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An Analysis of Deaf Students' Spelling Skills During a Year-Long Instructional Writing Approach

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Abstract

Numerous studies have shown that spelling presents unique challenges for children who are deaf or hard of hearing (d/hh), and most do not develop age appropriate spelling skills. Spelling errors from 29 middle school d/hh students were analyzed from writing samples that were gathered at the beginning, middle, and end of a year-long writing instructional approach. A linguistic analysis of spelling errors was used to assess each child's understanding of the phonological, morphological, orthographic, semantic, and visual imagery rules that apply to written words. Our results provide a descriptive analysis of the types of spelling errors made by middle school d/hh students. Results indicate that spelling should be directly targeted during writing lessons. The results provide important information on the acquisition of spelling skills with this unique population and the use of narrative samples to assess spelling.

Keywords

middle school, deaf/hard of hearing, exceptionalities, intervention strategies, spelling

It is well established that children born with an educationally significant hearing loss typically show early delays in acquiring language skills (either spoken or manual communication) as well as writing abilities. As these children grow, language and literacy skill deficits profoundly impede academic achievement (Davis, 1974; Davis & Blasdell, 1975; King & Quigley, 1985; Kyle & Harris, 2006; Marschark, 1993; Mayer, 2007; McEvoy, Marschark, & Nelson, 1999; Nittrouer, Caldwell, Lowenstein, Tarr, & Holloman, 2012). These well-documented language and literacy deficits usually include significant problems with spelling (Aaron, Keetay, Boyd, Palmatier, & Wacks, 1998; Alamargot, Lambert, Thebault, & Dansac, 2007; Allman, 2002; Geers & Hayes, 2011; Leybaert & Alegria, 1995; Olson & Caramazza, 2004; Padden, 1993; Sutcliffe, Dowker, & Campbell, 1999). To date, very few studies have been designed to examine the multiple linguistic bases of spelling errors with children who are deaf or hard of hearing (d/hh). The purpose of this study is to provide a descriptive analysis of the types of errors produced by d/hh students to inform spelling assessment and intervention for students.

The area of spelling among children who are d/hh has received little attention. We know from the breadth of literature focusing on participants with typical hearing that while spelling was once considered a skill to be learned through repetitive drill and practice, research has shown that spelling involves knowledge of a rule-based system that requires the integration of sound, pattern, and meaning relationships to generate orthographic output (Ehri, 1986; Masterson & Apel, 2000). This is supported by research demonstrating that English words generally conform to predicable letter patterns (Bear, Invernizzi, Templeton, & Johnson, 2000), which represent the underlying phonological representations of sound and letter combinations. These are the combinations that early writers with typical hearing rely on when spelling (Treiman & Bourassa, 2000).

Linguistic Bases of Spelling

Studies of spelling acquisition have shown that children with typical hearing first develop an awareness of the sound

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system of a language (phonological awareness), and then knowledge of the sound to letter correspondences that form the orthography of a language (Ehri, 2000; Ehri & Wilce, 1980). As orthographic skills mature, children begin to construct mental graphemic representations (MGRs), or mental images of words (Apel, 2011; Apel & Masterson, 2001). MGRs help in spelling words that do not conform to regular orthographic patterns. Knowledge of morphology and semantics further contribute to spelling development (Apel, Wilson-Fowler, Brimo, & Perrin, 2011; Verhoeven & Van Leeuwe, 2008; Wasowicz, 2007; Wolter, Wood, & D'zatko, 2009). Phonological awareness, orthographic awareness, mental graphemic representations, morphological awareness, and semantic knowledge together serve as the linguistic basis of mature spelling skills.

Phonological Awareness

Although far less is known about the developmental process of spelling with children who are d/hh, it is clear that they demonstrate areas of weakness in spelling not typical of their hearing peers (Allman, 2002; Colombo, Arfé, & Bronte, 2011; Harris & Moreno, 2004; Leybaert & Alegria, 1995; Sutcliffe et al., 1999). Children who are d/hh typically do not easily acquire the phonological awareness skills that serve as the foundation for spelling development because these skills are usually learned through audition (Aaron et al., 1998; Alamargot et al., 2007; Sterne & Goswami, 2000). Studies that have examined the importance of phonological knowledge to spelling for children who are d/hh present equivocal results. As reported by Leybaert and Alegria (1995), students who were d/hh exhibited more difficulty with non-phonologically transparent words than those that had salient sound/letter representations. This may indicate some use of phonological knowledge because words with transparent phonological properties were easier to spell. In a related study by Sutcliffe et al. (1999), children from signing schools appeared to use orthographic knowledge more in their spelling than phonological information, as evidenced by their spelling errors. Similarly, Harris and Moreno (2004) found that children who were deaf between 8 and 14 years of age did not demonstrate any significant reliance on phonological coding during a picture spelling task. Based on these results, it is clear that limited phonological awareness skills are likely to be one reason that children who are d/hh use spelling strategies that are different from their hearing peers.

