Chapter 4
Orthographic Mapping Facilitates Sight Word Memory and Vocabulary Learning

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Abstract Efficient word reading involves retrieving familiar written words from memory automatically by sight, and sounding out letters or guessing from context only when unfamiliar words are encountered. The process of storing written words for later immediate recall occurs through a process called orthographic mapping. This process involves connecting pronunciations to the written letters that represent those pronunciations in memory. It is not based upon visual memorization of picture-like forms of words. Letter sound knowledge and phonemic awareness are central to the orthographic mapping process. Four phases of development portray sight word learning that results from orthographic mapping. Studies show that orthographic mapping facilitates vocabulary learning.

To read text efficiently, one must be able to retrieve words from memory automatically by sight without analyzing letter by letter to decode them. This reliance on sight word reading frees up mental space for comprehending the meaning of the text. Efficient adult readers have a vast sight word memory bank from which to instantaneously retrieve the pronunciations and meanings of words. Emergent readers face the task of building their sight word memories through repeated exposure to written words. To understand how reading skill develops, one must explain how emergent readers achieve competence in reading words accurately and automatically. This chapter explains how the ability to store words in memory as sight words is governed by the reader's orthographic mapping skill.

Orthographic mapping refers to the process of connecting letters in the spellings of words to sounds in their pronunciations. This becomes possible once readers learn the alphabetic writing system, that is, how letters systematically symbolize sounds and how to distinguish those sounds in pronunciations of the words. Orthographic mapping is applied when words are read and also when words are spelt. This secures

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spellings of the words in memory and enables students to read words by sight and to spell words. Note that this is very different from the commonly held view that sight words are read by ignoring letter-sound relations in words and reading them in another way, by implanting strictly visual, picture-like forms of words in memory through repeated practice and memorization. Research has shown that this is not the case. More will be said about this subsequently.

It is important to clarify our view of sight word learning. The term may be interpreted in one of the three ways. To some, it refers to a method of instruction to teach sight words by giving students a set of flashcards to practice reading. To some, it is limited to the learning of irregularly spelled, high-frequency words. To others including us, it designates a process that involves readers' storing the spellings, pronunciations, and meanings of words in the brain for later activation when a text is read. It is important to recognize these distinctions. In the current chapter, the *process* of sight word acquisition is discussed separately from any method of instruction and is not limited to any specific word type. We use the term sight word to refer to what the mind does to store all types of written words in memory so that the spellings, pronunciations, and meanings of these words can be retrieved as soon as the readers' eyes alight upon the words, hence the term *sight* word (Ehri, 1992, 1998, 2005b; Kilpatrick, 2015). In this chapter, studies that support the explanation of sight word acquisition are discussed along with studies clarifying the effects of different instructional methods on sight word learning.

For proficient readers, practically all words are read from memory by sight (Ehri, 2014). Accumulation of sight words has occurred over time and through repeated exposure to spellings of words in and out of text (Ehri, 1992, 1998, 2005b). These readers are proficient because pronunciations and meanings are activated automatically when the written words are seen, allowing readers to expend their mental energy comprehending the text (Ehri, 2005b). Not only do proficient readers have the ability to automatically recognize words in print, but also they are able to read the words as single written units, without any pauses between parts of the word (Ehri, 2014).

Evidence that readers recognize words as single whole units (called *unitization)* was demonstrated in an experiment by Ehri and Wilce (1983) in which they assessed younger (second grade) and older (fourth grade) readers' ability to read familiar object words (i.e., *book*), consonant-vowel-consonant (CVC) nonwords (i.e., *baf*), and to name single digits (i.e., *4*, *3*, or *6*). Response latencies were measured. Results showed that the words children had already learned to read were read more quickly than unfamiliar nonwords and in fact were read as quickly as naming single digits. These findings indicate that familiar words are read as single whole units rather than as letters processed sequentially. Dehaene (2009) also found evidence that sight words are read by parallel processing, that is, with all the letters in a word processed at once, instead of sequentially.

All written words when practiced become sight words, not just high frequency or irregularly spelled words (Ehri, 1992, 2005b, 2014). However, even proficient readers come across words in print that are unfamiliar. In these instances, they must fall back on word-reading strategies in order to determine the pronunciation and meaning of the words. These are the same strategies that beginning readers use in order to determine

the correct pronunciation of unfamiliar words. These word-reading strategies may be applied by readers more than once until the word is stored as a sight word.

One possible strategy for reading an unfamiliar word is analogizing (Goswami, 1986; Ehri, 1998, 2005b, 2014). This entails finding a similarly spelled known word in memory and using it to read the new word. An example is using the word *mountain* to read *fountain*. Another strategy is prediction (Ehri, 1998, 2005b, 2014; Goodman, 1970; Tumner & Chapman 1998). This involves relying on picture, sentence, and letter clues to guess the unknown word. A third strategy is to apply knowledge of graphemes and phonemes in order to decode the unknown word. Phonemes are the smallest sounds in words (e.g., the word *she* has two phonemes), and graphemes are the letters that regularly symbolize phonemes in the writing system (e.g., *she* has two graphemes, SH and E). In order to apply a decoding strategy effectively, readers must match the graphemes to their corresponding phonemes blend the sequence to pronounce the unit, and then find the word in their mental lexical to recognize its meaning (Ehri, 2014).

