Automatic Abstract Anaphora Resolution in German

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Introduction

Some examples

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Dr. Grant thought **this** was a bad idea.

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that he had already done it. → cataphoric

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Abstract Anaphora

This system covers two broad classes of German abstract anaphors:

- Pronouns: *dies* ‘this’, *das* ‘that’, and *es* ‘it’
- Shell nouns: *Tatsache* ‘fact’, *Frage* ‘question’, *Problem* ‘problem’, etc.

Both as anaphora and cataphora

Antecedents (or catacedents) may have either verbal or nominal heads

System Design

Classification and Resolution

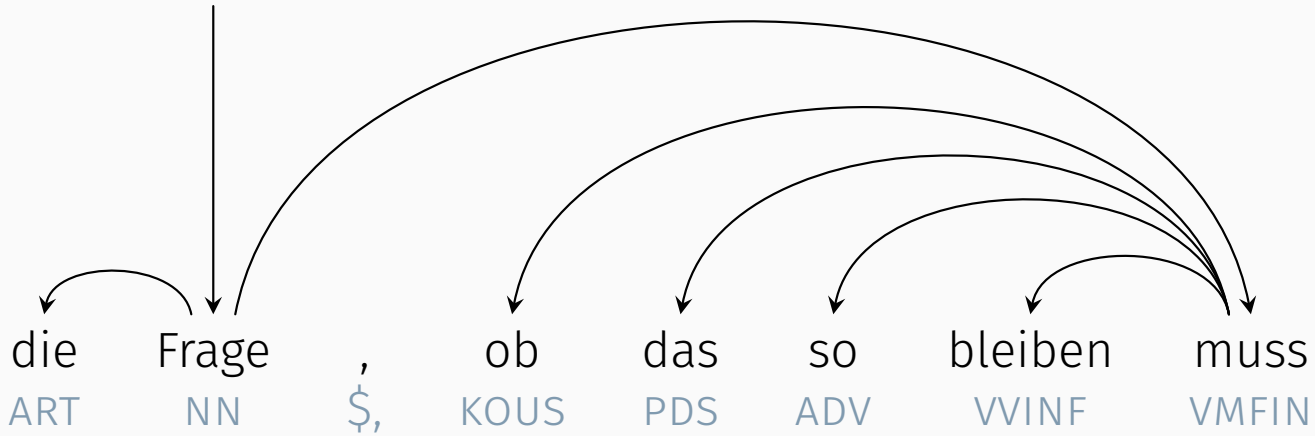
Usual approach involves two steps:

1. Classification: Deciding whether or not an instance requires resolution
2. Resolution: Deciding which potential antecedent belongs with a given anaphor instance

Motivation

- Need to reduce number and variety of candidates
- Effectiveness of sieve-based approaches in coreference resolution (Lee et al., 2013)
- Tendencies of shell nouns to prefer certain patterns (Schmid, 2000)
- Indications that annotator's behavior can be approximated by relatively simple heuristics (Artstein & Poesio, 2006)

Procedure



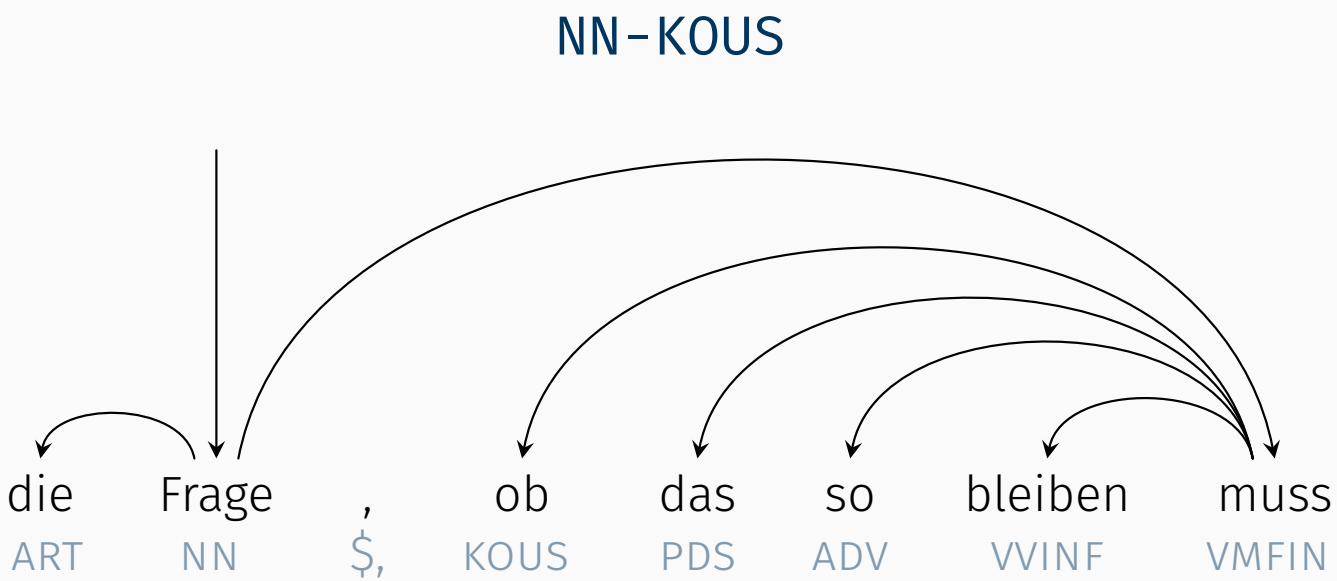
(‘the question whether it has to stay that way’)

Extraction Patterns

Name	Schema	Example
`NN-ist-dass`	sein $\rightarrow$ NN_1 sein $\rightarrow$ x_2 $x_2 \rightarrow$ dass	***Tatsache***$_1$ *ist, dass das nicht* *funktioniert*$_2$
`NN-KOUS`	$NN_1 \rightarrow V_2$ $V_2 \rightarrow$ KOU	*die* ***Frage***$_1$*, ob das so bleiben* *muss*$_2$
`PDS-last-verb`	V_2 ... {das|dies}$_1$	*...nicht* *gibt*$_2$*.* ***Das***$_1$ *wollen sie nun ändern.*
`PDAT-last-sent`	$ROOT_2$ $. NN_1$ $NN_1 \rightarrow$ PDAT	*Er* *hat*$_2$ *es schon getan. Diese* ***Tatsache***$_1$ *war ihr nicht bewusst.*

- This implementation includes 14 such extraction patterns
- Patterns ordered according to accuracy/specificity

