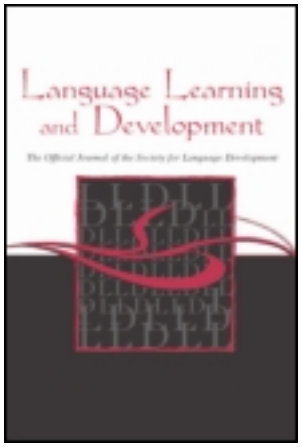

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Learning to Use an Alphabetic Writing System

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Learning to Use an Alphabetic Writing System

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Gaining facility with spelling is an important part of becoming a good writer. Here we review recent work on how children learn to spell in alphabetic writing systems. Statistical learning plays an important role in this process. Young children learn about some of the salient graphic characteristics of written texts and attempt to reproduce these characteristics in their own productions even before they use letters to represent phonemes. Later, children apply their statistical learning skills to links between phonemes and spellings, including those that are conditioned by context and morphology. Children use what they know about language and about letter names when learning about spelling, and learning to spell in turn influences their ideas about language. Although children learn about some aspects of spelling implicitly, explicit instruction has an important role to play. We discuss some implications of the research for the design of that instruction.

Language is a powerful method of communication. It fades quickly, however, and this evanescence limits its usefulness in some situations. To overcome this problem, some groups of people have invented more permanent methods of communication. The most useful of these methods, writing, derives much of its power from the fact that it represents language. To use Sampson's (1987) term, writing is glottographic. Different writing systems represent language at different levels, including the morpheme, the syllable, and the phoneme. Some systems represent more than one level of language. In this paper, we focus on writing systems that map onto language primarily at the level of phonemes, or alphabetic systems. We ask how children learn to use these systems for purposes of spelling, and we ask how parents and teachers can best help them to do so.

Researchers and educators sometimes refer to spelling as a low-level skill (Shankweiler & Lundquist, 1992). This label may imply that spelling is less important than and subservient to the skills that are involved in constructing and organizing sentences, paragraphs, and documents. But learning to spell is important, in part, because human attention is limited. Children who must devote a good deal of attention to spelling have fewer mental resources available for other aspects of writing. They cannot take full advantage of the power that writing provides, lowering their potential for success in a modern literate society.

One potential way to learn to spell would be to learn the orthographic form for each word in one's spoken vocabulary as a whole. Indeed, learning to spell was long seen as a process of rote whole-word memorization, making its study of relatively little interest to linguistically minded

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researchers. The rote memorization view was particularly attractive for writing systems such as English, where correspondences between sounds and spellings can be complex and inconsistent. The traditional view began to change in the 1970s when researchers discovered that some young children, before receiving formal literacy instruction, would invent their own spellings for words (Chomsky, 1971; Read, 1975). For example, a 6-year-old U.S. child might spell *dress* as ‹JRS› or *jump* as ‹JUP›. Such observations suggest that children sometimes construct spellings on the basis of their own analyses of the sounds in words. We consider the nature of children's invented spellings in a later section of this paper. Before doing so, however, we discuss how children write before they start to spell on a phonological basis.

PREPHONOLOGICAL WRITING

Consider Calvin, a first-grade student who, early in the school year, wrote ‹ACR› together with a picture of a playground. He told his teacher that he had written "I like swings and I like slides and I like the sun." Calvin already knew some conventional letter shapes, but the letters that he used did not correlate with the sounds in the words that he said he had written.

The writing of a number of young children, like Calvin's, does not appear to reflect phonology. When a child spells a number of words, however, he may use some phonologically reasonable letters by chance. To determine whether a child is truly a prephonological speller, we need to verify that the number of such cases is no greater than would be expected on the basis of chance alone. In order to do this, we have developed a procedure in which we ask children to spell a list of words and then score the spellings for their phonological plausibility with respect to the target words, or the words that the child was asked to spell (Kessler, Pollo, Treiman, & Cardoso-Martins, 2013; Pollo, Kessler, & Treiman, 2009). A spelling receives some credit even if it contains just one or two phonologically plausible letters. We then scramble the child's spellings with respect to the target words and score again. A computer program repeats that scrambling procedure thousands of times, determining how the score on the actual arrangement of the spellings and the target words compares to the score on the random rearrangements. Using this rearrangement procedure, we can select children whose spelling does not reflect phonology beyond the level expected by chance. We do not need to rely on intuition.

