Automatic classification of lexical stress errors for German CAPT

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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, F0, intensity
- Impacts intelligibility of non-native (L2) speech

Background & motivation

- Contrastive lexical stress (LS) difficult for French speakers
- CAPT can help; requires automatic diagnosis
- Classification of LS errors in L2 German unexplored

Classification of LS errors by French learners of German

How feasible is it?

Which features are most useful?

Data

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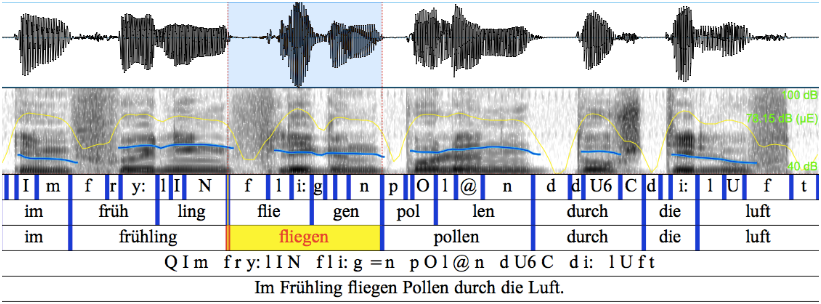
Subset of IFCASL corpus of French-German speech (Fauth et al. 2014)



Extracted utterances of 12 bisyllabic, initial-stress words

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

Data annotation

- Each token assigned a class label:

[correct], [incorrect], [none]

[bad_nsylls], [bad_audio]

- 15 annotators (12 native), each token labeled by $\geq$2
- Varying phonetics/phonology expertise

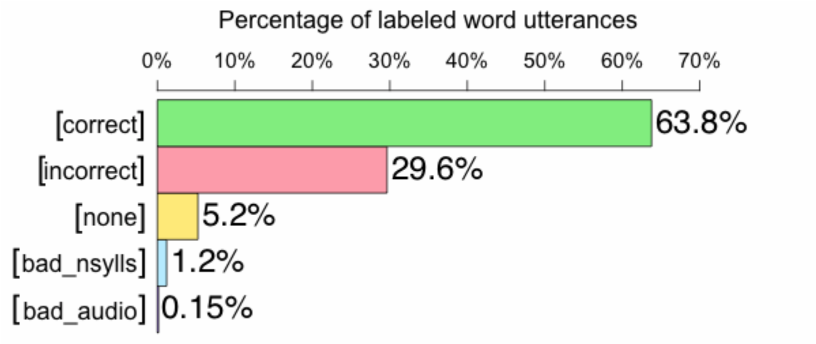
Data annotation

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

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
- Cross-validation (10 or 56 folds)

Feature sets

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Prosodic feature sets

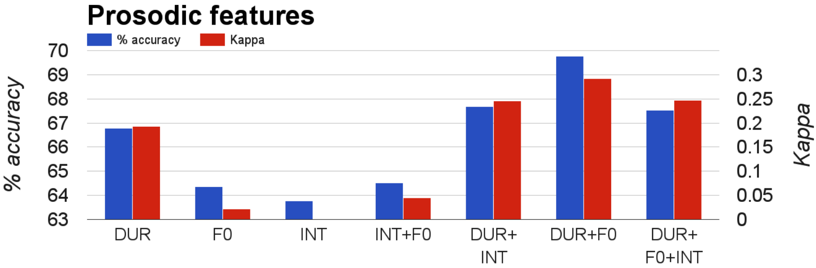
- DUR - Duration (relative syllable & nucleus lengths)
- F0 - Fundamental frequency (mean, max., min., range)
- INT - Intensity (mean, max.)

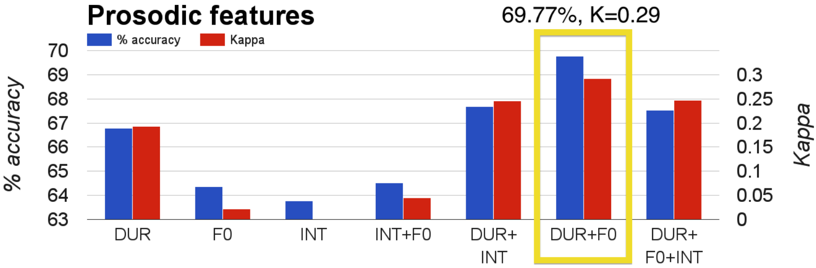
Pitch and energy contours calculated using JSnoori software (`http://jsnoori.loria.fr`)