Procedure



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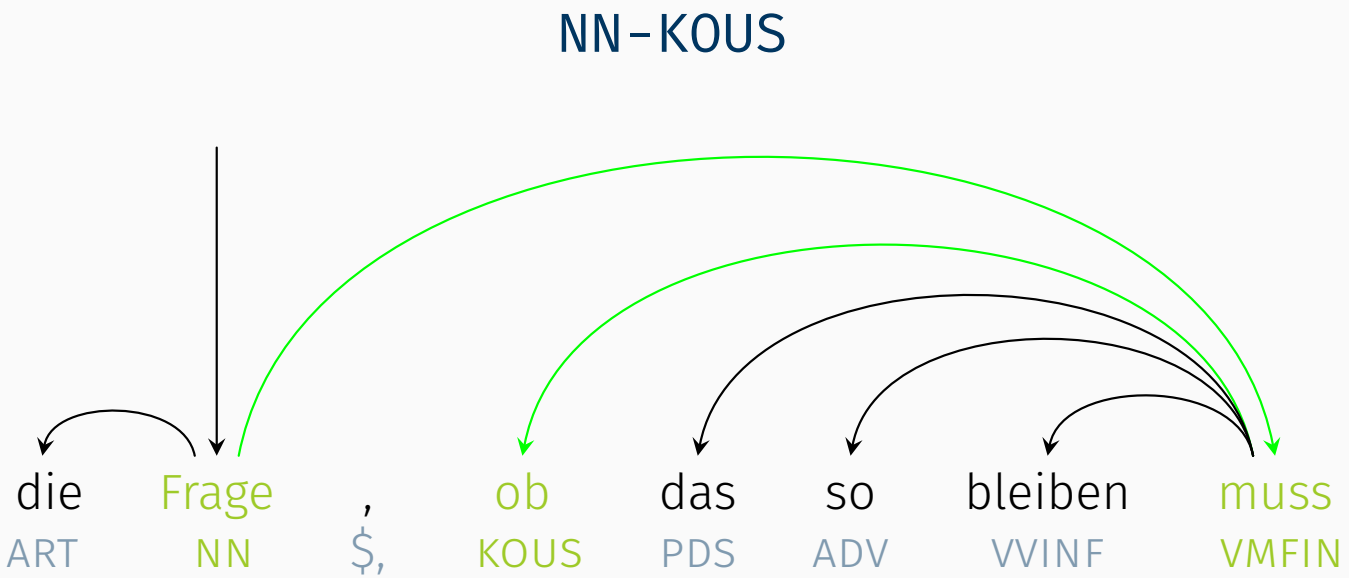
NN-KOUS
die
ART
Frage
NN
,
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ob
KOUS
das
PDS
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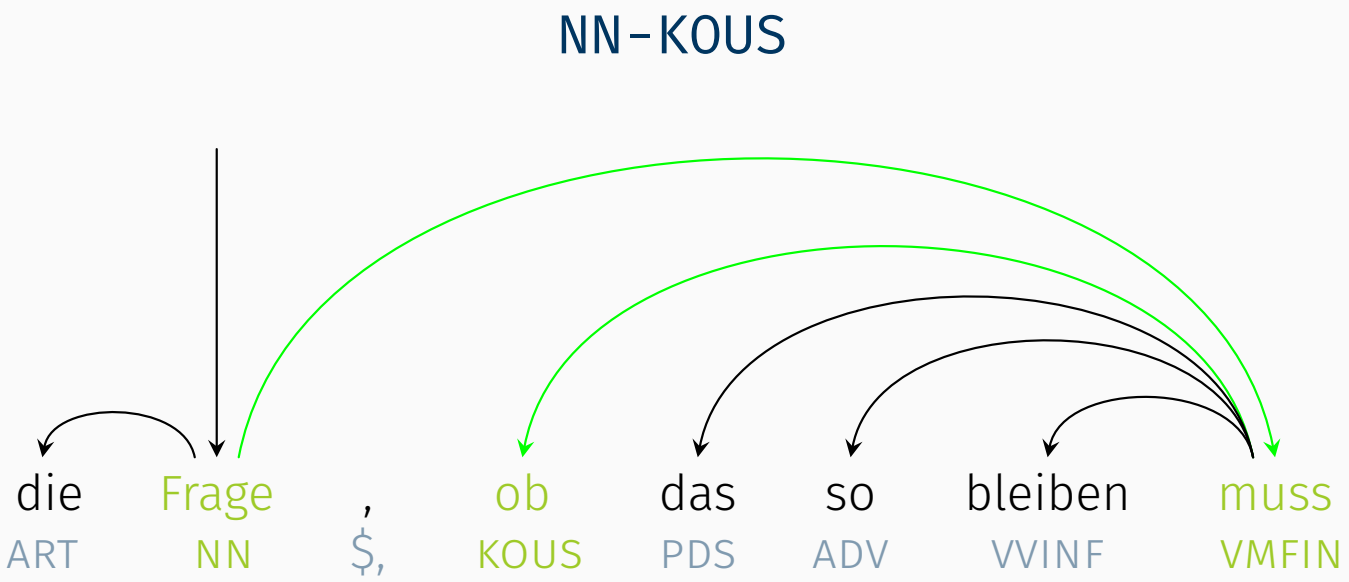
ADV
bleiben
VVINF
muss
VMFIN

Procedure

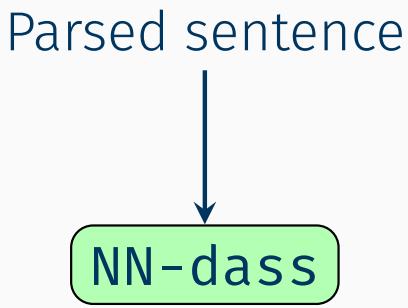


⇒ extracted anaphor–antecedent pair: `(Frage, muss)`

Classification Features

- Lemmas
- Germanet features, e.g.:
  - Semantic field of anaphor and mother of anaphor
  - Whether verbal mother of anaphor could also take a clausal complement
- Syntactic features, e.g:
  - Distance between anaphor & antecedent
  - Grammatical relation of anaphor & antecedent
  - Whether anaphor and antecedent have the same grammatical relation
  - Type of determiner of anaphor, if present
- Surface features, e.g.:
  - Whether head ends in *-ung*, *-keit*, or *-heit* (nominal antecedents)
  - Whether head ends in *-en* (substantivized verbs)

Architecture



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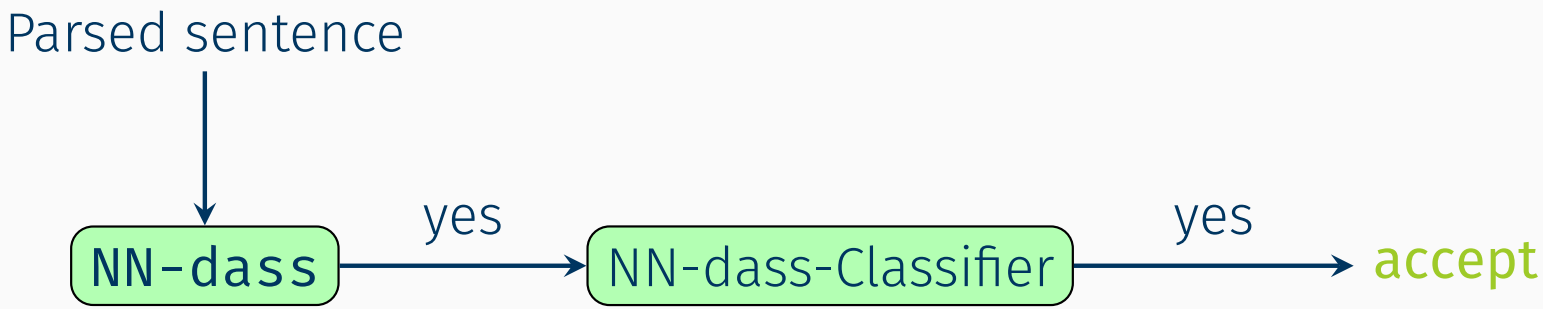

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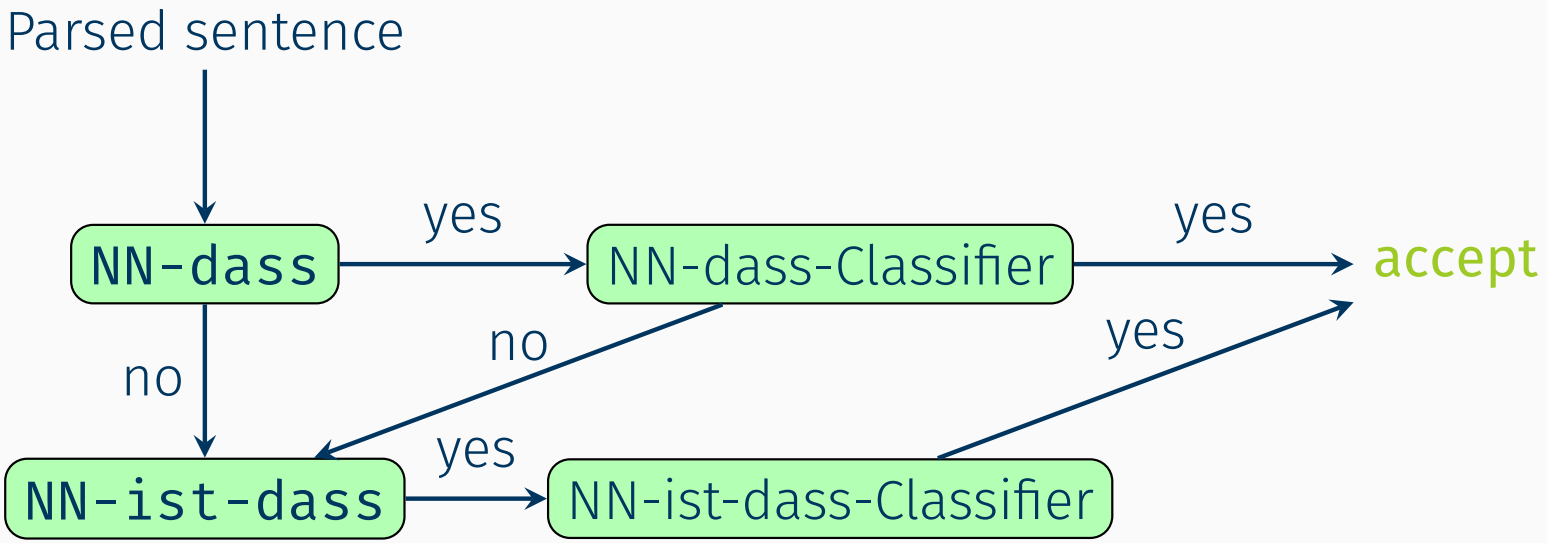

