Association for Psychological Science

Psychological Science in the Public Interest
2018, Vol. 19(1) 5–51

DOI: 10.1177/1529100618772271
www.psychologicalscience.org/PSPI
SAGE

Ending the Reading Wars: Reading Acquisition From Novice to Expert

Anne Castles[1,2], Kathleen Rastle[3], and Kate Nation[2,4]
[1]Department of Cognitive Science, Macquarie University; [2]Australian Research Council Centre of Excellence in Cognition and its Disorders; [3]Department of Psychology, Royal Holloway, University of London; and [4]Department of Experimental Psychology, University of Oxford

Abstract
There is intense public interest in questions surrounding how children learn to read and how they can best be taught. Research in psychological science has provided answers to many of these questions but, somewhat surprisingly, this research has been slow to make inroads into educational policy and practice. Instead, the field has been plagued by decades of "reading wars." Even now, there remains a wide gap between the state of research knowledge about learning to read and the state of public understanding. The aim of this article is to fill this gap. We present a comprehensive tutorial review of the science of learning to read, spanning from children's earliest alphabetic skills through to the fluent word recognition and skilled text comprehension characteristic of expert readers. We explain why phonics instruction is so central to learning in a writing system such as English. But we also move beyond phonics, reviewing research on what else children need to learn to become expert readers and considering how this might be translated into effective classroom practice. We call for an end to the reading wars and recommend an agenda for instruction and research in reading acquisition that is balanced, developmentally informed, and based on a deep understanding of how language and writing systems work.

Keywords
reading, language, reading acquisition, phonics, text comprehension

Learning to read transforms lives. Reading is the basis for the acquisition of knowledge, for cultural engagement, for democracy, and for success in the workplace. Illiteracy costs the global economy more than $1 trillion (U.S. dollars) annually in direct costs alone (World Literacy Foundation, 2015). The indirect costs are far greater because the failure to attain satisfactory literacy blocks people from acquiring basic knowledge, such as understanding information about hygiene, diet, or safety. Consequently, low literacy is a major contributor to inequality and increases the likelihood of poor physical and mental health, workplace accidents, misuse of medication, participation in crime, and welfare dependency, all of which also have substantial additional social and economic costs (World Literacy Foundation, 2015). Low literacy presents a critical and persistent challenge around the world: Even in developed countries, it is estimated that approximately 20% of 15-year-olds do not attain a level of reading performance that allows them to participate effectively in life (Organisation for Economic Cooperation and Development, 2016).

Not surprisingly, then, there has been intense public interest for decades in how children learn to read. This interest has often been realized in the form of vociferous argument over how children should be taught to read—a period of exchange that has become known as the "reading wars" (for reviews, see Kim, 2008; Pearson, 2004). Over many years, the pendulum has swung between arguments favoring a *phonics* approach, in which the sounds that letters make are taught explicitly (Chall, 1967; Flesch, 1955), and a *whole-language* approach, which emphasizes the child's discovery of meaning through experiences in a literacy-rich environment (Goodman, 1967; F. Smith, 1971). Most famously, Goodman (1967) characterized reading not as an analytic process but as a "psycholinguistic guessing game" in which readers use their graphic, semantic, and syntactic knowledge to *guess*

Corresponding Author:
Anne Castles, Department of Cognitive Science, Macquarie University, Sydney, Australia, 2109
E-mail: anne.castles@mq.edu.au

the meaning of a printed word. More recently, a *three-cueing* approach (known as the Searchlight model in the United Kingdom) has become pervasive, in which beginning readers use semantic, syntactic, and "graphophonic" (letter-sound) cues simultaneously to formulate an intelligent hypothesis about a word's identity (for discussion, see Adams, 1998). Debate around these broad approaches has played out across the English-speaking world.

The beginnings of the reading wars go back more than 200 years, when Horace Mann (then the Secretary of the Massachusetts Board of Education) rallied against teaching the relationship between letters and sounds, referring to letters as "skeleton-shaped, bloodless, ghostly apparitions" and asserting "It is no wonder that the children look and feel so death-like, when compelled to face them" (Adams, 1990, p. 22; see also Kim, 2008). It was standard practice at that time to teach children to read in such a way that they learned the links between letters and sounds explicitly. This practice goes back to the 16th century (Hart, 1569/1969; Mulcaster, 1582), but it became especially popular through Noah Webster's "blue-backed spellers" (so called because of their blue binding) produced during the 18th and 19th centuries. In particular, *The American Spelling Book* (Webster, 1787) was continuously republished over the following century and became one of the best-selling books of all time (Kendall, 2012).

Today, research in psychological science spanning several decades has provided answers to many of the most important questions about reading. There is a rich literature documenting reading development and a large and diverse body of work on the cognitive processes that serve skilled reading in adults. Much of this evidence is highly relevant to the question of how reading should be taught and, pleasingly, it has been examined in comprehensive government reviews of reading instruction, including those conducted in the United States (e.g., the National Reading Panel, 2000), the United Kingdom (e.g., the Rose Review; Rose, 2006), and Australia (e.g., the Department of Education, Science and Training, or DEST; Rowe, 2005). These reviews have revealed a strong scientific consensus around the importance of phonics instruction in the initial stages of learning to read. The research underpinning this consensus was surveyed in an article published in this journal more than 15 years ago (Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001). Yet this research has been slow to make inroads into public policy. Although some progress has been made relatively recently, most notably in the United Kingdom, there remains a very wide gap between the state of research knowledge about learning to read and the state of understanding in the public and in professional domains. Further, even where there is strong national guidance around reading instruction, implementation often devolves to the local level and is influenced by variations and biases in teacher training (see, e.g., Buckingham, Wheldall, & Beaman-Wheldall, 2013; Seidenberg, 2017).

The quality and scope of the scientific evidence today means that the reading wars should be over. But strong debate and resistance to using methods based on scientific evidence persists (see, e.g., Moats, 2007; Seidenberg, 2017). Why should this be the case? We believe that there have been two major limitations in the presentations of the scientific evidence in the public and professional domains. The first limitation is that, although there have been many reviews describing the strength of the evidence for phonics instruction (e.g., Rose, 2006), it is more difficult to find an accessible tutorial review explaining *why* phonics works. Our experience is that once the nature of the writing system is understood, the importance of phonics instruction in the initial stages of learning to read becomes obvious.

The second limitation is that there has not been a full presentation of evidence in a public forum about reading instruction that goes *beyond* the use of phonics. It is uncontroversial among reading scientists that coming to appreciate the relationship between letters and sounds is necessary and nonnegotiable when learning to read in alphabetic writing systems and that this is most successfully achieved through phonics instruction. Yet reading scientists, teachers, and the public know that reading involves more than alphabetic skills. To become confident, successful readers, children need to learn to recognize words and compute their meanings rapidly without having to engage in translation back to sounds. Therefore, it is important to understand how children progress to this more advanced form of word recognition and how teaching practice can support this. In addition, reading comprehension clearly entails more than the identification of individual words: Children are not literate if they cannot understand text. We believe that the relative absence of discussion of processes beyond phonics has contributed to ongoing resistance to the use of phonics in the initial stages of learning to read. That is, instead of showing how a foundation of phonic knowledge permits a child to understand and gain experience with text, this imbalance has allowed a characterization of phonics as "barking at print" (reading aloud robotically without understanding) to continue among educationalists (e.g., Davis, 2013; Samuels, 2007) and public figures (e.g., Rosen, 2012).

We aim in this review to address these important omissions. We define the goal of reading as being able to understand text—a task of immense complexity (see Box 1 for more detail on what we mean by reading)—and review what is known about how children achieve this goal. We then consider how reading should be

Box 1. What Is Reading?

The goal of reading is to understand what has been read, and thus the goal of reading development must be to develop a system that allows children to construct meaning from print. Our review takes a broad perspective on reading development, reflecting the fact that reading is complex. To set the scene, consider the challenges posed by this simple, two-sentence text:

Denise was stuck in a jam. She was worried what her boss would say.

What needs to happen for us to understand this text? First and foremost, we need to identify the **individual words**. This in itself is hugely challenging, requiring us to distinguish a word such as *jam* from all the numerous similar-looking words it could be, such as *jar* or *ham.* We must have a means of identifying words that may be unfamiliar, such as *Denise*, and of analyzing words which appear in a complex form, such as *worried.* Words are the building blocks of comprehension, but it's not just a matter of identifying words: Their **meanings** need to be activated, appropriate for the **context**. This means understanding *jam* with respect to traffic, not the fruit preserve. **Causal connections** need to be made within and across sentences to understand that *she* and *her* in the second sentence refer to *Denise* in the first sentence.

Despite its brevity, this text demands a good deal of **background knowledge**: that Denise was probably on her way to work but was running late because of heavy traffic. We can further infer, perhaps prompted by our knowledge of Denise, her routines or her attitudes. Perhaps she is in a car or on a bus; we might wish to ponder her relationship with her boss. Perhaps she has been late several times recently and is thus especially worried about their reaction; maybe she is en route for a meeting that, if missed, will have important consequences. We might know her boss, and make **inferences** based on his or her reputation, prompting us to think about the extent or nature of Denise's worry. We have no idea, but these are just some of the potential elaborations and inferences that are licensed by the text.

Other factors also add complexity. Making connections within a text and integrating information with background knowledge places demands on **working memory**. Dealing with an ambiguous word such as *jam* might engage **executive** skills if the contextually inappropriate meaning is activated and then needs to be ignored.

This brief analysis makes clear that reading is complex. Even a straightforward, two-sentence text has the potential to require a range of mental operations, ranging from word recognition through to an appreciation of theory of mind. The challenge facing the beginner reader is thus substantial.

taught to best support its development. Our article is structured in three major parts, spanning from children's early experiences of mapping letters to sounds to the fluent text processing characteristic of expert readers. In the first part, we explain why cracking the alphabetic code is so central to learning to read in alphabetic writing systems such as English and why it forms the foundation for all that comes later. Our central message here is that that *the writing system matters*. Although our review focuses primarily on reading in alphabetic systems, by providing a detailed account of the structure of different writing systems and the way in which they systematically map onto oral language, we aim to demystify the evidence about learning to read. In doing so, we hope to provide our readers with deep insight as to *why* particular teaching methods support initial reading acquisition.

In the second part, we move beyond alphabetic skills, reviewing the latest research on the acquisition of fluent word-recognition skills. Here, our central message is that *experience matters*. Children's experiences in reading are often subsumed under terms such as *print exposure*. However, to understand fully how children become skilled word readers, we need to unpack these terms and capture in much greater detail the rich and wide-ranging reading experiences that children have and how these experiences interact with their knowledge at different points in learning.

In the final section, we move to text comprehension. Here, our key message is that reading comprehension is multifaceted. To understand its complexities, we need to consider the range of linguistic and cognitive processes that are implicated in text comprehension and appreciate how these depend on children's knowledge, as well as features of the text itself and the purpose and goals of the reading situation.

At the end of each major section, we consider the implications of the science we have reviewed for the classroom and address controversies surrounding the teaching of these different aspects of reading. We note here that our focus is on typical reading development and on effective instruction in standard classroom settings. The extensive and important body of work on the complex needs of children with various kinds of learning difficulties is beyond our scope. Our aim, rather, is to provide our readers with the scientific background they need to promote best practice in the classroom and so minimize the proportion of children who struggle with reading as a result of nonoptimal teaching, or "instructional casualties" (Lyon, 2005).

1. Cracking the Alphabetic Code

If a child is exposed to a rich spoken-language environment, that child will almost certainly learn to understand and produce spoken language. As Pinker (2009) puts it, "there is almost no way to prevent it from happening, short of raising a child in a barrel" (p. 29). The same cannot be said for reading. Although reading is a heritable trait (Olson, Keenan, Byrne, & Samuelsson, 2014), influenced by multiple genes interacting with environmental factors in complex ways, it is nevertheless a learned skill that typically requires years of instruction and practice. When children begin to learn to read, they usually already have relatively sophisticated spoken-language skills, including knowledge of the meanings of many spoken words. The challenge of reading is to learn to associate arbitrary visual symbols—patterns of lines, curves, and dots—with those meanings. It is difficult for a skilled reader with perhaps decades of practice to appreciate the scale of this challenge. Although a child might be able to memorize the shapes or distinguishing features of a handful of words (e.g., *yellow* has "two sticks in the middle"; Seymour & Elder, 1986), the high confusability of written language together with limitations on memory means that this strategy would be very unlikely to scale up to a full vocabulary. Instead, children need to learn to *analyze the printed forms* of words and map these onto meaning. Precisely how they might most easily accomplish this depends on the nature of the writing system, so we turn now to considering the world's writing systems and how they are structured.

1.1. Writing systems and their implications for learning to read

Writing is a recent cultural invention, and writing systems vary substantially in how their visual symbols represent spoken language. All writing systems are a kind of code for spoken language, and learning to read requires children to crack how the code works for their language. Once this is understood, children have the means to access their rich spoken-language knowledge from print. The code that children must learn varies across different languages. Indeed, for languages that have more than one script (e.g., Japanese), children may need to learn more than one code, as these scripts may map onto spoken language in different ways. There are three major categories of writing system: *alphabetic* (in which symbols represent individual sounds or *phonemes*; e.g., English), *syllabic* (in which symbols represent whole syllables; e.g., Japanese Hiragana), and *morphophonetic* (in which symbols represent elements of both meaning and sound; e.g., Chinese). This latter class of writing system is sometimes referred to as *logographic*. There are also variations within these broad categories; for example, an *abjad* is an alphabetic writing system that represents the consonants of spoken language but not many of the vowels (e.g., Hebrew; for a description of writing systems associated with 131 languages, see Chang, Chen, & Perfetti, 2018).

There are many reasons why particular writing systems emerge for particular languages: Political influences, invasions, nationalism, and missionary activities have all contributed to the nature of writing around the world (for historical information about particular writing systems, see, e.g., Ager, 2018; Kamusella, 2009). However, one interesting idea, developed by Katz and Frost (1992), that is worthy of further study is that particular writing systems may be more suitable for individual languages than others—indeed, that "most languages get the orthography they deserve" (p. 67). For example, spoken Mandarin Chinese is characterized by a small number of syllables and consequently by a high number of *homophones*, or words with different meanings but pronounced the same way. A troublesome instance of this is the word *si*, which means both the number *4* and *death*, which is why it is quite common for hotels in China to skip from the third floor to the fifth floor. If

Chinese were written using an alphabet (particularly an alphabet with a one-to-one mapping between letters and sounds), then the ambiguity in the spoken language would be mirrored in the written language, leading to many *homographs*, or words with different meanings spelled in exactly the same way. The development of Chinese characters to communicate the spoken language prevents some of this ambiguity. In contrast, Katz and Frost (1992) argue that Indo-European languages such as English are characterized by less homophony and a larger number of much more complex syllables. The use of an alphabet in these cases permits the spoken language to be communicated visually with a relatively simple set of letters mapping to sounds (Katz & Frost, 1992; see also Frost, 2012).

There have been decades of argument, often invoking pedagogical philosophy, over how children can best learn to associate the visual symbols of writing to spoken language. However, a crucial point is that the most appropriate way to learn this mapping is governed not by pedagogical philosophy but by the nature of the writing system the child needs to learn. In alphabetic systems, the phonemes of the language are represented by letters or groups of letters (*graphemes*; e.g., *b* → /b/, *ph* → /f/). If a child learns to decode that symbol-to-sound relationship, then that child will have the ability to translate printed words into spoken language, thereby accessing information about meaning. In contrast, failing to appreciate the symbol-sound mapping in an alphabetic language would effectively turn reading acquisition into a paired-associate learning task, as the child attempts to memorize meanings for individual printed words. Although this strategy may be possible for a relatively small number of words, it is hard to imagine it scaling up to the tens of thousands of English words that adult readers can recognize (Brysbaert, Stevens, Mandera, & Keuleers, 2016).

Indeed, one virtue of learning to read in an alphabetic system is that each learning experience can facilitate future learning. For example, learning the pronunciation of *vet* can help the child to learn other words, such as *van* and *vow*. This capacity for generalization is much more limited in Chinese. Chinese characters are built from phonetic and semantic components that can provide some basis for generalization (although the information in these components may have quite low reliability; Lü, 2017). However, there are many more of these components that must be memorized than is the case for an alphabetic system; estimates suggest that there are 895 phonetic components and 214 semantic components that give rise the 4,300 or so characters thought to be sufficient for full literacy (Katz & Frost, 1992). Because of the difficulty and slow pace of learning characters through primary school, an alphabetic system for writing Chinese known as Pinyin was introduced in 1958. Pinyin instruction in Mainland China runs alongside the learning of Chinese characters in the early years of schooling and has been shown to facilitate reading achievement (Lin et al., 2010).

Even among the alphabetic systems that are the focus of this article, there is substantial variation in their *orthographic depth*, or the transparency with which symbols (graphemes) represent sounds (phonemes). *Shallow* orthographies are characterized by a consistent relationship between graphemes and phonemes (e.g., Italian), whereas *deep* orthographies are characterized by substantial inconsistency in this relationship (e.g., English). Nevertheless, even in deep orthographies, pronunciation is still strongly governed by the spelling-sound relationship. To put this into quantitative terms, Coltheart, Rastle, Perry, Langdon, and Ziegler (2001) estimated that approximately 80% of English monosyllables could be pronounced using a relatively small set of rules relating graphemes to phonemes. In the remaining 20% of cases, typically only one grapheme deviates from its most frequent pronunciation (e.g., *pint, have, chef*; see Section 1.4.2.2). However, most of the work on spelling-sound relationships has been conducted with monosyllables; researchers are only just beginning to consider spelling-sound relations in letter strings with more than one syllable (e.g., Ktori, Mousikou, & Rastle, 2018; Mousikou, Sadat, Lucas, & Rastle, 2017; Perry, Ziegler, & Zorzi, 2010).

Research on learning to read in English has often focused on the high degree of inconsistency in the relationship between spelling and sound (for discussion, see Share, 2008). However, it is important to recognize that this inconsistency can take a variety of forms, and this ultimately may have implications for reading instruction. English contains words with highly unusual spelling-sound relations, such as *friend, yacht, aisle*, and *plaid*, but there are also cases in which surrounding context can mitigate apparent spelling-sound inconsistency. For example, the vowel in *wash* appears unusual compared with *cash, stash*, and *dash*. However, this vowel pronunciation is shared with other words beginning with the letter *w* (e.g., *want, wand, watt*). Likewise, although the vowel pronunciation in *thread* is inconsistent with that in *beach, leap*, and *seat*, it is shared with other words ending with the letter *d* (e.g., *bread, stead, dead*). If these subregularities are taken into account, then the consistency of English spelling increases (Kessler & Treiman, 2001). Further, as we discuss in Section 2.2.3, many spelling-sound inconsistencies arise because of the preservation of *morphological* regularities in printed words (e.g., *magic* vs. *magician*; Treiman & Bourassa, 2000).

Substantial research has been conducted to determine whether orthographic depth has an impact on reading acquisition in alphabetic writing systems. In the most ambitious study of this type, Seymour, Aro, and Erskine (2003) compared children's reading aloud of simple words and nonwords across 13 European languages at the end of the first year of schooling (including nonwords in addition to words in studies of reading acquisition is important, given that they permit an assessment of a child's decoding skills that is relatively independent of his or her existing word knowledge; see Section 1.4.2). Results showed a substantial impact of orthographic depth: Children reading in English lagged well behind those reading in languages with shallow orthographies (e.g., Finnish). However, it is difficult to draw firm conclusions about the impact of orthographic depth from cross-linguistic comparisons of this nature because of the differences in the age at which children begin schooling in different countries. In the data reported by Seymour et al. (2003), the English children were up to 2 years younger than those in the other groups at the point of testing, and there were probably also variations in the nature of reading instruction across the groups.

L. H. Spencer and Hanley (2004) were able to investigate orthographic depth in a natural experiment made possible by the schooling system in Wales at that time. The children could attend either Welsh-medium or English-medium schools. Welsh, in contrast to English, has a shallow orthography, but across the two types of school, the children started at the same age, had the same form of reading instruction, and were broadly equivalent in socioeconomic status. Results of reading-aloud tests conducted across three time points during the first year of reading instruction showed a dramatic benefit for the children learning to read in Welsh. These data indicate that orthographic depth has a substantial impact on acquiring spelling-sound knowledge in the initial stages of learning to read. However, we are unaware of any evidence that these initial gains as a result of shallow orthography translate to later advantages in reading comprehension. Further, although orthographic depth affects the time taken to learn the spelling-to-sound mapping, the cognitive factors underlying reading performance appear to be similar across different European languages (Caravolas et al., 2012; Ziegler et al., 2010).

1.2. The development of alphabetic decoding skills

The nature of the writing system determines what will be required for children to make links between print and meaning, but it does not specify precisely how they do so. Therefore, we now turn to the rich body of work that has explored in detail how children's skills in alphabetic decoding develop—delineating what children initially bring to this complex task, how their knowledge changes over development, and the way in which their instructional experiences shape and modify their learning. We outline here just some key insights from this large body of work, providing references to reviews that expand on the theory and evidence in detail.

1.2.1. Inducing the alphabetic principle: The child's initial hypotheses about print. If left to their own resources, what hypotheses will preliterate children form about print and its relationship to sound and meaning? That is, on exposure to printed words, will children naturally induce the basic alphabetic principle that symbols represent sounds? If not, what is required for them to do so? These were the questions asked by Byrne and colleagues in a detailed series of experiments on preschool children between the ages of 3 and 5 years (Byrne, 1992; Byrne & Fielding-Barnsley, 1989, 1990; for a review, see Byrne, 2005). The experimenters used a transfer of training paradigm: Children who knew no letter names were taught to read aloud pairs of written words, such as *fat* and *bat*. Subsequently, they were challenged with a transfer task in which they were shown, for instance, the written word *fun* and then asked whether the word was "fun" or "bun." The results were clear: Across more than 80 preschool children who participated in the various experiments, virtually none succeeded on the transfer task. When left to their own devices, the children showed no evidence of inducing the alphabetic principle.

Further investigations were then conducted to determine what triggers the acquisition of the alphabetic principle in preschool children. Reliable success on the transfer task was typically achieved only when children were trained such that they could (a) segment phonemes in spoken words and identify their initial phonemes and (b) recognize the graphic symbols that corresponded to the key sounds in the transfer task (i.e., *b* and *f* in the example above; Byrne & Fielding-Barnsley, 1989). Note that once children had gained the alphabetic insight needed to succeed in the transfer task, their learning was relatively robust and could be generalized. For example, most children who were able to perform the task for a symbol in the initial position of the word were also successful when the same symbol was at the end.

As noted, the children in Byrne et al.'s studies who induced the alphabetic principle were typically able to segment phonemes explicitly in spoken words; for example, they could state that the word *pot* begins with a /p/ sound. This finding is consistent with a large body of research on the importance of the metalinguistic skill of phonemic awareness in reading acquisition, stemming from the work of the Libermans and their colleagues (A. M. Liberman, Cooper, Shankweiler, & Studdert-Kennedy, 1967; I. Y. Liberman, Shankweiler, Fischer, &

Carter, 1974; for review, see Melby-Lervåg, Lyster, & Hulme, 2012). This group proposed that to crack the alphabetic code, children must be able to abstract the relevant phonemic units from the stream of the speech they hear. This is a nontrivial task, because the segmentation of an acoustic signal does not correspond in any straightforward way with segmentation at the phoneme level: In continuous speech, phonemes overlap and run together. A large body of research is also consistent with Byrne et al.'s second finding—that acquiring the alphabetic principle requires children to learn the visual symbols of the writing system that correspond to phonemes. An intimate and reciprocal association exists among children's letter knowledge, their phonemic awareness, and their skill in alphabetic decoding (see, e.g., Castles & Coltheart, 2004; Castles, Coltheart, Wilson, Valpied, & Wedgwood, 2009; Hulme, Bowyer-Crane, Carroll, Duff, & Snowling, 2012).

In summary, it is clear that the fundamental insight that graphemes represent phonemes in alphabetic writing systems does not typically come naturally to children. It is something that most children must be taught explicitly, and doing so is important for making further progress in reading. Fortunately, however, the foundational knowledge required to trigger this insight is not extensive and, once acquired, puts children on a path to accruing further knowledge and firmly establishing their alphabetic decoding skills.

