Preordering and Word Order Freedom in Machine Translation

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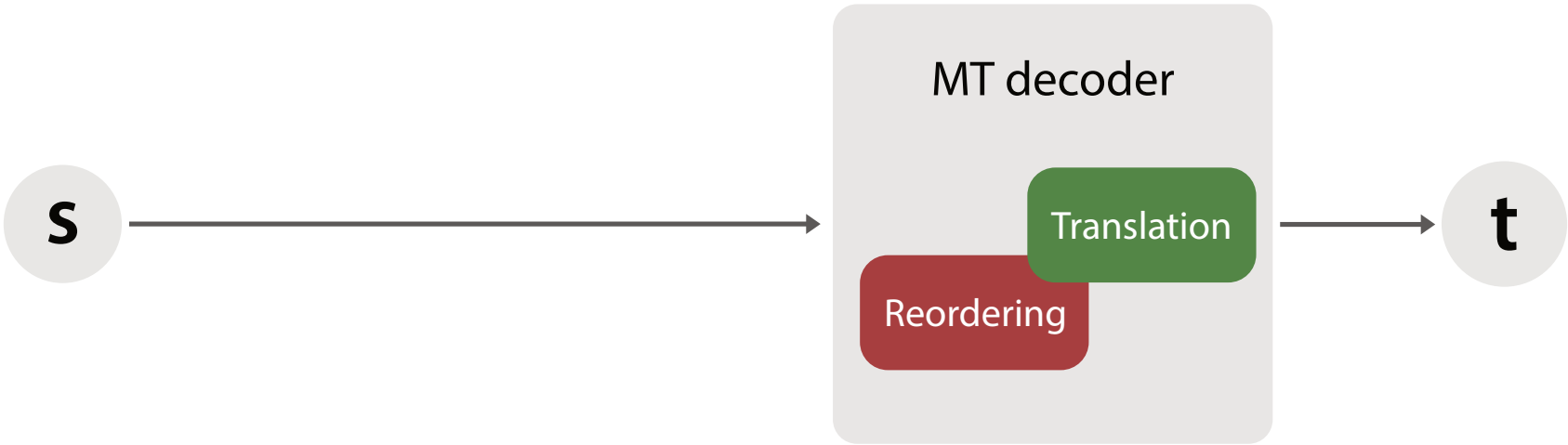
Reordering in PBMT



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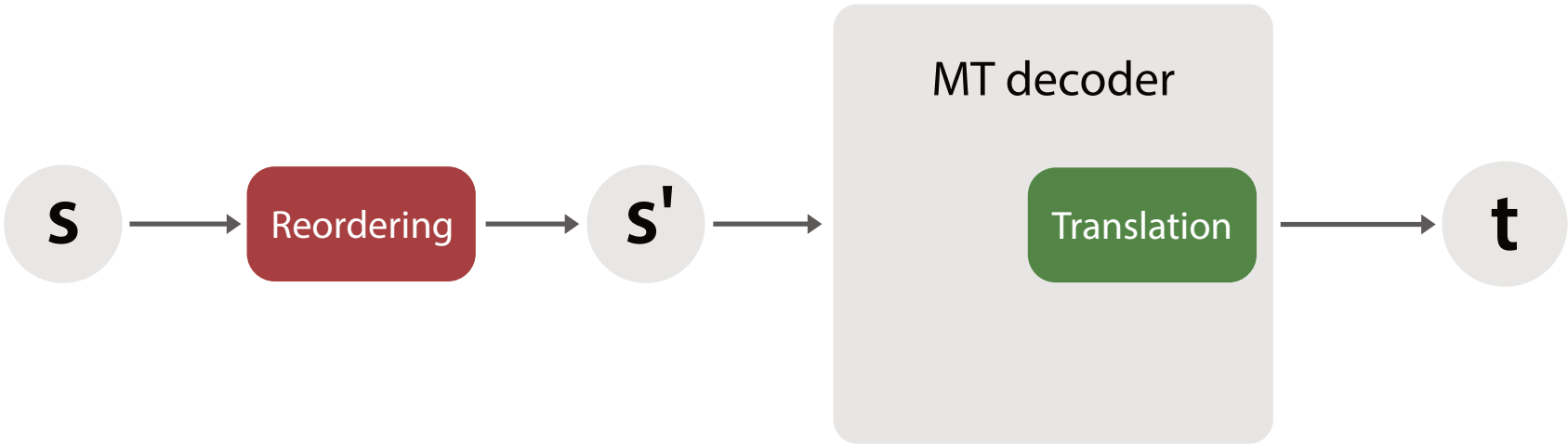