Orthographic Awareness

In addition to phonological awareness, the acquisition of mature spelling ability requires knowledge and recognition of the orthographic patterns in a language (e.g., *ng* is an allowable word ending in English but cannot be used to start a word). An understanding of orthographic rule patterns allows young children to establish increasingly accurate representations of the words that they spell (Deacon, Conrad, & Pacton, 2008). In a study by Padden (1993), children between the ages 4 and 9 who were severely or profoundly deaf provided writing samples for analysis of single word spelling. As age increased, spelling attempts demonstrated a growing knowledge of orthographic patterns. Related studies looking at orthographic knowledge of students who are d/hh generally confirm that improvements are made with instruction and age (Aaron et al., 1998; Alvarado, Punete, & Herrera, 2008; Miller, 2005). Research also shows that their spelling attempts typically follow orthographically allowable patterns (Olson & Caramazza, 2004), indicating that orthographic awareness may be a strength in the development of spelling skills for children who are d/hh.

Mental Graphemic Representations

As orthographic knowledge is acquired, young spellers also develop knowledge of MGRs. This allows a speller to retrieve stored images of words or parts of words (Apel, 2009, 2011). Mature spellers develop mental graphemic representations of words that do not follow regular spelling patterns. Included in this category are words of irregularity, or the words you "just need to know" how to spell. Developing MGRs is important, as this skill facilitates the ability to spell words that do not follow regular orthographic rules (e.g., yacht). Studies with individuals who are d/hh indicate that when attempting to spell words that do not follow regular spelling patterns (i.e., MGRs), students will still use orthographically acceptable attempts even if their attempt is wrong (Hanson, Shankweiler, & Fischer, 1983). Sutcliffe et al. (1999) looked at three types of words: "regular" (i.e., typical sound to letter correspondence), "exception" (i.e., unusual sound to letter correspondence with typical spelling pattern), and "strange" (i.e., words with unusual patterns and unique pronunciations). Results of their study suggested that children who are d/hh exhibit considerable delays in spelling "strange" words (e.g., circle, sword, tongue) when compared with "regular" or "exception" words (Sutcliffe et al., 1999).

Morphological Awareness

While phonological and orthographic information including MGRs serve a primary function in spelling development, research has also demonstrated that accurate spelling is facilitated by an understanding of morphology (Treiman & Cassar, 1996). Knowledge of morphological rules allows a writer to manipulate the spelling of a known root word by adding a prefix or suffix, thus creating another word (e.g., scene to scenic). In a study by Leybaert and Alegria (1995),

students who were d/hh made almost twice as many morphological errors as a hearing control group; however, the authors suggested that transparent morphological properties of spelling improve with increased exposure to written language. A related study by Olson and Caramazza (2004) showed that students who were deaf (hearing loss of at least 85 dB in their better ear) produced 12% of words as morphological variants of the target words (e.g., *responsible* for *responsibilities*), as compared with only 1% by students with typical hearing. However, although these studies show that children who are d/hh make considerably more morphological errors in spelling than their hearing peers, they do use morphological information productively. Breadmore, Olson, and Krott (2012) found that, unlike their hearing peers, children who are deaf use morphological knowledge independent of phonological knowledge, indicating that morphology can be learned. Given the restrictions placed on phonological acquisition due to the inability to access the auditory signal, knowledge of English morphological structures directly affects the spelling of d/hh children. Thus, writing programs that emphasize morphology may serve to inform and improve overall spelling abilities.

Semantic Awareness

Studies of children with typical hearing have shown that semantic knowledge is significantly correlated with spelling ability even after controlling for phonological awareness, alphabet knowledge, and letter writing fluency (Apel et al., 2011; Kim, Otaiba, Puranik, Folsom, & Gruelich, 2014; Verhoeven & Van Leeuwe, 2008; Wasowicz, 2007; Wolter et al., 2009). If word knowledge facilitates spelling accuracy, and children who are d/hh are known to exhibit vocabulary deficits (Kyle & Harris, 2010), there is reason to be concerned that deficits in vocabulary are likely to have a negative impact on their spelling ability. In a recent study, students who were d/hh produced words semantically similar that had no phonological or orthographic similarities to the target word (e.g., *sweep leaf* for *rake, ship* for *boat*) during a dictated spelling task (Bowers, McCarthy, Schwarz, Dostal, & Wolbers, 2014). Limited vocabulary knowledge may be one explanation as to why students did not produce the actual target word. This production pattern during a spelling task has not been observed in the spelling patterns of children with typical hearing. Thus, this is an area that requires additional studies to show how semantic knowledge and spelling are related in this population and in what contexts d/hh students use words that are spelled correctly but are not semantically accurate.

