Linguistic Complexity in Longitudinal and Cross-sectional Perspectives

What characterizes the development of German-as-a-Foreign-Language learners and what is indicative of successful exam performance?

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Introduction

- Language tests offer snapshots of specific facets of language proficiency using psychometrically optimized test items.
- How can we observe linguistic competence and its development longitudinally and directly based on authentic language productions?

(i) Profile analyses of selected linguistic means that are characteristic of specific **acquisition stages**, such as specific word orders, morphosyntax, . . .
- First language acquisition (Crystal et al. 1976; Fletcher et al. 2012), German (Clahsen & Hansen 2012) → Analyses support effective therapy (LARSP: Language Assessment, Remediation and Screening Procedure)
- Second language acquisition: German (Clahsen 1985; Grießhaber 2019), Rapid Profile based on Processability Theory (Pienemann 1998), DAKODA project (Schwendemann et al. 2025)

(ii) Continuous characterization based on the CAF triad (Skehan 1989; Bulté et al. 2025):
- **Linguistic Complexity**, Accuracy, Fluency

What is linguistic complexity?

- Complexity is “a matter of the **number and variety** of an item’s constituent elements and of the **elaborateness** of their interrelational structure.”
  (Rescher 1998)
- Language complexity is “the extent to which the language produced in performing a task is **elaborate** and **varied**.”
  (Ellis 2003)
- How can the degree of **elaborateness** and the **variety** of the language used by learners be concertized, and how are the analyses interpreted?

Analysis of linguistic complexity from two different perspectives

- Linguistic complexity as a measure for both **linguistic development** and for the evaluation of the **quality of texts** (Crossley 2020)
  - Cf. PISA test: 30 points in test are interpreted as corresponding to learning content of one school year.
- Are the same features indicative of development and quality? (Crossley & McNamara 2014)

⇒ Yushan Li and I investigated: Which linguistic complexity measures are characteristic for
  - the linguistic development of foreign language learners
  - the quality of foreign language essays

  based on large corpora of Chinese learners of German:
  - CDLK (Li & Wu 2023) and PGG (PhD thesis of Yushan Li 2025)

- Complexity analysis traditionally reductionist: few features (Bulté & Housen 2012)
  ⇒ We investigate complexity empirically broadly across different linguistic domains (morphology, lexis, syntax, discourse) and language use (Weiss & Meurers 2019a,b).

Broad evidence for linguistic complexity

- **Elaborateness** and **variety** of language have many different facets:

I. Which linguistic **forms of the linguistic system** occur?

e.g. Number of complex noun phrases per sentence, number of subordinate clauses
→ Theoretical linguistics, Second Language Acquisition research

II. Which **usage** of linguistic forms can be observed?

e.g. Word frequency, Age-of-Acquisition (AoA) norms
→ Usage-based linguistics, Corpus linguistics, Psychology

Evidence for linguistic complexity (cont.)

III. What type & amount of **meaning** is encoded, and how are they organized into a coherent **discourse**?

e.g. Concreteness, idea density, connectives, referential cohesion
→ Linguistics, Psychology (Text comprehension, e.g., Kintsch)

- Beside the complexity of language, some aspects of the difficulty of cognitive processing of language can also be quantified:

e.g. Memory demand (DLT, Gibson 2000), Expected continuation (Surprisal, Boston et al. 2008)
→ Psycholinguistics (Sentence processing)

⇒ CTAP (Chen & Meurers 2016b) calculates 845 complexity features for English and 500 features for German (Weiss & Meurers 2019a,b).

- CTAP is freely available at http://ctapweb.com

Manage and analyze texts with state-of-the-art NLP tools.

The Common Text Analysis Platform is a set of tools that helps you manage your text corpus and automatically analyze them for various purposes. Potential uses of the system include text complexity assessment, plagiarism detection, authorship attrition, and native language detection, etc.

The CTAP Tools include modules for corpus management, feature selection, analysis generation, and result visualization. Combination of the modules makes your text analysis highly flexible. For more detailed introduction of each module, please refer to the Documentation.

Lexicon

- Lexical **Diversity** (*say* vs. *explain, assert, . . .*)
  - Type-Token Ratio = *Typ*/*Tok*
  - Text length independent: Measure of Textual Lexical Diversity (MTLD, McCarthy 2005)
- Lexical **Frequency** (*Ship* more frequently used than *barque*)
  - Word frequency in SUBTLEX-DE (Brysbaert et al. 2011)
  - When aggregating, also consider variance and clustering methods (Chen & Meurers 2016a)
- Lexical **Semantics**
  - Synonymy: Number of words with same meaning (GermaNet Synsets, Hamp & Feldweg 1997)
  - Polysemy/Homonymy: Number of different word senses of a word

Morphology

- **Derivation**
  - Nominalization (*Zerstör-ung (destruction), Heiter-keit (cheerfulness)*, . . .)
  - Compounds (*Stadt-entwicklung-s-potential* (urban development potential), . . .)
- **Inflection**
  - Case (Genitive, . . .)
  - Verb forms (Subjunctive, . . .)

Syntax

- Systematic analysis of sentences, T-Units, clauses:
  - Mean **Length** (average sentence length, . . .)
  - **Number** of occurrences (Number of clauses per sentence, . . .)
  - Occurrence of **subtypes** (subordinate clauses, . . .)
- **Structural Variety**
  e.g., Parse edit distance between adjacent sentences, or globally in text
- Number and length of selected **elaborated constructions**
  e.g., complex noun phrases per sentence

Discourse

- Connectives (temporal, causal, . . .)
  - lexically based on Breindl et al. (2014) and Eisenberg et al. (2009)
  - challenging to determine whether an occurrence connects propositions
- Cohesion based on repetition of language material (local, global, cf. Graesser et al. 2012)

Current Investigation

- Which linguistic complexity measures are characteristic for
  (a) the linguistic development of German-as-a-Foreign-Language learners
  (b) the evaluation of the quality of foreign language essays

- Data: large corpora of Chinese learners of German:
  (a) Longitudinal sub-corpus of the CDLK (Li & Wu 2023)
  (b) Cross-sectional corpus PGG (PhD of Yushan Li 2025)

- Methodology:
  - computational linguistic analysis of 450 complexity features (Weiss & Meurers 2019a,b) with CTAP
  - data-driven selection of informative features for models using Explainable Boosting Machines (GAM)
  - enables quantitative and qualitative analysis at different levels of granularity

Cross-sectional Corpus: Graded Essays (PGG)

- Data source: National Examination for German Majors in China (PGG)
- nation-wide uniform exam for students of German in China for standardized assessment of learning success at the end of basic studies (end of 4th semester)
  - Data from all university types and regions, transcribed handwritten texts
  - Grading of the writing part of the high stakes PGG exam of very high quality

  → rather representative sample and good external validity (Moranski & Ziegler 2021)
- 31,395 texts with 5.4 million Tokens
  - Evaluation with 4 grades: 1-fail: 7,600, 2-pass: 9,769, 3-good: 10,072, 4-excellent: 3,954

Longitudinal Corpus (CDLK Sub-corpus)

- Longitudinal sub-corpus of the Chinese German Learner Corpus (CDLK, Li & Wu 2023).
- Sub-corpus of 163 German students (3 universities from different regions) for whom longitudinal data for four semesters exists
  - Chinese native speakers with English as first foreign language
  - started learning German at university with uniform curriculum and textbook
- Four data collections at the end of each semester of the two-year basic study period
  - last collection at the time of the PGG exam
  - transcribed handwritten texts
- 634 texts with 87,766 tokens
  - Texts from 4 semesters: 1 (142), 2 (172), 3 (169), 4 (151)

First Step: Identification of Informative Complexity Features

- Which features are informative regarding
  - Grade evaluation in the cross-sectional corpus: 1-fail, 2-pass, 3-good, 4-excellent
  - Semester number in the longitudinal corpus: 1st, 2nd, 3rd, 4th semester
- Challenges:
  - very many complexity features (450) and frequently high colinearity
  - Relationship complexity feature to grade/semester not necessarily linear
- Explainable Boosting Machines (EBM, Lou et al. 2012; Nori et al. 2019)
  - Extension of Generalized Additive Models (GAM, Hastie & Tibshirani 1987): machine learning (bagging, gradient boosting) for effective, iterative feature selection for model optimization

Feature Selection: Linguistic Complexity from Two Perspectives

- EBM selects from the 450 complexity features
  - 23 for Development (CDLK): Lexis 15 (55%), **Syntax 5 (22%)**, Discourse 2 (9%), **Morph. 1 (4%)**
  - 39 for Grading (PGG): Lexis 20 (51%), **Syntax 13 (33%), Morph. 3 (8%)**, Discourse (3%) 1, Length 2 (5%)

→ all dimensions of linguistic modeling are relevant!
  - The grading perspective focuses more on syntax and morphology.