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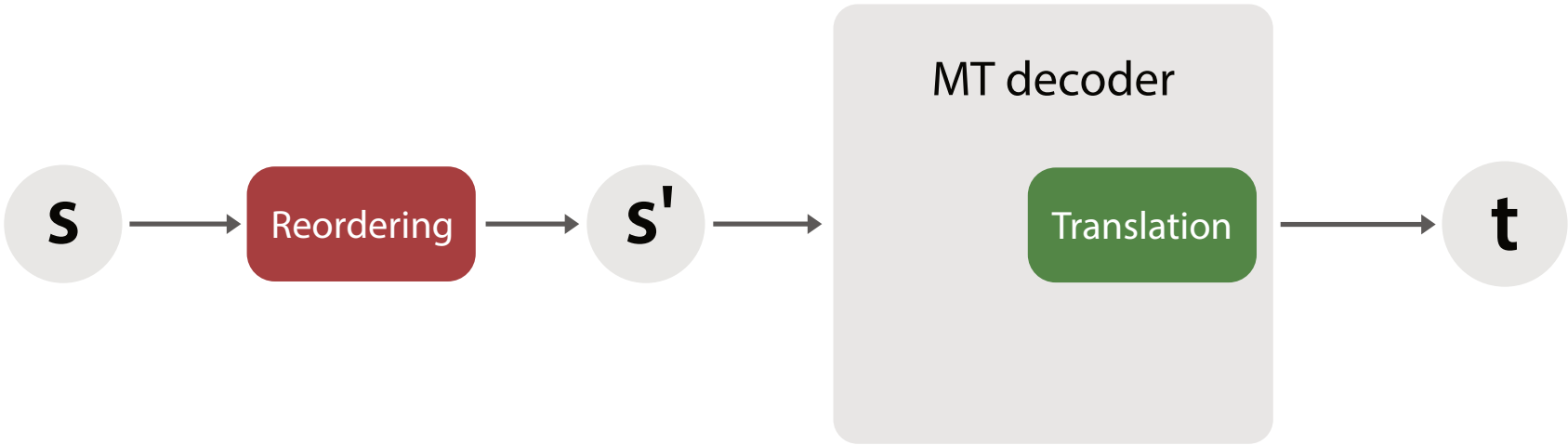

Preordering

\+ Works well for English–Japanese, English–Korean, ...

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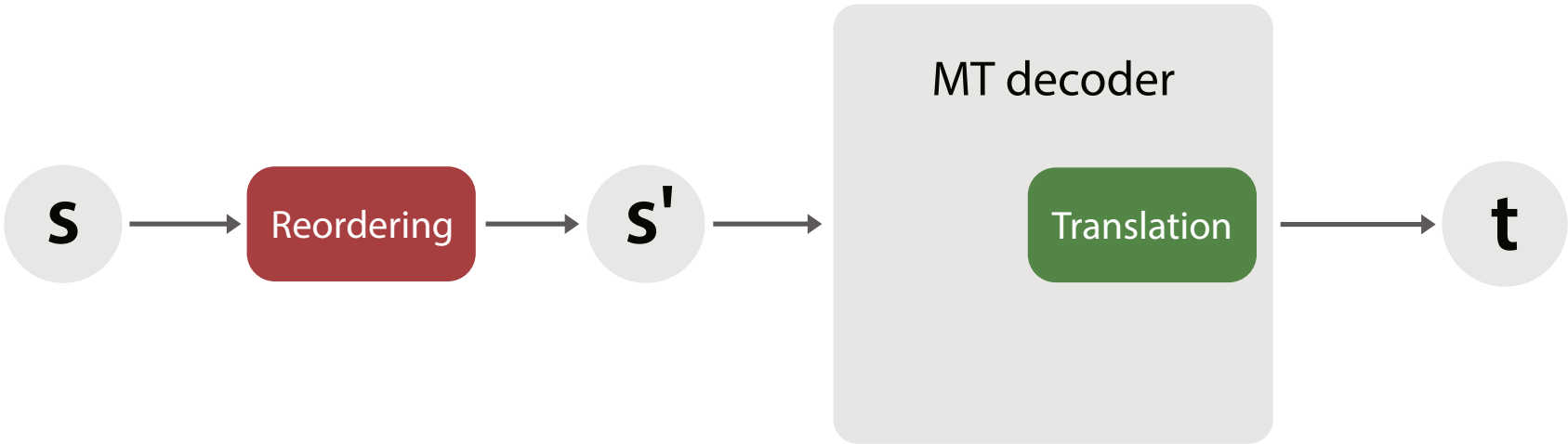

