Spelling Development and Disability in English

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Spelling has been called “the abandoned stepchild in the family of language arts” (Joshi, Treiman, Carreker, & Moats, 2008–2009, p. 9), often ignored by researchers and government granting agencies. This is unfortunate because spelling is an important aspect of literacy. Spellings are maps of linguistic content, and learning about words’ spellings benefits reading and vocabulary. And spelling is a critical part of effective written communication. Thus, poor spellers write fewer words and produce lower quality compositions than good spellers (Moats, Foorman, & Taylor, 2006). More people are writing today because of social media and other tools, but their writing will not communicate well if the “mechanics” of spelling and grammar are poor.

In this chapter, we discuss how spelling develops in typical children and in children with dyslexia. We focus on learners of English, a writing system that has traditionally been seen as highly irregular, even chaotic. Starting in the 1960s, however, language researchers began to point to previously unacknowledged regularities in the relations between spoken and printed English (e.g., Chomsky & Halle, 1968; Venezky, 1970), and psychologists and educators began to see that the learning of spelling involves much more than rote memorization. A linguistically based body of research on spelling development began to grow, even though research on spelling continued to lag behind research on reading.

The research that started in the 1970s and 1980s led to the idea that the major challenge in early literacy development is grasping the idea that the letters in words represent the sounds of speech, or phonemes (Ehri, 1991; Gentry, 1982; Henderson, 1985). Theories that take this phonological perspective, although they differ in some respects, see children as progressing from an initial period, during which their spellings are nonphonological, to a later stage, during which their spellings are phonologically adequate. For example, a child who writes quick as HS (Ehri, 1991) appears to be unable to conceptualize the spoken word as a string of phonemes. Rather than symbolizing the phonemes in the word, the child produces what seems to be a random string of letters. The subsequent emergence of phonologically based spellings such as CWIK and QUIC for quick reflects the child’s attempts to capture the word’s sound structure.

According to studies that adopt this phonological perspective, the spellings that children produce when they begin to write phonologically are based purely on sound. Additional sources of information come into play only later during the course of spelling development. Thus, more skilled spellers begin to consider the graphotactic acceptability of
their spellings: whether they comprise letter sequences that are permissible in the writing system. For example, a younger child may use *cw* at the beginning of *quick*, whereas an older child may know that *cw* does not normally occur at the beginnings of English words but that *qu* does. In addition, older children begin to use morphology to guide their spelling. They have observed that a *morpheme* (or unit of meaning) may be spelled the same even when its pronunciation changes, such as when the past tense ending is spelled as *ed* whether pronounced as /t/ (as in *jumped*), /d/ (as in *hemmed*), or /æd/ (as in *added*). Older children begin to use their knowledge of such patterns to avoid spellings such as JUMPT for *jumped*. (See Carlisle & Goodwin, Chapter 15, this volume.)

The phonological perspective has played an important role in the study of spelling and reading development. For example, it has drawn attention to the ways in which young children's misspellings reflect their knowledge about words' sounds. In the section that follows, we discuss some of these contributions. We argue, however, that the phonological perspective has given short shrift to nonphonological aspects of spelling and spelling development. As we will see, even beginning spellers use various sources of knowledge—not only phonological knowledge but also graphotactic and morphological knowledge—to guide their spellings. And there is heterogeneity with each of the phonological, graphotactic, and morphological domains; it is not the case that children learn about all phonological patterns or all morphological patterns at the same time. In later sections of the chapter, we discuss how the research and theory on spelling development in typical children has been used as a basis for studying children with dyslexia. We show that, although children with dyslexia lag behind typically developing children in learning to spell, they show the same general patterns of performance and make similar kinds of errors as typically developing younger children.

**Phonological Knowledge and Spelling Development**

The phonological perspective has drawn attention to one source of difficulty in learning to spell: the need to segment spoken words into phonemes and to symbolize speech at this level. Phonemic segmentation can be difficult for children, especially for certain linguistic structures. Much of the research from the 1970s through the 1990s documented how these difficulties affect young children's spelling, and we discuss some of the findings in this section (see also Read & Treiman, 2013; Treiman & Bourassa, 2000b).

**Consonant Clusters**

To a literate adult, it seems obvious that *note*, *hand*, and *snow* all contain the phoneme /n/. The adult thus understands that an *n* appears in the spelling of each word. Young children, however, sometimes leave out the *n* when spelling words such as *hand* and *snow*. They are less likely to omit the *n* of words such as *note* (Read, 1975; Treiman, 1991, 1993; Treiman, Zukowski, & Richmond-Welty, 1995). As these examples show, the position of a consonant in its syllable affects children's tendency to omit it in spelling.

Consider the case in which a child fails to spell the first consonant of a consonant cluster that appears at the end of a word or syllable, such as when spelling *hand* as HAD. Overall, children omit sonorant consonants (e.g., nasals such as /n/ and /m/) and liquids such as /l/ and /r/ in this position more frequently than obstruent consonants (e.g., /s/, /l/, /r/; see Treiman et al., 1995). Children seem to treat nasals and liquids as qualities of the vowel that precedes them rather than as separate segments. Because children consider nasality to be a property of the vowel rather than a separate unit, they may not use the letter *n* in spelling *hand*, producing HAD. With *risk*, the obstructent /s/ is less likely to be grouped with the vowel and is more likely to be spelled. Support for this notion comes from a study in which Treiman and colleagues (1995) asked children to pronounce nonwords sound by sound, putting out one token for each sound. For nonwords with final clusters beginning with nasals, such as *famp*, children often used just three tokens and pronounced three sounds: /æpl/, /æml/, and /pl/. These same children performed the phoneme counting task very accurately with syllables that did not contain clusters.

