

## Learning to Spell Words: Findings, Theories, and Issues

Rebecca Treiman

Washington University in St. Louis

### ABSTRACT

There has been less research on how children learn to spell than on how they learn to read, but a good deal is now known about spelling development. This article reviews studies of normative development, beginning with children's early scribbles and proceeding to prephonological spelling involving letters, phonologically influenced invented spelling, and more advanced spelling. Most of the studies deal with spelling development in alphabetic writing systems. Theories about how children learn to spell, including constructivist theories, stage and phase theories, dual-route theories, and Integration of Multiple Patterns, are presented and reviewed in light of the research evidence. The final section of the article discusses directions for future research and implications for children with spelling difficulties.

Much research on literacy development looks at how children learn to read. But learning to write is also important, and increasingly so now that people have so many opportunities to text, to tweet, and to use social media. The goal of this article is to review what is known about one of the skills that is involved in writing: the ability to spell individual words. I take a developmental approach in discussing the research on this topic, beginning with children's early scribbles and proceeding to more sophisticated spellings. Several theories about spelling development are then presented and critiqued in light of the research evidence. The last section of the article discusses some open questions and directions for future study.

### Research findings

#### *Children's early knowledge about writing's visual characteristics*

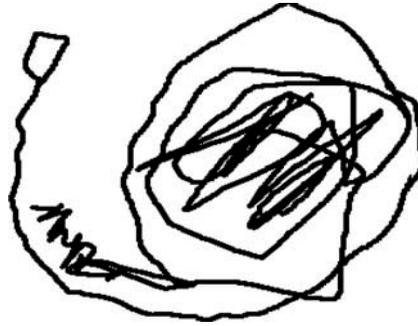
Before their second birthday, children will sometimes use crayons or pencils to make marks (Trivette, Hamby, Dunst, & Gorman, 2013). Toddlers spend more time scribbling with a normal pencil than with a nonfunctioning pencil that leaves no visible trace (Berefelt, 1987), showing that they have some interest in the marks themselves and not just in the motor activity of scribbling. In the making of marks, as in other areas, children often try to do what they have seen others do and try to produce similar results. Modern children as young as 2 or 3 years of age have seen many marks produced by others, for example, shopping lists and drawings. Some marks have been referred to as letters, words, or writing and others as pictures or drawings. Children have had the opportunity to observe that marks have different characteristics. For example, marks labeled as writing tend to be small and dark, whereas drawings are often large and colorful. Children try to reproduce some of these characteristics when they make their own marks, despite limitations in their motor abilities. As an example, consider the production by a U.S. 2½-year-old that is shown in [Figure 1](#). This girl said that the circular portion on the right was a drawing of a circle. She identified the portion with small squiggles on the bottom left as writing. The fact that the part of the production that the

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**CONTACT** Rebecca Treiman  [rtreiman@wustl.edu](mailto:rtreiman@wustl.edu)  Department of Psychological and Brain Sciences, Washington University in St. Louis, Campus Box 1125, St. Louis, MO 63130.

In 2014 Rebecca Treiman received the Distinguished Scientific Contributions Award of the Society for the Scientific Study of Reading. This review is based on the award address delivered during the 23rd Annual SSSR Meeting in Porto.

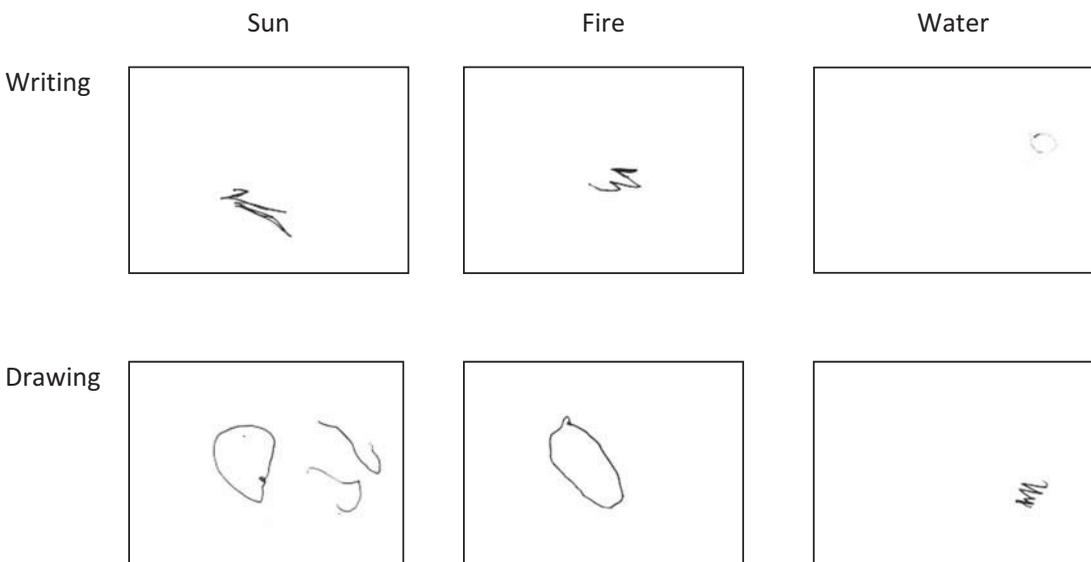
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**Figure 1.** Production by a 2½-year-old U.S. child. *Note.* The child identified the portion with denser squiggles at the bottom left as writing.

