

6-30-2016

Analysis of Patterns in Handwritten Spelling Errors among Students with Various Specific Learning Disabilities

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Analysis of Patterns in Handwritten Spelling Errors among Students with Various
Specific Learning Disabilities

by

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A thesis submitted in partial fulfillment
of the requirements for the degree of
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Date of Approval:

June 30, 2016

Keywords: Phonology, Orthography, Morphology, Dyslexia, Dysgraphia, OWL-LD, Spelling

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Abstract

Students diagnosed with specific learning disabilities struggle with spelling accuracy, but they do so for different reasons. For instance, students with dysgraphia, dyslexia, and oral-written language learning disability (OWL-LD) have distinct areas of weakness in cognitive processing and unique difficulties with the linguistic features necessary for accurate spelling (Silliman & Berninger, 2011). This project considered the spelling errors made by such students to determine if their unique learning profiles lead to distinct misspelling patterns.

Academic summaries handwritten by 33 students diagnosed with dysgraphia ($n=13$), dyslexia ($n=15$), and OWL-LD ($n=5$) were analyzed for type/complexity and number of spelling errors. Additionally, the differences in error frequency and complexity were analyzed based on whether academic material had been listened to or read. Misspellings were extracted from the students' essays and evaluated using an unconstrained linguistic scoring system (POMAS). Then, the complexity/severity of the misspelling was computed using a complexity metric (POMplexity).

Statistical results revealed that children within the diagnostic categories of dysgraphia, dyslexia, and OWL-LD appear to produce errors that are similar in complexity and frequency. Hence, students with specific learning disabilities do not appear to make patterns and numbers of errors specific to their diagnosis. Additionally, statistical results indicated that all students produced similar numbers of errors in both the reading and listening conditions, indicating that the mode of presentation did not affect spelling accuracy.

When spelling errors were analyzed qualitatively, some differences across diagnostic categories and variability within groups was noted. Students with dysgraphia produced misspellings involving a phoneme addition or omission. Phonological and orthographic errors typical of younger children were characteristic of misspellings produced by students with dyslexia. Individuals with OWL-LD tended to omit essential vowels and were more likely to misspell the same word in multiple different ways.

Overall, these results indicate that the subcategories of dysgraphia, dyslexia, and OWL-LD represent of gradients of impairment within the overarching category of specific learning disabilities. However, even within those subcategories, there is a wide degree of variability. Diagnostic categories, then, may suggest areas of linguistic weakness, but subcategories alone cannot be used for determining the nature of spelling intervention.

Chapter 1

Introduction

Spelling involves more than simply rote memorization of letter sequences. It is a complex word formation process that involves coordinating phonological, orthographic, and morphological processes, as well as attention and memory, to accurately form the conventional representation of a word (Bahr, 2015). The phonological aspect of spelling involves segmentation of words into their individual phonemes. Orthographic aspects of spelling involve an understanding of the language-specific rules and patterns for sound-letter correspondences and the arrangement of letters within a word. The morphological aspect of spelling involves an understanding of word meanings and their affixation (including inflections and derivations), which add new layers of meaning to words (Bahr, 2015). Proficiency in each of these knowledge bases is important for the development of strong spelling skills.

Children with learning disabilities express difficulties with specific aspects of linguistic processing which can lead to notably poor spelling skills. However, there is little research comparing the types of errors made by children with different types of language impairments. In light of the absence of prior research on this specific topic, this paper will discuss the linguistic processes involved in spelling, cognitive processes involved in spelling, and the spelling profiles of children with three specific learning disabilities: dysgraphia, dyslexia, and oral-written language learning disability (OWL-LD). Identifying linguistic error patterns associated with each subtype could lead to the development of better instructional programs for these students.

Linguistic Processes and Their Use in Spelling

Researchers once believed that the linguistic processes associated with spelling developed sequentially, starting with the identification of sounds (phonology), followed by the recognition of sound-letter correspondences and patterns (orthography), and finally the recognition of the meaning of word parts (morphology). This sequential development of linguistic processes, known as Stage Theory (Templeton & Bear, 1992), has been refined since current research indicates that children use phonological, orthographic, and morphological knowledge from the beginning of their spelling development (Carlisle, 2003; Deacon et al., 2013; Schlagal, 2001; Walker & Hauerwas, 2006).

Triple word form theory (Bahr, Silliman, & Berninger, 2009; Garcia, Abbott, & Berninger, 2010; Richards et al., 2006) describes how phonological, orthographic, and morphological knowledge are all employed in spelling from an early age. For strong spelling skills to develop, these three linguistic processes must be coded in memory, analyzed, and coordinated so that an accurate spelling results (Bahr et al., 2009). Exposure and practice increase the strength of association between phonemes, graphemes, and morphemes allowing the person to store commonly repeated patterns and familiar words easily (Deacon & Sparks, 2014). Weakness in one or more modes of linguistic processing could lead to difficulty with spelling (Moats, 1995). For example, a student who struggles with phoneme detection would likely struggle with learning sound to symbol correspondences and in turn struggle with building strong connections for patterns of letters and sounds in words.

By analyzing the type and nature of errors made by typically developing children over time, researchers have described patterns of how each linguistic process develops and integrates

with the others as the child learns to spell. While individual children acquire these linguistic processes at different rates, there are common trends in errors across grade levels (Bahr, Silliman, Berninger, & Dow, 2012).

Phonology. As children begin to spell, they learn to match each phoneme they hear to a letter in order to produce a correct spelling. For example, if the child wants to spell the word *cat*, he/she will segment the word into its individual phonemes /k/, /æ/, /t/, and then write the corresponding graphemes to produce the spelling *cat*. By representing each phoneme, the child constructs an intact phonological skeleton (Bourassa & Treiman, 2001) of the word. If the child adds, omits, or substitutes a phoneme it is considered to be a phonological error (Bahr et al., 2012; Silliman, Bahr, & Peters, 2006). Hence, if the child spelled *ct* for *cat*, he/she has omitted an aspect of the phonological skeleton and made a phonological error.

Vowel omission, as represented in the previous example, is common in very young spellers. Through exposure or direct instruction, students learn that all syllables must contain vowels, so vowel omission decreases as children progress through school (Treiman, Berch, Tincoff, & Weatherston, 1993). Another common error in young children is the omission of the less perceptually salient consonant in consonant clusters (Bourassa & Treiman, 2001). For example, they may spell the word *stick* as *sick*. Though frequently occurring in young spellers, the number of phonological errors made by typically developing spellers tends to decrease dramatically after first grade (Bahr et al., 2012).

Orthography. As children attempt to spell increasingly complex words, phonology alone is no longer sufficient for generating correct spellings. Children must learn the allowable orthographic patterns and spelling rules for their language in order to spell accurately. They must realize that letter position in a word and the surrounding phonemes affects the letter(s) that

should be used (Cassar & Treiman, 2004). For example, in English the sound /k/ can be represented by *c*, *k*, or *ck* depending upon the position of the sound within the word and/or the surrounding phonemes. For instance, *ck* is never used in the initial position of a word; it is only used in the medial and final word positions, as in *bracket* and *sick*. The letter *k* is used to represent the sound /k/ when it occurs before an *e* (*kettle*), *i* (*king*), or *y* (*sky*), while the letter *c* is used for the /k/ sound before *o* (*cot*), *u* (*cup*), *a* (*cap*), or prior to a consonant (*cream*, *clock*). When *c* is used before an *e* (*cent*), *i* (*city*), or *y* (*fancy*), it represents the sound /s/. The digraph *ck* is used to represent the sound /k/ when it occurs after short vowels, such as in the word *back*, but *k* is used after long vowels, such as in the word *beak*. If the child were to misspell *back* as *bak*, they have represented the phonological skeleton of the word, but made an orthographic error because they did not use the grapheme sequence expected for this sound in this position as dictated by the orthographic rules of their language.

Orthographic errors tend to become prominent after grade 1 (Bahr et al., 2012). A possible reason for this trend is that students in the early elementary years rely heavily on their phonological knowledge to guide their spelling and are often able to represent the phonological skeleton of a word despite not knowing the orthographic rules for the word. They also may have not have been taught the rules they need to use to spell target words or could have limited exposure to written language (Bahr et al., 2012).

