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An Exploration of Child and Word Factors Related to Word Reading in Developing Readers

Laura M. Steacy

Variable Vowel COLLABORATIVE An Interdisciplinary LD Hub

PROJECT Wordy

Project FLEX

developmental English Lexicon Project (d-ELP) An Interdisciplinary Research Hub

ies INSTITUTE OF EDUCATION SCIENCES

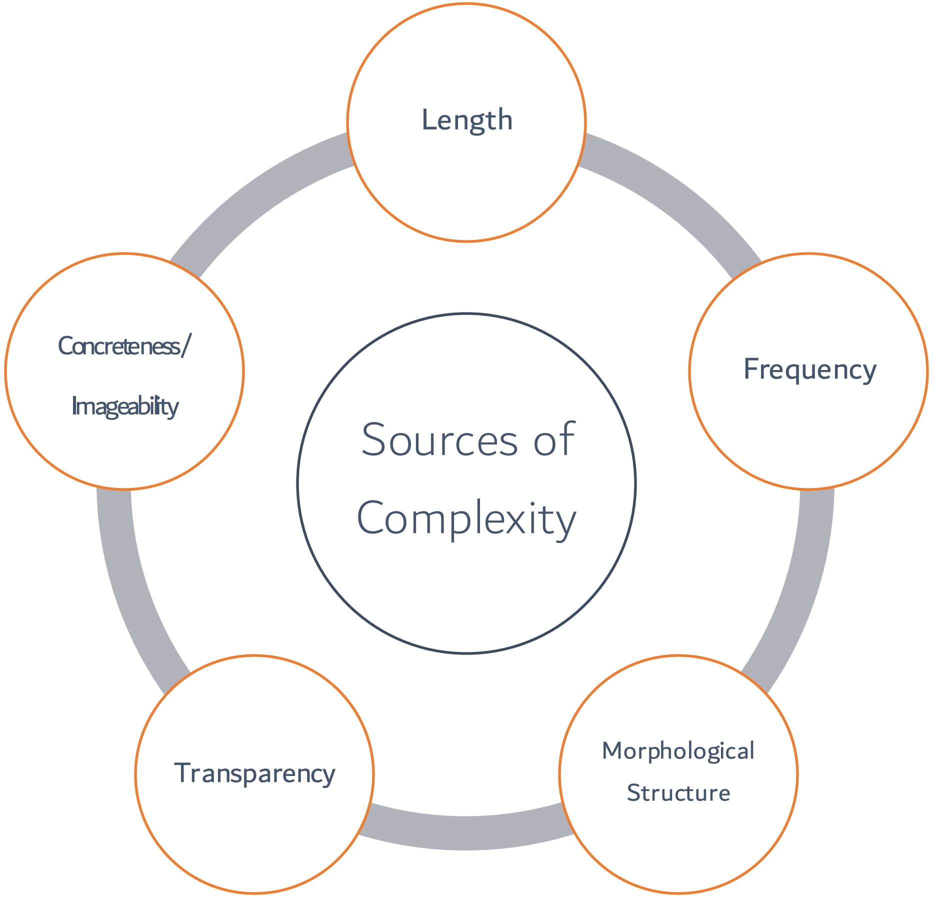
NIH *Eunice Kennedy Shriver* National Institute of Child Health and Human Development

Susie Dent @susie_dent · Jan 20

Word of the day is ‘finifugal’, from the 19th century: avoiding the end of something (a box set, an excellent book, sleep, etc.) because you want it to go on forever.

122 1.3K 6.2K 408K

Sources of Word Complexity



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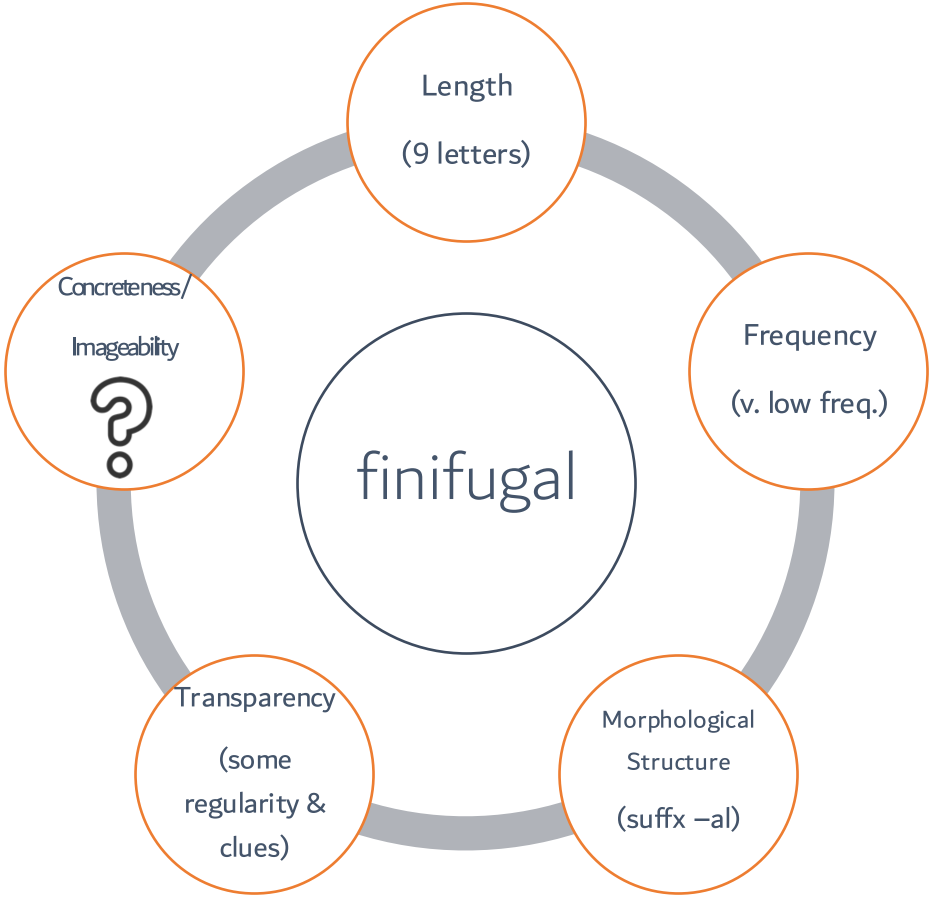
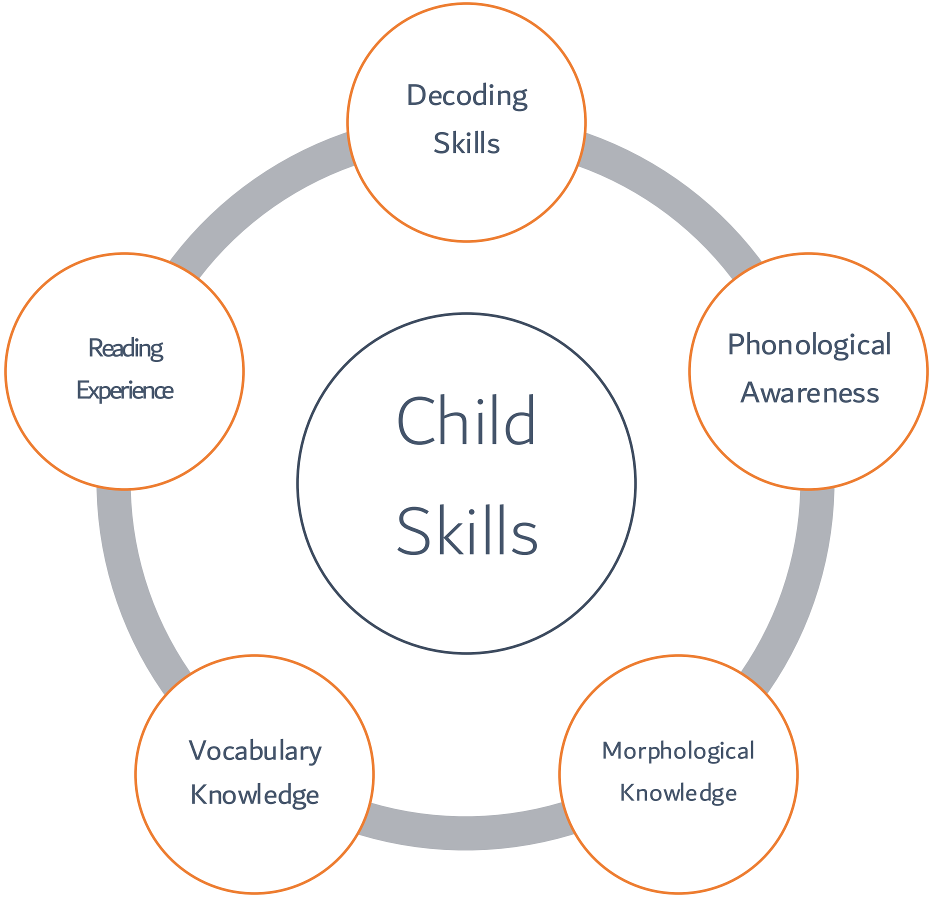