- Development and grading perspectives overlap only in 5 features:
  - Syntactic Variety (Mean Local Edit Distance for POS)
  - Syntactic Elaboration (Dependent Clause Ratio)
  - Lexical Variety (HDD excluding punctuation and numbers)
  - Lexical Frequency (SD of Verb Word Frequency per Million SUBTLEX Token)
  - and a potential Task Effect (Singular Proper Noun Density)

  but related features play a role in both (e.g., text length aspects)

⇒ Automated complexity analysis of large learner corpora enables a differentiated, variably fine-grained view on language development and text quality.

Global Characterization: Classification by Semester vs. by Grade

- Longitudinal: Results for classification into 4 semesters for 634 texts
  - Split: 80% Training and 20% Testing
  - Majority baseline: 27%
  - ⇒ Accuracy: 65% with 23 complexity features
- Cross-sectional: Results for evaluation with 4 grades for 31,395 texts
  - Split: 80% Training 20% Testing
  - Majority baseline: 32%
  - ⇒ Accuracy: 55% with 39 complexity features

⇒ Weaker classification for grading, although the data set is much larger.

- Grading apparently reflects other aspects besides linguistic development:
  - Accuracy
  - Appropriateness for task
  - Quality of content given the task (e.g., of argumentation)

Analysis of Classification by Semester

Semester	Precision	Recall	F1-Score	Support
1	**93%**	**93%**	93%	28
2	62%	74%	68%	35
3	55%	**47%**	51%	34
4	**50%**	**47%**	48%	30

- **Very good identification of beginners**
- **Weaker differentiation of advanced learners**
- **Especially also lower Recall**

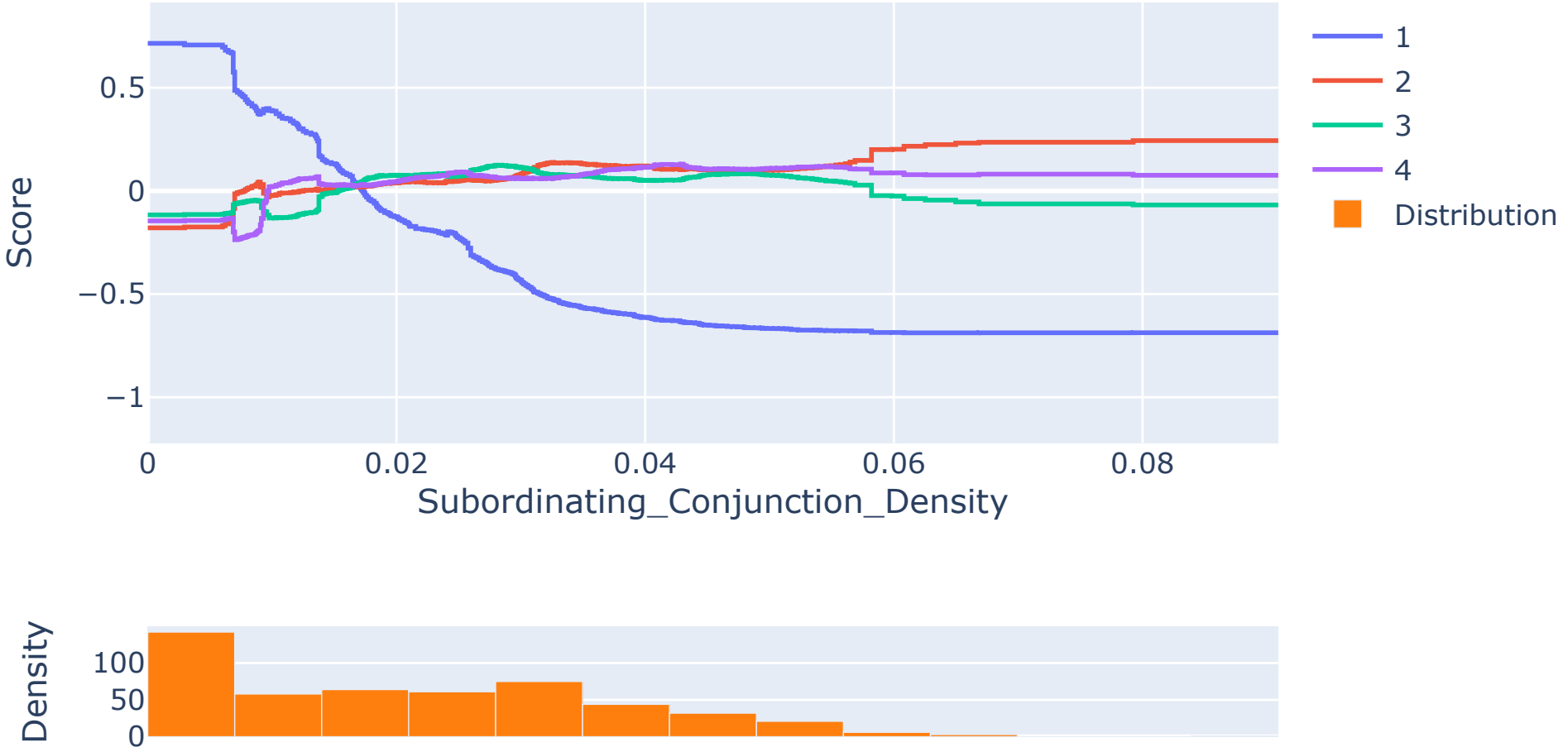
Analysis of Classification by Grade

	Precision	Recall	F1-Score	Support
1-Fail	73%	63%	68%	1520
2-Pass	49%	49%	49%	1954
3-Good	50%	65%	56%	2014
4-Excellent	55%	**26%**	36%	791

- **Weak Recall for excellent essays**
  - supports hypothesis that grading considers other aspects than linguistic development

