Probabilistic ParaMor

Christian Monson
Kristy Hollingshead
Brian Roark

Probabilistic ParaMor

A Baseline for Unsupervised Induction

The **ParaMor** System

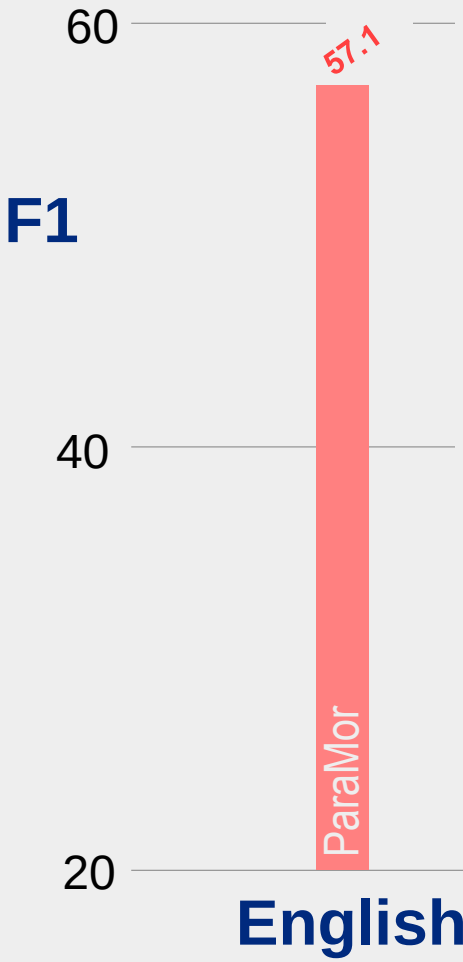
Morpho Challenge 2008

New Work

Probabilistic ParaMor

Morpho Challenge **2009**

Results of Linguistic Evaluation 2008

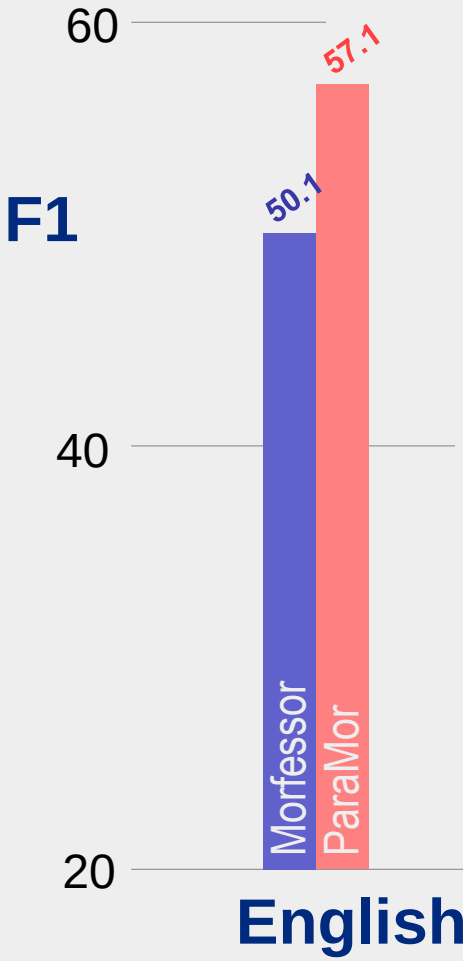


ParaMor

- Built for my Ph.D. thesis
- Rule-based
- Builds linguistically motivated paradigms

Word	ParaMor
dispute's	disput +e +'s
juried	juri +ed
losses	los +ses
…	…

Results of Linguistic Evaluation 2008



Morfessor

Baseline system for Morpho Challenge

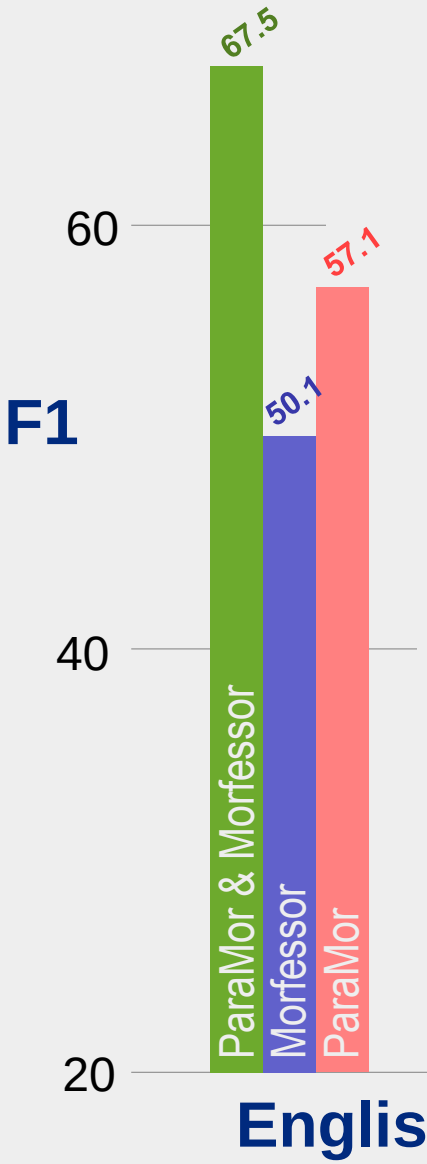
Freely available

Minimum Description Length

Black box segmentation

Word	ParaMor	Morfessor
dispute's	disput +e +'s	dispute/STM +'s/SUF
juried	juri +ed	juried/STM
losses	los +ses	losses/STM
…	…	…

Results of Linguistic Evaluation 2008



Submit **Both** analyses:

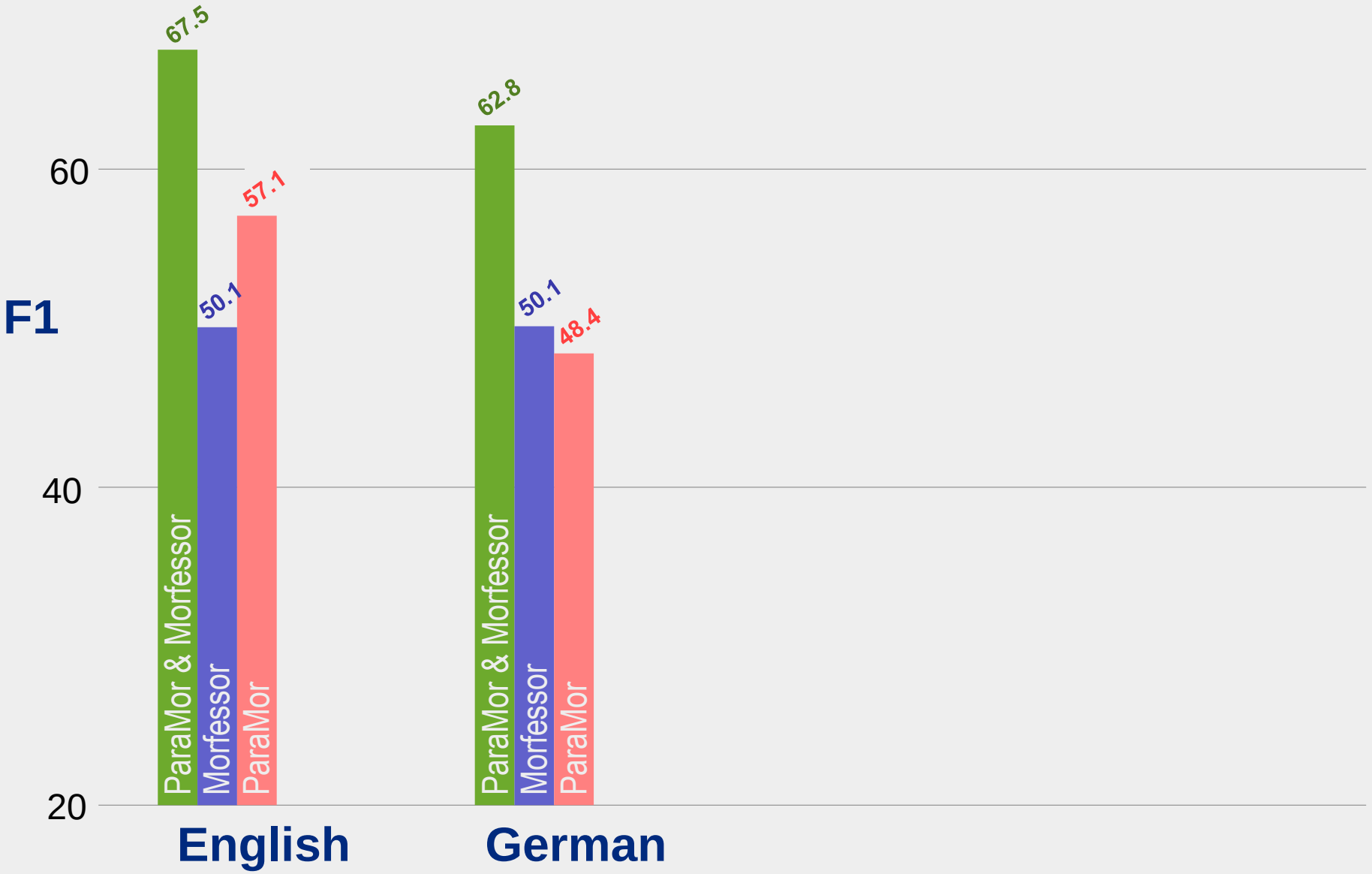
A ParaMor analysis and

A Morfessor analysis

Let the evaluation script average across the submitted analyses

Word	ParaMor	Morfessor
dispute's	disput +e +'s	dispute/STM +'s/SUF
juried	juri +ed	juried/STM
losses	los +ses	losses/STM
…	…	…

