Automatic classification of lexical stress errors for German CAPT

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Background & motivation

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Lexical stress: Accentuation/prominence of syllable(s) in a word

In German:

- Variable placement, contrastive function

um·FAHR·en	vs.	UM·fahr·en
to drive around		*to run over*

- Reflected by duration, fundamental frequency (F0), intensity[1]
- Impacts intelligibility of non-native (L2) speech[2]

[1] Dogil and Williams 1999.

[2] Hirschfeld 1994.

Background & motivation

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- Contrastive lexical stress (LS) difficult for French speakers[1]
- CAPT offers huge potential for individualized instruction

- Classification of LS errors in L2 German unexplored
- Promising recent work using machine learning for classification of English stress patterns[2]

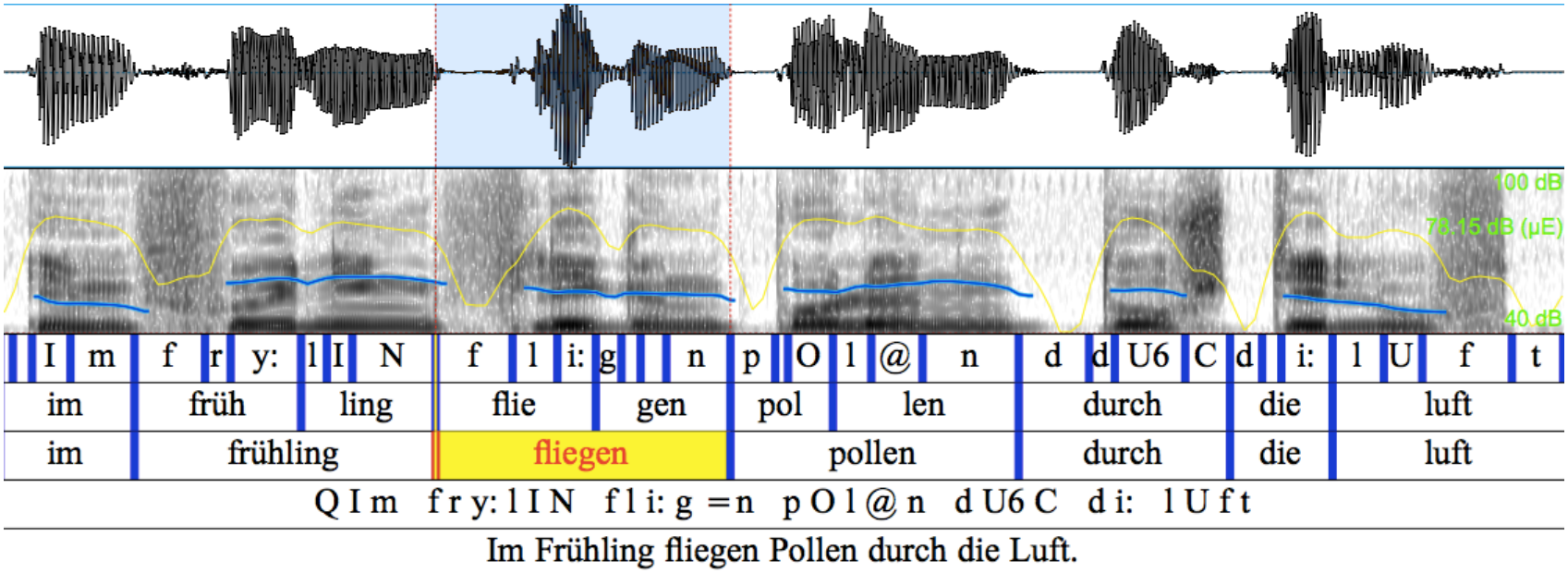
Our goal: explore classification-based detection of lexical stress errors by French learners of German

[1] Dupoux et al. 1997.

[2] Kim and Beutnagel 2011; Shahin et al. 2012.

Data

Subset of IFCASL corpus of French-German speech[1]



Extracted utterances of 12 bisyllabic, initial-stress words

- 668 tokens from 56 French speakers - manually annotated
- 477 tokens from 40 German speakers - assumed correct

[1] Fauth et al. 2014.

