The Role of the Contextual and Morphological Semantic Information in the Orthographic Learning of English Polysyllabic Words

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Overview

Purpose of Study

- The purpose of this study is to examine factors related to the acquisition of whole-word representations of polysyllabic words. the **effects of the semantic information** provided by context and morphemes on the acquisition of whole-word representations of polysyllabic words.

Semantic knowledge affects orthographic learning: Context

- Learning in short stories vs. in isolation (often, sorting)
- Unclear pattern of effects
  - Null effects: Cunningham (2006); Nation, Angell, & Castles (2007)
  - Negative effects (context worse): Landi et al. (2006)
  - Interaction effects: Context facilitates learning of irregular words (Wang et al., 2011)

Morphological information affects orthographic learning

- Morphemes as orthographic units
  - Frequently occurring consistent grapheme-phoneme units (Tucker et al., 2016)
  - Make morphological decoding easier
- Morphemes as semantic units
  - Directly link orthography and semantics (Pacton et al., 2018)
- May support word recognition in both ways
- Could morphological information create nascent semantic representations that improve orthographic learning?

Interaction of Context and Morphology

- Can morphologically complex words induce greater orthographic learning when learned in context rather than in isolation?
  - Encountering a morphologically complex word in a meaningful context might increase the amount of orthographic learning

Relation between Morphological Knowledge and Orth. Learning

- Does general morphological knowledge support orthographic learning after accounting for phonological decoding and general orthographic learning?
- Phonological decoding: Cornerstone of self-teaching (Share, 1995)
- General orthographic knowledge: Strongly related to orthographic learning (Cunningham, 2006)

Research Questions

1: Semantics/morphology in orthographic learning

- How strong are Grade 4 and 5 children's orthographic representations for polysyllabic words as shown on orthographic choice and spelling tasks
  - when practiced in context or isolation ?
  - when presented as monomorphemic or polymorphemic words?

2: Orthographic learning relation with morph. knowledge

- Does morphological knowledge relate to orthographic learning for printed polysyllabic words as measured by orthographic choice and spelling tasks
  - when controlling for phonological decoding and general orthographic knowledge?

Method

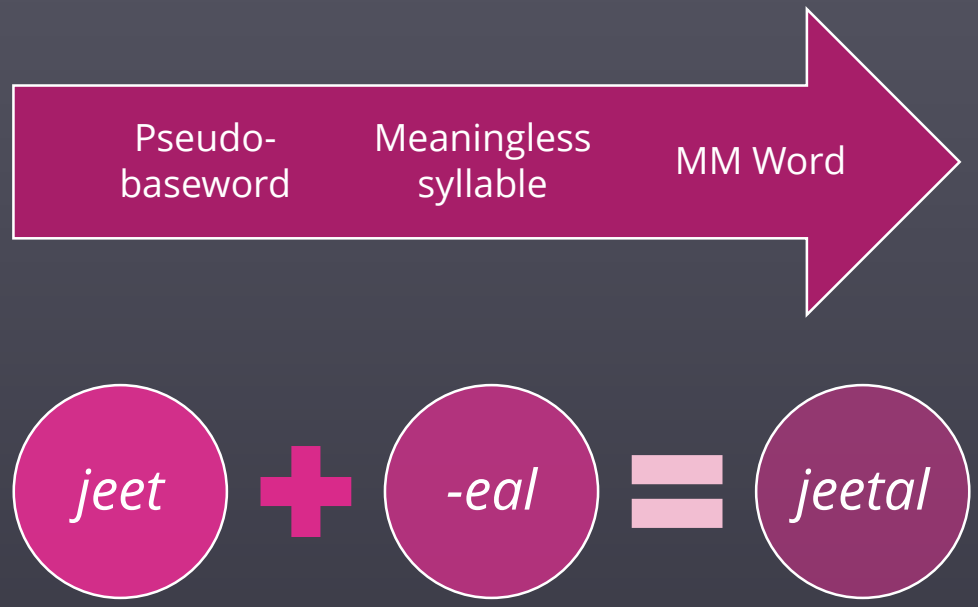
Participants (N = 73)

- Grades:
  - 4th (n = 29)
  - 5th (n = 44)
- IEP Status:
  - No (n = 64)
  - Yes (n = 9)

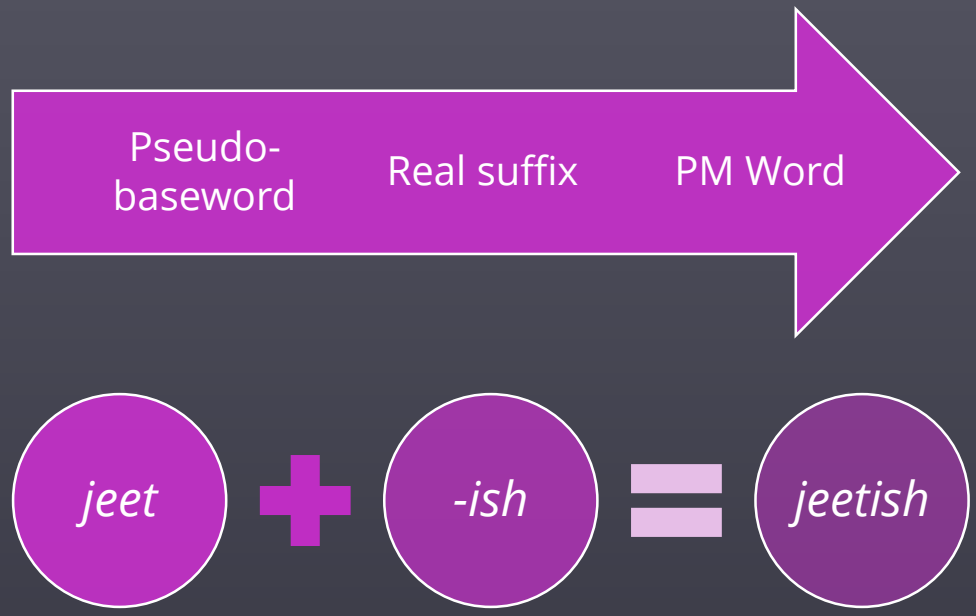
- Reading skill groups
  - Based on
    - TOWRE Sight Word Efficiency subtest
    - TOWRE Phonemic Decoding Efficiency subtest
  - Defined as
    - Typical reading skill: > 35%ile
      - (n – 55):
    - At-risk: ≥ 25%ile, ≤ 35%ile
      - (n = 12)
    - With reading difficulty: < 25%ile
      - n = 6

Stimuli: Bisyllabic pseudowords

Monomorphemic (*n* = 6)



Polymorphemic (*n* = 6)



Stimuli: Pseudo-baseword design

beel	yauk
foud	zeet
jeal	lerg
nawl	merd
roop	nurk
voun	zurt

- ✓ Four letters
  - reduce likelihood of length affecting representation quality
- ✓ Vowel GPCs with frequent alternatives
- ✓ CVVC or CVCC (orth.) pattern
  - avoided final *E* rule
- ✓ Variability in rime frequency
  - necessary because of challenges meeting all criteria without creating a real word