Results of Linguistic Evaluation 2008



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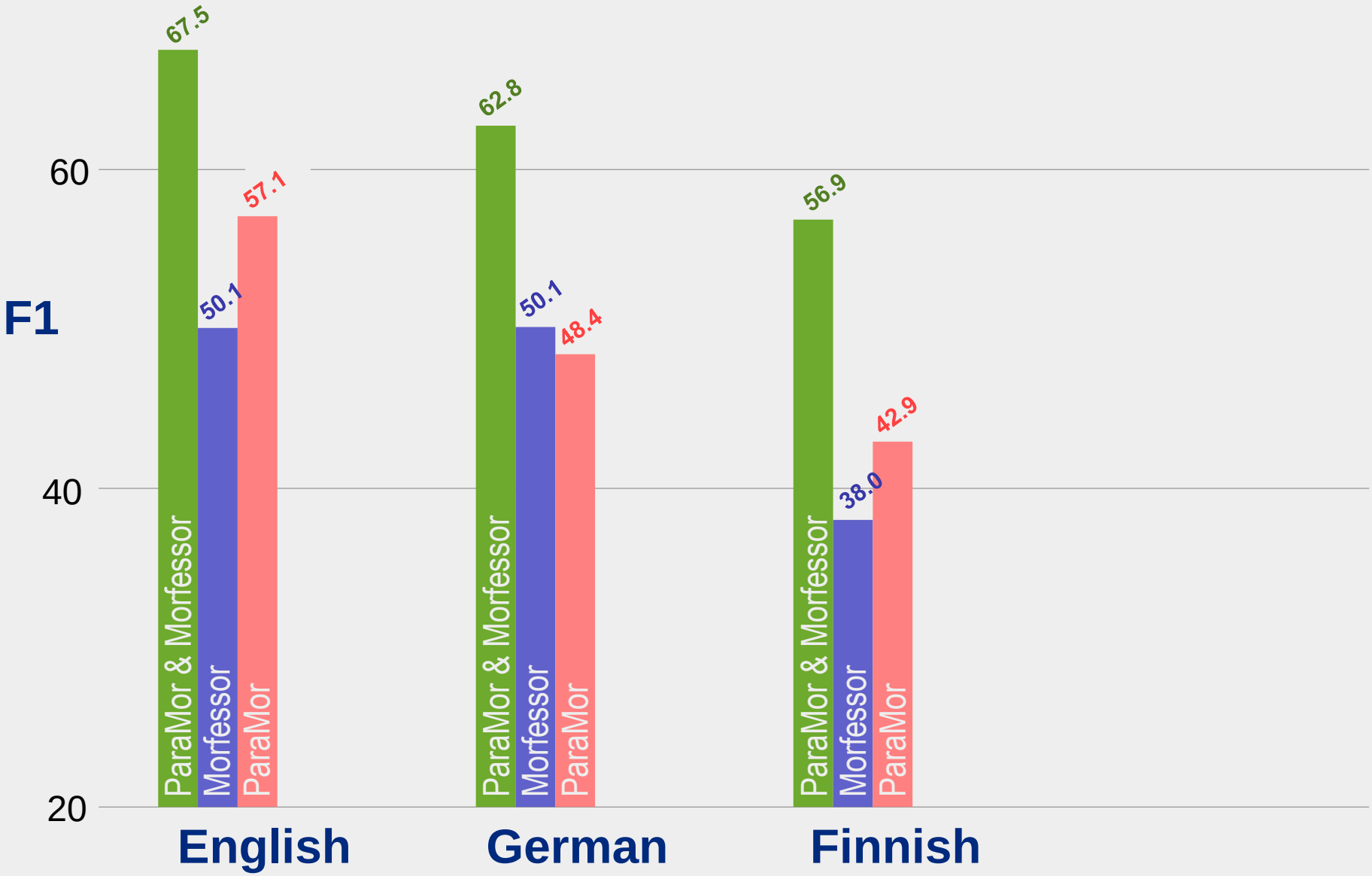

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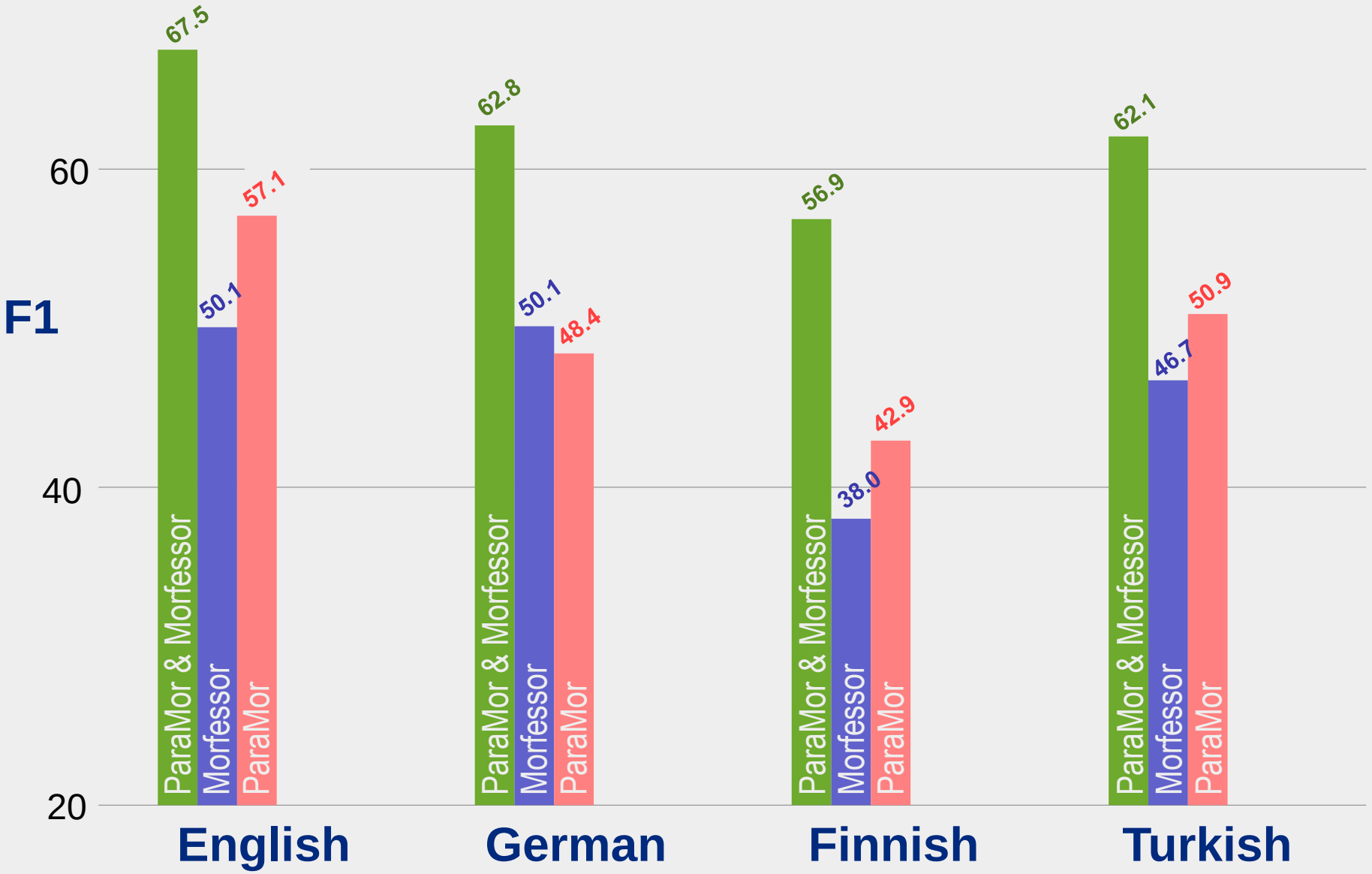
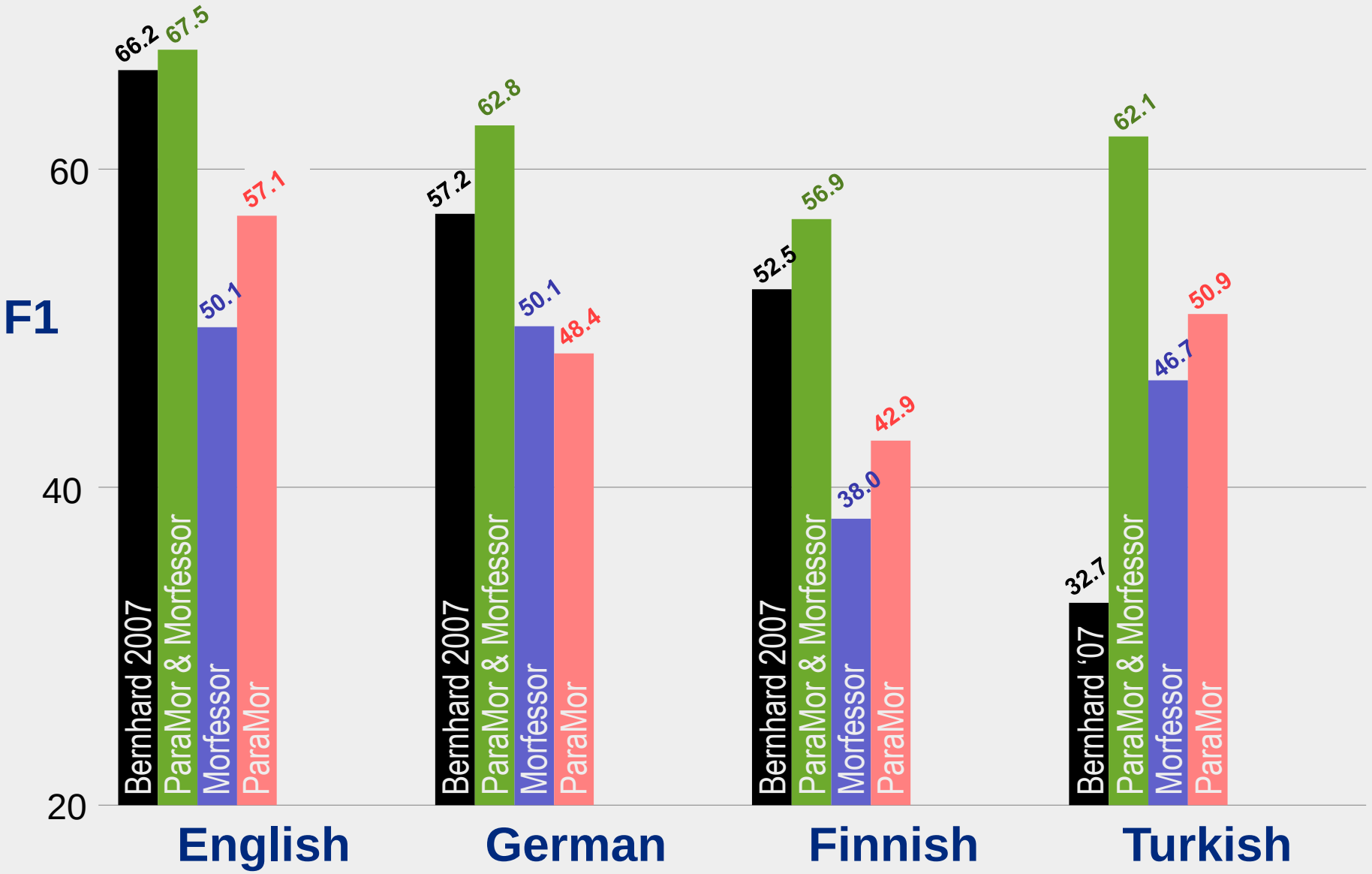


