

PREDICTIVE VALUE OF ORTHOGRAPHIC PROCESSING
FOR SPELLING PROFICIENCY

By

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Thesis

Submitted to the Faculty of the
Vanderbilt University School of Medicine
in partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE

in

Hearing and Speech Sciences

May, 2013

Nashville, Tennessee

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Introduction

Although reading proficiency is considered necessary for academic success, the impact of spelling proficiency on academic achievement is often overlooked. Poor spelling proficiency can contribute to related difficulty in written composition. According to the Cognitive Process Theory of Writing (Flower & Hayes, 1981), writing involves dividing limited cognitive resources (e.g., attention) between simultaneously planning, translating (also called transcribing), and reviewing a composition. If a disproportional amount of cognitive resources must be devoted to any one component, the other components will suffer. The need to focus on constructing correct spellings pilfers cognitive resources from planning and reviewing so that students who struggle with spelling also struggle to produce effective writing at the text level (Flower & Hayes, 1981).

In addition to hindering the quality of an individual's writing, poor spelling proficiency can influence teachers' perceptions of a student's capabilities, which could lead to reduced academic opportunities for the poor speller. Marshall and Powers (1969) found that when prospective teachers were instructed to grade essays strictly based on content, they assigned lower grades to essays that contained spelling errors compared to essays with the same content but no spelling errors. Spelling errors can also influence peer's perceptions of a person's general capability. Figueredo and Varnhagen (2005) reported that college students had more negative perceptions about the author of a written work that contained spelling errors than about the author of a written work that did not contain spelling errors. The presence of misspellings was

associated with negative ratings of the author's writing ability, general intelligence, and attention to detail.

Given the importance of spelling proficiency to academic success, researchers and educators must determine the most efficient and effective methods to teach spelling. Elucidating the linguistic basis of spelling, including the relative contributions of phonological awareness, orthographic knowledge, and morphological knowledge, is a step towards developing effective instruction, but relatively few studies have aimed to do so (Apel, Wilson-Fowler, Brimo, & Perrin, 2012; Cassar & Treiman, 1997; Walker & Hauerwas, 2006; Werfel, 2012). The construct of interest for the current study is *orthographic knowledge* which refers to an individual's general knowledge of orthographic conventions (Apel, 2011; Cassar & Treiman, 1997). Overall orthographic knowledge is comprised of *orthographic pattern knowledge* and *mental graphemic representations* (MGRs). Orthographic pattern knowledge refers to an individual's knowledge of the 240 or more graphemes that represent English phonemes and of permissible and impermissible ways of combining those graphemes to represent words. Orthographic knowledge includes knowledge of the alphabetic principle, constraints on letter combinations and positions (e.g., *ck* can occur in the middle or at the end of a word but not at the beginning), and conventions such as the long vowel sound represented by vowel-consonant-e combinations. MGRs are the orthographic equivalent of phonological representations; they are stored representations of words as whole or partial graphemic units. As with a phonological representation, a person can have a complete and accurate representation (e.g., *jump*), an incomplete representation (e.g., *ju_p*), or an inaccurate representation (e.g., *gump*) stored (Apel, 2011).

Studies examining the linguistic underpinnings of spelling proficiency have reported conflicted findings related to orthographic knowledge. Werfel (2012) reported that for a sample of second, third, and fourth graders, both orthographic knowledge and morphological knowledge predicted spelling proficiency. Apel et al. (2012) reported that for a sample of second and third graders, only morphological knowledge (called awareness in the article) predicted spelling proficiency. Walker and Hauerwas (2006) reported that different linguistic skills predict spelling at different grade levels. In first grade phonological awareness and orthographic knowledge predicted spelling. In second grade, orthographic knowledge predicted spelling. By third grade, morphological knowledge, not orthographic knowledge predicted spelling.