Having identified a group of prephonological spellers, we can examine the nature of their writing. By definition, these children's writings do not represent phonemes. Perhaps the children know that writing represents language but take it to represent some level of language other than that the phoneme. Indeed, Ferreiro and Teberosky (1982) claimed that young children, regardless of the type of writing system they are learning, go through a period during which they believe that writing represents syllables. This is a level of language that is more accessible than the phoneme (Liberman, Shankweiler, Fischer, & Carter, 1974). Although the hypothesis that writing represents syllables would be correct for a learner of a writing system like that used for the Yi language in southwestern China, it is not correct for a learner of a system like Spanish or English. The learner of an alphabetic writing system must abandon the syllabic hypothesis in order to move from what Ferreiro and Teberosky call the syllabic stage of literacy development into the alphabetic stage. Ferreiro and Teberosky's theory of literacy development has been characterized as constructivist, for it emphasizes the constructions or hypotheses

that emerge from children's minds as they try to understand aspects of the world, in this case writing. Ferreiro and Teberosky were strongly influenced by Piaget's stage theory of cognitive development, another constructivist theory. Their view of literacy development has been very influential in a number of countries in Latin America. Educators of young children in those countries consider it their job to identify the stage of literacy development that a child is in, helping children who are presyllabic move into the syllabic stage as a step toward becoming alphabetic spellers.

As support for the idea of a syllabic stage, Ferreiro and Teberosky (1982) reported that young writers of Spanish would sometimes produce spellings that contained the same number of letters as syllables, as in ‹AO› for *sapo* 'frog'. Similar sorts of spellings have been reported among learners of other Romance languages. For example, an Italian child spelled *primavera* 'spring' as ‹IAEA› (Pontecorvo, 1996) and a Portuguese-speaking child spelled *urubu* 'vulture' as ‹UUU› (Nunes Carraher, & Rego, 1984). Ferreiro and Teberosky also reported that some learners of Spanish would use one mark for each syllable in a spoken word, where the marks are not conventional letters. Although constructivist researchers report that young children generally pass through a syllabic stage (e.g., Pontecorvo & Zucchermaglio, 1988), the researchers have not always provided detailed criteria about the criteria that they use to classify children as syllabic spellers. Moreover, some of the evidence for syllabic spelling is anecdotal.

If children construct the hypothesis that writing is syllabic before they grasp that it represents the level of phonemes, then prephonological spellers should, at a minimum, produce longer spellings for words that contain more syllables than for words that contain fewer syllables. To test this prediction, we used the quantitative procedure described above to identify Brazilian children who were prephonological spellers (Pollo et al., 2009). These children, who were on average 4 years and 8 months of age, did not produce longer spellings when trying to spell two-syllable words than when trying to spell one-syllable words. In the same study, we also found negative results in a group of U.S. prephonological spellers with an average age of 4 years and 7 months. Cardoso-Martins, Corrêa, Lemos, and Napoleão (2006) also failed to find evidence for a syllabic stage of spelling development in Brazilian children. Overall, the findings of these studies speak against the idea that children who are exposed to alphabetic writing systems generally pass through a stage during which they take each symbol to represent a syllable—a hypothesis that would be highly inconsistent with the writing that they see around them.

Another view is that prephonological writers string letters of the alphabet together in a random fashion (Gentry, 1982). However, even at this early point in literacy development, children's spellings do not appear to be entirely random. Support for this claim comes from a study that examined Brazilian prephonological spellers with a mean age of 4 years and 3 months (Kessler et al., 2013). We found that these children tended to use letters and digrams (pairs of adjacent letters) that are common in the words of Portuguese. For example, one child's ‹VAVI› does not make phonological sense as a representation of the target word *dedo* 'finger', but it contains letters and digrams that are fairly common in written Portuguese. The U.S. and Brazilian prephonological spellers studied by Pollo et al. (2009), who were about 5 months older than those studied by Kessler et al., also tended to use letters and digrams that were common in the words of their respective languages. This meant that the U.S. and Brazilian prephonological spellers produced subtly different spellings. Portuguese words contain a higher proportion of vowel letters than English words, and the prephonological children in Brazil used a higher proportion of

vowel letters than the prephonological children in the United States. Portuguese words are more likely than English words to contain sequences of alternating consonants and vowels, and the prephonological children in Brazil showed more consonant–vowel alternation in their spelling than the prephonological children in the United States. Thus, letter strings such as ‹VAVI› and ‹BOSA› were more common among children in Brazil, and those such as ‹BTPR› were more common among children in the United States.

Differences in the frequencies of letters and letter pairs in English and Portuguese arise, in part, because of differences in the phonological systems of the spoken languages. For example, the consonant–vowel alternation that is often seen in the written words of Portuguese reflects in part the relatively high frequency of consonant–vowel syllables in spoken Portuguese. Prephonological spellers do not appear to know that the letter patterns that they use reflect phonological patterns, however. They do not, we suspect, divide letters into abstract categories of consonants and vowels. Rather, children learn about letter frequency and letter co-occurrence on a purely graphic basis, from exposure to the writing around them.