Results of Linguistic Evaluation 2008



Improvements to ParaMor

A Baseline for Unsupervised Induction

- The **ParaMor** System
- **Morpho Challenge 2008**

New Work

- **Probabilistic** ParaMor
- Morpho Challenge **2009**

One Joint Analysis

2 Separate Analyses is Unsatisfying

Fuse ParaMor and Morfessor

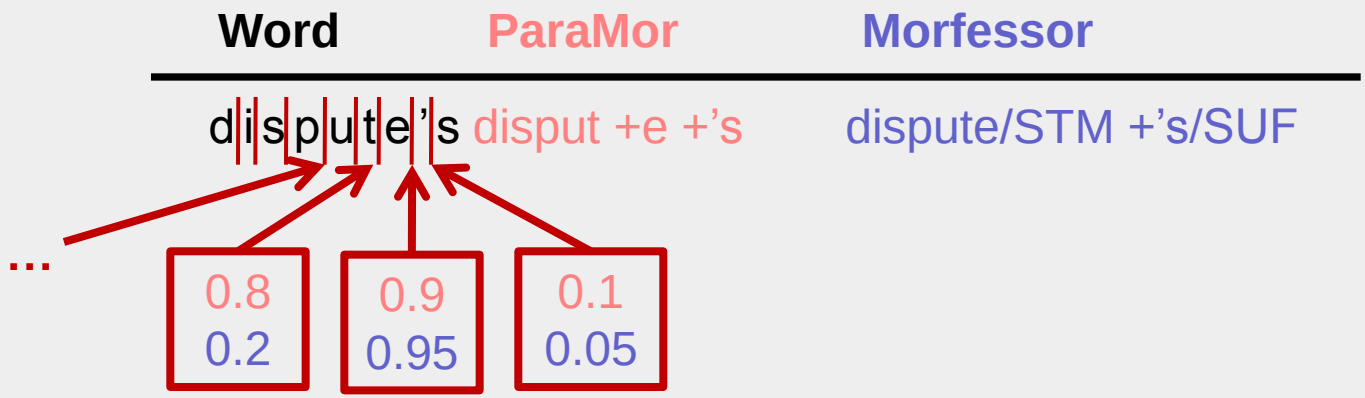
A **single** definitive segmentation

Word	ParaMor	Morfessor
dispute's	disput +e +'s	dispute/STM +'s/SUF
juried	juri +ed	juried/STM
losses	los +ses	losses/STM
…	…	…

We Want 1 Joint Analysis of Each Word

The Plan

Score each character boundary, *i*



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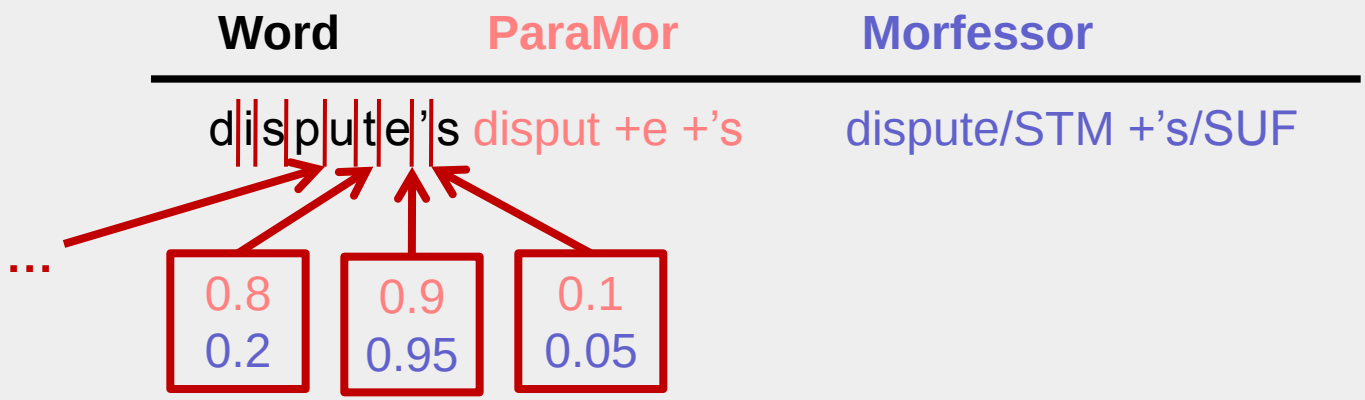


Compute weighted average

$Ave_i = \lambda \text{ParaMor}_i + (1 - \lambda)\text{Morfessor}_i$

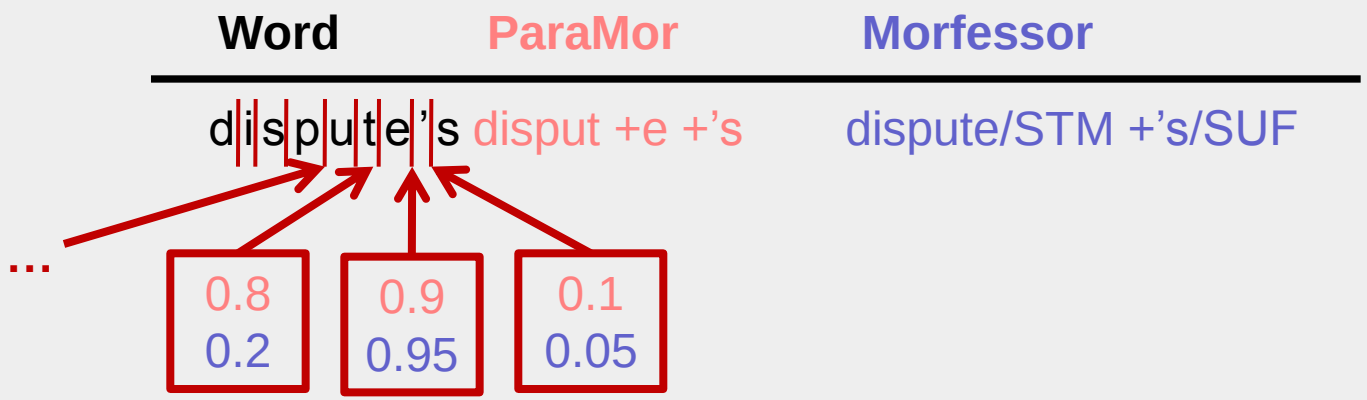
Segment when $Ave_i > \tau$,

τ : an empirical threshold

We Want 1 Joint Analysis of Each Word

The Plan

Score each character boundary, *i*



Where do these scores come from?

ParaMor is rule-based
➔ No numeric scores

Morfessor is a Blackbox
➔ No numeric scores

Tagging = Sequence Labeling

English Part-of-Speech Tagging

97.1% Accuracy

NP Chunking

F_1: 93.5%

Chinese Word-Segmentation

Above 90% Accuracy

Tagging = Sequence Labeling

English Part-of-Speech Tagging

97.1% Accuracy

NP Chunking

F_1: 93.5%

Chinese Word-Segmentation

Above 90% Accuracy

Morphological Segmentation

Tagging for Morphological Segmentation

Tag Each Character in Each Word As:

- A **Left-Edge** of a Morpheme
- A **Non-Left-Edge**

Our Tagger

- Finite State
- Log-Linear Model
  - 2nd order Markov assumption
  - Training
    - Perceptron Algorithm
    - Viterbi scoring
  - Testing
    - Forward-Backward

Now, Just Wait a Second!

Morpho Challenge

UNSUPERVISED induction

We're training a **SUPERVISED** tagger

Now, Just Wait a Second!

Morpho Challenge

UNSUPERVISED induction

We're training a **SUPERVISED** tagger

Mimic an Unsupervised Systems

Analyze data with ParaMor (or Morfessor)

Treat ParaMor's Analyses as THE TRUTH

Train a tagger to mimic ParaMor (or Morfessor)

Tagger Score = Segmentation Confidence

Hungarian Development Data

Hunglish Corpus (Varga et al., 2009)

500,000 word subset

	ParaMor		Morfessor	
Hungarian (τ=0.5)	Original	Tagger Mimic Mimic Tag Acc: **96.8%**	Original	Tagger Mimic Mimic Tag Acc: **95.5%**
Precision				
Recall				
F_1				

Hungarian Development Data

Hunglish Corpus (Varga et al., 2009)

500,000 word subset

Hunmorph (Trón et al., 2005)

Hand-Built Morphological Analyzer

	ParaMor		Morfessor	
Hungarian (τ=0.5)	Original	Tagger Mimic Mimic Tag Acc: 96.8%	Original	Tagger Mimic Mimic Tag Acc: 95.5%
Precision	64.8	63.7	72.9	72.5
Recall	30.4	32.2	31.3	28.8
F_1	41.4	42.7	43.8	41.3

