

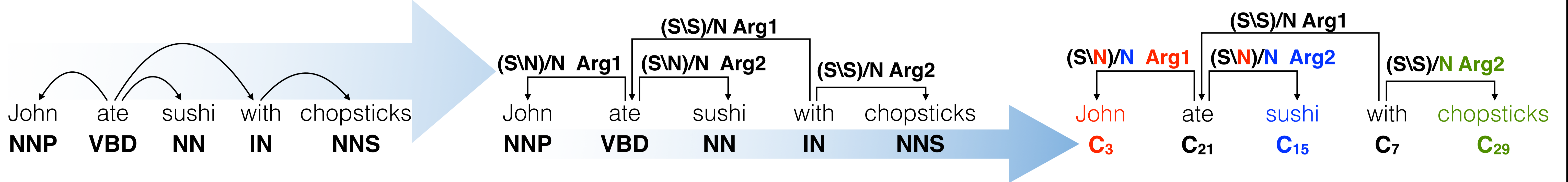
Labeled Grammar Induction with Minimal Supervision

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Dependency Grammar Induction:
Unlabeled Dependencies from POS tags

CCG Induction (Bisk & Hockenmaier 2013; 2015):
Labeled Dependencies from POS tags

This paper:
Labeled dependencies without POS tags



Most approaches to **grammar induction** are based on the assumption that **gold POS tags are available** to the induction system. POS tags are arbitrary, relatively clean, clusters, which we **replace with induced clusters**.

1. Induce and Label Clusters: Noun, Verb, Other

C₂₉
shares, sales, business, companies, prices, investors, them, people, bonds, stocks, earnings, officials, income, rates, markets, analysis, products, funds, operations, growth, banks, issues, costs, concern, traders, him, assets, loans, firms, results, here, ...

C₁₃
the, its, their, his, these, our, Robert, my, your, every, His, Hurricane, Sir, Their, Freddie, Dean, Du, Tom, Jim, Remic, Roger, Gary, Ronald, Kenneth, Alex, Bruce, Litigation, Jay, Alfred, Ad, CS, Andrew, negotiable, Thrift, Patrick, Allied, Speaker, ...