Given the lack of consensus within the literature, it may also be beneficial to investigate *orthographic processing*, or the efficiency with which one accesses and uses orthographic knowledge (Apel, 2011). Orthographic processing may be more influential for spelling proficiency than the mere presence or absence of knowledge. The basis for this supposition is that automaticity often is required to achieve proficiency with learned skills (see Samuels & Flor, 1997 for a review). For example, skilled reading requires automatic word recognition; the knowledge of how to decode words is not sufficient for an individual to become a skilled reader (LaBerge & Samuels, 1974). Likewise, it is hypothesized that to be a skilled speller an individual must not only possess orthographic knowledge, he must be able to quickly access and use that knowledge to produce accurate orthographic representations.

The purpose of this study was to collect preliminary data to ascertain whether it may be fruitful to investigate orthographic processing as a predictor of spelling

proficiency. Two research questions were addressed: (a) Is orthographic processing a better predictor of real word spelling proficiency than orthographic pattern knowledge? and (b) Is orthographic processing a better predictor of nonsense word spelling proficiency than orthographic pattern knowledge?

It was hypothesized that orthographic processing would better predict real word spelling proficiency compared to orthographic pattern knowledge. It was also hypothesized that orthographic processing would better predict nonsense word spelling proficiency compared to orthographic pattern knowledge. If orthographic processing is a better predictor of spelling proficiency than orthographic pattern knowledge, the findings could guide further research towards developing more effective methods of spelling instruction. Future research could investigate whether or not orthographic processing is a malleable factor and whether interventions aimed towards improving orthographic processing could improve spelling outcomes.

Because the purpose of this study was exploratory, the sample was small. Power was calculated as .44 for real word spelling and .15 for nonsense word spelling. Data from an additional 24 participants would fully power the study for predictive value of orthographic pattern knowledge and orthographic processing for real words.

Method

The Vanderbilt University Institutional Review Board approved the methods used in the study.

Participants

Twenty-two third grade children (n = 14 males) who attended two religious-affiliated private schools in Nashville, TN participated in the study. The mean age of the

participants was 9;1 (range 8;6 – 9;10). Included participants were monolingual speakers of English who demonstrated typical language abilities and typical word-recognition skills. Two children were eliminated from the participant pool because they did not meet inclusionary criterion (one child did not meet word recognition criteria, one child was reported by parents to be bilingual). Average maternal education level was 16 years (range 12 to 16+ years).

Measures

Six study measures were administered including two inclusionary measures, two predictor measures, and two outcome measures. See Table 1 for a description of study measures.

Table 1.

Study Measures

Variable	Measure	Type	Administration
Expressive Language	SPELT-3	Inclusionary	Individual
Word Recognition	TOWRE-2	Inclusionary	Individual
Orthographic Pattern Knowledge	OCT-A	Predictor	Group
Orthographic Processing	Reaction time	Predictor	Individual
Real Word Spelling	TWS-4	Outcome	Group
Nonsense Word Spelling	Nonsense word spelling assessment	Outcome	Group

Note. SPELT-3 = Structured Photographic Expressive Language Test – 3rd ed. (Dawson et al., 2003); TOWRE-2 = Test of Word Reading Efficiency – 2nd ed. (Torgesen et al., 2012); OCT-A = Orthographic Constraints Test – Adapted, adapted by the author from Treiman (1993); TWS-4 = Test of Written Spelling – 4th ed. (Larsen et al., 1999); Nonsense word spelling assessment stimuli from Campbell (1985)

Inclusionary measures. Two inclusionary measures were administered to ensure that participants had typical oral language abilities and typical word recognition skills. The Structured Photographic Expressive Language Test - Third Edition (SPELT-3; Dawson, Stout, & Eyer, 2003) measures expressive language abilities. The SPELT-3

taps morphology and syntax skills by eliciting word, phrase, and sentence-level responses to verbal prompts accompanied by picture cards. Participants were required to achieve a standard score of 85 to be included in the study.