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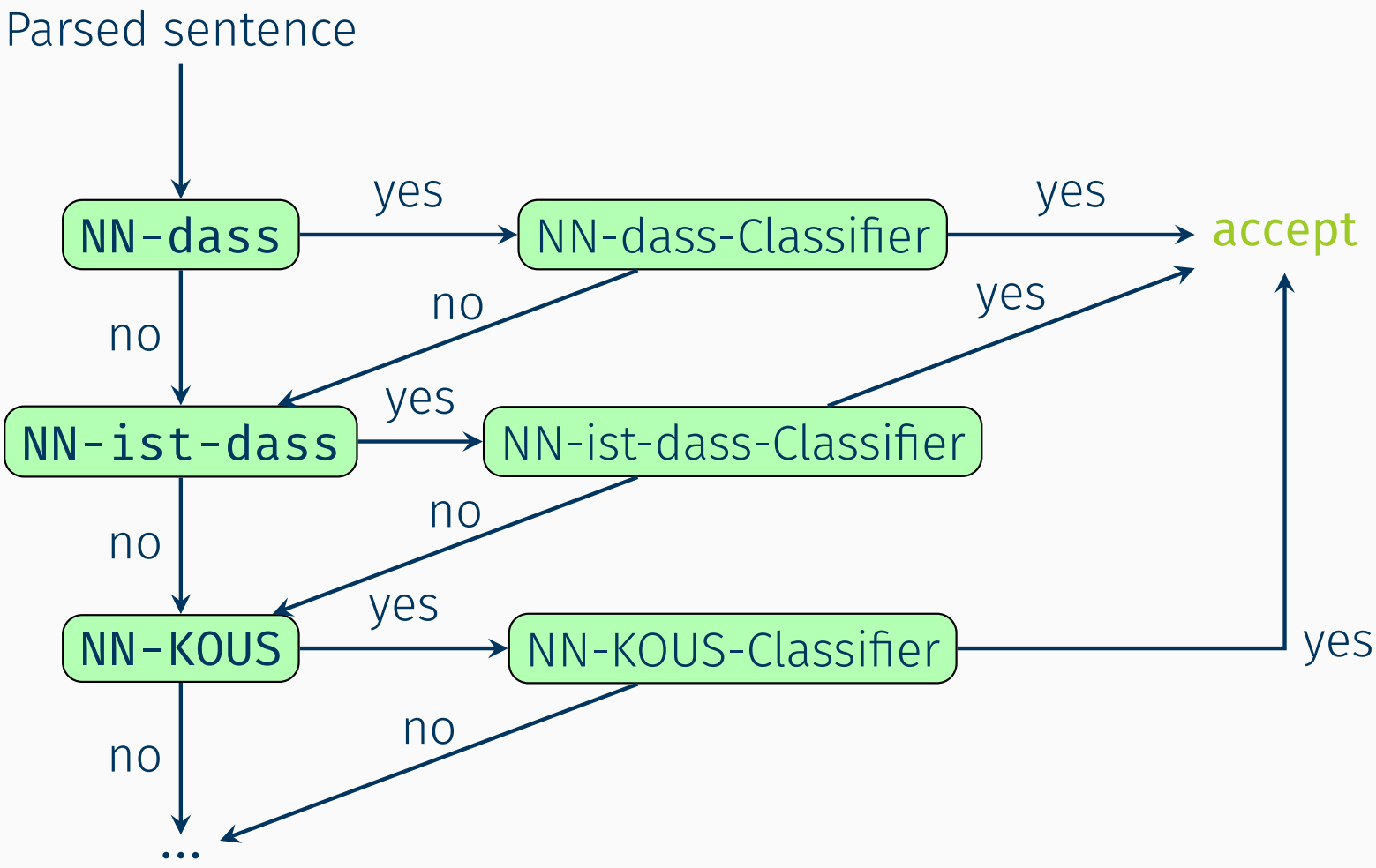

Evaluation

Data

Stems from two annotation projects:

- Dipper and Zinsmeister (2012) annotating the pronouns *dies*, *das*, and *es*
- Simonjetz and Roussel (2016) annotating German (and English) shell nouns

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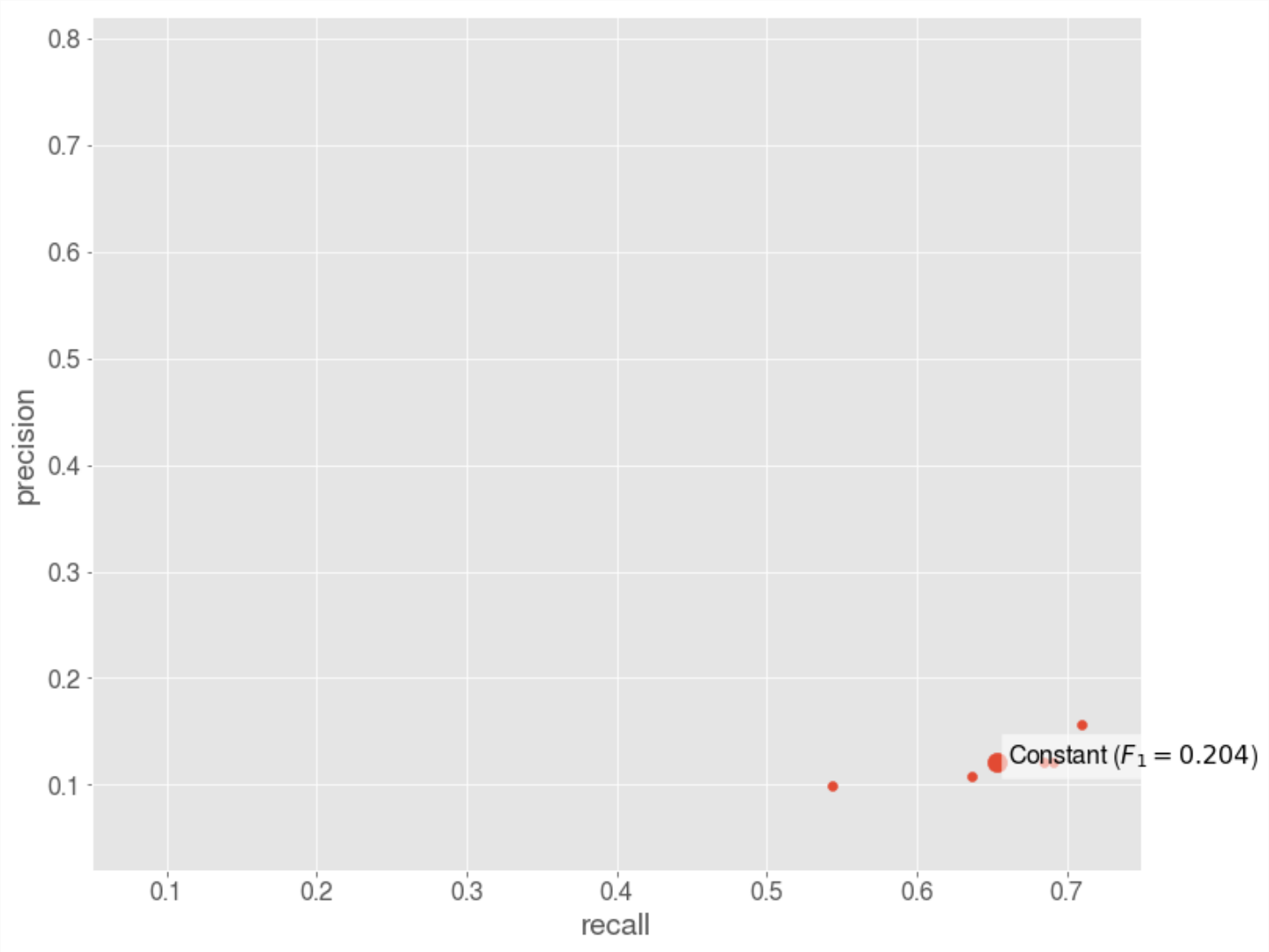
Corpus used here contains 1734 annotated German instances of abstract reference. Of these,

- 1086 are shell nouns
- 249 involve either *dies* or *das*, and
- 375 involve instances of *es*.
- The remaining 24 instances involve pronominal adverbs, such as *deshalb*, and are not covered by this study.