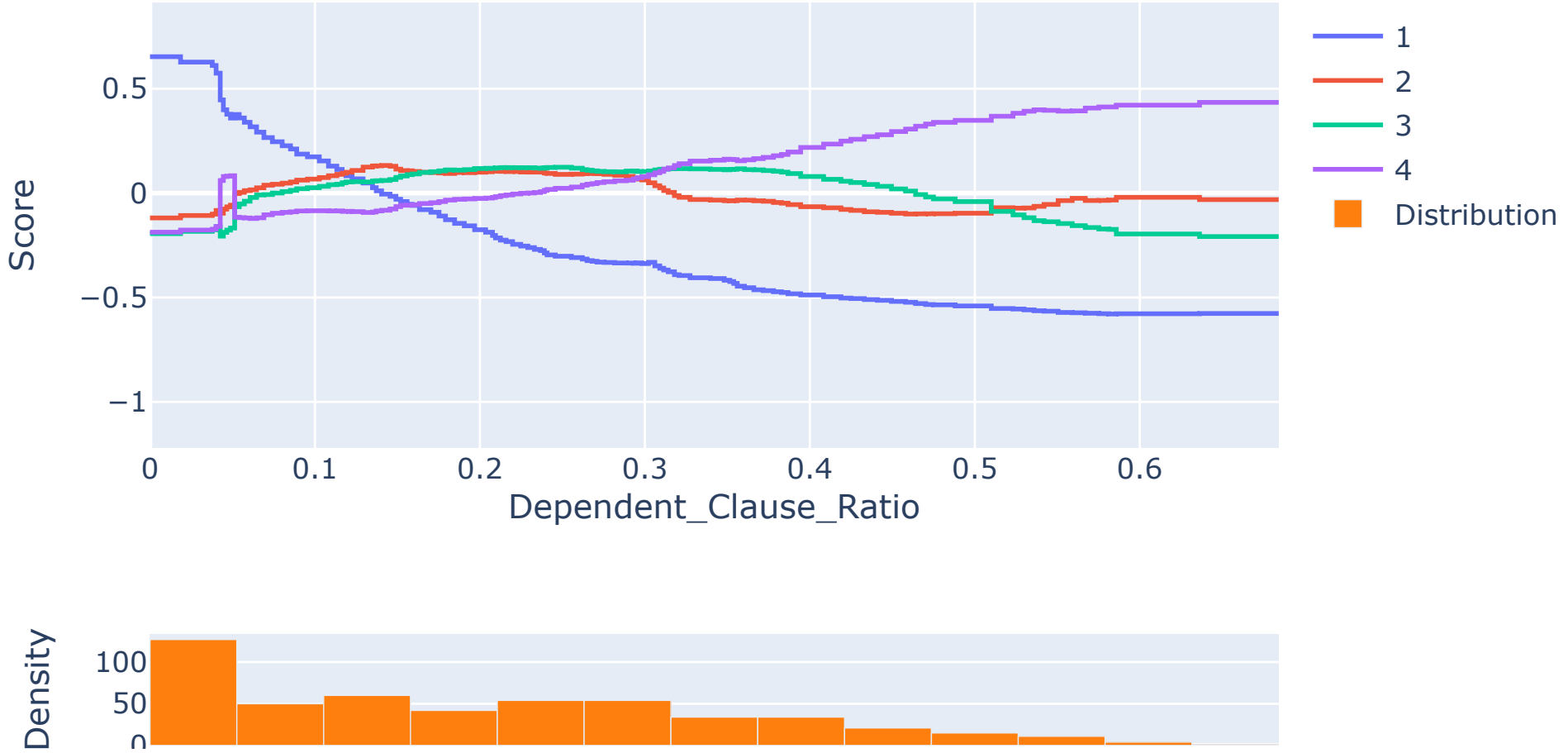
Fine-grained view on Longitudinal Development: Syntactic Elaboration

Subordinating Conjunction Density



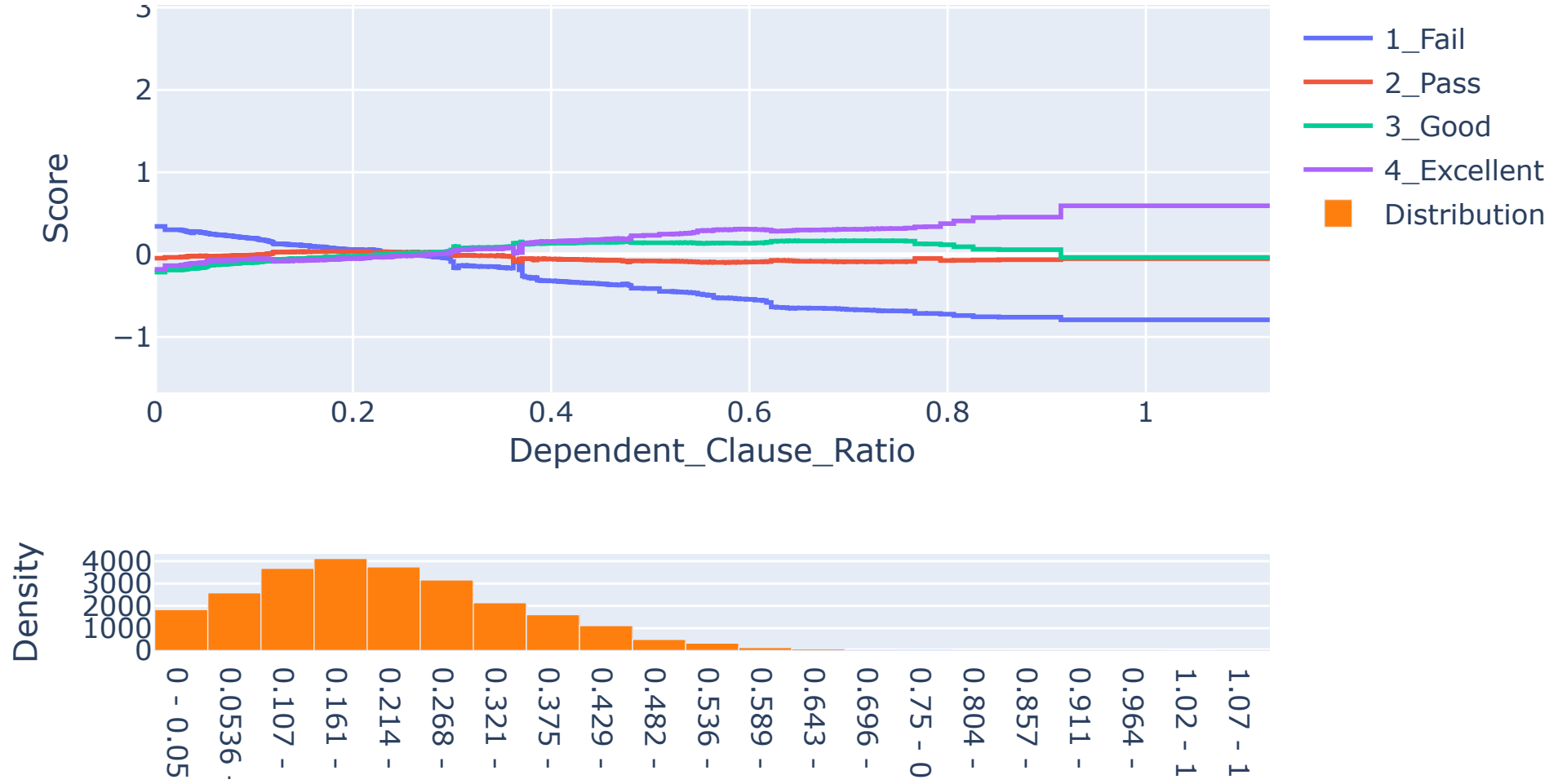
Fine-grained view on Longitudinal Development: Syntactic Elaboration