As readers advance in their grapheme–phoneme knowledge of the writing system and their memory for sight words, they acquire and apply their knowledge of larger grapho-syllabic units (e.g., *-tion, -ing, -ump*) in order to make the decoding process more efficient (Bhattacharya & Ehri, 2004; Ehri, 2014; Moats, 2010). Due to the variability and irregularity of the English writing system, grapheme–phoneme decoding may not produce a recognizable word match in memory. In these cases, readers must be flexible and try out alternative pronunciations of the words in order to uncover the appropriate pronunciation matching a real word (Elbro, de Jong, Houter, & Neilsen, 2012; Tumner & Chapman, 2012).

Ehri (1992, 1998, 2005b, 2014) explains that through repeated practice forming connections between graphemes and phonemes or grapho-syllabic relations, the spellings of words become bonded to their pronunciations via orthographic mapping. This connection-forming process stores words in memory by gluing spellings to their pronunciations and meanings to enable automatic sight word reading (Ehri, 1980, 1992, 1998, 2005b, 2014; Perfetti, 1992; Rack, Hulme, Snowling, & Wightman, 1994). Similarly, Share's (2004, 2008) self-teaching hypothesis suggests that decoding supports orthographic learning of words. According to the self-teaching hypothesis, translating the printed version of a word into its spoken form is the primary way in which the orthographic representations of words are learned. The decoding process directs readers' attention to the individual grapheme–phoneme relations in specific words and thus supports storage of the order and identity of the letter strings.

Examples of connections (both grapho-phonemic and grapho-syllabic) that readers may form to learn sight words are illustrated in Fig. 4.1. Capital letters represent the spellings of the words. Spaces are used to distinguish the letter units that map onto phonemes, syllables, or morphemes (i.e., smallest meaningful units in words). Arrows represent connections between the written and spoken units.

This connection-forming process also bonds letters to sounds in irregularly spelled words. As depicted in Fig. 4.1, most graphemes in irregularly spelled words map onto predictable phonemes. The letters that do not conform or are unpredictable include

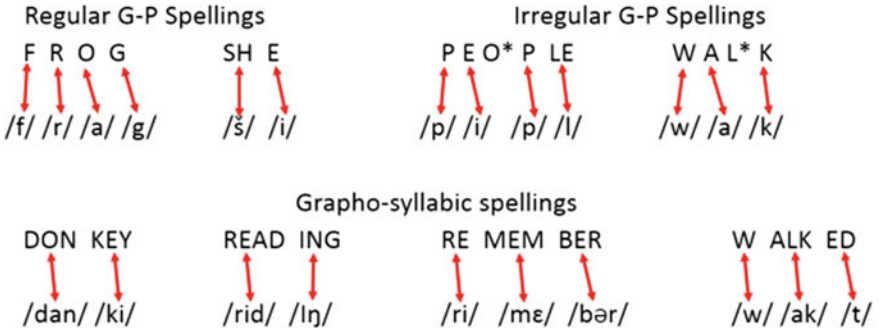

Fig. 4.1 Examples of connections to retain sight words in memory. *Note GP* grapho-phonemic. Capital letters = spellings. Spaces separate graphemes or spellings of syllables or morphemes. Lower case letters and symbols between slashes are IPA phonetic symbols far phonemes. Arrows = connections. * = silent letter

silent letters (indicated by an asterisk) and letters representing schwa vowels that lack a distinctive sound in unstressed syllables (e.g., schwa pronounced "uh" in the second syllable of *chicken*). Silent letters or letters spelling schwa vowels might be remembered as extra visual letter units. Alternatively, they might be more easily remembered if students create special mnemonic spelling pronunciations (e.g., *listen* pronounced "lis-ten"; *chocolate* pronounced "choc-o-late;" *chicken* pronounced "chick-en"), or if they recognize the letter as a member of a familiar multi-letter spelling pattern (e.g., *-alk* with a silent L in *talk, walk, chalk*) (Drake & Ehri, 1984; Landerl & Reitsma, 2005; Ocal, 2015). Thus, most if not all of the letters in irregularly spelled words can be stored in memory using the same connection-forming process as is used to remember regularly spelled words.

4.1 Requisite Skills for Successful Orthographic Mapping

Readers' phonemic awareness and knowledge of letter-sound regularities enable them to form connections between the spellings and pronunciations of words in order to store the bonded word units in memory (Ehri & Roberts, 2006; Ehri, 2005b, 2014). Studies show that children who have the ability to segment words into sounds and to identify letter names and sounds progress faster in their ability to learn to read than children who do not have these skills (National Reading Panel, 2000; Share, Jorm, MacLean, & Matthews, 1984). Phonemic awareness enables readers to segment and blends the sounds in pronunciations of words. Letter-sound knowledge enables readers to match graphemes in spellings to their corresponding phonemes in pronunciations of words. These grapheme–phoneme connections provide the glue for sight word storage. Studies have demonstrated how training in phonemic awareness and letter knowledge improves readers' ability to read words from memory (Boyer & Ehri, 2011; Ehri & Wilce, 1987; Shmidman & Ehri, 2010). Also phonemic

proficiency, that is, the ability to process the phonemes in mapping relations quickly, contributes to word-learning skill (Kilpatrick, 2018; Kilpatrick & O'Brien, Chap. 8 this volume).

