Identifying Grammar Rules for Language Education with Dependency Parsing in German

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Depling – SyntaxFest

Why identify grammar rules?

- Our larger mission: find appropriate texts for first language learners in primary school education (in German and other languages...)
- *Text difficulty* relies on many aspects; sentence length, word frequency, syntax...
- How can we determine the difficulty of a sentence given the existing grammar rules (syntax + morphosyntax)?
- How to even find grammar rules in text?

Our approach

- Create a new *query language* for translating grammar rules to syntactic/morphosyntactic patterns
- Build *patterns* for German syntactic phenomena (age appropriate) + assign them with difficulty
- Build a *matching algorithm* where *input*: parses + patterns, *output*: grammar rules
- *Evaluate* the matches with gold parses and parses from 4 parsers (Munderline, UDPipe, jPTDP, Turku)

Our main goals

- Create very restrictive patterns that would not be found erroneously/overzealously
- Descriptive and human-readable patterns
- Search on *dependency parses* (**not** just string methods or regex!)
- Fast and successful with our dependency parser

Why create a new query language?

- **Most** existing text query languages (ANNIS, Poliqarp, COSMAS II) do not support dependency parsing, use regex (too difficult), match meaningless strings...
- **PML-TQ** (Pajas and Štěpánek, 2009): very robust, too complex
- **TüNDRA** (Martens, 2012): almost perfect... but not quite (uses TIGER annotation, allows surface structure)

Query language template

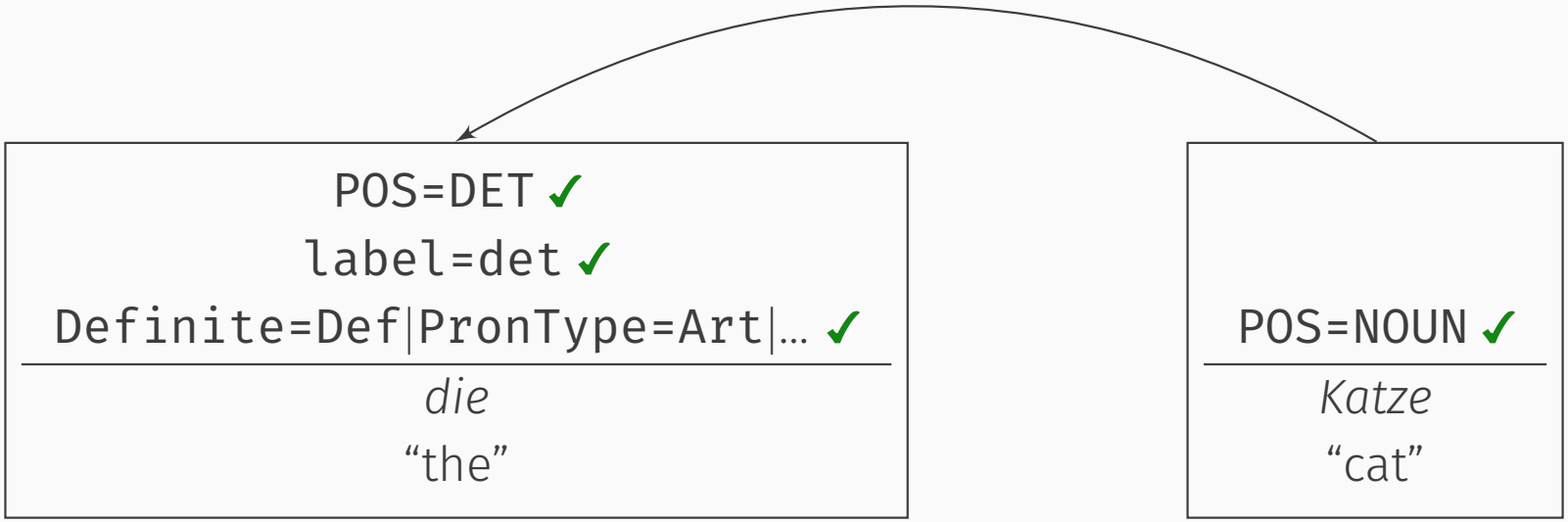
comp_word: POS={A,B}&
label={c}&
feature={d,e}&
lemma={'e'}&
wordform={'f','g'}&
wordform={h-,i-}&
wordform={-j-},
head_word: POS={A,B}&
label={c}&
feature={d,e}&
lemma={'e'}&
wordform={'f','g'}&
wordform={h-,i-}&
wordform={-j-},
tokenID(head_word) = headID(comp_word)

Figure 1: General template for a pattern with a *head-dependent* relation.

