Encoding Sentences with Graph Convolutional Networks for Semantic Role Labeling

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Copenhagen

Contributions

- Syntactic Graph Convolutional Networks
- State-of-the-art semantic role labeling model
  - English and Chinese

Semantic Role Labeling

- Predicting the predicate-argument structure of a sentence

Sequa makes and repairs jet engines.

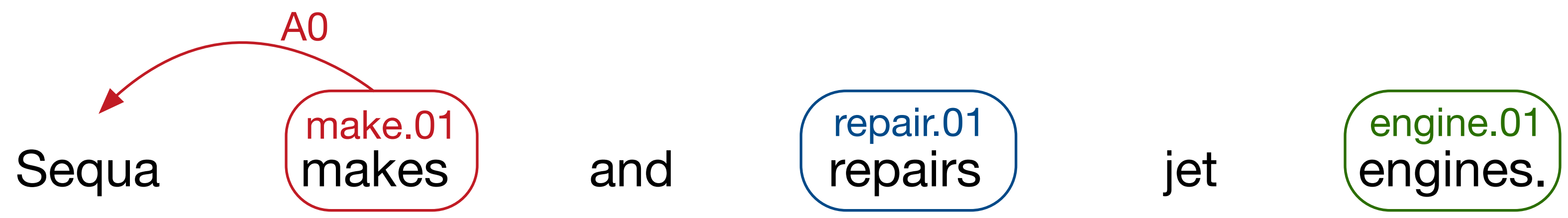
Semantic Role Labeling

- Predicting the predicate-argument structure of a sentence
  - Discover and disambiguate predicates

	make.01		repair.01		engine.01
Sequa	makes	and	repairs	jet	engines.

Semantic Role Labeling

- Predicting the predicate-argument structure of a sentence
  - Discover and disambiguate predicates
  - Identify arguments and label them with their semantic roles



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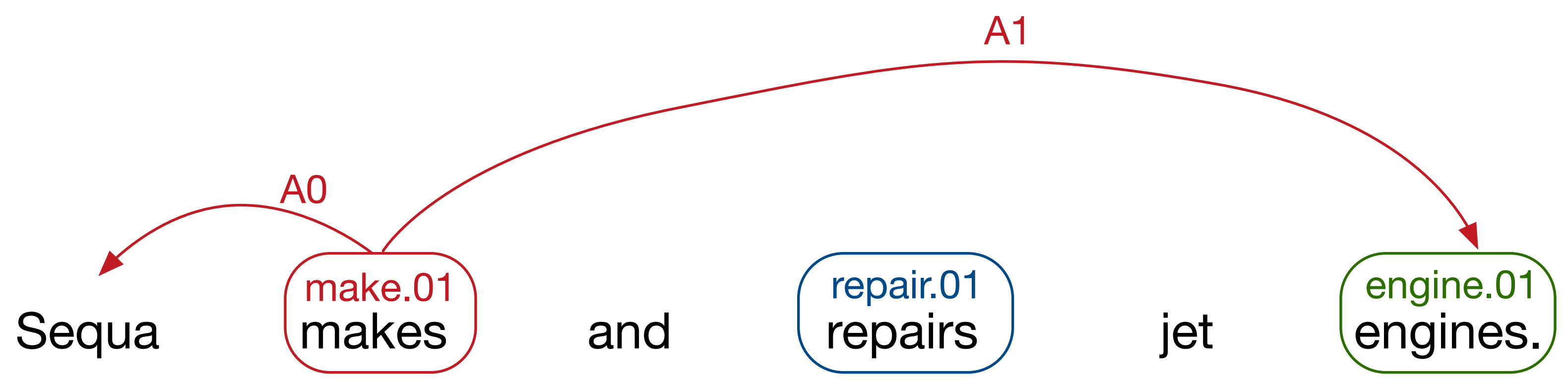

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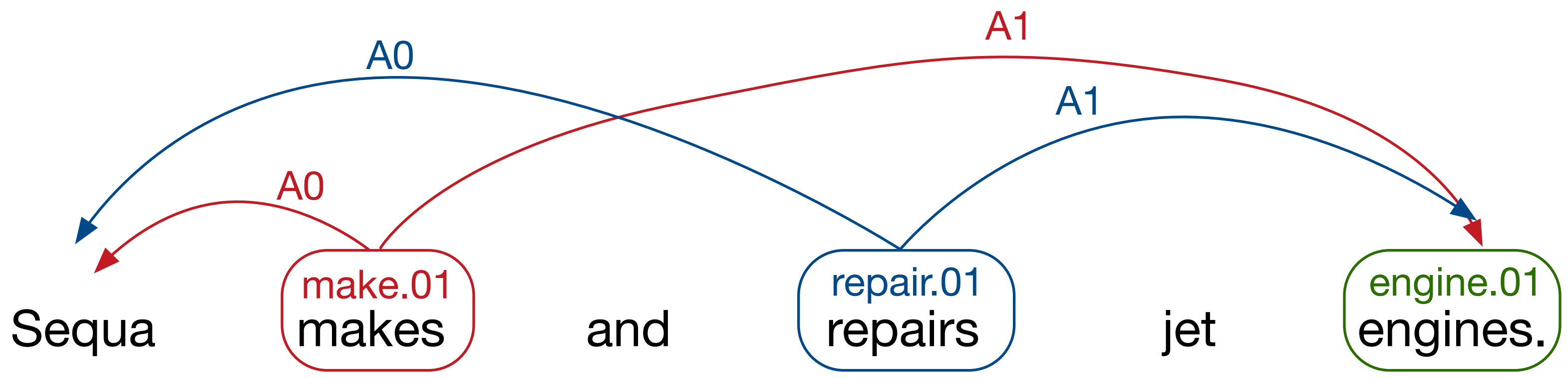

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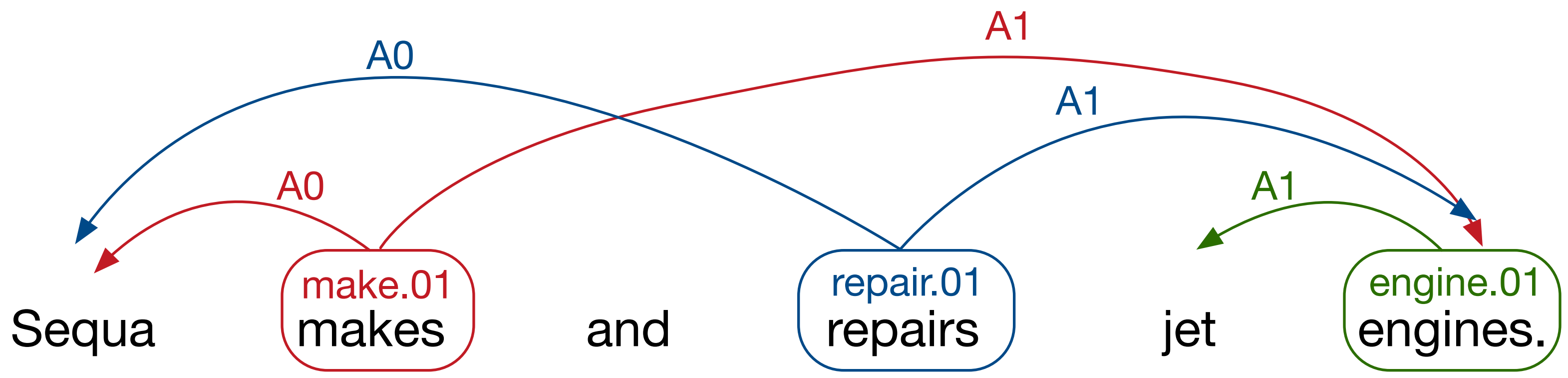
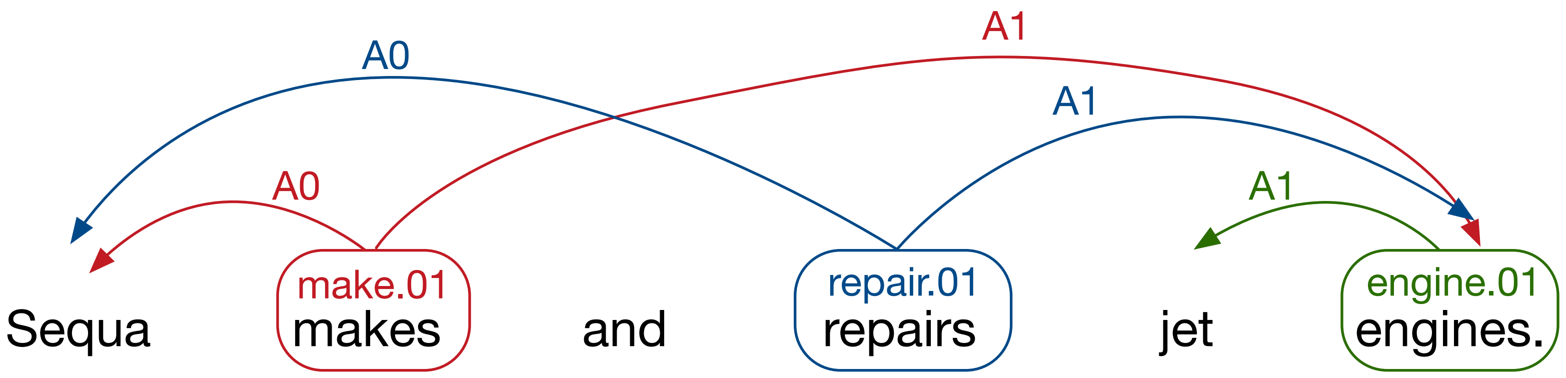


Semantic Role Labeling

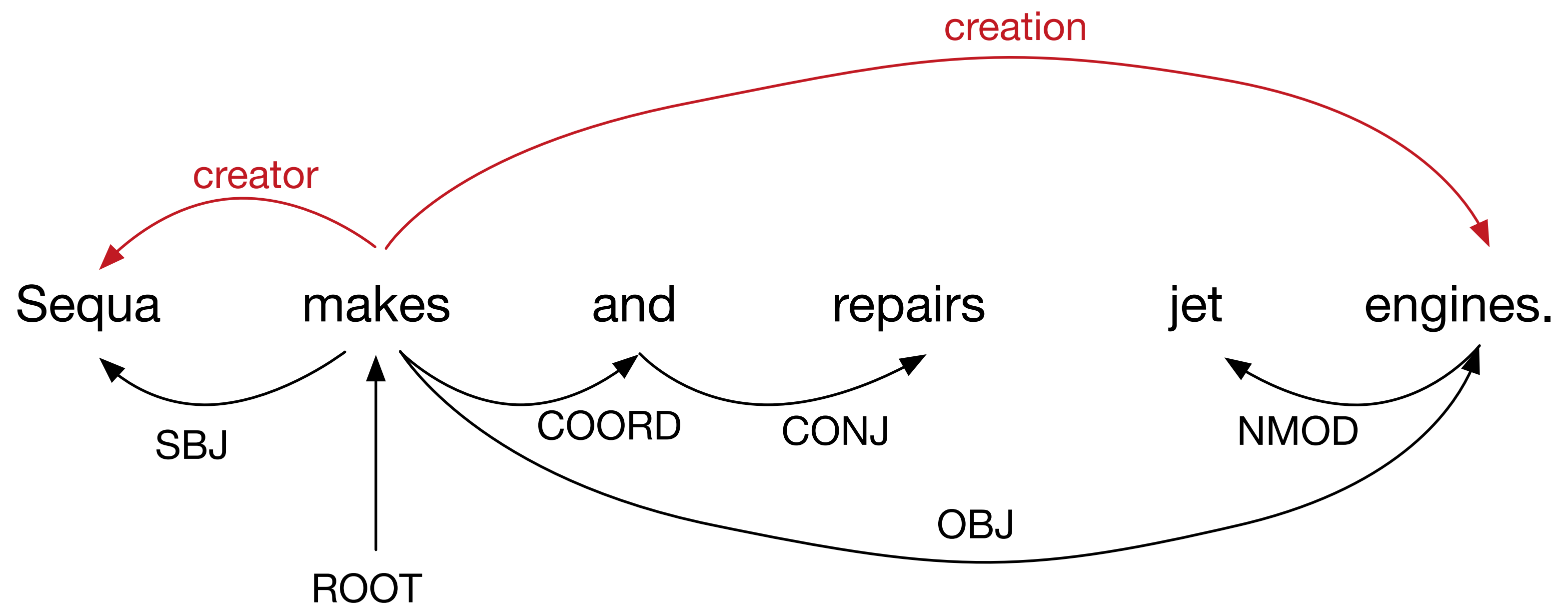
- Only the head of an argument is labeled
- Sequence labeling task for each predicate
- Focus on argument identification and labeling



