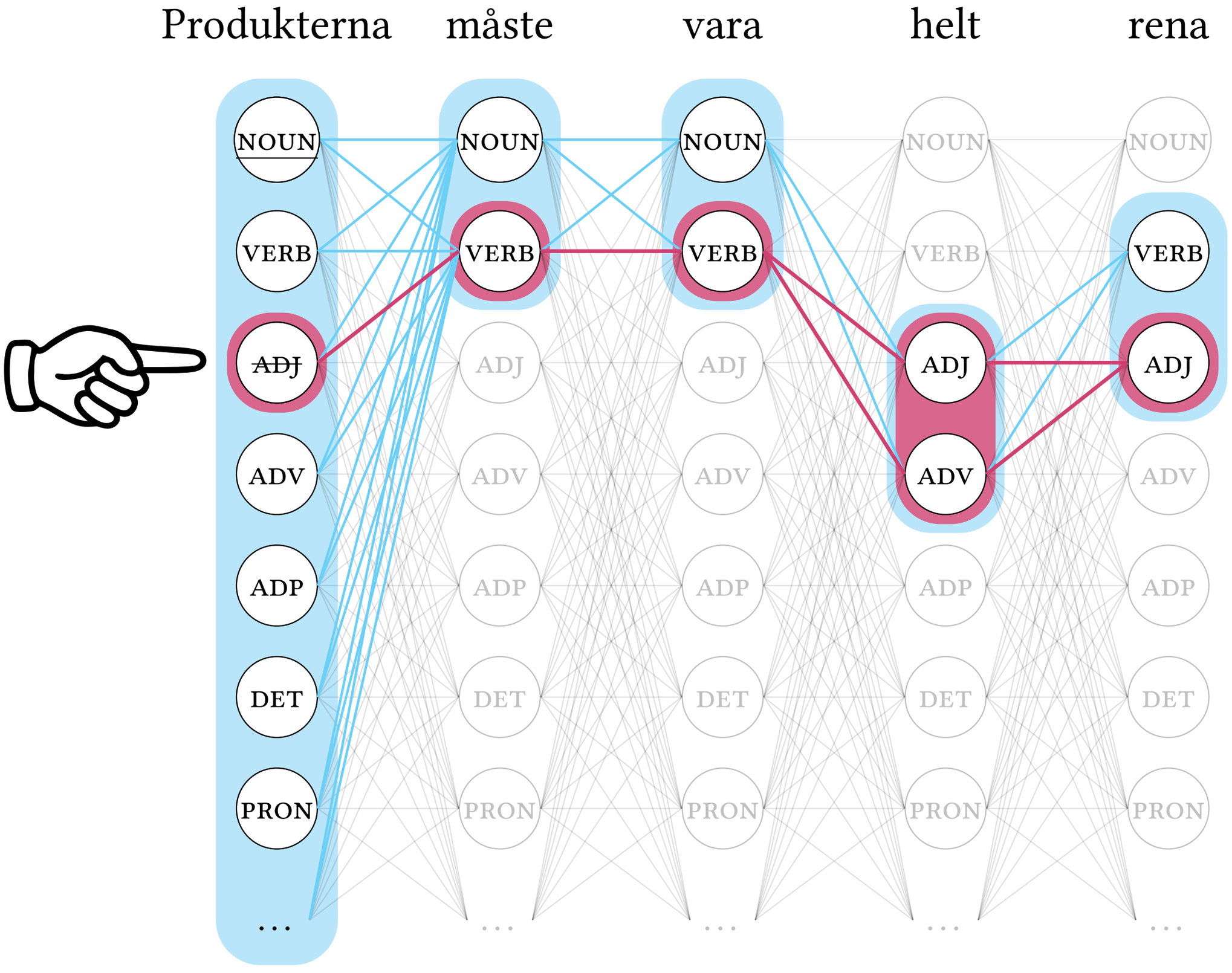

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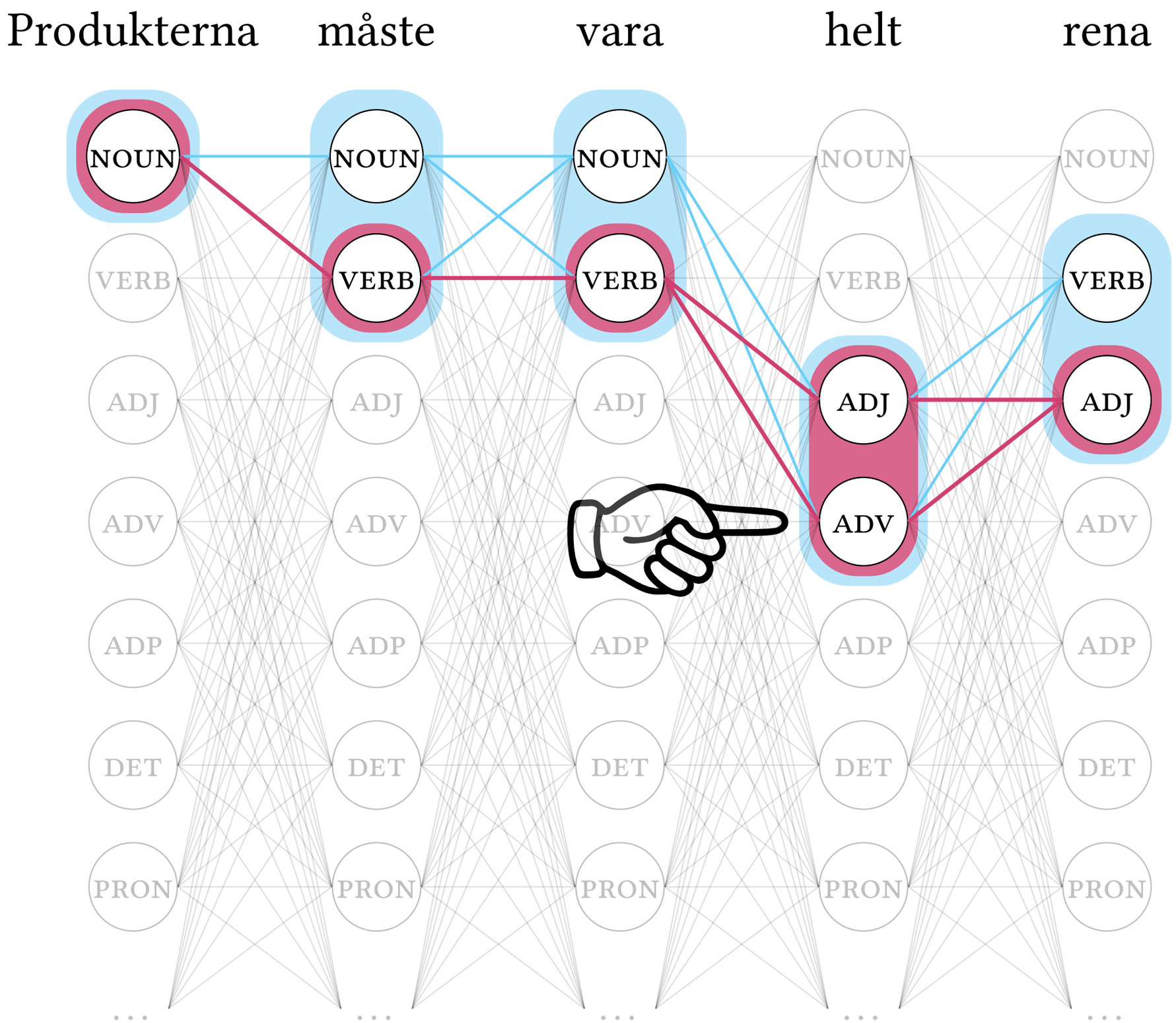

