Mapping of American English vocabulary by grade levels

Michael Flor, Steven Holtzman, Paul Deane and Isaac Bejar
Educational Testing Service, Princeton, NJ, USA

GR4L2 workshop, December 7, 2021, UCLouvain

Outline

Mapping of American English vocabulary by grade levels

- What we developed
- Why it was developed
- How it was done
- Notes
- CEFR connection

Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852

What

What

We developed a mapping of American English vocabulary by U.S. school grade levels (for native English speakers)

Comprehensive coverage:

126,260 words (forms)

Range:

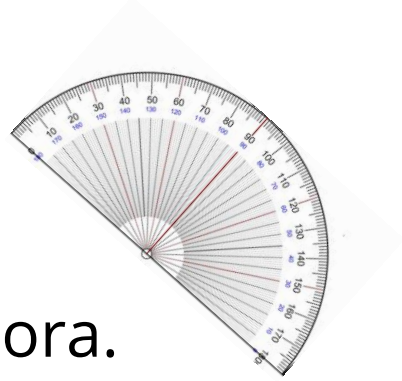
GL from **0** to **16** (from kindergarten till end of undergraduate studies)

53969	Word	GL
53970	hound	3.00
53971	hounded	3.00
53972	hounding	3.00
53973	hounds	3.00
53974	hour	1.50
53975	hourglass	5.00
53976	hourlong	9.06
53977	hourly	4.00
53978	hours	2.60
53979	house	0.74
53980	houseboat	6.15
53981	houseboats	6.15
53982	housebound	9.65
53983	housebreak	7.69
53984	housebreaker	11.17

Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852

Why

Why

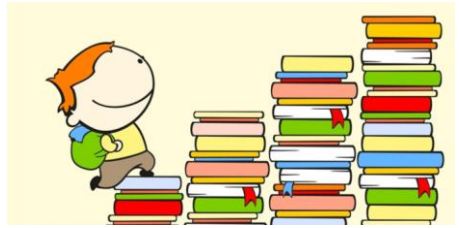


Why express vocabulary difficulty in terms of grade levels? There already are several types of scales and approaches:

- **Word frequency** – can be established with a variety of corpora.
- Binning vocabulary into **frequency bins** of 1000 words (Waring & Nation,1997), often also with morphological word-family relatives.
- **Age of Acquisition** (AoA) which is expressed in years of age, (Kuperman et al, 2012).
- **Word familiarity**, measured via crowdsourcing and expressed as proportion of people who know the word (Brysbaert et al, 2019).
- A variety of Computational (NLP) measures of word complexity (shared tasks: Shardlow et al., 2021, Yimam et al., 2018; etc.).

Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852

Why



Expressing vocabulary diffficulty in terms of grade levels
is very useful and convenient for educators !

For example, teachers and test-developers often need to check that their texts adhere to certain grade-level expectations,
and decide whether or not a word is appropriate for a given grade level.

Consider statements like
"word frequency of 6 per million", *or* ***0.000006,*** *or* ***log=-5.2,***
"is known by 70% of the general population",
"is learned on average at age 8", "is more difficult than 34% of other words"
such statements have only limited utility in many educational situations.

These are not the scales that educators are used to or are convenient for them to operate with.

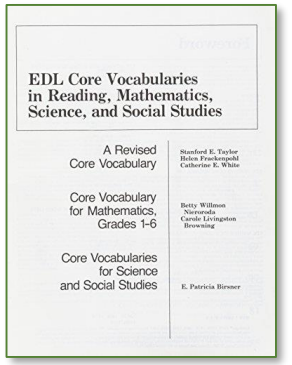
Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852

Why

A grade level scale for vocabulary is what educators often need.

We are not the first in this enterprise.

A book called "*EDL Core Vocabularies*" has seen multiple editions from 1949 to 1989, is widely used by teachers (and at ETS).
But it is old, and limited (10K words).
There are other books, but often also limited in scope.



Living Word Vocabulary is an excellent resource (Dale & O'Rourke, 1981).

We felt there is a need for an up-to-date wide-coverage resource that maps words to grade levels.

Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852

How

How

What does it mean to map words to grade levels?