The picture becomes more complex when one examines the type of consonant that fol-
lows the first consonant of a syllable-final cluster. Read (1975) noted that omissions of nasal consonants were more common if the following stop consonant was voiceless, as with the clusters /nt/ and /mp/, than if the stop was voiced, as with /nd/ (see also Read, 1986; Snowling, 1994). Treiman and colleagues (1995) replicated this finding, and further demonstrated that the effect of voicing was specific to nasals. Omissions of liquids did not vary as a function of the voicing of the following consonant.

Young children also tend to omit the internal consonants of initial clusters, such as when they spell snow as SO. When Treiman (1993) studied the classroom writings produced by first graders, she found that children omitted the second consonants of two-consonant syllable-initial clusters almost one-fourth of the time. Examples include SAK for snake, AFAD for afraid, and SET for sweat. In contrast, the children rarely omitted the first consonants of initial clusters. Omissions of the interior consonants of initial clusters have also been reported in experiments in which children are asked to spell dictated words and nonwords (Bruck & Treiman, 1990; Treiman, 1991). Whereas omissions of consonants in final clusters vary with the phonological makeup of the cluster, no such influences have been detected for initial clusters (Treiman, 1991, 1993). For all types of syllable-initial clusters, the interior phonemes are more likely to be omitted than the exterior phonemes.

Failures to spell consonants in initial clusters do not usually reflect misarticulation: Typically developing children sometimes fail to spell the interior consonants of initial clusters even though they pronounce them correctly (Bruck & Treiman, 1990; Treiman, 1991). Nor do the errors reflect just the serial position of the phoneme or letter in the word. Children are more likely to omit the l of blow than the l of along, even though l is the second letter in both five-letter words (Treiman, 1985a). Rather, children appear disinclined to break initial clusters into separate phonemes, treating them instead as a single spoken unit. In effect, children consider snow to contain the initial consonant unit /sn/, the onset, followed by the vowel /ow/. This idea is consistent with classic research showing that onsets form cohesive units for both children and adults (e.g., Bowey & Francis, 1991; Fowler, Treiman, & Gross, 1993; Kirtley, Bryant, Maclean, & Bradley, 1989; Treiman, 1992).

**Phonetic Factors**

Even if children are able to divide a spoken word into segments, they may classify some of the segments differently than assumed by the conventional writing system, leading to spelling errors. There are numerous demonstrations of this phenomenon. For instance, young children sometimes symbolize /dl/ before /t/ as j and /l/ before /l/ as ch (Treiman, 1993). These errors make sense phonetically. When /dl/ occurs before /l/, the contact between the tongue and the top of the mouth is made further back in the mouth than when /dl/ occurs before a vowel. Also, the closure is released more slowly than when /dl/ precedes a vowel. This gives /dl/ before /l/ a degree of friction or turbulence that is similar to (although not as marked as) the friction that occurs in /dʒ/, which is normally spelled as j. Likewise, /l/ becomes similar to /fl/, which is normally spelled as ch when it occurs before /l/. Spelling errors such as JRIE for dry and CHRAP for trap are thus reasonable mistakes that reflect children's sensitivity to the sounds of the words.

A similar tendency to spell words in graphotactically unconventional but phonetically plausible ways is found when stop consonants occur after /sl/. At the beginnings of words, voiceless (i.e., /pl/, /tl/, /kl/) and voiced (i.e., /bl/, /dl/, /gl/) stops contrast with one another. Thus, English speakers distinguish cot, which begins with /kl/, from got, which begins with /gl/. The distinction is lost after /sl/, and stops in this position are spelled as voiceless. Thus, Scot is spelled with c rather than g, even though its second sound is more similar in some ways to /gl/ than /kl/. Consequently, young children sometimes spell words like sky as SGI (Hannam, Fraser, & Byrne, 2007; Treiman, 1985b).

Yet another example involves syllabic /tl/. In American English, a word like hurt does not contain a separate vowel as it is pronounced. The /tl/ takes the place of the vowel and is said to be syllabic. U.S. children often omit the vowels in these contexts, producing errors such as HRT for hurt and BRUTR for brother (Treiman, Berch, Tincoff, & Weatherston, 1993). British children, who do not
pronounce the /ɛ/ in these contexts, tend to misspell *hurt* as HUT (Treiman, Goswami, Tincoff, & Leevers, 1997).