The Test of Word Reading Efficiency - Second Edition (TOWRE-2; Torgesen, Wagner, & Rashotte, 2012) measures word recognition skills. The TOWRE-2 is a timed test comprised of two subtests, sight word efficiency (SWE) and phonemic decoding efficiency (PDE), that require participants to read aloud lists of words and nonsense words, respectively, of increasing difficulty. The test yields a standard score for each subtest, as well as a composite total word reading efficiency (TWRE) score. Participants were required to achieve a TWRE standard score of 85 to be included in the study.

Dependent measures. The study protocol included four dependent measures: two predictor measures and two outcome measures. The predictor measures assessed orthographic pattern knowledge and orthographic processing. The outcome measures assessed real word and nonsense word spelling proficiency.

Predictor measures. The Orthographic Constraints Test – Adapted (OCT-A) assessed orthographic pattern knowledge. We adapted the Orthographic Constraints Test (OCT; 16 items) developed by Treiman (1993) to create the OCT-A. Because participants in the current study were third graders and Treiman’s OCT was developed for a study with first graders, items were added to the OCT to assess more advanced aspects of spelling (Templeton & Bear, 2005). The OCT-A is an untimed paper and pencil task that includes 26 items. Each item consists of a pair of nonsense words, and participants circle which of the two nonsense words looks more like a real word (e.g., ffeb vs. beff). See Appendix A for test stimuli.

A computerized reaction-time measure assessed orthographic processing. Reaction time on orthographic choice tasks has been used previously in the literature to assess orthographic processing (Cunningham & Stanovich, 1990). The reaction time measure contained items similar in format to the OCT-A, but assessed a more limited range of orthographic patterns. The measure only assessed orthographic patterns that third-grade students were expected to have mastered (e.g. conventions for using c, k, or ck; Templeton & Bear, 2005) because the items needed to be ones for which participants could achieve nearly 100% accuracy. The test contained 25 items, each consisting of a pair of nonsense words. The items were presented one by one on a computer screen, and participants were asked to identify which nonsense word in each pair looked more like a real word. Participants responded by pressing a button on the keyboard to correspond with their choice. Because this task is a measure of processing efficiency, participants were instructed to make their choice as quickly as possible.

Outcome measures. Two measures assessed spelling proficiency. One measure assessed real word spelling proficiency and one assessed nonsense word spelling proficiency.

The Test of Written Spelling - Fourth Edition (TWS-4; Larsen et al., 1999) assessed spelling proficiency for real words. The test consists of 50 real words of increasing spelling difficulty (e.g., less transparent orthographic patterns, multisyllabic words, multimorphemic words). For each item, the examiner reads the word aloud, reads it in a sentence, and then repeats the word.

A nonsense word spelling test assessed nonsense word spelling proficiency, which mimics spelling of words the child has never encountered before in print. The test

developed for this study was comprised of the stimuli used in a spelling study by Campbell (1985). The majority of the nonsense words were monosyllabic and followed the consonant, vowel, consonant (CVC) phonological form. Some items followed the CCVC or CVCC form. The test contained 65 nonsense words that students spelled from dictation. See Appendix B for test stimuli.

Procedures

Testing was completed in March, 2013 at the students' schools. Measures were administered by a certified speech-language pathologist (Werfel) and a speech-language pathology masters student (primary investigator; PI) who were familiar with the tests and followed test protocol sheets.

Each participant completed two assessment sessions. The measures in the first session (SPELT-3, TOWRE-2, reaction time) were administered individually. The inclusionary measures (SPELT-3 and TOWRE-2) were administered with standard administration and scoring procedures as described in the test manuals (Dawson et al., 2003; Torgesen et al., 2012). The orthographic processing measure was also administered during the first session. Order of administration of these three tasks was randomly assigned for each child using a random number generator. There were six assessment sequences.

The second session involved group administration of the remaining measures (TWS-4, OCT-A, nonsense word spelling test). Children were divided into small groups of not more than eight persons. The OCT-A was the second measure administered to all groups. Order of administration of the TWS-4 and the nonsense word spelling test was counterbalanced. See Table 2 for an illustration of group administration.