Typical elementary school children often make errors involving consonant sounds that are represented with more than one grapheme, such as digraphs, double letters, and syllabic /r/ (Moats, 1995). Students may misrepresent a digraph with only one grapheme such as *cip* for *chip* or use a single grapheme when it should be doubled, such as *litle* for *little*. When attempting to spell words with vocalic /r/, such as *car*, children may write *cr* or *ca*, omitting either the vowel or

the *r* itself. Additionally, long and short vowel errors are also common in early elementary school children. Children might represent long vowels with a single grapheme, typically the one whose sound matches the vowel name, such as *da* for *day* and *lik* for *like* (Moats, 1995). They also make errors with short vowels that are articulated in similar oral positions such as *fesh* for *fish* and *bad* for *bed* (Moats, 1995).

Orthographic errors decline as children progress from grades 1 to 9 and learn the rules of their language through explicit teaching and exposure to more words in the literature they read (Bahr et al., 2012). Despite this notable decline, orthographic errors continue to be the most common linguistic error in misspellings (Bahr et al., 2012). This could be attributed to a shift from dependence on phonology to the development and use of a stronger orthographic lexicon (Bahr et al., 2012).

Morphology. Morphological knowledge is an important aspect of spelling more complex, multisyllabic words, such as the academic vocabulary encountered in math and science classes. It involves an understanding of word meanings and how inflectional and derivational morphemes can be added to base words to create new layers of word meaning (Bahr, 2015). Inflectional morphemes alter the tense, number, or possession of a root word without changing the meaning, pronunciation, or grammatical role (Carlisle, 2003). The past tense *-ed* ending, plural *-s/es*, and possessive *-’s* are all examples of inflectional endings. Children accurately use inflectional endings including *-ed*, plural *-s*, and *-ing* in speech by age 4 (Rice, Wexler, & Hershberger, 1998) and typically master the use of these endings in their writing by second or third grade (Moats, 1995). Research suggests that the successful mastery of these morphemes occurs because they are common in children’s oral language and children receive significant

exposure to these endings in the books they read. Ample opportunities to read and spell words with these endings allow young children to store memories of these patterns (Moats, 1995).

Inflectional endings that retain their spellings even after they change their pronunciation can be difficult for young spellers (Moats, 1995). For example, the past tense *-ed* can be produced /t/, /d/, or /ɪd/ or /əd/. This suffix sounds like /t/ when it is added to a base word with a final sound that is unvoiced, such as *kissed*. It sounds like /d/ when the final sound of the base word is voiced, as in *played*. Finally, *-ed* sounds like /ɪd/ or /əd/ when the final sound in the base word is a /t/ or /d/, as in *wanted*. A child who does not recognize the association between the letter sequence *-ed* and an action occurring in the past may misspell the previous examples as *kisst*, *playd*, and *wantid*. To spell inflectional endings that change in pronunciation, children must have internalized the meaning of the ending in order to know that it is spelled the same even if it is pronounced differently (Carlisle, 2003).

Young spellers typically master inflectional endings earlier than derivational morphemes because the latter require a more complex understanding of word and suffix meanings (Carlisle, 2004). Derivational morphemes alter word meanings to create new, more complex vocabulary (Tyler & Nagy, 1989). An example of a derivational morpheme is the suffix *-tion*, which can be added to the root word *create* to make *creation*. Adding this suffix alters the meaning of the word and also shifts its grammatical role from verb to noun (Tyler & Nagy, 1989). Some derived words share predictable or transparent relationships between their sound, spelling, and meaning, such as the words *greet* and *greeter*. Other derived words have dissimilar pronunciations and orthographic alterations, such as the words *inspire* and *inspiration*. Children learn to spell words with transparent derivational morphemes more easily than with opaque suffixes because the base

words retain their spelling and pronunciation making the relationship between the derived form and the base word more apparent (Tyler & Nagy, 1989).

Morphology contributes to learning to spell in multiple ways. Storing morphological information allows children to more efficiently store information about word spellings in their mental lexicons (Nagy, Berninger, & Abbott, 2006). This means that a child can simply remember that *-ed* is added to the end of most verbs to indicate past tense instead of having to commit every verb's past tense form to memory. Also, connecting known morphemes allows a child to quickly form and learn new words (Nagy et al., 2006). For example, when a child learns that *-ible* means "capable of being," he or she can add this suffix to known words to make new ones, such as *sensible*, and *responsible* (Harrold, 2010).

In grades 4 and 5, morphological errors become more common, which can be attributed to students' need to spell increasingly complex words (Bahr et al., 2012). As children near the end of elementary school and move into middle and high school, they are expected to use academic, domain-specific vocabulary words, which are often complex and multi-morphemic. Examples of academic, domain-specific vocabulary include: *probability*, *exponential*, *revolutionary*, and *organism*. These types of words are infrequently occurring in students' everyday vocabulary and are generally reserved for academic settings. Therefore, the student has had fewer opportunities to practice and internalize their spellings. Students can use their understanding of morphology to spell these words accurately, while a lack of knowledge of these morphemes will likely result in spelling errors.

Interrelationships among Phonology, Orthography, and Morphology

It is important to note that each of these linguistic processes is closely interrelated with the others and it is crucial that they all function together to enable a speller to accurately form

words (Bahr, 2015). For instance, phonology and orthography are both applied in each attempt to spell a word because the speller must identify the sounds within the word and determine the correct grapheme sequences to pair with that sound (Garcia et al., 2010). Many phonemes can be represented with multiple different letters or letter sequences. For example, the short *e* can be spelled with an *e*, as in *bed* or an *ea*, as in *bread*. Additionally, many different sounds can be represented by the same sequence of letters. The same *ea* pattern that made the short *e* sound in *bread* could make the long *e* sound in the word *bead*. In these examples, children must integrate their knowledge of phonology and orthography in order to correctly spell the vowel digraph *ea*. Though *ea* is used as a digraph in the previous two examples, *ea* could function as two separate vowels, split between syllables as in the word *reapply*. In order to read and spell this word, children must integrate their knowledge of phonology, orthography, and morphology to create a word-specific spelling.

Phonology, morphology, and orthography are interrelated because the addition of morphemes can cause orthographic and phonological changes in spelling and pronunciation (Carlisle, 2004). For example, sometimes letters must be omitted or doubled when a morpheme is added. When *-ing* is added to *like*, the *e* is omitted to spell *liking*. When *-ed* is added to *drop*, another *p* must be added to make *dropped*. Some words involve phonological shifts, or a change in the pronunciation of a base word, when morphemes are added (Carlisle, 2004). For example, when *sign* becomes *signature*, the speller must understand that although the pronunciation has changed, the base word is spelled the same and the affix is added. These examples show the integration of phonology, morphology, and orthography in spelling.

Though certain linguistic processes have been noted to be more common at different ages, children continue making all three types of errors throughout their lives. Often when

attempting to spell a more complex word, children will fall back on spelling strategies that had worked when they were younger, such as sounding it out phonologically instead of using morphemes. This process is known as recursion (Silliman, Bahr, Nagy, & Berninger, in press). Recursion occurs because spelling development occurs in a dynamic, non-linear fashion in which children experiment with alternative ways to spell words by drawing upon the three different knowledge bases (Bahr et al., 2012). The linguistic processes of phonology, orthography, and morphology must function in sync with one another in order to allow an individual to develop robust spelling skills. Children who do not develop strong spelling skills may have specific language impairments, impeding their ability to process information used in spelling and writing.