Related work

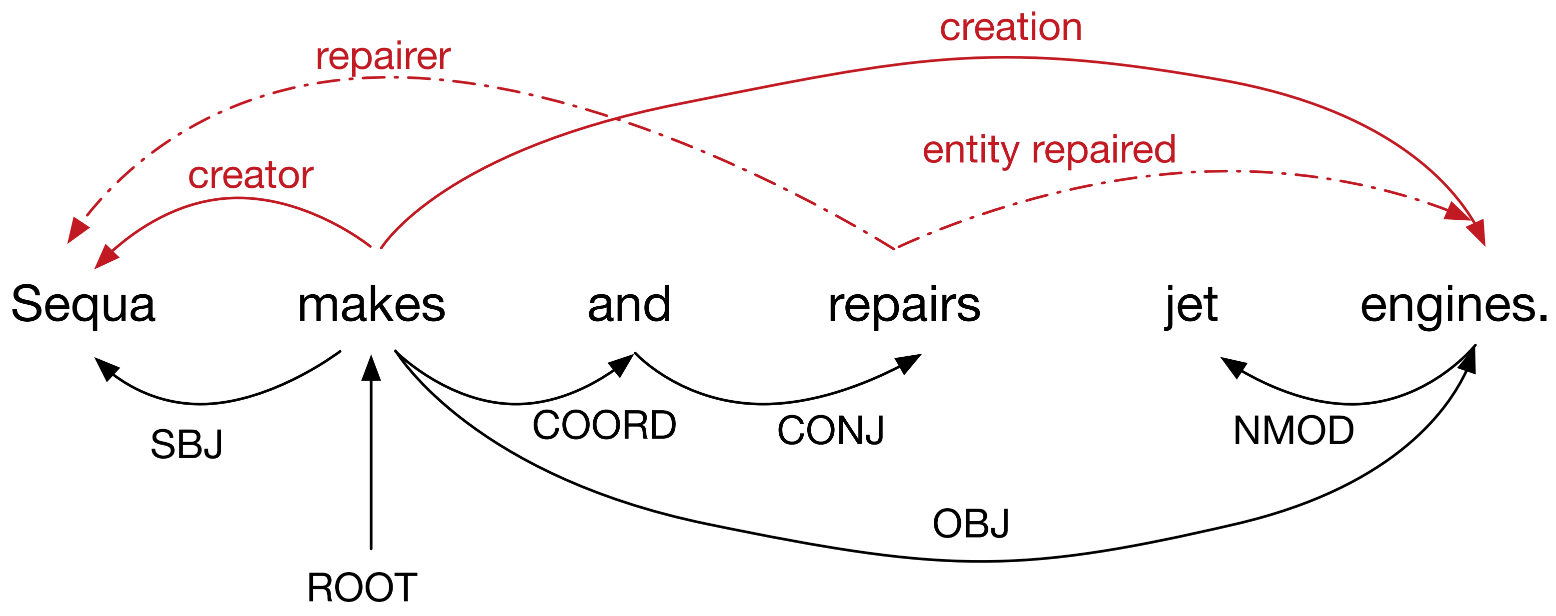
- SRL systems that use syntax with simple NN architectures
  - [FitzGerald et al., 2015]
  - [Roth and Lapata, 2016]
- Recent models ignore linguistic bias
  - [Zhou and Xu, 2014]
  - [He et al., 2017]
  - [Marcheggiani et al., 2017]

Motivations



- Some semantic dependencies are mirrored in the syntactic graph

Motivations



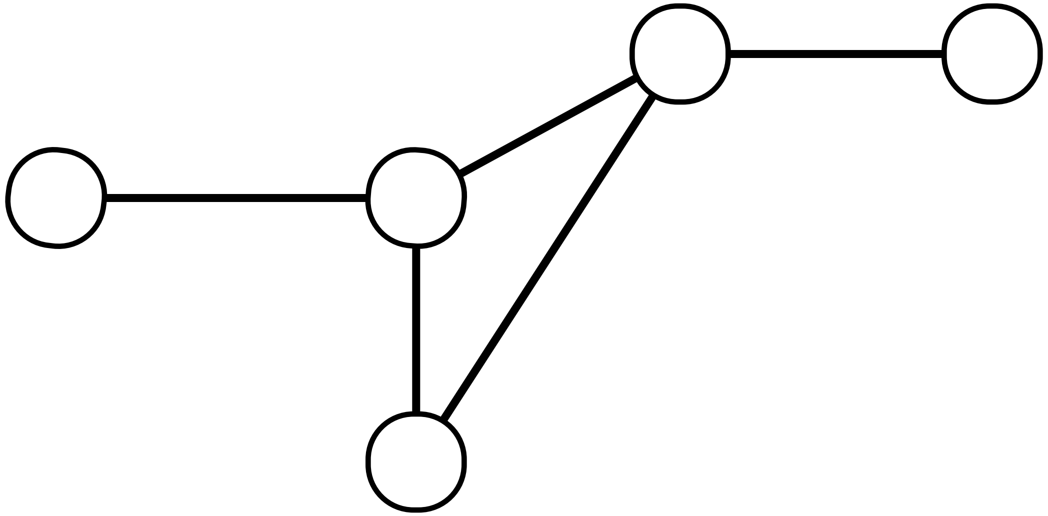
- Some semantic dependencies are mirrored in the syntactic graph
- Not all of them – syntax-semantic interface is not trivial

Encoding Sentences with Graph Convolutional Networks

- **Graph Convolutional Networks (GCNs)** [Kipf and Welling, 2017]
- Syntactic GCNs
- Semantic Role Labeling Model
- Experiments
- Conclusions

Graph Convolutional Networks (message passing)

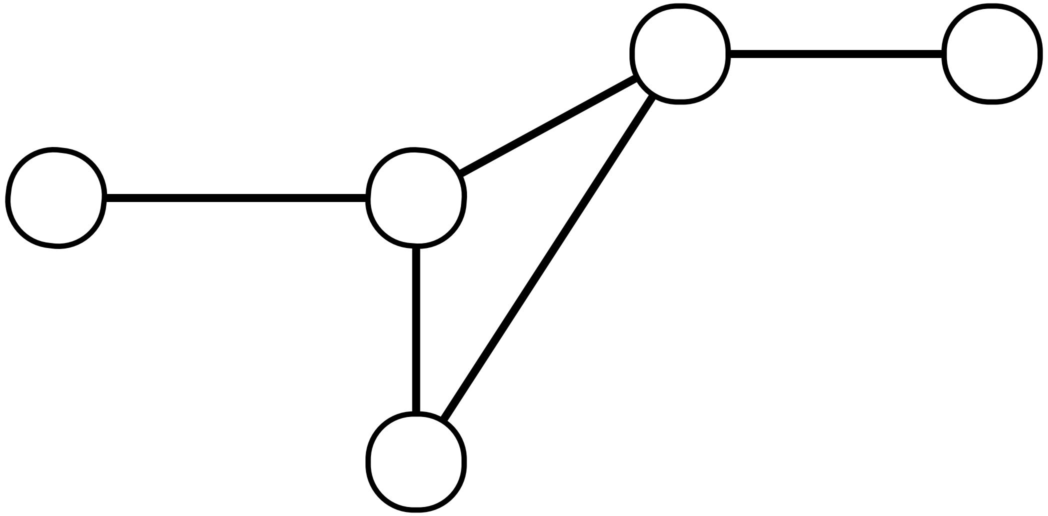
[Kipf and Welling, 2017]



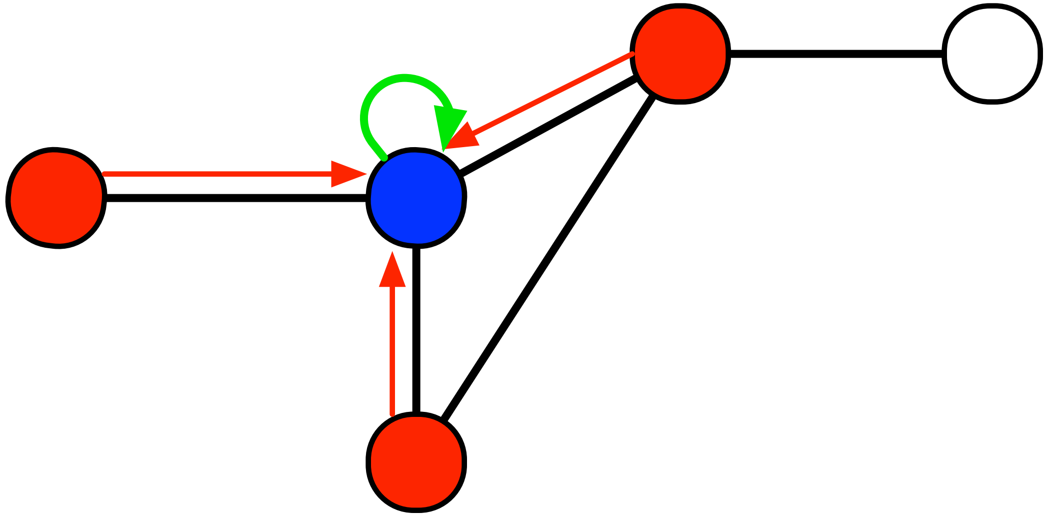
Undirected graph

Graph Convolutional Networks (message passing)

[Kipf and Welling, 2017]



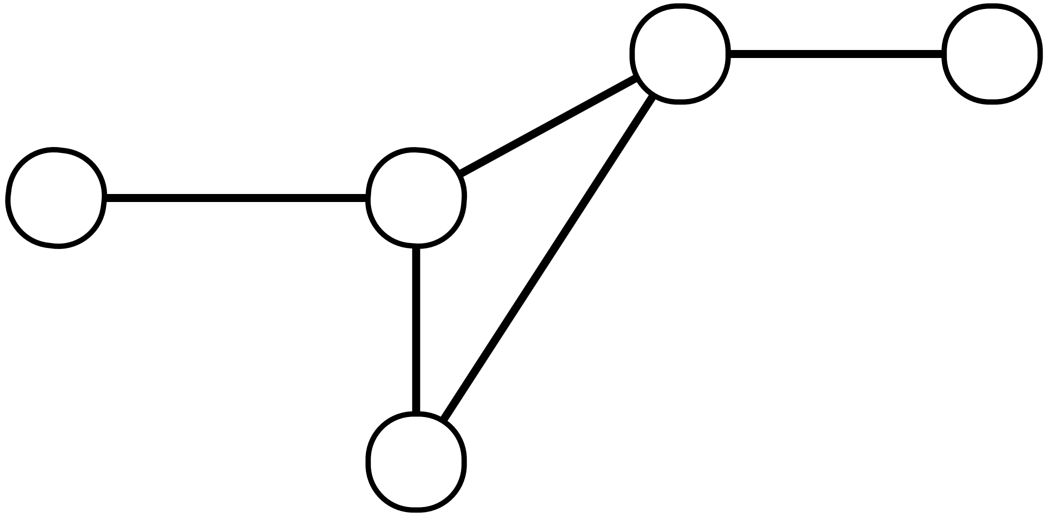
Undirected graph

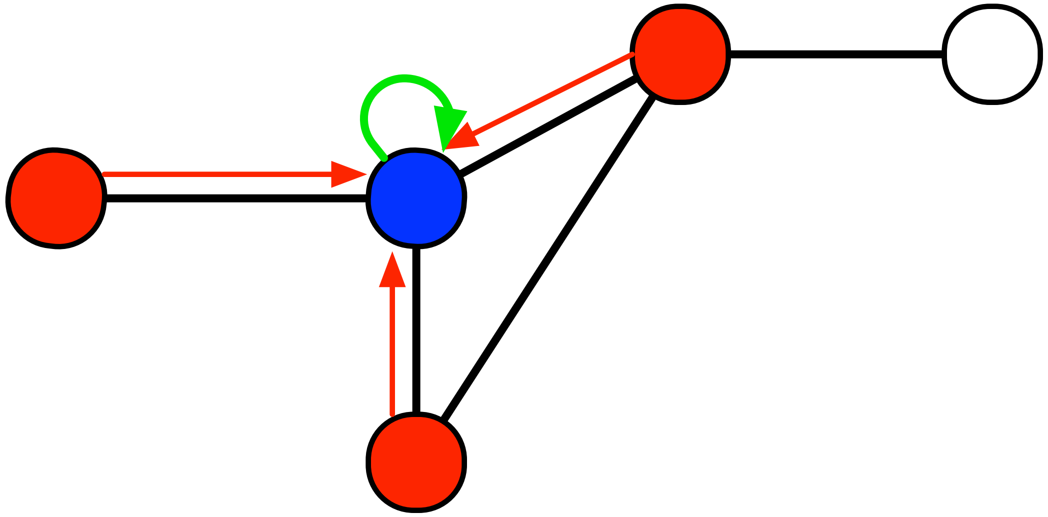


Update of the blue node

Graph Convolutional Networks (message passing)

[Kipf and Welling, 2017]





