Traditional Readability Formulas Compared for English

Bruce W. Lee^{1,2}

University of Pennsylvania¹ Pennsylvania, USA brucelws@seas.upenn.edu Jason Hyung-Jong Lee² LXPER AI Research (LAIR)² Seoul, South Korea jasonlee@lxper.com

Abstract

Traditional English readability formulas, or equations, were largely developed in the 20th century. Nonetheless, many researchers still rely on them for various NLP applications. This phenomenon is presumably due to the convenience and straightforwardness of readability formulas. In this work, we contribute to the NLP community by 1. introducing New English Readability Formula (NERF), 2. recalibrating the coefficients of "old" readability formulas (Flesch-Kincaid Grade Level, Fog Index, SMOG Index, Coleman-Liau Index, and Automated Readability Index), 3. evaluating the readability formulas, for use in text simplification studies and medical texts, and 4. developing a Python-based program for the wide application to various NLP projects.

1 Introduction

Readability Assessment (RA) quantitatively measures the ease of understanding or comprehension of any written text (Feng et al., 2010; Klare, 2000). Understanding text readability, or difficulty, is essential for research on any originated, studied, or shared ideas (Collins-Thompson, 2014). Such inherent property leads to RA's close applications to various areas of healthcare (Wu et al., 2013), education (Dennis, 2018), communication (Zhou et al., 2017), and Natural Language Processing (NLP), such as text simplification (Aluisio et al., 2010).

Machine learning (ML) or transformer-based methods have been reasonably successful in RA. The RoBERTa-RF-T1 model by Lee et al. (2021) achieves a 99% classification accuracy on OneStopEnglish dataset (Vajjala and Lučić, 2018) and a BERT-based ReadNet model from Meng et al. (2020) achieves about 92% accuracy on WeeBit dataset (Vajjala and Meurers, 2012). However, "traditional readability formulas" still seem to be actively used throughout the research published in popular NLP venues like ACL or EMNLP

(Uchendu et al., 2020; Shardlow and Nawaz, 2019; Scarton and Specia, 2018; Schwartz et al., 2017; Xu et al., 2016). The tendency to opt for traditional readability formulas is likely due their convenience and straightforwardness.

In this work, we hope to assist the NLP community by recalibrating five traditional readability formulas – originally developed upon 20th-century military or technical documents. The formulas are adjusted for the modern, standard U.S. education curriculum. We utilize the appendix B (Text Exemplars and Sample Performance Tasks) dataset, provided by the U.S. Common Core State Standards¹. Then, we evaluate the performances and applications of these formulas. Lastly, we develop a Python-based program for convenient application of the recalibrated versions.

But traditional readability formulas lack wide linguistic coverage (Feng et al., 2010). Therefore, we create a *new formula* that is mainly motivated by lexico-semantic and syntactic linguistic branches, as identified by Collins-Thompson (2014). From each, we search for the representative features. The resulting formula is named the New English Readability Formula, or simply **NERF**, and it aims to give the most generally and commonly accepted approach to calculating English readability.

To sum up, we make the contributions below. The related public resources are in appendix A.

- 1. We recalibrate five traditional readability formulas to show higher prediction accuracy on modern texts in the U.S. curriculum.
- **2.** We develop NERF, a generalized and easy-to-use readability assessment formula.
- **3.** We evaluate and cross-compare six readability formulas on several datasets. These datasets are carefully selected to collectively represent the diverse audiences, education curricula, and reading levels.

¹corestandards.org

4. We develop <Anonymous>, a fast open-source readability assessment software based on Python.

2 Related Work

The earliest attempt to "calculate" text readability was by Lively and Pressey (1923), in response to their practical problem of selecting science text-books for high school students (DuBay, 2004). In the consecutive years, many well-known readability formulas were developed, including Flesch Kincaid Grade Level (Kincaid et al., 1975), Gunning Fog Count (or Index) (Gunning et al., 1952), SMOG Index (Mc Laughlin, 1969), Coleman-Liau Index (Coleman and Liau, 1975), and Automated Readability Index (Smith and Senter, 1967).

These formulas are mostly linear models with two or three variables, largely based on superficial properties concerning words or sentences (Feng et al., 2010). Hence, they can easily combine with other systems with less burden of a large trained model (Xu et al., 2016). Such property also proved helpful in research fields outside computational linguistics, with some applications directly related to the public medical knowledge – measuring the difficulty of a patient material (Gaeta et al., 2021; van Ballegooie and Hoang, 2021; Bange et al., 2019; Haller et al., 2019; Hansberry et al., 2018; Kiwanuka et al., 2017).

3 Datasets

3.1 Common Core - Appendix B (CCB)

We use the CCB corpus to calibrate formulas. The article excerpts included in CCB are divided into the categories of story, poetry, informational text, and drama. For the simplification of our approach, we limit our research to story-type texts. This left us with only 69 items to train with. But those are directly from the U.S. Common Core Standards. Hence, we assume with confidence that the item classification is generally agreeable in the U.S.

CCB is the only dataset that we use in the calibration of our formulas. All below datasets are mainly for feature selection purposes only.

3.2 WeeBit (WBT)

WBT, the largest native dataset available in RA, contains articles targeted at readers of different age groups from the Weekly Reader magazine and the BBC-Bitesize website. In table 1, we translate those age groups into U.S. schools' K-* format. We downsample to $625\frac{\text{item}}{\text{class}}$ as per common practice.

| Properties | CCB | WBT | CAM | CKC | OSE | NSL |
|-------------|-------|-------|-------|-------|------|------|
| audience | Ntve | Ntve | ESL | ESL | ESL | Ntve |
| grade | K1-12 | K2-10 | A2-C2 | S7-12 | N/A | N/A |
| curriculum? | Yes | No | Yes | Yes | No | No |
| balanced? | No | Yes | Yes | No | Yes | No |
| #class | 6 | 5 | 5 | 6 | 3 | 5 |
| #item/class | 11.5 | 625 | 60.0 | 554 | 189 | 2125 |
| #word/item | 362 | 213 | 508 | 117 | 669 | 752 |
| #sent/item | 25.8 | 17.0 | 28.4 | 54.0 | 35.6 | 50.9 |

Table 1: Modified data. These stats are based on respective original versions. S: S.Korea Grade, Ntve: Native

3.3 Cambridge English (CAM)

CAM (Xia et al., 2016) classifies 300 items in the Common European Framework of Reference (CEFR) (Verhelst et al., 2001). The passages are from the past reading tasks in the five main suites Cambridge English Exams (KET, PET, FCE, CAE, CPE), targeted at learners at A2–C2 levels of CEFR.

3.4 Corpus of the Korean ELT (English Lang. Train.) Curriculum (CKC)

CKC (Lee and Lee, 2020b,a) is less-explored. It developed upon the reading passages appearing in the Korean English education curriculum. These passages' classifications are from official sources from the Korean Ministry. CKC represents a nonnative country's official ESL education curriculum.

3.5 OneStopEnglish (OSE)

OSE is a recently developed dataset in RA. It aims at ESL (English as Second Language) learners and consists of three paraphrased versions of an article from The Guardian Newspaper. Along with the original OSE dataset, we created a paired version (OSE-Pair). This variation has 189 items and each item has advanced-intermediate-elementary pairs.

In addition, OSE-Sent is a sentence-paired version of OSE. The dataset consists of three parts: adv-ele (1674 pairs), adv-int (2166), int-ele (2154).

3.6 Newsela (NSL)

NSL (Xu et al., 2015) is a dataset particularly developed for text simplification studies. The dataset consists of 1,130 articles, with each item re-written 4 times for children at different grade levels. We create a paired version (NSL-Pair) (2125 pairs).

3.7 ASSET

ASSET (Alva-Manchego et al., 2020) is a paired sentence dataset. The dataset consists of 360 sentences, with each item simplified 10 times.

4 Recalibration

4.1 Choosing Traditional Read. Formulas

We start by recalibrating five readability formulas. We considered Zhou et al. (2017) and the number of Google Scholar citations to sort out the most popular traditional readability formulas. Further, to make a fair performance comparison with our adjusted variations, we choose the formulas originally intended to output U.S. school grades but are based on 20th-century texts and test subjects.

Flesh-Kincaid Grade Level (FKGL) is primarily developed for U.S. Navy personnel. The readability level of 18 passages from Navy technical training manuals was calculated. The criterion was that 50% of subjects with reading abilities at the specific level had to score $\geq 35\%$ on a cloze test for a text item to be classified as the specific reading level. Responses from 531 Navy personnel were used.

$$\text{FKGL} = a \cdot \frac{\text{\#word}}{\text{\#sent}} + b \cdot \frac{\text{\#syllable}}{\text{\#word}} + c$$

where sent is sentence, and # refers to "count of."

The genius of Gunning Fog Index (FOGI) is the idea that word difficulty highly correlates with the number of syllables. Such a conclusion was deduced upon the inspection of Dale's list of easy words (Zhou et al., 2017; Dale and Chall, 1948). However, the shortcoming of FOGI is the overgeneralization that "all" words with more than two syllables are difficult. Indeed, "banana" is quite an easy word.

$$\text{FOGI} = a \cdot (\frac{\text{\#word}}{\text{\#sent}} + b \cdot \frac{\text{\#difficult word}}{\text{\#word}}) + c$$

Simple Measure of Gobbledygook (SMOG) Index, known for its simplicity, resembles FOGI in that both use the number of syllables to classify a word's difficulty. But SMOG sets its criterion a little high to more than three syllables per word. Additionally, SMOG incorporates a square root approach instead of a linear regression model.

$$\mathrm{SMOG} = a \cdot \sqrt{b \cdot \frac{\mathrm{\#polysyllable\ word}}{\mathrm{\#sent}}} + c$$

Coleman-Liau Index (COLE) is more of a lesserused variation among the five. But we could still find multiple studies outside computational linguistics that still partly depend on COLE (Kue et al., 2021; Szmuda et al., 2020; Joseph et al., 2020; Powell et al., 2020). The novelty of COLE is that it calculates readability without counting syllables, which was viewed as a time-consuming approach.

$$\text{COLE} = a \cdot 100 \cdot \frac{\text{\#letter}}{\text{\#word}} + b \cdot 100 \cdot \frac{\text{\#sent}}{\text{\#word}} + c$$

Automated Readability Index (AUTO) is developed for U.S. Air Force to handle more technical documents than textbooks. Like COLE, AUTO relies on the number of letters per word, instead of the more commonly-used syllables per word. Another quirk is that non-integer scores are all rounded up.

$$AUTO = a \cdot \frac{\text{\#letter}}{\text{\#word}} + b \cdot \frac{\text{\#word}}{\text{\#sent}} + c$$

4.2 Recalibration & Performance

4.2.1 Traditional Formulas, Other Text Types

We only recalibrate formulas on the CCB dataset. As stated in section 2.1, we limit to CCB's story-type items. In a preliminary investigation, we obtained low r2 scores (< 0.3, before and after recalibration) between the traditional readability formulas and poetry, informational text, and drama.

4.2.2 Details on Recalibration

We started with a large feature extraction software, LingFeat (Lee et al., 2021) and expanded it to include more necessary features. From CCB texts, we extracted the surface-level features in traditional readability formulas (i.e. #letter #word, #syllable #word) and put them in a dataframe.

CCB has 6 readability classes, but they are in the forms of range: K1, K2-3, K4-5, K6-8, K9-10, K11, and CCR (college and above). During calibration and evaluation, we estimated readability classes to K1, K2.5, K4.5, K7, K9.5, or K12 to model the general trend of CCB.

Using the class estimations as true labels and the created dataframe as features, we ran an optimization function to calculate the best coefficients (a, b, c in §4.1). We used non-linear least squares in fitting functions (Virtanen et al., 2020). Additional details are available in appendix B.

4.2.3 Coefficients & Performances

Table 2-a shows the original coefficients and the adjusted variations, rounded up to match significant figures. The adjusted traditional readability formulas can be obtained by simply plugging in these values to the formulas in section 4.1.

| a) Coef.s | FKGL | FOGI | SMOG | COLE | AUTO |
|------------|----------|---------|--------|---------|---------|
| original-a | 0.390 | 0.4000 | 1.043 | 0.05880 | 4.710 |
| adjusted-a | 0.1014 | 0.1229 | 2.694 | 0.03993 | 6.000 |
| original-b | 11.80 | 100.0 | 30.00 | -0.2960 | 0.5000 |
| adjusted-b | 20.89 | 415.7 | 8.815 | -0.4976 | 0.1035 |
| original-c | -15.59 | 0.0000 | 3.129 | -15.80 | -21.43 |
| adjusted-c | -21.94 | 1.866 | 3.367 | -5.747 | -19.61 |
| b) Perf. | FKGL | FOGI | SMOG | COLE | AUTO |
| r2 score | -0.03835 | -0.3905 | 0.1613 | 0.4341 | -0.5283 |
| r2 score | 0.4423 | 0.4072 | 0.3192 | 0.4830 | 0.4263 |
| Pearson r | 0.5698 | 0.5757 | 0.5649 | 0.6800 | 0.5684 |
| Pearson r | 0.6651 | 0.6381 | 0.5649 | 0.6949 | 0.6529 |

Table 2: a) Original & adjusted coefficients. b) Performance on CCB. Measured on U.S. Standard Curriculum's K-* Output. Bold refers to our new, adjusted versions.

5 The New English Readability Formula

5.1 Criteria

Considering the value of traditional readability formulas as essentially the generalized definition of readability for the non-experts (section 1), what really matters is the included features. The coefficients (or weights) can be recalibrated anytime to fit a specific use. Therefore, it is important to first identify handcrafted linguistic features that universally affect readability. Additionally, to ensure breadth and usability, we set the following guides:

1. We avoid surface-level features that lack linguistic value (Feng et al., 2010). They include #letter #word.

2. We include at most one linguistic feature from each linguistic subgroup. We use the classifications

from Lee et al. (2021); Collins-Thompson (2014).

3. We stick to a simplistic linear equation format.

5.2 Feature Extraction & Ranking

We utilize LingFeat for feature extraction. It is a public software that supports 255 handcrafted linguistic features in the branches of advanced semantic, discourse, syntactic, lexico-semantic, and shallow traditional. They further classify into 14 subgroups. We study the linguistically-meaningful branches: discourse (entity density, entity grid), syntax (phrasal, tree structure, part-of-speech), and lexico-semantics (variation ratio, type token ratio, psycholinguistics, word familiarity).

After extracting the features from CCB, WBT, CAM, CKC, and OSE, we first create feature performance ranking by Pearson's correlation. We used Sci-Kit Learn (Pedregosa et al., 2011). We take extra measures (Approach A & B) to model the features' general performances across datasets. Each approach runs under differing premises:

Premise A: "Human experts' dataset creation and labeling are partially faulty. The weak performance of a feature in a dataset does not necessarily indicate its weak performance in other data settings". **Premise B**: "All datasets are perfect. The weak performance of a feature in a dataset indicates the feature's weakness to be used universally."

After 78 hours of running, we decided not to extract features from NSL. Computing details are in appendix E. Among the features included in LingFeat, there are traditional readability formulas, like FKGL and COLE. These formulas performed generally well but a single killer feature, like type token ratio (TTR), often outperformed formulas. Traditional readability formulas and shallow traditional features are excluded from the rankings.

5.3 Approach A - Comparative Ranking

Under premise A, each dataset poses a different linguistic environment to feature performance. Further, premise A takes human error into consideration and agrees that data labeling is most likely inconsistent in some way. The literal correlation value itself is not too important under premise A.

Rather, we look for features that perform better than the others, under the same test settings. Thus, approach A's rewarding system is rank-dependent. In a dataset, features that rank 1-10 are rewarded 10 points, rank 11-20 get 9 points, ... and rank 91-100 get 1 point. Since there are five feature correlation rankings (one per dataset), the maximum score is 50. The results are in Table 3, in the order of score.

5.4 Approach B - Absolute Correlation

Under premise B, the weak correlation of a feature in a dataset is solely due to the feature's weakness to generalize. This is because all datasets are supposedly perfect. Hence, we only measure the feature's absolute correlation across datasets.

Approach B's rewarding system is correlation-dependent. In a dataset, features that show correlation value between 0.9-10 are rewarded 10 points, value between 0.8-0.89 get 9 points, ... and value between 0.0-0.09 get 1 point. Like approach A, the maximum score is 50. The result is in Table 4.