4.1.1 Phonemic Awareness

Castiglioni-Spalten and Ehri (2003) investigated the impact of phonemic segmentation instruction on beginning readers' ability to read new words. Kindergartners were assigned to three conditions: mouth treatment, ear treatment, and no-treatment control. In the mouth condition, students were trained to identify pictures of articulatory gestures that corresponded to the sequence of sounds in pronunciations of target words. The ear treatment was taught to represent the sequence of sounds in the target words with blocks. At the end of the training, both treatment groups outperformed the control group in phoneme segmentation skill. In addition, both treatment groups were able to spell the sounds in target words even though spelling words with letters was not taught. Interestingly, the mouth group trained with articulatory gestures was the only group to show the benefit of segmentation training in a sight word learning task. In this task, children practiced learning to read words over several trials.

In a follow-up study, Boyer and Ehri (2011) trained preschoolers to segment CV (consonant-vowel), VC, and CVC words into phonemes using either mouth pictures and letters, or only letters. Students were randomly assigned to one of two training conditions or to a control condition: (1) letters plus pictures of articulatory gestures (LPA), (2) letters only (LO), and (3) no treatment. Students in the LPA group were taught relationships between 15 graphemes and phonemes as well as relationships between pictures of articulatory gestures and spoken phonemes. Then they learned how to segment the training words into phonemes by representing them with these mouth pictures as well as with the letters. For example, segmentation of the nonword "po" was depicted with two pictures, the first showing lips closed and the second showing lips open and rounded; "po" was spelled with the letters P and O. Students in the LO group learned 15 grapheme-phoneme associations and how to use these associations to segment and spell the same words and nonwords. On a sight word-learning task following training, students in the LPA group learned to read the words more easily than the other two groups, and this advantage persisted on a one-week delayed posttest. The findings from both Castiglioni-Spalten & Ehri (2003) and Boyer and Ehri (2011) demonstrate the facilitative effect of phonemic segmentation training with articulatory pictures on sight word reading for beginning readers.

4.1.2 Letter Knowledge

As previously mentioned, grapheme–phoneme knowledge is essential for sight word learning. Studies have shown that children who have knowledge of letter shapes and

sounds are better able to read words they have previously read than children who do not know letter names or sounds. Ehri and Wilce (1985) demonstrated that as children progress into learning to read words, they shift from processing their visual features to processing connections between letters and sounds. Roberts (2003) trained preschool children who were non-readers for 16 weeks on either letter names or comprehension-focused instruction (the control group) and then examined whether letter name training improved children's ability to learn to read two types of words. One set was spelled phonetically with letters mapping sounds in the words (e.g., LFT to spell "elephant"). The other set was spelled non-phonetically with letters that did not represent any sounds in the words but were more salient visually (e.g., XKO to spell "elephant"). Students who received letter name training learned to read words spelled phonetically better than the non-phonetic words, whereas the control group showed the opposite pattern, with the non-phonetic set learned more easily. These results show that when prereaders learn letter names, they can apply them in remembering how to read words. This is their entre into the alphabetic writing system and into building a sight word vocabulary by forming letter-sound connections.

The contribution of grapheme–phoneme knowledge to building a sight vocabulary has also been studied in a classroom-based longitudinal study. Ehri, Satlow, and Gaskins (2009) worked with first, second, and third graders enrolled in a school for struggling readers. They compared two-word reading instructional programs. The Key method trained students to read new words by analogy to keywords. The Key-Plus method also taught analogizing to keywords. In addition, Key-Plus students learned to retain spellings of the keywords in memory by analyzing mapping relations between graphemes and phonemes within the words. To learn a keyword, students first counted phonemes in its pronunciation, then they matched graphemes in its spelling to its phonemes and explained the regularities, then they spelled the word from memory. Students who received the Key-Plus program showed superior word reading and spelling abilities during the first two years compared to students in the Key program. However, differences were diminished during the third year as the latter group caught up. This study provides further evidence for the contribution of grapheme–phoneme knowledge and orthographic mapping to word reading during the primary grades.

Learning letter names and their corresponding sounds is essential knowledge for beginning readers because it is the basis for grapheme–phoneme mapping which is essential for sight word learning. Learning associations between all the letters and their sounds can be a tedious task for young children. Studies have shown that it can be made easier with the use of *embedded picture mnemonics*. This involves imposing letter shapes on drawings of objects whose shapes resemble the letters and whose names begin with the sound of the letter (e.g., the letter *h* drawn as a house or *s* drawn as a snake). Ehri, Deffner, and Wilce (1984) demonstrated the benefit of this approach with preschoolers, kindergartners, and first graders. Students were taught each of several letters, either with embedded picture mnemonics, or with disassociated pictures whose names began with sounds represented by letters but whose shapes did not resemble the letters (e.g., *s* associated with a snake coiled up), or letters without any pictures. Results showed that students taught with embedded pic-

ture mnemonics performed significantly better learning letter-sounds than students in the other two groups. Interestingly, the other two groups did not differ, showing that pictures unrelated to the shapes of letters did not facilitate letter-sound learning, even though their names began with the relevant letter sounds. The reason is that they failed to provide a memorable link between letter shapes and sounds.