Stimuli: Pseudo-baseword design

-oop = 293 *roop*

-oom = 4,607 *room*

- ✓ Four letters
  - reduce likelihood of length affecting representation quality
- ✓ Vowel GPCs with frequent alternatives
- ✓ CVVC or CVCC (orth.) pattern
  - avoided final *E* rule
- ✓ Variability in rime frequency
  - necessary because of challenges meeting all criteria without creating a real word

Stimuli: Suffix & Syllable Selection

- Low Frequency
  - Meaningless syllable:
    -rass
    token frequency = 1,175
  - Real suffix:
    -ness
    token frequency = 1,269
- Low Frequency
  - Meaningless syllable:
    -bel
    token frequency = 3,765
  - Real suffix:
    -ful
    token frequency = 4,819

* Frequencies were obtained from a subset of the Educator's Word Frequency Guide corpus (EWFG; Zeno et al., 1995) that contained 15,093 words and included the frequency counts for grades 1–5

Stimuli: Pseudo-baseword foils

Distractor Type	*Voun* Distractor
Homophone	vown
Visual	voum
Visual's Homophone	vowm

	Target	HF	VD	VDH
1.	vounbel	vownbel	voumbel	vowmbel
2.	foudrass	fowdrass	toudrass	towdrass
3.	lergful	lurgful	fergful	furgful
4.	beelness	bealness	lealness	leelness
5.	yaukbel	yawkbel	vawkbel	vaukbel
6.	jealrass	jeelrass	yealrass	yeelrass
7.	merdful	murdful	merpful	murpful
8.	nawlness	naulness	nawtness	nautness
9.	zeetbel	zeatbel	zeedbel	zeadbel
10.	rooprass	rewprass	nooprass	newprass
11.	zurtful	zertful	surtful	sertful
12.	nurkness	nerkness	nurlness	nerlness

Note. HF = Homophone foil; VD = Visual distractor; VDH = Visual distractor's homophone

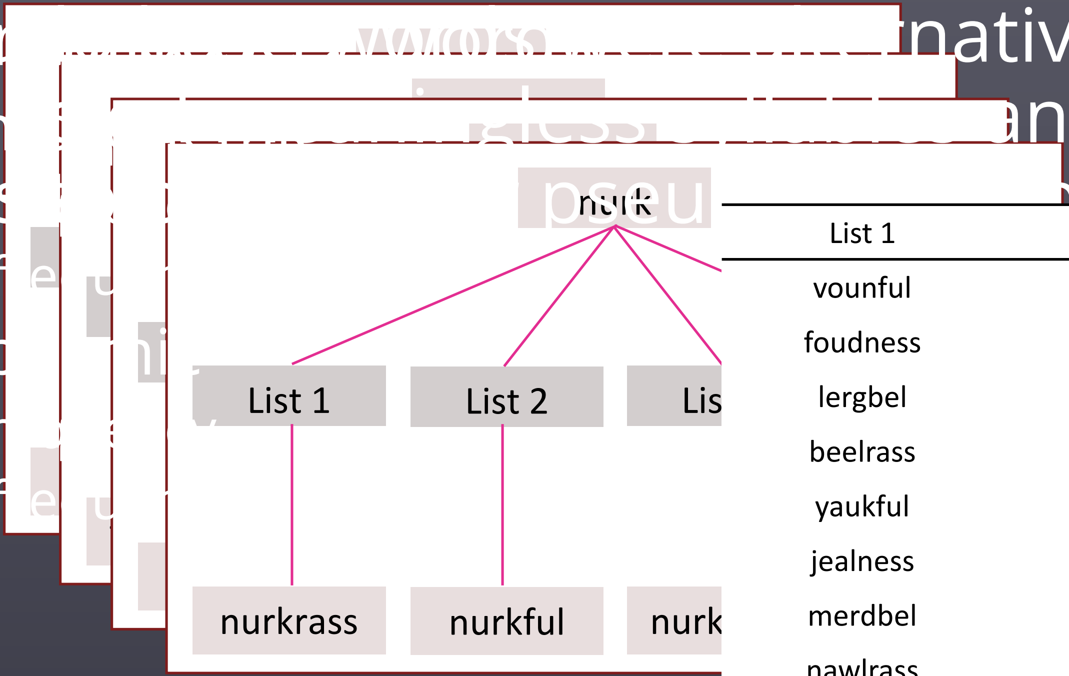
Stimuli: Pseudo-baseword foil homophones

- GPCs were selected with reasonably frequent alternatives
- Frequencies derived from GPC calculator
  - designed by Kearns (2018)
  - used in Siegelman, Kearns, & Rueckl (submitted)
  - based on frequencies for Grades 1-3 words in the EWFG
  - see https://phinder.devinkearns.org

Phon.	Pseudo-baseword	Foil
/æw/	ou = 192 words	ow = 125 words
/i/	ea = 317 words	ee = 271 words
/ɝ/	er = 1295 words	ur = 184 words
/ɔ/	au = 68 words	aw = 74 words
/u/	ew = 55 words	oo = 178 words

Stimuli: Word List Design

- Each list ... natively paired with the sel... and morphemes ... ic words
  - 6 monom...
    - 3 low-...
    - 3 high-f...
  - 6 bimorp...
    - 3 low-fr...
    - 3 high-f...



List 1	List 2	List 3	List 4
vounful	vounness	vounbel	vounrass
foudness	foudbel	foudrass	foudful
lergbel	lergrass	lergful	lergness
beelrass	beelful	beelness	beelbel
yaukful	yaukness	yaukbel	yaukrass
jealness	jealbel	jealrass	jealful
merdbel	merdrass	merdful	merdness
nawlrass	nawlful	nawlness	nawlbel
zeetful	zeetness	zeetbel	zeetrass
roopness	roopbel	rooprass	roopful
zurtbel	zurtrass	zurtful	zurtness
nurkrass	nurkful	nurkness	nurkbel

Orthographic Learning Task: Context

Condition Design: Stories (*N*= 12)

- 4 sentences (range: 3–5)
- 55 words (range: 54–57).
- 85 reading ease (Flesch, 1979) score (range: 79–88)
- Grade 4.4 readability level (range: 4–5)

Procedure

- The children were provided with a shuffled set of 12 stories
- They were instructed to read them aloud, one at a time.
- No corrective feedback was provided.
- The test examiner recorded the children’s reading errors on a scoring sheet.