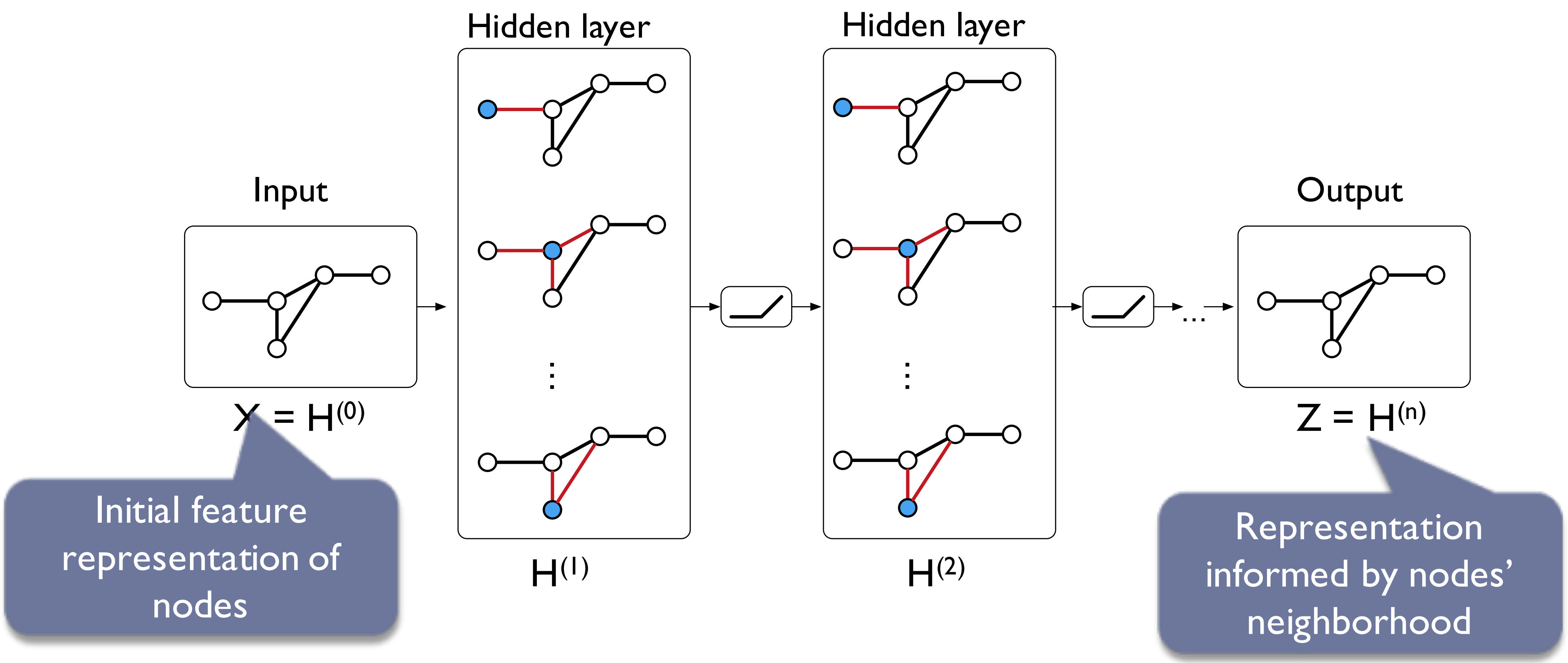
$$h_i = ReLU\left(W_0 h_i + \sum_{j \in \mathcal{N}(i)} W_1 h_j\right)$$

Self loop

Neighborhood

GCNs Pipeline

[Kipf and Welling, 2017]



GCNs Pipeline

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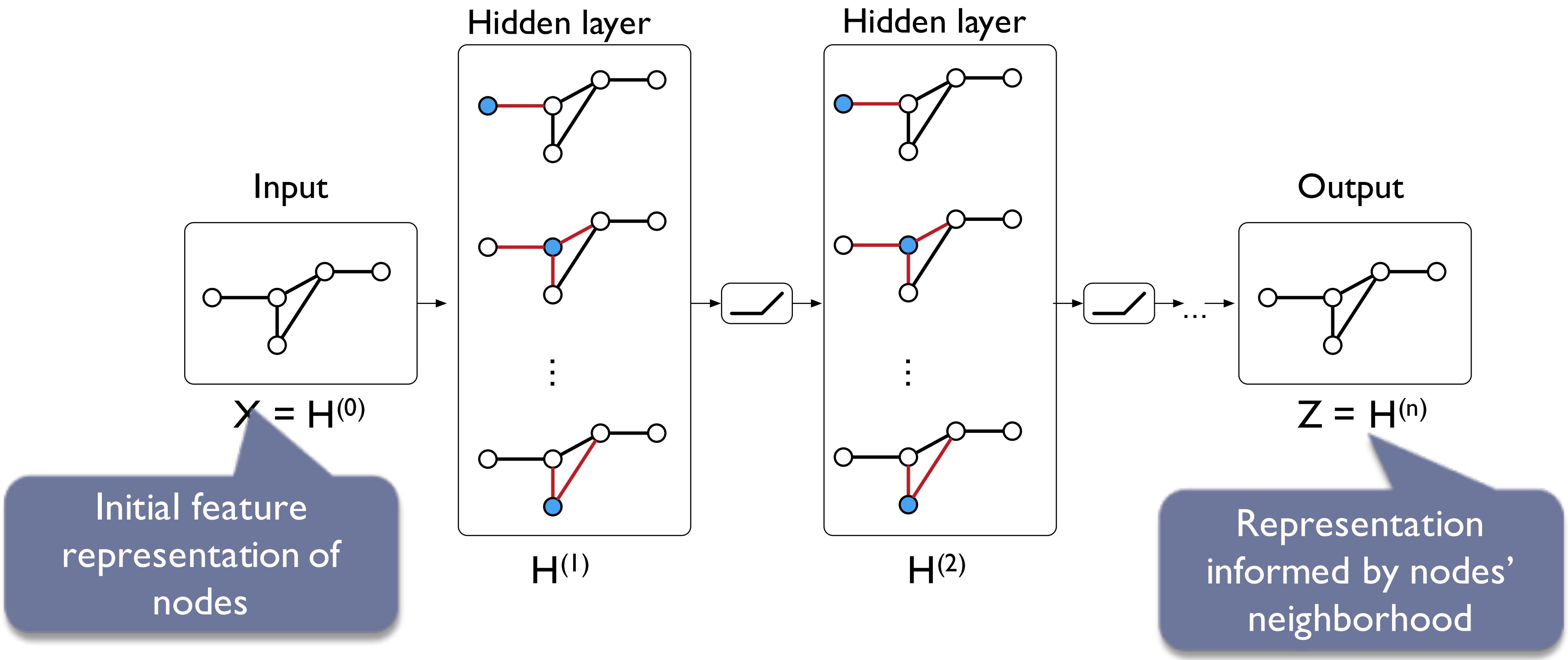
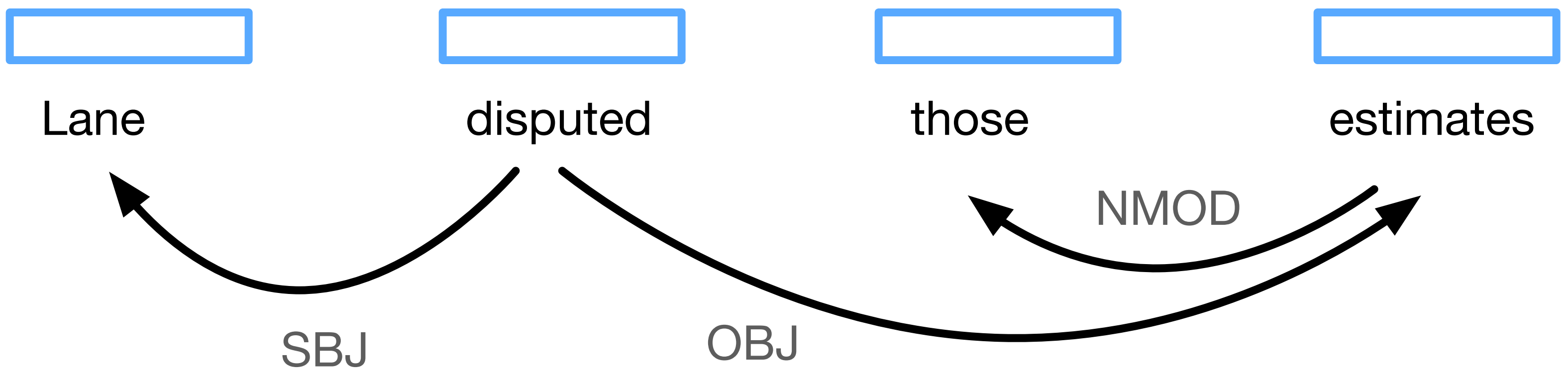


Extend GCNs for syntactic dependency trees

Encoding Sentences with Graph Convolutional Networks

- Graph Convolutional Networks (GCNs)
- **Syntactic GCNs**
- Semantic Role Labeling Model
- Experiments
- Conclusions

Example



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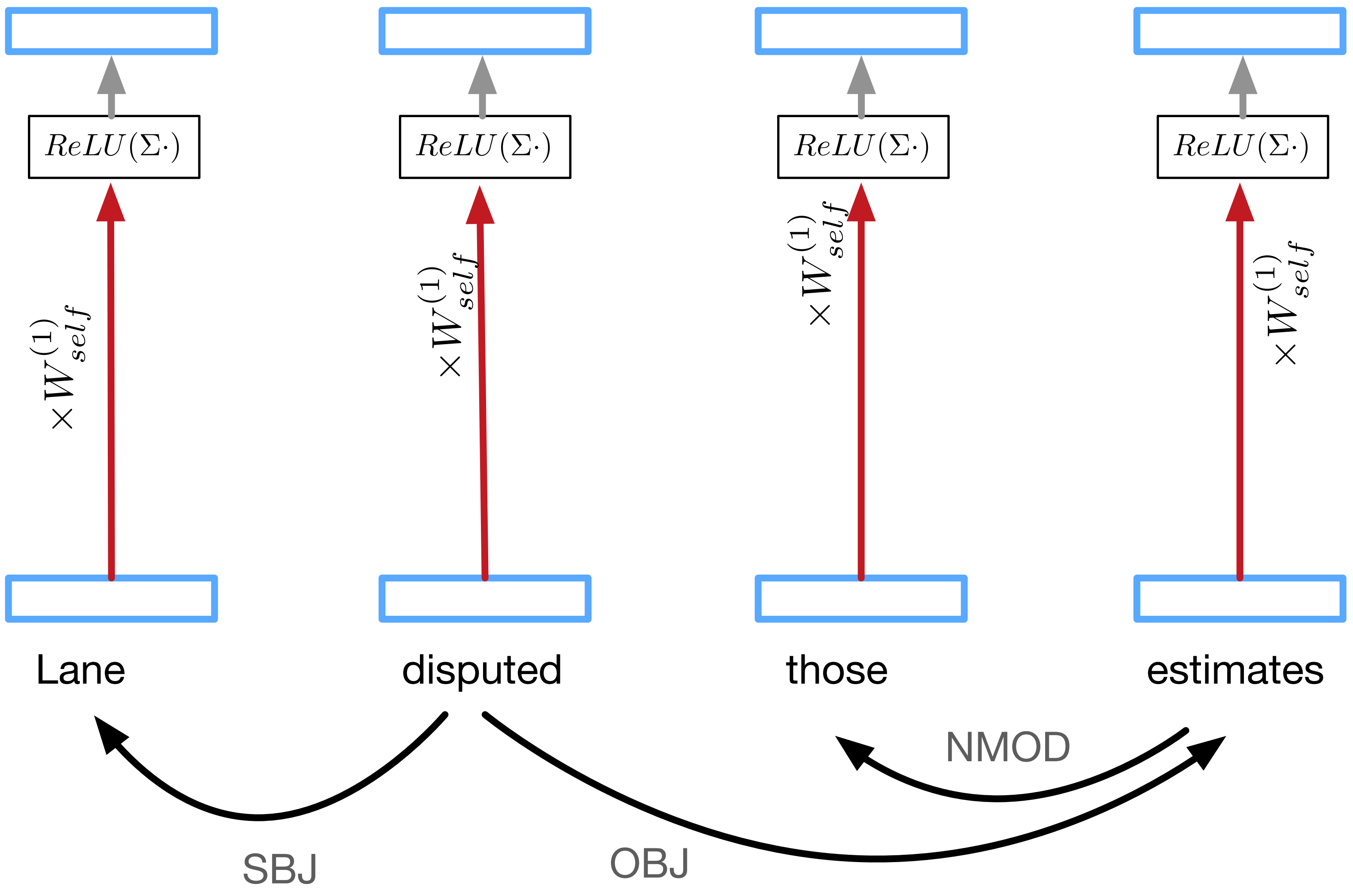

