Orthographic Knowledge Is Essential for Reading and Spelling

by Nancy Mather and Lynne Jaffe

A colleague recently assessed Samantha, a young girl (age 9 years, 11 months), and was puzzled by her test results. She described them in the following way: "On the GORT-4 (Gray Oral Reading Test-4, scaled scores, mean = 10, standard deviation = 3), she scored 10 on Reading Rate, 13 on Accuracy, and 14 on Reading Comprehension. Her performance on an untimed phonological awareness task was good, and her Full Scale IQ score of 130 places her in the gifted range. She had no difficulty reading nonsense words on an untimed task (85th percentile) and was in the average range (46th percentile) when reading a list of irregular words, although she had no difficulty with those same words in context. In fact, she seems to be a beautiful reader. Her only problem is spelling. She makes numerous spelling mistakes, even on simple words, such as spelling *very* as *vry*, *only* as *onle*, and *they* as *thay*. Within a paragraph, she often spells the same word three different ways." Our colleague's question to us was, "Why is this happening? Could this be dyslexia? Her written stories are absolutely amazing, but her spelling is truly awful."

Although dysgraphia may be a more accurate descriptor than dyslexia because her difficulties are with writing, not reading, our first thought was that this is a bright girl who demonstrates a disparity between the level of orthographic knowledge needed for reading and the orthographic knowledge needed for spelling. Reading, particularly for irregular words that cannot be easily sounded out, requires that a student have enough familiarity with the orthographic sequence (i.e., letter sequence) to recognize a word as familiar. Spelling, however, requires a much more rigorously established memory of the sequence of letters in a word, because it requires the student to recall the sequence in its entirety. Reading requires orthographic *recognition,* while spelling requires orthographic *recall* and application. This distinction is the likely reason why most adults can easily read words like *licorice, license, colonel, hors d'oeuvres,* and *rendezvous,* yet have difficulty spelling them accurately (see Kilpatrick, 2015, p. 83).

What Do the Terms Orthography, Orthographic Processing, and Orthographic Knowledge Mean?

Confusion exists regarding the meaning of various terms associated with orthographic knowledge (Apel, 2011). In the broadest sense, *orthography* refers to the conventions of the writing system of a language. It is defined as "the system of marks that make up a printed language. For the English language, orthography includes upper and lowercase letters, numerals, and punctuation marks" (Wagner & Barker, 1994, p. 245). *Orthographic processing* is the function through

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which the brain acquires orthographic knowledge. It includes forming, storing, and accurately and rapidly retrieving (a) individual letters, (b) letter sequences that make up common spelling patterns (e.g., *–et, –im, –ight, –ould*), and (c) letter sequences that make up whole words (Cunningham et al., 2011; Ehri, 2005). *Orthographic knowledge* is the information stored in memory regarding how to represent spoken language as written language, including the visual representations of specific words, commonly occurring combinations of letters, and the rules of a language regarding how speech is represented in writing (Apel, 2011; Georgiou et al., 2021).

Orthographic Mapping and the Development of Sight Word Reading

Orthographic mapping is the cognitive process by which readers associate speech sounds

with written letters (phoneme-grapheme associations) in a written word to store it for immediate retrieval "on sight." New readers learn sound-symbol associations and begin to sound out words by retrieving the sound of each letter, left to right, and then blending the sounds into a word. Typically, after a beginning reader has sounded out the same word several times, its letter patterns are mapped to its sounds, and the word becomes stored in long-term memory with its sound and meaning. This now-familiar word becomes a "sight word." Unfortunately, in schools the term sight word gets used in multiple ways (see sidebar). However, researchers in the area of orthographic learning use it in one way: a *sight word* is a word that has been previously encountered, typically multiple times, and learned to the point that it becomes instantly recognized. This is true regardless of whether the word is frequent or infrequent, or phonetically regular or irregular (see sidebar). A pool of sight words is referred to as an individual's *sight word vocabulary* or *orthographic lexicon*. The point here is that a word's letter sequence must get "mapped" onto its sounds and meaning in long-term memory (Ehri, 2007, 2014). Subsequently, when the word is encountered in text, the reader recognizes it, triggering both its pronunciation and meaning (Share, 1995).