Orthographic Learning Task: Context

Uses of psuedowords in stories

- *-ful* and *-bel*
  - shared the same set of stories
  - functioned as adjectives
- *-ness* and *-rass*
  - shared the same set of stories
  - functioned as nouns

Story with polymorphemic pseudoword

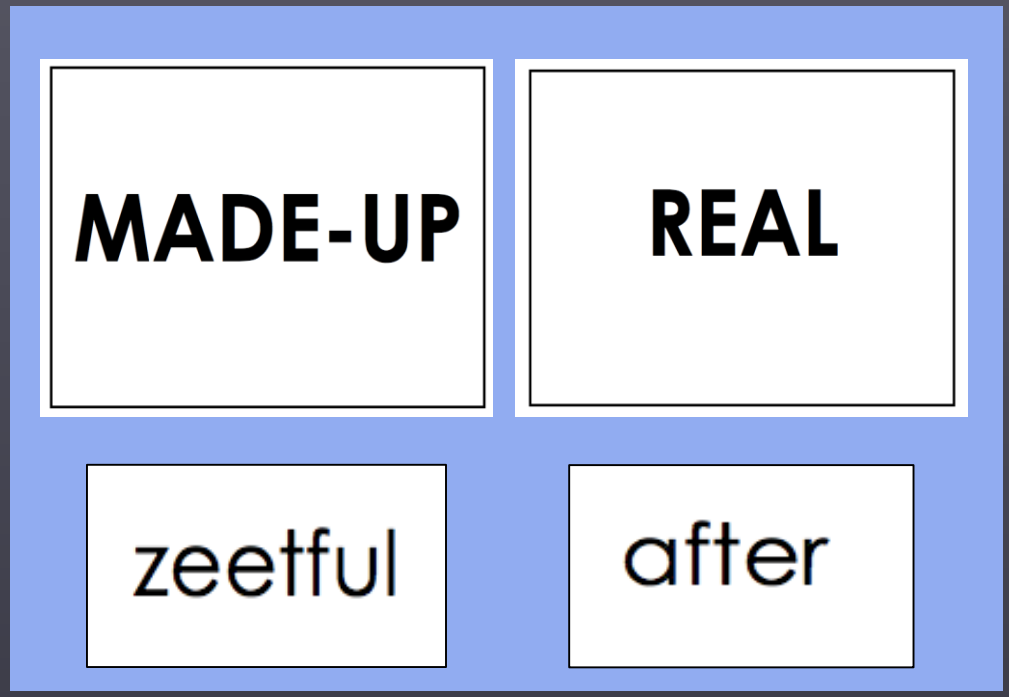
My older sister and I made a yaukful cake for my mom's birthday party. Everyone at the party liked the cake and said it was very yaukful. It was our first time baking and we were happy the cake turned out to be yaukful. We told mom we would make it again for her next year.

Story with polysyllabic pseudoword:

My older sister and I made a jealbel cake for my mom's birthday party. Everyone at the party liked the cake and said it was very jealbel. It was our first time baking and we were happy the cake turned out to be jealbel. We told mom we would make it again for her next year.

Orthographic Learning Task: Isolation

- Sorting Cards (*N* = 108)
  - 36 pseudoword cards (12 stimuli x 3)
  - 72 real word cards
- Procedure:
  - The task administrator modeled with a training set
  - Children told to read the words aloud, one at a time, and sort them into a real-word pile and a made-up word pile
  - No corrective feedback was provided



Procedure: Random Assignment

- Groups created
  - to conditions (context vs. isolation)
  - to one of the four alternative stimuli lists
- Procedure
  - The child list was split by grade (assignment blocked on grade)
  - Children in each grade were randomly assigned to one of eight groups (2 conditions × 4 stimulus lists)

Procedure: Lesson Delay

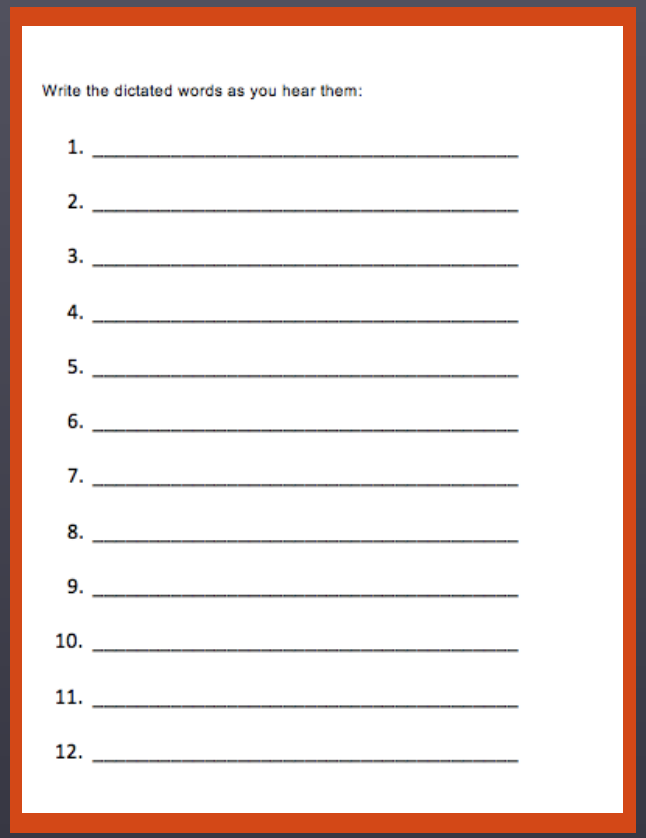
	Whole-Sample (N = 73)		Isolation Condition (n = 35)		Context Condition (n = 38)		Isolation vs. Context		
Variable	n	%	n	%	n	%	χ^2	*df*	*p*
Session-Delay							2.086	3	0.56
3 Days	64	88	31	**89**	33	**87**			
4 Days	7	10	3	**9**	4	**11**			
5 Days	1	1	0	**0**	1	**3**			
6 Days	1	1	1	**3**	0	**0**			

Note. Session-Delay = number of days elapsed between performing the orthographic learning task and completing the measures of orthographic learning.

* Numbers in boldface add up to 101% due to rounding error.

Measures: Orthographic Learning

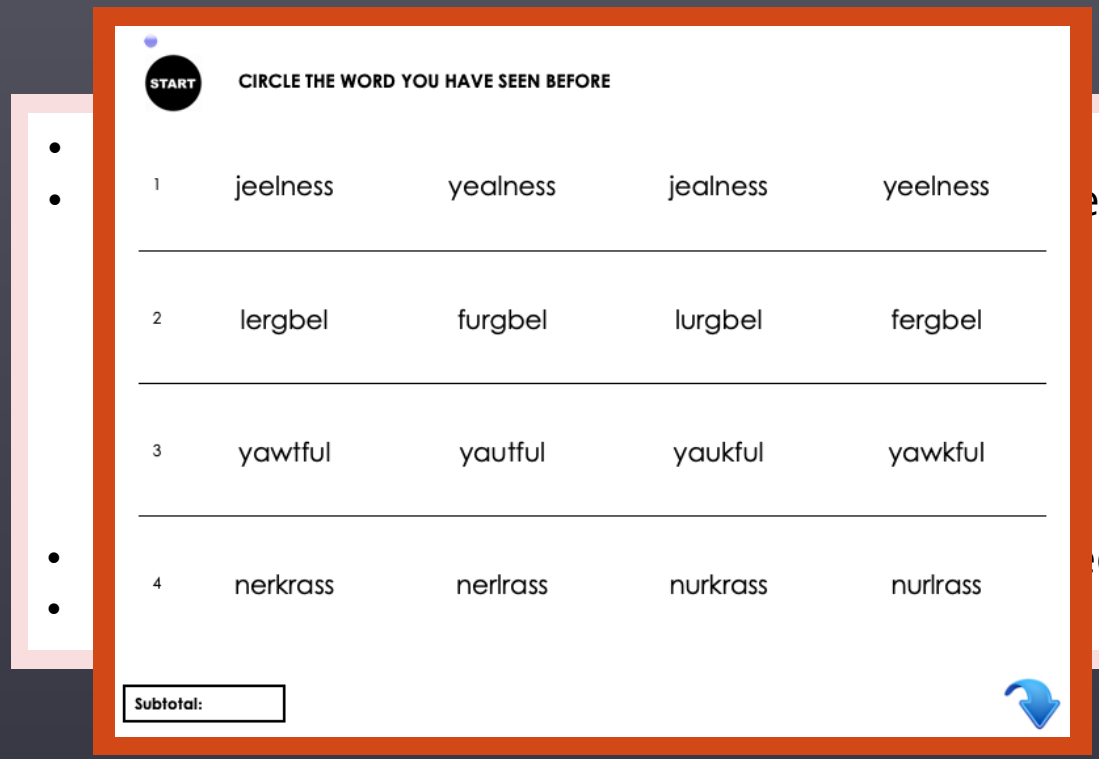
Spelling Task



Write the dictated words as you hear them:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____