Dependent Clause Ratio



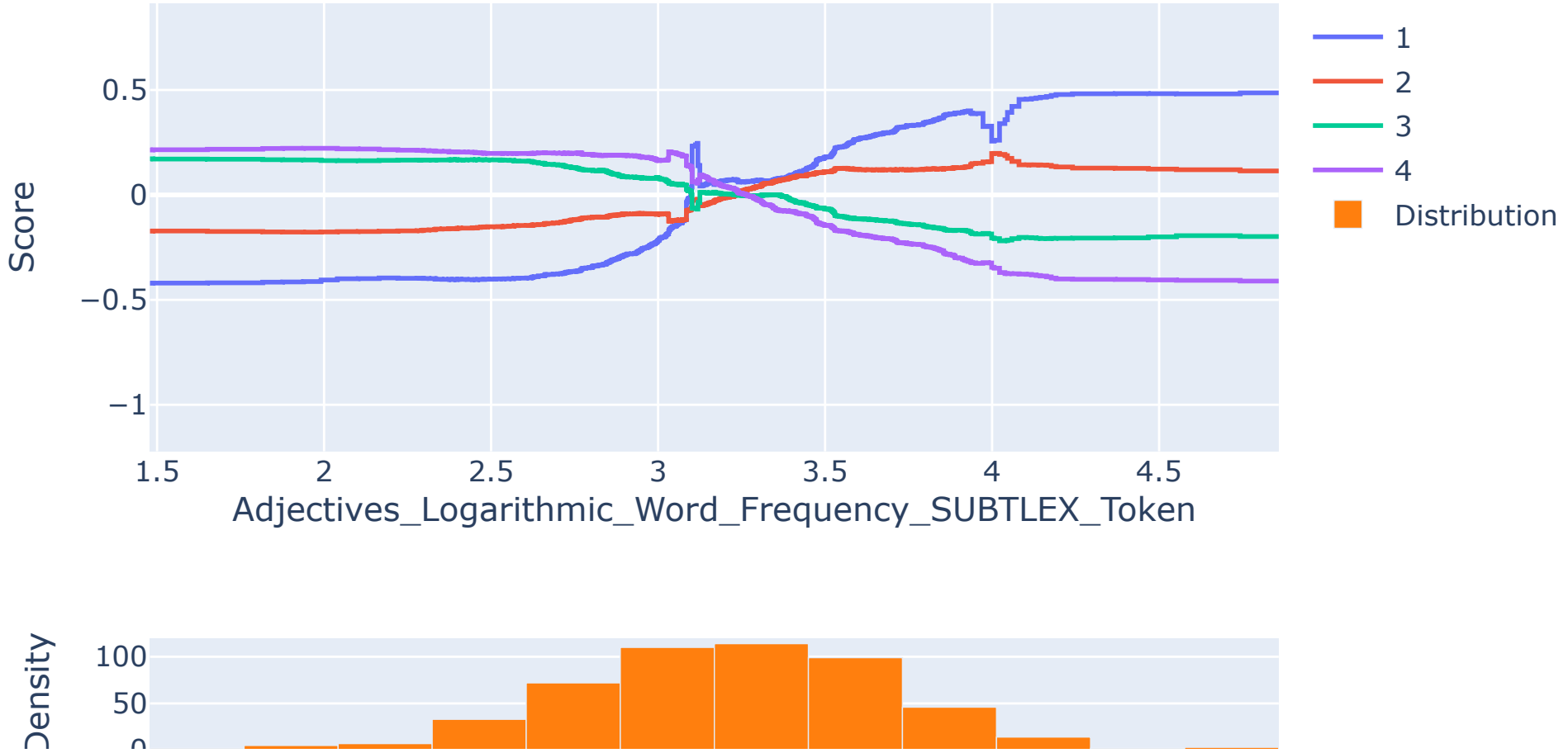
Fine-grained view on Grading: Syntactic Elaboration

Dependent Clause Ratio



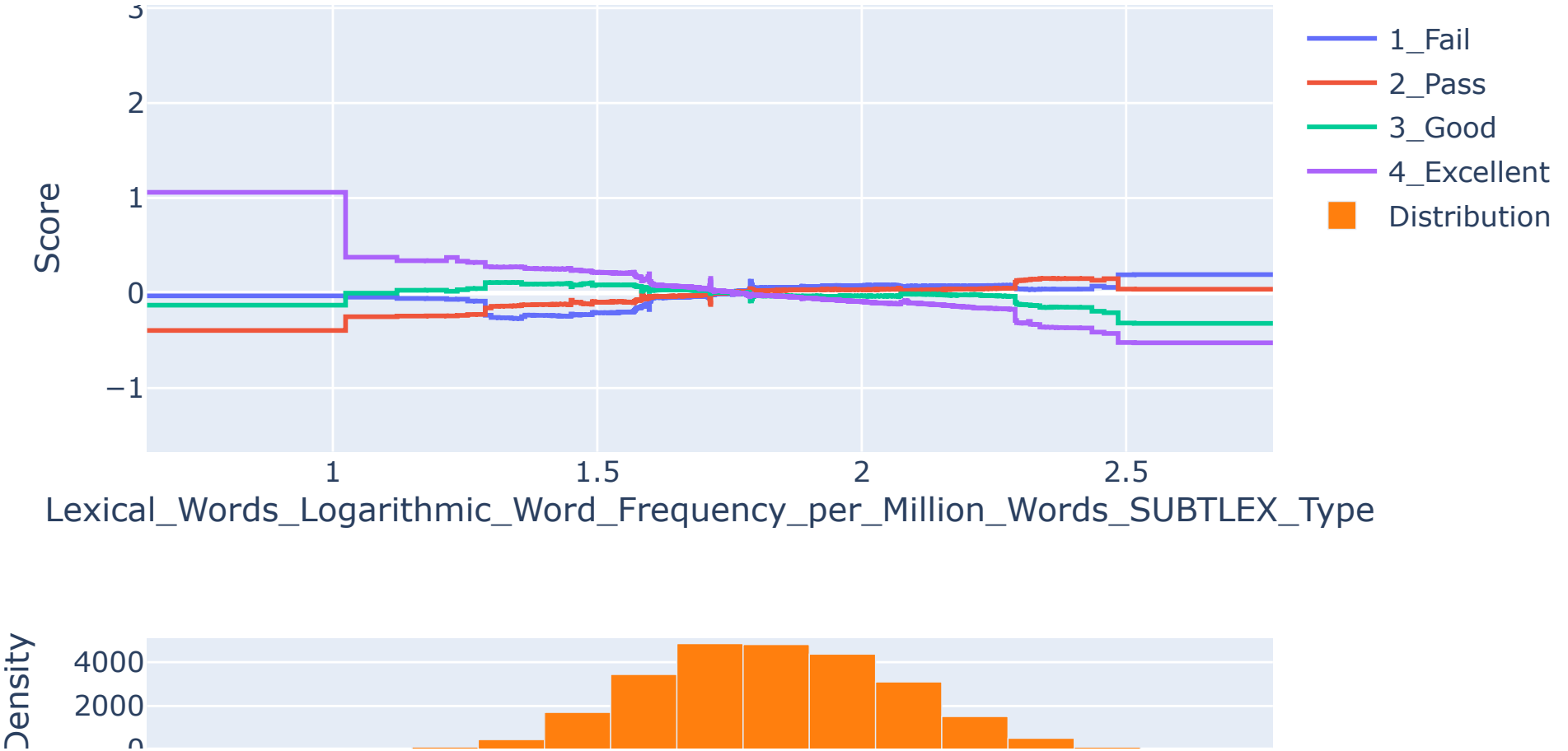
Fine-grained view on Longitudinal Development: Lexical Frequency