5.5 Analysis & Manual Feature Selection

First and the most noticeable, the top features under premise A & B are similar. In fact, the two results are almost replications of each other except for minor changes in order. We initially set two premises to introduce differing views (and hence

| | | | Feature | | CCI | 3 | WB | Т | CAN | Л | CKC | | OSI | E |
|-------|------------|-----------------|---------------|----------------------------------|-------|----|-------|-----|-------|----|-------|----|-------|-------|
| Score | Branch Sul | bgroup | LingFeat Code | Brief Explanation | r | rk | r | rk | r | rk | r | rk | r | rk |
| 43 | LxSem Psy | ycholinguistic | as_AAKuL_C | Kuperman Lemma AoA per Sent | 0.540 | 25 | 0.505 | 1 | 0.722 | 42 | 0.711 | 4 | 0.601 | 25 |
| 43 | LxSem Psy | ycholinguistic | as_AAKuW_C | Kuperman Word AoA per Sent | 0.537 | 28 | 0.503 | 2 | 0.722 | 43 | 0.711 | 6 | 0.602 | 24 |
| 40 | LxSem Psy | ycholinguistic | at_AAKuW_C | Kuperman Word AoA per Word | 0.703 | 5 | 0.308 | 36 | 0.784 | 20 | 0.643 | 21 | 0.455 | 66 |
| 40 | Synta Tre | ee Structure | as_TreeH_C | Tree Height per Sent | 0.550 | 21 | 0.341 | 30 | 0.686 | 51 | 0.699 | 9 | 0.541 | 44 |
| 40 | Synta Par | rt-of-Speech | as_ContW_C | # Content Words per Sent | 0.534 | 29 | 0.453 | 13 | 0.667 | 56 | 0.688 | 14 | 0.544 | 43 |
| 39 | LxSem Psy | ycholinguistic | at_AAKuL_C | Kuperman Lemma AoA per Word | 0.723 | 4 | 0.323 | 35 | 0.785 | 19 | 0.650 | 20 | 0.453 | 67 |
| 39 | Synta Phi | rasal | as_NoPhr_C | # Noun Phrases per Sent | 0.550 | 20 | 0.406 | 25 | 0.660 | 58 | 0.673 | 18 | 0.582 | 35 |
| 39 | Synta Phi | rasal | to_PrPhr_C | Total # Prepositional Phrases | 0.470 | 47 | 0.189 | 58 | 0.808 | 11 | 0.580 | 36 | 0.729 | 3 |
| 39 | Synta Par | rt-of-Speech | as_FuncW_C | # Function Words per Sent | 0.468 | 48 | 0.471 | 8 | 0.662 | 57 | 0.673 | 17 | 0.614 | 19 |
| 38 | LxSem Psy | ycholinguistic | to_AAKuL_C | Total Sum Kuperman Lemma AoA | 0.428 | 71 | 0.189 | 59 | 0.835 | 3 | 0.627 | 22 | 0.716 | 5 |
| 38 | LxSem Psy | ycholinguistic | to_AAKuW_C | Total Sum Kuperman Word AoA | 0.427 | 72 | 0.189 | 60 | 0.835 | 4 | 0.625 | 23 | 0.715 | 6 |
| 36 | Synta Phi | rasal | as_PrPhr_C | # Prepositional Phrases per Sent | 0.513 | 35 | 0.417 | 23 | 0.607 | 70 | 0.608 | 28 | 0.590 | 34 |
| 36 | LxSem Wo | ord Familiarity | as_SbL1C_C | SubtlexUS Lg10CD Value per Sent | 0.467 | 49 | 0.430 | 20 | 0.612 | 69 | 0.699 | 10 | 0.533 | 45 |
| 35 | LxSem Typ | pe Token Ratio | CorrTTR_S | Corrected Type Token Ratio | 0.745 | 1 | 0.006 | 228 | 0.846 | 1 | 0.445 | 65 | 0.692 | 7 |
| 35 | LxSem Wo | ord Familiarity | as_SbL1W_C | SubtlexUS Lg10WF Value per Sent | 0.462 | 52 | 0.437 | 19 | 0.605 | 71 | 0.693 | 12 | 0.523 | 48 |

Table 3: Top 15 (score \geq 35) handcrafted linguistic features under Approach A. r: Pearson's correlation between the feature and the dataset. rk: the feature's correlation ranking on the specific dataset. Full version in appendix D.

| | | | Feature | | CCE | 3 | WB | Г | CAN | Л | CKO | C | OSE |
|-------|--------|------------------|---------------|----------------------------------|-------|----|--------|-----|-------|----|-------|----|----------|
| Score | Branch | Subgroup | LingFeat Code | Brief Explanation | r | rk | r | rk | r | rk | r | rk | r rk |
| 35 | LxSem | Psycholinguistic | as_AAKuL_C | Kuperman Lemma AoA per Sent | 0.540 | 25 | 0.505 | 1 | 0.722 | 42 | 0.711 | 4 | 0.601 25 |
| 35 | LxSem | Psycholinguistic | as_AAKuW_C | Kuperman Word AoA per Sent | 0.537 | 28 | 0.503 | 2 | 0.722 | 43 | 0.711 | 6 | 0.602 24 |
| 32 | LxSem | Psycholinguistic | at_AAKuL_C | Kuperman Lemma AoA per Word | 0.723 | 2 | 0.323 | 35 | 0.785 | 42 | 0.650 | 22 | 0.453 67 |
| 32 | LxSem | Psycholinguistic | at_AAKuW_C | Kuperman Word AoA per Word | 0.703 | 5 | 0.308 | 36 | 0.784 | 20 | 0.643 | 21 | 0.455 66 |
| 31 | Synta | Phrasal | as_NoPhr_C | # Noun Phrases per Sent | 0.550 | 20 | 0.406 | 25 | 0.660 | 58 | 0.673 | 18 | 0.582 35 |
| 31 | Synta | Part-of-Speech | as_ContW_C | # Content Words per Sent | 0.534 | 29 | 0.453 | 13 | 0.667 | 56 | 0.688 | 14 | 0.544 43 |
| 31 | Synta | Phrasal | as_PrPhr_C | # Prepositional Phrases per Sent | 0.513 | 35 | 0.417 | 23 | 0.607 | 70 | 0.608 | 28 | 0.590 34 |
| 31 | Synta | Part-of-Speech | as_FuncW_C | # Function Words per Sent | 0.468 | 48 | 0.471 | 8 | 0.662 | 57 | 0.673 | 17 | 0.614 19 |
| 31 | LxSem | Psycholinguistic | to_AAKuL_C | Total Sum Kuperman Lemma AoA | 0.428 | 71 | 0.189 | 59 | 0.835 | 3 | 0.627 | 22 | 0.716 5 |
| 31 | LxSem | Psycholinguistic | to_AAKuW_C | Total Sum Kuperman Word AoA | 0.427 | 72 | 0.189 | 60 | 0.835 | 4 | 0.625 | 23 | 0.715 6 |
| 30 | LxSem | Type Token Ratio | CorrTTR_S | Corrected Type Token Ratio | 0.745 | 1 | 0.006 | 228 | 0.846 | 1 | 0.445 | 65 | 0.692 7 |
| 30 | LxSem | Variation Ratio | CorrNoV_S | Corrected Noun Variation-1 | 0.717 | 3 | 0.0858 | 131 | 0.842 | 2 | 0.406 | 78 | 0.612 21 |
| 30 | Synta | Tree Structure | as_TreeH_C | Tree Height per Sent | 0.550 | 21 | 0.341 | 30 | 0.686 | 51 | 0.699 | 9 | 0.541 44 |
| 30 | Synta | Phrasal | to_PrPhr_C | Total # Prepositional Phrases | 0.470 | 47 | 0.189 | 58 | 0.808 | 11 | 0.580 | 36 | 0.729 3 |
| 30 | LxSem | Word Familiarity | as_SbL1C_C | SubtlexUS Lg10CD Value per Sent | 0.467 | 49 | 0.430 | 20 | 0.612 | 69 | 0.699 | 10 | 0.533 45 |

Table 4: Top 15 (score \geq 30) handcrafted linguistic features under Approach B. Italic for the feature not in Table 3.

the results) to feature rankings. Then, we would choose the features that perform well in both.

But there seems to be an inseparable correlation between ranking-based (premise A) and correlation-based (premise B) approaches. CorrNoV_S (Corrected Noun Variation) was the only new top feature introduced under premise B.

Second, discourse-based features (mostly entity-related) performed poorly for use in our final NERF. As an exception, ra_NNToT_C (noun-noun transitions: total) scored 28 under premise A and 26 under premise B. On the other hand, a majority of lexico-semantic and syntactic features performed well throughout. This strongly suggests that a possible discovery of universally-effective features for readability is in lexico-semantics or syntax.

Third, the difficulty of a document heavily depended on the difficulty of individual words. In detail, as_AAKuL_C, as_AAKuW_C, to_AAKuL_C,

to_AAKuW_C showed consistently high correlations across the five datasets. As shown in Section 2, these five datasets have different authors, target audience, average length, labeling techniques, and the number of classes. Each dataset had at least one of these features among the top 5 performances.

The four features come from age-of-acquisition research by Kuperman et al. (2012), which now prove to be an important resource for RA. Such direct classification of word difficulties always outperformed frequency-based approaches like SubtlexUS (Brysbaert and New, 2009). Back to feature selection, we follow the steps below.

- 1. From top to bottom, go through ranking (table 3 & 4) to sort out the features that performed the best in each linguistic subgroup.
- **2.** Conduct step 1 to both datasets and compare the results to each other. Though this process, we only leave the features that duplicate in both rankings.

$$= \frac{0.04876 \cdot \sum \text{Word Age-of-Acquisition} - 0.1145 \cdot \sum \text{Word Familiarity}}{\text{\#Sentence}} \\ + \frac{0.3091 \cdot \text{\#Content Word} + 0.1866 \cdot \text{\#Noun Phrase} + 0.2645 \cdot \text{Constituency Parse Tree Height}}{\text{\#Sentence}} \\ + \frac{1.1017 \cdot \text{\#Unique Word}}{\sqrt{\text{\#Word}}} - 4.125$$

Equation) New English Readability Formula (NERF)

The steps above produce the same results for both approach A and B. The final selected features are as_AAKuL_C (psycholinguistic), as_TreeH_C (tree structure), as_ContW_C (part-of-speech), as_NoPhr_C (phrasal), as_SbL1C_C (word familiarity), CorrTTR_S (type token ratio). CorrNov_S (variation) only appeared under approach B, and we did not include it.

5.6 More on NERF & Calibration

The final NERF (section 4.5) is brought in three parts. The first is lexico-semantics, which measures lexical difficulty. It adds the total sum of each word's age-of-acquisition (Kuperman's) and the sum of word familiarity scores (Lg10CD in SubtlexUS). The sum is divided by # sentences.

The second is syntactic complexity, which deals with how each sentence is structured. We look at the number of content words, noun phrases, and the total sum of sentence tree height. Here, content words (CW) are words that possess semantic content and contribute to the meaning of the specific sentence. Following LingFeat, we consider a word to be a content word if it has "NOUN", "VERB", "NUM", "ADJ", "ADV" as a POS tag. Also, a sentence's tree height (TH) is calculated from a constituency-parsed tree, which we used the CRF parser (Zhang et al., 2020) to obtain. The related algorithms from NLTK (Bird et al., 2009) were used in calculating tree height. The same CRF parser was also used to count the number of noun phrase (NP) occurrences.

The third is lexical richness, given through type token ratio (TTR). This is the only section of NERF that is averaged on the word count. TTR measures how many unique vocabularies appear with respect to the total word count. TTR is often used as a measure of lexical richness (Malvern and Richards, 2012) and ranked the best performance on two native datasets (CCB and CAM). Importantly, these

| Metric | Human | NERF | FKGL | FOGI | SMOG | COLE | AUTO |
|-----------|---------|--------|----------|---------|--------|--------|---------|
| MAE | N.A. | N.A. | 2.844 | 3.413 | 3.114 | 2.537 | 3.377 |
| MAE | 3.509 | 2.154 | 2.457 | 2.516 | 2.728 | 2.378 | 2.514 |
| r2 score | N.A. | N.A. | -0.03835 | -0.3905 | 0.1613 | 0.4341 | -0.5283 |
| r2 score | -0.0312 | 0.5536 | 0.4423 | 0.4072 | 0.3192 | 0.4830 | 0.4263 |
| Pearson r | N.A. | N.A. | 0.5698 | 0.5757 | 0.5649 | 0.6800 | 0.5684 |
| Pearson r | 0.0838 | 0.7440 | 0.6651 | 0.6381 | 0.5649 | 0.6949 | 0.6530 |

Table 5: Scores on CCB. Measured on U.S. Standard Curriculum's K-* Output. Bold for new or adjusted.

two datasets represent US and UK school curriculums, and TTR seems a good evaluator. What was interesting is that out of the five TTR variations from Lee et al. (2021); Vajjala and Meurers (2012), corrected TTR generalized particularly well.

Like section 3, we use the non-linear least fitting method on CCB to calibrate NERF. The results match what we expected. For example, the coefficient for word familiarity, which measures how frequently the word is used in American English, is negative since common words often have faster lexical comprehension times (Brysbaert et al., 2011).

6 Evaluation, against Human

Here, we check the human-perceived difficulty of each item in CCB. We used Amazon Mechanical Turk to ask U.S. Bachelor's degree holders, "Which U.S. grade does this text belong to?" Every item was answered by 10 different workers to ensure breadth. Details on survey & datasets are in appendix B, C.

Table 5 gives a performance comparison of NERF against other traditional readability formulas and human performances. The human predictions were made by the U.S. Bachelor's degree holders living in the U.S. Ten human predictions were averaged to obtain the final prediction for each item, for comparison against CCB.

The calibrated formulas show a particularly great increase in r2 score. This likely means that the new

recalibrated formulas can capture the variance of the original CCB classifications much better when compared to the original formulas. We believe that such an improvement stems from the change in datasets. The original formulas are mostly built on human tests of 20th century's military or technical documents, whereas the recalibration dataset (CCB) are from the student-targeted school curriculum. Further, CCB is classified by trained professionals. Hence, the standards for readability can differ. The new recalibrated versions are more suitable for analyzing the modern general documents and giving K-* output by modernized standards.

MAE (Mean Absolute Error), r2 score, and Pearson's r improve once more with NERF. Even though the same dataset, same fitting function, and same evaluation techniques (no split, all train) were used, the critical difference was in the features. The shallow surface-level features from the traditional readability formulas also showed top rankings across all datasets but lacked linguistic coverage. Hence, NERF could capture more textual properties that led to a difference in readability.

Lastly, we observe that it is highly difficult for the general human population to exactly guess the readability of a text. Out of 690 predictions, only 286 were correct. We carefully posit that this is because: 1. the concept of "readability" is vague and 2. everyone goes through varying education. It could be easier to choose which item is more readable, instead of guessing how readable an item is. Given the general population, it is always better to use some quantified models than trust human.

7 Evaluation, for Application

7.1 Text Simplification - Passage-based

All readability formulas, whether recalibrated or not, show near-perfect performances in ranking the simplicity of texts. On both OSE-Pair & NSL-Pair, we designed a simple task of ranking the simplicity of an item. Both paired datasets include multiple simplified versions of an original item. Each row consists of various simplifications. A correct prediction is the corresponding readability formula output matching simplification level (e.g. original: highest prediction, ..., simplest: lowest prediction).

In OSE-Pair, a correct prediction must properly rank three simplified items. NERF showed a meaningfully improved performance than the other five traditional readability formulas before recalibration. NERF correctly classified 98.7% pairs, while the

| a) Adv-Ele | NERF | FKGL | FOGI | SMOG | COLE | AUTO |
|----------------------|---------------|------|------|----------------|------|------|
| Accuracy Accuracy | | | | 11.4% 11.4% | | |
| b) Adv-Int | NERF | FKGL | FOGI | SMOG | COLE | AUTO |
| Accuracy Accuracy | N.A. 77.8% | | | 12.2% 12.2% | | |
| c) Int-Ele | NERF | FKGL | FOGI | SMOG | COLE | AUTO |
| Accuracy Accuracy | N.A. 73.1% | | | 9.02% 9.02% | | |

Table 6: Scores on OSE-Sent. Bold for new or adjusted.

others stayed ≤95% (FKGL: 93.4%, FOGI: 92.6%, SMOG: 94.4%, COLE: 94.9%, AUTO: 92.6%). Recalibration generally helped the traditional readability formulas but NERF still showed better performance (FKGL: 97.8%, FOGI: 97.1%, SMOG: 94.4%, COLE: 89.9%, AUTO: 95.8%).

