Computational Linguistics and Intellectual Technologies:
Proceedings of the International Conference "Dialogue 2025"

April 23–25, 2025

Readability assessment of written Adyghe using a baseline approach

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Abstract

The study introduces a cross-linguistic approach extending the English-based Flesch Reading Ease formula for the assessment of Adyghe texts' readability level. The method relies on the corpus-based analysis of Adyghe shallow linguistic features, i.e. syllable length, word count, and sentence length. It allows to adjust the Flesch formula in accordance with these features by means of natural language processing (NLP) and corpus data analysis. Preliminary results showed that the adapted formula could overall adequately differentiate texts according to their complexity levels although it lacked precision in distinguishing between texts belonging to the same complexity range. The approach can be easily extended to other typologically different minority languages subject to their corpora size and availability.

Keywords: readability, text complexity, Flesch formula, shallow features, low-resource language, minority language, Adyghe

DOI: 10.28995/2075-7182-2025-23-XX-XX

Оценка сложности текстов на адыгейском с использованием типового подхода

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Аннотация

В настоящем исследовании представлен кросс-лингвистический метод адаптации англоязычной формулы Flesch Reading Ease для оценки уровня сложности адыгейских текстов. Метод опирается на корпусный анализ особенностей адыгейской лексики: размера слога, длины предложения и количества слов. Он позволяет скорректировать формулу Флеша в соответствии с лингвистическими особенностями адыгейского с помощью инструментов обработки естественного языка и анализа корпусных данных. Предварительные результаты показали, что адаптированная формула достаточно приемлемо различает тексты по уровню сложности, хотя ей не хватает точности в различении текстов, принадлежащих к одному и тому же диапазону сложности. Данный подход может быть с легкостью адаптирован на другие типологически различные малые языки в зависимости от объема и доступности корпусных данных.

Ключевые слова: формула Флеша, сложность текстов, адыгейский, малые языки, удобочитаемость текста, базовые лингвистические характеристики слова, малоресурсные языки

1 Introduction

Readability measure serves to estimate the complexity level of a given text comprehended by a reader. Readability level is dependent on the complexity of linguistic content, style quality, readability of print and reference to the reader (Bamberger, 2000, see also Rottensteiner,2010). As Dale and Chall (1949) put it, readability is "the sum total (including all the interactions) of all those elements within a given piece of printed material that affect the success a group of readers have with it" (23). Readability measures are commonly used in education including book publishing and language-learning applications, health care

and marketing domains (Antunes and Lopes, 2019, Madrazo Azpiazu and Pera, 2020, 644-645), as well as in psycholinguistics, e.g. L1/L2 reading comprehension (Baldwin, 1977, Xia et al., 2016).

Readability measures have been applied to assess text complexity in high-resource languages such as English (Aluisio et al., 2010), Spanish (Anula, 2007, Drndarević et al., 2013, Spaulding, 1956), German (Amstad, 1978, Hancke et al., 2012, Naderi et al., 2019), Swedish (Tillman and Hagberg, 2014), French and Portuguese (François and Miltsakaki, 2012), Russian (Karpov et al., 2014, Krioni et al., 2008, Oborneva, 2005a,b, Reynolds, 2016), Polish (Broda et al., 2014), Czech (Bendová, 2021), Chinese (Chen et al., 2011), Arabic (Al-Ajlan et al., 2008), and many others. Only few studies cover the topic of readability measures for low-resource languages such as Basque (Gonzalez-Dios et al., 2014), Sesotho (Sibeko, 2023), Bengali (Chakraborty et al., 2021), and Bangla (Islam et al., 2012).