Orthographic Choice Task



START

CIRCLE THE WORD YOU HAVE SEEN BEFORE

1	jeelness	yealness	jealness	yeelness
2	lergbel	furgbel	lurgbel	fergbel
3	yawtful	yautful	yaukful	yawkful
4	nerkrass	nerlrass	nurkrass	nurlrass

Subtotal:

Measures: General Reading Skills

- **Phonological decoding measures**
  - *Test of Word Reading Efficiency: Phonemic Decoding Efficiency subtest(TOWRE-PDE;* Torgesen et al., 1999)
  - *Woodcock Reading Mastery Test, third Edition*: *Word Attack subtest (WRMT3-WA;* Woodcock, 2011)
- **Morphological Knowledge Skill measures**
  - *Test of Morphological Structure: Derivation subtest* (TMS-D; Carlisle, 2000)
  - *Affix Knowledge Test* (AKT; Mitchell & Brady, 2014)
- **Orthographic Knowledge Skill measures**
  - Lexical: *Orthographic Choice Test* (Olson, Kliegel, Davidson, & Foltz, 1985)
  - Sub-lexical: *Letter String Task* (Cassar and Treiman, 1997)

Results

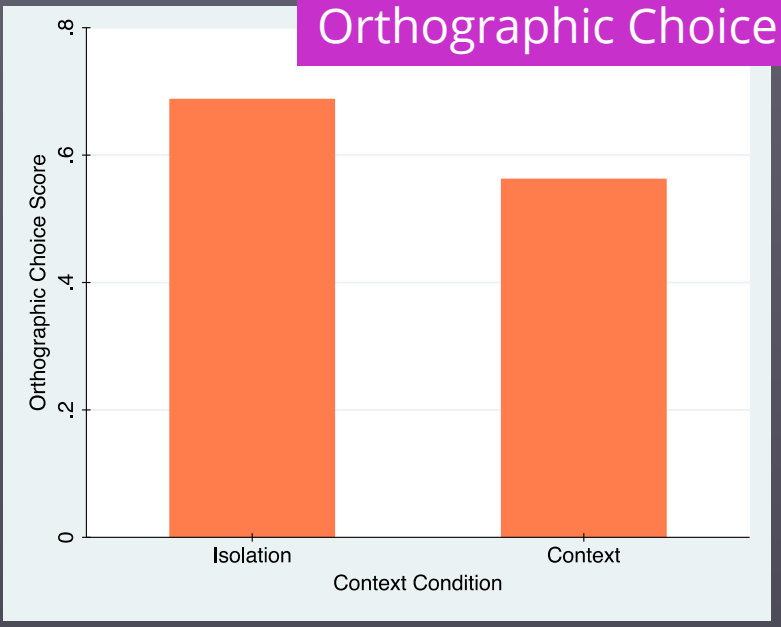
RQ#1

- How strong are Grade 4 and 5 children's orthographic representations for polysyllabic words as demonstrated on orthographic choice and spelling tasks
  - when practiced in context or isolation ?
  - when presented as monomorphemic or polymorphemic words?

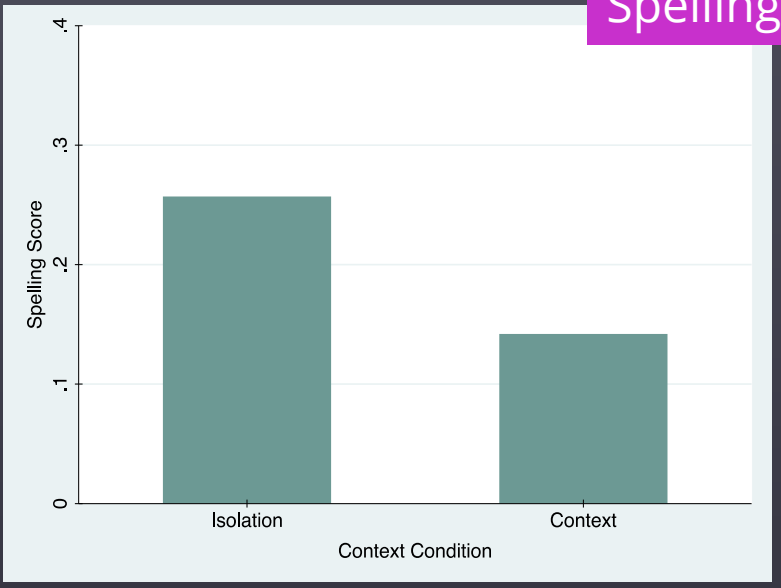
RQ#1: Condition

- Isolation > Context
  - Orthographic Choice
    - F(1, 280) = 5.86, *p* = .016
    - Partial η^2 = 0.020
  - Spelling
    - F(1, 280) = 7.53, *p* = .007
    - Partial η^2 = 0.026