Spelling Errors Among Children with Specific Language Impairments

As children progress through school and gain exposure to more words, most develop mature spelling skills (Thompson, Fletcher-Flinn, & Cottrell, 1999). However, some children reach adulthood as much stronger spellers highlighting a need to describe the differences between good and poor spellers. Several researchers (Bahr, 2015; Cassar & Treiman, 2004; Silliman et al., 2006) have investigated the differences between the errors of good spellers and poor spellers and found that spelling errors differ more by developmental ability than by error type. These results suggest that older children who are poor spellers tend to make the same types of errors as younger typically developing children. Additionally, poor spellers tend to expend much more time and effort attempting to spell than good spellers (Cassar & Treiman, 2004). Poor spellers, also, have knowledge of all three linguistic processes; however they may not use these separate knowledge sets to support each other and develop strong representations of words (Cassar & Treiman, 2004). Numerous researchers (Bruck, 1992; Landerl, Frith, & Wimmer, 1996) have found that typically developing spellers' performance on phonological tasks is

influenced by their orthographic knowledge, while poor spellers do not show an influence of orthographic knowledge when completing phonological tasks. The lack of consideration of orthographic information during phonological tasks leads researchers to believe that the two linguistic knowledge bases have weak interactions which poorly serves the child when attempting to spell (Cassar & Treiman, 2004).

Many children who are poor spellers are considered to have learning disabilities, which affect specific areas of language processing. Dysgraphia, dyslexia, and OWL-LD are all specific learning disabilities that impact spelling. Dysgraphia is marked by difficulty with orthographic processing, dyslexia is known for difficulty with phonological and orthographic processing, and OWL-LD is described as difficulty with phonological, orthographic, and morphological processing (Silliman & Berninger, 2011). The learning profiles of these specific learning disabilities (dyslexia, dysgraphia, and OWL-LD) will be discussed more below.

Dysgraphia. The first signs of dysgraphia typically become apparent in kindergarten when children struggle with producing legible handwriting. Symptoms of dysgraphia include difficulty with the automaticity of letter retrieval, written production of letters from memory, and copying letters and words (Silliman & Berninger, 2011). Dysgraphia is specific to handwriting and does not involve impairment of fine motor skills beyond those used for written language, nor does it involve difficulties with reading or language comprehension (Berninger & Richards, in press).

This problem with letter formation often affects other areas of written language, including spelling. The noted difficulty with legible handwriting impacts the integration of motor movements with the storage, processing, and analysis of orthographic patterns in working memory (Silliman & Berninger, 2011). While writing, children retrieve a word from their long-

term memory and store it in short-term memory while using linguistic processes to determine the correct sequence of letters. Children with dysgraphia have difficulty mentally storing the orthographic image of the word while they determine the appropriate letter sequence and hand movements needed to create that sequence (Silliman & Berninger, 2011). Additionally, dysgraphia is often accompanied by struggles with producing written composition because the challenges with handwriting draw cognitive resources away from other aspects of the writing process, including syntax (Silliman and Berninger, 2011). In summation, children with dysgraphia have trouble translating the mental image of a word into the written form due to the poor integration of motor movements with orthographic processing.

Dyslexia. In contrast, dyslexia typically causes impairment in both reading and spelling, while oral expression and listening comprehension are unaffected (Berninger & Richards, in press). Despite a normal IQ and adequate instruction, children with dyslexia express difficulty with letter recall and sound identification in kindergarten. By first grade, children with dyslexia experience difficulty reading and spelling real and nonsense words (Silliman & Berninger, 2011). This difficulty with reading and writing stems from an impairment in the processing of phonological and orthographic information.

Children with dyslexia have difficulty assembling an accurate phonological representation of spoken words in working memory and analyzing the sounds in words for the purposes of reading and writing (Silliman & Berninger, 2011). Due to underdeveloped phonological skills, children with dyslexia often display an overreliance on orthography and focus on how a word should look (Cassar, Treiman, Moats, Pollo, & Kessler, 2005). They also experience difficulty storing orthographic patterns, which impedes the ability to draw connections between the sound and letter sequences (Connelly & Dockrell, 2015). Additionally,

they have trouble storing written words in working memory, as well as challenges with integrating internal representations of orthographic sequences into hand movements for writing (Silliman & Berninger, 2011).

Bourassa & Treiman (2003) found that children with dyslexia make errors commonly noted in younger, typically developing spellers, including omissions of unstressed vowels, phonetically influenced consonant errors, and using a single letter to represent a phoneme that should be represented by more than one letter. They also found that children with dyslexia were more likely to add an *e* to the end of a word with a short vowel (*tripe* for *trip*) and did not double necessary consonants in words (*diner* for *dinner*). Bourassa & Treiman (2003) suggested that this could indicate that children with dyslexia have a poor understanding of orthographic markers for short and long vowels. These examples suggest that impairments in phonological and orthographic processing lead to poor spelling in children with dyslexia.

Oral and Written Language Learning Disability. OWL-LD and dyslexia are similar in that share impairments in phonological and orthographic processing (Silliman & Berninger, 2011). However, children with OWL-LD have oral and receptive language skills that fall at least two standard deviations below the mean on standardized tests, indicating a language impairment (LI), while children with dyslexia have typically developing oral language skills (Silliman & Berninger, 2011). Children with OWL-LD begin having difficulty with oral language in preschool, which persists and develops into difficulty with both oral and written language in the school-age years (Silliman & Berninger, 2011). They tend to have more significant difficulty with one or more language skill, including reading accuracy, listening and reading comprehension, syntax, morphology, and oral and written expression in sentences and texts (Berninger & Richards, in press). Children with OWL-LD are more likely to have specific

difficulty with morphological coding, or storing and processing word bases, prefixes, and suffixes, in both spoken and written words than children with dysgraphia or dyslexia (Silliman & Berninger, 2011).

The spelling errors made by children with OWL-LD would be expected to be similar to the errors made by children with dyslexia in many ways. Both groups have difficulty in phonological and orthographic processing which may lead to spelling errors, such as difficulty with consonant doubling, omitting unstressed vowels, displaying both elements of a digraph or diphthong, and representing short and long vowel sounds. In contrast, difficulty with morphological coding may also lead children with OWL-LD to make a higher number of errors involving morphology than the other groups. In summation, spelling errors in this population are a result of a widespread language impairment that permeates through many areas of language processing.

Cognitive Factors that Influence Spelling

While spelling poses a challenge for many students with learning disabilities, spelling within the context of a written composition increases the cognitive demands by requiring the integration of additional language and cognitive processing with the linguistic processes already used for spelling alone (Westwood, 2014). In an effort to explain the complex cognitive demands of written composition, Hayes and Berninger (2014) developed a framework that consists of four levels: the resource level, the process level, the control level, and the task environment. The resource level includes the cognitive processes that writers draw on when creating compositions. These resources include attention, working memory, long-term memory, and reading skill. When writing, students draw on knowledge stored in their long-term memory gained from experience

or information they have read to generate ideas. They must hold ideas in their working memory during the writing process and attend to the task despite distractions in their environment.

The process level includes a proposer, a translator, an evaluator, and a transcriber, which take an idea and transform it into a written form. The proposer generates the nonverbal idea of what will be written. The translator turns the idea into verbal form. The transcriber takes the verbal form and turns it into a written form. The evaluator checks all of the processes for accuracy. The control level includes task initiation, planning, and writing schemas which all put additional cognitive demands on the writing process. Finally, the task environment includes all of the elements that surround the writing task, such as the writing medium (handwriting or keyboarding), task materials, what has already been written and the collaborators.

As Hayes and Berninger (2014) outline in their framework, generating written composition is a cognitively demanding task requiring the adequate functioning and coordination of many different aspects of language and cognitive processing. Much of the research currently available analyzes spelling in the format of a spelling test in which one word is provided at a time. The increased demands of spelling within the context of written composition, typically expected in academic settings, warrants greater attention by researchers.

Purpose of the Present Study

Accurate spelling relies on the integration of phonology, orthography, and morphology. Children with dyslexia, dysgraphia, and oral and written language learning disability (OWL-LD) have profiles that reflect disruptions in distinct areas of linguistic processing. The treatment and instruction for children who have difficulty learning to spell should vary according to the needs of that child (Silliman & Berninger, 2011). Identifying, analyzing, and comparing linguistic error patterns within the context of academic writing by linguistic feature and complexity, could assist

in the development of instructional programs targeted to meet the specific needs of children who match these profiles. Differences in misspellings could also be analyzed to help with differential diagnosis. In order to better understand the specific needs of children with learning disabilities, this study sought to answer the following questions:

- 1) Does the complexity of handwritten spelling errors differ across the diagnostic categories of dyslexia, dysgraphia, and OWL-LD and by narrative condition (reading vs. listening)?
- 2) Does error frequency differ by diagnostic category and narrative condition?