Evaluation

- Comparisons with existing work
  - Classification $\rightarrow$ Was the instance correctly approved by some classifier/pattern?
  - Resolution $\rightarrow$ Was the instance correctly approved by the correct classifier/pattern?
- F_1 scores for classification
- Only accuracy for resolution

Classifiers and Baselines



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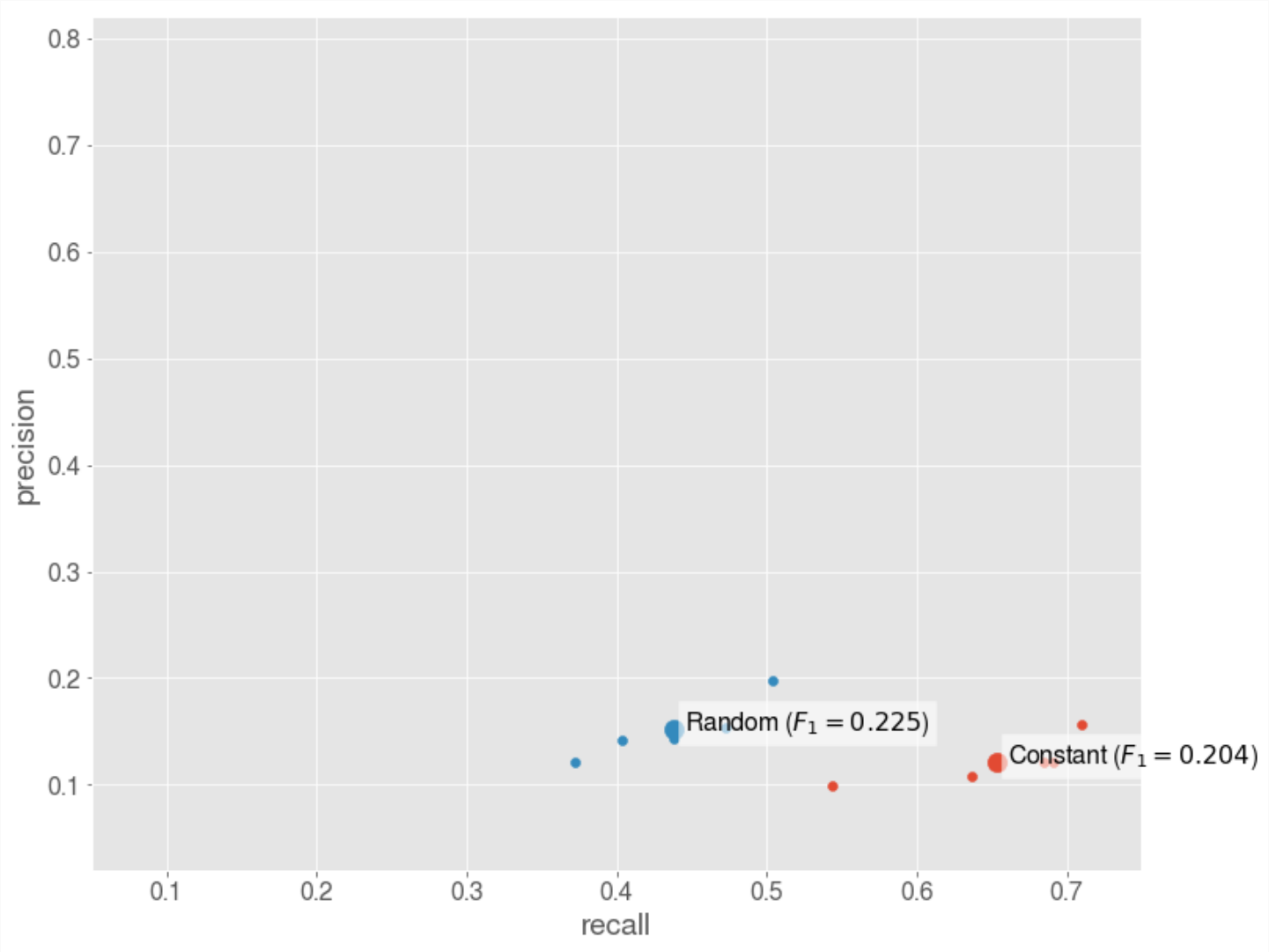

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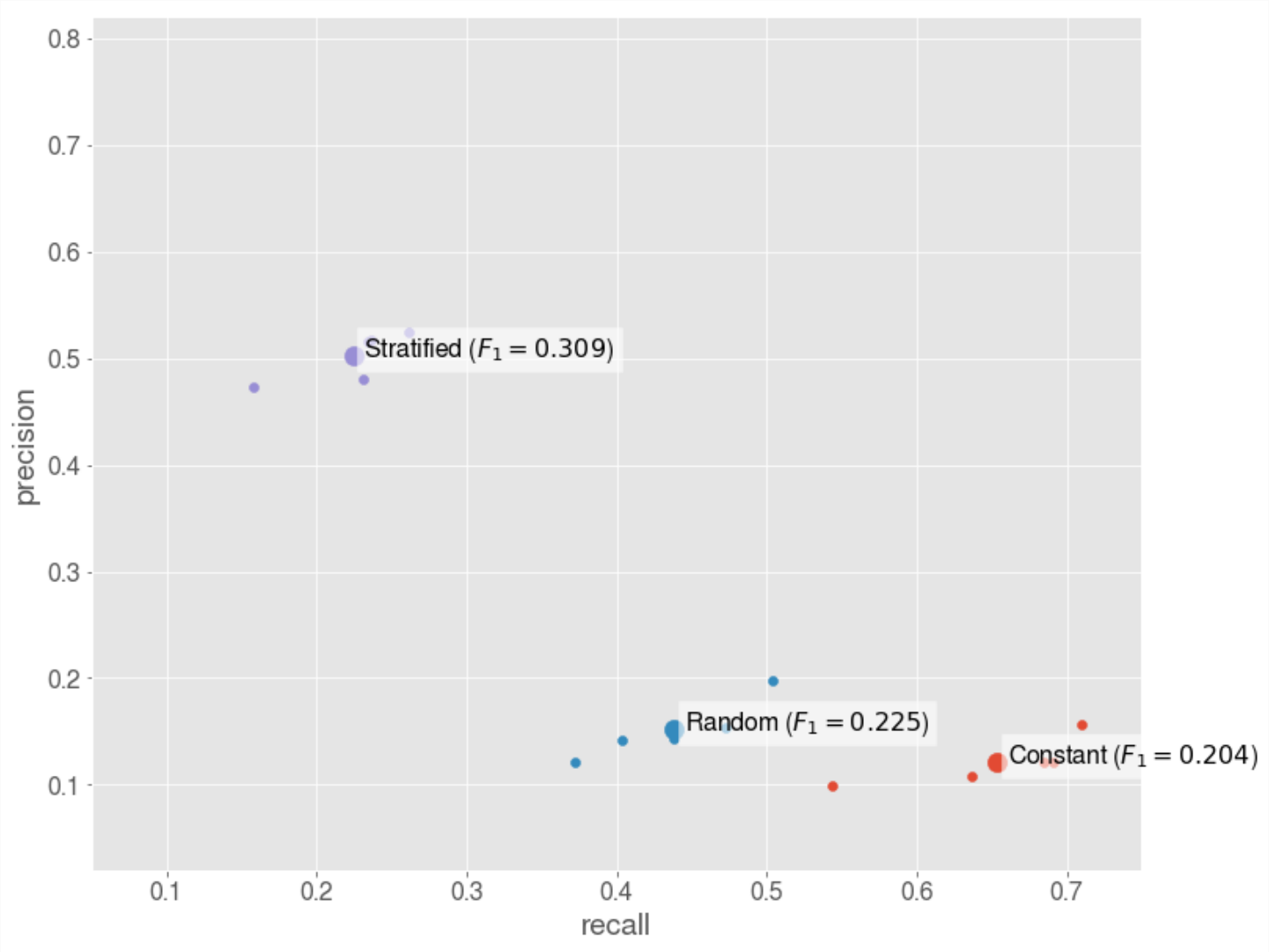