Data annotation

- Each token assigned a class label:

  3 stress classes:
  [correct], [incorrect], [none]

  2 error classes:
  [bad_nsylls], [bad_audio]

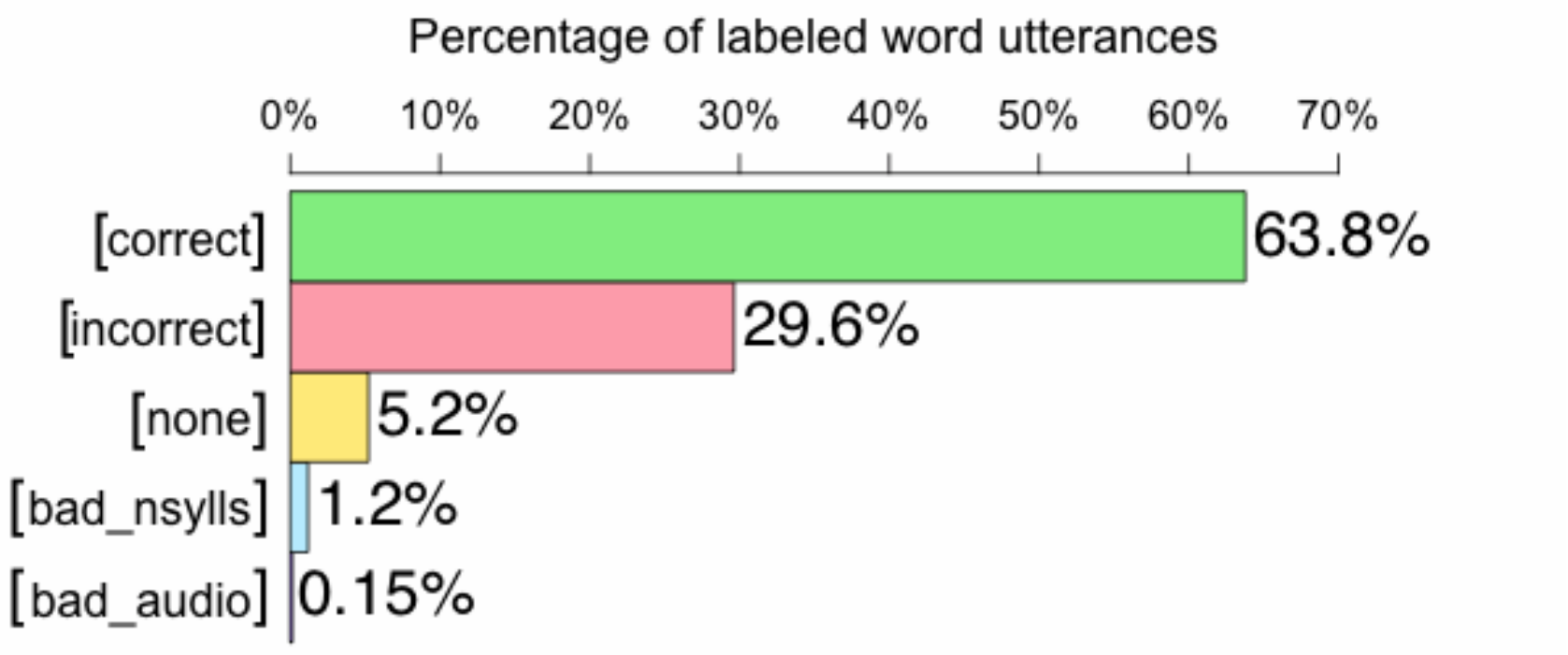
- 15 annotators (12 native), each token labeled by $\geq$2

Overall pairwise inter-annotator agreement

	Mean	Maximum	Median	Minimum
% Agreement	54.92%	83.93%	55.36%	23.21%
Cohen's κ	0.23	0.61	0.26	-0.01

- Variability not explained by annotator L1 or expertise
- Single gold-standard label selected for each token