Adjectives Log. Word Frequency SUBTLEX Token



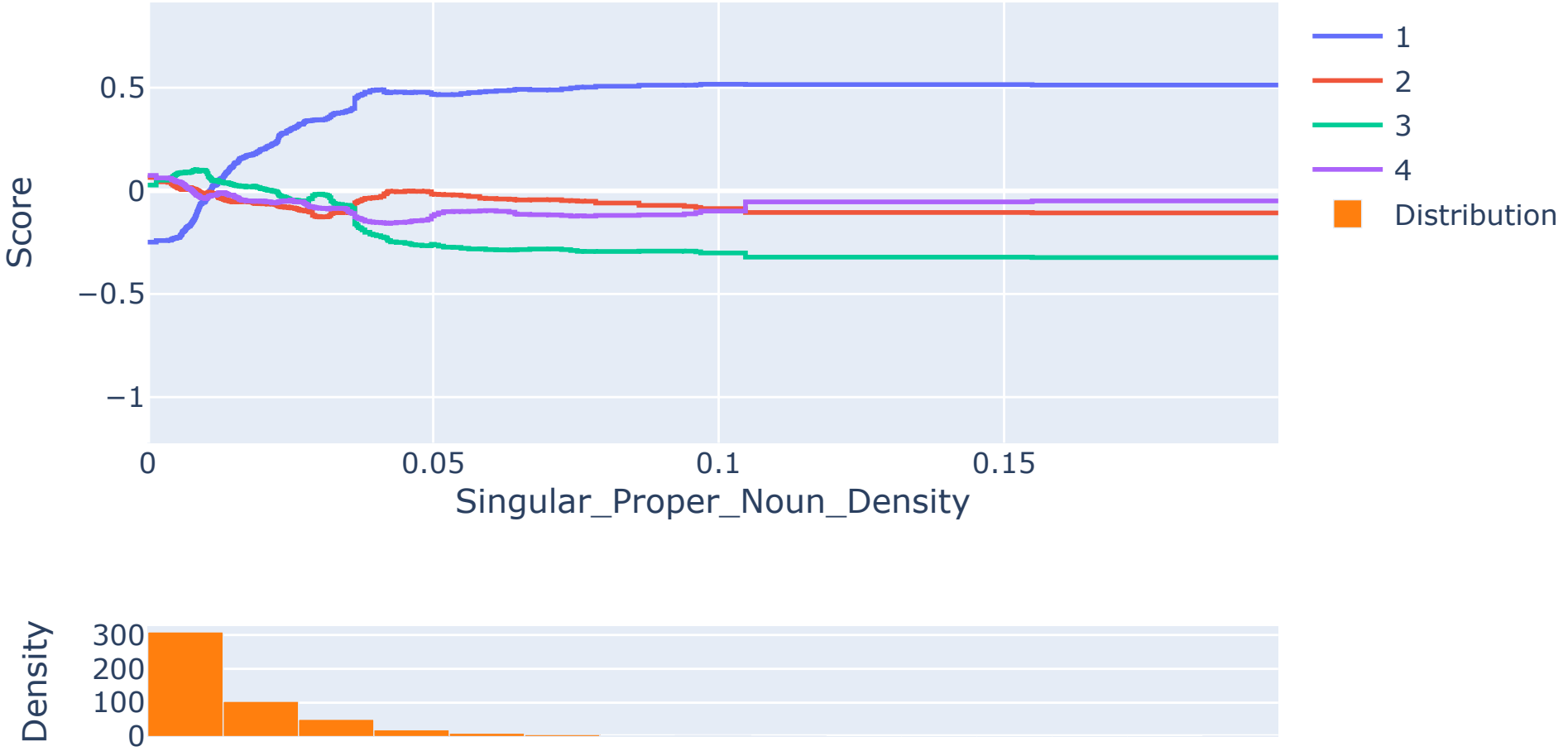
Fine-grained view on Grading: Lexical Frequency

Lexical Words Log. Word Frequency per Million Words SUBTLEX Type



Fine-grained view on Longitudinal Development: Idiosyncratic Lexical Property

Singular Proper Noun Density



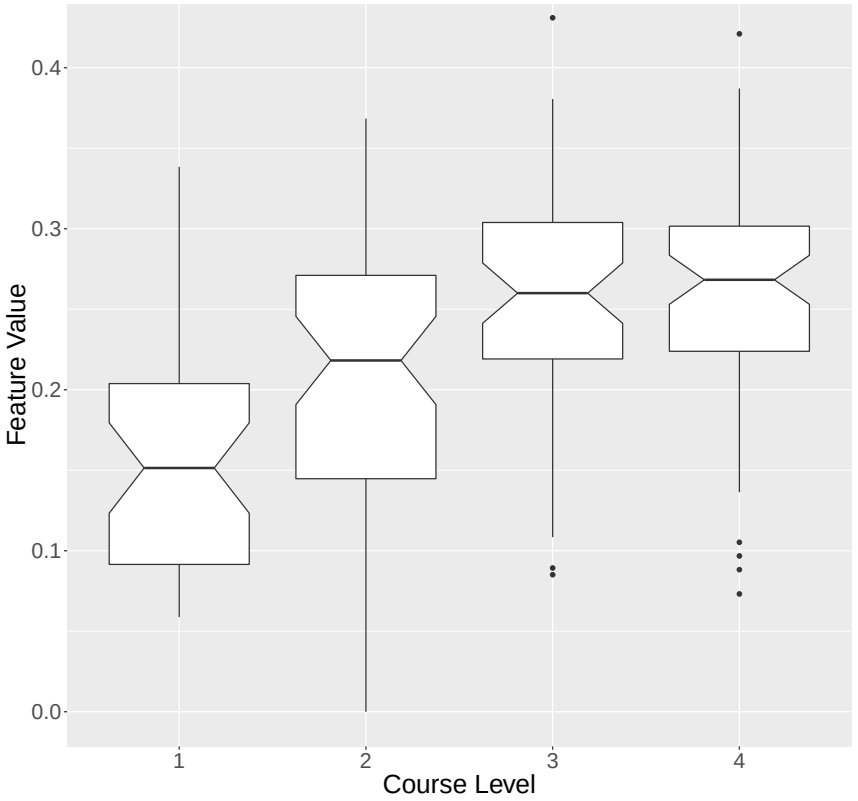
Influence of the Task on Complexity Analysis

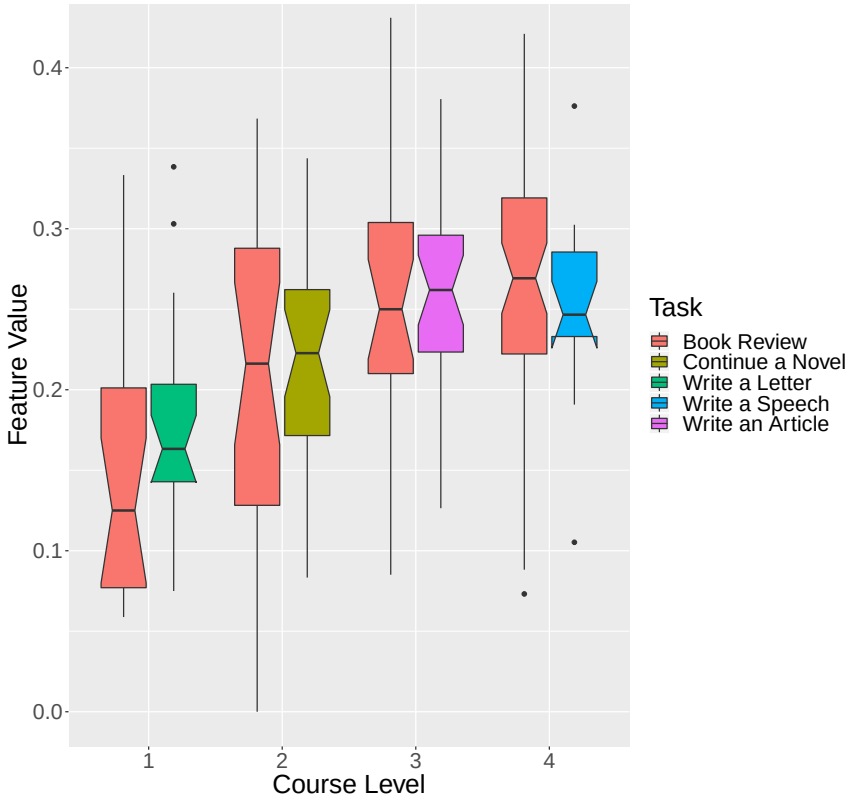
- Complexity can be an indicator of linguistic competence
  - but: Use of competence is task-dependent