In NSL-Pair, a correct prediction must properly rank five simplified items, which is a more difficult task than the previous. Nonetheless, all six formulas achieved 100% accuracies. The same results were achieved before and after CCB-recalibration. This hints that NSL-Pair is thoroughly simplified.

Readability formulas seem to perform well in ranking several simplifications on a passage-level. But there certainly are limits. First, one must understand that calculating "how much simple" is a much difficult task (Table 5). Second, the good results could be because sufficient simplification was done. For more fine grained simplifications, readability formulas could not be enough.

7.2 Text Simplification - Sentence-based

We were surprised that some existing text simplification studies are directly using traditional readability formulas for sentence difficulty evaluation. Our results show that using a formula-based approach is particularly useless in evaluating a sentence.

We tested both CCB-recalibrated and original formulas on ASSET. Here, a correct prediction must properly rank eleven simplified items. Despite the task difficulty, we anticipated seeing some correct predictions as there were 360 pairs. SMOG guessed 37 (after recalibration) and 89 (before recalibration) correct out of 360. But all the other formulas failed to make any correct prediction.

OSE-Sent poses an easier task. Since the dataset is divided into adv-int, adv-ele, and int-ele, the readability formulas now had to guess which is more difficult, out of the given two. We do obtain some positive results, showing that readability for-

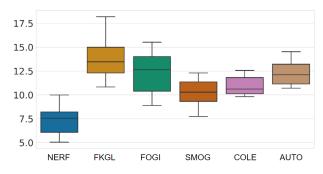


Figure 1: On medical texts. NERF, against five others.

mulas can be useful in the cases where only two sentences are compared. On ranking two sentences, NERF performs better by a large margin.

7.3 Medical Documents

We argue that NERF is effective in fixing the overinflated prediction of difficulty on medical texts. Such sudden inflation is widely-reported (Zheng and Yu, 2017) as the common weaknesses of traditional readability formulas on medical documents.

The U.S. National Institute of Health (NIH) guides that patient documents be \leq K-6 of difficulty. The most distinct characteristic of medical documents is the use of lengthy medical terms, like otolaryngology, urogynecology, and rheumatology. This makes traditional formulas, based on syllables, unreliable. But NERF uses familiarity and age-of-acquisition to penalty and reward word difficulty.

A medical term not found in Kuperman's and SubtlexUS will have no effect. Instead, it will simply be labeled a content word. But in traditional formulas, the repetitive use of medical terms (which is likely the case) results in an insensible aggregation of text difficulty. In case various medical terms appear, NERF rewards each as a unique word.

Among recent studies is Haller et al. (2019), which analyzed the readability of urogynecology patient education documents in FKGL, SMOG, and Fry Readability. We also analyze the same 18 documents from the American Urogynecologic Society (AUGS) by manual OCR-based scraping. As Figure 1 shows, it is evident that NERF helps regulate the traditional readability formulas' tendencies to over-inflate on medical texts. An example of the collected resource is given in appendix B.

8 Conclusion

So far, we have recalibrated five traditional readability formulas and assessed their performances. We evaluated them on CCB and proved that the adjusted variations help traditional readability formulas give output more in align with CCB, a common English education curriculum used throughout the United States. Further, we evaluated the recalibrated formulas' application on text simplification research. On ranking passage difficulty, our recalibrated formulas showed good performance. However, the formulas lacked performance on ranking sentence difficulty because they were calibrated on passage-length instances. We leave sentence difficulty ranking as an open task.

Apart from recalibration traditional readability formulas, we also develop a new, linguistically-rich readability formulas named NERF. We prove that NERF can be much more useful when it comes to text simplification studies and analyzing the readability of medical documents. Also, our paper serves as a cross-comparison among readability metrics. Lastly, we develop a public Python-based software, for the fast dissemination of the results.

9 Limitations

Our work's limitations mainly come from CCB. It is manifestly difficult to obtain solid, gold readability-labelled dataset from an officially accredited organization. CCB, the main dataset that we used to calibrate traditional readability formulas, has only 69 items available. Thus, we reasonably anticipate that variation in dialect, individual differences and general ability cannot be captured.

However, we highlight that NERF is developed upon several more datasets that represent diverse background, audience, and reading level. Hence, we believe that NERF can counter some of the shallowness of the traditional readability formulas, despite the still existing weaknesses.

One aspect of readability formulas that have not been deeply investigated is how the output changes depending on the text length. As we show in section 7, readability formulas fail to perform well on sentence-level items. But how about a passage of three sentences? Or does the performance have to do with the average number of words in the recalibration dataset? Is there some sensible range that the readability formulas work well for? These are some open question we fail to address in this work.

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A Public Resources We Developed

A.1 Python Library

A.1.1 As a Readability Tool

<Anonymous> supports six readability formulas: NERF, FKGL, FOGI, SMOG, COLE and AUTO. All formulas, other than NERF, are also available in recalibrated variations. A particularly useful feature of this library is that all formulas are fitted to give the U.S. standard school grading system as output. Compared to some other traditional readability formulas where a user has to refer to a table understand output, K-* based numbers are intuitive.

A.1.2 As a General Tool

We have plans to expand <Anonymous> to support various menial tasks in text analysis. We are to focus on the tasks that can be better performed using simplistic approaches. One feature that we had already implemented is text reading time estimation. Weller et al. (2020) has previously shown in a large-scale study that a commonly used rule-of-thumb for online reading estimates, 240 words per minute (WPM), shows better RMSE and MAE results when compared to more modern approaches using XLNet (Yang et al., 2019), ELMo (Peters et al., 2018) and RoBERTa (Liu et al., 2019). We implement 175, 240 and 300 WPM.

A.1.3 Basic Usage

For straightforward maintenance, we keep <Anonymous>'s architecture as simple as possible. There are not many steps for the user to take:

```
import <Anonymous>
new_object = <Anonymous>.request(...)
readability_score1 = new_object.NERF()
readability_score2 = new_object.FKGL()
readability_score3 = new_object.FOGI()
readability_score4 = new_object.SMOG()
readability_score5 = new_object.COLE()
readability_score6 = new_object.AUTO()
time_to_read = new_object.RT()
```

NERF(), FKGL(), FOGI(), SMOG(), COLE(), AUTO(), RT() are shortcut functions. It can be *slightly* faster to directly call in the full forms as: *new_english_readability_formula()* flesch_kincaid_grade_level()

```
fog_index()

smog_index()

coleman_liau_index()

automated_readability_index()

read_time()
```

Further, all readability formula functions (except for NERF) has option to choose the original or the adjusted variation. Default is set *adjusted* = *True*.

A.1.4 <Anonymous> Speed to Calculation

We care for the library's calculation speed so that it can be of practical use for research implementations. We chose the following items for evaluation. **ITEM A**

In those times panics were common, and few days passed without some city or other registering in its archives an event of this kind. There were nobles, who made war against each other; there was the king, who made war against the cardinal; there was Spain, which made war against the king. Then, in addition to these concealed or public, secret or open wars, there were robbers, mendicants, Huguenots, wolves, and scoundrels, who made war upon everybody. The citizens always took up arms readily against thieves, wolves or scoundrels, often against nobles or Huguenots, sometimes against the king, but never against the cardinal or Spain. It resulted, then, from this habit that on the said first Monday of April, 1625, the citizens, on hearing the clamor, and seeing neither the red-and-yellow standard nor the livery of the Duc de Richelieu, rushed toward the hostel of the Jolly Miller. When arrived there, the cause of the hubbub was apparent to all.

The Three Musketeers, Alexandre Dumas

ITEM B

The vaccine contains lipids (fats), salts, sugars and buffers. COVID-19 vaccines do not contain eggs, gelatin (pork), gluten, latex, preservatives, antibiotics, adjuvants or aluminum. The vaccines are safe, even if you have food, drug, or environmental allergies. Talk to a health care provider first before getting a vaccine if you have allergies to the following vaccine ingredients: polyethylene glycol (PEG), polysorbate 80 and/or tromethamine (trometamol or Tris).

COVID-19 Vaccine Information Sheet, Ministry of Health, Ontario Canada

ITEM C

BERT alleviates the previously mentioned unidirectionality constraint by using a "masked language model"(MLM) pre-training objective, inspired by the Cloze task.

Pre-training of Deep Bidirectional Transformers for Language Understanding, Jacob Devlin, Ming-Wei Chang, Kenton Lee, Kristina Toutanova

First, it is very obvious that AUTO does a great job in keeping calculation speed short for longer

| a) ITEM A | NERF | FKGL | FOGI | SMOG | COLE | AUTO |
|-----------|--------|--------|--------|--------|--------|--------|
| item * 1 | 0.6371 | 0.0002 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| item * 5 | 2.6450 | 0.0006 | 0.0005 | 0.0004 | 0.0001 | 0.0001 |
| item * 10 | 5.5175 | 0.0011 | 0.0010 | 0.0010 | 0.0004 | 0.0004 |
| item * 15 | 7.8088 | 0.0016 | 0.0016 | 0.0013 | 0.0003 | 0.0004 |
| item * 20 | 10.226 | 0.0021 | 0.0021 | 0.0018 | 0.0004 | 0.0004 |
| b) ITEM B | NERF | FKGL | FOGI | SMOG | COLE | AUTO |
| item * 1 | 0.3531 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| item * 5 | 1.2842 | 0.0003 | 0.0003 | 0.0002 | 0.0000 | 0.0000 |
| item * 10 | 2.5178 | 0.0005 | 0.0005 | 0.0004 | 0.0001 | 0.0001 |
| item * 15 | 3.6545 | 0.0009 | 0.0007 | 0.0006 | 0.0002 | 0.0002 |
| item * 20 | 4.8308 | 0.0010 | 0.0010 | 0.0009 | 0.0002 | 0.0002 |
| c) ITEM C | NERF | FKGL | FOGI | SMOG | COLE | AUTO |
| item * 1 | 0.1373 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| item * 5 | 0.1888 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| item * 10 | 0.2528 | 0.0002 | 0.0002 | 0.0002 | 0.0000 | 0.0000 |
| item * 15 | 0.3420 | 0.0003 | 0.0003 | 0.0002 | 0.0000 | 0.0000 |
| item * 20 | 0.3886 | 0.0004 | 0.0003 | 0.0003 | 0.0000 | 0.0000 |

Table 8: Speeds in seconds, on Items A, B and C.

texts as originally intended. Second, NERF's calculation speed linearly increases in respect to the text length. Though, we believe that NERF's speed is decent in its wide linguistic coverage, it seems true that the speed is weakness when compared to the other readability formulas.

A.2 Research Archive

Our datasets, preprocessing codes and evaluation codes can be found in <Anonymous>. Copyrighted resources are given upon request to the first author.

B External Resources

B.1 Python Libraries

pandas v.1.3.4 (Wes McKinney, 2010)

Calculations for Kuperman's AoA CSV, SubtlexUS word familiarity CSV, manage and manipulate data. For feature study purposes, correlate and rank features in Tables 3 and 4.

SuPar v.1.1.3 - CRF Parser

Constituency parsing on input sentences -> calculate tree height and count noun phrases.

spaCy v.3.2.0 (Honnibal and Johnson, 2015)

Sentence/dependency parsing on documents -> sent input into SuPar and count content words (POS).

Sci-Kit Learn v.1.0.1

Calculation, r2 score and MAE in Tables 2 and 5. **SciPy** v.1.7.3

Calculation of Pearson's r for Tables 2 and 5. Fitting function (scipy.optimize.curve_fit()) used to recalibrate traditional readability formulas and give coefficients for NERF in Table 2.

NLTK v.3.6.5

Calculation of tree height for NERF.

LingFeat v.1.0.0-beta.19

Extraction of handcrafted linguistic features.

B.2 Datasets

| New Class | CCB | WBT |
|-----------|-------------------|--------------------|
| K1.0 | K1 (Age 6-7) | N/A |
| K2.0 | N/A | Level 2 (Age 7-8) |
| K2.5 | K2-3 (Age 7-9) | N/A |
| K3.0 | N/A | Level 3 (Age 8-9) |
| K4.0 | N/A | Level 4 (Age 9-10) |
| K4.5 | K4-5 (Age 9-11) | N/A |
| K7.0 | K6-8 (Age 11-14) | KS3 (Age 11-14) |
| K9.5 | K9-10 (Age 14-16) | GCSE (Age 14-16) |
| K12.0 | K11-CCR (Age 16+) | N/A |

Table 9: Aged-based conversions for CCB and WBT.

We collected CCB by manually going through an official source². WBT was obtained from the authors³ in HTML format. We conducted basic preprocessing and manipulated WBT in CSV format. CAM was retrieved from an existing archive⁴. CKC was retrieved from a South Korean educational company⁵. OSE was retrieved from a public archive⁶. NSL was obtained from an American educational company⁷. AUGS medical texts (refer to Section 6.3) were manually scraped from the official website⁸. ASSET was obtained from a public repository⁹. Lastly, Table 8 shows how we converted WBT class labels to fit CCB and show in Table 1. All were consistent with intended use.

Further, to give more backgrounds to section 6.2, we give example pairs from ASSET and OSE-Sent. **ASSET**

- **0**: Gable earned an Academy Award nomination for portraying Fletcher Christian in Mutiny on the Bounty.
- 1: Gable also earned an Oscar nomination when he portrayed Fletcher Christian in 1935's Mutiny on the Bounty.
- **2**: Gable won an Academy Award vote when he acted in 1935's Mutiny on the Bounty as Fletcher Christian.

- **3**: Gable also won an Academy Award nomination when he played Fletcher Christian in the 1935 film Mutiny on the Bounty.
- **4**: Gable was nominated for an Academy Award for portraying Fletcher Christian in 1935's Mutiny on the Bounty.
- **5**: Gable also earned an Academy Award nomination in 1935 for playing Fletcher Christian in "Mutiny on the Bounty.
- **6**: Gable also earned an Academy Award nomination when he played Fletcher Christian in 1935's Mutiny on the Bounty.
- 7: Gable recieved an Academy Award nomination for his role as Fletcher Christian. The film was Mutiny on the Bounty (1935).
- **8**: Gable earned an Academy Award nomination for his role as Fletcher Christian in the 1935 film Mutiny on the Bounty.
- **9**: Gable also got an Academy Award nomination when he played Fletcher Christian in 1935's movie, Mutiny on the Bounty.
- **10**: Gable also earned an Academy Award nomination when he portrayed Fletcher Christian in 1935's Mutiny on the Bounty.

OSE-Sent (ADV-ELE)

ADV: The Seattle-based company has applied for its brand to be a top-level domain name (currently .com), but the South American governments argue this would prevent the use of this internet address for environmental protection, the promotion of indigenous rights and other public interest uses.

ELE: Amazon has asked for its company name to be a top-level domain name (currently .com), but the South American governments say this would stop the use of this internet address for environmental protection, indigenous rights and other public interest uses.

OSE-Sent (ADV-INT)

ADV: Brazils latest funk sensation, Anitta, has won millions of fans by taking the favela sound into the mainstream, but she is at the centre of a debate about skin colour.

INT: Brazils latest funk sensation, Anitta, has won millions of fans by making the favela sound popular, but she is at the centre of a debate about skin colour.

OSE-Sent (INT-ELE)

INT: Allowing private companies to register geo-

²corestandards.org/assets/Appendix_B.pdf

³Dr. Sowmya Vajjala, National Research Council, Canada

⁴ilexir.co.uk/datasets/index.html

⁵Bruce W. Lee, LXPER Inc., South Korea

⁶github.com/nishkalavallabhi/OneStopEnglishCorpus

⁷Luke Orland, Newsela Inc., New York, U.S.A.

⁸augs.org/patient-fact-sheets/

⁹github.com/facebookresearch/asset

graphical names as gTLDs to strengthen their brand or to profit from the meaning of these names is not, in our view, in the public interest, the Brazilian Ministry of Science and Technology said.

ELE: Allowing private companies to register geographical names as gTLDs to profit from the meaning of these names is not, in our view, in the public interest, the Brazilian Ministry of Science and Technology said.