Chapter 2

Methods

This is a reanalysis of data obtained from a previous study that focused on writing instruction for children with three types of learning disabilities (Berninger, Nagy, Tanimoto, Thompson, & Abbott, 2015; Niedo-Jones, 2014). This research study was approved by the IRB committee at the University of Washington.

Participants

Students with persistent handwriting, spelling, and/or oral and written language difficulties were recruited by distributing flyers to public schools in the Seattle, Washington area. Parents were asked to contact the researchers to indicate an interest in having their child participate in the study. Once identified, the parents were interviewed to rule out the presence of developmental disabilities, neurogenic disorders, psychiatric disorders, brain injuries or diseases in their children. ADHD was not an exclusion criterion as it often accompanies specific learning disabilities. Students who seemed likely to be candidates for having specific learning disabilities, based on the parental phone screening, were invited to the university for continued assessment of the students' eligibility. Parents completed a questionnaire about their child's developmental, medical, educational, and family history. Students were formally assessed to determine that they met eligibility criteria and to identify their specific learning disability as dysgraphia, dyslexia, or OWL-LD.

Differential diagnostic criteria for each diagnostic category have been described in Silliman and Berninger (2011) and will be listed briefly here. Students who were given the diagnosis of dysgraphia scored 2 to 3 standard deviations below the mean on two or more handwriting measures, had parent reported persistence of handwriting problems since early elementary school, and experienced no reading difficulties. Those with the diagnosis of dyslexia scored below average on word reading and spelling measures and parents had reported persistent reading and spelling problems that began in early elementary school. Individuals with the diagnosis of OWL-LD scored 2 to 3 standard deviations below the mean on syntactic listening or reading comprehension, or syntactic oral or written expression, with parent reports of persistent difficulties with listening comprehension, reading comprehension, written expression, and oral expression which began in the preschool years. All participants had received intervention in the past, but difficulty with written composition had persisted.

De-identified data from participants ($N=33$) diagnosed with dysgraphia ($n=13$), dyslexia ($n=15$), and OWL-LD ($n=5$) were obtained for further evaluation of spelling errors. These participants were drawn from a larger pool ($N=35$) who were 10 to 14 years of age and attended grades 4 to 9 (Niedo-Jones, 2014). In the larger sample, 80% of the participants were male. Children's ethnicities were reported by their parents to be European American ($n=29$), Asian ($n=1$), Asian American ($n=1$), Black ($n=1$), Hispanic ($n=1$), Pacific Islander ($n=1$), or Mixed ($n=3$). All but one of the participants' mothers had at least a college level of education. All but five of the fathers had at least a college education.

Materials

The spelling errors were obtained by collecting handwritten essays that students completed after reading or listening to computerized lessons (Niedo-Jones, 2014). Spelling errors

were evaluated by two scoring systems: the Phonological Orthographic Morphological Assessment of Spelling (POMAS: Bahr et al., 2012), and POMplexity. The POMAS was used initially to provide a qualitative analysis of the errors based on specific linguistic features. Next, POMplexity was used to provide a quantitative analysis of the severity of the misspelling. The lessons, POMAS, and POMplexity will be discussed in further detail below.

Writing Intervention Lessons. Writing samples were collected from students who completed an intensive writing intervention program. This program involved 18 lessons with various topics that involved handwriting, spelling, word reading, composition and comprehension. This study analyzed the summaries from Lessons 7-12, which focused on the comprehension of academic content related to mathematics. The lesson titles are listed in the graph below (Niedo-Jones, 2014).

Table 1: Writing Intervention Lesson Titles

Lesson	Reading Topic	Listening Topic
Lesson 7	Counting First	Number Line-Up
Lesson 8	Language of Math	Math by Hand
Lesson 9	Intervention of Zero and Place Value	Invention of Computation Algorithms
Lesson 10	World History Math	Spreading the Word About Math
Lesson 11	Native American Math	Lessons from Mathematics
Lesson 12	Writing and Reading in Math	What is Math?

The writing intervention program consisted of a reading and a listening component. First, students read a lesson on the iPad screen or listened to a lesson. They then wrote a summary on an iPad using a stylus. Students had five minutes to read or listen to the lesson through headphones. They were allowed to take notes as they read or listened and could refer to these

notes when writing their summary. Students were given 15 minutes to write a summary of the important information from the lesson. If the student stopped writing, the teacher or computer would prompt them to keep writing for the full 15 minutes. In a second session, the students completed a similar task with new material, which differed in the way the information was presented (i.e., listening then reading or vice versa).

Phonological Orthographic Morphological Assessment of Spelling. The Phonological Orthographic Morphological Assessment of Spelling (POMAS; Bahr et al., 2012) is an unconstrained scoring system based on triple word form theory (Bahr et al., 2009; Richards et al., 2006) that is a useful tool for the qualitative analysis of spelling errors. This scoring procedure goes beyond percent accuracy to broadly identify spelling errors within the linguistic categories of phonological, orthographic, and morphological and then further classifies these errors by specific linguistic features. For example, if the word *present* were misspelled as *pesent*, it would be classified as a phonological error because not all of the phonemes were present in the word. It would be further categorized as a cluster reduction because the /r/ was omitted from the cluster. In contrast, if the word *sense* were represented as *sence*, this would be classified as an orthographic error because the phonological skeleton was intact but the *s* was substituted with a *c*. This would be further categorized as an ambiguous letter error because the sound /s/ could be represented by either grapheme. Finally, if *mathematician* were misspelled as *mathematitian*, a morphological error occurred, which is more specifically categorized as a derivational suffix error because the suffix was misspelled. More details on this scoring system can be found in Bahr, Silliman, Berninger and Dow (2012) and Silliman, Bahr, and Peters (2006).

POMplexity. POMplexity quantifies how far the misspelling is from the target. This score compliments the qualitative analysis provided by the POMAS (Benson-Goldberg, 2014).

As depicted in Figure 1, this metric assigns individual scores to spelling errors in the categories of phonology, orthography, and morphology based on the complexity of the error (i.e., the severity of misspelling) from the target word.

Figure 1 demonstrates that phonological errors receive a score of .5 for errors related to syncope, 1 point for phoneme substitutions, 2 points for omissions or additions, and 3 points for omission of syllables that were unrelated to syncope. In the category of Orthography, a word would receive a score of .5 for an error involving word spacing, capitalization, real words used to represent an aspect of the phonological structure, and graphemes used in the wrong order. Words received a score of 1 for errors involving incorrect grapheme selection and failure to represent silent letters. A word was given a score of 2 if a word position error occurred, i.e., placing a grapheme in an illegal position. In the category of morphology, errors involving a homophone or an apostrophe in a contraction received .5 points. Errors involving either a misspelled base word or affix received a score of 1, while errors involving both the base word and an affix received 2 points. Finally, 3 points were given to errors that completely omitted a necessary affix or spellings that rendered the word unrecognizable. The increase in point value reflects the severity of the deviation from the target word.

POMplexity accounts for morphology's complex relationship with phonology and orthography. Morphological errors affect base words and/or affixes, but when an error involving morphology occurs, it also involves a misrepresentation of either the phonological or orthographic structure. For example, if *mathematician* were misspelled as *mathematitian*, a morphological error occurred affecting the derivational suffix. This error would receive 1 point in the morphology category. Additionally 1 point is given in the orthography category because of the incorrect grapheme selection.

POMplexity Scoring Instructions				
0	.5	1	2	3
Correct Spelling	Errors related to Syncope	Substitutions	Omissions/ Additions	Omission of a syllable (stressed or unstressed), but not syncope
jump	intrest/interest famly/family	junp	jup jumpe	consion/conclusion unstand/understand
Correct spelling	Sequencing error – all graphemes present but in wrong order; or real word used to represent aspect of phonological structure or word spacing/ capitalization/ hyphen errors	Grapheme Selection Error – including digraph and diphthong errors, silent letters are not represented	Positional Errors – graphemes in illegal positions	
watermelon	watermlone liquidies for liquidize exsightment for excitement	hause for house cant for chant com for comb	ckat for cat	
All morphemes represented correctly	Correctly spelled homophone used / missing apostrophe in a contraction	Either root or affix misspelled, including real word errors	Both root and affix spelled incorrectly – but can recognize attempt to spell two morphemes	Word appears to be syllabified, the syntactic role is unrecognizable, or only the root was represented.
walked painting	wait for weight cereal for serial	juped for jumped amusemnt for amusement liquidies for liquidize	jupt for jumped amusmnt for amusement liquadise for liquidize	asdet jump for jumped

Figure 1: POMplexity assigns points based on the complexity of the spelling error.

