Sampling Alignment Structure under a Bayesian Translation Model

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Alexandre Bouchard-Côté
Dan Klein

Training a Machine Translation System

Input:

Gracias , lo haré de muy buen grado .
Thank you , I shall do so gladly .

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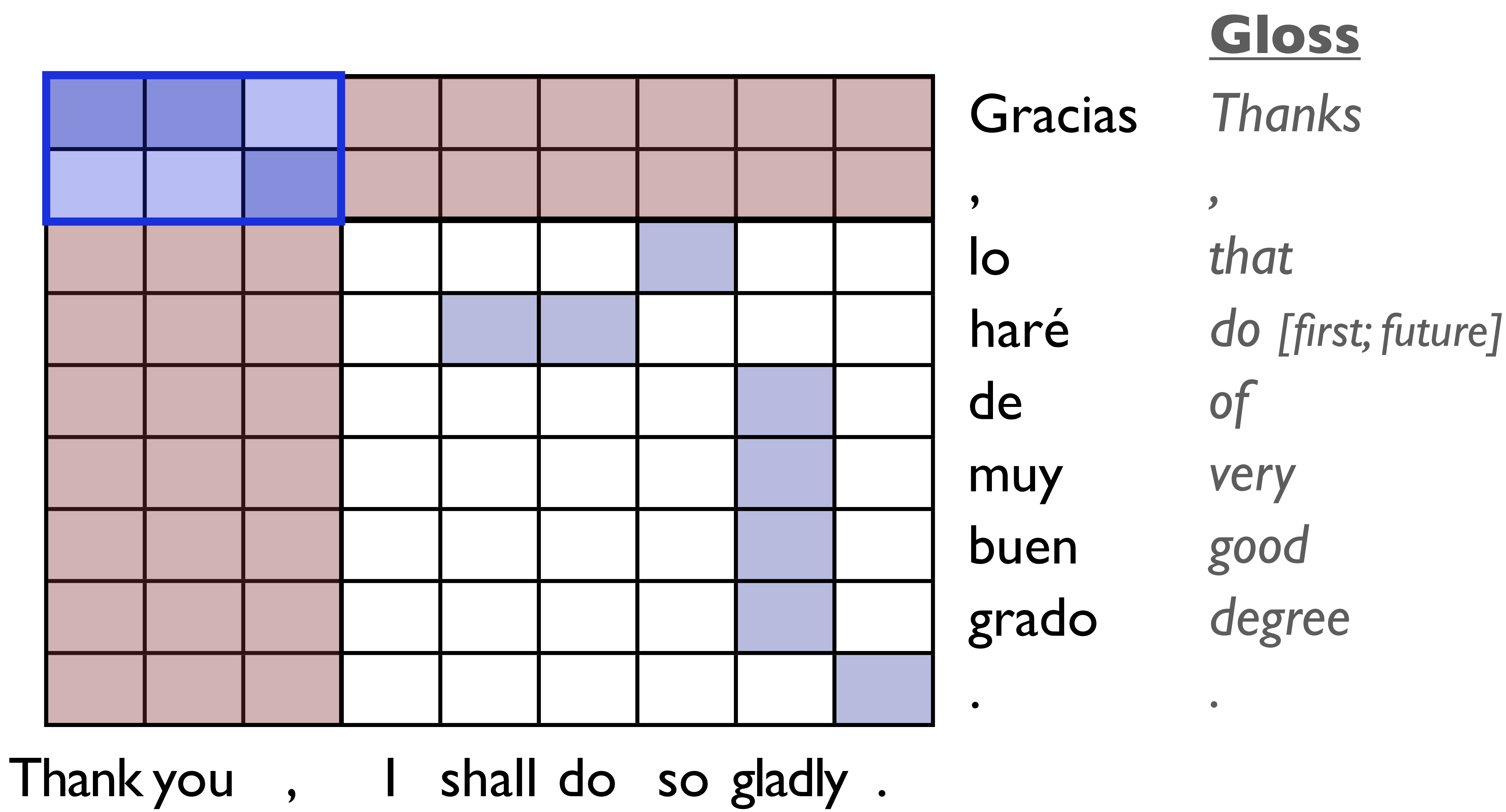

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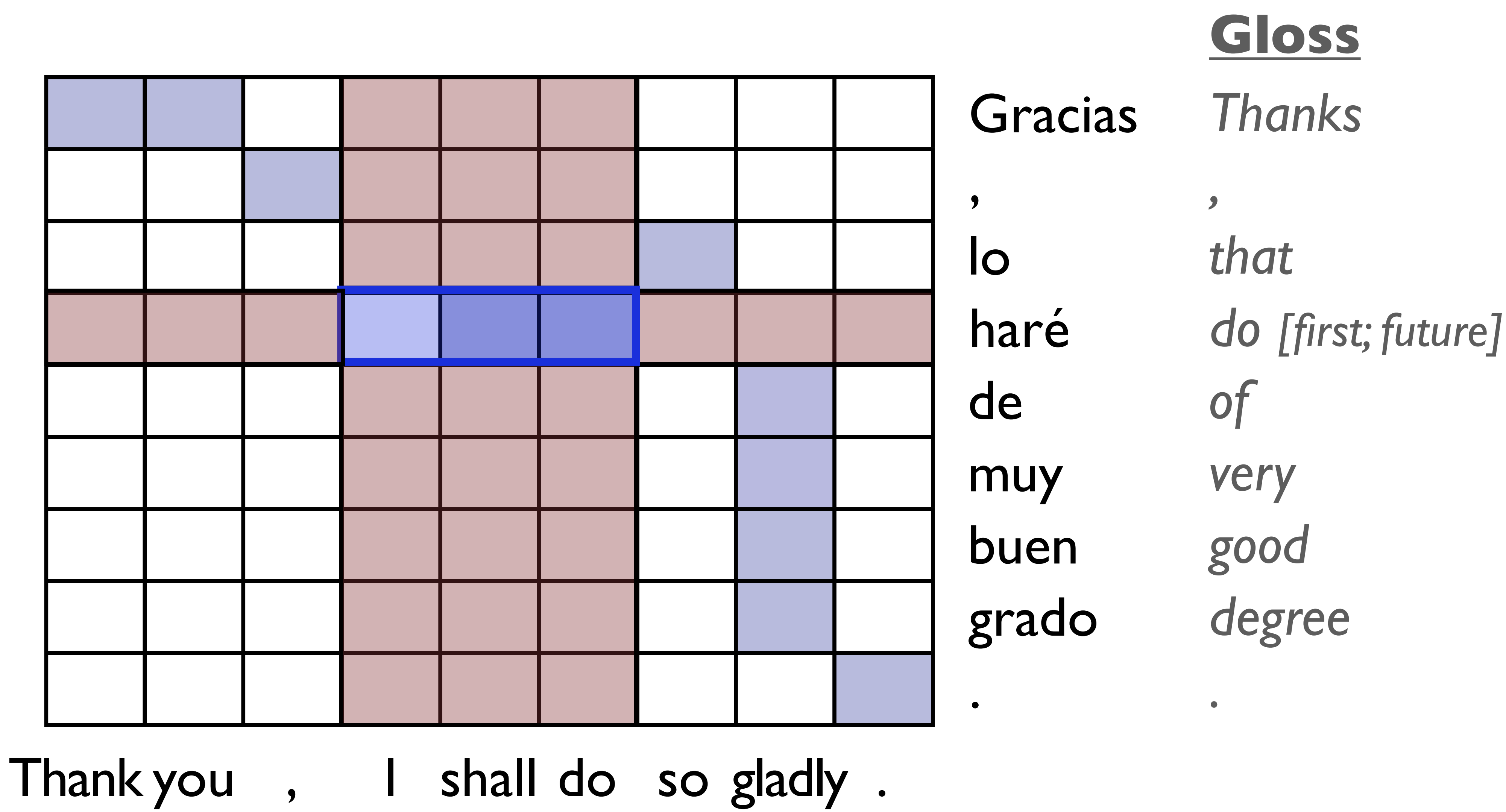
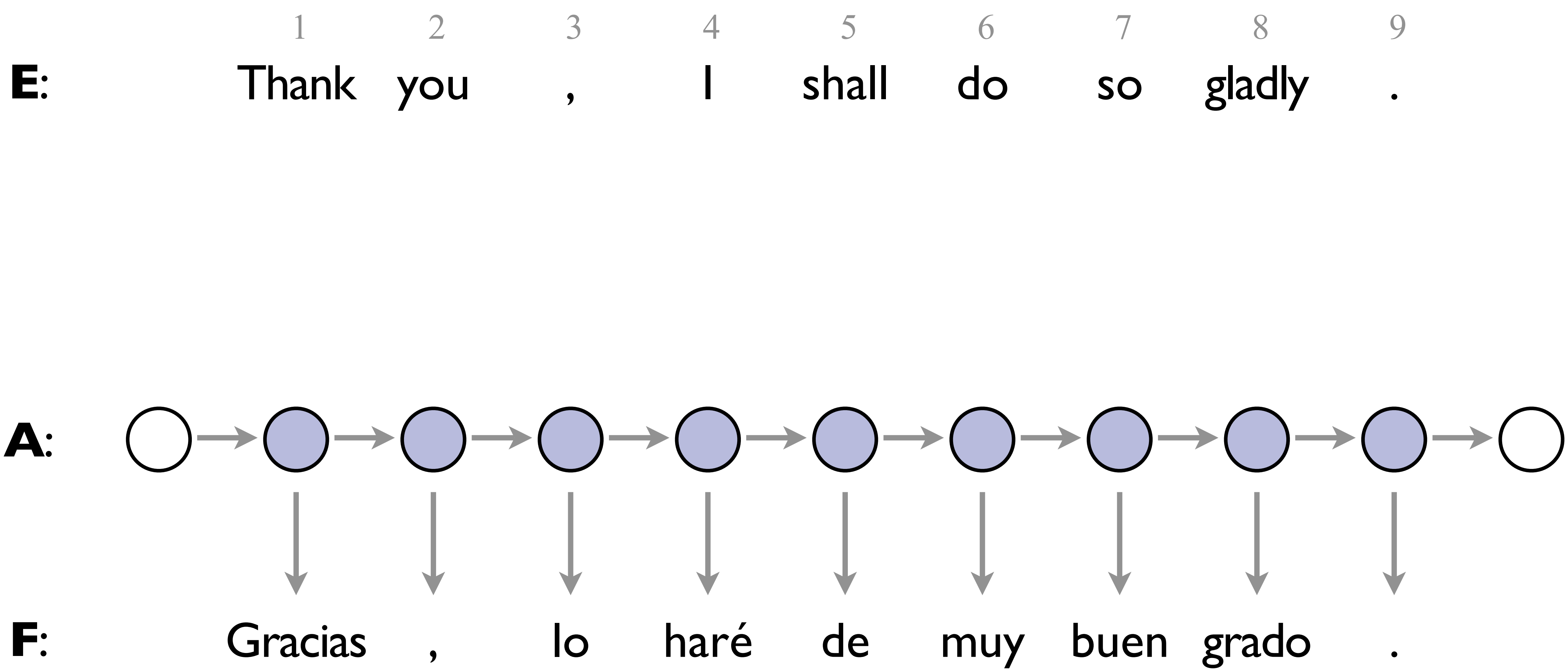


Statistical Word Alignment

E: Thank you , I shall do so gladly .

F: Gracias , lo haré de muy buen grado .

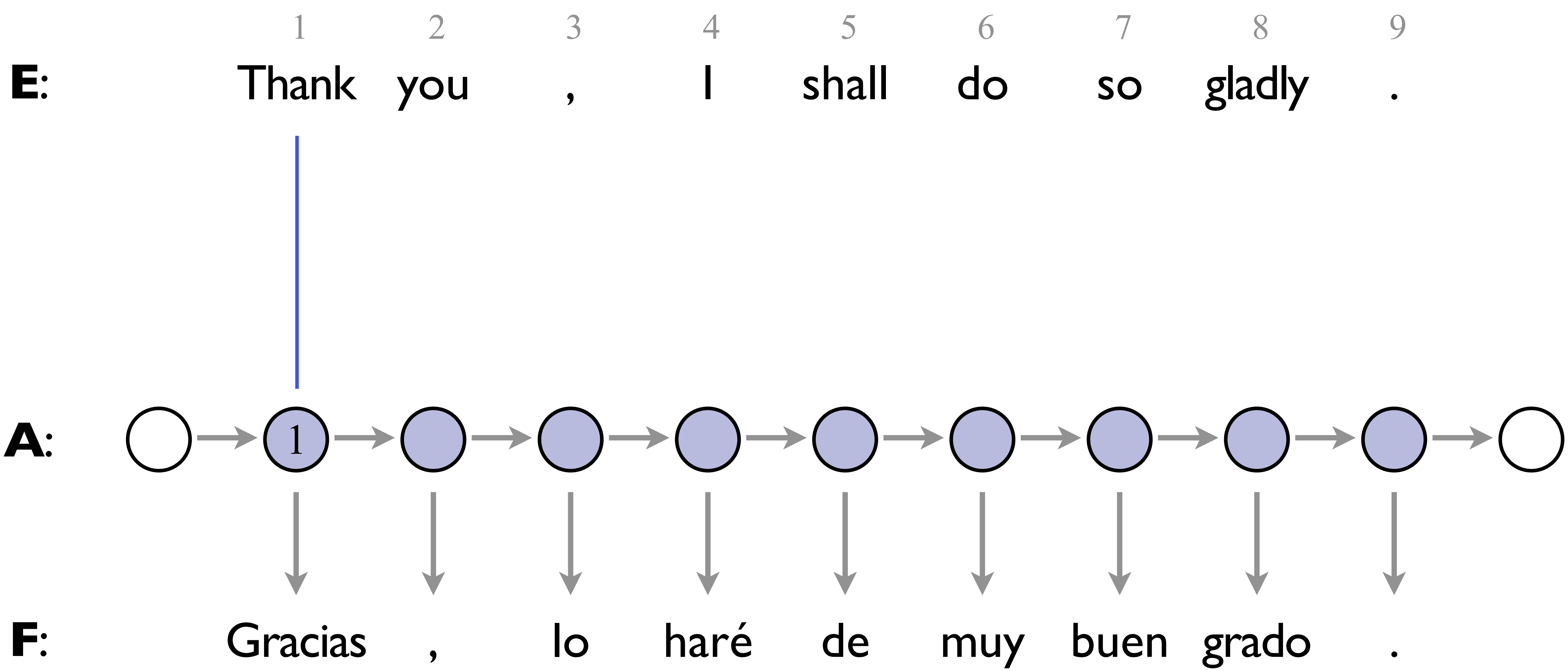
Statistical Word Alignment



Model Parameters

Emissions: $P(F_1 = \text{Gracias} \mid E_{A_1} = \text{Thank})$ *Transitions:* $P(A_2 = 3 \mid A_1 = 1)$

Statistical Word Alignment



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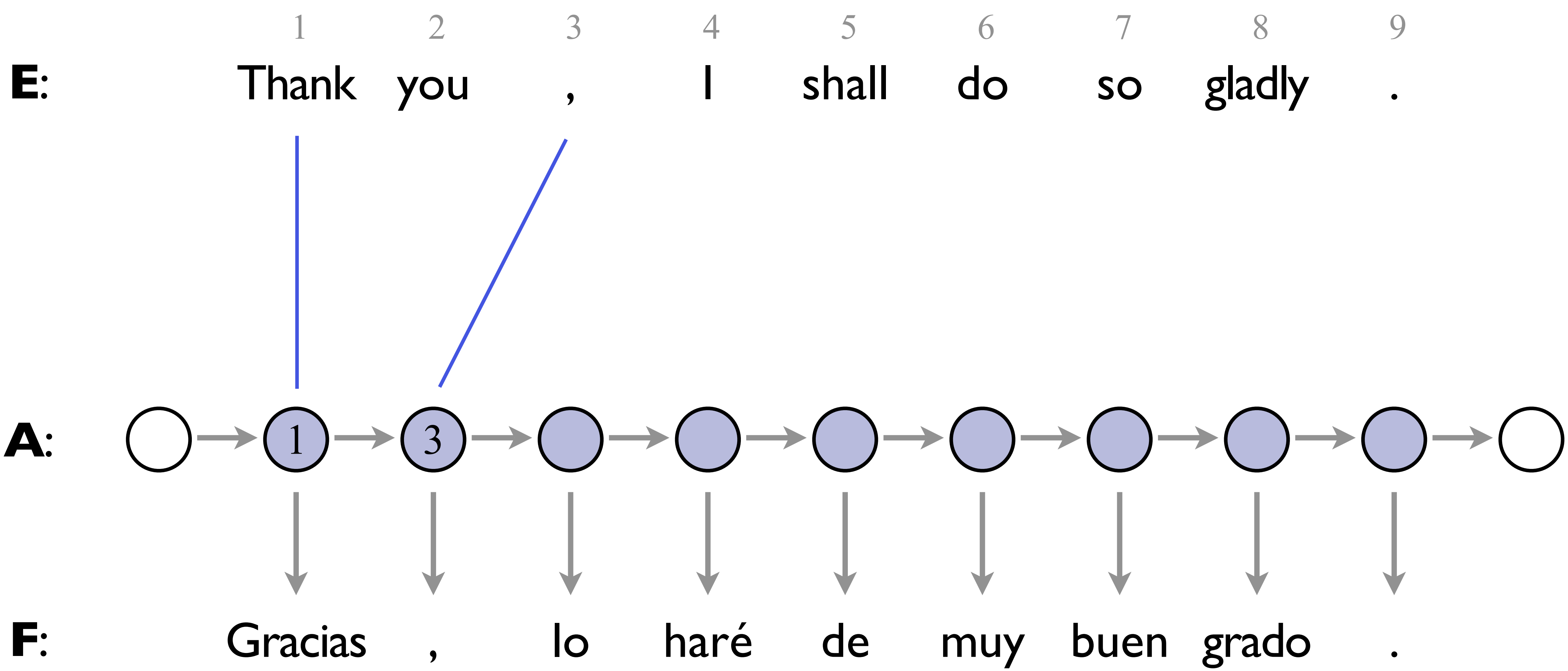

