

On the Applicability of Features of Linguistic Complexity to the Classification of Political Speeches

Zarah Weiß

University of Tübingen

zarah-leonie.weiss@uni-tuebingen.de

Abstract

This paper evaluates the applicability of linguistic complexity features to the tasks of party and government affiliation classification in political speeches from German *Bundestag* by comparing them to word embeddings. Using a linear SVM word embeddings outperform classification performance of complexity features, which, however, perform above chance. Different complexity dimensions exhibit intriguing performance differences and give evidence, that especially morphological and lexical complexity structurally varies across parties and government vs. non-government speeches.

1 Introduction

Linguistic complexity is a common field of research in computational linguistics Kyle 2016; Sheehan, Flor & Napolitano 2013; von der Brück 2008. It is usually applied in the educational domain: Together with accuracy and fluency, complexity is one of the dominating concepts of first language (L1) and second language (L2) development and commonly used to approximate language proficiency, text readability, and writing quality Biber, Gray & Staples 2014; Crossley, Kyle & McNamara 2015; Hancke 2013; Hancke, Vajjala & Meurers 2012; Kyle 2016; Lu & Ai 2015; Sheehan, Flor & Napolitano 2013. The benefit of using features of linguistic complexity to classify data, is that their results are highly interpretable. This is mandatory for educational purposes: It is not sufficient to rate a learner's proficiency, it is necessary to provide concrete feedback on how to improve. However, using linguistically interpretable features known from complexity analyses has also received interest in related ar-

eas of stylometric analyses Argamon et al. 2009; Dahllöf 2012; Le et al. 2011, see Grieve (2007) for an overview.

This article investigates a similar direction and analyzes political speeches from German *Bundestag* in terms of complexity. More concretely, 210 complexity features measuring sentential & phrasal, lexical, and morphological complexity, as well as textual cohesion and deagentivation are used to a) identify the party of a speaker, and b) determine whether a speaker is member of the ruling coalition at the time of her or his speech. The underlying questions are:

1. How beneficial are complexity features for party or government affiliation classification?
2. Can complexity features give linguistic insights in the data with respect to party or government affiliation classification?

To help answering these questions, word embeddings are used for comparison as an alternative approach. They are popular for a broad variety of tasks in computational linguistics, such as part of speech (POS) tagging, dependency parsing, but also author profiling tasks (Al-Rfou, Perozzi & Skiena 2013). While they do capture semantic relatedness by assigning similar positions in the semantic space covered by them to related terms, they are less straight forward to interpret for humans than complexity features. However, they may be used corpus independent and are thus more efficient to use than complexity features.

The remainder of the paper is structured as follows: first, a brief overview over complexity analyses and other classification tasks on political speeches is given. Then, the data set used is introduced. Section 4 discusses the features used in the classification experiments reported in section 5. The article closes with concluding remarks.

2 Related Work

One common strand in the analysis of political speeches is the analysis of political affiliations of parties or individuals, allowing to estimate similarities between them with respect to certain positions. This is highly related to political science and journalism. These analyses are often relying on word patterns (cf. Lowe et al. 2011, p. 124). Lowe et al. (ibid.) identify political affiliation on a continuous left to right scale using political categories assigned to sentences based on their content. Sim et al. (2013) are identifying the ideological position of American politicians expressed in their political texts using an ideology lexicon and a Bayesian Hidden Markov Model. Other research focuses more on the aspect of organization affiliation: Dahllöf (2012) performs a binary classification of gender, age, and political affiliation based on Swedish parliament speeches from 2003 to 2010 using binary word vectors indicating absence or presence of words. Koppel et al. (2009) identify both, ideological and organizational affiliation for Arabic texts. Party prediction is often performed based on social media data, in order to facilitate the analysis of voting behavior, see Gottipati et al. (2013). Abu-Jbara et al. (2012) use unsupervised learning methods to identify sub-group affiliation in political fora.