There are different approaches:

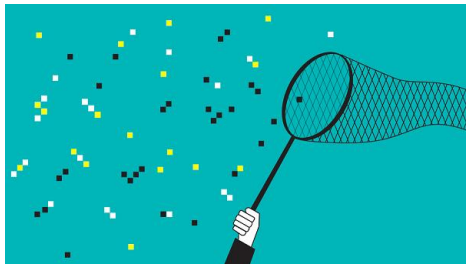
- Some researchers ask which words **are known** in different grade levels (known to a certain degree, and on average in population).
  LWV belongs to that camp.
- Other researchers focus on which words **are expected to be known** or expected to be learned in different grade levels (on average).
  Our study belongs in this group.

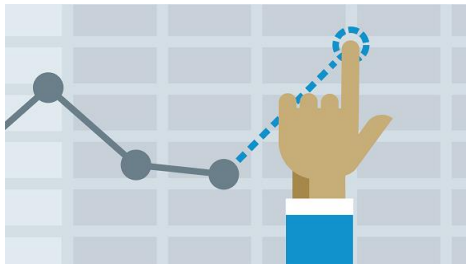
Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852

How

Our study involved two major stages:

- Empirical collection – to establish ‘ground truth’
- Statistically-based expansion (model and predict)





Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852

How

Data Collection

- We collected grade-level vocabulary lists from 70 sources, such as teachers and school websites, state education departments in USA, and published data by researchers and organizations working on vocabulary in USA.
- Overall, we collected data for >80K tokens (strings), each word with an **e**xpected **g**rade **l**evel designator (a number, call it XGL).
  This reduces to **21K** different word forms (types).
- Many words appear in multiple lists, with different XGL, and we generally averaged XGL values (thus we got fractional numbers, e.g. 3.56).
- From this effort we got the initial list of words mapped to grade levels, (with values in range 0-16).

Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852

How

- A **validation** study: how our grade levels compare to some other scales.
- Compared to data from Brysbaert & Biemiller (2017); 2 variables:
  AoAR (AoA rated) are the AoA norms from Kuperman et al. 2012;
  AoAT (AoA testing) is based on data from LWV.
- Original LWV has only even grades 4-6-8-10-12 (13&16), and B&B added GL2.
  LWV works with word senses (44K), and was reduced to 30K wordforms.
- B&B 2017 report Pearson correlation of AoAR to AoAT r=**0.757** (n=18K)
- Our collected VXGL list has an overlap of about 15K words with those lists.

Pearson correlations:

	AoAT	VXGL
AoAR	0.8112	**0.8107**
AoAT		**0.7792**

- Well, it looks that our scores are comparable
  to the others, at least in the relative ordering of words.

Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852

How

Prediction

- We have 21K words with VXGL scores, and want to expand to 126K.
- To provide coverage to many more words we use the usual statistical magic: build a prediction model with the existing data, and if it works well enough, use it to predict data for unknown cases.
- Initial prediction model uses 15K words.
- Our logic: utilize many variables in this prediction exercise, but we also want to utilize AoAR and AoAT, as strong predictors
- But for thousands of other words we won't have AoAT or AoAR scores. So we will see how we are doing with and without AoA.

Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852

How

Variables used in the prediction model. Some of them are 'usual suspects'.

- Square root of word length
- Syllable count per word (algorithmic)
- LSdiff = (num. letters – num.syllables)

- Associative Estimate of GL

- AoAT and AoAR

- TASA corpus: Log-transformed freq. value (SFI), IDF
- Wikipedia corpus: SFI, lemmatized SFI, IDF
- Gigaword corpus: SFI
- Google Books Ngrams data (>400 billion words) (using unigrams only): IDF, SFI, lemmatized SFI

- Number of senses in WordNet
- Number of inflected word-family members
- Number of lemmas in derivational family
- What major POS the word takes (noun/verb/adjective/adverb) (binary variables)

Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852

How

Prediction Results

- We used GBM regression. N=15K words. Training: 90%, Testing: 10%.

	Pearson Correlation to GL	RMSE
With AoAR and AoAT	**0.790**	**1.412**
Without	**0.601**	**1.948**

RMSE for ranges of true VXGL scores

	GL ≤ 3.5	3.5 – 6.5	6.5 – 9.5	> 9.5
With AoAR and AoAT	0.996	1.340	1.266	1.962
Without	1.727	1.817	1.398	2.831

Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852

How

Associative Estimate of Grade Level

A version of the Distributional Hypothesis:

A word's GL can be known by the GLs of words with which it keeps company.