**Letter Names**

In a number of countries, including the United States, children learn the names of many letters well before they start school. Children who are familiar with letter names sometimes use this knowledge to avoid the need to segment a string of sounds into smaller units. Consider the errors LEFit for *elephant*, FRMMR for *farmer*, and BAMBLBS for *bumblebees*. In these cases, children use a single consonant letter to symbolize all of the phonemes in the letter's name. For example, the *l* of LEFit represents the entire sequence /ɛl/. Such letter-name spellings have been noted in a number of studies of U.S. children (e.g., Chomsky, 1979; Ehri, 1991; Gentry, 1982; Read, 1975; Treiman, 1993, 1994). However, letter-name spellings do not occur equally often for all consonants. Treiman (1994) asked children to spell nonwords containing phoneme sequences that matched the names of the English consonants *r*, *l*, *m*, *n*, *f*, *s*, *t*, *p*, and *k*. For example, /gar/ contains the letter name for *r*, or /ɛl/, /ɛx/ contains the letter name for *f*, or /ɛf/, and /tib/ contains the letter name for *t*, or /ɛl/. Kindergartners and first graders produced most letter-name spelling errors for syllables containing the name of *r*. Syllables containing the letter-name *l* were the next most likely to receive letter-name spellings. Letter-name spellings were least common for syllables that contained the names of the letters *m*, *n*, *f*, *s*, *t*, *p*, and *k*. These differences among consonant letters in their susceptibility to letter-name spellings appear to reflect, in part, the sound properties of the letters' names (Treiman, 1993, 1994). To spell /gar/ as *gar*, one must divide it into /ɡ/ /ɛl/, and /ɛl/ and represent each phoneme with a letter. However, the /ɛl/ sequence is difficult to segment. As outlined earlier, children tend to group vowels and the following /ɛl/, treating them as a single unit. The letter *r* provides a ready-made spelling of /ɛl/, allowing children to spell the item without fully analyzing it at the phoneme level. Whereas some theories within the phonological framework (e.g., Bear & Smith, 2009; Gentry, 1982) have postulated a stage of spelling development during which children produce letter-name spellings whenever possible, these results show that letter-name spellings are more common for some letters than others. The differences reflect the phonological properties of the letters' names.

**Graphotactic Knowledge: Learning about What Words Look Like**

A fundamental assumption of the phonological perspective is that children have little or no useful knowledge about writing before they start to analyze words into phonemes and represent those phonemes with letters. Thus, even though young children may use letters of their writing system when asked to write words, their letter choices have been described as random (e.g., Gentry, 1982). Pollo, Kessler, and Treiman (2009) challenged this view on the basis of a study in which they compared the spellings of U.S. and Brazilian 4-year-olds who had not yet begun to spell phonologically. Pollo and colleagues found that the children's spellings, although phonologically implausible, conformed to a number of graphotactic patterns that exist in their respective languages. For instance, the children's spellings reflected sensitivity to letter frequency (e.g., *e* is more frequent in English words than in Portuguese words, whereas the opposite holds true for *a*) and bigram frequency (*ee* is more frequent in English words than in Portuguese words, whereas the opposite holds true for *nh*). Already at this early age, it appeared, children had begun to learn about the letters and letter combinations that occur in the printed words around them.

A sensitivity to graphotactic patterns shows itself even as children begin to incorporate phonological information into their spelling. For example, the first graders in Treiman's (1993) study used the *ck* digraph 38 times when it was not a part of a word's correct spelling. Among these errors, the digraph was used at the beginning of a word only twice, in the middle of a word 11 times, as in MRCKUT for *market*, and at the end of a word 25 times, as in BICK for *bike*. These results suggest that the children had some implicit knowledge that *ck* may not appear at the beginnings of words. Not all of children's errors are graphotactically legal—HRT does not have a vowel letter and CHRAP begins with an unusual sequence of letters—but chil-
Children appear to learn about some of the more frequent graphotactic patterns of the system earlier than suggested by theories within the phonological perspective.

Other studies have used a nonword choice task to investigate children's developing knowledge of graphotactic patterns. For example, Treiman (1993) presented children with 16 pairs of pronounceable nonwords. One nonword in each pair conformed to a specific graphotactic pattern of English, while the other did not. For example, *muck* has *ck* at the end and *ckun* has *ck* at the beginning, a position in which it never occurs in English. Children were asked to choose the item in each pair that looked more like a real word. If children make their judgments on the basis of sound only, both items would be equally likely to be chosen. However, if children consider graphotactic acceptability in making their judgments, they should choose the item that conforms to the graphotactic regularity at above-chance levels. Treiman found that kindergartners, first graders, and second graders all chose the conforming item significantly more than 50% of the time. These results support the idea that children learn about some graphotactic patterns rather early.

Cassar and Treiman (1997) used this nonword choice task to investigate children's knowledge of two types of graphotactic patterns concerning double consonants. One of these involved position: *mnus* is not acceptable and *nuss* is. Another involved the identity of the double consonant: *now* is not acceptable and *noss* is. Even kindergartners performed significantly above the level of chance on the items tapping knowledge of doublet position, whereas knowledge of doublet identity emerged in first grade. Cassar and Treiman also tested children's knowledge about the role of the phonological environment in singlet versus doublet use in bisyllabic words. In English, so-called long vowels in bisyllabic words are typically followed by singlets, as in *super*. Short vowels in such words are more likely to be followed by doublets, as in *supper*. Cassar and Treiman examined whether children listening to pronunciations for the nonwords chose, for example, *salip* for a pronunciation with /l/ in the first syllable and *sallip* for a pronunciation with /l/. Not until sixth grade and above did children show a clear knowledge of the correspondence between vowel quality and spellings with singlets and doublets when spelling nonwords. In another study, this one using words, Deacon, LeBlanc, and Sabourin (2011) found that children exhibited this knowledge by third grade. Either way, several years elapse between learning that doublets may occur in some positions and not in others and learning that a doublet often functions to indicate the quality of a preceding vowel. To understand the reasons for this gap, we must consider another important aspect of English spelling: contextual regularities in sound-to-spelling mapping.