To our knowledge, no such measures have been adapted for the minority languages of Russia including Adyghe, Bashkir, Tatar, Udmurt, and so forth. The paper aims to develop a cross-linguistic baseline approach that extends an English-based readability measure for Adyghe, a polysynthetic low-resource language, and makes it applicable to other minority languages. Adyghe's rich verb morphology and complex syllable structure provide sufficient input for the analysis of shallow features, improving the accuracy of complexity level estimation. The study's findings will be used to implement a text readability tool adapted to other low-resource languages, in addition to supporting research-based tasks in psycholinguistic experiments and second language instruction. Namely, it will be applied to prepare materials for tests diagnosing reading skills in elementary school students (e.g. the KARASIK test, Parešina, 2022; see also the Standardized Assessment of Reading Skills, Kornev, 1997). The implementation of the readability formula for Adyghe is available on GitHub.[1]

The paper is structured as follows: In Section 2, we overview extant readability metrics and focus on the adaptations of the Flesch Reading Ease. Section 3 presents the corpus data used in the experiments, NLP methods for collecting and processing it for the purpose of segmentation and syllable and sentence length estimates. Section 3.2 describes the adjustment of coefficients for Adyghe and the grading scores produced by the newly adapted formula; Section 3.3 provides error analysis. In Section 4, we discuss the implications of the obtained results and in Section 5, we conclude upon the experiment and outline future directions in the development of the formula.

2 Background

2.1 Readability metrics overview

Classic readability metrics are typically based on syllable-length, word-length and word-frequency variables given as parameters, complying with the assumption that longer sentences and longer words increase text complexity (Bailin and Grafstein, 2001, Sydes and Hartley, 1997). These variables consist of shallow linguistic features, namely, averages of words per sentence, syllables or letters per word, proportions of part-of-speech tags or out-of-simple-vocabulary words in text. Metrics computing scores based on a syllable and word level include the Flesch-Kincaid and Flesch Reading Ease (Flesch, Rudolph, 1948, Kincaid et al., 1975), Simple Measure of Gobbledygook (SMOG; McLaughlin, 1969), Gunning FOG Index (Gunning, 1971). Metrics based on word length or word frequency variables are applied to estimate syntactic complexity for the purpose of text simplification following the assumption that a text written for early readers contains more frequent words and shorter sentences (Chall and Dale, 1995, Crossley et al., 2008). This group of metrics includes the Automated Readability Index (ARI; Kincaid and Delionbach, 1973), Coleman Liau (Coleman, 1971), Läsbarhetsindex (LIX; Björnsson, 1983), Dale-Chall formula (Chall and Dale, 1995).

Compared to classic readability metrics, readability assessment in NLP approaches is classification-based and computes text cohesion and complexity on linguistic, discourse, and concept-based levels (Crossley et al., 2008, Dell'Orletta et al., 2012), such as the Coh-Metrix tool (Graesser et al., 2004). These approaches make estimates of text coherence using language models, parse tree-based predictors, computer probability and so on (François and Miltsakaki, 2012).

[1] `https://github.com/ulp16/FRE-ady`.

2.2 Flesch formula and its adaptation

The Flesch Reading Ease (FRE) formula is one of the most used classic readability formulae, which is also applied in numerous readability assessment tools. Because the formula relies on surface text features such as syllable-to-token and token-to-sentence ratios (Bendová, 2021), it has been adapted to a number of languages, including German (Amstad, 1978), Italian (Franchina and Vacca, 1986), Russian (Oborneva, 2005a,b, 2006), and Czech (Bendová, 2021).

FRE was developed by Rudolf Flesch (1948) for grading standard English reading material within the American education system, covering the range from approximately fourth grade to college graduate level with scores from 0 (unreadable) to 100 (very easy to read; Klare, 1969, see also DuBay, 2004). The FRE scores are calculated using Equation 1:

$$FRE_{\text{english}} = 206.835 - 1.015 \times ASL - 84.6 \times ASW \quad (1)$$

where *206.835*–a constant which delimits the ordinal FRE scale boundaries from 1 to 100,
ASL–Average Sentence Length based on number of words, and
ASW–Average number of Syllables per Word.
ASL and ASW coefficients are easily measured and are transparent to interpretation (Lanka and Pēks, 2013, 228). For English, FRE scores between 90–100 correspond to easy texts for junior students, 60–70 for school leavers and 0–30, for people with higher education. Equation 2 illustrates Oborneva's FRE formula:

$$FRE_{\text{russian}} = 206.835 - 1.3 \times ASL - 60.1 \times ASW \quad (2)$$

where 1.3 and 60.1 are adjusted coefficients calculated by multiplying the ratios of ASL and ASW in English and Russian by the original coefficients 1.015 and 84.6, respectively. The Russian ASL and ASW were determined on the basis of six million words from about 100 literary Russian-English fictions and dictionaries (Oborneva, 2005a,b, 2006). Kupriyanov et al. (2023) pointed out that Oborneva's formula was developed on fiction texts and therefore provided overestimated results for other types of texts. FRE for Russian was found to be the most suitable formula for evaluating texts in both Russian and Latvian; it was able to distinguish readability levels between Latvian texts written by 11$^{\text{th}}$ grade students and Physics textbooks, thereby demonstrating the latter's greater complexity (Lanka and Pēks, 2013, 233).

In our study, we followed the method of adapting an English FRE to another language drawing on Oborneva (2005a,b) because it preserves the FRE grading scale and uses easily available shallow textual properties as correction coefficients to adapt the formula to another language.

3 Experiment

3.1 Data and tools

We retrieved approximately 100000 lines of Adyghe (plain) texts by using API queries on the Adyghe corpus[2] provided by the Python *lingcorpora*[3] package. For English data, necessary as the basis for formula adjustment, we accessed the Brown Corpus, a one-million word electronic corpus of English texts such as news, reviews, editorial, fiction and so on,[4] using Natural Language Toolkit (NLTK).[5] To obtain counts for shallow features including the number of sentences, words, syllables and their averages from the English data we used in-built NLTK functions. For the Adyghe subcorpus we used a custom Python script for syllabification taking into consideration Adyghe syllable structure (Moroz, 2019) and characteristics of each letter in the the Adyghe alphabet including triple (e.g. *шIy*, *шъу*, *хъу*) and double letters (e.g. *Iy*, *шI*, *шъ*). Figure 1 illustrates an excerpt from the script output containing a list of tokens, their syllable structure and counts. For example, the adverb *ӀакIоу* 'together' is composed of two plosives (marked as O) *Ӏ* and *кI* and three vowels *а*, *о* and *у* (marked as V), making a total of two syllables. The

[2]The corpus is a closed pilot version of the Adyghe corpus which consists of press, (non-)fiction, and blog texts available at `http://web-corpora.net/AdygheCorpus/search/`

[3]`https://lingcorpora.github.io/lingcorpora.py/html/index.html`

[4]A complete list of genre is available at `http://icame.uib.no/brown/bcm-los.html`

[5]`https://www.nltk.org/api/nltk.corpus.html`

	token	syll	#
0	ащ	V0	1
1	дакIоу	0V0V	2
2	иIэнатIэкIи	V0VSV0V0V	5
3	лъагъэкIуатэ	0V0V0V0V	4

Figure 1: An output sample with estimates of Adyghe syllables for each token.

syllable structure of *ðакIoy* is therefore OVOV. We then used the language non-specific *Lexicon Count* and *Sentence Count* functions to calculate text statistics for shallow features in Adyghe via the *textstat* library.[6]. Estimates for shallow features in Adyghe and English corpora are given in Table 1. It indicates that, despite a roughly similar number of words in both Adyghe and English corpora, English sentences are on average 1.299 times longer and English syllables are 0.862 times longer than their corresponding Adyghe sentences and syllables.

Feature	Adyghe	Brown
sent	104298	57340
word	1640756	1161192
syll	4829110	1260859
avg syll	2.89	2.49
avg sent len	16.74	21.75

Table 1: Counts of sentences, words, syllables *syll*, average syllable number *avg syll* and sentence length *avg sent len*.

The relation and effect size of Adyghe and English data were assessed statistically using non-parametric[7] tests via R (R Core Team, 2021). The Mann-Whitney ranks test (Kilgarriff, 2001) showed a significant difference between the Adyghe syllable/sentence length groups and their English counterparts (p < 2.2e-16 for both). The Glass's Rank Biserial Coefficient showed a small but meaningful positive difference between Adyghe and English sentence length samples (rg = 0.228) and a small but significant negative difference between Adyghe and English syllable length (rg = -0.18). The results confirm the statistical soundness of the data in Adyghe and English used for the formula adjustment.