Table 2.

Sequence of Administration for Measures Administered in Groups.

Group size	First	Second	Third
n = 7	TWS-4	OCT-A	Nonsense word spelling
n = 8	Nonsense word spelling	OCT-A	TWS-4
n = 7	TWS-4	OCT-A	Nonsense word spelling

Note. OCT-A = Orthographic Constraints Test – Adapted, adapted by the author from Treiman (1993); TWS-4 = Test of Written Spelling – 4th ed. (Larsen et al., 1999)

Predictor measures. For the OCT-A, participants were instructed verbally to circle the nonsense word in each pair that looks more like a real word. Participants were given as much time as needed to complete the OCT-A.

The reaction time measure was presented using E-prime software (Psychology Software Tools, n.d.) on an Asus Eee PC 1005HA netbook with a 10.1 inch screen. Instructions for the task appeared on the screen and were read aloud by the examiner to the participant. Stimuli were presented as black text in Arial font on a white background. A fixation cross appeared between trials and participants were instructed to keep their fingers on the response keys throughout the test. Response keys were colored and participants were instructed to press the green key (d key) if the correct answer was on the left side of the screen and the red key (l key) if the correct answer was on the right side of the screen. The measure consisted of 25 items plus five unanalyzed practice items. For each participant, items were presented in a different, random order determined by the program. The position of the correct answer for any given item was randomly determined by the program, but the correct answer appeared on the left side of the screen for 50% of the trials and on the right side of the screen for 50% of the trials.

Participants completed five practice trials. Mean accuracy on the practice trials was 90% (range 60% – 100%; standard deviation 11%). Speed and accuracy feedback appeared on the screen after each practice trial. High levels of accuracy are required for reaction time measures because incorrect responses cannot be analyzed. After the practice trials, the instructions were repeated and participants completed the test trials. Mean accuracy on the test trials was 86.36% (range 60% - 100%; standard deviation 11%). No feedback was provided on the test trials.

Outcome measures. The TWS-4 was administered using standard administration procedures described in the manual (Larsen et al., 1999) with the exception of discontinuing when a ceiling is reached. All 50 items were administered for ease of group administration. Repetitions of stimuli were provided when requested by any participant within the group. After the testing session, responses were scored as correct or incorrect. Scoring was discontinued when a ceiling was reached.

For each item on the nonsense word spelling test, the examiner dictated the item number, said the word aloud, and repeated the word aloud. Items were repeated when requested by any participant within the group. Only 63 of the 65 items were scored because two test items occur twice. The first instance of each repeated item was scored. All orthographically acceptable answers were scored as correct; hence, there were multiple correct answers for many of the items. The PI generated a key of orthographically legal spellings for each word, which was checked by an experienced spelling researcher (Werfel). A research assistant scored the tests using the key. The research assistant generated a list of child errors. The PI reviewed the list and identified orthographically legal child spellings that were not contained in the original key. The

original key was revised to include the orthographically legal spellings and an experienced spelling researcher (Werfel) checked the revised key. The PI re-scored all nonsense word spelling tests to yield the final data set.

Results

Descriptive Statistics

Table 3 displays the descriptive statistics for all study measures. Table 4 displays correlations amongst all study variables.

Table 3.

Descriptive Statistics

Task	M (SD)	Range
SPELT-3 Standard Score	114.05 (4.23)	105 - 121
TOWRE-2		
SWE Standard Score	106.68 (10.99)	87 - 132
PDE Standard Score	103.55 (11.94)	82 - 123
TWRE Standard Score	105.36 (11.35)	86 - 129
OCT-A Raw Score (max = 26)	23.00 (2.55)	16 - 26
Reaction time (ms)	1540.86 (430.59)	975 - 2816
TWS-4 Raw Score (max = 50)	20.18 (5.23)	13 - 36
Nonsense Word Spelling (max = 63)	30.36 (9.18)	15 - 50

Note. SPELT-3 = Structured Photographic Expressive Language Test – 3rd ed. (Dawson et al., 2003); TOWRE-2 = Test of Word Reading Efficiency – 2nd ed., SWE = sight word efficiency subtest, PDE = phonemic decoding efficiency subtest, TWRE = total word reading efficiency (Torgesen et al., 2012); OCT-A = Orthographic Constraints Test – Adapted, adapted by the author from Treiman (1993); TWS-4 = Test of Written Spelling – 4th ed. (Larsen et al., 1999); Nonsense word spelling assessment stimuli from Campbell (1985)

Table 4.