**Contextual Regularities in Sound-to-Spelling Mapping**

Theories within the phonological perspective focus on one challenge in learning to spell: understanding that spoken words are divisible into phonemes and that writing represents speech at this level. However, another important challenge in learning to spell in English is learning to choose among the several alternative spellings for each phoneme that the writing system generally offers. In the past, it was assumed that spellers had little recourse other than to memorize the correct option in each case. However, recent studies have shown that the English spelling system has several levels of regularity that can be of considerable use to spellers (see Kessler & Treiman, 2003). We have already discussed how knowledge of graphotactic patterns can allow children to rule out spellings such as *nn* for a word-initial /nl/. We have mentioned, too, how phonological considerations can allow spellers to choose between two options that are graphotactically legal, as in *salip* and *salip*. In this section, we describe some recent studies of children's sensitivity to phonologically based contextual regularities and to regularities that are based on morphological considerations.

**Phonological Considerations**

The results of Cassar and Treiman (1997) and of Deacon and colleagues (2011) suggest that it takes quite some time for children to learn about how the choice between a single- and a double-letter spelling of a consonant is influenced by the quality of the preceding
vowel. Another phonologically based contextual regularity, and one that also takes years for children to master, concerns the influence of syllabic stress on use of single versus double consonants. When the inflectional suffixes (i.e., morphemes that mark plurals, verb tense, and comparatives, such as the *er in smarter* -ed and -ing are added to base words that feature stress on the second syllable (e.g., submit), the final consonant of the base word is typically doubled (e.g., submitted, submitting). When these suffixes are added to words with stress on the first syllable (e.g., limit), the final consonant of the base word does not usually double (e.g., limited, limiting). Bourassa and Bargen (2013) examined children's (second, fourth, and sixth graders) and adults' sensitivity to this regularity in a nonword spelling task. They found that only sixth graders and adults (the adults outperformed the sixth graders) were sensitive to the influence of syllabic stress on singlet versus doublet use. That is, only these two groups used singlets more often in spelling nonwords with first syllable stress (e.g., verlitting) and doublets more often in spelling nonwords with second syllable stress (e.g., verlitting).

In some cases, the choices among alternative spellings of a vowel or consonant depends on the identity of an adjacent phoneme. Consider that /a/ is often spelled as a when preceded by /w/ (as in wand), and as o when preceded by other consonants (as in pond). Similarly, /i/ is more likely to be spelled as ee when followed by /p/ (as in creep) and more likely to be spelled as ea when followed by /ml/ (as in cream). Many of these patterns are probabilistic rather than all-or-none (as shown by the existence of words such as leap and deem), but the patterns could nevertheless be useful to spellers. Treiman and Kessler (2006; see also Varnhagen, Boechler, & Steffler, 1999) studied children's sensitivity to preceding and following consonants in a nonword spelling task. Treiman and Kessler found that children spelling at the fourth-grade level were sensitive to the cases of preceding-consonant context that they studied. Not until the seventh-grade spelling level did children show a sensitivity to the cases of following-consonant context that were examined.

The literature just outlined underscores the heterogeneous nature of children's sensitivity to phonologically based contextual regularities. Different regularities appear to be acquired at different points in development, and generally later than sensitivity to simple graphotactic patterns (e.g., *nuck* vs. *ckum; *nuss* vs. *nuss; *noss* vs. *now*). Many of these regularities, both the graphotactic and the phonological ones, are not explicitly taught in classrooms. Rather, children appear to pick them up by observing the statistics of their language: which letters, sounds, and sound-spelling correspondences are repeatedly found together (Kessler, 2009). Thus, investigations of children's acquisition of graphotactic patterns and phonologically based contextual regularities support the idea that implicit statistical learning plays an important role in the development of spelling (e.g., Deacon, Conrad, & Pacton, 2008; Hayes, Treiman, & Kessler, 2006; Kessler, 2009; Pollo et al., 2009; Treiman & Kessler, 2006), as it does in the development of many other skills.

**Morphological Considerations**

The spelling of a morpheme often remains the same even when the pronunciation of that morpheme changes, an aspect of the English writing system that has been referred to as the principle of morphological constancy (e.g., Bourassa & Treiman, 2008). This principle can be understood with respect to the spelling of roots and suffixes. For example, the root *bead* retains its spelling when it occurs in the morphologically complex form *health*. The *ea* does not change to *e*, as might be expected given the change in pronunciation. Other examples, as mentioned earlier, are *jumped* and *hemmed*. These end with different sounds, /t/ for *jumped* and /d/ for *hemmed*, both of which are forms of the past tense suffix. The suffix is spelled in a consistent manner, -*ed*, in both words. As noted earlier, theories within the phonological perspective see use of morphology as a late development. However, as we will see, this is not always true. Some aspects of morphology influence spelling at an early age, whereas other aspects develop later. We begin with a review of the evidence with respect to children's spellings of roots.