Orthographic Choice



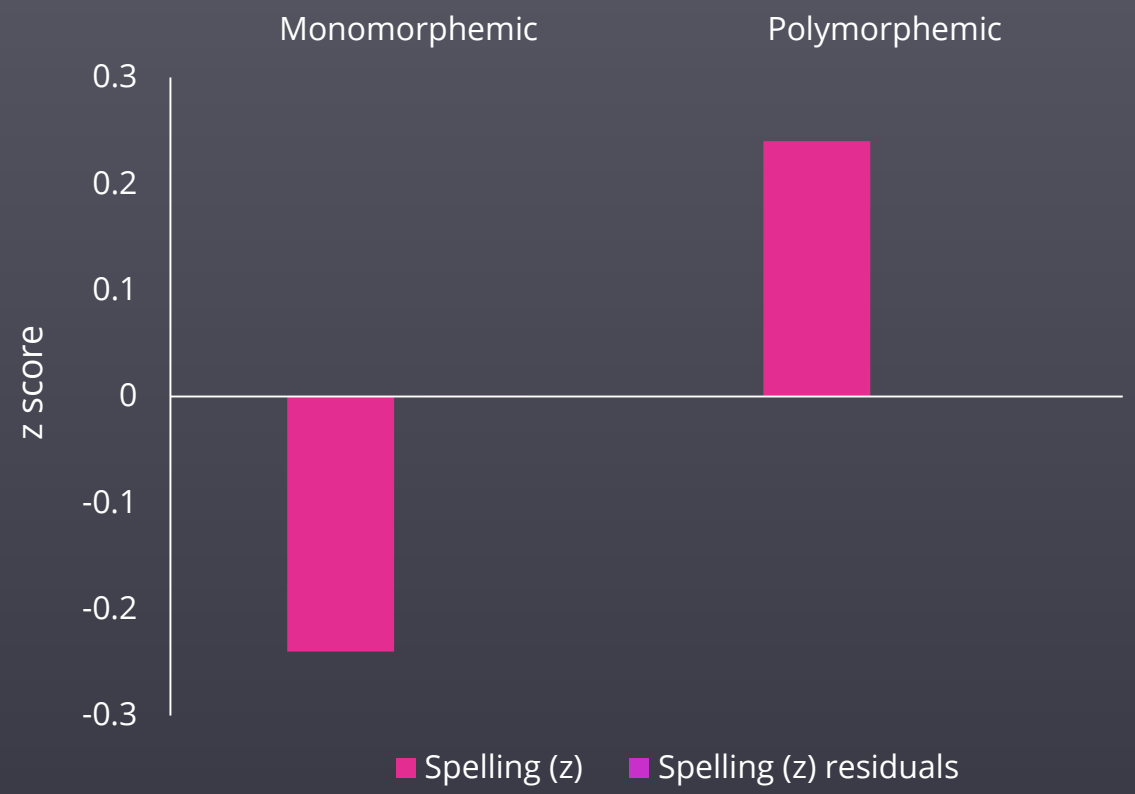
Spelling



RQ#1: Stimulus Type on Orthog. Choice

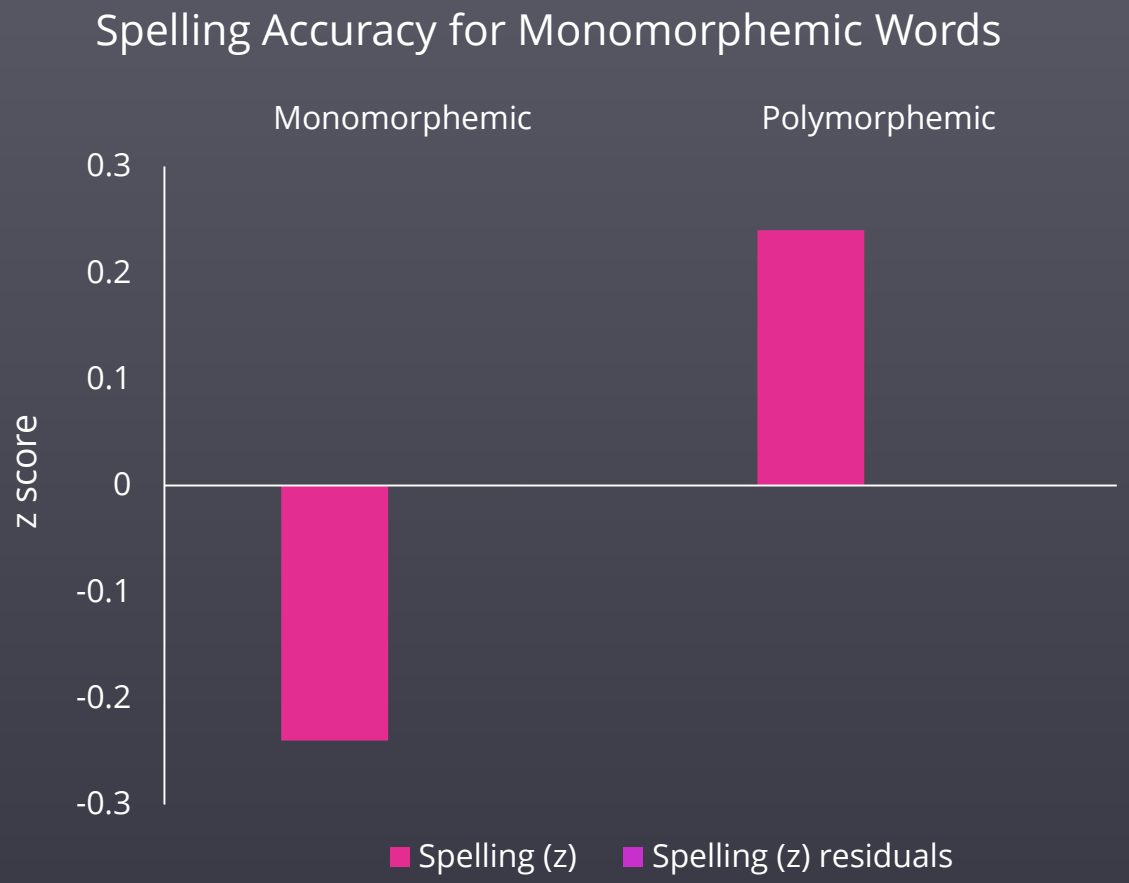
- No effect of morphological complexity

  $t = 0.00$, $p = 1$, $\beta = 0$



RQ#1: Stimulus Type on Spelling

- Spelling:
  - Students spelled bimorphemic words more accurately
  - $t = 4.23$, $p < .001$, $\beta = 0.24$
- Residualized spelling (accounting for gram frequency from *EWFG*)
  - $t = -0.09$, $p = .93$, $\beta = -0.01$



RQ#2

Orthographic learning relation with morph. knowledge

- Does morphological knowledge relate to orthographic learning for printed polysyllabic words?

RQ#2 Data Analytic Procedure

- Outcomes
  - Orthographic Choice (sum of items)
  - Spelling (sum of items)
- Covariates
  - Phonological decoding (composite)
  - Orthographic knowledge (composite)
- Construct of interest
  - Morphological knowledge (composite)

RQ#2: Orthographic Choice

- Total R^2 = .35
- Morphological knowledge composite
  - partial η^2 = 0.10
  - stronger relation than orthographic knowledge and phonological decoding

	Model 1			Model 2			Model 3		
Variable	*Coef.*	*SE*	η_p^2	*Coef.*	*SE*	η_p^2	*Coef.*	*SE*	η_p^2
Intercept	0.603	0.019***		0.603	0.019***		0.587	0.020***	
PD	0.007	0.020	0.002	-0.007	0.021	0.002	0.038	0.023	0.039
MK	0.079	0.022***	0.157	0.058	0.024**	0.079	0.063	0.023**	0.099
OK				0.054	0.029†	0.049	0.050	0.030†	0.041
RS							-0.053	0.022*	0.079
RS x PD							0.035	0.020†	0.044
RS x MK							0.042	0.028	0.033
RS x OK							-0.042	0.030	0.029
R^2		0.18			0.22			0.35	
ΔR^2					0.04			0.13	
F for ΔR^2		7.43***			3.59†			3.27*	

Note. PD = phonological decoding; MK = morphological knowledge; OK = orthographic knowledge; RS = reading skill.

$^{\dagger}p \leqslant .10$. $^{*}p \leqslant .05$. $^{**}p \leqslant .01$. $^{***}p \leqslant .001$.