The following is an example of the AUGS medical documents used in Section 6.3 and Figure 1. Interstitial Cystitis: Interstitial Cystitis/ Bladder Pain Syndrome Interstitial cystitis/bladder pain syndrome (IC/BPS) is a condition with symptoms including burning, pressure, and pain in the bladder along with urgency and frequency. About IC/BPS IC/BPS occurs in three to seven percent of women, and can affect men as well. Though usually diagnosed among women in their 40s, younger and older women have IC/BPS, too. It can feel like a constant bladder infection. Symptoms may become severe (called a "flare") for hours, days or weeks, and then disappear. Or, they may linger at a very low level during other times. Individuals with IC/BPS may also have other health issues such as irritable bowel syndrome, fibromyalgia, chronic headaches, and vulvodynia. Depression and anxiety are also common among women with this condition. The cause of IC/BPS is unknown. It is likely due to a combination of factors. IC/BPS runs in families and so may have a genetic factor. On cystoscopy, the doctor may see damage to the wall of the bladder. This may allow toxins from the urine to seep into the delicate layers of the bladder lining, causing the pain of IC/BPS. Other research found that nerves in and around the bladder of people with IC/BPS are hypersensitive. This may also contribute to IC/BPS pain. There may also be an allergic component.

C CCB Human Predictions

In Section 2.1, we mention that human predictions were collected on Amazon Mechanical Turk. Then, we compared human performance to readability formulas in Table 5. Here, surveys are designed.

Description: must choose which difficulty level does the text belong, "difficulty does not correlate with text length"

Qualification Requirement(s): Location is one of US, HIT Approval Rate (%) for all Requesters'

HITs greater than 80, Number of HITs Approved greater than 50, US Bachelor's Degree equal to true, Masters has been granted

All 69 story-type items from CCB were given. Each item had to be completed by at least 10 different individuals, resulting in 690 responses in total. They were given 6 representative examples. Payments were adequately and they were informed that the responds shall be used for research.

D Handcrafted Linguistic Features and the Respective Generalizability

We give full generalizability rankings that we obtained through LingFeat. Considering that much work has to be done on the generalizability of RA, we believe that these rankings are particularly helpful. Table 9, Table 10, Table 11, Table 12, Table 13, Table 14, Table 15 are expanded versions of Table 3 and Table 4. The features not shown scored a 0.

From the full rankings, it is clear that shallow traditional (surface-level), lexico-semantic and syntactic features are effective throughout all datasets. Advanced semantics and discourse features show some what similar mid-low performances. However, it should be acknowledged that among the worst performing are lexico-semantic and syntactic features, too. This is perhaps because LingFeat itself has a very lexico-semantics and syntax-focused collection of handcrafted linguistic features. Thus, more study is needed.

Even if two features are from the same group (phrasal), they could show drastically varying performances (# Noun phrases per Sent - scored 39 in approach A v.s. # Verb phrases per Sent - scored 1 in approach A). Hence, thorough feature study must always be conducted during research. In a feature selection for a readability-related model, a cherry picking the most well performing feature from each feature group is recommended.

E Computing Power

Single CPU chip. **Architecture**: x86_64; **CPU**(s): 16; **Model name**: Intel(R) Core(TM) i9-9900KF CPU @ 3.60GHz; **CPU MHz**: 800.024

| | | | Fe | eature | ССВ | WBT | CAM | СКС | OSE |
|----------|--------|--------------------------------------|--------------------------|--|----------------------|------------------------|-----------------------|-----------------------|------------------------|
| Score | Branch | Subgroup | LingFeat Code | Brief Explanation | r rk | r rk | r rk | r rk | r rk |
| 43 | | Shallow | as_Sylla_C | # syllables per Sent | 0.541 24 | 0.461 10 | 0.686 50 | 0.697 11 | 0.59 31 |
| 43 | | Psycholinguistic | | lemmas AoA of lemmas per Sent | 0.54 25 | 0.505 1 | 0.722 42 | 0.711 4 | 0.601 25 |
| 43 43 | | Shallow Psycholinguistic | as_Chara_C as_AAKuW_C | # characters per Sent AoA of words per Sent | 0.539 27 0.537 28 | 0.487 4 0.502 2 | 0.696 46 0.722 41 | 0.711 5 0.711 6 | 0.613 20 0.602 24 |
| 42 | | Tree Structure | as_FTree_C | length of flattened Trees per Sent | 0.505 37 | 0.485 5 | 0.677 54 | 0.719 2 | 0.622 16 |
| 40 | - | Psycholinguistic | at_AAKuW_C | AoA of words per Word | 0.703 5 | 0.308 36 | 0.784 20 | 0.643 21 | 0.455 66 |
| 40 | - | Tree Structure | as_TreeH_C | Tree height per Sent | 0.55 21 | 0.341 30 | 0.686 51 | 0.699 9 | 0.541 44 |
| 40 40 | - | Part-of-Speech Shallow | as_ContW_C as_Token_C | # Content words per Sent # tokens per Sent | 0.534 29 0.494 40 | 0.453 13 0.464 9 | 0.667 56 | 0.688 14 0.709 7 | 0.544 43 0.58 36 |
| 39 | | Psycholinguistic Psycholinguistic | at_AAKuL_C | lemmas AoA of lemmas per Word | 0.723 2 | 0.323 35 | 0.785 19 | 0.65 20 | 0.453 67 |
| 39 | | Phrasal | as_NoPhr_C | # Noun phrases per Sent | 0.55 20 | 0.406 25 | 0.66 58 | 0.673 18 | 0.582 35 |
| 39 | Synta | Phrasal | to_PrPhr_C | total # prepositional phrases | 0.47 47 | 0.189 58 | 0.808 11 | 0.58 36 | 0.729 3 |
| 39 38 | - | Part-of-Speech | as_FuncW_C to_AAKuL_C | # Function words per Sent | 0.468 48 0.428 71 | 0.471 8 0.189 59 | 0.662 57 0.835 3 | 0.673 17 0.627 22 | 0.614 19 0.716 5 |
| 38 | | Psycholinguistic Psycholinguistic | | total lemmas AoA of lemmas total AoA (Age of Acquisition) of words | 0.428 71 0.427 72 | 0.189 59 | 0.835 4 | 0.627 22 | 0.715 6 |
| 36 | | Phrasal | as_PrPhr_C | # prepositional phrases per Sent | 0.513 35 | 0.417 23 | 0.607 70 | 0.608 28 | 0.59 32 |
| 36 | LxSem | Word Familiarity | as_SbL1C_C | SubtlexUS Lg10CD value per Sent | 0.467 49 | 0.43 20 | 0.612 69 | 0.699 10 | 0.533 45 |
| 35 | | Type Token Ratio | | Corrected TTR | 0.745 1 | 0.006 228 | 0.846 1 | 0.445 65 | 0.692 7 |
| 35 34 | | Word Familiarity Part-of-Speech | as_SbL1w_C as_NoTag_C | SubtlexUS Lg10WF value per Sent # Noun POS tags per Sent | 0.462 52 0.551 19 | 0.437 19 0.304 38 | 0.605 71 0.624 65 | 0.693 12 0.608 29 | 0.523 48 0.48 61 |
| 34 | - | Psycholinguistic | as_AACoL_C | AoA of lemmas, Cortese and Khanna norm per Sent | 0.532 30 | 0.339 32 | 0.649 61 | 0.597 32 | 0.499 58 |
| 34 | | Psycholinguistic | as_AABrL_C | lemmas AoA of lemmas, Bristol norm per Sent | 0.532 31 | 0.339 31 | 0.649 62 | 0.597 31 | 0.499 57 |
| 34 | | Psycholinguistic | to_AABrL_C | total lemmas AoA of lemmas, Bristol norm | 0.451 56 | 0.134 100 | 0.808 10 | 0.561 38 | 0.637 12 |
| 33 33 | | Psycholinguistic Phrasal | as_AABiL_C to_NoPhr_C | lemmas AoA of lemmas, Bird norm per Sent | 0.459 55 0.416 76 | 0.458 11 0.148 84 | 0.582 73 0.809 8 | 0.653 19 0.527 52 | 0.443 69 0.659 9 |
| 33 | - | Part-of-Speech | to_ContW_C | total # Noun phrases total # Content words | 0.416 76 | 0.148 84 0.163 71 | 0.809 8 | 0.558 40 | 0.654 11 |
| 32 | | Variation Ratio | CorrNoV_S | Corrected Noun Variation-1 | 0.717 3 | 0.086 131 | 0.842 2 | 0.406 78 | 0.612 21 |
| 32 | LxSem | Variation Ratio | CorrVeV_S | Corrected Verb Variation-1 | 0.602 11 | 0.058 155 | 0.801 15 | 0.393 86 | 0.737 2 |
| 32 | | Psycholinguistic | to_AACoL_C | total AoA of lemmas, Cortese and Khanna norm | 0.451 57 | 0.134 101 | 0.808 9 | 0.561 39 | 0.637 13 |
| 32 32 | | Part-of-Speech Tree Structure | as_VeTag_C to_FTree_C | # Verb POS tags per Sent total length of flattened Trees | 0.428 70 0.396 87 | 0.476 6 0.166 69 | 0.578 74 0.805 12 | 0.588 34 0.538 49 | 0.505 55 0.676 8 |
| 31 | | Variation Ratio | SquaNoV_S | Squared Noun Variation-1 | 0.590 87 | 0.100 09 | 0.805 12 | 0.401 84 | 0.583 34 |
| 31 | | Variation Ratio | CorrAjV_S | Corrected Adjective Variation-1 | 0.591 12 | 0.078 134 | 0.779 21 | 0.422 70 | 0.584 33 |
| 31 | - | Part-of-Speech | to_AjTag_C | total # Adjective POS tags | 0.441 62 | 0.191 57 | 0.777 23 | 0.504 54 | 0.525 46 |
| 30 | | Variation Ratio | SquaVeV_S | Squared Verb Variation-1 | 0.559 17 | 0.076 138 | 0.777 22 | 0.384 90 | 0.716 4 |
| 30 30 | - | Part-of-Speech Phrasal | to_NoTag_C as_VePhr_C | total # Noun POS tags # Verb phrases per Sent | 0.441 61 0.383 90 | 0.129 107 0.455 12 | 0.805 13 0.59 72 | 0.55 44 0.586 35 | 0.636 15 0.505 54 |
| 29 | - | Word Familiarity | as_SbCDL_C | SubtlexUS CDlow value per Sent | 0.432 65 | 0.441 14 | 0.527 82 | 0.623 26 | 0.401 85 |
| 28 | Synta | Part-of-Speech | as_AjTag_C | # Adjective POS tags per Sent | 0.506 36 | 0.353 28 | 0.553 76 | 0.533 51 | 0.404 84 |
| 28 | Disco | Entity Grid | ra_NNTo_C | ratio of nn transitions to total | 0.476 44 | 0.078 135 | 0.754 35 | 0.451 64 | 0.602 23 |
| 28 28 | Synta | Tree Structure Word Familiarity | at_TreeH_C | Tree height per Word SubtlexUS CD# value per Sent | 0.476 45 0.431 67 | 0.419 22 0.437 17 | 0.416 104 0.525 84 | 0.597 33 0.624 24 | 0.41 81 0.404 82 |
| 28 | | Word Familiarity | | SubtlexUS SUBTLCD value per Sent | 0.431 68 | 0.437 17 | 0.525 85 | 0.624 25 | 0.404 83 |
| 28 | | Word Familiarity | | total SubtlexUS Lg10CD value | 0.37 93 | 0.14 95 | 0.797 16 | 0.491 56 | 0.621 17 |
| 27 | | Variation Ratio | SquaAjV_S | Squared Adjective Variation-1 | 0.531 32 | 0.141 94 | 0.754 34 | 0.407 77 | 0.573 37 |
| 27 | | Word Familiarity | | SubtlexUS FREQIow value per Sent | 0.443 60 | 0.426 21 | 0.52 86 0.509 91 | 0.552 42 0.542 48 | 0.425 77 |
| 26 26 | | Word Familiarity Word Familiarity | | SubtlexUS SUBTLWF value per Sent SubtlexUS FREQ# value per Sent | 0.44 63 | 0.441 15 0.441 16 | 0.509 91 | 0.542 48 | 0.425 76 0.425 75 |
| 26 | | Word Familiarity | | total SubtlexUS Lg10WF value | 0.365 99 | 0.144 93 | 0.795 17 | 0.477 58 | 0.611 22 |
| 25 | | Psycholinguistic | | total lemmas AoA of lemmas, Bird norm | 0.365 98 | 0.155 79 | 0.786 18 | 0.473 59 | 0.565 39 |
| 25 | | Word Familiarity | | total SubtlexUS FREQlow value | 0.348 109 | 0.201 51 | 0.774 24 | 0.414 74 | 0.555 40 |
| 24 24 | | Word Familiarity Word Familiarity | | total SubtlexUS FREQ# value total SubtlexUS SUBTLWF value | 0.34 116 0.34 115 | 0.206 48 0.206 47 | 0.77 26 0.77 27 | 0.403 82 0.403 81 | 0.551 41 0.551 42 |
| 23 | | Shallow | at_Sylla_C | # syllables per Word | 0.66 7 | 0.106 120 | 0.627 64 | 0.505 53 | 0.37 91 |
| 23 | Synta | Phrasal | to_SuPhr_C | total # Subordinate Clauses | 0.367 96 | 0.202 50 | 0.721 43 | 0.462 61 | 0.419 78 |
| 23 | - | Phrasal | to_VePhr_C | total # Verb phrases | 0.324 127 | 0.169 68 | 0.76 31 | 0.416 72 | 0.57 38 |
| 22 22 | | Wiki Knowledge Variation Ratio | WTopc15_S CorrAvV_S | Number of topics, 150 topics extracted from Wiki Corrected AdVerb Variation-1 | 0.58 15 0.542 23 | 0.007 227 0.059 154 | 0.645 63 0.71 44 | 0.605 30 0.333 99 | 0.191 122 0.474 63 |
| 22 | | Shallow | at_Chara_C | # characters per Word | 0.342 23 | 0.039 134 | 0.619 67 | 0.333 99 | 0.474 63 |
| 22 | | Part-of-Speech | to_CoTag_C | total # Coordinating Conjunction POS tags | 0.364 101 | 0.268 43 | 0.728 39 | 0.406 80 | 0.434 72 |
| 22 | | Part-of-Speech | to_FuncW_C | total # Function words | 0.33 126 | 0.159 77 | 0.773 25 | 0.385 89 | 0.636 14 |
| 22 | | Part-of-Speech | to_VeTag_C | total # Verb POS tags | 0.288 138 | 0.173 63 | 0.738 38 | 0.383 91 | 0.597 27 |
| 21 20 | | Wiki Knowledge Variation Ratio | WTopc20_S SquaAvV_S | Number of topics, 200 topics extracted from Wiki Squared AdVerb Variation-1 | 0.584 14 0.515 34 | 0.015 214 0.093 128 | 0.616 68 0.686 52 | 0.617 27 0.326 102 | 0.137 138 0.46 65 |
| 19 | | Phrasal | as_SuPhr_C | # Subordinate Clauses per Sent | 0.313 34 0.387 89 | 0.093 128 | 0.686 32 0.532 80 | 0.326 102 | 0.46 63 |
| 19 | - | Word Familiarity | | total SubtlexUS CDlow value | 0.348 107 | 0.148 87 | 0.764 30 | 0.394 85 | 0.513 53 |
| 18 | | Type Token Ratio | | Uber Index | 0.646 8 | 0.041 174 | 0.369 112 | 0.109 173 | 0.599 26 |
| 18 | | Wiki Knowledge | | Number of topics, 100 topics extracted from Wiki | 0.52 33 | 0.004 229 | 0.532 79 | 0.552 43 | 0.075 180 |
| 18 18 | | Wiki Knowledge Part-of-Speech | WNois20_S to_SuTag_C | Semantic Noise, 200 topics extracted from Wiki total # Subordinating Conjunction POS tags | 0.492 41 0.4 83 | 0.032 190 0.193 56 | 0.566 75 0.691 48 | 0.572 37 0.406 79 | 0.025 221 0.299 106 |
| 18 | | Word Familiarity | | total # Subordinating Conjunction POS tags total SubtlexUS SUBTLCD value | 0.4 83 | 0.193 36 | 0.691 48 | 0.406 79 | 0.299 106 0.515 52 |
| 18 | | Word Familiarity | | total SubtlexUS CD# value | 0.347 110 | 0.146 90 | 0.764 29 | 0.392 87 | 0.515 51 |
| 10 | | | | | 0.342 114 | 0.17 67 | 0.726 40 | | |