1.2.2. Phases of alphabetic decoding development. Once children have acquired the alphabetic principle, they can move on to learning the specifics of the relationships between graphemes and phonemes in their writing system and to applying this knowledge in their reading and spelling. This developmental process is itself a complex one: Several researchers have identified broad "phases" that children move through, reflecting the sequence of key skills that emerge with their increasing expertise (e.g., Ehri, 1999, 2002, 2005a; Frith, 1985; for reviews, see Ehri, 2005b, 2017). In all cases, the first phase posited is one before the acquisition of the alphabetic principle in which children "read" words by relying on visual cues, rote learning, or guessing. Of interest here, however, is how decoding develops once the alphabetic insight has occurred.

According to Ehri's phase theory (2005b, 2017), children first move into a *partial alphabetic phase* where they begin to use a rudimentary form of decoding. Persuasive evidence for this strategy comes from a classic study by Ehri and Wilce (1985; see also Rack, Hulme, Snowling, & Wightman, 1994) in which beginning readers were required to associate letter strings with spoken words over a series of trials. The letter strings were of two types: Those in one set were highly visually distinctive and were printed in different sizes and cases (e.g., *wBc* taught as the spelling of "giraffe"), whereas those in the other set contained cues as to the sounds of the associated words (e.g., *jrf* for "giraffe"). Ehri and Wilce observed that prereaders—children who could read no words and had little or no letter knowledge—found the visually distinctive spellings easier to learn, whereas children who could read some words and showed some evidence of mastery of the alphabetic principle learned the phonetic spellings more easily. Clearly these latter children could not yet be considered skilled alphabetic decoders, but they were nevertheless beginning to use insights from their alphabetic knowledge to make links between spellings and sounds. Spelling is an important driver of the transition into the partial alphabetic stage (Frith, 1985). Even a very limited repertoire of letters allows children to generate invented spellings that capture the sounds of words. Although beyond the scope of our review, it is worth noting that spelling skills are tightly linked to the process of reading acquisition and that spelling often operates in the service of reading (for a comprehensive review of spelling development, see Treiman & Kessler, 2014).

With further instruction and experience in reading and spelling, children move to what Ehri describes as a *full alphabetic phase*. They now have a much more complete knowledge of grapheme-phoneme relations and can apply this knowledge consistently across a whole printed word. Children can now decode unfamiliar printed words, allowing them to access their pronunciations and through them their meanings (if the words are familiar in oral form). Even where the alphabetic decoding process results in an incorrect pronunciation (e.g., "breek" for *break*), children may be able to draw on their oral vocabulary to correct the partial decoding attempt (Tunmer & Chapman, 2012) or use the mispronunciation itself to make links between printed and spoken words (Dyson, Best, Solity, & Hulme, 2017; Elbro & de Jong, 2017). Put simply, in this phase of reading acquisition, the child has cracked the alphabetic code. This is the critical starting point for learning to read, even though much remains to be acquired beyond this, as we will see later in our review.

1.3. Cracking the alphabetic code: Summary

We have established that learning to read in an alphabetic writing system such as English requires the acquisition of the alphabetic principle—the insight that the visual symbols of the writing system (graphemes) represent the sounds of the language (phonemes). We have also established that virtually all children require at least some assistance in learning this principle. Foundational skills such as phonemic awareness and letter knowledge are key precursors to this alphabetic insight, and these skills and bodies of knowledge interact reciprocally in complex ways (for reviews, see Bowey, 2005; Hulme et al., 2012; Marinus & Castles, 2015). Once this initial insight is acquired, children acquire increasingly sophisticated skills in alphabetic decoding, moving in broad phases from partial to full decoding ability (Ehri, 2017). In the next section, we consider the implications of these scientific findings for classroom instruction in relation to the initial periods of reading acquisition.

1.4. Implications for the classroom

1.4.1. Systematic phonics instruction. Systematic phonics refers to reading instruction programs that teach pupils the relationship between graphemes and phonemes in an alphabetic writing system. As explained above, the rationale for systematic phonics instruction is that a relatively small body of knowledge of how graphemes relate to phonemes provides children with the ability to decode most words in their language. Provided that children have adequate vocabulary, this sound-based representation can then be used to access the meanings of those words. If instruction instead focused on teaching children to associate printed words with their meanings directly, then learning to read would require memorization of tens of thousands of individual printed words. Thus, systematic phonics instruction should be viewed as a natural and logical consequence of the manner in which alphabetic writing systems represent spoken language.

Phonics programs are *systematic* when they teach grapheme-phoneme correspondences in an ordered manner. Such instruction is more straightforward in a shallow orthography than in a deep orthography, such as that of English. In English, there are just 26 letters to represent about 44 phonemes (depending on dialect), and thus the relevant grapheme-phoneme correspondences include single-letter graphemes (e.g., *d* → /d/, *f* → /f/) and multiletter graphemes (e.g., *ch* → /ʧ/, *ai* → /eɪ/, *eigh* → /eɪ/, and *ng* → /ŋ/). In one case, a single letter maps onto two phonemes, *x* → /ks/. As reviewed earlier, English has considerable inconsistency in its spelling-sound mapping, leading most systematic phonics programs to focus on teaching the more common correspondences (for a table of the most frequent grapheme-to-phoneme relationships for English monosyllables, see Rastle & Coltheart, 1999).

The evidence for the effectiveness of phonics instruction is extensive and has been surveyed comprehensively elsewhere. The most influential analysis arose as a result of the National Reading Panel convened by the U.S. Congress in the 1990s. Part of the work of the panel was to conduct a quantitative meta-analysis evaluating the impact of systematic phonics instruction compared with nonsystematic or no-phonics instruction (Ehri et al., 2001). On the basis of the combined results of 38 experiments involving 66 treatment-control comparisons, this meta-analysis yielded a moderate impact of phonics instruction (i.e., effect size) of 0.41,[1] which was much larger when phonics instruction began early (d = 0.55) than when it began after the first grade (d = 0.27). Phonics instruction improved decoding, spelling, and text comprehension. This result is broadly consistent with a subsequent meta-analysis of 14 randomized controlled trials investigating the impact of phonics instruction on reading accuracy (Torgerson, Brooks, & Hall, 2006), although the overall effect size was reduced (d = 0.27). More recently, two meta-analyses have concluded that phonics instruction is an effective intervention for poor readers (Galuschka, Ise, Krick, & Schulte-Korne, 2014; McArthur et al., 2012). The only meta-analysis that has examined the longer-term outcomes of phonics instruction produced a variable pattern of results, but there was clear evidence of benefits on spelling (Suggate, 2016).

These research studies have underpinned recommendations to adopt systematic phonics instruction methods in the United States (National Reading Panel, 2000), Australia (Rowe, 2005), and the United Kingdom (Rose, 2006). However, these recommendations have been implemented fully only in England, where, following the conclusions of the Rose (2006) review, state-funded schools have a statutory duty to provide systematic phonics instruction when children first start school (which normally occurs in England in the September following their fourth birthday). Schools' compliance with this duty is measured via a phonics screening check given to all children at the end of the second year of reading instruction, when children are 5 or 6 years old. This check requires children to read 20 words and 20 nonwords aloud; the nonwords are critical to assess pure spelling-to-sound knowledge, without any impact of memory for individual words. The recommendations have also informed legislation in the United States, including the No Child Left Behind Act of 2001 (2002) and the Every Student Succeeds Act (2015–2016), and systematic phonics instruction is included in the Common Core State Standards Initiative. However, implementation and accountability for reading performance in the United States rests with individual states, and not all states have adopted the Common Core (for adopters, see http://www.corestandards.org). This variation in reading instruction may contribute to the wide differences in reading achievement across U.S. states (U.S. Department of Education, 2015). The Australian government has recently proposed a federal screening program to test children's phonic knowledge; this is a matter of significant current debate and discussion (e.g., Buckingham, 2016).

Although the meta-analyses described above provide clear evidence for the effectiveness of systematic phonics instruction, the introduction of a statutory duty to provide high-quality systematic phonics instruction in England provides the opportunity to consider its impacts on a national scale. The evidence from performance on the phonics screening check suggests fairly dramatic year-over-year improvements in children's phonic knowledge since 2012, when the test was introduced: 58% passed in 2012, 69% in 2013, 74% in 2014, 77% in 2015, 81% in 2016, and 81% in 2017 (U.K. Department for Education, 2017). These results suggest that the policy has increased schools' compliance in delivering systematic phonics instruction and has perhaps improved the quality of its delivery. However, one important question is whether these gains have influenced literacy achievement more broadly. Inspection of performance on national standardized tests administered at the age of 7 show small but significant increases in reading comprehension associated with the national improvements observed in phonics knowledge, although it is not possible to conclude that this association reflects a causal relationship (Walker, Sainsbury, Worth, Bamforth, & Betts, 2015).

One approach to determining whether a causal relationship exists between phonics instruction and broader literacy performance was described in a report by the U.K. Centre for Economic Performance (Machin, McNally, & Viarengo, 2016). Specifically, because the phonics policy in England was piloted and then implemented across different school districts at different times, it is possible to assess the impact of this change on children's performance on national tests of reading comprehension administered at ages 5, 7, and 11 relative to children in "untreated" districts. Using this approach, Machin et al. (2016) documented strong impacts of the policy change on reading comprehension up to the age of 7. There was also a longer-term benefit at age 11, years after the original intervention occurred, for those children who had a high probability of starting school as struggling readers because they were nonnative speakers of English or were economically disadvantaged. These results are consistent with the view that explicit teaching of phonics assists all children to access text material relatively early in reading instruction and that this explicit instruction is particularly vital for some children (e.g., C. E. Snow & Juel, 2005).

1.4.2. Outstanding questions on phonics instruction. It will be clear from our review so far that there is strong scientific consensus on the effectiveness of systematic phonics instruction during the initial periods of reading instruction. Despite this, widespread misunderstanding in the public domain prevails: Some key myths about phonics instruction are addressed in Box 2. In addition, many outstanding questions remain regarding exactly *how* phonics instruction is best implemented in the classroom, given that there are, of course, multiple ways in which this could be done. Here, we review here some of the key questions, all of which in our view require further research to be resolved (for further discussion, see Stuart & Stainthorp, 2015).

1.4.2.1. Methods of phonics instruction. One ongoing debate regarding methods of phonics instruction (particularly within the United Kingdom) concerns whether a "synthetic" approach is preferable to an "analytic" one. Synthetic phonics programs teach grapheme-phoneme correspondences individually and in a specified sequence, and children are taught early to blend (*synthesize*, hence the term *synthetic*) individual phonemes together to make words. In contrast, analytic phonics programs begin with whole words, and grapheme-phoneme correspondences are taught by breaking those words down into their component parts. On the face of it, synthetic phonics would seem to have some clear advantages: By introducing grapheme-phoneme correspondences individually, it is possible to control the learning environment more effectively and to ensure that each correspondence is taught explicitly and in an optimal sequence. Empirical support for synthetic phonics has also come from a longitudinal study conducted in Clackmannanshire County, Scotland; Johnston and Watson (2004, 2005) reported strong and long-lasting gains in reading accuracy and spelling from a 16-week synthetic phonics intervention relative to two analytic phonics interventions. However, in our view, the evidence is not yet sufficient to conclude that a synthetic phonics approach should be preferred over an analytic one: Neither the Torgerson et al. (2006) meta-analysis nor that of the National Reading Panel (Ehri et al., 2001) found evidence for a difference in effect size across the two methods. Both of these reviews concluded that the key ingredient of a successful phonics program is that it is systematic. Beyond this, further research is required to determine which implementations are most effective.

A second outstanding question concerns whether phonics instruction should be limited to individual graphemes and phonemes, and their most common mappings, or should be extended beyond this. As noted earlier, many spelling-sound regularities in English are not captured by simple grapheme-phoneme rules and require consideration of other letters and phonemes in the word (e.g., the vowel sound associated with "oo" often changes when followed by "d," as in *hood, good*, and *stood*; Kessler & Treiman, 2001). Thus, there may be a case for extending phonics programs to include instruction on these context-sensitive rules once children have mastered the basic mappings (Vousden, Ellefson, Solity, & Chater, 2010). However, it is also possible that a limited set of grapheme-phoneme correspondences taught early will put children on a

Box 2. Some Myths About Phonics Instruction

Myth	Evidence	References
1. Phonics teaches children to read nonwords	The aim of phonics instruction is to equip children with the skills to sound out *words* independently. Nonwords are primarily used not for teaching but for assessment, to index children's phonics skills independently of their word knowledge. An analogy would be measuring heart rate to assess cardiovascular fitness: We don't train the heart to beat more slowly, but we assess this function to measure how effective a fitness training program has been.	Castles et al. (2009)
2. Phonics interferes with reading comprehension	At a basic level, phonics supports comprehension by allowing the child to link an unfamiliar printed word with a familiar word in oral vocabulary. Phonics also supports the development of fluent word reading ability, which in turn frees up the child's mental resources to focus on the meaning of a text. Ehri et al.'s (2001) meta-analysis found that children taught by a systematic phonics method made gains in text comprehension as well as in word reading and spelling.	Perfetti & Hart (2002) Ehri et al. (2001)
3. English is too "irregular" for phonics to be of value	It is true that the English writing system is complex, and many words violate typical letter-sound mappings. However, learning phonics will still take a child a long way: More than 80% of monosyllabic words are completely regular and, for those that are not, a "partial decoding" will often bring a child close to the correct pronunciation, which can then be refined using oral vocabulary knowledge.	Share (1995)
4. Phonics is boring for children and turns them off reading	Phonics instruction is often portrayed as robotic and mechanical, but this is at odds with the array of engaging and enjoyable structured phonics programs currently available. And, through its positive effects on reading attainment, phonics instruction is associated with greater motivation to read, more extensive reading for pleasure, and higher academic self-esteem.	Kirsch et al. (2002) Anderson et al. (1988) McArthur & Castles (2017)

path to independent reading and that more complex context-sensitive mappings will then be acquired through text experience (e.g., Stuart, Masterson, Dixon, & Quinlan, 1999; Ziegler, Perry, & Zorzi, 2014). A small body of research compares phonics programs that teach single grapheme-phoneme mappings (e.g., "oo" is pronounced as in *spook*) with programs that teach multiple mappings (e.g., "oo" can be pronounced as in *spook* or *hood*; see Shapiro & Solity, 2016). However, we believe that a systematic investigation of the optimal number and complexity of phonics rules to be taught is needed.

1.4.2.2. Teaching "sight words" along with phonics. Mastery of alphabetic decoding skills allows children to translate the spellings of most words they encounter into sound. However, as we have discussed, most alphabetic writing systems have at least some degree of spelling-to-sound irregularity, and English includes a number of high frequency words that are highly unusual (e.g., *eye, friend*). Many teachers address this problem by teaching these kinds of words as "sight words" or "tricky words" together with phonics instruction. Sight words are introduced in a range of ways, and this varies across classrooms. Teachers may use flash cards with single words printed on them for children to name, activity sheets involving the words, or weekly word lists for children to take home. In all cases, the intention is that, through repetition and feedback, children learn to recognize and name these tricky words fluently. However, this practice is controversial: Many phonics advocates argue that it is not only ineffective but also dangerous, causing children to become confused about letter-sound mappings and setting them up with bad reading habits that interfere with their ongoing phonics instruction (e.g., A. Clarke, 2012; Potter, 2012).

In our view, this concern is unwarranted, and the judicious selection of a small number of sight words for children to study in detail has its place in the classroom alongside phonics. As we have discussed, teaching phonics is crucial because it gives children the skills to translate orthography into phonology and thereby to access knowledge about meaning. However, when this is difficult because of spelling-to-sound complexities, there would seem to be a case for teaching children the pronunciations of a small number of such words directly, particularly those that they are likely to see very frequently in the texts they are reading (such as *the, come, have*, and *said*). In effect, this ensures that children can relate the visual symbols of writing to spoken language for as many words as possible and as early in their schooling as possible. Solity and Vousden (2009) demonstrated that the combination of knowledge of the 64 most common letter-sound mappings of English, together with familiarity with its 100 or so most frequent words, allows children to read aloud 90% of words in texts they typically encounter—putting them very efficiently on the path to independent reading.

It would be a different story if teaching sight words interfered with children's acquisition of alphabetic decoding skills, but evidence is lacking. In a large intervention study, McArthur et al. (2015) found that struggling readers who received mixed phonics and sight-word instruction made just as strong gains in their alphabetic decoding ability as those receiving phonics instruction alone. There was also no evidence from this study that sight-word teaching caused the children to become confused or to "unlearn" phonics rules that they had already acquired. Indeed, children who received an intensive period of sight-word instruction immediately after an intensive period of phonics instruction showed no deterioration in their alphabetic decoding ability and, in fact, continued to show improvements.

The McArthur et al. (2015) study was carried out with older struggling readers, all of whom had at least some phonics knowledge. What is known about beginning readers? Shapiro and Solity (2016) compared the effectiveness of two phonics programs being implemented in the first (Reception) year of schooling in the United Kingdom: Letters and Sounds (U.K. Department for Education and Skills, 2007), which teaches multiple letter-sound mappings and no sight words, and Early Reading Research (Shapiro & Solity, 2008), which teaches only the most consistent letter-sound mappings plus high-frequency sight words. Follow-up of reading and phonological awareness outcomes at the end of the second and third years of schooling revealed that the two programs were equally effective, indicating that the presence of sight words did not interfere with phonics learning. In fact, there was a tendency for children with low initial phonological awareness scores to do better with the Early Reading Research program, which suggests that being exposed to multiple alternative sound mappings for the same graphemes, rather than sight words, may have been a source of confusion for these children.

In summary, teaching phonics provides children with the principal means of getting from the printed form of a word to its spoken form but, given the depth of the English orthography, teaching some sight words can assist here as well. That said, many questions remain about the teaching of sight words. Most importantly, what method of teaching sight words is most effective? Successful methods are likely to involve engaging children in detailed study of the letters in the word and their sequence—with a focus on the difficult parts—and linking this with the word's pronunciation, but this has not been explored systematically. Moreover, what is the minimum level of alphabetic skill that beginning readers need in order for sight-word teaching to be effective? Sight-word learning is likely to be most successful when children have basic letter knowledge (Levin & Ehri, 2009); however, this does not mean that the introduction of sight words should be delayed until children have an extensive knowledge of many specific grapheme-phoneme correspondences. Finally, what is the optimal number of sight words to teach at different points in reading acquisition and with what intensity? Research is needed to answer these questions. A final important point to note, as we discuss in detail in Section 2.4.1, is that children learning "sight words" should not be seen as analogous to them learning to read "by sight." As we will see, the latter is a much more complex and protracted developmental process.

1.4.2.3. A role for "decodable" books? Decodable books are texts written for children that consist primarily of words that they can read correctly using the grapheme-phoneme correspondences that they have learned (with the exception of a few unavoidable irregular words such as *the* and *said*). These kinds of books provide children with an opportunity to practice what they have been taught explicitly in the classroom and to allow them to experience success in reading independently very early in reading instruction, albeit with a rather restricted word set. These books also allow teachers to effectively structure and sequence children's exposure to grapheme-phoneme correspondences in text. Evidence suggests that phonics teaching is more effective when children are given immediate opportunities to apply what they have learned to their reading (Hatcher, Hulme, & Ellis, 1994); so, for these reasons, we believe that there is a good argument for using decodable readers in the very early stages of reading instruction.

Beyond the initial stages of reading, however, the case for decodable books weakens. First, evidence indicates that once children have learned a core set of grapheme-phoneme correspondences, they get no more opportunity to practice these in decodable books than they do in other books they might be reading (i.e., books not specifically written with decodability in mind). Solity and Vousden (2009) analyzed the vocabulary within three sets of books in the United Kingdom: two structured reading schemes consisting of specially written books for school children containing high-frequency and phonically regular words and one set of story books found in typical Year 1 and 2 classrooms (i.e., children ages 5–7). They found that the percentage of monosyllabic words within the books that would be decodable by children knowing 64 grapheme-phoneme correspondences was equal across the three sets (approximately 75%). A second issue with decodable books is that they are likely to be somewhat restricted in word choice and so may tend to be inferior to real books in (a) maintaining children's interest and motivation to read and (b) in achieving the broader goals of building children's vocabularies and knowledge. Solity and Vousden (2009) give the example of the words used in the book *The Three Billy Goats Gruff* (Sharratt & Tucker, 2004) with the analogous decodable reader *Billy the Kid* (Miskin, 2008). The only word used to describe the characters speaking to each other in *Billy the Kid* is *said*, which is repeated 11 times. In contrast, in the book *The Three Billy Goats Gruff*, the word *said* is also used 11 times, but eight other words and phrases are used to describe how the different characters speak (e.g., *shouted out, grunted, replied, roared, snapped*, and *spluttered*). As we discuss later in this review, exposure to complex words and nuanced meanings is important. Therefore, in our view, once children move beyond the very early stages of reading, the benefits of decodable readers are likely to be outweighed by their limitations. More research is needed to determine when this tipping point occurs.

2. Becoming a Skilled Word Reader

We have argued that cracking the alphabetic code is essential for learning to read and that assisting children to do so is a nonnegotiable part of teaching them to read. It is this initial knowledge of spelling-sound relationships that allows children to access the meanings of printed words and thus gain the text experience that is essential for the acquisition of higher-level reading skills. However, the acquisition of phonic knowledge is by no means all there is to learning to read, even at the single-word level. In our view, one of the impediments to the translation of research into teaching practice and to the resolution of the reading wars has been a relative lack of attention to aspects of reading acquisition that go beyond alphabetic decoding, which give rise to arguments that "reading is more than phonics." This is a statement of the obvious to any reading scientist. Yet such statements are often used in public debate to undermine the case for the use of phonics in the initial stages of learning to read. In this section, we discuss how children move beyond alphabetic decoding to develop the ability to recognize words accurately and with ease. We begin with a review of what is known about the word-reading system and how it operates in skilled readers, making the case for processes beyond alphabetic decoding.

2.1. Word-reading processes in skilled reading

We have discussed how the process of alphabetic decoding is essential for *learning* to read, but it is important to note that even skilled adult readers continue to use alphabetic decoding and phonological processes as a matter of routine. The most obvious evidence of this is that skilled readers can generalize: They can read not only words with which they are highly familiar but also new words that they have never seen before (or indeed nonwords, such as *slint* and *vib*). There is also substantial evidence that alphabetic decoding processes affect skilled readers' word recognition and comprehension (Rayner, Schotter, Masson, Potter, & Treiman, 2014). One powerful demonstration of the impact of phonological decoding on skilled word recognition is the *pseudohomophone effect*. The letter strings *feal* and *feep* are both nonwords, but skilled readers find it more difficult to judge the former as not being a real word (see, e.g., Ziegler, Jacobs, & Klüppel, 2001). Both of these letter strings are different from the word *feel* by just one letter, so the only explanation for this result is that readers are translating the letter strings to sound. Likewise, participants who were asked to judge whether a printed word was a member of a particular semantic category made more false-positive errors in response to homophones of correct responses (e.g., responding that the word *rows* is a type of flower) than in response to similarly spelled control words (e.g., *robs*). This result indicates that the participants had translated *rows* into a phonological code, for only by doing so could they mistake this word for a type of flower. It is also important to note that the translation into a phonological code actually hurt performance in this task, but participants could not "turn off" that process. Further research suggests that this translation from spelling to sound occurs very rapidly in skilled readers and indeed is apparent even in cases in which participants are not aware that a stimulus has been presented (for reviews, see Rastle & Brysbaert, 2006; Leinenger, 2014).