Example 1: NP with definite determiner

comp_word: **POS=**{DET}&**label=**{det}&
feature={Definite=Def,PronType=Art},
head_word: **POS**={NOUN},
tokenID(head_word) = headID(comp_word)

Figure 2: Pattern to identify a noun phrase with a definite article.

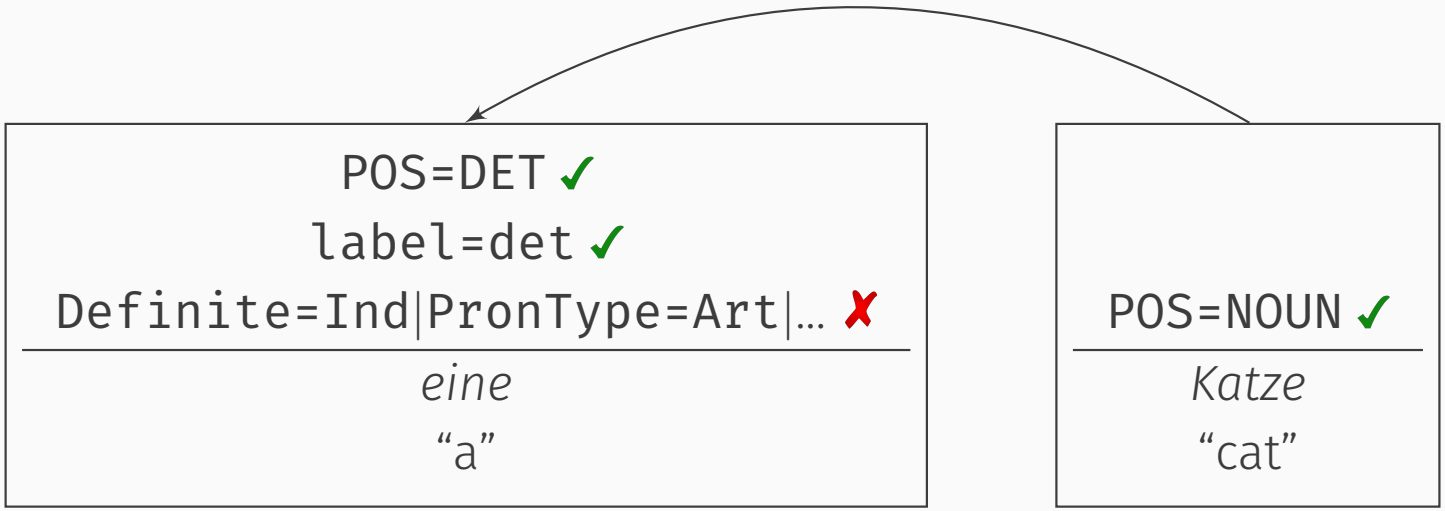


Match!

Example 1: NP with definite determiner (complex pattern)

comp_word: **POS=**{DET}&**label=**{det}&
feature={Definite=Def,PronType=Art},
head_word: **POS**={NOUN},
tokenID(head_word) = headID(comp_word)

Figure 3: Pattern to identify a noun phrase with a definite article.

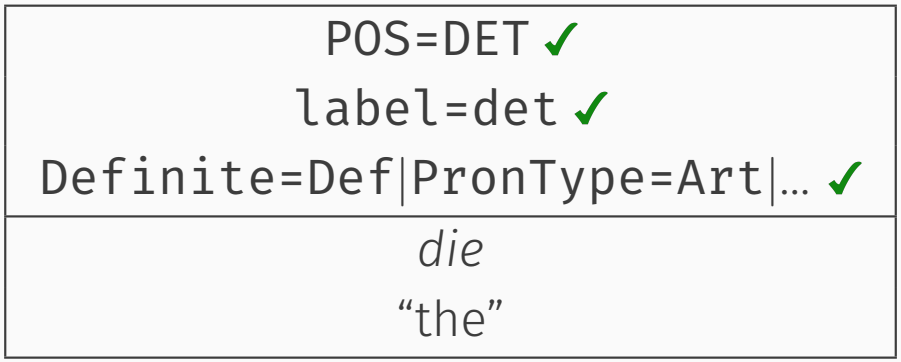


No match.