Unique Spelling Characteristics of D/hh Students

The few studies that have been conducted to examine the multiple linguistic bases of spelling errors show that children with educationally significant hearing loss are limited in their ability to access the phonological, morphological, and semantic cues critical for literacy-related skills (Burman, Nunes, & Evans, 2007; Marschark, Mouradian, & Halas, 1994; McAnally, Rose, & Quigley, 1994; Yoshinaga-Itano, Snyder, & Mayberry, 1996). One recent investigation that focused specifically on spelling skills included 20 adolescents at a state school for the deaf (Bowers et al., 2014). Results showed that the participants made more phonological errors than any other error type. Furthermore, participants made more semantic errors than orthographic errors, regardless of whether the words were spelled with regular or irregular patterns. These findings are consistent with studies that show that children who are d/hh use orthographic strategies rather than phonological strategies to spell, and that their ability to spell is compromised by limited English language abilities.

Interestingly, the spelling errors of children who are d/hh have been shown to be uniquely different from students who hear (Allman, 2002; Colombo et al., 2011; Padden, 1993; Sutcliffe et al., 1999). In addition to studies examining the linguistic bases of spelling, it has been noted in the literature that children who are d/hh frequently represent a spelling word with only the initial sound of the target word or refuse to attempt the target word at all (Bowers et al., 2014; Harris & Moreno, 2004). Alvarado et al. (2008) found that for students who are deaf, visual coding skills (i.e., fingerspelling) are correlated to orthographic skills. Mayer and Moskos (1998) noted that some word spelling combinations of d/hh students were similar to the hand shapes of signs (e.g., *cieseh* for *drink*, as *drink* uses a "c" for the sign). Padden (1993) reported that deaf students attempt to reproduce letters based on the visual shape of the target letters (e.g., *t* or *d* for *b*). Thus, these investigations have demonstrated a need to account for the use of visual or spatial information by students who are d/hh when they spell (Alvarado et al., 2008; Mayer & Moskos, 1998; Padden, 1993).

Assessment of Spelling Skills During Writing Instruction

In general, it is clear that children who are d/hh struggle with spelling and this can limit their written expression. Only a few studies have explored spelling changes across time to help guide instructional improvements. One study completed by Sirois, Boisclair, and Giasson (2008) measured invented spelling 3 times over a year of first grade, comparing a group of 31 children with severe to profound hearing loss with 25 children with typical hearing. The children with severe to profound hearing loss received 2 years of preschool intervention that included language and writing instruction prior to starting first grade. During their preschool instruction, the writing lessons emphasized the alphabetic principle. At the beginning of first grade, the children were tested on invented spelling and phonological

awareness. Their scores did not differ significantly from the scores of their hearing peers, indicating the value of focused instruction at an early age. However, the authors cautioned that although the preschool intervention was successful in making these children almost indistinguishable from hearing children in first grade, there is a need for concern about future literacy success.

In a related study by Mayer and Moskos (1998), student writing samples were examined for spelling changes over 2 years of academic work. The academic program used an integrated process-writing program that was holistic and emphasized the importance of meaningful communication. The study included 15 children between 5 and 9 years of age who were deaf and communicated primarily through sign, although most did not have a well-established first language. Results showed that most of the children's early spelling attempts did not necessarily exploit phonological knowledge; instead, they used a variety of cues to spell unknown words, relying on their exposure to print, sign, and speech. As the students became more aware of print, their spellings indicated a growing knowledge of orthographic patterns. However, this knowledge was not sufficient to allow them to develop the ability to spell with accuracy. As a consequence, the authors recommended caution in assuming that print exposure alone would allow children who are d/hh to develop age appropriate literacy skills.

At present, research does not provide evidence of the types of spelling errors produced by middle school students who are d/hh. This is an issue of critical importance because, in middle school, children should be using written expression to communicate clearly across a wide range of formats including general narratives, personal narratives, persuasive writing, and expository texts. Knowledge of students' spelling errors has the potential to inform further development of writing curricula specially designed for d/hh students. It can also assist educators in targeting specific linguistic areas of need to facilitate the greatest improvements in spelling and written expression.

The goal of the present study was to examine the spelling errors that occur in the writing of middle school students who are d/hh. Writing samples from a larger study were used to construct a descriptive analysis of the types of spelling errors produced by middle school students who were d/hh. Writing samples were obtained over 1 year in which students participated in an instructional approach called *Strategic and Interactive Writing Intervention* (SIWI; Wolbers, 2007, 2008). SIWI is a writing approach that incorporates explicitly taught strategies with guided classroom writing activities (Wolbers, 2007) for all genres of writing. Specific techniques that address the unique language needs of students who are d/hh are used. For example, there are embedded approaches for signing students aimed at developing their metalinguistic knowledge of American Sign Language (ASL) and English, and there are general language development strategies for students who are significantly delayed in their abilities to communicate concepts clearly to others.