⇒ Collaboration with Weiss (2017) based on Falko Georgetown Corpus (Siemen et al. 2006)

- 209 texts from 123 German L2 learners
- Take-home exams from four German courses at Georgetown University
  - Course level: intermediate (1) to advanced (4) level
  - Reference task (book review) + course-dependent task (novel continuation, letter, speech, article)

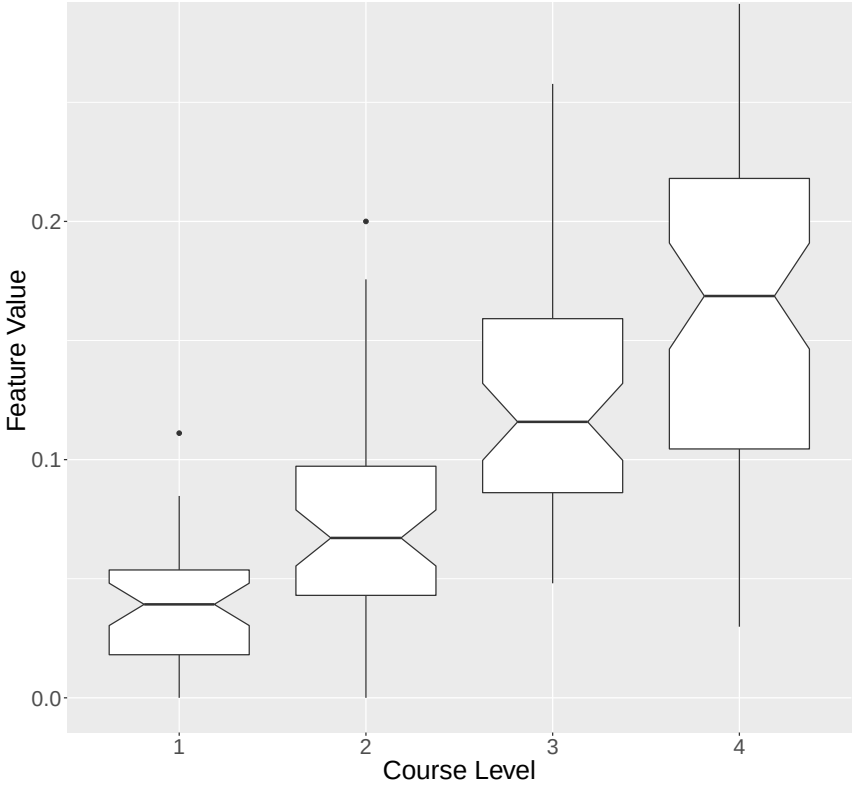
Clausal Complexity (dependent clause per clause)

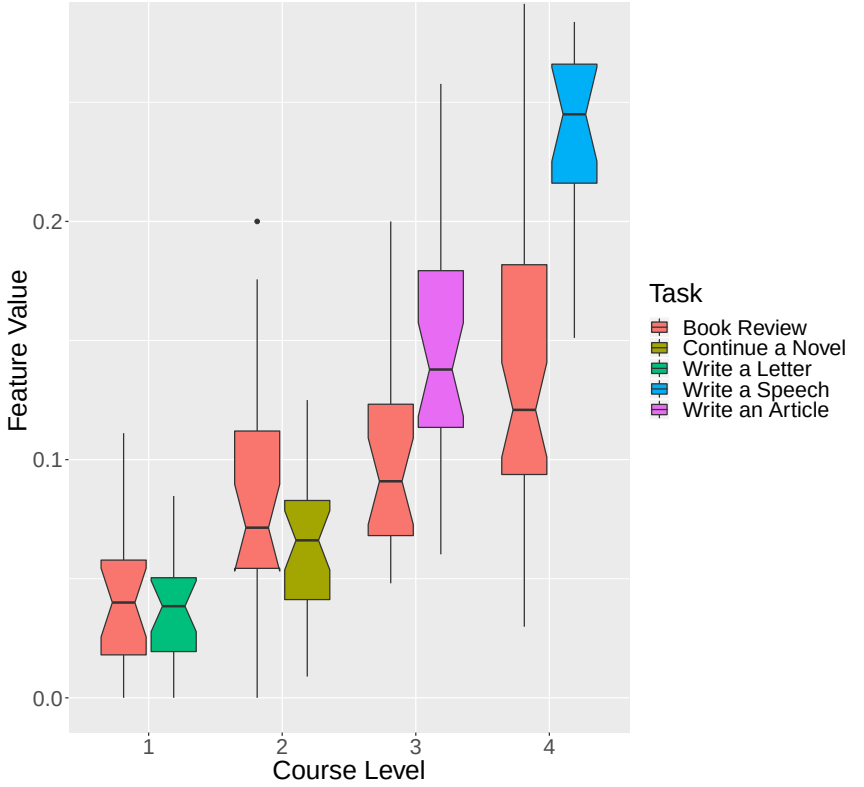




- systematic increase of embedded verbal projections
- little task differences

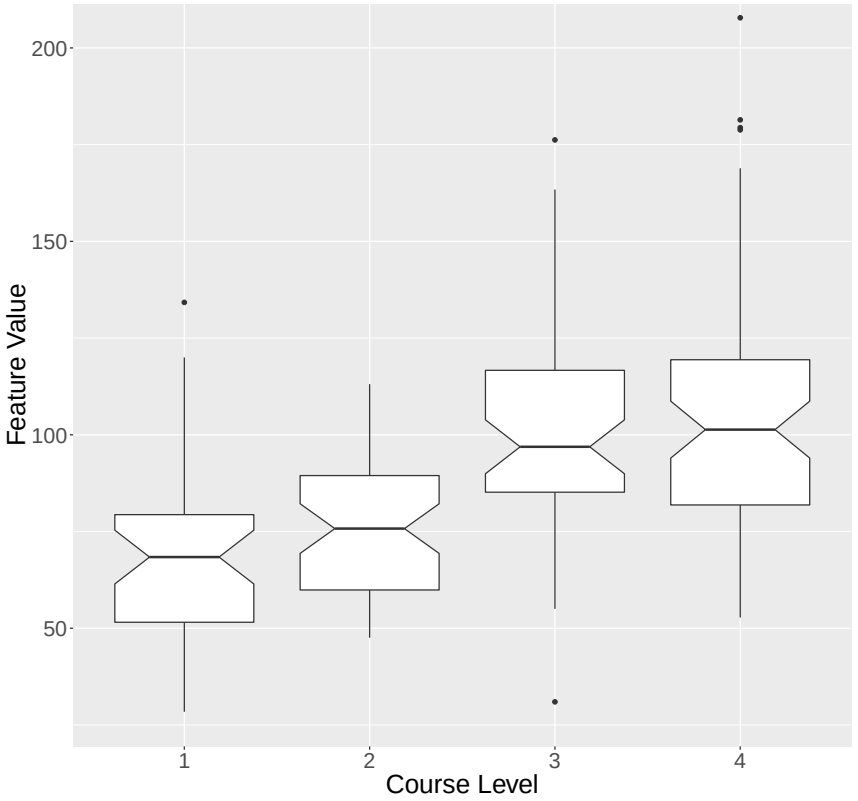
Morphological Complexity (derived nouns per noun)