Example 2: Definite pronoun (simple patterns)

head_word: **POS=**{DET}&**label=**{det}&
feature={Definite=Def,PronType=Art}

Figure 4: Pattern to identify a definite determiner.

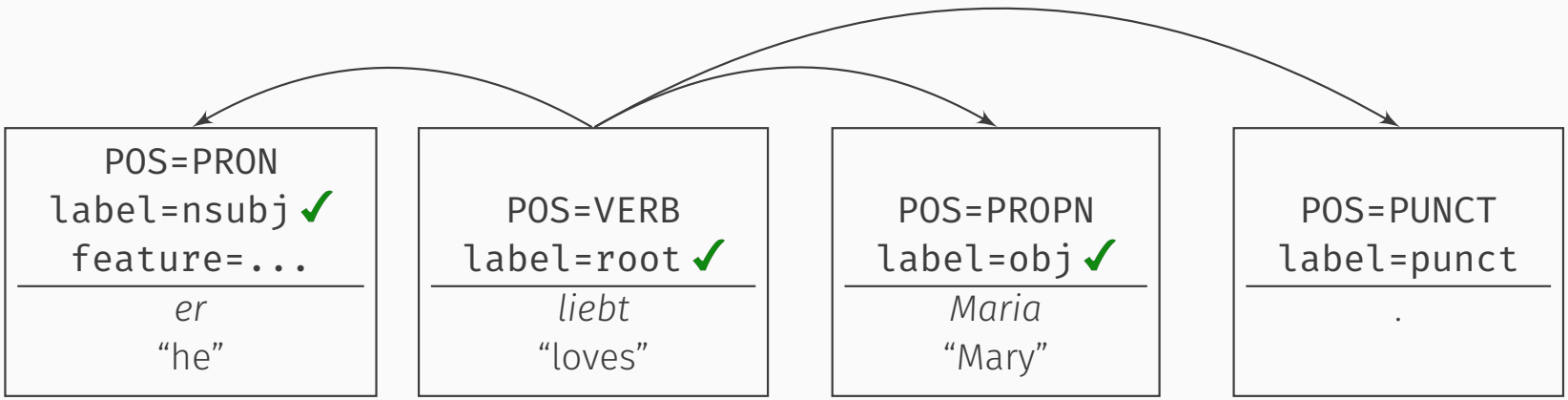


Example 3a: Transitive sentence (compound patterns)

comp_word: label={nsubj},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word)

AND

comp_word: label={obj},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word)



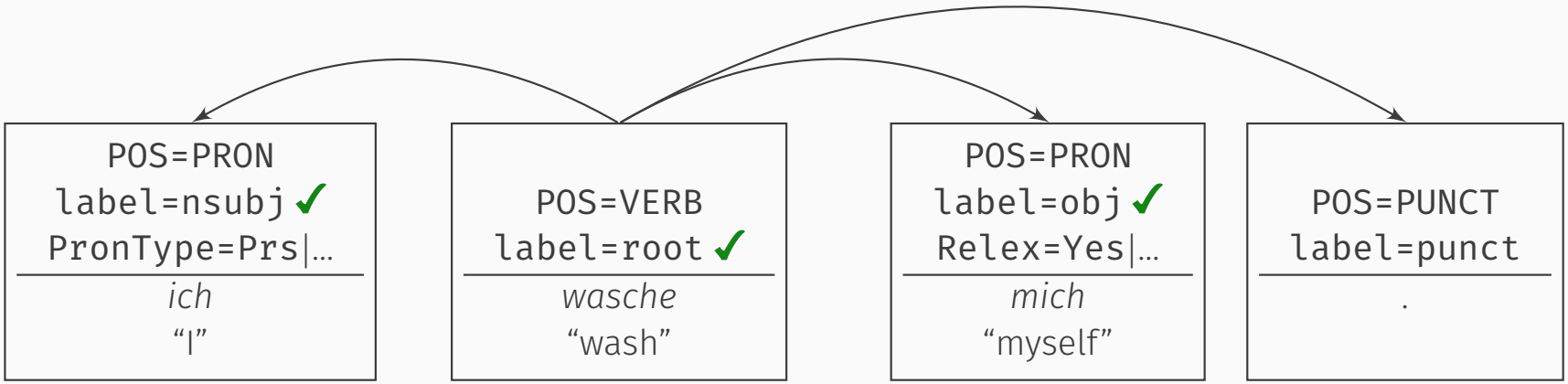
Match!