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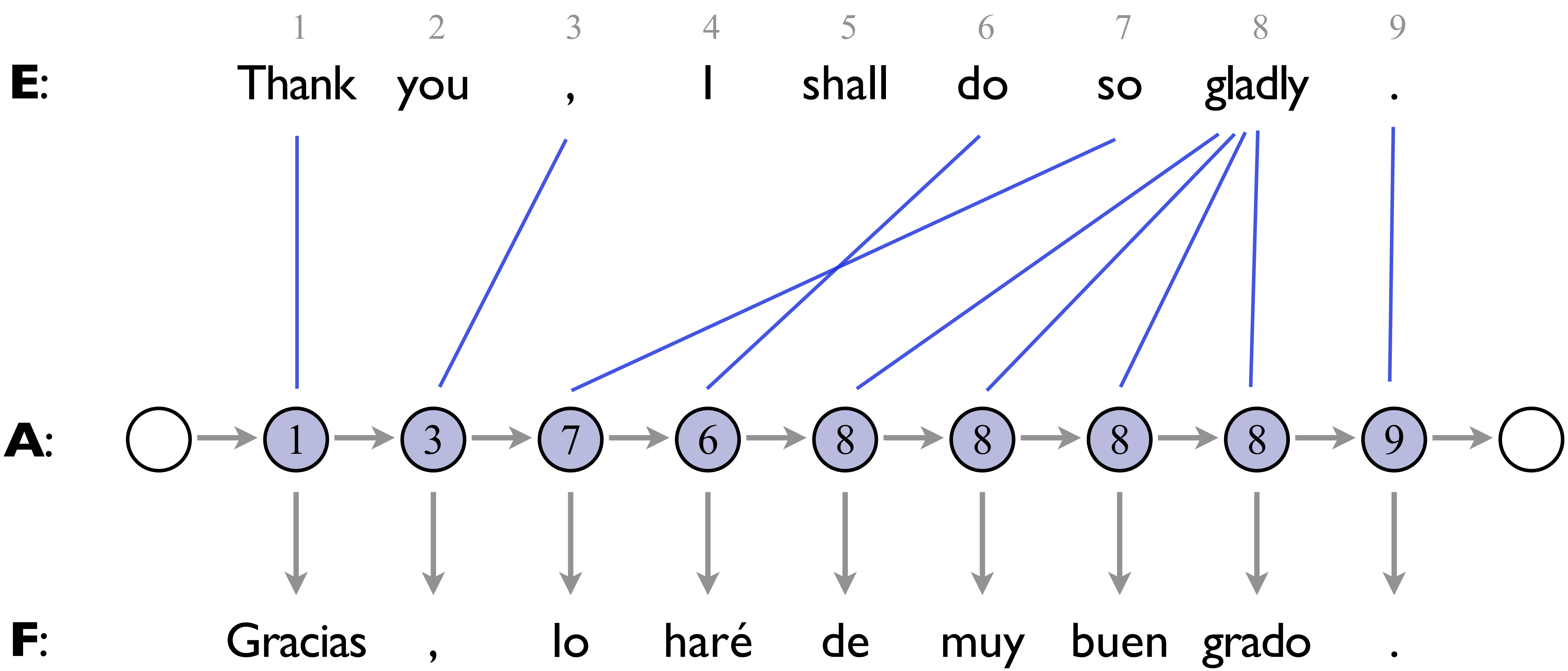
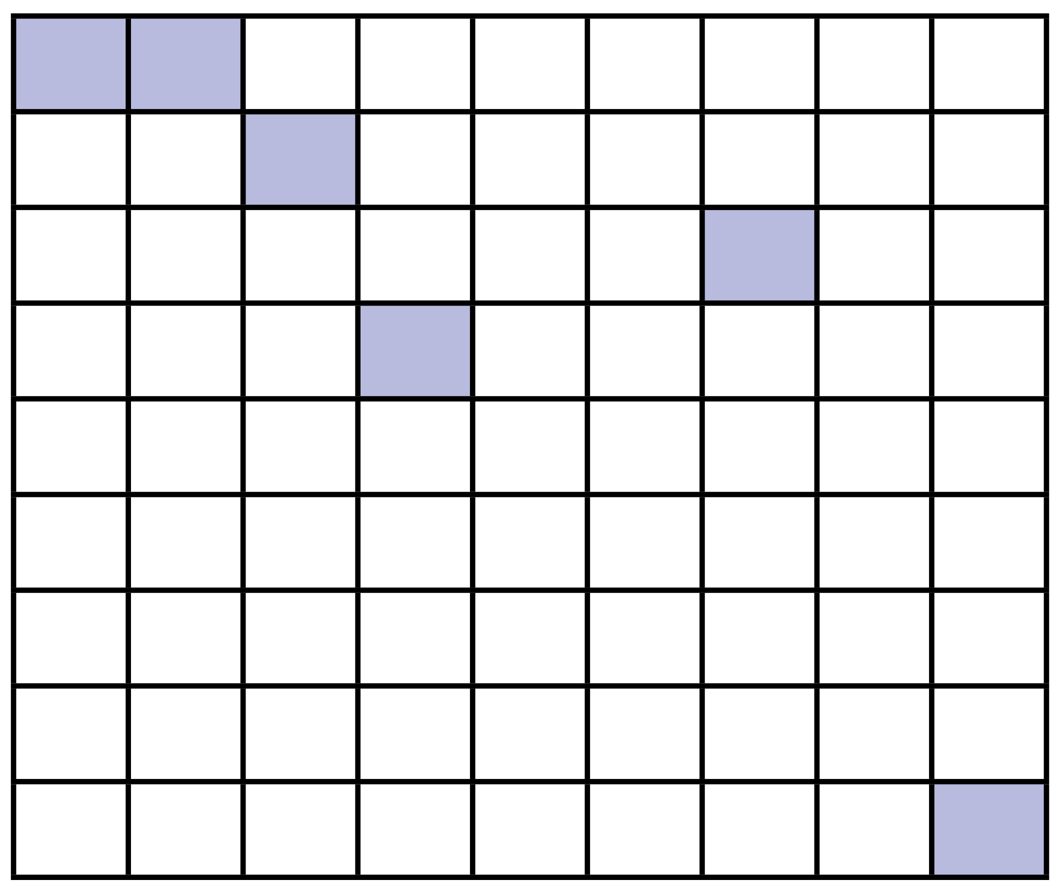


Model Parameters

Emissions: $P(F_1 = \text{Gracias} \mid E_{A_1} = \text{Thank})$ *Transitions:* $P(A_2 = 3 \mid A_1 = 1)$

What Happens in Practice

A real word alignment
(GIZA++ Model 4 with
grow-diag-final combination)



Gloss

Thanks
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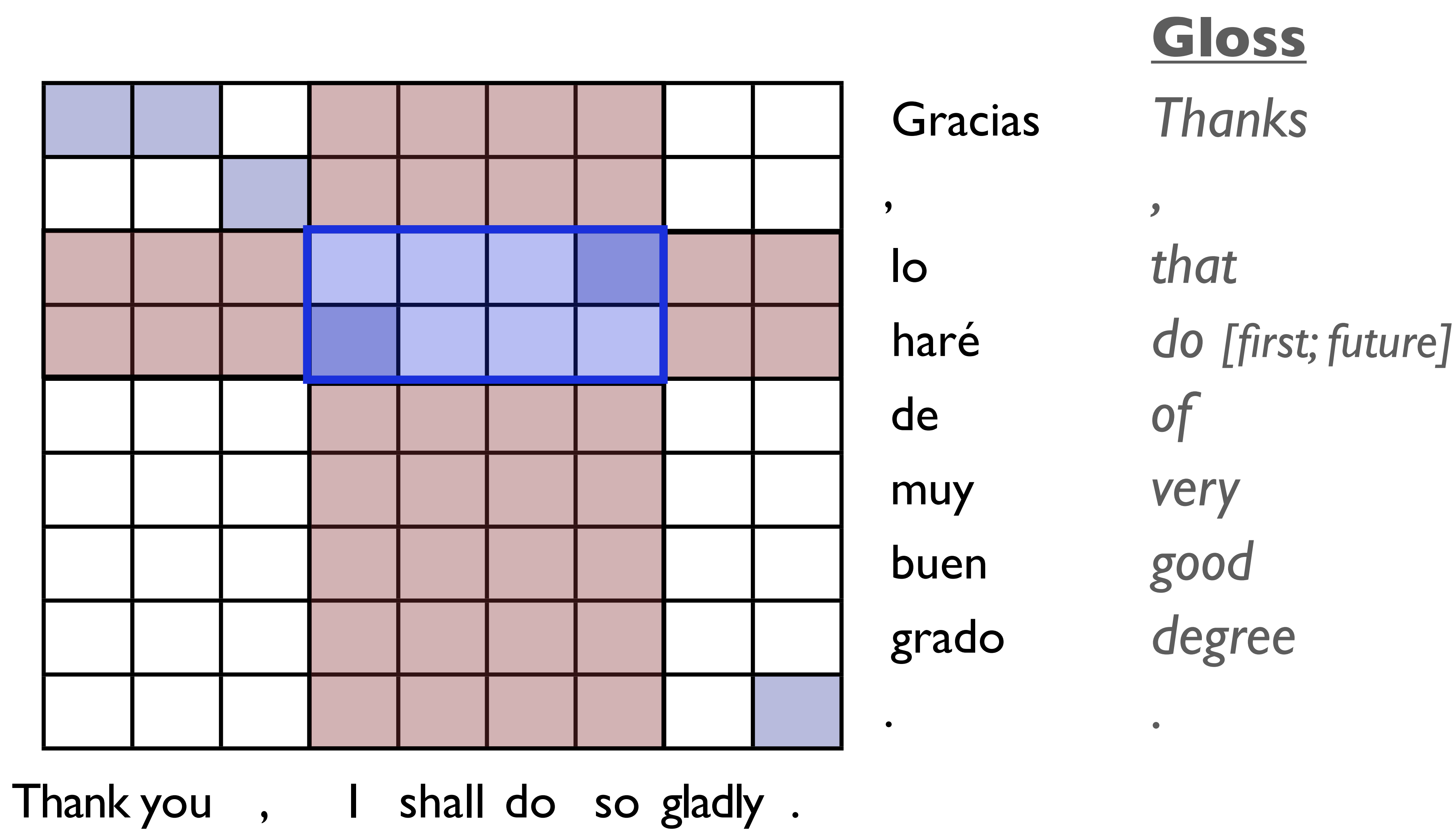

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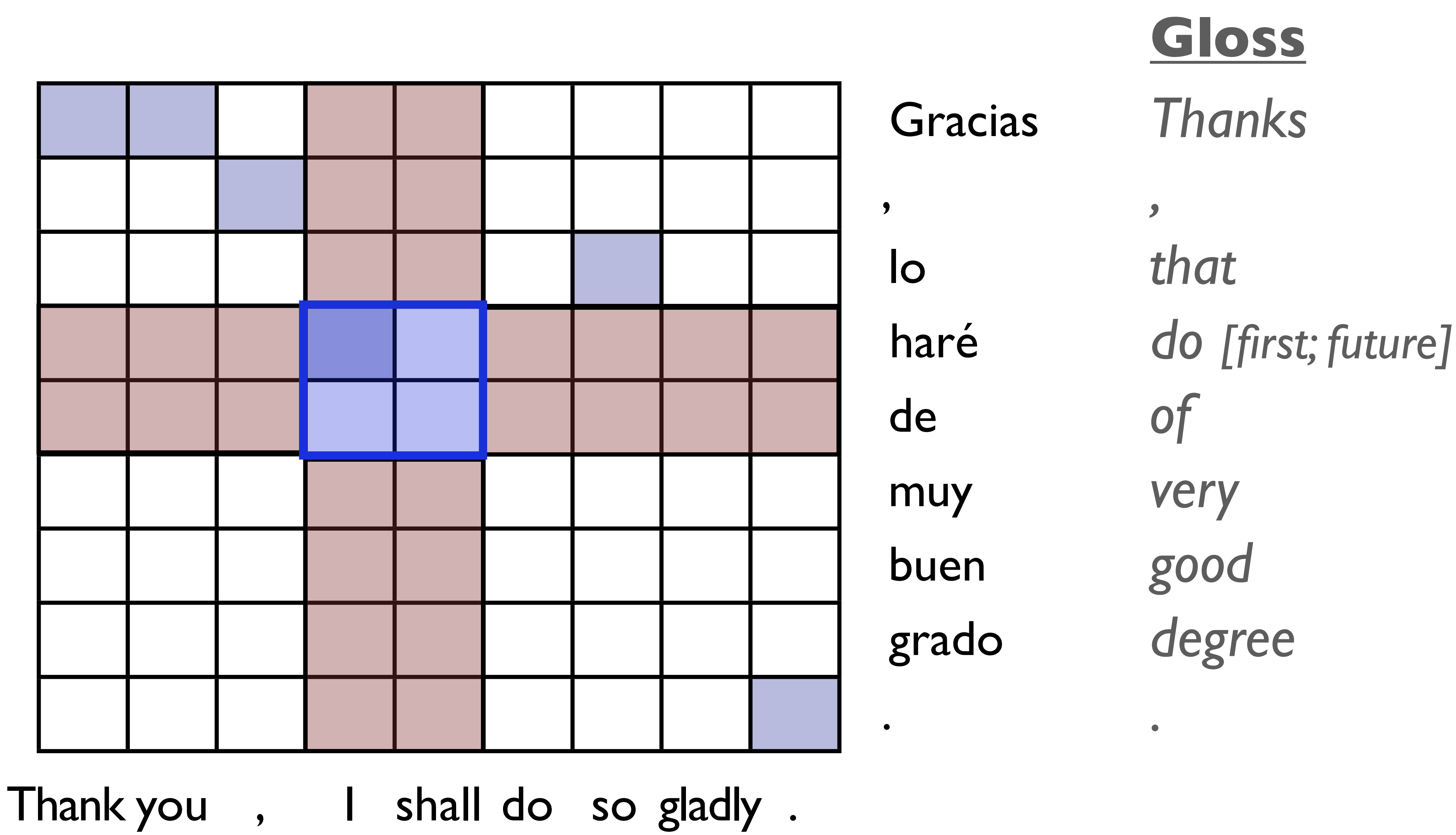

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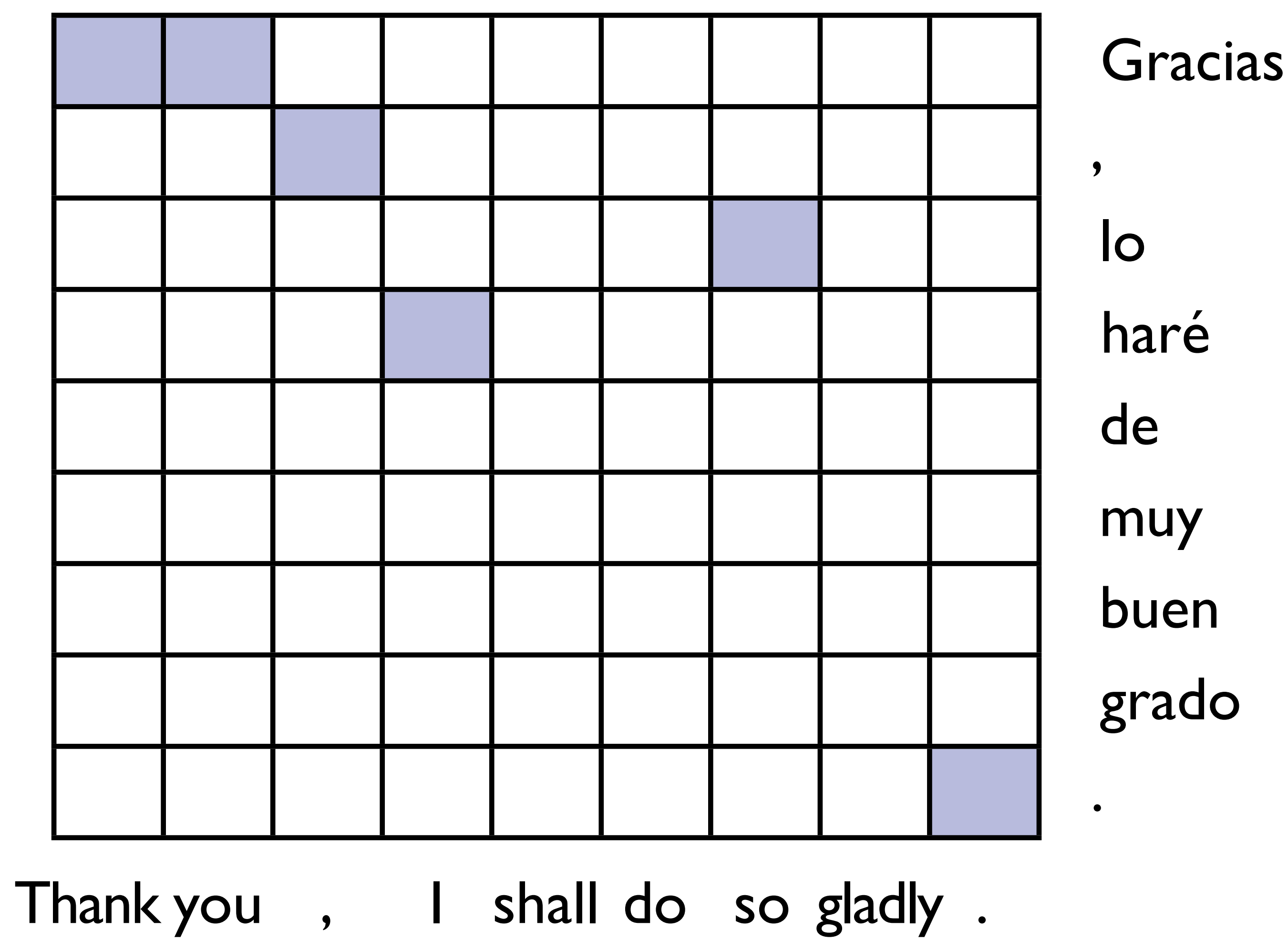