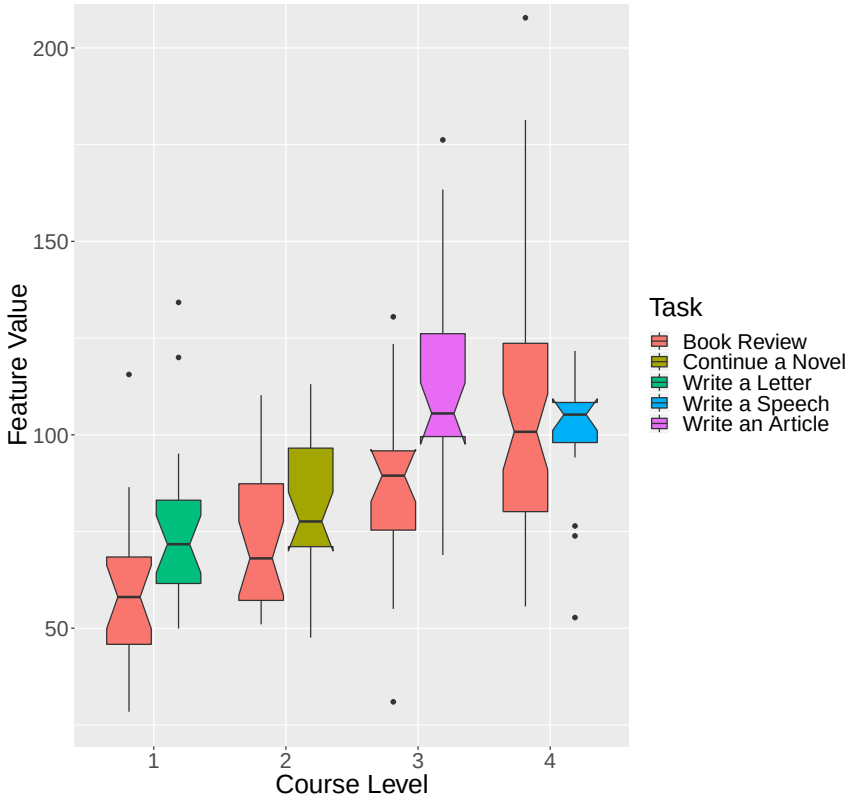




- systematic increase of derived nouns
- stronger task differences in higher courses

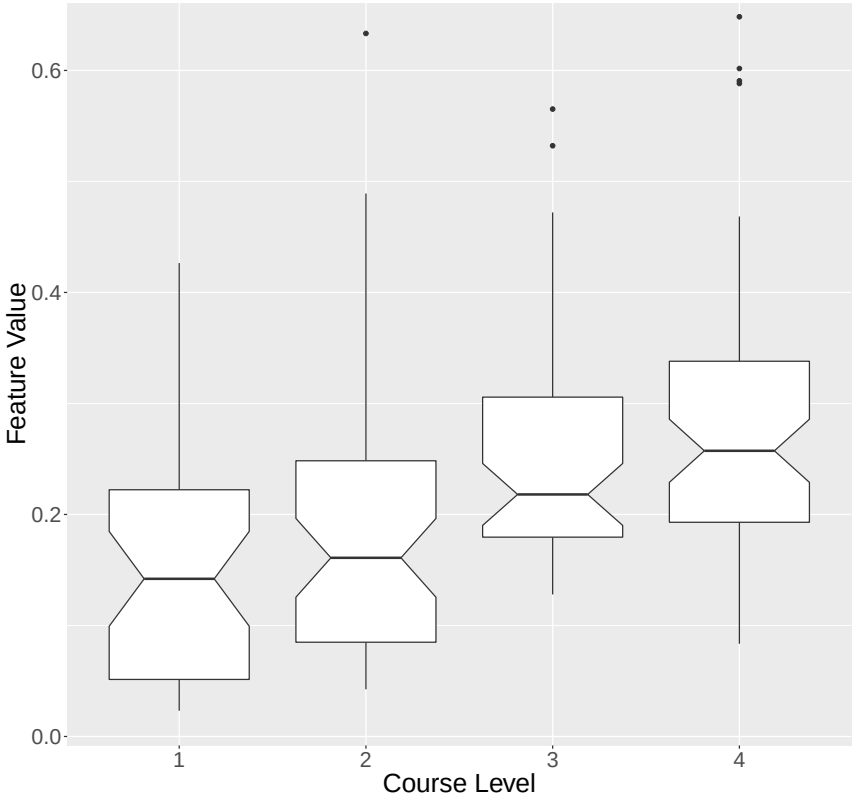
Lexical Complexity (MTLD)

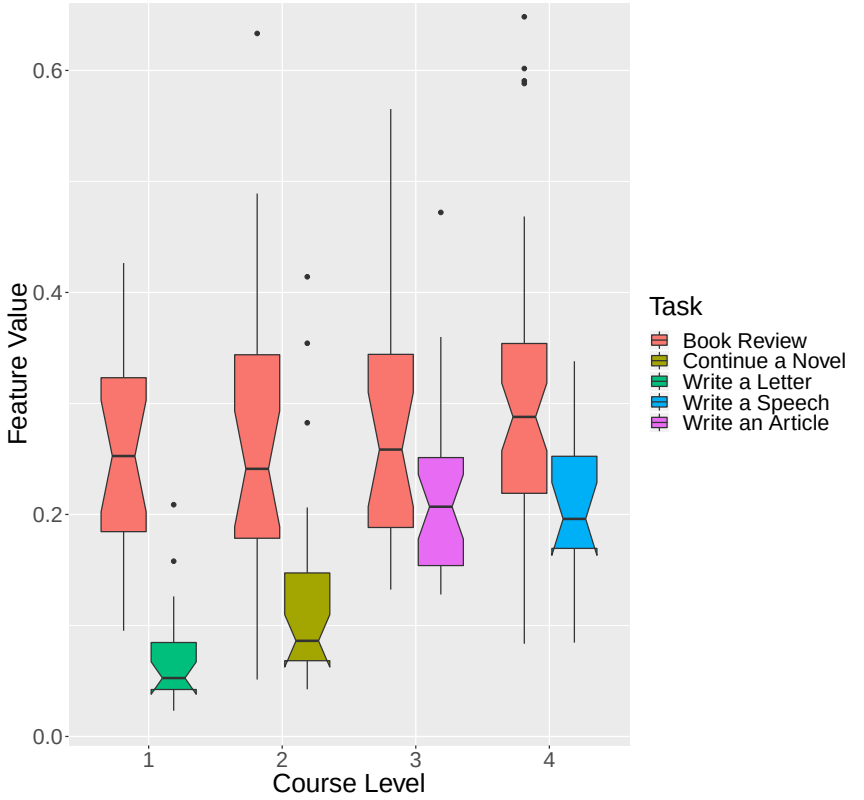




- Lexical diversity increases up to the third time point
- slight task dependence, stronger in advanced learners

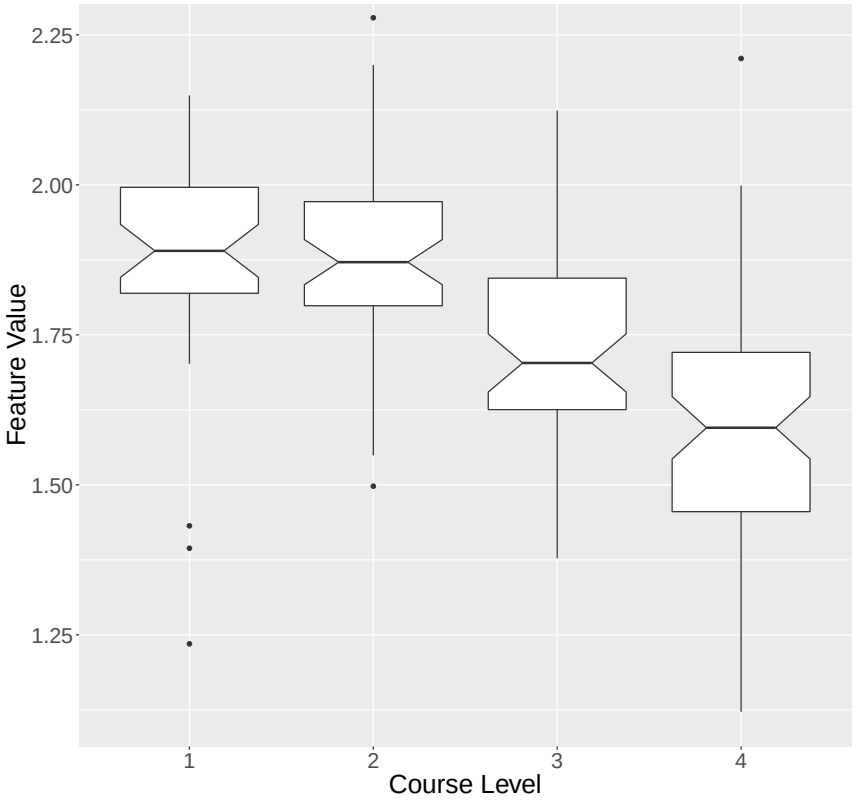
Discourse Complexity (global stem overlap per sentence)