Preordering

+ Works well for English–Japanese, English–Korean, ...
– Not that well for English–German, English–Czech, ...

Reordering in PBMT

Why the partial success?

- **Free word order** languages are difficult: many potential target word orders

Reordering in PBMT

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- **Source side often not enough** to predict a unique target word order

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Potential solution:

- Narrow down space of target word orders and let decoder decide

Reordering in PBMT

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- **Free word order** languages are difficult: many potential target word orders
- **Source side often not enough** to predict a unique target word order

Potential solution:

- Narrow down space of target word orders and let decoder decide
- Prepare MT system for this kind of input

Outline

1. Word Order Freedom
   - What exactly do we mean by free word order?
   - Can we measure it?

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   - Permutation Lattices
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   - What exactly do we mean by free word order?
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2. Translation with Permutation Lattices
   - Permutation Lattices
   - Lattice Silver Training
3. Experiments with two language pairs
   - English–Japanese
     Strict word order language
   - English–German
     Free word order language

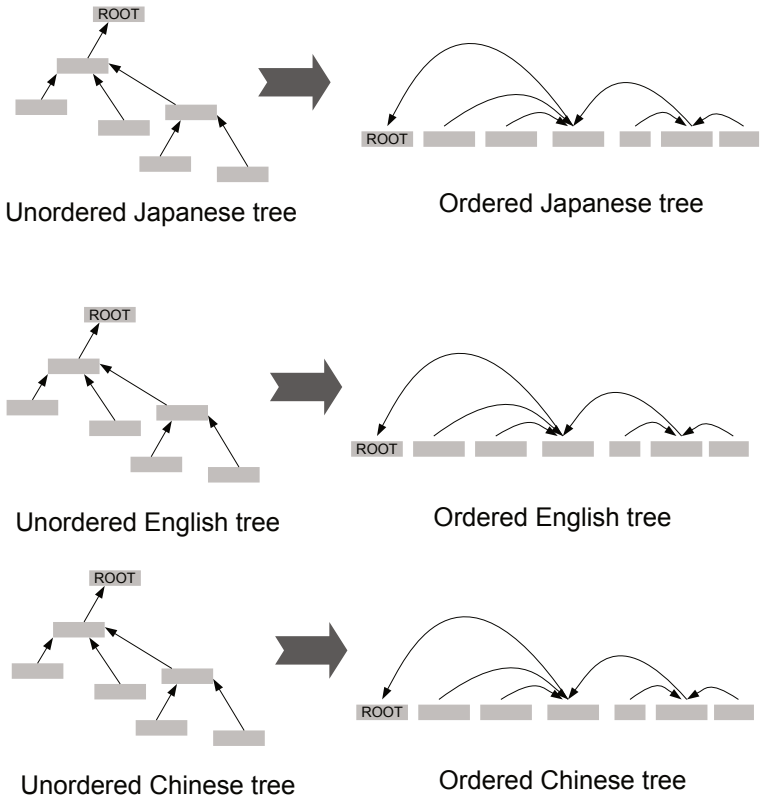
What Does Free Word Order Mean?