Data annotation results



Method

Train & evaluate CART classifiers using WEKA toolkit[1]

Training data

- Manually annotated L2 utterances
- Automatically annotated L1 utterances (all [correct])

Held-out testing data

- Feature comparison: 1/10 of L2 utterances (random)
- Unseen speakers: all utterances from 1 of 56 L2 speakers

Evaluation

- Compute agreement (% and κ) with gold standard
- Average across 10 or 56 folds

[1] `www.cs.waikato.ac.nz/ml/weka`

Feature sets

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Prosodic feature sets

- DUR - Duration (relative syllable & nucleus lengths)
- F0 - Fundamental frequency (mean, max., min., range)
- INT - Intensity (mean, max.)

Pitch and energy contours calculated using JSnoori software[1]

For German stress, duration seemingly best indicator, then F0[2]

[1] `jsnoori.loria.fr`

[2] Dogil and Williams 1999.

Feature sets

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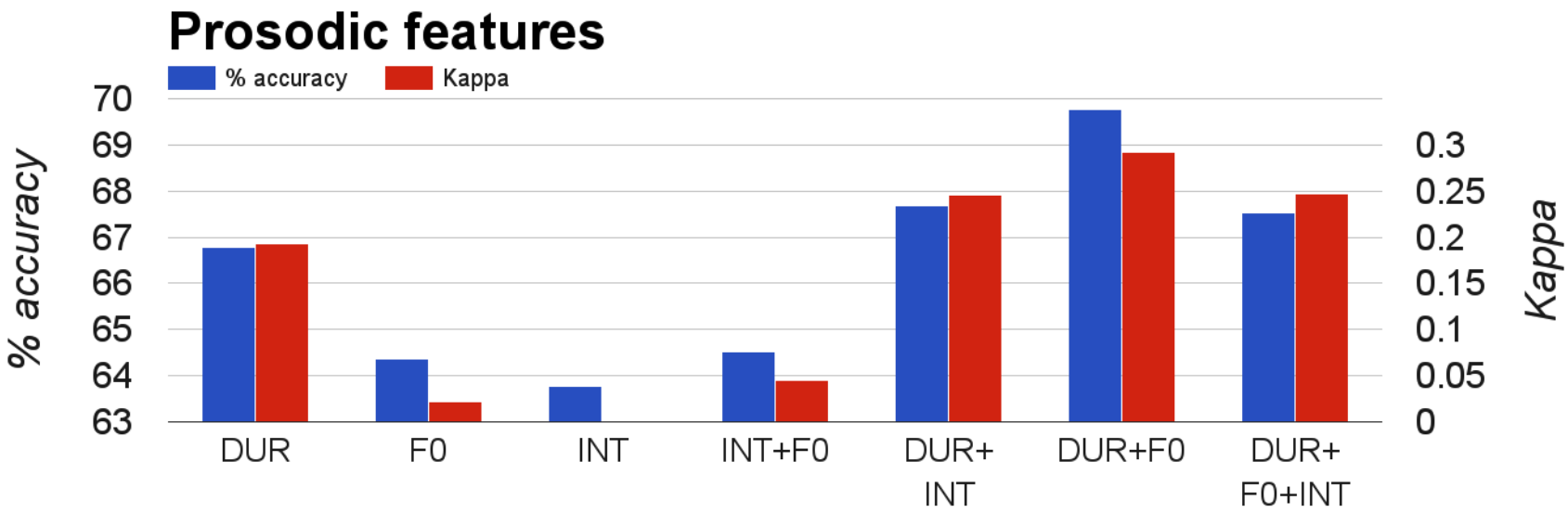
Prosodic feature sets