Thus, skilled readers of alphabetic writing systems continue to draw on the systematic relations between letters and sounds when they read and understand words. These skills alone, however, are not sufficient for fluent word reading. A simple example serves to illustrate this point: Readers of this article will be able to reliably distinguish the meanings of the two printed words *sail* and *sale*, even if they are presented in isolation with no contextual support. Yet readers cannot achieve this via alphabetic decoding alone because it would produce exactly the same pronunciation for each word. They can also immediately recognize and understand irregular words such as *have, come*, and *eye*, despite the fact that they cannot reach the meanings of these words via alphabetic decoding alone (and, in the case of *come*, despite the fact that alphabetic decoding actually leads to an incorrect meaning, that of a hair implement). Such words would place heavy demands on a reading system reliant purely on alphabetic decoding, requiring extra time and effort and perhaps the harnessing of additional top-down support from oral vocabulary or sentence context. But there is no evidence that this is so for skilled word readers: They can recognize and identify highly familiar irregular words just as efficiently as they can regular ones (Seidenberg, Waters, Barnes, & Tanenhaus, 1984).

These examples are taken from English, which is arguably an "outlier" orthography because of the high degree of inconsistency of its spelling-to-sound mappings (Share, 2008; see Section 1.1). Maybe expert readers of shallow orthographies continue to read words primarily via alphabetic decoding? This does not appear to be the case. Alphabetic decoding is a process of mapping graphemes onto phonemes, and it has been argued that this is carried out in a serial, left-to-right manner (Rastle & Coltheart, 1999, 2006; Rastle, Havelka, Wydell, Coltheart, & Besner, 2009). Therefore, if this process is being relied on, longer letter strings will be slower to read than shorter ones. For nonwords, which are unfamiliar to all readers and so must be read via alphabetic decoding, this is indeed the case: Long nonwords produce much longer reading latencies than short nonwords (Weekes, 1997). However, when skilled readers are reading familiar words, length has little or no effect on their reading latencies, and this is the case in English orthography (Weekes, 1997) and in a range of other orthographies, including Spanish, French, and German (Acha & Perea, 2008; Juphard, Carbonnel, & Valdois, 2004; Ziegler, Perry, Jacobs, & Braun, 2001).

The fact that word reading involves more than just alphabetic decoding is reflected in all major theories of skilled reading. Theories of skilled reading are among the most elaborate and well-specified in the field of psychological science. Indeed, several have been expressed as computer programs known as *computational models* that describe the precise cognitive operations involved in visual word recognition and reading aloud (e.g., Coltheart et al., 2001; Harm & Seidenberg, 2004; Perry, Ziegler, & Zorzi, 2007, 2010; Plaut, Mcclelland, Seidenberg, & Patterson, 1996). Box 3 provides an introduction to these computational models, although our review is agnostic as to which provides the most successful account of skilled reading performance. The important point is that all of the models converge in that they represent two key cognitive processes in word reading: one that involves the translation of a word's spelling into its sound and then to meaning, and one that involves gaining access to meaning directly from the spelling, without the requirement to do so via phonology.

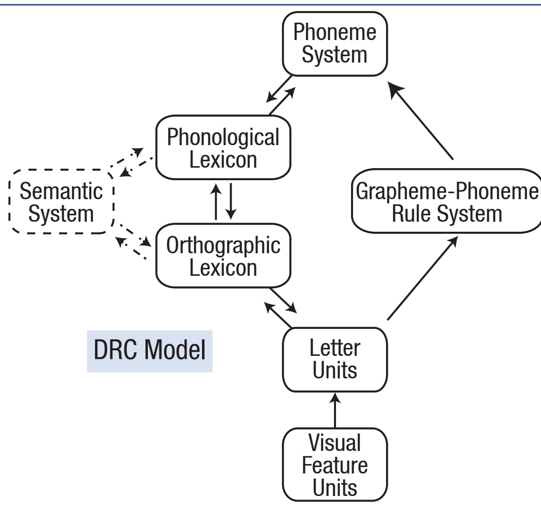
That these two broad mechanisms should emerge in readers of alphabetic orthographies makes perfect sense: Together, they allow optimal processing of words across the full spectrum from being new and unfamiliar to a reader, where alphabetic decoding is critical, to highly familiar, where direct access to meaning is more efficient (Share, 2008). Regardless of the particular orthography being read, it appears that a direct pathway from print to meaning is preferred for familiar words, most probably because the alphabetic decoding mechanism is slow, attention demanding (Besner, Reynolds, & O'Malley, 2009; Paap & Noel, 1991), and therefore not optimal for supporting the fast and efficient word reading that characterizes skilled readers. This dual-pathway architecture for deriving meaning from printed words is also apparent in the neural implementation of the reading system, as described in Box 4.

In summary, cognitive models converge in representing the fluent reading of familiar words as proceeding directly from print to meaning, without the requirement for alphabetic decoding. Knowing this is important because it maps out for us what the child

Box 3. Computational Models of Reading

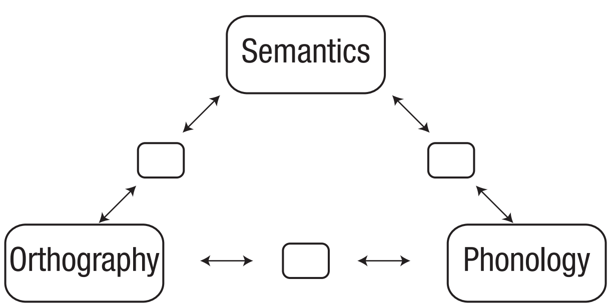
Computational models of reading are computer programs that describe in detail the cognitive operations proposed to underpin particular reading tasks, such as recognizing a word and reading it aloud. By writing a theory of reading as a computer program, one can make sure that the theory is complete and can be evaluated rigorously against human data. Development and testing of computational models has had a huge impact on our understanding of skilled reading and has informed theories of related reading phenomena, including reading acquisition, dyslexia and its remediation, and the genetic and neural bases of reading.

Three main computational models have been proposed: the DRC model (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001); the Triangle model (Harm & Seidenberg, 2004; Plaut, McClelland, Seidenberg, & Patterson, 1996); and the CDP+ model (Perry, Ziegler, & Zorzi, 2007, 2010). These models accept a printed letter string as input, and transform it to a pronunciation, or to the activation of stored knowledge of words. Researchers study the accuracy and speed with which these transformations are accomplished. The models are used to simulate typical reading, but can also be "lesioned" to simulate types of dyslexia acquired through brain injury or atypical development.

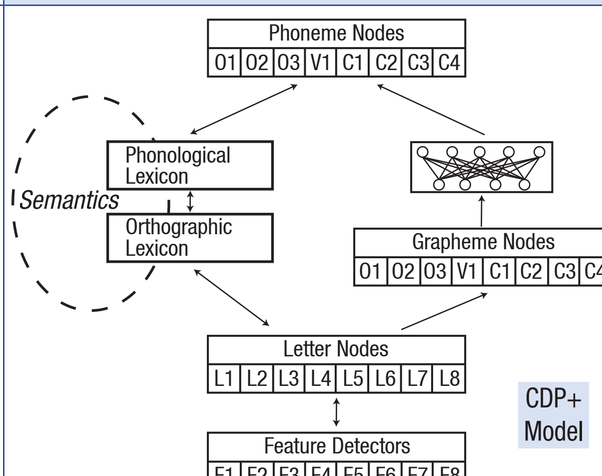


DRC Model

The DRC model is a static model of the skilled, adult reading system. The Triangle model simulates the process of learning to read as well as the adult system, and the CDP+ model is a hybrid that combines features of the other two models. All three models propose that reading involves stored knowledge of learned words, as well as knowledge of the relationship between spelling and sound. Using this latter type of knowledge allows the models to read both words and nonwords, such as *slint* or *vib*.



Triangle Model



CDP+ Model

needs to learn to become a skilled word reader and what the ultimate goal of educational instruction should be. It would be a mistake, however, to assume that knowledge of how the skilled system works is all that is needed to inform instruction. On the contrary, the assumption that the endpoint of learning to read determines how it should be taught was precisely the error made by theorists such as Goodman (1967). These theorists observed rapid construction of meaning for texts in skilled adult readers and concluded that instruction should focus on these skills. But such a conclusion is analogous to observing skilled concert pianists and concluding that piano instruction should involve putting a child in front of a Tchaikovsky score. The missing piece of the puzzle here is *how* these processes develop in children, so we turn now to reviewing the science on this question.

2.2. The development of fluent word-reading skills

As children progress toward becoming skilled readers, their heavy reliance on alphabetic decoding gradually decreases (Doctor & Coltheart, 1980; Harm & Seidenberg, 2004; Zoccolotti et al., 2005). That is, children make the transition from being "novices," reading words primarily via alphabetic decoding, to "experts," recognizing familiar written words rapidly and automatically, mapping their spellings directly to their meanings without recourse to decoding, a process we have referred to as *orthographic learning* (Castles & Nation, 2006; Nation & Castles, 2017). It is important to note that phonological processes still exert an influence on reading at this point, but they do so in a less overt way. For example, from as young as 7 years old, children reading sentences process nonwords that sound like words (e.g., *gerl*) more efficiently than control nonwords (e.g., *garl*). This shows that even in children's silent reading, phonological processing is at play (e.g., Blythe, Pagán, & Dodd, 2015; Jared, Ashby, Agauas, & Levy, 2016).

Orthographic learning is an umbrella term that encompasses both the acquisition of the word-specific knowledge required to access a particular word's meaning from print and also the accumulation of more general knowledge about orthographic regularities within the writing system (for example, in English, double letters such as "ll" tend to appear at the ends of words but not the beginnings; Cassar & Treiman, 1997; Pacton, Perruchet, Fayol, & Cleeremans, 2001). In the sections below, we explore what is known about this important, but less well understood, aspect of reading acquisition.

2.2.1. Self-teaching during independent reading.

The most influential theory of the transition to skilled word reading has been Share's *self-teaching hypothesis*, which sets out a theoretical framework (Jorm & Share, 1983; Share, 1995) and provides an experimental paradigm for exploring it (Share, 1999, 2004). The self-teaching hypothesis has alphabetic decoding at its core, the so-called sine qua non of reading acquisition. As we have explained, alphabetic decoding provides children with a means of accessing the spoken form of a word from its written form. But Share further proposes that, by requiring the child to engage in the effortful process of translating print to sound and therefore to focus on the letters in the word and their sequence, the act of decoding also provides an opportunity to acquire orthographic knowledge. This knowledge is then available on future encounters with the word, lessening the reliance on alphabetic decoding. Thus, through the combination of alphabetic decoding and repeated exposure, children are able to self-teach through their independent reading.

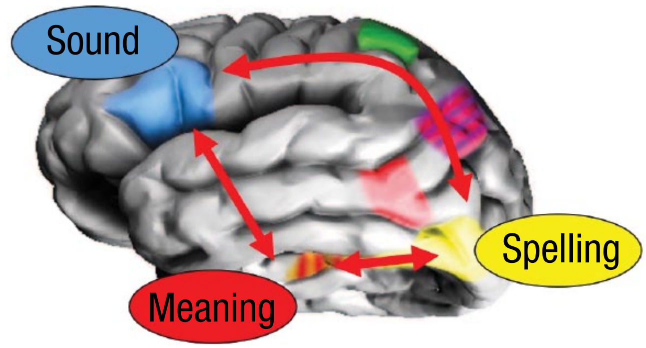
Share provided evidence for his hypothesis in an innovative series of experiments with children learning to read in Hebrew (Share, 1999, 2004). In his 1999 study, 8-year-old children independently read short stories aloud, each of which contained novel words (an English example is the item *Yait*, and children might read a story about how *Yait* is the coldest city in the world). Several days later, the children demonstrated substantial learning about the orthography of these new words: They were well above chance at selecting the correct spelling of the word (*Yait*) from alternative spellings that consisted of a homophone (e.g., *Yate*) and two visually similar items (e.g., *Yiat, Yete*). The inclusion of the homophone is important here because, as with our *sale-sail* example above, the children would not have been able to reliably distinguish the correct word from its homophone by relying on phonological decoding alone. The children also named the novel items faster than the homophones and, in a spelling task, were more likely to use the spelling of the word to which they had been exposed than that of the homophone. Thus, these results provide clear evidence of orthographic learning beyond alphabetic decoding: The children had learned something specific about the orthographic form of the words that they experienced during their independent reading. There have now been several similar demonstrations in deeper alphabetic orthographies, such as English (Cunningham, Perry, Stanovich, & Share, 2002; Kyte & Johnson, 2006; Wang, Castles, & Nickels, 2012; Wang, Castles, Nickels, & Nation, 2011), providing evidence of the generality of the self-teaching mechanism.

The self-teaching hypothesis provides a powerful paradigm for representing how children move from novice to expert. More generally, it has been influential in focusing attention squarely on learning and on the

Box 4. The Neural Bases of Reading

The past 20 years have seen increasing interest in how the brain supports skilled reading and its development. A recent meta-analysis bringing together neuroimaging studies of reading in alphabetic writing systems has yielded strong support for the proposal that there are two pathways to computing meaning from print (Taylor, Rastle, & Davis, 2013). The neural model of reading resulting from this meta-analysis is presented below. A *dorsal pathway* underpins phonologically mediated reading, and a *ventral pathway* underpins direct access to meaning from print. This model is also supported by neuropsychological data. For example, patients with damage to areas of the dorsal pathway have difficulty reading nonwords (e.g., Woollams & Patterson, 2012), whereas patients with damage to areas of the ventral pathway have particular difficulties reading words with atypical spelling-sound mappings (e.g., Woollams, Ralph, Plaut, & Patterson, 2007).

Regions within the left-hemisphere ventral pathway dubbed the "visual word form area" have been of particular interest to reading researchers (for review, see Dehaene & Cohen, 2011). This region appears to be tuned to written language; for example, it responds more strongly to words and nonwords than to consonant strings (Cohen et al., 2002). Further work characterizing this region has revealed a posterior-to-anterior gradient, with increasing sensitivity to higher-level properties of words (e.g., letters, bigrams, quadrigrams; Vinckier et al., 2007).



Neural Pathways of Skilled Reading
(adapted from Rastle, 2018)

Much less research has considered how the brain changes through reading development. Nevertheless, a recent meta-analysis of neuroimaging studies of reading in children revealed a network of dorsal- and ventral-pathway brain regions similar to that observed in adults (Martin, Schurz, Kronbichler, & Richlan, 2015). One interesting proposal that is consistent with the characterization of reading acquisition that we have put forward is that reliance gradually shifts with increasing reading skill from the dorsal to the ventral pathway (Pugh et al., 2000; Shaywitz et al., 2002). This is consistent with longitudinal data suggesting that areas of the ventral pathway continue to increase in sensitivity to printed words into adolescence (Ben-Shachar, Dougherty, Deutsch, & Wandell, 2011) and that this increase is associated with speeded word reading performance, but not nonword reading performance or phonological processing skill.

importance of understanding how learning takes place if reading development is to be understood. Key to this is the insight that the process of acquiring direct mappings between printed words and their meanings proceeds in an *item-based* fashion: At any particular point in time, a child may be reading some words slowly and with great effort while recognizing and understanding other words rapidly and efficiently, with less reliance on alphabetic decoding (Castles & Nation, 2006; Share, 1995). Indeed, this is even true for adult skilled readers, who must apply their orthographic learning processes to the numerous novel printed words they will encounter throughout their lifetimes (think *Google, blog*, and *selfie*). An item-based learning mechanism is now widely reflected in computational models of reading acquisition (e.g., Grainger, Lété, Bertand, Dufau, & Ziegler, 2012; Harm & Seidenberg, 2004; Pritchard, Coltheart, Marinus, & Castles, 2018; Ziegler et al., 2014).

However, there are some important aspects of the transition from novice to expert word reading on which the self-teaching hypothesis is largely silent. As discussed, central to the hypothesis is that *exposure* is key to this transition: Orthographic learning occurs as a function of alphabetic decoding together with repeated exposure to novel words in print. But what, precisely, does this exposure achieve? What changes in children's orthographic knowledge as a result of their experiences with printed words, and how does this lead to the changes in the nature and the efficiency of word recognition that are observed? And are all types of exposure equally valuable? To answer these questions, we need to move beyond the self-teaching hypothesis to more detailed theories of word-reading development.

2.2.2. Building expertise through experience with print. In his influential theory, Perfetti (1992, 2007; Perfetti & Hart, 2002) provides one answer to the question of what changes as a result of exposure to printed words: *lexical quality*. Perfetti defines lexical quality as the extent to which a stored mental representation of a word specifies its form and meaning in a way that is both precise and flexible. Precision of the representation—knowledge of the exact spelling—is important because it allows a child to distinguish a written word from similar-looking words, permitting direct access to its meaning (e.g., to differentiate *face* from *fact, fame*, and *lace*). Flexibility of the representation is important because it allows a child to adapt dynamically to different print-meaning combinations (such as reading about eating *jam* versus reading about getting in a *jam*; see Box 1). Once again, lexical quality applies at an item level: For any given reader, some frequently encountered words in their lexicon will be high in quality, whereas other less well-known words will be low in quality. But note that as children build their experience with print, the average quality of the words in their lexicon steadily increases.

Why is lexical quality so important for the transition from novice to expert reader? According to Perfetti and others (e.g., Ehri, 2005b), the answer to this question is that, as lexical quality builds, cognitive resources are freed up for comprehension. As we will see later in our review (Section 3.1), understanding text is a complex task that places heavy demands on attention, memory, and high-level language processes. When lexical quality is high, a reader's cognitive resources can be largely directed toward this challenging task because individual words are recognized rapidly, automatically, and with minimal conscious effort. In contrast, when lexical quality is low, some of the reader's limited cognitive resources must be directed to the more basic task of word recognition, and comprehension is compromised as a result. Thus, as with so many aspects of learning, "low-level" processes underpin, and are an essential foundation for, the high-level ones: Through repeated exposure to words, a child develops specialized and efficient basic word-recognition mechanisms that are optimized for reading for meaning.

Given the importance of these automatic and efficient word-recognition processes for skilled reading, a key question to ask is what promotes their emergence. Is it driven simply by the total number of exposures a child has had to a given word? Certainly, there is a positive association between indices of children's overall exposure to print and their reading ability (Mol & Bus, 2011; Stanovich & West, 1989). However, the answer appears to be more nuanced than this and, once again, to draw on considerations of the nature of the writing system. Consider once again the example of the word *face*. Successful discrimination of this word from the many other words in English that differ from it by only one letter (e.g., *fact, lace, fame*) requires the reader to develop a very precise recognition mechanism, one that attends to all of the letters in the word and their order. Otherwise, identification accuracy and access to meaning will be compromised. However, now consider the word *bird*. Few other four-letter words in English differ from this word by only one letter, so the discrimination challenge is substantially easier. A lexical recognition mechanism for *bird* that allows it to be efficiently and reliably identified can afford to be considerably less precise than one for *face*. Thus, overall print exposure may interact with the nature of the orthography to shape the development of a child's word-recognition system—a mechanism we refer to as *lexical tuning* (Castles, Davis, Cavalot, & Forster, 2007; Castles, Davis, & Letcher, 1999).

There is evidence for a lexical-tuning process playing out across reading development. For example, Castles et al. (2007) used a technique known as masked priming to probe how the precision of children's automatic word-recognition mechanisms changes between Year 3 and Year 5 (approximately between ages 8 and 10 in Australia). Masked priming involves the presentation of a prime stimulus very briefly before a target word to which the participant must respond in some way. Although the prime is presented so briefly that participants can rarely report seeing it, it nevertheless can affect performance on the target; for example, the prime word *face*, presented in lowercase, facilitates responses to the identical uppercase target word, *FACE* (Forster & Davis, 1984). Thus, manipulating the prime and its similarity to the target probes the mechanisms that underpin automatic word recognition. They found that, in Year 3, these mechanisms were quite "loosely" tuned. The children's responses to a word such as *FACE* were facilitated by a one-letter-different prime (e.g., *dace*), indicating that the prime was sufficiently similar to the target to activate its recognition mechanism. However, once the children had reached Year 5, this was no longer the case. The recognition mechanism was more finely tuned for those same words, and only a prime that was an exact match (i.e., *face* itself) was sufficient to facilitate performance.

Note that what is likely to be critical in the tuning of lexical representations is not age per se but reading experience (which is naturally correlated with age). In line with this, Andrews and colleagues (Andrews & Hersch, 2010; Andrews & Lo, 2012)—also using masked priming techniques—have reported variation in markers of lexical tuning in skilled readers, even among university students. Those who show evidence for high lexical quality, as indexed by their spelling skills, appear to show more precise tuning than those with less well-specified orthographic representations. This variation is associated with performance on measures of reading, spelling, and vocabulary in these adult participants. These data suggest that even in adults, there are substantial individual differences in the precision of the orthographic representations necessary for rapid word recognition and comprehension, reflecting variation in a person's literacy experiences over time. These influences are seen not just in isolated word-reading tasks but also in silent text reading, as revealed by eye-movement studies (e.g., Veldre & Andrews, 2015, 2016).

Thus far, we have discussed how the orthographic representations used in skilled reading are sharpened through an individual's literacy experiences over time. Because individuals do not experience all words in the same manner, it follows that there may be item-level variation in the nature of orthographic representations. One variable that has been particularly well studied in the skilled-reading literature is word *frequency*. It has long been thought that words that occur frequently have particularly robust orthographic representations and can thus be processed more rapidly (e.g., Forster & Chambers, 1973; for review, see Brysbaert, Mandera, & Keuleers, 2018). However, Zevin and Seidenberg (2002) make the point that word frequency is not just a variable relevant to skilled reading but also reflects the accumulation of instances in lexical memory over time. On that basis, they argue that the best reflection of experience in skilled reading is not actually frequency (i.e., how many times a word occurs in a corpus) but cumulative frequency (i.e., number of instances of experiencing a word through the whole of reading acquisition).

The number of times that someone encounters a particular word throughout a lifetime is the most basic characterization of lexical experience. However, some researchers have argued that lexical experience is more nuanced than a simple accumulation of instances; some kinds of instances are more important than others in shaping orthographic representations. One account posits that the *age* at which people experience particular words is important, such that experiences early in reading acquisition have greater impact on the development of orthographic representations than those late in reading acquisition (Morrison & Ellis, 1995). This age-of-acquisition effect is not yet well understood, but computational work suggests that it may reflect a fundamental property of systems that learn incrementally over time (Monaghan & Ellis, 2010). The *lexical legacy hypothesis* developed by Nation (2017) provides another account of the accumulation of experience, positing that the linguistic nature of people's experiences with particular words is also important (see also Baayen, 2010). For example, words that people experience in a range of different semantic and syntactic contexts might yield stronger orthographic representations than words that are repeated in the same contexts. The premise of this theory, demonstrated through behavioral and computational studies simulating the learning process, is that change is important for supporting learning (e.g., Jones, Dye, & Johns, 2017).

There is not yet consensus on which (if any) of these accounts provides an accurate characterization of the accumulation of lexical experience. Indeed, cumulative frequency (Zevin & Seidenberg, 2002), age of acquisition (Ghyselinck, Lewis, & Brysbaert, 2004; Juhasz & Rayner, 2006), and semantic and contextual diversity (Adelman, Brown, & Quesada, 2006; Jones, Johns, & Recchia, 2012; Plummer, Perea, & Rayner, 2013) have all been shown to affect skilled performance when reading words in isolation and in sentences. In addition, semantic properties of words have been demonstrated to influence skilled reading behavior: Words that have multiple meanings, a high degree of imageability (i.e., the degree to which a word can be visualized), or rich semantic features also enjoy an advantage in word recognition (Pexman, 2012; Taylor, Duff, Woollams, Monaghan, & Ricketts, 2015). It is possible that these effects also reflect the influence of these semantic properties on orthographic learning across development, shaping lexical quality (Nation, 2009). Further work will be necessary to discover how people's experiences with words accumulate over time to shape orthographic representations and how this learning is ultimately reflected in skilled reading behavior.

2.2.3. Morphology: Acquiring links between spelling and meaning. So far, we have described the formation of direct connections between print and meaning as proceeding in an item-based manner; children recognize some words very rapidly and with ease and continue to rely on alphabetic decoding processes for other words. Indeed, for the vast majority of printed words that children are exposed to in reading materials used in the initial years of instruction, this learning must proceed item by item because these are mostly short words containing only a single morpheme (Masterson, Stuart, Dixon, & Lovejoy, 2010). Unlike the systematic relationships between spelling and sound in an alphabetic language, there is no relationship between spelling and meaning where single morphemes are concerned. Although words that look similar (e.g., *cat, can, cut*) are similar in sound, they are not similar in meaning. This means that learning the meaning of one word does not usually assist in learning the meaning of another. Thus, the relationship between print and meaning needs to be learned one word at a time.