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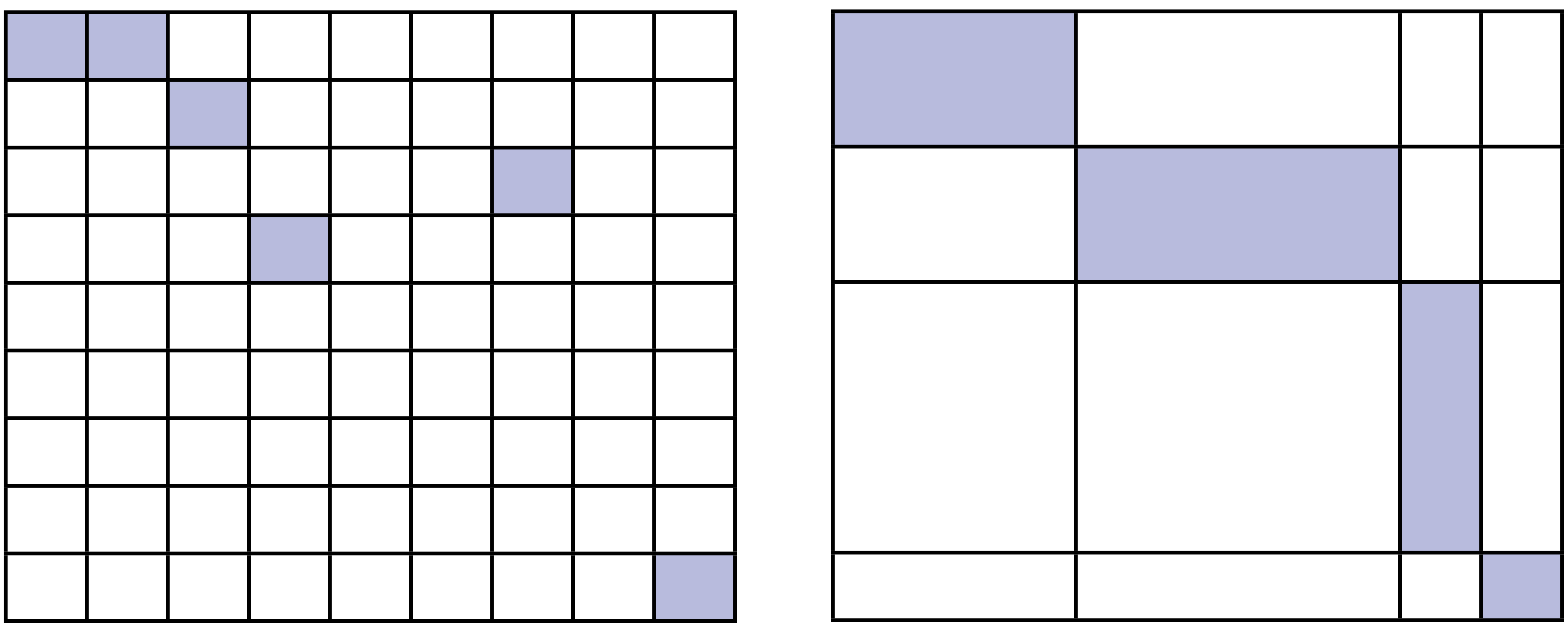
A sampled phrase alignment
(our system)



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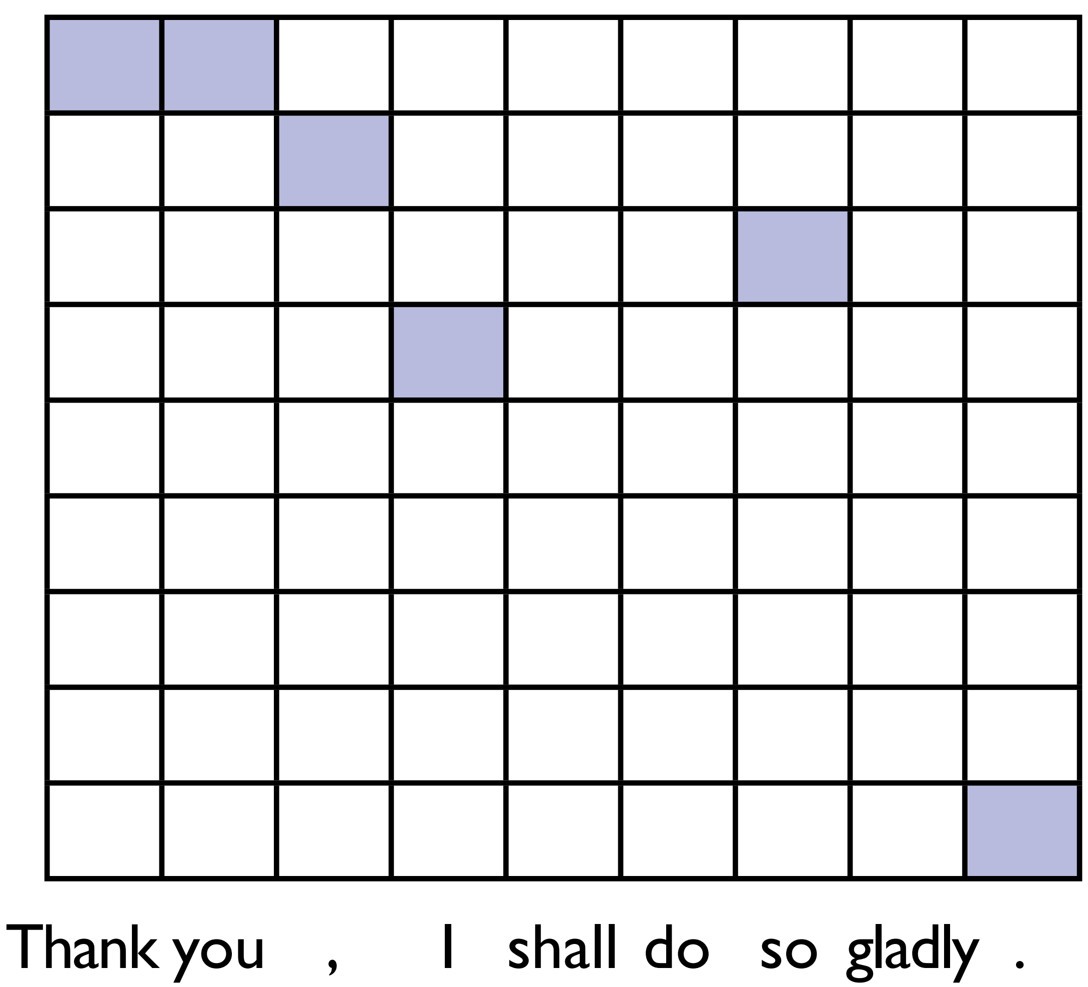

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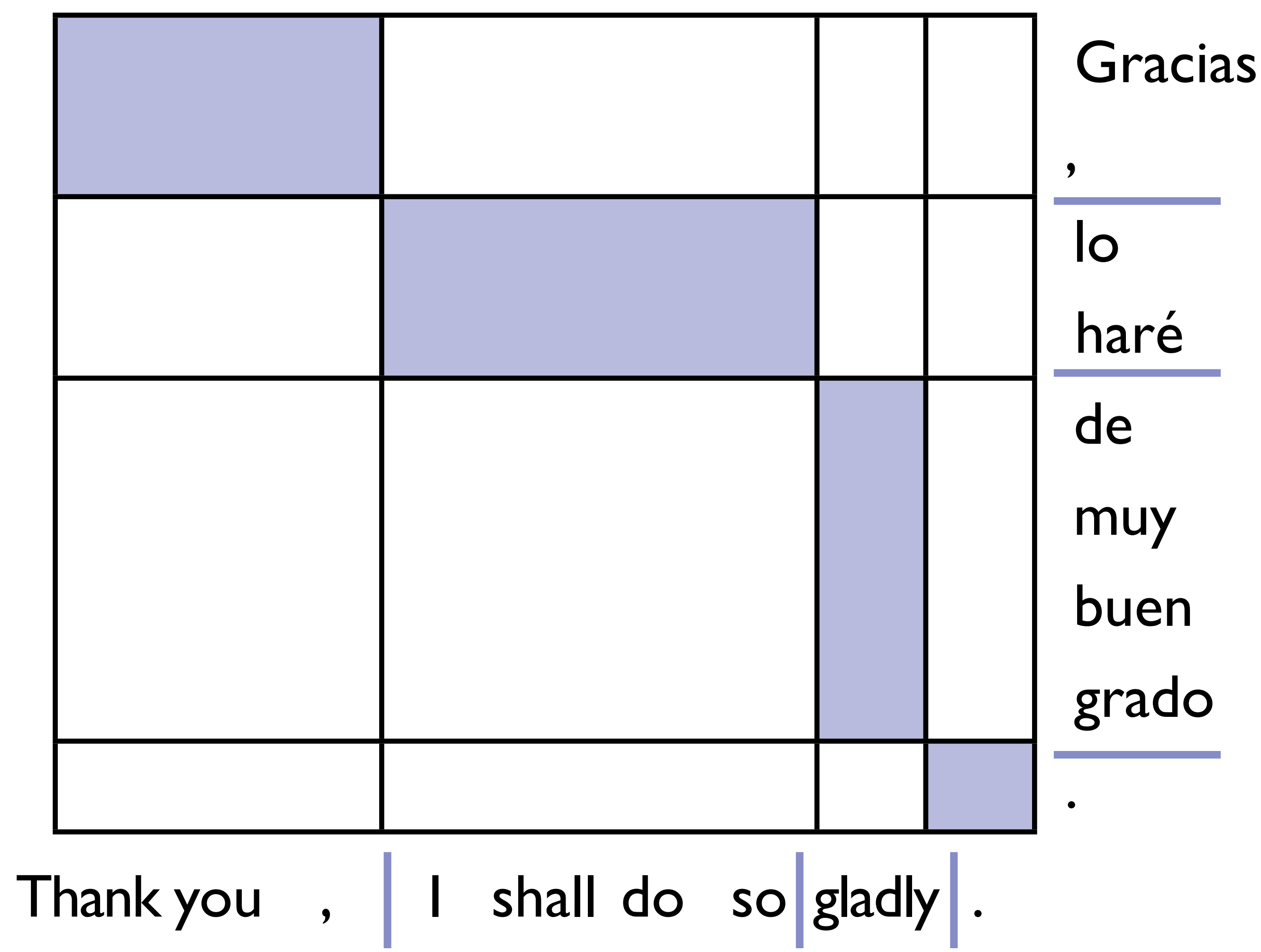

A Brief History of Phrase Alignment

The Challenge:

Train models that explicitly align phrases, not just words

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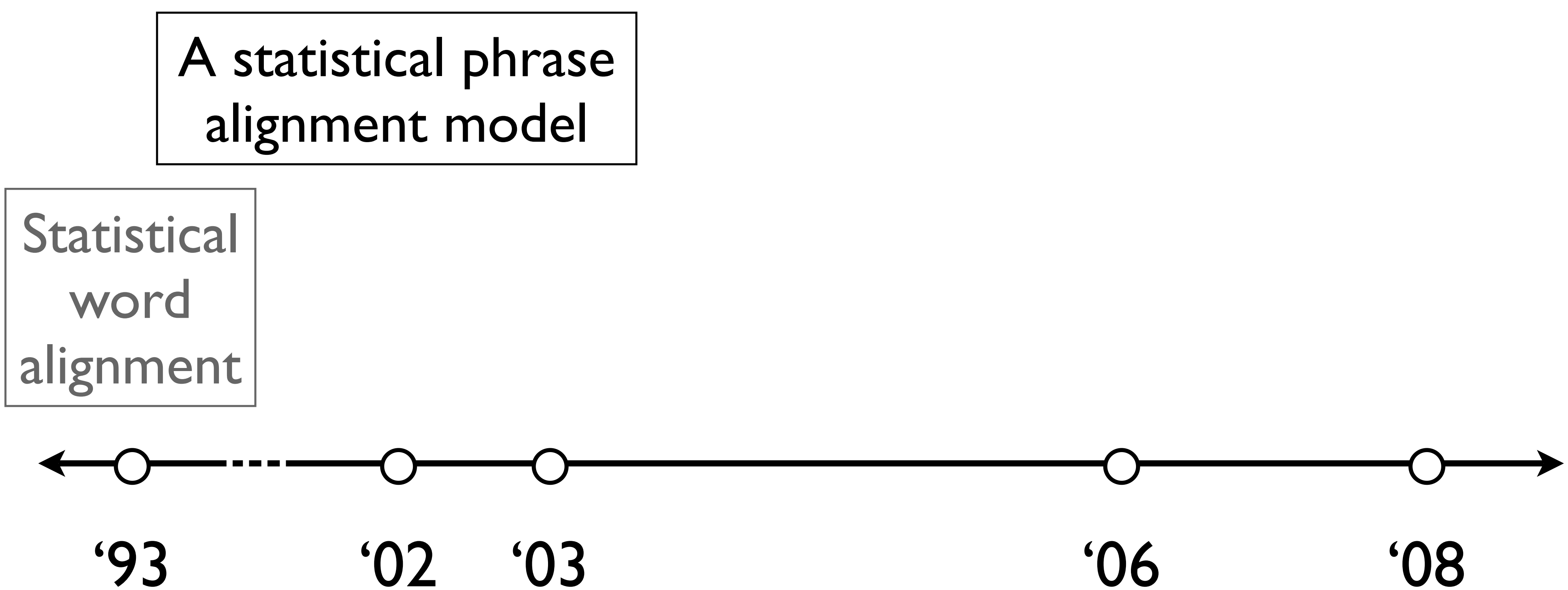

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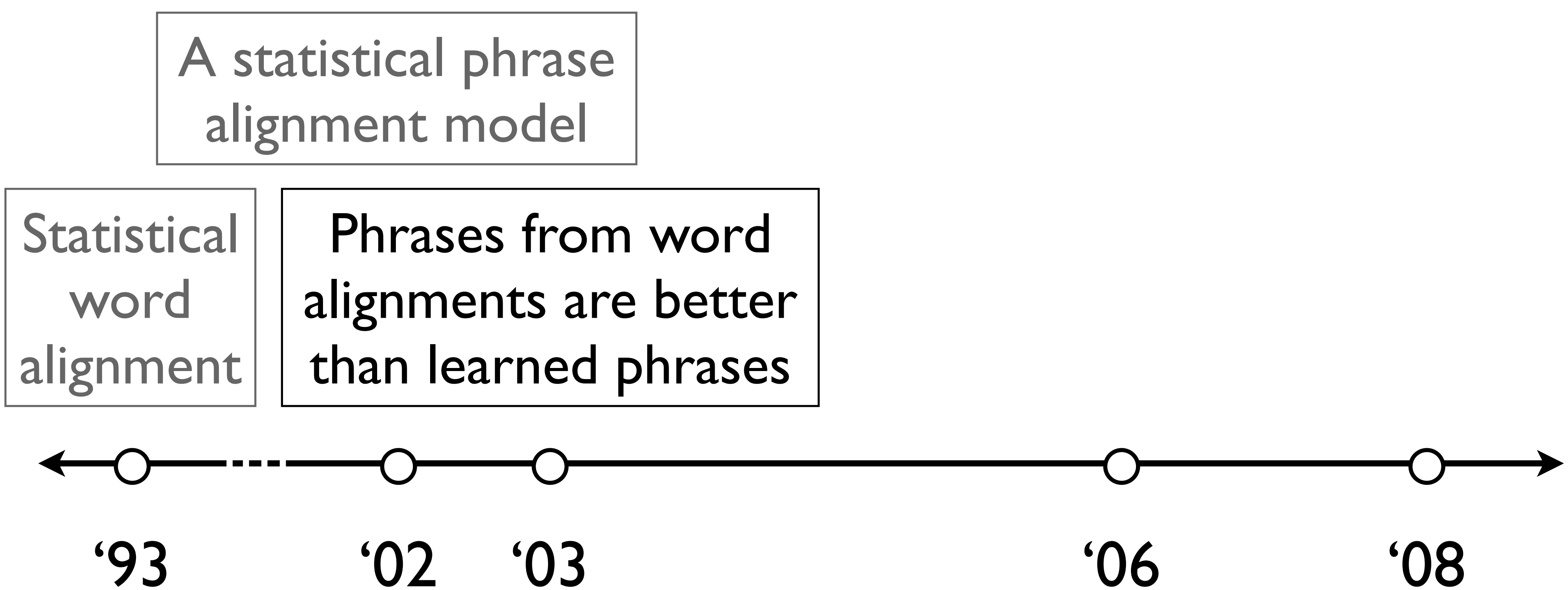

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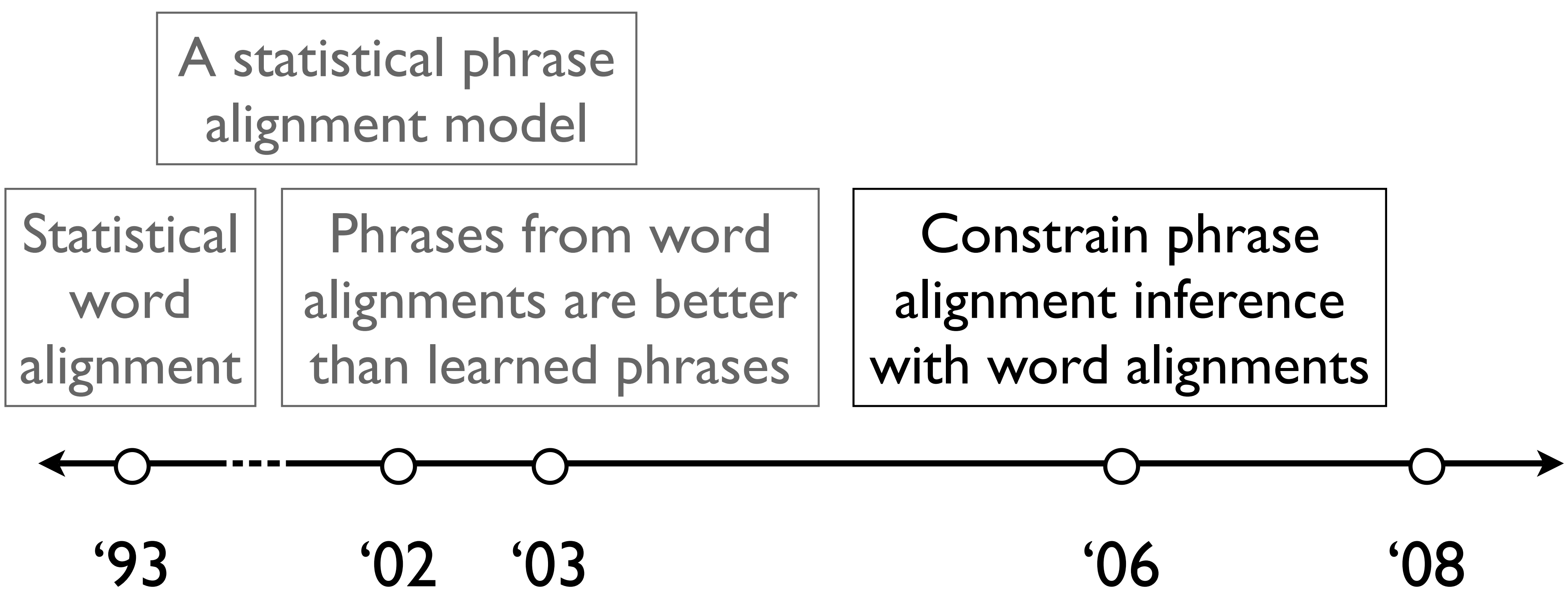