Procedures

Misspellings were extracted from the handwritten summaries taken from lessons 7-12 (Niedo-Jones, 2014) about mathematical concepts. Each lesson had a reading and a listening component, however, no student completed a summary for each modality (reading/listening) and lesson. Overall, students completed an average of 5 writing samples each over the 6 lessons. Twenty of the students completed six writing samples with a sample completed in both the reading and listening conditions for three consecutive lessons. One student completed only one lesson. The table on the next page demonstrates which lessons each participant completed. L indicates a completed listening lesson and R indicates a completed reading lesson.

Scoring Reliability

Each writing sample was transcribed by two undergraduate students in Communication Sciences and Disorders at a university in west central Florida. These transcriptions were compared and discrepancies were resolved by a third rater, who was a graduate student in speech-language pathology. All misspelled words were extracted from these summaries and placed in an Excel spreadsheet.

Once the misspelled words were identified, the primary investigator (a graduate student in speech-language pathology) coded these words with the POMAS and then assigned a POMplexity score. A second rater, also a graduate student in speech-language pathology, scored all misspelled words with both the POMAS and POMplexity. A third rater, who was instrumental in the development of the POMAS and POMplexity, then compared the POMplexity scores for all spelling words across the rates. When the POMplexity scores did not match, the spelling errors were discussed and consensus on scoring was obtained. The final scores resulting from the evaluation of three raters served as the final data for analysis.

Table 2: Lessons Completed by each Participant

Participant	Diagnosis	Lesson 7	Lesson 8	Lesson 9	Lesson 10	Lesson 11	Lesson 12
2	Dysgraphia					R	LR
3	OWL-LD				L	L	LR
9	Dysgraphia	LR	LR	LR			
10	Dyslexia			R	L	LR	LR
11	Dysgraphia		LR	LR			
12	Dysgraphia				LR	LR	LR
14	OWL-LD	L					
15	OWL-LD	R	R	LR			
16	OWL-LD	LR	R	LR			
17	Dysgraphia				LR	LR	LR
18	Dysgraphia				LR	LR	LR
21	OWL-LD				LR	LR	LR
23	Dysgraphia	R	LR	LR			
25	Dyslexia	R	LR	R			
26	Dyslexia	R	R	R			
27	Dyslexia				R	R	LR
29	Dyslexia				LR	LR	LR
30	Dyslexia				LR	LR	LR
31	Dyslexia				LR	LR	LR
33	Dyslexia	LR	LR	LR			
34	Dysgraphia	R	R	LR			
36	Dysgraphia				LR	LR	LR
37	Dyslexia	L	R				
39	Dyslexia	LR	LR	LR			
40	Dysgraphia	LR	LR	LR			
41	Dyslexia				LR	LR	LR
42	Dyslexia	LR	LR	LR			
43	Dyslexia				LR	LR	LR
46	Dysgraphia	LR	LR	LR			
50	Dyslexia				LR	LR	LR
53	Dysgraphia				R	R	LR
54	Dysgraphia				LR	LR	LR
56	Dyslexia				LR	LR	LR

Data Analysis

POMplexity data were collapsed across lessons to yield mean POMplexity scores for phonology, orthography and morphology for each participant in the reading and listening narrative conditions. These data were then compared across diagnostic categories and narrative condition with a three-way analysis of variance (ANOVA). Error frequency was normed by the number of words produced in each summary by narrative condition. Differences across diagnostic category was analyzed with a two-way ANOVA.

Chapter 3

Results

Academic summaries handwritten by 33 students diagnosed with dysgraphia ($n=13$), dyslexia ($n=15$), and OWL-LD ($n=5$) were analyzed for type/complexity and number of spelling errors in order to determine differences across diagnostic categories. Additionally, the differences in error frequency and complexity were analyzed based on whether the summary was written about academic material that had been listened to or read. In order to analyze the type/complexity and number of errors, misspellings were extracted from the essays and evaluated using the POMAS. Then the complexity of the misspellings in the phonological, orthographic, and morphological categories was analyzed using POMplexity. The POMplexity scores were analyzed to answer the following questions:

- 1) Does the complexity of handwritten spelling errors differ across the diagnostic categories of dyslexia, dysgraphia, and OWL-LD and by narrative condition (reading vs. listening)?
- 2) Does error frequency differ by diagnostic category and narrative condition?

Complexity of Spelling Errors Across Diagnostic Category and Narrative Condition

A three-way ANOVA with diagnostic category, narrative condition, and type of POMplexity score as the independent variables (IVs) and POMplexity score as the dependent variable did not reveal any significant interactions. Only the main effect for type of POMplexity score was significant, $F(2,58) = 11.631; p < .001, \eta^2_p = .286$. Post hoc testing with the LSD

procedure indicated that the morphology POMplexity scores were significantly lower than the phonology and orthography POMplexity scores across all diagnostic categories and summary conditions. Figure 2 displays the differences across POMplexity scores by diagnostic condition. These results suggest that there are no differences in performance that were attributable to diagnostic category or narrative condition. Students produced spelling errors of comparable complexity in all written summaries.

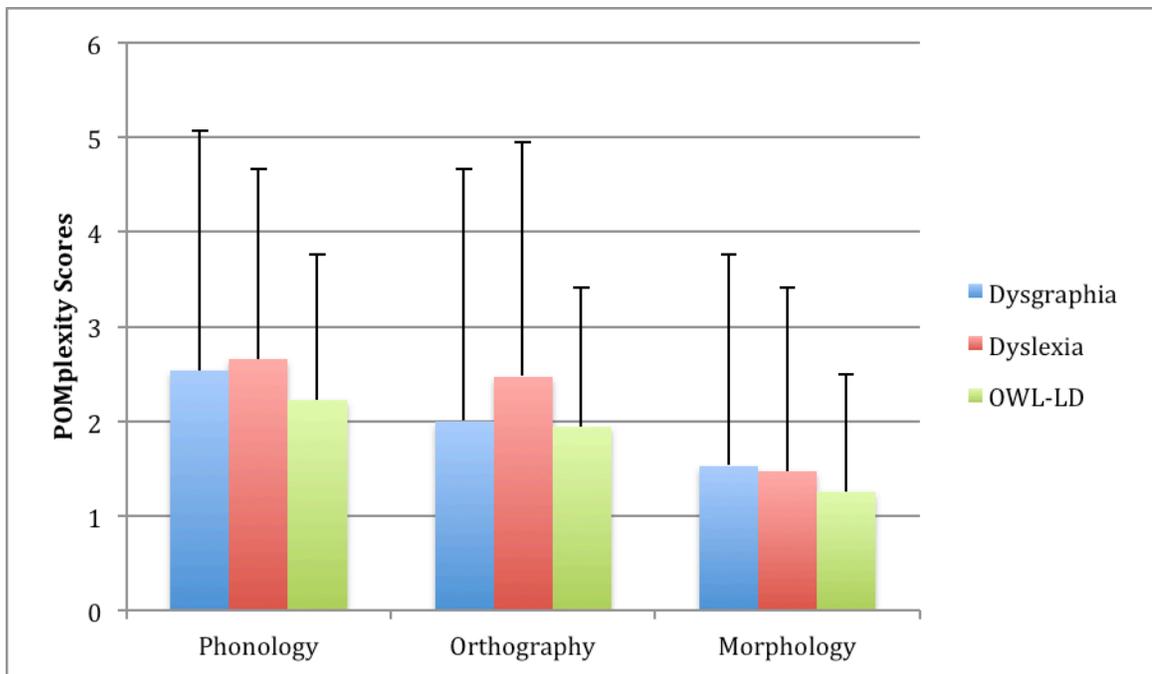


Figure 2. Differences in Error Severity (POMplexity) and Diagnostic Category

Frequency of Spelling Errors by Diagnostic Category and Narrative Condition

A two-way ANOVA was run with diagnostic category and narrative condition as the independent variables and the number of errors normed by the total number of words in each written summary served as the dependent variable. This analysis did not reveal a significant

interaction or any significant main effects (see Figure 3). This finding suggests that there is no difference across diagnostic categories in the normed number of spelling errors produced by students. In other words, all participants produced a similar number of errors during the writing intervention. In addition, these students did not demonstrate a difference in the number of errors produced in the listening versus reading summary conditions.

