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Spelling in Normal Children and Dyslexics

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Developmental dyslexia is typically defined on the basis of reading problems. *Dyslexia* is a disorder in learning to read that sometimes exists in children who have adequate learning opportunities, no known brain damage, and no serious emotional or personality disorders. Although the definition of dyslexia focuses on reading, dyslexics also have serious problems with spelling. Indeed, dyslexics' spelling levels are typically below their reading levels, and spelling problems persist even among dyslexics who have apparently "caught up" in reading (Boder, 1973; Critchley, 1975). Despite the severity of spelling problems in dyslexics, much less is known about dyslexics' spelling than about their reading. The chapters in the present volume are no exception to the general trend, because most of them focus on reading as opposed to writing.

To understand the spelling problems of dyslexics, one must first know something about how normal children learn to spell and the kinds of errors they make. Without such a background, one may label dyslexics' errors as "bizarre," not knowing that such errors are common among young children who are progressing normally in learning to spell and read. The first part of this chapter, therefore, provides an overview of the development of spelling in normal children. In the second part of the chapter, I review the research that has been done with dyslexics. The focus is on studies that have compared dyslexics with normally developing younger children. I ask whether dyslexics show the same patterns of performance as do normal younger children or whether they make quali-

tatively different types of spelling errors. That is, do dyslexics learn to spell in much the same way as do normal children, only more slowly, or do they show unusual patterns of development?

THE DEVELOPMENT OF SPELLING IN NORMAL CHILDREN

The Precursors of Alphabetic Writing

For most children in a literate society, writing does not emerge all at once in kindergarten or first grade. Typically, a long period of development precedes the first independent readable spellings. Thus, preschoolers may "write" by making marks with a crayon or pencil before they know the conventional letters. Their writing, unconventional as it is, differs noticeably from their drawing. For example, children's writings tend to be smaller than their drawings and often consist of linearly arranged strings of symbols (Ferreiro & Teberosky, 1982; Tolchinsky-Landsmann & Levin, 1985). Although children as young as 3 or 4 years old know that writing looks different than drawing, they do not yet understand that alphabetic writing represents the sounds of language. Instead, young children seem to believe that the written forms of words should reflect their meanings. For example, they think that the names of large objects, such as *whale*, should be spelled with more letters than the names of small objects, such as *mosquito* (Ferreiro & Teberosky, 1982; Levin & Korat, 1993; Levin & Tolchinsky Landsmann, 1989; Lundberg & Tornéus, 1978).

The hypothesis that the physical features of words are analogous to the physical features of the corresponding objects becomes untenable as children learn more about print. For example, a child named Jessie might learn to spell her own name and the word *Dad*. She observes that the word *Dad* has fewer letters than the word *Jessie*, even though Dad is bigger and older than Jessie. Thus, the child is forced to give up the idea that printed words are direct representations of meaning and to entertain the possibility that print might represent speech.

According to some investigators (e.g., Ferriero & Teberosky, 1982), children first believe that the correspondence between writing and speech is at the level of the syllable. Only later do children learn that, for English and other alphabetic systems, the link between print and speech is primarily at the level of individual sounds or phonemes. Bobby, the 5-year-old kindergartener whose writing is reproduced in Fig. 9.1, seems to relate print and speech mainly at the syllabic level. Bobby writes the monosyllabic words *should* and *be* with one letter each. The use of *b* for *be* reflects the letter's name; the use of *c* for *should* may reflect the similarity between

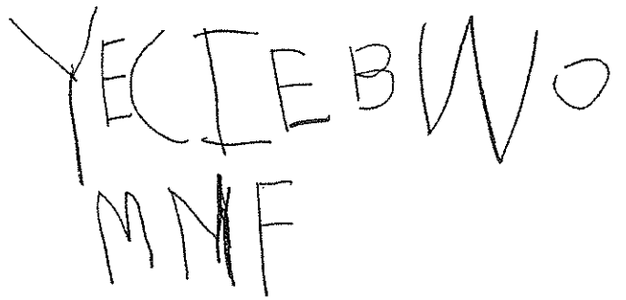

FIG. 9.1. Message written by Bobby, a kindergartener. Message reads, "Why should I be warm enough?" This message was produced when Bobby's mother told him that he must wear a jacket or sweater when he went outside so that he would be warm.

the name of the letter *c*, /si/, and the first sound in the spoken form of *should*, /ʃ/. Bobby's spellings of *why* as "ye" and *I* as "ie" reflect a syllabic hypothesis overlaid with the effects of experience. Bobby's older brother had told him that an *e* should be added to the end of the word when a letter says its name. Thus, Bobby included an *e* after his *y* spelling of *why* and his *i* spelling of *I*. The syllabic hypothesis also surfaces in Bobby's two-letter spelling of *enough*. Had Bobby not written *warm* as he did, one might have concluded that he linked print and speech solely at the level of syllables. However, Bobby's "wom" spelling of *warm* reveals a beginning ability to divide syllables into smaller units of sound and to represent these units with letters. Bobby seems to have segmented the spoken word *warm* into three parts, writing *w* for the initial /w/, *o* for the middle /ɔr/, and *m* for the final /m/. His failure to treat /r/ as a separate unit is typical of beginning spellers and is discussed later. Bobby's case forms a bridge between what I have called the *precursors of alphabetic writing* and the emergence of the alphabetic principle.

The Alphabetic Principle Emerges

Trevor, the first grader whose writing is depicted in Fig. 9.2, is a year older than Bobby and has a stronger grasp of the alphabetic principle. In the two entries from his writing journal that appear in Fig. 9.2, Trevor uses the alphabetic principle more or less consistently instead of only sporadically, as Bobby does. For example, the spoken word *eat* contains two phonemes, /i/ and /t/, and Trevor uses one letter to symbolize each phoneme. *Pop* has three phonemes, /p/, /ɑ/, and /p/, and Trevor spells it with three letters. Trevor seems to fall back on a syllabic strategy when he writes *like* as "l" on the second line of his October 6 journal entry. On

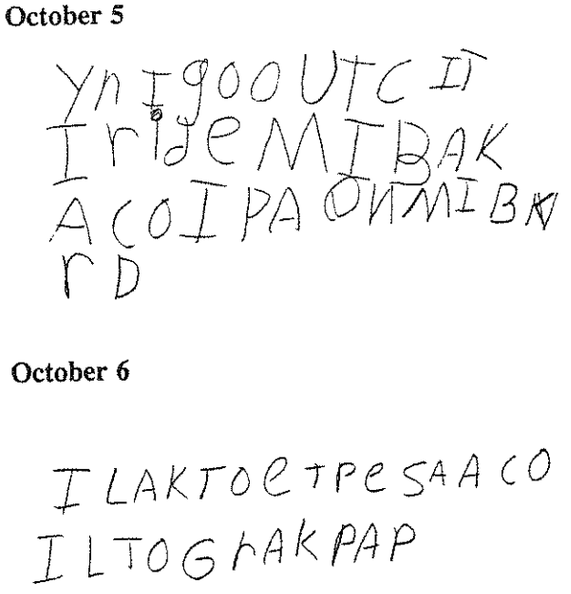

FIG. 9.2. Journal entries of Trevor, a first grader. October 5 entry reads, "When I go outside I ride my bike and I play on my bike ride." October 6 entry reads, "I like to eat pizza and I like to drink pop."

the first line, though, he writes this word as "lak," using one letter for each of its three sounds. Jillian, a classmate of Trevor's whose journal entry from late March appears in Fig. 9.3, has an even better grasp of the alphabetic principle than Trevor does.

Much of the research on children's early spelling has focused on children whose spellings are similar to Trevor's and Jillian's. The pioneering research in this area was carried out by Read (1975). He analyzed over 2,500 spellings produced by 32 children who began to write as preschoolers, generally between about 2½ and 4 years old. Although these children were younger than Trevor and Jillian, their spellings were similar. Read suggested that children spell primarily by trying to symbolize the sounds in words rather than by trying to reproduce memorized strings of letters. However, because the children in Read's study began to write much earlier than usual, Gibson and Levin (1975) suggested that the findings might not generalize to children who learn to write and read at school.

