

# Generalizing Natural Language Analysis through Span-relation Representations

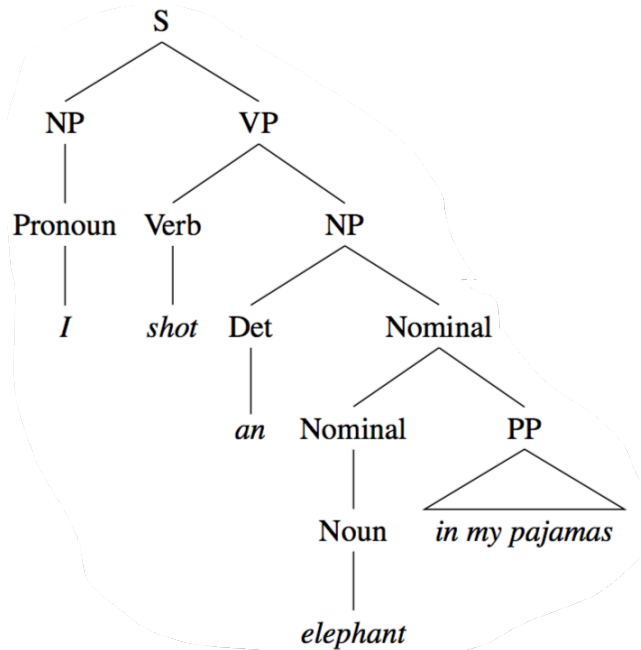
**Zhengbao Jiang**<sup>1</sup>, Wei Xu<sup>2</sup>, Jun Araki<sup>3</sup>, Graham Neubig<sup>1</sup>

Carnegie Mellon University<sup>1</sup>, Ohio State University<sup>2</sup>, Bosch Research North America<sup>3</sup>

zhengbaj@cs.cmu.edu

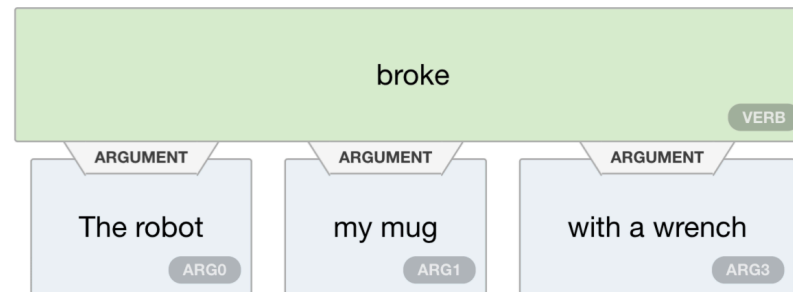
# Motivation

- NLP tasks are different
  - Capture different information

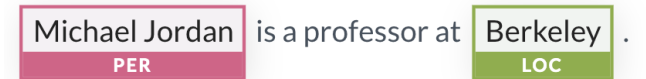


syntax

The robot broke my mug with a wrench .



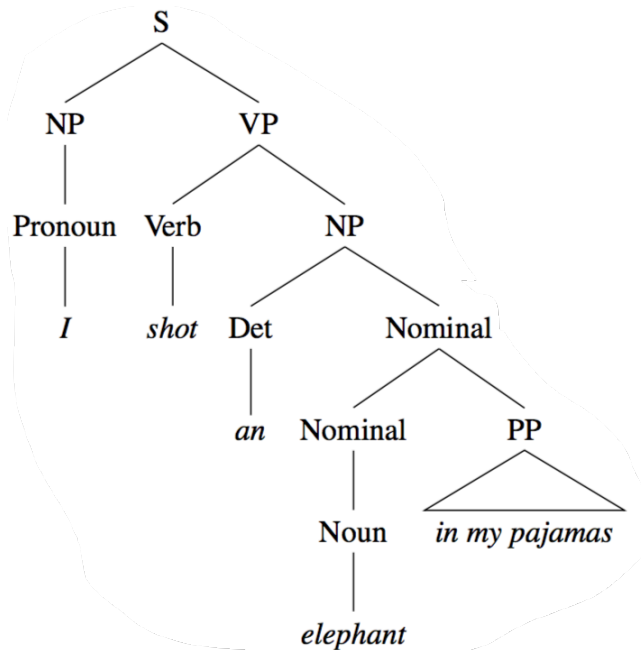
semantics



Information content

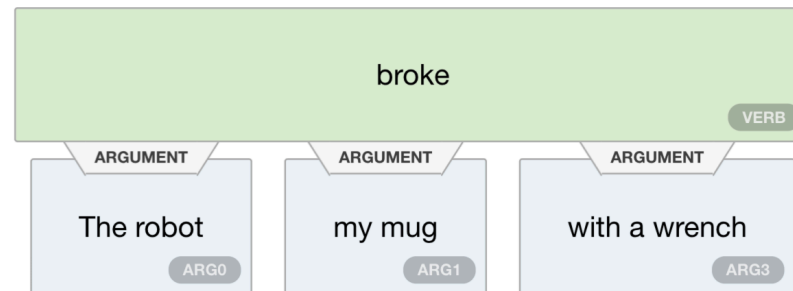
# Motivation

- NLP tasks are different
  - Capture different information
  - Differ in output structure

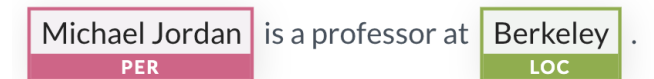


tree

The robot broke my mug with a wrench .

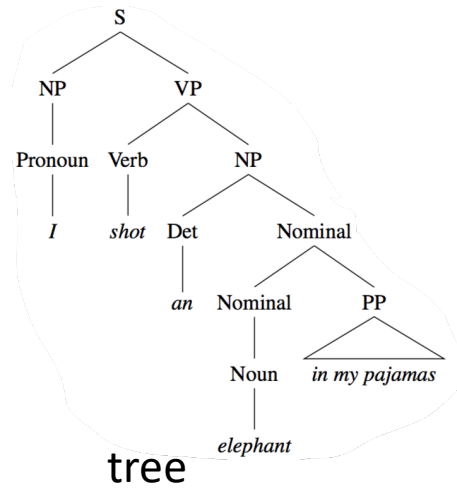


linked spans

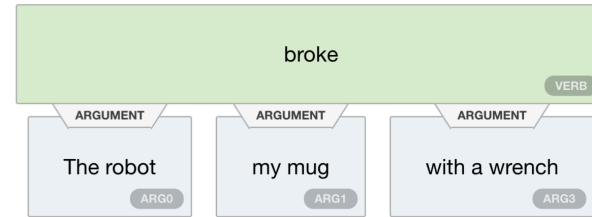


label sequence

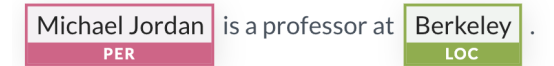
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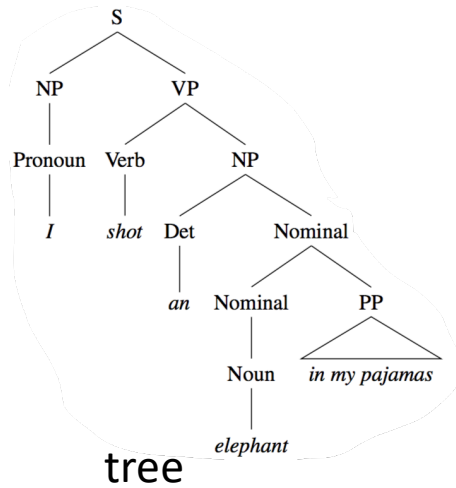


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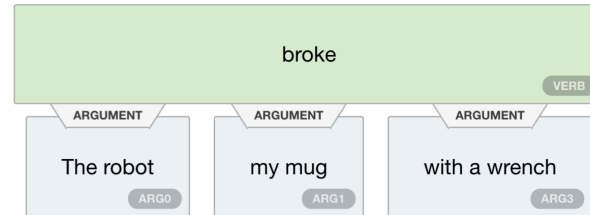