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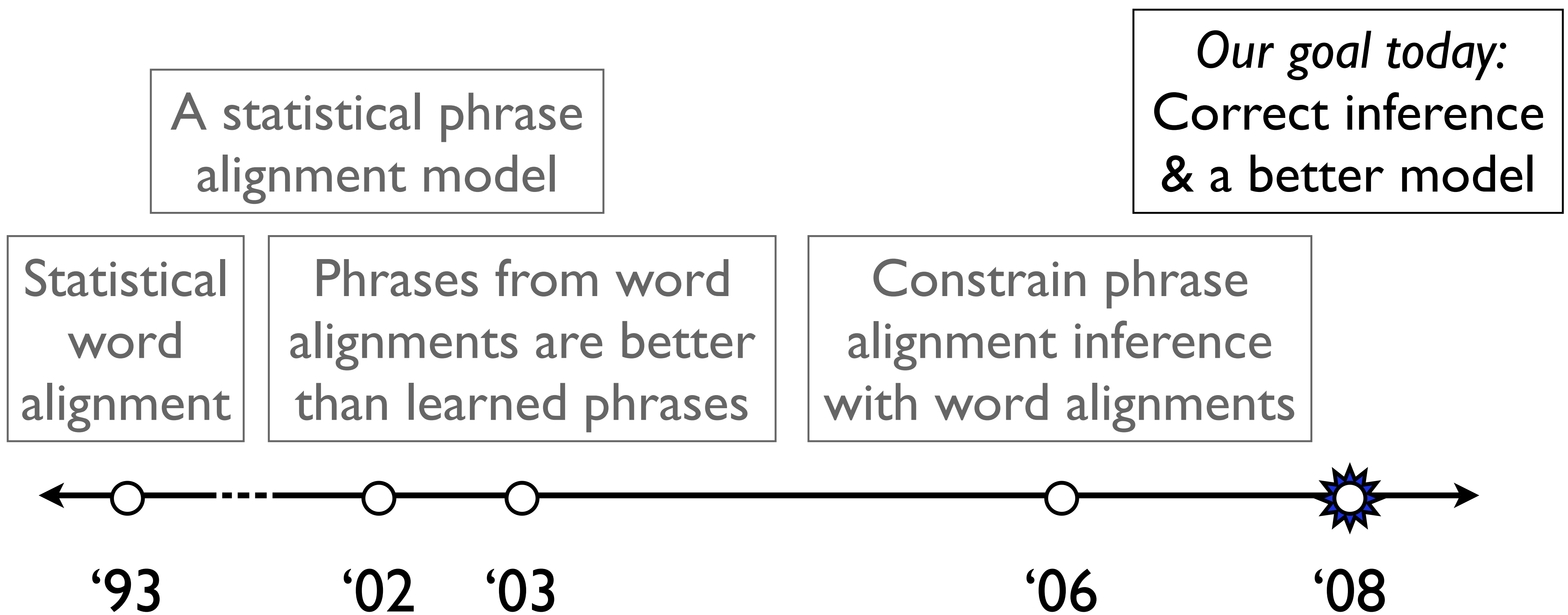

A Generative Phrase Alignment Model

Process for generating a sentence pair:

A Generative Phrase Alignment Model

Process for generating a sentence pair:

Choose number of phrase pairs

A Generative Phrase Alignment Model

Process for generating a sentence pair:

Choose number of phrase pairs

Generate each phrase pair

日本 冻结	提供 援助	向 俄
Japan to freeze	aid	to Russia

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Keep the English order

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Japan to freeze aid to Russia

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Process for generating a sentence pair:

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Reorder the Chinese phrases

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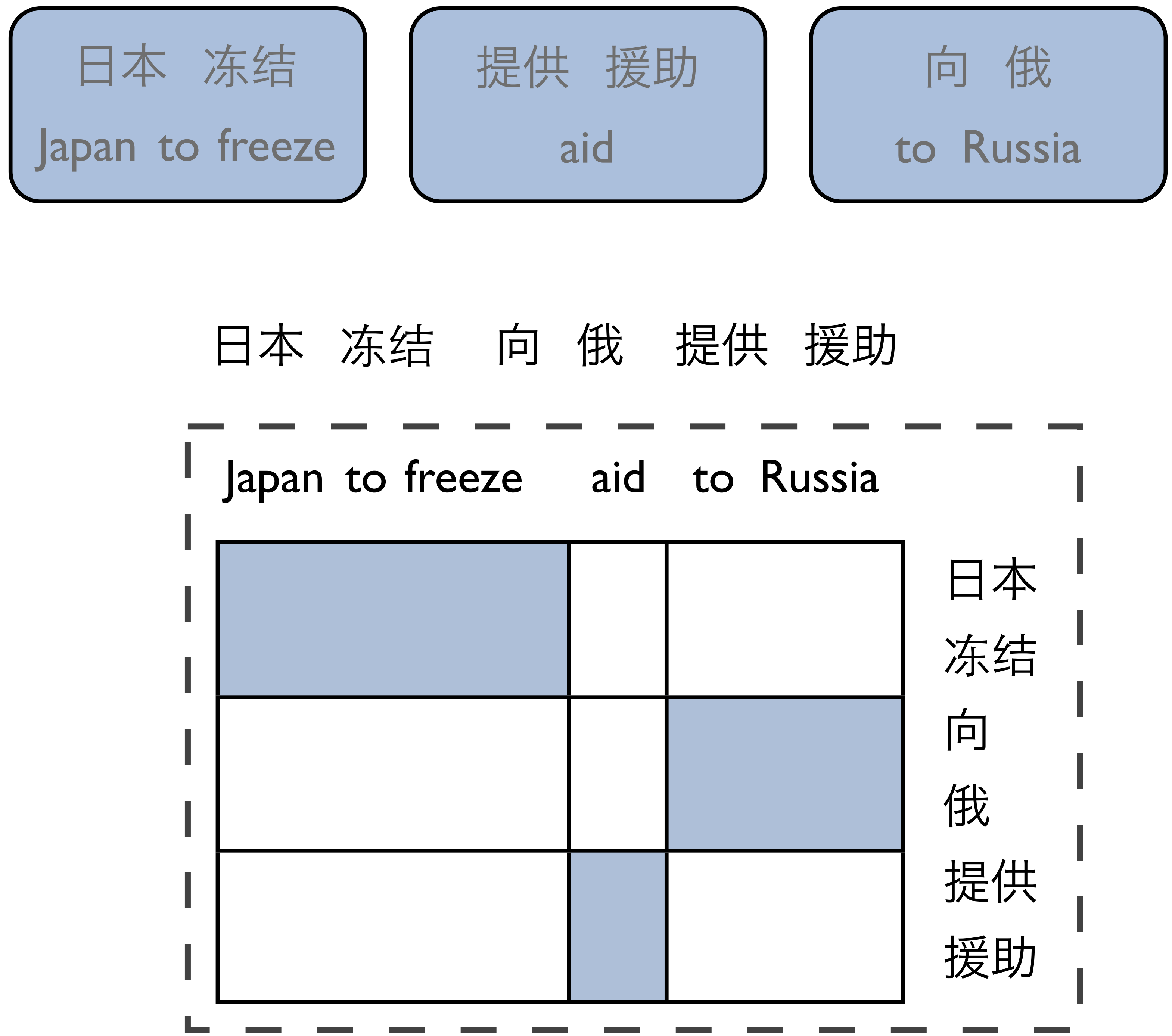

A phrase-aligned sentence pair
(a list of phrase pairs and a permutation)

Estimating Model Parameters

A phrase-aligned sentence pair a *is*

a list of phrase pairs $\langle e, f \rangle$ *and a permutation* σ_a .

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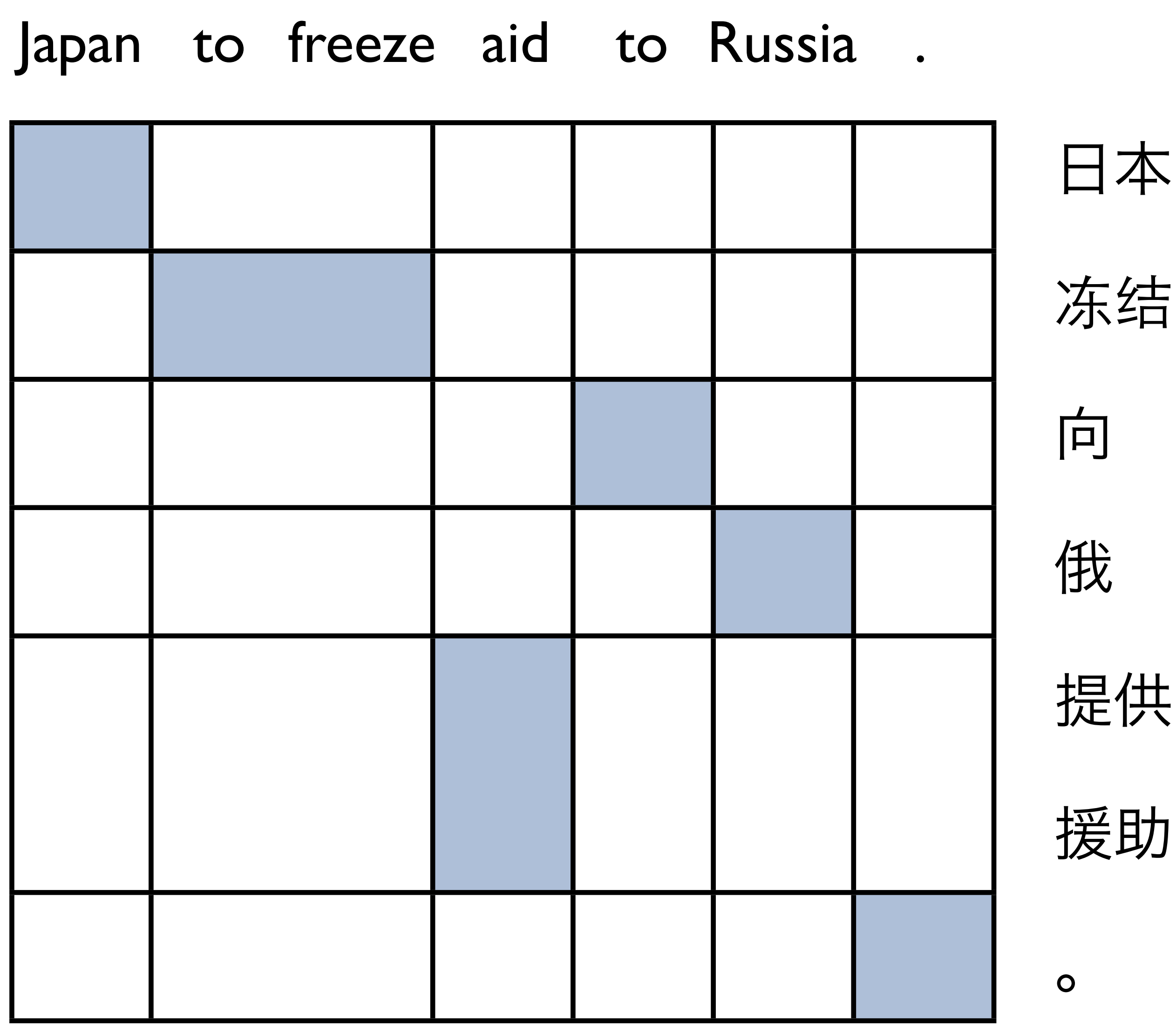
Maximum likelihood:
choose ϕ *to maximize the probability of the training corpus:*

$$\max_{\phi} \prod_{(\mathbf{e},\mathbf{f})} \left[\sum_{a \text{ for } (\mathbf{e},\mathbf{f})} \prod_{\langle e,f \rangle \in a} \phi(\langle e, f \rangle) \cdot \delta(\sigma_a) \right]$$

We Need a Prior over Phrase Pairs



<u>Gloss</u>

Japan

freeze

to

Russia

supply

assistance

。

We Need a Prior over Phrase Pairs

Japan to freeze aid to Russia .

	Gloss
日本	*Japan*
冻结	*freeze*
向	*to*
俄	*Russia*
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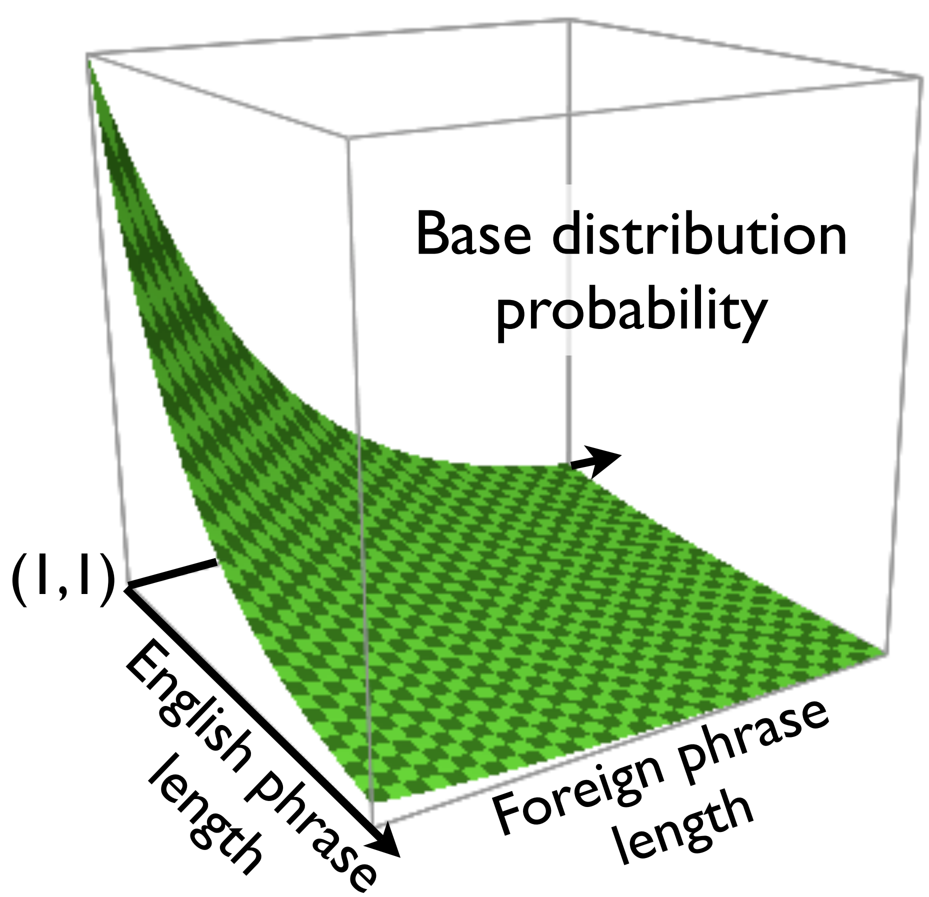
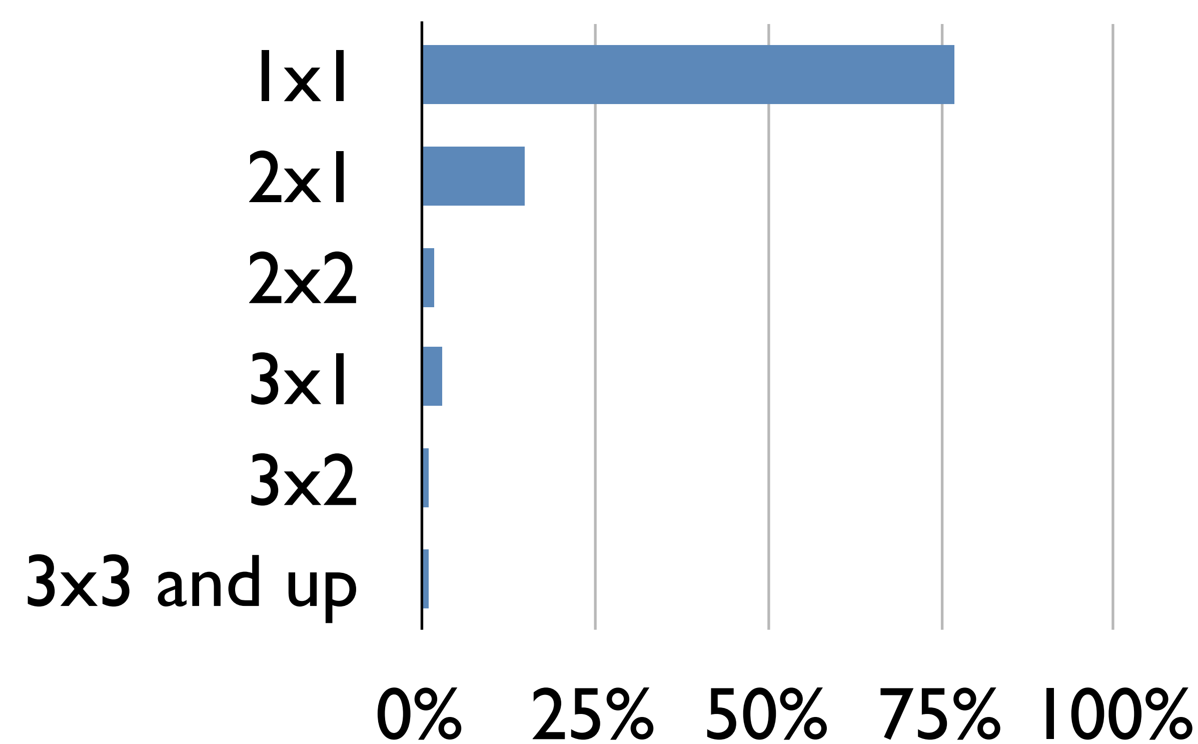
Our Prior, in Brief