Example 3b: Reflexive sentence

comp_word: **label**={nsubj},
head_word: **POS**={VERB}&**label**={root},
tokenID(head_word) = headID(comp_word)

AND

comp_word: **label**={obj},
head_word: **POS**={VERB}&**label**={root},
tokenID(head_word) = headID(comp_word)



Also a match...

Exclude operator

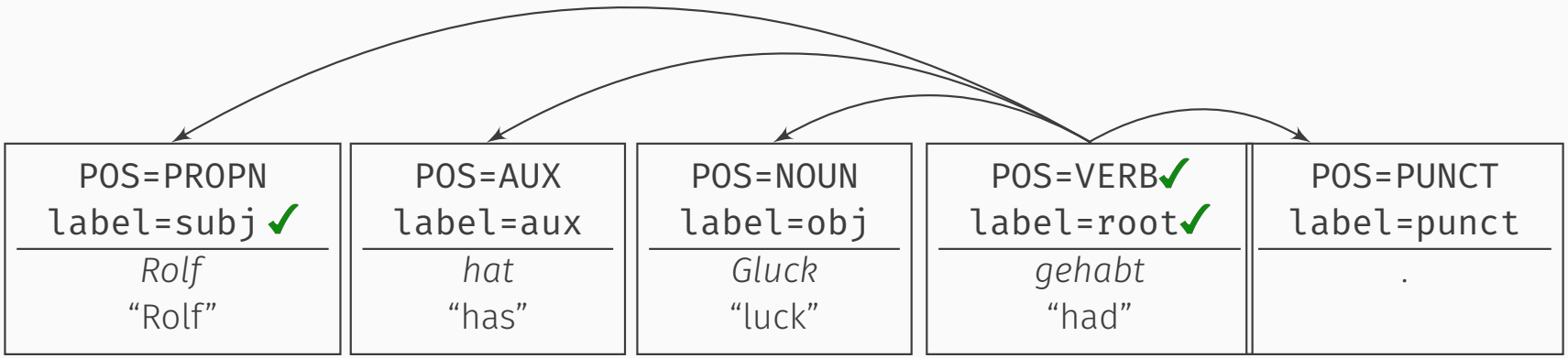
- Distinguish similar patterns by **excluding** the parts of the pattern that should not match
- Example: Pattern to **only** match simple mono-transitive sentences (not bitransitive sentences, not reflexive sentences)

comp_word: **label**={nsubj},
head_word: **POS**={VERB}&**label**={root},
tokenID(head_word) = headID(comp_word)
AND
comp_word: **label**={obj},
head_word: **POS**={VERB}&**label**={root},
tokenID(head_word) = headID(comp_word)
AND
∼*(comp_word:* **label**={iobj},
head_word: **POS**={VERB}&**label**={root},
tokenID(head_word) = headID(comp_word))
AND
∼*(comp_word:* **label**={obj,iobj}& **feature**=
{PronType=Prs,Reflex=Yes},
head_word: **POS**={VERB}&**label**={root},
tokenID(head_word) = headID(comp_word))

Example 3a, revised

comp_word: label={nsubj},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word)
AND
comp_word: label={obj},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word)
AND

∼(*comp_word:* label={iobj},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word))
AND
∼(*comp_word:* label={obj,iobj}& feature=
{PronType=Prs,Reflex=Yes},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word))