Sometimes, these regularities between spelling and meaning can lead to inconsistencies between spelling and sound, as in the case of *magical* and *magician* (e.g., Treiman & Bourassa, 2000). Once readers start to gain experience with these types of morphologically complex words, they may learn that particular groups of letters are associated with particular meanings. This knowledge then allows them to interpret or produce new words that they may not have seen before (e.g., George W. Bush's "I'm the *decider* and I decide what's best"; Rastle & Davis, 2008). Such generalization would be impossible in the case of novel words with a single morpheme (e.g., determining the meaning of *slint* or *vib*).

Acquiring knowledge of how morphology underpins the mapping between spelling and meaning is an important process in the development of skilled reading. Once morphological regularities between spelling and meaning are discovered, orthographic learning does not need to proceed one item at a time. Instead, for those words comprising more than one morpheme, recognizing and getting to the meaning of printed words can be based on analysis of the constituents (e.g., recognizing *darkness* through analysis of its components {dark} + {-ness}). English is thought to be a morphologically sparse language, but even so, around 80% of words in the English language are built from more than one morpheme (e.g., *darkness, cleanliness, blackbird*; see Baayen, Piepenbrock, & Van Rijn, 1993). Thus, the acquisition of morphological knowledge presents a dramatic advantage in acquiring the mapping between spelling and meaning (Rastle, 2018).

What, then, is known about how children learn mappings between spelling and meaning? By the time children start school, they have rich morphological knowledge that they use in their own language production and comprehension (e.g., Berko, 1958; Carlisle, 1995). But when and how does this become intimately linked with orthography? There has been a great deal of research investigating the development of children's explicit knowledge of morphological relationships and how this knowledge relates to reading ability. This explicit knowledge is known as *morphological awareness*. It refers to a child's ability to reflect on and manipulate the morphological structure of words (Carlisle, 1995) and is typically measured using oral tasks. For example, a child might be asked to produce the appropriate word in a question such as "farm: My uncle is a _____" (Mahony, 1994). Very young children can perform simple versions of such tasks (e.g., "This is a wug; now there are two of them; these are two _____"; Berko, 1958). Substantial research suggests that children's success in performing these explicit, oral tasks is associated with success in reading aloud and reading comprehension (e.g., Carlisle, 2000; Deacon & Kirby, 2004; Singson, Mahony, & Mann, 2000), although these associations often become apparent only in the later years of primary school.

Morphological knowledge also has clear impacts on spelling in the primary school years, although there is debate regarding the age at which these effects become evident. In an important longitudinal study, Nunes, Bryant, and Bindman (1997) showed that children demonstrate morphological knowledge in their spellings, but that the quality of this knowledge changes substantially between the ages of 6 and 10. Although children adopt morphological spelling patterns relatively early, they apply them incorrectly to irregular verbs (e.g., *keped* for *kept*) and even words that are not verbs (e.g., *sofed* for *soft*). It is not until a later stage of acquisition that children can apply this knowledge appropriately. Further, although Treiman and Cassar (1996) found evidence that children as young as 7 years old could use rudimentary morphological knowledge in their spelling performance, this has not always been replicated (e.g., Larkin & Snowling, 2008; for discussion, see Pacton & Deacon, 2008).

Although evidence suggests that children's explicit morphological knowledge is associated with reading performance (e.g., Carlisle, 2000; Singson et al., 2000), research is still needed to understand precisely how the reading process itself is influenced by morphological knowledge at different points in reading acquisition. Substantial evidence indicates that children between the ages of 7 and 11 analyze the morphological structure of printed letter strings during word-recognition tasks, at least to some degree. Children read aloud nonwords with a morphological structure more rapidly than those without one (Burani, Marcolini, & Stella, 2002), and they read aloud morphologically complex words with a high-frequency stem (e.g., *locally*) more quickly than those with a lower-frequency stem (e.g., *avidly*; Deacon, Whalen, & Kirby, 2011). Likewise, research suggests that children have difficulty classifying morphologically structured letter strings such as *quickify* as nonwords (relative to nonwords without morphological structure; e.g., *quickilt*), a finding replicated in Italian (Burani et al., 2002), French (Casalis, Quémart, & Duncan, 2015), and English (Dawson, Rastle, & Ricketts, 2017).

However, research using masked priming has shown that morphemic analysis of printed words is not fully automated in children. For example, Beyersmann, Castles, and Coltheart (2012) found that although 10-year-olds showed facilitation in masked priming for morphologically related pairs of words (e.g., *golden* primed recognition of *GOLD*), there was no priming between pairs of words sharing pseudo-morphological overlap (e.g., *corner-CORN*). This effect is routinely seen in skilled adult readers (Rastle, Davis, & New, 2004) and reflects their ability to analyze the morphological structure of a word rapidly, arising before the analysis of whole words (Taft, 1994; Taft & Forster, 1975). Further research, including with participants during the period of secondary education, is needed to determine when and how abstract morphological representations used during word recognition are instantiated and in what ways these change over the course of reading acquisition.

2.3. Becoming a skilled word reader: Summary

We have reviewed the evidence that expert readers can gain access to the meanings of many words directly from their printed forms and that reading progress is characterized by a gradual transition from a profile of reading words primarily via alphabetic decoding to one of heavy reliance on this direct mechanism. Acquiring knowledge of morphological regularities is an important part of this transition, allowing the child to capitalize on systematic mappings between spelling and meaning. The process by which this transition from novice to expert word reader occurs is complex, and many questions remain. However, it is clear that reading experience matters. Exposure to print provides the dynamic database from which children can accumulate detailed orthographic knowledge, supported by a foundation of alphabetic decoding skill.

What, then, are the implications for teaching? What can be done in an educational setting to promote this transition? The answers to these questions are less straightforward than in the case of phonics and alphabetic decoding. In the next section, we consider some of the misunderstandings and controversies in relation to teaching fluent word-reading skills, and we provide guidance based on the implications of the scientific research.

2.4. Implications for the classroom

2.4.1. Sight words revisited. A natural first response to the question of how to promote fluent word-reading skills might be to propose extensive teaching of sight words in the manner described in Section 1.4.2.2. Such a response, however, is overly simplistic. First, the fact that children can successfully say the name of a sight word when they see it does not mean that they have acquired the kind of sophisticated orthographic knowledge about that word that supports fluent word recognition. In other words, teaching a "sight word" does not guarantee reading "by sight." As we have discussed, word-reading expertise develops over time and typically rests on a foundation of alphabetic decoding together with broader reading experience. Second, learning individual sight words could only ever be a drop in the ocean in terms of children's orthographic learning: It is estimated that from the middle of childhood onward, children learn approximately 3,000 new words per year (Nagy & Herman, 1984). Clearly, teaching each of those new words as sight words would be an insurmountable task for both teacher and student.

This does not mean, however, that teaching sight words makes no contribution to building fluent word-reading skills. On the contrary, it plays a part in what we see as the deeper response to the question of how to promote fluent word reading, which is to get children as quickly as possible to a point where they can read independently. Reading for themselves allows children to build their *experience* with printed words, which, as we emphasize in our key message for this section, is crucial for building word-reading fluency. Once children can read even simple texts on their own—either for pleasure or for learning—their exposure to words grows rapidly. Ultimately, it is children's own extensive, varied, and rich experience in reading that undoubtedly plays the most important role in their transition from novice to expert readers (Willingham, 2017a). Thus, again we argue that there is a case for judicious instruction on high-frequency, difficult-to-decode words as part of a comprehensive and phonics-rich reading-instruction program.

2.4.2. Teaching morphological skills. We have argued that morphology provides an important degree of regularity in the relationship between print and meaning (Plaut & Gonnerman, 2000; Rastle, Davis, Marslen-Wilson, & Tyler, 2000) and that coming to appreciate morphological relationships may therefore be an important part of becoming a skilled, fluent reader (Rastle, 2018). Likewise, Kirby and Bowers (2017) conceptualize morphology as a "binding agent" (p. 439) that relates orthography, phonology and semantic information and thus enhances representational quality (see also J. S. Bowers & Bowers, 2017).

Many children may acquire morphological knowledge implicitly through their language and reading experience. However, we believe that, because of the importance of morphology in relating word forms to their meanings, there is an argument for explicit instruction on this aspect of the writing system (for a fuller discussion of this issue as it applies to classroom practice, see, e.g., Kirby & Bowers, 2017; Nunes & Bryant, 2006).

The concept of morphological instruction in reading goes back at least to Webster's spellers, which were published continuously through the 18th and 19th centuries (Webster, 1787). For example, the 1824 edition of the speller includes explicit instruction on individual prefixes and suffixes, along with their roles in word formation (e.g., how to use *-ess* to denote the feminine gender; how to use *-ly* to denote a quality or manner of action). Morphological instruction continues to feature in literacy curricula today. For example, the National Curriculum in England specifies in some detail the prefixes and suffixes that must be taught during primary schooling, their roles in word formation, and the way in which they modify the spelling patterns of stems (U.K. Department for Education, 2014). However, despite the long history of morphological instruction in literacy curricula, there has been less research on the nature of this form of instruction and its effectiveness than there has on methods of instruction that focus on communicating the nature of the primary spelling-sound regularities in alphabetic writing systems. Further, research has shown that teacher knowledge of morphology is sparse and patchy, and many teachers are unaware of the ways in which morphemes communicate meaning and govern spelling construction (Hurry et al., 2005). This seems to be a critical gap in teacher knowledge.

Several studies have attempted to assess the impact of morphological training interventions on literacy outcomes (for reviews, see, e.g., P. N. Bowers, Kirby, & Deacon, 2010; Goodwin & Ahn, 2013). These studies have used a range of morphological interventions, age groups, and outcome measures. Encouragingly, they have often found an impact of morphological instruction on some measures, including vocabulary, reading aloud, reading comprehension, and spelling. For example, the meta-analysis reported by Goodwin and Ahn (2013) found significant effects of morphological instruction on decoding, vocabulary, spelling, phonological awareness, and morphological awareness but not on reading comprehension or fluency. However, the limited number of studies and their heterogeneity makes it difficult to draw specific recommendations for the classroom. For example, in contrast to most studies of phonics interventions that are focused on the initial stages of learning to read, the meta-analysis reported by Goodwin and Ahn (2013) included participants from preschool through high school.

It is also important to consider what form of intervention is being compared with the morphological instruction. P. N. Bowers et al. (2010) reported moderate effect sizes for morphological instruction compared with regular classroom instruction but noted that these effect sizes fall substantially compared with alternative treatments mostly consisting of phonological interventions. Of course, the nature of regular classroom instruction almost certainly differs across studies (see also Kirby & Bowers, 2017). Research comparing morphological instruction with systematic phonics instruction in young children is very limited. Devonshire, Morris, and Fluck (2013) reported that morphological instruction improved young children's literacy skills compared with an approach that they described as "traditional phonics" (p. 85). However, although the phonics control condition in their study did provide systematic instruction on grapheme-phoneme relationships, it appeared to mix this instruction with rote learning of whole words and encouragement to guess words from context or picture cues, features that may not characterize effective systematic phonics programs.

In summary, though we believe that explicit instruction on the nature of morphological relationships in the writing system is likely to benefit the acquisition of literacy, the form of instruction likely to be most effective remains unclear. One important question is this: When should morphological instruction linked to printed words begin? Some researchers have argued that it should be introduced at the earliest stages of learning to read, before alphabetic knowledge is firmly established (e.g., J. S. Bowers & Bowers, 2017; Devonshire et al., 2013). However, this suggestion awaits evidence. Analyses of the Children's Printed Word Frequency Database (Masterson et al., 2010) suggest that children's text experience in the first year of reading instruction consists overwhelmingly of words with a single morpheme (Rastle, 2018). Thus, morphological instruction can play only a limited role and may detract from vital time spent learning spelling-sound relationships. Instead, we would predict that the benefits of explicit morphological instruction are more likely to be observed somewhat later in reading development, promoting learning as children accumulate the experience necessary to accomplish the direct mapping between spelling and meaning (Rastle, 2018). That is not to say that classroom instruction should not include activities to support the development of rich vocabulary knowledge, which of course will include morphologically complex words. This can be achieved via listening activities, storytelling, and so on (see Section 3.4). When and how explicit instruction regarding orthography-morphology links should be introduced are important questions for future research.

2.4.3. Motivating children to read. As we have discussed, the single most effective pathway to fluent word reading is print experience: Children need to see as many words as possible, as frequently as possible (Stanovich & West, 1989). Teachers can seek to provide as much exposure to print as they can during classroom activities and in homework, but what they can achieve will be minuscule compared with the exposure that children can attain for themselves during their independent reading. Anderson, Wilson, and Fielding (1988) monitored the out-of-school reading habits, both of books and of other kinds of text, of a group of U.S. Grade 5 children (ages 10 and 11). On the basis of the amount of time the children reported spending reading per day, Anderson et al. estimated the number of words that the children would have been exposed to over a year. Those at the 10th percentile of time spent reading were estimated to be exposed to approximately 60,000 words per year; those at the 50th percentile, 900,000 words; and those at the 90th percentile, more than *4 million* words. This study was conducted before the digital era, and modern children's habits are likely to have changed somewhat; however, it is unlikely that the staggering variability in children's print exposure during their independent activities has altered greatly. And these differences in exposure have cumulative effects on reading ability over time, with the rich getting richer and the poor getting poorer—the so-called *Matthew effect* (Stanovich, 1986).

Such statistics point to the huge value of fostering a love of reading in children and a motivation to read independently. But how is this to be achieved? This question has plagued educators (and parents) for decades, and there are no easy answers. In his book *The Reading Mind*, Daniel Willingham (2017a) discusses a range of strategies and the evidence for their efficacy. He begins by noting that one widely used method—rewarding children for reading—may paradoxically have a negative impact on their motivation to read. Although provision of a reward will induce a desired behavior in the short term, the long-term impact is to lead children to believe that the behavior must have no intrinsic value in its own right, and they are therefore less likely to engage in it in the absence of a reward than if they had never been rewarded in the first place (see Deci, Koestner, & Ryan, 1999).

Potentially more effective strategies for increasing children's motivation to read that are suggested by Willingham fall into two broad categories: maximizing the value of reading and making the choice to do so easy. Children will value the activity of reading more if they have opportunities to read texts that they are interested in, that their friends are reading, or that are of some practical use to them. For example, comics, books of song lyrics, movie novelizations, or sporting skill manuals are all texts that—although they do not fall into the category of great literature—may be intrinsically motivating to a child. In relation to making the choice easy, Willingham notes that the amount of personal time that children spend reading depends not just on whether they want to read but also on whether they want to do it *more* than all the other available options. He refers to a recent survey in which 30% of teenagers reported that they enjoyed reading "a lot" but also reported that they enjoyed other activities such as watching videos and gaming more (Rideout, 2015). To shift the decision in favor of reading, Willingham suggests making that option as available as possible, noting that even small increases in availability have been shown to affect choices in other contexts; for example, moving the salad bar closer to restaurant diners by just 10 inches is enough to make them more likely to select food from it (Rozin et al., 2011; see Halpern, 2015). Therefore, Willingham recommends making sure that reading material is highly visible—in every classroom, in multiple rooms in the house, in the car, and so on—to maximize the chance that children will pick something up and read it. This "nudge" practice is nicely illustrated by an airline that has initiated a children's book club, complete with "flybraries"—mobile libraries of children's books on holiday flights (see Brown, 2017).

A final point to note here is that the desire to read is integrally linked with reading ability itself: Children are more motivated to read, and engage in it more, when they are good at it (Mol & Bus, 2011; Willingham, 2017a). Therefore, the question of how to best motivate children to read should not be seen as divorced from the question of how best to teach them. On the contrary, one clear and achievable means of maximizing motivation is to ensure that children have solid basic skills and consider being "a reader" a key part of their identities. Skilled alphabetic decoding and fluent word reading are fundamental to achieving this outcome, but they are not all there is to it—as we see in the next section.

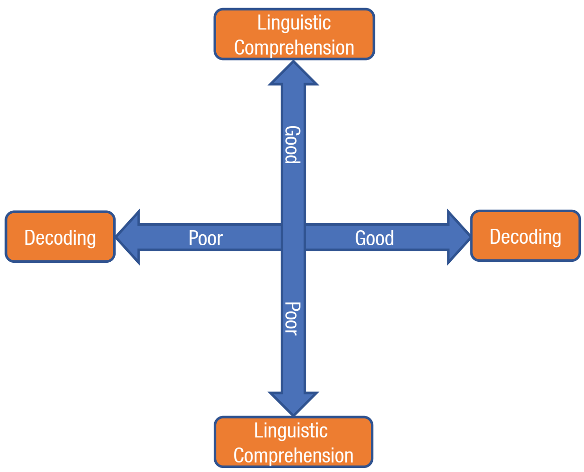
3. Learning to Comprehend Text

Children need to be able to identify the majority of words contained in a written text if they are to comprehend it. Clearly, however, text comprehension requires much more than the capacity to identify and read individual words. Indeed, these simple but important insights are the basis of the highly influential *Simple View of Reading* (Gough & Tunmer, 1986; Hoover & Gough, 1990; for a discussion, see Box 5).

A glance back to Box 1 reminds us that reading comprehension is complex, even for a simple

Box 5. The Simple View of Reading

The Simple View of Reading (Gough & Tunmer, 1986; Hoover & Gough, 1990) posits that reading comprehension is the product of two sets of skills, "decoding" and "linguistic comprehension" ($R = D \times C$). The logical case for the Simple View is clear and compelling: Decoding and linguistic comprehension are both necessary, and neither is sufficient alone. A child who can decode print but cannot comprehend is not reading; likewise, regardless of the level of linguistic comprehension, reading cannot happen without decoding. This simple framework has had influence both within and beyond the scientific community: Its clarity is appreciated by practitioners and it has formed the basis of national reading reforms in England (Rose, 2006).



The Simple View of Reading

Support for the Simple View

Measures of decoding and of linguistic comprehension each predict reading comprehension and its development, and together the two components account for almost all the variance in this ability (e.g., Lervåg, Hulme & Melby-Lervåg, 2017). Early in development, reading comprehension is highly constrained by limitations in decoding. As children get older, the correlation between linguistic and reading comprehension strengthens, reflecting the fact that once a level of decoding mastery is achieved, reading comprehension is constrained by how well an individual understands spoken language (LARRC, 2015).

Limitations of the Simple View

Although the Simple View is a useful framework, it can only take us so far. First, it is not a model: It does not tell us how decoding and linguistic comprehension operate or how they develop. Second, in testing predictions of the Simple View, the field has been inconsistent in how the key constructs are defined and measured. In relation to decoding, as Gough and Tunmer (1986) themselves noted, it can refer to the overt "sounding out" of a word or to skilled word recognition, and measures vary accordingly. In relation to linguistic comprehension, measures used have ranged from vocabulary to story retell, inference making, and verbal short-term memory. To fully understand reading development, we need more precise models that detail the cognitive processes operating within the decoding and linguistic comprehension components of the Simple View.

two-sentence text. The multifaceted nature of reading comprehension means that no single unified model or account details all that happens as a person reads a text, let alone how a child develops the capacity to understand written language. In its broadest sense, understanding comprehension requires us to describe how people construct meaning from information in their environment—a huge topic that is not restricted to written language and that is well beyond the scope of this article. Instead, we will constrain our review to key factors that influence the development of reading comprehension and those aspects of the literature that are most relevant for teaching and classroom practice.

3.1. Reading comprehension: A view from skilled reading

As for word reading (see Section 2.1), much is known about the processes involved in reading comprehension in skilled adult readers. The sentence processing literature is rich and extensive, much of it informed by experiments that monitor eye movements as people read text silently (for review, see Rayner et al., 2016). Complementing this is the large discourse processing literature (for review, see Schober, Rapp, & Britt, 2018). Alongside eye-movement studies that monitor reading as it happens on-line, much has been learned using methods that probe comprehension off-line—that is, after the material has been read. Standard paradigms for this include probing memory for text or asking participants comprehension questions after they have read a passage. This evidence base from adults is important because it identifies what needs to develop, so we begin by summarizing some findings from this literature (for detailed reviews, see Kintsch, 1998; Kintsch & Rawson, 2005; McNamara & Magliano, 2009; O'Brien, Cook, & Lorch, 2015; Zwaan & Radvansky, 1998). Another important point to note at the outset is that many of the cognitive operations involved in reading comprehension are not specific to reading, but serve language comprehension more generally.

There is general consensus that as people read, they construct a mental representation of the situation being described by the text, linking information from the text with relevant background knowledge. The product of comprehension is not a verbatim record of what has been read, replicating its form and structure; instead, meaning emerges from the formation of a *situation model* (e.g., Kintsch, 1998; Zwaan & Radvansky, 1998) that builds dynamically as people read, culminating in a rich representation of the text that goes beyond what is stated explicitly. The foundation of the situation model is delivered by incremental analysis of words and their syntactic roles in phrases or sentences. This connects with knowledge drawn either from information provided explicitly in the text or from readers' relevant background knowledge. Knowledge is broadly conceived and may include information such the meanings of words, rules of grammar, knowledge of events and temporal relations, episodes, scenarios, emotions, and characters. Inferences need to be made beyond what is overtly stated to establish meaning within and between sentences and need to draw on background knowledge (see Box 1, in which we infer that Denise was in a car and on her way to work). Good evidence suggests that important aspects of reading comprehension and inference generation happen automatically, but readers can also deploy strategies to support comprehension (for relevant discussion, see Cook & O'Brien, 2015). Together, these allow people to construct meaning actively as they read, adapting their strategies and focus according to the properties of the text (e.g., its difficulty) and their goals (e.g., reading for pleasure versus reading for study).

In summary, reading comprehension is not a single entity that can be explained by a unified cognitive model. Instead, it is the orchestrated product of a set of linguistic and cognitive processes operating on text and interacting with background knowledge, features of the text, and the purpose and goals of the reading situation.

3.2. Factors influencing development of reading comprehension in children

Having set out some of the steps involved in skilled reading comprehension, we turn to consider what might be important for its development. By the time children learn to read, they already have a sophisticated language system that allows them to produce and comprehend oral language; this oral language system continues to develop during the primary school years. This system and the linguistic knowledge derived from it serve reading comprehension, once children can read for themselves. As we shall see, oral language sets a vital foundation for reading comprehension and its development.

Perfetti and Stafura's (2014) Reading Systems Framework identifies three constructs that underpin reading comprehension. The first is concerned with *knowledge*, be it linguistic knowledge, orthographic knowledge, or general knowledge. The second describes *processes* involved in reading, in which they include decoding, word identification, meaning retrieval, sentence parsing, inferring, and comprehension monitoring, along with the interaction of these processes with each other, and with knowledge. The third factor captures *general cognitive resources* such as memory. All of these factors matter. Consider, for example, poor comprehenders—children who read words at age-appropriate levels but have difficulty understanding what they have read (or heard—listening comprehension also tends to be low). A common research strategy is to compare the performance of poor comprehenders and skilled comprehenders on a particular task hypothesized to be relevant to explaining individual differences in reading comprehension. Broadly speaking, poor comprehenders show weaknesses on measures that tap all three of Perfetti and Stafura's constructs—knowledge, processes implicated in reading, and general cognitive factors (for review, see Nation, 2005; Oakhill, Cain, & Elbro, 2014). Importantly however, no "magic profile" captures why an individual child might struggle. Given the complexities of comprehension, this is perhaps not surprising: As Perfetti (1994) notes, "there is room for lots of things to go wrong when comprehension fails" (p. 885).