child identified as writing is more contained and linear than the part identified as drawing may suggest that the child has some knowledge about certain visual distinctions between writing and drawing.

One cannot draw conclusions from a single example, of course, but systematic studies support the idea that the scribbles that children produce when they are asked to write are somewhat different from the scribbles that they produce when they are asked to draw. One piece of evidence comes from studies in which adults were shown productions that children made under instructions to draw and productions that the same children made under instructions to write. The adults were asked which productions came from which task. Adults performed above the level of random guessing, although by no means perfectly, with the productions of 3-year-olds (Levin & Bus, 2003, for Dutch and Israeli children; Treiman & Yin, 2011, for Chinese children). When adults had the opportunity to study several productions from the same child before making a decision, they performed above the level of chance even with the productions of 2-year-olds (Treiman & Yin, 2011). Additional evidence that young children are familiar with some of the visual features of writing comes from studying the characteristics of their productions. Even when children's attempts to write do not contain recognizable units from the writing system of the child's culture, they may be small and may show a tendency toward linearity, and they may be made with a dark implement (Mortensen & Burnham, 2012; Treiman & Yin, 2011). The writings in Figure 2, which were produced by a Chinese girl of 2 years



**Figure 2.** Productions by Chinese child of 2 years 8 months who was asked to write the characters for 'sun,' 'fire,' and 'water' and, separately, to draw pictures of them.

8 months, have some of these characteristics, and they look somewhat different from the child's drawings. This child selected a colored crayon to produce one of her drawings but a black pen to do all of her writing.

Preschool children often cannot state what makes writing look different from drawing (Mortensen & Burnham, 2012), and adults probably do not tell them about this explicitly. It is likely that children use their implicit *statistical-learning* skills to learn about the distinctions. Statistical learning is the ability to learn about the frequencies of objects and events and combinations thereof based on exposure to them. This ability is present from infancy, and it operates in language and in other domains, as when infants learn that some spoken syllables are more likely than others to be adjacent to one another in a stream of speech (Saffran, Aslin, & Newport, 1996; see Romberg & Saffran, 2010, for a review). Children could apply their statistical-learning skills to the marks they see, learning that marks that are labeled as letters or words or that are said to be produced through the process of writing tend to have certain characteristics and that they differ, in some ways, from marks that are labeled as pictures, drawings, or maps.

Parents and preschool teachers sometimes dismiss children's early productions as scribbles. However, the results reviewed suggest that these scribbles may reflect more knowledge than appears on the surface and may represent an early step in the development of writing.

### **Prephonological writing**

By around 4 years of age, children who are asked to write will often produce recognizable symbols from the writing system to which they have been exposed, arranging them along a line (Rowe, 2015). Children may use the conventionally correct letters when writing their own first name. When asked to write other words, however, children may use letters that are not correct and not phonologically plausible (Levin, Both-de Vries, Aram, & Bus, 2005; Pollo, Kessler, & Treiman, 2009). For example, one 4-year-old child wrote <cran> for *bus* and <aef> for *motorcycle*, not even using more letters for the phonologically longer word than the phonologically shorter word. Such children have been called *prephonological* spellers, in that their productions do not reflect the sounds in words.