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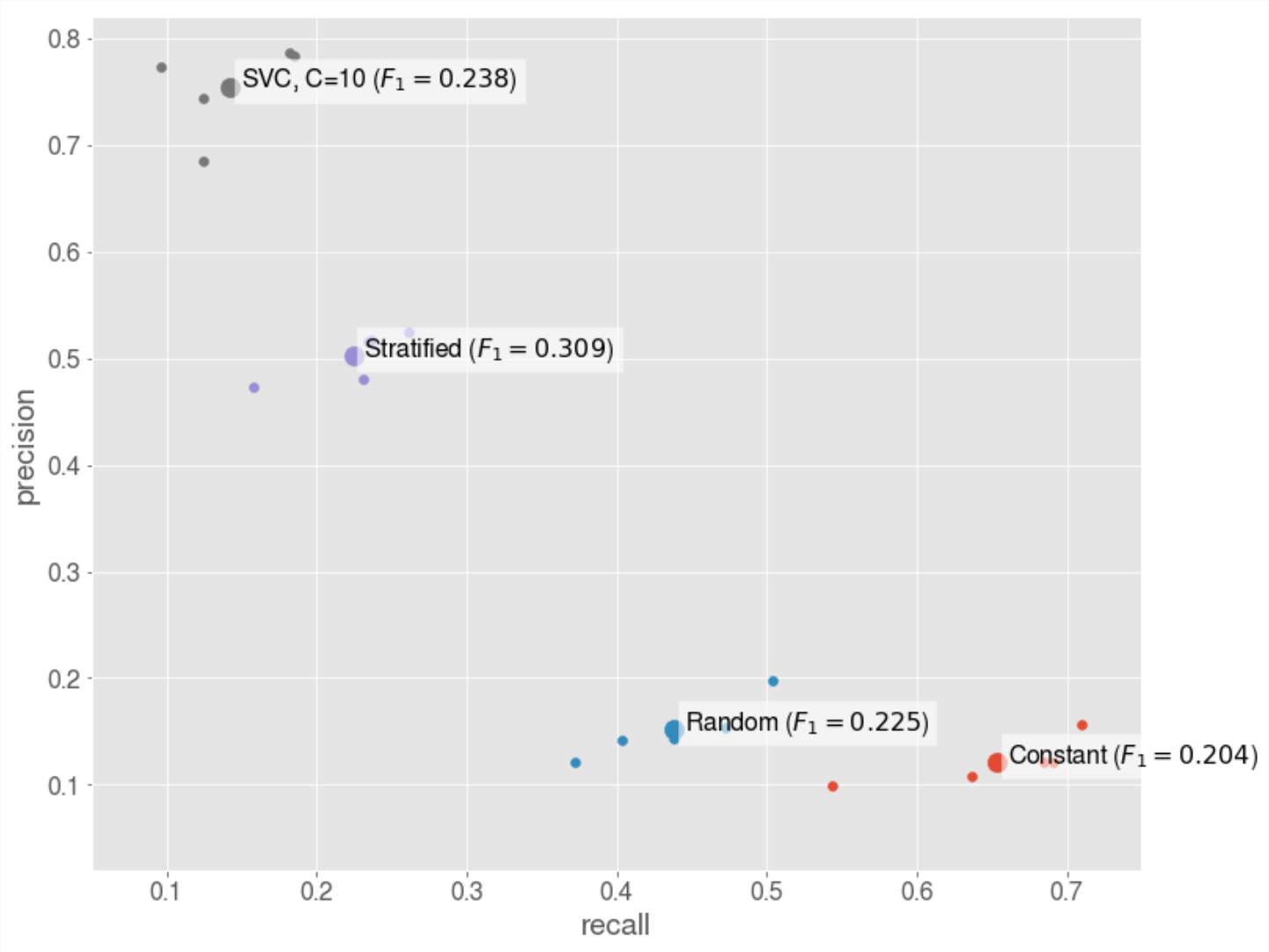

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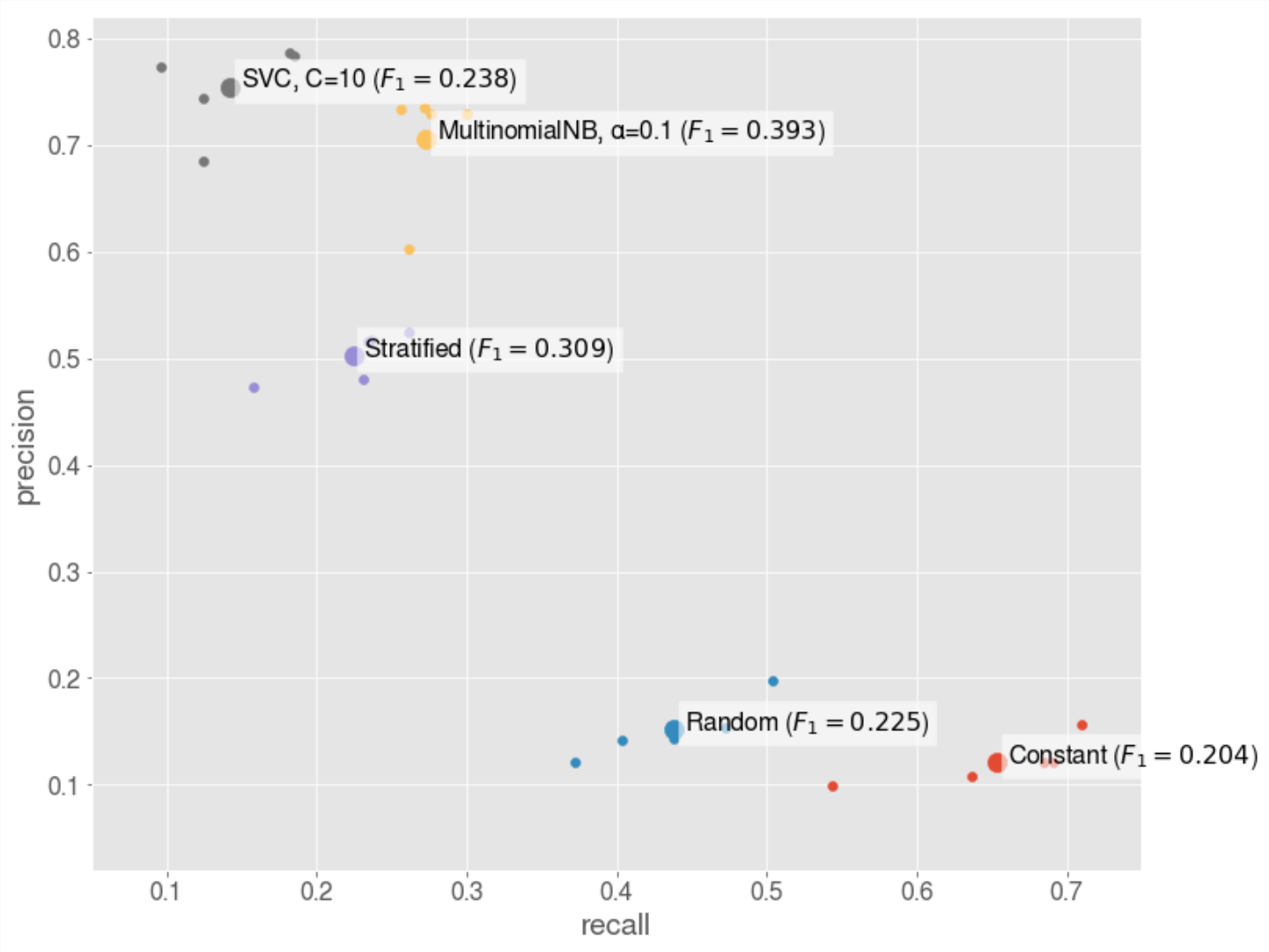