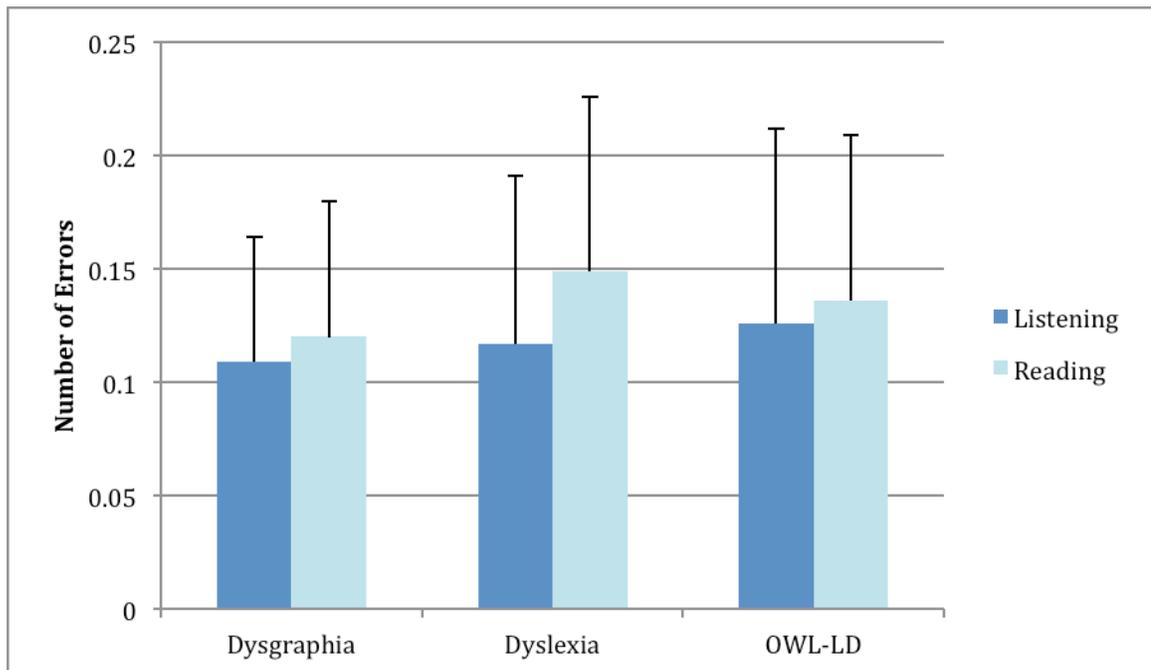


Figure 3. Differences in Error Rate Across Diagnostic Category and Narrative Condition

Qualitative Analysis of Spelling Errors by Diagnostic Category

Two students from each category who attempted to spell the word *mathematics* in their essays were selected for further analysis. The word *mathematics* was chosen for multiple different reasons. First, *mathematics* is a complex multisyllabic word containing two morphemes, stressed and unstressed vowels, and a digraph. The complexity of this word

provides a significant number of opportunities for spelling errors. Additionally, *mathematics* is an domain-specific word; meaning students are unlikely to have a great deal of experience writing the word outside of an academic task. Finally, this word was used many times by several students in different diagnostic categories, allowing contrasts across diagnostic groups. A comparison of misspellings of the word *mathematics* is found in Table 3.

Table 3: Misspellings of the Word *Mathematics*

Dysgraphia	Dyslexia	OWL-LD
ID 9 mathmatics (2) math maticts	ID 33 mathamatics	ID 15 mathimathics (11) mathimathicse mathimatics mathimathis (2) mathimathice mathimathiccs matheimatics mathiamtaics mathinathis mathimat
ID 34 mathema tics mathematics (2)	ID 37 mathnmatitics	ID 16 mthamatcs

This analysis, like the quantitative analysis, revealed that members in each diagnostic group all produced phonological, orthographic, and morphological errors in their attempts to spell this word. However, this analysis also revealed a difference in the nature of the misspellings across diagnostic categories.

Among students with dysgraphia, one student (ID 9) made errors involving word boundaries, weak syllable deletion (syncope), and phoneme addition (epenthesis). The other student analyzed (ID 34) made errors involving a word boundary in one attempt, but correctly

spelled the word in his or her next two attempts. These students with dysgraphia produced spellings that were correct or much closer to the accurate representation of the word than students in the other groups. This would be expected because children with dysgraphia do not share the deficits in phonological knowledge that the other groups have and they do not have as much recognizing morphological components of words (Silliman & Berninger, 2011). The unstressed vowel omission, consonant addition, and inappropriate word boundary errors could be attributed to weaknesses with orthographic short-term memory.

Among students with dyslexia, the first (ID 33) made errors involving unstressed vowels and the second (ID 37) made errors in grapheme selection and the addition of multiple phonemes. The addition of extra phonemes misrepresents the phonological skeleton of the word, a common error in younger, typically developing spellers and older children with impaired spelling. Children with dyslexia are known to make errors similar to those made by younger spellers (Bourassa & Treiman, 2003). Phonological and orthographic errors would be expected in this group due to the known deficits in phonological and orthographic processing (Silliman & Berninger, 2011).

Students with OWL-LD produced the most errors and they produced misspellings that deviated furthest from the correct spelling of the word. For example, the first student (ID 15) attempted to spell the word *mathematics* 21 times with 11 different combinations of letters. This student made multiple errors involving unstressed vowel selection, phoneme addition, phoneme deletion, orthographic reversals, syllable deletion, nasal consonant selection, and real word errors. The student also demonstrated significant difficulty adding the final suffix to a word. The number of errors in the addition of the suffixes indicates weak morphological knowledge and a insufficient knowledge of morphological endings. The second student (ID 16) made errors

involving the omission of stressed vowels and difficulty with unstressed vowel selection. The lack of a vowel in a syllable reveals an immature understanding of basic orthographic knowledge. The diversity of error types and the severity of the misspellings' deviation from the correct spelling support prior research, which indicates that students with OWL-LD have difficulty processing morphological, orthographic, and phonological information (Silliman & Berninger, 2011).

Results of the qualitative analysis uncovered error types that aligned with previous research (Silliman & Berninger, 2011). Specifically, these findings demonstrate that:

- 1) Students with dysgraphia have intact phonological and morphological processing, but difficulty with orthographic short-term memory
- 2) Students with dyslexia have deficits in phonological and orthographic knowledge, and
- 3) Students with OWL-LD have problems processing phonological, orthographic, and morphological information.

However, between the two students analyzed in each category, within-group differences were evident. Both students with dysgraphia showed difficulty with word boundary placements, but only one student made errors involving omitting and adding graphemes. The problem with word boundaries could be related to poor handwriting, while orthographic short-term memory issues are related to the grapheme omissions.

Within-group differences were also noted between the two students with dyslexia. The first student (ID 33) was able to accurately represent the phonological skeleton of the word, whereas the second student (ID 37) added several letters that altered the phonological skeleton of this word. The latter student may have had more difficulty with phonological processing than the first. Alternatively, the first student may have had stronger instruction in spelling and learned

strategies to ensure that all phonemes in a word were represented. Both options support the idea that within group differences occur. Finally, between the two students with OWL-LD, the first (ID 16) demonstrated a lack of orthographic knowledge affecting the use of vowels within syllables, evidenced by his use of only two vowels in a four syllable word. The second student (ID 15) did not seem to be aware that all syllables require vowels and evidences considerable variability in spelling the target word.