Following up on Read's (1975) research, I analyzed a large collection of first graders' writings (Treiman, 1993). My study differed from Read's in that the children were not precocious or advanced. They were learning to read and write at school rather than at home. The children's teacher

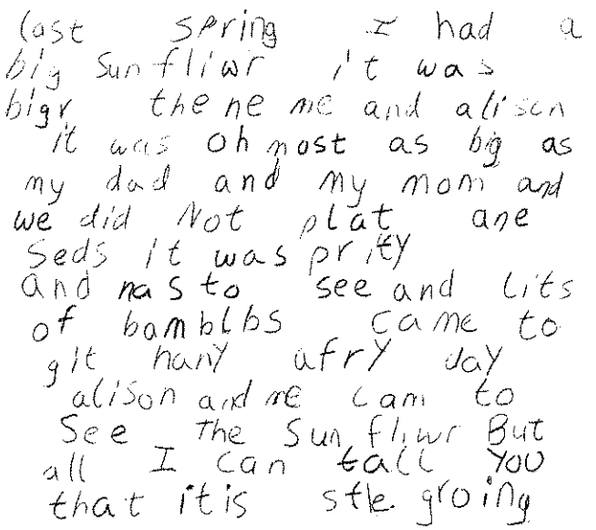

FIG. 9.3. Story written by Jillian, a first grader, in late March. Story reads, "Last spring I had a big sunflower. It was bigger than me and Alison. It was almost as big as my dad and my mom. And we did not plant any seeds. It was pretty and nice to see and lots of bumblebees came to get honey. Every day Alison and me came to see the sunflower. But all I can tell you that it is still growing."

was a strong believer in the whole-language approach. Although school policy dictated that the children receive some phonics instruction, the teacher stressed independent writing. She felt that children should figure out the spellings of words on their own, and thus did not tell them how to spell a word even if they asked. I collected 5,617 spellings that were produced by 43 children who were in this same teacher's first-grade class during two successive school years.

Data like mine (Treiman, 1993) and Read's (1975) reveal the kinds of spellings that are produced by children engaged in meaningful writing. To complement such naturalistic data, a number of experimental studies have been conducted. In the following sections, I discuss four conclusions about early spelling development in normal children that are suggested by the results of the naturalistic and experimental research.

Children May Use Groups of Sounds That Are Larger Than Single Phonemes. When children first begin to relate print and speech, they seem to do so at the level of syllables (Ferreiro & Teberosky, 1982). English-speaking children may realize that this syllabic hypothesis is untenable when they learn to write or recognize their name and try to

understand why their name is spelled as it is (Ferreiro & Teberosky, 1982). At 3½, for example, Bobby knew the spelling of his name. He seemed to understand the function of the *b*s because he could hear the syllable /bi/ in the spoken form of his name. However, he was puzzled about the *o* and *y*, because there was no /o/ or /wai/ in his name's spoken form. Having heard his parents and older brother discuss the silent *k* of *knife* and other peculiarities of English, Bobby concluded that the *o* and *y* in his name were silent letters. Solutions such as these, creative as they are, cannot last forever. As children learn the conventional spellings of words, they see that the number of letters in a word's spelling does not usually match the number of syllables in its spoken form. Children are forced to go beyond the syllabic hypothesis and to relate print and speech at a more fine-grained level. But what level of analysis is appropriate? Children's analyses of spoken words do not always reach the level of single phonemes, and they may therefore spell groups of phonemes with single letters.

One example of this grouping phenomenon involves final consonant clusters. Children sometimes fail to spell the first consonants of these clusters. For example, Trevor did not represent the /ŋ/ of *drink*, writing "grak" (Fig. 9.2), and Bobby failed to spell the /r/ of *warm*, writing "wom" (Fig. 9.1). These omissions occur for a variety of phonemes, including *nasals* like the /ŋ/ of *drink* and the *liquids* /r/ and /l/ as in *warm* and *cold* (Read, 1975, 1986; Snowling, 1994; Treiman, 1993; Treiman, Zukowski, & Richmond-Welty, 1995). Children may produce errors like "wom" for *warm* because they consider *warm* to contain three units of sound—initial /w/ followed by /ɔr/ followed by /m/. For children, /ɔ/ and /r/ form a single unit rather than a sequence of two phonemes. Children may use a single vowel letter to represent this unit, producing "wom." Consistent with this interpretation, first graders who were asked to pronounce the individual sounds of syllables while putting down one token for each sound often used three tokens for a nonword such as /pɪlt/ (*pilt*), saying that its three sounds were /p/, /ɪl/, and /t/ (Treiman et al., 1995).

Another case in which children seem to group together what for adults are separate phonemes is that of initial consonant clusters. Young children sometimes fail to spell the second and third consonants of these clusters. For example, Trevor spelled *play* as "pa" (Fig. 9.2) and another first grader spelled *street* as "set" (Treiman, 1993; see also Bruck & Treiman, 1990; Miller & Limber, 1985; Treiman, 1985b, 1991). Children's omissions of consonants in initial clusters, like their omissions of consonants in final clusters, may reflect their groupings of sounds. Syllable-initial consonant clusters, or *onsets*, appear to form cohesive units for both children and adults (Bowey & Francis, 1991; Fowler, Treiman, & Gross, 1993; Kirtley, Bryant, Maclean, & Bradley, 1989; Treiman, 1985a, 1989, 1992). Children

may consider the spoken word *play* to contain the initial consonant unit /pl/ followed by the vowel /e/. They may symbolize the onset with a single letter rather than analyzing it into two phonemes and symbolizing each phoneme with a separate letter.

A final example of children's tendency to use units larger than single phonemes in relating print and speech is their use of a consonant letter to represent all of the phonemes in the letter's name. Examples include "frmmr" for *farmer*, "lefit" for *elephant*, and Jillian's "bamblbs" for *bumblebees* (Fig. 9.3). The first *r* of "frmmr" apparently stands for both /ɑ/ and /r/, which together constitute the name of the letter *r*. In "lefit," *l* represents /ɛl/, the name of the letter *l*. In "bamblbs," the last *b* seems to symbolize both /b/ and /i/. Several researchers have observed such letter-name spellings among young children (Chomsky, 1979; Ehri, 1986; Gentry, 1982; Read, 1975; Treiman, 1993, 1994). The errors appear to be more common for some consonants than for others (Treiman, 1993, 1994). Errors such as "frmmr" for *farmer* and "lefit" for *elephant*, which involve letter-name spellings of *r* and *l*, are more frequent than errors such as "bamblbs" for *bumblebees* and "ms" for *mess*, which involve letter-name spellings of *b* and *s*. Children most often group /ɑr/ and /ɛl/—the two English letters whose names consist of a vowel phoneme followed by a liquid phoneme. Because of the close bond between vowels and liquids (Derwing & Nearey, 1990, 1991; Treiman, 1984; Treiman et al., 1995), children are likely to use a familiar letter-name spelling for a vowel-liquid sequence, such as *r* for /ɑr/.

Misspellings such as "wom" for *warm*, "pa" for *play*, and "cr" for *car* suggest that children do not suddenly grasp the idea that print represents the level of phonemes. For some period of time, normally developing children may be unable to carry out full phonemic analyses of spoken words. They divide *warm* into /w/ + /ɔr/ + /m/, *play* into /pl/ + /e/, and *car* into /k/ + /ɑr/. During this time, children symbolize speech at a level that is intermediate between syllables and phonemes rather than dividing words into individual phonemes and representing each phoneme with a letter.

Children's Errors May Represent Aspects of Words' Sounds That Are Not Obvious to Adults. Even when children succeed in fully dividing spoken words into phonemes, their analyses may not always match those assumed by conventional English. For example, the children in Read's (1975) study sometimes spelled /d/ before /r/ as *g* or *j*, writing *dreidel* as "gradl" or *dragon* as "jragin." Trevor makes the same sort of error in "grak" for *drink* (Fig. 9.2). Also, the children studied by Read sometimes symbolized /t/ before /r/ as *ch*, spelling *try* as "chrie" or *truck* as "chrac." These errors, which also appear in other studies (Treiman, 1985c, 1993),

are not as bizarre as they might first seem. The use of *j* or *g* for /d/ before /r/ makes sense given that /d/ in this context is pronounced similarly to the initial sound of *Jim*, /ʤ/, which is typically spelled as *j* (*Jim*) or *g* (*gym*). When /d/ occurs before /r/, the contact between the tongue and the top of the mouth is made further back in the mouth than when /d/ occurs before a vowel. Also, the closure is released more slowly than when /d/ precedes a vowel. This gives /d/ before /r/ a degree of frication or turbulence that is similar to (although not as marked as) the frication that occurs in /ʤ/. Likewise, /t/ becomes similar to the /tʃ/ of *Chuck* when it occurs before /r/. Errors such as "gradl" for *dreidel* and "chrie" for *try* are thus reasonable spellings that reflect the words' sounds. The errors suggest that children have analyzed spoken words into phonemes but that their phonemic classifications do not match those assumed by the conventional writing system.