We Can Do Better

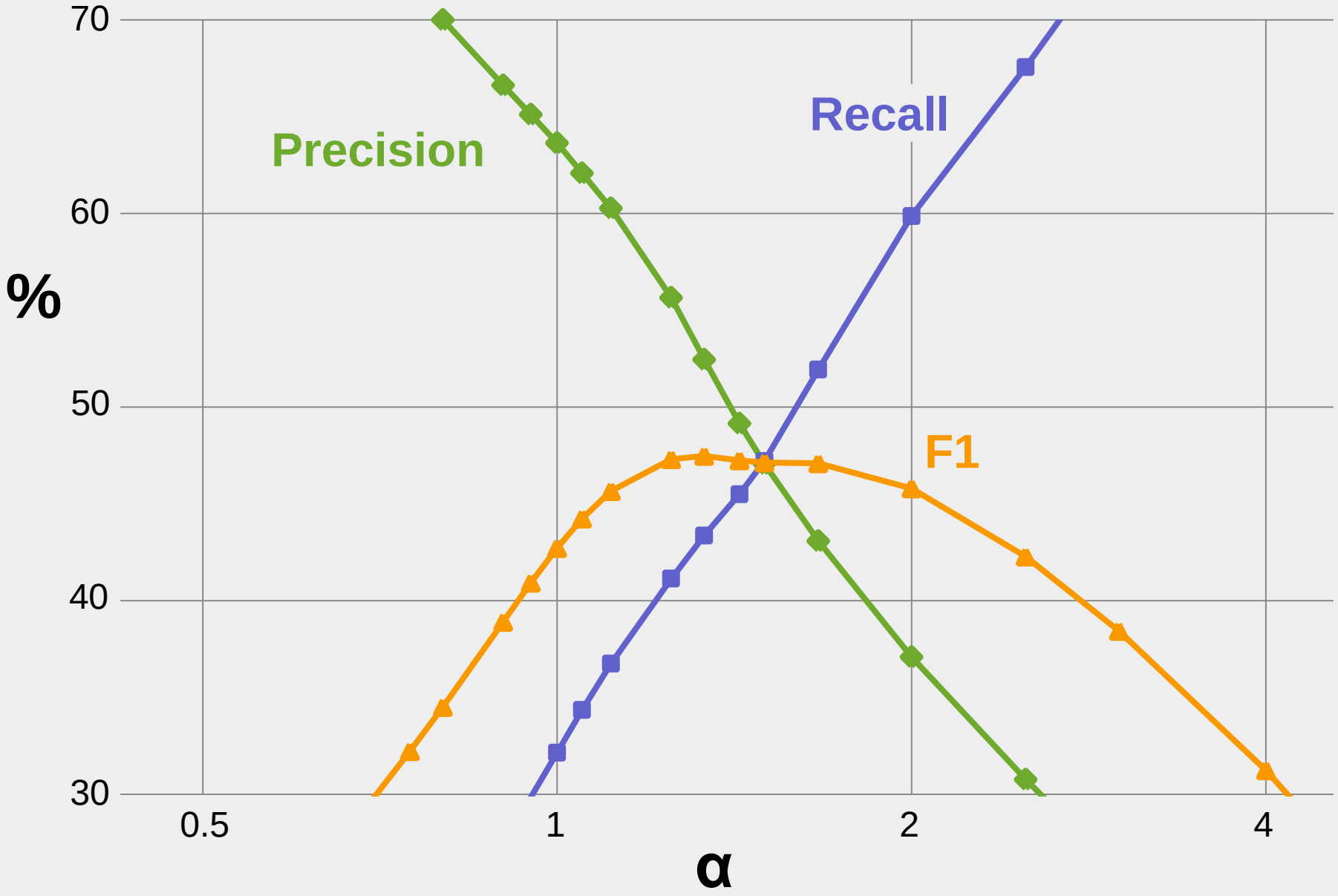
Optimize for F_1

Sort the tagger's scores of all character boundaries in the corpus

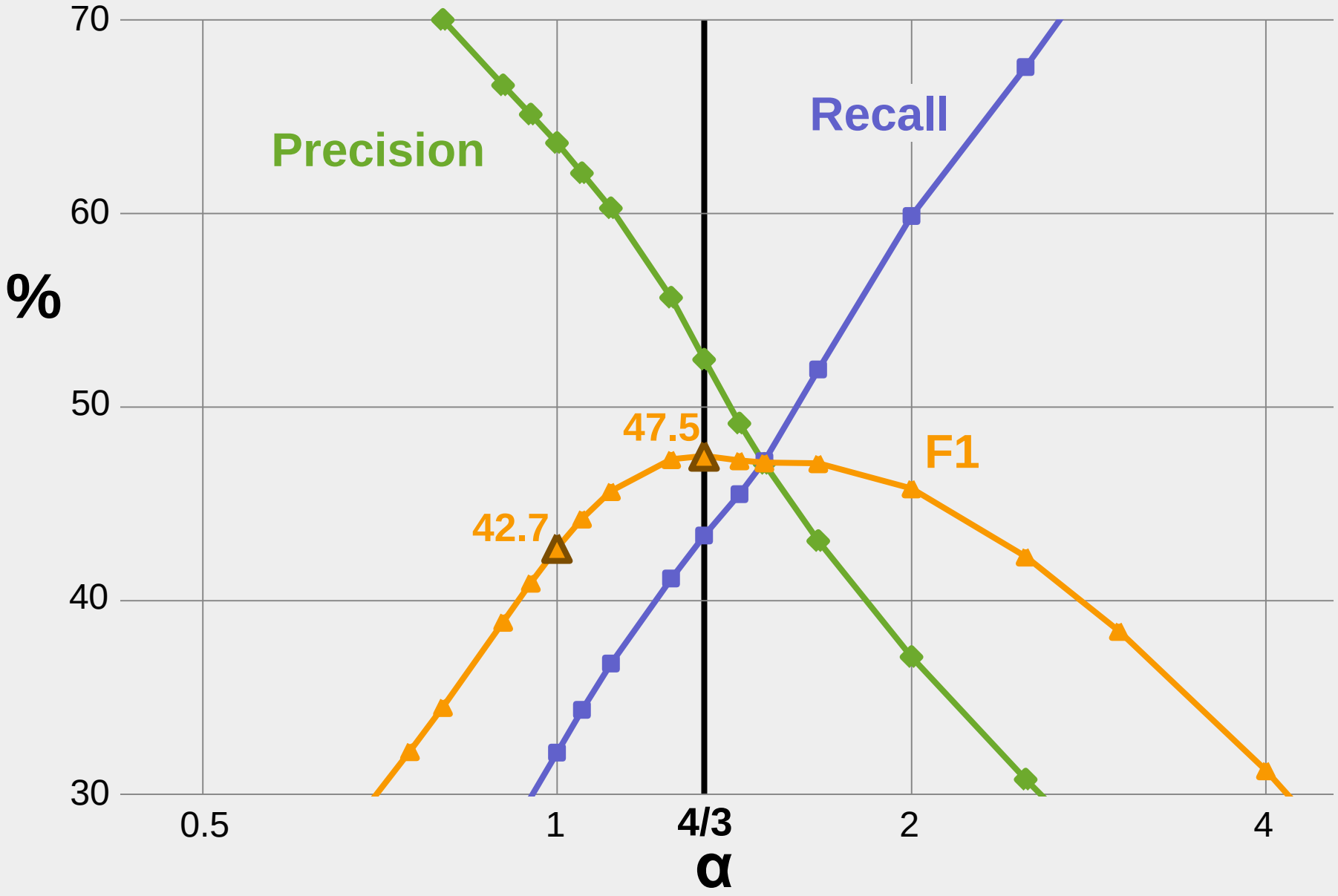
Let k be the # of segmentations at τ=0.5