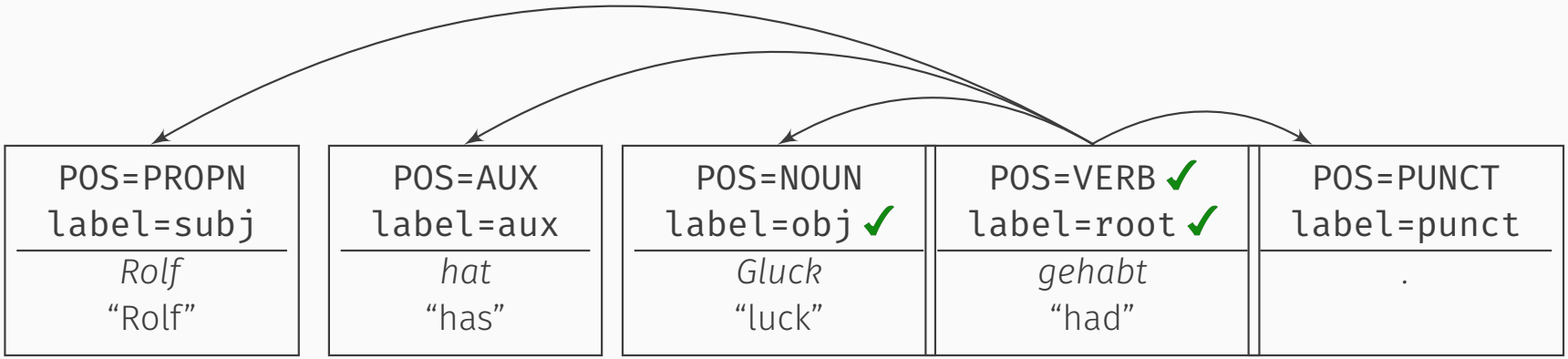


Part 1: Match!

Example 3a, revised

comp_word: label={nsubj},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word)
AND
comp_word: label={obj},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word)
AND

∼(*comp_word:* label={iobj},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word))
AND
∼(*comp_word:* label={obj,iobj}& feature=
{PronType=Prs,Reflex=Yes},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word))

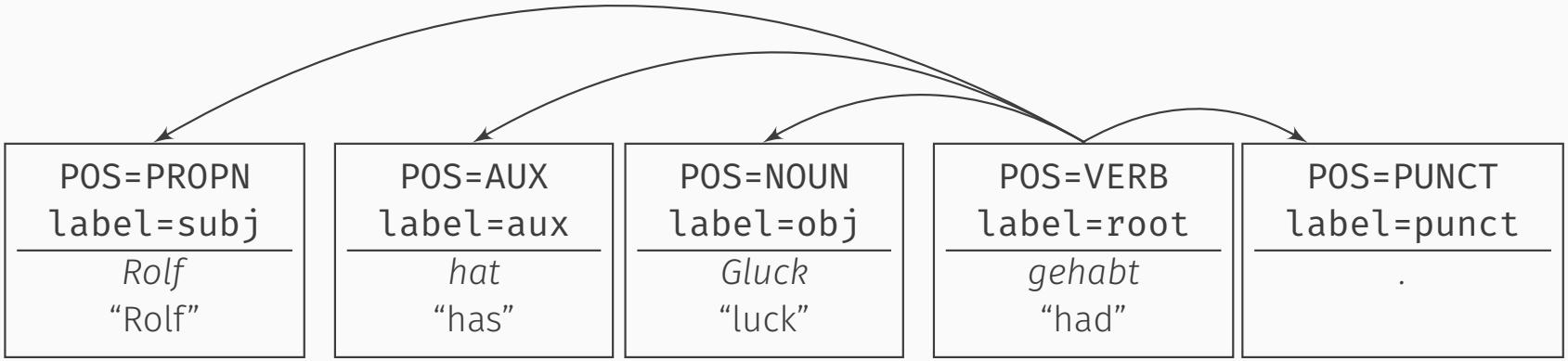


Part 2: Match!