- DUR - Duration
- F0 - Fundamental frequency
- INT - Intensity

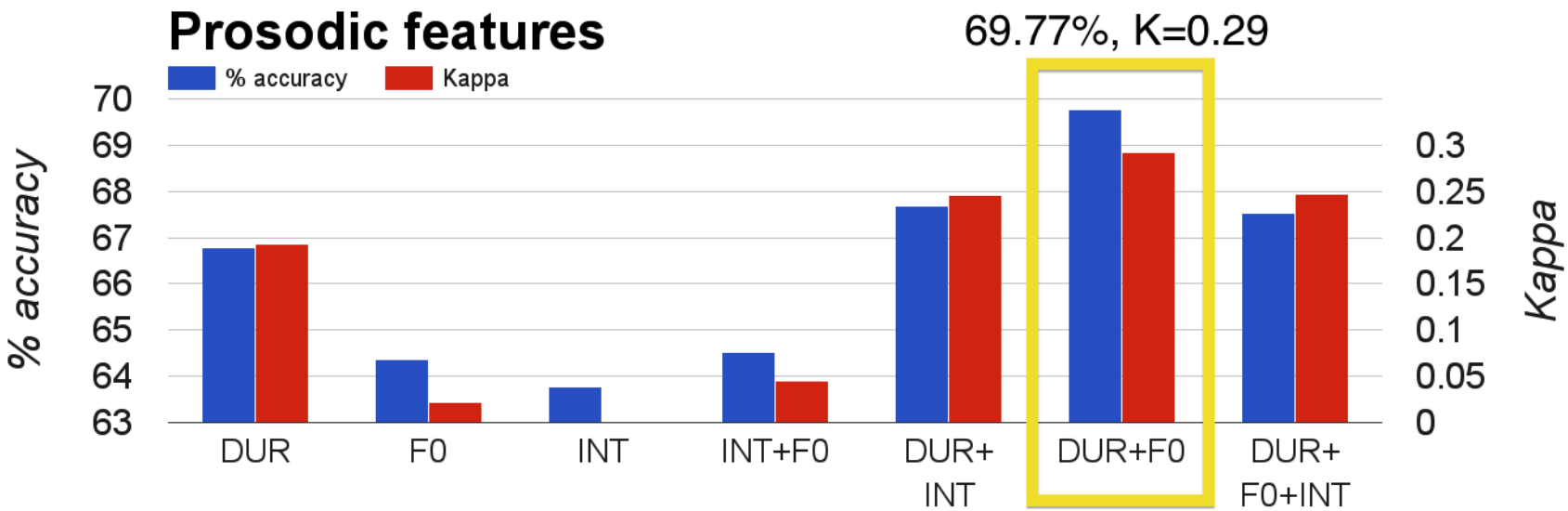
Other features

- WD - Word uttered (e.g. *Flagge*)
- LV - Speaker's skill level (A2|B1|B2|C1)
- AG - Speaker's age/gender (Girl|Boy|Woman|Man)