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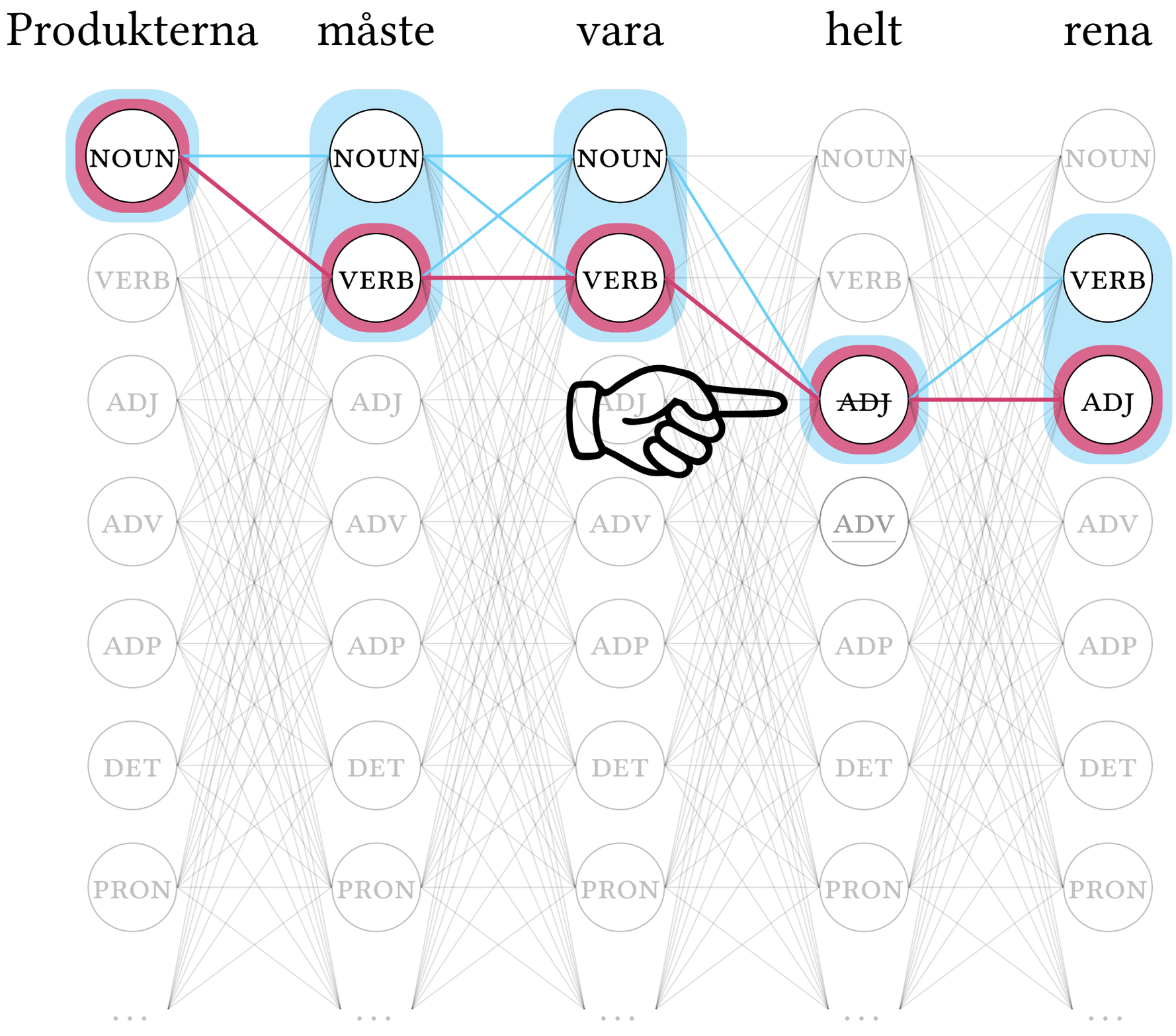

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