A Dirichlet Process Prior that

- Strongly prefers shorter phrases (base distribution)
- Strongly prefers to reuse phrases (concentration)
- Plays nicely with our sampler (collapsed Gibbs)



Observed phrase pair sizes



Sampling Phrase Alignments

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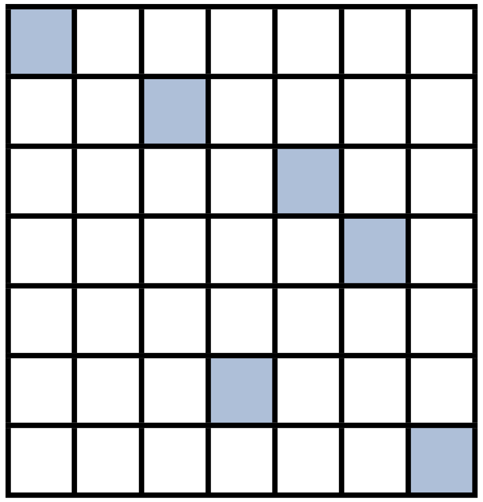
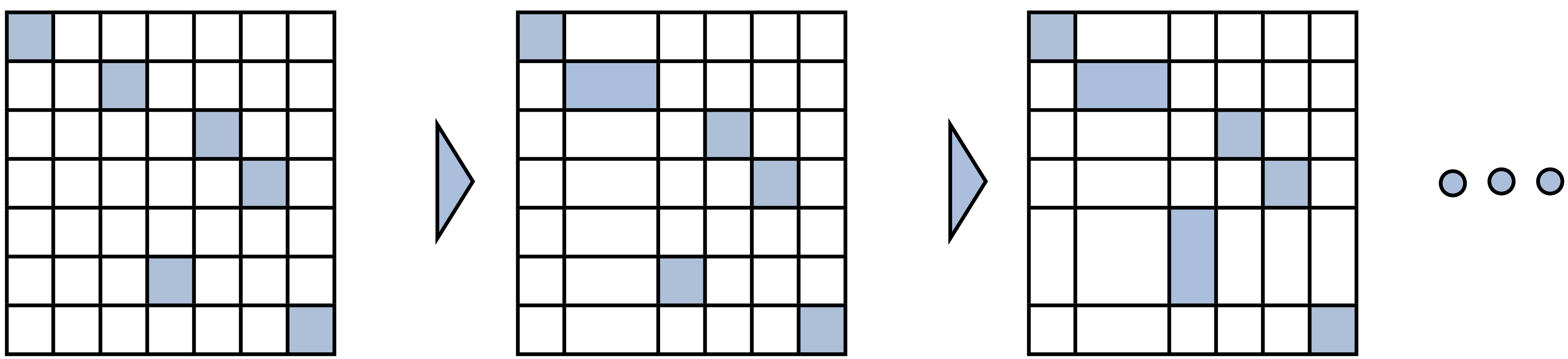
Initial phrase alignment



Sampling Phrase Alignments

Initial phrase alignment

Stochastically apply local edit operators



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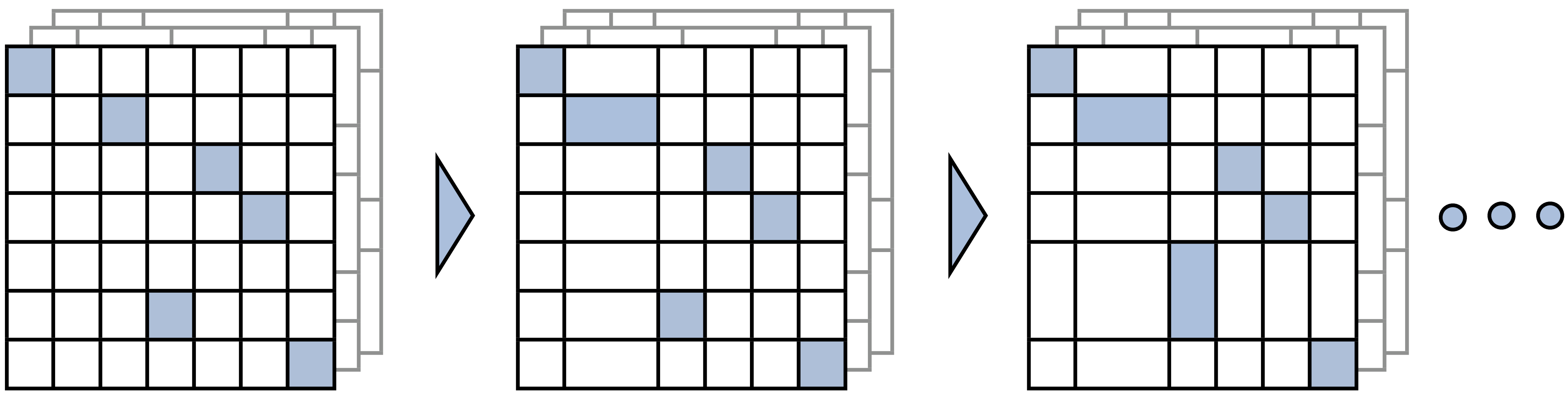

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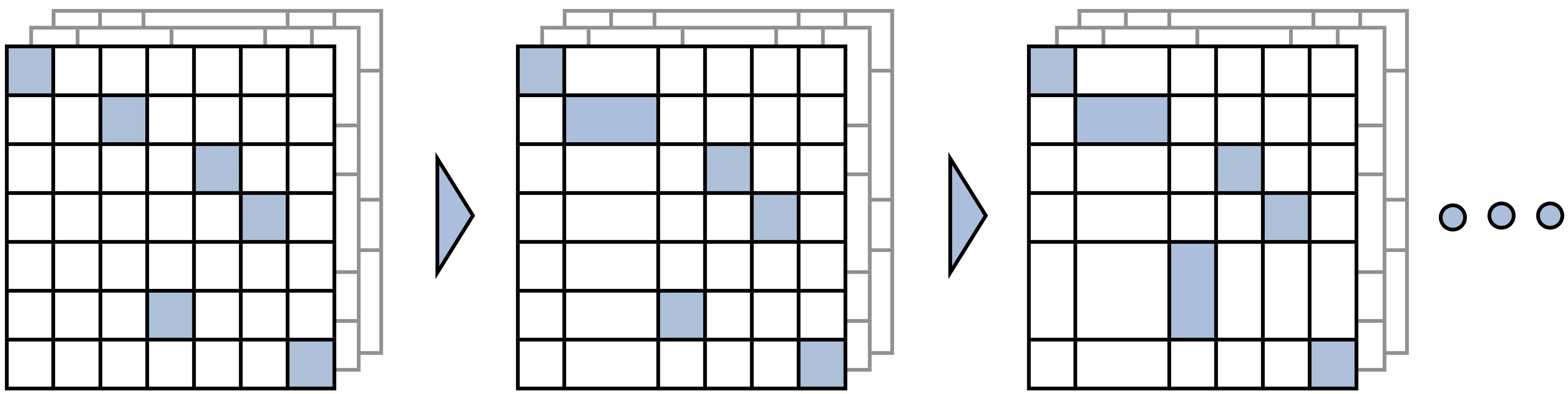
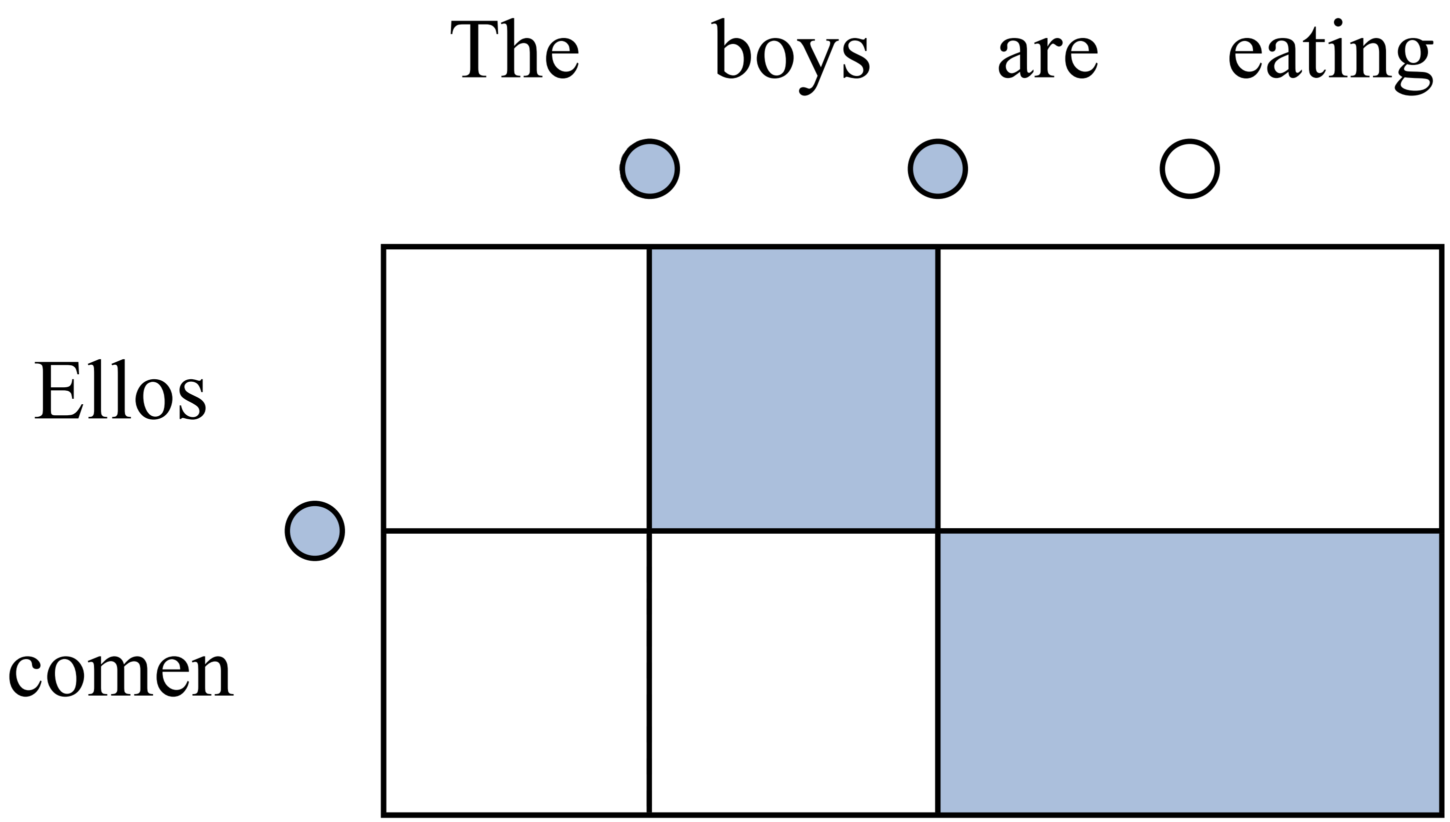


As samples are generated:

- Track phrase pair counts for current sample
- Average phrase alignment counts over all samples

Gibbs Sampling Example: Flip Operator



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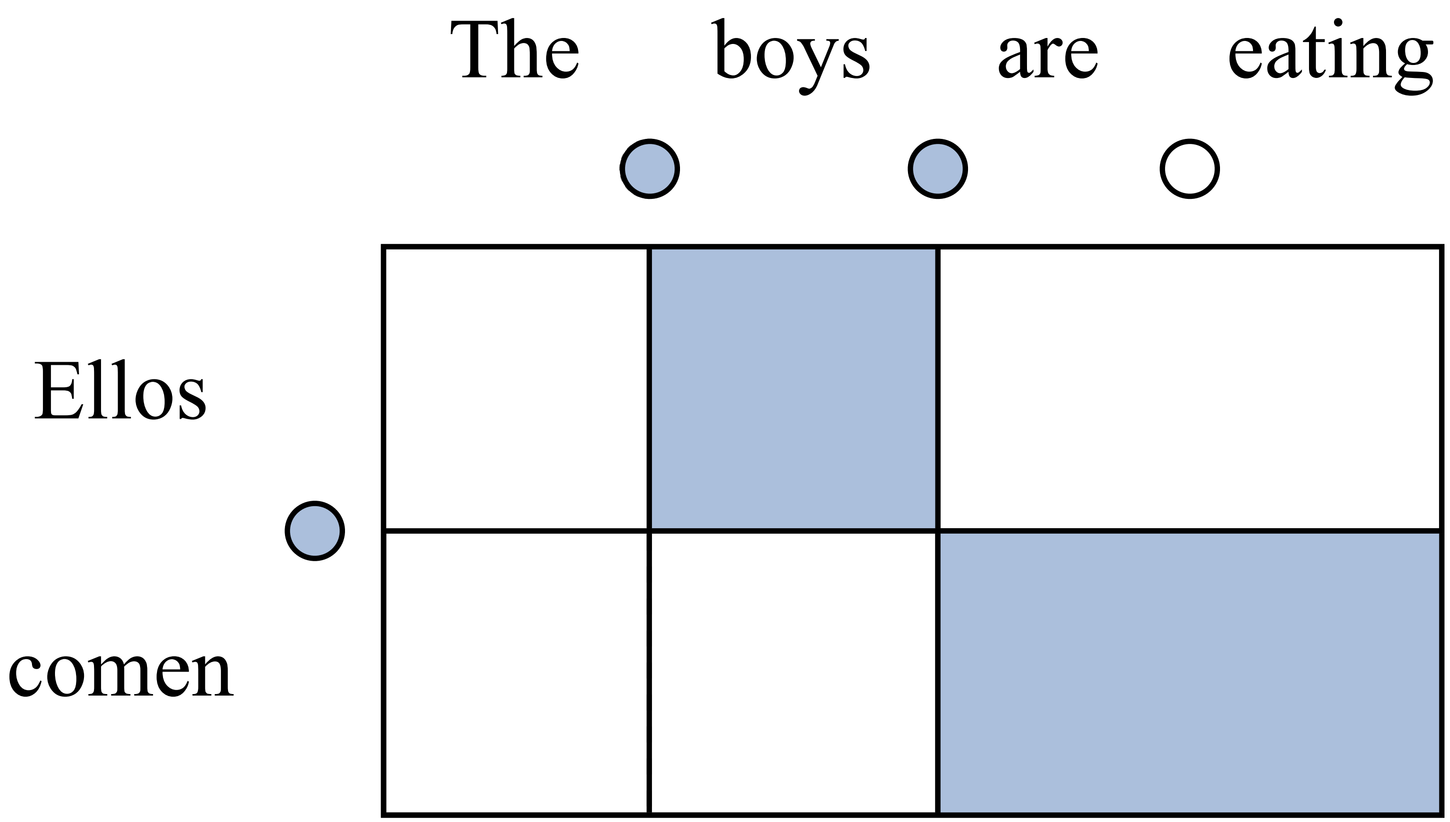

Procedure:

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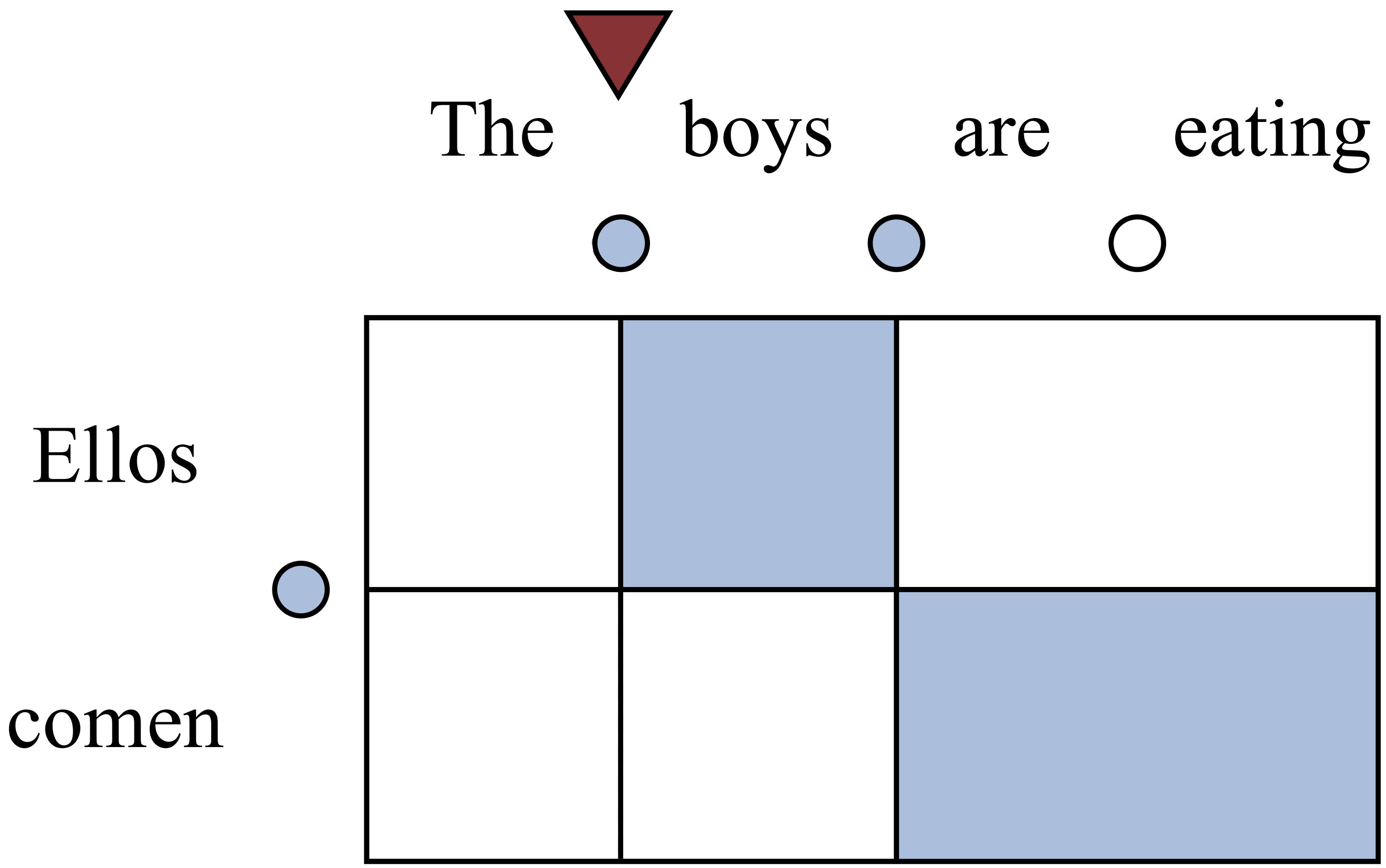
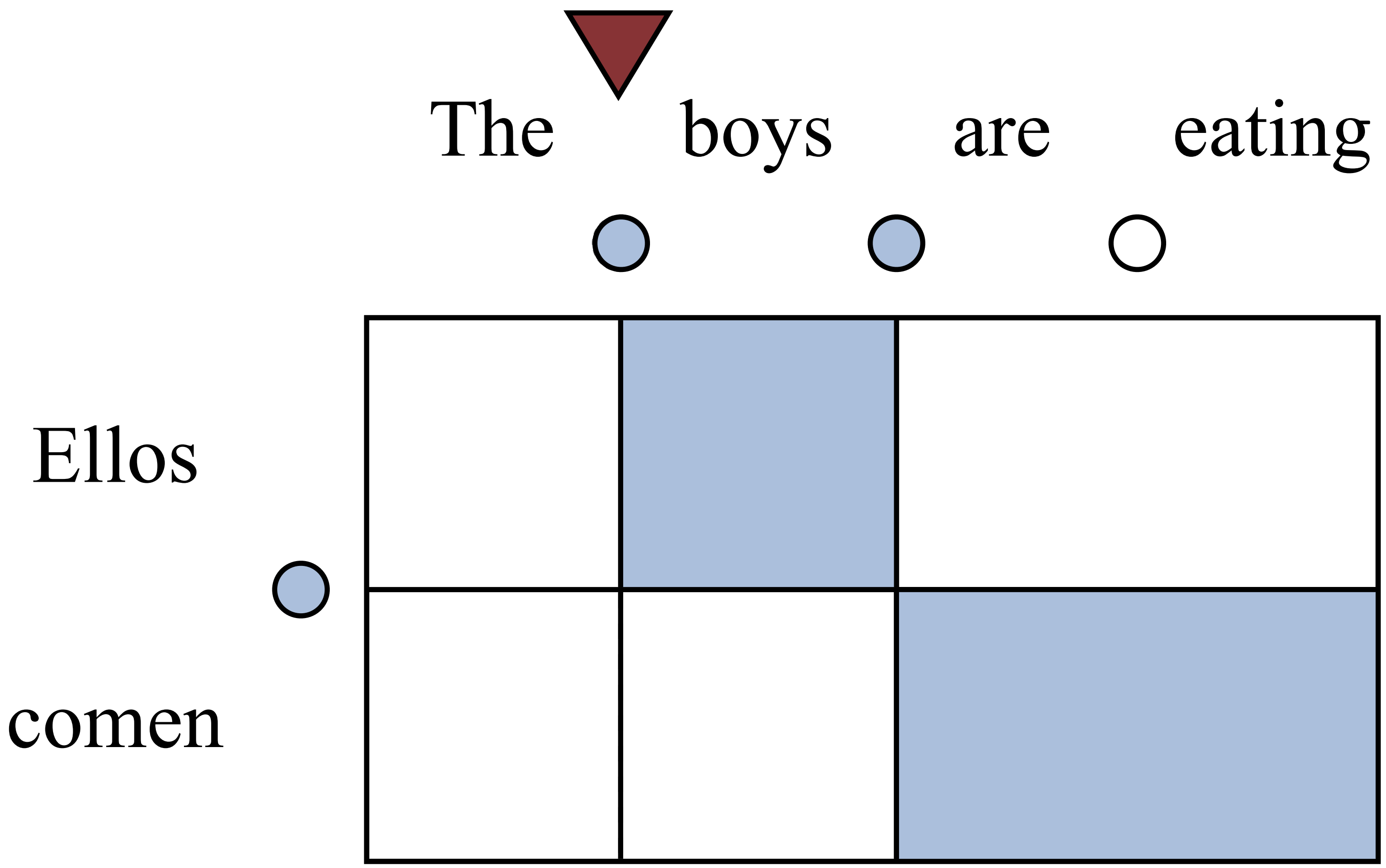


Procedure:

- Choose a position

Gibbs Sampling Example: Flip Operator



Procedure:

- Choose a position
- List all outcomes

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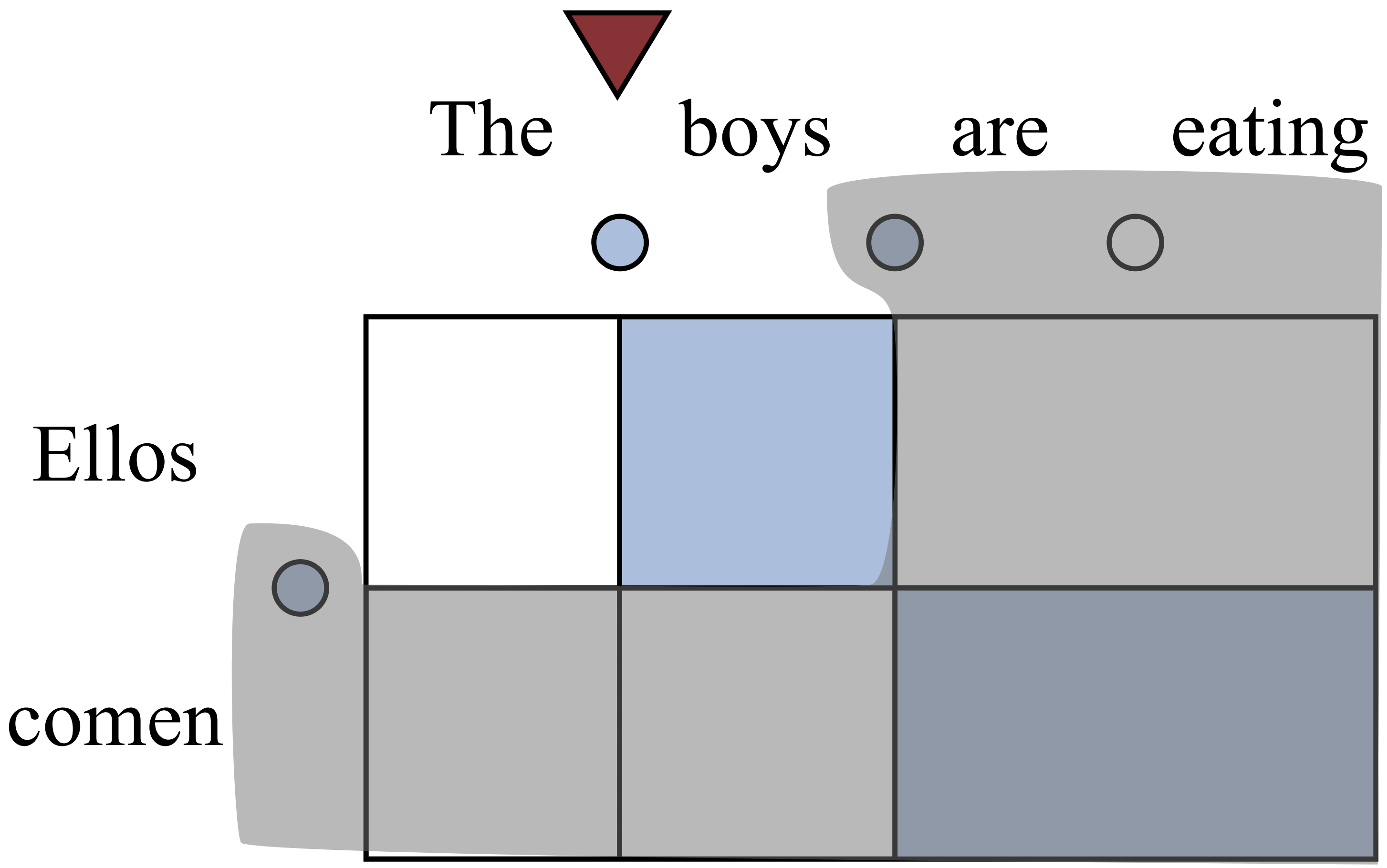

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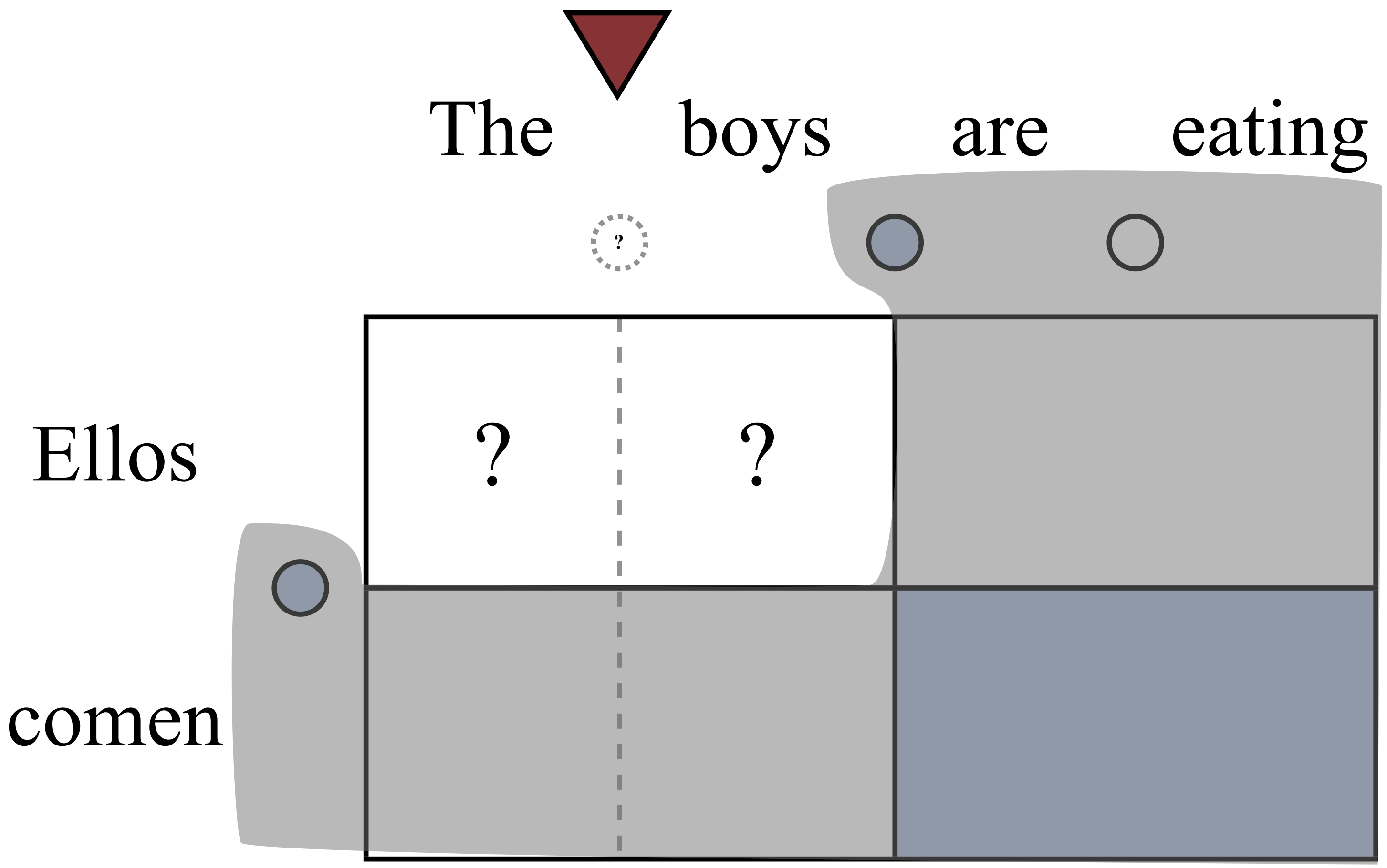

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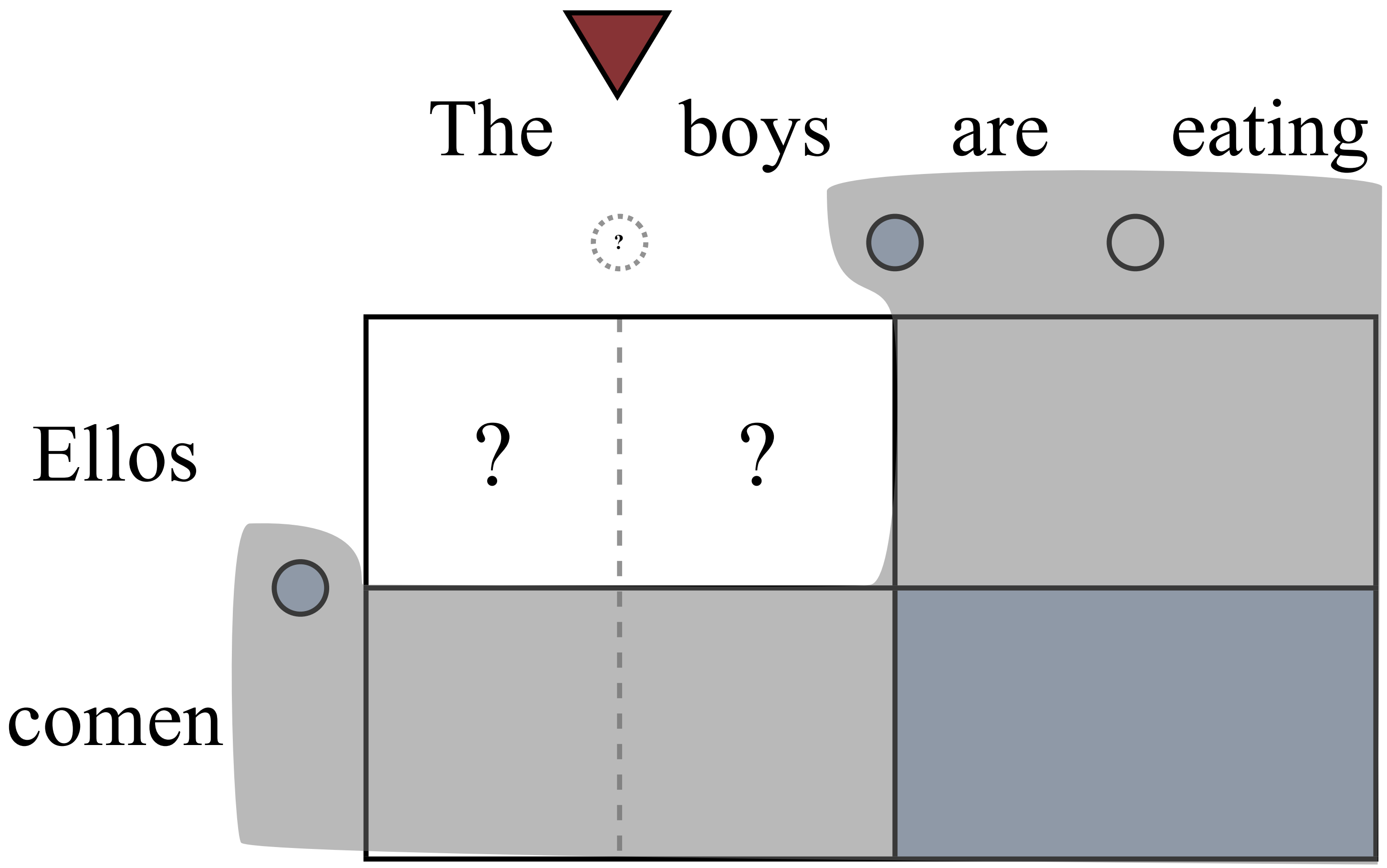

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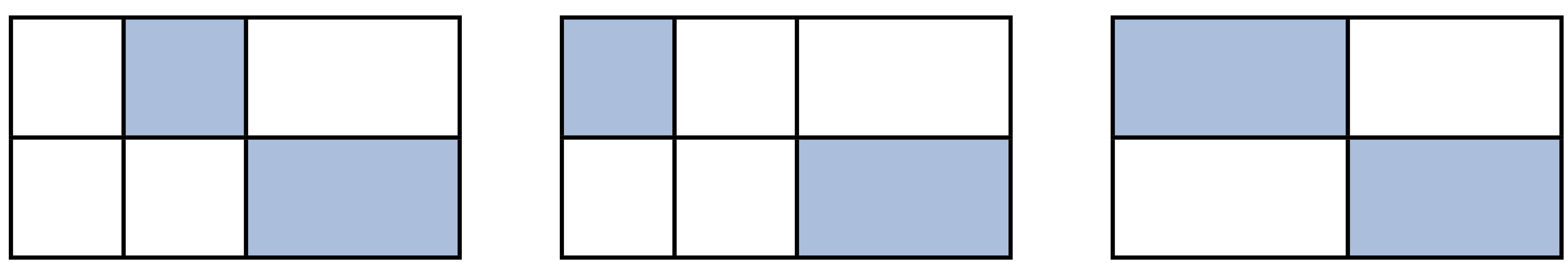