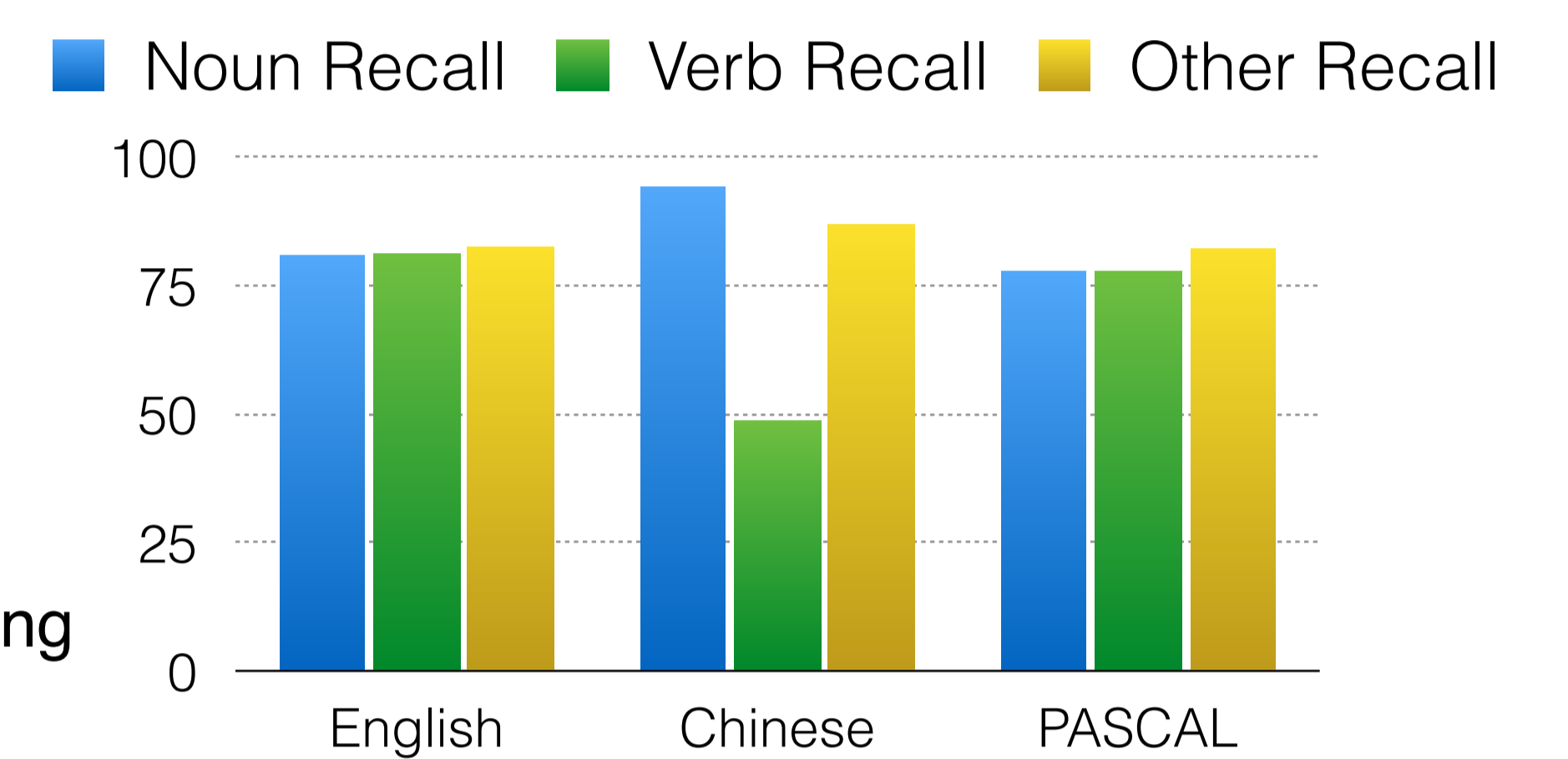
C₂₅
's, is, was, are, has, were, had, rose, fell, 're, ended, expects, whose, 've, remains, gained, owns, includes, became, jumped, holds, takes, provides, climbed, grew, gets, operates, sells, tumbled, seeks, becomes, begins, eased, allowed, helps, ...

Data:

- CCGbanks: English and Chinese
- Dependency Corpora: 10 PASCAL Challenge Languages

Metric:

Recall from majority vote cluster labeling from 3 annotated words per cluster.