Errors such as "hr" for *her* and Jillian's "bigr" for *bigger* and "sunfliwr" for *sunflower* (Fig. 9.3) may also reflect phonemic analyses that do not match those embodied in the standard English writing system. *Her* is conventionally spelled as if it contained three phonemes—an initial consonant followed by a vowel followed by /r/. In most varieties of American English, however, *her* does not contain a separate vowel. Rather, /r/ takes the place of the vowel and is said to be syllabic. The spoken word *her* contains two units of sound rather than three. American children may analyze *her* into /h/ followed by syllabic /r/ and may therefore spell it without a vowel (Read, 1975; Treiman, 1993; Treiman, Berch, Tincoff, & Weatherston, 1993; Treiman, Goswami, Tincoff, & Leevers, 1997). Thus, even when children do analyze speech at a fine-grained level, their analyses may not always match those assumed by the conventional writing system.

Children's Misorderings of Letters Are Often Linguistically Based. We have seen that omission errors as in "bow" for *blow* and substitution errors as in "chruck" for *truck* are phonologically based. For example, the latter error does not reflect any visual similarity between *t* and *ch*, but instead reflects the similarity in sound between /t/ before /r/ and /tʃ/. It is widely assumed that errors that involve the misordering of letters from the conventional spelling of a word have a visual rather than a phonological basis. A child who misspells *her* as "hre" is thought to have reversed the *e* and the *r* in the memorized spelling of the word. However, if reversal errors always reflected the misordering of letters in memory, one could not explain why errors such as "hre" for *her* are more common than errors such as "hme" for *hem* (Treiman, 1993; Treiman et al., 1993). To explain this difference, one must consider the linguistic structures of the two words. The spoken form of *hem* consists of a consonant followed by a vowel and another consonant. The linguistic structure of the spoken

word helps children sequence the vowel and the *m* in spelling. For children, however, the spoken form of *her* contains an initial consonant followed by a syllabic /r/. Young children frequently omit the vowel altogether when spelling such words, as discussed earlier. In other cases, a child may remember having seen an *e* in the printed form of *her* or may realize that this word, like all other English words, must contain a vowel. Because the spoken form of the word does not indicate where the vowel should go, the child may misspell the word as "hre." Errors that include a final *e* may be particularly common because many words, like *came* and *hope*, end with a "silent" *e*. Thus, an error such as "hre" for *her* may be an invention that reflects both phonology—the syllabic /r/ in the word's sound—and orthographic knowledge—the knowledge that all English words must contain a vowel letter. It may be largely a coincidence that this error contains all of the letters of the conventional spelling.

Children's Spellings Reflect the Orthographic Patterns to Which They Have Been Exposed. The words of English or of any other language are not random strings of letters. Instead, the letters follow predictable patterns. Some of the patterns reflect the sound patterns of the spoken language. For example, printed English words do not begin with *bw* because spoken words do not begin with /bw/. Other constraints on the arrangements of letters in printed words are purely orthographic. For example, *ck* may occur in the middles and at the ends of English words, as in *packet* and *pack*, but may not occur at the beginnings of words.

The first graders in my naturalistic study (Treiman, 1993) appeared to appreciate these orthographic patterns, for they made more errors like "kack" for *cake*, which conform to the positional constraints on *ck*, than "ckak" for *cake*, which violate the constraints. Apparently, the children had begun to pick up the restriction against initial *ck*. The restriction was not formally taught at school. The children probably discovered it on their own from seeing words like *sick* and *package* but not words like *ckan*. The children appeared to follow other orthographic patterns of English as well. Further evidence of children's knowledge of orthographic patterns comes from experimental findings. In one study, children were shown pairs of pronounceable nonwords such as *ckun* and *nuck* and judged which one looked more like a real word (Treiman, 1993). The correct answer, of course, is *nuck*. Middle-class kindergartners performed significantly above chance when tested near the end of the school year and performance improved in first and second grades. The results of this and other studies (Cassar & Treiman, in press; Niles, Grunder, & Wimmer, 1977; Pick, Unze, Brownell, Drozdal, & Hopmann, 1978; Rosinski & Wheeler, 1972) indicate that children learn which letter sequences may and may not occur in English words.

Young children's spelling errors are not always orthographically legal. This is especially true when there are strong counteracting factors involving phonology. For example, as discussed previously, children may misspell *her* as "hr," using a single consonant letter for the syllabic /r/. This error is phonologically reasonable but orthographically odd, in that it does not include a vowel. Orthographic correctness is one of several factors that are involved in children's spelling. For young children, it is a weaker force than phonological correctness. Still, many of children's errors reveal a surprisingly good knowledge of the letter patterns that do and do not occur in print.

Toward More Sophisticated Spelling

As children progress, their knowledge of the spelling system grows and deepens and they become better and better spellers. At least four kinds of changes occur with increasing spelling skill.

Children Internalize the Classifications of Sounds That Are Embodied in the Conventional Orthography. As children learn to read, they see how sounds are classified by the conventional writing system. For example, the first sound of *dry* is classified as /d/ rather than /ʤ/, *her* is considered to contain a vowel, and *warm* is considered to contain /r/. Before children learn to read, their choices in cases such as these may not match those of the conventional writing system. For example, some children may classify the first sound of *dry* as a type of /ʤ/ rather than a type of /d/. As children see that this sound is always spelled with *d*, their classifications gradually change. Learning to read and write may thus shape children's conceptions of speech, changing their classifications of certain potentially ambiguous sounds (Derwing, 1992; Fowler, 1991). Orthography, originally learned as a representation of speech, takes on a life of its own and begins to influence children's views about the language itself.

Children Rely More on Conventional Spellings. When children first start to write, they may know the conventional spellings of only a few words. For example, when Bobby wrote the message in Fig. 9.1 he knew how to spell his own name, the names of other family members, and a few common words like *no*. If children do not ask an adult how to spell sounds (like Bobby, who wanted to write the message on his own) or if the adult will not provide such information (like the teacher in the classroom studied by Treiman, 1993), children must come up with spellings on their own. Given their limited knowledge, it is not surprising that children's choices are sometimes unconventional. As children learn

to read and spell more and more words, they acquire a broader base of knowledge from which to induce conventional phoneme–grapheme correspondences. In addition, many children are explicitly taught these correspondences as part of phonics instruction. As a result, unconventional spellings become less common. Errors increasingly involve possible spellings of sounds that are used in the wrong contexts. For example, a child may misspell *plaid* as "plad," using the typical *a* rather than the atypical *ai* to represent the /æ/ phoneme.

Children Rapidly Learn About the Letter Patterns in Printed Words. As discussed earlier, even young children know a good deal about the letter patterns that may appear in printed words. Orthographic knowledge increases rapidly across the early school years as children learn more and more words and make generalizations about the kinds of letter sequences that do and do not occur (Cassar & Treiman, in press; Niles et al., 1977; Pick et al., 1978; Rosinski & Wheeler, 1972; Treiman, 1993). Thus, even when older children's spellings are wrong, the errors often "look right."

Children Come to Understand That Morphemes Are Often Spelled in a Consistent Fashion. The English writing system is typically considered an alphabet, albeit irregular. However, English often deviates systematically from the alphabetic principle in the case of words that contain more than one morpheme or unit of meaning. For example, one would expect *health* to be spelled as *helth* based on the phonemes that it contains. The *a* in the conventional spelling shows that the word is morphologically related to *heal*. As another example, *jumped* and *hemmed* end with different phonemes—/t/ for *jumped* and /d/ for *hemmed*. However, because the final sounds both represent the past tense marker, the words are both spelled with final *ed*.

It takes time for children to learn about the morphological consistencies in English spelling (Carlisle, 1987; Ehri, 1986; Gentry, 1982; Henderson, 1985; Templeton, 1992; Waters, Bruck, & Malus-Abramowitz, 1988). Indeed, poor adult spellers may never fully master this aspect of the system (Fischer, Shankweiler, & Liberman, 1985). Errors such as "finaly" for *finally* or "sine" for *sign* may arise because children do not know that *finally* is related to *final* or that *sign* is related to *signal*. A word such as *signal* may not even be in a young child's vocabulary. In addition, children may not have mastered the often complex rules by which suffixes and prefixes are added to spoken words. For example, the changes that take place between *magic* and *magician* or *original* and *originality* involve variations in pronunciation and stress.

With simple suffixes and relatively common words, even young children have some ability to represent morphological relationships among

words in spelling. Treiman, Cassar, and Zukowski (1994) examined children's spellings of words like *dirty* and *attic*. Both words contain a *flap*—a quick tap of the tongue against the upper part of the mouth. Flaps, being voiced, are similar to /d/ and children often misspell them as *d* (Read, 1975). If children use the root word *dirt* to aid their spelling of *dirty*, they should be unlikely to misspell the flap of *dirty* with a *d*. Such errors should be more common on *attic*, which is not related to *at*. Supporting these predictions, even kindergartners produced more correct spellings of flaps when there was a stem that could help them, as with *dirty*, than when there was no such stem, as with *attic*. However, young children did not use their knowledge of the stem to the maximum extent possible. They were not as likely to spell *dirty* with a *t* as to spell *dirt* with a *t*. Children's ability to use morphological relations to aid their spelling improves across the school years (see also Treiman & Cassar, 1996).