- Multiple word orders expressing the same meaning

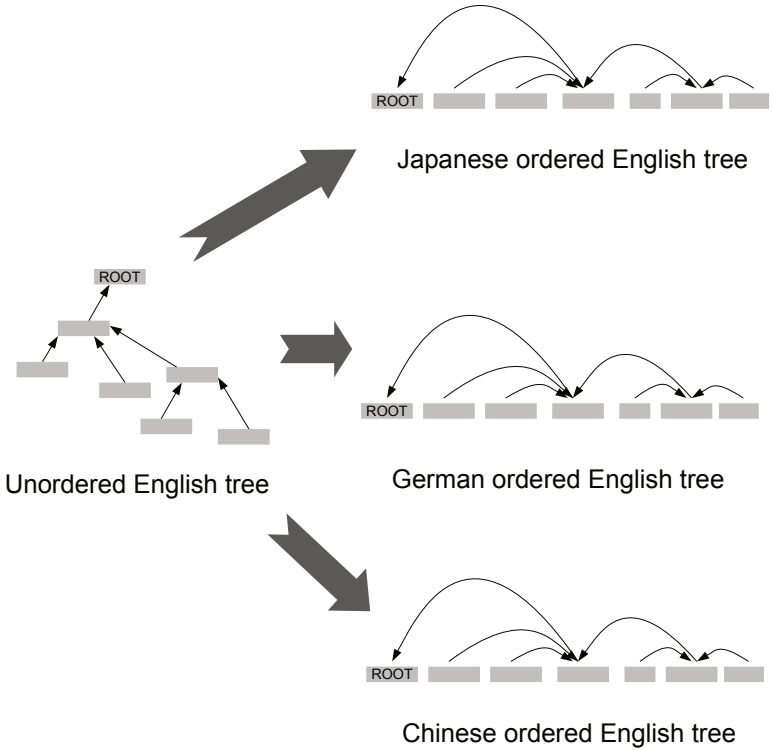
What Does Free Word Order Mean?

- Multiple word orders expressing the same meaning
  $\rightarrow$ Fuzzy definition!
- Can we quantify and compare languages' word order freedom?

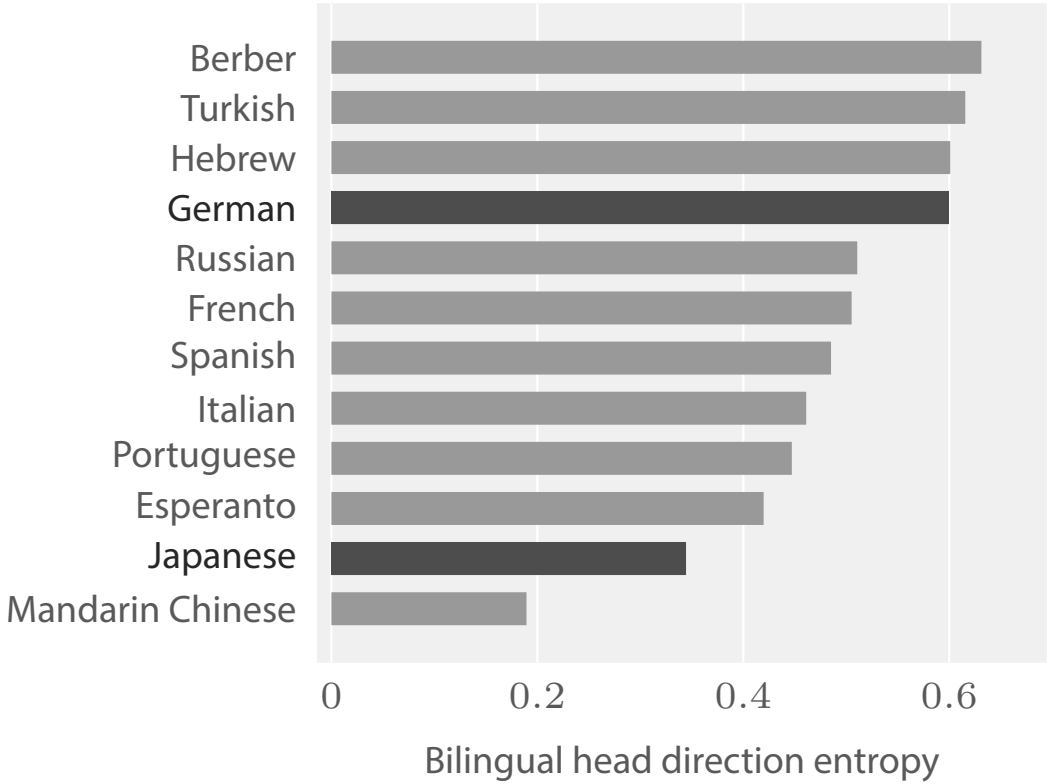
Estimating Word Order Freedom: Futrell et al. (2015)