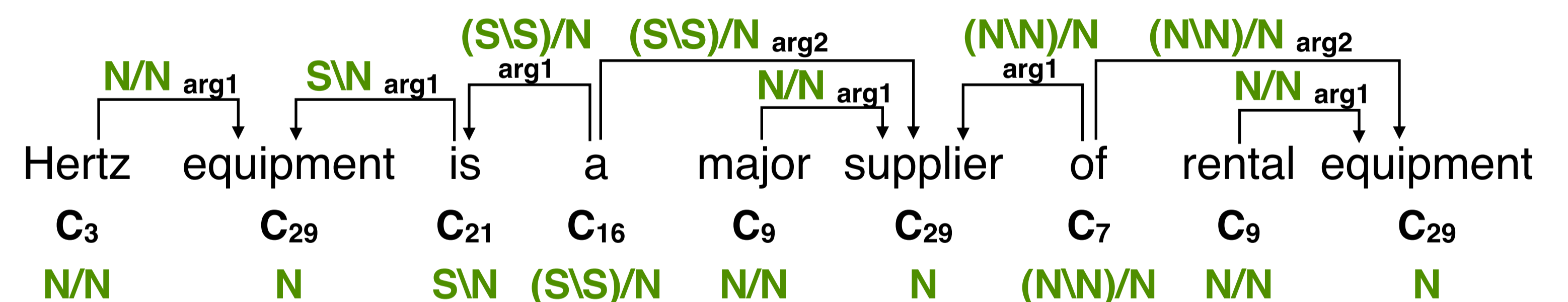


We use the Bayesian Mixture of Multinomials model (BMMM) of Christodoulopoulos et al. 2011 to induce word clusters. BMMM performs a **type-based clustering** based on **token-level features** and automatically inferred **morphology** [Morfessor (Creutz & Lagus 2006)]. Based on the Universal POS tags of the three most common words, clusters are labeled as **N**(oun), **V**(erb) or **O**(ther).

2. Induce a Grammar and Learn Labeled Dependencies

	Hertz	equipment	is	a	major	supplier	of	rental	equipment
Labels	the, its, their, his, these, our, Robert, my, your, every, His, Hurricane, Sir, Their, Freddie, Dean, Du, Tom, Jim, Remic, Roger, Gary, Ronald, Kenneth, Alex, Bruce, Litigation, Jay, Alfred, Ad, CS, Andrew, negotiable, Thrift, Patrick, Allied, Speaker, ...	shares, sales, business, companies, prices, investors, them, people, bonds, stocks, earnings, officials, income, rates, markets, analysis, products, funds, operations, growth, banks, issues, costs, concern, traders, him, assets, loans, firms, results, here, ...	's, is, was, are, has, were, had, rose, fell, 're, ended, expects, whose, 've, remains, gained, owns, includes, became, jumped, holds, takes, provides, climbed, grew, gets, operates, sells, tumbled, seeks, becomes, begins, eased, allowed, helps, ...	the, its, their, his, these, our, Robert, my, your, every, His, Hurricane, Sir, Their, Freddie, Dean, Du, Tom, Jim, Remic, Roger, Gary, Ronald, Kenneth, Alex, Bruce, Litigation, Jay, Alfred, Ad, CS, Andrew, negotiable, Thrift, Patrick, Allied, Speaker, ...	shares, sales, business, companies, prices, investors, them, people, bonds, stocks, earnings, officials, income, rates, markets, analysis, products, funds, operations, growth, banks, issues, costs, concern, traders, him, assets, loans, firms, results, here, ...	shares, sales, business, companies, prices, investors, them, people, bonds, stocks, earnings, officials, income, rates, markets, analysis, products, funds, operations, growth, banks, issues, costs, concern, traders, him, assets, loans, firms, results, here, ...	the, its, their, his, these, our, Robert, my, your, every, His, Hurricane, Sir, Their, Freddie, Dean, Du, Tom, Jim, Remic, Roger, Gary, Ronald, Kenneth, Alex, Bruce, Litigation, Jay, Alfred, Ad, CS, Andrew, negotiable, Thrift, Patrick, Allied, Speaker, ...	shares, sales, business, companies, prices, investors, them, people, bonds, stocks, earnings, officials, income, rates, markets, analysis, products, funds, operations, growth, banks, issues, costs, concern, traders, him, assets, loans, firms, results, here, ...	shares, sales, business, companies, prices, investors, them, people, bonds, stocks, earnings, officials, income, rates, markets, analysis, products, funds, operations, growth, banks, issues, costs, concern, traders, him, assets, loans, firms, results, here, ...
R0		N	S		N	N		N	N
R1	N/N	S/S	S/N	S/S	N/N	N/N	N/N	N/N	N/N
R2	(S/S)/(S/S)	(N/N)/(N/N)	(S/S)/(S/S)	(N/N)/(N/N)	(N/N)/(N/N)	(N/N)/(N/N)	(N/N)/(N/N)	(N/N)/(N/N)	(N/N)/(N/N)

CCG Induction: Nouns can have the CCG **category N**, verbs can have the CCG **category S**, and may take adjacent nouns as arguments (S/N, S/N, (S/N)/N, etc.). All words can modify (XIX) adjacent N and S.