$ReLU(\Sigma\cdot)$
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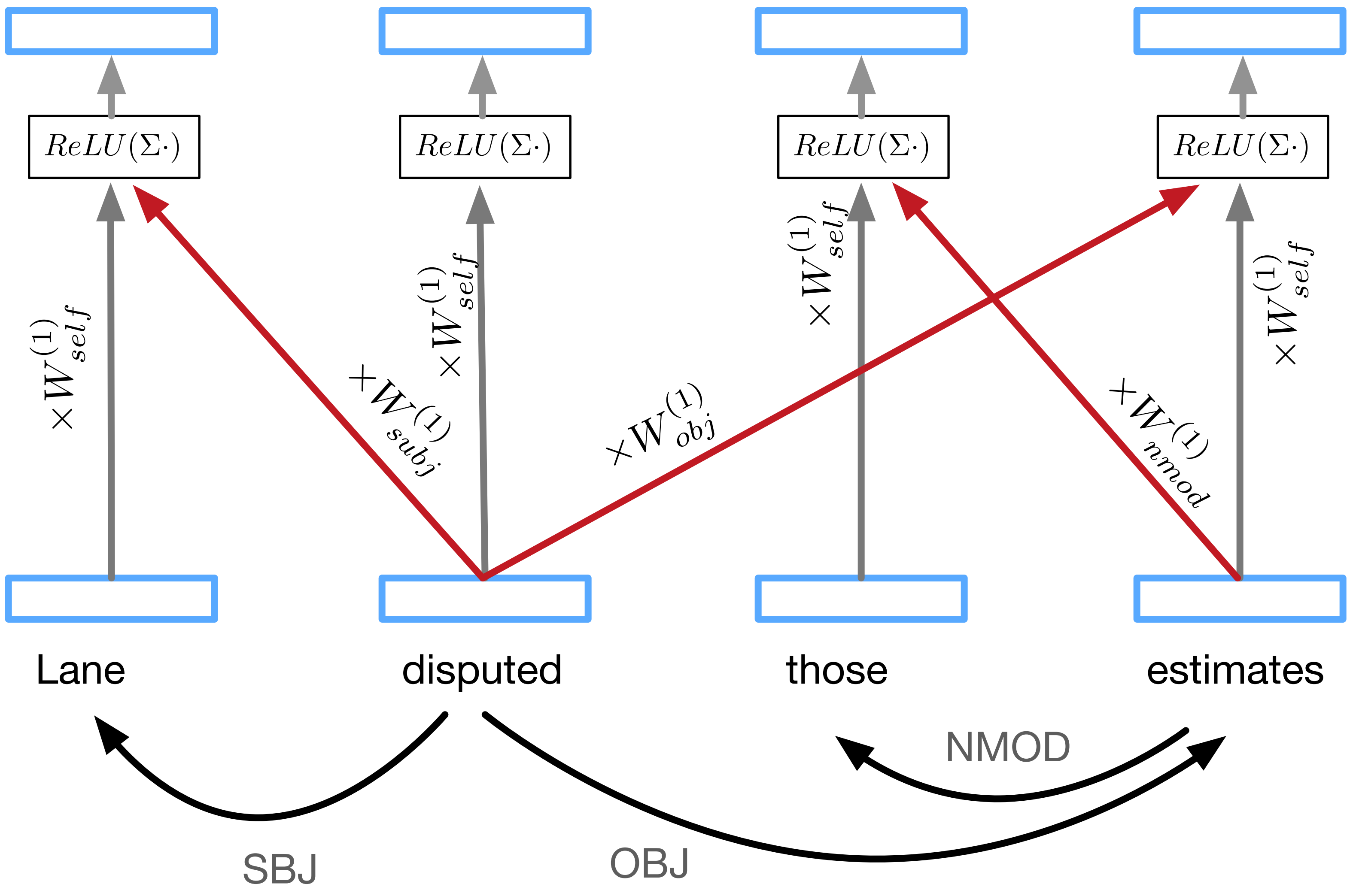
$ReLU(\Sigma\cdot)$
$ReLU(\Sigma\cdot)$
$\times W_{self}^{(1)}$
$\times W_{self}^{(1)}$
$\times W_{self}^{(1)}$
$\times W_{self}^{(1)}$
Lane
disputed
those
estimates
NMOD
SBJ
OBJ

Example



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$\times W^{(1)}_{subj}$
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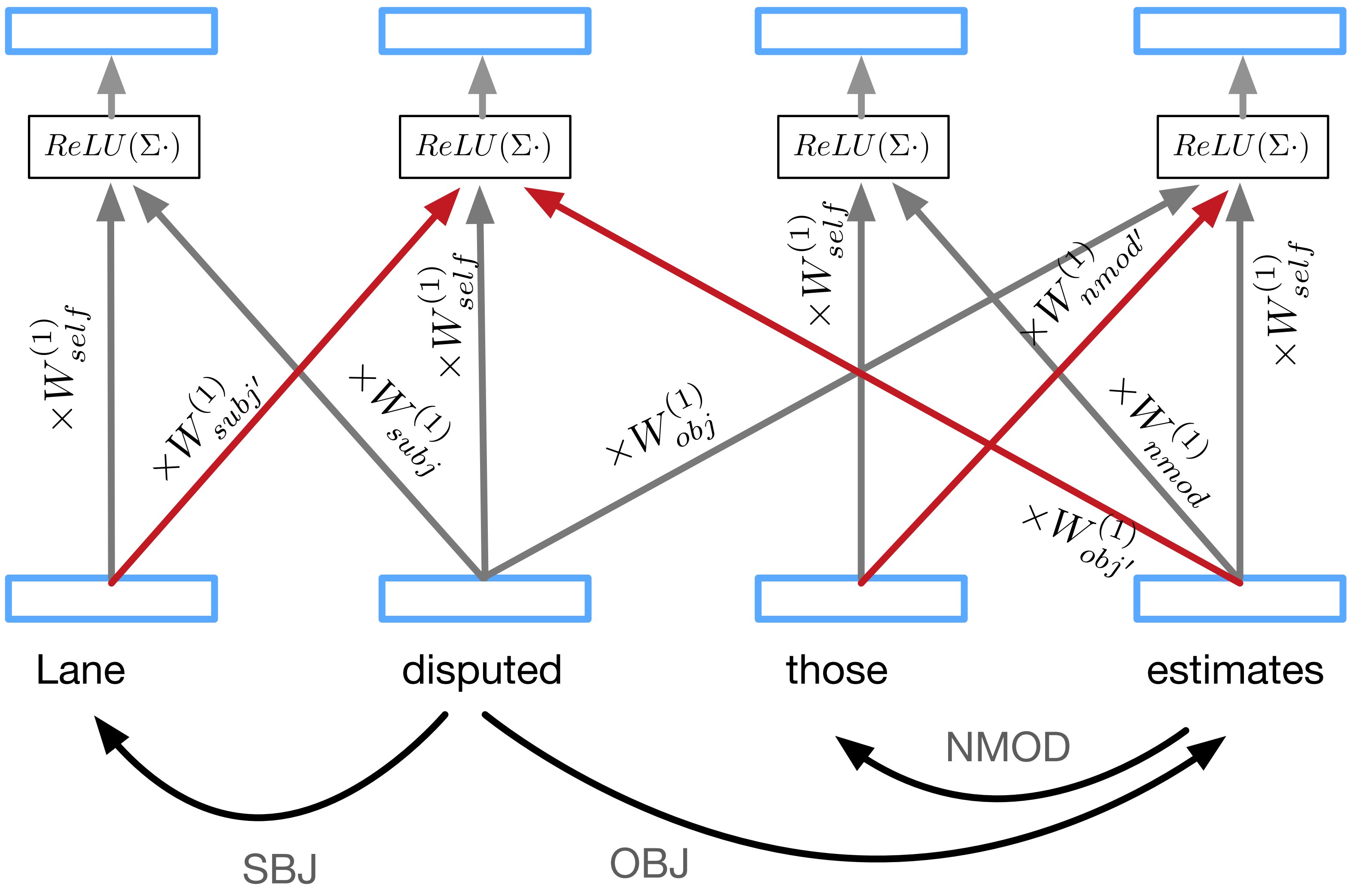

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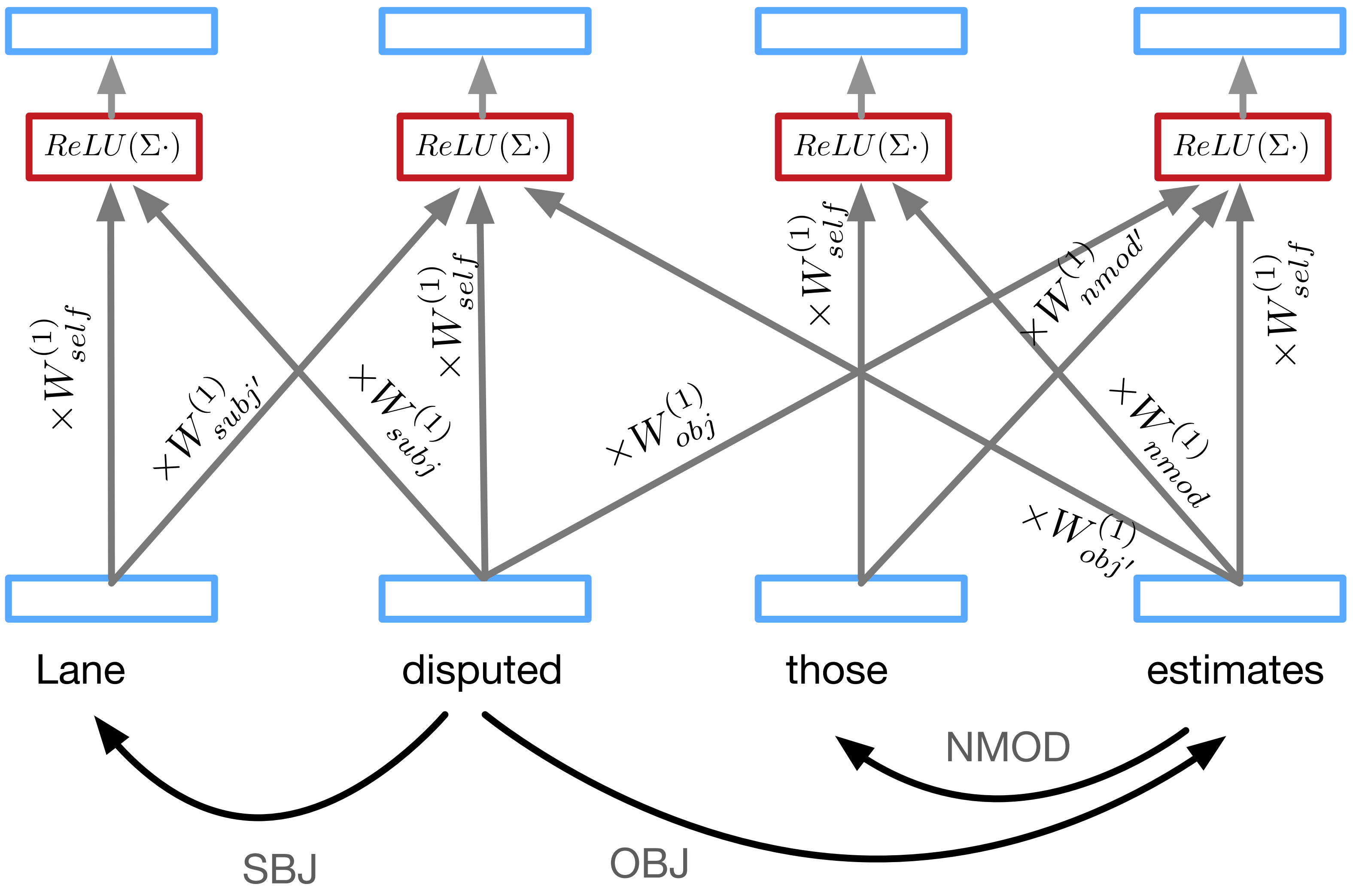

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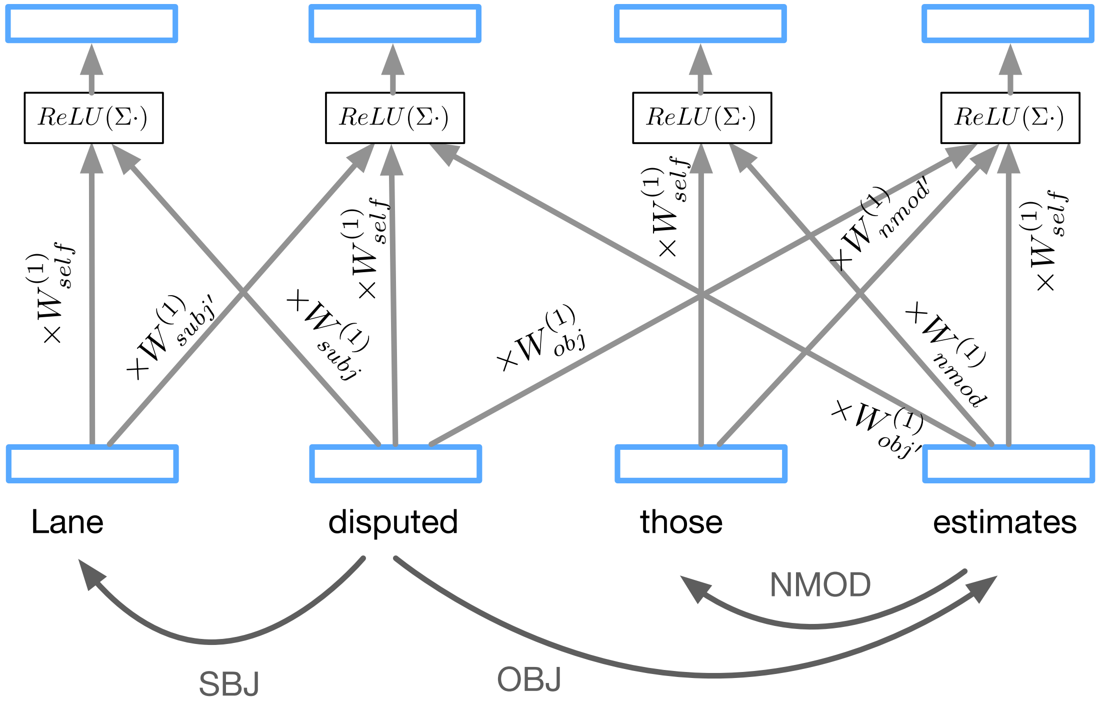