Schmidman and Ehri (2010) replicated and extended these findings with English-speaking 5-year-old children learning Hebrew letters. Because the children did not speak Hebrew, letter-sound associations were taught with English labels for pictures. Children were taught Hebrew letter-sound relations either with embedded pictures mnemonics (i.e., Hebrew letter ש symbolizing the sound /sh/ was embedded in a drawing of a ship with the hull as the base and sails resembling the vertical lines) or with disassociated mnemonics (i.e., letter ש associated with a ship drawn as an ocean liner with no resemblance to the letter's shape). Letter-sound relations were practiced until children learned them all. Results supported previous findings (Ehri, Deffner, & Wilce, 1984). Letter-sounds taught with embedded pictures were learned more easily and were remembered significantly better in a one-week follow-up test. In addition, the embedded letters enhanced children's ability to learn to read English words written with Hebrew letters and to spell English words using Hebrew letters. These results underscore the foundational role of letter-sound knowledge in learning to read and spell words and the value of embedded picture mnemonics for teaching letter-sound relations.

4.2 Phases in the Development of Sight Word Reading

Beginning readers follow a developmental trajectory as they acquire reading and spelling skills. Ehri (2005a, 2014) has proposed four developmentally distinct phases that depict the progression in sight word reading and spelling abilities of beginning and emergent readers. Rather than being discrete non-overlapping stages, the phases are conceptualized as fluid and overlapping in the processes and knowledge sources used to read words. The phases are labeled to reflect the predominant type of spelling-sound connection that students use to remember how to read and spell words. The connections advance from non-alphabetic, visually salient connections to partial grapho-phonemic connections, to full grapho-phonemic connections, to grapho-syllabic connections. Characteristics and abilities of learners at the various phases are summarized in Table 4.1.

The *pre-alphabetic phase* is characterized by a lack of knowledge of the alphabetic system. Children in this phase do not possess knowledge of letter name or sound connections and therefore are unable to apply these skills to read and spell words (Ehri, 2005a). If children read words, it is because they remember some visual feature of the word. They may read *camel* by remembering the two humps or *look* by the two eyeballs in the middle (Gough, Juel, & Griffith, 1992). Children at this phase also rely on visual contextual clues from the environment. Examples include reading

Table 4.1 Summary of the emergence of knowledge, skills, and strategies characterizing Ehri's pre-alphabetic, partial alphabetic, full alphabetic, and consolidated alphabetic phases of development in learning to read and spell words

Pre-alphabetic	Partial alphabetic	Full alphabetic	Consolidated alphabetic
Limited or no letter knowledge	Most letter names and some GPCs	Major GPCs and some larger spelling units	Many grapho-syllabic and morphemic spelling units
Lack of phoneme segmentation	Partial phoneme segmentation	Full phoneme segmentation	
No GPC mapping	Partial GPC mapping; correct directional orientation to print	Complete GPC mapping	Grapho-syllabic and morphemic mapping as well as GPC mapping
Growing knowledge of spoken language: pronunciations, syntax, meanings of words	Growing knowledge of spoken language continues	Growing knowledge of spoken language continues	Growing knowledge of spoken language including morphemic units continues
Sight word memory			
Reading words by remembering salient visual or context cues; semantic substitution errors; no letter-sound connections; memory unreliable except for personal name	Reading words by remembering partial GPC connections; confusing similarly spelled words	Reading words by remembering full GPC connections; accuracy, automaticity, and unitization of word recognition are emerging	Reading words by remembering larger spelling units as well as GPC connections; accuracy, automaticity, unitization established for known words
Strategies to read unfamiliar words			
No word decoding ability	Little or no word decoding ability	Growing ability to decode unfamiliar words using GPCs	Proficient decoding of unfamiliar words using GPCs and larger units
Cannot analogize	Cannot analogize	Limited use of analogizing due to small sight vocabulary	Greater use of analogizing as sight word vocabulary grows
Words predicted from visual cues, context, pictures	Words predicted using initial letters and context	Prediction to support and confirm words decoded or read by analogy	Prediction to support and confirm words decoded or read by analogy
Spelling			
Non-phonetic spellings of unfamiliar words using scribbling, pseudo-letters, or letters	Partial phonetic spellings of unfamiliar words using letter names or GPCs	Complete phonetic spellings of unfamiliar words using GPCs	Grapho-syllabic and morphemic units as well as GPCs to spell unfamiliar words
No memory for correct spellings except for personal name	Limited memory for correct spellings	Good memory for correct spellings of many known words	Proficient memory for correct spellings of known words

Note: *GPC* grapheme–phoneme correspondences/connections

a *McDonald's* sign by recognizing the golden arches and reading a *STOP* sign by recognizing the red octagonal shape.

Masonheimer, Drum, and Ehri (1984) demonstrated pre-alphabetic children's reliance on visual and contextual clues in an experiment. The researchers took familiar signs and logos, such as the *PEPSI* logo, and changed one letter in the spelling (e.g., XEPSI). Children in the pre-alphabetic phase did not notice the difference and continued to read the label as if it was spelled properly. This occurred even when the experimenter warned children that there may be a mistake in the spelling. This showed that children were reading the environment rather than the print.