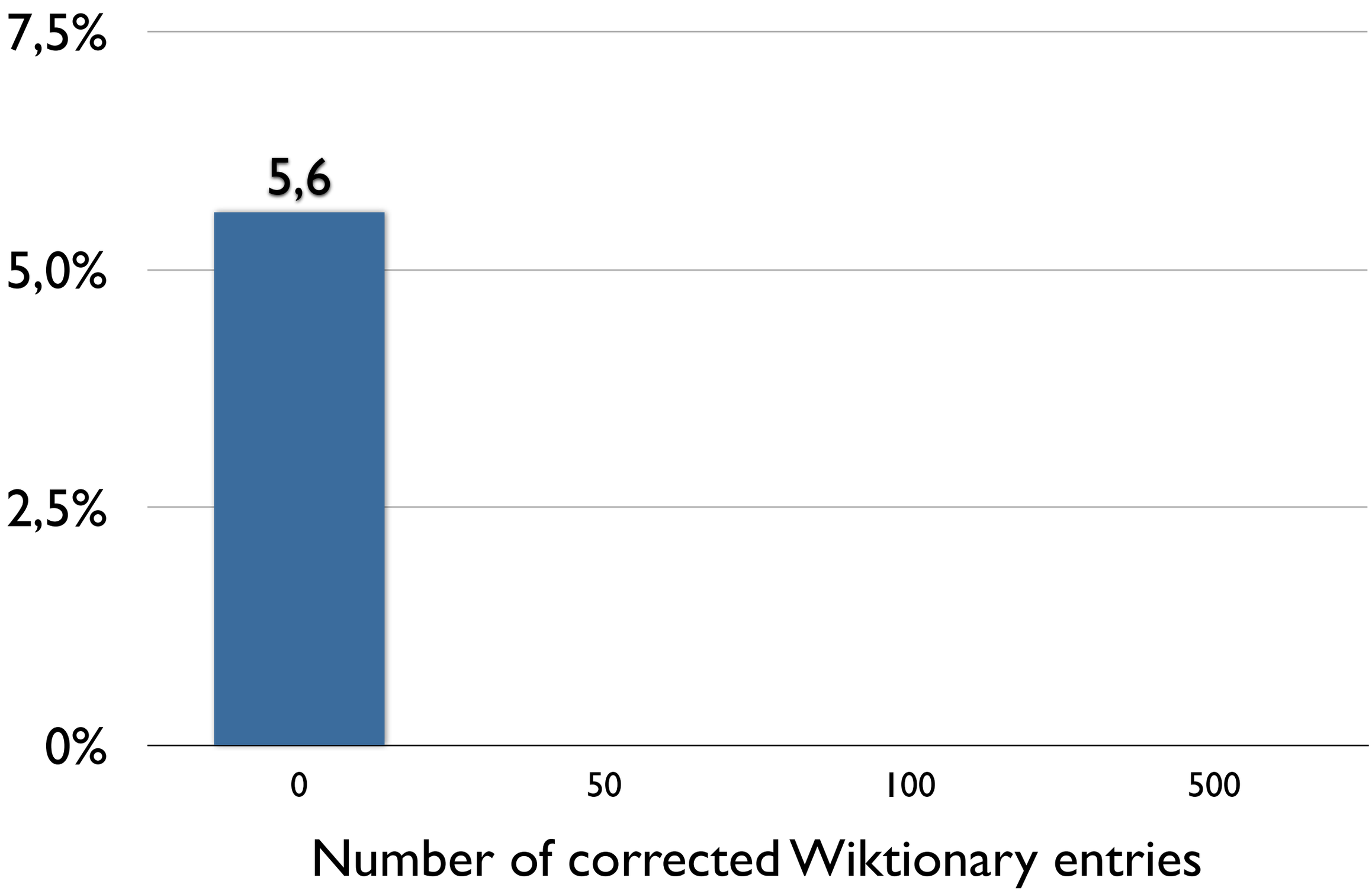

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