Child Skills Associated with Reading Success



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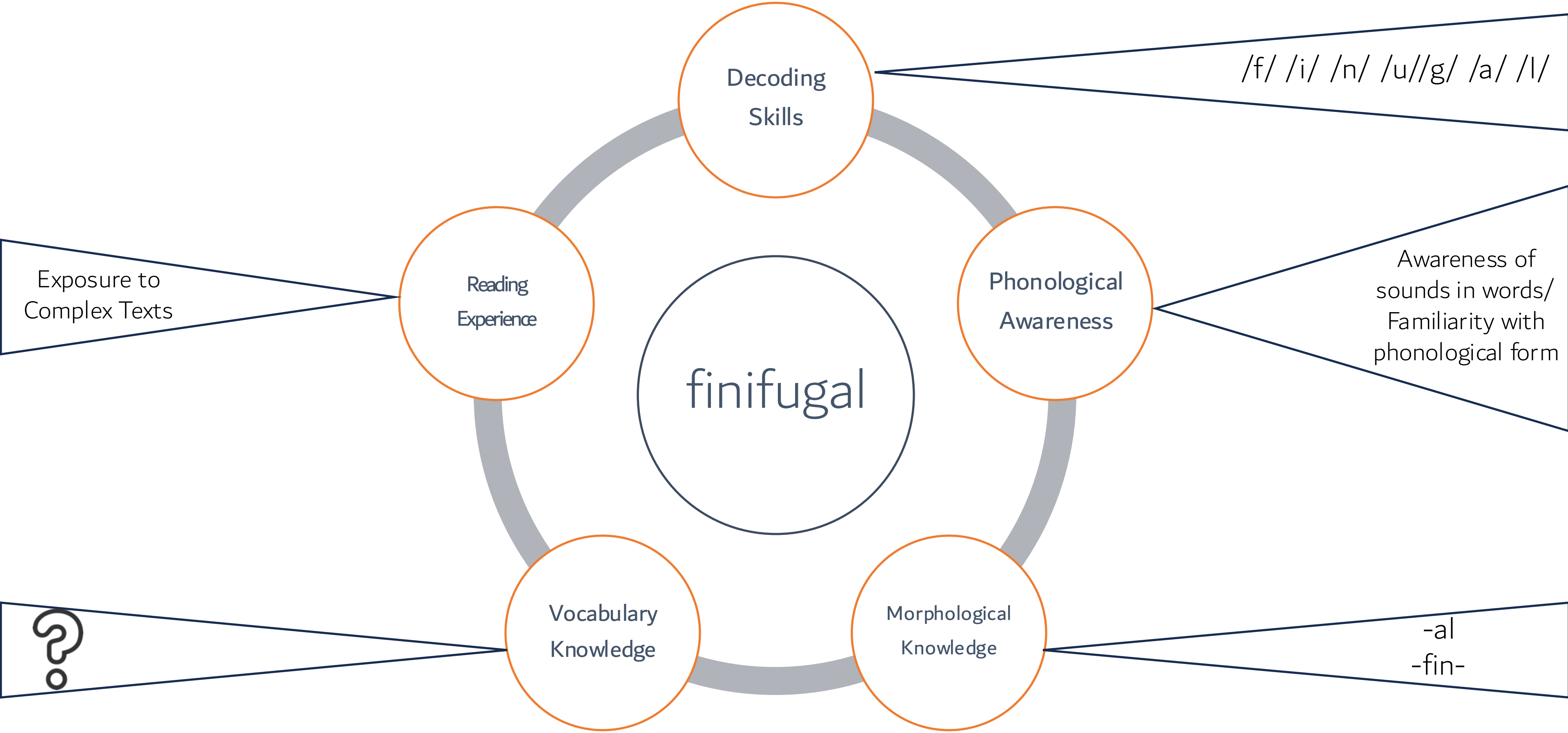

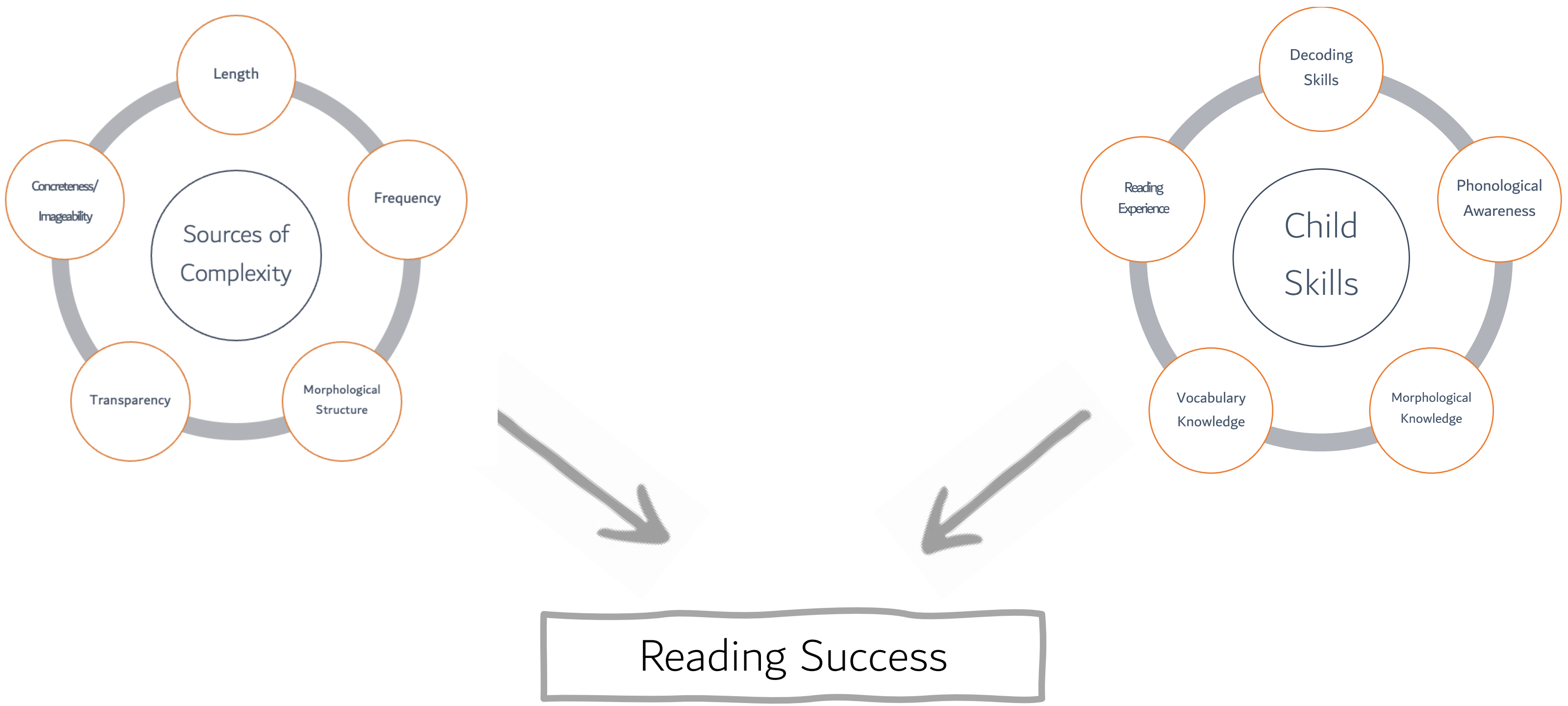
Sources of Complexity
Length
Frequency
Morphological Structure
Transparency
Concreteness/ Imageability
Child Skills
Decoding Skills
Phonological Awareness
Morphological Knowledge
Vocabulary Knowledge
Reading Experience
Reading Success

Individual Differences in Development Across Word Reading and Decoding

CHILD DEVELOPMENT

Child Development, May/June 2021, Volume 92, Number 3, Pages e252–e269

Modeling and Visualizing the Codevelopment of Word and Nonword Reading in Children From First Through Fourth Grade: Informing Developmental Trajectories of Children With Dyslexia

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Jay G. Rueckl
University of Connecticut

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Florida Center for Reading Research, Florida State University

Developmental studies examining relations between word reading (WR) and decoding in typical and dyslexic populations routinely cut the reading distribution to form distinct groups. However, dichotomizing continuous variables to study development is problematic for multiple reasons. Instead, we modeled and visualized the parallel growth of WR and nonword reading (NWR) factor scores longitudinally in a Grade 1–4 developmental sample (N = 588). The results indicate that while WR and NWR growth factors are highly related (r = .71), the relation between WR and NWR trajectories change as a function of initial WR. Results are interpreted within computational models of dyslexia in which children with dyslexia overfit orthography → phonology relations at the level of the word, limiting the development of sublexical representations needed to read nonwords.