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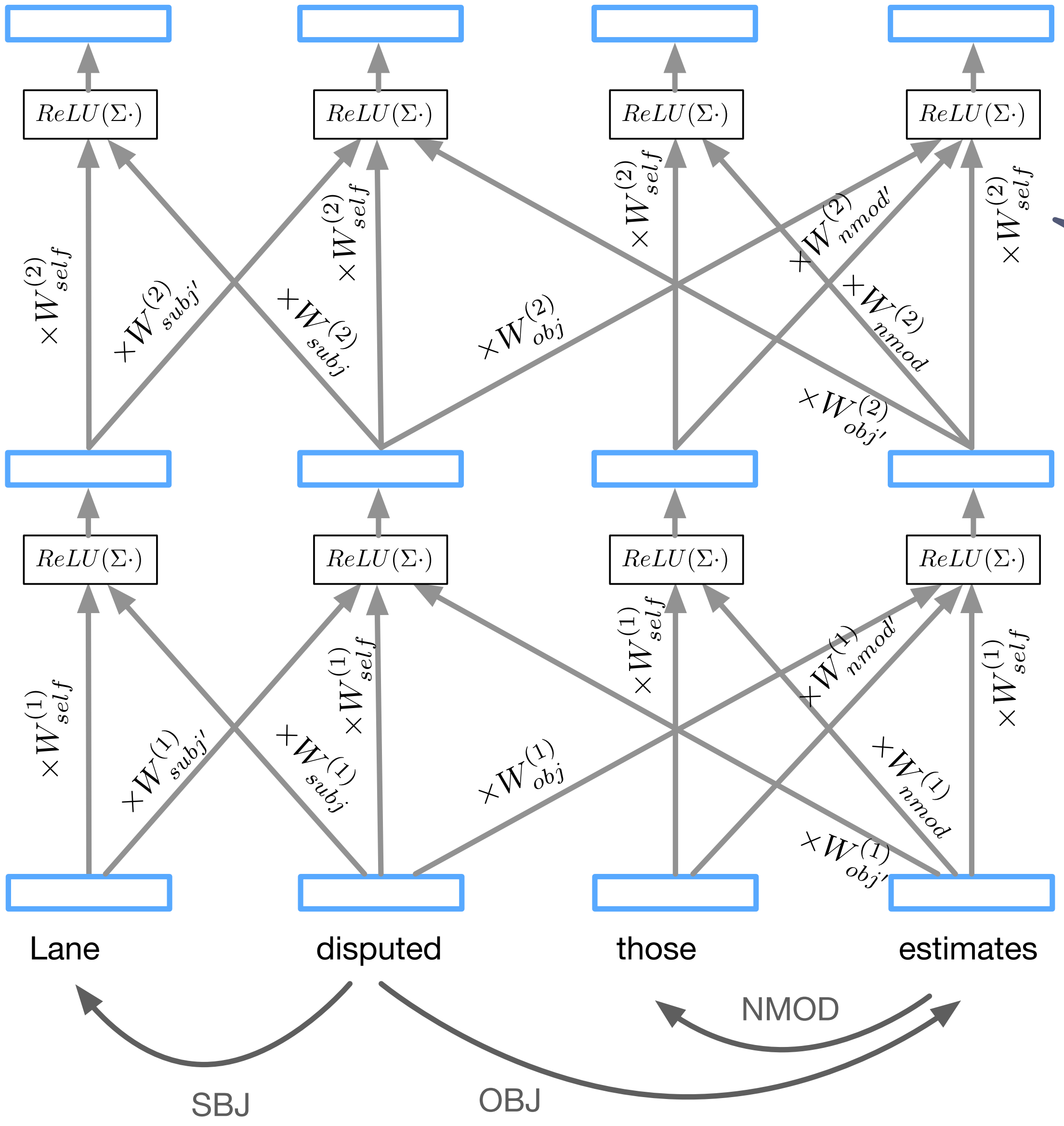

Stacking GCNs widens the syntactic neighborhood

Syntactic GCNs

$$h_v^{(k+1)} = ReLU\left(\sum_{u \in \mathcal{N}(v)} W_{L(u,v)}^{(k)} h_u^{(k)} + b_{L(u,v)}^{(k)}\right)$$

Syntactic GCNs

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Syntactic neighborhood

Syntactic GCNs

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Message

Syntactic neighborhood

Syntactic GCNs

Message

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Syntactic neighborhood

Messages are direction and label specific

Syntactic GCNs

Message

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Syntactic neighborhood

Messages are direction and label specific

- Overparametrized: one matrix for each label-direction pair
- $W_{L(u,v)}^{(k)} = V_{dir(u,v)}^{(k)}$

Edge-wise Gates

- Not all edges are equally important

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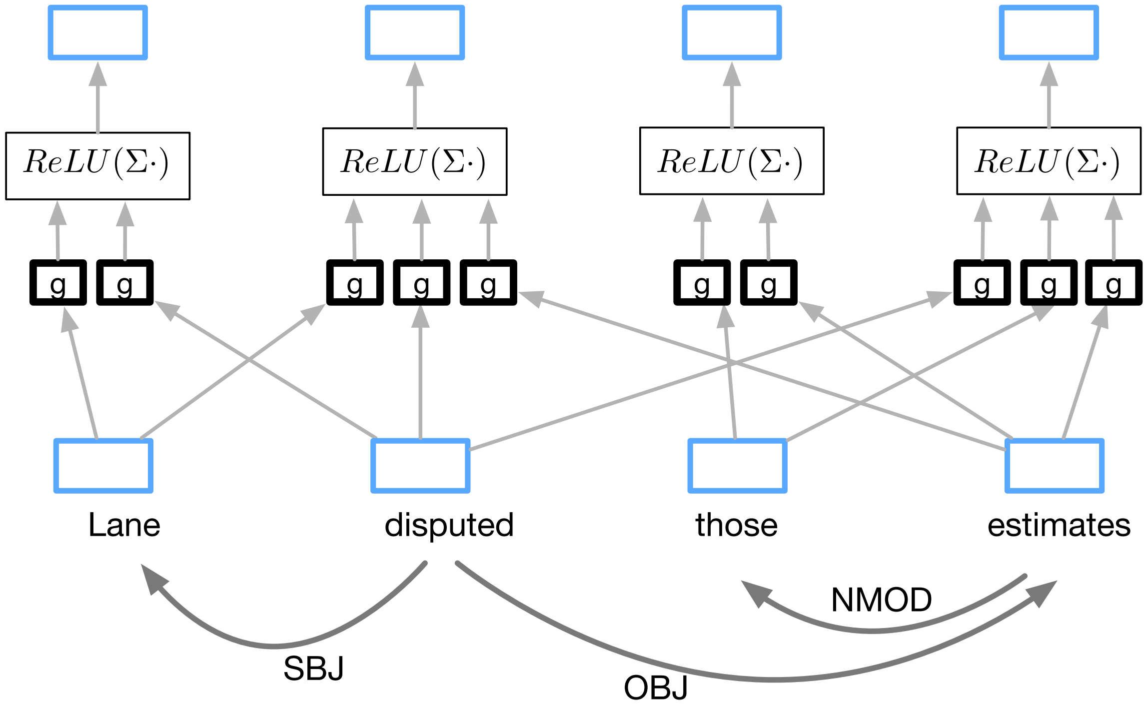

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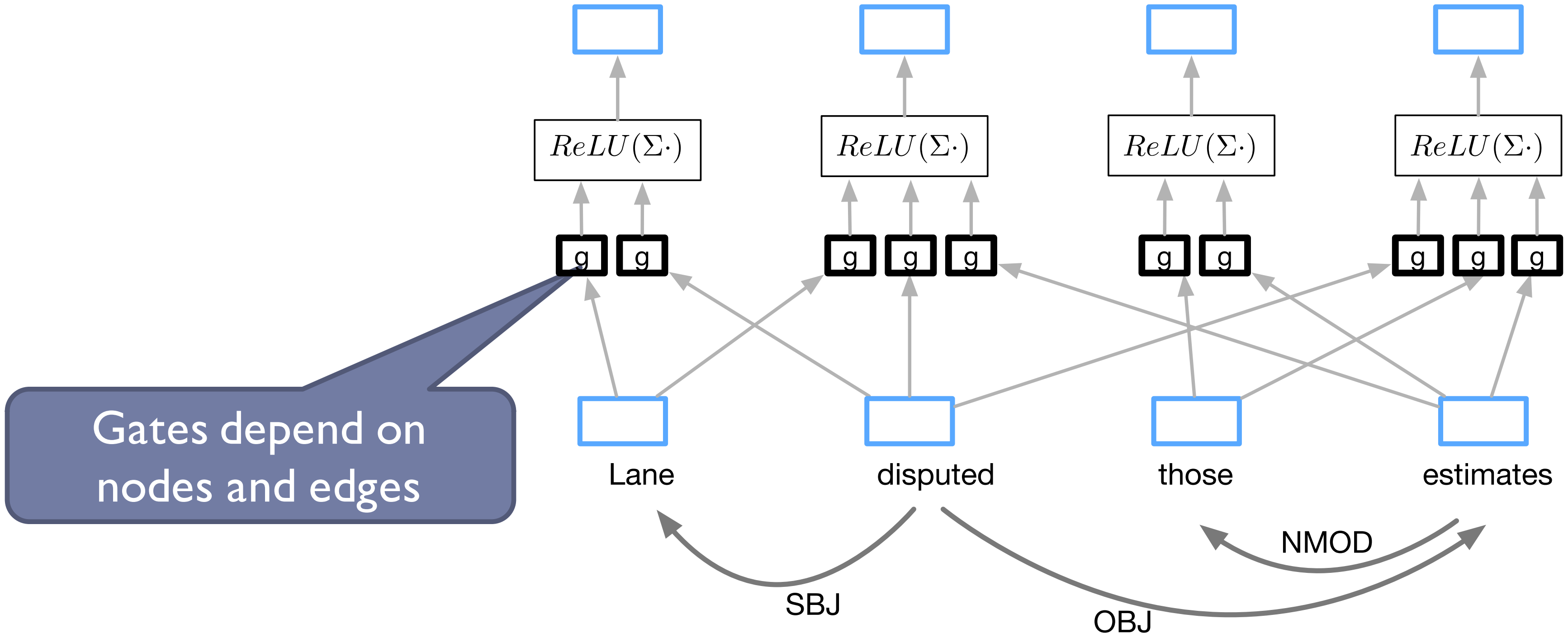

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- **Semantic Role Labeling Model**
- Experiments
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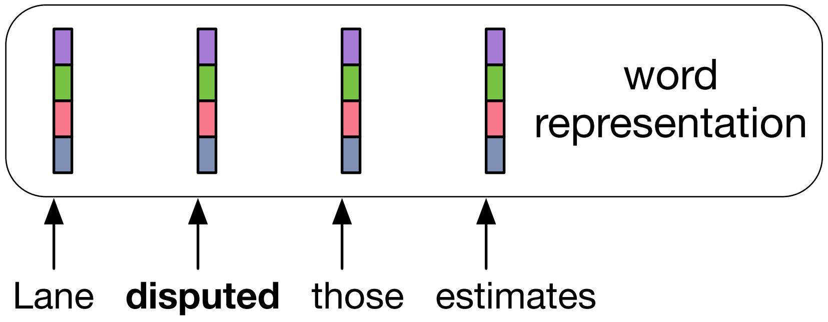
Our Model

- Word representation
- Bidirectional LSTM encoder
- GCN Encoder
- Local role classifier

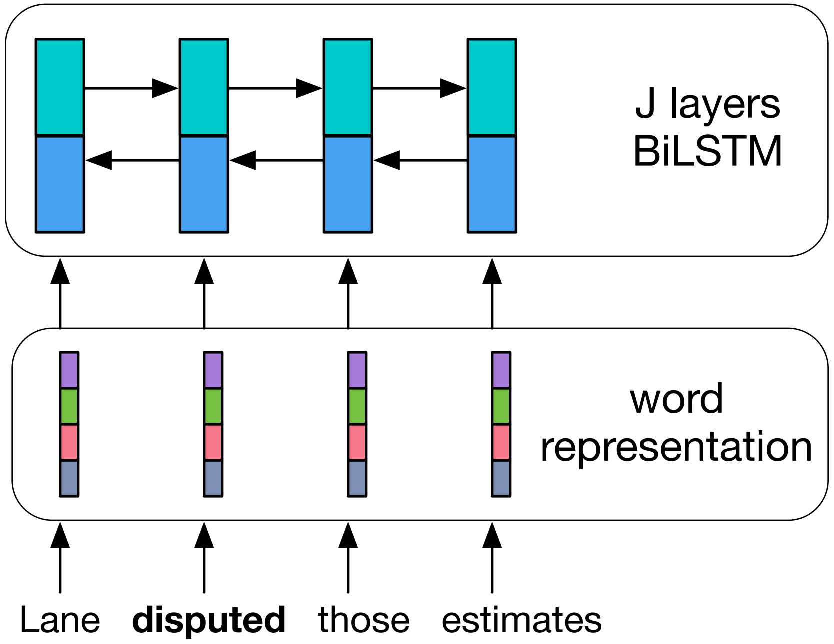
Word Representation

- Pretrained word embeddings
- Word embeddings
- POS tag embeddings
- Predicate lemma embeddings
- Predicate flag



