Published in final edited form as:

J Speech Lang Hear Res. 2012 December ; 55(6): 1587–1599. doi:10.1044/1092-4388(2012/10-0335).

Linguistic Pattern Analysis of Misspellings of Typically Developing Writers in Grades 1 to 9

Ruth Huntley Bahr

Department of Communication Sciences and Disorders 4202 E. Fowler Ave. PCD 1017
University of South Florida Tampa, FL 33620 813-974-3182 rbahr@cas.usf.edu

Elaine R. Silliman

Department of Communication Sciences and Disorders 4202 E. Fowler Ave. PCD 1017
University of South Florida Tampa, FL 33620 813-974-9812 silliman@cas.usf.edu

Virginia W. Berninger

College of Education 322 Miller Hall, Box 353600 University of Washington Seattle, WA 98195
206-616-6372 vwb@u.washington.edu

Michael Dow

Department of Mental Health, Law and Policy 4202 E. Fowler Ave. MHC 2633 University of South
Florida Tampa, FL 33620 813-974-1928 dow@usf.edu

Abstract

Purpose—A mixed methods approach, evaluating triple word form theory, was used to describe linguistic patterns of misspellings.

Method—Spelling errors were taken from narrative and expository writing samples provided by 888 typically developing students in grades 1–9. Errors were coded by category (phonological, orthographic, and morphological) and specific linguistic feature affected. Grade level effects were analyzed with trend analysis. Qualitative analyses determined frequent error types and how use of specific linguistic features varied across grades.

Results—Phonological, orthographic, and morphological errors were noted across all grades, but orthographic errors predominated. Linear trends revealed developmental shifts in error proportions for the orthographic and morphological categories between grades 4–5. Similar error types were noted across age groups but the nature of linguistic feature error changed with age.

Conclusions—Triple word-form theory was supported. By grade 1, orthographic errors predominated and phonological and morphological error patterns were evident. Morphological errors increased in relative frequency in older students, probably due to a combination of word-formation issues and vocabulary growth. These patterns suggest that normal spelling development reflects non-linear growth and that it takes a long time to develop a robust orthographic lexicon that coordinates phonology, orthography, and morphology and supports word-specific, conventional spelling.

Copyright 2012 by The American Speech-Language-Hearing Association

Publisher's Disclaimer: This is an author-produced manuscript that has been peer reviewed and accepted for publication in the *Journal of Speech, Language, and Hearing Research (JSLHR)*. As the “Papers in Press” version of the manuscript, it has not yet undergone copyediting, proofreading, or other quality controls associated with final published articles. As the publisher and copyright holder, the American Speech-Language-Hearing Association (ASHA) disclaims any liability resulting from use of inaccurate or misleading data or information contained herein. Further, the authors have disclosed that permission has been obtained for use of any copyrighted material and that, if applicable, conflicts of interest have been noted in the manuscript.

Keywords

Spelling; triple word form theory; spelling errors; non-linear development

Learning to spell is more difficult than learning to recognize words because spelling requires not only learning grapheme-phoneme correspondences, but also developing an orthographic lexicon (Ehri, 1980; Olson, Forsberg, & Wise, 1994), where word-specific spelling, pronunciations, and morphological structures and word meanings are stored and accessed. On the one hand, accessing this lexicon can often place distinctive “demands on orthographic memory” (Moats, 2009, p. 271) relative to grapheme position and sequences. On the other hand, this multi-format lexicon may facilitate coordination of the interrelationships among orthography, phonology, and morphology.

Spelling is also a developmentally patterned linguistic activity (Treiman & Kessler, 2006; Treiman, Kessler, Zevin, Bick, & Davis, 2006) that originates in children's knowledge of oral language components. When children start to spell, oral linguistic units begin a journey wherein they are progressively transformed into written units (Perfetti, 2007). For example, beginning spellers draw on their oral language knowledge of the earliest acquired inflectional morphemes (present progressive *-ing*, plural *-s*, regular third person singular *-s*, and regular past tense *-ed*) to employ these same morphemes in their natural writing (Turnbull, Deacon, & Kay-Raining Bird, 2011). Also, by kindergarten, many children begin to apply their existing phonological knowledge of pronunciation combined with emerging orthographic knowledge to produce invented spellings. Hence, *pack* might be spelled as *pak* (Treiman & Bourassa, 2000), which then preserves the minimal phoneme representation, known as the phonological skeleton (Bourassa & Treiman, 2003).

In this article we report on qualitative linguistic patterns of misspellings evidenced by children in grades 1–9. Compositions collected in cross-sectional studies on typical writing development in grades 1 to 9 (Berninger, Cartwright, Yates, Swanson, & Abbott, 1994; Berninger, Yates, Cartwright, Rutberg, Remy, & Abbott, 1992; Berninger, Whitaker, Feng, Swanson, & Abbott, 1996) were previously analyzed at each grade level (1 to 9), for number of words, number of correctly spelled words, sentence, and text level structures, and quality (content and organization). Subsequent to the initial cross-sectional studies in this project, a new study of spelling was planned and conducted based on a conceptual framework that has recently emerged from both research groups collaborating in the current study -- triple word-form theory (Berninger, Garcia, & Abbott, 2009; Bahr, Silliman, & Berninger, 2009; Garcia, Abbott, & Berninger, 2010): Triple Word Form theory predicts that spelling development depends on learning to code into memory, analyze, and coordinate the three word forms and their parts: 1) phonological (coding and analyzing phonemes and other sound units in spoken words); 2) orthographic (coding and analyzing written words and the single letters, letter groups, and larger letter patterns in them); and 3) morphological (coding and analyzing base words, prefixes, and inflectional and derivational suffixes in both spoken and written words). Triple word form theory has empirical support from interdisciplinary research studies: instructional (Bahr et al., 2009; Berninger, Nagy et al., 2003), brain imaging (Richards et al., 2006; Richards, Berninger, & Fayol, 2009), cross-sectional (Nagy, Berninger, & Abbott, 2006), longitudinal (Garcia et al., 2010), and family genetics (Berninger, Raskind, Richards, Abbott, & Stock, 2008). For reviews of cross-linguistic evidence, see Bahr et al. (2009), Berninger and Fayol (2008), Bourassa and Treiman (2007), and Nunes and Bryant (2006). Children must learn how to cross-map the interrelationships among these codes (Berninger, Raskind et al., 2008; Nunes & Bryant, 2006) to learn to read and spell. Such cross-code interrelationships may also advance vocabulary development by connecting new meanings to their corresponding word forms (Verhoeven & Perfetti, 2011).

Previous research with typically developing children has primarily focused on the analysis of spelling errors in kindergarten to grade 4 (e.g., Apel, 2010, Deacon & Dhooge, 2010; Turnbull et al., 2011), often concentrating on the development of orthographic knowledge (e.g., Sharp, Sinatra, & Reynolds, 2008). The current study, in contrast, provides much needed data on spelling errors in older typically developing students (i.e., grades 5–9). With some exceptions (e.g., Garcia et al., 2010), few spelling studies have addressed this age group or examined changes in linguistic relationships among phonological, orthographic, and morphological knowledge over this grade span. In addition, prior studies have not been motivated by a conceptual framework that can potentially explain individual variation. We argue that triple word form theory provides a viable theoretical prism from which to investigate the variations in spelling patterns of typically developing child writers. At the same time, the results could also provide a reference point for understanding the linguistic nature of spelling errors of child writers with language impairment in future research and clinical practice. To achieve this aim, the role of triple word-form theory in classifying the error patterns of students in grades 1–9 is considered. A sampling of typical phonological, orthographic and morphological spelling errors are discussed first followed by a review of the limitations of existing scoring systems in classifying misspelled words.