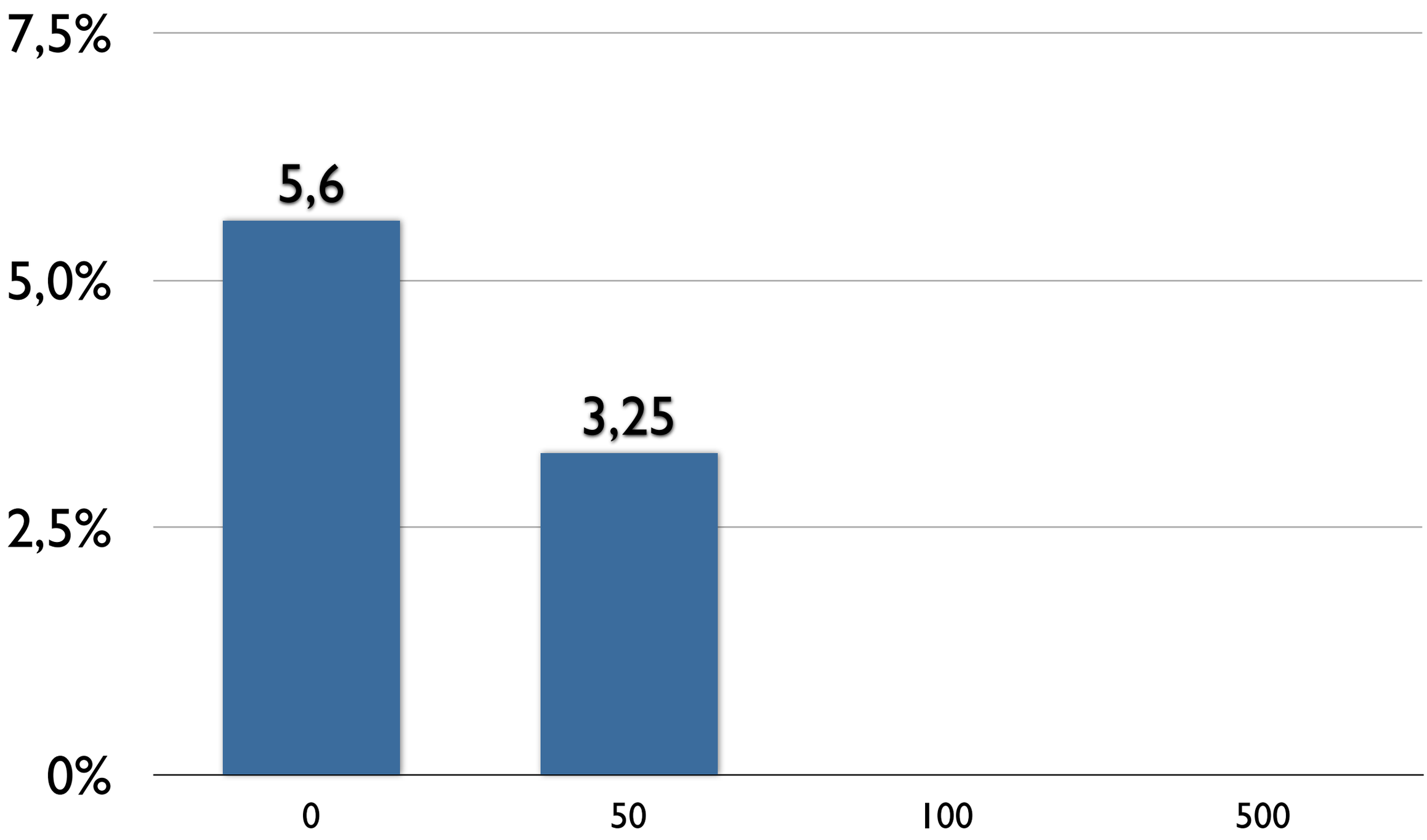

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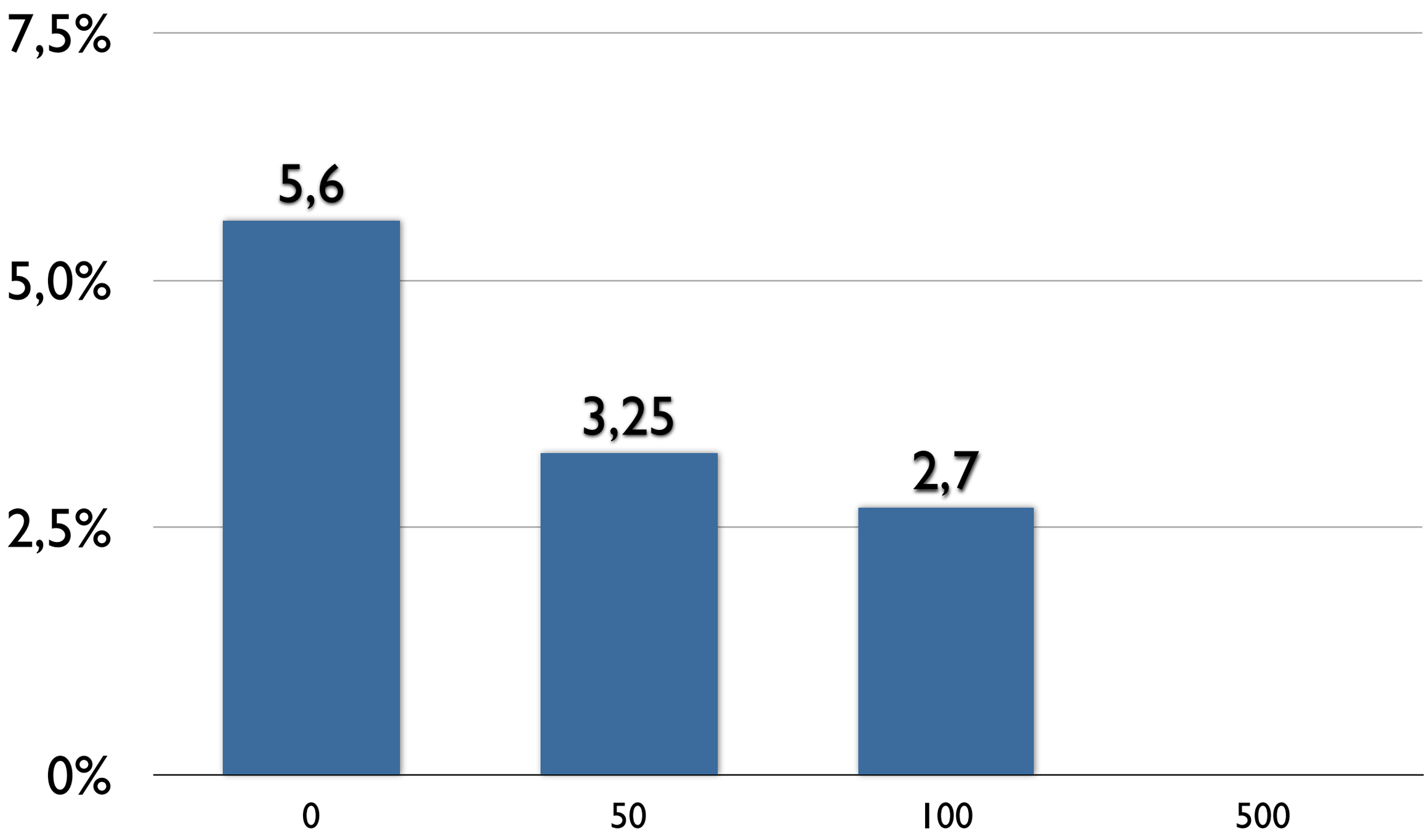