Estimating Word Order Freedom: Our Bilingual Approach



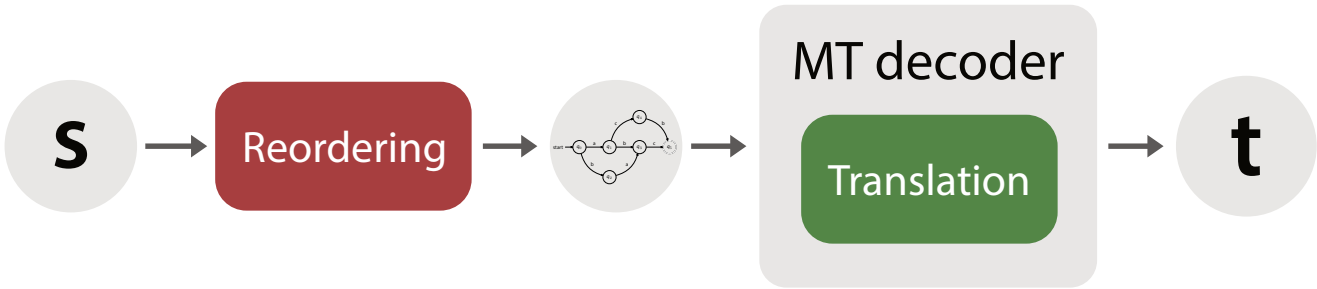
Word Order Freedom



Free Word Order

What to do about Free Word Order?

- Instead of choosing 1-best word order, work with *n*-best



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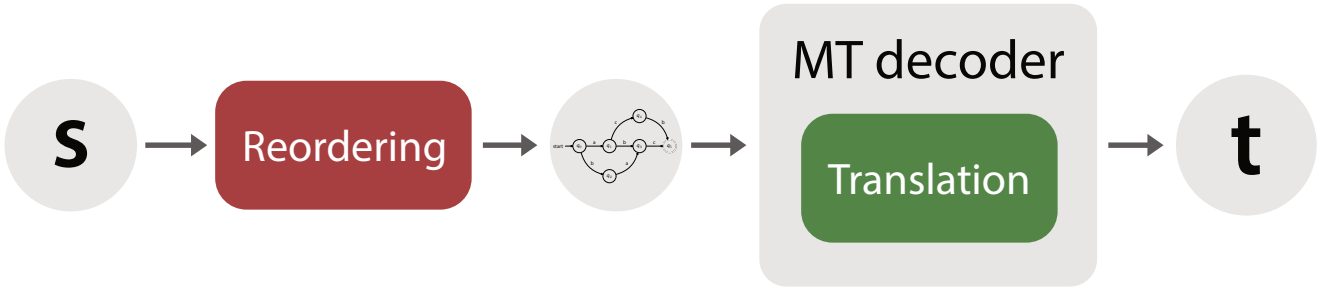
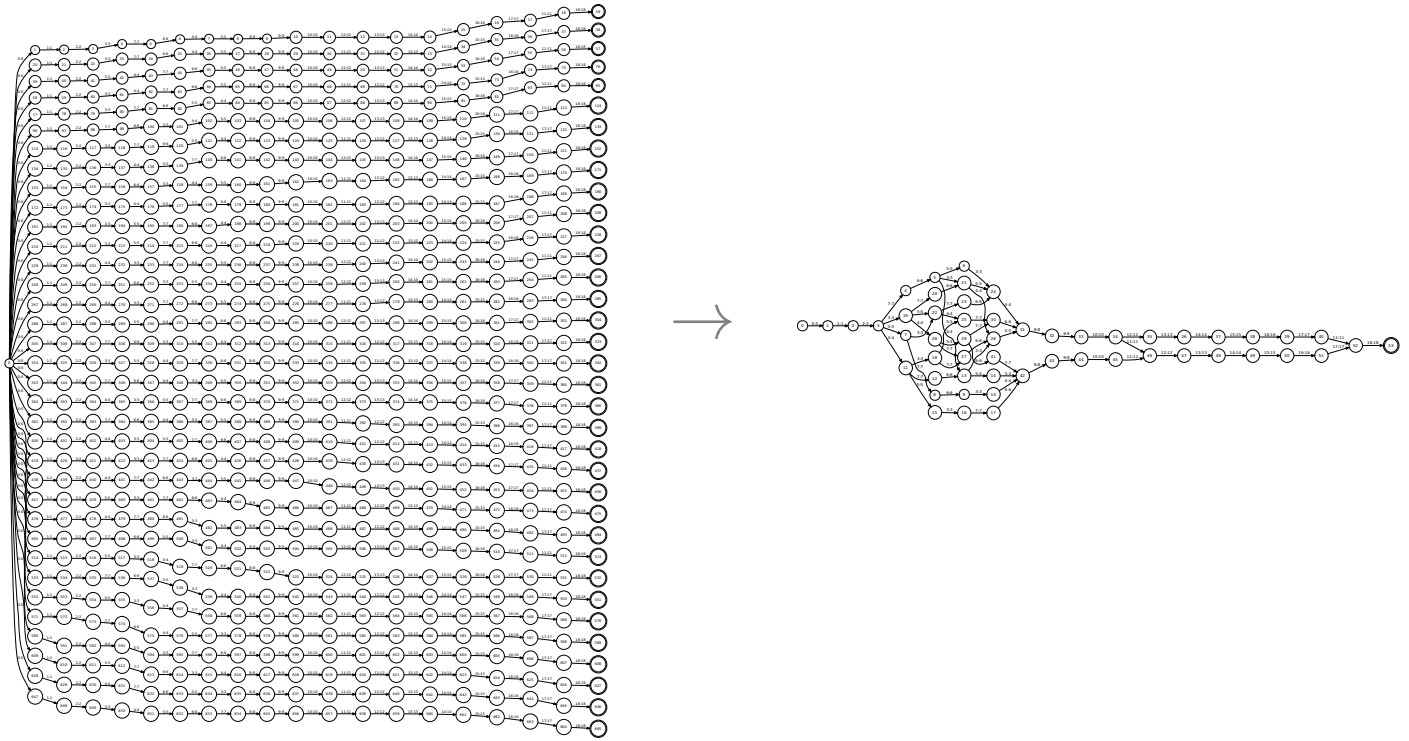