The approach of this paper, however, goes in another direction and stands in the tradition of complexity analyses. Although sharing some features with stylometry Argamon et al. 2009; Grieve 2007, linguistic complexity is especially known in the field of L1 and L2 development. Generally, complexity develops along the lines of the quantity, the depth of the internal structure, and the inter-relatedness of its constituents Housen, Vedder & Kuiken 2012; Rescher 1998. In linguistics, this notion of complexity is applied to separate linguistic domains such as syntax, morphology, or the lexicon Housen, Vedder & Kuiken 2012 and operationalized in terms of ratios, frequencies or indexes. These are often used for predictive purposes, for example to evaluate L1 and L2 proficiency Biber, Gray & Staples 2014; Hancke 2013; Kyle 2016, text readability Hancke, Vajjala & Meurers 2012; Sheehan, Flor & Napolitano 2013; von der Brück 2008, and writing skills Crossley, Kyle & McNamara 2015, 2016; Lu & Ai 2015; Yannakoudakis, Briscoe & Medlock 2011. However, their high interpretability makes them

also especially suited for descriptive analyses Kyle 2016, for example the investigation of developmental progression Crossley, Kyle & McNamara 2015; Kyle 2016 or the analysis of differences in German schoolbooks across publishers Bryant et al. To Appear.

3 Data

For this study, German political speeches from the 13th to 17th legislative period of German *Bundestag* were analyzed. 215,061 speeches held between February 8th, 1996 and September 3rd, 2013 were extracted from 985 protocols obtained from the PolMine-Plenardebattenkorpus (PDK) by Blättle & Berenz (2012), which contains protocols from German parliaments on state and federal level. These speeches are hybrids between spoken and formal written language, as they are usually formulated prior to the session, and held by proficient speakers, yet they are also adjusted spontaneously to reactions from the audience or the development of the current discussion. Audience comments encoded in the speeches were removed for the analysis. Also, moderation sections such as speaker announcements and attendance lists were excluded automatically, by removing speeches held by the respective *Bundestags(-Vize)Präsident(-in)*. The remaining data set contains 120,331 speeches.

The PDK contains meta information on each speaker's party, function, and name, as well as on each protocol's legislative period, protocol number, and protocol date. Participation in the governing coalition was inferred by combining a speaker's party affiliation with the speech's legislative period and added as additional meta information.¹ For this, CDU and CSU were considered to be a single party as well as PDS and Linke, although PDS and Linke only merged in June 2007. Removing 102 speeches without party information, this lead to 62,650 government and 57,579 opposition speeches. The government affiliation subcorpus (GA) was compiled from all opposition speeches and a random sample of the same amount of government speeches. For party classification only speeches from CDU, FDP, Bündnis 90/Grüne, Linke and SPD were considered in the party affiliation sub corpus (PA). Since the amount

¹The governing coalition of each legislative period was obtained from https://de.wikipedia.org/wiki/Liste_der_deutschen_Bundesregierungen.

of speeches contributed by the parties is highly unbalanced, for each party a random sample of 11,059 speeches was used for PA.

4 Features

Two different types of high-dimensional feature vectors were designed: on the one hand complexity features and on the other hand word embeddings as a strong base line to test these complexity features against. In order to keep the analyses feasible despite the large data set, each document was presented by a single vector averaged over the entire document, instead of allowing for multidimensional matrices.

4.1 Polyglot Word Embeddings

German word embeddings were retrieved from the Polyglot project (Al-Rfou, Perozzi & Skiena 2013), in which word embeddings for 107 languages were trained based on their respective Wikipedias. They did not perform normalization with respect to case or inflection to preserve linguistic information. For German 50-dimensional word embeddings were trained on 687,000,000 tokens and 9,474,000 types. To represent the speeches with word embeddings, each speech was tokenized using the *nlk.tokenize WORDPUNCT-TOKENIZER*. Then, preliminary experiments were performed to identify the best performing embedding model. The results are shown in table 1. In order to represent each speech in a single vector, word embeddings for each token in a speech were averaged to a single vector. This significantly outperformed concatenating word vectors of the first 20 tokens in a speech.² On the averaged word embeddings, further preprocessing was tested: Speeches were stemmed using the *nlk.stem SNOWBALLSTEMMER*. This did not increase performance when either using the original Polyglot embeddings or embeddings, where embeddings with the same stem were averaged. Also, two stop word lists were introduced. Since stop words are highly data dependent (Forman 2003), two stop word lists were compiled automatically for each task sub corpus, once by considering every token a stop word that occurred at least once in 50 percent of all speeches and once for 67 percent of all speeches. The application of the lists either

²Concatenating more tokens was not feasible given corpus size and word embedding dimensions. An embedding length was deemed not feasible if a single fold took more than five minutes to train and test.

harmed performance or did not affect it. Thus, averaged word embeddings scaled were chosen for the embedding model.