Summary of Results

Overall, the quantitative results revealed that the children in the diagnostic categories of dysgraphia, dyslexia, and OWL-LD appear to produce errors that are similar in complexity and frequency. The only difference that was significant was that morphological POMplexity scores were lower than the phonology and orthography POMplexity scores. Hence, students with specific learning disabilities do not appear to make patterns of errors specific to their diagnosis. Previous research (Bourassa & Treiman, 2003; Connelly & Dockrell, 2008; Silliman et al., 2006) has illustrated that students with specific learning disabilities make errors similar to students at younger ages. This present study revealed that students diagnosed with specific learning disabilities produce misspellings that are similar in complexity and frequency to other students diagnosed with other specific learning disabilities. However, when spelling errors were analyzed qualitatively, some differences across groups were noticed. Students with OWL-LD tended to omit essential vowels and were more likely to misspell the same word in multiple different ways. These findings illustrate difficulty with integrating phonological, orthographic and morphological information while spelling

Chapter 4

Discussion

Students diagnosed with dysgraphia, dyslexia, and OWL-LD all struggle with spelling accuracy. Research has shown that these three specific learning disabilities have distinct areas of weakness and unique causes for their difficulties with spelling. However, current research has not previously compared the specific types of spelling errors made by each group to determine if their unique learning profiles lead to distinct error patterns.

This study analyzed misspellings in the context of handwritten academic essays to determine how errors differed in complexity, frequency, and type across diagnostic categories and narrative contexts (i.e., academic material was either listened to or read before a summary was written). Statistical results showed similar POMplexity scores across linguistic categories for all diagnostic groups. Hence, all three groups produced errors that were equal in severity. When errors were considered by linguistic category, all three groups had lower POMplexity scores for morphology than for phonology or orthography, which suggests that the misspelling patterns noted did not interfere with the ability to recognize the target word. Additionally, results indicated that all groups produced similar numbers of errors in both the reading and listening conditions.

The qualitative analysis using the POMAS codes showed within group differences in the types of spelling errors made by individuals in each diagnostic category. Additionally, the qualitative analysis revealed that students with OWL-LD were more inconsistent in their spelling

of the same word than the other groups, suggesting inconsistent strategy use when attempting to spell new or complex words. This discussion will address results as they relate to the research questions, study strengths and limitations, educational and clinical implications, and directions for future research.

Error Severity and Diagnostic Category

Students with dysgraphia, dyslexia, and OWL-LD are characterized by unique profiles of impaired cognitive and linguistic processes. In terms of the cognitive processes that impact writing, students with dysgraphia struggle with transcribing an idea into the written form because of challenges with letter formation and orthographic short-term memory. According to the Hayes and Berninger (2014) model, the breakdown in their spelling occurs at the process level. This means that students with dysgraphia differ from students with dyslexia and OWL-LD, in that the latter groups seem to struggle more with breakdowns at the resource level. The resource level includes the cognitive processes of attention, working memory, long-term memory, and reading skill which writers draw on when creating compositions. The groups with dyslexia and OWL-LD also struggle with reading, which impairs their storage of new words and orthographic patterns. The results revealed that all groups made errors of similar severity levels across the linguistic categories, indicating that the integration of phonology, orthography, and morphology can be affected in similar ways for different reasons.

Results also indicated that all participants received similar POMplexity scores for phonology and orthography. The similarity of scores in these two categories is interesting because research has shown that typically developing spellers make fewer phonological errors after first grade (Bahr et al., 2012). The students in this study were all in grades 4-9, therefore, their continued errors in phonology could indicate weak orthographic processing leading to a

reliance on phoneme-grapheme correspondences. The continued reliance of students in all diagnostic categories on phonological spelling illustrates the use of immature spelling strategies during writing activities (Bahr et al., 2012). The similarities in the phonology and orthography scores could also indicate that all three groups of disordered spellers have difficulty integrating phonological and orthographic information.

All participants also received lower scores for morphology codes than phonology or orthography. Lower POMplexity scores for morphology are most likely attributed to the fact that the scores in the phonology and orthography sections explain each grapheme in error, while the morphological score reflects the integrity of the entire word. For example, the omission of a phoneme was worth 2 points in the phonology category. If the child left 3 phonemes out of a word, that word would have a score of 6 for phonology. On the other hand, each orthographic substitution received one point. So, if the word *cycle* was misspelled as *sicel*, then the score would be 3 representing the *s/c* and *i/y* and *el/le* substitutions. There was no set limit on how high a score could be for the phonology or the orthography category. In contrast, the highest score a misspelling could earn in the category of morphology was 3, for completely omitting the affix(es) or not segmenting the word correctly. However, the most common score in this category was 1, indicating that either the root word or affix was misspelled.

Though the quantitative analysis showed fewer morphological errors across all diagnostic categories, the qualitative analysis revealed that students with OWL-LD seemed to have more difficulty with morphology than the other groups. These students were inconsistent in their understanding of how to add suffixes to the base word. This was evidenced by their multiple misspellings of the same word and spelling of a suffix differently each time it was used. Students with dyslexia and dysgraphia made some errors that affected the phonological skeleton of a word

and misrepresented a few orthographic rules, but their spellings were more recognizable than the attempts made by the students with OWL-LD. Phonological errors and orthographic errors are expected among students with dyslexia because they are known to have deficits in phonological and orthographic processing (Silliman & Berninger, 2011). On the other hand, the spelling errors made by students with dysgraphia are most likely related to the difficulties with handwriting and impairments in orthographic short term memory.

Error Frequency, Narrative Condition, and Diagnostic Category

Students with dysgraphia, dyslexia, and OWL-LD made spelling errors with similar frequency in both the reading and listening conditions. This finding suggested that error frequency was not affected by narrative condition. It could be that the writing process itself had more influence on spelling errors than the mode of presentation. The complex demands placed on students when composing academic essays may have limited the use of available cognitive resources for the production of accurate spelling (Hayes & Berninger, 2014). Composition requires the use of attention and memory for generating ideas, forming sentences, and organizing of sentences into a logical flow that explains an idea. Adding academic content to this equation increases the complexity of the task because this vocabulary is often filled with more complex and less familiar words than writers typically use. The errors made in the reading and listening tasks were likely a result of difficulty spelling in the context of academic composition regardless of its presentation mode.

Study Strengths and Limitations

Two strengths were identified in this study. The first strength was the analysis of spelling errors in the naturalistic context of summaries instead of single-word spelling tests. Compositions represent writing in a natural context and this type of composition is frequent

among upper elementary and middle school students. Though students are expected to spell correctly within this context, the process of composition places higher cognitive demands on students by drawing on cognitive resources, such as attention and memory (Hayes & Berninger, 2014). Because students focus their cognitive resources on generating and organizing ideas into logical sentences, the writing process leaves fewer resources to focus on spelling. Hence, the increased demands of composing led to more errors. Therefore, the use of summaries in this study elicited the types of errors students likely make when writing essays in school.

One could argue that a benefit of single word tests is that they insure that all participants will use the same words and that words with specific orthographic or morphological patterns can be analyzed. However, this study controlled these factors within the essays by having the students summarize content from a standardized lesson. The content of the summaries was similar because all students were exposed to the same information, which in turn led them to use similar vocabulary. Most students attempted to use the higher-level vocabulary from the lesson when summarizing. An additional benefit of using multiple essays for this study was that variability could be analyzed across days and contexts instead of forming conclusions based on the performance on a single test. Some students wrote much more in some essays than others. This finding could be related to the students' mood that day, their interest in the material, or their background knowledge of the topic. These factors can influence a student's confidence and success in attempting to spell new or complex words.

The second strength was the ability of the POMAS to show the specific error types made by an individual within the context of an essay. This allowed easy access to identify individual patterns in spelling. Though the POMplexity did not show differences in the complexity/severity of the errors students make, the POMAS was able to reveal differences in the type and nature of

errors. Analyzing spelling errors by type and nature, instead of by right or wrong in the conventional sense, provides much more information about the linguistic processes a child uses confidently and those that are difficult. A teacher, tutor, or speech-language pathologist could use the POMAS to analyze the errors in a single student's essay to analyze error types for an individual student. Depending on the type of errors the child made, instruction could target specific skills, such as specific orthographic rules, phonological awareness skills, or teach the meaning of morphemes and how to add affixes to words.