Developmental Overview of Phonological, Orthographic, and Morphological Patterns

Phonologically-based spellings

A common spelling pattern in kindergarten and grade 1 involves the substitution of the letter name for the liquid phonemes /r/ and /l/ (Bourassa & Treiman, 2001). For example, early spellers often access their phonological knowledge to generate *elephant* as *lefít* or *far* as *fi*, which suggests emerging understanding of letter sequences (i.e., orthotactics) in the context of interactions with print. Many tend to spell a phoneme sequence with a single letter name, resulting in a phonologically-based spelling pattern.

Early phonologically-based spelling attempts also frequently include word-initial consonant cluster reduction, which arises from children's inexperience in segmenting the cluster into separate phonemes (Treiman, 1991). Instead, clusters are analyzed as a unit interacting with the vowel. For example, in the word *play* (/ple/), it is difficult for young children to separate perceptually the /l/ from the vowel, making it challenging for them to understand that the /l/ is represented independently from the vowel. Errors also occur in word-final nasal clusters. For example, the /nd/ in *sand*, can result in misspellings, such as *sad* (Treiman, 1991), likely due to difficulties encountered in separating the nasal from the vowel in word-final nasal clusters.

Orthographic spellings

As beginning spellers learn sound-letter correspondences, particular patterns of orthographic features become evident (Cassar & Treiman, 1997). One such pattern involves consonant doubling, which occurs when children understand that a word contains a doubled consonant but do not recognize its positional constraints. In written English, doubled consonants occur in medial or final positions after a short vowel but cannot occur in the initial position e.g., *press*. However, young children might mark the doubled consonant in the wrong position, such as *ppres* (see also Wright & Ehri, 2007), indicating an emerging awareness of the need for a doubled consonant and illustrating that beginning spellers are still mastering word-specific knowledge about positional constraints leading to integration of phonological and orthographic knowledge (Bourassa & Treiman, 2007; Cassar & Treiman, 1997).

Another orthographic pattern involves the omission of silent *-e*. Beginning spellers may lack or not consistently access the knowledge that, when adding a silent *-e* to the end of a word, the preceding vowel is long. For example, misspelling *trade* as *trad* indicates inadequate orthographic analysis of the long vowel-silent *-e* relationship (Moats, 2000).

A key developmental issue then becomes understanding orthographic constancy, which is essential for the development of a memory for word-specific spellings or an orthographic lexicon. According to Venezky (1999), mastering the orthographic constancy of the past tense inflection versus its phonological variations requires specific morphophonemic knowledge. For instance, there are three ways to pronounce the past tense form of verbs: 1) *kissed*, the *-ed* is pronounced as /t/; 2) *played*, the *-ed* is pronounced as /d/; and 3) *needed*, the *-ed* is pronounced as /əd/ resulting in a two syllable word. A focus on pronunciation (phonology) alone could lead to misspellings in the first two monosyllabic instances, i.e., *kist* and *playd*, while the misspelling of the two syllable form might acknowledge the syllable boundary, e.g., *needid*. These variations demonstrate multiple, but constrained, ways for children to represent underlying linguistic knowledge (Sangster & Deacon, 2011; Windsor, Scott, & Street, 2000). A child who spells *kissed* as *kist* is familiar with verb morphology but cannot consistently mark that knowledge orthographically.

Morphological spellings

Morphological awareness encompasses both inflectional and derivational relations as well as compounding. *Inflectional* morphology does not change meaning, pronunciation, or grammatical role. The original word root is maintained whereby tense agreement, aspect, number, or possession is suffixed via the past tense *-ed*, present progressive *-ing*, plural *-s/es*, and possessive *'s*, respectively. In the oral domain, inflectional markers for tense agreement, an obligatory morphosyntactic aspect in finite clauses, are accurately produced by age 4 years (Rice, Wexler, & Hershberger, 1998). Derivational morphology, on the other hand, is central to new word formation and integral to the configuration of novel and more complex meanings. As Carlisle (2004) notes, a prime characteristic of derivations is the transformation of *both* meaning and form. For example, when the suffix *-ior* is added to the word root of the verb *behave*, not only does a new meaning result, *behavior*, but also the grammatical role shifts to a noun.

Depending on the linguistic complexity of spelled words, children as early as grade 1 show some degree of metalinguistic sensitivity to morphological root constancy in determining if an inflectional marker is appropriate. For example, Treiman and Cassar (1996) found variable sensitivity to past tense inflection in two-morpheme words with a nasal consonant, like *tuned*, which can be decomposed into the transparent root word *tune*, whereas the same children remained less sensitive to nasal consonant clusters in a one-morpheme unit, spelling *brand* as *brad*. Others (Deacon, 2008; Deacon & Bryant, 2006a, b; Deacon, Kirby, & Casselman-Bell, 2009; Rabin & Deacon, 2008) reported similar results. Other inflectional evidence from nonword assessment in grade 4 demonstrates the contributions of morphosyntax to spelling development. Good spellers were more responsive to singular-plural inflections than poor spellers but both groups were less sensitive to inflected and noninflected verbs (Bourassa, Beaupre, & MacGregor, 2011). Even some adult populations may not automatically access conventional inflectional spellings (Mitchell, Kemp, & Bryant, 2011).

On the other hand, derivational knowledge requires the coordination of both form and meaning (Carlisle, 2004) and shows continued growth after grade 4 (Berninger, Abbott, Nagy, & Carlisle, 2010). As predicted by triple word-form theory, basic derivational knowledge appears to develop concurrently with inflectional suffixes in both the oral and written domains (Carlisle, 2003; Carlisle & Fleming, 2003; Deacon, 2008; Rabin & Deacon,

2008; Sangster & Deacon, 2011; Wolter, Wood, & D'ztko, 2009). However, as Carlisle (2004, 2007) points out, the complexity of morphophonological relations increases with derivational morphology as opposed to inflectional morphology. One reason for increased complexity is the frequency with which “a given affix is attached to base words” (Carlisle, 2004, p. 324). Word families, or the “frequency with which the base word appears in other words” (Carlisle & Katz, 2006, p. 669), are another factor that can influence the ease of morphological awareness. A third factor affecting complexity is that the difficulty of determining semantic relatedness appears distributed along a continuum of root constancy from more transparent to more opaque. Derived words, sharing semantic, orthographic, and phonological similarity, result in more transparency or predictability in the relations among sound, spelling, and meaning, such as *teach* and *teacher* and *assign* and *assignment*, contrasted with *sign* and *signature*. In the latter example, the semantic relationship is more opaque. Transparent relations are easier for children in grade 1 to analyze as morphologically related than are meanings that shift along the transparency continuum, as is the case when orthographic and/or phonological dissimilarity occur. In contrast to derivational suffixes, prefixes are more constant in their meanings (Graves, 2006).

Finally, few studies have examined children's production of inflections in spontaneous writing. Turnbull et al. (2011) analyzed the journal writing of 10 children (kindergarten to grade 1). The order of learning to spell inflectional suffixes paralleled their order in the oral domain; however, because of reduced constancy between the oral and written forms of *-ed*, accuracy in obligatory written contexts was not manifested by the end of grade 1. In contrast, Green et al. (2003) examined written narratives of children in grades 3 and 4, finding that regular and irregular verb and plural inflections were produced frequently and accurately (over 80% of the time) by grade 3 with increased accuracy in grade 4. Two other studies (Carlisle, 1996; Moats, Foorman, & Taylor, 2006) examined derivational errors in narrative writing in a general way in grades 3 and 4, respectively. The low frequency of derivational errors in both studies suggested that either these children encountered little difficulty with derivations or did not use derivations to any extent.