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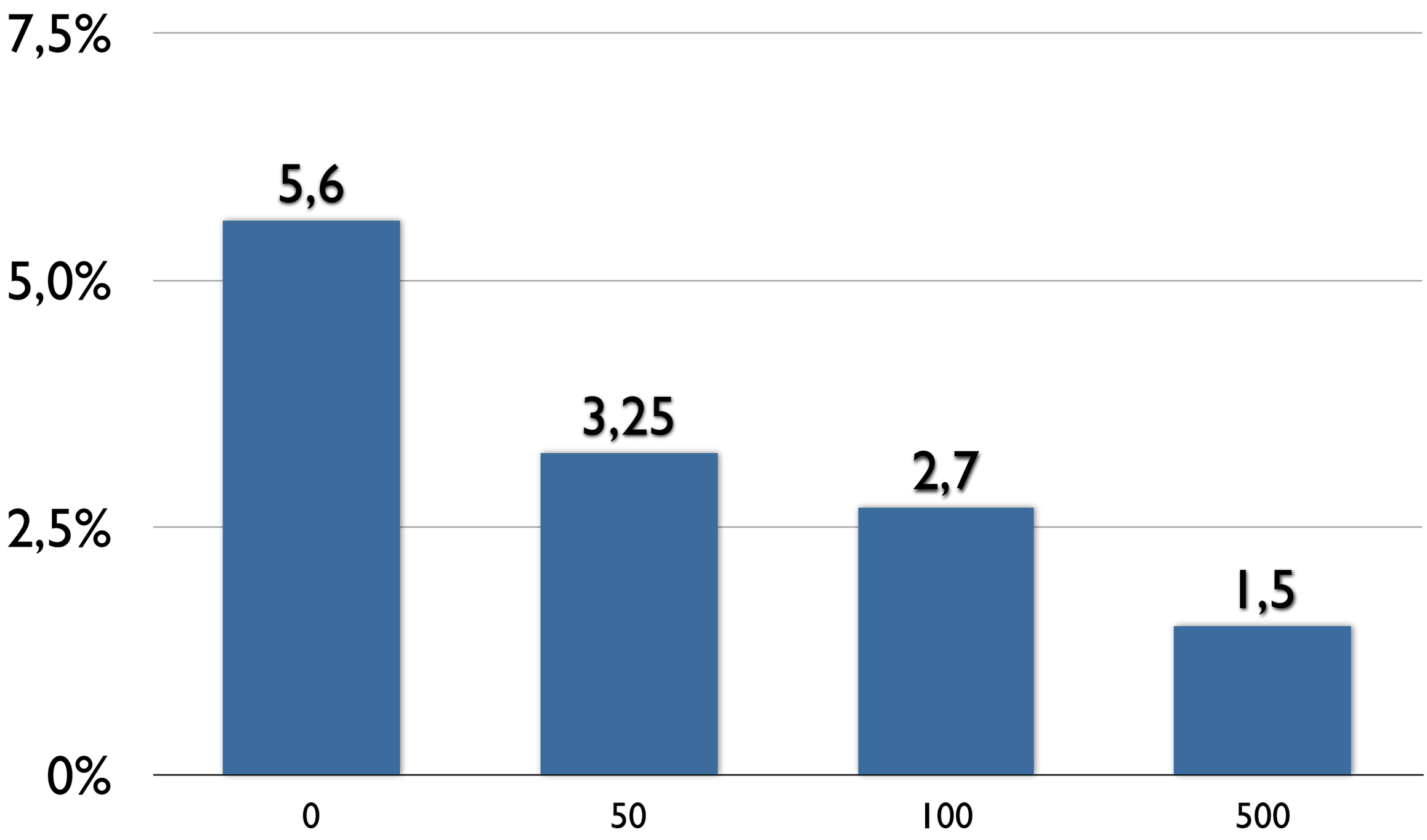

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