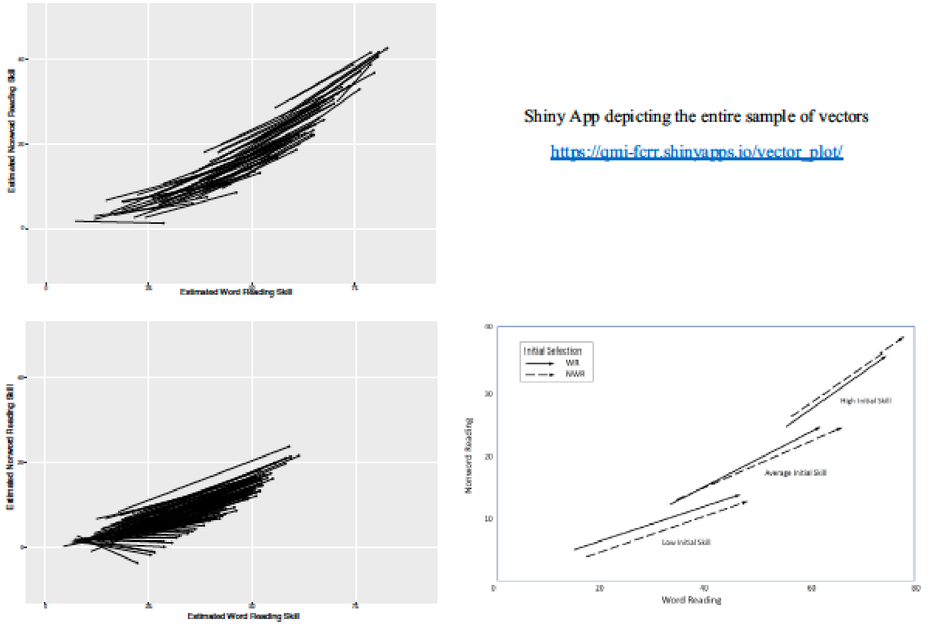

Figure 3. Vector plots illustrating estimated growth trajectories of word (x-axis) versus nonword (y-axis) reading (Grades 1–4) as a function of estimated initial word reading (WR) and nonword skill in first grade, in clockwise order starting in the upper left hand corner, for (a) random sampling of 25% of the subjects: (b) Shiny App depicting vectors as a function of first grade phonological awareness skill; (c); aggregated vectors for low, average, and high groups based on initial word and nonword reading (NWR) skill, and (d) total sample of subjects with low initial WR skill.

Steacy et al., *Child Development*, 2022

Increasing Complexity through School

Temperature changes make rocks expand and contract. Where there are extreme daily temperature changes, such as in a desert, expansion and contraction can help make rocks break apart. Another important mechanical weathering process is called abrasion. Think about what happens when you use sandpaper to smooth a piece of wood or an emery board to file your fingernails. When gravity, wind, or moving water causes rocks to run against each other, the rocks wear down or break into smaller pieces.

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What makes some words harder for some children?

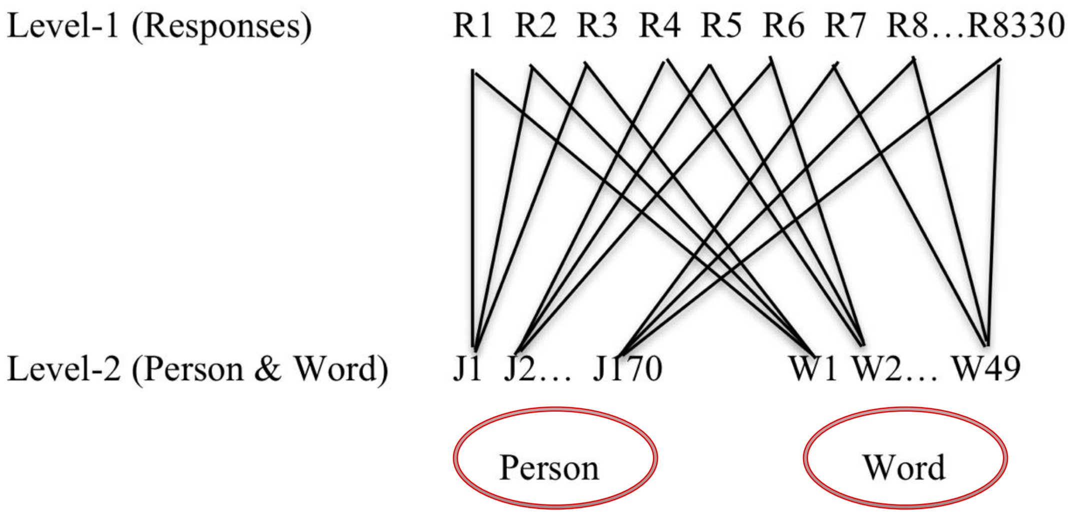
Promise of Item-Level Analyses

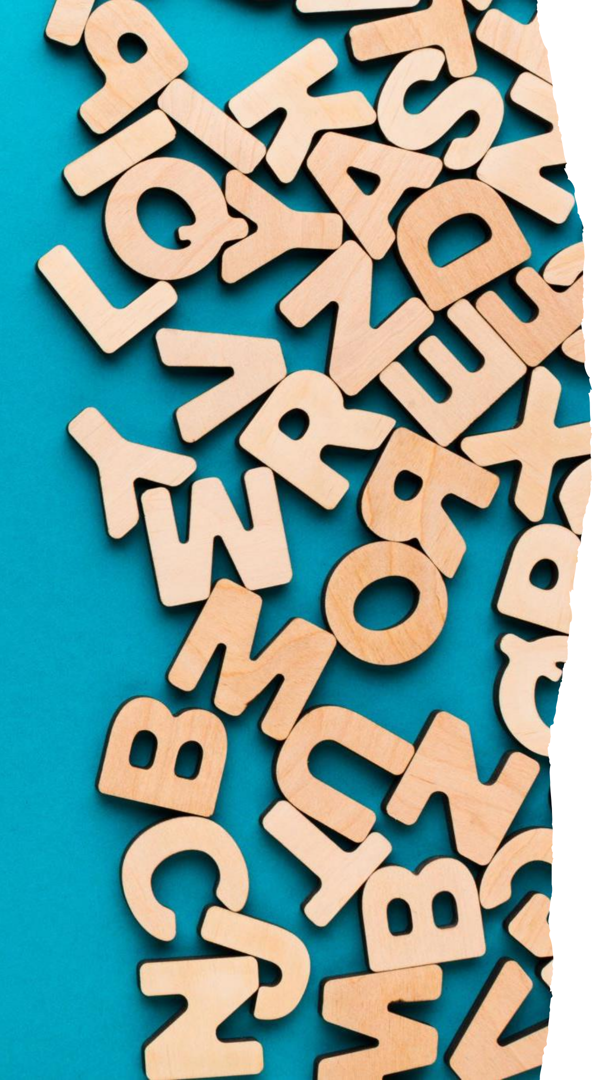
- Explanatory item response modeling uses item and person covariates to explain what is being measured (De Boeck, Cho, & Wilson, 2016)

- Item-level analytic approaches have recently afforded opportunities to examine the underlying processes in reading:
  - Word and nonword reading (e.g., Gilbert, Compton, & Kearns, 2011; Cho, Gilbert, & Goodwin, 2013)
  - Letter acquisition (e.g., Kim, Petscher, Foorman, & Zhou, 2010)
  - Vocabulary acquisition (e.g., Elleman et al., 2017)
  - Reading comprehension (e.g., Miller et al., 2014)

Explanatory Item Response Models

- These analyses allow us to partition variance across words (items) and persons and test interactions across person and word





Phonological Recoding and Learning to Read

- In most languages, the relationship between symbol and sound is systematic, whereas the relationship between symbol and meaning is arbitrary.
- A child learning to read English can exploit regularities like this to access the phonology of words. In contrast, knowing that a word starts with the letter D tells the child nothing about its meaning.
- The first steps in becoming literate, therefore, require acquisition of the system for mapping between symbol and sound.
- The process of learning and applying these mappings has been called phonological recoding.