Another important lesson from the literature on poor comprehenders is that even when a group-level difference is seen on a particular task, it does not follow that the factor manipulated in that task is the underlying cause or explanation for the reading comprehension problem. Although knowledge, processing, and general cognitive factors are ostensibly separable, the reality is that they are difficult to disentangle, as Perfetti and Stafura (2014) recognize. For example, how well a child knows a word influences how efficiently it is processed, and this, in turn, influences the demands placed on general resources such as working memory (defined as the mechanisms or processes involved in the control, regulation, and active maintenance of task-relevant information in the service of complex cognition; Baddeley, 2012). Thus, a group difference in working memory might be observed for verbal information, but this might not reflect a memory problem per se; it might be a consequence of differences in vocabulary knowledge. Low vocabulary constrains comprehension, as we discuss shortly, but low knowledge itself might be a consequence of differences in processing. For example, children who struggle to generate inferences are less able to use context to discover the meaning of new words (Cain, Oakhill, & Lemmon, 2004), and this might lead to differences in vocabulary knowledge over time, as children get older. Thus, not only is comprehension multifaceted (i.e., the factors interact in multiple ways during the process of reading), it is also complex *developmentally*. With this complexity in mind, we now discuss what is needed to bring about effective reading comprehension, guided by our brief overview of the processes involved in reading comprehension and the principles set out by the Reading Systems Framework (Perfetti & Stafura, 2014).

3.2.1. Knowledge. Knowledge is fundamental to comprehension. Perfetti and Stafura (2014) highlight orthographic, linguistic, and general knowledge as key sources of knowledge to be acquired. Given our overview of word-reading development in earlier sections, orthographic knowledge requires no further consideration, other than to reiterate that reading comprehension cannot happen without adequate levels of word-reading skill.

What types of linguistic knowledge are important? Overwhelming evidence indicates that vocabulary knowledge matters: Understanding the majority of individual words within a text is a prerequisite to understanding that text. Vocabulary correlates with reading comprehension (for review, see M. Spencer, Quinn, & Wagner, 2017). This tight association might reflect bidirectional influences: Oral vocabulary sets the foundation for reading comprehension and successful reading itself and then provides opportunities to expand vocabulary. For younger children, at least, vocabulary seems to drive the development of reading comprehension. Quinn, Wagner, Petscher, and Lopez (2015) analyzed longitudinal data from U.S. children between Grades 1 and 4 (approximately ages 7–10) to investigate the nature of the developmental correlation. They found that vocabulary had a strong effect on growth in reading comprehension, but not vice versa. This is not to say that children do not learn new words via reading. Once children can read, reading provides the major substrate for vocabulary growth (Nagy & Herman, 1984), but variations in word learning might be driven more by factors associated with vocabulary learning itself, rather than reading comprehension.

Rich vocabulary knowledge subsumes not just the number of individual words known, but how well they are known and how flexibly they can be used in a given context (this is critical given that the majority of words are polysemous—i.e., they have multiple meanings or "senses" to a greater or lesser extent; Rodd, in press). Beyond single words, text comprehension demands knowledge of multiword utterances (e.g., the meaning of the phrase "by the way" cannot be deduced from the meaning of its individual words); idioms (e.g., "kick the bucket," "break the ice"), and other figurative expressions that occur frequently in text. Poor comprehenders show reduced knowledge of idioms and figurative expressions (Cain & Towse, 2008; Nation, Clarke, Marshall, & Durand, 2004), as do some children who are reading in their nonnative language (Murphy, 2018; S. A. Smith & Murphy, 2015). For second-language learners, reading comprehension processes are not deficient in themselves, but limitations in reading comprehension might follow from differences in knowledge relative to children whose first language is the majority language.

Alongside lexical knowledge, children need to know how words in a sentence operate together. It is not surprising, then, that performance on tasks that tap syntactic comprehension or awareness of morphology in spoken language is associated with reading comprehension (e.g., Lervåg, Hulme, & Melby-Lervåg, 2017; Muter, Hulme, Snowling, & Stevenson, 2004), and children with poor reading comprehension tend to perform less well than their peers on morphological awareness measures similar to those discussed earlier in Section 2.2.3 (Nation et al., 2004; Tong, Deacon, Kirby, Cain, & Parrila, 2011). Children need to know how cohesive devices such as anaphor (i.e., words that refer to earlier antecedents, such as how *she* and *her* refer to *Denise* in Box 1) and connectives (e.g., *so, because, but*) work because these allow information and ideas to be integrated across phrases and sentences. This is essential for a coherent and cohesive situation model to be constructed. Children with poor reading comprehension are less skilled at dealing with anaphor and other cohesive devices (e.g., Cain, Patson, & Andrews, 2005; Ehrlich & Remond, 1997).

Like vocabulary, knowledge of grammar and syntax is part of a child's spoken-language repertoire. Many longitudinal studies show that oral language proficiency at school entry predicts later reading comprehension (e.g., Hulme, Nash, Gooch, Lervåg, & Snowling, 2015; Lervåg et al., 2017). Likewise, poor comprehenders have weaknesses in oral language that predate the onset of reading (Catts, Adlof, & Ellis-Weismer, 2006; Elwér et al., 2015; Nation, Cocksey, Taylor, & Bishop, 2010), consistent with the view that oral language is at the foundation of reading comprehension. We agree with this conclusion. It is important to add, however, that written language is different from spoken language (e.g., Olson, 1977, 1996), meaning that the task of reading comprehension brings its own challenges. There are differences in formality and tone, and, strikingly, even books written for beginning readers contain language that is quite different from what is heard in ambient conversation in terms of content and complexity (see Box 6). Thus it follows that once children can read, they have the opportunity to learn new aspects of language via engagement with written text.

Turning to knowledge more broadly, higher levels of relevant background knowledge are associated with higher levels of comprehension (e.g., Barnes, Dennis, & Haefele-Kalvaitis, 1996; Kendeou & van den Broek, 2007). As with vocabulary, the availability of background knowledge in long-term memory allows relevant knowledge to be activated as the situation model builds during reading. This provides a coherent representation of the text and is required for the formation of many types of inference (e.g., Kintsch & Rawson, 2005); it also serves to enrich the situation model. Willingham (2017a) illustrates the importance of background knowledge by inviting his readers to consider the following text:

> Carol Harris was a problem child from birth. She was wild, stubborn, and violent. By the time Carol turned eight, she was still unmanageable. Her parents were very concerned about her mental health. There was no good institution for her problem in her State. Her parents finally decided to take some action. They hired a private teacher. (p. 122)

This makes perfect sense as a text, but imagine that, instead of Carol Harris, the protagonist is in fact Helen Keller, the well-known writer who was both deaf and blind from a young age. This knowledge changes one's perspective on the text or, as Willingham tells his readers, "Your situation model is colored by information outside the text, namely, other relevant knowledge from your memory. If that knowledge is missing, the situation model won't be the same." Poor readers tend to have less background knowledge and are less likely to draw on it as they read (for review, see Compton, Miller, Elleman, & Steacy, 2014).

3.2.2. Processing. Knowledge is clearly important, but knowledge needs to be activated and processed during the course of reading comprehension. Several processes are engaged as people read. In this section, we focus briefly on three: meaning activation, inference generation, and comprehension monitoring.

We discussed earlier how the nature of the writing systems dictates how children get from print to meaning when reading words (see Section 1.1). Reading experience allows words to be identified rapidly and accurately and for their meanings to be activated and integrated during sentence processing. Children are known to vary in word-reading skill and in vocabulary knowledge. But are there variations in the processes that allow meaning to be activated that cannot be explained by differences in word-reading skill and vocabulary knowledge? This is a hard question to answer given the difficulty of separating knowledge and processing, as discussed earlier in our introduction to Section 3.2. Children with lower levels of reading comprehension are slower to make semantic judgments about words, and they show different patterns of semantic priming for some stimuli (e.g., Henderson, Snowling, & Clarke, 2013; Nation & Snowling, 1999). These findings are consistent with the idea that word knowledge is not all or nothing: Even if a word is known by a child, it might be known less well or in a way that is less connected to other words, relative to the connections that other children might form. A consequence of this might be less rich input into the situation model and, in turn, reduced comprehension.

Once activated, word meanings also need to be integrated into the text representation as reading unfolds. Perfetti and Stafura (2014) describe this as word-to-text integration. They also note that skilled readers are better able to integrate words into the situation model, a finding they attribute to differences in "the knowledge of word meanings or the use of this knowledge during text reading" (p. 32). Information that is activated but not needed for the situation model needs to be disregarded. Some evidence demonstrates that less-skilled comprehenders are not as adept at suppressing or inhibiting out-of-date information (Gernsbacher & Faust, 1991; Pimperton & Nation, 2010), influencing

Box 6. The Language of the Book

Written language is different from spoken language. Speech usually takes place in a communicative context, meaning that some cues that are present in speech (e.g., prosody, gesture, tone of voice, facial expression) are absent in writing. To compensate, written language draws on a much larger vocabulary and more complex grammar: Noun phrases and clauses are longer and more embedded, and the passive voice is much more common.

Comparing Novels and Films

Baines (1996) analyzed the language content of three novels (*Wuthering Heights, Of Mice and Men,* and *To Kill a Mockingbird*) and their film scripts. He randomly sampled 25 passages of 100 words from each and found differences in language content and structure. Films contained far fewer polysyllabic words, suggesting lexical content that is morphologically less rich. Vocabulary was also less diverse. For example, in the script extract from *To Kill a Mockingbird*, only 7 words began with the letter "u" (*ugly, under until, up, upstains, us, used*). In contrast, the novel extract contained 17 words (*unceiled, uncontrollable, uncrossed, under, undress, unhitched, unique, unless, unlighted, unpainted, until, up, upon, upstairs us, use, used*). The two genres also differed in sentence complexity. Seeing the film or even reading the script is no substitute for reading the novel.

Learning About the Differences Between Spoken and Written Language Starts Early

Strikingly, even books written for prereaders contain language that is quite different from what is heard in ambient conversation. Montag, Jones, and Smith (2015) analyzed the vocabulary in 100 children's books, selected from those recommended for preschoolers aged 0 to 60 months and typically used by parents in shared reading. They compared their content with the vocabulary used by caregivers in child-directed conversations. The books included a larger number of unique words, showing that the vocabulary encountered via shared reading is more diverse. Children with more shared book experience have the opportunity to develop a larger and more diverse vocabulary.

Differences in Syntax, Not Just Vocabulary

Cameron-Faulkner and Noble (2013) analyzed the content of 20 picture books aimed at 2-year-olds and compared this with child-directed speech. Books contained many more complex utterances (e.g., two verb sentences, subject-predicate sentences), which suggests that shared book reading may be an important source of language experience for children. Turning to books that children might read themselves, Montag and McDonald (2014) also found greater syntactic complexity. Complex sentences seen in written language such as object-relatives (e.g., *the student who the teacher scolded finally finished the assignment*) and passive-relatives are virtually absent in child-directed speech; they are rare too in adult speech, but they do feature in children's reading. Reading thus provides the opportunity to learn new syntactic forms—those that characterize the "language of the book."

how well the situation model is updated. However, this might reflect limitations in background knowledge as well (e.g., McNamara & McDaniel, 2004).

Comprehension is fundamentally about making inferences. Children make inferences in spoken language from a young age. This capacity continues to develop through the school years (e.g., Barnes et al., 1996; Currie & Cain, 2015) and predicts reading comprehension (e.g., Language and Reading Research Consortium [LARRC] & Logan, 2017; Lervåg et al., 2017). For some children, inference generation is a problem. Poor comprehenders find it difficult to integrate ideas across a text and are less skilled at answering questions that require an inference to be made (for review, see

Cain & Oakhill, 2009). It is difficult to determine whether these difficulties reflect stable and reliable individual differences (a) in the process (or processes) of inference generation itself, (b) in knowledge (e.g., inadequate vocabulary or background knowledge), or (c) awareness of when it is necessary or helpful to make an inference. Limitations in working memory may also affect the integration process; words and sentences might be understood and relevant knowledge might be available, but limitations in cognitive resources prevent information from being integrated during the course of processing (see Section 3.2.3).

Another skill that has been implicated in reading comprehension is *comprehension monitoring*. This is typically defined as the collection of strategies or skills used to evaluate one's own comprehension, to identify when comprehension has gone astray, and, where appropriate, to repair any misunderstanding. It has been measured using tasks in which children are asked to underline meaningless words or phrases in a text or by asking children whether a story containing inconsistencies makes sense and, if not, asking them to explain what was wrong (e.g., Oakhill, Hartt, & Samols, 2005). Performance in comprehension monitoring increases during the primary school years and is associated with reading comprehension ability, arguably because it taps the capacities needed to monitor, update, and integrate information as the situation model builds (e.g., LARRC & Geomans-Maldonado, 2017). These findings are difficult to interpret because it is not clear what traditional tasks of comprehension monitoring are measuring. In one sense, they tap the product of comprehension: the extent to which children have understood what they have read well enough to be able to reflect on its fidelity. It is not clear whether this is akin to the more automatic processes that happen as long-term memory is activated during the course of normal reading.

A different approach is to measure comprehension monitoring more directly, during reading itself, rather than relying on a metacognitive task that taps children's ability to reflect on their cognitive processes after reading has happened. In adults, reading times (as measured by monitoring eye movements during silent text reading) are influenced by plausibility. For example, in the sentence *John used a knife [an axe] to chop carrots*, reading and rereading times are longer for the *axe* version of the sentence (Rayner, Warren, Juhasz, & Liversedge, 2004).

Children are also sensitive to plausibility when reading (Joseph et al., 2008), and individual differences in oral language (specifically, a variable comprising vocabulary, verbal knowledge, and story recall) predict the extent to which 7- to 12-year-old children show longer rereading times when plausibility is violated (Connor et al., 2015). Note that this study showed that Grade 5 children (approximately age 10) noticed the implausibility, in that initial reading times were longer for implausible targets than for plausible targets. However, only those children with higher levels of oral language skill showed longer rereading times on implausible targets, which is consistent with an attempt to integrate and make sense of the text. These eye-movement data reflect fast and perhaps largely automatic processing. Likewise, Eilers, Tiffin-Richards, and Schroeder (2018) found that 9-year-old children are sensitive to discourse-level expectations when reading, showing surprise (i.e., longer reading times) when they encountered a repeated name (e.g., *Peter gets up from his bed. Right away Peter makes breakfast*), rather than the expected anaphor (i.e., *he* rather than *Peter* in the second sentence). More generally, the finding that oral language and verbal knowledge predict reading strategies is consistent with the close connection between language proficiency and reading comprehension. This is likely to be relevant both for in-the-moment updating and rereading during sentence processing and for the more active monitoring that occurs when reflecting on comprehension or when a text is long, complex, or lacking in coherence.

Related to notions of comprehension monitoring is the concept of *standard of coherence*, defined as a person's criteria for coherent understanding of a text and therefore the extent of their motivation to make sense of what they are reading (e.g., van den Broek, Bohn-Gettler, Kendeou, Carlson, & White, 2011). It is not clear whether individual differences in an overall standard of coherence explain individual differences in reading comprehension, but it seems unlikely. Standard of coherence is likely to vary for everyone, depending on the purpose of reading, their motivation to read, their knowledge and interest in the topic, the quality of the text, and so on (Graesser, Singer, & Trabasso, 1994). Likewise, skilled readers flexibly adapt their reading behavior depending on their task, whether it is reading for meaning or proofreading, for example (Kaakinen & Hyönä, 2010; Schotter, Bicknell, Howard, Levy, & Rayner, 2012). However, little research has explored the factors that promote what is sometimes referred to as *purposeful reading* or how the current standard of coherence set by a child influences his or her reading behavior. We consider this to be an important avenue for future work. The notion that successful reading always results in a complete and fully specified interpretation of the text is misguided. What matters is being able to adjust one's reading to suit one's reading purpose, given the demands of the task, among other factors (for further information, see discussion of "good-enough" and aligned perspectives, e.g., Christianson, 2016; Ferreira, Bailey, & Ferraro, 2002; Wonnacott, Joseph, Adelman, & Nation, 2016).

In closing this section, it is worth emphasizing again that the critical determiner of reading comprehension in the early years is word-reading skill. Although we know quite a lot is known about how word-reading skill develops, as reviewed in the first part of this article, far fewer studies have investigated how word reading plays out during the process of reading comprehension itself, given that words are normally read silently and in meaningful sentences. As technology has advanced, more is being learned about this from studies of children's eye movements as they read. Having established many of the basic parameters in children's eye-movement control while reading (for reviews, see Blythe, 2014; Blythe & Joseph, 2011; Reichle et al., 2013), the field is well poised to learn more about how word-, sentence-, and discourse-level factors interact as children read for meaning.

3.2.3. General cognitive resources. Our review of reading comprehension so far has emphasized the linguistic knowledge and resources needed to construct an adequate situation model. What is the role of general factors such as executive functions? This term refers to a set of cognitive processes that allow people to plan, organize, control, and regulate resources to achieve a goal. Working memory, cognitive flexibility, and inhibitory control are examples of executive skill, and all have been implicated in reading comprehension. We will focus here on working memory because this has been discussed most in the literature on children's reading development. Working memory training is also an approach to intervention that we review later (Section 3.4.3), and it is thus important to consider its theoretical basis (for a discussion of executive skills more broadly in relation to reading comprehension, see Sesma, Mahone, Levine, Eason, & Cutting, 2009).

As noted earlier, working memory can be defined as the mechanisms or processes involved in the control, regulation, and active maintenance of task-relevant information in the service of complex cognition (Baddeley, 2012). It is easy to generate hypotheses about why working memory might matter for reading comprehension. For example, people with greater working memory resources might be at an advantage because they can retain more information. This might allow more inferences to be generated and connections to be made. Additional processing resources may also assist with reactivating relevant information from the text itself or from background knowledge; effective control of working memory may allow irrelevant information to be deactivated or suppressed, freeing resources for ongoing comprehension.

In short, the availability of working memory resources should facilitate the building of a detailed, rich and well-connected situation model. In line with this prediction, a strong relationship exists between reading comprehension and individual differences in working memory tasks across the life span (e.g., Daneman & Merikle, 1996). Longitudinal work has shown that working memory performance is associated with vocabulary and inference making—key factors that influence reading comprehension (e.g., Currie & Cain, 2015; Daugaard, Cain, & Elbro, 2017). Poor working memory has been considered a cause of impairments in children's reading comprehension, and ample evidence suggests that poor comprehenders perform less well on a listening span task. This complex working memory task requires the simultaneous storage and processing of verbal information—for example, listening to a series of unconnected sentences and answering questions about them while remembering the final word of each sentence, and then reporting those words in correct serial order (e.g., Carretti, Borella, Cornoldi, & De Beni, 2009; Nation, Adams, Bowyer-Crane, & Snowling, 1999). Poor comprehenders also perform less well on tasks tapping more specific components of working memory for verbal material, such as interference control, suppression, and updating (e.g., Pimperton & Nation, 2010).

The interplay between memory and reading comprehension is nicely illustrated in a study by Hua and Keenan (2014). They asked children to read a text and then asked them questions about it. Some questions required an inference to be made; in line with the results of many other studies, children found these questions harder to answer than literal questions that could be answered by direct reference to the text. Hua and Keenan also analyzed what information needed to be remembered from the text to answer each question. Inference questions required more text premises to be remembered than did literal questions. This increases the complexity of the integration processes required to answer such questions. The children were also asked what they could remember from the text. If the relevant premises were remembered, the question could be answered, regardless of whether it required an inference to be made or not. Less-skilled comprehenders in this study answered fewer questions correctly than did skilled comprehenders, but memory for text premises accounted for differences in comprehension performance.

These findings highlight the role of memory in reading comprehension. But *why* do children differ in text memory? Are there differences in the working memory that constrain comprehension? Or are differences in memory a natural consequence of how well the children understand the material in the first place, in line with the perspective that domain-free working memory does not exist as a separate construct (e.g., MacDonald & Christiansen, 2002; Van Dyke, Johns, & Kukona, 2014)? Relevant to this question, there is strong evidence for a close association between *verbal* working memory and comprehension but not for an association between nonverbal working memory and comprehension. For example, Yeari (2017) found that adults who performed better on tasks that measure working memory span were better able to retain, reactivate, and inhibit textual and inferential information when reading. However, these findings held only when listening span was used to estimate working memory span. When working memory was indexed using tasks that placed fewer demands on verbal skills (memory span tasks comprising digits or visuospatial information), there was no relationship between working memory and reading comprehension. This observation is in line with findings from the literature on poor comprehenders, in which deficits in *verbal* working memory are clear (Carretti et al., 2009; Pimperton & Nation, 2010). Evidence for deficits in nonverbal working memory tasks is less robust, which casts doubt on the hypothesis that global aspects of working memory play a major causal role. Whether it is meaningful to talk about *verbal* memory capacity independent of language processing itself remains an open question.

3.3. Learning to comprehend text: Summary

The Reading Systems Framework (Perfetti & Stafura, 2014) helps set out the complexities of reading comprehension and how this interfaces with the word-reading system. Word recognition and high-quality lexical knowledge provide the necessary input to reading comprehension, but knowledge and processes beyond the individual word level are vital too. These aspects are not all specific to reading but are features of language comprehension more broadly. As we have noted, by the time children learn to read, they already have in place a sophisticated language system, setting the critical foundation for reading comprehension. Consistent with this, a range of oral language skills measured in preschool are closely associated with later reading comprehension, and this relationship continues through the primary school years (e.g., LARRC & Logan, 2017; Lervåg et al., 2017). Reading brings additional challenges—not just the need to learn how to read words but also the fact that written language has complexities that are less evident in conversational language (Box 6). In the early years of reading development, reading comprehension is constrained by limitations in word-reading ability, for obvious reasons: Comprehension will suffer if a child cannot read the words in a text. As word-reading skills strengthen, reading comprehension becomes constrained by limitations in knowledge and the capacity to build a rich and coherent representation of language, regardless of whether the language is heard or read (LARRC, 2015). This demands a range of spoken-language skills, often subsumed under the general construct of "listening comprehension" (see Box 5); in skilled readers, the correlation between listening comprehension and reading comprehension is almost perfect (e.g., Gernsbacher, Varner, & Faust, 1990).

Our key messages highlight the complex and multifaceted nature of reading comprehension and the associated difficulty of separating knowledge, processing, and general resources such as memory. High-quality knowledge promotes efficient processing, which places fewer demands on resources. Taking a developmental perspective adds further complexity as we try to explain why children might have difficulty with reading comprehension. What might start as a processing difference (e.g., the ease of word identification) might escalate to differences in knowledge (e.g., vocabulary), and vice versa. Undoubtedly, other factors beyond the scope of this review—such as motivation to read, attitudes about reading, or knowledge about reading for different purposes—also contribute in complex and important ways (for review, see Willingham, 2017a).

3.4. Reading comprehension: Implications for the classroom

Our review has made clear that reading comprehension is complex and multifaceted. Its foundation is in language more generally, but written language presents additional challenges for the reader, including but not limited to the need to identify and recognize printed words. We have described how comprehension comes about through the interaction of knowledge (e.g., vocabulary, background knowledge), processes that operate on text (e.g., meaning activation, inference generation), and general cognitive factors (e.g., working memory). With this as a backdrop, we consider implications for the classroom.

The appreciation that reading comprehension is a complex construct leads quickly to the realization that improving reading comprehension is unlikely to be simple. The literature on reading comprehension instruction is vast, and its methodological quality varies. We focus on some key messages here because a comprehensive review is beyond the scope of this article. Fortunately, however, some of the literature has been expertly synthesized into accessible accounts and practical guides, including recent books by Oakhill et al. (2014), Stuart and Stainthorp (2015), and P. J. Clarke, Truelove, Hulme, and Snowling (2013).

3.4.1. Assessing reading comprehension. Assessment has its place in the classroom, allowing teachers to identify children who may need additional support. This is important because some children find reading comprehension difficult, despite being able to read words at an age-expected level; these children can go unnoticed in the classroom, and their needs can go unmet. Likewise, some children get off to a good start but reading comprehension plateaus—the so-called fourth-grade slump (e.g., Leach, Scarborough, & Rescorla, 2003). Assessment also matters when it comes to evaluating an instructional approach. A typical research strategy is to deliver a theoretically motivated intervention to a group of children and test its efficacy by determining whether it leads to improvement on a standardized assessment relative to a control group.