4.2 Complexity Features

For the complexity vectors, 210 measures of linguistic complexity were used. They cover the sentential & clausal, phrasal, lexical, and morphological domain as well as from the domains of textual cohesion & coherence and textual deagentivation. These features were designed by Hancke (2013), Galasso (2014), and Weiß (2015), but reorganized into more coherent feature sets following Kyle (2016) and McNamara et al. (2014).³

Single Feature Sets

Sentential & Clausal Complexity (SEN) contains 21 features, most of which origin from the syntactic feature set by Hancke (2013). These are several clause, (complex) t-unit, non-terminal, and sentence ratios measuring either construction depth or length. Furthermore, it includes all three topological field related features by Weiß (2015), which measure syllable distances between arguments and verbs, finite verbs and their verbal complex, and the ratio of non-subject prefields. For formulae and detailed feature descriptions, please see Hancke (2013, pp. 17–41), Weiß (2015, pp. 30–32).

Phrasal Complexity (PHR) contains 57 features, which origin from the syntactic feature set by Hancke (2013). They measure ratios of phrase coordination, modifier quantities, *to*-marked infinitives, phrase lengths, dependents, and NP, VP, and PP frequencies. Furthermore, all complex NP and VP features by Weiß (2015) were included, which measure POS and position dependent modifier ratios, verb cluster lengths and types, and periphrastic tense patterns. For formulae and detailed feature descriptions, please see (Hancke 2013, pp. 17–41) and Weiß (2015, pp. 20–30).

Lexical Complexity (LEX) contains 46 features, including lexical diversity measures such as five variants of type-token ratio, and 12 types of lexical variation features, lexical frequency features, features of lexical relatedness, such as

³Feature calculation requires extensive Natural Language Processing (NLP) and is thus computationally costly. Feature calculation took in total eight days when calculating each legislative period separate on a server. The resulting feature table is available https://github.com/zweiss/ML4CL_2016/tree/master/ml4cl_project/.

Model	Government Affiliation			Party		
	F1	Pre	Rec	F1	Pre	Rec
Avgeraged word embeddings	0.6705	0.6864	0.6556	0.2933	0.3059	0.2997
Concatenated word embeddings	0.6317	0.6553	0.6098	0.2788	0.2811	0.2794
Stemmed text on avg. word embeddings	0.6699	0.6863	0.6543	0.2796	0.2949	0.2867
Stemmed text on avg. stem embeddings	0.6677	0.6845	0.6520	0.2919	0.3023	0.2965
Stop word t=0.50 avg. word embeddings	0.6408	0.6578	0.6251	0.2798	0.2895	0.2840
Stop word t=0.67 avg. word embeddings	0.6590	0.6701	0.6487	0.2823	0.2920	0.2863

Table 1: Performance of word embedding features on government affiliation classification.

hypernymy and synonymy, and shallow syllable based word length measures. For formulae and detailed feature descriptions, please see (Hancke 2013, pp. 17–35).

Morphological Complexity (MOR) contains 42 features: verbal inflection (person, tense, mood), verb type (full, auxiliary, modal), derivational morphology determining latinate terms and compound ratios. For formulae and detailed feature descriptions, please see (ibid., pp. 42–45).

Textual Cohesion (COH) includes 36 features, most of which origin from Galasso (2014). They capture pronoun ratios, noun, argument, stem and content word overlap, connective counts, and features based on syntactic functions, such as subject, object, etc., as well as three features used to describe the basic properties of each text, namely total number of sentences, paragraphs and words. Furthermore, they contain all five conditional clause measures from Weiß (2015). For further details, please see (Galasso 2014, pp. 7–16) and Weiß (2015, pp. 34–37).

Textual Deagentivation (DEA) contains 8 features implemented by Weiß (ibid.). They measure ratios of *man* (one), *lassen* (to let) + reflexive pronoun, (quasi) passives, participle modifiers, half modals, and infinitival constructions as well as the coverage of deagentivational patterns. For more details, please see Weiß (ibid., pp. 32–33).