Derivational morphology involves changes in syntactic class and/or meaning, such as when the adjective *cloudy* is derived from the noun *cloud*. Research indicates that it takes time for children to deal with deriva-
tional relations that feature considerable differences in pronunciation and stress within a derived word–base word pair. For example, Zutell (1980) found that fourth graders had difficulty using related words to spell reduced vowels in morphologically complex words. An example of such a reduced vowel is the second vowel in inflammation, which is derived from inflame. Similarly, Carlisle (1987; see also Bourassa & Treiman, 2008; Carlisle & Goodwin, Chapter 15, this volume) found that correct spellings for segments such as c in the word magician are not consistently achieved until the middle school years. In contrast, several studies have shown that young children do use morphological constancy, to some extent, to aid their spelling in more phonologically transparent derivational contexts, as well as inflectional contexts (e.g., cars–car, laughing–laugh). One example involves flaps. In North American English, words such as shouting and motor contain a medial flap, a brief tap of the tongue against the upper part of the mouth. Flaps, being voiced, are similar to /d/, and young children often spell them as d (Treiman, 1993). Treiman, Cassar, and Zukowski (1994) found that first and second graders produced more correct spellings of flaps when there was a root word that could help them, as with the inflected form shouting and the derived form cheater, than when there was no such root word, as with motor. However, the children did not use morphological constancy to the maximal extent, in that t spellings for shouting and cheater were less common than t spellings for the base forms shout and cheat.

In another set of experiments, Treiman and Cassar (1996) focused on word-final consonant clusters. We noted earlier that children sometimes omit the interior consonants of final-consonant clusters when spelling one-morpheme words, for example, spelling sink as SIK. Treiman and Cassar asked whether 6-year-old children use morphological constancy to overcome this phonological segmentation problem by comparing performance on inflected two-morpheme words, such as tuned, to performance on one-morpheme control words, such as brand. They found that the children were more likely to include the n in tuned than in brand, suggesting that the children used their knowledge of the base forms to aid their spelling of the inflected forms. However, consistent with the finding of Treiman et al. (1994), children were less likely to include the n in tuned than in tune.

Work by Deacon and colleagues has provided analyses of children’s use of morphology with a variety of whole-word spellings rather than particular critical segments. Deacon and Bryant (2006) administered spelling tests to 6- to 8-year-olds that included both inflected and derived words, each with paired control items. The children were asked to spell the first segments of target words (e.g., miss in missed and missile, add in addition and address). Consistent with the findings outlined earlier, children in all age groups were better at spelling the beginnings of experimental words than control words across both variations of words, inflected and derived. Using similar stimuli, however, Deacon (2008) found evidence that children process inflected forms more easily than derived forms.

Deacon and Dhooge (2010) had second graders spell base, inflected, derived, and one-morpheme control words that contained the same critical letter-sound sequences (e.g., trick, tricked, tricky, and trickle), thus allowing for a well-controlled analysis of the spelling of entire roots in both inflected and derivational forms (cf. Deacon, 2008; Deacon & Bryant, 2006). Of particular interest is the accuracy of spellings for the common sequence in the various word types. Deacon and Dhooge (2010) found that children were most accurate at spelling base words and least accurate at spelling those very same segments in the one-morpheme control words. Accuracy was equivalent for inflected and derived forms, and performance for these forms fell between those for the base and control items.

The literature reviewed thus far suggests that children can use morphology to aid their spelling of roots in a variety of morphologically complex forms, in some cases as early as 6 years of age. In a more stringent test, Bourassa and Treiman (2008; see also Deacon et al., 2011) compared children’s performance on words that do and do not follow the principle of morphological constancy. For example, the c in music is retained in musician and the t of shout is retained in shouting (Treiman et al., 1994); these words show morphological constancy. In some other cases, however, the spellings of roots change when derivational affixes are added. For
example, the *ai* of *explain* is not retained in *explanation*. Bourassa and Treiman (2008) reasoned that, while children who correctly include the *c* in a word like *musician* may be using the root word to benefit spelling, their performance might also reflect memory for the entire word form. More compelling evidence for adherence to morphological constancy would come from erroneous use of the critical segment in words like *explanation*. For example, children who spell *explanation* as EXPLANATION are probably using the root word, *explain*, as the basis for spelling the morphologically complex word. Bourassa and Treiman examined performance on items like *musician* and *explanation* by typically developing children who spelled at the fourth- and sixth-grade levels. Children who spelled at the sixth-grade level were more likely than children who spelled at the fourth-grade level to apply the principle of morphological constancy in appropriate cases (i.e., for items like *musician*) and, more importantly, in inappropriate cases (i.e., for items like *explanation*) as well.

The research outlined earlier indicates that even young children are in some cases sensitive to roots when dealing with a variety of morphologically complex inflected and derived forms, contrary to the predictions of theories within the phonological framework. However, the more difficult cases noted earlier (e.g., sensitivity to the root in *magician*) underline the critical role of linguistic complexity in the development of morphological knowledge. This point becomes even more apparent when one considers investigations of children’s sensitivity to inflectional and derivational suffixation.

Evidence for early sensitivity to inflectional suffixation was reported by Deacon and Bryant (2005). These investigators asked 6- to 8-year-olds to complete a fill-in-the-blank task, adding the appropriate spelling (e.g., *er*) to inflected words (e.g., *smarter*) and one-morpheme control words (e.g., *corner*). If children rely only on sound when spelling, performance should be equivalent for the two word types. However, an understanding of the morphemic status of *-er* in words like *smarter* would lead to superior performance in the inflected word condition. Deacon and Bryant did in fact find an advantage for the inflected word condition, even among the 6-year-olds.