Ehri's Orthographic Mapping Theory

One prominent theory that explains how skilled readers acquire the tens of thousands of words that are instantly recognized is Ehri's *or-*

thographic mapping theory (Ehri, 2007). In this developmental sequence, phonemic awareness is the necessary foundation on which orthographic memory is built (Miles & Ehri, 2019). As young readers use phonemic awareness and phonic decoding skills to sound out words, they pass through overlapping phases of sight word development. Before mastering alphabetic knowledge, beginning readers form associations between visual cues and spoken words but are unaware of letter-sound associations (e.g., they recognize the *M* for McDonald's). They first note an association between the most prominent sounds in a word and the representative letters, then progress to sounding out a word letter by letter, and finally they say the word. After sounding out a given word several times, its letter sequence becomes bonded with the sounds in the spoken word as well as its meaning in memory. Also, with more reading experience, readers recognize common letter patterns in words, such as digraphs, diphthongs, and morphemes (e.g., *th, ou, tion*), which are then stored in memory along with their sounds. As readers master more and more orthographic patterns in printed words, their sight vocabularies grow exponentially (Ehri, 2005, 2007, 2014; Kilpatrick, 2015, 2020). Quick access to these orthographic representations in memory then facilitates fluent reading and comprehension (Cunningham et al., 2011).

Dyslexia in Relation to Phonological and Orthographic Weaknesses

Readers with dyslexia typically have difficulty with some or all of the following abilities: developing phonemic awareness, establishing stable phoneme-grapheme associations, and developing accurate and fast recognition of words. Consequently, these readers do not develop a strong phonics foundation on which to map letter sequences and word parts, slowing the development of a sight vocabulary. The reader often guesses at words when reading and over-relies on context clues to identify words. Recent research suggests that children with dyslexia are as likely to have difficulties in orthographic knowledge as in phonological awareness and rapid automatized naming (Georgiou et al., 2021).

Typical readers with accurate and efficient phonemic awareness and phonic decoding ability automatically create orthographic images of decoded words in memory. Readers with a weakness in the ability to process orthographic information are less likely to perceive the orthographic pattern initially; thus, no stable memory for the letter sequence is established. Subsequently, when they see a word, even if

they have seen it multiple times before, that word does not register as familiar or activate its pronunciation. Consequently, they depend on sounding out words for identification, acquire sight words more slowly, read less fluently, and spell words phonetically. Some students,

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Once a word has been retrieved and spelled, a writer may examine it to see if it "looks right." While this may seem like a visual memory task, it more likely involves determining if the sequence gets a "direct hit" in the orthographic lexicon.

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however, especially those with strong oral language, are good readers but poor spellers, because they form only partial orthographic representations in memory. This is likely because, as stated above, a more firmly established orthographic image is required for spelling than for reading. In addition, readers with strong oral language abilities are supported by passage context and vocabulary knowledge when reading, which helps them to identify words that are not well established in orthographic memory. This support is not available while spelling.

Accurate spelling requires retrieval of each letter or letter combination in the correct sequence. Once a word has been retrieved and spelled, a writer may examine it to see if it "looks right." While this may seem like a visual memory task, it more likely involves determining if the sequence gets a "direct hit" in the orthographic lexicon. For example, both *train* and *trane* are accurate spellings phonetically, but only *train* is spelled correctly. *Train* may be sufficiently established in orthographic memory to read it correctly, but not to spell it reliably. Thus, when checking if it looks right, *train* may get a direct hit, while *trane* finds no entry in the orthographic memory system, which is why it doesn't look right. When a reader who has a limited sight word vocabulary is asked which word looks right, the response is likely to be, "Words never look right to me" (Willows & Terepocki, 1993, p. 35).