Not only do prephonological spellers tend to use letters that are common in the written words of their language generally, they also tend to use letters that are common in their own individual experience. One such word is the child's own name. A child's name is probably not a word that would appear very often in storybooks. However, it is a word that parents and preschool teachers often write for the child and a word that is important to him or her. It draws the child's attention, just as the child's spoken name does (Mandel, Jusczyk, & Pisoni, 1995). Correspondingly, the Brazilian and U.S. prephonological writers in the studies we have described (Kessler et al., 2013; Pollo et al., 2009) tended to use letters from their own names at relatively high rates. When the Brazilian boy Matheus spelled *cavalo* 'horse' as ‹MDHIUS›, for example, two thirds of the letters that he used were from his name. Similar results have been found in studies that classified children as prephonological spellers on the basis of researchers' intuitions rather than on the basis of quantitative tests (Bloodgood, 1999).

The results we have described speak against the idea that 4- and 5-year-olds who are familiar with letters of their alphabet but who do not yet write phonologically produce random strings of letters (Gentry, 1982). Instead, the productions bear some formal similarities to the written words to which the children have been exposed. The results also speak against the idea that children often construct hypotheses about writing that fly in the face of the writing that they see around them (Ferreiro & Teberosky, 1982). Instead, even young children are influenced by the writing in their environment.

We attribute the similarities between children's early written productions and those in their environment to statistical learning, that is, the process whereby organisms pick up patterns by observing and internalizing the relative frequency with which objects and events occur and co-occur. Such learning begins early in life in the domain of language. Infants find human speech to be interesting and attractive (Shultz & Vouloumanos, 2010), and they use their statistical learning skills to begin learning about its phonological characteristics. Infants start to do this even before they know the meanings of spoken words. For example, infants who are exposed to English appear to learn, somewhere between 6 and 10 months of age, that two-syllable words are more likely to have stress on the first syllable than the second syllable (Jusczyk, Cutler, & Redanz, 1993). Writing, usually small black lines on a white background, is less attractive to infants and children than is speech. Testifying to this difference, preschool children who are being read a storybook by an adult are much less interested in looking at the print than in listening to the

speech or in looking at the pictures (Evans & Saint-Aubin, 2005). However, children in literate societies typically see enough examples of writing to begin learning about some of its characteristics well before formal instruction in reading and writing begins. By 5 years of age, the results we have reviewed suggest, many children have learned that some letters and groups of letters occur more often than others. A young U.S. child is not explicitly taught that ‹th› is a common letter sequence in English, but children learn this and other patterns implicitly. When asked to produce their own writing, children often attempt to reproduce the characteristics that they have observed.

Children whose early knowledge about the graphic properties of writing reflects attentiveness to the statistical properties of a broad sample of words, recent evidence suggests, are in a good position to succeed in later literacy development. Support for this idea comes from the results that Kessler et al. (2013) found when the Brazilian children whose prephonological spellings were studied at the mean age of 4 years and 3 months were retested 2.5 years later. At that time, the children were given a standardized spelling test, and their spellings were scored for conventional correctness. The more closely the frequencies of the digrams in the children's early prephonological spellings correlated with the frequencies of those sequences in Portuguese words, the better the children tended to score on the later spelling test. The more often the children used letters from their own names in their early prephonological spellings, in contrast, the worse the children tended to perform on the later test of conventional spelling. Scrutinizing a child's early writing, therefore, may potentially provide some useful information about that child's potential for later success.

Further work will be needed to explore the role of statistical learning in early writing in more detail. Before children write using well-formed letters of their alphabet, for example, do they apply their statistical learning skills to learning what lines and shapes can combine into legal letters? Also, what specific statistics about letters do prephonological spellers extract from the texts to which they are exposed? The results so far suggest that these children learn about the frequencies of individual letters and digrams, but we do not yet know whether the frequencies that they extract are pooled across contexts or computed separately for different positions of words. Children who have begun to spell phonologically are sensitive to the positions in which certain letters and letter groups may occur in words, learning for example that *ck* sometimes occurs in the middles and at the right edges of English words but not at the left edges (Treiman, 1993). However, we do not yet know whether prephonological spellers extract such contextual information.