Later sensitivity to inflectional suffixation has been observed in children’s spellings of verb endings. For instance, Nunes, Bryant, and Bindman (1997) demonstrated that young children often spell endings for regular (e.g., *helped*) and irregular (e.g., *slept*) past tense verbs phonetically (in this case, with *t*). By approximately 8 years of age, children begin to employ -ed both correctly and incorrectly (e.g., SLEPED; another example of an overextension of the principle of morphological constancy). A recent study by Bourassa, Beaupre, and MacGregor (2011) highlights another case where the ability to accurately spell verb endings is slow to develop. Using a nonword spelling task, these investigators examined whether children understand that a /zl/ sound following long vowels requires an *s* spelling for inflected verbs (e.g., *Al scrays the fish in the afternoon*) but a ze or se spelling for noninflected verbs (e.g., *Joe and Sue will scraze the bike*). Bourassa and colleagues found that sensitivity to this distinction was present in children spelling at the fifth-grade level but not in children spelling at the third-grade level.

The relatively little research that is available on children’s spelling of derivationalsuffixes also points to the heterogeneous nature of morphological knowledge. Generally, children take longer to grasp derivational suffixes than to grasp inflectional ones. For instance, we noted earlier Deacon and Bryant’s (2005) finding that 6- to 8-year-olds were more likely to fill in the last sections of words correctly in inflected words than in control counterparts (e.g., more accurate spelling of *er* in *smarter* than in *corner*); however, these investigators observed no such difference for derived words and their counterparts (e.g., equally accurate spelling of *ness* in *kindness* and *witness*). More recently, Sangster and Deacon (2011) found that 9-year-olds (but not 7-year-olds) were better able to identify the correct ending out of phonologically plausible options (e.g., *y*, *ie*, or *ey*) for derived words (e.g., *lucky*) than for one-morpheme words (e.g., *study*). Thus, children learn about the spellings of at least some derivational suffixes by around 9 years of age. As Sangster and Deacon note, future research will need to examine children’s sensitivity to the over 100 derivational suffixes that exist in English (Anglin, 1993). Indeed, derivational suffixes that denote conceptually difficult distinctions may cause spelling dif-
ficulties into the late elementary school years. For instance, the difference between the -ion (abstract noun endings as in frustration) and the -ian (agentive noun endings as in musician) suffixes appears to be beyond the grasp of 10-year-olds except through explicit and intensive instruction (Nunes & Bryant, 2006).

Conclusions about Typical Spelling Development

Our discussion of typical spelling development shows that analyzing words into phonemes is one of the difficulties in learning the English writing system. Certain phoneme sequences are particularly difficult to analyze, and even when children do analyze them into smaller units, they may not always do so in the conventional manner. However, phonological analysis is not the only stumbling block in the learning of English. Learning that most phonemes have more than one possible spelling, and learning the probabilistic patterns and rules that help one to choose among them, is another critical skill. We have seen that children demonstrate knowledge of certain graphotactic patterns (e.g., knowledge of positional constraints) and contextual regularities (e.g., knowledge of roots across a variety of morphologically complex forms) at an age earlier than envisaged by adherents to the phonological perspective. Other such patterns (e.g., the spelling of many derivational suffixes) are later to develop.

Spelling in Children with Dyslexia

An important question is whether what we have learned about spelling development in typical children applies to children with developmental dyslexia, or children who have great difficulty learning to read and write, despite normal intelligence, adequate learning opportunities, and no serious emotional or personality disorders. As compared to typically developing children of the same age—a chronological-age match design—children with dyslexia perform poorly on various spelling production tests. A more interesting and theoretically relevant comparison involves older children with dyslexia and younger, typically developing individuals who perform at the same level on a standardized spelling test—a spelling-level match design. If children with dyslexia learn to spell in much the same way as typically developing individuals but at a slower rate, then the spelling patterns of older children with dyslexia should be indistinguishable from those of younger, typically developing children of the same spelling level. For example, children with dyslexia should have difficulties with the same linguistic structures and make the same types of errors. However, if children with dyslexia approach the task of spelling in a qualitatively different way than do typical children, then the two groups may show very different patterns of performance.

Weak Phonological Knowledge but Strong Graphotactic Knowledge?

One hypothesis that has been explored in many studies, and one that grew out of the phonological perspective described earlier, is that the core problem in children with dyslexia is a phonological processing deficit (e.g., Goswami & Bryant, 1990; Rack, Snowling, & Olson, 1992; Siegel, Share, & Geva, 1995). Children attempt to compensate for their phonological problems by relying on rote memory for visual word forms and knowledge of graphotactic patterns. According to this hypothesis, children with dyslexia should perform more poorly than younger, typically developing children on tests of phonological skills but better on tests of graphotactic skills. While research has supported the idea that children with dyslexia perform either as well as (e.g., Bourassa & Treiman, 2003; Cassar, Treiman, Moats, Pollo, & Kessler, 2005; Friend & Olson, 2008; Nelson, 1980) or better than (e.g., Siegel et al., 1995) spelling-level matched younger learners on measures of graphotactic accuracy, comparisons of these groups on measures of phonological accuracy have yielded mixed results. Some researchers (e.g., Bruck, 1988, Friend & Olson, 2008; Kibiel & Miles, 1994) have reported a phonological deficit in children with dyslexia compared to spelling-level matched control children. Other studies (e.g., Bourassa & Treiman, 2003; Cassar et al., 2005; Moats, 1983; Nelson, 1980) have found that children with dyslexia perform similarly to spelling-level matched controls in terms of both phonological accuracy and tests of graphotactic knowledge.
How does one reconcile these mixed results? The studies outlined earlier varied considerably with respect to stimuli and measurement standards. Bourassa and Treiman (2003; see also Treiman, 1997) argued that, when examining phonological accuracy, it is important to provide in-depth analyses of error types. A spelling such as FOZ for chip defies phonological explanation and thus may reflect a phonological deficit. Spellings such as PAD for plaid and HAD for band (in which a phoneme is not represented) and JRY for dry (in which the initial phoneme is represented in a nonconventional way) are also commonly classified as phonologically inaccurate. However, as discussed earlier, these errors have a phonological basis and are common among typically developing children. If children with dyslexia make errors of this type, we cannot conclude that they fail to appreciate the role of phonology in spelling.