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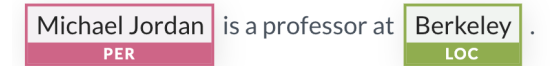
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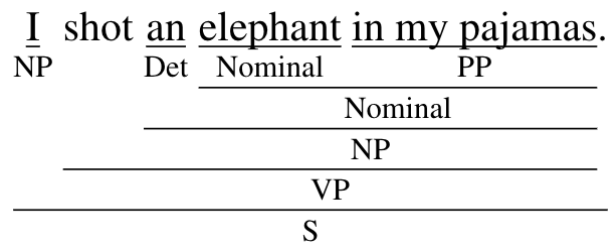


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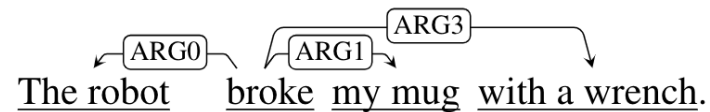


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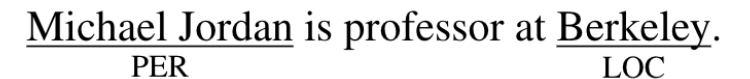
unified representational formalism



span-relation

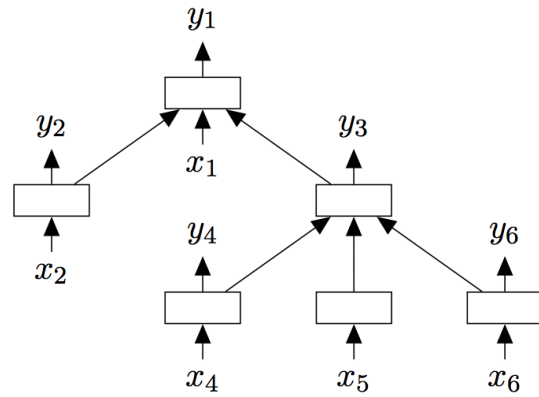


span-relation

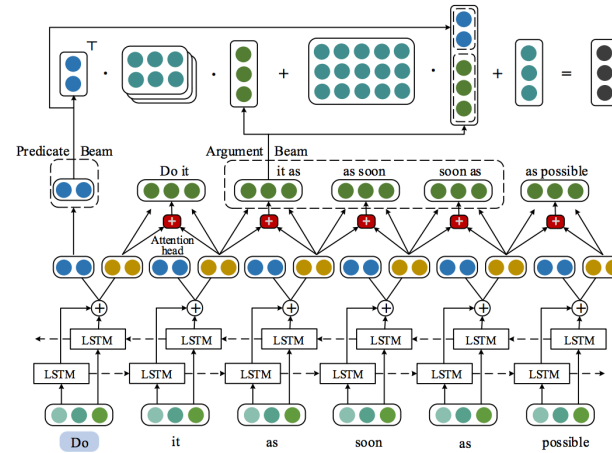


span-relation

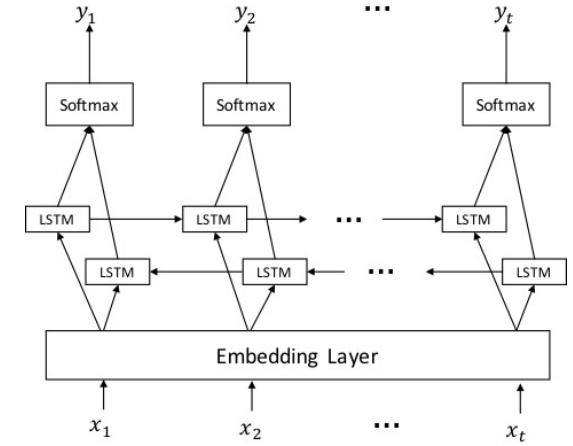
# Motivation



tree-based

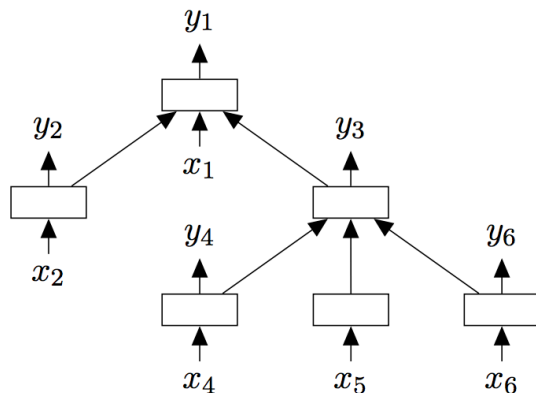


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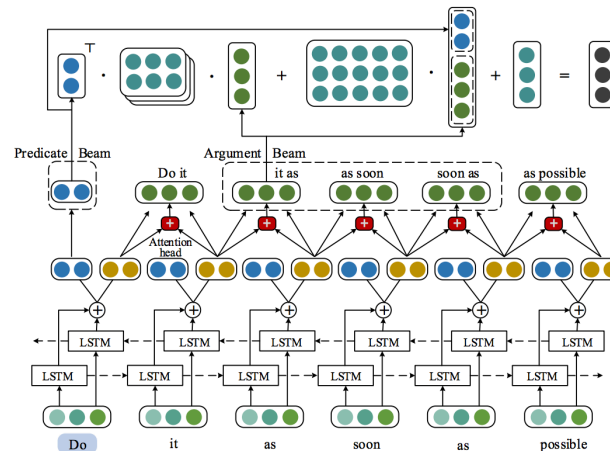


sequence labeling

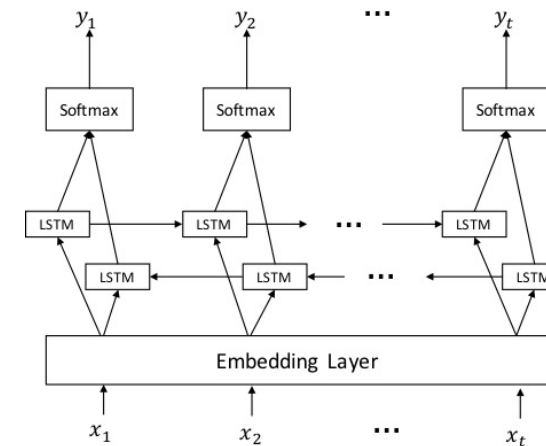
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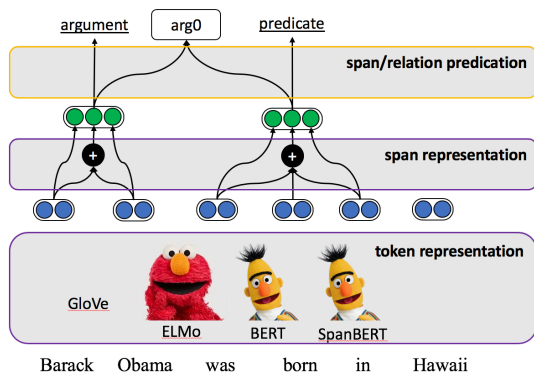


span-based

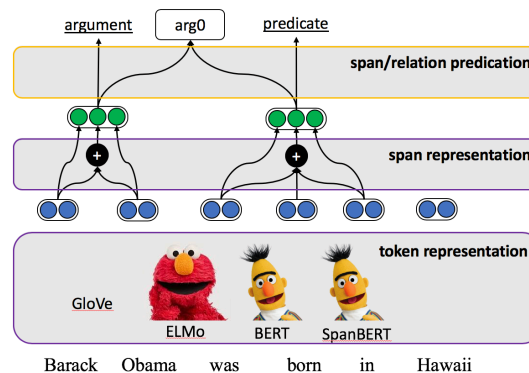


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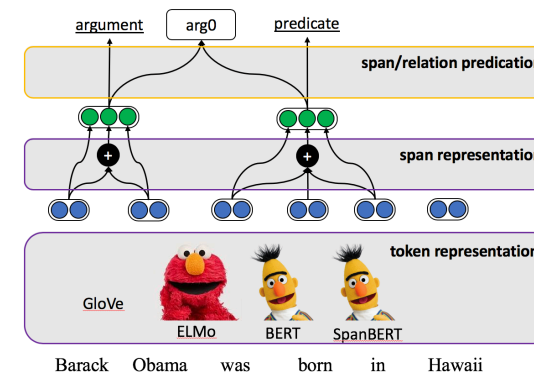
unified model



SpanRel



SpanRel



SpanRel

# A Unified View: Span-relation Representation

- BRAT annotation interface

Destacados representantes del Parlamento y la prensa rusos criticaron hoy el "belicismo" ha definido como posible blanco de su lucha antiterrorista.