Table 1. Demographic Information for Participants.

Demographic	*M*	*SE*	Minimum	Maximum
Age (years, months)	13, 2	1, 1	11, 8	14, 9
Unaided hearing	88 dB	21 dB	21 dB	113 dB
Aided hearing	35 dB	18 dB	17 dB	98 dB[a]
SAT-HI Reading Comp	2.7	1.1	1.3	6.1

Note. N = 29. SE = standard error; SAT-HI = *Stanford Achievement Test for the Hearing Impaired.*
[a]Two students used no amplification.

When using SIWI, students work with a classroom teacher to create "publishable" pieces of work to present to an audience (e.g., thank you letters, reports of field trips for class newsletters). Unlike typical class writing assignments, students are encouraged to interact and collaborate during all aspects of the writing process, and the teacher gradually transfers more and more control over the writing to students. As a result of SIWI lessons, significant gains have been achieved in both discourse-level (i.e., coherence, organization, text structure elements) and sentence- or word-level (i.e., length, sentence complexity, sentence awareness) writing skills (Wolbers, 2008; Wolbers, Dostal, & Bowers, 2012). Although spelling was not a central objective of SIWI lessons, students are exposed to accurately spelled words during guided writing sessions with the teacher. When a student suggests a word, phrase, or sentence to be added to the co-constructed text, the teacher generally writes or types correctly spelled words onto the board. At times, the teacher may ask a student for help with spelling a word while she writes it, but there are no guidelines provided to teachers about when to emphasize spelling. Using the writing samples collected over 1 year of SIWI, a descriptive analysis was conducted to examine the types of spellings errors that occurred in the spontaneous writing samples of middle school d/hh students.

Method

Participants and Setting

A total of 29 sixth-, seventh-, and eighth-grade students attending a state school for the deaf participated in the study. Demographic information for all students is included in Table 1. The school's communication philosophy is to practice simultaneous communication (i.e., spoken English and manually coded English). The students' pure tone averages in their better ear were calculated, with a mean of 88 dB unaided, and 35 dB aided. The *Stanford Achievement Test for the Hearing Impaired* (SAT-HI; Mitchell, Qi, & Traxler, 2007; Trybus & Karchmer, 1977) was given at the

beginning of the academic year. The average reading comprehension score for the group was a reading grade level score of 2.7. The SAT-HI was given once per year; thus, end of the year scores were not available.

Over the school year, students spent between 2 and 2.5 hours per week in SIWI activities. The students' language arts teacher, who is fluent in English and ASL, conducted all of the SIWI lessons, examinations, and writing samples.

Written samples used for spelling analysis. Three independent written language samples in the form of personal narratives were obtained from each participant at the beginning, middle, and end of the academic year. The students were given an open-ended writing prompt that asked them to share a personal experience. This prompt was administered in class and read aloud and signed to ensure accessibility; no time limit was set for completion. Each writing sample was coded at the word level for spelling errors. Every word spelled incorrectly was counted once. If the same word was misspelled in the text in the same way, it was only counted once. The writing samples were coded for spelling errors by a speech–language pathologist, a teacher of the deaf, a seventh-grade English teacher, and an assistant professor of deaf education. All three samples were collected under equivalent conditions.

Spelling analysis. Spelling accuracy (i.e., the total number of words with no spelling errors divided by total number of words) was calculated for each writing sample. The rationale for using a percentage was to equalize all samples regardless of length. All samples were examined in context to determine whether the word was semantically and morphologically appropriate for the sentence. If a word was spelled correctly but used inappropriately in context (e.g., *strip* for *strep* was a semantic error; *scare* for *scared* was a morphological error), it was counted as an error. A list of all incorrectly spelled words (or words spelled correctly but used in the wrong context) was generated. Each word identified as a spelling error was analyzed for its specific error pattern(s). A Multi-linguistic Coding (MLC) system designed to better address the spelling errors made by children who are d/hh was used (Bowers et al., 2014). MLC has been used in previous studies and demonstrated to be sensitive to the underlying linguistic process errors made by typically hearing children (Apel & Masterson, 2001; Masterson & Apel, 2010; McCarthy, Hogan, & Catts, 2012) as well as children who are d/hh (Bowers et al., 2014).