RQ#2: Spelling

- Total R^2 = .25
- Morphological knowledge composite
  - partial η^2 = 0.45
  - stronger relation than orthographic knowledge
  - weaker relation than phonological decoding

	Model 1			Model 2			Model 3		
Variable	*Coef.*	*SE*	η_p^2	*Coef.*	*SE*	η_p^2	*Coef.*	*SE*	η_p^2
Intercept	0.211	0.014***		0.211	0.014***		0.214	0.016***	
PD	0.037	0.014**	0.085	0.029	0.015†	0.049	0.036	0.019†	0.054
MK	0.045	0.016**	0.102	0.034	0.018†	0.050	0.033	0.019†	0.046
OK				0.029	0.021	0.027	0.033	0.024	0.029
RS							-0.018	0.018	0.016
RS x PA							-0.006	0.016	0.002
RS x MK							0.005	0.023	0.001
RS x OK							0.000	0.024	0.000
R^2		0.22			0.24			0.25	
ΔR^2					0.02			0.01	
F for ΔR^2		9.70***			1.9			0.33	

Note. PD = phonological decoding; MK = morphological knowledge; OK = orthographic knowledge; RS = reading skill.

† $p \leqslant .10$. * $p \leqslant .05$. ** $p \leqslant .01$. *** $p \leqslant .001$.

Discussion

RQ#1: Acquisition of orth. representations

- Children appear to acquire stronger orthographic representations of polysyllabic words when they are presented in isolation than when they are presented in context
    - consistent with data from Martin-Chang, Ouellette, and Bond (2017), Nation, Angell, and Castles (2007), and Ricketts, Bishop, Pimperton, and Nation (2011)
    - in contrast to the findings of Ouellette (2010) and Ouellette and Fraser (2009)
- Morphological effects appear to be orthographic

RQ#2: Morphological knowledge and orthographic learning

- Morphological knowledge appears to relate to orthographic learning of polysyllabic words in children with and without reading difficulties (separate from decoding skill and orthographic knowledge).
  - Compare this to the monosyllabic word literature where orthographic learning is predicted by
    - phonological decoding skill (Ricketts et al., 2011; Cunningham, Perry, Stanovich, & Share, 2002)
    - lexical orthographic knowledge skill (Cunningham, 2006; Cunningham et al., 2002), and
    - sub-lexical orthographic knowledge skill (Cunningham, 2006).
- Consistent with the view that children use units of increasing size … morphemes or orthographic units (Ehri, 2005).
  - Consistent with the converging evidence supporting the role of morphological knowledge in word recognition and comprehension (e.g., Deacon, Tong, & Francis, 2017; Kearns, 2015).
  - Still could be orthographic and index familiarity

Limitations

- Sample homogeneity
  - linguistic background (monolingual English speakers)
  - Race (White)
  - Socioeconomic status (middle- to high-income)
  - Reading skills (mostly at or above average)
- Design and Instrumentation
  - Children were not asked to defined the stimuli
  - Children in the context condition were not asked comprehension questions
  - Possible priming effect in the orthographic choice task

Future Research

- Item-response analysis
- Different morphological units
- Larger sample of children with reading difficulties
- English language learners

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ADDITIONAL SLIDES IN CASE YOU NEED THEM

List of Pseudo Base-words Used to Create Orthographic Choice Task

Target			Homophone Foil				
Base-Word	Rime	Rime Freq.	Base-Word	Rime	Rime Freq.	VSD	DH
nurk	-urk	111	nerk	-erk	**169**	nurl	nerl
yauk	-auk	1	yawk	-awk	**175**	vawk	vauk
nawl	-awl	278	naul	-aul	**679**	nawt	naut
zurt	-urt	2088	zert	-ert	**2425**	surt	sert
beel	-eel	4309	beal	-eal	**5222**	leal	leel
zeet	-eet	6257	zeat	-eat	**13194**	zeed	zead
roop	-oop	**293**	rewp	-ewp	4	noop	newp
merd	-erd	**472**	murd	-urd	444	merp	murp
lerg	-erg	**898**	lurg	-urg	155	ferg	furg
foud	-oud	**1973**	fowd	-owd	747	toud	towd
jeal	-eal	**5222**	jeel	-eel	4309	yeal	yeel
voun	-oun	**21775**	vown	-own	17799	voum	vowm

Note. Rime Freq. = rime frequency; VSD = visually similar distractor; DH = distractor's homophone.

[a] Frequency counts in boldface indicate higher token Frequency for the target-homophone foil pair.

Test of Morphological Structure- Part 1-Derivation (Carlise, 2000)

1. warm.	He chose the jacket for its _____.
2. teach.	He was a very good _____.
3. permit.	Father refused to give _____.
4. profit.	Selling lemonade in summer is _____.
5. appear.	He cared about his _____.
6. express.	"OK" is a common _____.
7. four.	The cyclist came in _____.
8. remark.	The speed of the car was _____.
9. protect.	She wore glasses for _____.
10. perform.	Tonight is the last _____.
11. expand.	The company planned an _____.
12. revise.	This paper is his second _____.
13. reason.	Her argument was quite _____.
14. major.	He won the vote by a _____.
15. deep.	The lake was well known for its _____.
16. equal.	Boys and girls are treated with _____.
17. long.	They measured the ladder's _____.
18. adventure.	The trip sounded _____.
19. absorb.	She chose the sponge for its _____.
20. active.	He tired after so much _____.
21. swim.	She was a strong _____.
22. human.	The kind man was known for his _____.
23. wash.	Put the laundry in the _____.
24. humor.	The story was quite _____.
25. assist.	The teacher will give you _____.
26. mystery.	The dark glasses made the man look _____.
27. produce.	The play was a grand _____.
28. glory.	The view from the hill top was _____.

Affix Knowledge Test: Part 1-Suffix Knowledge-Real Words (Mitchell and Brady, 2014)

1. Do you think the word **'warmish'** means:
   a) Very warm
   b) A little cold
   c) Kind of warm
2. What do you think the word **'causeless'** means?
   a) A result that happened without a reason
   b) A consequence of someone's actions
   c) Not important
3. What do you think the word **'likelihood'** means?
   a) The top of a fancy robe that others admire
   b) How much of a chance there is that something will happen
   c) Being certain that something will happen
4. What do you think the word **'climatology'** means?
   a) Techniques for climbing
   b) When the climate changes over time
   c) The study of the climate
5. What do you think the word **'forceful'** means?
   a) Strong
   b) Lengthy
   c) Weak
6. Do you think the word **'authorship'** means:
   a) The activity of writing books or poems
   b) A collection of books or poems
   c) When a person who writes has a boat
7. What do you think the word **'historian'** means?
   a) A book describing the main events that happened in the past
   b) A person who studies what happened in the past
   c) Being like something from the past
8. Do you think the word **'thunderous'** means:
   a) Loud like thunder
   b) Rain clouds
   c) Able to make thunder
9. What do you think the word **'notable'** means?
   a) Writing something down
   b) Something that is unusual or special
   c) Something that is ordinary or typical
10. What do you think the word **'betterment'** means?
    a) When a person bets on something
    b) A mint that is especially tasty
    c) Improving something
11. Do you think the word **'crystallize'** means:
    a) To be like a crystal
    b) To turn something into crystals
    c) To believe in the power of crystals
12. Which of these descriptions represents the word **'blockage'**?
    a) A football player running to catch a pass
    b) A tall tower of blocks falling on the floor
    c) A group of cars stopped across the road
13. What do you think the word **'activist'** means?
    a) A machine that has lots of movement when it is on
    b) A person who works to change things in society in good ways
    c) An army fighting against the enemy
14. Which of these descriptions best fits the word **'closure'**?
    a) A person who is responsible for the clothes of kings and queens
    b) When textbooks have the answers to questions at the back of the book
    c) The feeling that something important in life has come to an end
15. Do you think the word **'thicken'** means:
    a) To increase the thickness of something
    b) A measurement of thickness
    c) To decrease the thickness of something
16. What do you think the word **'centrality'** means?
    a) To move away from the center
    b) To be at the center
    c) To move in a circle motion