3.2 Coefficient adjustment

We computed correction coefficients for the FRE formula by multiplying ratios of English to Adyghe averages for ASL and ASW (1.299 and 0.862) by the original coefficients 1.015 and 84.6, respectively. Preliminary testing of Adyghe preschooler texts (described below) resulted in an overly high score of 145. Although FRE scores exceeding 100 are technically possible, the text under analysis with the FRE score of 121.22 should consist of sentences with a single one-syllable word (Diamond Jr and Levy, 1994, Shneyderman et al., 2021, 2022). To prevent FRE scores from exceeding the scale boundaries, we reduced the English FRE constant from 206.835 to 150.835 by ensuring that the FRE score for the preschool texts corresponded to the range of 100.0–90.0. The constant was adjusted similarly to Amstad's (1978) adaptation of German FRE. The Amstad FRE relies on the adjusted weight of ASW measure and constant delimitating the scale as average word length in German tends to be higher that in English, see eq. 3.

$$FRE_{\text{german}} = 180 - ASL - (58.5 \times ASW) \tag{3}$$

The Amstand FRE was shown to provide good indication of sentence complexity in German texts alongside with neural-based models (Anschütz and Groh, 2022). Equation 4 illustrates the adjusted FRE for-

[6]The default English implementation is available at `https://pypi.org/project/textstat/`

[7]We chose these tests due to non-parametric distribution of all the samples diagnosed by the Anderson-Darling normality test (p < 2.2e-16).

mula for Adyghe:

$$FRE_{\text{adyghe}} = 150.835 - (1.32 \times ASL) - (72.93 \times ASW) \quad (4)$$

where 150.835–a corrected constant,
1.32–a corrected coefficient for ASL,
0.86–a corrected coefficient for ASW.

We then selected five samples of Adyghe texts from educational resources: fictions/poems for preschoolers (Апиш et al., 2017) and 5th grade learners of Adyghe (Apiš and Udžuxu, 2014), scholarly texts for 11th grade learners (Мамий et al., 2011), abstracts from the scientific conference proceedings aimed at higher education audience (Kesebeževa et al., 2021), and articles from the Adyghe newspaper (Адыгэ псалъэ №39, 2025) targeted at a wide range of age groups. The scores computed for each sample using the adapted Adyghe FRE formula and their text length[8] are given in Table 2. As is shown in

Target level	Text length	Exp FRE range	Ady FRE	Interpretation	Source
preschool	9397	100.0–90.0	90.48	very easy to read	anthology
5th grade	7648	100.0–90.0	91.32	very easy to read	textbook
11th grade	10099	60.0–70.0	66.51	standard language	handbook
higher education	13661	70.0–80.0	76.82	fairly easy to read	abstracts
unspecified	9500	70.0–80.0	75.24	fairly easy to read	newspaper

Table 2: Length of a text sample, expected FRE score ranges, observed FRE scores and reading interpretation for Adyghe texts written for preschoolers, learners in the 5th and 11th grades, higher education audience, newspaper readers.

Table 2, the adjusted FRE formula classified the preschool and 5th grade texts according to the expected complexity range of 100.0–90.00 as "very easy to read". However, the texts suitable for the 5th grade were scored higher in readability than the texts for preschoolers (91.32 versus 90.48). The FRE formula rated the 11th grade texts as written in "standard language" based on the 60.0–70.0 range,[9] while the abstracts and newspaper articles scored on a higher readability level of 70.0–80.0 as "fairly easy to read". The FRE scores did not appear to have been significantly impacted by differences in text length across the samples.

3.3 Error analysis

The text statistics shown in Table 3 offer some explanation for the above-mentioned FRE scores.