Example 3a, revised

comp_word: label={nsubj},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word)
AND
comp_word: label={obj},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word)
AND

∼(*comp_word:* label={iobj},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word))
AND
∼(*comp_word:* label={obj,iobj}& feature=
{PronType=Prs,Reflex=Yes},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word))

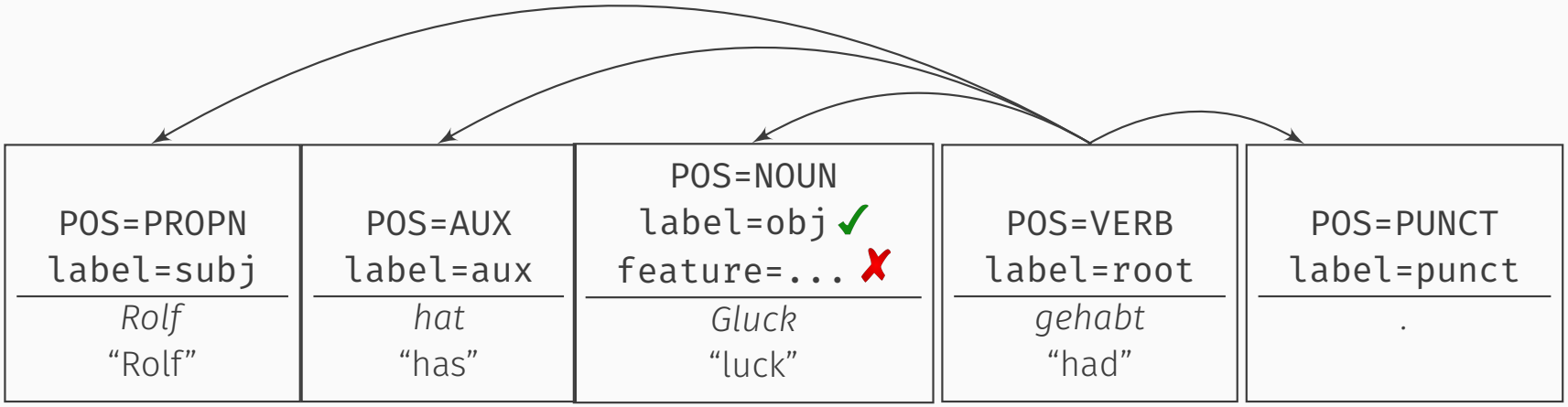


Part 3: `comp_word` not found → No match.

Example 3a, revised

comp_word: label={nsubj},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word)
AND
comp_word: label={obj},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word)
AND

∼(*comp_word:* label={iobj},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word))
AND
∼(*comp_word:* label={obj,iobj}& feature={PronType=Prs,Reflex=Yes},
head_word: POS={VERB}&label={root},
tokenID(head_word) = headID(comp_word))



Part 4: Partial match → No match.

Matching process

135 patterns for syntactic/morphosyntactic German grammar rules

ID	Description	Dif.	Pattern
222	Auxiliary verb “haben”, present indicative	1	head_word: POS={AUX} & wordform={“hab”,“habe”,“hast”,“hat”,“haben”} & feature= {Mood=Ind,VerbForm=Fin}
240	Composed forms: Perfect indicative	1	comp_word: {<222>,<218>}, head_word: POS={VERB} & feature={VerbForm=Part}, tokenID(head_word)=headID(comp_word)
289	Simple clause with intransitive verb, with auxiliary verb	1	(comp_word: label={nsubj}, head_word: POS={VERB}&label={root}, tokenID(head_word)=headID(comp_word)) AND (comp_word: POS={AUX} & label={aux}, head_word: POS={VERB} & label={root} & feature={VerbForm=Part}, tokenID(head_word)=headID(comp_word)) AND ∼(head_word: label={obj}) AND ∼(head_word: label={iobj}) AND ∼(head_word: POS={PUNCT}&wordform={“?”}) AND ∼(head_word: feature={Mood=Imp}&label={root})

Dictionaries

For string matches, lemma matches, affix matches:

- Dictionary of 15K German words from 117K corpus of children's texts
- Every word has orthographic, phonological, morphological information

NB: Word matches **should** be used sparingly; dependencies are favoured.