Additional work is also needed to determine how the statistical learning principles discussed here play out in nonalphabetic writing systems. In Chinese, for example, certain groups of strokes tend to occur in certain positions of characters but not in other positions. Recent evidence suggests that Chinese children have acquired some knowledge of these patterns by the age of six (Anderson et al., 2013).

Although many questions remain, the results we have discussed so far suggest that children know some things about writing's surface form before they grasp its sound-symbolizing function, just as they know some things about the phonological forms of words before they know what the words mean. In both the domain of written language and the domain of spoken language, this early knowledge appears to reflect implicit statistical learning about surface forms. That learning begins earlier in case of spoken language than in the case of written language, but similar processes may be involved.

EARLY PHONOLOGICAL SPELLING

Around the age of 5 or 6, in many countries, children move from prephonological writing such as Calvin's ‹ACR› for "I like swings and I like slides and I like the sun" to phonologically based writing such as Calvin's later ‹JAC JUPT› for "Jack jumped." Some of these early phonological spellings are so distant from conventional ones that that typical spell-checkers have difficulty with them. For example, the spell-checker that we used when writing this article suggested *Jack* as a possible target for ‹JAC›, but it did not suggest *jumped* as a possible target for ‹JUPT›. Clearly, though, ‹JUPT› is phonologically based. Other early prephonological spellings, such as ‹CHAREZE› for *cheese*, are even more distant from conventional spelling in that they include some letters that are not phonologically motivated.

Some invented spellings reflect children's difficulty in fully analyzing spoken words into phonemes. Consider the errors that children make when spelling the initial consonants of clusters. Children sometimes fail to spell the second elements of the clusters, as in ‹SOREY› for *story* or ‹FI› for *fly*. Such errors have been documented both in experimental studies in which children are asked to spell lists of words and in naturalistic studies (Shankweiler & Lundquist, 1992; Treiman, 1991, 1993). The errors have been documented not only among learners of English but also among learners of other alphabetic writing systems, such as Spanish (Manrique & Signorini, 1994). Spellings such as ‹f› for syllable-initial /fl/ suggest that children, like many linguists, treat a syllable-initial consonant cluster, or onset, as a cohesive unit. Indeed, studies of phonemic awareness report that young children have difficulty segmenting onset clusters (Jiménez González & Haro García, 1995; Treiman & Weatherston, 1992). Many children appear to categorize the /fl/ unit as similar to /f/ and spell it accordingly. In most cases, the spelling error does not reflect a lack of knowledge about the correspondence between /l/ and ‹l› or a lack of knowledge about the shape of ‹l›. Thus, children who fail to spell the /l/ of words like *fly* often include the /l/ when spelling words like *love*, where /l/ is not part of a cluster. In most cases, too, spelling errors on initial clusters do not reflect mispronunciation of the clusters. Rather, the errors reflect children's difficulty in conceptualizing onset clusters as strings of phonemes.

Consonant clusters at the ends of syllables also cause difficulties for children who are starting to spell phonologically. Whereas children tend to leave out the second consonants of two-consonant initial clusters, they tend to leave out the first elements of syllable-final consonant clusters. For example, the child who wrote ‹JUPT› for *jumped* omitted the /m/. The child appeared to consider the nasal to be a property of the vowel rather than a separate unit that merits its own letter (Read, 1975; Treiman, Zukowski, & Richmond-Welty, 1995). This conception has some validity: Talkers anticipate the nasality of the upcoming /m/ while pronouncing the vowel, giving the vowel a nasal quality.

Given the difficulty of analyzing speech at a fine-grained level, children sometimes use shortcuts. Some of these shortcuts are based on the knowledge of letter names that many children acquire at an early age and bring with them to the task of spelling. For example, a U.S. child can write ‹R› for *car* if she detects the sequence /ɑɪ/ in the spoken word and if she writes down the letter that has this name. The child's knowledge of *R*'s name allows her to produce a phonologically based spelling of *car* at a time when she does not yet spell other words phonologically. If the child can also use her knowledge of *K*'s name in order to spell the initial /k/ of *car*, she may be able to produce a more elaborate spelling, ‹KR›, before she can isolate the individual phonemes within the /ɑɪ/ unit. Indeed, young U.S. children produce a number of spellings like ‹R› and

‹KR› for *car* (Treiman, 1993, 1994). Further evidence that children use their knowledge of letter names when inventing spellings comes from learners of Portuguese (Pollo, Kessler, & Treiman, 2005, 2007) and Hebrew (Levin, Patel, Margalit, & Barad, 2002). Children use what they know when learning new things, the same sort of bootstrapping that they show in the learning of spoken language (Fisher, Gertner, Scott, & Yuan, 2010).