Intercorrelations among the Variables

Variable	1	2	3	4	5	6	7
1. SPELT-3							
2. TOWRE-2 TWRE	.13						
3. TOWRE-2 SWE	.21	.93**					
4. TOWRE-2 PDE	.03	.94**	.74**				
5. OCT-A	.00	.12	.15	.10			
6. Reaction Time	.04	-.05	-.02	-.07	-.06		
7. TWS-4	-.09	.31	.17	.40	.38	-.22	
8. Nonsense Word Spelling	-.01	.54**	.36	.65**	.15	.13	.48*

Note. SPELT-3 = Structured Photographic Expressive Language Test – 3rd ed. (Dawson et al., 2003); TOWRE-2 = Test of Word Reading Efficiency – 2nd ed., SWE = sight word efficiency subtest, PDE = phonemic decoding efficiency subtest, TWRE = total word reading efficiency (Torgesen et al., 2012); OCT-A = Orthographic Constraints Test – Adapted, adapted by the author from Treiman (1993); TWS-4 = Test of Written Spelling – 4th ed. (Larsen et al., 1999); Nonsense word spelling assessment stimuli from Campbell (1985)

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Orthographic Pattern Knowledge and Orthographic Processing as Predictors of Spelling Proficiency

Four hierarchical regression analyses were performed to compare the relative predictive value of orthographic pattern knowledge and orthographic processing for real word spelling proficiency and nonsense word spelling proficiency. Results are displayed in Table 5 for real word spelling and Table 6 for nonsense word spelling.

Table 5.

Hierarchical Regressions for Real Word Spelling

Step	Variable	R ²	R ² change	p
1.	Orthographic pattern knowledge	.144	.144	n.s.
2.	Orthographic processing	.182	.038	n.s.
1.	Orthographic processing	.048	.048	n.s.
2.	Orthographic pattern knowledge	.182	.134	n.s.

Table 6.

Hierarchical Regressions for Nonsense Word Spelling

Step	Variable	R ²	R ² change	p
1.	Orthographic pattern knowledge	.021	.021	n.s.
2.	Orthographic processing	.041	.020	n.s.
1.	Orthographic processing	.017	.017	n.s.
2.	Orthographic pattern knowledge	.041	.023	n.s.

When orthographic pattern knowledge was entered first it accounted for 14.4% of the variance in real word spelling. Orthographic processing accounted for an additional 3.8% of the variance after orthographic pattern knowledge had been entered. When orthographic processing was entered first it accounted for 4.8% of the variance in real word spelling. Orthographic pattern knowledge accounted for an additional 13.4% of the variance after orthographic processing was entered. Neither orthographic pattern knowledge nor orthographic processing predicted a statistically significant portion of the variance in real word spelling.

When orthographic pattern knowledge was entered first it accounted for 2.1% of the variance in nonsense word spelling. Orthographic processing accounted for an additional 2% of the variance after orthographic pattern knowledge had been entered. When orthographic processing was entered first it accounted for 1.7% of the variance in nonsense word spelling. Orthographic pattern knowledge accounted for an additional 2.4% of the variance after orthographic processing was entered. Neither orthographic pattern knowledge nor orthographic processing predicted a statistically significant portion of the variance in nonsense word spelling.

Discussion

The purpose of this study was to collect preliminary data to ascertain whether it may be fruitful to investigate orthographic processing as a predictor of spelling proficiency. Two research questions were addressed: (a) Is orthographic processing a better predictor of real word spelling proficiency than orthographic pattern knowledge? and (b) Is orthographic processing a better predictor of nonsense word spelling proficiency than orthographic pattern knowledge?