Texts	AvgSentLen	AvgSylLen
11th grade	15.36	2.89
newspaper	14.71	2.54
abstracts	10.17	2.71
preschool	7.08	2.19
5th grade	4.8	2.31

Table 3: Average sentence *AvgSentLen* and syllable length *AvgSylLen* observed in the evaluated samples sorted by *AvgSentLen*.

The 11th grade texts contained on average the longest sentences and words (in syllables), followed by the newspaper articles and conference abstracts. In contrast, the preschool and 5th grade texts had on average the shortest sentences and smallest number of syllables in words. Such differences in sentence and syllable length among these samples were mostly explained by their paragraph and sentence structure. First, although several paragraphs overlapped between the two samples, the preschool texts were taken from a monolingual textbook and the 5th-grade texts from a bilingual (Adyghe-Russian) textbook.

[8] Text length is a number of tokens in each sample.
[9] The score corresponds to the US 8th and 9th-grade levels.

Second, the preschool texts comprised six large paragraphs of prose texts, over 70 poems[10] and several dialogues, whereas the 5th grade texts contained mostly prose including dialogues with two- to four-word sentences, one-word exclamations (e.g. *АмкІышъ!* 'Nightingale!') and two- to three-word questions (e.g. *Хэта зэныбджэгъухэр?* 'Who [are] friends?'). Finally, most sentences in the 11th grade sample and newspaper articles tended to be long and complex, while sentences in the abstracts were relatively shorter.

4 Results and discussion

The above findings show that the FRE formula with adjusted coefficients and constant rated scholarly Adyghe texts roughly in the expected complexity range distinguishing between highly readable and standard texts. Without correcting the FRE constant, the formula produced overrated scores surpassing the limit of 100, e.g. 145 for the preschool texts. The formula also did not capture fine-grade differences between the preschool and 5th grade texts, on the one hand, and the scientific abstracts and the 11th grade texts, on the other. Instead, it placed the 5th grade texts and scientific texts higher on the readability scale than those suitable for preschoolers and students in the 11th grade. While the scholarly texts scored satisfactorily on the FRE scale, both the newspaper articles and conference abstracts were ranked as similar, quite readable texts suitable for school students.

Variance in the FRE readability rankings can be accounted by several factors: First, the monolingual preschool texts are structurally more complex than the 5th grade texts for bilingual learners, see Table 3. Second, the FRE does not consider syntactic structure of a sentence and lexical semantics of a word including neologisms, terminology, learned words, borrowings, stylistic devices and so forth. It is therefore unclear whether the FRE is relevant for rating verses as their syntactic structure and lexicon properties are often stylistically motivated including comma-separated sentences spread over several lines and/or words used figuratively. Redish (1981) argues that readability (Flesch) formulas are limited to prose texts whereas poems should be evaluated using the Dale-Chall formula based on a vocabulary list of acceptable words taking into consideration nonce-words and acronyms. Newspaper articles and conference abstracts should also be assessed for readability separately from standard academic textbooks and fiction/non-fiction prose since their straightforward sentence structure tends to be combined with lexically and/or semantically complex words.

5 Conclusion and future directions

In this paper, we have introduced a baseline approach that allows to grade Adyghe texts according to the FRE scale majorly ranking them in the expected readability ranges. Further empirical verification and statistical evaluation of the formula are needed to attain optimal results for grading written Adyghe. We intend to extend the approach for Buryat, Tatar, and Udmurt, using corpora APIs from the *lingcorpora* package.

As future work, we may potentially consider implementing FRE features in a classifier along the lines of *Textometer* (Laposhina and Lebedeva, 2021) or *Jasnopis* (Broda et al., 2014). The classifier could be enriched with features of distributional lexical similarity based on vector representations of word embeddings (see e.g. Anschütz and Groh, 2022, Martinc et al., 2021) and morphological information using a parser for Adyghe (e.g. *uniparser-grammar-adyghe*; Arkhangelskiy and Medvedeva, 2016).[11]

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[10] The poems ranged from two to 119 lines, with a one- to four-word lines, e.g.:
Аргъоир пэдыд,
ЫІпэ – мастэу мэлыд, [...]

[11] `https://github.com/timarkh/uniparser-grammar-adyghe`

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