Reading words based on the visual clues is unreliable and insufficient to accommodate all the words necessary to become a proficient reader. As children begin to learn the names and sounds of letters, they transition to the *partial alphabetic phase*. Knowledge of letter names and sounds is used to read and spell words, although the connections made are incomplete. Children at this phase rely on the most salient sounds in a word (e.g., the */m/* and */d/* in *mud*), often the beginning and ending sounds, to form connections to letters. This creates confusion and causes reading errors when the beginning and ending sounds in two words are similar, for example, *step* and *stop.*

Children in the partial phase lack the ability to segment pronunciations into their full array of phonemes. They have difficulty blending a sequence of sounds to form words. They lack complete knowledge of grapheme–phoneme relations, especially vowel spellings. These limitations make it difficult for children in the partial alphabetic phase to remember how to read and spell words reliably, and to decode and generate spellings of unknown words. Children may use partial cues to guess words when they read, for example, reading *spin* as *spoon,* and they may spell *spoon* with only an *s* and *n.*

Ehri and Wilce (1985) examined the difference between pre-alphabetic and partial alphabetic phase readers. Kindergartens were distinguished by their phase of development. They were given practice learning to read two types of words, like those used by Roberts (2003) mentioned previously. One set of words contained visually distinct spellings that bore no relationship to the phonetic spelling of the word (e.g., *mask* spelled uHo). In the other set of words, letters represented sounds phonetically (e.g., *giraffe* spelled JRF). The results demonstrated that pre-alphabetic phase children learned to read the visually distinct spelling more readily than the phonetic spellings, whereas the partial-phase readers were better able to learn the phonetically spelled words than the visual words. These results support the claim that pre-alphabetic readers rely on visual cues to recall how to read words, but as children transition into reading, they focus on relations between letters and sounds, or phonetic cues in letters, to read words. Several researchers have replicated and extended these findings (deAbreu & Cardoso-Martins, 1998; Rack et al., 1994; Roberts, 2003; Scott & Ehri, 1989; Treiman & Broderick, 1998; Treiman & Rodriguez, 1999).

When children are able to form complete connections between letters in spellings and phonemes in pronunciations, children transition into the *full alphabetic phase*. This transition becomes possible when they learn the major grapheme–phoneme relations of the alphabetic system. To read an unfamiliar word, children in the full

alphabetic phase are able to decode, that is, to transform graphemes into a sequence of phonemes and to blend the phonemes to pronounce a recognizable word. To spell a word, children in this phase are able to segment a pronunciation into phonemes and match each phoneme with a letter that typically represents that sound. Readers learn sight words at this phase by forming complete connections between graphemes and phonemes and storing the spelling in memory bonded to its pronunciation and meaning. These processes work for the majority of words learned by readers at the full alphabetic phase. However, if spellings are irregular or contain letter-sound relations that children have not yet learned, they may have difficulty decoding the words or remembering complete spellings, and the connections stored in memory in these cases may remain partial.

Miles (2015) studied differences between children in the partial and full alphabetic phases in various literacy tasks. Kindergartners were grouped by phase based on their ability to decode CVC nonwords. Students were given practiced learning to read a set of sight words on flashcards over trials. Full-phase readers learned the words more readily than partial phase readers. On posttests, full-phase readers remembered the spellings of the words better than partial readers. Also they performed better on tasks to assess orthographic mapping, spelling, and sentence generation. Miles concluded that full-phase readers were better able to form full grapheme–phoneme connections of the words, as evidenced on the spelling task, and this enabled them to store more stable representations of pronunciations, spellings, and meanings of the word amalgams in memory.

As more words are retained in memory, readers transition into the *consolidated alphabetic phase*. At this phase, the increase in storage of written words is supported mainly by readers' ability to form grapho-syllabic connections. Use of larger letter chunks involving spelling patterns that recur in different words, including rimes, syllables, morphemes, and whole unitized words makes decoding and encoding sight words, especially multi-syllabic words, more efficient, and accurate than in the full phase. Whereas full-phase readers would need to process seven grapheme–phoneme connections to remember how to read and spell *computer*, readers in the consolidated phase would need only three grapho-syllabic connections, *com-put-er*, thus reducing the memory load.

The benefit of grapho-syllabic mapping was investigated by Bhattacharya and Ehri (2004). Adolescents who were reading substantially below grade level (i.e., third, fourth, and fifth grade-equivalent levels) were randomly assigned to two treatment groups or a no-treatment control group. The two treatment groups practiced reading 100 multi-syllabic words broken into four lists taught on different days. The syllable group analyzed grapho-syllabic units in the words by counting spoken syllables and then matching each to its spelling within the word. They read the lists in this way four times. The whole word group practiced reading the same words as whole units and practiced reading the lists six times. Results indicated that students who received grapho-syllabic mapping instruction performed better on tasks of reading and spelling practiced words and on a transfer task decoding novel words than the other two groups. These results support the claim that multi-syllabic words are more effectively stored in memory when grapho-syllabic connections are processed.

4.3 Word-Reading Experiences: Impact on Orthographic Mapping

As children progress through the primary grades, their word-reading skills are strengthened by various experiences reading words. They may receive intentional and explicit instruction in decoding new words, or they may simply be exposed to new words as they read books independently, or as they read labels posted around the classroom, or as they read single words on flashcards. It is important to consider the impact of these word-reading experiences. The ultimate goal is to have all words stored in memory as sight words. As previously explained, the most effective way to secure new words in memory is through orthographic mapping, that is, analyzing the grapheme–phoneme or grapho-syllabic units in words. Several researchers have investigated the effect of word-learning experiences on students' ability to store words in memory.