One lesson from the literature on reading-comprehension assessment is that it is not easy to measure: It is not a single entity that can be cleanly and reliably captured by a "gold-standard" test. Indeed, standardized tests that are marketed as reading comprehension assessments can vary enormously. At one extreme, some tests place heavy demands on word-level reading rather than understanding (Nation & Snowling, 1997). At the other, some contain questions that can be answered correctly without even reading the text (Keenan & Betjemann, 2006). Neither of these extremes are helpful, of course, but even well-validated and reliable instruments vary in the aspects of reading comprehension they tap. Some of this variation is associated with factors such as the length of the text, its format, and the age of the reader. It is not surprising, then, that across children, the correlation between performance on one comprehension test and another is not always high (e.g., Keenan & Meanan, 2014). And for everyone, reading comprehension varies as a function of knowledge—even a strong reader will struggle if the content of the text is largely unfamiliar.

It follows that educators need to be aware of what a particular test is measuring, and this requires some knowledge about what reading comprehension is and why it can vary. To this end, it is helpful to consider the definition of reading comprehension established by the RAND Reading Study Group (C. Snow, 2002). This group was asked to establish a research and development agenda to improve reading comprehension standards in U.S. schools. They defined reading comprehension as the "process of simultaneously extracting and constructing meaning through interaction and involvement with written language" (p. 11) and argued that this demands an appreciation of the reader (e.g., individual capacities of the child), the text (e.g., complexity, genre), and the situation (e.g., skimming, studying, reading for pleasure). Although devised to guide a research agenda, this definition is highly relevant for those involved in education too.

3.4.2. Reading comprehension instruction: Lessons from the National Reading Panel. What instructional approaches best help children to extract and construct meaning from text? The National Reading Panel (2000) considered this question at length, reviewing hundreds of studies. Not all provided the information needed to generate effect sizes, and some were of low quality in terms of methodology or scientific relevance; for some instruction approaches, the evidence base was not large enough to warrant firm conclusions. Nevertheless, the National Reading Panel identified the benefits of explicitly teaching children strategies to prompt active engagement with text. Some key strategies emerge from the principles of reciprocal teaching (e.g., Palinscar & Brown, 1984), in which children are encouraged to discuss a text with peers and teachers using methods such as clarification, summarization, prediction, and question generation. These strategies tended to generate large effect sizes when comprehension was assessed using measures designed by the experimenters. Such measures are typically quite close to the intervention in content or style. However, some (but not all) studies also reported encouraging medium effect sizes on more general assessments of reading comprehension, which suggests that strategy instruction can promote learning that generalizes.

Another encouraging finding is that the benefits of strategy instruction appear to emerge after relatively little instruction: There is little evidence that longer or more intensive strategy interventions lead to greater improvements in reading comprehension. As discussed by Willingham (2006), this makes sense if strategies are thought of not as skills that keep developing but as "tricks" that, once explained and discovered, are available for children to use in other situations. In this view, explicitly teaching a strategy helps children to understand the purpose of reading more quickly than they would otherwise, via self-discovery; although strategies can be learned quickly and to good effect, continued instruction and practice does not yield further benefits. Willingham (2006) also drew our attention to the fact that more consistent effects are seen when strategy instruction is applied in later grades (approximately fourth grade onward in the United States). This probably reflects the fact that a reasonable level of reading fluency is needed before children can benefit properly from text-level strategy instruction. How much instruction and when it is best delivered are important questions for further research, and both have clear implications for the classroom. Explicit strategy instruction is effective, it can be short (Willingham suggests five or six sessions), and it works best once the basics of word-reading fluency are in place.

Reciprocal teaching strategies are important and effective, but no amount of strategy instruction can bring about successful comprehension if the text cannot be understood because of limitations in knowledge or difficulties with activating knowledge in the service of comprehension. As Willingham (2006) notes,

> to "summarize," you need to comprehend enough to differentiate the main idea from subordinate ideas. For "comprehension monitoring" to be useful, not only do you need to recognize that you don't understand a passage, but also to be able to comprehend the material when you reread it." (p. 44)

Strategy instruction depends on content, and an appreciation of content demands knowledge. The National Reading Panel considered one type of knowledge instruction in detail—vocabulary. Since then, however, two large meta-analyses have been published on the topic of whether vocabulary instruction improves passage comprehension (Elleman, Lindo, Morphy, & Compton, 2009; Wright & Cervetti, 2017), so we focus on these more recent reviews in the next section.

3.4.3. Vocabulary. The observation that children with good and richly connected word knowledge are better at reading comprehension (Section 3.2.1) leads to the prediction that teaching vocabulary should improve reading comprehension. To assess this, Elleman et al. (2009) conducted a meta-analysis of 37 different studies. They found that although vocabulary instruction led to significant improvements on custom-made comprehension passages containing the taught words (effect size: $d = 0.50$), transfer to standardized assessments of reading comprehension was less impressive, averaging an effect size of only $d = 0.1$. Wright and Cervetti (2017) reported exactly the same pattern: Children receiving vocabulary instruction outperformed children in the control group on comprehension passages containing instructed words, but transfer to more general comprehension measures was negligible.

The finding that comprehension of passages containing taught words improved substantially is an important one, especially given that the instructional demands of this approach are relatively minimal. Wright and Cervetti (2017) reported the number of minutes of instruction per word associated with successful transfer; it is striking how low this number was, less than 1 min per word in some studies. This suggests that even a brief instructional opportunity to develop word knowledge can help reading comprehension. This points to the utility of teaching content-relevant vocabulary before children are expected to use that vocabulary to learn from text.

Both meta-analyses attempted to address which types of vocabulary instruction might be most effective. However, no firm conclusions could be drawn. There were, however, hints in the data suggesting that more active approaches might be more beneficial than more passive ones (e.g., working in small groups and discussing the words in detail as opposed to reading brief definitions).

As noted, vocabulary instruction by itself does not lead to improvements in passage comprehension, as assessed by a general standardized test. This suggests that direct vocabulary instruction alone is insufficient. This is not surprising given what is known about the complexities of reading comprehension (Section 3.1 and Box 1) and the fact that learning a set of words can only have limited utility, given the unconstrained and unlimited nature of vocabulary. However, both meta-analyses identified approaches that might lead to greater transfer. First, instruction that taught multiple and flexible strategies for establishing word meaning (e.g., using contextual cues, synonyms, syntactic constraints) showed a more general treatment effect: Children in the intervention group outperformed those in the control group on standardized reading-comprehension measures (e.g., Nelson & Stage, 2007). This finding is consistent with the results of a large study by P. J. Clarke, Snowling, Truelove, and Hulme (2010) in which poor comprehenders received training in oral language, text comprehension, or a combination of both. All three groups received multiple types of strategy instruction, working with narrative as well as vocabulary, and all three groups showed improvements in reading comprehension, as assessed by a standardized test at the end of the intervention. These gains were maintained 11 months later for children in the oral language and combined groups. Note that both groups also showed improvements in expressive vocabulary, and these improvements mediated improvements in reading comprehension. In short, intervention improved vocabulary and growth in vocabulary supported reading comprehension. This finding suggests that vocabulary instruction in the context of broader oral language is effective in shifting reading comprehension.

A second fruitful approach is to focus on specific types of words (e.g., those words that are not yet known but need to be known to comprehend a variety of texts and curricular topics—akin to so-called Tier 2 words, described by Beck, McKeown, & Kucan, 2013).

Likewise, systematic instruction in more formal or technical academic vocabulary holds promise, especially because such words are rare in speech. Crosson and McKeown (2016) described an instructional approach using explicit instruction of bound Latin roots (e.g., *spect*, as in the words *prospect, specimen, spectacles, inspect, prospector, respect; voc*, as in *vocal, advocate, vocalize, vocabulary, vociferous*). They found that U.S. sixth- and seventh-grade students (approximately 11–13 years old) were able to learn about the Latin roots after fairly minimal instruction and that this helped them comprehend words containing those roots when reading them in context. Wright and Cervetti also noted the effectiveness of instructional approaches that focus on the connectivity of new words to other words (via semantic categories or synonym games). This fits with the idea that vocabulary knowledge needs to be flexible and nuanced to the relevant context (Section 3.2.2). Words that act as cohesive ties, marking features such as temporal order (*first, initially, before, after*) and causality (*because, thus, since*), are also important to learn because they play a critical role in the construction of a coherent and cohesive situation model, allowing ideas to be connected across phrases and sentences. Quigley (2018) provided a comprehensive review of classroom approaches to support vocabulary growth.

Vocabulary is just one component of knowledge. C. E. Snow (2017) stresses that other aspects of knowledge also matter for language and literacy development. The gradual acquisition of knowledge and cultural literacy—via teaching, conversations, experiences, and of course reading itself—is critical (e.g., Hirsch, 2016). Arguably, however, it is not just knowing things that matters—children need to bring relevant knowledge to the fore during the process of reading comprehension, especially when inferences need to be made that depend on that knowledge. Is it possible to deliver instruction to target this critical component of reading comprehension?

3.4.4. Inferences. Many of the instructional strategies reviewed by the National Reading Panel are implicated in inference generation in some way. The National Reading Panel itself did not specifically discuss the impact of inference instruction on inferential comprehension, but the literature has been recently reviewed by Elleman (2017). Inference instruction was shown to benefit reading comprehension (as assessed by standardized tests, d = 0.58); alongside this general effect, performance on inferential aspects of comprehension also improved (d = 0.68). Not surprisingly, transfer to literal comprehension was lower. These are encouraging effects; once again, instruction benefits seemed to follow quickly and more practice was not associated with greater gains (Willingham, 2017b). Unfortunately, it was not possible to identify which instructional approaches are most beneficial because of limitations in the size or quality of the evidence base. In addition, many of the studies contained multiple components, which makes it impossible to compare the effectiveness of specific strategies.

We agree with Elleman's (2017) call for future studies to isolate and assess the efficacy of specific instruction components. This is the only way to truly identify what works. A good example of this approach is provided by Elbro and Buch-Iversen (2013), who taught 11-year-olds to use graphic organizers to explicitly draw on background knowledge to make a "gap-filling" inference. Graphic organizers are visual displays, maps, or diagrams (in this case, a series of connected boxes that students fill in) that demonstrate the relationship between ideas. A gap-filling inference requires information to be imported from long-term memory to provide the necessary connection between premises in a text. After only eight 30-min sessions, children taught to use graphic organizers out-performed their peers on a bespoke reading comprehension task (different passages but with inference demands similar to those of the training passages; d = 0.92) and a general assessment of reading comprehension (average d = 0.69). Furthermore, the training advantage was maintained over time. These findings indicate that children can be taught to activate background knowledge spontaneously and that this capability transfers to new situations. More generally, the findings point to the utility of combining direct strategy instruction with reading for meaning, using rich texts that place demands on background knowledge.

3.4.5. Working memory. In addition to the availability of knowledge in long-term memory, working memory is implicated in the reading-comprehension process (Section 3.2.3). If working memory resources limit comprehension, is it possible to improve reading comprehension by strengthening working memory? The answer to this question seems to be "no." Simons et al. (2016) provided an extensive review of cognitive training programs in this journal and found little evidence that such training affects everyday cognitive performance, including reading. A meta-analysis focusing specifically on working memory training came to the same conclusion, finding no evidence of reliable transfer to reading comprehension (Melby-Lervåg, Redick, & Hulme, 2016). On the basis of the available evidence, then, current working memory training programs do not improve reading comprehension. Instead, instruction should focus on developing lexical quality at the word level and optimizing children's knowledge and skills so that limited working memory resources can be used to best effect.

3.5. Reading comprehension in the classroom: Summary

Understanding that reading comprehension is complex and multifaceted is relevant for thinking about assessment and effective instruction. The foundation of reading comprehension is provided by oral language: Vocabulary, grammar, and narrative skills at school entry and beyond predict later reading comprehension (e.g., LARRC & Logan, 2017; Lervåg et al., 2017). Even before children can read, interventions that target oral language lead to improvements in reading comprehension (Fricke, Bowyer-Crane, Haley, Hulme, & Snowling, 2013). This is an important observation and underlines the idea that not all teaching to improve reading comprehension needs to involve written text. While children are focusing on the discovery of the alphabetic principle and learning to read words, for example, instruction in oral language will bring about gains in knowledge and enhance the processing skills that will subsequently serve reading comprehension. Given that language proficiency at school entry varies enormously (e.g., Norbury et al., 2016), some children will need extensive language support.

Comprehension strategies can be taught, and evidence suggests that they can be learned quickly and applied to new reading material after relatively little instruction. More evidence is needed to identify which strategies should be taught, when, and for how long. While strategy instruction might be quick, the acquisition of knowledge is gradual and continuous. This can be assisted by direct teaching and using structured materials that support the curriculum; ultimately, however, it relies on rich input, much of which will come from reading experience itself (e.g., Hirsch, 2016). We discussed earlier the value of reading experience and the need to motivate children to read more (Section 2.4.2). We repeat that message here—teaching children to read and then providing opportunities for varied, extensive, and successful reading experience is fundamental.

4. Conclusions

We commenced this review by asking why the reading wars have continued. Despite extensive scientific evidence, accumulated over decades, for the centrality of alphabetic decoding skills as a foundation of learning to read, there remains resistance to using phonics instruction methods in the classroom. We suggested that two factors may have contributed to this resistance. First, limited knowledge about the nature of writing systems among many practitioners means that they are not equipped to understand *why* phonics works for alphabetic systems. Second, practitioners know that there is more to reading than alphabetic skills, but a full presentation of the scientific evidence in relation to these more advanced aspects of reading acquisition in a public interest forum has been lacking; as a result, calls for a greater focus on phonics instruction can seem unbalanced.

We have sought to address both of these issues by providing a comprehensive tutorial review on the science of learning to read that spans from foundational alphabetic skills right through to the sophisticated set of processes that characterize skilled reading comprehension. We have attempted throughout to explain not just the *whats* of the evidence, but also the *whys*, so that practitioners are in a position to make informed judgments about how the evidence we have presented might be translated into effective classroom practice. Emerging from these explanations are three central messages in relation to each of the major aspects of reading acquisition we have reviewed: that the writing system matters, that experience matters, and that the ultimate goal of reading—comprehension—is not a unitary construct but a multifaceted process. Given its breadth, our review is of course limited in detail; in Box 7, we make recommendations on further reading suitable for practitioners that covers many of these issues in depth.

What then, are the broad implications of our review for developing instructional principles and for setting an agenda for ongoing research in reading acquisition? One clear message is that teaching and research must be informed by a detailed knowledge of the writing system being learned and of the broader language system it represents. In relation to teaching, teacher training programs are doing future educators a huge disservice if they do not equip them with this knowledge. There appears to be a long way to go: Evidence from studies across a range of countries suggests that teacher knowledge in these areas is typically very limited (see, e.g., Aro & Björn, 2016; Fielding-Barnsley, 2010; Hurry et al., 2005; Moats, 2009). In relation to research, much remains to be learned about how children acquire more sophisticated knowledge about the structure of their writing system and the way in which it represents sound and meaning, particularly for morphologically complex and polysyllabic words. Questions about the development of text comprehension also remain.

A second broad implication of our review is the need to get the balance right in setting the agenda for instruction, and for future research. The term *balanced literacy* is in widespread use, often to describe programs with "a bit of everything" and typically involving limited and nonsystematic phonics instruction (see P. Snow, 2017). This is unfortunate because it is clear from our review

Box 7. Recommended Further Reading for Practitioners and Parents

Adams, M.J. (1990). *Beginning to read: Thinking and learning about print.* Cambridge, MA: MIT Press.
Carroll, J. M., Bowyer-Crane, C., Duff, F.J., Hulme, C., & Snowling, M.J. (2011). *Developing language and literacy: Effective intervention in the early years.* West Sussex, England: Wiley-Blackwell.
Clarke, P. J., Truelove, E., Hulme, C., & Snowling, M.J. (2013). *Developing reading comprehension.* West Sussex, England: Wiley.
Dehaene, S. (2009). *Reading in the brain.* New York, NY: Penguin Viking.
Kilpatrick, D.A. (2015). *Essentials of assessing, preventing and overcoming reading difficulties.* Hoboken, NJ: Wiley.
Moats, L.C. (2010). *Speech to print: Language essentials for teachers.* Baltimore, MD: Brookes Publishing.
Oakhill, J., Cain, K., & Elbro, C. (2014). *Understanding and teaching reading comprehension: A handbook.* Abingdon, England: Routledge.
Seidenberg, M. (2017). *Language at the speed of sight: How we read, why so many can't, and what can be done about it.* New York, NY: Basic Books.
Stuart, M., & Stainthorp, R. (2015). *Reading development and teaching.* Thousand Oaks, CA: SAGE.
Willingham, D. (2017). *The reading mind: A cognitive approach to understanding how the mind reads.* San Francisco, CA: Jossey-Bass.
Wolf, M. (2007). *Proust and the squid: The story and science of the reading brain.* New York, NY: Harper Collins.

that many different factors come together to produce a child who reads fluently for meaning and that instruction needs to consider all of them. In our view, it would be valuable to reclaim a term such as *balanced instruction* and recast it in a more nuanced way that is informed by a deep understanding of how reading develops. The guiding principle here would be that although there are many different aspects of reading that must be learned—alphabetic decoding, fluent word reading, text comprehension—this does not mean that instructional time should be devoted equally to all of them at all points in reading acquisition. Rather, instructional regimens to support these various abilities are likely to be most effective at particular points in development, and limited teaching time should be structured to reflect this. For example, detailed instruction in morphological regularities or strategies for text comprehension is unlikely to produce maximum benefits before children have mastered basic alphabetic decoding skills. From a research perspective, there is much to be learned about the time-course of acquisition of different reading skills and how they interact with each other and with the knowledge they depend on and produce. Further research is needed to produce a developmentally informed and balanced literacy instruction program, well-placed to prevent instructional casualties (Lyon, 2005).

In conclusion, the state of the science of learning to read was reviewed comprehensively in this journal more than 15 years ago (Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001). It is thus surprising and concerning that the reading wars continue. It is our hope that this review will contribute to ending these wars, so that a further examination of the status of this debate 15 years hence will not be required.

Acknowledgments

We are grateful to our editors, reviewers, and many others who provided helpful feedback on earlier versions of this manuscript, including Max Coltheart, Saskia Kohnen, Rauno Parrila, Charles Perfetti, Valerie Reyna, Roddy Roediger, Elizabeth Schotter, Maggie Snowling, Rhona Stainthorp, Rebecca Treiman, and Hua-Chen Wang. We also gratefully acknowledge research assistance support from Megan Bird, Benedetta Cevoli, Nardeen Massoud, and Julianne Pascoe.

Declaration of Conflicting Interests

The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

Funding

This work was supported by Australian Research Council Centre of Excellence in Cognition and Its Disorders Grant CE 110001021 (to A. Castles and K. Nation), Economic and Social Research Council Grants ES/L002264/1 and ES/P001874/1 (to K. Rastle), Economic and Social Research Council Grant ES/M009998/1 (to K. Nation and A. Castles), and The Leverhulme Trust Grant RPG-2015-070 (to K. Nation).

Note

1. An effect size is a measure of the overall strength of a phenomenon, rather than just its statistical significance (which is greatly influenced by sample size). The most widely used measure, Cohen's *d* (Cohen, 1969), represents the standardized difference between two means. By convention, an effect size (*d*) of 0.2 is considered small, 0.5 is considered medium, and greater than 0.8 is considered large.

References

Acha, J., & Perea, M. (2008). The effects of length and transposed-letter similarity in lexical decision: Evidence with beginning, intermediate, and adult readers. *British Journal of Psychology*, *99*, 245–264. doi:10.1348/000712607X224478

Adams, M. J. (1990). *Beginning to read: Thinking and learning about print*. Cambridge, MA: MIT Press.

Adams, M. J. (1998). The three-cueing system. In F. Lehr & J. Osborn (Eds.), *Literacy for all issues in teaching and learning* (pp. 73–99). New York, NY: Guilford Press.

Adelman, J. S., Brown, G. D. A., & Quesada, J. F. (2006). Contextual diversity, not word frequency, determines word-naming and lexical decision times. *Psychological Science*, *17*, 814–823. doi:10.1111/j.1467-9280.2006.01787.x

Ager, S. (2018). *Omniglot: The online encyclopedia of writing systems and languages*. Retrieved from https://www.omniglot.com/index.htm

Anderson, R. C., Wilson, P. T., & Fielding, L. G. (1988). Growth in reading and how children spend their time outside of school. *Reading Research Quarterly*, *23*, 285–303. doi:10.1598/rrq.23.3.2

Andrews, S., & Hersch, J. (2010). Lexical precision in skilled readers: Individual differences in masked neighbor priming. *Journal of Experimental Psychology: General*, *139*, 299–318. doi:10.1037/a0018366

Andrews, S., & Lo, S. (2012). Not all skilled readers have cracked the code: Individual differences in masked form priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *38*, 152–163. doi:10.1037/a0024953

Aro, M., & Björn, P. M. (2016). Preservice and inservice teachers' knowledge of language constructs in Finland. *Annals of Dyslexia*, *66*, 111–126.

Baayen, R. H. (2010). Demythologizing the word frequency effect: A discriminative learning perspective. *Mental Lexicon*, *5*, 436–461.

Baayen, R. H., Piepenbrock, R., & Van Rijn, H. (1993). The CELEX Lexical Database [CD-ROM]. Philadelphia: Linguistic Data Consortium, University of Pennsylvania.

Baddeley, A. (2012). Working memory: Theories, models, and controversies. *Annual Review of Psychology*, *63*, 1–29. doi:10.1146/annurev-psych-120710-100422

Baines, L. (1996). From page to screen: When a novel is interpreted for film, what gets lost in the translation? *Journal of Adolescent and Adult Literacy*, *39*, 612–622. Retrieved from http://www.jstor.org/stable/40015652

Barnes, M. A., Dennis, M., & Haefele-Kalvaitis, J. (1996). The effects of knowledge availability and knowledge accessibility on coherence and elaborative inferencing in children from six to fifteen years of age. *Journal of Experimental Child Psychology*, *61*, 216–241. doi:10.1006/jecp.1996.0015

Beck, I. L., McKeown, M. G., & Kucan, L. (2013). *Bringing words to life: Robust vocabulary instruction*. New York, NY: The Guilford Press.

Ben-Shachar, M., Dougherty, R. F., Deutsch, G. K., & Wandell, B. A. (2011). The development of cortical sensitivity to visual word forms. *Journal of Cognitive Neuroscience*, *23*, 2387–2399. doi:10.1162/jocn.2011.21615

Berko, J. (1958). The child's learning of English morphology. *Word*, *14*, 150–177. doi:10.1080/00437956.1958.11659661

Besner, D., Reynolds, M., & O'Malley, S. (2009). When underadditivity of factor effects in the Psychological Refractory Period paradigm implies a bottleneck: Evidence from psycholinguistics. *The Quarterly Journal of Experimental Psychology*, *62*(11), 2222–2234. doi:10.1080/17470210902747187

Beyersmann, E., Castles, A., & Coltheart, M. (2012). Morphological processing during visual word recognition in developing readers: Evidence from masked priming. *The Quarterly Journal of Experimental Psychology*, *65*, 1306–1326. doi:10.1080/17470218.2012.656661

Blythe, H. (2014). Developmental changes in eye movements and visual information encoding associated with learning to read. *Current Directions in Psychological Science*, *23*, 201–207. doi:10.1177/0963721414530145

Blythe, H., & Joseph, H. (2011). Children's eye movements during reading. In S. P. Liversedge, I. D. Gilchrist, & S.

Everling (Eds.), *The Oxford handbook of eye movements* (pp. 643–662). New York, NY: Oxford University Press.