Cross-Linguistic Comparisons

Shallow

Deep

Table 2
Data (% Correct) From Seymour, Aro, and Erskine's (2003) Large-Scale Study of Reading Skills at the End of Grade 1 in 14 European Languages

Language	Familiar real words	Pseudowords
Greek	98	92
Finnish	98	95
German	98	94
Austrian German	97	92
Italian	95	89
Spanish	95	89
Swedish	95	88
Dutch	95	82
Icelandic	94	86
Norwegian	92	91
French	79	85
Portuguese	73	77
Danish	71	54
Scottish English	34	29

Note. From "Foundation Literacy Acquisition in European Orthographies," by P. H. K. Seymour, M. Aro, and J. M. Erskine, 2003, *British Journal of Psychology, 94,* pp. 153, 156. Copyright 2003 by the British Psychological Society. Reprinted with permission.

Full vs. Partial Decoding

(Castles & Nation, 2006; Elbro et al., 2012; Tunmer & Chapman, 2012; Venezky, 1999)

- Full decoding occurs when the reader has sufficient decoding skills to decode the word and the word contains regular relationships between orthography and phonology.

right ✓ / raɪt /

- Partial decoding occurs when the reader does not have sufficient decoding skills to decode the word, or the word is irregular and cannot be pronounced correctly by applying common decoding rules

yacht ✗ / yɒt /

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Exploring Individual Differences in Irregular Word Recognition Among Children With Early-Emerging and Late-Emerging Word Reading Difficulty

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Models of irregular word reading that take into account both child- and word-level predictors have not been evaluated in typically developing children and children with reading difficulty (RD). The purpose of the present study was to model individual differences in irregular word reading ability among 5th grade children (N = 170), oversampled for children with RD, using item-response crossed random-effects models. We distinguish between 2 subtypes of children with word reading RD, those with early emerging and late-emerging RD, and 2 types of irregular words, "exception" and "strange." Predictors representing child-level and word-level characteristics, along with selected interactions between child- and word-characteristics, were used to predict item-level variance. Individual differences in irregular word reading were predicted at the child level by nonword decoding, orthographic coding, and vocabulary; at the word level by word frequency and a spelling-to-pronunciation transparency rating; and by the Reader group × Imageability and Reader group × Irregular word type interactions. Results are interpreted within a model of irregular word reading in which lexical characteristics specific to both child and word influence accuracy.

Irregular Word Reading

- Multiple sources of individual differences in irregular word reading
- In irregular words, lexical processing helps to fill voids resulting from the mismatch between orthography and phonology
- Allowing word- and child-attributes to compete for variance in the same model provides an opportunity to consider new, and possibly untested, approaches to effectively teach irregular word reading skills

Set for Variability/ Mispronunciation Correction

- Newly revived but older construct
- The ability to disambiguate the "mismatch" between the decoded form of a word and its actual pronunciation
- Set for variability was first coined by Gibson and Levin (1975) and later resurrected by Venezky (1999)

scissors
[/ˈskɪsərz/]

Expert Rating

Irregular Word Reading Task

We are interested in learning about how children read irregular words. Irregular words are not spelled using conventional spelling rules. An example of an irregular word is “mother”. It is an irregular word because you cannot exactly arrive at the word’s pronunciation by sounding it out.

Children unfamiliar with these words may apply decoding strategies when asked to read them. We would like to see how effective these decoding strategies may be for correctly identifying the word pronunciations. We assume that decoding strategies will be more successful for reading some irregular words than others.

Below you will find a list of irregular words. We would like you to pretend that the letter string is unfamiliar to you and apply a decoding strategy to the letter string and rate the ease of matching your recoded form of the letter string to the actual word pronunciation. Rate the difficulty of making the match between recoded form and pronunciation on a scale from 1 to 6, with 1 being very easy and 6 being very difficult.

Word	Rating					
ocean	1	2	3	4	5	6
iron	1	2	3	4	5	6
island	1	2	3	4	5	6
break	1	2	3	4	5	6

Measuring the distance between regularized decoding pronunciation and the actual phonological representation.

e.g. the lexical distance for

yacht
suede
$>$
pint
touch

Steacy et al., *Journal of Educational Psychology, 2017*

Behavior Research Methods
https://doi.org/10.3758/s13428-023-02205-2

Spelling-to-pronunciation transparency ratings for the 20,000 most frequently written English words

Ashley A. Edwards[1] · Valeria M. Rigobon[1] · Laura M. Steacy[1] · Donald L. Compton[1]

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Abstract

Given English orthography's quasi-regular nature, applying common decoding rules to a word does not always result in a correct pronunciation matching the stored phonological form (e.g., the word *tongue*). To arrive at a correct pronunciation, developing readers must make the match between a decoded pronunciation and a word's correct pronunciation stored in memory. Developmentally, this matching process varies as a function of child skill (e.g., decoding, vocabulary) and word characteristics (e.g., spelling-to-pronunciation transparency, concreteness), with each being continuously distributed. Spelling-to-pronunciation transparency ratings represent a global measure of the ease of arriving at a word's correct pronunciation from its decoded pronunciation and in experimental studies has been shown to be a critical dimension in assessing the difficulty of a word for developing readers (e.g., Steacy et al., 2022a, 2022b). This study aimed to create a database of spelling-to-pronunciation transparency ratings for the 23,282 most frequently written English words, made available in the supplemental materials for future analyses. We asked adults to rate words' spelling-to-pronunciation transparency on a scale of 1–6 (1 = very easy to match, 6 = very difficult). Results of multiple regression analyses revealed variance in ratings to be unaccounted for by other word features, demonstrating the uniqueness of these ratings. Furthermore, words that are considered irregular, classified previously as strange, or contained at least one schwa received higher ratings, demonstrating strong associations between transparency and regularity. Lastly, these ratings significantly predicted both adult word naming time and child word reading accuracy above and beyond other word features known to predict reading.

Keywords Spelling-to-pronunciation transparency · Regularity · Set for variability · Word ratings

Measurement of Set for Variability

- SfV has been operationalized using an oral language mispronunciation task
- Tasks have been done in both opaque (English, Danish) and transparent (Dutch) languages (Elbro et al., 2012)
- Elbro et al. report that mispronunciations based on spelling pronunciations in Danish are more predictive than those based on other substitutions (e.g., telefonen ('the telephone') mispronounced "deleponen")

Set for Variability as a Second Step in Decoding

- During orthographic learning, SfV may bridge the gap between the decoded form of a word (spelling pronunciation) and the word's actual phonological representation/phonological form

- The ability to match the decoded form with the stored phonological form (SfV) serves as a bridge between decoding and lexical pronunciations (Elrbo et al., 2012)

set for variability

decoded form

phonological form

[/ˈskɪsərz/]

Set for Variability as an Item Specific and Metalinguistic Skill

treasure	break
spinach	onion
deaf	whom
kind	weather
island	ninth
piano	chemist
prove	iron
lizard	camel
veins	scent
mystery	metal
measles	blind
ache	lamb
deny	soup
pudding	devil
stomach	rely
chorus	tongue
body	scissors
pigeon	river
rhythm	post
money	wasp

- Transparency of the word, set for variability, and word reading skill impacted performance
- Both item-specific set for variability and general child level performance on the task were strong predictors of item-specific word reading
- Good phonological skills and word reading skills can support general decoding but may not lead to the correct pronunciation of irregular words

Steacy et al., 2019, *Scientific Studies of Reading*

Predictive Power of Set for Variability

- SfV demonstrated complete statistical dominance over all other predictors

Variable importance in random forest

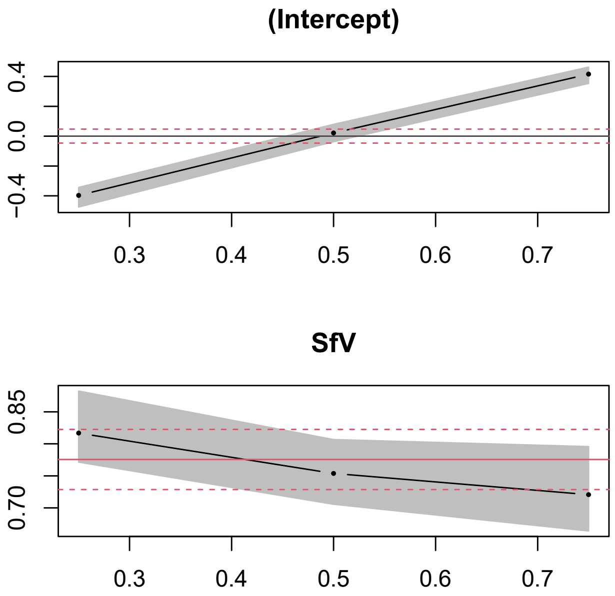
Variable	Percent increase in mean squared error	Increase in node purity
Set for variability	23.54	161.07
Attention	8.39	75.67
Rapid letter naming	7.99	65.47
Phonological awareness	7.87	101.35
Vocabulary	3.47	61.71

Note. Increase in node purity refers to the decrease in residual sum of squares from splitting on the variable averaged over all the trees. A split with a large increase in node purity is more informative.