SPELLING IN DEVELOPMENTAL DYSLEXIA

Given the overview of spelling development in normal children, I now turn to the case of dyslexics. As mentioned previously, dyslexics have serious problems with spelling, often more serious problems than they do with reading. The dyslexics who wrote the jokes in Fig. 9.4 were

Two guys in the desert oone guy has a car door. So the other guy says why do you have a car doo? becose if im hot il open the window.

Haw do you stop a dull frum crcing -tak a away his credicrd

What do yuo get when you sros a mink and a kagroo -a fer cote with pocits

Noc noc hos wer Bow how Don't criy its oley a joke

FIG. 9.4. Jokes written by dyslexic children aged 8 to 11. First joke reads, "Two guys in the desert. One guy has a car door. So the other guy says why do you have a car door? Because if I'm hot I'll open the window." Second joke reads, "How do you stop a bull from charging? Take away his credit card." Third joke reads, "What do you get when you cross a mink and a kangaroo? A fur coat with pockets." Fourth joke reads, "Knock knock who's there? Boo hoo. Don't cry, it's only a joke."

between 8 and 11 years old. They had at least average IQs and were receiving individualized treatment using a phonics approach. Although these children were at least two years older than the first graders Trevor and Jillian, their spelling is not much better.

As compared to normal children of the same age, dyslexics perform poorly on any type of spelling test. A more interesting and theoretically important comparison involves older dyslexics and younger normal children. If dyslexics learn to spell in much the same way as normal children, but at a slower rate, they should be indistinguishable from younger normal children of the same spelling level. However, if dyslexics approach the task of spelling in a qualitatively different way than normal children, then the two groups may show very different patterns of performance. Such differences, if they exist, would provide valuable clues to the nature and causes of dyslexics' spelling and reading problems. In the following review, I therefore concentrate on studies that have used a *spelling-level match* design, in which dyslexics are compared with younger normal children who perform at the same level on some particular spelling test. The studies reviewed here examine individuals who have been identified as dyslexic or as having specific learning disabilities in the area of written language. I do not consider studies of children who are identified as generally learning disabled. These children's difficulties extend to academic areas other than reading and spelling, and their spelling problems might differ from those of dyslexic children.

Because most research on dyslexia has focused on reading, many studies have used a reading-level-match design in which dyslexics are compared with younger normal children of the same reading level. The problem with this design, if used to investigate spelling skills, is that dyslexics are typically more delayed in spelling than in reading. Dyslexics who are matched with younger normal children in reading ability may spell more poorly than the normals. If the dyslexics are worse than the reading-level-matched normals on spelling or some related skill, the difference could reflect the lack of matching of the two groups for spelling level. However, if the dyslexics are not worse than the normals, their performance becomes more impressive.

In the following sections, I discuss studies that have attributed dyslexics' spelling problems to difficulties with serial order, difficulties in grasping the alphabetic nature of English writing, and difficulties in understanding the morphological basis of the English writing system.

Dyslexia as a Problem With Serial Ordering

Early researchers suggested that dyslexics have a general difficulty with serial ordering in language that shows up in the misordering of letters in spelling as well as in the misordering of words in speech (Critchley, 1975;

Lecours, 1966; Orton, 1931). In addition to misordering letters in words, dyslexics may also rotate individual letters, for example writing *b* as *d*. The dyslexics who produced the spellings depicted in Fig. 9.4 made some sequencing errors, as in *yuo* for *you*, and some letter reversal errors, as in *dull* for *bull*.

Several researchers have asked whether dyslexics are more likely than younger normal children to make errors that involve the misordering of letters in words. Nelson (1980) tested 30 children who had been diagnosed as dyslexic by a hospital clinic. The dyslexic children, who averaged 11.1 years old, were compared with 30 normally achieving children with a mean age of 7.7 years. The two groups of children performed at the same level on a single-word spelling test that Nelson developed. Examining the dyslexics' first 20 errors on this test, Nelson found that 8% involved misorderings of letters from the conventional spelling of the word. The figure was 9% for the control children, not a significant difference. Moats (1983) studied 27 dyslexic children in the fourth through eighth grades, the majority of whom attended a private school for dyslexics. The dyslexic children scored at a second- or third-grade level on a standardized single-word spelling test. The dyslexics were compared with 27 second graders who performed at the same level on the spelling test. Moats found that 2% of the dyslexics' errors on the spelling test involved serial order. The figure for the normal second graders was 4%, a nonsignificant difference. Pennington et al. (1986) compared 24 dyslexic adults with family histories of dyslexia to 17 normally achieving children with an average age of 11.6 years. Both groups had a mean grade equivalent of about 6.6 on a standardized spelling test. Pennington et al. found that sequencing errors were uncommon (less than 8%) in both groups. Neither the adult dyslexics nor the normal control group made any reversal errors, such as *b* for *d*.

Although there are gaps in the research—for example, a lack of studies that have used a spelling-level-match design to examine reversal errors in dyslexic children—the results do not support the idea that dyslexics are especially prone to serial ordering errors or letter reversal errors in spelling. In fact, the research on normal children's spelling reviewed earlier suggests that errors involving the misordering of letters from the conventional spelling of a word do not necessarily reflect problems in visual memory. "Hre" for *her* may be an invention that reflects the syllabic /r/ in the word's spoken form and the writer's knowledge that all English words must contain a vowel letter. It may be little more than a coincidence that the error contains the same letters as the conventional spelling but in the wrong order. Research is needed to determine whether the misordering errors of dyslexics are influenced by the same factors that operate for normal children.

Dyslexia as a Problem in Grasping the Alphabetic Basis of English Spelling

As the idea that dyslexia reflects a general problem with serial ordering waned in popularity, dyslexics' problems came to be seen as primarily linguistic in nature. Specifically, dyslexics were thought to have difficulty in learning and using the alphabetic principle. Dyslexics may progress normally through the precursors of alphabet writing (although this has not been investigated, to my knowledge). However, because of underlying phonological difficulties, dyslexics stumble when it comes to grasping the alphabetic principle. Dyslexics try to compensate for this problem by relying heavily on visual memorization. The alphabetic principle hypothesis has been put forward by many investigators (e.g., Frith, 1985; Goswami & Bryant, 1990; Liberman, Rubin, Duques, & Carlisle, 1985; Shankweiler et al., 1995; Stanovich, 1992). Even those who argue that there are different subtypes of dyslexia typically claim that the majority of dyslexics have trouble with phonological processing (e.g., Boder, 1973).

The idea that most developmental dyslexics have difficulty learning and using the alphabetic principle leads to several predictions. First, dyslexics' spelling errors should differ from those of younger normal children of the same spelling level. Dyslexics should be more likely to produce bizarre spellings that have little or no phonological connection to the target word. Second, dyslexics should perform relatively well on common words whose spellings they have been able to memorize. However, they should have great difficulty constructing plausible spellings for unfamiliar words and nonsense words. Third, because dyslexics tend to rely heavily on memorization, their knowledge of orthographic patterns may actually be better than that of younger normal children of the same spelling level. Finally, dyslexics' phonological skills should be worse than those of spelling-level-matched controls. These predictions are explored in turn in the following sections.

"Phonetic" and "Nonphonetic" Errors. A number of researchers have tested the hypothesis that dyslexics have trouble learning and using the alphabetic principle by examining their spelling errors. To find out whether dyslexics' errors show less understanding of the alphabetic principle than do the errors of normally progressing younger children, researchers have typically divided errors into "phonetic" and "nonphonetic" categories. Phonetic errors, such as "plad" for *plaid*, are those in which each phoneme is represented with a letter or letter group that may be used to symbolize that sound in conventional English. Some investigators use a strict criterion for phonetic errors, counting an error as phonetic only if it sounds like the target word when read aloud. "Plad" for *plaid* is a phonetic error by the strict criterion. "Tak" for *take* is not

phonetically correct by a strict criterion because the rules of English call for a final *e* in this context. Other investigators use a lax criterion for phonetic errors. They count an error as phonetic if each phoneme is symbolized with a letter that is used in some English word to represent that sound, even if not in the same context. By this criterion, "tak" for *take* is phonetic, because /e/ is spelled with single *a* in words such as *bacon*. Nonphonetic errors include "pad" for *plaid*, "wom" for *warm*, and "doo" for *door*, in which a phoneme is not represented. Also, "plag" for *plaid* and "jry" for *dry* are counted as nonphonetic because some phoneme is symbolized with a letter that is never used to represent that phoneme in conventional English. Researchers have assumed that children who make a preponderance of phonetic errors understand the alphabetic principle. Children who make many nonphonetic errors are believed to lack an appreciation of the alphabetic principle. They are thought to spell words via rote visual memorization rather than via a sound-based process. As I discuss later, these assumptions are problematic. Before discussing these problems, however, I review the studies that have employed a phonetic/nonphonetic classification.