Types of Orthographic Errors in Reading and Spelling

In the past, certain types of errors have been described as associated with a weakness in orthographic knowledge.

In **reading**, these include:
- difficulty learning and remembering words with an irregular element
- continuing to sound out words after many exposures
- over-relying on context for word recognition
- confusion of little words that share some letters (e.g., *of/for*) and similar-looking letters and words (e.g., *b/d*, *on/no*)
- slow word perception and reading rate

In **spelling**, the types of errors include:
- representing all or most of the phonemes in the correct sequence, but with incorrect graphemes
- reversing certain letters (e.g., *b* and *d*) and transposing little words (e.g., *saw* and *was*)
- spelling common high frequency words as they sound (e.g., spelling *they* as *thay*)
- regularizing the irregular element of exception words (e.g., *spelling said* as *sed*)
- spelling the same word inconsistently
- violating rules of English spelling by creating illegal letter strings (e.g., spelling *watch* as *wacth)*

Adapted from Willows, 1991, p. 170

As children develop in reading, they acquire an implicit knowledge of permissible letter sequences (Hultquist, 1997). This knowledge, however, does not evolve as quickly in readers with weaknesses in orthographic processing.

Case Examples

It is often easier to understand students' difficulties by looking at examples of their writing and spelling rather than analyzing their reading errors. The following three cases illustrate the writing of students with weaknesses in orthographic processing.

Spence: Below is a writing sample with a translation from Spence, a fifth-grade student who reads several years above his grade level. Although there is some evidence of phonemic processing errors (e.g., omitting sounds, vowel confusions), there are also many orthographic errors.

Within the last two lines, he has spelled the word *again* four different ways with each being a fairly accurate phonetic spelling. In his title, he spells the word *beams* as *beems*, but then near the end, he spells it as *dens*. He reverses the letter *b* in the words *beams* and *behind* and breaks the word *because* into two words. On the first line, he has slowly and carefully sounded out *night*, capturing the long *e* sound before the *t*. One interesting fact was that after Spence finally learned how to spell the word *police*, the police appeared in every story he wrote.

One Hi beems dark night a lade lift The Unuvsed. She got in to her Van and Stated home. Wine the lade got home She Called Police be cuse theman dehnd tren on his hi dens augene and augen agen and agene...

Lopter is made of gas and mabe Venes to be egzakt thar cak mercere Venes Erth mars, Lupiter, Sate uyraniss ploto neptun. Thay hav lust resently Descouverd to new planits Thos

> **High Beams**
>
> One dark night
> a lady left the
> university. She got into
> her van and started home.
> When the lady got home
> she called the police
> because the man behind
> turned on his high beams
> again and again
> again and again…

> Jupiter is
> made of gas
> and maybe Venus.
> To be exact, they're called
> Mercury, Venus, Earth,
> Mars, Jupiter, Saturn,
> Uranus, Pluto, Neptune.
> They have just
> recently discovered
> two new planets. Those…

Additional examples of his attempted spellings from an essay are presented below. Just from viewing this small set of words, it is clear that Spence is listening to the sounds in words and that he also has a strong vocabulary.

In the next excerpted writing sample describing the planets, Spence wrote several words with a reversed letter *j*. In the second line, he spelled the word *made* as *mabe* and then the word *maybe* as *mabe* as well. Again, he spelled words the way they sound, such as *egzakt* for *exact,* rather than the way their sounds are represented in English orthography. Also, note how he does not realize that English words rarely end in the letter *v* (e.g., *hav*). This illustrates how a word can be read accurately hundreds of times if one has sufficient orthographic recognition for reading, and still not be mapped sufficiently to enable full recall of the word's spelling.