Scoring Approaches to Misspellings: Constrained and Unconstrained

Since the seminal spelling study of Bruck and Waters, 1988) on spelling and dyslexia, the cross-linguistic study of children's spelling development typically has focused on quantifying errors as an index of spelling accuracy (e.g., Apel, Wolter, & Masterson, 2006; Dixon & Kaminska, 2007; Gillis & Ravid, 2006; Landerl & Wimmer, 2008; Wanzek et al., 2006), although there are exceptions (e.g., Moats et al., 2006). For discussion ease, approaches to the scoring of spelling can be dichotomized as constrained or unconstrained.

Constrained approaches

In a constrained approach (Ball, 1993; Bruck & Waters, 1988; Caravolas, Hulmes, & Snowling, 2001; Tangel & Blachman, 1992, 1995), the examiner gives credit to an orthographically acceptable production of a phonological spelling, like *reche* for *reach*. In this case, the silent *-e* at the end of the word makes the vowel long. Other approaches assess structural and positional knowledge (Treiman & Bourassa, 2000) and do not count orthographically legal sequences that are not real words in English, like spelling *frip* for *trip*, as an error. These types of approaches are more top-down. A preselected schema is applied to error classification. Although students' spellings can be compared to the adult form, little is learned about the nature of spelling development, much less individual variations in development.

Unconstrained approaches

The aim here is to identify how children are actually using phonology, orthography, and morphology in permissible ways to spell, although the outcome may not be an accurate spelling. Examples would be *rech* for *reach* or *neceseite* for *necessity* (Bruck & Waters, 1988). Even though the words are spelled incorrectly, there is a match between phonemes and graphemes (i.e., the phonological skeleton is preserved) making the words phonetically plausible. This type of approach would seem to be most valuable in identifying the individual contributions of phonological, orthographic and morphological features in that error interpretation is considered independently from orthographic constraints.

Moats (2001) describes a similar linguistic approach to spelling analysis where orthographic substitutions were defined as “speech sounds spelled according to identifiable phonetic strategies” (p. 53), phonological substitutions involved phoneme substitutions and omissions and morphophonological spellings focused on inflections and contractions. The problem with this system is that it does not adequately differentiate between the linguistic sources of knowledge. For instance, homonyms, like *their* and *there*, were classified as orthographic errors, which does not consider the semantic basis for that error type. Another example was *werey* for *worry* as a phonological error with an r-controlled vowel. Here, the phonological structure of the word is preserved, so it could be an orthographic error because the child spelled the word as it sounded and used an inappropriate orthographic interpretation of the r-colored vowel. An unconstrained system allows for this type of flexible error interpretation and illustrates that for individual children there may be multiple interpretations for one misspelling.

Qualitative appraisal of linguistic patterns of misspellings with advancing grade levels is pertinent for two reasons. First, discerning patterns of misspellings can ultimately enhance understanding of how students with language impairment orchestrate their phonological, orthographic, and morphological knowledge. Second, broader insight into misspellings can lead to more individualized instruction and intervention for all students (Reed, 2008). However, little is known at a fine-grained level about these variations across a wide range of grade levels (Bourassa & Treiman, 2007; Sharp et al., 2008) and what linguistic feature errors occur while students are engaged in independent composing.

Purpose of the Study

The study derives from a grounded theory perspective, which utilizes open coding to discover “patterns, themes, and/or categories” (Patton, 2002, pp. 453–454) from the data. To this end, compositions collected in cross-sectional studies in grades 1 to 3 (Berninger et al., 1992), grades 4 to 6 (Berninger et al., 1994), and grades 7 to 9 (Berninger et al., 1996) were identified for later open coding. At each of the three developmental levels studied, the same narrative and expository composition prompts were used for the five-minute samples so that composing could be compared across genre in writing development (for a review, see Berninger, 2009).

Triple word-form theory serves as the basis of an unconstrained analysis of misspellings. Once the linguistic features were identified, the following research question was asked: Did the linguistic patterns of spelling errors (phonological, orthographic, and morphological) differ as a function of grade level? A qualitative analysis was completed to further examine variations in error patterns with a more fine-grained lens.

Method

Participants

Participant data on spelling were taken from a larger cross-sectional study of normal writing development (Berninger et al., 1992, 1994, 1996). This sample was representative of the U.S. population in terms of mother's educational level and family racial/ethnic background (based on US census data at time study was conducted). A total of 888 students from grades 1 to 9 participated, all of whom were enrolled in general education classrooms: 50 boys, 50 girls in each of six grade levels (1 – 6), and 48 boys, 48 girls in each of three grade levels (7– 9). Participants in grades 1–3 attended eight different elementary schools in three participating school systems in the Seattle, Washington area. Mothers' educational level ranged from high school to college and beyond. Children in grades 4–6 attended five urban and suburban schools in the greater Seattle area. Mothers' educational level ranged from less than high school to college and beyond. Participants in grades 7–9 attended two suburban junior high schools serving a diverse student body (Berninger et al., 1996). Mothers' educational level ranged from less than high school to college. Table 1 lists the racial/ethnic distributions for all students.

Procedures

Two genres were administered to the 888 children, a narrative and an expository writing sample, because multiple composing tasks increase reliability (Olinghouse & Santangelo, 2011; Verheyden, Van den Branden, Rijlaarsdam, van den Berg, & De Maeyer, in press). The narrative writing sample was identical for all grade levels, and began with the prompt “One day _____ had the best or worst day at school. The expository writing sample prompt was also identical for all grade levels, and began with the sentence “I like _____ because _____.” Both prompts solicited topics that were familiar to students irrespective of their ethnic and socioeconomic status (SES). Research (McCutchen, 1986; McCutchen, Francis, & Kerr, 1997) shows that children write more on topics when they have background knowledge. All compositions were marked after 5-minutes by the examiner or the older students. Only spelling errors before the 5-minute limit were analyzed at all grade levels. At the beginning of the session, each participant was instructed that they could make revisions at any time by crossing out and rewriting (Berninger et al., 1992, 1994, 1996).

Data collection—Students in grades 1 to 3 were tested during individual sessions between February and May in a quiet space provided by each school. Participants in grades 4 to 6 were also tested in individual sessions in the sixth or seventh month of the school year. Participants in grades 7 to 9 composed their narrative and expository samples in the second of two group testing sessions (Berninger et al., 1996). In the first three grades, each participant was asked to read the text just composed to the researcher, who transcribed any words that were not legible in the student's composition. In the other grades, the researcher looked at what the child had just written and if any word was not legible, pointed to it, and asked for clarification.

Total number of words and coded spelling errors—Table 2 displays the mean number of words and standard deviations for the 1776 writing samples (888 different participants $\times$ 2 writing samples), and the mean number of misspellings and standard deviations across the two writing samples ($N = 6,492$ total; $n = 3,264$ in grades 1 to 4; $n = 3,228$ in grades 5 to 9). Then the number of errors and type of each error was determined using the Phonological, Orthographic, and Morphological Assessment of Spelling (POMAS).

POMAS—The POMAS was first proposed by Silliman, Bahr, and Peters, 2006) and subsequently expanded in this study. An unconstrained, qualitative, scoring system, the POMAS embodies triple word-form theory in that it identifies errors within three broad categories of development, phonological, orthographic, and morphological, and then allows for further classification into specific linguistic features derived from General American English. In this study a total of 41 linguistic features emerged. For instance, if the word *and* was misspelled as *ad*, the error would be classified initially as a phonological error because not all of the phonological skeleton elements were represented in the child's written production. This error would then be further classified as difficulty with a sonorant (nasal) cluster. However, if the child wrote *triped* for *tripped*, this would be coded as an orthographic error because the child was able to convey the phonological structure. That is, the child marked the past tense of *trip* but did not demonstrate the appropriate orthographic notation. This error would be classified as difficulty with the linguistic feature of letter doubling.