Four studies have found that dyslexics do not produce a higher percentage of nonphonetic errors than do younger normal children of the same spelling age. Nelson (1980), in the study described earlier, used a lax criterion to distinguish between phonetic and nonphonetic errors. The percentage of errors that were nonphonetic was 35% for dyslexics and 36% for younger normal children, a nonsignificant difference. In some of the analyses reported by Moats (1983), a lax criterion was used to classify errors as phonetic or nonphonetic by reference to the conventional spelling system. For dyslexic children in the fourth through eighth grades, 39% of the errors were nonphonetic. The figure was 44% for normal second graders. The difference was not significant. Pennington et al. (1986) used both lax and strict scoring systems in their study of dyslexic adults and normally achieving children. Using a lax criterion, 35% of the dyslexic adults' errors were phonetically inaccurate, as compared to 33% of the normal children's errors. Using a strict criterion, 75% of the adults' errors were inaccurate, as were 71% of the normal children's. The differences were not significant. Finally, Bradley and Bryant (1979) studied 62 dyslexic children with a mean age of 10 years, 4 months, and 30 younger normal children. The two groups performed similarly on a standardized spelling test, with spelling ages of about 7 years. For both dyslexics and normals, at least one phoneme was spelled correctly in at least 90% of the errors. Errors in which none of the phonemes were correct were no more common among the dyslexics (3%) than among the normals (5%). These results suggest that dyslexics' errors do not differ from those of younger normal readers and spellers in phonetic accuracy.

However, other studies have found nonphonetic errors to be more frequent among dyslexics than among normal children of the same spelling level. Bruck (1988) compared 17 dyslexic children who attended a remedial reading and spelling program at a reading disabilities clinic with 17 normal children. The dyslexics had a mean age of 10.7 years and the normals a mean age of 7.6 years. Both groups had a grade equivalent of about 3.6 on a standardized spelling test. The children spelled real words and nonwords, and Bruck used a strict criterion to score the children's errors as phonetic or nonphonetic. For dyslexics, 59% of the errors were nonphonetic. The figure was 41% for the normal children, a significant difference. A potential problem with this study is that the dyslexics produced somewhat fewer correct spellings of real words than the normals did, although the difference was not significant. Even though the dyslexic and control groups performed similarly on the standardized spelling test, the dyslexics' true level of performance may have been overestimated by this test. Because of measurement error, two samples that have the same mean score on a test may differ when tested again, the means reverting closer to the true population means. This problem of regression to the mean frequently arises in studies using a spelling-level- or reading-level-match design (Jackson & Butterfield, 1989). If the dyslexics in Bruck's study were poorer spellers than the controls, it would not be surprising that their errors were less phonetic. The errors of poorer spellers tend to be less phonetic than the errors of better spellers according to either strict or lax classification schemes (Finucci, Isaacs, Whitehouse, & Childs, 1983; Lennox & Siegel, 1993; Nelson, 1980).

A similar problem may arise in the study by Olson (1985). He compared a group of dyslexics (mean age 15.3 years) with younger normal children (mean age 10.1 years). The two groups performed similarly on a standardized single-word reading test. When the children's spellings were rated for phonetic similarity to the target word, the dyslexics' errors were significantly less phonetic than were the normal children's errors. However, if the dyslexics were poorer spellers than the control children, this is not surprising.

Stronger support for the idea that dyslexics' spelling errors are less phonetic than those of normal children comes from two studies in which children spelled many items containing consonant clusters. Bruck and Treiman (1990) tested 23 dyslexics (mean age 10 years, 2 months) and 23 normal first and second graders who performed at the same level on a standardized spelling test. Using a lax criterion for phonetic legality, the dyslexics produced 36% nonphonetic errors as compared to 21% for the normal children. The difference was statistically reliable. Kibel and Miles (1994) studied 21 dyslexic children between 9 and 15 years old and 21 normal children aged 7 to 11. The children were matched on a pairwise

basis for their performance on a standardized spelling test. When given words that contained many consonant clusters, the dyslexics were significantly more likely than the normals to produce errors in which phonemes were omitted or incorrectly represented. Both Bruck and Treiman and Kibel and Miles found that dyslexics often failed to spell consonants in clusters, as in "bot" for *blot*. As discussed earlier, such errors are nonphonetic according to traditional classification schemes but are common among young normal children. It appears that dyslexics make cluster omission errors even more frequently than do younger normal children of the same spelling level.

A serious problem with all the studies that have classified errors as phonetic or nonphonetic from the viewpoint of the conventional system involves the classification scheme itself. Researchers have typically assumed that children who make many nonphonetic errors fail to represent the sounds of words in their spelling and instead spell on a visual basis. This assumption is probably incorrect. As I have shown, errors such as "bot" for *blot*, "wom" for *warm*, and "jry" for *dry*—errors that are nonphonetic by either a strict or a lax criterion—are common among normal beginners. They reflect children's tendency to treat /bl/ and /ɔr/ as units and their classification of /d/ before /r/ as a type of /ʤ/. The errors are very much phonologically based. If dyslexics make many "nonphonetic" errors, we can say that their spellings are not conventional but we cannot claim that they fail to appreciate the role of phonology in spelling.

Moats (1983) attempted to go beyond traditional phonetic/nonphonetic classification schemes in some of her analyses by determining whether dyslexics' errors were phonetically accurate from the perspective of normal beginning spelling. Thus, "wed" for *wind* and "chran" for *train* were classified as preconventional phonetically accurate errors. There are some problems with Moats' classification scheme. "Stuck" for *struck* was considered phonetically inaccurate, even though research discussed earlier shows that omissions of the second and/or third consonants of initial clusters are common among normal beginners. As another example, "wom" for *warm* was counted as phonetically inaccurate, even though such liquid omissions are common among young children. Such problems would lead Moats to overestimate the percentage of errors that were phonetically inaccurate from both the viewpoint of the conventional system and the viewpoint of normal children's early spellings. It is striking, then, that only 16% of dyslexics' errors fell into this phonetically inaccurate category. This percentage is lower than the percentages of nonphonetic errors reported for dyslexic children by Bruck (1988), Bruck and Treiman (1990), and Nelson (1980), and for dyslexic adults by Pennington et al. (1986). It was also lower than the percentage of nonphonetic errors that Moats obtained when she used traditional scoring criteria.

Thus, many of dyslexics' errors that are "nonphonetic" with regard to the conventional English writing system are indeed phonologically based. Dyslexics' "nonphonetic" errors are more likely to be reasonable errors, such as "stuck" for *struck* and "wet" for *went*, than bizarre errors, such as "foz" for *past* (Bruck & Treiman, 1990; Kibel & Miles, 1994; Moats, 1983). Dyslexics' spelling errors are qualitatively similar to those of normal younger children. It is still unclear whether dyslexics' tendency to make relatively primitive phonologically based spellings such as "stuck" for *struck* and "wet" for *went* is higher than would be expected given their scores on standardized spelling tests. The results of Moats (1983) suggest that it is not, whereas the results of Bruck and Treiman (1990) and Kibel and Miles (1994) suggest that it is. What is clear is that dyslexics attempt to represent the sounds of words in their spelling, even if they do not necessarily do so in a conventional manner.

Spelling of Nonwords. If dyslexics have trouble grasping the alphabetic principle and instead rely on visual memorization, they should have special difficulty spelling nonwords. Dyslexics should perform as well on common real words as do younger normal children of the same spelling level. However, dyslexics should do significantly more poorly on nonwords. Put another way, the difference between real words and nonwords should be larger for dyslexics than for younger normal children of the same spelling level. Although many investigators have tested this hypothesis for reading (see Rack, Snowling, & Olson, 1992), only a few have done so for spelling.

In Bruck's (1988) study, described earlier, children's spellings of nonwords were scored as correct or incorrect using a strict criterion. The spelling had to be pronounced like the target word using conventional spelling-sound rules in order to count as correct. The difference between real words and nonwords was not significantly larger for the dyslexics than for the normal children. Siegel and Ryan (1988) used a reading-level-match design. They compared groups of reading-disabled children who scored at the second through sixth grade levels on a standardized reading test (n = 43) and groups of normally achieving children who scored at the same levels (n = 67). When the children's spellings of nonwords were classified as correct or incorrect, the dyslexics produced significantly fewer correct spellings than the normals. A problem with this study is that no data on the children's spelling of real words are reported. As compared to the normal children, the dyslexics may have been poorer spellers of real words as well as poorer spellers of nonwords. Finally, Martlew (1992) compared 12 dyslexic children with a mean age of 10 years and 3 months to 12 normal children about 2 years younger. The two groups performed similarly on a standardized spelling test. The children were asked to spell

eight words and three nonwords. The dyslexics made significantly more errors on the nonwords than did the younger normal children, but did not make significantly more errors on the words. These results suggest that dyslexics have particular difficulties with nonwords. However, the small number of stimuli and the small number of participants make it difficult to draw strong conclusions.

