

# Incorporating Word-Level Phonemic Decoding into Readability Assessment

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## Motivation & Background

To learn how to read, children must first learn to decode written letters and phonemes and their connection to speech sounds. Current approaches in *automatic readability assessment* (ARA) of text, however, fail to reflect the *orthographic instruction carried out in classrooms*. Large language models and transformer architectures perform well with ARA, but they lack the interpretability necessary for the teachers and educators that need ARA tools. Many feature-based ARA approaches offer interpretable output, but they often focus on syntactic and semantic features of text and do not address phonetic aspects relevant to readability. Our primary research question is as follows:

**RQ.** How do phonemic/phonetic features that characterize the decoding process contribute to current feature-based readability assessment methods, focusing on children who are in the *learning how to read* category of readers?

## Method

We created functions that map to educational spelling/reading development stages and associated linguistic patterns provided by *Words Their Way* (WTW), a method of orthographic instruction commonly used in classrooms. Our resulting feature set is presented in Table 1. The functions utilize syllable counts, parts of speech, and IPA (International Phonetic Alphabet) translations to add efficiency and comprehensiveness to regular expression searches for text features, resulting in vectorized representations. We compare results with the feature set presented by Lee et al. (2021).

## Conclusions & Implications

Features designed to capture the phonetic patterns characteristic of educational development stages for reading and spelling provide valuable information in ARA not represented in syntactic and semantic feature sets. When working to solve tasks like readability assessment, there is value in incorporating real-world knowledge from the domain of education to create transparent and interpretable tools.



This research is part of CAST (Child Adaptive Search Tool), which has the goal to empower emergent searchers and meet the specific search needs of children. This research is supported by National Science Foundation Award #1763649

## Experiment

### Data:

- Reading AtoZ (RAZ): texts curated and labeled by education professionals for kindergarten to 5<sup>th</sup> grade.
- WeeBit: texts gathered from online resources for kindergarten to 10<sup>th</sup> grade.
- Science: texts gathered from online science resources for 2<sup>nd</sup> to 12<sup>th</sup> grade.

### Procedure:

- Using each individual feature set (WTW and Lee) as well as a combined feature set, we classified the data in two ways: multiclass (classification of all grade levels) and binary (classification at each grade boundary).
- For each type of classification, four models were employed: Random Forest Classifier, Logistic Regression, Support Vector Machine, and Multilayer Perceptron. The best model was used for evaluation and comparison.
- We collected both accuracy and F1 scores for each individual feature set and the combined feature set. We also carried out feature importance analysis.

Table 1: WTW Feature Set

Stage	Feature	Examples
Derivational Relations	Greek Roots	hydrate, epidermis, antipathy
	Latin Roots	circumference, respiration, benevolent
	Advanced Suffixes	audible, hesitancy, optician, compulsory
	Assimilated Prefixes	illogical, aggregate, obscure, irrelevant
Syllables & Affixes	VV Syllable Juncture	cre-ate, li-ar, pi-ano, po-em, vide-o
	VCCV Syllable Juncture	chap-ter, pub-lic, san-dal, pen-cil, won-der
	VCCV Doublet Syllable Juncture	bliz-zard, pat-tern, mam-mal, vil-lage, kit-ten
	VCCCV Syllable Juncture	pump-kin, dol-phin, bot-tle, laugh-ter, ac-tress
	VVCV Syllable Juncture	sea-son, eas-y, float-ed, pea-nut, lea-der
	Compound Words	bedroom, headlight, snowflake, anything, windmill
	Inflectional Endings for Adjectives	helpless, bodily, careful, boldest, safely
Within Word Pattern	Advanced Inflectional Endings	hopped, hopping, hoping, danc(e)ing
	Basic Inflectional Endings	plants, beaches, picked, puppies, lea(f)ves
Letter-Name Alphabetic	Complex Consonants	lunch, fudge, knock, guide, cage, cease, wise
	CVC Short Vowels	camp, test, stomp, shrunken, hill, fling

## Results & Findings

- The WTW feature set (15 features) performed within approximately 10% of the Lee feature set (190 features) in terms of accuracy and F1 scores.
- Combining the Lee feature set and the WTW feature set improved performance at most grade boundaries in binary classification (Table 2).
- The WTW feature set performed better than the Lee feature set at the 3<sup>rd</sup> to 4<sup>th</sup> and 4<sup>th</sup> to 5<sup>th</sup> grade boundaries (Table 2).
- The combined feature set revealed the importance of certain added features from the WTW feature set.

Table 2: Feature Set Performance at Grade Boundaries

Grade Boundary	Feature Set	Accuracy	F1 Score
Kindergarten   1 <sup>st</sup>	Lee	98%	98%
	Lee & WTW	99%	99%
	WTW	92%	92%
1 <sup>st</sup>   2 <sup>nd</sup>	Lee	87%	82%
	Lee & WTW	87%	82%
	WTW	81%	72%
2 <sup>nd</sup>   3 <sup>rd</sup>	Lee	85%	84%
	Lee & WTW	86%	85%
	WTW	76%	73%
3 <sup>rd</sup>   4 <sup>th</sup>	Lee	76%	73%
	Lee & WTW	78%	76%
	WTW	81%	79%
4 <sup>th</sup>   5 <sup>th</sup>	Lee	71%	72%
	Lee & WTW	74%	72%
	WTW	74%	72%



Full paper and references available using this QR code.



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