Indeed, fine-grained analyses indicate that spellings of children with dyslexia are often phonologically motivated. Bourassa and Treiman (2003) provided an analysis of the performance of children with dyslexia and spelling-level matched control children on the Treiman–Bourassa Early Spelling Test (T-BEST; Treiman & Bourassa, 2000a). This test includes words and nonwords that feature phonological obstacles for typical beginning spellers, including interior consonants of initial (e.g., the r in trip) and final (e.g., the n in sank) consonant clusters, syllabic /l/ (e.g., the final syllable in supper), phoneme sequences corresponding to letter names (e.g., bar), and /ld/ before /l/ (e.g., drip). Bourassa and Treiman found that the children with dyslexia and control children were equally likely to produce these phonologically based errors. The two groups did not differ on other measures of use of phonology in spelling. Nor did they differ in terms of the graphotactic legality of their spellings. Importantly, these results held true for the nonwords as well as for the words. If children with dyslexia attempt to compensate for their phonological problems by using visual memory, then they should have had particular difficulty spelling nonwords, which have no representation in memory and are therefore more likely to draw on phonological processes.

Cassar and colleagues (2005) also provided a fine-grained linguistic analysis of the spelling performance of children with dyslexia and spelling-matched control children. Using a larger stimulus set than Bourassa and Treiman (2003) that consisted of nonwords, they confirmed Bourassa and Treiman’s finding that children with dyslexia and controls perform similarly on initial consonant clusters (but see Bruck & Treiman, 1990), final consonant clusters, and letter-name sequences. Cassar and colleagues also found that children with dyslexia and controls do not differ in their ability to deal with reduced vowels in unstressed syllables, as in the o of carrot. Moreover, the groups did not differ in terms of the overall graphotactic legality of their spellings or in performance on choice tasks that assessed knowledge about the legal positions of consonant doublets (nuss vs. nnus), vowel doublet identity (beek vs. haak), and consonant doublet identity (gatt vs. gawu).

Clearly, detailed analyses have provided no strong support for the idea that spellings of children with dyslexia are characterized by weak phonological knowledge, for which the children compensate with strong graphotactic knowledge. Further work needs to clarify whether children with dyslexia differ from typically developing younger children with respect to other linguistic factors outlined here. For instance, research has yet to address how children with dyslexia compare to controls in knowledge of phonologically based contextual regularities, including the relationship between vowel quality and singlet versus doublet use (e.g., Cassar & Treiman, 1997), the relationship between syllabic stress and singlet versus doublet use (e.g., Bourassa & Bargen, 2013), and the influence of consonant context on vowel spellings (e.g., Treiman & Kessler, 2006).

**Weak Morphological Knowledge?**

Do children with dyslexia have difficulty with the morphological, rather than phonological, bases of spelling? Several researchers, including Carlisle (1987; Carlisle & Goodwin, Chapter 15, this volume), have suggested that they do. Supporting this idea, some research has suggested that children with dyslexia lack sensitivity to morphologically based contextual regularities when spelling root forms. Hauerwas and Walker (2003) compared 11- to 13-year-old children with dyslexia to 7- to 8-year-old normally achieving children. The children with dyslexia were less likely
than the typical children to spell a root morpheme consistently in morphologically complex and base words. For example, the children with dyslexia did not necessarily spell call the same way when it appeared in called and when it appeared without an inflectional suffix. Tesmeli and Seymour (2006) found similar results when they compared the spellings of 13- to 14-year-old children with dyslexia with those of 9- to 10-year-old typically developing children. However, the dyslexic and control groups in the studies of Hauerwas and Walker (2003) and Tesmeli and Seymour (2006) do not seem to have been well matched for spelling ability. Although the older and younger children performed similarly on one standardized spelling test, the older children were substantially worse at spelling the base forms of the morphologically complex words. Their greater inconsistency in spelling complex words and base forms could have reflected their poorer overall spelling ability, not their dyslexic status (Bourassa & Treiman, 2008).

Other studies that feature well-matched dyslexic and control groups (i.e., matched on spelling performance on base forms, as well as on standardized tests) have found that children with dyslexia do not lack sensitivity to morphologically based contextual regularities when spelling root forms. For example, Bourassa, Treiman, and Kessler (2006) evaluated the ability of children with dyslexia and spelling-level matched controls to use morphology to resolve the obstacles involving flaps and interior consonants of final-consonant clusters that were outlined earlier. Bourassa and colleagues found that, like the typically developing younger children, the children with dyslexia produced significantly more correct spellings of flaps in morphologically complex words, such as dirty, than in morphologically simple words, such as duty. The children with dyslexia were also significantly less likely to omit the first consonant of a final cluster in inflected words such as tuned than in morphologically simple words such as brand. Neither the dyslexic nor the typically developing group showed maximal sensitivity to root constancy, in that performance on the morphologically complex forms fell below that on the base forms, but both groups showed some tendency to maintain the spelling of a root when it occurred in complex forms. Moreover, contrary to the results of the studies discussed earlier, Bourassa and colleagues found that children with dyslexia and controls were equally consistent in their spellings, whether correct or incorrect, of root morphemes in base word–complex word pairs. For example, the groups were equally likely to spell lace as LASE and laced as LASED, and equally likely to spell wait as WAT and waiting as WATING.