Ehri and Roberts (1979) examined how different word-reading experiences facilitate learning the identities of written words, including their pronunciations, meanings, and spellings. The authors hypothesized that different experiences may strengthen one identity more than another. First graders were randomly assigned to two groups. One group read target words embedded in meaningful sentences. The other group read single target words on flashcards and then heard each word spoken in a meaningful sentence. Homonym pairs such as *rows/rose* and *chews/choose* were used as the target words to study the process of attaching meanings to spellings while controlling for the pronunciations of words. Performance on posttests following learning supported the idea that word-reading experiences influence which identities of words are strengthened. Students who read words in context learned more about the semantic identities of words than students in the isolation group, as indicated by their ability to embed the words in semantically accurate sentences. However, students in the isolation group could read the words faster and remembered their spellings better than students who read the words in sentences.

Ehri and Wilce (1980) replicated and extended these findings by targeting only function words which are high-frequency words that include determiners (e.g., *the*, *that*), conjunctions (*and*, *but*), prepositions (*in*, *of*), pronouns (*she*, *they*), auxiliary verbs (*be*, *have*), modals (*may*, *could*), and quantifiers (*some*, *both*). The grammatical functions and meanings of these words are activated mainly when they accompany other words in sentences. Importantly, many function words appear on pre-primer and primer word lists and are among the first words taught to beginning readers because they are needed to construct a meaningful text.

Ehri and Wilce (1980) examined the role of word-reading experiences on first-graders' acquisition of the syntactic/semantic and orthographic identities of a set of function words. One group of first graders read function words embedded in meaningful sentences, while the other group read each word in isolation and then heard it used in a meaningful sentence. Results supported the previous findings of Ehri and Roberts (1979). The sentence reading group learned more about the syntactic/semantic identities of the words whereas the isolation group learned more about

their orthographic identities. One explanation for poorer orthographic learning in the sentence context group is that context readers spent less time looking at and decoding words in sentences because the context helped them identify the words and because their eyes quickly moved on to subsequent words in the sentence. Greater attention to and reliance on context reduced the opportunity for orthographic mapping to occur so that letters in spellings could become bonded to phonemes in their pronunciations. An explanation for weaker syntactic/semantic learning in the isolation condition is that when this group read the function words outside of a written sentence context, the grammatical relations of the words were not activated when they were read. It was only afterward when children heard the sentences that the relations were exposed. However, because the function words were buried in the spoken sentences, this very likely obscured readers' awareness of their grammatical role.

Word-reading experiences were also assessed by Johnston (2000) in first graders using predictable text in three different ways. The repeated reading group read the same predictable text ten times over the course of four days. The sentence context group read the predictable text chorally and then read the text on a chart without the illustrations and built the story using sentence strips. The word bank group underlined words they could read in the predictable text while they read unillustrated copies silently. The underlined words were then written on flashcards and practiced. Performance on immediate and delayed word recall tests revealed that the students in the word bank group learned to read the most words. While these results support the use of reading words in isolation, it is important to note that the words were taken from a meaningful text that the students practiced reading. This is unlike having students repeatedly read lists of isolated words such as Dolch words that remain disconnected from any context activating their meanings.

Because many common high-frequency words are irregularly spelled, it is believed that children learn to read and spell these words differently from regularly spelled words. Wang, Castles, Nickles, and Nation (2011) investigated whether embedding words in context or isolation impacts the orthographic learning of regularly and irregularly spelled words differently. These researchers first introduced the second graders to target nonwords orally by pronouncing the words and pairing them with picture cards showing their made-up meanings. After children learned the spoken words, they practiced reading their written forms four times either in a story context or in isolation on a list. Results showed that both regularly and irregularly spelled words were read more accurately in context than in isolation, presumably because context activated meanings to prime word memory. However, spellings of the words were not better remembered when the words were read in isolation than in context, contrary to findings cited earlier in other studies with younger children. On average over half of the regular spellings were recalled whereas only 15% of the irregular spellings were recalled correctly. Both reading and spelling errors on irregular words involved regularizations of the letter-sound correspondences. These findings show that the same processes affect the learning of regular and irregular words. Because spellings of the latter deviate from expected grapheme–phoneme relations, they are simply harder to learn.

Miles (2015) investigated the impact of word-learning experiences on native and nonnative English-speaking kindergarten students. They were taught to read words either embedded in meaningful sentences or displayed in isolation on flashcards. Results supported previous findings by showing that learning to read words was superior when words were read in isolation, whereas learning the words' syntactic and semantic identities was better when the words were read in contexts. The latter finding was evident in students' ability to produce more grammatically correct and contextually rich sentences. The same pattern held for both native and nonnative speakers.

Taken together, these studies show that word-learning experiences matter. The type or extent of information that is remembered about newly encountered words is influenced by whether the word is read in isolation or context and whether the word is regularly or irregularly spelled. To have a word securely stored in memory as a sight word, it is important for all of its identities to be represented, including its pronunciation, spelling, syntactic function, and meaning. Any instructional program designed for beginning readers should make provisions for all of these identities to become bonded together in memory to support growth in children's sight vocabularies.

4.4 Impact of Orthographic Mapping on Vocabulary Learning

The aforementioned theory and research reveal the essential role that orthographic mapping plays in sight word learning. In addition, orthographic mapping, the process that establishes the spellings of words in memory has been shown to be instrumental in vocabulary learning. This role is not commonly recognized. Vocabulary learning has been regarded mainly as a process of learning associations between pronunciations and meanings of new words without much regard for the involvement of word spellings. Rosenthal and Ehri (2008) point out that it is common for instructional programs to suggest many strategies that help students' learn new vocabulary words but to ignore the value of attending to the spellings of words. Recently several studies have shown that exposing learners to the spellings of words whose pronunciations and meanings are being learned boosts their memory for the words (Ehri, 2005b; Miles, Ehri, & Lauterbach, 2016; Lucas & Norbury, 2014; Mengoni, Nash, & Hulme, 2013; Ricketts, Bishop, & Nation, 2009; Rosenthal & Ehri, 2008).