Table 10: Part A. The full generalizability ranking of handcrafted linguistic features under Approach A. r: Pearson's correlation between the feature and the dataset. rk: the feature's correlation ranking on the specific dataset.

| | | | | Feature | ССВ | WBT | CAM | СКС | OSE |
|----------|-----------------|--------------------------------------|--------------------------|--|------------------------|------------------------|------------------------|------------------------|------------------------|
| Score | Branch | Subgroup | LingFeat Code | Brief Explanation | r rk |
| | | Wiki Knowledge | WTopc05_S | Number of topics, 50 topics extracted from Wiki | 0.549 22 | 0.033 186 | 0.514 89 | 0.533 50 | 0.042 203 |
| 17 | - | Part-of-Speech | as_AvTag_C | # Adverb POS tags per Sent | 0.32 129 | 0.292 41 | 0.526 83 | 0.43 67 | 0.415 79 |
| 16 16 | | Type Token Ratio Wiki Knowledge | WRich15_S | Bi-Logarithmic TTR Semantic Richness, 150 topics extracted from Wiki | 0.591 13 0.495 39 | 0.062 149 0.02 208 | 0.07 200 0.48 95 | 0.001 229 0.549 45 | 0.523 47 0.037 209 |
| 16 | | Part-of-Speech | as_CoTag_C | # Coordinating Conjunction POS tags per Sent | 0.38 91 | 0.411 24 | 0.463 97 | 0.442 66 | 0.293 107 |
| 15 | | Phrasal | to_AvPhr_C | total # Adverb phrases | 0.356 105 | 0.17 66 | 0.705 45 | 0.298 111 | 0.432 73 |
| 15 | | Shallow | TokSenL_S | log(total # tokens)/log(total # sentence) | 0.293 137 | 0.352 29 | 0.297 130 | 0.544 46 | 0.198 121 |
| 14 | | Wiki Knowledge | | Semantic Richness, 200 topics extracted from Wiki | 0.465 50 | 0.029 195 | 0.446 102 0.316 124 | 0.556 41 | 0.027 219 |
| 13 13 | Synta Synta | Phrasal Phrasal | at_PrPhr_C ra_NoPrP_C | # prepositional phrases per Word ratio of Noun phrases # to Prep phrases # | 0.57 16 0.477 43 | 0.133 103 0.149 83 | 0.316 124 | 0.323 105 0.345 97 | 0.366 92 0.389 87 |
| 13 | Disco | Entity Grid | ra_SNTo_C | ratio of sn transitions to total | 0.448 58 | 0.019 210 | 0.514 88 | 0.196 133 | 0.518 49 |
| 13 | | Word Familiarity | | SubtlexUS Lg10CD value per Word | 0.408 78 | 0.161 75 | 0.541 78 | 0.204 130 | 0.392 86 |
| 13 | Synta | Part-of-Speech | as_SuTag_C | # Subordinating Conjunction POS tags per Sent | 0.366 97 | 0.295 39 | 0.407 105 | 0.427 68 | 0.151 131 |
| 13 | | Shallow Tree Structure | TokSenS_S | sqrt(total # tokens x total # sentence) | 0.241 154 0.27 145 | 0.064 147 0.069 143 | 0.758 32 0.755 33 | 0.249 121 0.309 108 | 0.498 59 0.515 50 |
| 13 13 | Synta Synta | Tree Structure Phrasal | to_TreeH_C as_AvPhr_C | total Tree height of all sentences # Adverb phrases per Sent | 0.27 143 0.244 152 | 0.328 34 | 0.733 33 0.427 103 | 0.309 108 | 0.313 30 |
| 12 | Disco | Entity Grid | ra_NSTo_C | ratio of ns transitions to total | 0.426 73 | 0.033 187 | 0.516 87 | 0.266 117 | 0.505 56 |
| 12 | Synta | Phrasal | to_AjPhr_C | total # Adjective phrases | 0.339 120 | 0.182 62 | 0.682 53 | 0.327 101 | 0.271 111 |
| 11 | | Wiki Knowledge | | Semantic Noise, 50 topics extracted from Wiki | 0.462 53 | 0.061 150 | 0.455 100 | 0.412 75 | 0.118 151 |
| 11 | | Phrasal | ra_PrNoP_C | ratio of Prep phrases # to Noun phrases # | 0.421 75 | 0.162 74 | 0.276 135 | 0.344 98 | 0.37 90 |
| 11 10 | Sna 1r Synta | Shallow Phrasal | TokSenM_S ra_VeNoP_C | total # tokens x total # sentence ratio of Verb phrases # to Noun phrases # | 0.189 173 0.46 54 | 0.112 116 0.164 70 | 0.674 55 0.124 174 | 0.177 140 0.041 209 | 0.486 60 0.027 220 |
| 10 | | Entity Density | at UEnti C | number of unique Entities per Word | 0.127 197 | 0.307 37 | 0.548 77 | 0.253 119 | 0.124 149 |
| 9 | | Variation Ratio | SimpNoV_S | Noun Variation-1 | 0.499 38 | 0.087 130 | 0.038 212 | 0.031 213 | 0.337 95 |
| 9 | • | Part-of-Speech | at_VeTag_C | # Verb POS tags per Word | 0.431 69 | 0.187 61 | 0.076 196 | 0.111 171 | 0.011 224 |
| 9 | | Word Familiarity | | SubtlexUS Lg10WF value per Word | 0.399 84 | 0.089 129 | 0.531 81 | 0.24 123 | 0.412 80 |
| 9 | • | Part-of-Speech | ra_VeNoT_C | ratio of Verb POS # to Noun POS # | 0.397 86 | 0.198 53 0.032 192 | 0.234 142 | 0.171 142 | 0.067 186 0.435 71 |
| 9 9 | | Word Familiarity Word Familiarity | | SubtlexUS SUBTLCD value per Word SubtlexUS CD# value per Word | 0.37 94 0.37 95 | 0.032 192 | 0.492 93 0.492 94 | 0.324 103 0.324 104 | 0.435 71 |
| 9 | | Phrasal | as_AjPhr_C | # Adjective phrases per Sent | 0.323 128 | 0.239 46 | 0.387 106 | 0.357 95 | 0.157 127 |
| 9 | AdSem | WB Knowledge | BClar15_S | Semantic Clarity, 150 topics extracted from WeeBit | 0.025 221 | 0.161 76 | 0.38 108 | 0.481 57 | 0.315 100 |
| 8 | | Wiki Knowledge | WNois15_S | Semantic Noise, 150 topics extracted from Wiki | 0.388 88 | 0.033 188 | 0.454 101 | 0.454 63 | 0.006 226 |
| 8 | | Entity Density | at_EntiM_C | number of Entities Mentions #s per Word | 0.17 180 | 0.204 49 | 0.501 92 | 0.292 112 | 0.127 146 |
| 8 7 | | WB Knowledge Phrasal | BClar20_S ra_PrVeP_C | Semantic Clarity, 200 topics extracted from WeeBit ratio of Prep phrases # to Verb phrases # | 0.004 227 0.485 42 | 0.147 88 0.055 157 | 0.3 129 0.184 158 | 0.462 60 0.189 136 | 0.308 104 0.219 117 |
| 7 | | Word Familiarity | | SubtlexUS CDlow value per Word | 0.362 102 | 0.047 166 | 0.474 96 | 0.31 107 | 0.431 74 |
| 7 | Synta | Part-of-Speech | ra_CoNoT_C | ratio of Coordinating Conjunction POS # to Noun POS # | 0.02 224 | 0.277 42 | 0.159 163 | 0.013 222 | 0.132 142 |
| 7 | | Part-of-Speech | at_CoTag_C | # Coordinating Conjunction POS tags per Word | 0.218 161 | 0.267 44 | 0.02 220 | 0.111 172 | 0.087 169 |
| 7 | • | Part-of-Speech | ra_NoCoT_C | ratio of Noun POS # to Coordinating Conjunction # | 0.022 222 | 0.254 45 | 0.019 221 | 0.053 201 | 0.109 157 |
| 6 6 | | Phrasal Entity Grid | ra_VePrP_C ra_XNTo_C | ratio of Verb phrases # to Prep phrases # ratio of xn transitions to total | 0.475 46 0.339 119 | 0.018 211 0.103 124 | 0.301 127 0.658 59 | 0.255 118 0.327 100 | 0.249 114 0.29 108 |
| 6 | | WB Knowledge | BTopc15_S | Number of topics, 150 topics extracted from WeeBit | 0.133 193 | 0.146 92 | 0.209 151 | 0.416 73 | 0.03 217 |
| 6 | LxSem | Word Familiarity | | SubtlexUS SUBTLWF value per Word | 0.181 175 | 0.196 54 | 0.095 184 | 0.021 220 | 0.109 156 |
| 6 | | Word Familiarity | _ | SubtlexUS FREQ# value per Word | 0.181 174 | 0.196 55 | 0.095 183 | 0.021 219 | 0.109 155 |
| 5 5 | | Part-of-Speech Wiki Knowledge | ra_NoVeT_C | ratio of Noun POS # to Verb POS # Semantic Richness, 100 topics extracted from Wiki | 0.432 66 0.364 100 | 0.118 111 0.002 232 | 0.149 168 0.33 123 | 0.112 170 0.411 76 | 0.051 197 0.041 206 |
| 5 | | Entity Grid | ra NXTo C | ratio of nx transitions to total | 0.339 118 | 0.002 232 | 0.62 66 | 0.28 116 | 0.041 200 |
| 5 | | Part-of-Speech | at_FuncW_C | # Function words per Word | 0.28 142 | 0.04 175 | 0.181 159 | 0.461 62 | 0.032 215 |
| 5 | | WB Knowledge | BTopc20_S | Number of topics, 200 topics extracted from WeeBit | 0.25 150 | 0.135 99 | 0.025 215 | 0.418 71 | 0.044 198 |
| 5 | | Variation Ratio | SimpVeV_S | Verb Variation-1 | 0.286 139 | 0.048 165 | 0.081 193 | 0.003 226 | 0.48 62 |
| 5 | | Part-of-Speech | ra_VeCoT_C | ratio of Verb POS # to Coordinating Conjunction # | 0.192 172 | 0.172 64 | 0.134 171 | 0.022 218 | 0.054 194 |
| 5 4 | | Word Familiarity Phrasal | at_SbFrL_C at_NoPhr_C | SubtlexUS FREQlow value per Word # Noun phrases per Word | 0.176 178 0.424 74 | 0.171 65 0.066 146 | 0.061 203 0.089 188 | 0.001 228 0.005 224 | 0.09 165 0.042 202 |
| 4 | • | Type Token Ratio | | unique tokens/total tokens (TTR) | 0.375 92 | 0.025 200 | 0.367 113 | 0.163 147 | 0.344 94 |
| 4 | | Wiki Knowledge | | Semantic Noise, 100 topics extracted from Wikip | 0.34 117 | 0.021 207 | 0.376 109 | 0.426 69 | 0.03 216 |
| 4 | - | Phrasal | at_SuPhr_C | # Subordinate Clauses per Word | 0.204 165 | 0.157 78 | 0.246 140 | 0.314 106 | 0.073 182 |
| 4 | | Phrasal WR Knowledge | ra_SuNoP_C | ratio of Subordinate Clauses # to Noun phrases # | 0.081 203 | 0.163 72 | 0.224 146 | 0.307 109 | 0.086 170 |
| 4 | | WB Knowledge Part-of-Speech | BNois15_S ra_AjVeT_C | Semantic Noise, 150 topics extracted from WeeBit ratio of Adjective POS # to Verb POS # | 0.035 214 0.411 77 | 0.162 73 0.034 185 | 0.341 119 0.133 172 | 0.221 127 0.156 150 | 0.091 164 0.005 227 |
| 3 | - | Phrasal | ra_NoVeP_C | ratio of Noun phrases # to Verb phrases # | 0.406 79 | 0.068 145 | 0.069 201 | 0.031 212 | 0.003 227 |
| 3 | | Wiki Knowledge | | Semantic Richness, 50 topics extracted from Wiki | 0.405 80 | 0.063 148 | 0.347 117 | 0.301 110 | 0.035 211 |
| 3 | | Phrasal | ra_AvPrP_C | ratio of Adv phrases # to Prep phrases # | 0.4 82 | 0.014 217 | 0.222 147 | 0.196 135 | 0.115 152 |
| 3 | | Variation Ratio | SimpAjV_S | Adjective Variation-1 | 0.398 85 | 0.109 118 | 0.279 134 | 0.073 192 | 0.201 120 |
| 3 | - | Phrasal Part-of-Speech | ra_NoSuP_C ra_NoAjT_C | ratio of Noun phrases # to Subordinate Clauses # ratio of Noun POS # to Adjective POS # | 0.157 185 0.121 199 | 0.153 80 0.152 81 | 0.228 145 0.125 173 | 0.052 205 0.114 169 | 0.04 207 0.004 228 |
| 3 | | Part-of-Speech | ra_NoAj1_C ra_SuNoT_C | ratio of Subordinating Conjunction POS # to Noun POS # | 0.121 199 0.085 202 | 0.132 81 0.149 82 | 0.123 173 | 0.114 169 | 0.004 228 |
| 3 | | WB Knowledge | BNois20_S | Semantic Noise, 200 topics extracted from WeeBit | 0.129 196 | 0.148 85 | 0.202 153 | 0.167 144 | 0.032 214 |
| 2 | | Phrasal | ra_VeSuP_C | ratio of Verb phrases # to Subordinate Clauses # | 0.349 106 | 0.137 98 | 0.307 126 | 0.127 167 | 0.043 200 |
| 2 | - | Phrasal | ra_SuVeP_C | ratio of Subordinate Clauses # to Verb phrases # | 0.345 113 | 0.052 160 | 0.343 118 | 0.376 93 | 0.083 172 |
| 2 | Synta Disco | Part-of-Speech Entity Grid | ra_CoFuW_C ra_ONTo_C | ratio of Content words to Function words ratio of on transitions to total | 0.284 141 0.333 123 | 0.023 203 0.04 178 | 0.2 154 0.288 133 | 0.376 94 0.06 199 | 0.042 201 0.383 88 |
| 2 | | Entity Grid Entity Grid | ra_NOTo_C | ratio of no transitions to total | 0.333 123 | 0.04 178 | 0.288 133 | 0.06 199 | 0.383 88 |
| 2 | | WB Knowledge | BRich10_S | Semantic Richness, 100 topics extracted from WeeBit | 0.196 170 | 0.044 171 | 0.369 111 | 0.035 210 | 0.336 96 |
| 2 | Disco | Entity Density | to_UEnti_C | total number of unique Entities | 0.308 134 | 0.132 105 | 0.3 128 | 0.023 216 | 0.31 102 |
| 2 | - | Part-of-Speech | ra_AjCoT_C | ratio of Adjective POS # to Coordinating Conjunction # | 0.0 229 | 0.148 86 | 0.049 207 | 0.091 181 | 0.077 177 |
| 2 | Synta | Part-of-Speech | ra_AjNoT_C | ratio of Adjective POS # to Noun POS # | 0.074 205 | 0.146 89 | 0.031 213 | 0.068 195 | 0.041 205 |

Table 11: Part B. The full generalizability ranking of handcrafted linguistic features under Approach A.