El presidente de la Duma (cámara baja), Guennadi Selezniyov, calificó de "claramente agresivo" del Kremlin para Chechenia, Serguéi Yastrzhembski.

El asesor presidencial dijo que Rusia puede lanzar un ataque preventivo contra los campos.

entity

"People tend to see risk primarily on that one dimension," says Timothy Kochis, national director of the Center for Strategic and International Studies. But therein lies another aspect of investment risk: the hazard of shaping your portfolio. This is clearly not good news to all you people who sleep like babies every night, lulled by the promise of high returns. Risk wears many disguises, and investments that are low in one type of obvious risk may be high in another.

chunking

RESULTS: Angiotensin II inhibited endothelial cell proliferation by 50-60%.

Thalidomide had no direct effect on endothelial cells.

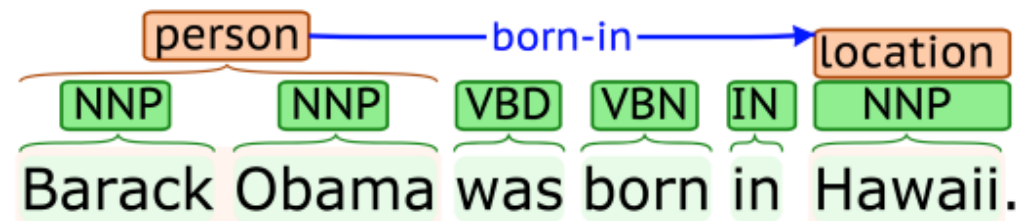
event

ROOT Otukt skulle enligt protestanternas tolkning av detta uttalande vara ett av de mest betydande stegen i den svenska riksdagens historia.

ROOT Man har efterhand kommit att acceptera ett annat skäl för skilsmässa.

dependency

- Labeled **relations** between span pairs.



- Spans of **one/multiple** words with their labels



# Span-oriented Tasks

Task	<u>Spans</u> annotated with labels
NER	<u>Barack Obama</u> was born in <u>Hawaii</u> . person location
Consti.	And <u>their suspicions</u> of <u>each other</u> run <u>deep</u> . NP NP ADVP PP VP NP S
POS	<u>What</u> <u>kind</u> <u>of</u> <u>memory</u> ? WP NN IN NN
ABSA	Great laptop that offers many great <u>features</u> ! positive

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→ **1. Named entity recognition**  
Spans are named entities

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## 1. Named entity recognition

Spans are named entities

## 2. Constituency parsing

Spans are (nested) constituents

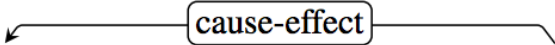
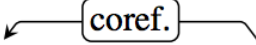


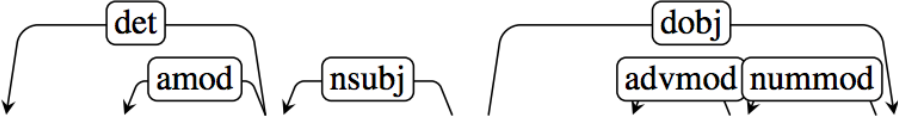

# Span-oriented Tasks

Task	Spans annotated with labels	
NER	<u>Barack Obama</u> was born in <u>Hawaii</u> . person location	→ 1. <b>Named entity recognition</b> Spans are named entities
Consti.	And <u>their suspicions</u> of <u>each other</u> run <u>deep</u> . NP NP ADVP PP VP NP S	→ 2. <b>Constituency parsing</b> Spans are (nested) constituents
POS	<u>What</u> <u>kind</u> <u>of</u> <u>memory</u> ? WP NN IN NN	→ 3. <b>Part-of-speech tagging</b> Spans are single-token words
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POS	<u>What</u> <u>kind</u> <u>of</u> <u>memory</u> ? WP NN IN NN	→ <b>3. Part-of-speech tagging</b> Spans are single-token words
ABSA	Great laptop that offers many great <u>features</u> ! positive	→ <b>4. Aspect-based sentiment analysis</b> Spans are aspects

# Relation-oriented Tasks

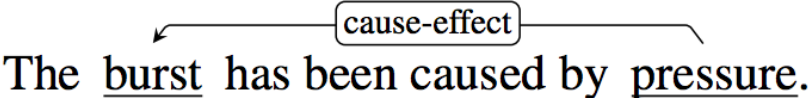
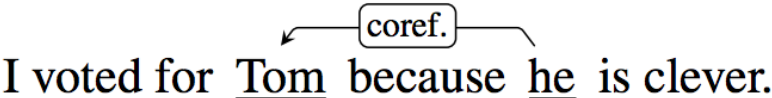
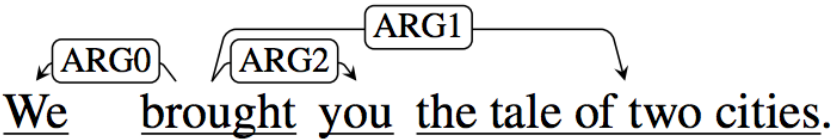
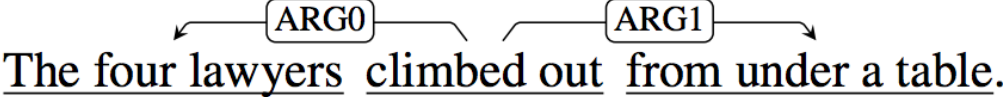
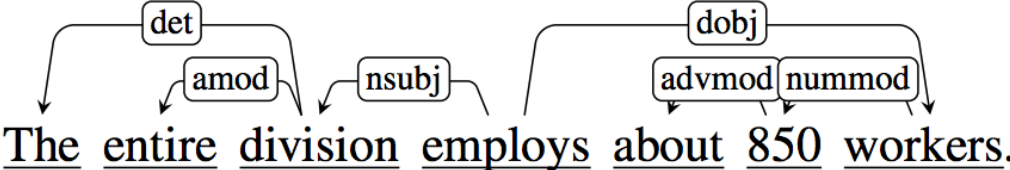
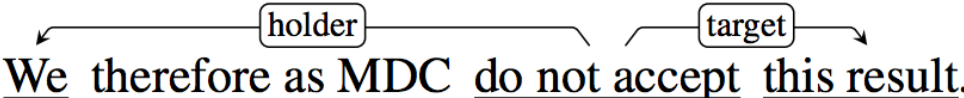
Task	<u>Spans</u> and <b>relations</b> annotated with labels
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Coref.	 I voted for <u>Tom</u> because <u>he</u> is clever.
SRL	 <u>We</u> <u>brought you</u> <u>the tale of two cities</u> .
OpenIE	 <u>The four lawyers</u> <u>climbed out</u> <u>from under a table</u> .
Dep.	 <u>The</u> <u>entire</u> <u>division</u> <u>employs</u> <u>about</u> <u>850</u> <u>workers</u> .
ORL	 <u>We</u> <u>therefore as MDC</u> <u>do not accept</u> <u>this result</u> .

# Relation-oriented Tasks

## 5. Relation extraction

Spans are entities.

Relations are their relationships.