Although prephonological writers do not seem to treat writing as representing the sounds in words, they know a number of things about writing's visual appearance. Like younger children, they possess some knowledge that writing is generally arranged along a line and that it is usually small and dark. Prephonological writers also appear to have some knowledge about the letters and letter groups in words of their language. They tend to use letters that are common in the language more often than letters that are less common, and they tend to use *digrams* (pairs of adjacent letters) in proportion to their frequency of occurrence in the language (Kessler, Pollo, Treiman, & Cardoso-Martins, 2013; Pollo et al., 2009). That is, these children have some knowledge about the *graphotactic* patterns of their writing system (patterns involving the order and arrangement of letters).

Prephonological spellers who are exposed to different written languages, even ones that use the same alphabet, may make subtly different productions that reflect graphotactic differences between the written languages. Evidence for this idea comes from a study by Pollo et al. (2009) that compared the productions of U.S. prephonological spellers, who had an average age of 4 years 7 months, and Brazilian prephonological spellers, who had an average age of 4 years 8 months. One difference between the languages to which these children were exposed is that written words in Portuguese contain a higher proportion of vowel letters than written words in English. As one example, four of the eight letters in the Portuguese word *alfabeto* 'alphabet' are vowels, as compared to three of the eight letters in the English word *alphabet*. Correspondingly, Brazilian prephonological spellers used a higher proportion of vowel letters in their spellings than did U.S. prephonological spellers. Another difference between Portuguese and English is that, even for words that contain the same proportion of vowel letters, the vowels in Portuguese words are more likely to appear immediately adjacent to consonants. That is, Portuguese words show more consonant–vowel alternation than English words. All three pairs of adjacent letters in the Portuguese *bota* 'boot' consist of a consonant letter and a

vowel letter, for example, whereas the figure is two of three for the English word *boot*. Correspondingly, Brazilian prephonological writers showed more consonant–vowel alternation in their writing than did U.S. prephonological writers.

The results described so far suggest that, before children link letters to sounds, they use their statistical-learning skills to pick up information about the graphotactic patterns in the writing they see. One word that children see quite often, and one that is of special interest to them, is their own first name. Studies have shown that children often use letters from their name when asked to write other words. In several studies, the percentage of letters used by a child that appeared in the child's given name exceeded 40% for children who appeared to spell in a prephonological manner (Bloodgood, 1999, for U.S. children; Both-de Vries & Bus, 2008, for Dutch children; Kessler et al., 2013, for Brazilian children). These children seem especially likely to use the first letter of their name when writing other words (Both-de Vries & Bus, 2008).

Another letter string that children often see, in addition to their own name, is the alphabet sequence or part of it. For example, a child may see *My ABC Book* on a book cover or the entire alphabet sequence on a poster on the wall of a preschool classroom. Probably as a result of such experiences, prephonological writers produce some spellings that include alphabetic-order digrams, as in one child's <abeucy> for *dinosaur*. Indeed, the U.S. and Brazilian prephonological spellers tested by Pollo et al. (2009) were more likely to use alphabetic-order digrams than expected by chance.

These and other findings (Zhang, Yin, & Treiman, 2017) show that children begin to learn about the *outer form* of writing before they learn about its *inner function*, that is, how it works to represent language. Children have not learned about all aspects of writing's outer form by the age of 4 or 5, of course, but they have made a start. Measuring the quality of a child's prephonological productions may thus provide useful information about the child's rate of progress and likelihood of future success (Kessler et al., 2013).

### **Invented spelling**

A 4-year-old who writes <y>, <o>, and <b> along a line when asked to spell *glass* does not seem to be choosing letters based on their sound values. By age 5 or 6, children who are exposed to alphabetic writing systems begin to incorporate phonology into their spelling. Productions such as <gas> for *glass* or <bonn> for *balloon* are not correct, but they represent at least some of the sounds in the spoken words. Such productions are often called *invented spellings* because they seem to have been constructed by children rather than retrieved from a memorized store of whole-word spellings. These spellings have been extensively studied, especially in the case of native speakers of American English who are learning to spell in English (see Read & Treiman, 2013, for a review).