A study by Rosenthal and Ehri (2008) reported also in Ehri (2005b) was one of the first to investigate this role. In two experiments, students were taught the pronunciations and meanings of several very low-frequency words. Second graders were taught six words, for example, *tot* (a young child) and *gam* (a family of whales), and fifth graders were taught ten words, for example, *vibrissa* (the whiskers on a cat), and *scrivello* (the tusks on an elephant). In both experiments, the words were pronounced, defined, presented in sentences, and accompanied by drawings of their meanings on flashcards. Students were given several practice trials through the words

to learn them. The words were divided into two sets for each age group. One set displayed the spelling of the word below the picture on study and feedback trials, but not when word pronunciations and meanings were being recalled. The experimenter did not draw attention to the spelling of the words but just exposed them beneath the drawings on the cards. The other set of words was not accompanied by any spellings during the study or feedback periods. However, students pronounced these words extra times.

Results showed that spellings facilitated vocabulary learning for both grade levels. Second graders performed better recalling pronunciations of words when they had seen spellings than when they had not seen spellings. Fifth graders were divided into high and low groups based on their reading and spelling ability. Both high- and low-ability groups remembered pronunciations better when words were accompanied by spellings than when they were not. This effect was especially strong for high readers. Seeing spellings also significantly boosted the fifth graders' memory for the meanings of words. Results demonstrated that spellings contribute to vocabulary learning in both younger and older readers. The explanation rests on facilitation from orthographic mapping. Seeing spellings of the words activates connections between graphemes and phonemes and bonds spellings to their pronunciations in memory. This serves to better secure these previously unfamiliar pronunciations and meanings in memory.

Phonological working memory has been regarded as playing a critical role in readers' memory for vocabulary words (Gathercole, 2006). However, results of Rosenthal and Ehri's (2008) study suggest that vocabulary learning is more reliant on orthographic memory than on phonological memory. Findings of their study showed very little difference between high- and low-ability readers in their memory for pronunciations of vocabulary words when spellings were not provided during learning, indicating an inconsequential difference in the phonological memory of stronger and weaker readers. However, there was a substantial difference between high and low readers in their memory for pronunciations of vocabulary words when they did see the spellings of words, suggesting that orthographic mapping skill, not phonological memory skill, is a better explanation of why good word-level readers have superior vocabulary learning skill compared to students with weaker word-reading skill.

Supporting Rosenthal and Ehri's (2008) findings, Rickets, Bishop, and Nation (2009) also detected orthographic facilitation in a vocabulary learning study with 8–9 year-olds who were taught pseudowords paired with novel meanings. In addition, the authors investigated the influence of orthographic consistency. Words were spelled either with reliable or variable grapheme–phoneme mappings (i.e., cases where consonants or vowels could be spelled in more than one way, for example, long *e* could be spelled *jeet* or *jeat*). Children learned pronunciations of the vocabulary words better when spellings were shown during study periods than when spellings were not seen. There was some evidence that variable vowel spellings produced more limited orthographic facilitation during learning, but by the final session, consistency exerted no differential effects. This indicates that in order to produce orthographic

facilitation, it is more important for spelling-sound relations to be systematic than to have only one unique orthographic form.

To further investigate the role of orthography in vocabulary learning, Rosenthal and Ehri (2011) examined the effect of reading novel words aloud versus silently. Fifth graders were randomly assigned either to an oral or a silent word-reading condition. Eight low-frequency words were selected from their previous study (Rosenthal & Ehri, 2008). A passage was created to teach the meaning of each word which was repeated three times and underlined in the passage. Students read the passages silently. However, students in the oral condition were instructed to say the underlined target words out loud when they came to them. Students in the silent condition were instructed to put a check next to the underlined words if they had seen them before. Results demonstrated that the oral decoding strategy better supported vocabulary learning. Students who read the words aloud performed significantly better on pronunciation-meaning association and spelling tasks. The authors note that while these effects were evident for both stronger and weaker readers, they were especially large for weaker readers. Results provide evidence for orthographic mapping effects. Pronouncing embedded words aloud while looking at the spelling of the words supports the formation of connections between spellings, pronunciations, and meanings, and this better secures the new vocabulary words in memory. Because weaker readers are more likely to skip over unfamiliar words without decoding them, being required to decode the words exerts a bigger impact on their vocabulary learning.

Miles et al. (2016) also examined the effect of orthography on vocabulary learning for native and nonnative English speakers. College students who had learned English as a second language and native English speakers were both taught the meanings and pronunciations of very low-frequency words. Words were pronounced, defined orally, and depicted. Learners were exposed to spellings during learning but not during testing in one condition but they were not shown spellings in the other condition. Results indicated that exposure to spellings improved memory for the words' pronunciations but not for their meanings. The authors note that ceiling effects may have precluded the detection of a difference on the meaning task. Interestingly, native English speakers outperformed nonnative speakers on memory for pronunciations even though the two groups were enrolled at the same university and did not differ in GPA, word decoding ability, or English vocabulary knowledge. Why orthographic facilitation was not as strong among nonnative speakers awaits further study.