Steacy et al., 2022, *Reading Research Quarterly*

Predictive Power of Set for Variability

Quantile Regression



Steacy et al., 2022, *Reading Research Quarterly*

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Routledge
Taylor & Francis Group

Check for updates

Modeling Complex Word Reading: Examining Influences at the Level of the Word and Child on Mono- and Polymorphemic Word Reading

Laura M. Steacy[a], Valeria M. Rigobon[a], Ashley A. Edwards[a], Daniel R. Abes[a], Nancy C. Marencin[a], Kathryn Smith[a], James D. Elliott[a], Lesly Wade-Woolley[b], and Donald L. Compton[a]

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ABSTRACT

Purpose: The probability of a child reading a word correctly is influenced by both child skills and properties of the word. The purpose of this study was to investigate child-level skills (set for variability and vocabulary), word-level properties (concreteness), word structure (mono- vs polymorphemic), and interactions between these properties and word structure within a comprehensive item-level model of complex word reading. This study is unique in that it purposely sampled both mono- and polymorphemic polysyllabic words.

Method: A sample of African American ($n = 69$) and Hispanic ($n = 6$) students in grades 2–5 ($n = 75$) read a set of mono- and polymorphemic polysyllabic words ($J = 54$). Item-level responses were modeled using cross-classified generalized random-effects models allowing variance to be partitioned between child and word while controlling for other important child factors and word features.

Results: Set for variability and the interaction between concreteness and word structure (i.e., mono- vs polymorphemic) were significant predictors. Higher probabilities of reading poly- over monomorphemic words were identified at lower levels of concreteness with the opposite at higher levels of concreteness.

Complex Word Reading

alligator
animal
anticipate
beastly
capitalize
categorize
caterpillar
classical
confession
confusion
congratulate
considerate
convention
cultural
disloyalty
edgy
elephant
entirely

family
finality
flowery
gallery
heavenly
independence
intensity
macaroni
magician
majority
masterful
metal
movement
mustang
natural
odorous
organist
origin

paradise
parent
pepperoni
potato
precision
pyramid
raccoon
remember
rosy
routine
salamander
secretive
security
showy
stylish
surrender
tarantula
unworkable

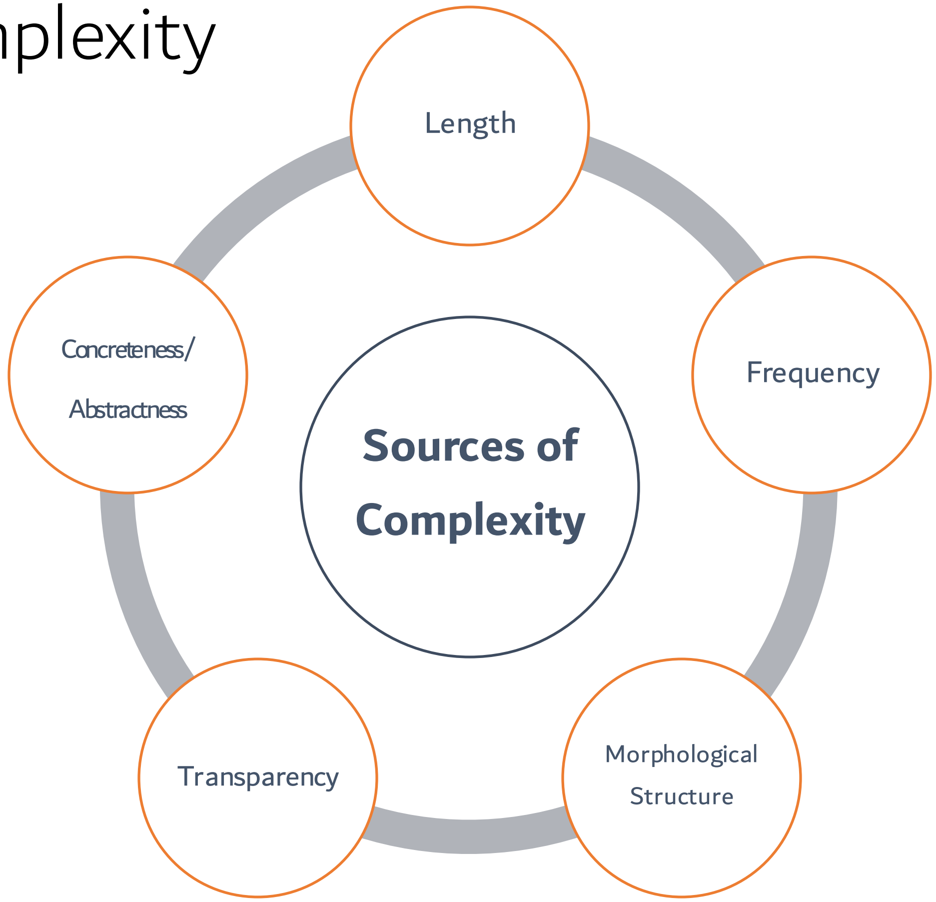
morpheme – smallest unit of meaning in language

Multisyllabic words with 1 morpheme (e.g., salamander)

vs.

Multisyllabic words with 2 or more morphemes (e.g., natural, magician)

Sources of Word Complexity



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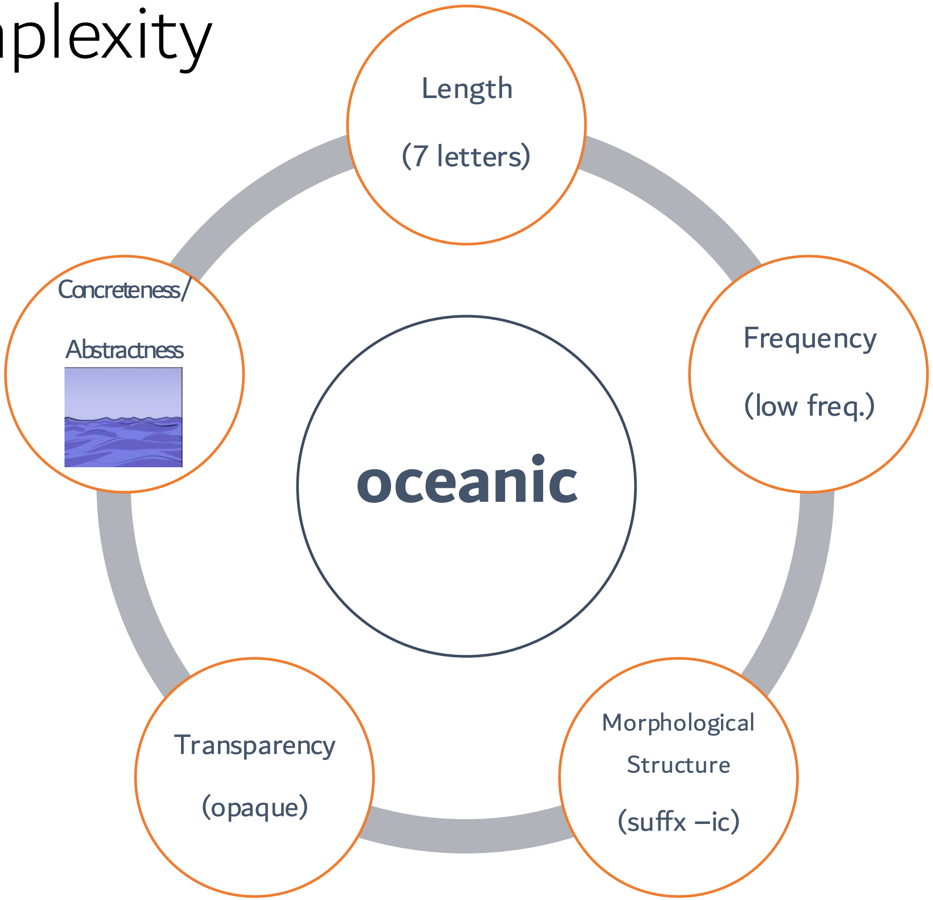
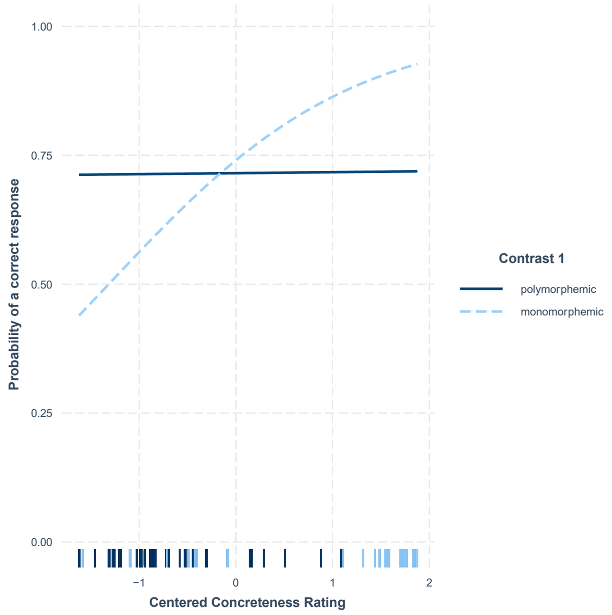


Complex Word Reading



Steacy et al., 2022, *Scientific Studies of Reading*

Scientific Studies of Reading, 18:55–73, 2014

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Have We Forsaken Reading Theory in the Name of "Quick Fix" Interventions for Children With Reading Disability?