In a similar way, morphological errors were scored when the child demonstrated difficulty with inflections and derivations. For example, *kisst* for *kissed* is a morphological error that would be further analyzed as a difficulty with an inflected suffix. Derivations were similarly coded in terms of prefixes and suffixes. For instance, if *attention* was spelled as *attension*, it would be coded as a misspelled (derivational) suffix. Prefixed derivations were also included in the morphological code, as were homonym misspellings (e.g., *there* for *their*). The POMAS also allows for the possibility that an error might overlap between two areas of development, like *tis* for *its*, which the POMAS classifies as a phonological-orthographic reversal (i.e., metathesis).¹

Data reduction—Each sample was identified by grade level, gender, and genre (narrative versus expository). The errors were coded by category (phonological, orthographic, and morphological) and specific linguistic feature affected. For each participant, the number of errors associated with each linguistic feature within a major category — phonological, orthographic, and morphological — was summed to determine the total number of errors in each category. For statistical analyses, these individual category totals were then normalized by the total number of spelling errors produced by the participant.

Quantitative and qualitative analyses—The quantitative analyses were completed to note patterns within the linguistic categories associated with grade. Qualitative analyses evaluated how the nature of linguistic feature errors differed in the early (grades 1–4) versus later grades (grades 5–9).

Interrater agreement—Of the 888 participants, 20 percent ($n = 178$) were randomly selected for recoding of linguistic features associated with misspellings in both their narrative and expository samples. Random selection occurred across both grade and gender. The raters consisted of the first author and two students enrolled in a Master's of Science degree program in speech-language pathology located in west central Florida.

A four-step process was used to determine point-to-point interrater agreement after the samples were initially coded by the graduate student in consultation with the first author. First, linguistic feature definitions that arose during initial coding were reviewed within each of the three POMAS categories (phonology, orthography, and morphology). Second, the two raters jointly coded samples and reached agreement on samples that were not included in the actual agreement phase. Third, for both grades 1 – 4 and 5 – 9, the assigned rater then

¹A copy of the POMAS codes, definitions, and examples is available from the first author.

independently judged randomly selected samples from 178 participants (20% of the total sample). Finally, responses were compared for each linguistic feature across raters (Bakeman & Gottman, 1986).

Point-to-point agreement was determined to be 75% on linguistic feature coding. Miles and Huberman (1994) report an average agreement percentage of approximately 70% is adequate for the preliminary use of a new qualitative approach. This level of agreement occurred because the same error can be interpreted in different ways. Given the word *went* spelled as *whent*, the first rater could code the addition of *h* as a silent letter because the *h* is silent in many words beginning with *wh-*, such as *what* and *where*. On the other hand, this error could be coded as an epenthesis, which more simply states an extra letter occurs. Neither interpretation is incorrect.

Results

The data were analyzed in two ways to provide a fine-grained analysis of the spellings of students in grades 1–9. In the first analysis we examined linguistic patterns by grade. Next, we conducted a qualitative analysis on the frequency and nature of errors in younger and older writers.

Effects of Grade Level and Type of Errors

Since the spelling analysis was conducted on an existing dataset and our primary interest was patterns across grades, the researchers decided to collapse the genre factor for each dependent variable by adding the number of errors noted in each condition together and dividing that number by the total number of errors for that linguistic category. Given the fact that these two writing samples were devised to be appropriate for all students in grades 1–9, it was felt that any real differences attributable to genre would be more evident if topics had been chosen to correspond with grade levels. Therefore, by combining, spelling errors from the two genres, a more comprehensive picture of the writing process would be portrayed. (Olinghouse & Santangelo, 2011; Verheyden et al., in press). In addition, the effects of gender were considered in a series of exploratory analyses and determined to be non-significant.

Given the potential relationships among the three dependent variables (i.e., ipsative relationships), a correlational analysis was conducted. The correlational values for each pair of error types (phonological-orthographic, phonological-morphological, and orthographic-morphological) was determined for each grade level (see Table 3). The median intercorrelation for each error type was negative and less than .25. This finding suggested that the data only had tendencies toward ipsativity, meaning that specific *F* and *p* values in an analysis could be related to one another. However, any apparent relationships among the grades could be considered.

F max tests were used to determine homogeneity of variance across grades for each dependent variable. Results indicated nonsignificant *F* max values for the phonological and orthographic categories (*F* max = 1.54 and 1.98, respectively) and a somewhat higher (marginally significant at *p* = .05) *F* max (4.03) for the morphological category. These results suggest that differences in variances across grades were not problematic for the ANOVA results and were within acceptable limits.

A one-way between groups ANOVA by grade for each dependent variable was conducted. The following between groups effects were noted: phonological errors, $F(8, 886) = 7.004$, $p < .001$; orthographic errors, $F(8, 886) = 8.272$, $p < .001$; morphological errors, $F(8, 886) = 12.159$, $p < .001$. More importantly, we analyzed for a linear trend effect and the results

were as follows: phonological errors, $F(1, 886) = 47.986, p < .001$, orthographic errors, $F(1, 886) = 50.357, p < .001$, and morphological errors, $F(1, 886) = 77.866, p < .001$. The latter F values were over six times larger than the between groups effects cited above (6.85, 6.088, and 6.404, respectively); therefore, the relationship among the grades by linguistic category was strongly linear.

The noted linear trend, displayed in Figure 1, illustrates that phonological and orthographic error rates decline as grade increases, while the morphological error rate increases with grade. The latter finding would be expected as several investigators (e.g., Berninger et al., 2010; Nunes & Bryant, 2006) found that inflectional and derivational use increased with age. What is interesting to observe is the apparent developmental shift in the frequency of phonological versus morphological errors that occurs between grades 4 and 5. The developmental shift is also apparent in the relationships of the proportions of error type by grade. Students in grades 1–4 made significantly more orthographic errors than other error types, while students in grades 5–9 displayed a smaller gap among error types.

Qualitative Analyses of Misspellings

A qualitative analysis was completed to further describe the error patterns within these data. As noted in Table 4, the error patterns across grades seemed to show a gradual shift from phonological dependence to the building of an orthographic lexicon (see Figure 1). In the early grades, the errors involved representing the phonological skeleton, whereas older children demonstrated difficulty with the consistent application of English phonological and orthographic rules. An example of how the quality of a specific error would differ by age is illustrated in the children's use of the silent *e* rule (resulting in a letter name feature error). Younger children (i.e., grades 1–4) would simply omit the final *e*, resulting in *pal* for *pale*. Older children (i.e., grades 5–9) would also omit the *e*, but usually in the context of suffix addition, like *lonly* for *lonely*.

Although orthographic errors occurred the most frequently across all grades, phonological errors continued to be present in the upper grades. Young children tended to use cluster reduction (*stuck* for *struck*). They also experienced difficulties with sonorant clusters (*ad* for *and*), vocalic —r (*cos* for *curls*), and long vowel spellings (*kipe* for *keep*). On the other hand, phonological error patterns in grades 5–9 involved misrepresentations of diphthongs (*thought* for *thought*) and consonant reversals (*alawys* for *always*). Finally, younger students tended to add extra letters while older students omitted letters (*alway* for *always*).

The major difference in the morphology category across grades was the increase in inflectional and derivational errors. Students in grades 1–4 had difficulties with inflectional generalization, like *snowmans* for *snowmen*, or used phonological spellings for inflected forms, like *kist* for *kissed*. Inflectional errors occurred much less frequently in grades 5–9. Instead, errors involved misapplication of the appropriate suffix sometimes combined with misspelling of the root word, e.g., spelling *oppertunitys* for *opportunities*.