Some of the divergences between children's early phonological spellings and conventional spellings reflect children's difficulties in analyzing spoken words into smaller units. Other divergences occur when children's classifications of the sound units within words do not match those of the conventional writing system. Consider errors such as ‹JRIP› or ‹GRIP› for *drip* (Read, 1975; Treiman, 1985). The English writing system groups the initial sound of *drip* with the /d/ of words like *dip* and spells it in the same way, as ‹d›. When speakers say /d/ before /ɪ/, however, the blade of the tongue is further back in the mouth, anticipating the position of the following /ɪ/. This makes the initial sound of *drip* similar or identical to the /dʒ/ of *gym* or *jump*. Some children thus classify the initial sound of *drip* as /dʒ/ and spell it accordingly. Likewise, some children's spelling reflects the fact that the second consonant of *sky* sounds similar to the /g/ of *guy*. The second consonant of *sky* is not aspirated, as /k/ generally is at the beginnings of words like *kit*. Children who have learned to break onset clusters into their components may thus use ‹g› to spell the second sound of a word like *sky* (Hannam, Fraser, & Byrne, 2007).

The difficulties that children face in learning to spell are often attributed to irregularities in writing systems (Seymour, Aro, & Erskine, 2003). Overall, spelling acquisition does appear to proceed more quickly in writing systems that have simple and consistent links from spellings to sounds than in writing systems that are more complex, such as English (Caravolas, 2004). At an early age, however, many of children's spelling errors cannot be traced to irregularity in sound-to-spelling correspondences. For example, learners of English sometimes omit /l/ when spelling clusters like /sl/ of *slip* even though virtually all /sl/ clusters are standardly spelled as ‹sl›. *Tar* and *pen* are highly regular in their spelling-to-sound correspondences, but young children may misspell them as ‹TR› and ‹PN›, respectively, under the influence of letter names.

LEARNING TO DEAL WITH COMPLEX MAPPINGS BETWEEN SOUNDS AND SPELLINGS

Part of becoming a competent speller is learning to deal with the complexities that many writing systems possess. Before considering how children do this, we need to ask why alphabetic writing systems do not reflect speech in a perfectly regular and consistent manner. Even writing systems that are considered to be quite regular, such as Spanish, have some complexities in the sound-to-spelling direction. A major reason for this is that writing is more conservative than speech. Pronunciations may change rather substantially within a few hundred years. Spellings, however, often do not change to keep up. Although wholesale spelling reforms sometimes occur, changes in spelling are typically piecemeal and slow. The different pace of change for written and spoken language means that spellings may not represent current pronunciations in a straightforward way.

To understand the sorts of complexities in sound-to-spelling correspondences that can result from sound change, we must consider the nature of sound change itself. Sometimes, sound changes result in a total loss of distinction between two phonemes: a complete merger. For example, in Spanish, there used to be a contrast between two phonemes that were spelled, quite

regularly, as ‹b› versus ‹v›, with pronunciations similar to those in English. Later, those sounds merged into one phoneme. The spellings remained the same. Now /b/ is spelled as ‹b› in some words, including *base* ‘base’, and as ‹v› in other words, including *vaso* ‘glass’. The total loss of a phoneme is also a sort of merger: the phoneme merges with nothingness. The loss of /h/ in Spanish helps to explain why words like *hija* ‘daughter’ have ‹h› in their spelling but no /h/ in their pronunciation.

Phonemic mergers that occur in the absence of spelling change cause difficulty for spellers. For the most part, learners of Spanish have no way of knowing whether a given /b/ was the original /b/, and so to be spelled as ‹b›, or the original /v/, and so to be spelled as ‹v›. They must learn which spelling of /b/ is conventional in specific words. Not surprisingly, learners of Spanish make mistakes in this process (Justicia, Defior, Pelegrina, & Martos, 1999).

A phoneme sometimes changes only in certain phonological contexts, such as before specific sounds. If such a conditional change turns the original phoneme into another phoneme that already occurs in the language, the result is called a phonemic split–merger. If a split–merger occurs in the absence of spelling change, a phoneme may end up having more than one possible spelling in certain environments but not in other environments. For example, in the southern United States /ɛ/ changed to /ɪ/ when it occurred immediately before the nasal consonants /n/ or /m/. Thus, *pen* is now pronounced the same as *pin*. The pronunciation of /ɛ/ did not change in other environments. Before this conditioned sound change, /ɪ/ was almost always spelled as ‹i› and /ɛ/ was almost always spelled as ‹e›. After the sound change in this dialect, the spelling of /ɪ/ is still highly predictable when it is not followed by /n/ or /m/. Here, it is virtually always ‹i›. When /ɪ/ is followed by /n/ or /m/, however, it is sometimes spelled as ‹e›, as in *pen*, and sometimes as ‹i›, as in *pin*. A speller who is not a historical linguist does not know whether any given /ɪ/ before /n/ or /m/ was originally /ɪ/, and so to be spelled as ‹i›, or originally /ɛ/, and so to be spelled as ‹e›. Thus, spelling will be difficult in this situation. A speller who considers phonological context, however, will have relatively little difficulty spelling /ɪ/ before a phoneme other than /n/ or /m/, as in *pit*. This is because there are no alternative spellings other than ‹i› in this environment.