Fantastick
Amazing
Colosol
energeAfishint
inpurveus
Hethy
gloreus

> fantastic
> amazing
> colossal
> energy efficient
> impervious
> healthy
> glorious

Aaron. Aaron is in the eighth grade. He has received three years of special education services. Unlike Spence who had no difficulty with reading, Aaron struggles with both reading and spelling. His teacher reports that he is still about two years behind in reading but is progressing quite well. A writing sample from Aaron with a translation is presented below. His teacher provided him with the spelling of the title: Mystical Creatures.

A severe discrepancy exists between Aaron's ideation and his spelling. He spells several common irregular words incorrectly but attempts to preserve the sound structure of the words (e.g., *wee, sum, wher, wen, lokt*). The spelling of the word *visited* as *vizzated* does not look like a possible English spelling, but it captures all of the sounds in the correct sequence.

> Mystical Creatures
>
> Hi my name is fred.
> I'm the most unuique ~~mystical~~ mystical creature
> in the planit.
> Becos I can travle throw time demnchins.
> And I have the body of a garla and the
> weings and ~~tall~~ tell of a dragген,
> The demchin ~~I~~ I lev in is cald the land
> of ~~mystical~~ mystical creaturEs.
> One day me and my wife talk about
> doing sum time traveling.
> wee did not now wher we wanted to travle
> to so we lokt at the map's we hade.
> Her is one I hard Julie call out wht is
> it I ask.
> she brot it over and it red planit erth.
> I thot about it and I rolized we have
> never vizzated this planit.
> And that is wen the trable began.

Mystical Creatures

Hi, my name is Fred.
I'm the most unique mystical creature
In the planet.
Because I can travel through time dimensions.
I have the body of a gargoyle and the
wings and tail of a dragon.
The dimension I live in is called the land
of mystical creatures.
One day me and my wife talked about
doing some time traveling.
We did not know where we wanted to travel
to so we looked at the maps we had.
Here is when I heard Julie call out. What is
it I ask?
She brought it over and it read planet Earth.
I thought about it and I realized we have
never visited this planet.
And that is when the trouble began.

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Melinda. Melinda was a senior in college when she wrote the response seen above to a test question.

Even though Melinda read all of her class assignments, she complained that it took her forever to complete them. Her other difficulty, a continuing source of frustration to her, was her spelling and poor punctuation. Her misspelled words are mostly phonetically accurate (e.g., *exselirate*), but she still makes spelling errors on common words that she has read thousands of times, such as *child*, *parents*, and *learning*. She spelled *they're* differently twice in the same sentence, and *parents* once incorrectly, and then correctly. Despite the amount of reading she has done, she has not mastered common spelling rules (e.g., drop the *e* before adding *ing*) or syllable patterns (e.g., *exampel*). Her pattern of errors is typical of a person with a severe weakness in orthographic memory.

Assessment of Orthographic Learning

While orthographic knowledge is obviously central to skilled word recognition, a general consensus does not exist on the best way to measure this ability (Olson et al., 1994). Over the past few decades, several types of measures have been used in research as well as on standardized tests. Some of the first measures that were developed included orthographic and homophone choice tasks (Stanovich & West, 1989).

In orthographic choice tasks, the reader chooses the word that is spelled correctly from two options that sound alike—a correctly spelled word and a pseudo-homophone (e.g., *sleep-sleap;* Manis et al., 1990). Olson et al. (1994) explained that in this type of task, although phonological processing may occur, it is not sufficient to make a decision about the accuracy of the spelling because both letter strings sound exactly the same. Precise memory for the correct letter sequence is required.

In homophone choice tasks, the reader is asked a question and then must choose the correct answer from two homophones (e.g., Which is a flower? *rows* or *rose;* Stanovich & West, 1989). In a similar task, the individual listens to a sentence such as, "The flower is a rose," and is then presented with a word that is either the correct one (e.g., *rose*) or an incorrect homonym (e.g., *rows*; Manis et al., 1990). Here, both alternatives could potentially be in the student's orthographic lexicon as a familiar sequence, but only one is correct in terms of the meaning needed to answer the question.