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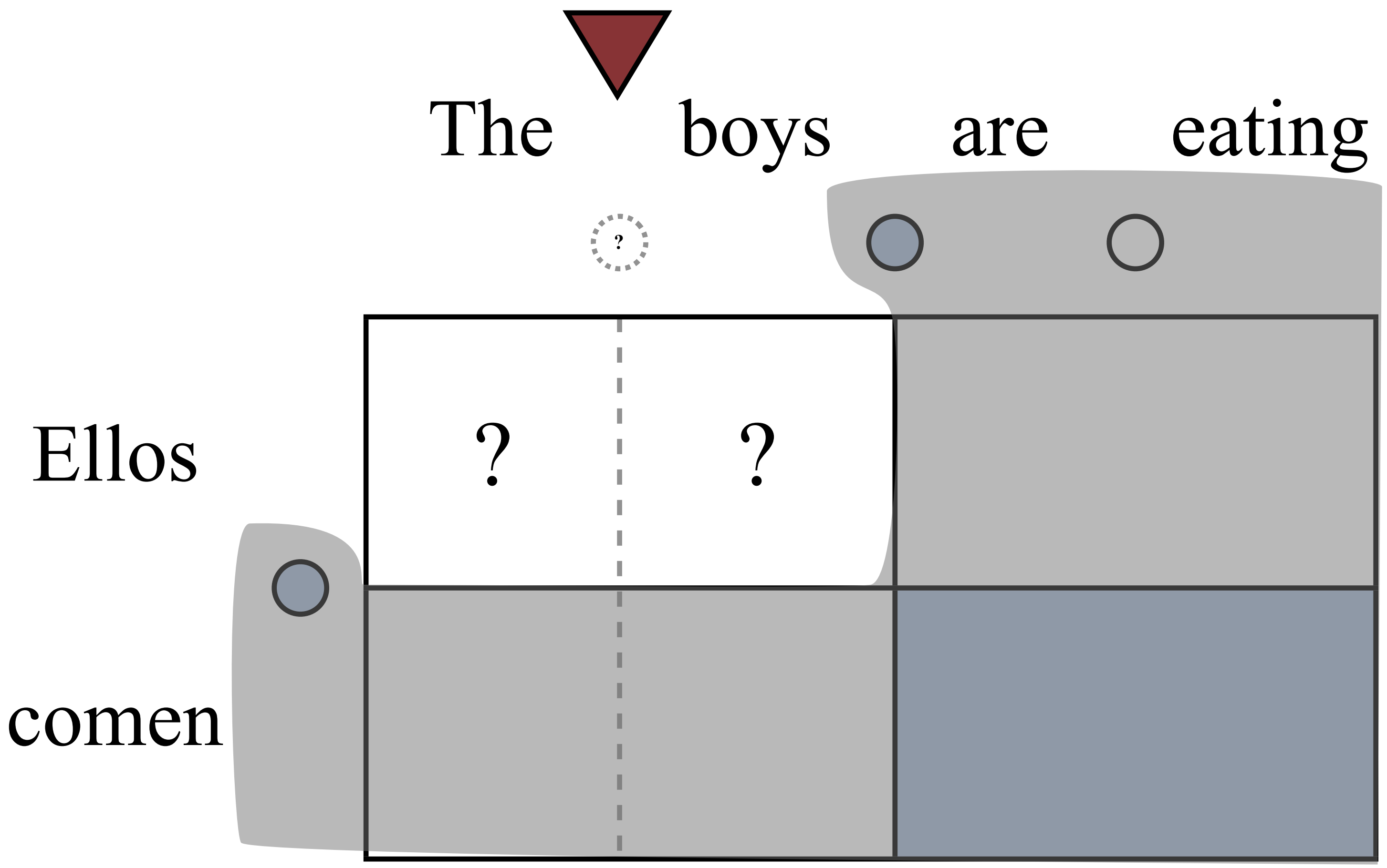
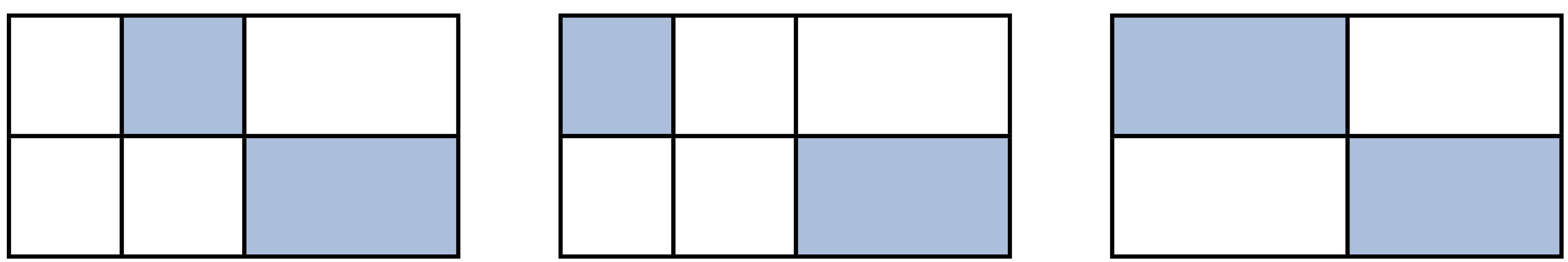


Procedure:

- Choose a position
- List all outcomes
- Compute posteriors



$$P(\cdot|state) \propto \quad P(boys, ellos)\cdot P(the, -) \quad\quad P(boys, -)\cdot P(the, ellos) \quad\quad P(the\ boys, ellos)$$

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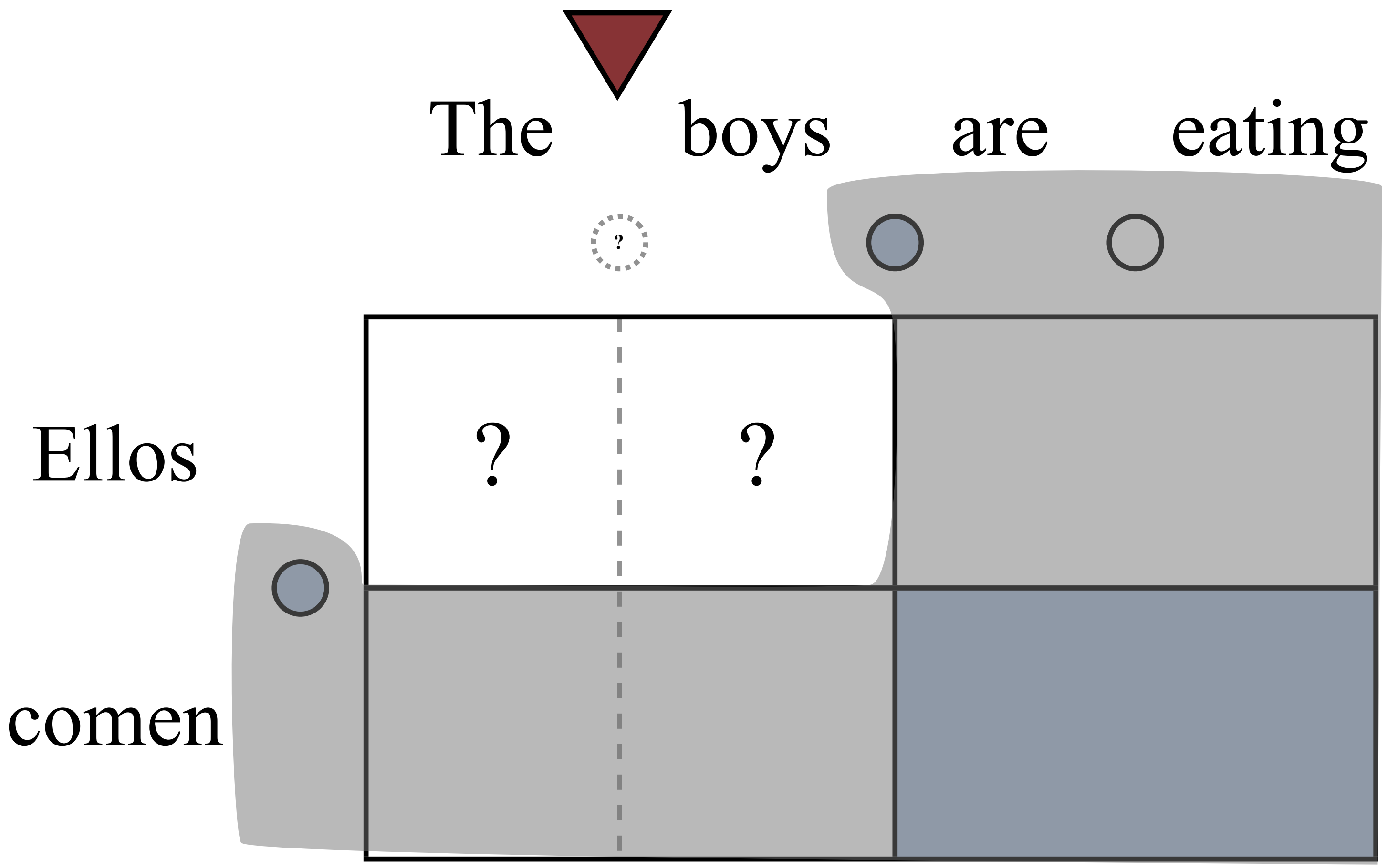

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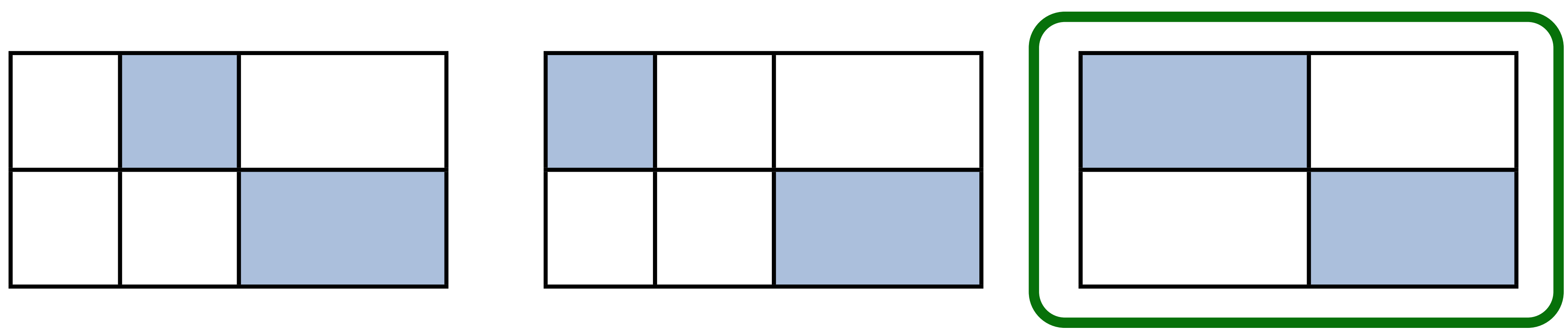

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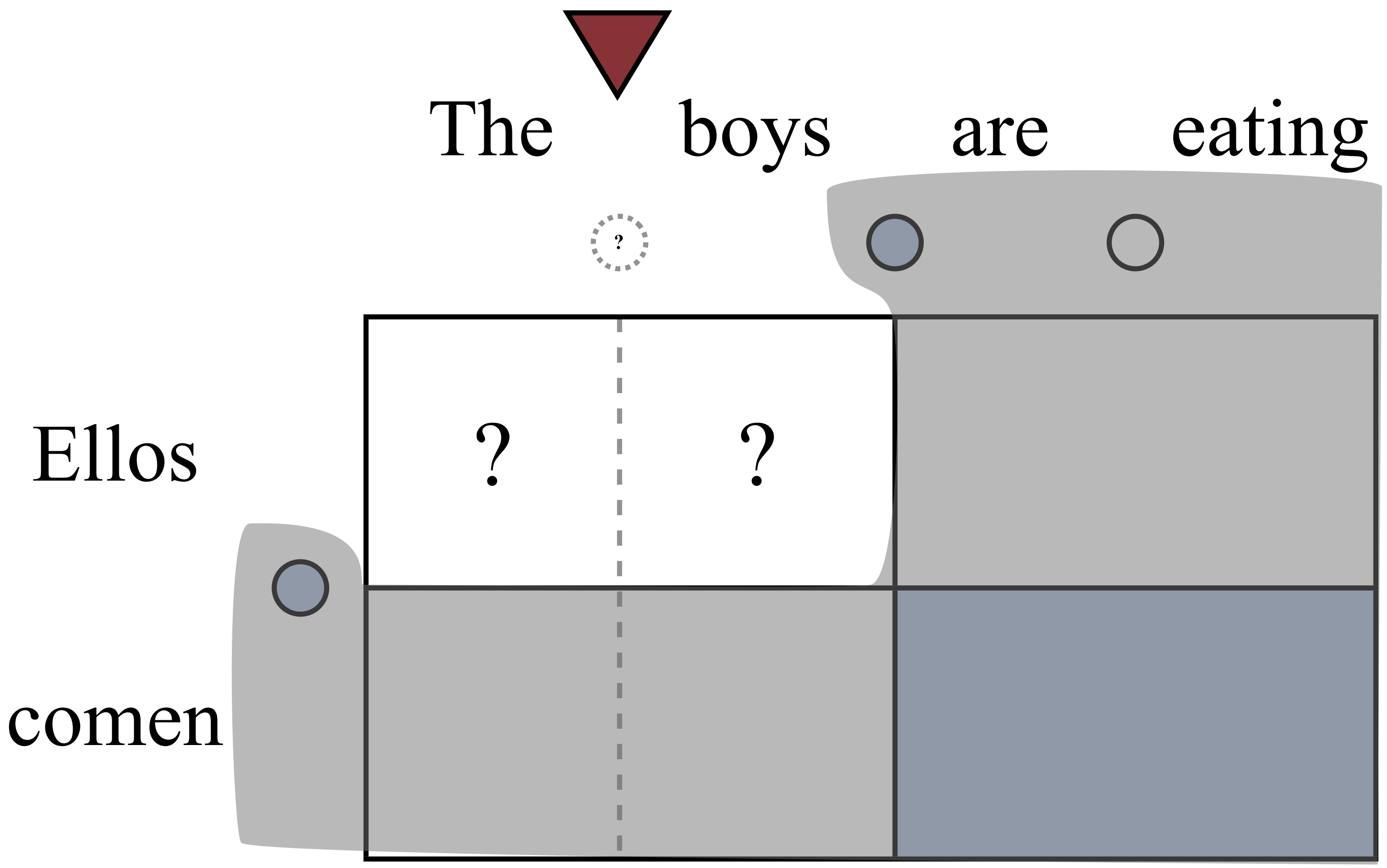
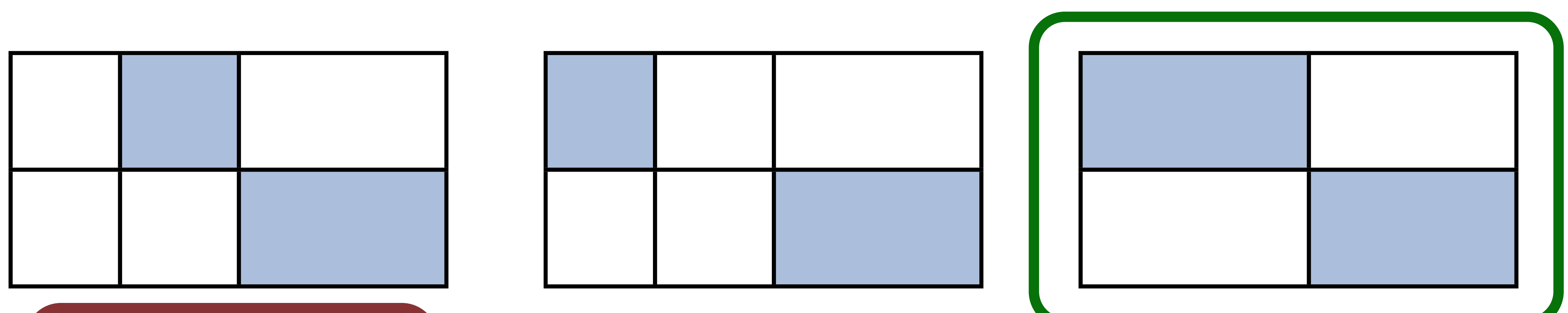