| | | | | Feature | CC | В | WB | Т | CA | M | CK | C | os | E |
|-------|--------|------------------|---------------|--|-------|-----|-------|-----|-------|-----|-------|-----|-------|-----|
| Score | Branch | Subgroup | LingFeat Code | Brief Explanation | r | rk |
| 1 | Synta | Part-of-Speech | ra_SuVeT_C | ratio of Subordinating Conjunction POS # to Verb POS # | 0.36 | 103 | 0.053 | 159 | 0.109 | 177 | 0.282 | 115 | 0.137 | 139 |
| 1 | Synta | Part-of-Speech | ra_AjAvT_C | ratio of Adjective POS # to Adverb POS # | 0.357 | 104 | 0.042 | 172 | 0.056 | 204 | 0.091 | 180 | 0.044 | 199 |
| 1 | LxSem | Psycholinguistic | at_AABrL_C | lemmas AoA of lemmas, Bristol norm per Word | 0.333 | 124 | 0.029 | 194 | 0.462 | 98 | 0.284 | 113 | 0.217 | 118 |
| 1 | LxSem | Psycholinguistic | at_AACoL_C | AoA of lemmas, Cortese and Khanna norm per Word | 0.333 | 125 | 0.029 | 193 | 0.462 | 99 | 0.284 | 114 | 0.217 | 119 |
| 1 | AdSem | WB Knowledge | BNois10_S | Semantic Noise, 100 topics extracted from WeeBit | 0.193 | 171 | 0.036 | 180 | 0.37 | 110 | 0.161 | 149 | 0.33 | 97 |
| 1 | AdSem | WB Knowledge | BNois05_S | Semantic Noise, 50 topics extracted from WeeBit | 0.158 | 184 | 0.011 | 219 | 0.351 | 116 | 0.15 | 153 | 0.325 | 98 |
| 1 | AdSem | WB Knowledge | BTopc10_S | Number of topics, 100 topics extracted from WeeBit | 0.197 | 169 | 0.038 | 179 | 0.364 | 114 | 0.166 | 145 | 0.323 | 99 |
| 1 | Disco | Entity Density | to_EntiM_C | total number of Entities Mentions #s | 0.139 | 191 | 0.02 | 209 | 0.335 | 122 | 0.0 | 230 | 0.312 | 101 |
| 1 | AdSem | WB Knowledge | BRich05_S | Semantic Richness, 50 topics extracted from WeeBit | 0.126 | 198 | 0.051 | 162 | 0.24 | 141 | 0.051 | 207 | 0.309 | 103 |
| 1 | LxSem | Psycholinguistic | at_AABiL_C | lemmas AoA of lemmas, Bird norm per Word | 0.203 | 166 | 0.11 | 117 | 0.266 | 138 | 0.053 | 202 | 0.302 | 105 |
| 1 | Synta | Tree Structure | at_FTree_C | length of flattened Trees per Word | 0.28 | 143 | 0.14 | 96 | 0.097 | 182 | 0.1 | 177 | 0.152 | 130 |
| 1 | Synta | Phrasal | at_VePhr_C | # Verb phrases per Word | 0.31 | 132 | 0.138 | 97 | 0.079 | 194 | 0.032 | 211 | 0.009 | 225 |
| 1 | Synta | Part-of-Speech | ra_NoAvT_C | ratio of Noun POS # to Adverb POS # | 0.261 | 147 | 0.133 | 102 | 0.101 | 180 | 0.052 | 204 | 0.034 | 212 |
| 1 | Synta | Part-of-Speech | ra_CoVeT_C | ratio of Coordinating Conjunction POS # to Verb POS # | 0.302 | 135 | 0.133 | 104 | 0.023 | 218 | 0.133 | 164 | 0.088 | 168 |

Table 12: Part C. The full generalizability ranking of handcrafted linguistic features under Approach A.

| | | | Fe | eature | ССВ | WBT | CAM | CKC | OSE |
|----------|--------|------------------------------------|--------------------------|---|----------------------|----------------------|----------------------|----------------------|----------------------|
| Score | Branch | Subgroup | LingFeat Code | Brief Explanation | r rk |
| 35 | LxSem | Psycholinguistic | as_AAKuL_C | lemmas AoA of lemmas per Sent | 0.54 25 | 0.505 1 | 0.722 42 | 0.711 4 | 0.601 25 |
| 35 | LxSem | Psycholinguistic | as_AAKuW_C | AoA of words per Sent | 0.537 28 | 0.502 2 | 0.722 41 | 0.711 6 | 0.602 24 |
| 33 | ShaTr | Shallow | as_Chara_C | # characters per Sent | 0.539 27 | 0.487 4 | 0.696 46 | 0.711 5 | 0.613 20 |
| 33 | Synta | Tree Structure | as_FTree_C | length of flattened Trees per Sent | 0.505 37 | 0.485 5 | 0.677 54 | 0.719 2 | 0.622 16 |
| 32 | LxSem | Psycholinguistic | at_AAKuL_C | lemmas AoA of lemmas per Word | 0.723 2 | 0.323 35 | 0.785 19 | 0.65 20 | 0.453 67 |
| 32 | LxSem | Psycholinguistic | at_AAKuW_C | AoA of words per Word | 0.703 5 | 0.308 36 | 0.784 20 | 0.643 21 | 0.455 66 |
| 31 | Synta | Phrasal | as_NoPhr_C | # Noun phrases per Sent | 0.55 20 | 0.406 25 | 0.66 58 | 0.673 18 | 0.582 35 |
| 31 | | Shallow | as_Sylla_C | # syllables per Sent | 0.541 24 | 0.461 10 | 0.686 50 | 0.697 11 | 0.59 31 |
| 31 | | Part-of-Speech | as_ContW_C | # Content words per Sent | 0.534 29 | 0.453 13 | 0.667 56 | 0.688 14 | 0.544 43 |
| 31 | - | Phrasal | as_PrPhr_C | # prepositional phrases per Sent | 0.513 35 | 0.417 23 | 0.607 70 | 0.608 28 | 0.59 32 |
| 31 | | Shallow | as_Token_C | # tokens per Sent | 0.494 40 | 0.464 9 | 0.65 60 | 0.709 7 | 0.58 36 |
| 31 | - | Part-of-Speech | as_FuncW_C | # Function words per Sent | 0.468 48 | 0.471 8 | 0.662 57 | 0.673 17 | 0.614 19 |
| 31 | | Psycholinguistic | to_AAKuL_C | total lemmas AoA of lemmas | 0.428 71 | 0.189 59 | 0.835 3 | 0.627 22 | 0.716 5 |
| 31 | | Psycholinguistic | to_AAKuW_C | | 0.427 72 | 0.189 60 | 0.835 4 | 0.625 23 | 0.715 6 |
| 30 | | Type Token Ratio | | Corrected TTR | 0.745 1 | 0.006 228 | 0.846 1 | 0.445 65 | 0.692 7 |
| 30 | | Variation Ratio | CorrNoV_S | Corrected Noun Variation-1 | 0.717 3 | 0.086 131 | 0.842 2 | 0.406 78 | 0.612 21 |
| 30 | - | Tree Structure | as_TreeH_C | Tree height per Sent | 0.55 21 | 0.341 30 | 0.686 51 | 0.699 9 | 0.541 44 |
| 30 | Synta | | to_PrPhr_C | total # prepositional phrases | 0.47 47 | 0.189 58 | 0.808 11 | 0.58 36 | 0.729 3 |
| 30 | | Word Familiarity | as_SbL1C_C | SubtlexUS Lg10CD value per Sent | 0.467 49 | 0.43 20 | 0.612 69 | 0.699 10 | 0.533 45 |
| 30 | | Word Familiarity | as_SbL1W_C | SubtlexUS Lg10WF value per Sent | 0.462 52 | 0.437 19 | 0.605 71 | 0.693 12 | 0.523 48 |
| 29 | | Variation Ratio | SquaNoV_S | Squared Noun Variation-1 | 0.645 9 | 0.124 109 | 0.815 7 | 0.401 84 | 0.583 34 |
| 29 | | Variation Ratio | CorrVeV_S | Corrected Verb Variation-1 | 0.602 11 | 0.058 155 | 0.801 15 | 0.393 86 | 0.737 2 |
| 29 | - | Part-of-Speech | as_NoTag_C | # Noun POS tags per Sent | 0.551 19 | 0.304 38 | 0.624 65 | 0.608 29 | 0.48 61 |
| 29 | | Psycholinguistic | to_AABrL_C | total lemmas AoA of lemmas, Bristol norm | 0.451 56 | 0.134 100 | 0.808 10 | 0.561 38 | 0.637 12 |
| 29 | | Psycholinguistic | to_AACoL_C | total AoA of lemmas, Cortese and Khanna norm | 0.451 57 | 0.134 101 | 0.808 9 | 0.561 39 | 0.637 13 |
| 29 | | Part-of-Speech | to_NoTag_C | total # Noun POS tags | 0.441 61 | 0.129 107 | 0.805 13 | 0.55 44 | 0.636 15 |
| 29 29 | | Phrasal | to_NoPhr_C | total # Noun phrases | 0.416 76 0.402 81 | 0.148 84 0.163 71 | 0.809 8 | 0.527 52 0.558 40 | 0.659 9 |
| 28 | | Part-of-Speech Psycholinguistic | to_ContW_C as AACoL C | total # Content words AoA of lemmas, Cortese and Khanna norm per Sent | 0.402 81 | 0.165 /1 | 0.804 14 0.649 61 | 0.538 40 | 0.654 11 0.499 58 |
| 28 | | Psycholinguistic Psycholinguistic | as_AACoL_C as_AABrL_C | lemmas AoA of lemmas, Bristol norm per Sent | 0.532 30 | 0.339 32 | 0.649 61 | 0.597 32 | 0.499 58 |
| 28 | | Psycholinguistic Psycholinguistic | as_AABiL_C | lemmas AoA of lemmas, Birstof norm per Sent | 0.332 31 | 0.339 31 | 0.582 73 | 0.653 19 | 0.443 69 |
| 28 | | | as_SbCDL_C | SubtlexUS CDlow value per Sent | 0.439 33 | 0.438 11 | 0.527 82 | 0.623 26 | 0.443 69 |
| 28 | | Word Familiarity | | SubtlexUS CD# value per Sent | 0.432 63 | 0.437 17 | 0.527 82 | 0.623 20 | 0.401 83 |
| 28 | | | | SubtlexUS SUBTLCD value per Sent | 0.431 68 | 0.437 17 | 0.525 85 | 0.624 25 | 0.404 83 |
| 28 | | Part-of-Speech | as VeTag C | # Verb POS tags per Sent | 0.428 70 | 0.476 6 | 0.578 74 | 0.588 34 | 0.505 55 |
| 28 | | Tree Structure | to FTree C | total length of flattened Trees | 0.396 87 | 0.166 69 | 0.805 12 | 0.538 49 | 0.676 8 |
| 27 | - | Variation Ratio | SquaVeV_S | Squared Verb Variation-1 | 0.559 17 | 0.076 138 | 0.777 22 | 0.384 90 | 0.716 4 |
| 27 | | Variation Ratio | SquaAjV_S | Squared Adjective Variation-1 | 0.531 32 | 0.141 94 | 0.754 34 | 0.407 77 | 0.573 37 |
| 27 | | Part-of-Speech | as_AjTag_C | # Adjective POS tags per Sent | 0.506 36 | 0.353 28 | 0.553 76 | 0.533 51 | 0.404 84 |
| 27 | | • | as_SbFrL_C | SubtlexUS FREQlow value per Sent | 0.443 60 | 0.426 21 | 0.52 86 | 0.552 42 | 0.425 77 |
| 27 | | Part-of-Speech | to_AjTag_C | total # Adjective POS tags | 0.441 62 | 0.191 57 | 0.777 23 | 0.504 54 | 0.525 46 |
| 27 | | Word Familiarity | as_SbSBW_C | SubtlexUS SUBTLWF value per Sent | 0.44 63 | 0.441 15 | 0.509 91 | 0.542 48 | 0.425 76 |
| 27 | | | | SubtlexUS FREO# value per Sent | 0.44 64 | 0.441 16 | 0.509 90 | 0.542 47 | 0.425 75 |
| 27 | Synta | • | as_VePhr_C | # Verb phrases per Sent | 0.383 90 | 0.455 12 | 0.59 72 | 0.586 35 | 0.505 54 |
| 26 | - | Shallow | at_Sylla_C | # syllables per Word | 0.66 7 | 0.106 120 | 0.627 64 | 0.505 53 | 0.37 91 |
| 26 | | Variation Ratio | CorrAjV_S | Corrected Adjective Variation-1 | 0.591 12 | 0.078 134 | 0.779 21 | 0.422 70 | 0.584 33 |
| 26 | | Entity Grid | ra_NNTo_C | ratio of nn transitions to total | 0.476 44 | 0.078 135 | 0.754 35 | 0.451 64 | 0.602 23 |
| 26 | | Tree Structure | at_TreeH_C | Tree height per Word | 0.476 45 | 0.419 22 | 0.416 104 | 0.597 33 | 0.41 81 |
| 26 | - | Word Familiarity | | total SubtlexUS Lg10CD value | 0.37 93 | 0.14 95 | 0.797 16 | 0.491 56 | 0.621 17 |
| 26 | | Word Familiarity | | total SubtlexUS Lg10WF value | 0.365 99 | 0.144 93 | 0.795 17 | 0.477 58 | 0.611 22 |
| 26 | | Word Familiarity | | total SubtlexUS FREQlow value | 0.348 109 | 0.201 51 | 0.774 24 | 0.414 74 | 0.555 40 |
| 26 | | Word Familiarity | | total SubtlexUS SUBTLWF value | 0.34 115 | 0.206 47 | 0.77 27 | 0.403 81 | 0.551 42 |
| 26 | | Word Familiarity | | total SubtlexUS FREQ# value | 0.34 116 | 0.206 48 | 0.77 26 | 0.403 82 | 0.551 41 |
| | | | | • | | | 1 | | |

Table 13: Part A. The full generalizability ranking of handcrafted linguistic features under Approach A. r: Pearson's correlation between the feature and the dataset. rk: the feature's correlation ranking on the specific dataset.