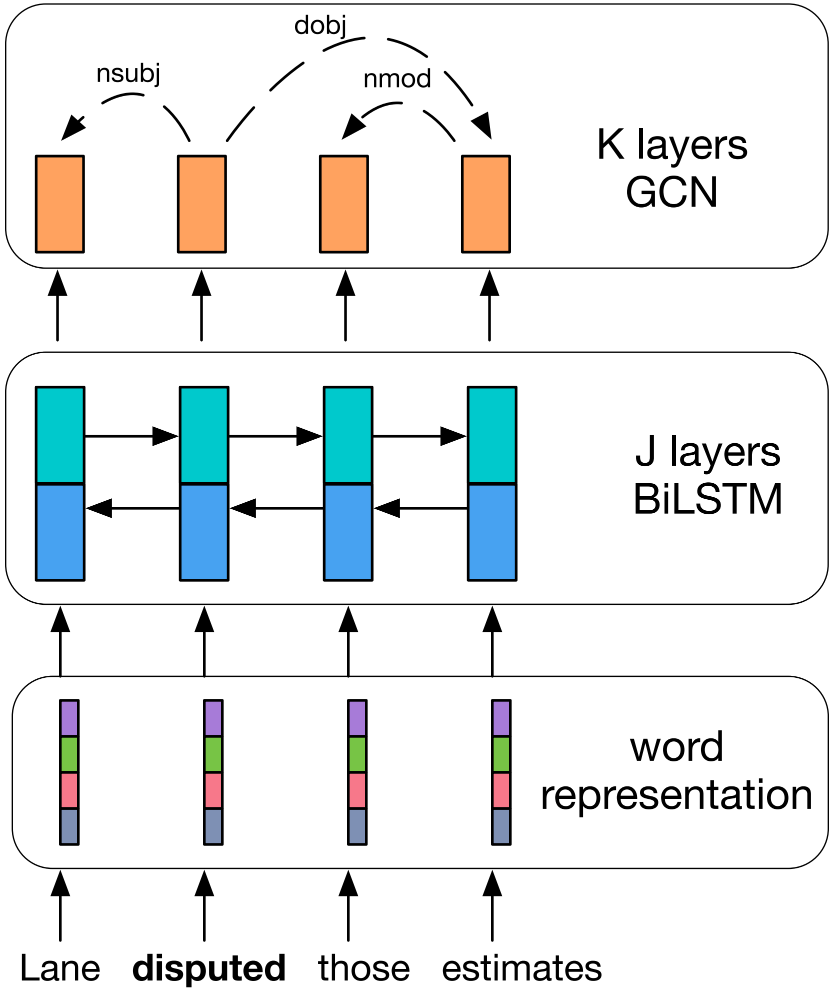
BiLSTM Encoder

- Encode each word with its left and right context
- Stacked BiLSTM



GCNs Encoder

- Syntactic GCNs after BiLSTM encoder
  - Add syntactic information
  - Skip connections
  - Longer dependencies are captured



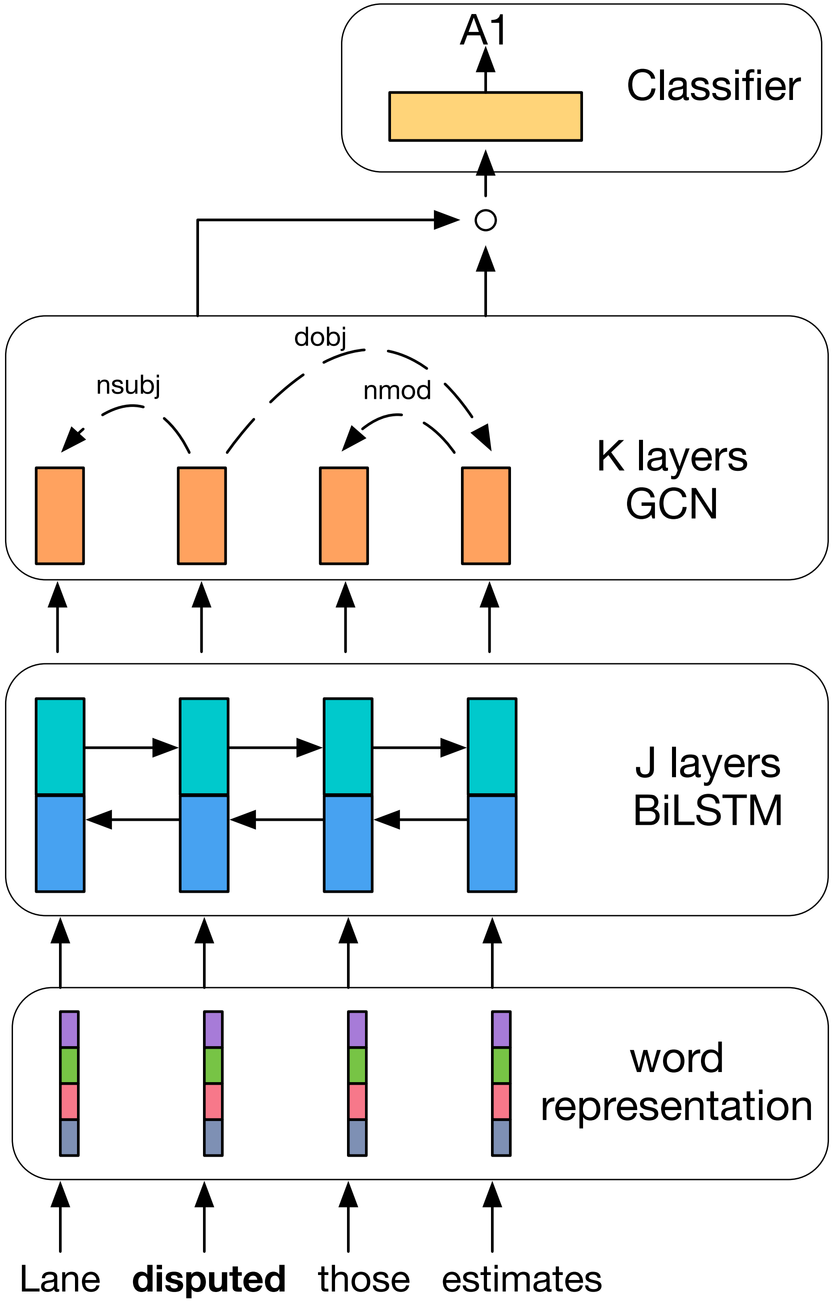
Semantic Role Classifier

- Local log-linear classifier

$$p(r|t_i, t_p, l) \propto \exp(W_{l,r}(t_i \circ t_p))$$

predicate representation

candidate argument representation



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- **Experiments**
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Experiments

- Data
  - CoNLL-2009 dataset - English and Chinese
  - F1 evaluation measure
- Model
  - Hyperparameters tuned on English development set
  - State-of-the-art predicate disambiguation models

Ablation Experiments (English Dev set)

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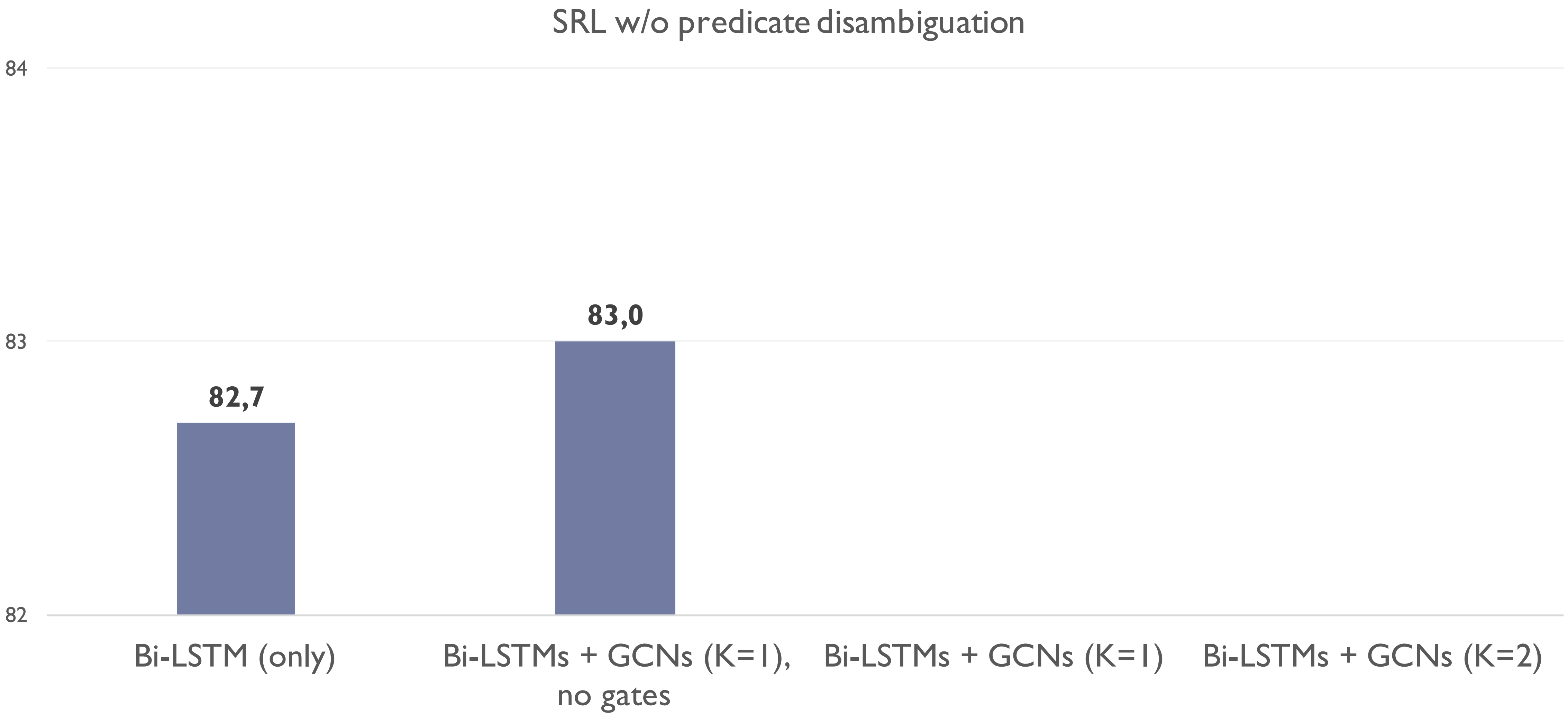

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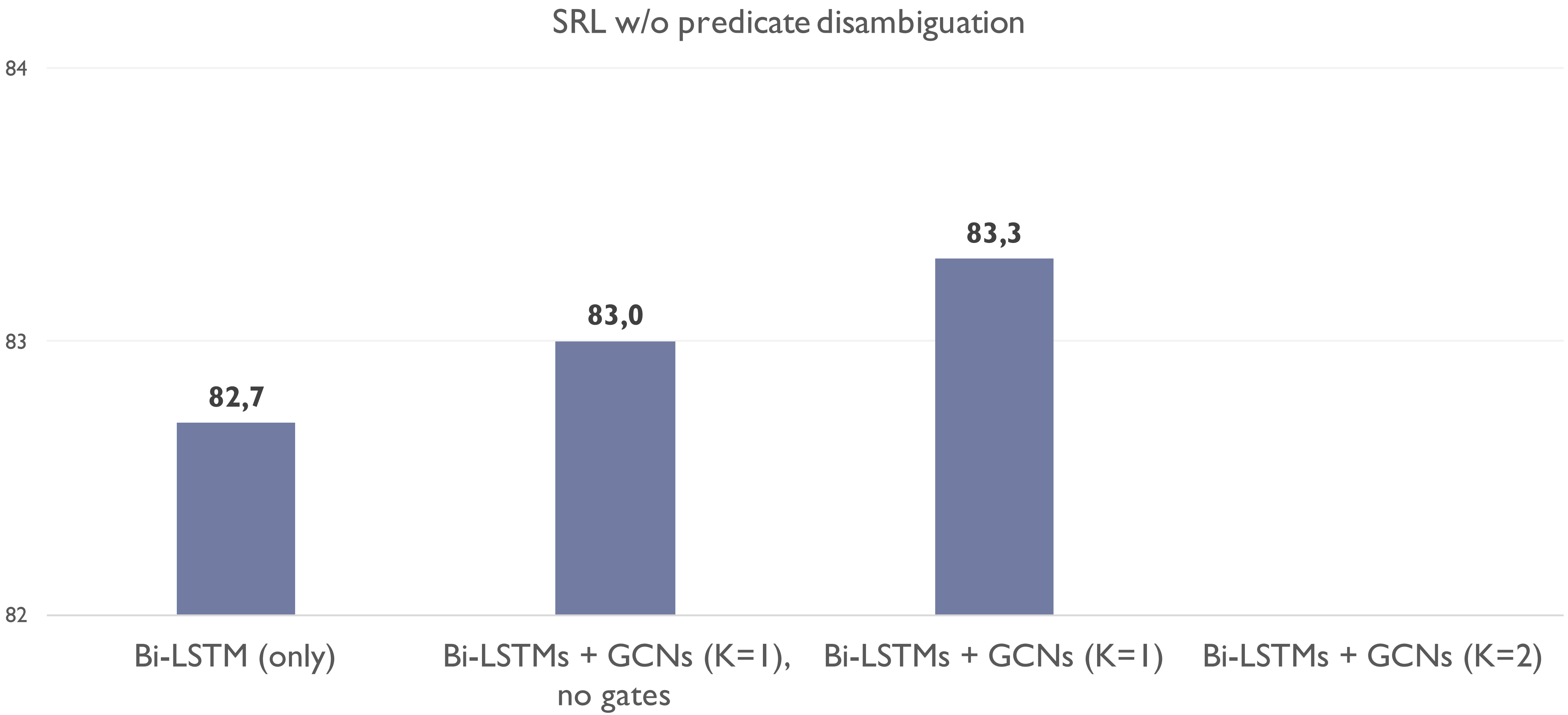