Children's experiences with their own names may help them move from prephonological writing to phonologically influenced invented spelling. Supporting this view, one study found that Dutch children tended to use the first letter of their given name in a phonologically appropriate manner before they did so for other letters (Both-de Vries & Bus, 2008). Children's advanced knowledge of the first letter of their name may reflect, in part, the fact that parents are especially likely to talk with them about this letter and its characteristics and to use this letter in talking to them about other words (Levin & Aram, 2005; Treiman et al., 2015). For example, a mother may tell her son John that *jar* has <j> in it, like *John* does. Children's knowledge about the names of letters may also help them move from prephonological spelling to phonological spelling. Before they begin to incorporate phonology into their spelling, many U.S. children have learned that <t> is called /ti/, that <r> is called /ar/, and so on. One study reported that some U.S. 5-year-olds could use their knowledge of letter names to produce spellings such as <t> for the made-up word /tib/ (which contains the name of <t>, /ti/) and <r> for /var/ (which contains the name of <r>, /ar/; Treiman, 1994). The children were able to do this at a time when they were unable to produce phonologically motivated spellings for nonwords such as /mib/ or /fep/, which do not contain letter names.

Spellings that contain some phonologically appropriate letters may include omissions, substitutions, and intrusions, and each of these types of errors can arise for a variety of reasons. Omissions sometimes involve initial phonemes, as in the aforementioned ⟨r⟩ for /var/, but they are more likely to involve phonemes in later positions of a word, as when a child fails to represent the vowel and final consonant of *cut* and simply produces ⟨k⟩ (Treiman, Berch, & Weatherston, 1993). Phonemes in *onset* clusters (consonant clusters at the beginnings of words or syllables) are also susceptible to omission. For example, a child may fail to represent the /l/ in the initial cluster of *flat*, writing ⟨fat⟩ (Bruck & Treiman, 1990). The child's failure to symbolize /l/ does not reflect only the position of the phoneme within the word, for the second-position /l/ of *flat* is more likely to be omitted than is the second-position /l/ of *alone* (Treiman, 1985). Rather, omissions such as that of /l/ in *flat* reflect the fact that onset clusters form cohesive units and that it is difficult for children to conceptualize these units as sequences of phonemes (Bertelson, de Gelder, & van Zon, 1997, for speakers of Dutch; Bruck & Treiman, 1990, for speakers of English). Consonant clusters at the ends of syllables are also associated with omissions. For example, U.S. children may omit the ⟨m⟩ of *jump* because they consider nasalization to be a property of the vowel rather than a separate segment that deserves its own letter (Read, 1975; Treiman, 1993). Children produce errors such as *flat* and *jump* even though these words would be classified as *regular* by any measure of the predictability of sound–spelling correspondences.

Children who are beginning to spell phonologically may also substitute one letter or letter group for another. In some cases, the substitution is a common alternative spelling of the sound in question in the language as a whole. For example, the child who wrote *cut* as ⟨kt⟩ probably analyzed the word as beginning with /k/ and knew that ⟨k⟩ may represent /k/. In other cases, the substitution is a common spelling of the sound in the dialect spoken by the child. For example, young children from southern Indiana often substitute ⟨ɪ⟩ for ⟨e⟩ in words like *pen* (Treiman, 1993). This reflects the fact that they pronounce the vowel of *pen* identically to the vowel of *pin*. Young speakers of African American English from Detroit may substitute ⟨t⟩ for ⟨d⟩ in words like *salad*, consistent with the way in which they pronounce this consonant (Treiman & Bowman, 2015). A final example of sound-based substitutions is use of ⟨ch⟩ or ⟨c⟩ in place of the ⟨t⟩ of *truck*. The child who wrote ⟨chruk⟩ for *truck* probably chose ⟨ch⟩ because the initial sound of *truck* is similar to the initial sound of *Chuck* (Read, 1975; Treiman, 1993). The child who wrote ⟨cruk⟩ for *truck* probably associated the sound in question with ⟨c⟩, the first letter of ⟨ch⟩, rather than with the whole ⟨ch⟩ sequence. Substitutions of ⟨j⟩ or ⟨g⟩ for the first letter of *dress* have a similar explanation: The initial sound of *dress* is similar to the initial sound of *Jess*, a sound that is conventionally spelled with either ⟨j⟩ (as in *Jess*) or ⟨g⟩ (as in *gentle*). In some of these cases, it can be difficult for parents and teachers to appreciate the reasons behind a child's errors. This may be especially true if the adult does not speak the same dialect as the child.