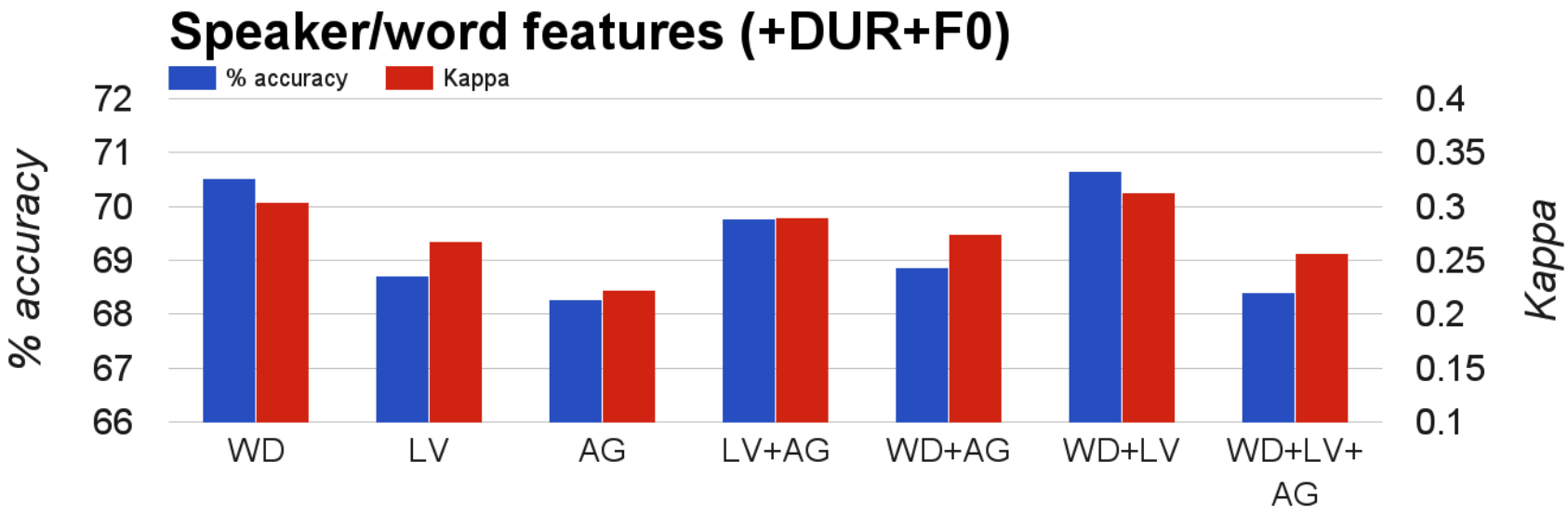
Results


Prosodic features
% accuracy
Kappa
70
69
68
67
66
65
64
63
0.3
0.25
0.2
0.15
0.1
0.05
0
DUR
F0
INT
INT+F0
DUR+ INT
DUR+F0
DUR+ F0+INT

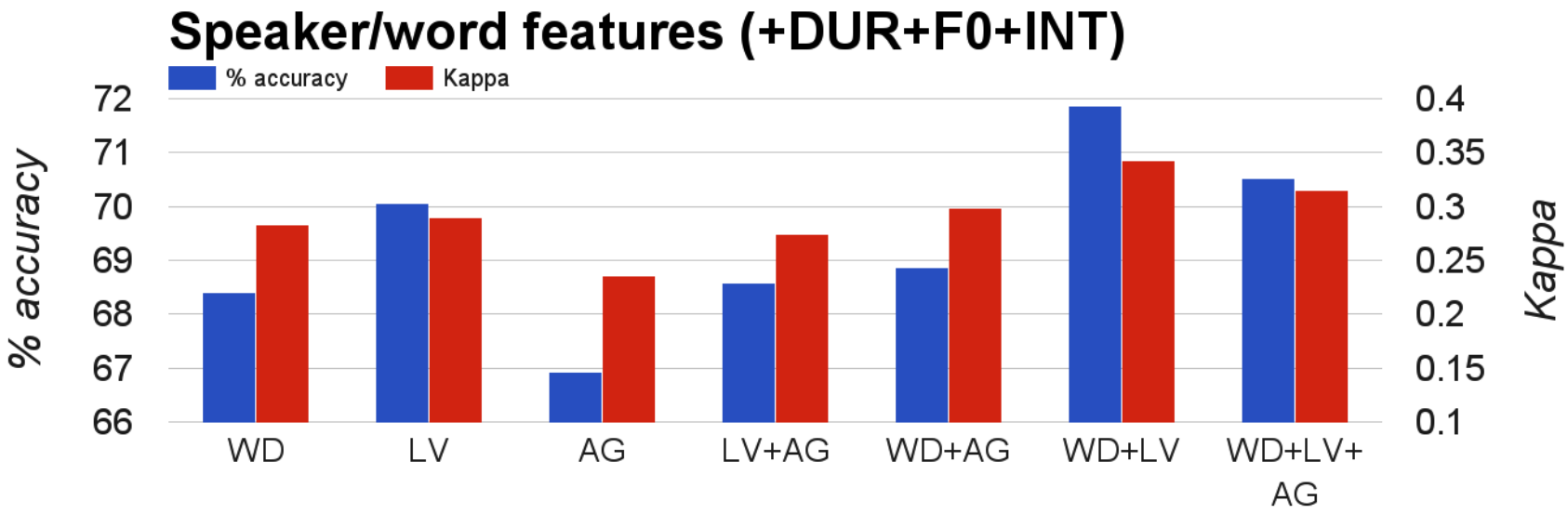
Results


Prosodic features
69.77%, K=0.29
% accuracy
Kappa
70
69
68
67
66
65
64
63
0.3
0.25
0.2
0.15
0.1
0.05
0
% accuracy
Kappa
DUR
F0
INT
INT+F0
DUR+ INT
DUR+F0
DUR+ F0+INT