Segment at $\alpha\ k$ character boundaries

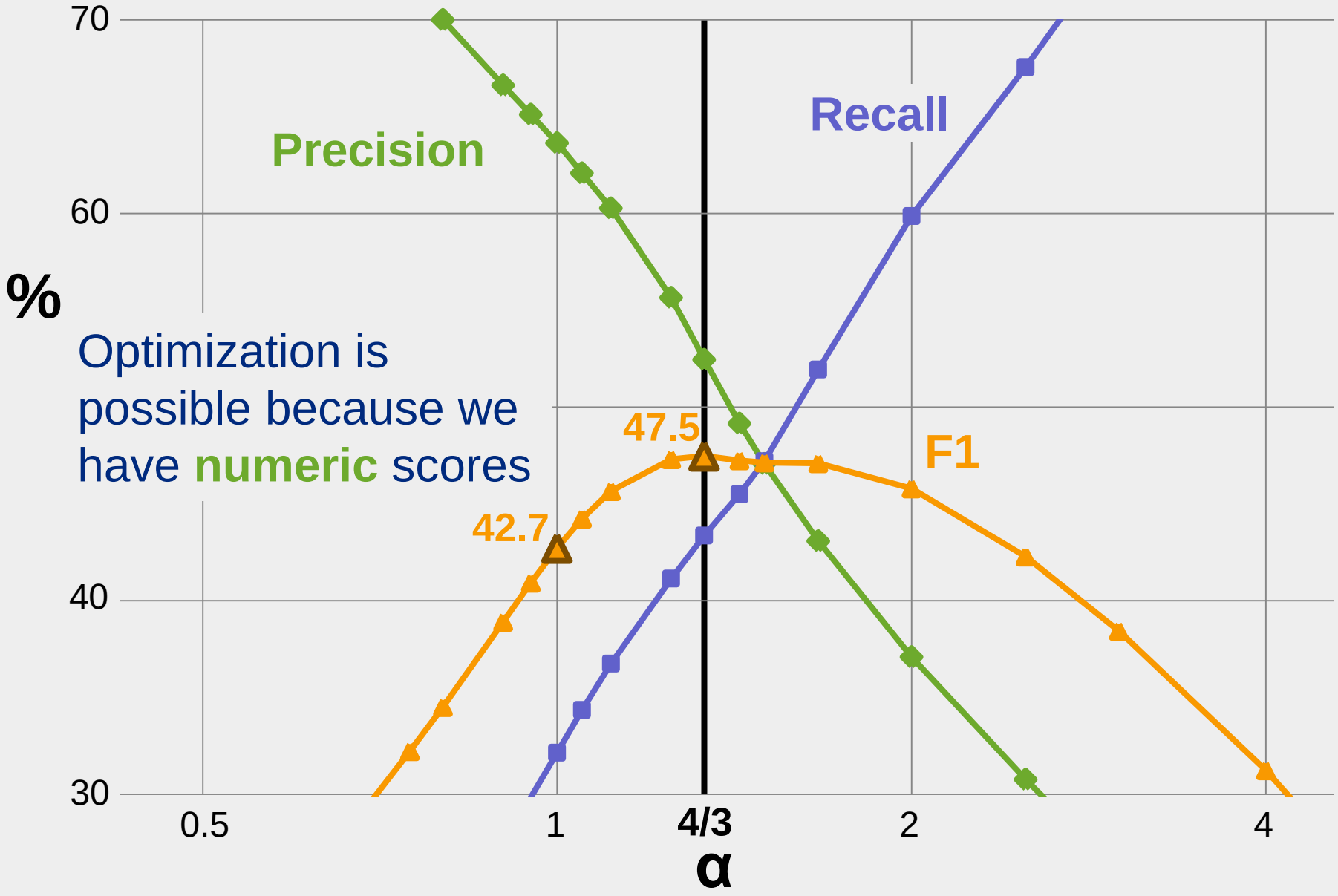
ParaMor Hungarian – Adjusting α



ParaMor Hungarian – Adjusting α



ParaMor Hungarian – Adjusting α



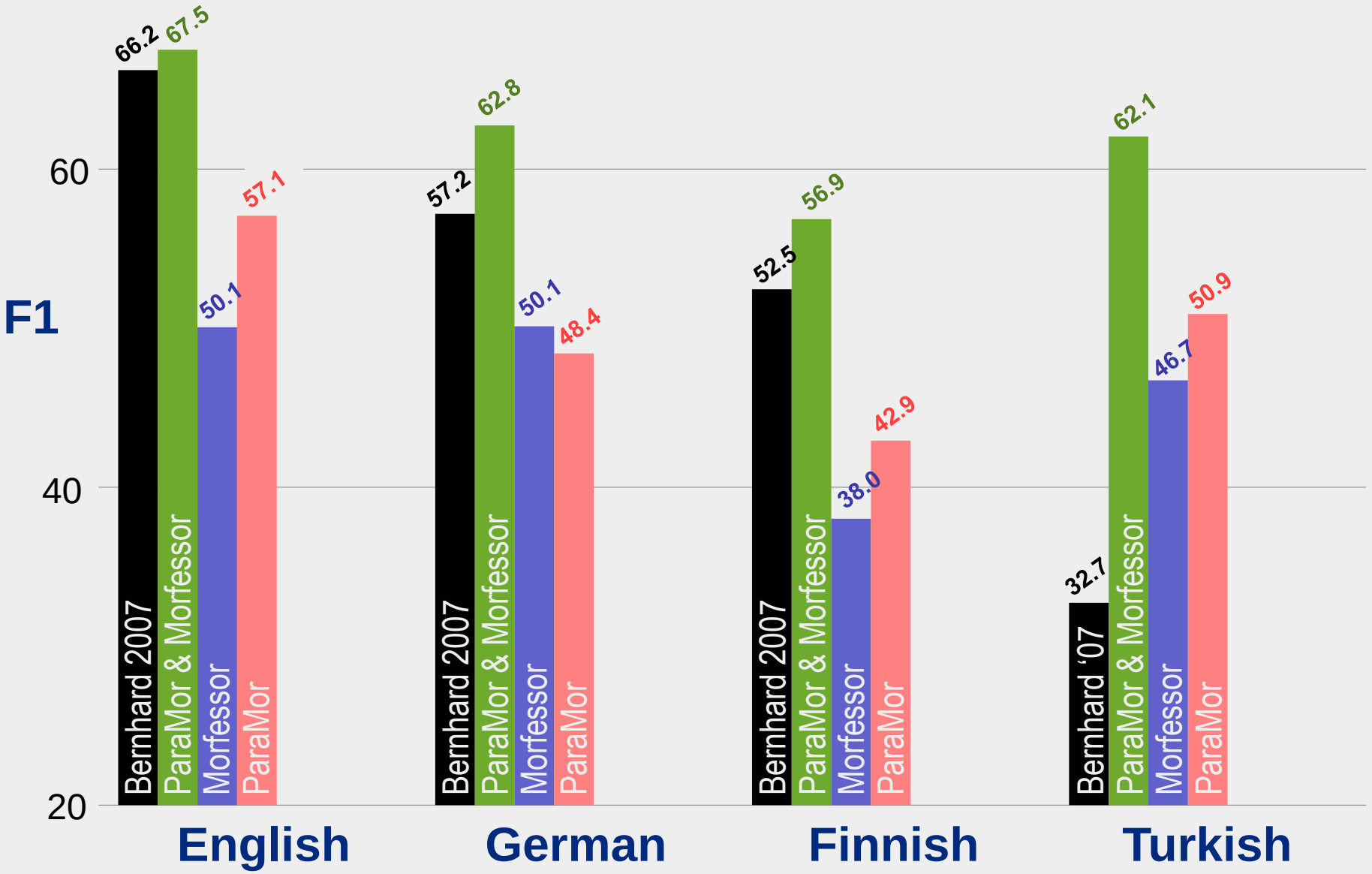
Optimize toward a Metric

A Statistical Framework Allows Optimization

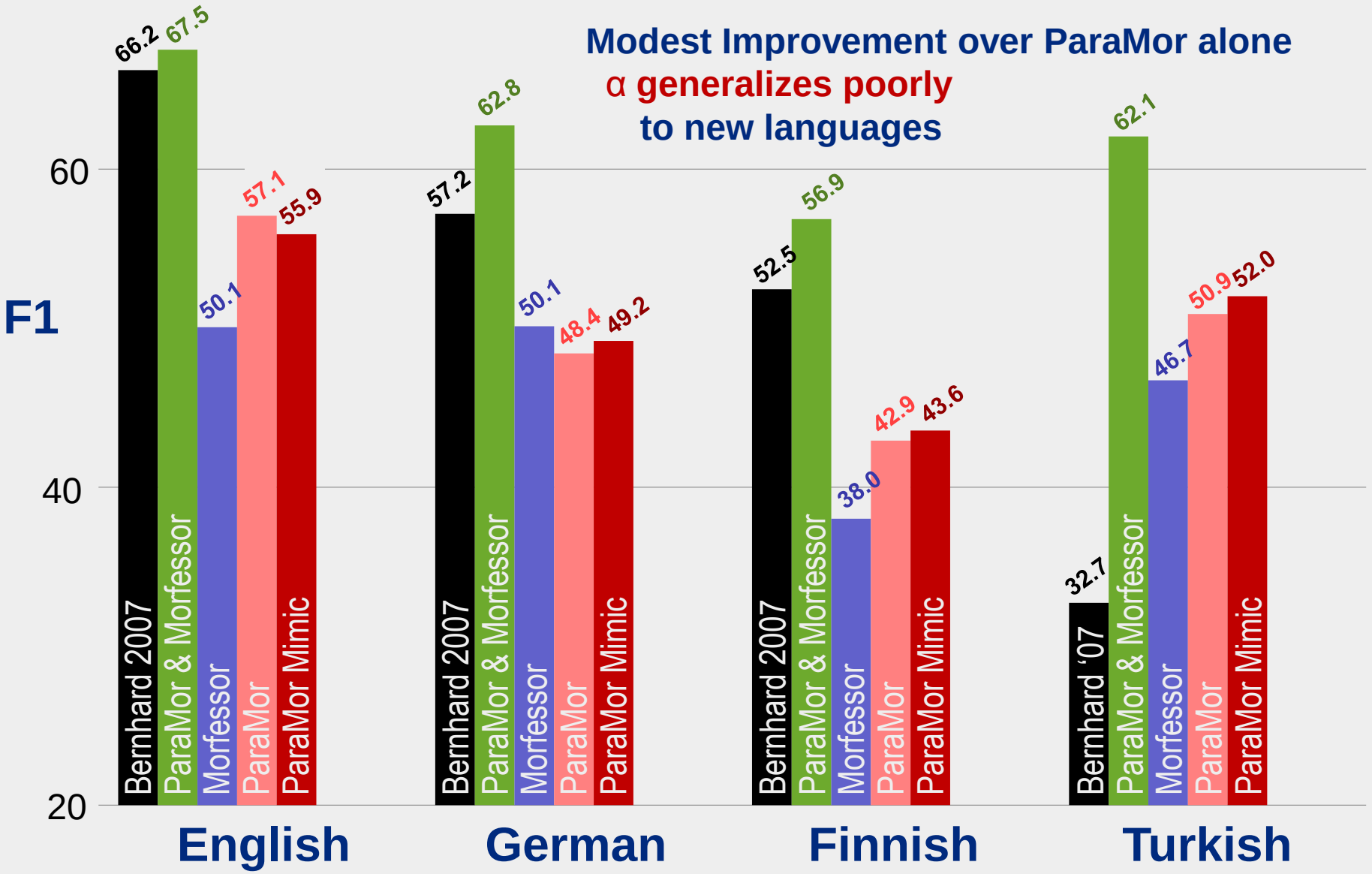
Improved over the original ParaMor and Morfessor

	ParaMor			Morfessor		
Hungarian	Original	Tagger Mimic		Original	Tagger Mimic	
		α=1	α=4/3		α=1	α=3/2
Precision	64.8	63.7	52.5	72.9	72.5	59.3
Recall	30.4	32.2	43.4	31.3	28.8	39.3
F_1	**41.4**	42.7	**47.5**	**43.8**	41.3	**47.3**