Discussion

This mixed method study provided new insights into the misspellings of children in grades 1–9. From a quantitative perspective, the value of the POMAS was demonstrated in its utility to classify spelling errors into phonological, orthographic, and morphological categories. Moreover, the trend analysis demonstrated changes in the proportion of error patterns across grades. From a qualitative standpoint, error analyses revealed that both spelling skill, as measured by the number of errors, and developmental patterns should be considered in order to understand variations in students' performances.

Differences Attributable to Grade

The trend analysis revealed that the distribution of error types changed with grade. As expected, the mean number of misspellings decreased with grade with a notable decline evident between grades 4–5. Orthographic errors predominated across all grades, showing a marked decline from grades 1 to 9. The frequency of morphological errors increased from grade 1 to 9, but visual inspection suggests that most of the increase was completed by grade 5, whereupon some leveling out occurred. In contrast, the phonological error rate remained relatively flat after grade 1. Moreover, the change in error patterns between grades 4 and 5 was accentuated by a reversal in the frequency of morphological versus phonological errors. Hence, linguistic error distribution shifted with grade and no specific error category disappeared. In fact, when proportions of errors from the phonological and morphological categories were combined, they accounted for 30% of the total errors from grades 1–9.

As noted previously, studies that contrast percentage data over time, such as percentages of three different spelling errors, should consider whether the statistical problem of ipsativity may have affected the results. In this case, the median intercorrelation of the three error types was $-.25$, showing a small tendency toward ipsativity (approximately 6% of the variance). In contrast, the statistical findings were very strong and robust. The linear trends showed F values of 48, 50, and 78, which are very large effects. Thus, the strong statistical findings are not meaningfully called into question due to mild ipsativity. In fact, the percentage changes shown in Figure 1 are readily interpretable by visual inspection.

The observed patterns of errors across grades may reflect the way in which the spelling system actually functions. Although the phonological, orthographic, and morphological categories can be assessed as discrete components, in reality and consistent with language as a whole, students may be attempting to work through interactions among the three components. Hence, some aspects of variability may not be related to a specific category but to discovering how to cross-map the *relationships* among the three categories and specific linguistic features (For evidence and discussion, see Berninger, Raskind et al., 2008). Moreover, within children, it is likely that the three categories develop at different rates (Bourassa et al., 2011). Spelling errors may also reflect students' underdeveloped skills for detecting and correcting violations in spelling or knowing when to apply these skills. For example, one older student misspelled *beautiful* in an expository writing sample as *buetiful* and *bueatiful*, while another spelled *because* in a narrative sample as *becauce* and *becouse*.

Although data about distributional shifts is important for delineating overall changes in spelling development, these findings yield minimal information that is relevant for understanding the instructional needs of individual students. The qualitative analysis has the potential to provide this information.

Qualitative Patterns

Four areas are highlighted from the qualitative findings. First, errors in morphological production increased with grade level. However, in grades 5 to 9, only 12% of derivations were misspelled, a relatively small percentage. It also appeared that the error patterns for grades 5–9 required more advanced knowledge of derivational morphology than that evidenced in grades 1–4. This finding supports results from several studies (e.g., Berninger et al., 2010; Nagy et al., 2006) on the growth of derivational morphology knowledge after grade 4. Many of the derivational errors involved misspelling of the root word. It may be that, when adding morphophonemic complexity, some students resorted to a phonological strategy for spelling the root, e.g., *practly* for *practically*. However, it was unknown whether these instances were related to increased morphophonemic complexity alone or whether students reverted to the use of more stable phonotactic patterns when spelling root words of

this type. More needs to be known about the extent to which orthotactic probabilities interface with lexical choices in the spelling of derivational complexity (Apel et al., 2006). Nevertheless, it is clear that instruction should focus on derivational morphology patterns in spelling across all grades, not just at higher grade levels (cf. Berninger et al., 2010; Bowers, Kirby & Deacon, 2010; Carlisle, 2007).

Second, the quality of spelling errors changed with grade. In other words, students tended to have difficulty with the *same* linguistic features but *how* these features were manifested differed with grade. As illustrated in Table 4, a student in grades 1–4 might omit the silent *e* (*pal* for *pale*), whereas an older student would only omit the silent *e* when a suffix was applied (*lonly* for *lonely*), suggesting that the root word spelling may still be in flux (Carlisle, 2007). It remains unresolved whether morphophonemic complexity or reliance on word-specific knowledge (Mitchell et al., 2011) influenced this omission in older students. A second possibility is that, as the flexibility of morphological problem solving improves over time, students can approach a linguistic feature in a more recursive manner. It is possible that students overgeneralize inflectional morphology rules, for example, *time-timing*, where the *-e* is dropped, to derivational contexts, such as *lonly* for *lonely*. In this situation, although rule application was likely automatic in the inflectional context, it had not been fully reworked at higher levels in derivational contexts. The recursive process at work suggests that spelling, comparable to many aspects of child development, follows a non-linear trajectory.

A third pattern of interest related to how the frequency of the spelling pattern influenced performance in the later grades and is best illustrated with the spelling of short vowels. Students in the early grades tended to substitute one vowel for another, as *het* for *hit*, while older students experienced difficulty with short vowel digraphs, spelling *hed* for *head* or *thaught* for *thought*. These findings support work on statistical patterns in spelling (e.g., Treiman & Kessler, 2006; Treiman et al., 2006) and strongly suggest that more attention should be paid to word frequency in the development of spelling word lists and inventories.

The fourth area of interest displayed on Table 4 pertains to the continued interplay between semantic analysis and the generation of conventional spellings. This relationship is best captured by the difficulty that students in all grades experienced in the spelling of homonyms, such as *they're* for *their*, *new* for *knew*, and *witch* for *which*. Surprisingly, there has been little research on homonym development especially in the school-age years (e.g., Mazzocco, 1997; Mazzocco, Myers, Thompson, & Desai, 2003; Simon & Simon, 1973). The general consensus is that homonym disambiguation during reading and spelling requires some level of semantic analysis to select the appropriate word form in the particular linguistic context as opposed to selecting the most familiar word form. The persistence of homonym ambiguity may be related to non-mutually exclusive factors: the additional processing burden that students encounter while engaged in natural writing under timed conditions and inadequate instructional guidance on the importance of contextual analysis. In a similar vein, the difficulties that students in grades 5–9 experienced with word boundaries, such as *eachother* for *each other* and *some times* for *sometimes*, may illustrate how increased vocabulary growth does not necessarily align with full knowledge about compounding as a semantic strategy for the creation of new word-forms related in meaning. More study is needed on the development of compounding knowledge in spelling as well as the effects of specific instruction on when to divide or compound meanings (Moats, 2000).

Educational and Clinical Implications

Educational implications—Although the initial research team (Berninger et al., 1992, 1994, 1996) collected teacher questionnaire data on writing instruction programs, questions were not asked at each grade level about the how phonological, orthographic, and

morphological aspects of spelling were taught. Thus, the effect of instructional variations on misspellings cannot be determined in these cross-sectional studies. When combined with other research-supported educational recommendations for teaching students strategies for morphological and contextual analysis (Berninger & Fayol, 2008; Bowers et al., 2010; Joshi, Treiman, Carreker, & Moats, 2008–2009; Wolter et al., 2009), current results provide insight into instructional targets for teaching how to cross-map connections among phonology, orthography, and morphology from the earliest grades. In addition, understanding of form-meaning relationships among word roots, inflections, and derivations, as well as compounding, is a critical aspect of the word-formation process and is also essential for advancing knowledge of new word meanings. As Berninger et al. (2010) point out, word-formation processes and vocabulary knowledge are related, but not identical, mechanisms.

Clinical implications—This study demonstrated the clinical utility of the POMAS in that a linguistic feature approach allowed a fine-grained perspective into misspelling patterns across a broad range of grades in typically developing writers. The use of an unconstrained scoring system allowed consideration of alternate interpretations and challenged the notion that misspellings can be categorized in an invariant way, as in a constrained system.