Affix Knowledge Test: Part 2-Prefix Knowledge-Real Words (Mitchell and Brady, 2014)

1. Do you think the word **'unclean'** means:
   a) Full of soap
   b) Dirty
   c) Not dirty
2. Do you think the word **'befriend'** means:
   a) Someone who takes care of bees and beehives
   b) To meet someone again after you haven't seen them for a long time
   c) To get to know someone and share things with him
3. Which of these things could be described as a **'monotone'**?
   a) When a person's voice is always at one level
   b) When a song is sung by two singers
   c) When a person's voice goes up and down
4. Which of these pairs of things would best be described as a **'mismatch'**?
   a) A yellow sock and another yellow sock
   b) Pancakes and syrup
   c) A black shoe and a green shoe
5. Which of these things could best be described as **'interoffice'**?
   a) Offices in different countries
   b) Sharing or using things within the same office
   c) Sharing or sending between different offices
6. Do you think the word **'antihero'** means:
   a) A person in a book who rescues others
   b) A person in a book who is mean to others or selfish
   c) A person in a book who has unusual superpowers
7. Do you think the word **'disvalue'** means:
   a) To figure out what something is worth
   b) To think something is worth less than you used to think it was worth
   c) To insult someone during an argument
8. Which of these situations could be described by the word **'malpractice'**?
   a) When a doctor harms his patients
   b) When a teacher reads to her students every day
   c) When a person accidentally steps on his friend's foot
9. Do you think the word **'entrust'** means:
   a) A bank or large safe
   b) To give something to a person for protection
   c) To think someone is not being honest
10. What do you think a **'multifamily'** home is?
    a) A home that only one family lives in
    b) A home that a family has lived in at many different times
    c) A home that many families live in at the same time
11. Do you think the word **'postwar'** means;
    a) Before a war
    b) After a war
    c) Mail sent during a war
12. What do you think the word **'rediscover'** means?
    a) To find something again
    b) To find something for the first time
    c) To hide something from view
13. Which of these describes the meaning of the word **'transplant'**?
    a) To move a bush from one place to another place
    b) To help a flower grow by giving it soil and water
    c) A tree that grows both in the forest and the desert
14. Do you think the word **'coexist'** means:
    a) To live in peace with others
    b) To leave a room with another person
    c) To live quietly by yourself
15. What do you think the word **'substandard'** means?
    a) Above a standard
    b) At a standard
    c) Below a standard
16. Which of these fits with the word **'insecure'**?
    a) Feeling confident and strong
    b) Feeling anxious and uncertain
    c) Feeling like a bug

Affix Knowledge Test: Part 3-Suffix Knowledge-Pseudowords (Mitchell and Brady, 2014)

A. *'Mox'* is a made-up word that means *'smooth.'*

A1. Which of these made-up words could mean **'possible to smooth out'**?
a). moxist b). moxable c). moxful

A2. If *'mox'* means *'smooth'*, which word could mean to **'make smooth'**?
a). moxian b). moxous c). moxen

A3. Which could mean **'kind of smooth'**?
a). moxish b). moxship c). moxize

A4. Which could mean **'being in a group of things that all can be described as smooth'**?
a). moxless b). moxhood c). moxology

B. *'Plip'* is a made-up word that means *'hope.'*

B1. Which of these made-up words do you think could mean **'full of hope'**?
a). plipish b). plipility c). plipous

B2. If *'plip'* means *'hope'*, which word could mean **'having the quality of being hopeful'**?
a). plipen b). plipize c). plipship

B3. Which could mean **'without hope'**?
a). plipure b). plipless c). plipage

C. *'Dort'* is a made-up word that means *'to stop.'*

C1. Which of these made-up words could mean **'the result of being stopped'**?
a). dortment b). dortist c). dortless

C2. If *'dort'* means *'to stop'*, which word could mean **'the act of stopping'**?
a). dortish b). dortful c). dorture

C3. Which could mean **'how much something is getting stopped'**?
a). dortage b). dortian c). dortology

D. *'Roonil'* is a made-up word that means *'special.'*

D1. Which of these made-up words could mean **'a person who is special'**?
a). roonilist b). roonilable c). roonilous

D2. If *'roonil'* means *'special'*, which word could mean **'to make into something special'**?
a). roonilship b). roonilize c). roonilhood

D3. Which could mean **'a way of being special'**?
a). roonility b). roonilen c). roonilment

E. *'Flur'* is a made-up word that means *'space.'*

E1. Which of these words do you think could mean **'a person who is from space'**?
a). flurable b). flurian c). flurhood

E2. If *'flur'* means *'space'*, which word could mean **'filled with space'**?
a). flurment b). flurage c). flurful

E3. Which could mean **'the study of space'**?
a). flurology b). flurure c). flurility

Affix Knowledge Test: Part 4-Prefix Knowledge-Pseudowords (Mitchell and Brady, 2014)

A. *'Splin'* is a made-up word that means *'to learn.'*

A1. Which of these made-up words do you think could mean **'not learned'**?

a). multisplinned b). unsplinned c). subsplinned

A2. If *'splin'* means *'to learn'*, which word could mean **'to learn again'**?

a). monosplin b). insplin c). resplin

A3. Which word could mean **'to learn after'**?

a). postsplin b). ensplin c). dissplin

A4. Which word could mean **'against learning'**?

a). malsplinning b). antisplinning c). besplinning

B. *'Jort'* is a made-up word that means a *'thought.'*

B1. Which of these made-up words do you think could mean **'one thought'**?

a). monojort b). enjort c). misjort

B2. If *'jort'* means *'thought'*, which word could mean **'evil thoughts'**?

a). transjorts b). antijorts c). maljorts

B3. Which could mean **'many thoughts'**?

a). cojorts b). multijorts c). disjorts

B4. Which could mean **'not having a thought'**?

a). injort b). subjort c). postjort

C. *'Glick'* is a made-up word that means *'to hide.'*

C1. Which of these made-up words could mean **'to hide with another person'**?

a). unglick b). coglick c). transglick

C2. If *'glick'* means *'to hide'*, which word could mean **'the opposite of hiding'**?

a). malglicking b). interglicking c). disglicking

C3. Which could mean **'to hide under something'**?

a). reglick b). monoglick c). subglick

C4. Which could mean **'to hide badly'**?

a). misglick b). beglick c). multiglick

D. *'Lanost'* is a made-up word that means *'forest.'*

D1. Which of these made-up words do you think could mean **'across the forest'**?

a). unlanost b). colanost c). translanost

D2. If *'lanost'* means *'forest'*, which word could mean **'between forests'**?

a). mislanosts b). interlanosts c). antilanosts

D3. Which could mean 'completely forested'?

a). belanosted b). relanosted c). inlanosted

D4. Which could mean 'to put into the forest'?