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Vanderbilt University

Exploring Differential Effects Across Two Decoding Treatments on Item-Level Transfer in Children With Significant Word Reading Difficulties: A New Approach for Testing Intervention Elements

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[a]Florida Center for Reading Research; [b]Florida State University; [c]Middle Tennessee State University; [d]The Hospital for Sick Children; [e]University of Toronto

ABSTRACT

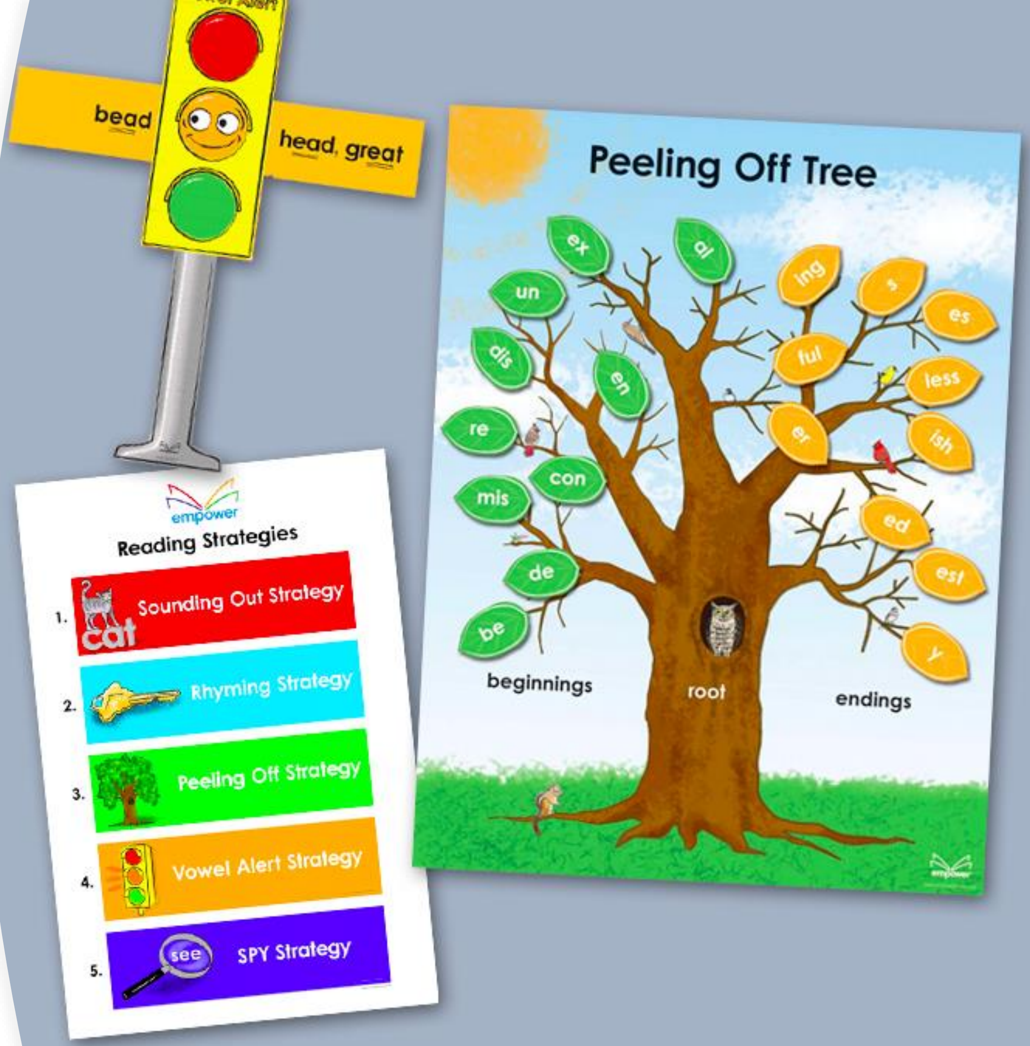
In English, gains in decoding skill do not map directly onto increases in word reading. However, beyond the Self-Teaching Hypothesis, little is known about the transfer of decoding skills to word reading. In this study, we offer a new approach to testing specific decoding elements on transfer to word reading. To illustrate, we modeled word-reading gains among children with reading disability enrolled in Phonological and Strategy Training (PHAST) or Phonics for Reading (PFR). Conditions differed in sublexical training with PHAST stressing multilevel connections and PFR emphasizing simple grapheme-phoneme correspondences. Thirty-seven children with reading disability, 3rd to 6th grade, were randomly assigned 60 lessons of PHAST or PFR. Crossed random-effects models allowed us to identify specific intervention elements that differentially impacted word-reading performance at posttest, with children in PHAST better able to read words with variant vowel pronunciations. Results suggest that sublexical emphasis influences transfer gains to word reading.

Design

- 37 children identified with RD in grades 3 through 6
- Children received 60 lessons, twice a week for 1.5 hours/lesson, of either the Phonological and Strategy Training (PHAST; Lovett, Lacerenza, & Borden, 2000) or Phonics for Reading (PFR; Archer, Flood, Lapp, & Lungren, 2002)
- Cluster randomized design with small groups randomly assigned to condition

Design

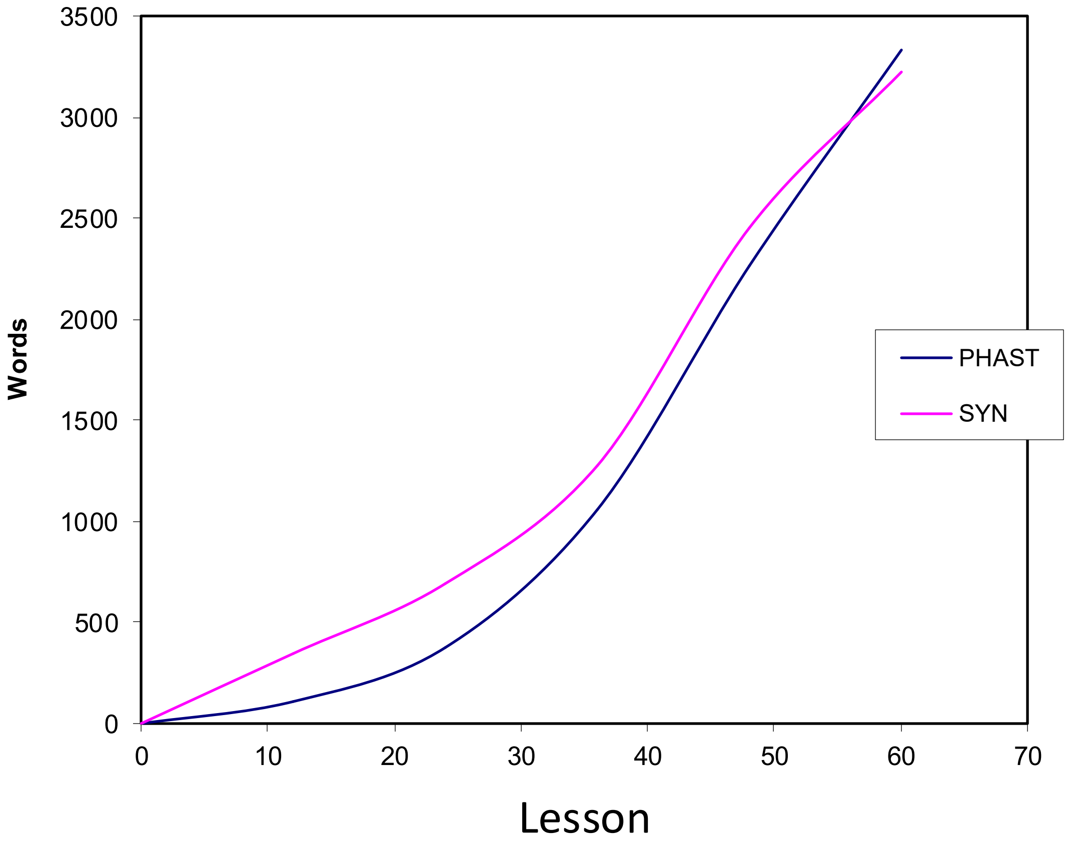
- PHAST (Empower)
  - Remediation of basic phonological awareness and letter-sound-learning difficulties
  - Trains at multiple orthographic-phonological connection level
  - Specific training of five word identification strategies:
    - Sounding out
    - Compare and Contrast (rime unit)
    - Vowel Variation
    - Seek the Part You Know (SPY)
    - Peeling-Off Affixes
- Phonics for Reading (PFR)
  - Synthetic phonics program targeting general phonics rules