- Decoding with *n*-best permutations:
  - **1) Inference:** Compactly encode *n*-best WOs into lattice
  - **2) Training:** Estimate parameters for translating lattices

Permutation Lattices



Lattice Training

Q: How to extract the phrase table?

Gold Training

(target-order $\mathbf{s}'$, $\mathbf{t}$)

+ compact
+ less noisy
– may not cover preordered input

Lattice Training

Q: How to extract the phrase table?

Gold Training	**Predicted Training**
(target-order $\mathbf{s}'$, $\mathbf{t}$)	(predicted $\mathbf{s}'$, $\mathbf{t}$)
+ compact	? less compact
+ less noisy	– more noisy
– may not cover preordered input	+ covers preordered input

Lattice Training

Q: How to extract the phrase table?

Gold Training

(target-order $\mathbf{s}'$, $\mathbf{t}$)

+ compact
+ less noisy
– may not cover preordered input

Predicted Training

(predicted $\mathbf{s}'$, $\mathbf{t}$)

? less compact
– more noisy
+ covers preordered input

Lattice Silver Training

($\mathbf{s}'$ from *n*-best most similar to gold, $\mathbf{t}$)

+ compact
+ less noisy
+ covers preordered input

Preordering Models

Reordering Grammar

Stanojević and Sima'an (2015)

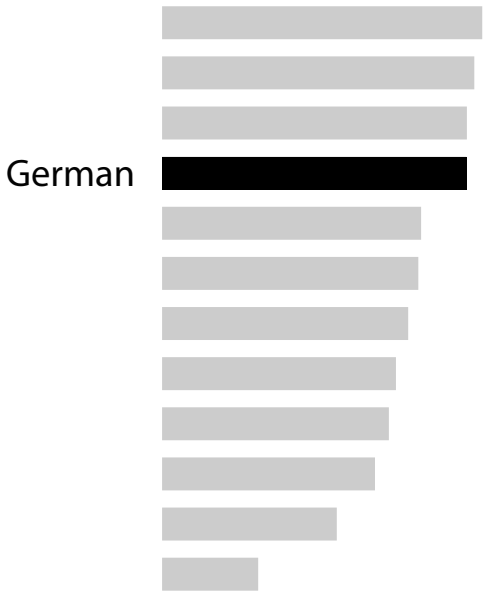
- Hierarchical, probabilistic model
- Unsupervised (no syntax)
- Beyond ITG (based on PETs)