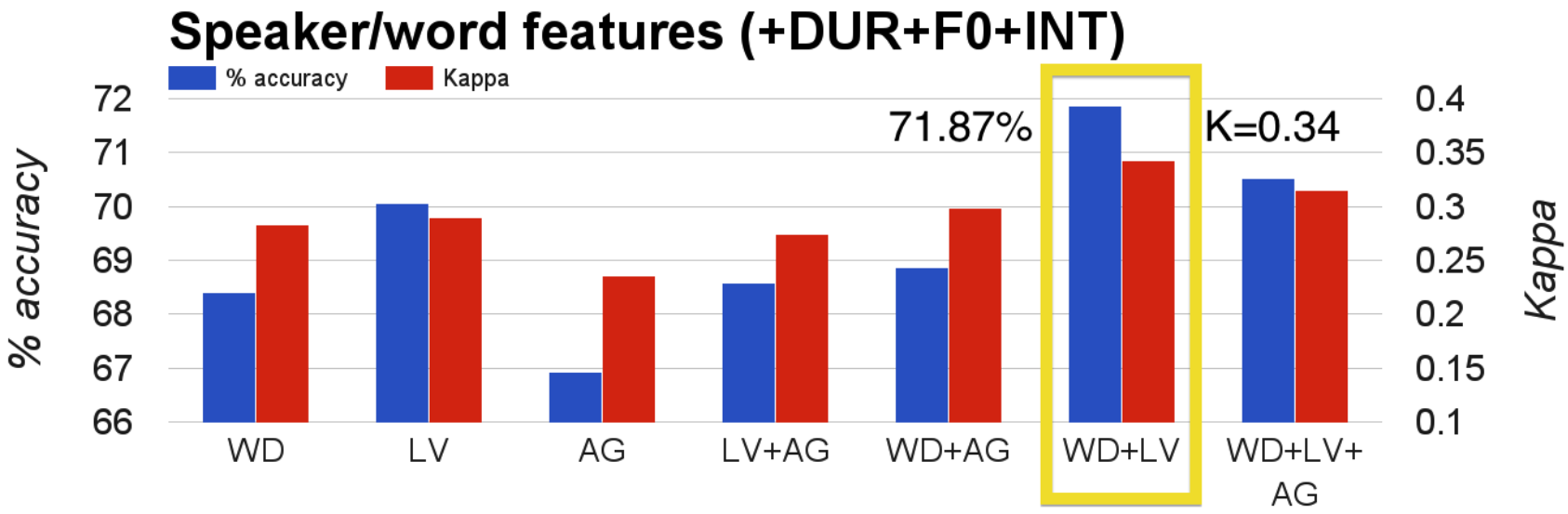
Results


Speaker/word features (+DUR+F0)
% accuracy
Kappa
72
71
70
69
68
67
66
0.4
0.35
0.3
0.25
0.2
0.15
0.1
WD
LV
AG
LV+AG
WD+AG
WD+LV
WD+LV+ AG