When using the MLC system, spelling errors from the writing samples were coded and placed into categories consistent with previous research. These included phonological awareness (PA) errors, orthographic pattern awareness (OPA) errors, MGR errors, morphological awareness (MA) errors, and semantic awareness (SA) errors (Apel, 2011; Wasowicz, 2007). PA errors were coded when a sound was added or deleted (e.g., either *timfe* or *ti* for *time*) and for all letter reversals. OPA errors were coded when a rule for combining letter or patterns governing spelling has been violated. Consistent with other published spelling assessments and current literature (Apel, 2011), sound to letter correspondence errors were included in the OPA category, not as a PA error (Masterson & Apel, 2010). For example, *swin* for *swim* was scored as an OPA error, as all phonemes were represented (e.g., consonant–vowel–consonant [CVC] configuration). MGR errors were coded when a word that is non-phonetic in its spelling, such as *city*, was spelled "phonetically" (e.g., *cidy*), or the word was spelled differently on repeated attempts (i.e., the student has difficulty developing an MGR for that specific word). MA errors were coded when a word was spelled with an incorrect morpheme, affix, or suffix (e.g., *gaved* for *gave* and *talk* for *talked*). SA errors were coded when the wrong word was used (e.g., *two* for *to*; or *dog* for *car*). It should be noted that verb or tense agreement errors were not included as semantic errors.

For this study, the MLC system was extended to include an additional category for errors related to visual imagery (VI). This category was added because a preliminary review of the beginning, middle, and end of the year writing samples showed a number of unique errors that would not fit in previous categories (e.g., incorrect use of visually similar, different sounding letters, words that looked visually similar to ASL signs) as well as several pictures embedded in text (i.e., participant drew a picture of a monkey in his or her writing passage, instead of writing the word). These findings were consistent with findings by Mayer and Moskos (1998) and Padden (1993), whose studies provide evidence that children who are d/hh are more likely to use pictures in their writing to represent words than their typically hearing peers. The MLC system categories, defining characteristics and examples are shown in Table 2.

Reliability. For inter-rater reliability of spelling errors, 20% of all samples were independently coded by the first, second, and fifth authors. Pearson's correlation between the raters revealed a positive, high correlation ($r = .955$, $p < .001$). After inter-rater reliability was calculated, a consensus was reached for all discrepancies and the agreed upon codes were used in the overall analysis. For inter-rater reliability spelling error category placement, 20% of the spelling errors were analyzed by the first and third authors. Pearson's correlation revealed a positive, high correlation ($r = .978$, $p < .001$).

Results

Each word identified as an incorrect spelling was analyzed to see whether a specific error pattern could be recognized. Spelling errors were analyzed by category (see Table 2) for all of the writing samples. Results show that the spelling

Table 2. Multi-Linguistic Coding (MLC) System Categories, Defining Characteristics and Examples.

MLC categories	Defining characteristics and examples
Phonological Awareness (PA) errors	Errors of SOUND
	omission or addition of phonemes not in the word
	all letter reversals
Orthographic Pattern Awareness (OPA) errors	Errors of regular PATTERNS
	incorrect consonant substitutions (d/t; n/m; s/tch)
	rules for combining letters (*kry* for *cry; jrum* for *drum*)
	patterns that govern spelling (*ran* for *rain; lader* for *ladder*)
	positional constraints on spelling patterns (*ckow* for *cow*)
Mental Graphemic Representation (MGR) errors	Errors of IRREGULARITY (you just have to memorize the word)
	correct "phonetic" spelling of non-phonetic words (*cidy* for *city*)
	incorrect vowels preceding –ng, r, l (*reng* for *rang; whil* for *wheel*)
	incorrect spelling for repeated attempts (stopd, stopt, stoppd)
Morphological Awareness (MA) errors	Errors of MODIFICATION (i.e., prefix, suffix, tense change)
	incorrect use of morphemes
	wrong tense is represented (*walk* for *walked*)
Semantic Awareness (SA) errors	Errors of MEANING
	suffix modification errors represent another word (*fry* for *fried; drive* for *drivers*)
	wrong word used (*dog* for *car*)
	split compound word into two separate words
Visual Images (VI)	Use of VISUAL information or ASL influence
	mental image of word based on ASL sign (*vorival* for *funeral*)
	word reversals (*cake cup* for *cupcake*)
	incorrect use of visually similar, different sounding letters (*diat dilke* for *dirt bike*)
	capitalization to show emotion (HAPPY, DONE, HAPPENED NEXT)
	abbreviations (*B-day* for *birthday, Wed* for *Wednesday*)
	use of pictures embedded in text instead of English word

Note. ASL = American Sign Language.

error patterns stayed relatively stable for the entire year, with no statistically significant variation for any of the six categories, $F(1, 28) = 0.279$, $p = .602$, $\eta_p^2 = .01$. Table 3 includes the percentage of PA, OPA, MGR, MA, SA, and VI errors. A description of errors for each category is given below.

PA errors remained consistent throughout the school year, with no statistically significant variation from the beginning, the middle, and the end of the year writing samples, $F(1, 28) = 0.293$, $p = .593$, $\eta_p^2 = .010$. Although there was no statistically significant difference in PA errors, participants were observed to make more PA errors throughout the year. Specifically, the percentage of PA errors increased from 31 at the beginning of the year ($M = 1.37$ errors per writing sample) to 40 at the end of the year ($M = 1.58$).