Another format involves a letter string choice task where the person is presented with two pseudowords, one of which contains an impermissible letter pattern. The person must choose the word that looks more like a real English word (e.g., *delk* or *dekl;* Siegel et al., 1990; Treiman, 1993).

Orthographic processing has also been measured by asking students to identify letter orientation errors (Badian, 2005) and to read and spell exception (irregular) words. Reading exception words measures a reader's skill in recognizing words instantly (Coltheart, 1978). Since the irregular part of the word has to be stored in memory and cannot be determined by sound alone, these tasks require orthographic processing. Although the use of these types of tasks has been criticized because they measure skill in both word recognition and spelling (Burt, 2006), determination of the correct response requires more than just phonological decoding, so they genuinely measure a student's orthographic memory for those words. Furthermore, a measure such as the letter string choice task (discriminating between legal and illegal spelling patterns) is not based on prior word-specific knowledge (Siegel et al., 1990), but rather on memory for common spelling patterns in written English. In 1994, Berninger noted that the lack of consensus on how to best measure orthographic processes has impeded progress. This observation is still true.

Beginning Readers

It is difficult to determine orthographic processing weaknesses in beginning readers as they have not had sufficient print exposure to develop robust memories of orthographic sequences (Stanovich & West, 1989). The development of phoneme awareness/proficiency and orthographic mapping is essential for the development of skilled orthographic processing. Thus, readers who have had limited exposure to print or who have weaknesses in phonemic processing may appear to have issues with orthographic processing. In reality, however, their difficulties may stem from weaknesses in phonemic processing, limited instruction, or inadequate opportunities with print. To help build students' orthographic knowledge in preschool and kindergarten, teachers should introduce words orally, and also write the words for the children to see (O'Leary & Ehri, 2020).

Instruction and Intervention

Although some uncertainty still exists regarding the best ways to intervene with students who have weaknesses in orthographic knowledge, initial instruction in reading should begin with a focus on developing grapheme-phoneme correspondences along with instruction in both phonemic blending and phonemic

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Reading and spelling instruction should be integrated so that every reading rule is taught along with the corresponding spelling rule.

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segmentation (skills needed for orthographic mapping), coupled with reading practice. Reading and spelling instruction should be integrated so that every reading rule is taught along with the corresponding spelling rule.
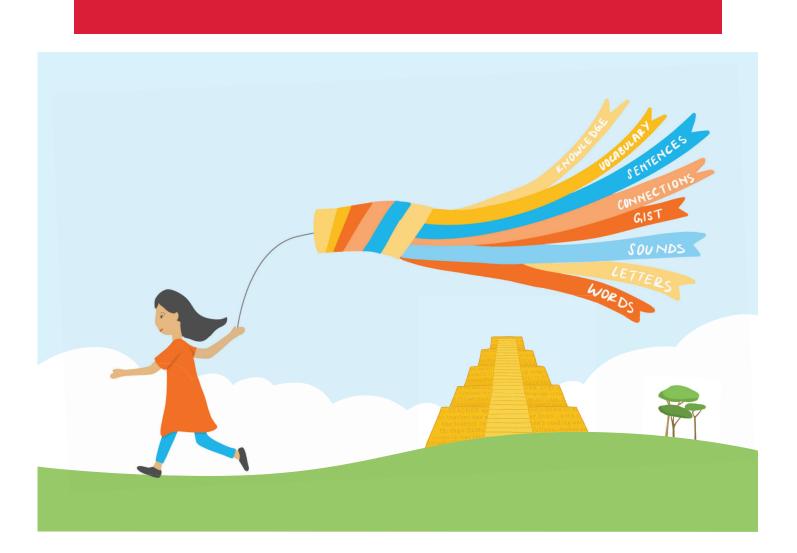
A good initial sequence of instruction for spelling would be (a) providing instruction in phoneme blending and phoneme segmentation; (b) using tasks and materials that reinforce the connections between the phonemes and graphemes and that involve the accurate sequencing of sounds; (c) teaching common letter sequences, letter patterns, and morphemes; and (d) reviewing and practicing spelling rules. Instruction in irregular words should be integrated slowly into the lessons, drawing attention to the irregular part of the word by

highlighting, circling, or color coding it. While researchers have not directed much attention to the practice, decades of practical experience in teaching have suggested that multimodal presentations of letters, word parts, and words may be useful, such as having a student say the letter or word, trace the letter or word several times while saying the letter sounds, and then write the word from memory.