Feature Set Combinations

Aside from the single feature sets, the following feature set combinations were used in separate models: all feature sets combined (ALL), all feature sets except for the worst performing feature set for the respective task (ALL-???), and

an automatically selected feature set, which was derived automatically from ALL by using importance weights. These weights were assigned using *sklearn.feature_selection*’s `SELECTFROMMODEL`. As estimator a linear SVM with an error term penalty of 0.01 on L1 penalty norm assuming a primal optimization problem lead to the best results, reducing feature dimensionality from 210 to 66 for party classification and to 68 for government affiliation identification.

5 Experiment

Two classification experiments were performed: On the one hand, government affiliation classification (GAC) was performed as a binary task: government vs. opposition. On the other hand, party affiliation to either CDU, FDP, Bündnis 90/Grüne, Linke and SPD was predicted. It should be noted, that party affiliation classification (PAC) and GAC are necessarily dependent on each other, and that it is beyond the limit of the experiments to account for that. For both tasks, the same algorithm and feature selections were used.

5.1 Set-Up

As classification algorithm a Support Vector Machine (SVM) with a linear kernel was chosen. This is a recommended choice for classification (Dahllöf 2012; Forman 2003). The experiments rely on the `LINEARSVC` implementation from the `SKLEARN` package. Classification was treated as a primal optimization problem for all experiments, because the `LINEARSVC` documentation suggests this, if sample size exceeds feature size.⁴ With this comes the requirement of

⁴<http://scikit-learn.org/stable/modules/generated/sklearn.svm.LinearSVC>.

using the squared hinge loss function to penalize the model instead of the simple hinge loss function. Aside from these adjustments, the default setup was used, because parameter changes either decreased performance (especially for increases in the stopping criterion tolerance) or did not affect it significantly. Due to the known sensitivity of SVMs to feature scaling,⁵ embeddings as well as all complexity features were scaled to the range $[-1; 1]$ using the `MAXABSSCALER` from the *sklearn.preprocessing* module. This scaling range was preferred over a $[0; 1]$ scaling to preserve information on zero values, which may possibly occur in complexity feature vectors.

Training and testing was performed using stratified 10-folds cross validation. For GAC averaged binary F1-score, precision, and recall were chosen and averaged weighted F1-score, precision, and recall for PAC. To establish whether the performance differences are beyond chance, two-sampled significance testing for related samples was performed using the *scipy.stats* implementation and assuming a conservative significance level $\alpha \leq 0.01$. As a lower base line on chance level the `DUMMYCLASSIFIER` from the *sklearn.dummy* module was used with a stratified classification strategy. On the balanced sub corpora, this performs equivalent to a uniformly random classification strategy.

5.2 Results & Discussion

Table 2 shows f1 score, precision, and recall for GAC and PAC for each model as well as model complexity in terms of feature vector length. Most models outperform the random baseline, except for sentential complexity and textual coherence for GAC, which do not show a significant difference, and textual deagentivation for both tasks, which performs even significantly worse than the random baseline in terms of f1 score and recall for GAC. Also, all models in both classification tasks perform significantly worse than word embeddings: Even the best performing model, which is for both tasks the one containing all feature sets except for textual deagentivation (ALL-DEA), performs for each measure more than 4% worse than word embeddings for GAC. For PAC, the difference between word embeddings and ALL-DEA is with 1% less drastic, yet still significant. Second

best feature combination for both tasks is using all features (ALL). However, the difference between ALL and ALL-DEA is not significant for either task. Also automatic feature selection AUTO did not improve performance for either task. Concerning the first question of this study, namely how beneficial complexity features for party classification or ruling coalition identification are, these results lead to the following conclusion: While complexity features allow to distinguish speeches held by members of the respective current ruling coalition and speeches held by members of different parties, easier obtainable methods, such as word embeddings, are clearly better suited for this task.