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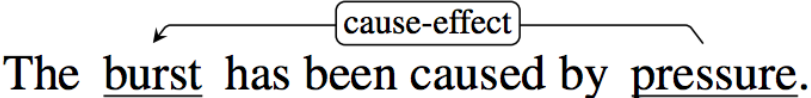
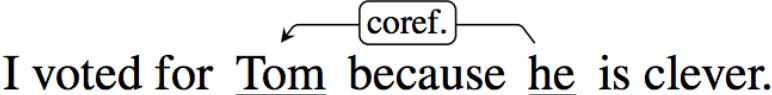
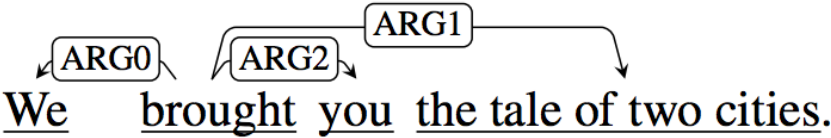
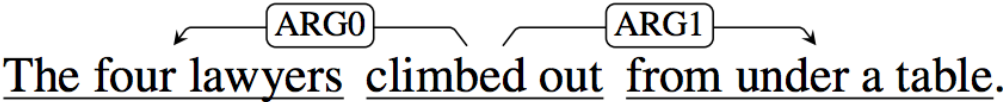
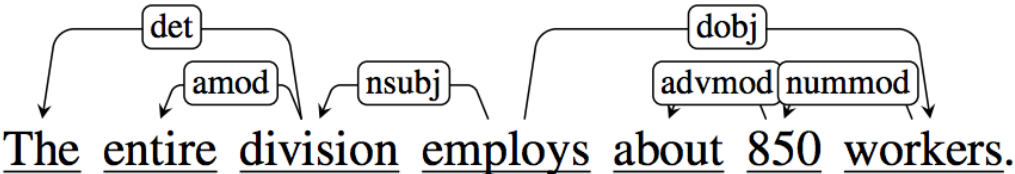
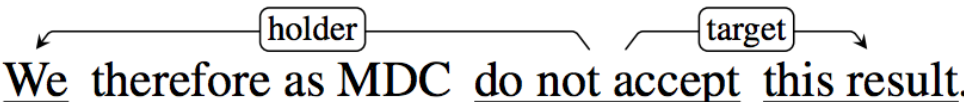
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## 5. Relation extraction

Spans are entities.  
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## 6. Coreference resolution

Spans are mentions  
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Spans are predicates/arguments

Relations link predicates with arguments

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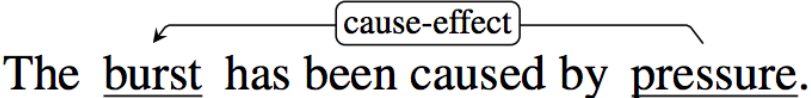
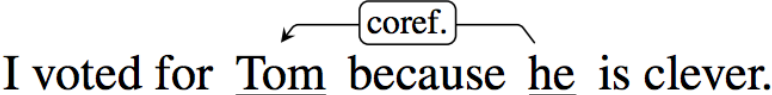
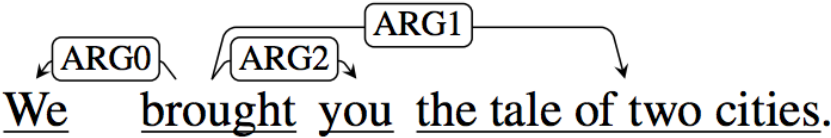
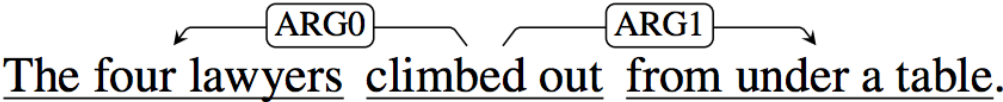
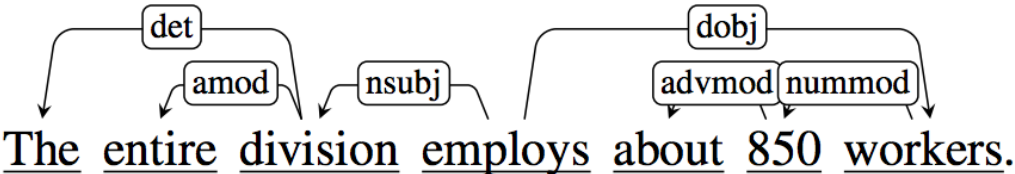
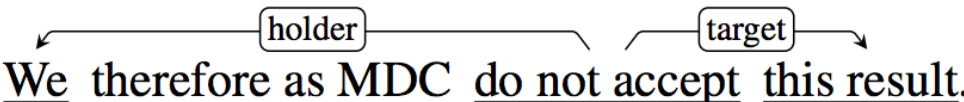
## 8. Open information extraction

Spans are predicates/arguments  
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## 9. Dependency parsing

Spans are words  
Relations are their dependencies

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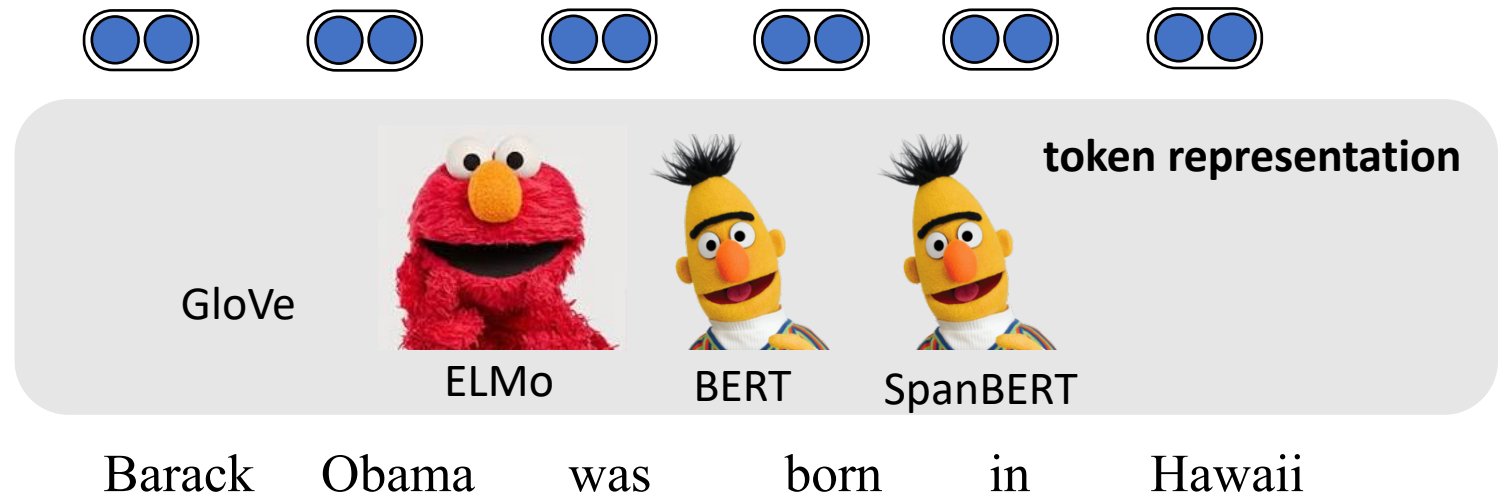
## 10. Opinion role labeling