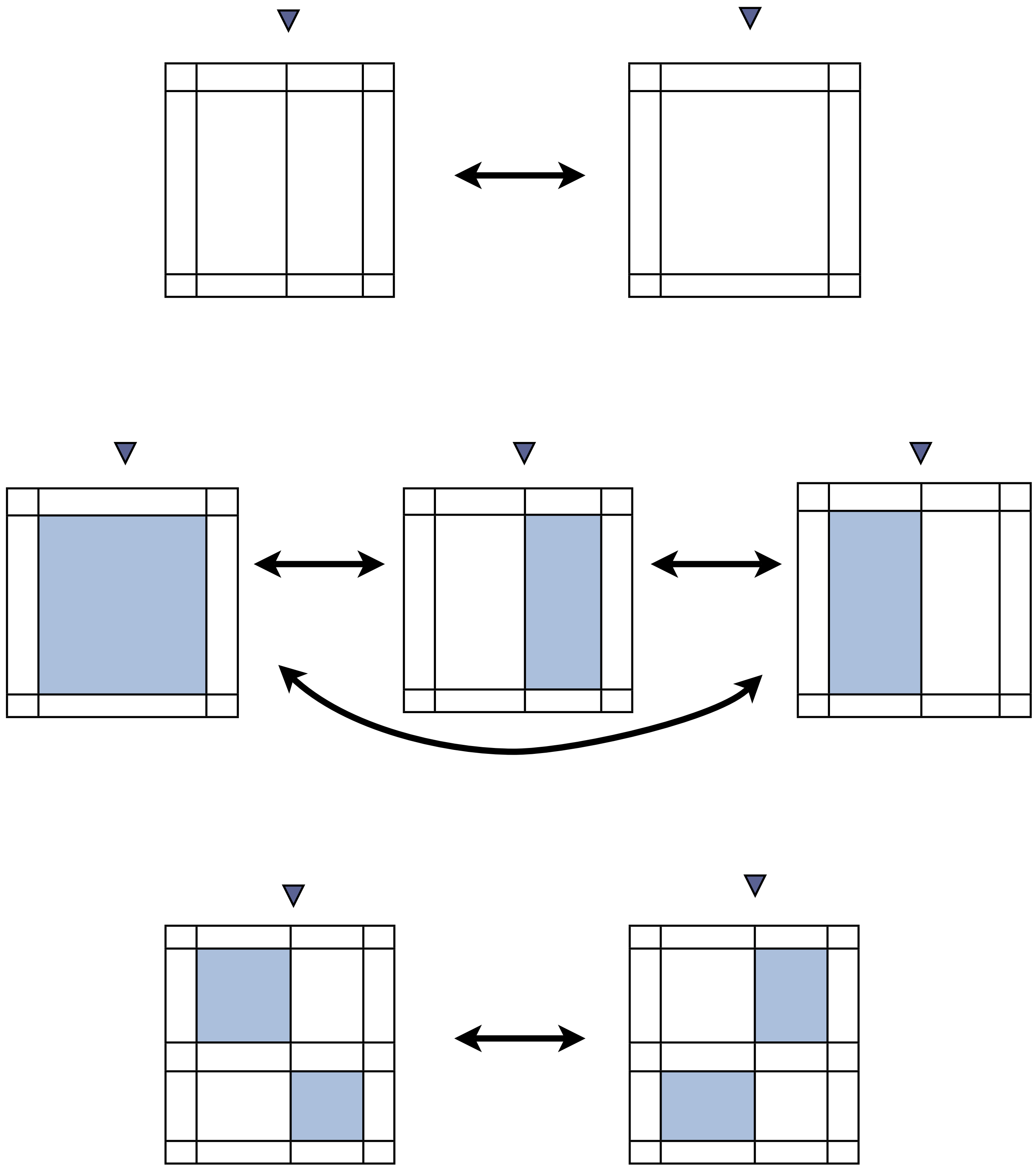
Procedure:

- Choose a position
- List all outcomes
- Compute posteriors
- Choose an outcome
- Update statistics



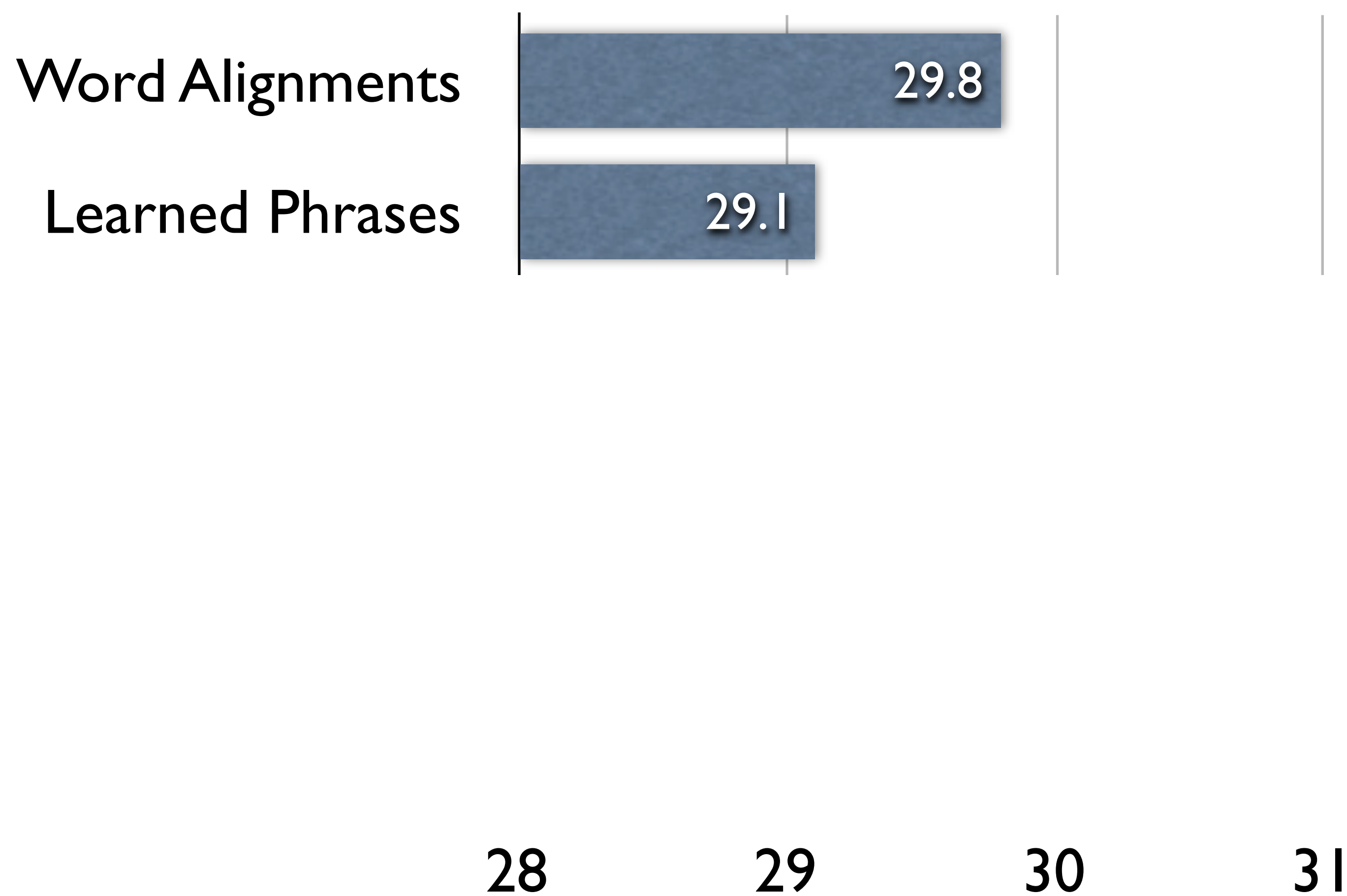
$$P(\cdot|state) \propto \quad \boxed{\begin{matrix} P(boys, ellos)\cdot \\ P(the, -) \end{matrix}} \quad \begin{matrix} P(boys, -)\cdot \\ P(the, ellos) \end{matrix} \quad \boxed{P(the\ boys, ellos)}$$

The Flip Operator Configurations



Performance Results

Translation performance in a phrase-based system (Moses) for English-Spanish parliamentary proceedings (Europarl)



* Includes additional lexical features to discourage undesirable phrase pairs

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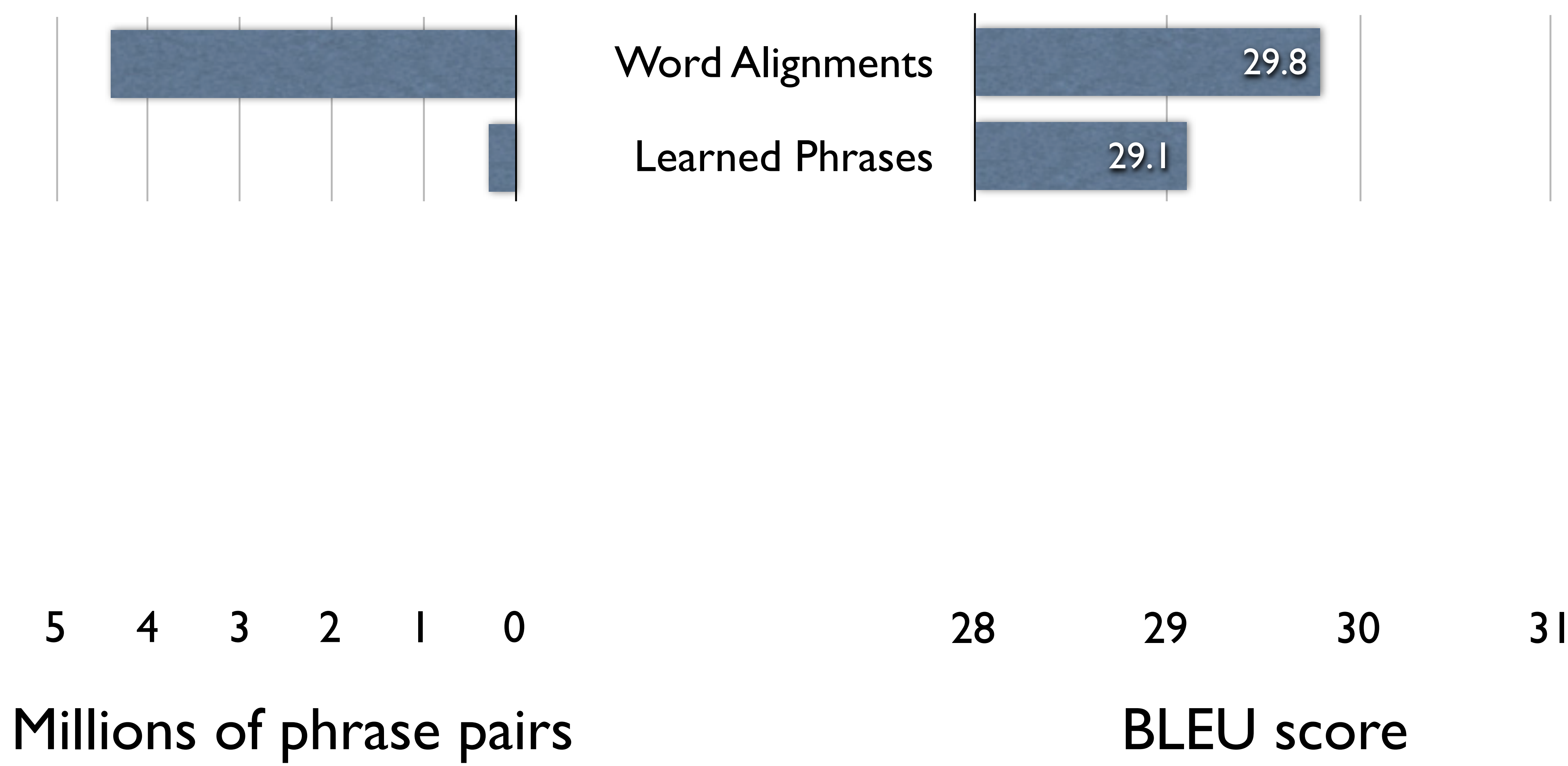

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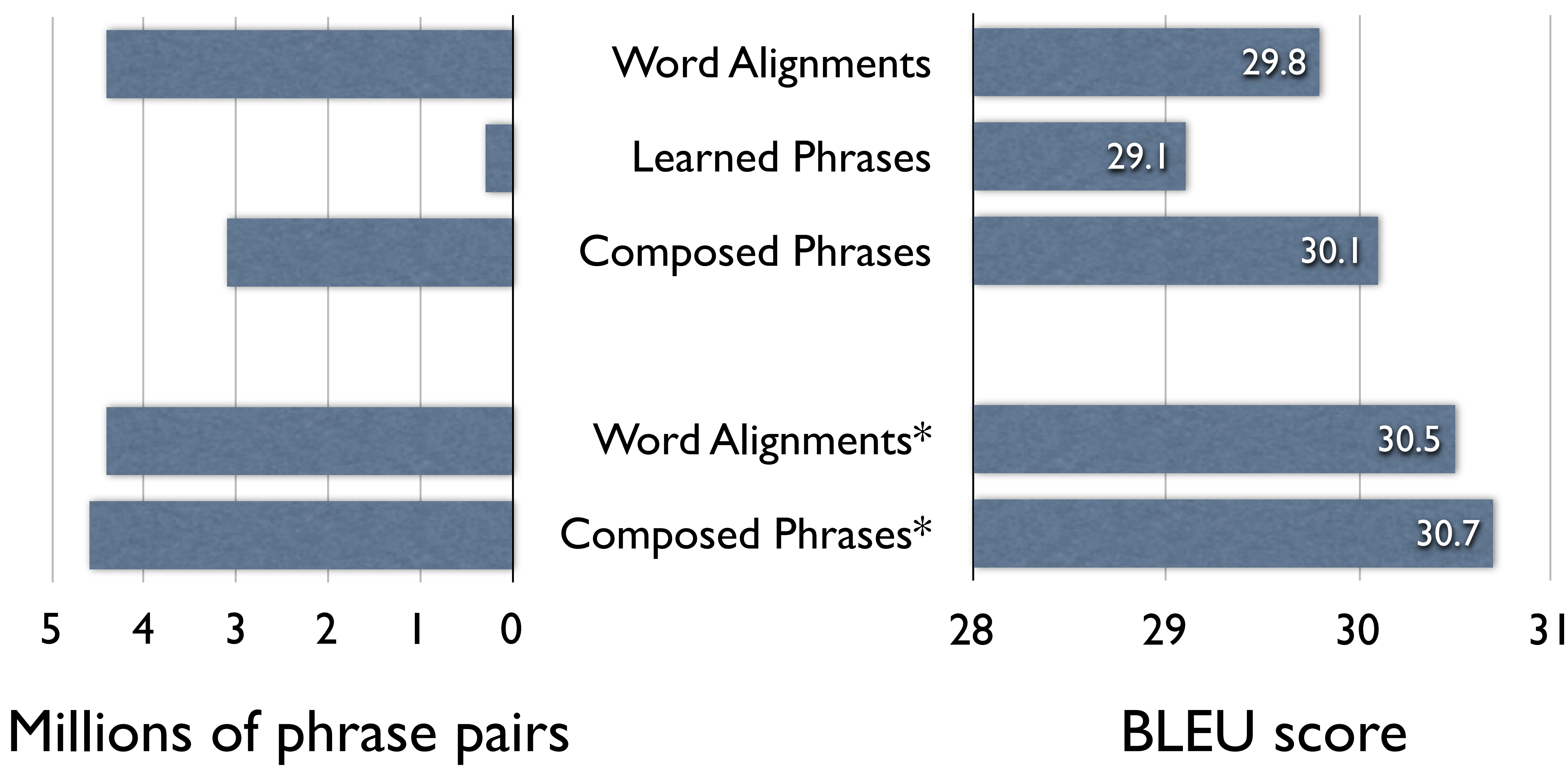

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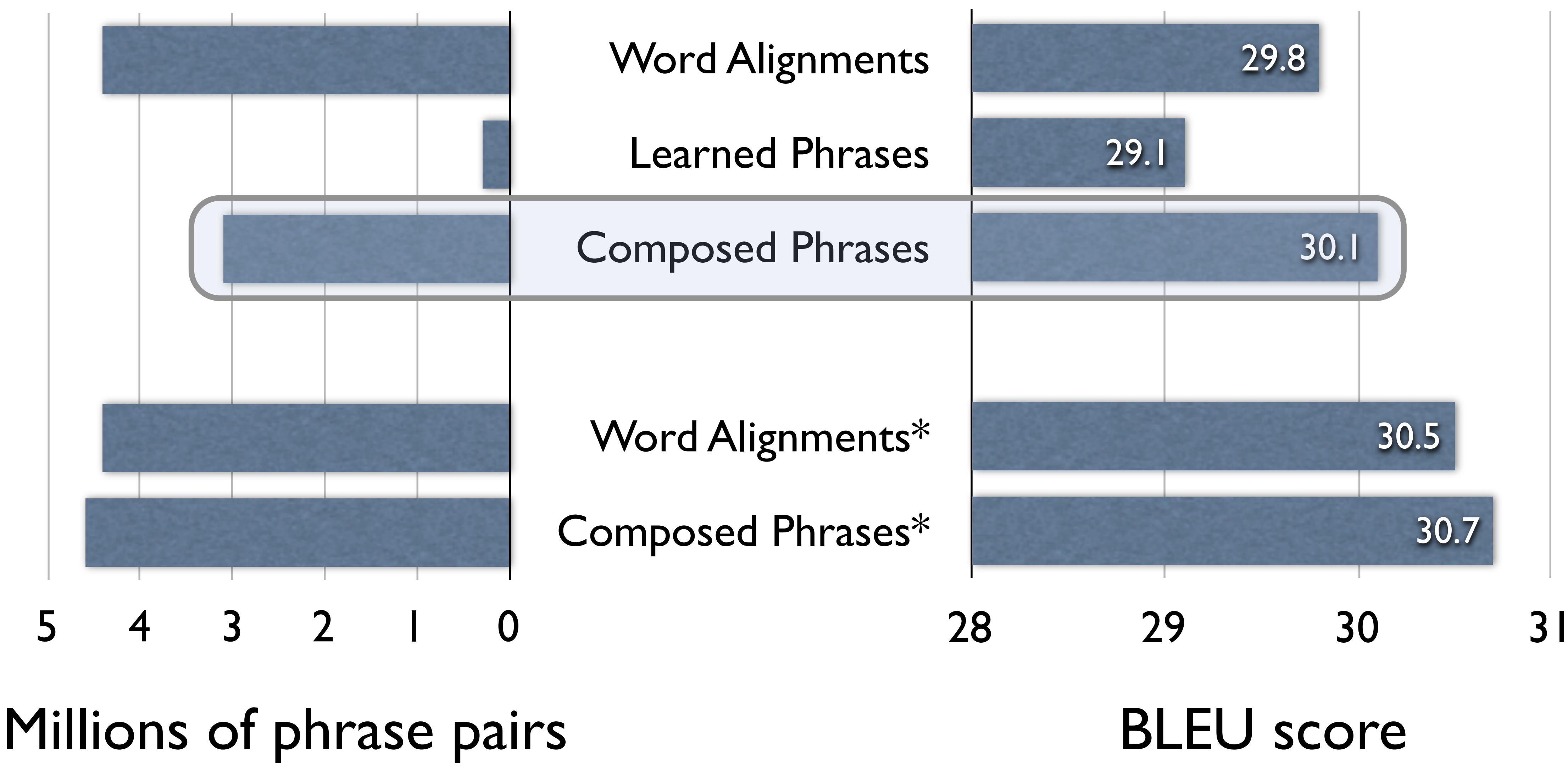

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