Results of Linguistic Evaluation 2009



ParaMor Mimic



ParaMor & Morfessor – Tagger Mimic

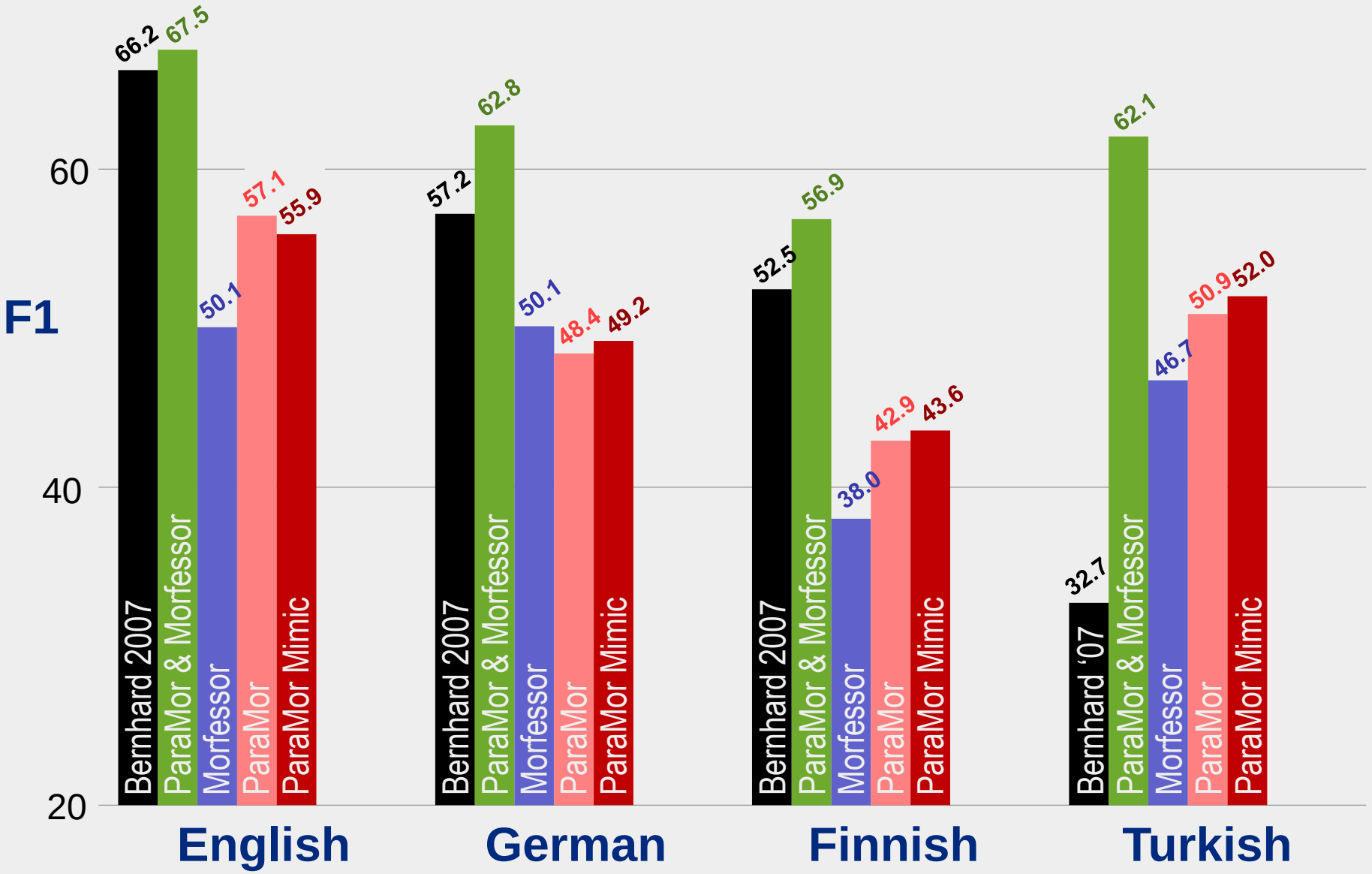
Weight ParaMor and Morfessor Equally

$\lambda = 0.5$

$Ave_i = \lambda \text{ParaMor}_i + (1 - \lambda)\text{Morfessor}_i$

Adjust α over Ave_i

Results of Linguistic Evaluation 2009



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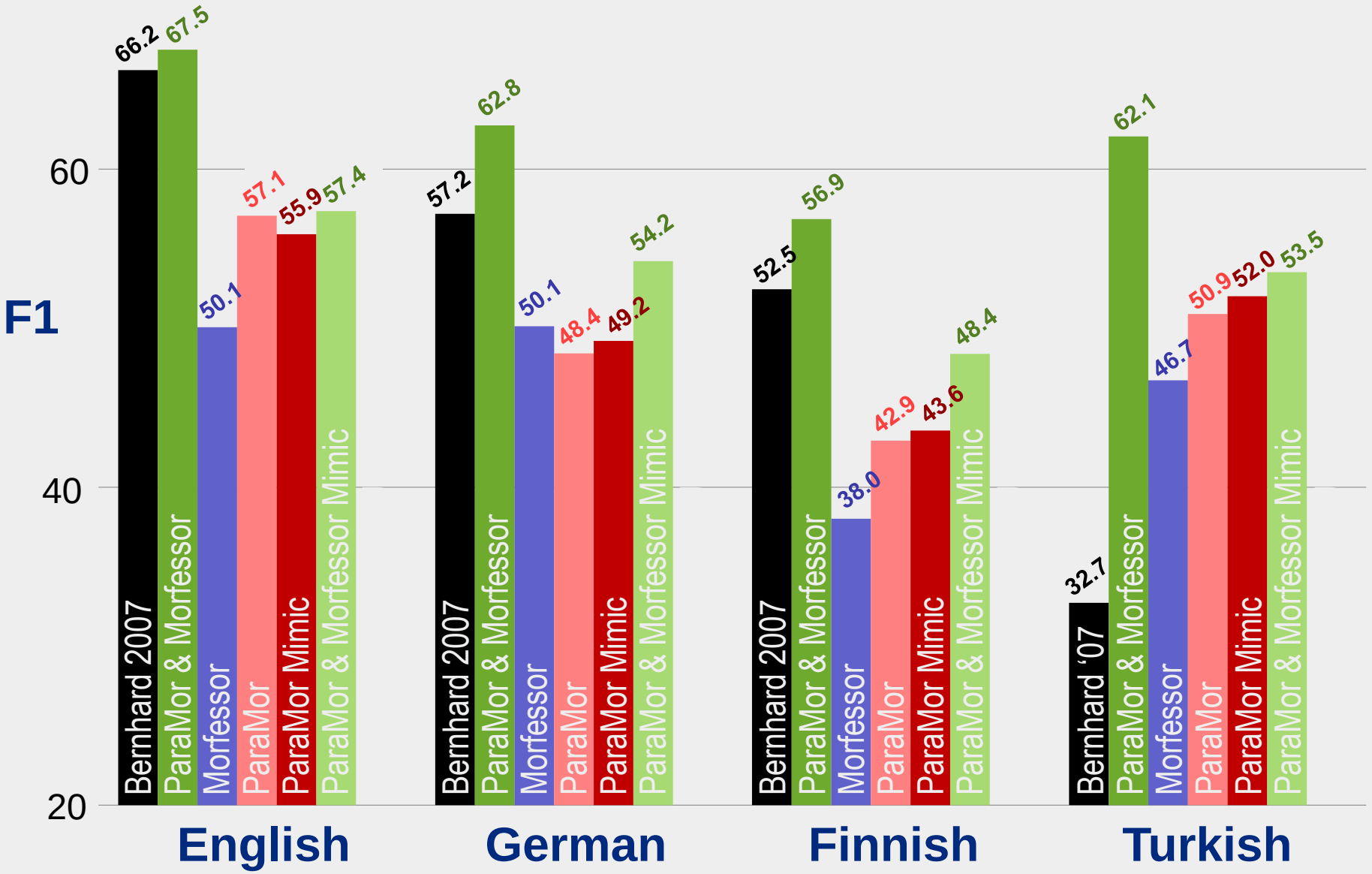
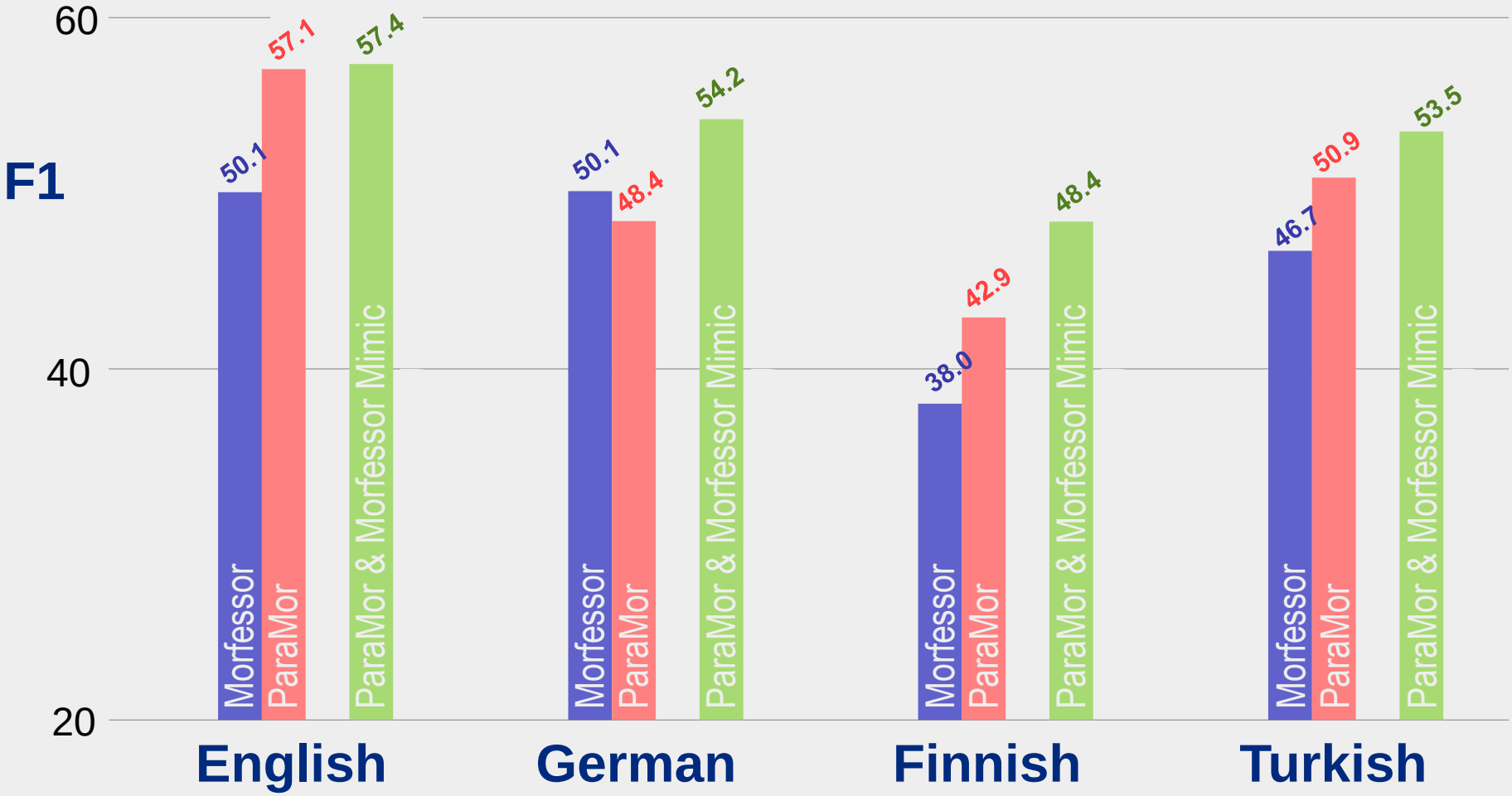
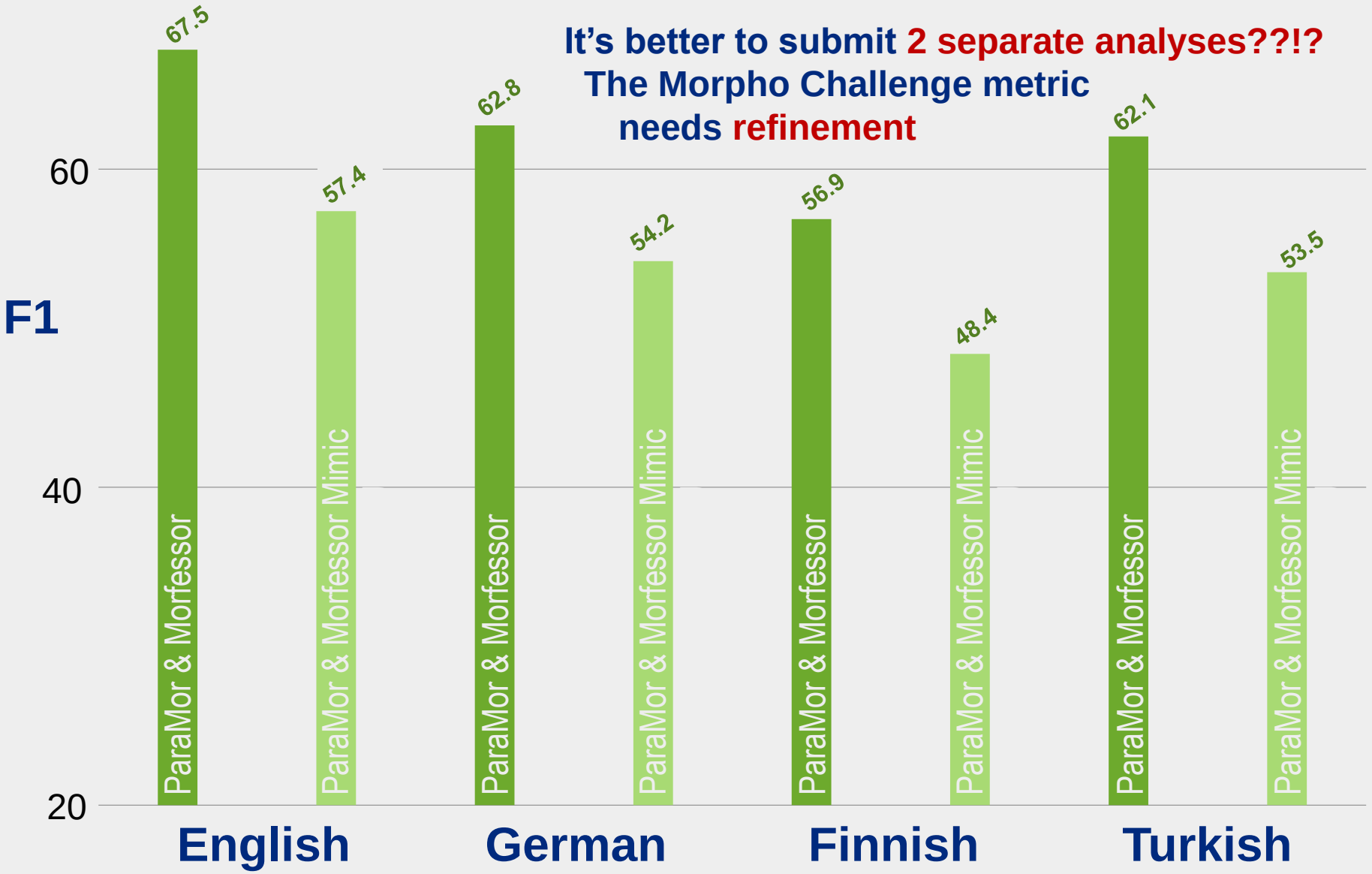