Neither orthographic pattern knowledge nor orthographic processing predicted real word spelling proficiency. In real word spelling, orthographic pattern knowledge accounted for 14.4% of the variance when entered first. Orthographic processing only accounted for an additional 3.8% of the variance after orthographic pattern knowledge had been partialled out. When orthographic processing was entered first, it accounted for 4.8% of the variance in real word spelling. Orthographic pattern knowledge accounted for an additional 13.4% of the variance after orthographic processing was partialled out.

Neither orthographic pattern knowledge nor orthographic processing predicted nonsense word spelling, and the predictors accounted for less variance than they did for real word spelling. When orthographic pattern knowledge was entered first, it accounted for only 2.1% of the variance. Orthographic processing accounted for an additional 2% of the variance after orthographic pattern knowledge was partialled out. When orthographic processing was entered first, it accounted for only 1.7% of the variance. Orthographic pattern knowledge accounted for an additional 2.4% of the variance after orthographic processing was partialled out.

The general trend within these data is that orthographic pattern knowledge accounted for more variance in spelling proficiency than orthographic processing, but that neither were significant predictors of real word spelling and nonsense word spelling proficiency. The finding that neither orthographic pattern knowledge nor orthographic processing were significant predictors of real word spelling and nonsense word spelling proficiency is consistent with other findings in the literature. Apel et al. (2012) assessed orthographic pattern knowledge as well as other predictors for spelling proficiency and found only morphological knowledge (referred to by them as morphological awareness) to uniquely predict real word spelling. Werfel (2012) found both orthographic knowledge and morphological knowledge to uniquely predict spelling, but the measure of orthographic knowledge used was a composite score that included both MGRs and orthographic pattern knowledge. Additionally, Walker and Hauerwas (2006) found that by third grade, orthographic knowledge no longer predicted spelling. Taken together, these previous findings and the findings of the present study suggest that neither orthographic pattern knowledge nor orthographic processing significantly influence spelling proficiency of children in the late elementary grades.

Based on these findings, teaching spelling with a focus on orthographic patterns may not be the most effective method of instruction, at least in the later elementary grades. It appears that spelling may be more highly influenced by an individual's word-specific MGRs or their morphological knowledge than by their general knowledge of English orthography. Although English spelling is highly regular, it is also highly complex with words from many different languages adhering to different orthographic conventions. Rather than attempting to teach the myriad of patterns, it may be more

beneficial to bolster other types of knowledge, such as morphological knowledge and MGR-learning strategies, to improve spelling outcomes. Future research should aim to develop effective means of instruction after further elucidating the underlying skills that affect spelling proficiency. To assess the role of MGRs, a follow-up study is planned in which participants will complete timed and untimed choice tasks using real words rather than nonsense words.

Limitations

An additional limitation of the current study was that only orthographic pattern knowledge and orthographic processing for orthographic patterns were assessed. The role of MGRs as a predictor was not assessed due to methodological limitations; when nonsense words are used, researchers can be confident that pattern knowledge is being assessed because participants will not have MGRs for words that they have never encountered. When assessments utilize real words, however, researchers cannot be certain whether participants made decisions based on word-specific comparison to an established MGR or based on more general knowledge of orthographic conventions.

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Appendix A

Appendix A: OCT-A stimuli

ffeb, beff
neezing, neezeing
nuck, kcun
pately, patelee
dau, daw
aut, awt
kerightfle, kerightful
ib, yb
unbise, unnbise
yinn, yikk
cariest, caryiest
ddaled, dalled
vadding, vayying
teeded, teed
munn, muun
moyl, moil
flosenenes, floseneness
gry, gri
injecure, innjecure
chym, chim
epemies, epemyes
ckader, dacker
vaad, vadd
iit, ist
bei, bey
norrified, norrofied