4.5 Types of Words Read by Beginning Readers

Words differ in the extent that the activation of their meanings is dependent on the presence of other words. Whereas nouns can be meaningful by themselves, verbs and function words require contexts. Both Ehri (1975) and Morris (1992) found that context -dependent words were more difficult for children to distinguish and use than context-independent words. Children who had not yet learned to read were unable to distinguish context-dependent words as separate units in sentence

segmentation tasks. Often they combined these words with adjacent content words and based segmentation on stress points rather than word units. For example, three words were detected in the following sentence, with stress points in bold: The**dog** /is**sleeping**/onthe**rug**/. Beginning readers also demonstrated difficulty distinguishing context-dependent words as separate units in a finger-point reading task requiring them to point to each word as they recited a sentence (Morris, 1992). Both studies revealed that young children lack awareness of context-dependent words as separate units of speech. It is not until they see these words in print and learn to read them that they become aware of their separate identities (Ehri, 1975).

To confirm that activation of meanings is diminished for context-dependent words compared to nouns and adjectives when the words are presented out of context, Ehri (1976) investigated the impact of word class in a paired associate word-learning task. Five high-frequency unambiguous words from each of the following word classes were taught: a noun, adjective, past tense verb, preposition, and function word. Each word was paired with a distinctive visual squiggle. Results showed that kindergartners and first graders were better able to remember content-rich words than context-dependent words. Memory for associations between words and their squiggles were much easier to learn when the words were nouns and adjectives than when the words were verbs, prepositions, and function words.

As these studies show, context-dependent words are more difficult to learn than context-independent words. Morris (2001) extended these findings to fifth and sixth graders. Native English speakers and English language learners' (ELLs) writing samples were examined. The analysis showed that ELLs left out more function words than content words in their writing, and they spelled content words more accurately than function words. ELLs demonstrated the ability to spell complex spelling patterns in content words, but often misspelled high-frequency function words. Unstressed function words were most often spelled incorrectly. This pattern of spelling errors was not observed with native English speakers. These findings suggest that ELLs require additional instruction in order to learn the distinct identities of function words, and that their phonological, syntactic, and semantic identities are more influential than their high word frequency in learning their spellings (for more discussion of teaching ELLs to read, see Geva, Xi, Massey-Garrison, & Mak, Chap. 6, this volume).

Miles (2015) also investigated whether there was a difference in native and non-native English speakers' ability to learn to read content and function words. Kindergarteners were taught two sets of words each containing three content and three function words. Students were taught the words and then tested on their ability to read the words over three trials. After the word-reading activity, students were asked to spell each word and use the word in a sentence. Results confirmed those of previous studies. Content words were easier to read, spell, and embed in grammatically correct, contextually rich sentences than function words. This occurred even though the content words were of lower frequency than the function words and thus presumably more difficult to learn. Additionally, results of hierarchical linear models showed that language proficiency as measured by a vocabulary test accounted for variance in function word reading but not content word reading, suggesting that familiarity

with colloquial English impacts beginners' ability to learn to read context-dependent words (Miles, 2015).

4.6 Conclusions

Sight word reading is the most efficient way to read words. Research has demonstrated that sight words are acquired through a grapho-phonemic-based process called orthographic mapping. Orthographic mapping involves forming connections between graphemes in spellings of words and phonemes in their pronunciations. As a result, the spellings of words enter memory bonded to their pronunciations and meanings. Subsequently when eyes alight on these words, they are recognized immediately. Also students' ability to spell the words is supported. Knowledge of grapheme–phoneme relations combined with the ability to distinguish separate phonemes in spoken pronunciations provides the glue that secures the spellings in memory.

In order to retain sight words in memory, beginners need to possess some requisite skills including knowledge of grapheme–phoneme relations and phonemic awareness, especially segmentation and blending. Segmentation facilitates the activation of connections between graphemes and phonemes when words are read. Blending facilitates the application of a decoding strategy to read unfamiliar words. This initiates the process of retaining written words in memory, so they can be read by sight. Learning letter names and letter sounds enables children to acquire the letter knowledge that is needed for mapping.

Beginners progress through four phases of development in learning to read words by sight. Growth is characterized by their knowledge of the alphabetic writing system as it is used for orthographic mapping, from pre-alphabetic involving the use of non-phonetic visually salient cues, to partial alphabetic connections, to full alphabetic grapheme–phoneme connections, to consolidated alphabetic connections involving multi-letter units and spelling patterns.

The conditions for reading words influence what aspects of words are learned. Syntactic and semantic identities of words are better learned when the words are read in context, whereas orthographic identities are better learned when words are read outside of contexts in isolation. It is especially important for beginners to learn to read context-dependent words such as function words in context to establish connections between spellings and meanings of these words.

Research into sight word learning helps us understand why teaching letter knowledge and phonemic awareness at the outset should be a priority in early literacy instruction. That way, beginners possess the foundation needed to acquire decoding skill, spelling skill, and memory for sight words. Indeed, this is precisely what research into preventing and intervening with reading difficulties has shown (Kilpatrick, 2015; National Reading Panel, 2000; O'Connor & Vadasy, 2011; Shaywitz, 2003; Snow, Burns, & Griffith, 1998).

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