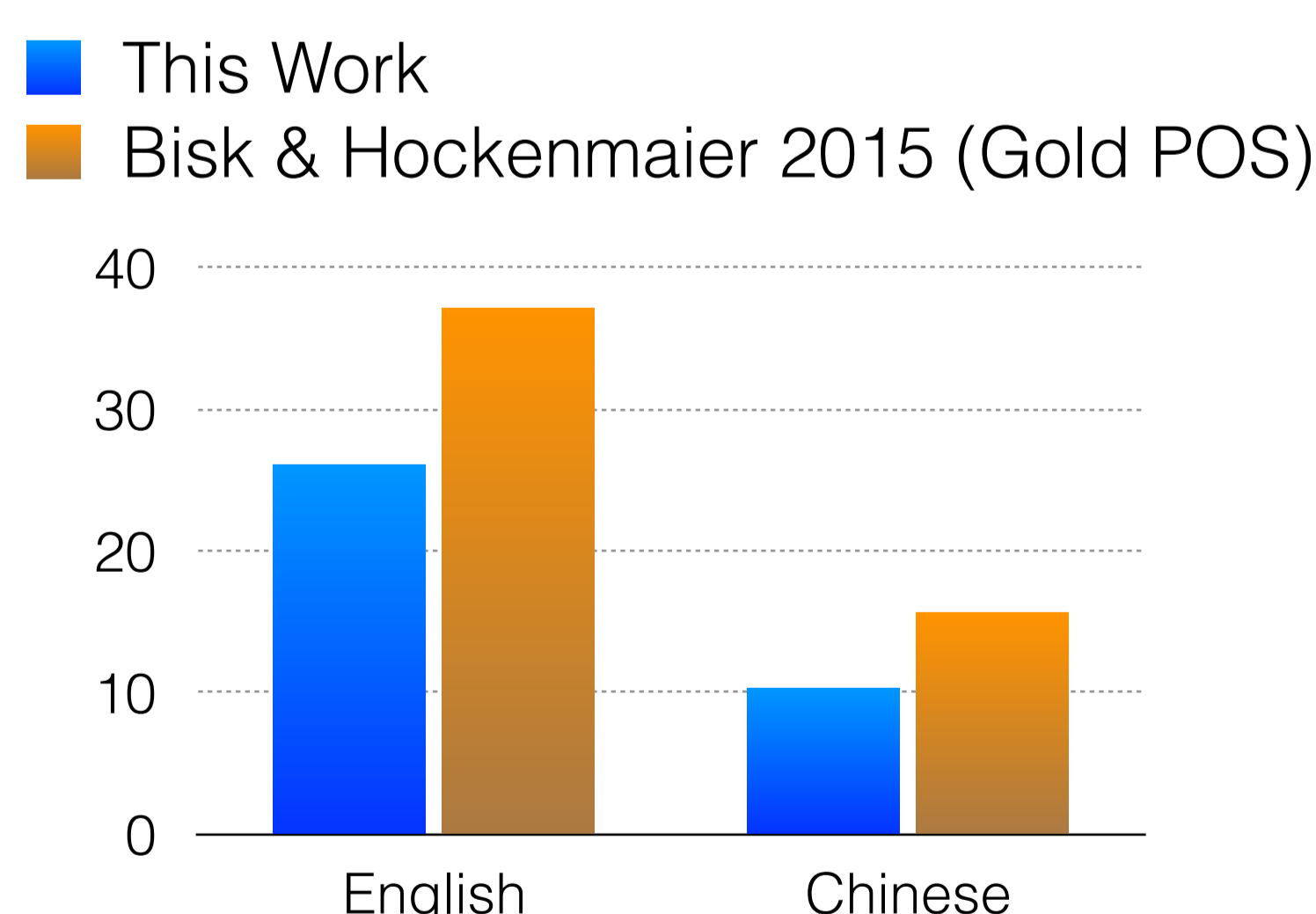


We train a parsing model (Bisk & Hockenmaier 2013;2015) on the induced parse forests. The parser returns CCG derivations and hence **labeled dependencies**.