The next step in the clinical development of the POMAS is to investigate the impact of the most frequently occurring linguistic features in separating good from poor spellers and in identifying misspelling patterns that may be characteristic of students with language impairment (LI). Given this data base of errors, it becomes possible to select words that, developmentally, would be more likely to elicit misspellings and, therefore, lead to prediction of potential error patterns and eventually to more targeted spelling instruction. A linguistic feature approach to item selection would also sample the breadth of spelling in the balanced way that Moats (1995) recommends. To that end, development of a spelling inventory that contains these frequently occurring features is currently under way. This measure focuses on the identification of qualitative differences in misspellings rather than accuracy. Linguistic feature analysis would eventually assist speech-language pathologists in determining the overlap, if any, between students who are poor spellers and those with LI (Silliman et al., 2006).

Conclusions

The use of a fine-grained analysis generated support for triple word-form theory. The strongest source of evidence was located in the error patterns. By grade 1, orthographic errors predominated and errors attributed to phonological and morphological patterns were evident. As grade level increased, the number of orthographic errors significantly decreased while morphological errors increased. However, phonological errors continued. In fact, the proportion of errors attributed to both phonology and morphology remained remarkably constant across grades (30% of the errors across grades were represented by these two categories combined). The shift to proportionally more morphological errors in the older age groups likely relates to a combination of word-formation issues combined with vocabulary growth. These patterns reconfirm that it takes a long time to develop a robust and well-coordinated orthographic lexicon, which is intertwined with the development of more literate vocabulary.

What may be of greatest importance, however, is the nonlinearity of spelling development as reflected in the length of time necessary for the phonological, orthographic, and morphological codes to become interconnected into a single system of representation. The suggestion here is that individual variability is prominent. Conceptually, from a nonlinear perspective, this finding implies that students within and across grade levels, are in different

states of change between consolidation of new patterns and dissolution of older patterns. As reviewed in Silliman (2010), newly evolving abilities are more vulnerable to situational demands that often can result in greater variability of students' performance. An example of this nonlinearity would be the difficulty with root constancy evidenced by older students. It appears that those students whose morphological awareness is still evolving fall back on more stable strategies, such as a phonologically-based sounding out strategy, to spell the root when morphophonemic complexity increases. Future spelling research on triple word-form theory and cross word-form mapping should consider relationships between instruction and its effects on individual variability, including students with LI.

Acknowledgments

This study would not been possible without the spelling analyses provided by Kelly Fawcett and Jennifer James. Portions of these data were presented at the 2005 and 2006 meetings of the American Speech-Language-Hearing Association, the 2007 Florida Reading Research Conference, and the 15th European Conference on Reading in 2007.

References

- Apel K. Kindergarten children's initial spoken and written word learning in a storybook context. *Scientific Studies of Reading*. 2010; 14:440.
- Apel K, Wolter J, Masterson J. Effects of orthotactic and phonotactic probabilities during fast mapping on 5 year-olds learning to spell. *Developmental Neuropsychology*. 2006; 29:21–42. [PubMed: 16390287]
- Bahr, RH.; Silliman, ER.; Berninger, VW. What spelling errors have to tell about vocabulary learning. In: Wood, C.; Connelly, V., editors. *Reading and spelling: Contemporary perspectives*. Routledge; New York, NY: 2009. p. 109-129.
- Bakeman, R.; Gottman, JM. *Observing interaction: An introduction to sequential analysis*. Cambridge University Press; Cambridge, MA: 1986.
- Ball EW. Assessing phonemic awareness. *Language, Speech, & Hearing Services in Schools*. 1993; 24:130–139.
- Berninger VW. Highlights of programmatic, interdisciplinary research on writing. *Learning Disabilities Research & Practice*, 24. 2009:69–80.
- Berninger V, Abbott R, Nagy W, Carlisle J. Growth in phonological, orthographic, and morphological awareness in grades 1 to 6. *Journal of Psycholinguistic Research*. 2010; 39:141–163. [PubMed: 19826956]
- Berninger V, Cartwright AC, Yates CM, Swanson HL, Abbot RD. Developmental skills related to writing and reading acquisition in the intermediate grades. *Reading & Writing*. 1994; 6:161–196.
- Berninger, VW.; Fayol, M. *Encyclopedia of language and literacy development*. Canadian Language and Literacy Research Network; London, ON: 2008. Why spelling is important and how to teach it effectively; p. 1-13.
- Berninger, VW.; Garcia, NP.; Abbott, RD. Multiple processes that matter in writing instruction and assessment. In: Troia, GA., editor. *Instruction and assessment for struggling writers: Evidence-based practices*. Guilford Press; New York: 2009. p. 15-74.
- Berninger, V.; Nagy, W.; Carlisle, J.; Thompson, J.; Hoffer, D.; Abbott, S.; Abbott, R.; Richards, T.; Aylward, E. Effective treatment for dyslexics in grades 4 to 6. In: Foorman, B., editor. *Preventing and remediating reading difficulties: Bringing science to scale*. York Press; Timonium, MD: 2003. p. 382-417.
- Berninger VW, Raskind W, Richards T, Abbott RD, Stock P. A multidisciplinary approach to understanding developmental dyslexia within working memory architecture: Genotypes, phenotypes, brain, and instruction. *Developmental Neuropsychology*. 2008; 33:707–744. [PubMed: 19005912]
- Berninger V, Whitaker D, Feng Y, Swanson HL, Abbott RD. Assessment of planning, translating, and revising in junior high writers. *Journal of School Psychology*. 1996; 34:23–52.