Results of Linguistic Evaluation 2009

Significant improvement over ParaMor alone and Morfessor alone

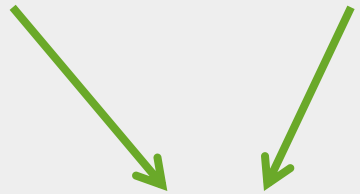


Results of Linguistic Evaluation 2009



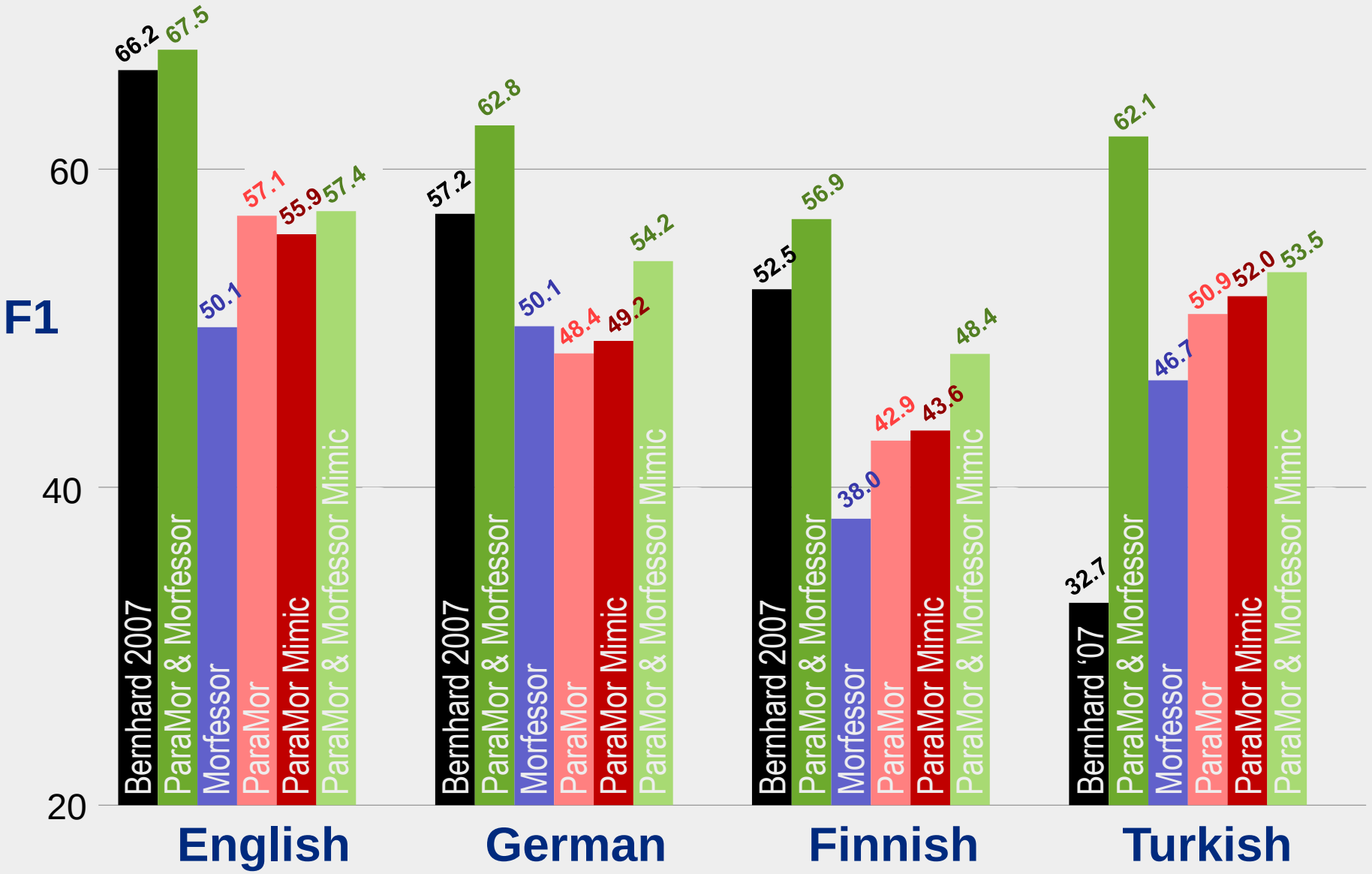
Union of ParaMor and Morfessor

Word	ParaMor	Morfessor
dispute's	disput +e +'s	dispute/STM +'s/SUF



disput +e +'s

Results of Linguistic Evaluation 2009



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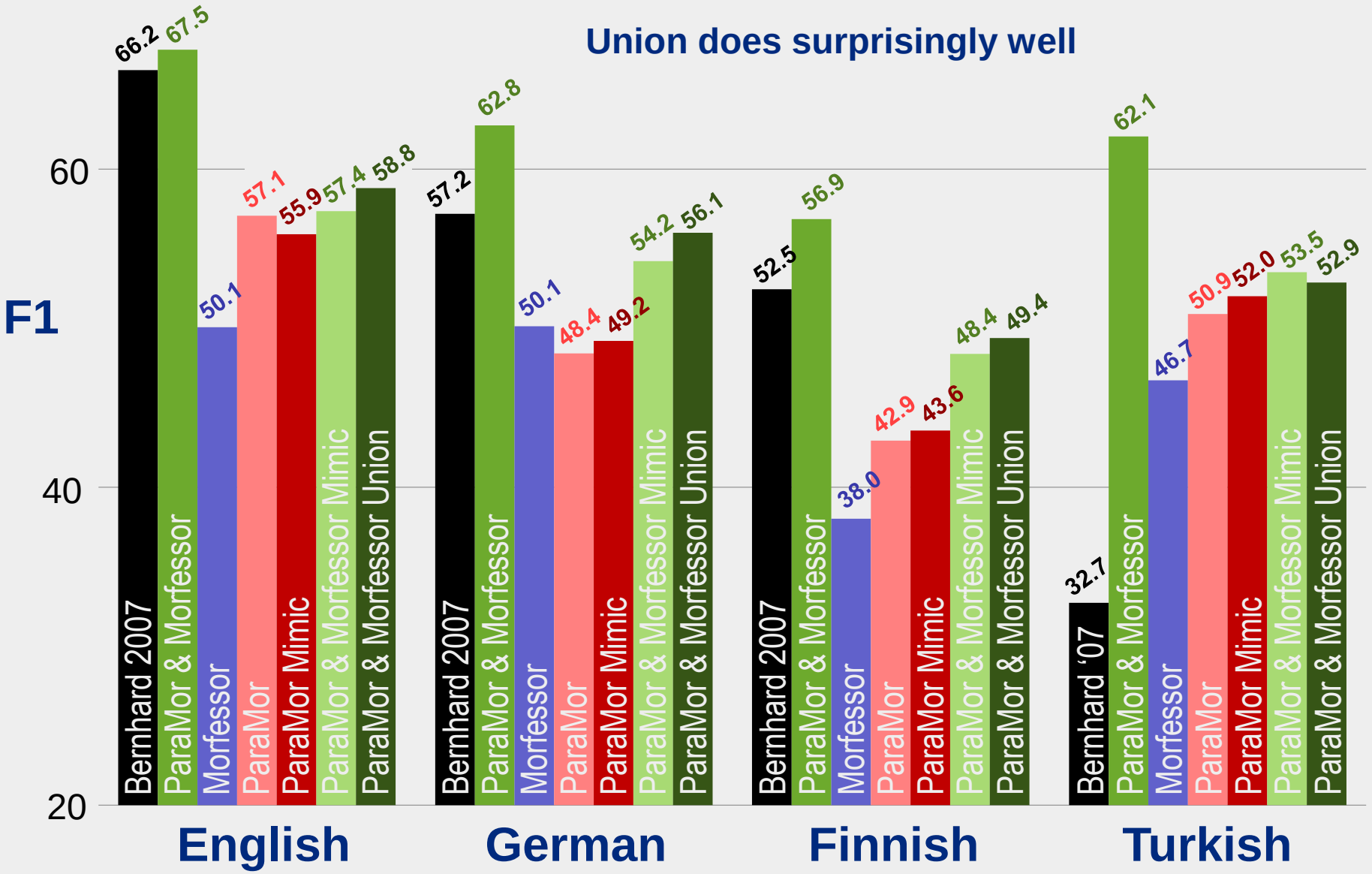


Tagger Mimics for Morphology Are:

Disappointing

- **Small** gains when moving to other languages
- The **Morpho Challenge metric** needs work
- Joint mimic **doesn't outperform Union**

Encouraging

- Produces **meaningful numeric scores** for both:
  - Rule-based systems (e.g. ParaMor)
  - Blackbox systems (e.g. Morfessor)
- **Enables** metric tuning

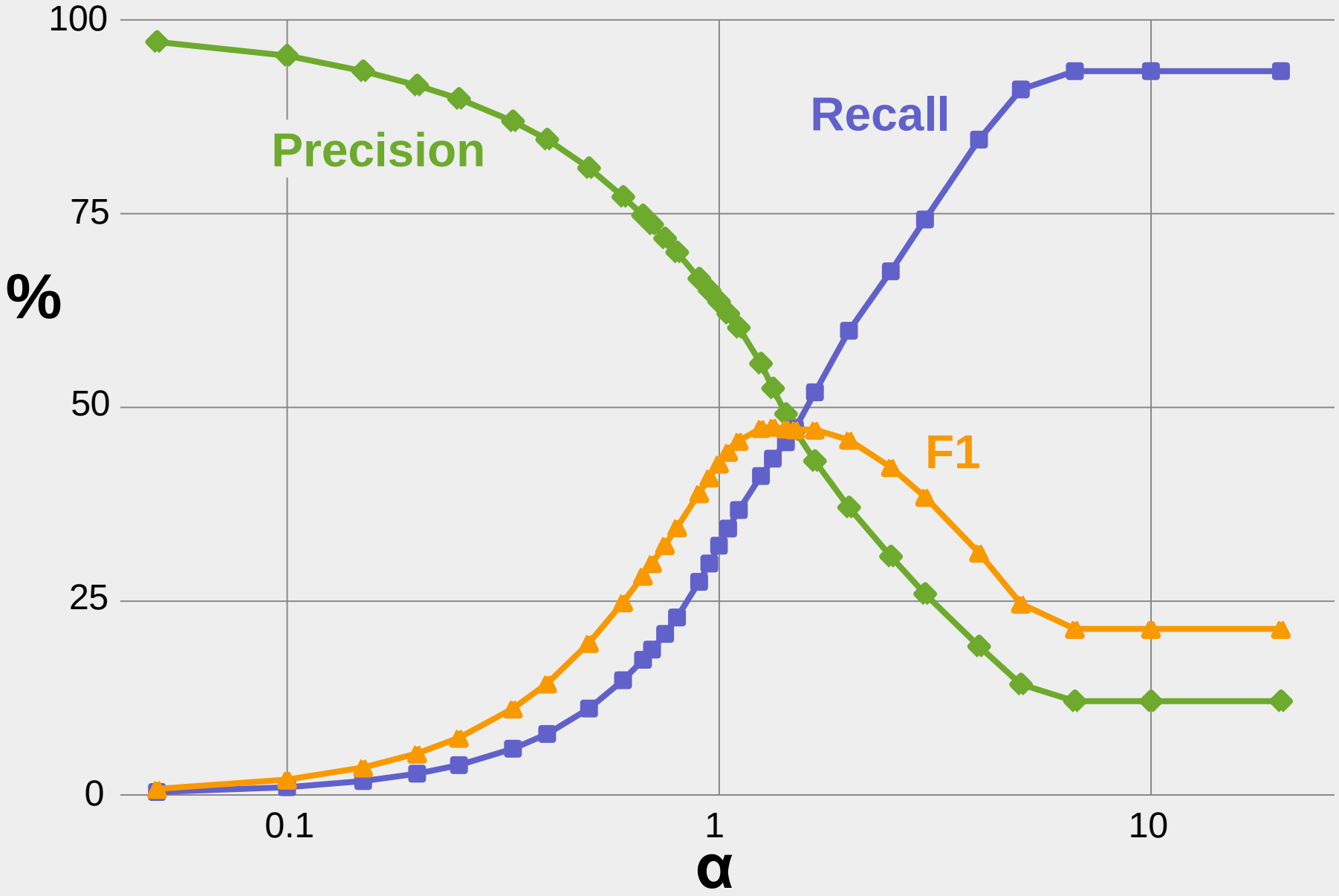
ευχαριστώ

(Thank You!)