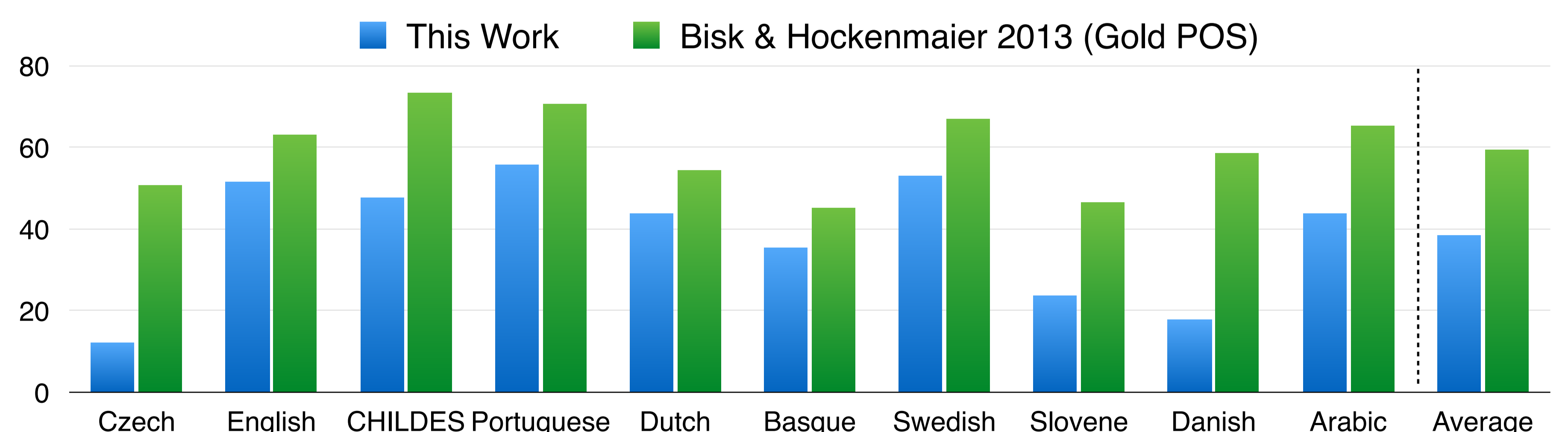
3. Parsing Evaluation

Bisk & Hockenmaier 2015 produce labeled dependencies with an **unsupervised CCG** system based on **gold POS tags**. We show that performance degrades only slightly (less than 1/3 on average) with **induced word clusters**.

Labeled F1 on CCGbank



Directed Attachments on Dependency Treebanks



Analysis & Future Work

Every language poses its own challenges. In panel 2 we see that identifying verbs proves difficult in Chinese. Additionally, in panel 4 we find the largest gaps in languages with rich morphology. Better clustering or feedback from the syntax may help address these issues.

References:

- Creutz & Lagus. Morfessor in the Morpho challenge. *Proc of PASCAL Challenge Workshop on Unsupervised Segmentation of Words into Morphemes*. 2006
- Christodoulopoulos et al. A Bayesian mixture model of PoS induction using multiple features. *Proc of EMNLP 2011*
- Bisk & Hockenmaier 2012 Simple Robust Grammar Induction with Combinatory Categorical Grammars. *Proc of AAAI 2012*
- Bisk & Hockenmaier 2013 An HDP Model for Inducing Combinatory Categorical Grammars. *Trans. of the ACL*. 2013
- Bisk & Hockenmaier 2015 Probing the Linguistic Strengths and Limitations of Unsupervised Grammar Induction. *Proc of ACL 2015*