Bowers, J. S., & Bowers, P. N. (2017). Beyond phonics: The case for teaching children the logic of the English spelling system. *Educational Psychologist*, *52*, 124–141. doi:10.1080/00461520.2017.1288571

Bowers, P. N., Kirby, J. R., & Deacon, S. H. (2010). The effects of morphological instruction on literacy skills. *Review of Educational Research*, *80*, 144–179. doi:10.3102/0034654309359353

Bowey, J. (2005). Predicting individual differences in learning to read. In M. J. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 155–172). Malden, MA: Blackwell. doi:10.1002/9780470757642.ch9

Brown, M. (2017 August 27) Flybraries [Blog post]. Retrieved from https://web.archive.org/web/20170829052440/https://interlibnet.org/2017/08/27/flybraries

Brysbaert, M., Mandera, P., & Keuleers, E. (2018). The word frequency effect in word processing: A review update. *Current Directions in Psychological Science*, *27*, 45–50. doi:10.1177/0963721417727521

Brysbaert, M., Stevens, M., Mandera, P., & Keuleers, E. (2016). How many words do we know? Practical estimates of vocabulary size dependent on word definition, the degree of language input and the participant's age. *Frontiers in Psychology*, *7*, 1116. doi:10.3389/fpsyg.2016.01116

Buckingham, J. (2016). *Focus on phonics: Why Australia should adopt the year 1 phonics screening check*. Retrieved from https://www.cis.org.au/app/uploads/2016/11/rr22.pdf

Buckingham, J., Wheldall, K., & Beaman-Wheldall, R. (2013). Why Jaydon can't read: The triumph of ideology over evidence in teaching reading. *Policy*, *29*(3), 21–32.

Burani, C., Marcolini, S., & Stella, G. (2002). How early does morpholexical reading develop in readers of a shallow orthography? *Brain and Language*, *81*, 568–586. doi:10.1006/brln.2001.2548

Byrne, B. (1992). Studies in the acquisition procedure for reading: Rationale, hypotheses, and data. In P. B. Gough, L. C. Ehri, & R. Treiman (Eds.), *Reading acquisition* (pp. 1–34). Hillsdale, NJ: Erlbaum.

Byrne, B. (2005). Theories of learning to read. In M. J. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 104–119). Malden, MA: Blackwell. doi:10.1002/9780470757642.ch6

Byrne, B., & Fielding-Barnsley, R. (1989). Phonemic awareness and letter knowledge in the child's acquisition of the alphabetic principle. *Journal of Educational Psychology*, *81*, 313–321. doi:10.1037/0022-0663.81.3.313

Byrne, B., & Fielding-Barnsley, R. (1990). Acquiring the alphabetic principle: A case for teaching recognition of phoneme identity. *Journal of Educational Psychology*, *82*, 805–812. doi:10.1037/0022-0663.82.4.805

Cain, K., & Oakhill, J. (2009). Reading comprehension development from 8 to 14 years. In R. K. Wagner, C. Schatschneider, & C. Phythian-Sence (Eds.), *Beyond decoding: The behavioral and biological foundations of reading comprehension* (pp. 143–175). New York, NY: The Guilford Press.

Cain, K., Oakhill, J., & Lemmon, K. (2004). Individual differences in the inference of word meanings from context: The influence of reading comprehension, vocabulary knowledge, and memory capacity. *Journal of Educational Psychology*, *96*, 671–681. doi:10.1037/0022-0663.96.4.671

Cain, K., Patson, N., & Andrews, L. (2005). Age- and ability-related differences in young readers' use of conjunctions. *Journal of Child Language*, *32*, 877–892. doi:10.1017/S0305000905007014

Cain, K., & Towse, A. S. (2008). To get hold of the wrong end of the stick: Reasons for poor idiom understanding in children with reading comprehension difficulties. *Journal of Speech, Language, and Hearing Research*, *51*, 1538–1549. doi:10.1044/1092-4388(2008/07-0269)

Cameron-Faulkner, T., & Noble, C. (2013). A comparison of book text and child directed speech. *First Language*, *33*, 268–279. doi:10.1177/0142723713487613

Caravolas, M., Lervåg, A., Mousikou, P., Efrim, C., Litavský, M., Onochie-Quintanilla, E., . . . Hulme, C. (2012). Common patterns of prediction of literacy development in different alphabetic orthographies. *Psychological Science*, *23*, 678–686. doi:10.1177/0956797611434536

Carlisle, J. F. (1995). Morphological awareness and early reading achievement. In L. B. Feldman (Ed.), *Morphological aspects of language processing* (pp. 189–209). Hillsdale, NJ: Erlbaum.

Carlisle, J. F. (2000). Awareness of the structure and meaning of morphologically complex words: Impact on reading. *Reading and Writing*, *12*, 169–190. doi:10.1023/A:1008131926604

Carretti, B., Borella, E., Cornoldi, C., & De Beni, R. (2009). Role of working memory in explaining the performance of individuals with specific reading comprehension difficulties: A meta-analysis. *Learning and Individual Differences*, *19*, 246–251. doi:10.1016/j.lindif.2008.10.002

Carroll, J. M., Bowyer-Crane, C., Duff, F. J., Hulme, C., & Snowling, M. J. (2011). *Developing language and literacy: Effective instruction in the early years*. West Sussex, England: Wiley-Blackwell.

Casalis, S., Quémart, P., & Duncan, L. G. (2015). How language affects children's use of derivational morphology in visual word and pseudoword processing: Evidence from a cross-language study. *Frontiers in Psychology, 6,* Article 452. doi:10.3389/fpsyg.2015.00452

Cassar, M., & Treiman, R. (1997). The beginnings of orthographic knowledge: Children's knowledge of double letters in words. *Journal of Educational Psychology*, *89*, 631–644. doi:10.1037/0022-0663.89.4.631

Castles, A., & Coltheart, M. (2004). Is there a causal link from phonological awareness to success in learning to read? *Cognition*, *91*, 77–111. doi:10.1016/s0010-0277(03)00164-1

Castles, A., Coltheart, M., Wilson, K., Valpied, J., & Wedgwood, J. (2009). The genesis of reading ability: What helps children learn letter–sound correspondences? *Journal of Experimental Child Psychology*, *104*, 68–88. doi:10.1016/j.jecp.2008.12.003

Castles, A., Davis, C., Cavalot, P., & Forster, K. (2007). Tracking the acquisition of orthographic skills in developing readers: Masked priming effects. *Journal of Experimental Child Psychology*, *97*, 165–182. doi:10.1016/j.jecp.2007.01.006

Castles, A., Davis, C., & Letcher, T. (1999). Neighbourhood effects on masked form priming in developing readers. *Language and Cognitive Processes*, *14*, 201–224. doi:10.1080/016909699386347

Castles, A., & Nation, K. (2006). How does orthographic learning happen? In S. Andrews (Ed.), *From inkmarks to ideas: Current issues in lexical processing* (pp. 151–179). Hove, England: Psychology Press.

Catts, H. W., Adlof, S., & Ellis-Weismer, S. (2006). Language deficits in poor comprehenders: A case for the simple view of reading. *Journal of Speech, Language, and Hearing Research*, *49*, 278–293. doi:10.1044/1092-4388(2006/023)

Chall, J. S. (1967). *Learning to read: The great debate*. New York, NY: McGraw Hill.

Chang, L. Y., Chen, Y. C., & Perfetti, C. A. (2018). GraphCom: A multidimensional measure of graphic complexity applied to 131 written languages. *Behavior Research Methods, 50, 427*. doi:10.3758/s13428-017-0881-y

Christianson, K. (2016). When language comprehension goes wrong for the right reasons: Good enough, underspecified, or shallow language processing. *Quarterly Journal of Experimental Psychology*, *69*, 817–828. doi:10.1080/17470218.2015.1134603

Clarke, A. (2012, July 31). Teaching sight words [Blog post]. Retrieved from https://www.spelfabet.com.au/2012/07/teaching-sight-words

Clarke, P. J., Snowling, M. J., Truelove, E., & Hulme, C. (2010). Ameliorating children's reading-comprehension difficulties. *Psychological Science*, *21*, 1106–1116. doi:10.1177/0956797610375449

Clarke, P. J., Truelove, E., Hulme, C., & Snowling, M. J. (2013). *Developing reading comprehension*. West Sussex, England: John Wiley & Sons.

Cohen, J. (1969). *Statistical power analysis for the behavioral sciences*. New York, NY: Academic Press.

Cohen, L., Lehéricy, S., Chochon, F., Lemer, C., Rivaud, S., & Dehaene, S. (2002). Language-specific tuning of visual cortex? Functional properties of the visual word form area. *Brain*, *12*, 1054–1069. doi:10.1093/brain/awf094

Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review*, *108*, 204–256. doi:10.1037//0033-295x.108.1.204

Compton, D. L., Miller, A. C., Elleman, A. M., & Steacy, L. M. (2014). Have we forsaken reading theory in the name of "quick fix" interventions for children with reading disability? Scientific Studies of *Reading*, *18*, 55–73. doi:10.1080/10888438.2013.836200

Connor, C., Radach, R., Vorstius, C., Day, S. L., McLean, L., & Morrison, F. J. (2015). Individual differences in fifth graders' reading and language predict their comprehension monitoring development: An eye-movement study. *Scientific Studies of Reading: The Official Journal of the Society for the Scientific Study of Reading*, *19*, 114–134. doi:10.1080/10888438.2014.943905

Cook, A. E., & O'Brien, A. E. (2015). Passive activation and instantiation of inferences during reading. In E. J. O'Brien, A. E. Cook, & R. F. Lorch, Jr. (Eds.), *Inferences during reading* (pp. 19–41). Cambridge, England: Cambridge University Press.

Crosson, A., & McKeown, M. (2016). Middle school learners' use of Latin roots to infer the meaning of unfamiliar words. *Cognition and Instruction*, *34*, 148–171. doi:10.1080/07370008.2016.1145121

Cunningham, A. E., Perry, K. E., Stanovich, K. E., & Share, D. L. (2002). Orthographic learning during reading: Examining the role of self-teaching. *Journal of Experimental Child Psychology*, *82*, 185–199. doi:10.1016/S0022-0965(02)00008-5

Currie, N. K., & Cain, K. (2015). Children's inference generation: The role of vocabulary and working memory. *Journal of Experimental Child Psychology*, *137*, 57–75. doi:10.1016/j.jecp.2015.03.005

Daneman, M., & Merikle, P. M. (1996). Working memory and language comprehension: A meta-analysis. *Psychonomic Bulletin & Review*, *3*, 422–433. doi:10.3758/BF03214546

Daugaard, H. T., Cain, K., & Elbro, C. (2017). From words to text: Inference making mediates the role of vocabulary in children's reading comprehension. *Reading and Writing*, *30*, 1773–1788. doi:10.1007/s11145-017-9752-2

Davis, A. (2013). To read or not to read: Decoding synthetic phonics. *Impact: Philosophical Perspectives on Educational Policy*, *2013*(20), 1–38. doi:10.1111/2048-416x.2013.12000.x

Dawson, N., Rastle, K., & Ricketts, J. (2017). Morphological effects in visual word recognition: Children, adolescents, and adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. Advance online publication. doi:10.1037/xlm0000485

Deacon, S. H., & Kirby, J. R. (2004). Morphological awareness: Just "more phonological"? The roles of morphological and phonological awareness in reading development. *Applied Psycholinguistics*, *25*, 223–238. doi:10.1017/S0142716404001110

Deacon, S. H., Whalen, R., & Kirby, J. R. (2011). Do children see the *danger* in *dangerous*? Grade 4, 6, and 8 children's reading of morphologically complex words. *Applied Psycholinguistics*, *32*, 467–481. doi:10.1017/s0142716411000166

Deci, E. L., Koestner, R., & Ryan, R. M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychological Bulletin*, *125*, 627–668. doi:10.1037/0033-2909.125.6.627

Dehaene, S. (2009). *Reading in the brain*. New York, NY: Penguin Viking.

Dehaene, S., & Cohen, L. (2011). The unique role of the visual word form area in reading. *Trends in Cognitive Sciences*, *15*, 254–262. doi:10.1016/j.tics.2011.04.003

Devonshire, V., Morris, P., & Fluck, M. (2013). Spelling and reading development: The effect of teaching children multiple levels of representation in their orthography. *Learning and Instruction*, *25*, 85–94. doi:10.1016/j.learninstruc.2012.11.007

Doctor, E. A., & Coltheart, M. (1980). Children's use of phonological encoding when reading for meaning. *Memory & Cognition*, *8*, 195–209. doi:10.3758/BF03197607

Dyson, H., Best, W., Solity, J., & Hulme, C. (2017). Training mispronunciation correction and word meanings improves children's ability to learn to read words. *Scientific Studies of Reading*, *21*, 392–407. doi:10.1080/10888438.2017.1315424

Ehri, L. C. (1999). Phases of development in learning to read words. In J. Oakhill & R. Beard (Eds.), *Reading, development and the teaching of reading: A psychological perspective* (pp. 79–108). Oxford, England: Blackwell Science.

Ehri, L. C. (2002). Phases of acquisition in learning to read words and implications for teaching. In R. Stainthorp & P. Tomlinson (Eds.), *Learning and teaching reading* (pp. 7–28). British Journal of Educational Psychology Monograph Series II: Part 1. London, England: British Journal of Educational Psychology.

Ehri, L. C. (2005a). Development of sight word reading: Phases and findings. In M. J. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 135–154). Malden, MA: Blackwell. doi:10.1002/9780470757642.ch8

Ehri, L. C. (2005b). Learning to read words: Theory, findings, and issues. Scientific Studies of *Reading*, *9*, 167–188. doi:10.1207/s1532799xssr0902_4

Ehri, L. C. (2017). Orthographic mapping and literacy development revisited. In K. Cain, D. L. Compton, & R. K. Parrila (Eds.), *Theories of reading development* (pp. 169–190). Amsterdam, The Netherlands: John Benjamins. doi:10.1075/swll.15.08ehr

Ehri, L. C., Nunes, S. R., Willows, D. M., Schuster, B. V., Yaghoub-zadeh, Z., & Shanahan, T. (2001). Systematic phonics instruction helps students learn to read: Evidence from the National Reading Panel's meta-analysis. *Reading*, *36*, 250–287. doi:10.3102/00346543071003393

Ehri, L. C., & Wilce, L. S. (1985). Movement into reading: Is the first stage of printed word learning visual or phonetic? *Reading Research Quarterly*, *20*, 163–179. doi:10.2307/747753

Ehrlich, M., & Remond, M. (1997). Skilled and less skilled comprehenders: French children's processing of anaphoric devices in written texts. *British Journal of Developmental Psychology*, *15*, 291–309. doi:10.1111/j.2044-835X.1997.tb00522.x

Eilers, S., Tiffin-Richards, S. P., & Schroeder, S. (2018). The repeated name penalty effect in children's natural reading: Evidence from eye tracking. *Quarterly Journal of Experimental Psychology*. Advance online publication. doi:10.1177/1747021818757712

Elbro, C., & Buch-Iversen, I. (2013). Activation of background knowledge for inference making: Effects on reading comprehension. *Scientific Studies of Reading*, *17*, 435–452. doi:10.1080/10888438.2013.774005

Elbro, C., & de Jong, P. (2017). Orthographic learning is verbal learning: The role of spelling mispronunciations. In K. Cain, D. Compton, & R. Parrila (Eds.), *Theories of reading development* (pp. 148–168). Amsterdam, The Netherlands: John Benjamins.

Elleman, A. M. (2017). Examining the impact of inference instruction on the literal and inferential comprehension of skilled and less skilled readers: A meta-analytic review. *Journal of Educational Psychology*, *109*, 761–781. doi:10.1037/edu0000180

Elleman, A. M., Lindo, E. J., Morphy, P., & Compton, D. L. (2009). The impact of vocabulary instruction on passage-level comprehension of school-age children: A meta-analysis. *Journal of Research on Educational Effectiveness*, *2*, 1–44. doi:10.1080/19345740802539200

Elwér, Å., Gustafson, S., Byrne, B., Olson, R. K., Keenan, J. M., & Samuelsson, S. (2015). A retrospective longitudinal study of cognitive and language skills in poor reading comprehension. *Scandinavian Journal of Psychology*, *56*, 157–166. doi:10.1111/sjop.12188

Every Student Succeeds Act of 2015, Pub. L. No. 114-95 § 114 Stat. 1177 (2015–2016).

Ferreira, F., Bailey, K. G. D., & Ferraro, V. (2002). Good-enough representations in language comprehension. *Current Directions in Psychological Science*, *11*, 11–15. doi:10.1111/1467-8721.00158

Fielding-Barnsley, R. (2010). Australian pre-service teachers' knowledge of phonemic awareness and phonics in the process of learning to read. *Australian Journal of Learning Difficulties*, *15*, 99–110. doi:10.1080/19404150903524606

Flesch, R. (1955). *Why Johnny can't read—and what you can do about it*. New York, NY: Harper & Brothers.

Forster, K. I., & Chambers, S. M. (1973). Lexical access and naming time. *Journal of Verbal Learning and Verbal Behavior*, *12*, 627–635. doi:10.1016/S0022-5371(73)80042-8

Forster, K. I., & Davis, C. (1984). Repetition priming and frequency attenuation in lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *10*, 680–698. doi:10.1037/0278-7393.10.4.680

Fricke, S., Bowyer-Crane, C., Haley, A. J., Hulme, C., & Snowling, M. J. (2013). Efficacy of language intervention in the early years. *Journal of Child Psychology and Psychiatry*, *54*, 280–290. doi:10.1111/jcpp.12010

Frith, U. (1985). Beneath the surface of developmental dyslexia. In K. Patterson, J. Marshall, & M. Coltheart (Eds.), *Surface dyslexia, neuropsychological and cognitive studies of phonological reading* (pp. 301–330). London, England: Erlbaum.

Frost, R. (2012). Toward a universal model of reading. *Behavioral & Brain Sciences*, *35*, 263–279. doi:10.1017/S0140525X11001841

Galuschka, K., Ise, E., Krick, K., & Schulte-Korne, G. (2014). Effectiveness of treatment approaches for children and adolescents with reading disabilities: A meta-analysis of randomized controlled trials. *PLOS ONE*, *9*(2), Article e89900. doi:10.1371/journal.pone.0089900

Gernsbacher, M. A., & Faust, M. E. (1991). The mechanism of suppression: A component of general comprehension skill. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *17*, 245–262. doi:10.1037/0278-7393.17.2.245

Gernsbacher, M. A., Varner, K. R., & Faust, M. E. (1990). Investigating differences in general comprehension skill. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *16*, 430–445. doi:10.1037/0278-7393.16.3.430

Ghyselinck, M., Lewis, M. B., & Brysbaert, M. (2004). Age of acquisition and the cumulative-frequency hypothesis: A review of the literature and a new multi-task investigation. *Acta Psychologica*, *115*, 43–67. doi:10.1016/j.actpsy.2003.11.002

Goodman, K. S. (1967). Reading: A psycholinguistic guessing game. *Journal of the Reading Specialist*, *6*, 126–135. doi:10.1080/19388076709556976

Goodwin, A. P., & Ahn, S. (2013). A meta-analysis of morphological interventions in English: Effects on literacy outcomes for school-age children. *Scientific Studies of Reading*, *17*, 257–285. doi:10.1080/10888438.2012.689791

Gough, P., & Tunmer, W. (1986). Decoding, reading, and reading disability. *Remedial and Special Education*, *7*, 6–10. doi:10.1177/074193258600700104

Graesser, A. C., Singer, M., & Trabasso, T. (1994). Constructing inferences during narrative text comprehension. *Psychological Review*, *101*, 371–395. doi:10.1037/0033-295X.101.3.371

Grainger, J., Lété, B., Bertand, D., Dufau, S., & Ziegler, J. C. (2012). Evidence for multiple routes in learning to read. *Cognition*, *123*, 280–292. doi:10.1016/j.cognition.2012.01.003

Halpern, D. (2015). *Inside the Nudge Unit: How small changes can make a big difference*. London, England: WH Allen.

Harm, M. W., & Seidenberg, M. S. (2004). Computing the meanings of words in reading: Cooperative division of labor between visual and phonological processes. *Psychological Review*, *111*, 662–720. doi:10.1037/0033-295X.111.3.662

Hart, J. (1969). *An orthographie*. Menston, England: The Scolar Press. (Original work published 1569).

Hatcher, P. J., Hulme, C., & Ellis, A. W. (1994). Ameliorating early reading failure by integrating the teaching of reading and phonological skills: The phonological linkage hypothesis. *Child Development*, *65*, 41–57. doi:10.1111/j.1467-8624.1994.tb00733.x

Henderson, L., Snowling, M., & Clarke, P. (2013). Accessing, integrating, and inhibiting word meaning in poor comprehenders. *Scientific Studies of Reading*, *17*, 177–198. doi:10.1080/10888438.2011.652721

Hirsch, E. D. (2016). *Why knowledge matters: Rescuing our children from failed educational theories*. Cambridge, MA: Harvard Education Press.

Hoover, W., & Gough, P. (1990). The simple view of reading. *Reading and Writing*, *2*, 127–160. doi:10.1007/bf00401799

Hua, A. N., & Keenan, J. M. (2014). The role of text memory in inferencing and in comprehension deficits. *Scientific Studies of Reading*, *18*, 415–431. doi:10.1080/10888438.2014.926906

Hulme, C., Bowyer-Crane, C., Carroll, J. M., Duff, F. J., & Snowling, M. J. (2012). The causal role of phoneme awareness and letter-sound knowledge in learning to read: Combining intervention studies with mediation analyses. *Psychological Science, 23, 572*. doi:10.1177/0956797611435921

Hulme, C., Nash, H. M., Gooch, D., Lervåg, A., & Snowling, M. J. (2015). The foundations of literacy development in children at familial risk of dyslexia. *Psychological Science*, *26*, 1877–1886. doi:10.1177/0956797615603702

Hurry, J., Nunes, T., Bryant, P., Pretzlik, U., Parker, M., Curno, T., & Midgley, L. (2005). Transforming research on morphology into teacher practice. *Research Papers in Education*, *20*, 187–206. doi:10.1080/02671520500078291

Jared, D., Ashby, J., Agauas, S., & Levy, B. (2016). Phonological activation of word meanings in grade 5 readers. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *42*, 524–541. doi:10.1037/xlm0000184

Johnston, R., & Watson, J. (2004). Accelerating the development of reading, spelling and phonemic awareness skills in initial readers. *Reading and Writing*, *17*, 327–357. doi:10.1023/B:READ.0000032666.66359.62

Johnston, R., & Watson, J. (2005). *The effects of synthetic phonics teaching on reading and spelling attainment: A seven year longitudinal study*. Retrieved from http://www.gov.scot/Resource/Doc/36496/0023582.pdf

Jones, M. N., Dye, M., & Johns, B. T. (2017). Context as an organizing principle of the lexicon. *Psychology of Learning and Motivation*, *67*, 239–283. doi:10.1016/bs.plm.2017.03.008

Jones, M. N., Johns, B. T., & Recchia, G. (2012). The role of semantic diversity in lexical organization. *Canadian Journal of Experimental Psychology*, *66*, 115–124. doi:10.1037/a0026727

Jorm, A. F., & Share, D. L. (1983). An invited article: Phonological recoding and reading acquisition. *Applied Psycholinguistics*, *4*, 103–147. doi:10.1017/S0142716400004380

Joseph, H., Liversedge, S. P., Blythe, H. I., White, S. J., Gathercole, S. E., & Rayner, K. (2008). Children's and adults' processing of anomaly and implausibility during reading: Evidence from eye movements. *The Quarterly Journal of Experimental Psychology*, *61*, 708–723. doi:10.1080/17470210701400657

Juhasz, B. J., & Rayner, K. (2006). The role of age of acquisition and word frequency in reading: Evidence from eye fixation durations. *Visual Cognition*, *13*, 846–863. doi:10.1080/13506280544000075

Juphard, A., Carbonnel, S., & Valdois, S. (2004). Length effect in reading and lexical decision: Evidence from skilled readers and a developmental dyslexic participant. *Brain and Cognition*, *55*, 332–340. doi:10.1016/j.bandc.2004.02.035

Kaakinen, J., & Hyönä, J. (2010). Task effects on eye movements during reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *36*, 1561–1566. doi:10.1037/a0020693

Kamusella, T. (2009). *The politics of language and nationalism in modern central Europe*. New York, NY: Palgrave MacMillan.

Katz, L., & Frost, R. (1992). The reading process is different for different orthographies: The orthographic depth hypothesis. In R. Frost & L. Katz (Eds.), *Orthography, Phonology, Morphology, and Meaning* (Vol. 94, pp. 67–84). Amsterdam, The Netherlands: Elsevier Science. doi:10.1016/S0166-4115(08)62789-2

Keenan, J. M., & Betjemann, R. S. (2006). Comprehending the gray oral reading test without reading it: Why comprehension tests should not include passage-independent items. Scientific Studies of *Reading*, *10*, 363–380. doi:10.1207/s1532799xssr1004_2

Keenan, J. M., & Meenan, C. E. (2014). Test differences in diagnosing reading comprehension deficits. *Journal of Learning Disabilities*, *47*, 125–135. doi:10.1177/0022219412439326

Kendall, J. (2012). *The forgotten founding father: Noah Webster's obsession and the creation of an American culture*. New York, NY: Berkeley Books.