Spans are opinions/holders/targets  
Relations link opinions to holders/targets

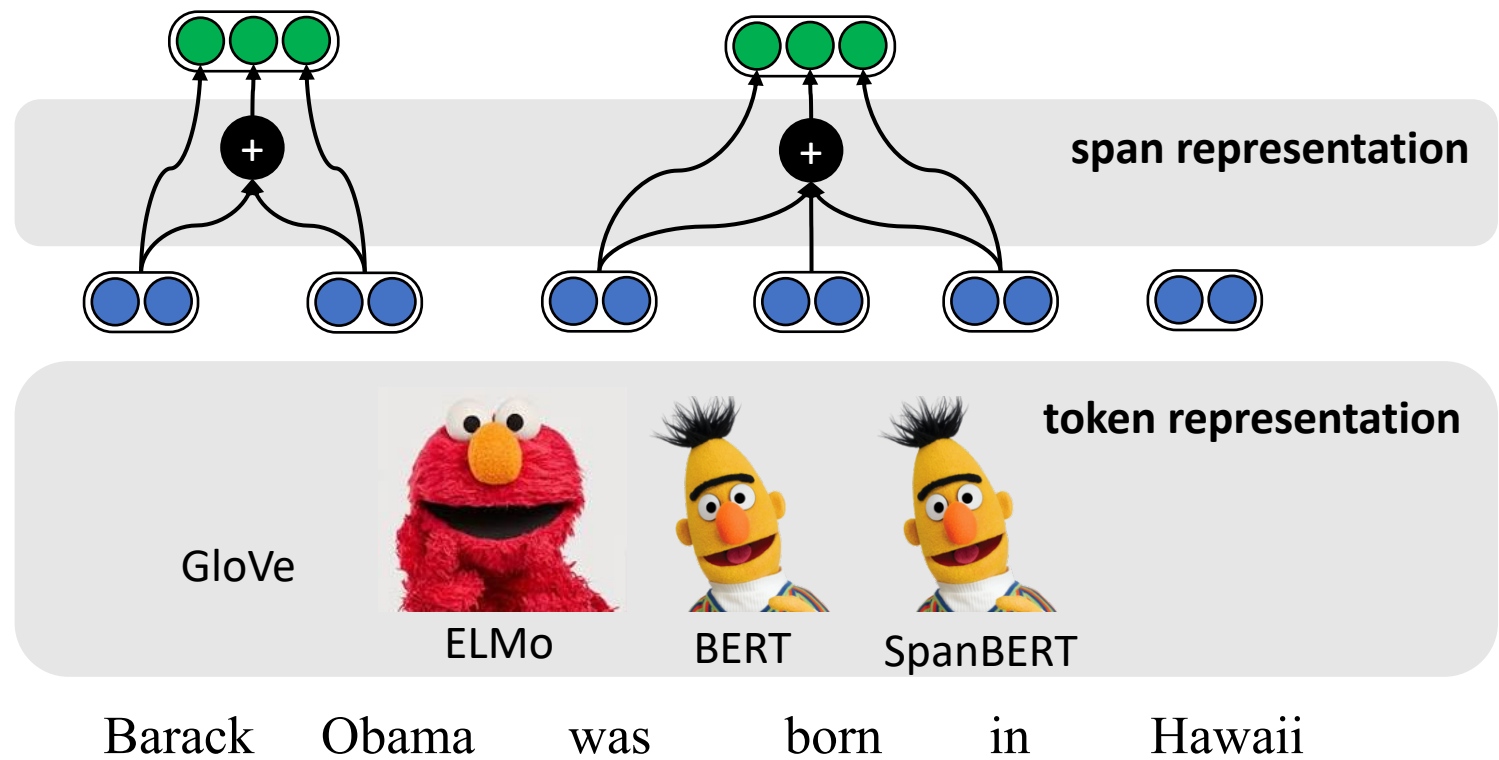
# SpanRel Model

Barack Obama was born in Hawaii

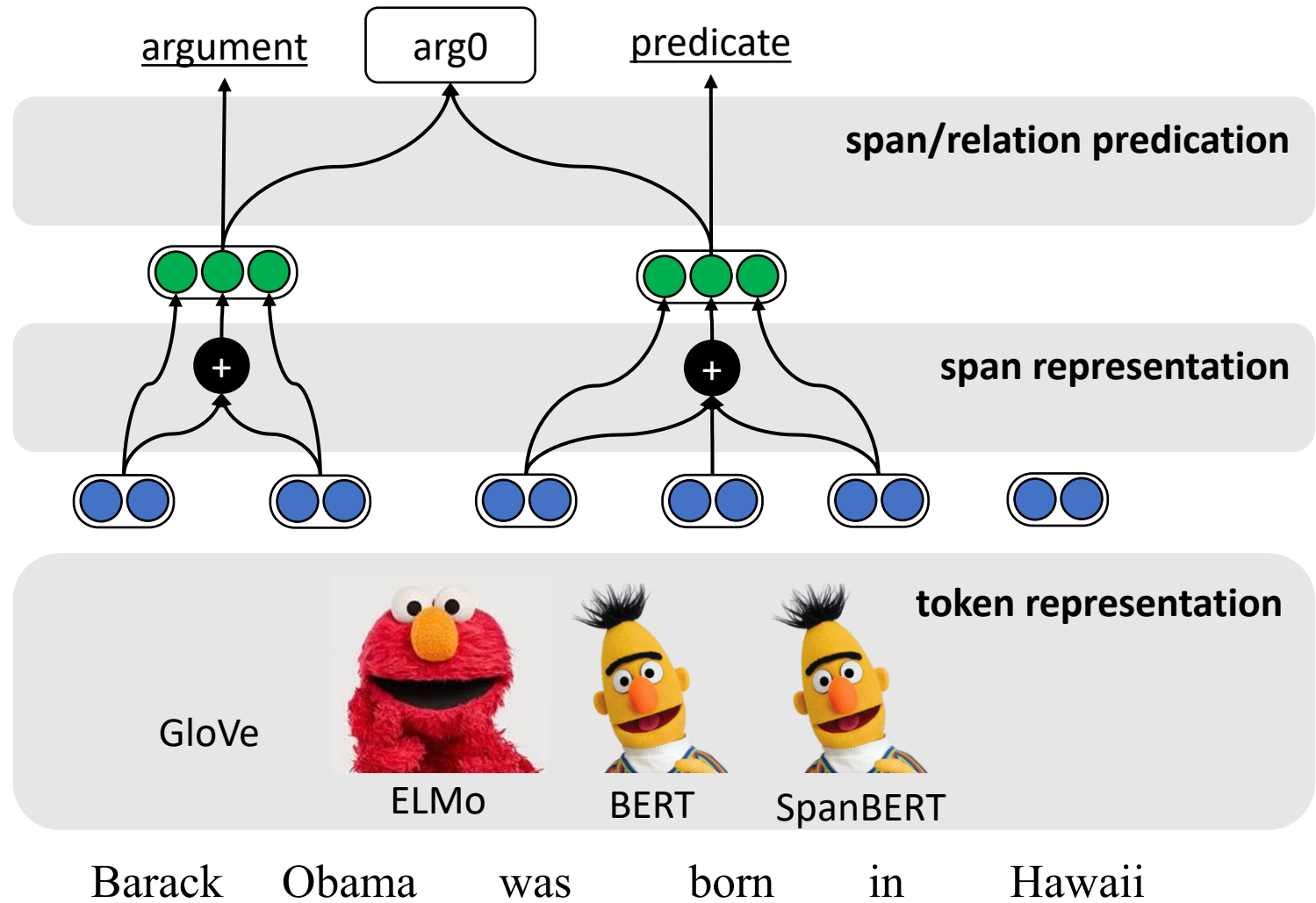
# SpanRel Model



# SpanRel Model

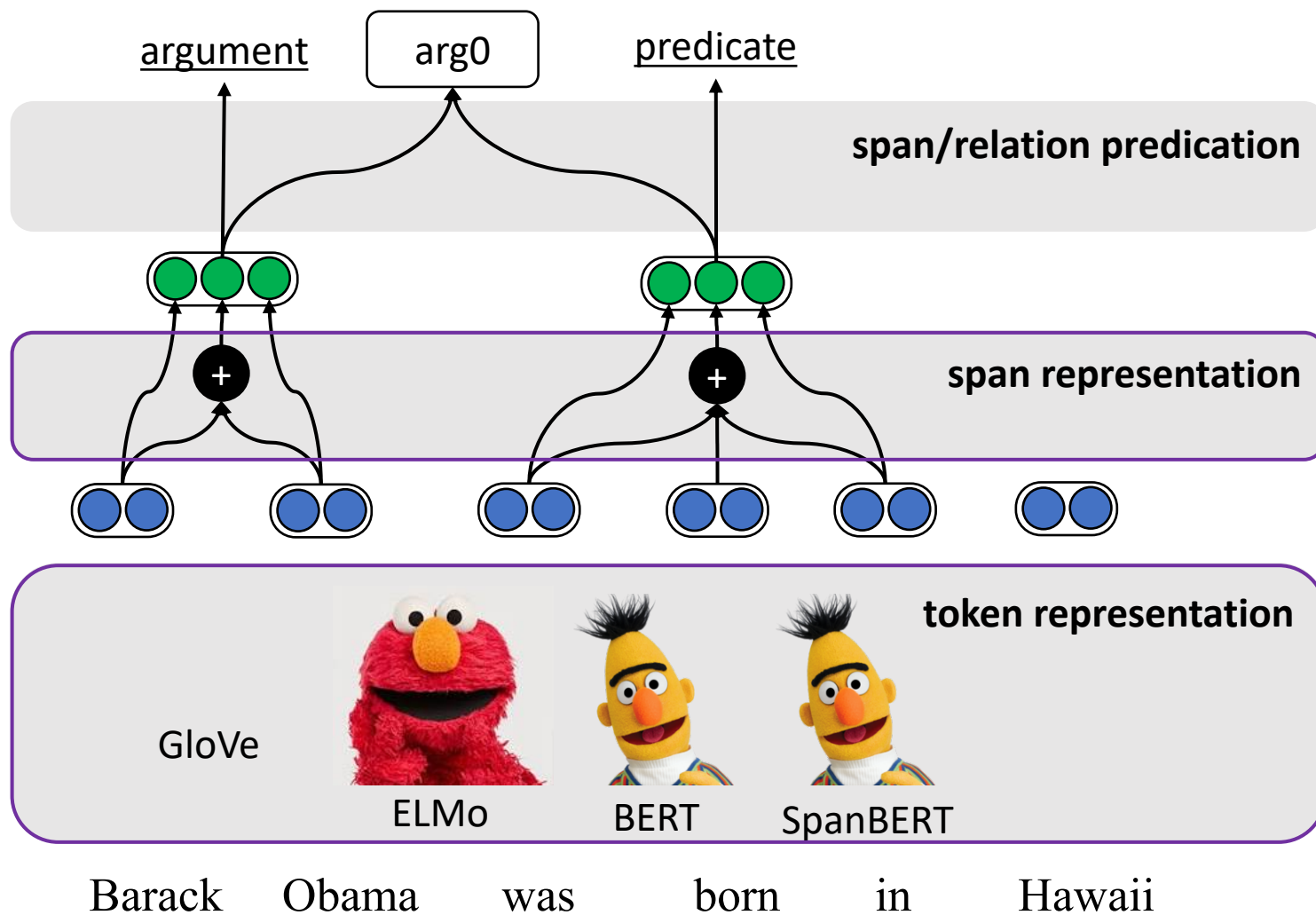


# SpanRel Model



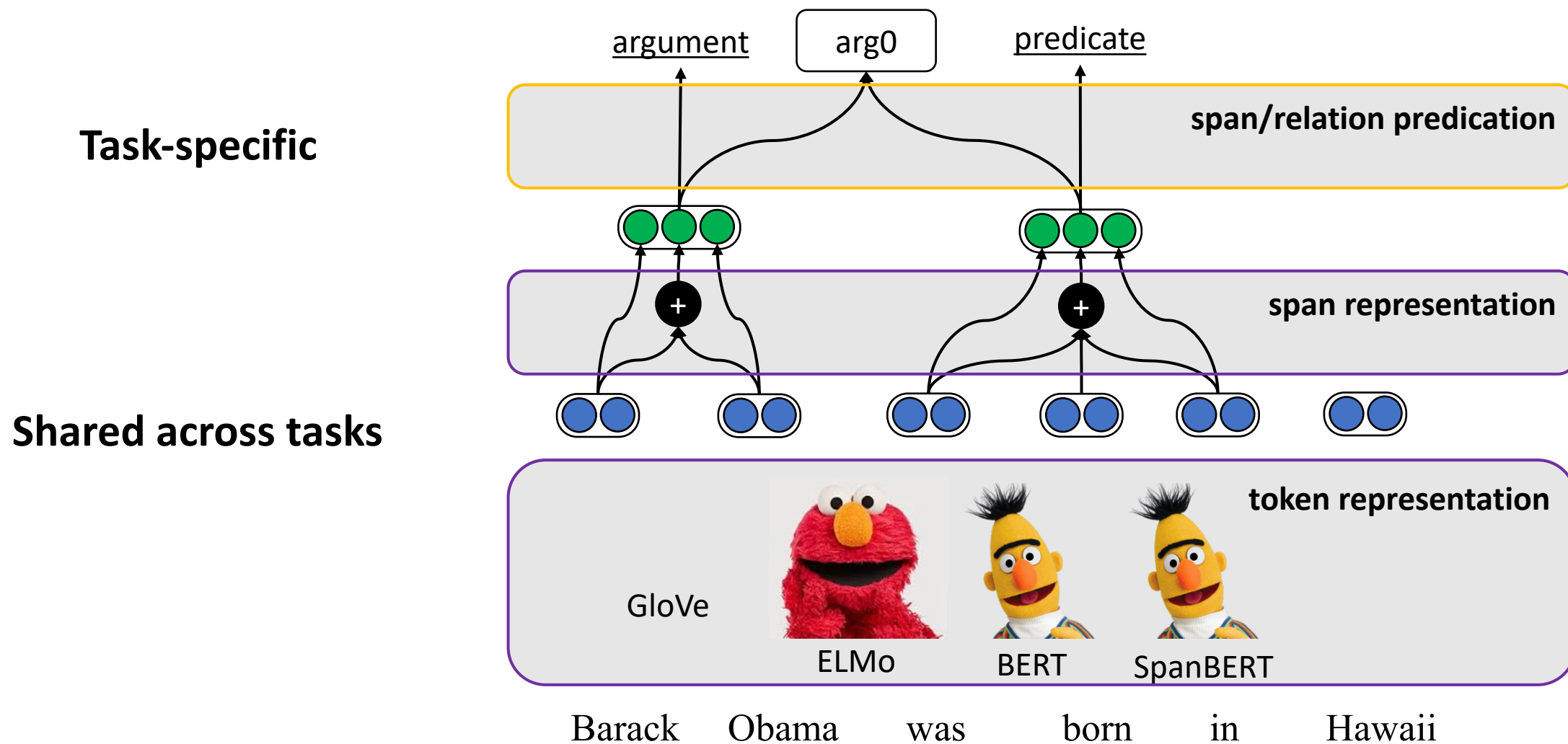


# SpanRel Model



Shared across tasks

# SpanRel Model

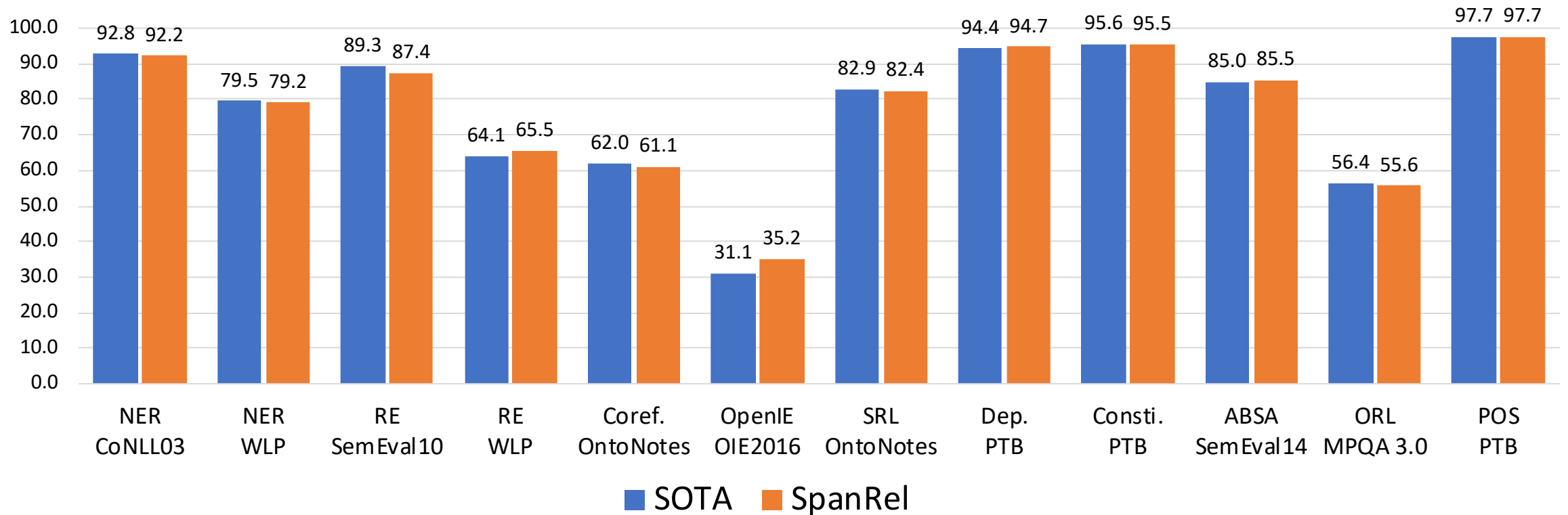


# Experimental Settings

- General Language Analysis Datasets (GLAD) benchmark.
  - 8 datasets: CoNLL03, WLP, SemEval10, OntoNotes, OIE2016, PTB, SemEval14, MPQA 3.0.
- Evaluation metrics.
  - Major metric: span-based F1.
  - Task-specific metrics.
- Implementation details.
  - Token representation: GloVe, ELMo, BERT, SpanBERT.
  - Different pruning ratio/max span length for different tasks.