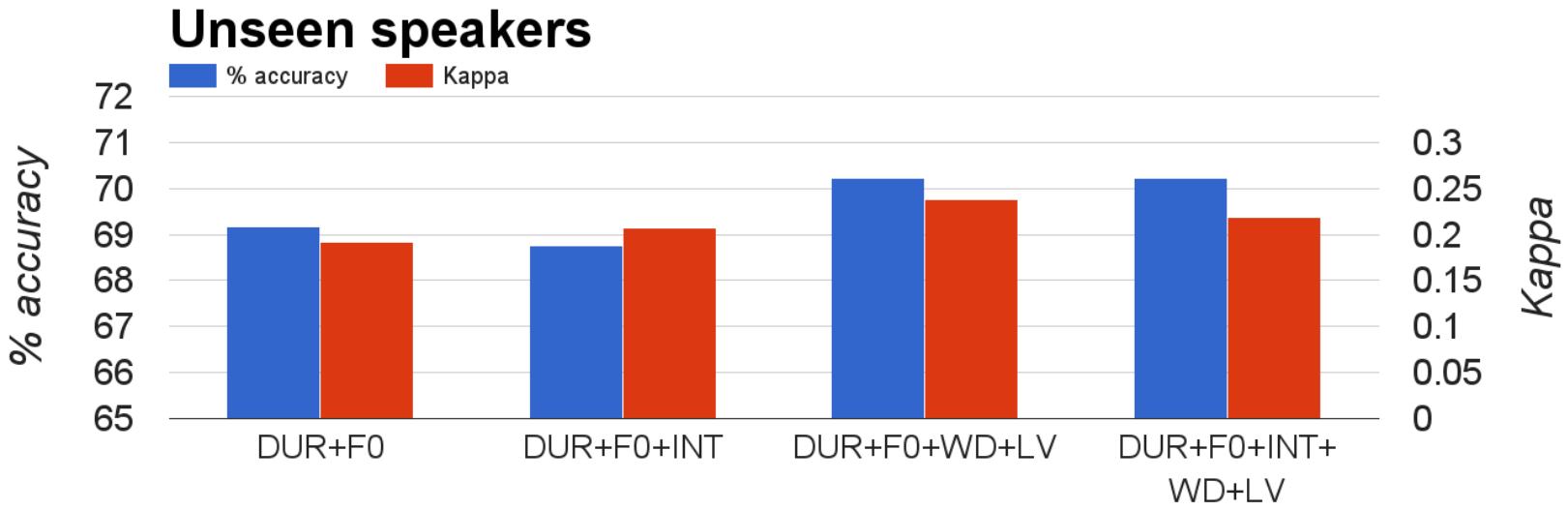
Results


Speaker/word features (+DUR+F0+INT)
% accuracy
Kappa
72
71
70
69
68
67
66
0.4
0.35
0.3
0.25
0.2
0.15
0.1
WD
LV
AG
LV+AG
WD+AG
WD+LV
WD+LV+ AG