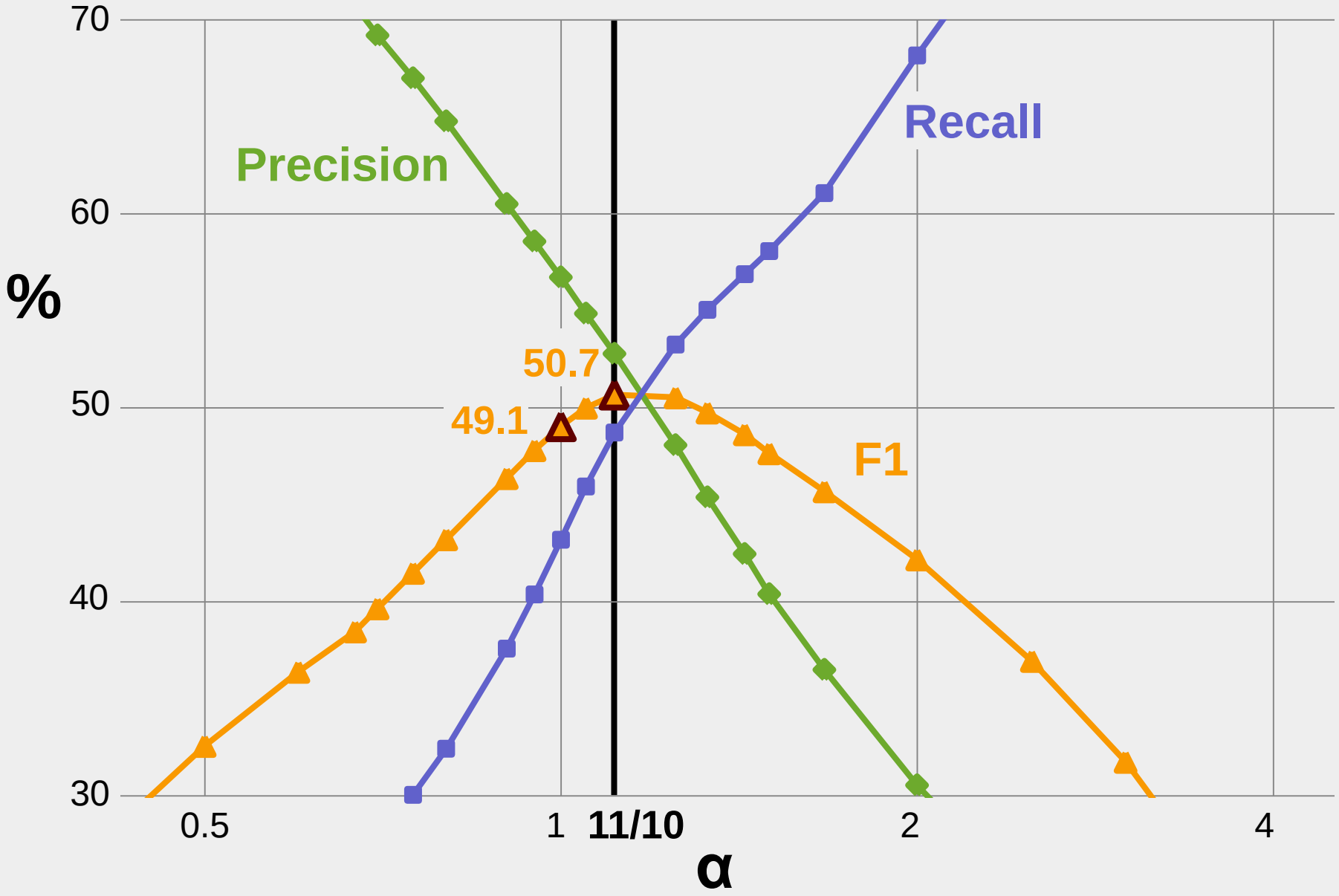
Kristy Hollingshead
Tagger-in-Chief

Brian Roark
Head Thinker

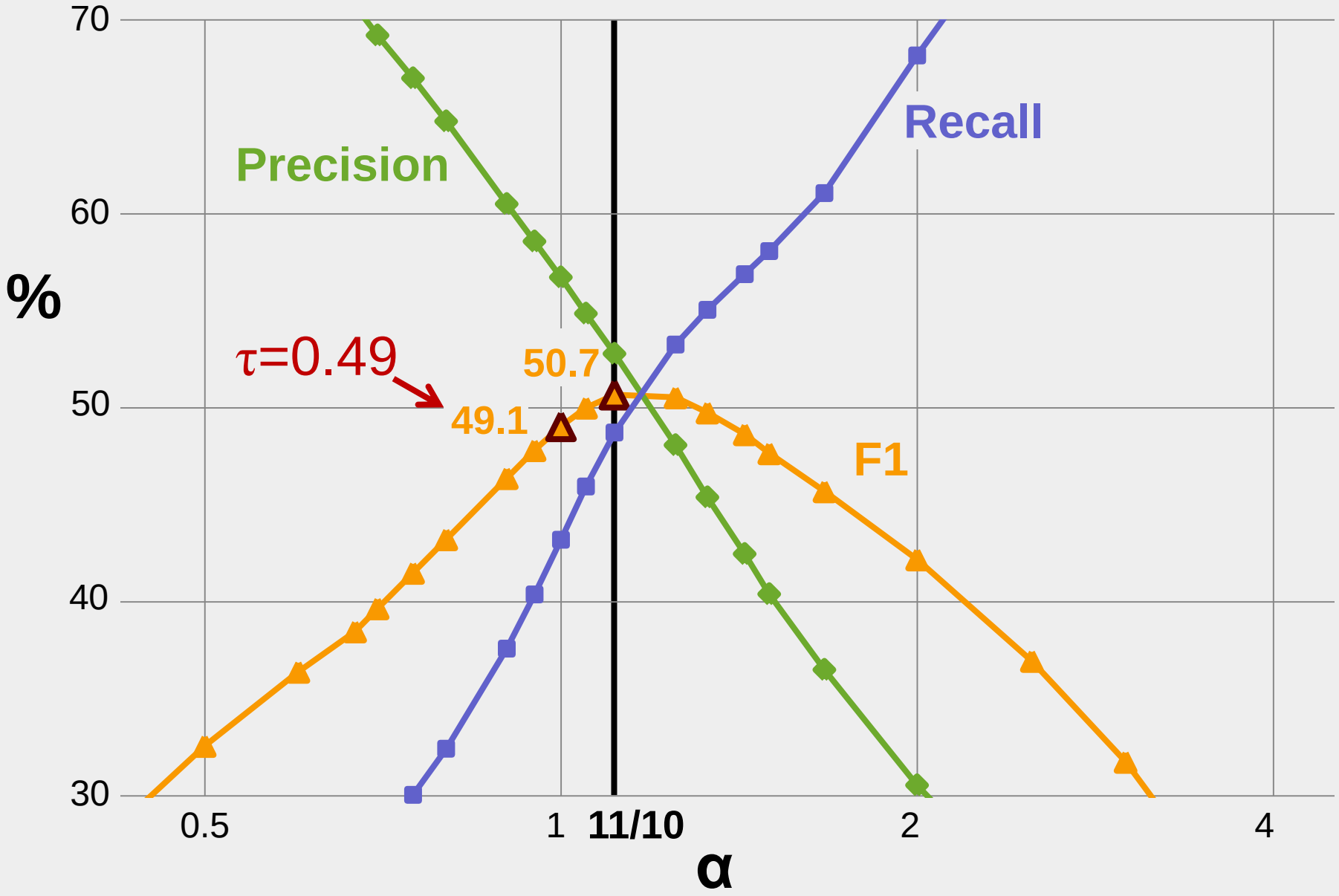
ParaMor Hungarian – Adjusting α



ParaMor & Morfessor



ParaMor & Morfessor

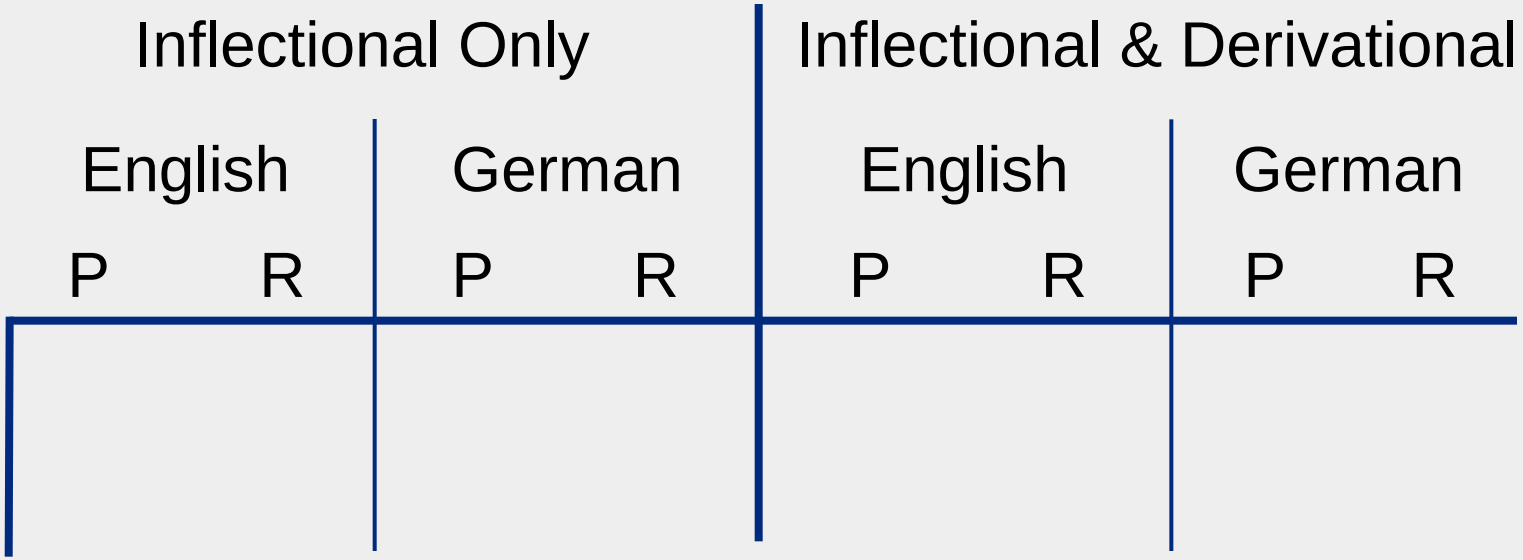


Preliminary Linguistic Evaluation

Built

2 styles of answer keys

For 2 languages



Preliminary Linguistic Evaluation

Built

2 styles of answer keys

For 2 languages

	Inflectional Only				Inflectional & Derivational			
	English		German		English		German	
	P	R	P	R	P	R	P	R
ParaMor	33.0	**81.4**	42.8	**68.6**	48.9	53.6	60.0	33.5

Preliminary Linguistic Evaluation

Built

2 styles of answer keys

For 2 languages

	Inflectional Only				Inflectional & Derivational			
	English		German		English		German	
	P	R	P	R	P	R	P	R
ParaMor	33.0	81.4	42.8	68.6	48.9	53.6	60.0	33.5
Morfessor	53.3	47.0	38.7	44.2	**73.6**	34.0	**66.9**	37.1