- Berninger VW, Yates C, Cartwright AC, Rutberg J, Remy E, Abbot RD. Lower level developmental skills in beginning writing. *Reading & Writing*. 1992; 4:257–280.
- Bourassa DC, Beupre J, MacGregor K. Fourth graders' sensitivity to morphological context in spelling. *Canadian Journal of Experimental Psychology*. 2011; 65:109–114. [PubMed: 21668093]
- Bourassa DC, Treiman R. Spelling development and disability: The importance of linguistic factors. *Language, Speech, & Hearing Services in Schools*. 2001; 32:172–181.
- Bourassa D, Treiman R. Spelling in children with dyslexia: Analyses from the Treiman-Bourassa early spelling test. *Scientific Studies of Reading*. 2003; 7:309–333.
- Bourassa, D.; Treiman, R. Linguistic factors in spelling development. *Encyclopedia of Language and Literacy*. 2007. Retrieved from: <http://www.literacyencyclopedia.ca/pdfs/topic.php?toopld=228>
- Bowers PN, Kirby JR, Deacon SH. The effects of morphological instruction on literacy skills: A systematic review of the literature. *Review of Educational Research*. 2010; 80:144–179.
- Bruck M, Waters G. An analysis of spelling errors of children who differ in their reading and spelling skills. *Applied Psycholinguistics*. 1988; 9:77–92.
- Caravolas M, Hulme C, Snowling MJ. The foundations of spelling ability: Evidence from a 3-year longitudinal study. *Journal of Memory and Language*. 2001; 45:751–774.
- Carlisle JF. An exploratory study of morphological errors in children's written stories. *Reading and Writing*. 1996; 8:61–72.
- Carlisle JF. Morphology matters in learning to read: A commentary. *Reading Psychology*. 2003; 24:291–332.
- Carlisle, JF. Morphological processes that influence learning to read. In: Stone, CA.; Silliman, ER.; Ehren, BJ.; Apel, K., editors. *Handbook of language and literacy: Development and disorders*. Guilford; NY: 2004. p. 318–339.
- Carlisle, JF. Fostering morphological processing, vocabulary development, and reading comprehension. In: Wagner, RK.; Muse, AE.; Tannenbaum, KR., editors. *Vocabulary acquisition: Implications for reading comprehension*. Guilford; NY: 2007. p. 78–103.
- Carlisle JF, Fleming J. Lexical processing of morphologically complex words in the elementary years. *Scientific Studies of Reading*. 2003; 7:239–253.
- Carlisle J, Katz L. Effects of word and morpheme familiarity on reading of derived words. *Reading and Writing*. 2006; 19:669–693.
- Cassar M, Treiman R. The beginnings of orthographic knowledge: Children's knowledge of double letters in words. *Journal of Educational Psychology*. 1997; 89:631–644.
- Deacon SH. The metric matters: Determining the extent of children's knowledge of morphological spelling regularities. *Developmental Science*. 2008; 11:396–406. [PubMed: 18466373]
- Deacon SH, Bryant P. Getting to the root: Young writers' sensitivity to the role of root morphemes in the spelling of inflected and derived words. *Journal of Child Language*. 2006a; 33:401–417. [PubMed: 16826832]
- Deacon SH, Bryant P. This turnip's not for turning: Children's morphological awareness and their use of root morphemes in spelling. *British Journal of Development Psychology*. 2006b; 24:567–575.
- Deacon SH, Dhooge S. Developmental stability and changes in the impact of root consistency on children's spelling. *Reading and Writing*. 2010; 23:1055–1069.
- Deacon SH, Kirby JR, Casselman-Bell M. How robust is the contribution of morphological awareness to general spelling outcomes? *Reading Psychology*. 2009; 30:301–318.
- Dixon M, Kaminska Z. Does exposure to orthography affect children's spelling accuracy? *Journal of Research in Reading*. 2007; 30:184–197.
- Ehri, L. The development of orthographic images. In: Frith, U., editor. *Cognitive processes in spelling*. London Academic Press; 1980. p. 311–338.
- Garcia N, Abbott RD, Berninger VW. Predicting poor, average, and superior spellers in grades 1–6 from phonological, orthographic, and morphological, spelling, or reading composites. *Written Language & Literacy*. 2010; 13:61–99.
- Gillis S, Ravid D. Typological effects on spelling development: Across linguistic study of Hebrew and Dutch. *Journal of Child Language*. 2006; 33:621–659. [PubMed: 17017281]

- Graves, MF. The vocabulary book: Learning and instruction. Teachers College Press; New York, NY: 2006.
- Green L, McCutchen D, Schwiebert C, Quilan T, Eva-Wood A, Juelis J. Morphological development in children's writing. *Journal of Educational Psychology*. 2003; 95:752–761.
- Joshi RM, Treiman R, Carreker S, Moats LC. How words cast their spell. *American Educator*. Winter; 2008–2009 32(4):6–16. 42–43.
- Landerl K, Wimmer H. Development of word reading fluency and spelling in a consistent orthography: An 8-year follow-up. *Journal of Educational Psychology*. 2008; 100:150–161.
- Mazzocco MMM. Children's interpretation of homonyms: A developmental study. *Journal of Child Language*. 1997; 24:441–467. [PubMed: 9308427]
- Mazzocco MMM, Myers GF, Thompson LA, Desai SS. Possible explanations for children's literal interpretations of homonyms. *Journal of Child Language*. 2003; 30:879–904. [PubMed: 14686088]
- McCutchen D. Domain knowledge and linguistic knowledge in the development of writing ability. *Journal of Memory and Language*. 1986; 25:431–444.
- McCutchen D, Francis M, Kerr S. Revising for meaning: Effects of knowledge and strategy. *Journal of Educational Psychology*. 1997; 89:667–676.
- Miles, MB.; Huberman, AL. *Qualitative data analysis: An expanded sourcebook*. Second ed.. Sage Publications; Thousand Oaks, CA: 1994.
- Mitchell P, Kemp N, Bryant P. Variations among adults in their use of morphemic spelling rules and word-specific knowledge when spelling. *Reading Research Quarterly*. 2011; 46:119–133.
- Moats, LC. *Spelling development, disability, and instruction*. York Press; Baltimore: 1995.
- Moats, LC. *Speech to print: Language essentials for teachers*. Paul H. Brooks; Baltimore, MD: 2000.
- Moats, LC. Spelling disability in adolescents and adults. In: Bain, AM.; Bailet, LL.; Moats, LC., editors. *Written language disorders: Theory into practice*. Second ed.. Pro-Ed; Austin, TX: 2001. p. 43–75.
- Moats, LC. Teaching spelling to students with language and learning disabilities. In: Troia, GA., editor. *Instruction and assessment for struggling writers: Evidence-based practices*. Guilford Press; New York: 2009. p. 269–289.
- Moats L, Foorman B, Taylor P. How quality of writing instruction impacts high-risk fourth graders' writing. *Reading & Writing*. 2006; 19:363–391.
- Nagy W, Berninger VW, Abbott RD. Contributions of morphology beyond phonology to literacy outcomes of upper elementary and middle-school students. *Journal of Educational Psychology*. 2006; 98:134–147.
- Nunes, T.; Bryant, P. *Improving literacy by teaching morphemes*. Routledge; New York: 2006.
- Olinghouse, NG.; Santangelo, T. Generalizability of writing scores: One or multiple genres?. Feb. 2011 Unpublished manuscript
- Olson, R.; Forsberg, H.; Wise, B. Genes, environment, and the development of orthographic skills. In: Berninger, VW., editor. *The varieties of orthographic knowledge-I: Theoretical and developmental issues*. Kluwer Academic Press; Dordrecht, the Netherlands: 1994. p. 27–71.
- Patton, MQ. *Qualitative research and evaluation methods*. 3rd ed.. Sage; Thousand Oaks, CA: 2002.
- Perfetti C. Reading ability: Lexical quality to comprehension. *Scientific Studies of Reading*. 2007; 11:357–383.
- Rabin J, Deacon H. The representation of morphologically complex words in the developing lexicon. *Journal of Child Language*. 2008; 35:453–465. [PubMed: 18416867]
- Reed DK. A synthesis of morphology interventions and effects on reading outcomes for students in grades K–12. *Learning Disabilities Research & Practice*. 2008; 23:36–49.
- Rice ML, Wexler K, Hershberger S. Tense over time: The longitudinal course of tense acquisition in children with specific language impairment. *Journal of Speech, Language, and Hearing Research*. 1998; 41:1412–1431.
- Richards TL, Aylward EH, Berninger VW, Field KM, Grimme AC, Richards AL. Individual fMRI activation in orthographic mapping and morpheme mapping after orthographic or morphological spelling treatment in child dyslexics. *Journal of Neurolinguistics*. 2006; 19:56–86.