According to some theories about the mental processes of skilled spellers, people do not consider the context in which a phoneme occurs when deciding how to spell it (Barry & Seymour, 1988). They pool the probabilities of different spellings across all of the words that they know and use these pooled probabilities in order to choose a spelling. Research shows, however, that older children and adults take context into account. In one study (Treiman & Kessler, 2006, Experiment 1), U.S. children ranging in age from around 6 to 13 were asked to spell the vowels of such nonwords as /klɛd/ and /klɛb/. If children’s choices were driven by the probability of spellings pooled across context, then they should use ‹e› more often than ‹ea› for both /klɛd/ and /klɛb/. That is, they should favor the spellings ‹cled› and ‹cleb› over the spellings ‹clead› and ‹cleab›. This is because the /ɛ/-‹e› correspondence is more frequent in English overall than the /ɛ/-‹ea› correspondence. In addition, it is graphically simpler. If children’s choices were influenced by the following consonant, then they should produce more ‹ea› spellings for /klɛd/ than /klɛb/. That is, ‹clead› spellings should be more common than ‹cleab› spellings. This is because the /ɛ/-‹ea› correspondence is more common before /d/ (as in *head* and *instead*) than before /b/ (as in *web*). For the older children in the study—children of around 8 and older—influences of the following consonant began to be apparent. The effects of consonantal context reached a maximum around the age of 11.

The results mentioned above, together with other findings (see Kessler, 2009, for a review), suggest that, for English, older children and adults consider the surrounding elements when deciding how to spell a phoneme. They are not limited to context-free probabilities, as some researchers have suggested (Barry & Seymour, 1988). People use context because it improves the probability of selecting a correct spelling, even though it may not raise that probability to 1.0. For example, although the ‹ea› spelling of /ɛ/ is more common before *d* than before other consonants, a number of words do not have ‹ea› before /d/ (e.g., *bed, fed*). Still, older children and adults are more likely to use the ‹ea› spelling when /ɛ/ occurs before /d/ than when it occurs before a segment such as /b/. The fact that the older children and adults use upcoming segments to spell the current one speaks against the idea that they work one phoneme at a time, moving from the first phoneme of the word to the last (cf. Simon & Simon, 1973).

As we saw earlier, most phonologically driven contextual patterns involve adjacent segments, given the nature of sound change. This probably helps people to learn the patterns, for studies show that people more easily learn about contextual patterns involving adjacent elements than about those involving non-adjacent context (Newport & Aslin, 2004). However, even experienced spellers do not use surrounding context as much as would be expected given the strength of the patterns in the writing system itself. For example, about half of the monosyllabic English words with /aɪ/ followed by /t/ are spelled with ‹igh›, as in *night* and *flight*. U.S. university students are more likely to use ‹igh› when /aɪ/ precedes /t/ than when it precedes another consonant when they are asked to spell novel words in experiments. That is, they are influenced by the final consonant to some extent. However, university students use ‹igh› about a quarter of the time before /t/, not half the time (Treiman, Kessler, & Bick, 2002). This imbalance may reflect the fact that people pay more attention to the phoneme they are trying to spell than to the surrounding context. Also, the particular neighboring segment that is helpful is not always the same. In a few cases, for example, the preceding consonant is more helpful than the following one in selecting a vowel spelling in English (Kessler & Treiman, 2001). When the final consonant is influential, the specific influences differ from one vowel phoneme to another. Moreover, some of the patterns apply to fairly small sets of words.

The ability to use surrounding elements to help select among potential spellings of a phoneme develops gradually. In the study of Treiman and Kessler (2006) that was mentioned earlier, children who were younger than around 8 years of age did not show context effects for the particular pairs of vowels and following consonants that were examined. This was true even though the spellings of these vowels were influenced by the following consonant in reading materials targeted at children and in the English vocabulary as a whole. A similar lack of context use by younger children was also seen in a study of British 5- and 6-year-olds. In that study, children's vowel spelling choices were predicted by the overall frequency of the sound-to-spelling correspondence, with no additional impact of the frequency of the spelling in the particular final-consonant context (Caravolas, Kessler, Hulme, & Snowling, 2005). Children probably learn contextual patterns relatively slowly for the same reasons that adults use them less than would be expected given their strength in the vocabulary. For example, children may be especially likely to focus on the phoneme that they are in the process of writing, to the exclusion of the surrounding ones. Also, it takes time for children to learn patterns that apply to fairly small sets of words.