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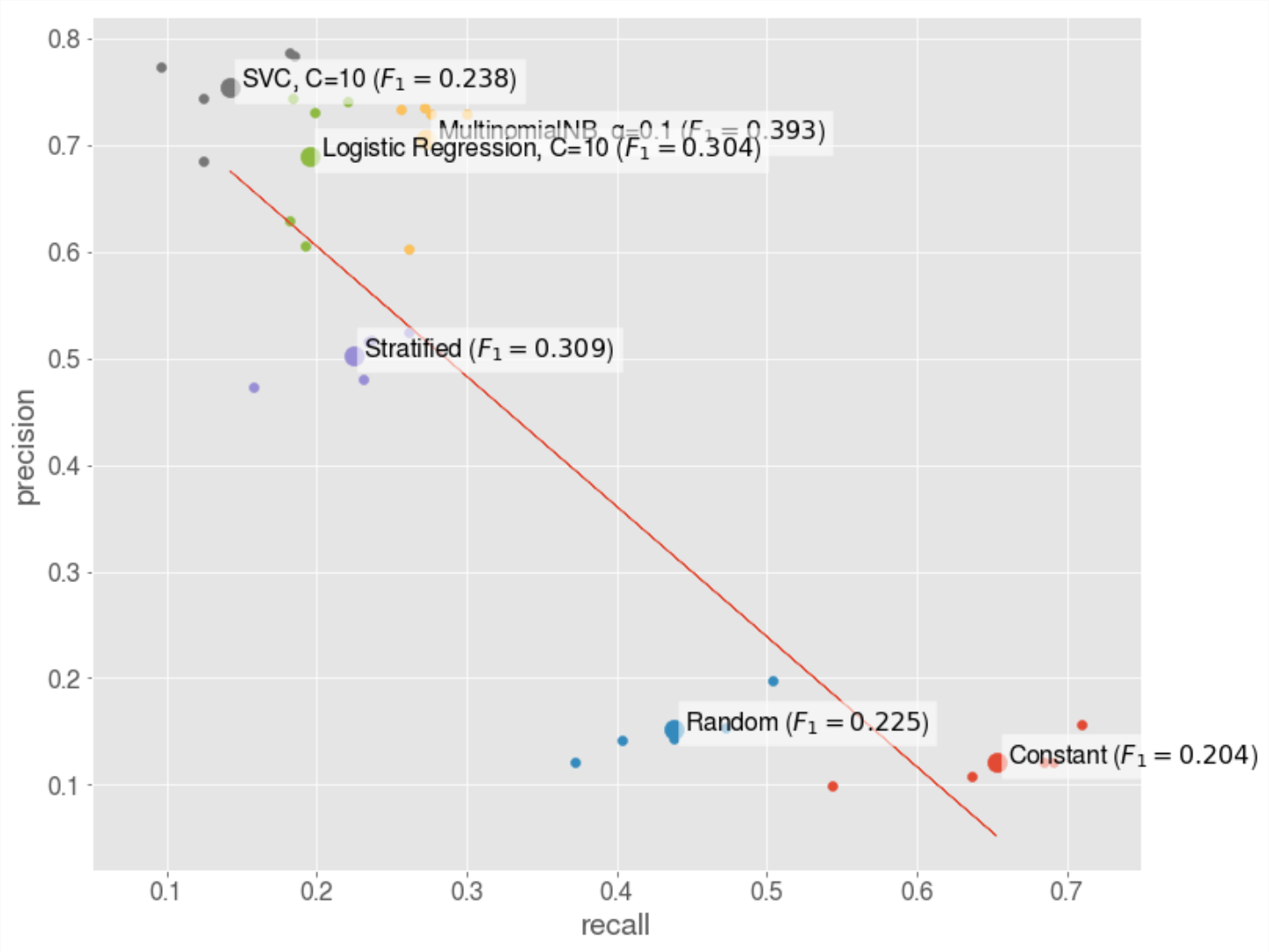


Cataphoric Shell Nouns

- Most similar study, Kolhatkar and Hirst (2014):
  - Baseline (patterns alone), 57%
  - Additional heuristics, 69%
- This system:
  - Baseline (patterns alone): $F_1 = 0.104$, $P = 0.059$, $R = 0.478$
  - Baseline resolution accuracy, 72.2%
  - $\Rightarrow$ 34.5% overall
  - Best classifier: $F_1 = 0.413$, $P = 0.899$, $R = 0.272$
  - With resolution accuracy of 87%
  - $\Rightarrow$ 23.7% overall

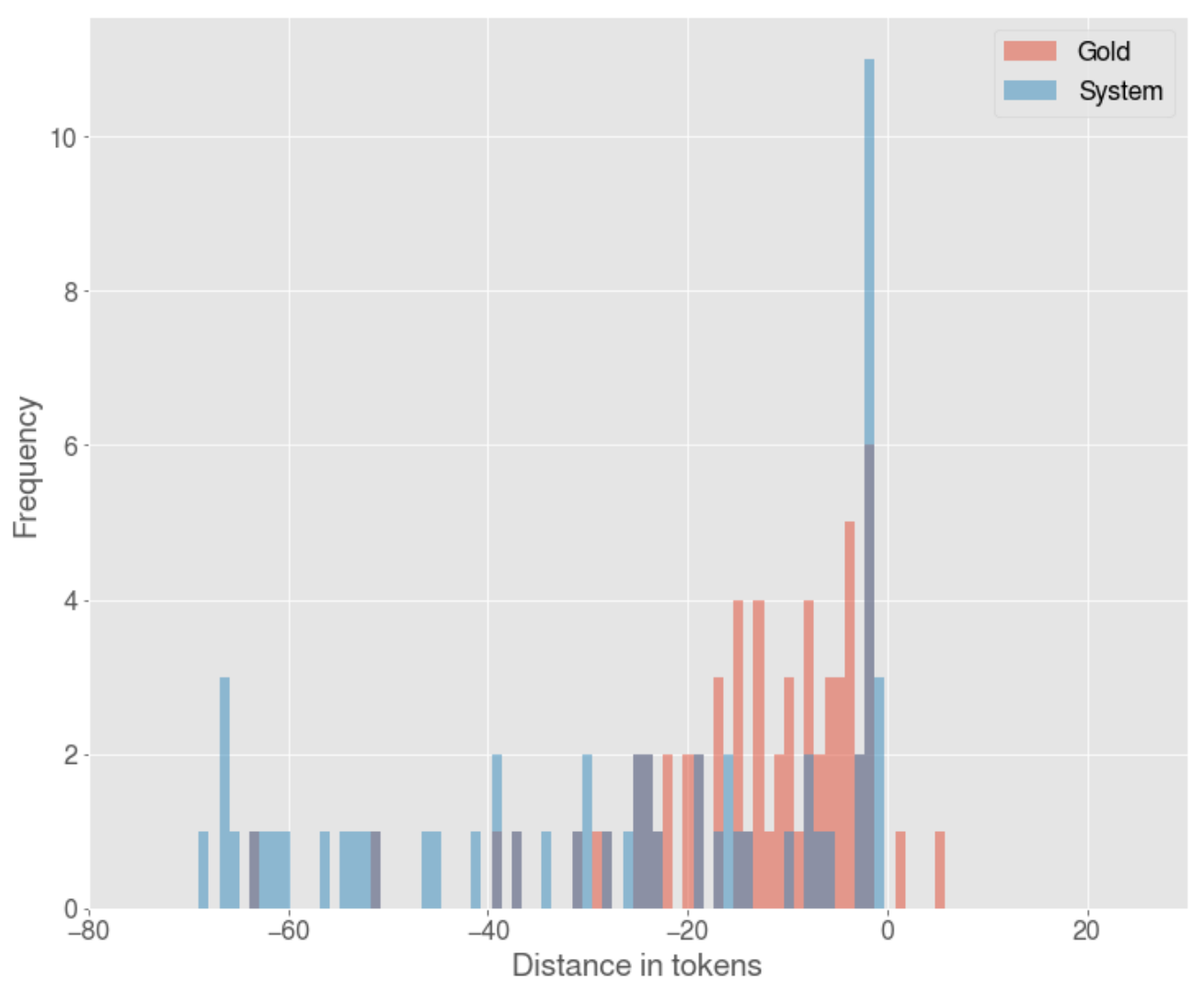
Anaphoric Shell Nouns

- Most similar study, Kolhatkar and Hirst (2012) examined instances of *this issue*
  - Baseline (adjacent sentence): 22.93%
  - With classifier, 59.91%
- This system:
  - Baseline classifier: $F_1 = 0.041$, $P = 0.021$, $R = 0.640$
  - Baseline resolution accuracy, 14.00%
  - $\Rightarrow$ 8.96% overall
  - Best classifier, $F_1 = 0.263$, $P = 0.354$, $R = 0.214$
  - Resolution accuracy of 30.7%
  - $\Rightarrow$ 6.57% overall

Pronouns

- Most similar study, Jauhar et al. (2015):
  - Classification Baseline: $F_1 = 0.217$, $P = 0.121$, $R = 1.000$
  - Class. + Resolution Baseline: $F_1 = 0.165$, $P = 0.153$, $R = 0.179$
  - Classification: $F_1 = 0.386$, $P = 0.352$, $R = 0.429$
  - Class. + Resolution: $F_1 = 0.222$, $P = 0.226$, $R = 0.218$
- This system:
  - Baseline: $F_1 = 0.590$, $P = 0.430$, $R = 0.946$
  - Baseline resolution accuracy: 12.6%
  - Best classifier, $F_1 = 0.762$, $P = 0.691$, $R = 0.853$
  - Resolution accuracy of 15.4%
  - $\Rightarrow$ 13.14% overall

Extraction pattern errors (Pronouns)