The case of MWEs

- Gold treebanks annotate **MWEs** with **compound**, but some parsers fail to.
- Also, what about lexicalized phrases?
- We pre-process dependency parse inputs before matching with patterns to **merge** lexicalized phrases.

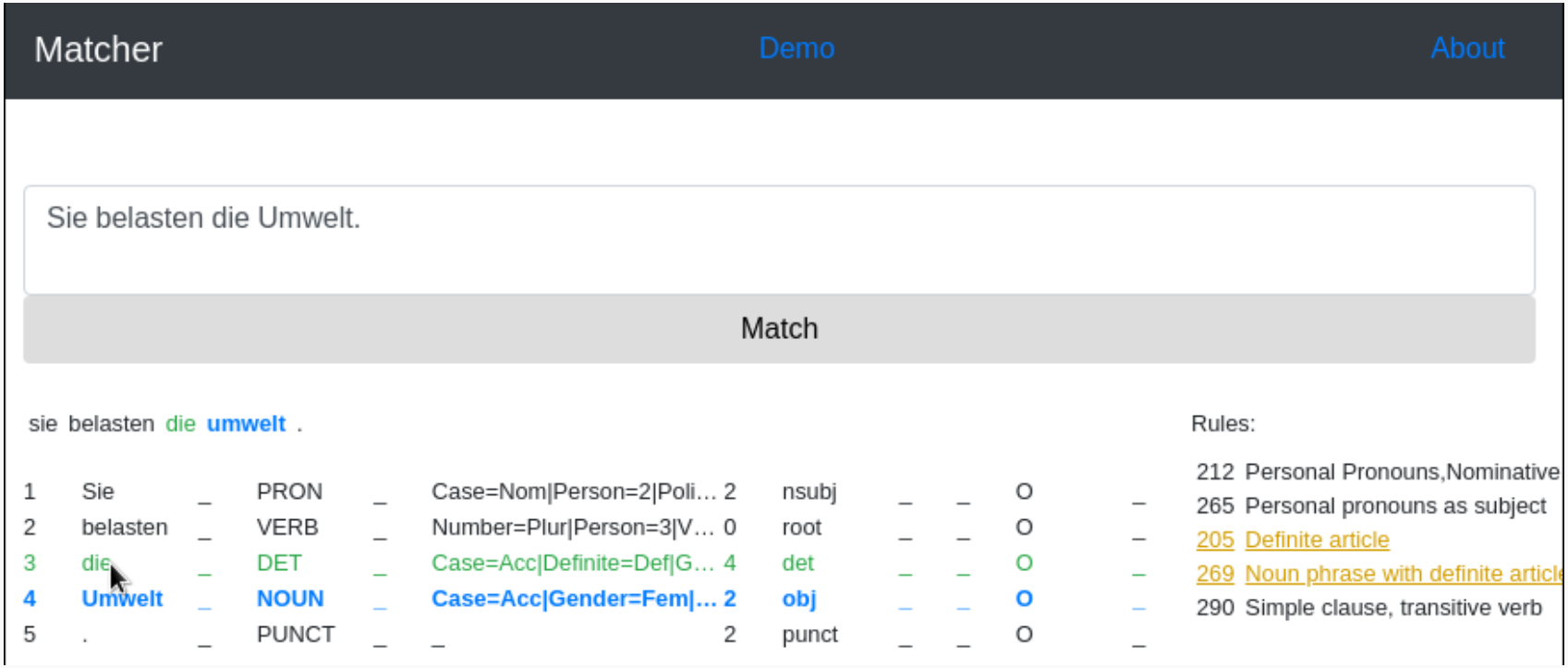
1. Compose list of relevant phrases + their *head* word
2. Find phrase in dependency parse
3. Concatenate words to one “word” with *head* features

```
1  As    ADV    _           2   advmod
2  soon  ADV    Degree=Pos  22  advmod
3  as    SCONJ  _           9   mark
4  ...
```

```
2  As soon as  ADV  Degree=Pos  22  advmod
4  ...
```

Implementation

- Implementation of the algorithms in Python3
- Dependency parsing: MUNDERLINE (Volokh and Neumann, 2012)
- Available to the partners through API and online tool



Evaluation

→ How well does the matcher work?