For OPA errors, results did not significantly vary from the beginning, the middle, and the end of the year writing samples, $F(1, 28) = 0.922$, $p = .345$, $\eta_p^2 = .32$. The percentages of errors at the beginning, the middle, and the end of the year writing samples were 22, 16, and 18, respectively. To investigate how many sound to letter correspondence errors were included in the OPA category, these data were further analyzed. There were 62 total OPA errors (28, 13, and 21) in the writing samples. Results showed that a total of 34 OPA errors, (17, 5, and 12) were not errors of sound to letter correspondence. This indicates that 28 OPA errors, 11, 8, and 9, respectively, consisted of a sound to letter correspondence error (i.e., phonological mismatch of sound and letter choice; for example, *arrate* for *arrive*), instead of

Table 3. Percentages of MLC Categories by Time (Beginning, Middle, and End of Year).

Category	Beginning (%)	Middle (%)	End (%)
PA	31	29	40
OPA	22	16	18
MGR	3	8	3
MA	11	14	9
SA	18	19	18
VI	16	15	11

Note. MLC = Multi-Linguistic Coding; PA = Phonological Awareness errors; OPA = Orthographic Pattern Awareness errors; MGR = Mental Graphemic Representation errors; MA = Morphological Awareness errors; SA = Semantic Awareness errors; VI = Visual Images.

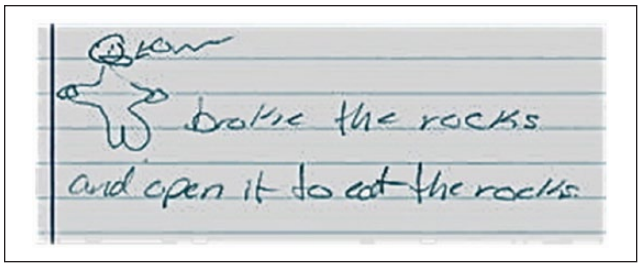

Figure 1. Example of visual image error in the form of a picture for target word.

other orthographic errors that are not sound but pattern and rule related (e.g., *laf* for *laugh, lader* for *ladder*).

The rate for MGR errors stayed consistent across participants during the school year, $F(1, 28) = 0.000$, $p = 1.00$. Further analysis of the MGR errors revealed that participants made few to no MGR errors across the school year; specifically, MGR errors at the beginning of the year accounted for 3% ($M = 0.1379$, range = 0–3) and stayed consistent at 3% through the end of the year ($M = 0.1379$, range = 0–2). While it might be unlikely that improvement would result in a decrease of errors due to a floor effect, we still see a small decrease in errors even when the sample word count increases.

MA errors, like previous errors types, did not vary across the year, $F(1, 28) = 0.373$, $p = .546$, $\eta_p^2 = .013$. Examination of the means across the year demonstrated that MA errors stayed consistent. Specifically, participants exhibited MA errors within their spelling, 11% at the beginning of the year ($M = 0.48$, range = 0–4), with a slight decrease to 9% at the end of the year ($M = 0.34$, range = 0–2).

Changes in SA errors were not statistically significant across the year, $F(1, 28) = 0.069$, $p = .816$, $\eta_p^2 = .002$. Examination of the samples revealed numerous SA errors, indicating a lack of understanding for word meaning. Examples include *tired* for *tried, read* for *real, mouth* for *month*, and *nerves* for *nervous*. SA error rates from the beginning, middle, and end of the year were 18% 19%, and 18%, respectively.

As anticipated by the preliminary screening of the narrative samples, students demonstrated a number of VI errors in their writing; however, changes were not statistically significant across the year, $F(1, 28) = 1.24$, $p = .275$, $\eta_p^2 = .042$. VI occurred in the form of drawing a picture instead of the target word (e.g., picture of monkey drawn by a participant embedded in the text to represent his idea of the noun instead of the orthography for the target word *monkey*; see Figure 1), word reversals, incorrect use of visually similar, different sounding letters, capitalization to show emotion, abbreviations, or spelling a word based on signs used in ASL (e.g., *vorival* for *funeral, ahh* for *scream*). At the beginning, middle, and end of the year, VI error rates were 16%, 15%, and 11%, respectively, demonstrating a larger percentage of errors than in either the MGR or MA categories.

Table 4. Spelling Accuracy by Time (Beginning, Middle, and End of Year) Writing Samples.

Time	*M*	*SE*
Beginning	88%*	15%
Middle	95%**	4%
End	94%	6%

Note. SE = standard error.
*$p < .05$ beginning to middle of year samples. **$p < .05$ beginning to end of year samples.