Two limitations to this study may have affected findings. The first limitation was the restrictions of the POMplexity scoring system in the morphology category. The morphology scoring system had a ceiling of 3, but placed no limits on the scores that could be given in the categories of phonology and orthography. This scoring system restriction may have impacted the results making it appear that the participants made less severe errors in morphology than other categories, when this may not have actually been the case.

The second limitation of this study was the small sample of participants with OWL-LD. There were 13 students with dysgraphia, 15 students with dyslexia, and only 5 with OWL-LD. Larger groups limit variability better than small groups. Because there were so few students with OWL-LD and there was significant variability in their performances, these five individuals may not have been representative of the entire population. Ideally, there would have been more participants with OWL-LD to match the other two groups and decrease the effect of within group variability.

Educational and Clinical Implications

The lack of consistent, diagnosis-specific error patterns in type, severity, and frequency of errors support the recent changes to the DSM-5 which indicated that specific learning

disabilities exist on a continuum rather than fit neatly into specific subcategories (Tannock, 2014). Recent changes to the DSM-5 have created one broad category of SLD, in which specific descriptive terms can be used to characterize the specific array of academic problems a child experiences. Academic difficulties are not static. Students can fluidly move along a continuum as skills strengthen in certain areas or new areas of weakness emerge. Areas may strengthen after intervention is provided and new areas of weakness may emerge as children are exposed to new and more difficult content in school. For example, students in kindergarten may struggle with reading and spelling words, but as they progress to higher grade levels, their disability may manifest in difficulty with reading comprehension, understanding word problems in math, or writing composition.

The subcategories of dysgraphia, dyslexia, and OWL-LD could be considered as descriptive terms to represent of gradients of ability and impairment within the overarching category of specific learning disabilities. However, even within those subcategories, there is a wide degree of variability. Though diagnostic categories may be helpful for evaluative purposes, giving a slightly more specific explanation of what areas the child struggles with, subcategories alone cannot be used for determining intervention because of the variability and fluidity of students within each subcategory. An analysis of the student's specific array of difficulties at that time is more important for intervention than the specific diagnostic subcategory, because it provides insight into the exact areas the individual child struggles with and where his or her strengths lie.

When analyzing students' spelling errors to determine a course of instruction or treatment, it is important for teachers, tutors and speech-language pathologists to consider the context of spelling errors and the use of a scoring system that will provide information on the

type of errors students are making. Analyzing spelling within the context of a written summary provides more information about a student's functional academic writing abilities than a single-word spelling test because written compositions place greater cognitive demands on the student and are a better reflection of spelling use in context. According to the Common Core State Standards (National Governor's Association Center for Best Practices & Council of Chief State School Officers, 2016), a student in the 8th grade must be able to demonstrate command of standard English capitalization, punctuation, and correct spelling when writing. When writing, students are expected to compose cohesive, logically organized essays on discipline-specific content in which they explain claims, counterclaims, reasons, and evidence. As Hayes and Berninger (2014) explain, the process of written composition draws on cognitive resources including attention, and short-term and long-term memory. With these cognitive resources focused on generating ideas, translating them into syntactically correct sentences, and constructing logical arguments, fewer cognitive resources can be devoted to spelling. So, misspellings are more likely and these spelling patterns could be qualitatively different than the misspellings on a single word test.

An unconstrained scoring system like the POMAS, would allow instructors to analyze and identify the specific types of linguistic errors in a student's composition. Results from this analysis would help determine the course of remediation. For example, the POMAS would show if a child was making primarily orthographic errors, such as mistakes with letter doubling. If the student had primary difficulties with letter doubling, then instruction could target this orthographic pattern to help the students understand when to use double letters. On the other hand, tests that score a word as right or wrong indicate spelling accuracy, but do not explain

where breakdowns occurred. Therefore, these tests do not provide instructors with much information about how to help the student improve.

Results of this study showed that students with dysgraphia, dyslexia and OWL-LD all made errors in each linguistic category (phonology, orthography, and morphology). Hence, evidence from this project reveals that students with learning disabilities all can benefit from instruction in the orthographic and morphologic rules of their language and how to integrate these rules with the phonological information that they hear in the word. For example, many of these students appear to lack the knowledge of how to use orthographic markers to indicate short or long vowel sounds and how to add affixes to words. These skills can be specifically and explicitly taught, providing these students with strategies to use when attempting new or complex words. Students with OWL-LD in particular, need instruction on vocabulary and suffixes to build their word knowledge and help them with morphological processing. Instruction in vocabulary will help students when determining root words. Additionally, specific strategies should be taught to help with adding suffixes, such as when to double letters (*skipping*), omit a silent *e* (*making*), change a *y* to an *i* (*denied*), or keep the base word as it was (*played*). Other research (Garcia et al., 2010) has indicated that stronger readers are usually stronger spellers, so improving the reading skills of a child with dyslexia or OWL-LD, in addition to teaching orthographic and morphological rules, may help improve spelling skills.

Directions for Future Research

Two directions for future research are suggested. The first direction considers modes of written expression other than handwriting. The present study focused solely on spelling errors in the context of handwritten essays. Other written modes of expression, such as typing, may alleviate some the challenges of letter formation experienced by students with dysgraphia,

though it would not address their deficiency in orthographic short-term memory. Future research could compare the type and frequency of handwritten spelling errors to errors made in typed summaries. Due to the known difficulties that students with dysgraphia have with handwriting, this research could help shed light on whether typing would be an effective form of intervention for these students.

Additionally, future research could work to improve the sensitivity of the POMplexity scoring system. Currently the morphological POMplexity codes .5 for a real word error, 1 point for a misspelling of the base word or affix, 2 points for the misspelling of both a base word and the affix, and 3 points for the omission of an affix or the production of a unrecognizable word. However, words can have multiple affixes, so the system also should be able to score each affix error separately. Finally, scores should be available for the addition of unnecessary morphemes (*towarded*), irregular verbs (*runned*), irregular plurals (*mouses*), incorrect morpheme selection (*mathematition*), and for words in which the root and affix were spelled correctly but not joined correctly (*denyed*). The new morphological POMplexity score could assign the smallest point value for homophones, contractions, apostrophes, and real word errors. It could give slightly more points for morpheme selection errors and errors in the joining of root and affix. It could give a greater point value for each misspelled morpheme and errors involving irregular verbs and plurals and the greatest point value for the addition or omission of a suffix.

Conclusion

This study sought to determine if differences existed in the misspellings of students in grades 4-9 with different learning disabilities. Results of this study revealed that students with dysgraphia, dyslexia, and OWL-LD made errors that were similar in complexity and frequency in their handwritten summaries. All students had similar scores for phonological, orthographic

and morphological errors, indicating poor integration of phonological, orthographic, and morphological information. This means that students with learning disabilities may need continued instruction in phonological mapping, orthographic rules and morphological patterns well into their middle school years. Instruction should not stop at the word level, but increase to spelling within the context of a sentence and then an essay. It is important to help students develop strategies for spelling when their cognitive resources are being taxed through the process of composition.

While the students in all three diagnostic categories were similar quantitatively, the qualitative analysis revealed differences. Error patterns within groups seemed to be based more on individual strategies than diagnostic category. For example, in the OWL-LD group, one student omitted obligatory vowels. Another student with OWL-LD made vowel selection errors, but he or she demonstrated an awareness that all syllables must contain a vowel. These within group differences could be attributed to the task or the severity of impairment for a particular individual. Alternatively, some students may have had better instruction on strategies and rules for spelling than others. Finally, some differences were found among the diagnostic categories. Children with OWL-LD were more inconsistent in their spelling of the same word than the other groups, indicating a lack of strategy use when attempting to spell new or complex words.

In order to meet the needs of an individual child, his or her spelling should be evaluated and intervention should be geared toward the specific needs of that individual. Targets for intervention can be determined by using an unconstrained scoring system to analyze the specific type and nature of an individual's spelling errors within the context of handwritten composition. Intervention can then be personalized to meet the needs of the student based not on their diagnosis, but on their individual needs.

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