→ How well our parser performs compared to others?

- Evaluation on gold parses
- Evaluation on parsers:
  - `Munderline` Volokh and Neumann (2012)
  - `UDPipe` (Straka and Straková, 2017)
  - `jPTDP` (Nguyen and Verspoor, 2018)
  - `Turku` neural parser pipeline (Kanerva et al., 2018)

Results on gold parses

Dev set: 152 sentences + Test set: 101 sentences

	Gold
Total	978
TP	922
FP	26
FN	56
Precision	0.9726
Recall	0.9427
F1	0.9574

Table 1: Dev set results

	Gold
Total	776
TP	734
FP	32
FN	42
Precision	0.9582
Recall	0.9459
F1	0.9520

Table 2: Test set results.

Results on parsers

- **Turku** most successful (Precision, Recall)
- **jPTDP** doesn't output morphological features

	Gold	*MUNDERLINE*	*UDPipe*	*jPTDP*	*Turku*
Total	978	978	*911*	978	*911*
TP	922	742	638	249	788
FP	26	92	105	98	89
FN	56	236	273	729	123
Prec.	0.9726	0.8897	0.8587	0.7176	**0.8985**
Rec.	0.9427	0.7587	0.7003	0.2546	**0.8650**
F1	0.9574	0.8190	0.7715	0.3758	**0.8814**

Table 3: Results on dev set.

Results on parsers

- **Turku** most successful (Precision, Recall)
- **jPTDP** doesn't output morphological features

	Gold	*MUNDERLINE*	*UDPipe*	*jPTDP*	*Turku*
Total	776	776	664	776	664
TP	734	601	496	246	587
FP	32	80	89	68	96
FN	42	175	168	530	77
Prec.	0.9582	**0.8825**	0.8479	0.7834	0.8594
Rec.	0.9459	0.7745	0.7470	0.3170	**0.8840**
F1	0.9520	0.8250	0.7942	0.4514	**0.8716**

Table 4: Results on test sets.

Discussion: Why not 100% accuracy?

- The selected rules have limited scope
  e.g. Prepositional phrases with ellipsis not found
- Dependency parsing choices:
  - Conjunctions: second part is `conj` (now fixed!)
  - No position information: advantage and disadvantage
- Gold parses vs. Parser output:
  - MWE expressions (addressed)
  - Multiword tokens ("zum" $\rightarrow$ "zu" + "dem") (now fixed!)

Future Work

- Integration to the text difficulty evaluation
- Patterns and resources for Greek, English, Spanish
- Improvement and extension of our patterns, use in other NLP applications...

Thank you to our coworkers, our SyntaxFest reviewers, and **you**!

Questions?

Demo?

```
1 C’   ce    PRON  _ Number=Sing|Person=3|PronType=Dem                          4 nsubj _
2 est  être  AUX   _ Mood=Ind|Number=Sing|Person=3|Tense=Pres|VerbForm=Fin 4 cop   _
3 la   le    DET   _ Definite=Def|Gender=Fem|Number=Sing|PronType=Art         4 det   _
4 fin  fin   NOUN  _ Gender=Fem|Number=Sing                                    0 root  _
5 !    !     PUNCT _ _                                                        4 punct _
```

References i

Kanerva, J., Ginter, F., Miekka, N., Leino, A., and Salakoski, T. (2018). Turku neural parser pipeline: An end-to-end system for the conll 2018 shared task. In *Proceedings of the CoNLL 2018 Shared Task: Multilingual Parsing from Raw Text to Universal Dependencies*, pages 133–142.

Martens, S. (2012). TüNDRA: TIGERSearch-style treebank querying as an XQuery-based web service. In *Proceedings of the joint CLARIN-D/DARIAH Workshop'Serviceoriented Architectures (SOAs) for the Humanities: Solutions and Impacts', Digital Humanities*.

Nguyen, D. Q. and Verspoor, K. (2018). An Improved Neural Network Model for Joint POS Tagging and Dependency Parsing. In *Proceedings of the CoNLL 2018 Shared Task: Multilingual Parsing from Raw Text to Universal Dependencies*, pages 81–91, Brussels, Belgium. Association for Computational Linguistics.

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