Based on the results of these few studies, it is not clear whether dyslexics have more trouble spelling nonwords than would be expected given their level of performance on real words. An important issue that has not been addressed in the research concerns the scoring of nonword spellings. The same issues arise here as in scoring errors on real words. For example, most researchers would consider "pit" for /pɪlt/ (*pilt*) an error. However, the error is not bizarre but is of a type common among normal beginners. Even if dyslexics could be shown to have more difficulty using conventional phoneme–grapheme correspondences to spell nonwords than expected given their level of performance on real words, I suspect that their errors are more like "pit" for /pɪlt/ than like "gam" for /pɪlt/.

Orthographic Knowledge. As discussed earlier, normal children quickly learn which letter sequences may and may not occur in printed words. Their spellings, even when incorrect, often reveal a knowledge of orthographic patterns. For example, first graders are more likely to misspell *cake* as "cack" than as "ckak" (Treiman, 1993).

Given their level of performance on standardized spelling tests, dyslexics' knowledge of orthographic patterns appears to be as good as or even better than normals'. Nelson (1980), in the study described earlier, classified dyslexics' and normals' spelling errors as orthographically legal (e.g., "cack" for *cake*) or illegal (e.g., "ckak" for *cake*). For dyslexics, 82% of the errors were orthographically legal. The figure was 87% for normal children, not a significant difference. In the study by Pennington et al. (1986), both the dyslexic adults and the normal children produced 95% or more orthographically legal errors. Perhaps because of their greater exposure to print, the dyslexics were significantly better than the younger normal children on a measure of complex orthographic accuracy that assessed such things as correct doubling of the *p* in *opportunity* and use of *phys* in *physician*.

In two other studies, dyslexics and normals were matched on reading ability rather than spelling ability. In Olson's (1985) study, described earlier, the spelling errors of dyslexic and normal children were rated for visual similarity to the target word. No reliable differences were found between the dyslexics and the normals. As mentioned earlier, however, the dyslexics' errors were rated as less phonetically accurate than the

normals'. Siegel, Share, and Geva (1995) compared groups of dyslexics performing at the first-grade through eighth-grade levels on a standardized single-word reading test ($n = 255$) with groups of normal children performing at each of these levels ($n = 340$). The children were shown pairs of nonwords such as *moke* and *moje* and were asked which one looked more like a word. The correct answer, of course, is *moke*. The dyslexics did significantly better than the normal children. Given that the dyslexics studied by Olson and Siegel et al. may have been poorer spellers than the normal controls, it is striking that they did as well as or better than the normals on the orthographic measures.

Thus, dyslexics' orthographic skills are at least commensurate with their overall level of spelling (and reading) development. Indeed, the results of Pennington et al. (1986) and Siegel et al. (1995) suggest that dyslexics may actually know more than younger normal children about the orthographic sequences that may and may not occur in English words.

Phonological Awareness. The results of Bruck and Treiman (1990) suggest that dyslexics' phonological awareness skills are lower than expected given their performance on standardized spelling tests. The dyslexic children in this study performed significantly worse than did the younger normal children in phoneme deletion tasks, for example, deleting the /p/ of /ploi/ to yield /loi/. Children in both groups often responded /oi/ rather than /loi/, but the dyslexics did so even more often than the normals. The dyslexics were also poorer than the spelling-level-matched normal children in phoneme recognition tasks such as detecting the /l/ in /ploi/. These difficulties, it appeared, were linked to children's tendency to omit the *l* when spelling syllables such as /ploi/. These results support the idea that dyslexics have a special tendency to treat onset clusters in spoken words as units. To my knowledge, no other studies have used a spelling-level-match design to compare the phonological skills of older dyslexics and younger normals.

Conclusions About the View of Dyslexia as a Problem in Grasping the Alphabetic Principle. The idea that dyslexia reflects a difficulty learning and using the alphabetic principle has been widely accepted by reading researchers. For example, the results reviewed by Rack et al. (1992) suggest that dyslexics have more difficulty pronouncing nonwords than would be expected given their level of performance on real words, especially if the nonwords are phonologically complex (e.g., *molsmit*) or if they have not been preceded by similar real words. Spelling is thought to involve phonology to a greater extent than reading (e.g., Bradley & Bryant, 1979; Goswami & Bryant, 1990). One would therefore expect phonological difficulties to manifest themselves even more clearly in spelling than in reading. Surprisingly, the studies reviewed here yield mixed results. Some studies

find dyslexics' spelling to be indistinguishable from that of normal younger children, whereas other studies find differences.

Dyslexics' spelling errors are qualitatively similar to those of younger normal children. Far from being bizarre or unmotivated, dyslexics' misspellings usually have a linguistic basis. Dyslexics do not predominantly make errors like "foz" for *past* that reflect total ignorance of alphabetic principle. Rather, they tend to produce spellings like "wid" for *wind*, "bot" for *blot*, and "crd" for *card*—spellings that are similar to those produced by normal beginners. These errors may appear "nonphonetic" when judged against the conventional English writing system. However, the errors have a reasonable linguistic explanation.

Some of the studies point to quantitative differences between dyslexics and normal younger children. Specifically, dyslexics may make a larger number of primitive phonologically based spellings such as "bot" for *blot* and "crd" for *card* than do normal children of the same spelling age. Dyslexics' phonological skills may be somewhat lower than expected given their level of performance on standardized spelling tests, and their orthographic skills may be somewhat better. Dyslexics' errors, to a greater degree than normals', may reflect the use of units larger than single phonemes. Thus, dyslexics may be especially likely to write /ɑr/ with a single *r* or /bl/ with a single *b*. However, other studies have not found quantitative or qualitative differences between dyslexics and younger normal children.

The evidence does not support the strong claim that dyslexics are unable to link speech and print in their spelling. However, dyslexics may have more difficulty doing this at a fine-grained level than would be expected given their ability to spell real words. Moats (1983) and Nelson (1980) may not have found differences between dyslexics and spelling-level-matched controls because they analyzed children's errors on standardized spelling tests. These tests include words with a variety of linguistic structures; they do not permit an in-depth investigation of particular word types. To determine whether dyslexics and younger normal children show different patterns of spelling errors, we must look in detail at their performance on specific kinds of words and nonwords and must go beyond simple phonetic/nonphonetic classification schemes.

Dyslexia as a Problem in Grasping the Morphological Basis of English Spelling

In normal children, the development of spelling does not stop with the acquisition of the alphabetic principle. As discussed earlier, children learn that alphabetic spelling is sometimes overridden by morphological considerations. Thus, *health* is not spelled as *helth*, as it sounds, but with an *a* that shows its link to *heal*. Do dyslexics grasp the morphological basis

of English spelling or does development stop, for them, with the acquisition of the alphabetic principle? Few studies have addressed this issue.

Carlisle (1987) studied 17 ninth graders who were identified as having specific learning disabilities in reading and written language skills. The ninth graders performed at the same level as a group of fourth graders on a standardized spelling test. They were comparable to the fourth graders on a spelling test involving base words such as *magic* and derived forms such as *magician*. However, the learning-disabled ninth graders were significantly better than the fourth graders on an oral test tapping knowledge of derivational morphology. They seemed to know more about derivational morphology than they could reveal in print. The learning-disabled students appeared to spell derived words as wholes to a greater degree than did the fourth graders. For instance, they might spell *magic* correctly but be unable to spell *magician*, or vice versa. Thus, Carlisle's dyslexics seemed to have difficulty going beyond the alphabetic principle to grasp the morphological basis of English spelling.

Bruck (1993) found a different pattern of results in a study of 15 college students with childhood diagnoses of dyslexia. The dyslexics were compared with 15 sixth graders who performed at a similar level (eighth to ninth grade) on a standardized spelling test. The dyslexics performed worse than the sixth graders on most of the experimental spelling tests, except for tests involving knowledge and use of morphological information. Here, the college dyslexics did as well as the sixth graders. Bruck suggested that use of morphological information was less of a problem for her adult dyslexics than might be expected, perhaps because these students were reading complex materials on a daily basis.