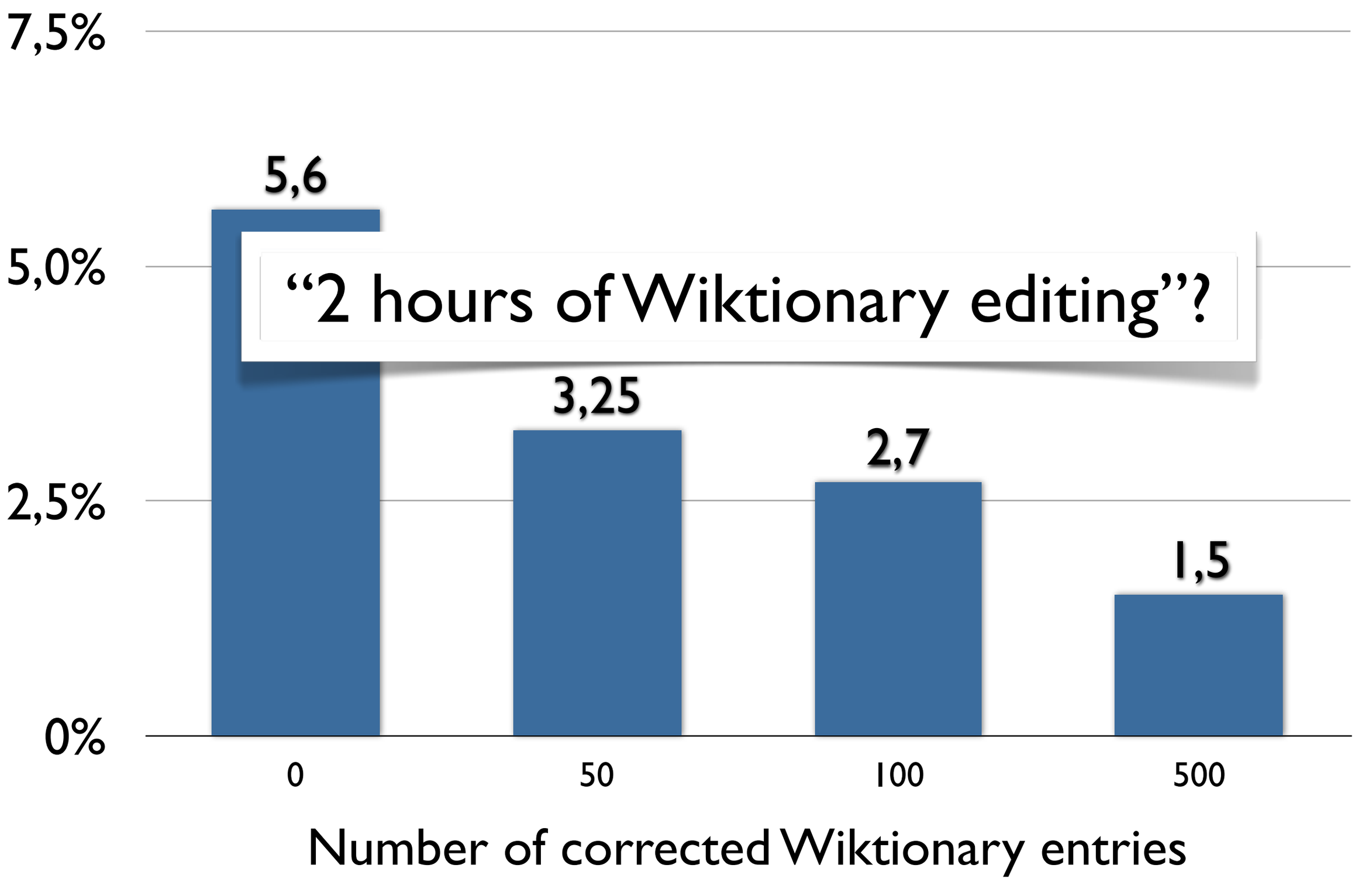

Conclusion

- Powerful discriminative latent variable models
- Coupled type and token constraints
- >25% error reduction over state of the art
- No label propagation, model minimization, etc.
- Potential extensions: NER, frame semantics, ...

Thanks!

Alexander Rush, Klaus Macherey
Yoav Goldberg, Keith Hall, Kuzman Ganchev and Hao Zhang