Earlier, we saw that children apply their statistical learning skills to the graphic forms of the texts that they see. Children learn, for example, that some letters and letter groups are more common than others. As children gain more experience with reading and writing, they apply

their statistical learning skills to the links between phonemes and letters. They derive context-based statistics, such as that a certain spelling of a phoneme is common in one context and that another spelling is common in another context. They then apply these patterns when producing their own spellings. Children gradually learn these patterns even though many of them are not explicitly taught. For example, although teachers often tell children such things as "/ɛ/ is spelled as ‹e›, as in *wet*," they may not tell children that ‹ea› is another possible spelling for /ɛ/. Even if they do, they may not tell them that the ‹ea› spelling is more likely to occur before /d/ than before other consonants. Indeed, because adults' statistical knowledge is often implicit, they may be unable to describe such context-conditioned patterns. Although children do gradually pick up statistical patterns involving links between letters and sounds, people are not, as portrayed by some theories (Brown, 1998), ideal statistical learners. It takes some time for them to learn about context conditioning. Even spellers with years of experience have not fully internalized all of the patterns in the written words to which they are exposed.

We have focused so far on the role of surrounding segments in selecting among alternative spellings for sounds, but morphological considerations may be important as well. For example, /t/ and /d/ are normally spelled in English as ‹t› and ‹d›, respectively. When /t/ or /d/ is a regular past tense marker, however, it is spelled as ‹ed›, as in *jumped* and *called*. In this and certain other respects, the English writing system reflects morphology and not only phonology. The child mentioned earlier, Calvin, failed to honor this morphological pattern when he wrote ‹JUPT› for *jumped*. When studying the spelling of Calvin and his fellow students, Treiman (1993) found that, pooling across the spellings produced over the course of the school year, there were more ‹ed› spellings of /t/ and /d/ when these were regular past tense endings, as in *messed*, than when they were not regular past tense endings, as in *fast*. However, ‹t› spellings of regular past tense /t/ and ‹d› spellings of regular past tense /d/ outnumbered correct ‹ed› spellings among the 6-year-olds in this and some other studies (Varnhagen, McCallum, & Burstow, 1997). Calvin and his classmates did not receive explicit tuition about the ‹ed› spelling of the past tense, consistent with the whole-language orientation of their teacher, but many children do receive such instruction. Still, children may make errors such as ‹calld› for *called* even after several years of literacy instruction that includes explicit instruction about the use of ‹ed› (Varnhagen et al., 1997). One reason for this is that using a vowel–consonant letter sequence to spell a consonant phoneme is quite unusual. It does not conform to children's general knowledge about how sound-to-spelling correspondences work. The ‹ed› spelling of the past tense marker is less odd when the past tense is /ɪd/, as *hunted*, than when it is /d/ or /t/. Correspondingly, children appear to produce more correct spellings of the past tense ending when it is /ɪd/ than when it is /d/ or /t/ (Treiman, 1993; Varnhagen et al., 1997).

SPELLING INSTRUCTION

Spelling instruction at school has often been based on the idea that spelling, especially for complex writing systems such as that of English, involves largely the rote memorization of whole words. Although few researchers currently support this idea, it continues to influence instruction. In many schools, children are given a list of spelling words each Monday. The words may be unrelated to one another in their spelling patterns or sound patterns but may be chosen, instead, because they are all related to a theme that the class is studying. Children are asked to memorize

the words' spellings, and they are tested on them on Friday. But spelling involves much more than rote memorization, as we have seen, and instruction should reflect this.

The whole-language approach to literacy instruction is based on the idea, most famously espoused by John Dewey, that children learn best when they discover the principles behind a system by actively using it. Because young children do not normally receive explicit instruction about spoken language, the argument goes, explicit instruction is not needed for written language either. Educational approaches that follow from the constructivist view of Ferreiro and Teberosky (1982) also emphasize the idea of children discovering things for themselves. Calvin, the first grader whose spellings we have described, had a teacher who was a strong advocate of the whole-language approach. She expected students to write largely on their own, and she did not tell them how to spell words even if they asked.