Although some of the letters in the spellings that children produce during the period under consideration are phonologically motivated, not all are. Some are intrusions that do not seem to reflect attempts to represent a sound in a word's spoken form. An example is the ⟨ɫ⟩ in one child's ⟨pelot⟩ for *potato*. Among the U.S. kindergartners (average age around 5 years 11 months) in one study, letters from children's names were likely to occur as intrusions (Treiman, Kessler, & Bourassa, 2001). Indeed, it was Emily who wrote ⟨pelot⟩ for *potato*. Letters that are frequent in the language as a whole were also likely to be used intrusively. According to these results, ⟨ɫ⟩ would be a more common intrusion than ⟨j⟩. In these respects, the spellings of children who have begun to spell phonologically are similar to those who have not. Both groups tend to use letters that are highly familiar to them in their spellings.

Further evidence of nonphonological influences on children's spelling productions is that U.S. 6-year-olds usually avoided *doublets* such as ⟨hh⟩ and ⟨yy⟩, which do not occur in English (Treiman, 1993). These children were more likely to double letters such as ⟨ɫ⟩ and ⟨s⟩, which do double in written English. Children were more likely to use these doublets in noninitial positions of words (e.g., ⟨fass⟩ for *face*), where consonants sometimes double in English, than in initial position, where

consonants hardly ever double. These and other results (Wright & Ehri, 2007) show that children who have begun to use phonology to select letters possess some graphotactic knowledge and that they use this knowledge when making their spelling choices. Although these children's spelling is influenced by phonology, it is not the only influence.

As an example of how several types of knowledge can influence young children's letter choices, consider the *taps* that occur in the American English pronunciations of words such as *city*, *spider*, *eater*, and *reading*. A tap is a quick flap of the tongue just behind the upper teeth. It is *voiced*, meaning that the vocal cords vibrate during its production. In this respect, taps are more similar to /d/, which is voiced, than to /t/, which is not voiced. When offered a choice between <d> and <t> to spell a tap, U.S. 5- and 6-year-olds showed an overall preference for <d> (Bourassa, Treiman, & Kessler, 2006; Treiman, Cassar, & Zukowski, 1994; Wolter, Wood, & D'zatko, 2009). Taps are more likely to be spelled as <t> than as <d> in English words, so children's preference for <d> points to an influence of phonology. That is, the voicing of the flap promotes <d> spellings. Children in these studies were also influenced by the morphological structure of the word (the smaller units of meaning within it). They were more likely to choose <t> for words like *eater*, which have a stem that ends with /t/, than for words like *city*, which do not have such a stem. Use of <t> was least common for words like *reading*, where the voicing of the tap (phonology) encourages uses of <d> and where the existence of a stem with a final /d/ spelled as <d> (morphology) also encourages this choice.

### Later developments

The ability to symbolize each phoneme with a plausible letter is not the endpoint of spelling development. This is especially true in languages such as English and French, where a given sound may have different spellings in different words. Taps in English have this property, as already discussed. Multiple spellings are also observed for /i/ (which may be spelled <ee> as in *deep* or <ea> as in *steam*, among other possibilities), /a/ (<o> as in *pond* or <a> as in *want*), /f/ (<ff> as in *buff* or <f> as in *beef*), and many other phonemes. Often, however, children do not have to choose among the spelling options at random. There are a number of sources of information within the writing system that they can use to increase their chance of making the correct choice.

In some cases, consideration of a word's morphological structure or of morphologically related words can help children to choose among the spelling alternatives for sounds within it. This is true for the taps of words like *eater* and *reading*, as mentioned previously, and it is true for many other words in English and other languages. For example, French children could use the fact that *ouvert* /uvɛʁ/, the masculine form of 'open', is related to *ouverte* /uvɛʁt/, the feminine form, when trying to spell it. If children recall that *ouvert* /uvɛʁ/ has a silent consonant letter at the end of its spelling, as many French words do, they could infer on the basis of *ouverte* /uvɛʁt/ that the silent letter is probably <t>. Indeed, the French 7- and 9-year-olds in one study were more likely to include the correct final letter in words like *ouvert* than words like *esprit* 'spirit', where the final consonant is also silent but where no well-known related word provides a cue (Sénéchal, 2000).