Neural Preordering

de Gispert et al. (2015); Jehl et al. (2014)

- Preorders dep. tree recursively
- NN to decide pairwise ordering of subtrees
- We extend search to *n*-best branch-and-bound

Translation Experiment: English→German

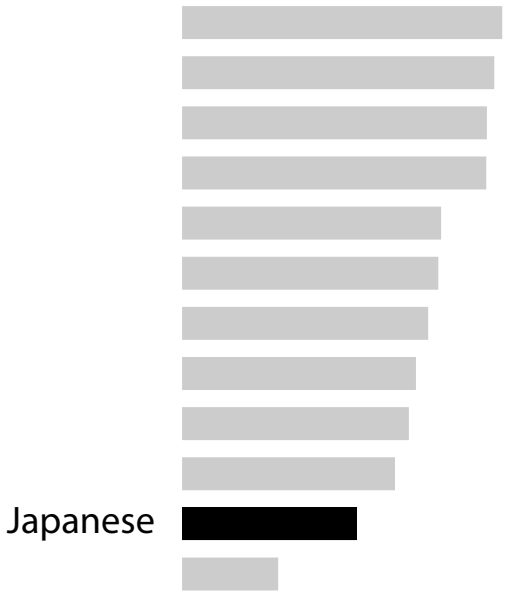


On WMT newstest 2015.

- Big oracle WO gain:
  +4.92 over baseline (21.76 BLEU)
- 1-best with DL 6 performs poorly
- Lattices with Silver Training and DL 0
  on par with baseline +0.12

Software: Moses (with extended lattice support). Optimizer: Batch MIRA (15 iterations, BLEU averaged over 3 runs).
Training data: 4.5m sentence pairs (WMT16). LM (5-gram): 189m sentences (WMT16). Dev/Test: newstest2014/newstest2015.

Translation Experiment: English→Japanese



On NTCIR Patent translation task.

- Big oracle WO gain:
  +4.57 over baseline (29.65 BLEU)
- 1-best with DL 6 performs well: +2.49
- Lattices with DL 0 enables additional improvement: +2.85

Software: Moses (with extended lattice support). Optimizer: Batch MIRA (15 iterations, BLEU averaged over 3 runs).
Training data: NTCIR-8 Patent Translation Task. Target tokenization: KyTea 5 Neubig et al. (2011). LM (5-gram): NTCIR-8. Dev/Test: NTCIR-7/NTCIR-9.

Summary of our Contributions

Bilingual Head Direction Entropy:

- Information-theoretic measure of word order freedom

Permutation Lattices produced from preordering models:

- Valuable tool to address uncertainty in word order
- Strict word order (En→Ja)
  - Additional improvements over 1-best preordering with DL 0
- Free word order (En→De)
  - Lattice Silver Training important for model estimation
  - Enable automatic preordering with DL 0

Thank You!

Questions?

de Gispert, A., Iglesias, G., and Byrne, W. (2015). Fast and accurate preordering for smt using neural networks. In *Proceedings of the Conference of the North American Chapter of the Association for Computational Linguistics - Human Language Technologies (NAACL HLT 2015)*.

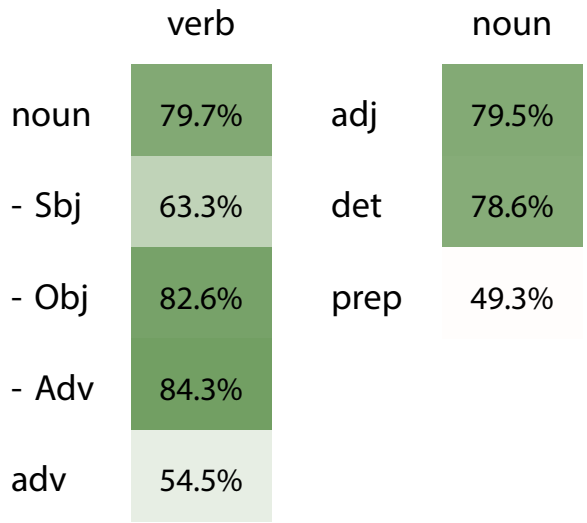
Futrell, R., Mahowald, K., and Gibson, E. (2015). Quantifying word order freedom in dependency corpora. In *Proceedings of the Third International Conference on Dependency Linguistics (Depling 2015)*, pages 91–100, Uppsala, Sweden. Uppsala University, Uppsala, Sweden.