CONCLUSIONS

Developmental dyslexia has typically been defined by exclusion. Dyslexics are individuals who fail to develop literacy skills commensurate with their age and general level of intellectual functioning, and whose difficulties cannot be explained by lack of educational opportunity, known brain damage, or emotional or personality disorder. Researchers have long sought symptoms that would positively identify dyslexics and distinguish them from those with other types of reading and spelling problems. Spelling errors, it was thought, might be markers of dyslexia. Thus, individuals who make large numbers of misordering errors such as "trial" for *trail*, reversal errors such as "dull" for *bull*, or "nonphonetic" errors such as "fegr" for *finger* might be positively identified as dyslexic. The errors would shed light on the underlying causes for their disability.

These hopes have not materialized in any simple form. Dyslexics' spelling certainly looks more primitive than that of normal children of

the same age. However, dyslexics' spelling does not look all that different from the spelling of younger children. According to some studies, in fact, dyslexics are indistinguishable from younger normal children in terms of misordering errors, reversal errors, and ability to spell words and nonwords in a "phonetic" manner. Such results lead to the sobering suggestion that spelling errors may not provide markers of dyslexia and may not shed light on the underlying causes of the disability. In this view, dyslexics learn to spell much as normal children do, only much more slowly. The reasons for the slowness remain a mystery.

However, other studies have found subtle differences between the spellings of dyslexics and younger normal children. These differences lie not in misordering errors and reversal errors, long thought to be the hallmark of dyslexia, but in phonologically based errors. Dyslexics, even more than younger normal children, may have difficulty carrying out fine-grained analyses of spoken words. They may be more apt to produce errors such as "bot" for *blot* or "crd" for *card*, in which sequences of phonemes are spelled as units. These errors are not markers of dyslexia in any simple sense, because young normal children make them as well. However, the errors may be especially persistent in dyslexics. What may turn out to distinguish dyslexics from normals may be a profile of performance in which primitive phonologically based errors coexist with relatively high levels of knowledge about the orthographic structure of printed words. In this view, dyslexics understand that print is a representation of spoken language. However, their difficulty in analyzing spoken syllables into small units makes it hard for them to learn conventional phoneme–grapheme correspondences.

Although there has been much less research on spelling than on reading, the situation is starting to change (see Brown & Ellis, 1994; Perfetti, Fayol, & Rieben, in press; Moats, 1995; Templeton & Bear, 1992; Treiman, 1993). We now understand that research on abnormal development cannot proceed in the absence of detailed knowledge of normal development. Without this background, one may label certain dyslexic misspellings as "bizarre," not knowing that these errors are common among normally developing younger children and that they have a reasonable linguistic basis. The stage is set for more sophisticated research on the spelling development of dyslexic children. The findings, it is hoped, will help to clear up the many questions and ambiguities that have arisen in the research reviewed here.

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REFERENCES

Boder, E. (1973). Developmental dyslexia: A diagnostic approach based on three atypical reading–spelling patterns. *Developmental Medicine and Child Neurology, 15,* 663–687.

Bowey, J. A., & Francis, J. (1991). Phonological analysis as a function of age and exposure to reading instruction. *Applied Psycholinguistics, 12,* 91–121.

Bradley, L., & Bryant, P. E. (1979). Independence of reading and spelling in backward and normal readers. *Developmental Medicine and Child Neurology, 21,* 504–514.

Brown, G. D. A., & Ellis, N. C. (Eds.). (1994). *Handbook of normal and disturbed spelling: Theory, process and intervention.* Chichester, England: Wiley.

Bruck, M. (1988). The word recognition and spelling of dyslexic children. *Reading Research Quarterly, 23,* 51–69.

Bruck, M. (1993). Component spelling skills of college students with childhood diagnoses of dyslexia. *Learning Disability Quarterly, 16,* 171–184.

Bruck, M., & Treiman, R. (1990). Phonological awareness and spelling in normal children and dyslexics: The case of initial consonant clusters. *Journal of Experimental Child Psychology, 50,* 156–178.

Carlisle, J. F. (1987). The use of morphological knowledge in spelling derived forms by learning-disabled and normal students. *Annals of Dyslexia, 27,* 90–108.

Cassar, M., & Treiman, R. (in press). The beginnings of orthographic knowledge: Children's understanding of simple letter patterns. *Journal of Educational Psychology.*

Chomsky, C. (1979). Approaching reading through invented spelling. In L. B. Resnick & P. A. Weaver (Eds.), *Theory and practice of early reading* (Vol. 2, pp. 43–65). Hillsdale, NJ: Lawrence Erlbaum Associates.

Critchley, M. (1975). Specific developmental dyslexia. In E. H. Lenneberg & E. Lenneberg (Eds.), *Foundations of language development: A multidisciplinary approach* (Vol. 2, pp. 361–366). New York: Academic Press.

Derwing, B. L. (1992). Orthographic aspects of linguistic competence. In P. Downing, S. D. Lima, & M. Noonan (Eds.), *The linguistics of literacy* (pp. 193–211). Amsterdam/Philadelphia: John Benjamins.

Derwing, B. L., & Nearey, T. M. (1990, November). *Real-time effects of some intrasyllabic collocational constraints in English.* Paper presented at the International Conference on Spoken Language Processing, Kobe, Japan.

Derwing, B. L., & Nearey, T. M. (1991, August). *The "vowel-stickiness" phenomenon: Three experimental sources of evidence.* Paper presented at the Twelfth International Congress of Phonetic Sciences, Aix-en-Provence, France.

Ehri, L. C. (1986). Sources of difficulty in learning to spell and read. In M. L. Wolraich & D. Routh (Eds.), *Advances in developmental and behavioral pediatrics* (Vol. 7, pp. 121–195). Greenwich, CT: JAI Press.

Ferreiro, E., & Teberosky, A. (1982). *Literacy before schooling.* New York: Heinemann.

Finucci, J. M., Isaacs, S. D., Whitehouse, C. C., & Childs, B. (1983). Classification of spelling errors and their relationship to reading ability, sex, grade placement, and intelligence. *Brain and Language, 20,* 340–355.

Fischer, F. W., Shankweiler, D., & Liberman, I. Y. (1985). Spelling proficiency and sensitivity to word structure. *Journal of Memory and Language, 24,* 423–441.

Fowler, A. E. (1991). How early phonological development might set the stage for phoneme awareness. In S. A. Brady & D. P. Shankweiler (Eds.), *Phonological processes in literacy: A tribute to Isabelle Y. Liberman* (pp. 97–117). Hillsdale, NJ: Lawrence Erlbaum Associates.

Fowler, C. A., Treiman, R., & Gross, J. (1993). The structure of English syllables and polysyllables. *Journal of Memory and Language, 32,* 115–140.

Frith, U. (1985). Beneath the surface of developmental dyslexia. In K. E. Patterson, J. C. Marshall, & M. Coltheart (Eds.), *Surface dyslexia: Neuropsychological and cognitive studies of phonological reading* (pp. 301–330). Hillsdale, NJ: Lawrence Erlbaum Associates.

Gentry, J. R. (1982). An analysis of developmental spelling in GNYS AT WRK. *The Reading Teacher, 36,* 192–200.

Gibson, E. J., & Levin, J. (1975). *The psychology of reading.* Cambridge MA: MIT Press.

Goswami, U., & Bryant, P. E. (1990). *Phonological skills and learning to read.* Hove, England: Lawrence Erlbaum Associates.

Henderson, E. (1985). *Teaching spelling.* Boston: Houghton Mifflin.

Jackson, N. E., & Butterfield, E. C. (1989). Reading-level-matched designs: Myths and realities. *Journal of Reading Behavior, 21,* 387–412.

Kibel, M., & Miles, T. R. (1994). Phonological errors in the spelling of taught dyslexic children. In C. Hulme & M. Snowling (Eds.), *Reading development and dyslexia* (pp. 105–127). London: Whurr.

Kirtley, C., Bryant, P., Maclean, M., & Bradley, L. (1989). Rhyme, rime, and the onset of reading. *Journal of Experimental Child Psychology, 48,* 224–245.

Lecours, A.-R. (1966). Serial order in writing—A study of misspelled words in "developmental dysgraphia." *Neuropsychologia, 4,* 221–241.

Lennox, D., & Siegel, L. S. (1993). Visual and phonological spelling errors in subtypes of children with learning disabilities. *Applied Psycholinguistics, 14,* 473–488.

Levin, I., & Korat, O. (1993). Sensitivity to phonological, morphological, and semantic cues in early reading and writing in Hebrew. *Merrill-Palmer Quarterly, 39,* 213–232.

Levin, I., & Tolchinsky Landsmann, L. (1989). Becoming literate: Referential and phonetic strategies in early reading and writing. *International Journal of Behavioural Development, 12,* 369–384.

Liberman, I. Y., Rubin, H., Duques, S., & Carlisle, J. (1985). Linguistic abilities and spelling proficiency in kindergarteners and adult poor spellers. In D. B. Gray & J. F. Kavanagh (Eds.), *Biobehavioral measures of dyslexia* (pp. 163–176). Parkton, MD: New York Press.