To answer the second question, namely if complexity features give linguistic insights in the data that word embeddings cannot give, a closer look at the single feature sets is required. In fact, feature sets widely differ in terms of their performance: The best performing feature set for GAC is morphological complexity (MOR), which significantly outperforms lexical complexity (LEX), the second best feature set. These two sets are among the best performing models for PAC, too, together with phrasal complexity (PHR). Neither significantly differs from the others. The worst performing feature sets are textual deagentivation (DEA) and sentential complexity (SEN), again for both tasks. As for general differences between GAC and PAC: Aside from the across all models higher performance for GAC, which is to be expected given the lower complexity of binary tasks, two differences seem remarkable: First, while precision and recall are very similar for all models for PAC, the same holds only for the random baseline and LEX for GAC. For all other models, including the one using word embeddings, precision is higher than recall i.e. the models overestimate affiliation with the government. Second, while for GAC there are clear performance differences between the single feature sets, the same does not hold for PAC, where several feature sets perform alike. For the second question these results lead to the following conclusion: Some complexity features detect differences between speeches held by members of a government and an opposition. This holds especially for lexical and morphological features. These features have proven to be highly beneficial in previous studies on complexity, too (Hancke, Vajjala & Meurers 2012; Vajjala & Meurers 2012). However, some features, like textual coherence

html#sklearn.svm.LinearSVC.

⁵<http://scikit-learn.org/stable/modules/svm.html>.

Model	Dim	Government Affiliation			Party Affiliation		
		F1	Pre	Rec	F1	Pre	Rec
Base Line	0	0.4986	0.4985	0.4987	0.2004	0.2005	0.2004
Embeddings	64	0.6705*	0.6864*	0.6556*	0.2933*	0.2997*	0.3059*
ALL	210	0.6154*,−	0.6327*,−	0.5995*,−	0.2773*,−	0.2834*,−	0.2896*,−
ALL-DEA	202	0.6231*,−	0.6428*,−	0.6051*,−	0.2801*,−	0.2858*,−	0.2920*,−
AUTO	68; 66	0.6140*,−	0.6298*,−	0.5995*,−	0.2655*,−	0.2745*,−	0.2805*,−
SEN	21	0.5041 −	0.5484*,−	0.4682 −	0.2257*,−	0.2363*,−	0.2394*,−
PHR	57	0.5361*,−	0.5656*,−	0.5104 −	0.2463*,−	0.2544*,−	0.2611*,−
LEX	46	0.5667*,−	0.5689*,−	0.5656*,−	0.2430*,−	0.2509*,−	0.2586*,−
MOR	42	0.5959*,−	0.6054*,−	0.5869*,−	0.2451*,−	0.2536*,−	0.2605*,−
COH	36	0.5257 −	0.6013*,−	0.4677 −	0.2327*,−	0.2454*,−	0.2506*,−
DEA	8	0.4604 ^v ,−	0.5021*,−	0.4259 ^v ,−	0.2086 −	0.2223*,−	0.2236*,−

Table 2: F1 score, precision, and recall of government and party affiliation classification given varying models. Significant difference for $\alpha \leq 0.01$ compared to base line indicated by * (better) and ^v (worse), to word embeddings by + (better) and − (worse).

and deagentivation or sentential complexity seem to be less relevant. For DEA this low performance is probably influenced by the small set size. However, for SEN and COH the results indicate that neither sentential complexity nor the use of coherence markers are indicative for government affiliation. As for PAC, the differences between feature sets are less telling, except for the very small DEA feature set. However, since the features perform significantly better than the random baseline and feature set combinations leads to a significant performance increase, this does not seem to indicate that there are no differences in the style of speeches held by members of different parties. Instead, this seems to indicate that there are relevant differences in each of these feature sets.

Finally, it should be noted that there is the strong possibility of government and party affiliation influencing each other, since the ruling coalition does not consist of the same parties each legislative period. Further in depth investigations would be necessary, to identify whether and to which extent these two factors influence each other.

6 Conclusion

This paper investigated the applicability of complexity features to a domain different from lan-

guage acquisition. Applicability was operationalized in terms of a) general benefit for a text classification task, and b) achieved additional linguistic insights in the data. As text classification tasks, a speaker’s party and government affiliation were chosen. The results showed that while complexity features could not compete with word embeddings, they did find enough structural differences to outperform the uninformed baseline. Furthermore, the results showed that government affiliation seems to influence lexical and morphological complexity, while sentential complexity and textual cohesion are not, and party affiliation seems to be influenced by a series of complexity dimensions. To investigate these differences further, a more detailed analysis of the single features within each feature set to identify the most informative features would be necessary, to obtain more detailed information on how government and party affiliation influence speech style. Also, a careful analysis on how party and government affiliation influence each other as dependent factors would be necessary in future work. The here presented study successfully showed that complexity analyses are of relevance outside the domain of language development. It also lays the foundations for such future work by making a table of the PDK with 210 complexity features publicly available.

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