- '*the company*': take a fixed set of common words, for which VXGL are known.
- To predict VXGL for a new word, check it's co-occurrence (in large corpora) with the reference '*company*', and use the average (mean) value as predictor.
- We used: Longman Dictionary of Contemporary English (LDOCE) defining vocabulary list (2000 words) and the Oxford 3000 "most important words". The unified list has 3259 unique word forms for which we have VXGL values.
- For association measure we used mutual conditional probability, of the form:

$$MCP = p(A,B) / P(A)* P(B)$$

- The data comes from a word-to-word co-occurrence database trained on Wikipedia (co-occurrence within paragraphs – Flor & Beigman Klebanov, 2014)

Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852

How

Associative Estimate of Grade Level

- And thus for a new word we take average of 3259 MCP values
- For the Unified List (the reference set itself), we check self-consistency: predict VXGL by using AEGL of all other words on this list (leave-one-out). Pearson correlation of predicted value with VXGL is **0.738**.
- AEGL is a decent VXGL predictor: For 15K words, Pearson correlation of predicted value with VXGL is **0.392**.
- And it is not correlated with frequency: Correlation with Google-Books Lemmatized SFI is **0.037**.

Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852

Notes

Notes

Limitations

- We should improve ‘gold’ VXGL values by collecting more data.
- We should improve the prediction model to further reduce RMSE.
- Our data is per word-forms, not senses …
- We did not include multi-word expressions yet.

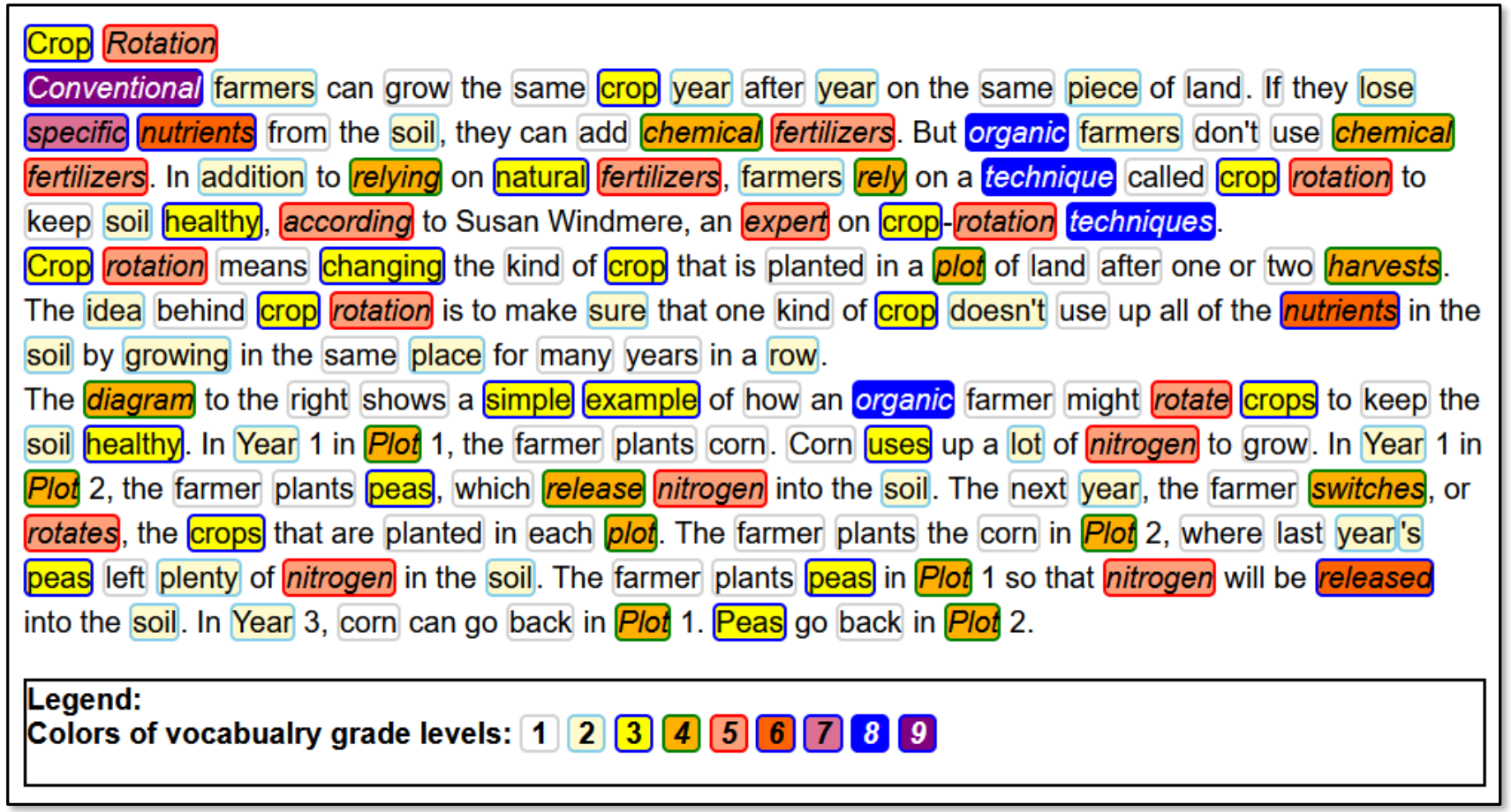
But even the current version is useful and is already utilized at ETS

Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852

Notes

Example use of VXGL data:

- Coloring words in text by grade level (rounded VXGL values)



Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852

CEFR connection

CEFR

How does VXGL data relate to CEFR?

- We used the English Profile CEFR vocabulary (American English version)
- We have 6313 single words in common with VXGL
- For each word, we used the lowest available CEFR level.
- Translated CEFR levels A1-A2-B1-B2-C1-C2 to scores 1-6.

- Pearson correlation of VXGL to CEFR is **0.63**
- Wikipedia IDF values for same set correlate to CEFR at 0.46.
- Adding VXGL and Wikipedia IDF values into a linear regression raises the correlation with CEFR to **0.67** (adjusted R-square is 0.45).

Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852

Thank you

contact: mflor@ets.org

References

Brysbaert, M., Mandera, P., McCormick, S.F. & Keuleers, E. (2019). Word prevalence norms for 62,000 English lemmas. *Behavior Research Methods,* 51, 467–479.

Brysbaert, M., & Biemiller, A. (2017). Test-based age-of-acquisition norms for 44 thousand English word meanings. *Behavior Research Methods,* 49, 1520–1523.

Dale, E., & O'Rourke, J. (1981). The living word vocabulary, the words we know: A national vocabulary inventory. Chicago: World Book.

English Vocabulary Profile Online. https://www.englishprofile.org/wordlists/evp

Flor M., & Beigman Klebanov, B. (2014). ETS Lexical Associations System for the COGALEX-4 Shared Task. In M.Zock, R.Rapp, Ch.R.Huang (eds.), *Proceedings of the 4th Workshop on Cognitive Aspects of the Lexicon*, pages 35–45. At COLING- 2014 conference, Dublin, Ireland

Kuperman, V., Stadthagen-Gonzalez, H., & Brysbaert, M. (2012). Age-of-acquisition ratings for 30,000 English words. *Behavior Research Methods*, 44, 978–990.

Nation, I.S.P., & Waring, R. (1997). Vocabulary size, text coverage, and word lists. In N. Schmitt and M. McCarthy (eds.), *Vocabulary: Description, Acquisition and Pedagogy*. Cambridge University Press, Cambridge: 6-19.

Shardlow, M., Evans, R., Paetzold, G.H. & Zampieri, M. (2021). SemEval-2021 Task 1: Lexical Complexity Prediction. In *Proceedings of the 15th International Workshop on Semantic Evaluation (SemEval-2021)*, pages 1–16.

Taylor, E. (ed) (1989). EDL Core Vocabularies in Reading, Mathematics, Science, and Social Studies. Steck-Vaughn Company, Austin, Texas.

Yimam, S.E, Biemann, C., Malmasi, Sh., Paetzold, G.H., Specia, L., Stajner, S., Tack, A., & Zampieri, M. (2018). A Report on the Complex Word Identification Shared Task 2018. In *Proceedings of the Thirteenth Workshop on Innovative Use of NLP for Building Educational Applications*, pages 66–78.

Copyright © 2021 by Educational Testing Service. All rights reserved. ETS and the ETS logo are registered trademarks of Educational Testing Service (ETS). 462301852