The results we have reviewed show that children pick up many patterns in written language, even when these patterns are not explicitly pointed out. However, the results also show that implicit statistical learning can be slow and incomplete. Rather than relying on children to form generalizations for themselves, adults often convey generalizations to them (Csibra & Gergely, 2009). One way of doing so is through the use of generic statements. By about 2.5 years of age, children can recognize that a generic statement such as "birds fly" is meant to apply to birds in general, not just specific birds (Graham, Nayer, & Gelman, 2011). Parents and teachers can take advantage of the power of generics by telling children such things as "‹o›s are round" or "words do not start with ‹ck›." Through such statements, children can learn things that would otherwise require exposure to many individual instances. Generic statements such as "/tʃ/ is spelled as ‹ch›" are more difficult for children to understand than those such as "bird fly" or "‹o›s are round," requiring as they do the knowledge that words may be broken into smaller segments and the knowledge that writing symbolizes these segments. However, research showing that instruction that includes systematic phonics leads to better spelling and reading outcomes than instruction that does not (Ehri, Nunes, Stahl, & Willows, 2001) suggests that children benefit from the power of generics in learning about alphabetic writing systems. Given that children learn to read and write at a later age than they learn to speak and understand their native language, and given that writing is not part of the human genetic endowment in the way that speech is, explicit teaching has an important role to play in the learning of written language.

Although the use of systematic phonics instruction benefits spelling, current approaches to teaching phonics have some limitations. Phonics instruction usually focuses on correspondences from spellings to sounds and downplays correspondences from sounds to spellings. Children do not always generalize as widely as one might think, however, and more direct instruction about the sound-to-spelling direction could be helpful. Children are usually taught about the most common correspondences between sounds and spellings but not usually about how to choose among alternative possibilities, when those exist. It could be helpful to draw children's attention to the fact that context can help in making these choices and to specific ways in which it can help. Yet another limitation of phonics instruction, as often practiced, is that it relies on worksheets and drills that are boring for children. This type of instruction may seem uncreative and not engaging. However, children can be taught about the patterns in words in a way that is interesting as well as educational (see Joshi, Treiman, Carreker, & Moats, 2008–2009, for a discussion of some promising methods).

Teachers' own literacy is a double-edged sword, for it can make it hard for them to understand why children make some of the errors they do (Moats, 1994). Adults' conceptions of language

have been shaped by their knowledge of the system that they use to represent it, just as people's conceptions about the world have been shaped by maps. Seeing a map of their city can help people to understand the spatial relationships among its neighborhoods, but seeing a map on which Greenland looks very large may give them a mistaken impression of this country's size. Similarly, the map that spelling provides helps people to appreciate many things about language but may distort their ideas about others. Teachers who have had the opportunity to learn about phonology and spelling will understand that a 6-year-old who writes ‹CHRAP› for *trap* probably does not need to be told that he should listen more carefully to the word before spelling it. The child has already listened carefully. Instead, the teacher might tell the child that he did a good job of writing the sounds that he heard but that the initial portion of this word is normally written as ‹tr› even though it sounds like it should be written as ‹chr›. As another example, teachers who have had the opportunity to learn about phonology will understand that a child who omits the /ɹ/ of *trap* altogether probably needs help in analyzing the cluster into smaller units of sound. The child probably does not extra drill on the correspondence between /ɹ/ and *r* or extra practice at pronouncing the word.

SUMMARY AND CONCLUSIONS

To fully participate in a modern society, one must learn the spoken language of that society. One must also learn the written form of that language. Given that some children with normal spoken language development learn to read and write slowly or with great difficulty, we urge language researchers to devote more attention to the learning of written language.

Writing represents language, and this means the characteristics of written language are closely tied to the properties of spoken language. Some of the characteristics of spoken language that underlie writing are visible on writing's surface. Children in modern literate societies, who are surrounded by print from an early age, begin to learn about the surface properties of writing quite early. However, a true understanding of writing must be founded on the knowledge that writing symbolizes language and an understanding of the structure of that language. Difficulties in these areas can slow the pace of spelling development and can led to errors even in learners of highly regular alphabetic writing systems. Additional difficulties arise when writing systems are complex. The choice among alternative spellings for a sound can often be made easier if the speller considers context or morphology, but it takes children some time to learn about the conditioning factors.

When learning to use a writing system, children apply many of the same learning mechanisms that they use for other purposes. These include statistical learning, learning through language, and use of the known to tackle the unknown. In turn, learning about their writing system reveals children's language to them in a way that would not happen if they used language only for speaking and listening. Writing gives children a tool that they can use to make their thoughts visible and permanent, a tool that is vital for success in modern societies.

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