Jehl, L., de Gispert, A., Hopkins, M., and Byrne, B. (2014). Source-side preordering for translation using logistic regression and depth-first branch-and-bound search. In *Proceedings of the 14th Conference of the European Chapter of the Association for Computational Linguistics*, pages 239–248 (12 pages), Gothenburg, Sweden. Association for Computational Linguistics.

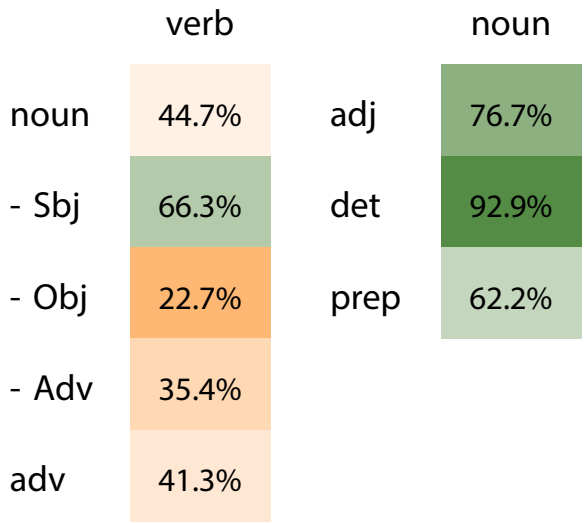
Neubig, G., Nakata, Y., and Mori, S. (2011). Pointwise prediction for robust, adaptable japanese morphological analysis. In *Proceedings of the 49th Annual Meeting of the Association for Computational Linguistics: Human Language Technologies*, pages 529–533, Portland, Oregon, USA.

Stanojević, M. and Sima'an, K. (2015). Reordering Grammar Induction. In *Proceedings of the 2015 Conference on Empirical Methods in Natural Language Processing*, pages 44–54, Lisbon, Portugal. Association for Computational Linguistics.

Word Order Freedom: Micro Level



(a) English–Japanese



(b) English–German

Number of Permutations vs. Lattice Size

		Lattice	
Permutations	Kendall τ	States	Transitions
Monotone	83.78	23	22
5	84.69	24	52
10	85.23	33	69
100	86.20	72	138
1000	86.75	123	233

Table: Permutations and lattice size (En–De).

Experiments: Neural Reordering on English-German

		Translation	Word order
	DL	BLEU	Kendall τ
Baseline	6	21.76	54.75
Oracle order	6	26.68	58.05
	0	26.41	57.92
First-best	6	21.21[A]	53.44
Lattice (silver)	0	21.88[B]	54.51

Software: Moses (with extended lattice support).
Optimizer: Batch MIRA (15 iterations, BLEU averaged over 3 runs).
Training data: 4.5m sentence pairs (WMT16). LM (5-gram): 189m sentences (WMT16).
Dev/Test: newstest2014/newstest2015.

[A]Stat. significant against baseline. [B]Stat. significant against first-best.

Experiments: Reordering Grammar on English-Japanese

		Translation	Word order
	DL	BLEU	Kendall τ
Baseline	6	29.65	44.87
Oracle order	6	34.22	56.23
	0	30.55	53.98
First-best	6	32.14[A]	49.68
Lattice	0	32.50[AB]	50.79

Software: Moses (with extended lattice support). Optimiser: Batch MIRA (15 iterations).
Training data: NTCIR-8 Patent Translation Task. Target tokenization: KyTea 5 Neubig et al. (2011). LM (5-gram): NTCIR-8. Dev/Test: NTCIR-7/NTCIR-9.

[A]Stat. significant against baseline. [B]Stat. significant against first-best.