More recently, Bourassa, Deacon, Bargen, and Delmonte (2011) employed Deacon and Dhooge's (2010) items to compare children with dyslexia and spelling-level matched controls, with mean spelling grade levels of 2.3 and 2.2, respectively, on their sensitivity to root constancy in both inflected and derived forms. Bourassa, Deacon, and colleagues found that the children with dyslexia and control children performed virtually identically, showing the same pattern of results that Deacon and Dhooge had previously observed with second graders; that is, the children with dyslexia and controls were most accurate at spelling the critical segments in the base words (e.g., trick) and least accurate at spelling those segments in the one-morpheme control words (e.g., trickle). Accuracy was equivalent for inflected (e.g., tricked) and derived (tricky) forms, and performance for these forms fell between those for the base and control items. Thus, the children with dyslexia and control children were equally sensitive to inflectional and derivational morphology, although not to maximal extent, a finding consistent with Bourassa and colleagues (2006).

A final piece of evidence for the sensitivity of children with dyslexia to root constancy comes from the previously discussed study by Bourassa and Treiman (2008), which included older children with dyslexia who performed comparably to the typically developing children on a standardized spelling test. We noted earlier Bourassa and Treiman's argument that, whereas correct use of the c in a word like musician may reflect adherence to morphological constancy and/or whole-word memory for morphologically complex forms, erroneous spellings such as EXPLAINATION for explanation are especially convincing evidence of adherence to morphological constancy. Bourassa and Treiman found that children with dyslexia performed comparably to the typically developing children on this latter type of item; that is, children with dyslexia sometimes overextended the principle...
of morphological constancy, and they did so to the same extent as the typically developing younger children. Moreover, use of the critical segments varied as a function of spelling level in children with dyslexia: Those who spelled at a sixth-grade level were more likely to make errors such as EXPLANATION than those dyslexics who spelled at a fourth-grade level. Finally, in line with the findings of Bourassa and colleagues (2006), the children with dyslexia were as consistent as the younger, control children when spelling, either correctly or incorrectly, the root morphemes in base word–complex word pairs.

On the whole, the research indicates that English learners with dyslexia show some knowledge that roots are often spelled in the same way across different forms in which they appear. How do these children deal with the variety of suffixes that exist in the language? Few studies have addressed this issue using a spelling-level match design. Egan and Pring (2004; see also Hauerwas & Walker, 2003) reported that children with dyslexia made more spelling errors on regular past tense verb endings than did younger control children. Silliman, Bahr, and Peters (2006) studied poor spellers (approximately 10 years of age) who performed very similarly to a group of typically developing children (approximately 7 years of age) on a standardized spelling test. They reported that the poor spellers had greater difficulty than the typically developing children in representing a small set of derived morphological markers (e.g., the _ion in location_). However, Silliman and colleagues did not include one-morpheme control items with identical endings (e.g., _nation_; cf. Deacon and Bryant, 2005; Sangster & Deacon, 2011) in order to isolate children’s sensitivity to the morphemic status of these markers. Future research needs to provide more detailed analyses of the performance of children with dyslexia on these and the many other suffixes that exist in English in order to determine whether they have a pervasive deficit in knowledge of suffixes.

**Summary and Concluding Remarks**

Spelling is an important component of literacy, providing language users with necessary tools for effective written communication. The literature we have reviewed highlights the many challenges that arise in mastering the English writing system. According to investigators who take what we have described as a phonological perspective in the study of spelling development (e.g., Ehri, 1991; Gentry, 1982; Henderson, 1983), children’s early spellings feature random strings of letters. As children get older, they begin to produce phonologically based spellings. Sensitivity to graphotactic patterns and morphological relations are thought to be later developmental achievements. The research we have reviewed suggests that these views of spelling development are too limited. Even prephonological spellers know something about the letters and letter combinations of their writing system, and children who are labeled as phonological spellers also use some graphotactic and phonologically and morphologically based regularities to guide their spellings. Moreover, phonological, graphotactic, and morphological knowledge are heterogeneous constructs. Within each domain, children progress from simple to increasingly complex patterns. Dividing speech into phonemes and representing those phonemes with letters are challenging for learners of English, but learning about the roles of graphotactic, phonological, and morphological context in selecting among spellings is also challenging.

Much of what we have learned about typical spelling development, our review of the literature shows, can be extended to children with dyslexia. That is, whereas children with dyslexia learn about the writing system more slowly than other children, they appear to face many of the same stumbling blocks and make many of the same kinds of linguistically motivated errors. These findings, we believe, have important implications for instruction. All children will benefit from training methods that target particular linguistic trouble spots (e.g., Masterson & Apel, 2007; also see Masterson & Apel, Chapter 31, and Wolter & Squires, Chapter 32, this volume), but such training may need to be more intensive and explicit for children with dyslexia.

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