a). postlanost b). interlanost c). enlanost

Orthographic Choice Task (Olson et al., 1985)

1.	goat	gote	34.	example	exsample
2.	wize	wise	35.	wagun	wagon
3.	nuisance	nusance	36.	deep	deap
4.	wheat	wheet	37.	believe	beleave
5.	distance	distence	38.	goast	ghost
6.	liberty	libberty	39.	hurt	hert
7.	true	trew	40.	travel	travle
8.	sammon	salmon	41.	sensitive	sensative
9.	importent	important	42.	compliment	complimant
10.	anser	answer	43.	condence	condense
11.	smoke	smoak	44.	sevral	several
12.	resourse	resource	45.	mystery	mysterey
13.	grone	grown	46.	deamon	demon
14.	explane	explain	47.	store	stoar
15.	few	fue	48.	captain	captin
16.	streem	stream	49.	skait	skate
17.	toward	toard	50.	streat	street
18.	salad	sallad	51.	studdy	study
19.	roar	rore	52.	easy	eazy
20.	ashure	assure	53.	aplause	applause
21.	nostrils	nostrels	54.	wreath	reath
22.	coat	cote	55.	baisment	basement
23.	purched	perched	56.	senaters	senators
24.	wait	wate	57.	suddin	sudden
25.	faught	fought	58.	pavemant	pavement
26.	thum	thumb	59.	dream	dreem
27.	between	betwean	60.	tape	taip
28.	backwards	backwords	61.	every	evry
29.	scare	scair	62.	interesting	intresting
30.	engine	anjine	63.	alternative	alternitive
31.	dignity	dignaty	64.	muscle	mussle
32.	culpret	culprit	65.	trowsers	trousers
33.	hearth	harth			

Letter String Task (Cassar and Treiman, 1997)

1. boap	bowp	16. dilk	dilc
2. wibz	wibs	17. glick	glyck
3. jeex	jeeks	18. cleyd	cleed
4. fage	fayj	19. lasp	lassp
5. qoast	quost	20. dayk	dake
6. lape	laip	21. vosst	vost
7. holp	hollp	22. sckap	skap
8. vose	voaz	23. showk	shoke
9. Ym	phim	24. prant	prahnt
10. booce	buice	25. llyth	lith
11. furb	Wrb	26. splot	spliut
12. nurm	nerm	27. squyt	squit
13. hoin	hoyn	28. sthrud	strud
14. toove	tuve	29. thram	trham
15. lerst	lurst	30. sprad	srpad

Descriptive Statistics and Correlations for Variables in Regression Analysis

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
Orthographic learning measures													
1. Orthographic learning composite	1												
2. Orthographic choice posttest	.84***	1											
3. Spelling posttest	.84***	.42***	1										
Phonological decoding measure													
4. WRMT3-WA	.30**	0.14	.36**	1									
Morphological knowledge measures													
5. Morphological knowledge composite	.47***	.42***	.38***	.25*	1								
6. TMS-D	.41***	.37***	.33**	0.12	.90***	1							
7. AKT	.43***	.38***	.36**	.34**	.90***	.63***	1						
Orthographic knowledge measures													
8. Orthographic knowledge composite	.46***	.39***	.39***	.43***	.50***	.46***	.45***	1					
9. OCT	.44***	.43***	.31**	.34**	.49***	.45***	.44***	.81***	1				
10. LST	.31**	.19†	.33**	.36**	.33**	.30**	.30**	.81***	.33**	1			
Reading skill measures													
11. Reading skill composite SS	0.04	-0.1	0.16	.54***	.25*	.22†	.23*	.38***	.33**	.29**	1		
12. TOWRE-SWE SS	0	-0.07	-0.07	.33**	.27**	.25*	.24*	.38***	.33**	.29**	.93***	1	
13. TOWRE-PDE SS	0.07	-0.1	.23*	.70***	0.18	0.15	0.17	.30**	.26**	.23*	.90***	.67***	1
M	0	0.6	0.21	19.2	0	17.5	42.5	0	59	27.1	203	101	102
SD	-0.84	-0.18	-0.13	-3.71	-0.9	-4.01	-8.6	-0.81	-4.13	-1.57	-20.8	-12.5	-10.3

Note. WRMT3-WA = Woodcock Reading Mastery Test, Third Edition-Word Attack subtest (Woodcock, 2011); TMS-D = Test of Morphological Structure-Derivation (Carlisle, 2000); AKT = Affix Knowledge Test (Mitchell and Brady, 2014); OCT = Orthographic Choice Test (Olson et al., 1985); LST = Letter String Test (Cassar & Treiman, 1997); TOWRE-SWE SS = Test of Word Reading Efficiency-Sight Word Efficiency subtest standard score (Torgesen et al., 1999); TOWRE-PDE = Test of Word Reading Efficiency-Phonemic Decoding Efficiency subtest standard score (Torgesen et al., 1999).

* $p \leqslant .05$. ** $p \leqslant .01$. *** $p \leqslant .001$.

Performance on Orthographic Choice Task by Item

List 1 (n = 16)		List 2 (n = 19)		List 3 (n = 20)		List 4 (n = 18)	
Stimulus	%	Stimulus	%	Stimulus	%	Stimulus	%
yaukful	56	yaukness	42	yaukbel	75	yaukrass	78
jealness	56	jealbel	68	jealrass[a]	35	jealful	44
zurtbel	44	zurtrass[a]	32	zurtful[a]	40	zurtness	44
beelrass	50	beelful	74	beelness	60	beelbel	89
vounful	63	vounness	42	vounbel	60	vounrass	89
roopness	94	roopbel	68	rooprass	80	roopful	78
merdbel	44	merdrass[a]	37	merdful	70	merdness	56
nurkrass	56	nurkful	74	nurkness	70	nurkbel	44
zeetful	69	zeetness	58	zeetbel	80	zeetrass	61
foudness	69	foudbel	58	foudrass	75	foudful	61
lergbel[a]	31	lergrass	42	lergful	55	lergness	56
nawlrass	56	nawlful	68	nawlness	55	nawlbel	83

[a] Proportion test showed a non-significant above chance (> 25%) accuracy rate.

Performance on Spelling Task by Item

List 1 (n = 16)		List 2 (n = 19)		List 3 (n = 20)		List 4 (n = 18)	
Stimulus	%	Stimulus	%	Stimulus	%	Stimulus	%
yaukful	6	yaukness	21	yaukbel	10	yaukrass	0
jealness	25	jealbel	0	jealrass	10	jealful	22
zurtbel	19	zurtrass	21	zurtful	35	zurtness	44
beelrass	13	beelful	37	beelness	50	beelbel	11
vounful	44	vounness	0	vounbel	15	vounrass	0
roopness	19	roopbel	5	rooprass	20	roopful	17
merdbel	19	merdrass	26	merdful	10	merdness	39
nurkrass	25	nurkful	42	nurkness	30	nurkbel	6
zeetful	50	zeetness	37	zeetbel	15	zeetrass	33
foudness	50	foudbel	26	foudrass	45	foudful	39
lergbel	0	lergrass	32	lergful	5	lergness	33
nawlrass	6	nawlful	5	nawlness	0	nawlbel	0

Note. Proportion test showed a non-significant above chance (> 50%) accuracy rate for all items.