Past first grade, the development of phonemic proficiency, which appears to be facilitated by training of skills using phonemic substitution and deletion activities, will help readers develop more detailed and automatic analyses of the internal structure of words and acquire increasingly explicit and more solidly established orthographic representations (Kilpatrick, 2015). Overall, the most effective interventions for students with weaknesses in orthographic processing include phonemic manipulation activities, systematic phonics and spelling instruction, and fluency building activities.

Remaining Questions

Although controversy still exists regarding the exact role of orthographic processing in reading and spelling, clearly, some individuals with dyslexia have trouble storing and retrieving specific letter sequences in words, which affects both their reading and spelling development. Kilpatrick (2015) differentiates between visual memory, which has little to do with reading, and orthographic memory (the ability to establish and retrieve specific letter sequences), which is necessary for both reading and spelling. Learning sight words is not based on picture-like retrieval of whole words, but rather on mapping written words to their pronunciations (Miles & Ehri, 2019). Because some readers with dyslexia have deficient orthographic learning processes and only develop partial representations of spelling patterns and words, the formation of these connections is much slower to develop (Ehri & Saltmarsh, 1995). The goals should be to help them develop phonemic awareness skills and, subsequently, the accuracy and automaticity of word reading skills displayed by their typically developing peers.

Why is this mapping such an easy process for most readers, but so slow to develop for others? Although the development of orthographic knowledge clearly depends upon both phonemic awareness and print experience, how do we explain students like Samantha whose data was described at the opening of this paper and Spence, who have advanced oral language proficiency, good phonemic awareness (at least on untimed tasks), and are avid readers, but poor

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spellers? Most likely they have acquired partial representations of words that are sufficient for reading but not for spelling. Why is Melinda an accurate but slow reader, and why does Aaron struggle with both reading and spelling? Are their representations of words even more impaired, thus compromising both areas of literacy development?

Final Thought

For typically developing readers for whom sight word acquisition happens with such ease, orthographic knowledge seems to develop as a matter of course. For struggling readers and spellers, including some students with dyslexia and/or dysgraphia, a weakness in orthographic processing is a major contributing factor to their reading and spelling difficulties. These students require skillful intervention. ∎

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Nancy Mather

Nancy Mather is a Professor Emerita at the University of Arizona in Tucson. She has served as a learning disabilities teacher, a diagnostician, a university professor, and an educational consultant. She has published numerous articles and books and conducts workshops on assessment and instruction both nationally and internationally. Dr. Mather is a coauthor of the *Woodcock-Johnson IV*. Her most recent book on dyslexia is *Essentials of Dyslexia: Assessment and Intervention*. She is currently working on the Tests of Dyslexia, a comprehensive measure designed to help identify individuals with dyslexia, as well as the *Test of Orthographic Competence* (2nd ed.), a measure designed to identify weaknesses in orthographic knowledge..

Lynne Jaffe

Lynne Jaffe, Ph.D., recently retired from a full-time private practice in psychoeducational evaluation, consultation, and educational therapy for students with dyslexia and comorbid disorders and was an adjunct assistant professor in the Department of Disability and Psychoeducational Studies at the University of Arizona. Her professional history includes work as the learning disabilities specialist on a statewide consultant team for the Arizona State Schools for the Deaf and the Blind, as well as in schools for court-adjudicated adolescents. She has coauthored four books on report writing for psychologists and diagnosticians, and was the lead consultant for the American Printing House for the Blind in adapting the Woodcock-Johnson III and IV test batteries for braille readers.

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