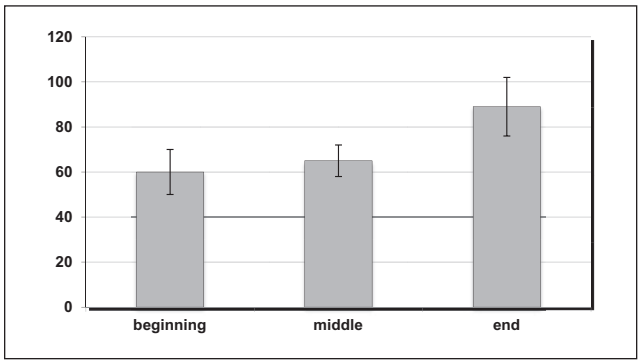

Figure 2. Total number of different words for beginning, middle, and end of the year writing samples.

Frequency of spelling accuracy between subjects for beginning, middle, and end of the year writing samples was calculated (see Table 4) and was statistically significant from the beginning of the year to the middle of the year. Spelling accuracy, on average, increased from 88% of words spelled correctly at the beginning of the year to 95% at the midpoint and 94% at the end of the year (see Table 4).

Once all of the samples were analyzed, it was deemed worthwhile to try and determine whether the consistency in spelling errors across linguistic areas was associated with more diverse word selection as the year progressed. To do this, the total number of different words found in each writing sample was examined. Results revealed a significant main effect for change in the total number of different words, $F(2, 56) = 5.092$, $p < .001$ (see Figure 2). Specifically, the average number of different words increased from 60 (standard error [*SE*] = 10) at the beginning of the year to 89 (*SE* = 13) at the end of the year. Pair-wise comparisons show a significant increase in the total number of different words used from the beginning to the end of the year ($p < .001$), as well as at the middle and end of the year ($p < .05$).

Discussion

The goal of this study was to examine the types of spelling errors that occur in the spontaneous writing of middle

school students who are d/hh. Writing samples were collected over a year while students participated in the SIWI. By assessing spelling errors using MLC, individual as well as group deficits in spelling can be described.

Results indicate that middle school students who are d/hh made a significant number of phonological, orthographic, and visual imagery errors at all points—beginning, middle, and end of the year—in the study. The types of errors they made remained relatively stable across the year, with little change in any category. It is no surprise that PA errors predominated. These results are consistent with previous studies that show that children in Grades 5 through 12 who are d/hh have greatest difficulty with the phonological aspect of spelling (Aaron et al., 1998; Alamargot et al., 2007). An increase in PA errors was observed during the year, with an increase from 31% to 40% at the end of the year. This might be explained by the simple fact that the children in the study were attempting to spell more words at the end of the year than at the beginning of the year; thus, more spellings attempted revealed that these particular children continue to struggle with sound to letter correspondence when using new vocabulary words.

The proportion of OPA errors with a phonological component and the small number of MGR errors also support the idea that phonological awareness is the primary deficit area for this group. The small number of MGR errors may indicate that the students did not use many irregular words in their writing. Our findings and the literature support the conclusion that children who are d/hh use orthographic information far better than phonological information. Recent research supports the idea that MGRs and phonological awareness develop independently (Apel, 2009), suggesting it is possible that the smaller percentage of OPA errors and high proportion of PA errors indicate that learning word patterns and stored mental images of words are areas of strength of d/hh students.

The category that had not been used before in MLC is VI. The need for this category was anticipated based on previous research as well as experience with this population. As found in previous studies (Alvarado et al., 2008; Mayer & Moskos, 1998; Padden, 1993), deaf children inserted pictures for words in their writing. Because students were asked to complete a personal narrative writing sample, it is hypothesized that the high usage of pictures was to express an idea or thought that they did not know how to spell but was important to include in their writing. In addition, some students wrote words that were visually similar to signs found in ASL. One example was the spelling of the word *funeral* as *vorival*. The use of two "V" hand shapes to sign this word in combination with the visual image of the length and shape of the word *funeral* makes the error understandable. In a different sample, the word *ahhh* spelled out was used to represent the word *scream*. Throughout the samples, students consistently made an effort to spell the whole word rather than refusing to attempt the word or putting the first letter and leaving the rest blank, which are typical errors seen in research using single word spelling tests (Bowers et al., 2014; Padden, 1993). Therefore, while the percentages of spelling errors in the VI category were high (16, 15, and 11, respectively), this can be seen as a strength of deaf writers: accessing and using the information they have in one language to convey their message in English writing samples. Thus, there is value in using spontaneous writing samples to investigate spelling because these attempts provide a means of determining what words individuals are attempting to use and what linguistic features are included in their spontaneous writing samples.