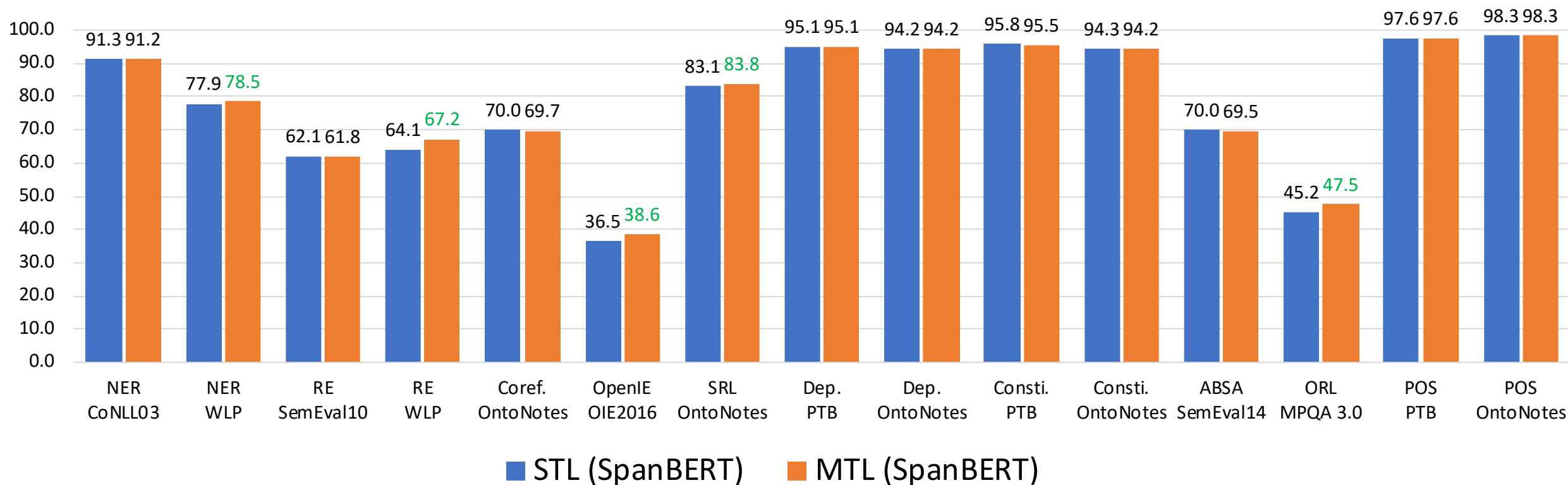
# Comparison with SOTA

- Achieves comparable performances as task-specific SOTA methods



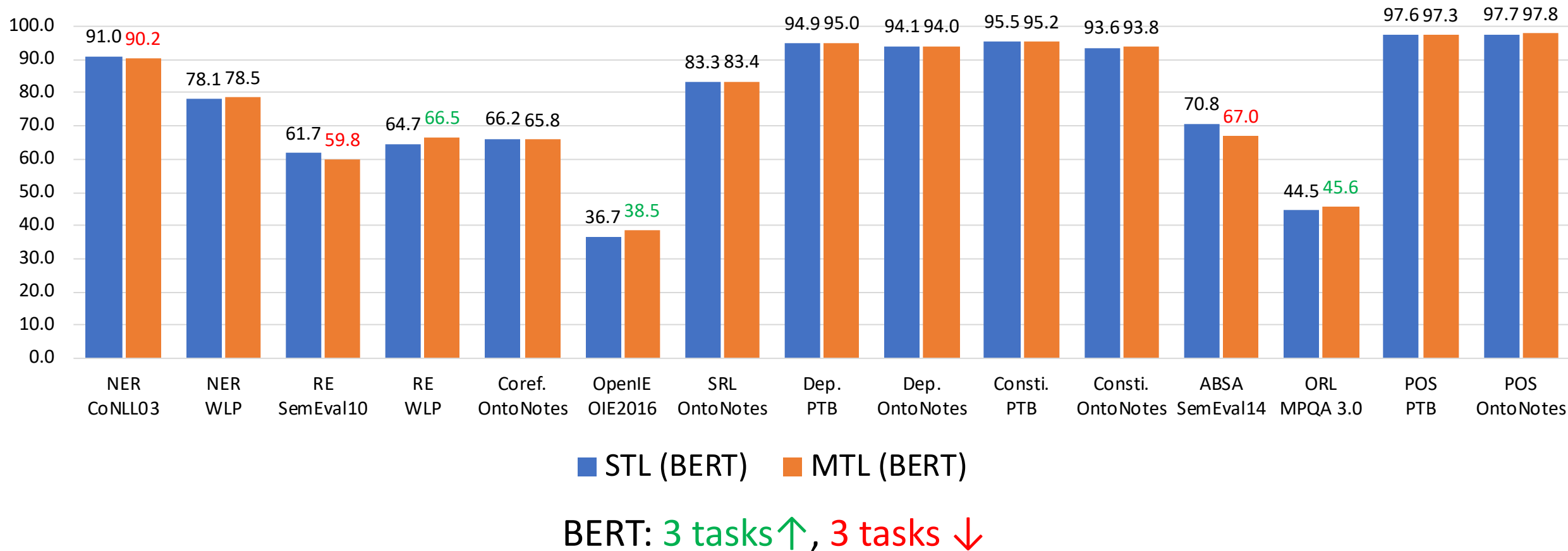
# Multi-task Learning

- Significant improvements on 5/15 tasks with SpanBERT.