| | | |] | Feature | ССВ | WBT | CAM | CKC | OSE |
|----------|----------------|------------------------------------|--------------------------|--|------------------------|------------------------|------------------------|------------------------|------------------------|
| Score | Branch | Subgroup | LingFeat Code | Brief Explanation | r rk | r rk | _ r rk | _ r rk | _ r rk |
| 25 | ShaTr | Shallow | at_Chara_C | # characters per Word | 0.443 59 | 0.2 52 | 0.619 67 | 0.402 83 | 0.443 68 |
| 25 | • | Phrasal | to_SuPhr_C | total # Subordinate Clauses | 0.367 96 | 0.202 50 | 0.721 43 | 0.462 61 | 0.419 78 |
| 25 | | | to_AABiL_C | total lemmas AoA of lemmas, Bird norm | 0.365 98 | 0.155 79 | 0.786 18 | 0.473 59 | 0.565 39 |
| 25 | • | Part-of-Speech | to_CoTag_C | total # Coordinating Conjunction POS tags | 0.364 101 | 0.268 43 | 0.728 39 | 0.406 80 | 0.434 72 |
| 25 25 | - | Part-of-Speech | to_FuncW_C | total # Function words | 0.33 126 | 0.159 77 | 0.773 25 | 0.385 89 | 0.636 14 |
| 23 | • | Phrasal Variation Ratio | to_VePhr_C CorrAvV_S | total # Verb phrases Corrected AdVerb Variation-1 | 0.324 127 0.542 23 | 0.169 68 0.059 154 | 0.76 31 0.71 44 | 0.416 72 0.333 99 | 0.57 38 0.474 63 |
| 24 | | Word Familiarity | | total SubtlexUS CDlow value | 0.342 23 | 0.039 134 | 0.764 30 | 0.333 99 | 0.513 53 |
| 24 | | Word Familiarity | | total SubtlexUS CD# value | 0.347 110 | 0.146 90 | 0.764 29 | 0.392 87 | 0.515 51 |
| 24 | | Word Familiarity | | total SubtlexUS SUBTLCD value | 0.347 111 | 0.146 91 | 0.764 28 | 0.392 88 | 0.515 52 |
| 23 | AdSem | Wiki Knowledge | WTopc20_S | Number of topics, 200 topics extracted from Wikipedia | 0.584 14 | 0.015 214 | 0.616 68 | 0.617 27 | 0.137 138 |
| 23 | AdSem | Wiki Knowledge | WTopc15_S | Number of topics, 150 topics extracted from Wikipedia | 0.58 15 | 0.007 227 | 0.645 63 | 0.605 30 | 0.191 122 |
| 23 | | Variation Ratio | SquaAvV_S | Squared AdVerb Variation-1 | 0.515 34 | 0.093 128 | 0.686 52 | 0.326 102 | 0.46 65 |
| 23 | - | Part-of-Speech | to_AvTag_C | total # Adverb POS tags | 0.342 114 | 0.17 67 | 0.726 40 | 0.352 96 | 0.469 64 |
| 23 | | Part-of-Speech | as_AvTag_C | # Adverb POS tags per Sent | 0.32 129 | 0.292 41 | 0.526 83 | 0.43 67 | 0.415 79 |
| 23 22 | • | Part-of-Speech Phrasal | to_VeTag_C as_SuPhr_C | total # Verb POS tags # Subordinate Clauses per Sent | 0.288 138 0.387 89 | 0.173 63 0.357 26 | 0.738 38 0.532 80 | 0.383 91 0.495 55 | 0.597 27 0.265 112 |
| 22 | | Part-of-Speech | as_CoTag_C | # Coordinating Conjunction POS tags per Sent | 0.38 91 | 0.337 20 | 0.332 80 | 0.442 66 | 0.203 112 |
| 22 | - | Phrasal | to_AvPhr_C | total # Adverb phrases | 0.356 105 | 0.17 66 | 0.705 45 | 0.298 111 | 0.432 73 |
| 22 | | Tree Structure | to_TreeH_C | total Tree height of all sentences | 0.27 145 | 0.069 143 | 0.755 33 | 0.309 108 | 0.515 50 |
| 21 | Disco | Entity Grid | ra_NSTo_C | ratio of ns transitions to total | 0.426 73 | 0.033 187 | 0.516 87 | 0.266 117 | 0.505 56 |
| 21 | | Part-of-Speech | to_SuTag_C | total # Subordinating Conjunction POS tags | 0.4 83 | 0.193 56 | 0.691 48 | 0.406 79 | 0.299 106 |
| 20 | LxSem | Type Token Ratio | UberTTR_S | Uber Index | 0.646 8 | 0.041 174 | 0.369 112 | 0.109 173 | 0.599 26 |
| 20 | - | Phrasal | at_PrPhr_C | # prepositional phrases per Word | 0.57 16 | 0.133 103 | 0.316 124 | 0.323 105 | 0.366 92 |
| 20 | | Wiki Knowledge | | Number of topics, 50 topics extracted from Wiki | 0.549 22 | 0.033 186 | 0.514 89 | 0.533 50 | 0.042 203 |
| 20 | | Wiki Knowledge | . – | Number of topics, 100 topics extracted from Wiki | 0.52 33 | 0.004 229 | 0.532 79 | 0.552 43 | 0.075 180 |
| 20 20 | | Entity Grid | ra_SNTo_C | ratio of sn transitions to total | 0.448 58 0.408 78 | 0.019 210 0.161 75 | 0.514 88 0.541 78 | 0.196 133 0.204 130 | 0.518 49 0.392 86 |
| 20 | | Word Familiarity Entity Grid | ra_XNTo_C | SubtlexUS Lg10CD value per Word ratio of xn transitions to total | 0.408 /8 | 0.101 /3 | 0.658 59 | 0.204 130 | 0.392 80 |
| 20 | | Phrasal | to_AjPhr_C | total # Adjective phrases | 0.339 120 | 0.182 62 | 0.682 53 | 0.327 100 | 0.271 111 |
| 20 | - | Phrasal | as_AvPhr_C | # Adverb phrases per Sent | 0.244 152 | 0.328 34 | 0.427 103 | 0.38 92 | 0.356 93 |
| 20 | | Shallow | TokSenS_S | sqrt(total # tokens x total # sentence) | 0.241 154 | 0.064 147 | 0.758 32 | 0.249 121 | 0.498 59 |
| 19 | AdSem | Wiki Knowledge | WNois20_S | Semantic Noise, 200 topics extracted from Wiki | 0.492 41 | 0.032 190 | 0.566 75 | 0.572 37 | 0.025 221 |
| 19 | Synta | Phrasal | ra_NoPrP_C | ratio of Noun phrases # to Prep phrases # | 0.477 43 | 0.149 83 | 0.34 120 | 0.345 97 | 0.389 87 |
| 19 | | Word Familiarity | | SubtlexUS Lg10WF value per Word | 0.399 84 | 0.089 129 | 0.531 81 | 0.24 123 | 0.412 80 |
| 19 | | Word Familiarity | | SubtlexUS SUBTLCD value per Word | 0.37 94 | 0.032 192 | 0.492 93 | 0.324 103 | 0.435 71 |
| 19 19 | | Word Familiarity Part-of-Speech | as_SuTag_C | SubtlexUS CD# value per Word # Subordinating Conjunction POS tags per Sent | 0.37 95 0.366 97 | 0.032 191 0.295 39 | 0.492 94 0.407 105 | 0.324 104 0.427 68 | 0.435 70 0.151 131 |
| 19 | • | Word Familiarity | | SubtlexUS CDlow value per Word | 0.362 102 | 0.293 39 | 0.407 103 | 0.427 08 | 0.131 131 |
| 18 | | Wiki Knowledge | | Semantic Richness, 150 topics extracted from Wiki | 0.495 39 | 0.02 208 | 0.48 95 | 0.549 45 | 0.037 209 |
| 18 | | Wiki Knowledge | | Semantic Richness, 200 topics extracted from Wiki | 0.465 50 | 0.029 195 | 0.446 102 | 0.556 41 | 0.027 219 |
| 18 | | Wiki Knowledge | | Semantic Noise, 50 topics extracted from Wiki | 0.462 53 | 0.061 150 | 0.455 100 | 0.412 75 | 0.118 151 |
| 18 | Synta | Phrasal | ra_PrNoP_C | ratio of Prep phrases # to Noun phrases # | 0.421 75 | 0.162 74 | 0.276 135 | 0.344 98 | 0.37 90 |
| 18 | | Entity Grid | ra_NXTo_C | ratio of nx transitions to total | 0.339 118 | 0.097 127 | 0.62 66 | 0.28 116 | 0.278 110 |
| 18 | | Shallow | TokSenL_S | log(total # tokens)/log(total # sentence) | 0.293 137 | 0.352 29 | 0.297 130 | 0.544 46 | 0.198 121 |
| 18 | | Shallow | TokSenM_S | total # tokens x total # sentence | 0.189 173 | 0.112 116 | 0.674 55 | 0.177 140 | 0.486 60 |
| 17 17 | • | Phrasal Entity Density | as_AjPhr_C | # Adjective phrases per Sent | 0.323 128 0.127 197 | 0.239 46 0.307 37 | 0.387 106 0.548 77 | 0.357 95 0.253 119 | 0.157 127 0.124 149 |
| 16 | | Phrasal | at_UEnti_C ra_VePrP_C | number of unique Entities per Word ratio of Verb phrases # to Prep phrases # | 0.127 197 | 0.307 37 | 0.348 77 | 0.255 118 | 0.124 149 0.249 114 |
| 16 | | Wiki Knowledge | | Semantic Noise, 150 topics extracted from Wiki | 0.388 88 | 0.033 188 | 0.454 101 | 0.454 63 | 0.006 226 |
| 16 | | Psycholinguistic | | lemmas AoA of lemmas, Bristol norm per Word | 0.333 124 | 0.029 194 | 0.462 98 | 0.284 113 | 0.217 118 |
| | | Psycholinguistic | | AoA of lemmas, Cortese and Khanna norm per Word | 0.333 125 | 0.029 193 | 0.462 99 | 0.284 114 | 0.217 119 |
| 16 | | Entity Density | at_EntiM_C | number of Entities Mentions #s per Word | 0.17 180 | 0.204 49 | 0.501 92 | 0.292 112 | 0.127 146 |
| 16 | | WB Knowledge | BClar15_S | Semantic Clarity, 150 topics extracted from WeeBit | 0.025 221 | 0.161 76 | 0.38 108 | 0.481 57 | 0.315 100 |
| 15 | | Type Token Ratio | | Bi-Logarithmic TTR | 0.591 13 | 0.062 149 | 0.07 200 | 0.001 229 | 0.523 47 |
| 15 | | Wiki Knowledge | | Semantic Richness, 50 topics extracted from Wiki | 0.405 80 | 0.063 148 | 0.347 117 | 0.301 110 | 0.035 211 |
| 15 | | Type Token Ratio | | TTR Sementic Biologos, 100 topics extracted from Wilei | 0.375 92 | 0.025 200 | 0.367 113 | 0.163 147 | 0.344 94 |
| 15 15 | | Wiki Knowledge Wiki Knowledge | | Semantic Richness, 100 topics extracted from Wiki Semantic Noise, 100 topics extracted from Wiki | 0.364 100 0.34 117 | 0.002 232 0.021 207 | 0.33 123 0.376 109 | 0.411 76 0.426 69 | 0.041 206 0.03 216 |
| 15 | | Entity Density | to_UEnti_C | total number of unique Entities | 0.34 117 | 0.021 207 | 0.376 109 | 0.426 69 | 0.03 210 |
| 15 | | WB Knowledge | BClar20_S | Semantic Clarity, 200 topics extracted from WeeBit | 0.004 227 | 0.132 103 | 0.3 129 | 0.462 60 | 0.308 104 |
| 14 | | Entity Grid | ra_NOTo_C | ratio of no transitions to total | 0.348 108 | 0.022 204 | 0.383 107 | 0.056 200 | 0.378 89 |
| 14 | | Phrasal | ra_SuVeP_C | ratio of Subordinate Clauses # to Verb phrases # | 0.345 113 | 0.052 160 | 0.343 118 | 0.376 93 | 0.083 172 |
| 13 | • | Phrasal | ra_PrVeP_C | ratio of Prep phrases # to Verb phrases # | 0.485 42 | 0.055 157 | 0.184 158 | 0.189 136 | 0.219 117 |
| 13 | | Variation Ratio | SimpAjV_S | Adjective Variation-1 | 0.398 85 | 0.109 118 | 0.279 134 | 0.073 192 | 0.201 120 |
| 13 | - | Phrasal | ra_VeSuP_C | ratio of Verb phrases # to Subordinate Clauses # | 0.349 106 | 0.137 98 | 0.307 126 | 0.127 167 | 0.043 200 |
| 13 | | Part-of-Speech | at_NoTag_C | # Noun POS tags per Word | 0.347 112 | 0.104 122 | 0.295 131 | 0.148 154 | 0.107 159 |
| 13 | | Entity Grid Phrasal | ra_ONTo_C at_SuPhr_C | ratio of on transitions to total # Subordinate Clauses per Word | 0.333 123 0.204 165 | 0.04 178 0.157 78 | 0.288 133 0.246 140 | 0.06 199 0.314 106 | 0.383 88 0.073 182 |
| 12 | Syma | | at_AABiL_C | lemmas AoA of lemmas, Bird norm per Word | 0.204 163 | 0.137 78 | 0.246 140 | 0.053 202 | 0.073 182 0.302 105 |
| 13 13 | LxSem | | | | U.=UU 100 | · ··· 11/ | 0.200 130 | 0.000 202 | 0.002 103 |
| 13 | | | | - | | 0.038 179 | 0.364 114 | 0.166 145 | 0.323 99 |
| | AdSem | WB Knowledge WB Knowledge | BTopc10_S BNois10_S | Number of topics, 100 topics extracted from WeeBit Semantic Noise, 100 topics extracted from WeeBit | 0.197 169 0.193 171 | 0.038 179 0.036 180 | 0.364 114 0.37 110 | 0.166 145 0.161 149 | 0.323 99 0.33 97 |
| 13 13 | AdSem AdSem | WB Knowledge | BTopc10_S | Number of topics, 100 topics extracted from WeeBit | 0.197 169 | | | I | |

Table 14: Part B. The full generalizability ranking of handcrafted linguistic features under Approach B.