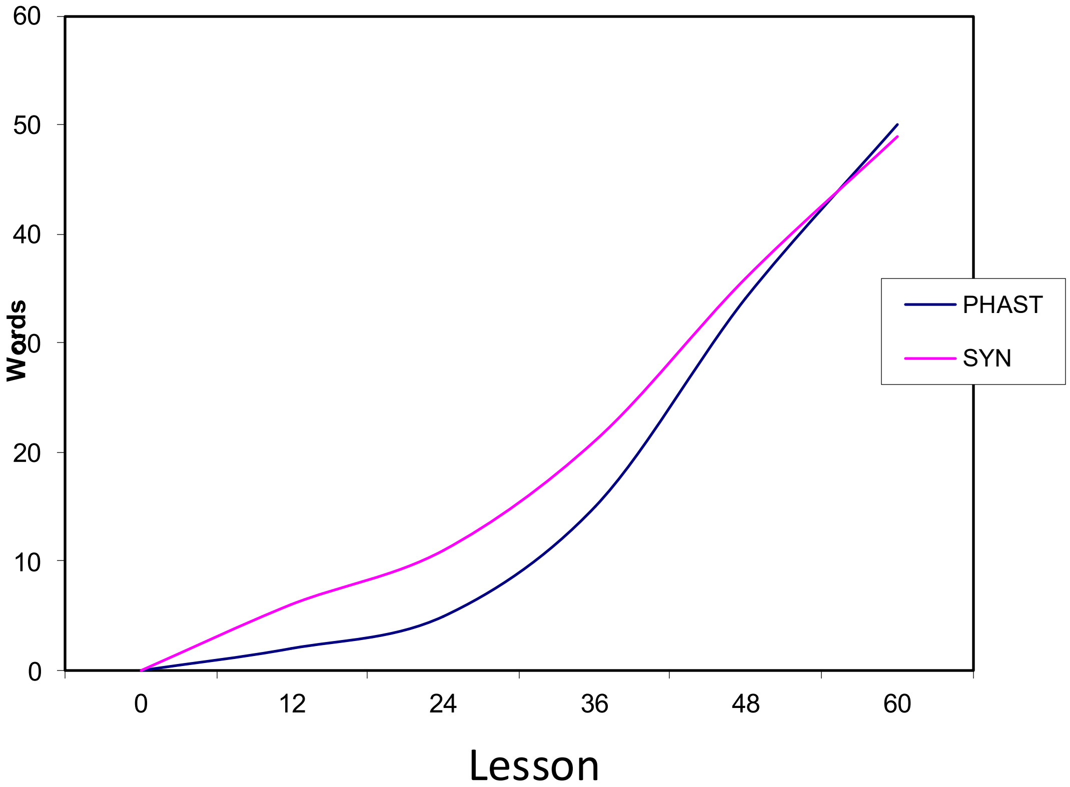
Measure of Responsiveness

- The responsiveness measure was designed to be sensitive to individual differences in learning while also having the capacity to change systematically and predictably with instruction.
  - A systematic procedure was developed for sampling words for the responsiveness measure that was based on an optimal growth function predicting when a large corpus of words become decodable as a function of the intervention lessons.
  - This allowed individual growth on the assessment measure to generalize to a larger corpus of decodable words.
  - Individual growth was referenced against an optimal growth function based on the intervention.

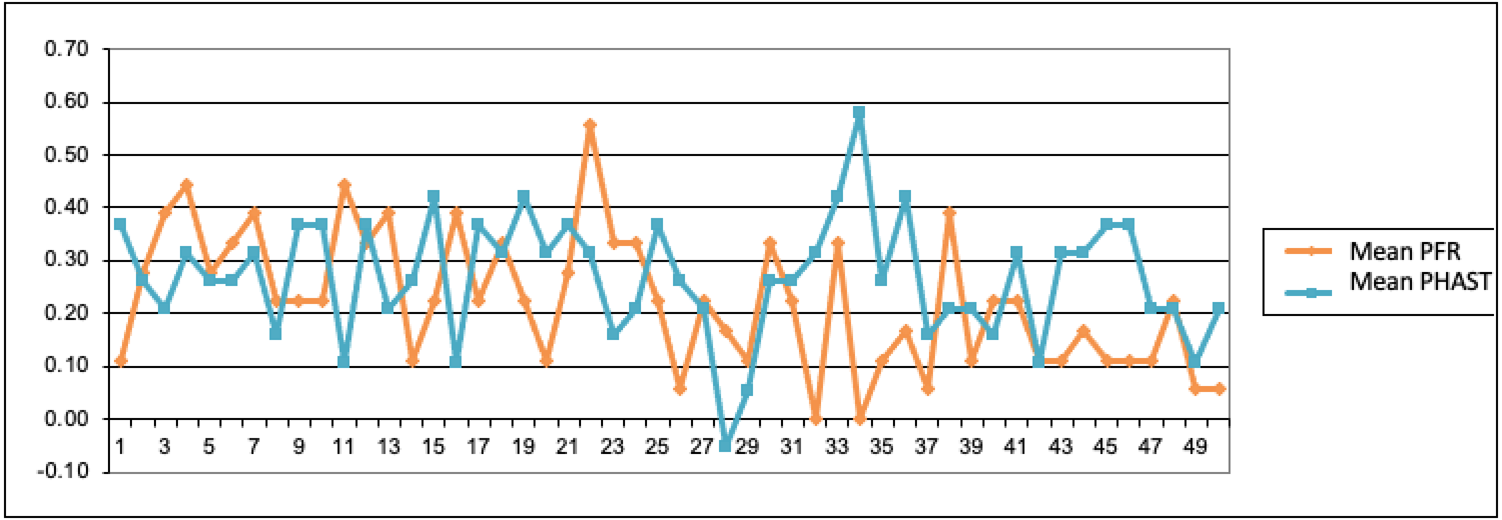
Optimal Growth Function Corpus



Optimal Growth Function Measure



Posttest Item Means by Group



Posttest Item Effect Sizes

Item	ES		Item	ES
sad	0.79		finish	0.65
math	-0.03		camera	-0.03
gift	-0.43		distant	-0.65
tail	-0.28		amazing	-0.21
limit	-0.03		shout	-0.17
visit	-0.15		reflect	0.09
cake	-0.17		perfectly	1.11
goat	-0.13		negative	0.22
drop	0.36		shining	1.34
string	0.31		organized	0.54
planet	-0.88		gravity	0.54
husband	0.07		primitive	0.46
sixth	-0.44		destroyed	-0.37
beside	0.38		screen	0.22
artist	0.42		available	-0.23
seated	-0.64		constantly	0.25
crime	0.30		expensive	-0.03
gather	-0.04		holiday	0.59
unlike	0.44		construction	0.37
repeat	0.44		underneath	0.59
sharply	0.19		pleasant	0.74
enter	-0.57		equipment	0.30
floating	-0.36		instrument	-0.03
chosen	-0.26		applying	0.16
operate	0.32		argument	0.43