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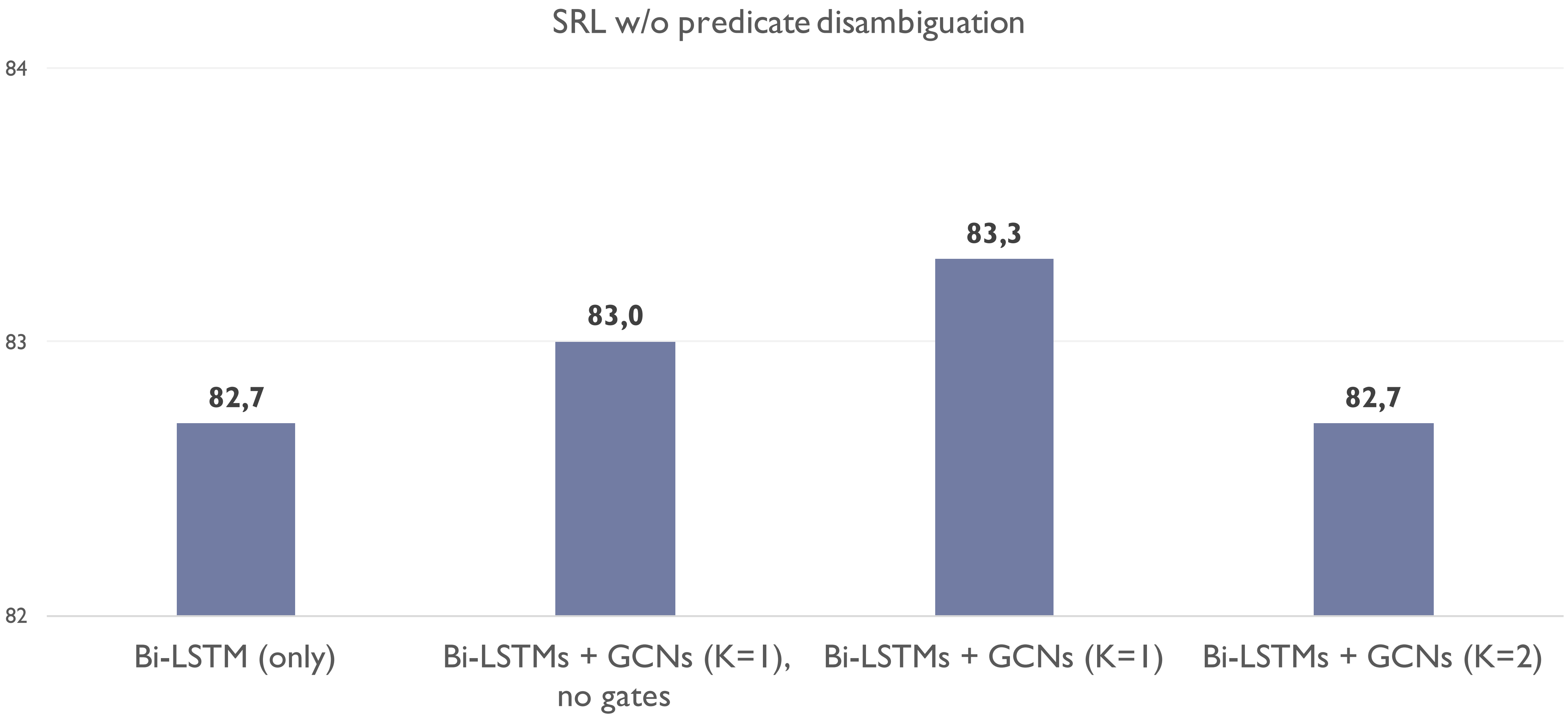
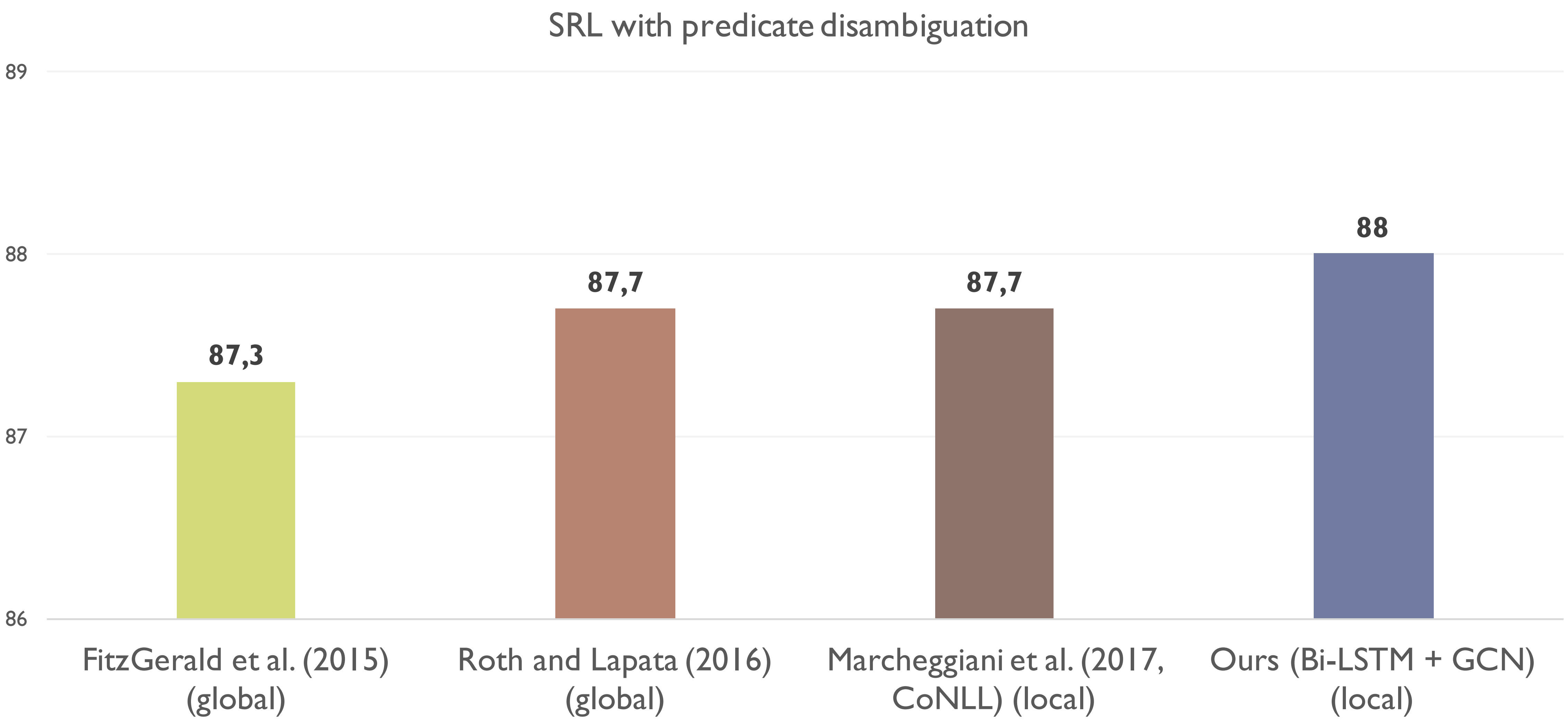
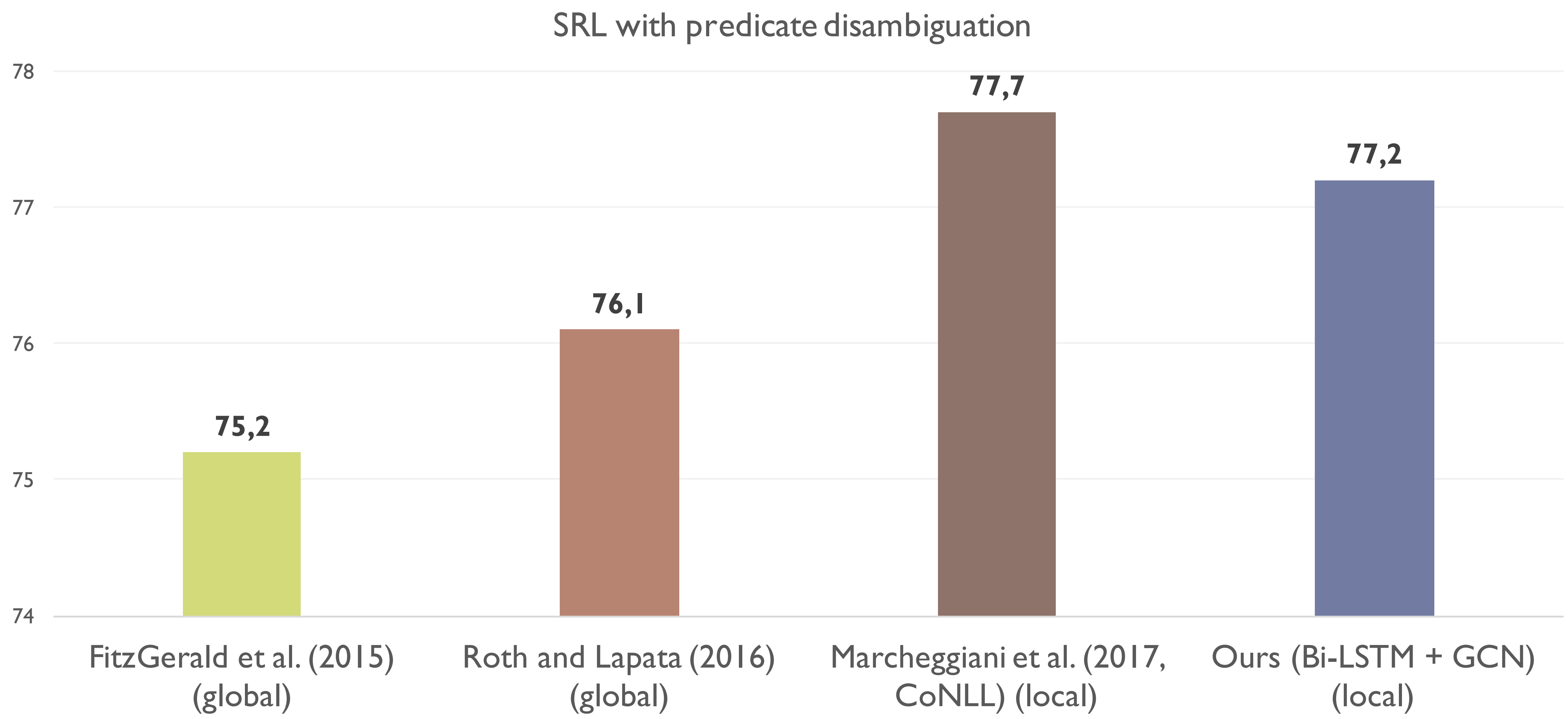