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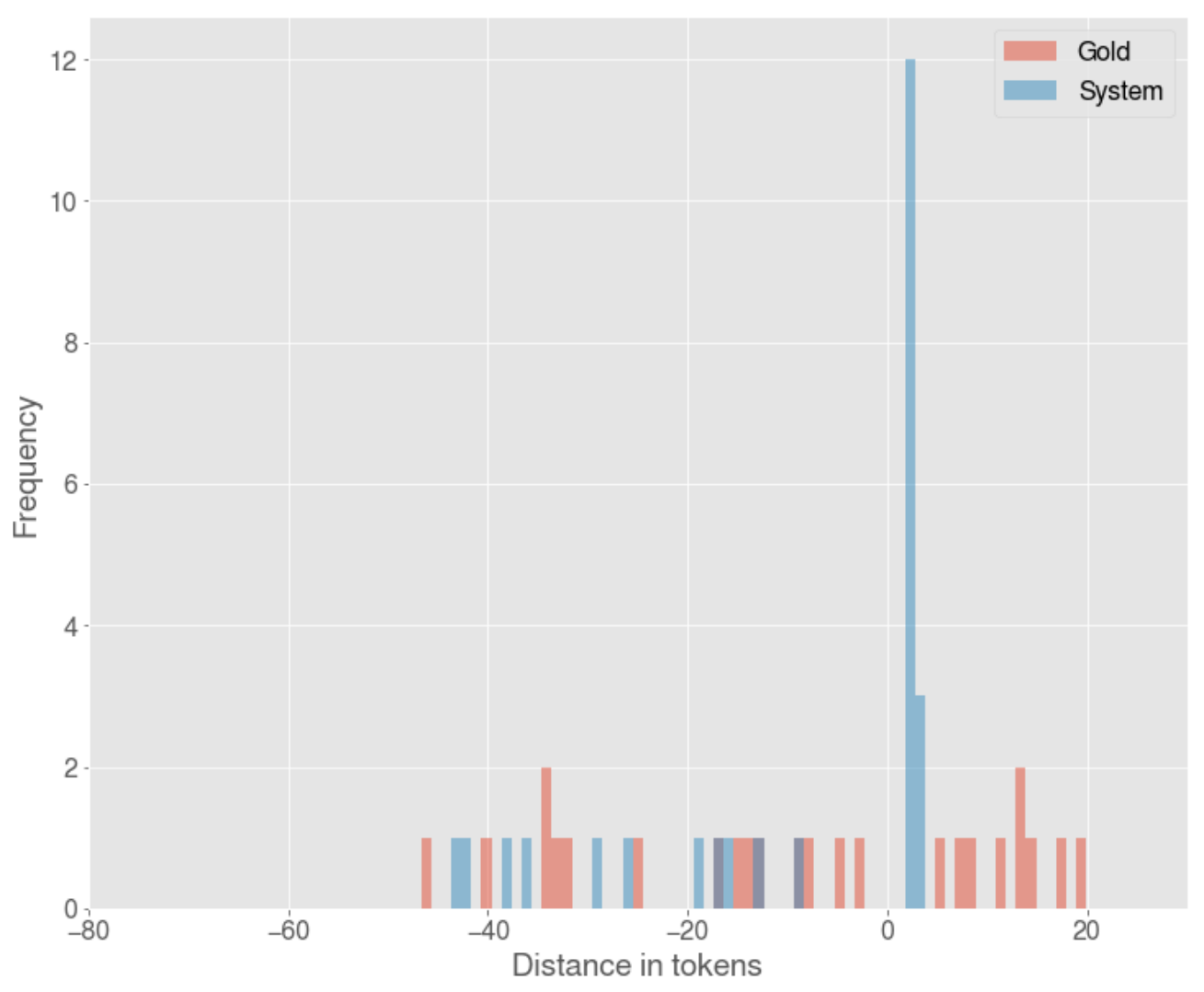

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Summary

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- System shows least improvement over baseline for pronouns
  $\rightarrow$ Lack of relevant features
- These features work much better for shell nouns
- Ideas for future work:
  - Better features targeting pronouns
  - Mixing data between similar patterns (i.e., *this* $\approx$ *this NN*)
  - Integrating NP coreference information

Thanks!

https://github.com/ajroussel/aaarg

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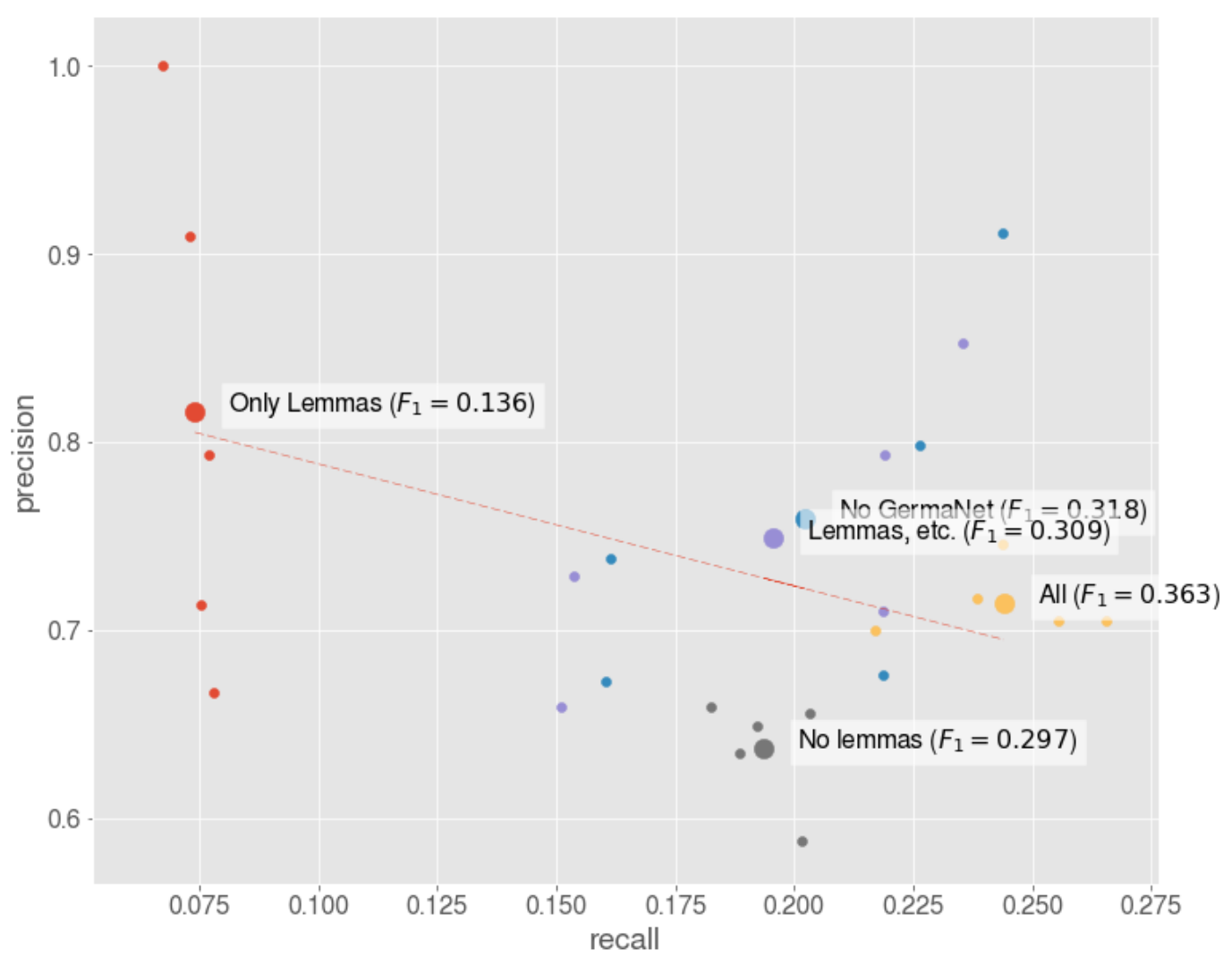
Feature Set Comparison