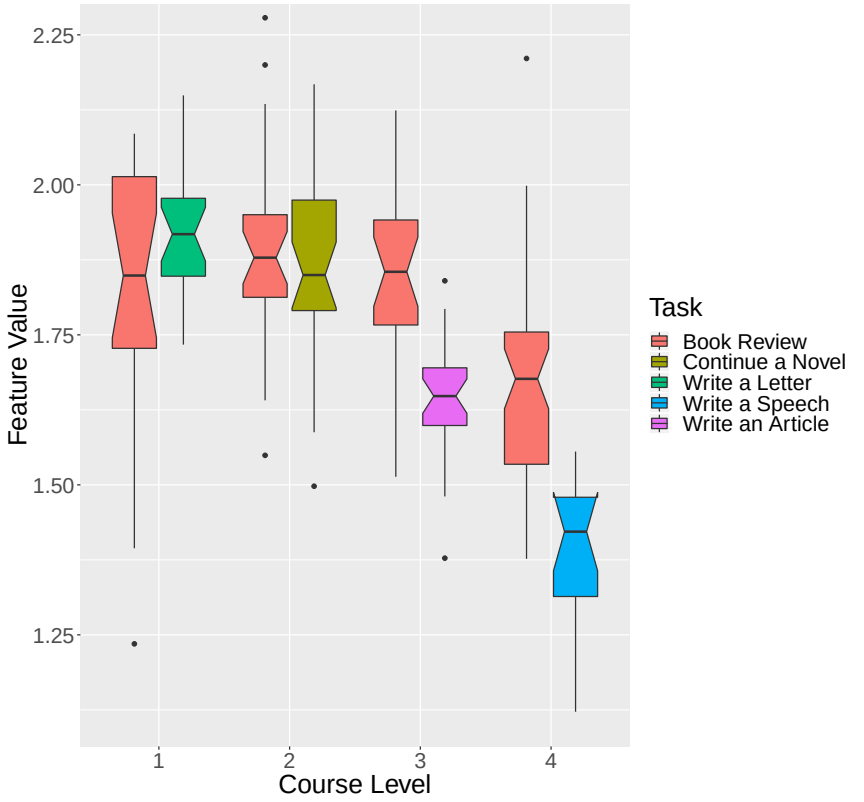




- Reference tasks without development
- specific tasks show systematic increase

Language Use (log type frequency per type in SUBTLEX-DE)





- increase of rarer words especially in advanced learners
- Task dependence in advanced learners

Discussion of Task Dependence of Linguistic Complexity

- Task dependence of linguistic complexity observed especially in advanced learners.
  - Advanced learners possess more varied linguistic material.
  - Advanced competence lies in the use of *appropriate complexity* (Pallotti 2023) according to *functional adequacy* (Kuiken & Vedder 2017)
- Complexity analysis should distinguish between
  - individually available and used linguistic material, and
  - functional appropriate use.
- Following variationist linguistic perspectives, we could distinguish:
  - Which functions are realized? (Variable)
  - Which of the linguistic means that can realize this function are used? (Variants)

Considerations on a Variationist Linguistic Perspective

- Complexity (variety, elaborateness) can be investigated on both levels:
  (i) Advanced learners can address *more varied and elaborated* ***functions*** appropriately and
  (ii) use *more varied and elaborate variants for the* ***realization*** of a function

- Example for (ii): Is functionally appropriately modification used for a picture description?
  - Are varied different variants of modification used?
    (e.g., pre-nominal/post-nominal/adverbial, varied lexical or phrasal)
  - How elaborate are the options used?
    (e.g., low-frequency adjectives, prenominal participial constructions)

From Analysis to Intervention

- Profile analyses (e.g., Language Assessment, Remediation and Screening Procedure, LARSP, Crystal et al. 1976) systematically serve as basis for focused interventions.
- Unlike profile analyses, complexity analyses are not related to specific acquisition stages, but provide continuous measures.
  - Since complexity analysis is possible for both learner output and input, interventions can provide input enrichment of developmentally proximal language.

$\Rightarrow$ Alignment of learners with adaptive, developmentally proximal input

- Complex primed input continuation writing tasks (Chen & Meurers 2017, 2019; Chen et al. 2022)
- Enrichment in human-computer dialogues (Glandorf & Meurers 2024; Glandorf et al. 2025)

Summary

- Linguistically broad modeling of complexity as elaborateness and variety of linguistic means is feasible for large, representative corpora
  - supports characterization of learner texts that is interpretable at varying levels of granularity
- Linguistic complexity can be interpreted in relation to development or writing quality,
  - but manifests itself partially in different aspects of linguistic complexity, and the
  - assessment of written products is also influenced by other factors.
- Interpretation of linguistic complexity measures is dependent on the task.
  - Features are differently susceptible to task effects.
  - Task dependence observable especially for advanced learners

  → A variationist perspective on functions and their realization could advance such analyses

Outlook: Connecting Profile Analyses and Complexity Analyses?

- Extend German profile analyses with more linguistic aspects that empirically turn out to be indicative of certain stages (e.g., as with the English Grammar Profile)?
- Motivate complexity analyses more theoretically instead of purely data-driven, making task and its functional requirements explicit.

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Topics in CDLK and PGG Corpora

- Longitudinal CDLK sub-corpus: *My family*, *An unforgettable experience*, *Image description*, *Work or Master's degree?*, *Should cell phones be allowed in the classroom?*
- PGG cross-sectional corpus:

Year	Topic	# Texts	# Tokens
2012	*Interns wanted for Chinese classes*	2.783	494.525
2013	*Writing to parents to convince them to agree to their child's participation in a rural mission*	983	206.536
2014	*Father and son*	2.233	481.430
2015	*Parents must limit children's computer time*	3.164	570.865
2016	*Emigration*	3.285	586.975
2017	*Do a Master's or work straight away*	3.371	537.032
2018	*The five most popular subjects of study*	3.432	550.801
2019	*Proportion of men with overweight and obesity in Germany in the years 2005 to 2017*	4.195	714.894
2020	*Debt among young people*	3.968	666.475
2021	*Time management*	3.981	616.631
		31.395	**5.426.164**

Longitudinal Corpus: CDLK Sample of 163 Learners

Group	Semester 1		Semester 2		Semester 3		Semester 4		Sum	
	Text	Token	Text	Token	Text	Token	Text	Token	Text	Token
1	27	3.520	29	4.147	27	3.528	24	3.207	107	14.402
2	26	2.672	24	3.072	23	3.600	20	2.832	93	12.176
3	23	2.239	23	3.116	24	3.330	23	3.379	93	12.064
4	36	3.427	37	4.925	36	4-605	36	4.192	145	17.149
5	30	4.997	59	8.121	59	10.025	48	8.832	196	31.975
Sum	**142**	**16.855**	**172**	**23.381**	**169**	**25.088**	**151**	**22.442**	**634**	**87.766**