Lundberg, I., & Tornéus, M. (1978). Nonreaders' awareness of the basic relationship between spoken and written words. *Journal of Experimental Child Psychology, 25,* 404–412.

Martlew, M. (1992). Handwriting and spelling: Dyslexic children's abilities compared with children of the same chronological age and younger children of the same spelling level. *British Journal of Educational Psychology, 62,* 375–390.

Miller, P., & Limber, J. (1985, October). *The acquisition of consonant clusters: A paradigm problem.* Paper presented at the Boston University Conference on Language Development, Boston, MA.

Moats, L. C. (1983). A comparison of the spelling errors of older dyslexic and second-grade normal children. *Annals of Dyslexia, 33,* 121–139.

Moats, L. C. (1995). *Spelling: Development, disabilities and instruction.* Baltimore: York Press.

Nelson, H. E. (1980). Analysis of spelling errors in normal and dyslexic children. In U. Frith (Ed.), *Cognitive processes in spelling* (pp. 475–493). London: Academic Press.

Niles, J. A., Grunder, A., & Wimmer, C. (1977). The effects of grade level and school setting on the development of sensitivity to orthographic structure. In P. D. Pearson & J. Hansen (Eds.), *Reading: Theory, research, and practice* (pp. 183–186). Clemson, SC: National Reading Conference.

Olson, R. K. (1985). Disabled reading processes and cognitive profiles. In D. Gray & J. Kavanagh (Eds.), *Biobehavioral measures of dyslexia* (pp. 215–243) Parkton, MD: York Press.

Orton, S. T. (1931). Special disability in spelling. *Bulletin of the Neurological Institute of New York, 1,* 159–192.

Pennington, B. F., McCabe, L. L., Smith, S. D., Lefly, D. L., Bookman, M. O., Kimberling, W. J., & Lubs, H. A. (1986). Spelling errors in adults with a form of familial dyslexia. *Child Development, 57,* 1001–1013.

Perfetti, C. A., Fayol, M., & Rieben, L. (Eds.). (in press). *Learning to spell: Research, theory, and practice across languages.* Mahwah, NJ: Lawrence Erlbaum Associates.

Pick, A. D., Unze, M. G., Brownell, C. A., Drozdal, D. G., & Hopmann, M. R. (1978). Young children's knowledge of word structure. *Child Development, 49,* 669–680.

Rack, J. P., Snowling, M. J., & Olson, R. K. (1992). The nonword reading deficit in developmental dyslexia: A review. *Reading Research Quarterly, 27,* 29–53.

Read, C. (1975). *Children's categorization of speech sounds in English* (NCTE Research Report No. 17). Urbana, IL: National Council of Teachers of English.

Read, C. (1986). *Children's creative spelling.* London: Routledge and Kegan Paul.

Rosinski, R. R., & Wheeler, K. E. (1972). Children's use of orthographic structure in word discrimination. *Psychonomic Science, 26,* 97–98.

Shankweiler, D., Crain, S., Katz, L., Fowler, A. E., Liberman, A. M., Brady, S. A., Thornton, R., Lundquist, E., Dreyer, L., Fletcher, J. M., Stuebing, K. K., Shaywitz, S. E., & Shaywitz, B. A. (1995). Cognitive profiles of reading-disabled children: Comparison of language skills in phonology, morphology, and syntax. *Psychological Science, 6,* 149–156.

Siegel, L. S., & Ryan, E. B. (1988). Development of grammatical-sensitivity, phonological, and short-term memory skills in normally achieving and learning disabled children. *Developmental Psychology, 24,* 28–37.

Siegel, L. S., Share, D., & Geva, E. (1995). Evidence for superior orthographic skills in dyslexics. *Psychological Science, 6,* 250–254.

Snowling, M. J. (1994). Towards a model of spelling acquisition: The development of some component skills. In G. D. A. Brown & N. C. Ellis (Eds.), *Handbook of spelling: Theory, process and intervention* (pp. 111–128). Chicester, England: Wiley.

Stanovich, K. E. (1992). Speculations on the causes and consequences of individual differences in early reading acquisition. In P. B. Gough, L. Ehri, & R. Treiman (Eds.), *Reading acquisition* (pp. 307–342). Hillsdale, NJ: Lawrence Erlbaum Associates.

Templeton, S. (1992). Theory, nature, and pedagogy of high-order orthographic development in older students. In S. Templeton & D. R. Bear (Eds.), *Development of orthographic knowledge and the foundations of literacy* (pp. 253–277). Hillsdale, NJ: Lawrence Erlbaum Associates.

Templeton, S., & Bear, D. (1992). *Development of orthographic knowledge and the foundations of literacy.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Tolchinsky-Landsmann, L., & Levin, I. (1985). Writing in preschoolers: An age related analysis. *Applied Psycholinguistics, 6,* 319–339.

Treiman, R. (1984). On the status of final consonant clusters in English syllables. *Journal of Verbal Learning and Verbal Behavior, 23,* 343–356.

Treiman, R. (1985a). Onsets and rimes as units of spoken syllables: Evidence from children. *Journal of Experimental Child Psychology, 39,* 161–181.

Treiman, R. (1985b). Phonemic analysis, spelling, and reading. In T. Carr (Ed.), *New directions for child development: The development of reading skills* (Vol. 27, pp. 5–18). San Francisco: Jossey-Bass.

Treiman, R. (1985c). Phonemic awareness and spelling: Children's judgments do not always agree with adults'. *Journal of Experimental Child Psychology, 39,* 182–201.

Treiman, R. (1989). The internal structure of the syllable. In G. Carlson & M. Tanenhaus (Eds.), *Linguistic structure in language processing* (pp. 27–52). Dordrecht, The Netherlands: Kluwer.

Treiman, R. (1991). Children's spelling errors on syllable-initial consonant clusters. *Journal of Educational Psychology, 83,* 346–360.

Treiman, R. (1992). The role of intrasyllabic units in learning to read and spell. In P. B. Gough, L. Ehri, & R. Treiman (Eds.), *Reading acquisition* (pp. 65–106). Hillsdale, NJ: Lawrence Erlbaum Associates.

Treiman, R. (1993). *Beginning to spell: A study of first-grade children.* New York: Oxford University Press.
Treiman, R. (1994). Use of consonant letter names in beginning spelling. *Developmental Psychology, 30,* 567–580.
Treiman, R., Berch, D., Tincoff, R., & Weatherston, S. (1993). Phonology and spelling: The case of syllabic consonants. *Journal of Experimental Child Psychology, 56,* 267–290.
Treiman, R., & Cassar, M. (1996). Effects of morphology on children's spelling of final consonant clusters. *Journal of Experimental Child Psychology, 63,* 141–170.
Treiman, R., Cassar, M., & Zukowski, A. (1994). What types of linguistic information do children use in spelling? The case of flaps. *Child Development, 65,* 1310–1329.
Treiman, R., Goswami, U., Tincoff, R., & Leevers, H. (1997). Effects of dialect on American and British children's spelling. *Child Development, 68,* 211–227.
Treiman, R., Zukowski, A., & Richmond-Welty, E. D. (1995). What happened to the "n" of *sink*? Children's spellings of final consonant clusters. *Cognition, 55,* 1–38.
Waters, G. S., Bruck, M., & Malus-Abramowitz, M. (1988). The role of linguistic and visual information in spelling: A developmental study. *Journal of Experimental Child Psychology, 45,* 400–421.

10

Children's Understanding of the Connection Between Grammar and Spelling

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When psychologists and teachers talk about regularities and irregularities in written language, they are usually referring to rules for representing sounds by alphabetic letters. They call a written word "regular" if its spelling conforms to accepted letter-sound correspondences, and "irregular" if it does not. However, there are strong lexical and grammatical regularities in English spelling, and in the spelling of most other European languages as well. Words such as *heal* and *health* or *muscle* and *muscular* share a lexical root that is represented by the same spelling sequence, despite the fact that these sequences actually represent different sounds. The final phonemes in the three words *waited, killed,* and *kissed* are different in each case, but they are spelled in the same way in all three words for syntactic reasons: All three words are past verbs, and "-ed" is the conventional spelling for the past tense morpheme. Much the same point can be made about the opening phonemes in the words *where* and *who.* These are pronounced differently but spelled the same, and the common spelling reflects their common grammatical status: Both are interrogatives.

No one disputes the existence of these regularities, and several people have drawn attention to their importance in learning to read (Beers & Beers, 1992; Frith, 1985; Marsh & Desberg, 1983; Marsh, Friedman, Desberg, & Saterdahl, 1981; Marsh, Friedman, Welch, & Desberg, 1980; Smith,