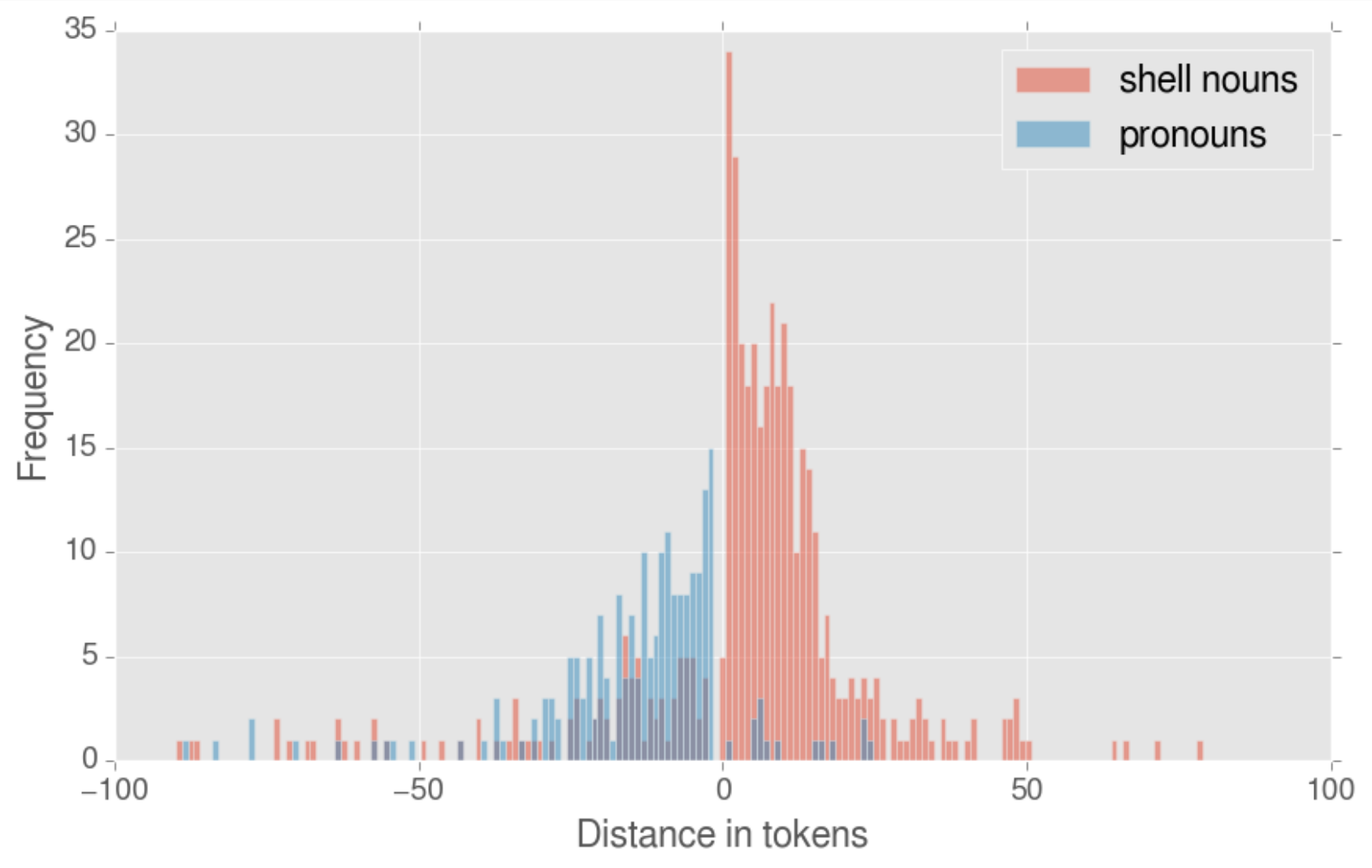
Complete Feature Set

Feature	Examples
Anaphor	
Lemma	*das*, *es*, *Umstand*
Number	Sing./Pl.
Grammatical function	*subj*, *obja*
Whether parent precedes anaphor	Yes/No
Whether parent is subjunctive	Yes/No
Whether parent is clausal verb	Yes/No
Semantic field	*Attribut*, *Kommunikation*
Parent semantic field	*Gefühl*, *Perzeption*
Semantic fields of dep. adjectives	*Bewegung*, *Menge*
Whether dep. article is definite or indefinite	Yes/No
Dep. determiners	*dieser*, *kein*, *beiden*

Complete Feature Set

Antecedent	
Dependent preposition lemmas	*zu*, *für*, *nach*
Dependent complementizers	*dass*, *ob*, *weil*
Grammatical function	*root*, *objc*
Length	No. of tokens
Gender	*Masc*, *Fem*, *Neut*
Semantic field	*Attribut*, *Kommunikation*
Embedding depth	No. of deps. to sentence root
If nominal, ending	*-ung*, *-heit*, *-en*
Whether antecedent contains question mark	Yes/No
Relation	
Distance between anaphor/antecedent	No. of tokens
Whether anaphor precedes antecedent	Yes/No
Whether anaphor/antecedent funcs. match	Yes/No
Whether colon between anaphor/antecedent	Yes/No

Abstract Anaphora Distribution



Classifiers and Baselines

	Classification			Resolution
Name	Precision	Recall	F_1-score	Accuracy
Constant	0.121	**0.654**	0.204	0.353
Random	0.155	0.446	0.230	0.359
Stratified	0.518	0.234	0.322	0.259
MultinomialNB, $\alpha = 0.1$	0.674	0.244	**0.356**	0.525
SVC, $C = 10$	0.742	0.132	0.224	0.340
Logistic Regression, $C = 10$	0.722	0.185	0.292	0.559
Voting	**0.774**	0.179	0.288	**0.563**

Table 1: Classification performance and resolution accuracy

Cataphoric Shell Nouns

	Classification			Resolution
Name	Precision	Recall	F_1-score	Accuracy
Constant	0.059	**0.478**	0.104	0.722
Random	0.062	0.255	0.100	0.658
Stratified	0.233	0.102	0.140	0.910
MultinomialNB, $\alpha = 0.1$	0.729	0.269	0.391	0.836
SVC, $C = 10$	0.736	0.128	0.216	**0.928**
Logistic Regression, $C = 10$	**0.899**	0.272	**0.413**	0.870
Voting	0.893	0.254	0.390	0.885

Table 2: System performance for cataphoric shell noun instances

Anaphoric Shell Nouns

	Classification			Resolution
Name	Precision	Recall	F_1-score	Accuracy
Constant	0.021	**0.640**	0.041	0.140
Random	0.020	0.272	0.046	0.113
Stratified	0.056	0.083	0.084	**0.375**
MultinomialNB, $\alpha = 0.1$	0.354	0.214	0.263	0.307
SVC, $C = 10$	0.000	0.000	NaN	NaN
Logistic Regression, $C = 10$	**0.442**	0.119	**0.293**	0.083
Voting	0.428	0.109	0.274	0.083

Table 3: System performance for anaphoric shell noun instances

Pronouns

	Classification			Resolution
Name	Precision	Recall	F_1-score	Accuracy
Constant	0.430	**0.946**	0.590	0.126
Random	0.499	0.767	0.603	**0.164**
Stratified	0.658	0.835	0.733	0.135
MultinomialNB, $\alpha = 0.1$	0.691	0.819	0.749	0.150
SVC, $C = 10$	0.691	0.853	**0.762**	0.154
Logistic Regression, $C = 10$	0.693	0.808	0.745	0.160
Voting	**0.697**	0.820	0.752	0.158

Table 4: System performance for pronominal abstract anaphora

Per-anaphor classification performance

Anaphor	*N*	Recall	Precision	F_1-score
Zusicherung 'pledge'	1	1.000	1.000	1.000
Notwendigkeit 'need'	7	0.714	1.000	0.833
Tatsache 'fact'	21	0.684	1.000	0.813
Überzeugung 'conviction'	8	0.667	1.000	0.800
Versuch 'attempt'	7	0.571	1.000	0.727
Ansicht 'view'	42	0.471	0.889	0.615
Forderung 'demand'	26	0.450	0.900	0.600
dies 'this'	59	0.420	0.913	0.575
das 'that'	191	0.430	0.829	0.566
Meinung 'opinion'	30	0.364	1.000	0.533
Argument 'argument'	5	0.333	1.000	0.500

Table 5: Classification performance of Naive Bayes classifier for particular anaphors

Difficult cases

(5) **Eines** ist auch klar, und **dazu** stehen wir auch: *Kontrolle ist gut, Vertrauen in Kontrolle ist besser*. Aber **das** wird der Vorschlag dieser vier Staaten bei den Bürgerinnen und Bürgern in dieser Form nicht erreichen.
‘One thing is clear and we stand behind this too: Control is good, trust in control is better. But the proposal of these four states in this form won’t achieve this.’

Difficult cases

(6) *Wir*, die Vertreter der Bürger, der Menschen Europas, erreichen innerhalb der Institutionen etwas, und wir debattieren darüber kurz vor Mitternacht und werden ermahnt, wir sollen uns kurz fassen. **Das** ist ein Wiederholungsfall!

'Within the institutions, we – the representatives of the citizens, of the people of Europe – are actually achieving something, and, as we debate it shortly before midnight, we are enjoined to keep things brief. This is not the first time this has happened.'

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