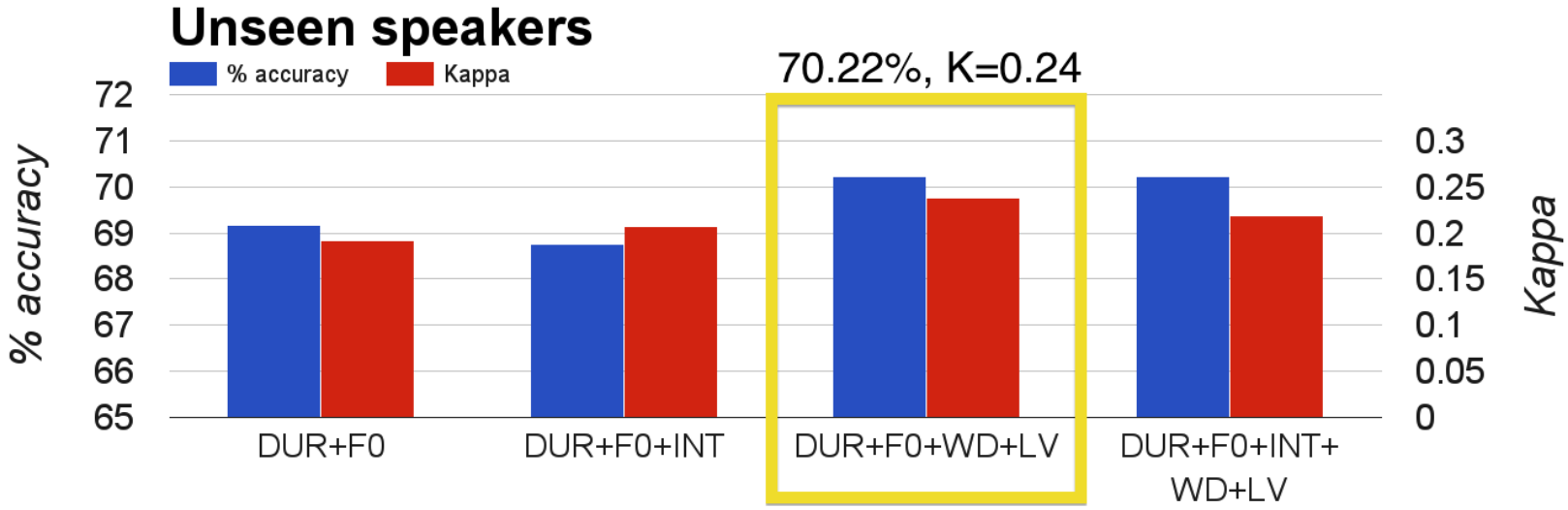
Results


Speaker/word features (+DUR+F0+INT)
% accuracy
Kappa
72
71
70
69
68
67
66
0.4
0.35
0.3
0.25
0.2
0.15
0.1
71.87%
K=0.34
WD
LV
AG
LV+AG
WD+AG
WD+LV
WD+LV+ AG

Results


Unseen speakers
% accuracy
Kappa
72
71
70
69
68
67
66
65
0.3
0.25
0.2
0.15
0.1
0.05
0
DUR+F0
DUR+F0+INT
DUR+F0+WD+LV
DUR+F0+INT+ WD+LV

Results


Unseen speakers
% accuracy
Kappa
70.22%, K=0.24
72
71
70
69
68
67
66
65
% accuracy
0.3
0.25
0.2
0.15
0.1
0.05
0
Kappa
DUR+F0
DUR+F0+INT
DUR+F0+WD+LV
DUR+F0+INT+ WD+LV

Results

	% agreement	κ
Best classifier vs. gold standard	71.87%	0.34
Majority baseline vs. gold standard	63.77%	0.00
Human vs. human	54.92%	0.23

- Results are encouraging in this context
- Still want better performance for real-world use

Conclusion

- Classification-based diagnosis of lexical stress errors novel approach in German CAPT
- Results of $>$70% accuracy encouraging (especially considering low human-human agreement)
- Still much room for improvement

Future directions

- More powerful machine learning algorithms
- Additional features (e.g. vowel quality, phrase information)
- Online, semi-supervised learning/active learning

Selected references

- G. Dogil and B. Williams. “The phonetic manifestation of word stress”. In: *Word Prosodic Systems in the Languages of Europe*. Ed. by H. van der Hulst. Walter de Gruyter, 1999. Chap. 5, pp. 273–334.
- E. Dupoux, C. Pallier, N. Sebastian, and J. Mehler. “A Destressing ‘Deafness’ in French?” In: *Journal of Memory and Language* 36.3 (Apr. 1997), pp. 406–421.
- C. Fauth, A. Bonneau, F. Zimmerer, J. Trouvain, B. Andreeva, V. Colotte, D. Fohr, D. Jouvet, J. Jügler, Y. Laprie, O. Mella, and B. Möbius. “Designing a Bilingual Speech Corpus for French and German Language Learners: A Two-Step Process”. In: *9th Language Resources and Evaluation Conference (LREC)*. Reykjavik, Iceland, 2014, pp. 1477–1482.
- U. Hirschfeld. *Untersuchungen zur phonetischen Verständlichkeit Deutschlernender*. Vol. 57. Forum Phoneticum. 1994.
- Y.-J. Kim and M. C. Beutnagel. “Automatic assessment of American English lexical stress using machine learning algorithms”. In: *SLaTE*. 2011, pp. 93–96.
- M. A. Shahin, B. Ahmed, and K. J. Ballard. “Automatic classification of unequal lexical stress patterns using machine learning algorithms”. In: *2012 IEEE Spoken Language Technology Workshop (SLT)*. IEEE, Dec. 2012, pp. 388–391.