In other cases, consideration of the context within a word in which a segment appears can help children to choose among alternative spellings. Some evidence for this claim was mentioned earlier: U.S. children as young as 6 years of age were less likely to spell initial consonants with doublets, as in <ff> for /f/, than to spell final consonants with doublets (Treiman, 1993). By the age of 7, children in another study were more likely to use a final doublet such as <ff> if they spelled the preceding vowel with a single letter than if they spelled the preceding vowel with more than one letter. That is, children were more likely to produce spellings like <suff> than spellings like <sooff> (Hayes, Treiman, & Kessler, 2006). This was true even though, according to the children's teachers, children had not been explicitly taught to use single consonant letters after vowel spellings of more than one letter. The children must have learned on their own that English includes a number of words like <deaf>, with two vowel letters before a final <f>, but that words like <deaff> virtually never occur. As another

example, children could learn that English words hardly ever end with ⟨v⟩. Words that would be expected on a phonological basis to end with ⟨v⟩ usually have ⟨e⟩ after it, as in *love* and *have*.

In the aforementioned study by Hayes et al. (2006), as in other studies (Treiman & Kessler, 2006), younger children did not use context as much as older children and adults did. That is, learning to take advantage of context to help choose among possible spellings of a sound can be a long process. One reason for this is that different aspects of context are important in different cases. For the choice between single consonant letters and doublets, for example, the number of preceding vowel letters is important. For the choice between ⟨ee⟩ and ⟨ea⟩ as a spelling of /i/, the identity of the following consonant is important: ⟨ee⟩ is more likely to occur before /p/ than before a number of other consonants. For the choice between ⟨o⟩ and ⟨a⟩ as a spelling of /a/, the identity of the preceding consonant is important: ⟨a⟩ is more likely to occur after /w/ than after many other consonants. Another reason why learning to use context can be a long process is that a number of patterns hold for many words of a language but not all. For example, although /i/ is more likely to be spelled as ⟨ee⟩ before /p/ than before /m/ (e.g., *deep, steep* vs. *team, steal*), this is not always true (*cheap, seem*).

Many contextually based patterns are not covered in the spelling instruction that is typically provided in schools. Although children can use their statistical-learning skills to pick up the patterns on their own, instruction could probably speed the process. For example, teachers could tell students that *have* has a final ⟨e⟩ to protect it from ending with ⟨v⟩ and that *love* has a final ⟨e⟩ for similar reasons. Or, in what may be a more effective approach, teachers could help students to come up with examples and to discover the pattern. To provide such instruction, teachers themselves need to be conscious of patterns that they may follow only implicitly.

In Finnish, Italian, and some other languages, most phonemes have the same spelling in all of the words in which they occur. Overall, learning to spell takes less time in these languages than in languages like English (Marinelli, Romani, Burani, & Zoccolotti, 2015). This does not mean, however, that learners of English have no recourse but memorize by rote such things as which words with final /f/ end with ⟨f⟩ and which end with ⟨ff⟩. In many cases, although not all, there are patterns within the writing system that can help spellers to make a choice. Children can learn about and benefit from these patterns, even when they do not hold true for every word of a language.

## Theories of spelling development

### **Constructivist theory**

One theory about spelling development that has been particularly influential in South America and some areas of Europe is the *constructivist* theory put forward by Ferreiro and Teberosky (1982). These researchers proposed that, from an early age, children build their own hypotheses about how writing works. Children test their hypotheses against the writing that they see, discarding or modifying some hypotheses and developing others. One hypothesis that young children are thought to construct, according to this theory, is that letters in printed words stand for syllables in spoken words. As evidence, constructivists cite such cases as that of an Argentinian child who wrote *palo* 'stick' as ⟨po⟩ (Ferreiro & Teberosky, 1982) and that of a U.S. 5-year-old who wrote ⟨ewbe⟩ for the four-syllable word *elevator* and who wrote the same number of letters as syllables for some other words as well (Vernon, 1993). Another hypothesis that young children are thought to hold is that the visual forms of words should reflect characteristics of the objects for which they stand. For example, a child may write *dog* with more letters or larger letters than *puppy* because dogs are generally larger than puppies.

The constructivist view has helped to underline that children learn a good deal about writing from an early age, before formal instruction begins at school. Some of the specific hypotheses that children are thought to construct according to this theory have not been supported by well-controlled experiments, however (Pollo et al., 2009). As one example, children do not appear to

go through a period during which they consistently write words using the same number of letters as syllables (Cardoso-Martins, Corrêa, Lemos, & Napoleão, 2006; Pollo et al., 2009; Treiman, Pollo, Cardoso-Martins, & Kessler, 2013). There is support for other hypotheses, however. For example, prephonological writers tend to produce larger spellings for words that represent large objects than for those that represent small objects (Zhang & Treiman, 2015).