- Richards TL, Berninger VW, Fayol M. fMRI activation differences between 11-year-old good and poor spellers' access in working memory to temporary and long-term orthographic representations. *Journal of Neurolinguistics*. 2009; 22:327–353.
- Sangster L, Deacon SH. Development in children's sensitivity to the role of derivations in spelling. *Canadian Journal of Experimental Psychology*. 2011; 65:133–139. [PubMed: 21244134]
- Sharp AC, Sinatra GM, Reynolds RE. The development of children's orthographic knowledge: A microgenetic perspective. *Reading Research Quarterly*. 2008; 43:206–226.
- Silliman ER. Language learning disability and individual differences: Can we see between the lines? *Topics in Language Disorders*. 2010; 30:22–27.
- Silliman ER, Bahr RH, Peters ML. Spelling patterns in preadolescents with atypical language skills: Phonological, morphological, and orthographic factors. *Developmental Neuropsychology*. 2006; 29:93–123. [PubMed: 16390290]
- Simon DP, Simon HA. Alternative uses of phonemic information in spelling. *Review of Educational Research*. 1973; 43:115–137.
- Tangel DM, Blachman BA. Effect of phoneme awareness instruction on the invented spelling of first grade children. *Journal of Reading Behavior*. 1995; 27:153–185.
- Tangel DM, Blachman BA. Effect of phoneme awareness instruction on kindergarten children's invented spelling. *Journal of Reading Behavior*. 1992; 24:233–261.
- Treiman R. Children's spelling errors on syllable-initial consonant clusters. *Journal of Educational Psychology*. 1991; 83:346–360.
- Treiman R, Bourassa DC. Children's written and oral spelling. *Applied Psycholinguistics*. 2000; 21:183–204.
- Treiman R, Cassar M. Effects of morphology on children's spelling of final consonant clusters. *Journal of Experimental Child Psychology*. 1996; 63:141–170. [PubMed: 8812040]
- Treiman R, Kessler B. Spelling as statistical learning: Using consonantal context to spell vowels. *Journal of Educational Psychology*. 2006; 98:642–652.
- Treiman R, Kessler B, Zevin JD, Bick S, Davis M. Influence of consonantal context on the reading of vowels: Evidence from children. *Journal of Experimental Child Psychology*. 2006; 93:1–24. [PubMed: 16115645]
- Turnbull K, Deacon S, Kay-Raining Bird E. Mastering inflectional suffixes: A longitudinal study of beginning writers' spellings*. *Journal of Child Language*. 2011; 38:533–553.
- Venezky, RL. *The American way of spelling: The structure and origins of American English orthography*. Guilford Press; New York: 1999.
- Verheyden, L.; Van den Branden, K.; Rijlaarsdam, G.; van den Berg, H.; De Maeyer, S. Translation of thought to written text while composing: Advancing theory, knowledge, methods, and applications. Fayol, M.; Alamargot, D.; Berninger, V., editors. Psychology Press; New York: in press
- Verhoeven L, Perfetti CA. Introduction to this special issue: Vocabulary growth and reading skill. *Scientific Studies of Reading*. 2011; 15:1–7.
- Wanzek J, Vaughn S, Wexler J, Swanson EA, Edmonds M, Kim AH. A synthesis of spelling and reading interventions and their effects on the spelling outcomes of students with LD. *Journal of Learning Disabilities*. 2006; 39:528–543. [PubMed: 17165620]
- Windsor J, Scott CM, Street CK. Verb and noun morphology in the spoken and written language of children with language learning disabilities. *Journal of Speech, Language, and Hearing Research*. 2000; 43:1322–1336.
- Wolter JA, Wood A, D'zatko KW. The influence of morphological awareness on the literacy development of first-grade children. *Language, Speech, and Hearing Services in Schools*. 2009; 40:286–298.
- Wright DM, Ehri LC. Beginners remember orthography when they learn to read words: The case of doubled letters. *Applied Psycholinguistics*. 2007; 28:115–133.

Figure 1. Differences in error rates (mean percentage of errors by linguistic category) across grades 1–9. The error bars show ± 1 standard error of the mean (SEM).

Table 1

Racial/Ethnic Representation of Participants in Grades 1 to 9 (Berninger et al., 1992, 1994, 1996)

	Grades 1–3 (<i>n</i> = 300)	Grades 4–6 (<i>n</i> = 300)	Grades 7–9 (<i>n</i> = 288)
Caucasian	84%	70%	73%
Asian American	6%	14%	18%
African American	6%	10%	5%
Hispanic	3%	4%	4%
Native American	<1%	1%	NA
Other	NA	1%	<1%

\$watermark-text

\$watermark-text

\$watermark-text

Table 2

Mean Number of Words and Misspellings across Both Writing Samples (n = 1776 total) for Grade 1 to 9 Participants (n = 888). Standard Deviations Are in Parenthesis

Grade	N	Mean Age (Yrs; Mo.)	Mean # of Words	Mean # of Misspellings	% Errors
1	100	6;9 (4.4 mo.)	34.1 ^a (18.1)	7.88 (5.90)	23%
2	100	8;0 (4.8 mo.)		5.77 (5.46)	17%
3	100	8;8 (4.9 mo.)		4.73 (4.66)	14%
4	100	10;1 (5.0 mo.)	56.5 (20.9)	4.99 (4.92)	9%
5	100	11;1 (5.4 mo.)	127.6 (23.4)	3.91 (4.08)	3%
6	100	12;0 (4.8 mo.)	153.2 (24.4)	3.16 (3.17)	2%
7	96	12;11 (4.4 mo.)	129.5 (43.4)	3.46 (3.31)	3%
8	96	13;8 (5.0 mo.)	128.6 (34.0)	2.57 (3.15)	2%
9	96	14;8 (5.9 mo.)	141.7 (38.0)	3.22 (3.80)	2%

^aBerninger et al. (1992) reported results for grades 1–3 as a whole.

Table 3

Means and Standard Deviations (in Parentheses) of the Distributions of Error Percentages across Linguistic Categories²

Grade	Phonological	Orthographic	Morphological
1	25.71% (15.46%)	52.44% (21.76%)	7.45% (11.18%)
2	17.99% (15.36%)	59.33% (24.77%)	7.08% (12.20%)
3	20.36% (17.39%)	48.09% (28.4%)	10.36% (14.81%)
4	17.38% (17.4%)	51.10% (27.71%)	13.59% (16.35%)
5	15.78% (17.7%)	41.46% (28.01%)	21.30% (20.2%)
6	14.86% (16.77%)	37.33% (26.93%)	20.83% (21.85%)
7	13.45% (19.06%)	41.55% (29.03%)	22.76% (20.62%)
8	11.18% (18.29%)	39.91% (27.46%)	19.25% (22.43%)
9	11.89% (16.41%)	36.15% (30.59%)	21.83% (21.98%)

²The percentage totals for each grade do not total 100% as the combination errors (like consonant reversal; that is, *agian* for *again*) and uncodable words were not included.

Table 4

Most Frequent Error Types by Grade (Raw Number of Errors by Grade Groupings in This Sample Are Listed in Parentheses), Indicating Changes in Error Patterns by Grade Groups

Grades	Phonological	Orthographic	Morphological
1–4	Consonant Reversals (dosen't/doesn't) (<i>n</i> = 229) Long Vowel (kipe/keep) (<i>n</i> = 213) Sonorant Cluster Reduction (sad/sand) (<i>n</i> = 143) Epenthesis (tolid/told) (<i>n</i> = 93)	Letter Name (cr/car) (includes silent –e) (<i>n</i> = 716) Unstressed Vowel (differant/different) (<i>n</i> = 636) Digraphs (sip/ship) (<i>n</i> = 367) Ambiguous Letter (sereal/cereal) (<i>n</i> = 254) Borrowed Letter Sequences (tuf/tough) (<i>n</i> = 234)	Contractions (was'nt/wasn't) (<i>n</i> = 41) Homonyms (there/their) (<i>n</i> = 160) Inflections (bike/bikes) (<i>n</i> = 195)
5–9	Consonant Reversals (alawys/always) (<i>n</i> = 160) Long Vowel (relized/realized) (<i>n</i> = 149) Consonant Deletion (alway/always) (<i>n</i> = 91) Diphthongs (arond/around) (<i>n</i> = 65)	Unstressed Vowel (prisoner/prisoner) (<i>n</i> = 327) One Word (some times/sometimes) (<i>n</i> = 229) Consonant Doubling (untill/until) (<i>n</i> = 178) Word Boundary (eachother/each other) (<i>n</i> = 171)	Contractions (weve/ we've) (<i>n</i> = 225) Homonyms (there/they're) (<i>n</i> = 191) Inflections (kiss/kissed)(<i>n</i> = 263) Derivations (practly/practically) (<i>n</i> = 95)