Other features

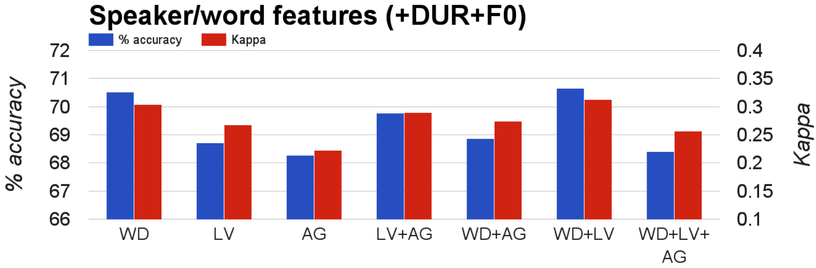
- WD - Word uttered (e.g. *Flagge*)
- LV - Speaker's CEFR skill level (A2|B1|B2|C1)
- AG - Speaker's age/gender (Girl|Boy|Woman|Man)

Results


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

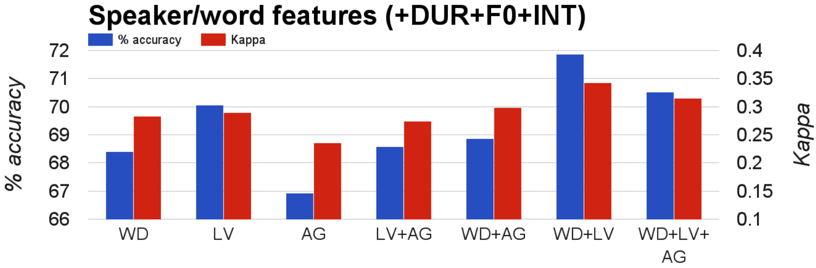

Prosodic features
69.77%, K=0.29
% accuracy
Kappa
70
69
68
67
66
65
64
63
0.3
0.25
0.2
0.15
0.1
0.05
0
DUR
F0
INT
INT+F0
DUR+ INT
DUR+F0
DUR+ F0+INT

Results

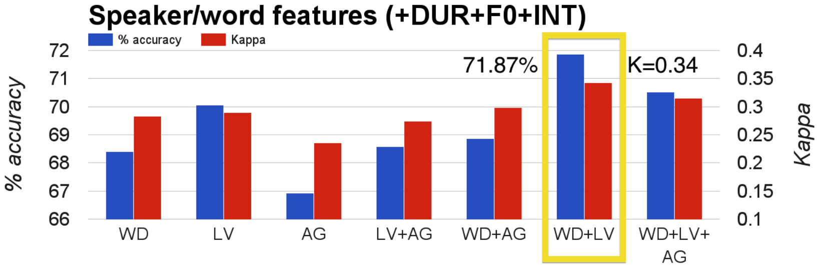


Speaker/word features (+DUR+F0)
% accuracy
Kappa
72
71
70
69
68
67
66
0.4
0.35
0.3
0.25
0.2
0.15
0.1
WD
LV
AG
LV+AG
WD+AG
WD+LV
WD+LV+AG

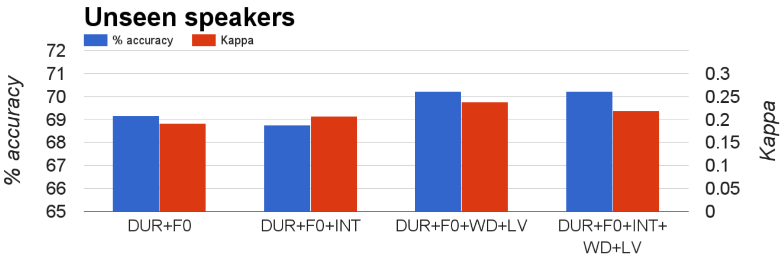
Results



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

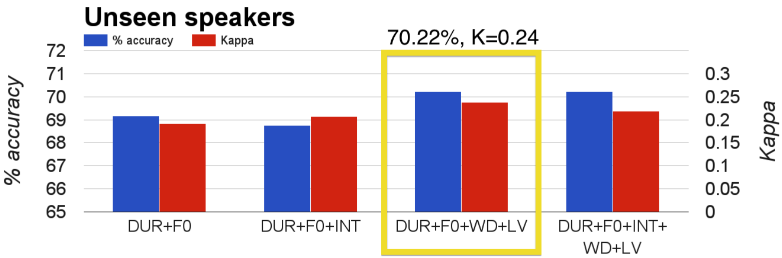

Speaker/word features (+DUR+F0+INT)
% accuracy
Kappa
72
71
70
69
68
67
66
0.4
0.35
0.3
0.25
0.2
0.15
0.1
71.87%
K=0.34
WD
LV
AG
LV+AG
WD+AG
WD+LV
WD+LV+AG
% accuracy
Kappa

Results



Unseen speakers
% accuracy
Kappa
% accuracy
72
71
70
69
68
67
66
65
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


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

	% agreement	κ
Best classifier vs. gold standard		
Random test set	71.87%	0.34
Unseen speakers	70.22%	0.24
Majority ([correct]) classifier vs. gold	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

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- 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