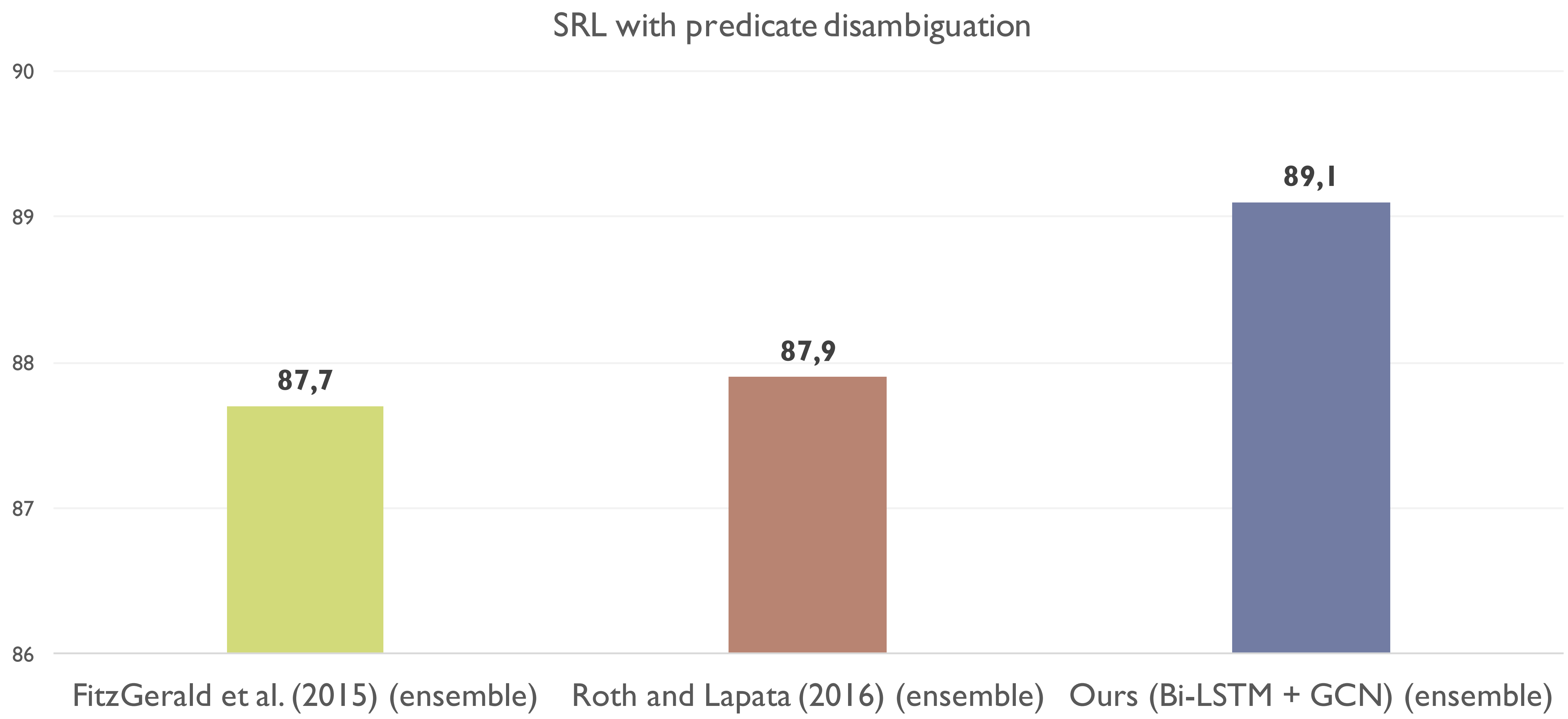
English Test Set



English Out of Domain



English Test Set (Ensemble)



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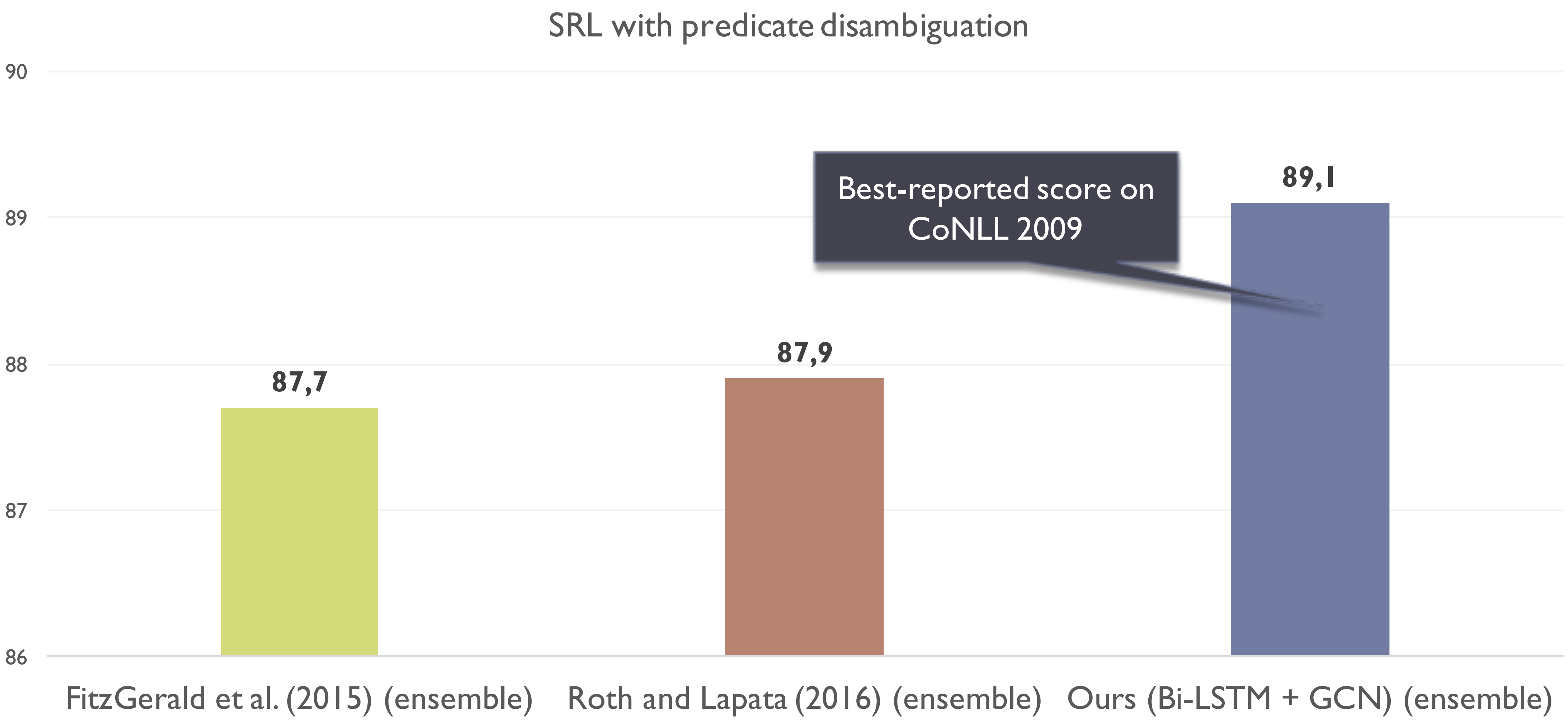
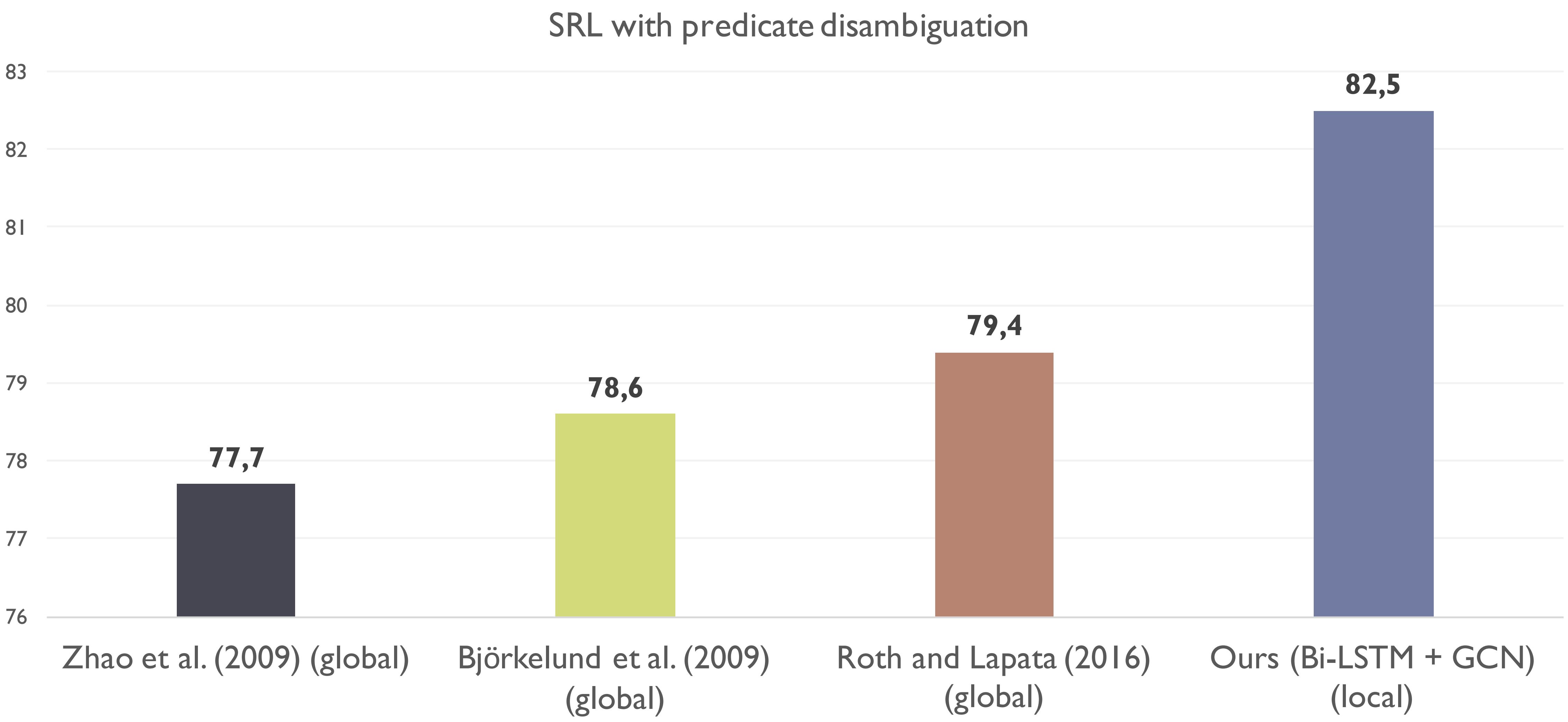
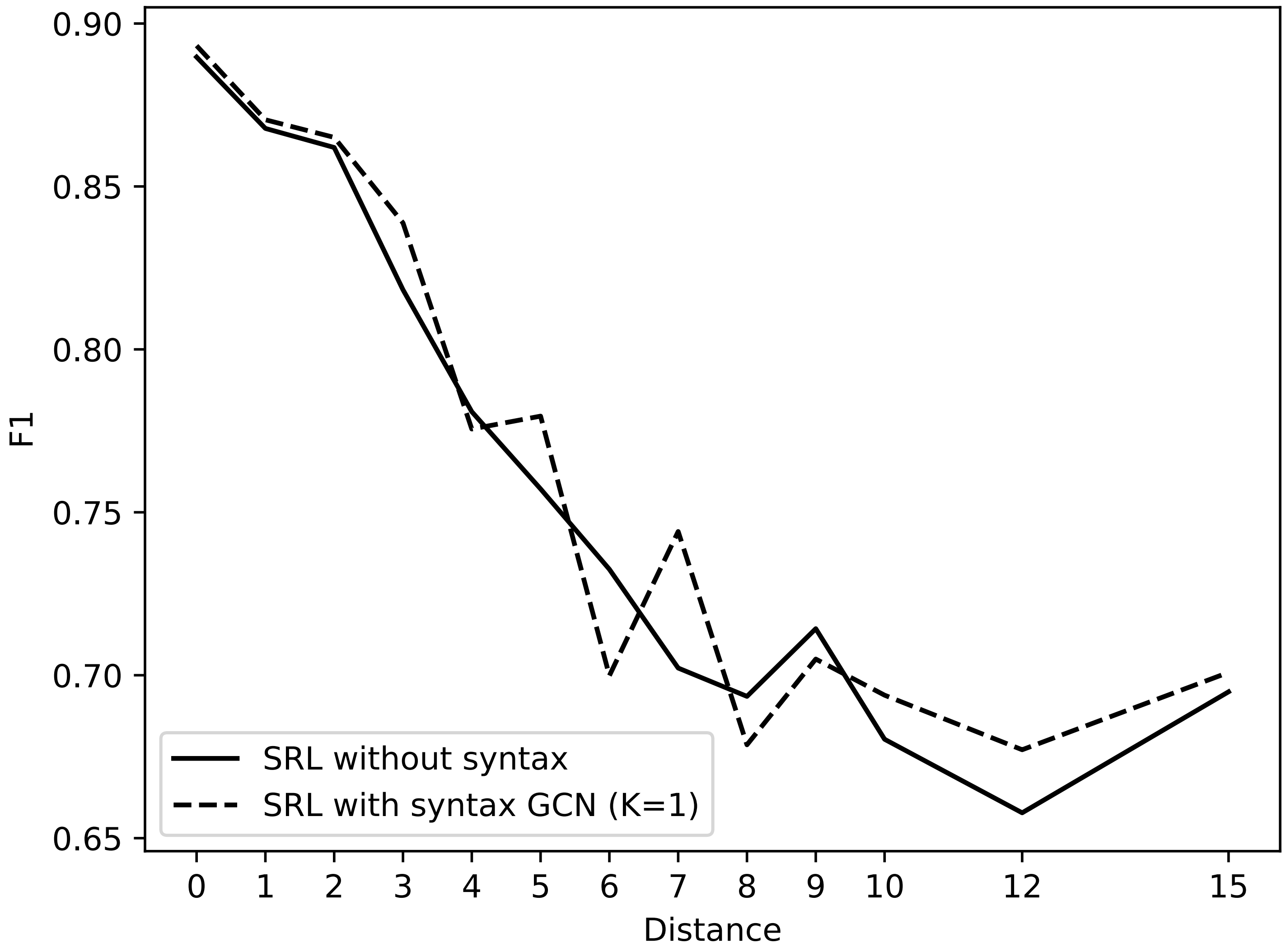


Chinese Test Set



Long-range Dependencies (English Dev Set)



Conclusion

- Syntax-aware state-of-the-art model for dependency-based SRL
  - English and Chinese
- GCNs for encoding syntactic structures into NN
  - Semantics, coreference, discourse

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- Funding:
  - ERC StG BroadSem 678254
  - NWO VIDI 639.022.518
  - Amazon Web Services (AWS) grant

github.com/diegma/neural-dep-srl