| | | | | Feature | ССВ | WBT | CAM | CKC | OSE |
|----------|----------------|----------------------------------|--------------------------|--|------------------------|------------------------|------------------------|------------------------|------------------------|
| Score | Branch | Subgroup | LingFeat Code | Brief Explanation | r rk |
| 12 | LxSem | Variation Ratio | SimpNoV_S | Noun Variation-1 | 0.499 38 | 0.087 130 | 0.038 212 | 0.031 213 | 0.337 95 |
| 12 | Synta | Part-of-Speech | ra_NoVeT_C | ratio of Noun POS # to Verb POS # | 0.432 66 | 0.118 111 | 0.149 168 | 0.112 170 | 0.051 197 |
| 12 | • | Phrasal | ra_AvPrP_C | ratio of Adv phrases # to Prep phrases # | 0.4 82 | 0.014 217 | 0.222 147 | 0.196 135 | 0.115 152 |
| | • | Part-of-Speech | ra_VeNoT_C | ratio of Verb POS # to Noun POS # | 0.397 86 | 0.198 53 | 0.234 142 | 0.171 142 | 0.067 186 |
| 12 12 | Synta Disco | Part-of-Speech Entity Density | ra_SuVeT_C | ratio of Subordinating Conjunction POS # to Verb POS # | 0.36 103 0.337 121 | 0.053 159 0.114 113 | 0.109 177 0.273 136 | 0.282 115 0.066 196 | 0.137 139 0.157 128 |
| 12 | Synta | Part-of-Speech | as_UEnti_C at_AjTag_C | number of unique Entities per Sent # Adjective POS tags per Word | 0.334 122 | 0.114 113 | 0.275 130 | 0.000 190 | 0.137 128 |
| 12 | Synta | Phrasal | ra_SuAvP_C | ratio of Subordinate Clauses # to Adv phrases # | 0.309 133 | 0.008 226 | 0.141 170 | 0.241 122 | 0.111 153 |
| 12 | | Part-of-Speech | at_FuncW_C | # Function words per Word | 0.28 142 | 0.04 175 | 0.181 159 | 0.461 62 | 0.032 215 |
| | • | WB Knowledge | BTopc20_S | Number of topics, 200 topics extracted from WeeBit | 0.25 150 | 0.135 99 | 0.025 215 | 0.418 71 | 0.044 198 |
| 12 | AdSem | Wiki Knowledge | WClar05_S | Semantic Clarity, 50 topics extracted from Wiki | 0.212 164 | 0.014 218 | 0.214 150 | 0.235 124 | 0.102 161 |
| | | WB Knowledge | BRich10_S | Semantic Richness, 100 topics extracted from WeeBit | 0.196 170 | 0.044 171 | 0.369 111 | 0.035 210 | 0.336 96 |
| 12 | | WB Knowledge | BClar05_S | Semantic Clarity, 50 topics extracted from WeeBit | 0.14 190 | 0.041 173 | 0.339 121 | 0.164 146 | 0.289 109 |
| 12 | | Entity Density | to_EntiM_C | total number of Entities Mentions | 0.139 191 | 0.02 209 | 0.335 122 | 0.0 230 | 0.312 101 |
| 11 11 | • | Phrasal Part-of-Speech | ra_VeNoP_C at_VeTag_C | ratio of Verb phrases # to Noun phrases # # Verb POS tags per Word | 0.46 54 0.431 69 | 0.164 70 0.187 61 | 0.124 174 0.076 196 | 0.041 209 0.111 171 | 0.027 220 0.011 224 |
| 11 | • | Part-of-Speech | ra_AjVeT_C | ratio of Adjective POS # to Verb POS # | 0.431 09 | 0.034 185 | 0.133 172 | 0.111 171 | 0.005 227 |
| 11 | | Part-of-Speech | ra_SuAvT_C | ratio of Subordinating Conjunction POS # to Adverb POS # | 0.314 131 | 0.021 206 | 0.106 178 | 0.136 156 | 0.18 124 |
| 11 | | Variation Ratio | SimpVeV_S | Verb Variation-1 | 0.286 139 | 0.048 165 | 0.081 193 | 0.003 226 | 0.48 62 |
| 11 | | Part-of-Speech | ra_CoFuW_C | ratio of Content words to Function words | 0.284 141 | 0.023 203 | 0.2 154 | 0.376 94 | 0.042 201 |
| 11 | Synta | Part-of-Speech | at_SuTag_C | # Subordinating Conjunction POS tags per Word | 0.259 148 | 0.13 106 | 0.085 192 | 0.252 120 | 0.135 141 |
| 11 | AdSem | Wiki Knowledge | WClar20_S | Semantic Clarity, 200 topics extracted from Wikipedia | 0.144 187 | 0.016 212 | 0.308 125 | 0.23 125 | 0.034 213 |
| 11 | | WB Knowledge | BTopc05_S | Number of topics, 50 topics extracted from WeeBit | 0.139 192 | 0.009 224 | 0.291 132 | 0.144 160 | 0.222 116 |
| 11 | | WB Knowledge | BRich05_S | Semantic Richness, 50 topics extracted from WeeBit | 0.126 198 | 0.051 162 | 0.24 141 | 0.051 207 | 0.309 103 |
| 11 | Synta | | ra_SuNoP_C | ratio of Subordinate Clauses # to Noun phrases # | 0.081 203 | 0.163 72 | 0.224 146 | 0.307 109 | 0.086 170 |
| 11 | | WB Knowledge | BNois15_S | Semantic Noise, 150 topics extracted from WeeBit | 0.035 214 | 0.162 73 | 0.341 119 | 0.221 127 0.133 164 | 0.091 164 |
| 10 | - | Part-of-Speech Phrasal | ra_CoVeT_C | ratio of Coordinating Conjunction POS # to Verb POS # | 0.302 135 0.299 136 | 0.133 104 0.06 151 | 0.023 218 0.256 139 | 0.133 164 | 0.088 168 0.077 176 |
| 10 10 | Synta Synta | Tree Structure | ra_AvSuP_C at FTree C | ratio of Adv phrases # to Subordinate Clauses # length of flattened Trees per Word | 0.299 130 | 0.06 131 | 0.236 139 | 0.128 103 | 0.077 170 |
| 10 | Disco | Entity Density | as_EntiM_C | number of Entities Mentions #s per Sent | 0.242 153 | 0.015 215 | 0.219 148 | 0.051 206 | 0.168 125 |
| 10 | Disco | Entity Grid | LoCoDPW_S | Local Coherence distance for PW score | 0.239 155 | 0.002 230 | 0.195 156 | 0.143 161 | 0.141 136 |
| 10 | | Entity Grid | LoCoDPA_S | Local Coherence distance for PA score | 0.239 156 | 0.002 231 | 0.195 157 | 0.143 162 | 0.141 135 |
| 10 | Synta | Part-of-Speech | at_CoTag_C | # Coordinating Conjunction POS tags per Word | 0.218 161 | 0.267 44 | 0.02 220 | 0.111 172 | 0.087 169 |
| 10 | LxSem | Variation Ratio | SimpAvV_S | AdVerb Variation-1 | 0.214 163 | 0.098 126 | 0.353 115 | 0.021 221 | 0.089 166 |
| 10 | • | Phrasal | ra_AjPrP_C | ratio of Adj phrases # to Prep phrases # | 0.201 168 | 0.036 181 | 0.155 164 | 0.095 178 | 0.252 113 |
| 10 | | WB Knowledge | BNois20_S | Semantic Noise, 200 topics extracted from WeeBit | 0.129 196 | 0.148 85 | 0.202 153 | 0.167 144 | 0.032 214 |
| 10 9 | | WB Knowledge Phrasal | BRich20_S | Semantic Richness, 200 topics extracted from WeeBit | 0.047 211 0.424 74 | 0.104 121 0.066 146 | 0.112 176 0.089 188 | 0.221 126 0.005 224 | 0.143 134 0.042 202 |
| 9 | Synta Synta | Phrasal | at_NoPhr_C ra_NoVeP_C | # Noun phrases per Word ratio of Noun phrases # to Verb phrases # | 0.424 74 | 0.068 145 | 0.069 100 | 0.003 224 | 0.042 202 |
| 9 | | Phrasal | ra_PrAvP_C | ratio of Prep phrases # to Adv phrases # | 0.32 130 | 0.003 143 | 0.003 201 | 0.031 212 | 0.071 183 |
| 9 | Synta | Phrasal | at_VePhr_C | # Verb phrases per Word | 0.31 132 | 0.138 97 | 0.079 194 | 0.032 211 | 0.009 225 |
| 9 | Synta | Part-of-Speech | ra_CoAvT_C | ratio of Coordinating Conjunction POS # to Adverb POS # | 0.284 140 | 0.04 176 | 0.16 162 | 0.079 189 | 0.119 150 |
| 9 | Synta | Part-of-Speech | ra_NoAvT_C | ratio of Noun POS # to Adverb POS # | 0.261 147 | 0.133 102 | 0.101 180 | 0.052 204 | 0.034 212 |
| 9 | Disco | Entity Grid | LoCohPW_S | Local Coherence for PW score | 0.229 159 | 0.034 183 | 0.012 227 | 0.146 157 | 0.148 133 |
| 9 | Disco | Entity Grid | LoCohPA_S | Local Coherence for PA score | 0.229 160 | 0.034 184 | 0.012 226 | 0.146 158 | 0.148 132 |
| 9 | Synta | Phrasal | ra_SuPrP_C | ratio of Subordinate Clauses # to Prep phrases # | 0.218 162 | 0.048 164 | 0.015 224 | 0.07 194 | 0.227 115 |
| 9 | Synta | Part-of-Speech | ra_VeAjT_C | ratio of Verb POS # to Adjective POS # | 0.177 177 | 0.059 153 | 0.203 152 | 0.162 148 | 0.042 204 |
| 9 | Synta | Part-of-Speech Phrasal | at_ContW_C ra_NoSuP_C | # Content words per Word ratio of Noun phrases # to Subordinate Clauses # | 0.161 183 0.157 185 | 0.057 156 0.153 80 | 0.23 143 0.228 145 | 0.183 139 0.052 205 | 0.055 193 0.04 207 |
| 9 | • | Phrasal | ra_PrAjP_C | ratio of Prep phrases # to Adj phrases # | 0.137 183 | 0.133 80 0.035 182 | 0.228 143 | 0.032 203 | 0.04 207 |
| 9 | • | Part-of-Speech | ra_NoAjT_C | ratio of Noun POS # to Adjective POS # | 0.121 199 | 0.152 81 | 0.125 173 | 0.114 169 | 0.004 228 |
| 9 | | WB Knowledge | BClar10_S | Semantic Clarity, 100 topics extracted from WeeBit | 0.079 204 | 0.015 216 | 0.269 137 | 0.148 155 | 0.181 123 |
| 9 | Synta | Part-of-Speech | | ratio of Coordinating Conjunction POS # to Noun POS # | 0.02 224 | 0.277 42 | 0.159 163 | 0.013 222 | 0.132 142 |
| 8 | Synta | Part-of-Speech | | ratio of Adjective POS # to Adverb POS # | 0.357 104 | 0.042 172 | 0.056 204 | 0.091 180 | 0.044 199 |
| 8 | Synta | Part-of-Speech | ra_SuCoT_C | ratio of Subordinating Conj POS # to Coordinating Conj # | 0.274 144 | 0.054 158 | 0.019 222 | 0.143 163 | 0.077 179 |
| 8 | Synta | Part-of-Speech | ra_VeSuT_C | ratio of Verb POS # to Subordinating Conjunction # | 0.266 146 | 0.046 169 | 0.09 186 | 0.105 175 | 0.065 188 |
| 8 | Synta | Phrasal | ra_AvNoP_C | ratio of Adv phrases # to Noun phrases # | 0.257 149 | 0.128 108 | 0.072 199 | 0.044 208 | 0.051 196 |
| 8 | Synta Synta | Part-of-Speech Phrasal | ra_SuAjT_C | ratio of Subordinating Conjunction POS # to Adjective POS # ratio of Noun phrases # to Adv phrases # | 0.244 151 0.235 157 | 0.008 225 0.102 125 | 0.074 197 0.09 187 | 0.082 187 | 0.138 137 0.071 185 |
| 8 | Synta Synta | Phrasal | ra_NoAvP_C ra_AjAvP_C | ratio of Adj phrases # to Adv phrases # | 0.233 137 | 0.102 123 | 0.09 187 | 0.082 188 | 0.071 183 |
| 8 | Synta | Part-of-Speech | ra_AvSuT_C | ratio of Adverb POS # to Subordinating Conjunction # | 0.202 167 | 0.024 201 | 0.003 230 | 0.114 168 | 0.067 187 |
| 8 | | Part-of-Speech | ra_VeCoT_C | ratio of Verb POS # to Coordinating Conjunction # | 0.192 172 | 0.172 64 | 0.134 171 | 0.022 218 | 0.054 194 |
| 8 | | Word Familiarity | | SubtlexUS FREQ# value per Word | 0.181 174 | 0.196 55 | 0.095 183 | 0.021 219 | 0.109 155 |
| 8 | | Word Familiarity | | SubtlexUS SUBTLWF value per Word | 0.181 175 | 0.196 54 | 0.095 184 | 0.021 220 | 0.109 156 |
| 8 | | Wiki Knowledge | | Semantic Clarity, 100 topics extracted from Wiki | 0.178 176 | 0.01 223 | 0.153 167 | 0.171 143 | 0.084 171 |
| 8 | | Wiki Knowledge | | Semantic Clarity, 150 topics extracted from Wiki | 0.165 182 | 0.011 221 | 0.161 161 | 0.185 138 | 0.074 181 |
| 8 | | Entity Grid | LoCohPU_S | Local Coherence for PU score | 0.129 195 | 0.023 202 | 0.103 179 | 0.084 184 | 0.13 144 |
| 8 | • | Part-of-Speech | ra_VeAvT_C | ratio of Verb POS # to Adverb POS # | 0.108 200 | 0.078 136 | 0.229 144 | 0.025 215 | 0.079 174 |
| 8 | | Part-of-Speech | ra_SuNoT_C | ratio of Subordinating Conjunction POS # to Noun POS # | 0.085 202 | 0.149 82 | 0.039 211 | 0.155 151 | 0.158 126 0.1 162 |
| 8 | | WB Knowledge Part-of-Speech | BRich15_S ra_NoCoT_C | Semantic Richness, 150 topics extracted from WeeBit ratio of Noun POS # to Coordinating Conjunction # | 0.025 220 0.022 222 | 0.059 152 0.254 45 | 0.154 166 0.019 221 | 0.145 159 0.053 201 | 0.109 157 |
| 8 | | | | Measure of Textual Lexical Diversity (default $TTR = 0.72$) | 0.0 230 | 0.103 123 | 0.119 175 | 0.053 201 | 0.0 231 |
| | | 71 | 0 | | | | | | |

Table 15: Part C. The full generalizability ranking of handcrafted linguistic features under Approach B.

| | Feature | | | CCI | CCB WB | | BT CAM | | CKC | | OSE | | |
|-------|---------|------------------|---------------|--|--------|-----|-----------|-------|-----|-------|-----|-------|-----|
| Score | Branch | Subgroup | LingFeat Code | Brief Explanation | r | rk | r rk | r | rk | r | rk | r | rk |
| 7 | LxSem | Word Familiarity | at_SbFrL_C | SubtlexUS FREQlow value per Word | 0.176 | 178 | 0.171 65 | 0.061 | 203 | 0.001 | 228 | 0.09 | 165 |
| 7 | Synta | Part-of-Speech | ra_AvNoT_C | ratio of Adverb POS # to Noun POS # | 0.171 | 179 | 0.108 119 | 0.076 | 195 | 0.084 | 185 | 0.023 | 222 |
| 7 | Disco | Entity Grid | LoCoDPU_S | Local Coherence distance for PU score | 0.154 | 186 | 0.032 189 | 0.086 | 191 | 0.087 | 182 | 0.111 | 154 |
| 7 | Synta | Phrasal | at_AvPhr_C | # Adverb phrases per Word | 0.144 | 188 | 0.113 115 | 0.047 | 208 | 0.029 | 214 | 0.058 | 191 |
| 7 | Synta | Phrasal | ra_AjSuP_C | ratio of Adj phrases # to Subordinate Clauses # | 0.133 | 194 | 0.04 177 | 0.195 | 155 | 0.001 | 227 | 0.079 | 173 |
| 7 | Synta | Phrasal | ra_AjVeP_C | ratio of Adj phrases # to Verb phrases # | 0.104 | 201 | 0.01 222 | 0.055 | 205 | 0.083 | 186 | 0.124 | 148 |
| 7 | Synta | Part-of-Speech | ra_CoAjT_C | ratio of Coordinating Conjunction POS # to Adjective POS # | 0.068 | 206 | 0.051 161 | 0.176 | 160 | 0.074 | 191 | 0.104 | 160 |
| 7 | Synta | Part-of-Speech | ra_AvCoT_C | ratio of Adverb POS # to Coordinating Conjunction # | 0.029 | 216 | 0.119 110 | 0.024 | 216 | 0.022 | 217 | 0.107 | 158 |
| 7 | Synta | Part-of-Speech | ra_AjSuT_C | ratio of Adjective POS # to Subordinating Conjunction # | 0.025 | 219 | 0.001 233 | 0.024 | 217 | 0.204 | 131 | 0.057 | 192 |
| 7 | Synta | Phrasal | ra_SuAjP_C | ratio of Subordinate Clauses # to Adj phrases # | 0.02 | 223 | 0.022 205 | 0.05 | 206 | 0.204 | 129 | 0.029 | 218 |
| 7 | Synta | Phrasal | ra_PrSuP_C | ratio of Prep phrases # to Subordinate Clauses # | 0.002 | 228 | 0.076 139 | 0.143 | 169 | 0.07 | 193 | 0.13 | 143 |
| 6 | Synta | Part-of-Speech | ra_AvVeT_C | ratio of Adverb POS # to Verb POS # | 0.168 | 181 | 0.011 220 | 0.097 | 181 | 0.053 | 203 | 0.053 | 195 |
| 6 | Synta | Part-of-Speech | ra_AjNoT_C | ratio of Adjective POS # to Noun POS # | 0.074 | 205 | 0.146 89 | 0.031 | 213 | 0.068 | 195 | 0.041 | 205 |
| 6 | Synta | Phrasal | ra_VeAjP_C | ratio of Verb phrases # to Adj phrases # | 0.067 | 207 | 0.072 142 | 0.087 | 190 | 0.104 | 176 | 0.064 | 189 |
| 6 | Synta | Part-of-Speech | ra_AvAjT_C | ratio of Adverb POS # to Adjective POS # | 0.061 | 208 | 0.049 163 | 0.088 | 189 | 0.107 | 174 | 0.039 | 208 |
| 6 | Synta | Phrasal | ra_NoAjP_C | ratio of Noun phrases # to Adj phrases # | 0.05 | 209 | 0.084 132 | 0.073 | 198 | 0.128 | 166 | 0.062 | 190 |
| 6 | Synta | Part-of-Speech | ra_NoSuT_C | ratio of Noun POS # to Subordinating Conjunction # | 0.049 | 210 | 0.075 140 | 0.004 | 229 | 0.186 | 137 | 0.077 | 178 |
| 6 | Synta | Phrasal | ra_VeAvP_C | ratio of Verb phrases # to Adv phrases # | 0.039 | 213 | 0.084 133 | 0.155 | 165 | 0.065 | 198 | 0.097 | 163 |
| 6 | Synta | Part-of-Speech | ra_CoSuT_C | ratio of Coordinating Conj POS # to Subordinating Conj # | 0.03 | 215 | 0.076 137 | 0.044 | 210 | 0.196 | 134 | 0.001 | 229 |
| 6 | Synta | Phrasal | at_AjPhr_C | # Adjective phrases per Word | 0.027 | 218 | 0.046 167 | 0.029 | 214 | 0.076 | 190 | 0.126 | 147 |
| 6 | Synta | Phrasal | ra_AjNoP_C | ratio of Adj phrases # to Noun phrases # | 0.01 | 226 | 0.046 168 | 0.013 | 225 | 0.066 | 197 | 0.127 | 145 |
| 6 | Synta | Part-of-Speech | ra_AjCoT_C | ratio of Adjective POS # to Coordinating Conjunction # | 0.0 | 229 | 0.148 86 | 0.049 | 207 | 0.091 | 181 | 0.077 | 177 |
| 5 | Synta | Phrasal | ra_AvAjP_C | ratio of Adv phrases # to Adj phrases # | 0.044 | 212 | 0.044 170 | 0.066 | 202 | 0.086 | 183 | 0.088 | 167 |
| 5 | Synta | Part-of-Speech | at_AvTag_C | # Adverb POS tags per Word | 0.029 | 217 | 0.072 141 | 0.095 | 185 | 0.011 | 223 | 0.078 | 175 |
| 5 | Synta | Phrasal | ra_AvVeP_C | ratio of Adv phrases # to Verb phrases # | 0.02 | 225 | 0.068 144 | 0.005 | 228 | 0.003 | 225 | 0.071 | 184 |
| 5 | Disco | Entity Grid | ra_XXTo_C | ratio of xx transitions to total | 0.0 | 231 | 0.025 198 | 0.0 | 231 | 0.0 | 231 | 0.0 | 230 |
| 5 | Disco | Entity Grid | ra_XSTo_C | ratio of xs transitions to total | 0.0 | 232 | 0.025 197 | 0.0 | 232 | 0.0 | 232 | 0.0 | 232 |
| 5 | Disco | Entity Grid | ra_SSTo_C | ratio of ss transitions to total | 0.0 | 233 | 0.025 199 | 0.0 | 233 | 0.0 | 233 | 0.0 | 233 |

Table 16: Part D. The full generalizability ranking of handcrafted linguistic features under Approach B.