### **Stage and phase theories**

Stage and phase theories provide another way of conceptualizing the development of spelling (Ehri, 2000; Frith, 1985; Gentry, 1982). These theories describe the development of children's spelling skills in terms of their increasing ability to map sounds to letters. After an initial period during which children do not use letters for their sound values, often called the *prealphabetic* phase, children move to a period during which they map some of the sounds in words to letters, the *partial alphabetic* phase. Later, during the *full alphabetic* phase, children become able to map all of the sounds in words. During the fourth period of spelling development, the *consolidated alphabetic* phase, children begin to treat common letter sequences as chunks and to follow the graphotactic conventions of their language. Much of the work on stage and phase theories has examined learners of English, but the theories have also been applied to learners of other alphabetic writing systems (Cardoso-Martins et al., 2006).

Stage and phase theories have played an important role in guiding research on spelling development. They have inspired research showing that learning to spell is not, as previously thought (Jensen, 1962), largely a process of rote memorization. The theories have drawn attention to the phonological knowledge that children possess and their use of phonological knowledge in spelling. Indeed, the research I have reviewed shows that phonology is very important in learning to spell. A weakness of stage and phase theories is that they give short shrift to nonphonological knowledge, suggesting that such knowledge emerges only in the most advanced phase of development. The newer research reviewed here shows that nonphonological knowledge is important from the beginning, with children learning about some aspects of writing's outer form before they learn how it represents the sounds of speech.

### **Dual-route theories**

*Dual-route* theories (Barry, 1994; Kreiner & Gough, 1990) postulate that spelling may be accomplished by using a system of rules that link phonemes to *graphemes*, which are defined within these theories as individual letters or letter groups such as ⟨sh⟩ that stand for single phonemes. This system of rules forms the basis of the *nonlexical route*. Spelling may also be accomplished by using spellings of whole words that have been stored in memory, the *lexical route*. Dual-route theorists classify some words, such as *flat* and *ship*, as regularly spelled. For these words, both the lexical and nonlexical routes support the correct spelling. Other words, including *have* and *front*, are classified as *exceptions* because they deviate from the rules of the nonlexical route. Involvement of the lexical route is thought to be required in order to produce the correct spellings of these words. Developmental versions of dual-route theories propose that young children rely heavily or even exclusively on the nonlexical route (Sprenger-Charolles, Siegel, & Bonnet, 1998). As children get older, they increasingly use the lexical route. The lexical route is thought to be particularly important for learners of writing systems such as English, those that dual-route theories classify as *deep* because there is no simple set of rules linking phonemes to graphemes that can account for the spellings of all words. Other writing systems, such as Finnish and Italian, are classified as *shallow*. The lexical route is thought to play a smaller role for learners of such systems.

Dual-route theories have inspired much research, and they have drawn attention to differences in the pace of spelling development in learners of different alphabetic writing systems (Marinelli et al., 2015). However, it is not the case that the only systematic patterns within a writing system that are available for spellers' use are the simple context-free associations between phonemes and graphemes

that are highlighted by most versions of dual-route theory. It is not the case that words that deviate from such associations must be memorized as wholes, and it is not the case that all words that follow simple rules at the level of phonemes and graphemes are equally easy for children to spell. Phonology is important in spelling, as dual-route theories suggest, but phonologically based patterns may be probabilistic rather than all-or-none, and they may involve context. Graphotactics and morphology play important roles in spelling, and these roles are not adequately acknowledged by dual-route theories.

### **Integration of Multiple Patterns**

*Integration of Multiple Patterns* (IMP) is a framework put forward by Treiman and Kessler (2014) to describe the development of spelling. It postulates that children learn about two classes of patterns: those that involve writing's outer form and those that involve links between written symbols and language, that is, writing's inner function. Links between written symbols and linguistic units may involve phonology, but they may involve morphology and other aspects of linguistic structure as well. This framework thus grants a larger role to nonphonological knowledge than do stage and phase theories. According to IMP, children are most likely to use a particular spelling when multiple patterns support its use. When different sources of information conflict, with some favoring one spelling and others favoring a different spelling, children's choices will vary correspondingly. In these cases, it will be harder for children to learn the conventional spelling of the word. IMP stresses the role of statistical learning in learning about spelling. This process allows children to pick up patterns from the print that they see, probabilistic patterns as well as patterns that hold for all words.