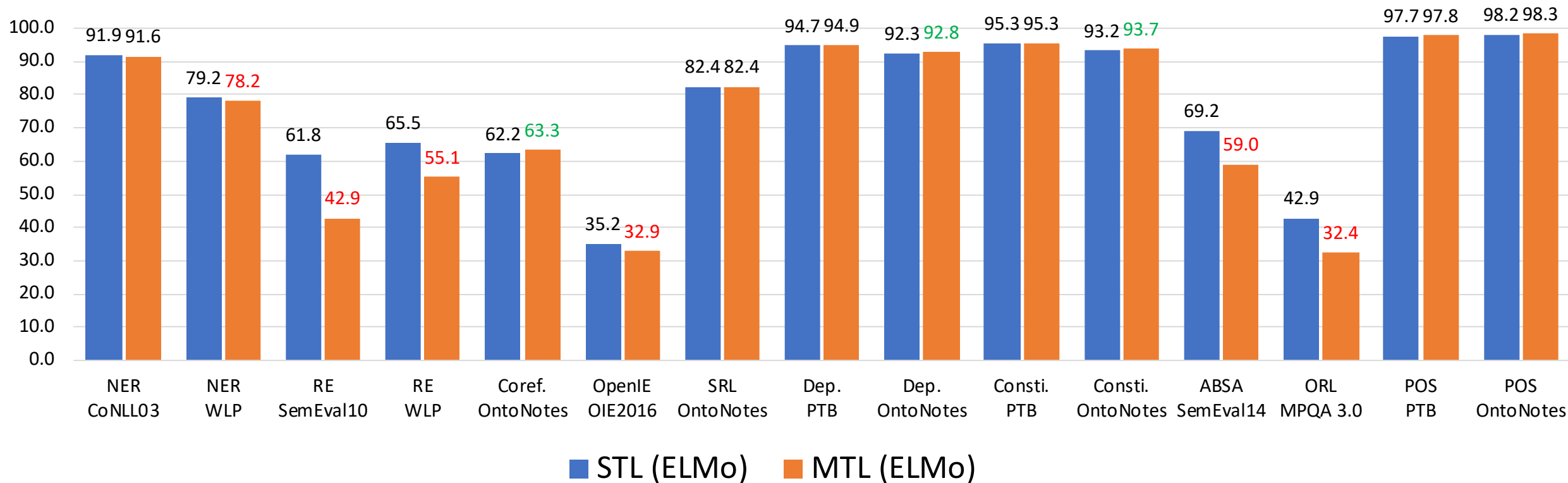


SpanBERT: 5 tasks ↑, 0 tasks ↓

# Multi-task Learning



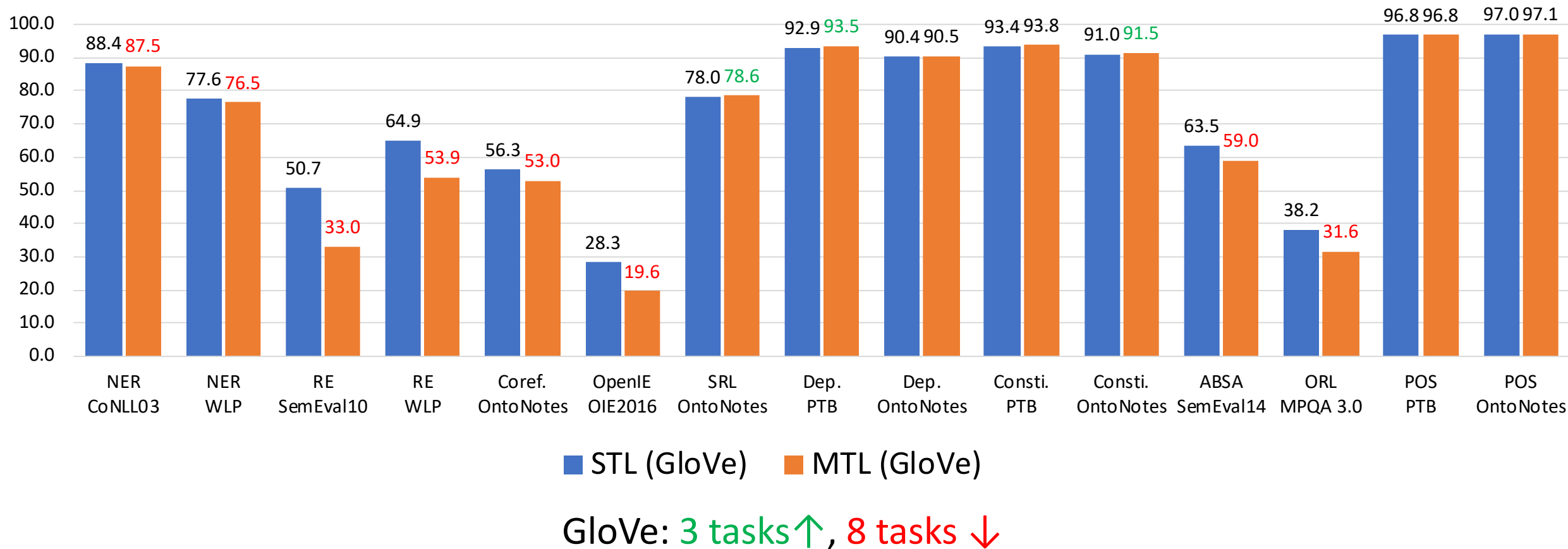
# Multi-task Learning



ELMo: 3 tasks ↑, 6 tasks ↓

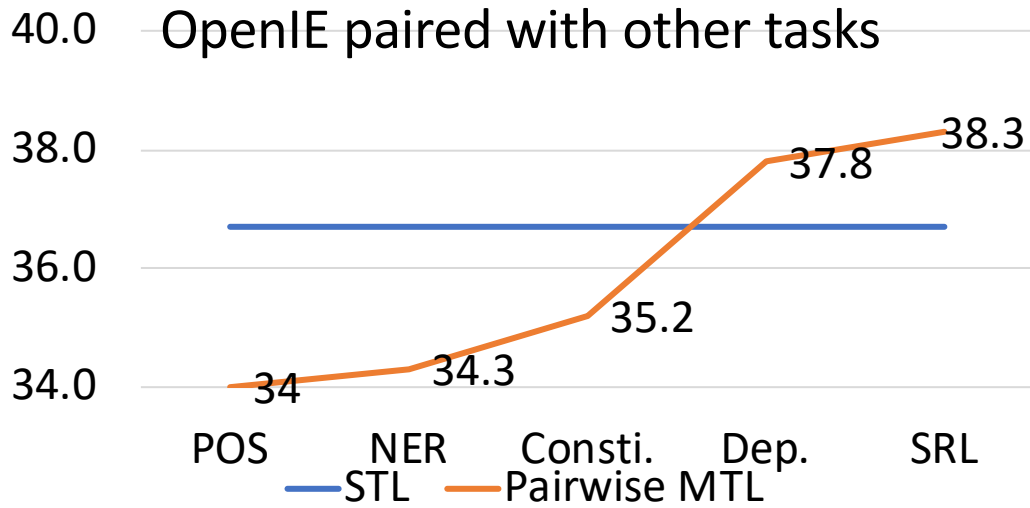
# Multi-task Learning

- Stronger models show consistent improvements from MTL, weaker models less so.



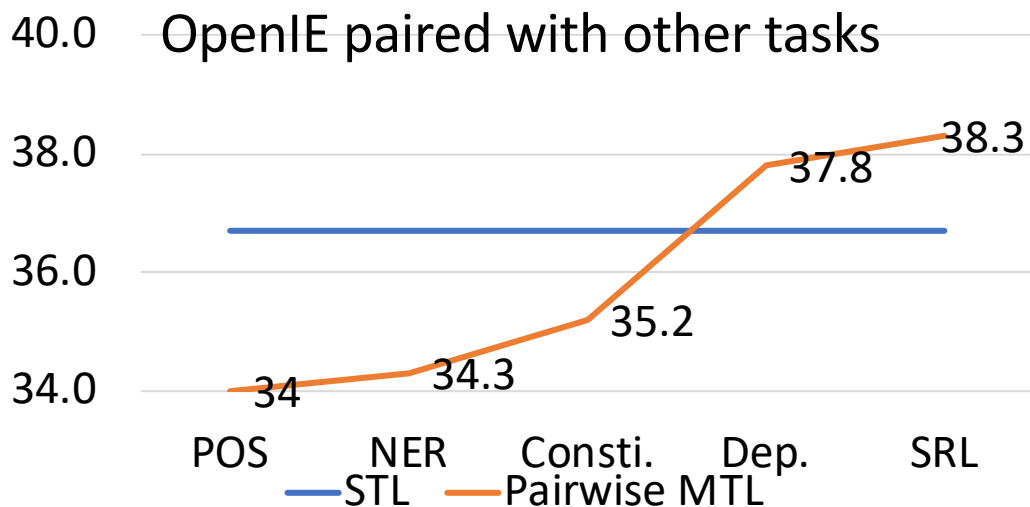


# Task-relatedness Analysis

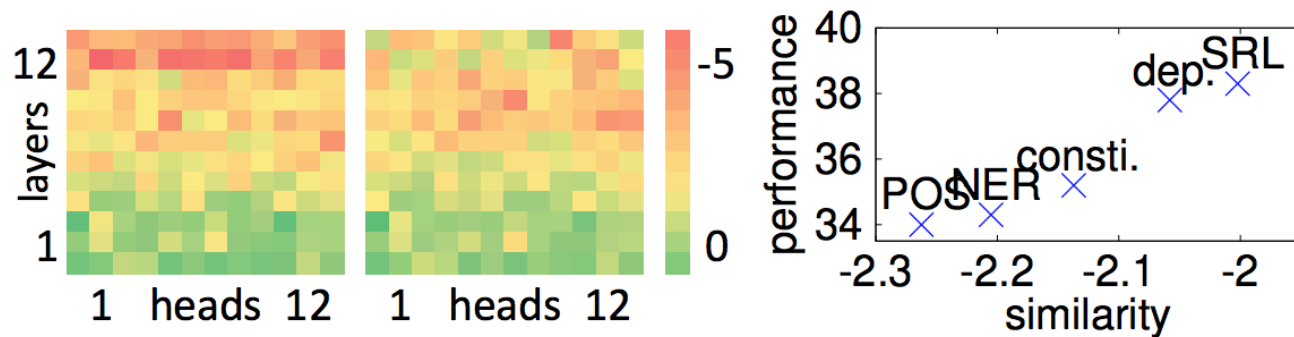


Tasks are not equally helpful to each other.

# Task-relatedness Analysis



Tasks are not equally helpful to each other.



Attn similarity of OpenIE/POS and OpenIE/SRL.

Tasks with similar attention as OpenIE help more.

## Take away

1. A large variety of NLP tasks can be unified as span-relation prediction problems.
2. Multitask learning across a large number of different tasks helps, and how to better reconcile them is a challenging and rewarding future direction.

Paper: <https://arxiv.org/pdf/1911.03822.pdf>  
Code: <https://github.com/neulab/cmu-multinlp>