Results

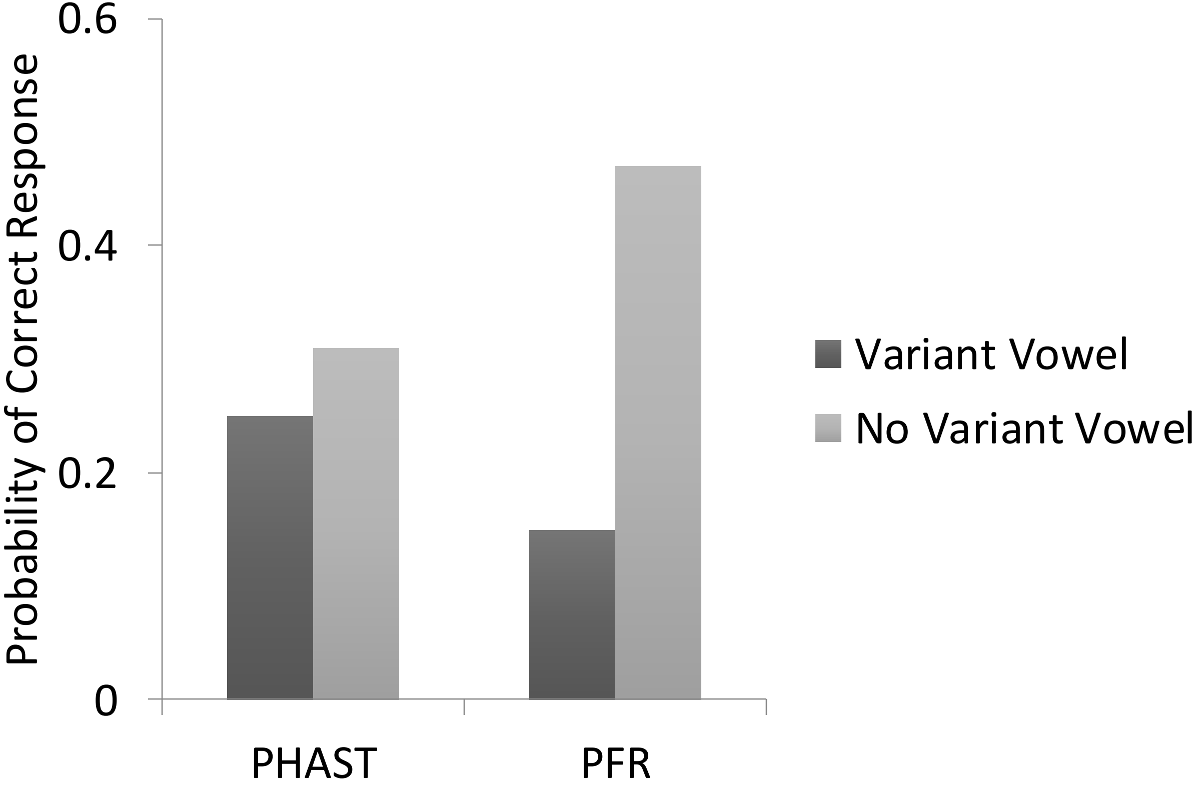
Table 2

Fixed Effects and Variance Estimates for Responses on the Treatment Aligned Measure

	Unconditional model			Interaction model		
Fixed Effects Parameter	Est.	(SE)	z	Est.	(SE)	z
Intercept (γ_{000})	-.178	(.493)	.360	-1.447	(.825)	1.753
Item covariate						
γ_{001} Pretest	—	—	—	**1.314**	**(.246)**	**5.353**
Child covariates						
γ_{002} Condition	—	—	—	-.652	(.350)	1.863
γ_{003} Vocabulary	—	—	—	.013	(.007)	1.807
γ_{004} PA	—	—	—	.032	(.057)	.560
γ_{005} RAN	—	—	—	.050	(.038)	1.319
γ_{006} Word Identification	—	—	—	**.091**	**(.013)**	**7.293**
Word covariates						
γ_{007} Letters	—	—	—	**-.580**	**(.119)**	**4.884**
γ_{008} Keyword	—	—	—	.301	(.370)	.813
γ_{009} Variant Vowel	—	—	—	**-1.582**	**(.379)**	**4.172**
γ_{010} Affixes	—	—	—	-.094	(.452)	.209
γ_{011} Concreteness	—	—	—	.246	(.180)	1.370
Interactions						
γ_{012} PA × Keyword	—	—	—	.010	(.051)	.195
γ_{013} Condition × Variant Vowel	—	—	—	**1.247**	**(.304)**	**4.104**
γ_{014} Condition × Affixes	—	—	—	.357	(.322)	1.109
γ_{015} Condition × Keyword	—	—	—	-.016	(.296)	.053

Random Effects	Variance	Variance
Intercepts		
Word	3.781	.858
Person	2.220	.084
Group	1.639	<.001
Person slopes		
Letters	—	.066

Variant Vowel Interaction



Program Comparison

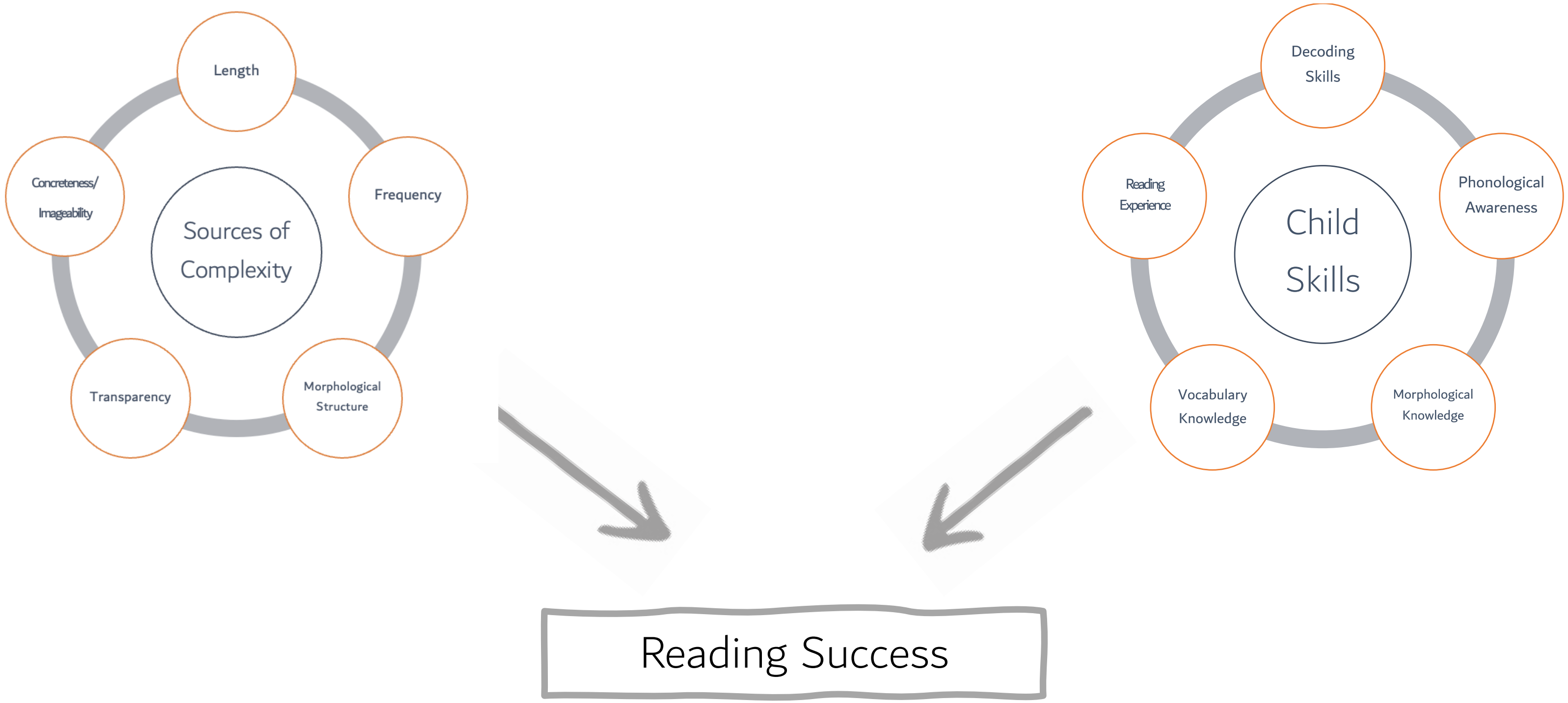
- Overall, word reading variance on our treatment aligned measure was explained at the item-level by pretest performance, at the person-level by word identification, and at the word-level by the number of letters in the word and whether it contained a variant vowel
- There was a significant interaction between condition and variant vowel
- This interaction indicated that despite no overall difference between the effectiveness of the programs, there was a significant advantage for PHAST in terms of flexibility with variant vowels

Conclusions

Analyses at the item level allowed us to examine the impact of specific treatment characteristics

The “Vowel Alert” strategy in PHAST seemed to result in greater flexibility in reading words that included variant vowels

A corpus level analysis of the 5000 most frequent words revealed that over 50% of the decodable words contained a variable vowel pattern (including words containing schwa).


Length
Frequency
Morphological Structure
Transparency
Concreteness/ Imageability
Sources of Complexity
Decoding Skills
Phonological Awareness
Morphological Knowledge
Vocabulary Knowledge
Reading Experience
Child Skills
Reading Success

Susie Dent @susie_dent · Jan 20

Word of the day is 'finifugal', from the 19th century: avoiding the end of something (a box set, an excellent book, sleep, etc.) because you want it to go on forever.

122 1.3K 6.2K 408K

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@LMSteacy
@theFCRR

Thank you!

lsteacy@fcrr.org

Variable Vowel COLLABORATIVE An Interdisciplinary LD Hub

PROJECT Wordy

Project FLEX

developmental English Lexicon Project (d-ELP) An Interdisciplinary Research Hub

ies INSTITUTE OF EDUCATION SCIENCES

NIH *Eunice Kennedy Shriver* National Institute of Child Health and Human Development