Stage and phase theories and dual-route theories have not paid much attention to children's very early written productions. IMP, in contrast, suggests that children begin to learn at an early age about writing's visual form. The research reviewed here supports this idea, showing that modern children develop some knowledge about the outer form of writing as early as 2 or 3 years of age, well before they learn how written symbols are linked to language. Further support for IMP comes from demonstrations that multiple sources of information influence children's spelling choices. For example, research reviewed earlier shows that U.S. children's choices between ⟨t⟩ and ⟨d⟩ as spellings for taps are influenced by the voicing of the tap, a phonological factor, and whether the word in question has a stem ending with /t/ or /d/, a morphological factor. Another example of the use of multiple patterns comes from comparing children's ability to spell the final sounds of words like *fibs* and *fees*. The use of ⟨s⟩ in *fibs* is motivated by two patterns: the fact that it marks a plural and the fact that use of ⟨z⟩ would be graphotactically unusual. The use of ⟨s⟩ in *fees* is motivated by the fact that it marks a plural but less so graphotactically, in that the alternative spelling ⟨feeze⟩ would be graphotactically acceptable. Correspondingly, the British 5- to 8-year-olds in one study were more likely to use ⟨s⟩ when spelling words like *fibs* than when spelling words like *fees* (Kemp & Bryant, 2003). These and other findings (Bree, van der Ven, & van der Maas, 2017, with Dutch children; Pacton, Fayol, & Perruchet, 2005, with French children) support the idea that children tend to learn the spelling of a word most easily when several sources of information support the spelling and that they tend to have difficulty when this is not the case.

### **Open questions and issues**

We now have a good deal of information about how children learn to spell, but much work remains to be done. Cross-linguistic research is one important topic for future studies. A good deal of the research on spelling, like the research on reading, has examined English (Share, 2008). More studies are needed with learners of other languages, not only those that use the Latin alphabet but also those that use other scripts and other types of writing systems. Such studies can help us understand what about learning to spell is universal and what is tied to a particular language, writing system, or culture.

Research on spelling development is motivated, in part, by a desire to understand why some children have difficulty learning to spell, how these children can be identified before their difficulties become severe, and how they can best be taught. The studies reviewed here focused on normative development, in part because an understanding of how a skill typically develops is an important foundation for understanding why it sometimes does not develop in a typical fashion. Studies suggest that the aspects of a writing system that cause difficulty for typically developing children are the same ones that cause difficulty for children with serious spelling problems (Cassar, Treiman, Moats, Pollo, & Kessler, 2005, for English-speaking children; Protopapas, Fakou, Drakopoulou, Skaloumbakas, & Mouzaki, 2013, for Greek speakers). For example, consonant clusters cause problems for children across the range of spelling ability, but some children overcome these problems faster than other children. Thus, what we have learned about the linguistic features that are important for spelling development in typical children is also relevant for children with spelling problems.

To increase our understanding of children with spelling difficulties and our ability to help these children, we need more experimental studies to examine different teaching methods. Children learn to spell, in part, as they encounter words while reading and during the course of other activities (Share, 1999), but instruction can help them to progress more quickly. We need to know more about which types of instruction work best. We also need to know more about how to measure children's spelling abilities. The spelling tests that are often used for educational and research purposes score productions as correct or incorrect, but such scoring is not ideal for young children. For example, although <kt> is not the correct spelling of *cut*, it reveals more knowledge than <deba> for *cut*, which in turn reveals more knowledge than <vvvv> or a squiggle. The development of tests and scoring methods that are sensitive to different levels of knowledge can help in grouping children for instruction, predicting which children are likely to have difficulties in the future, and providing extra help to those who need it. Several of our recent studies have examined methods of scoring young children's spellings and the ability of these measures to predict future performance, and more work along these lines is needed (Kessler et al., 2013; Treiman, Kessler, Pollo, Byrne, & Olson, 2016). With better measures of spelling itself, we may need to rely less on other measures.

The ability to spell individual words is just one of the many skills that good readers and writers possess. But it is an important skill, in part because knowing the conventional spellings of words helps people to recognize the words in reading as well as to write them. I hope to have shown in this article that much has been learned about the development of spelling. The findings are helpful in understanding the problems faced by children with spelling difficulties and in improving how spelling is assessed and taught.

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