A statistically significant change in spelling accuracy from the beginning to the middle of the year writing samples (90%–95%) was noted, with students sustaining the increased accuracy in the end of the year sample (94%). Results suggest students may have been more aware of their intended audience and writing mechanics and were possibly motivated to spell with increased awareness and accuracy. While students maintained an increase of spelling accuracy from the middle to the end of the year, the significant increase in new vocabulary may have inhibited further increases in accurate spelling.

Due to the high percentages of correctly spelled words in the writing samples, representative samples were chosen to analyze writing samples at the word level. This analysis revealed that word selection typically involved very early spelling words. For example, in one selected sample, 15 different simple to spell words (e.g., kitty, mom) accounted for 66% of all the words used in a 326-word narrative. Across this sample, 29% of the words are represented in the preprimer, primer, or first-grade Dolch lists (Dolch, 1942, 1948). In three other selected samples, these early Dolch words represented 61% of 187 words used, 58% of 123 words used, and 53% of 133 words used. A review of these selected samples shows that students often chose words that were simple in structure, would typically be spelled accurately by much younger children with typical hearing, and lacked diversity. This analysis may also in part explain the low percentages of MGR errors, as students were more likely to use less complex words in their spontaneous writing.

It should be noted that analyzing writing samples, as opposed to a directed spelling task, posed limitations. By using written samples alone, only words chosen by the students were available for analysis. Although the use of written narrative samples provides an authentic representation of each child's writing, future studies might combine the use of writing samples with a set of spelling words designed to elicit specific targets as a potentially more sensitive measure of determining what, if any, changes in spelling occur.

As a result of participating in SIWI, a year-long writing intervention, important gains were made in written language skills (see Wolbers et al., 2012); however, the writing

intervention did not specifically target spelling. There was a significant increase in the total number of different words that students used in their writing samples, a jump from 55 different words at the beginning of the year to 72 at the end of the year. While number of words produced by students in their writing significantly increased, only limited spelling improvements as evidenced by written narrative samples were noted. The absence of significant changes in the types of spelling errors across the year suggests that spelling instruction through incidental rather than direct teaching is not adequate to significantly improve spelling skills.

To improve spelling, educators must consider the types of errors that children make and create instructional programs designed to target their deficit areas, which are empirically different from the needs of hearing students (Kyle & Harris, 2006). The results of this study indicate that to improve the spelling skills of children who are d/hh, spelling should be targeted using a wide variety of examples as part of a sequenced curriculum. Allman (2002) noted that d/hh students use visual cues such as known spelling patterns, speechreading, and sign cues when attempting to spell words. Research should be conducted to determine whether individuals who are d/hh utilize visual speechreading information to aid in spelling. For example, examining the impact of specific letter combinations (e.g., minimal pairs) could provide information regarding what therapeutic approaches best improve orthographic knowledge. Explicit use of sign cues (e.g., first letter of a word, provide ASL sign and then fingerspell word) may also be beneficial when used in conjunction with writing approaches. Examining targeted speechreading and use of sign cuing interventions could lead to a better understanding of how students who are d/hh integrate phonological and orthographic information related to spelling words.

Currently, fingerspelling is not a strategy used during SIWI for writing instruction except to spell a word with no sign (e.g., proper names). Alamargot and his colleagues (2007) have suggested the use of fingerspelling words before a student attempts to write the word and translate to English may improve writing and spelling abilities by maximizing the use of visual–spatial processing. Thus, adding an intervention component to SIWI that addresses the unique spelling needs of students, including the use of fingerspelling strategies, should be considered. This pedagogical approach of using fingerspelling during writing instruction would target the specific needs of d/hh students who use visualization as a strategy for spelling purposes.

The MLC system used in this study might prove beneficial when used in conjunction with writing instruction as a way of directly addressing spelling deficits. Changing the current MLC system to a flowchart that students can use to assess what types of errors are occurring in their spontaneous writing samples may prove to be a successful intervention, as students begin to understand what types of errors they are producing in their written expression.

In conclusion, there is no question that spelling is an educational issue that needs to be addressed to achieve success in writing. The integration of a spelling curriculum within the structure provided by SIWI might serve to enhance both the content and form of written language. This curriculum could include addressing phonological deficits. Specifically, strategies would address sound to letter correspondence via fingerspelling and presenting phonic information via a visual modality to students who are d/hh during writing or spelling tasks. To focus on orthographic deficits, strategies could include reviewing predicable letter patterns within target words. When tackling morphological deficits, teaching prefixes and suffixes of target words to children who are d/hh may aid in increasing their knowledge and understanding of word formulation. The curriculum could also improve semantic knowledge by explicitly teaching synonyms and focusing on word categorization. Finally, the use of visual information should be addressed within the curriculum by directly translating ASL signs to English words, and using fingerspelling to teach vocabulary that does not have a direct sign. Thus, pedagogical strategies that specifically target the needs of d/hh students could be implemented in writing approaches for improved spelling outcomes.

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