Kendeou, P., & van den Broek, P. (2007). The effects of prior knowledge and text structure on comprehension processes during reading of scientific texts. *Memory & Cognition*, *35*, 1567–1577. doi:10.3758/BF03193491

Kessler, B., & Treiman, R. (2001). Relationships between sounds and letters in English monosyllables. *Journal of Memory and Language*, *44*, 592–617. doi:10.1006/jmla.2000.2745

Kilpatrick, D. A. (2015). *Essentials of assessing, preventing and overcoming reading difficulties*. Hoboken, NJ: Wiley.

Kim, J. S. (2008). Research and the reading wars. In F. M. Hess (Ed.), *When research matters: How scholarship influences education policy* (pp. 89–111). Cambridge, MA: Harvard Education Press.

Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. Cambridge, England: Cambridge University Press.

Kintsch, W., & Rawson, K. A. (2005). Comprehension. In M. J. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 209–226). Malden, MA: Blackwell doi:10.1002/9780470757642.ch12

Kirby, J., & Bowers, P. (2017). Morphological instruction and literacy: Binding phonological, orthographic, and semantic features of words. In K. Cain, D. L. Compton, & R. K. Parrila (Eds.), *Theories of reading development* (pp. 437–462). Amsterdam, The Netherlands: John Benjamins. doi:10.1075/swll.15.24kir

Kirsch, I., de Jong, J., Lafontaine, D., McQueen, J., Mendelovits, J., & Monseur, C. (2002). *Reading for change performance and engagement across countries. Results from Pisa 2000*. Organisation for Economic Co-operation and Development. Retrieved from https://www.oecd.org/edu/school/programmeforinternationalstudentassessment pisa/33690904.pdf

Ktori, M., Mousikou, P., & Rastle, K. (2018). Cues to stress assignment in reading aloud. *Journal of Experimental Psychology: General*, *147*, 36–61. doi:10.1037/xge0000380

Kyte, C. S., & Johnson, C. J. (2006). The role of phonological recoding in orthographic learning. *Journal of Experimental Child Psychology*, *93*, 166–185. doi:10.1016/j.jecp.2005.09.003

Language and Reading Research Consortium. (2015). Learning to read: Should we keep things simple? *Reading Research Quarterly*, *50*(2), 151–161. doi:10.1002/rrq.99

Language and Reading Research Consortium, & Geomans-Maldonado, G. (2017). Development of comprehension monitoring in beginner readers. *Reading & Writing*, *30*, 2039–2067. doi:10.1007/s11145-017-9765-x

Language and Reading Research Consortium, & Logan, J. (2017). Pressure points in reading comprehension: A quantile multiple regression analysis. *Journal of Educational Psychology*, *109*, 451–464. doi:10.1037/edu0000150

Larkin, R. F., & Snowling, M. J. (2008). Morphological spelling development. *Reading & Writing Quarterly*, *24*, 363–376. doi:10.1080/10573560802004449

Leach, J. M., Scarborough, H. S., & Rescorla, L. (2003). Late-emerging reading disabilities. *Journal of Educational Psychology*, *95*, 211–224. doi:10.1037/0022-0663.95.2.211

Leinenger, M. (2014). Phonological coding during reading. *Psychological Bulletin*, *140*, 1534–1555. doi:10.1037/a0037830

Lervåg, A., Hulme, C., & Melby-Lervåg, M. (2017). Unpicking the developmental relationship between oral language skills and reading comprehension: It's simple, but complex. *Child Development*. Advance online publication. doi:10.1111/cdev.12861

Levin, I., & Ehri, L. (2009). Young children's ability to read and spell their own and classmates' names: The role of letter knowledge. *Scientific Studies of Reading*, *13*, 249–273. doi:10.1080/10888430902851422

Liberman, A. M., Cooper, F. S., Shankweiler, D. P., & Studdert-Kennedy, M. (1967). Perception of the speech code. *Psychological Review*, *74*, 431–461.

Liberman, I. Y., Shankweiler, D., Fischer, F. W., & Carter, B. (1974). Explicit syllable and phoneme segmentation in the young child. *Journal of Experimental Child Psychology*, *18*, 201–212.

Lin, D., McBride-Chang, C., Shu, H., Zhang, Y., Li, H., Zhang, J., . . . Levin, I. (2010). Small wins big: Analytic pinyin skills promote Chinese word reading. *Psychological Science*, *21*, 1117–1122. doi:10.1177/0956797610375447

Lü, C. (2017). The roles of pinyin skill in English-Chinese biliteracy learning: Evidence from Chinese immersion learners. *Foreign Language Annals*, *50*, 306–322. doi:10.1111/flan.12269

Lyon, R. G. (2005). *Dr. G. Reid Lyon – converging evidence – reading research what it takes to read/Interviewer: David Boulton*. Children of the code. Retrieved from http://www.childrenofthecode.org/interviews/lyon.htm#Instructionalcasualties

MacDonald, M. C., & Christiansen, M. H. (2002). Reassessing working memory: Comment on Just and Carpenter (1992) and Waters and Caplan (1996). *Psychological Review*, *109*, 35–54. doi:10.1037/0033-295X.109.1.35

Machin, S., McNally, S., & Viarengo, M. (2016). *"Teaching to teach" literacy* (Centre for Economic Performance Discussion Paper No. 1425). Retrieved from http://cep.lse.ac.uk/pubs/download/dp1425.pdf

Mahony, D. L. (1994). Using sensitivity to word structure to explain variance in high school and college level reading ability. *Reading and Writing: An Interdisciplinary Journal*, *6*, 19–44. doi:10.1007/BF01027276

Marinus, E., & Castles, A. (2015). Precursors to reading: Phonological awareness and letter knowledge. In E. Bavin & L. Naigles (Eds.), *Handbook of child language* (2nd ed., pp. 661–680). Cambridge, England: Cambridge University Press.

Martin, A., Schurz, M., Kronbichler, M., & Richlan, F. (2015). Reading in the brain of children and adults: A meta-analysis of 40 functional magnetic resonance imaging studies. *Human Brain Mapping*, *36*, 1963–1981.

Masterson, J., Stuart, M., Dixon, M., & Lovejoy, S. (2010). Children's printed word database: Continuities and changes over time in children's early reading vocabulary. *British Journal of Psychology*, *101*, 221–242. doi:10.1348/000712608X371744

McArthur, G., & Castles, A. (2017). Helping children with reading difficulties: Some things we have learned so far. *Npj Science of Learning*, *2*(1), Article 7. doi:10.1038/s41539-017-0008-3

McArthur, G. M., Castles, A., Kohnen, S., Larsen, L., Jones, K., Anandakumar, T., & Banales, E. (2015). Sight word and phonics training in children with dyslexia. *Journal of Learning Disabilities*, *24*, 391–407. doi:10.1177/0022219413504996

McArthur, G. M., Eve, P. M., Jones, K., Banales, E., Kohnen, S., Anandakumar, T., . . . Castles, A. (2012). Phonics training for English-speaking poor readers. *Cochrane Database of Systematic Reviews*, *12*, 1–104. doi:10.1002/14651858.CD009115.pub2

McNamara, D. S., & Magliano, J. (2009). Toward a comprehensive model of comprehension. In B. H. Ross (Ed.), *The psychology of learning and motivation* (Vol. 51, pp. 297–384). San Diego, CA: Academic Press. doi:10.1016/S0079-7421(09)51009-2

McNamara, D. S., & McDaniel, M. A. (2004). Suppressing irrelevant information: Knowledge activation or inhibition? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *30*, 465–482. doi:10.1037/0278-7393.30.2.465

Melby-Lervåg, M., Lyster, S. A., & Hulme, C. (2012). Phonological skills and their role in learning to read: A meta-analytic review. *Psychological Bulletin*, *138*, 322–352.

Melby-Lervåg, M., Redick, T. S., & Hulme, C. (2016). Working memory training does not improve performance on measures of intelligence or other measures of "far transfer." *Perspectives on Psychological Science*, *11*, 512–534. doi:10.1177/1745691616635612

Miskin, R. (2008). *Billy the kid*. Oxford, England: Read Write Inc.

Moats, L. (2009). Still wanted: Teachers with knowledge of language. *Journal of Learning Disabilities*, *42*, 387–391. doi:10.1177/0022219409338735

Moats, L. C. (2007). *Whole-language high jinks: How to tell when "scientifically-based reading instruction" isn't*. Thomas B. Fordham Institute. Retrieved from https://files.eric.ed.gov/fulltext/ED498005.pdf

Moats, L. C. (2010). *Speech to print: Language essentials for teachers*. Baltimore, MD: Brookes Publishing.

Mol, S. E., & Bus, A. G. (2011). To read or not to read: A meta-analysis of print exposure from infancy to early adulthood. *Psychological Bulletin*, *137*, 267–296. doi:10.1037/a0021890

Monaghan, P., & Ellis, A. W. (2010). Modeling reading development: Cumulative, incremental learning in a computational model of word naming. *Journal of Memory and Language*, *63*, 506–525. doi:10.1016/j.jml.2010.08.003

Montag, J. L., Jones, M. N., & Smith, L. B. (2015). The words children hear. *Psychological Science*, *26*, 1489–1496. doi:10.1177/0956797615594361

Montag, J. L., & MacDonald, M. C. (2015). Text exposure predicts spoken production of complex sentences in 8- and 12-year-old children and adults. *Journal of Experimental Psychology: General*, *144*, 447–468. doi:10.1037/xge0000054

Morrison, C. M., & Ellis, A. W. (1995). Roles of word frequency and age of acquisition in word naming and lexical decision. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*, 116–133. doi:10.1037/0278-7393.21.1.116

Mousikou, P., Sadat, J., Lucas, R., & Rastle, K. (2017). Moving beyond the monosyllable in models of skilled reading: Mega-study of disyllabic nonword reading. *Journal of Memory and Language*, *93*, 169–192. doi:10.1016/j.jml.2016.09.003

Mulcaster, R. (1582). *Elementarie*. London, England: T. Vautroullier. Retrieved from http://ota.ox.ac.uk/text/3176.html

Murphy, V. A. (2018). Literacy development in linguistically diverse pupils. In D. Miller, F. Bayran, J. Rothman, & L. Serratrice (Eds.), *Bilingual cognition and language: The state of the science across its subfields. Studies in Bilingualism* (Vol. 54, pp. 155–182). Amsterdam, The Netherlands: John Benjamins. doi:10.175/sibil.54.08mur

Muter, V., Hulme, C., Snowling, M. J., & Stevenson, J. (2004). Phonemes, rimes, vocabulary, and grammatical skills as foundations of early reading development: Evidence from a longitudinal study. *Developmental Psychology*, *40*, 665–681. doi:10.1037/0012-1649.40.5.665

Nagy, W. E., & Herman, P. A. (1984). *Limitations of vocabulary instruction* (Technical Report No. 326). Center for the Study of Reading, University of Illinois at Urbana-Champaign. Retrieved from http://hdl.handle.net/2142/17599

Nation, K. (2005). Children's reading comprehension difficulties. In M. J. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 248–265). Malden, MA: Blackwell. doi:10.1002/9780470757642.ch14

Nation, K. (2009). Form-meaning links and the development of visual word recognition. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*, 3655–3674. doi:10.1098/rstb.2009.0119

Nation, K. (2017). Nurturing a lexical legacy: Reading experience is critical for the development of word reading skill. *Npj Science of Learning*, *2*, 1–4. doi:10.1038/s41539-017-0004-7

Nation, K., Adams, J. W., Bowyer-Crane, C. A., & Snowling, M. J. (1999). Working memory deficits in poor comprehenders reflect underlying language impairments. *Journal of Experimental Child Psychology*, *73*, 139–158. doi:10.1006/jecp.1999.2498

Nation, K., & Castles, A. (2017). Putting the learning in orthographic learning. In K. Cain, D. Compton, & R. Parrila (Eds.), *Theories of reading development* (pp. 147–168). Amsterdam, The Netherlands: John Benjamins.

Nation, K., Clarke, P., Marshall, C. M., & Durand, M. (2004). Hidden language impairments in children: Parallels between poor reading comprehension and specific language impairment? *Journal of Speech, Language, and Hearing Research*, *47*, 199–211. doi:10.1044/1092-4388(2004/017)

Nation, K., Cocksey, J., Taylor, J. S. H., & Bishop, D. V. M. (2010). A longitudinal investigation of early reading and language skills in children with poor reading comprehension. *Journal of Child Psychology and Psychiatry*, *51*, 1031–1039. doi:10.1111/j.1469-7610.2010.02254.x

Nation, K., & Snowling, M. (1997). Assessing reading difficulties: The validity and utility of current measures of reading skill. *British Journal of Educational Psychology*, *67*, 359–370. doi:10.1111/j.2044-8279.1997.tb01250.x

Nation, K., & Snowling, M. J. (1999). Developmental differences in sensitivity to semantic relations among good and poor comprehenders: Evidence from semantic priming. *Cognition*, *70*, B1–B13. doi:10.1016/S0010-0277(99)00004-9

National Reading Panel. (2000). *Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction* (NIH Publication No. 00-4769). National Institute of Child Health & Development. Retrieved from https://www1.nichd.nih.gov/publications/pubs/nrp/Documents/report.pdf

Nelson, J. R., & Stage, S. A. (2007). Fostering the development of vocabulary knowledge and reading comprehension though contextually-based multiple meaning vocabulary instruction. *Education and Treatment of Children*, *30*, 1–22. doi:10.1353/etc.2007.0003

No Child Left Behind Act of 2001, P.L. 107–110, 20 U.S.C. § 6319 (2002).

Norbury, C. F., Gooch, D., Wray, C., Baird, G., Charman, T., Simonoff, E., . . . Pickles, A. (2016). The impact of nonverbal ability on prevalence and clinical presentation of language disorder: Evidence from a population study. *Journal of Child Psychology and Psychiatry*, *57*, 1247–1257. doi:10.1111/jcpp.12573

Nunes, T., & Bryant, P. (2006). *Improving literacy by teaching morphemes*. New York, NY: Routledge.

Nunes, T., Bryant, P., & Bindman, M. (1997). Morphological spelling strategies: Developmental stages and processes. *Developmental Psychology*, *33*, 637–649. doi:10.1037/0012-1649.33.4.637

Oakhill, J., Cain, K., & Elbro, C. (2014). *Understanding and teaching reading comprehension: A handbook*. Abingdon, Oxon, England: Routledge.

Oakhill, J., Hartt, J., & Samols, D. (2005). Levels of comprehension monitoring and working memory in good and poor comprehenders. *Reading and Writing*, *18*, 657–686. doi:10.1007/s11145-005-3355-z

O'Brien, E. J., Cook, A. E., & Lorch, R. F. (Eds.). (2015). *Inferences during reading*. Cambridge, England: Cambridge University: Press.

Organisation for Economic Cooperation and Development. (2016). *Programme for international student assessment results from PISA 2015: United Kingdom*. Retrieved from http://www.oecd.org/pisa/pisa-2015-United-Kingdom.pdf

Olson, D. R. (1977). From utterances to text: The bias of language in speech and writing. *Harvard Educational Review*, *47*, 257–281.

Olson, D. R. (1996). Towards a psychology of literacy: On the relations between speech and writing. *Cognition*, *60*, 83–104.

Olson, R. K., Keenan, J. M, Byrne, B., & Samuelsson, S. (2014). Why do children differ in their development of reading and related skills? *Scientific Studies of Reading*, *18*, 38–54. doi:10.1080/10888438.2013.800521

Paap, K. R., & Noel, R. W. (1991). Dual-route models of print to sound: Still a good horse race. *Psychological Research*, *53*, 13–24. doi:10.1007/BF00867328

Pacton, S., & Deacon, S. H. (2008). The timing and mechanisms of children's use of morphological information in spelling: A review of evidence from French and English. *Cognitive Development*, *23*, 339–359. doi:10.1016/jcogdev200709004

Pacton, S., Perruchet, P., Fayol, M., & Cleeremans, A. (2001). Implicit learning out of the lab: The case of orthographic regularities. *Journal of Experimental Psychology*, *130*, 401–426. doi:10.1037/0096-3445.130.3.401

Palinscar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction*, *1*, 117–175. doi:10.1207/s1532690xci0102_1

Pearson, P. D. (2004). The reading wars. *Educational Policy*, *18*, 216–252. doi:10.1177/0895904803260041

Perfetti, C. A. (1992). The representation problem in reading acquisition. In P. B. Gough, L. C. Ehri, & Treiman, R. (Eds.), *Reading acquisition* (pp. 145–174). Hillsdale, NJ: Erlbaum.

Perfetti, C. A. (1994). Psycholinguistics and reading ability. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 849–894). San Diego, CA: Academic Press.

Perfetti, C. A. (2007). Reading ability: Lexical quality to comprehension. *Scientific Studies of Reading*, *11*, 357–383. doi:10.1080/10888430701530730

Perfetti, C. A., & Hart, L. (2002). The lexical quality hypothesis. In L. Verhoeven, C. Elbr, & P. Reitsma (Eds.), *Precursors of functional literacy* (pp. 189–212). Amsterdam, The Netherlands: John Benjamins.

Perfetti, C. A., & Stafura, J. (2014). Word knowledge in a theory of reading comprehension. *Scientific Studies of Reading*, *18*, 22–37. doi:10.1080/10888438.2013.827687

Perry, C., Ziegler, J. C., & Zorzi, M. (2007). Nested incremental modeling in the development of computational theories: The CDP+ model of reading aloud. *Psychological Review*, *114*, 273–315. doi:10.1037/0033-295X.114.2.273

Perry, C., Ziegler, J. C., & Zorzi, M. (2010). Beyond single syllables: Large-scale modeling of reading aloud with the Connectionist Dual Process (CDP++) model. *Cognitive Psychology*, *61*, 106–151. doi:10.1016/j.cogpsych.2010.04.001

Pexman, P. M. (2012). Meaning-based influences on visual word recognition. In J. S. Adelman (Ed.), *Visual word recognition: Volume 2* (pp. 24–43). New York, NY: Psychology Press.

Pimperton, H., & Nation, K. (2010). Suppressing irrelevant information from working memory: Evidence for domain-specific deficits in poor comprehenders. *Journal of Memory and Language*, *62*, 380–391. doi:10.1016/j.jml.2010.02.005

Pinker, S. (2009). *Language learnability and language development*. Cambridge, MA: Harvard University Press.

Plaut, D. C., & Gonnerman, L. M. (2000). Are non-semantic morphological effects incompatible with a distributed connectionist approach to lexical processing? *Language and Cognitive Processes*, *15*, 445–485. doi:10.1080/01690960050119661

Plaut, D. C., McClelland, J. L., Seidenberg, M. S., & Patterson, K. (1996). Understanding normal and impaired word reading: Computational principles in quasi-regular domains. *Psychological Review*, *103*, 56–115. doi:10.1037/0033-295X.103.1.56

Plummer, P., Perea, M., & Rayner, K. (2014). The influence of contextual diversity on eye movements in reading.

Journal of Experimental Psychology: Learning, Memory, and Cognition, *40*, 275–283. doi:10.1037/a0034058

Potter, D. (2012, February 16). Sight words [Blog post]. Retrieved from http://blendphonics.org/?page_id = 765

Pritchard, S. C., Coltheart, M., Marinus, E., & Castles, A. (2018). A computational model of the self-teaching hypothesis based on the dual-route cascaded model of reading. *Cognitive Science*. Advance online publication. doi:10.1111/cogs.12571

Pugh, K. R., Mencl, W. E., Jenner, A. R., Katz, L., Frost, S. J., Lee, J. R., . . . Shaywitz, B. A. (2000). Functional neuroimaging studies of reading and reading disability (developmental dyslexia). *Mental Retardation and Developmental Disabilities Research Reviews*, *6*, 207–213.

Quigley, A. (2018). *Closing the vocabulary gap*. Abingdon, England: Routledge.

Quinn, J. M., Wagner, R. K., Petscher, Y., & Lopez, D. (2015). Developmental relations between vocabulary knowledge and reading comprehension: A latent change score modeling study. *Child Development*, *86*, 159–175. doi:10.1111/cdev.12292

Rack, J., Hulme, C., Snowling, M., & Wightman, J. (1994). The role of phonology in young children learning to read words: The direct-mapping hypothesis. *Journal of Experimental Child Psychology*, *57*, 42–71. doi:10.1006/jecp.1994.1003

Rastle, K. (2018). The place of morphology in learning to read in English. *Cortex*. Advance online publication. doi:10.1016/j.cortex.2018.02.008

Rastle, K., & Brysbaert, M. (2006). Masked phonological priming effects in English: Are they real? Do they matter? *Cognitive Psychology*, *53*, 97–145. doi:10.1016/j.cogpsych.2006.01.002

Rastle, K., & Coltheart, M. (1999). Serial and strategic effects in reading aloud. *Journal of Experimental Psychology*, *25*, 482–503. doi:10.1037//0096-1523.25.2.482

Rastle, K., & Coltheart, M. (2006). Is there serial processing in the reading system; and are there local representations? In S. Andrews (Ed.), *From inkmarks to ideas: Current issues in lexical processing* (pp. 3–24). Hove, England: Psychology Press.

Rastle, K., & Davis, M. H. (2008). Morphological decomposition based on the analysis of orthography. *Language and Cognitive Processes*, *23*, 942–971. doi:10.1080/01690960802069730

Rastle, K., Davis, M. H., Marslen-Wilson, W. D., & Tyler, L. K. (2000). Morphological and semantic effects in visual word recognition: A time-course study. *Language and Cognitive Processes*, *15*, 507–537. doi:10.1080/01690960050119689

Rastle, K., Davis, M. H., & New, B. (2004). The broth in my brother's brothel: Morpho-orthographic segmentation in visual word recognition. *Psychonomic Bulletin & Review*, *11*, 1090–1098. doi:10.3758/BF03196742

Rastle, K., Havelka, J., Wydell, T. N., Coltheart, M., & Besner, D. (2009). The cross-script length effect: Further evidence challenging PDP models of reading aloud. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *35*, 238–246. doi:10.1037/a0014361

Rayner, K., Foorman, B. R., Perfetti, C. A., Pesetsky, D., & Seidenberg, M. S. (2001). How psychological science informs the teaching of reading. *Psychological Science in the Public Interest*, *2*, 31–74. doi:10.1111/1529-1006.00004

Rayner, K., Schotter, E., Masson, M., Potter, M. C., & Treiman, R. (2016). So much to read, so little time: How do we read, and can speed reading help? *Psychological Science in the Public Interest*, *17*, 4–34. doi:10.1177/1529100615623267

Rayner, K., Warren, T., Juhasz, B. J., & Liversedge, S. P. (2004). The effect of plausibility on eye movements in reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *30*, 1290–1301. doi:10.1037/0278-7393.30.6.1290

Reichle, E., Liversedge, S., Drieghe, D., Blythe, H., Joseph, H., White, S., & Rayner, K. (2013). Using E-Z Reader to examine the concurrent development of eye-movement control and reading skill. *Developmental Review*, *33*, 110–149. doi:10.1016/j.dr.2013.03.001

Rideout, V. J. (2015). *The common sense census: Media use by tweens and teens*. San Francisco, CA: Common Sense Media.

Rodd, J. (in press). Lexical ambiguity. In S.-A. Rueschemeyer & M. G. Gaskell (Eds.), *Oxford handbook of psycholinguistics* (2nd ed). Oxford, England: Oxford University Press.

Rose, J. (2006). *Independent review of the teaching of early reading final report*. U.K. Department for Education and Skills. Retrieved from http://dera.ioe.ac.uk/5551/2/report.pdf

Rosen, M. (2012, April 3). This summer's phonics test is not a reading test [Blog post]. Retrieved from http://michaelrosenblog.blogspot.com.au/2012/04/this-summers-phonics-test-is-not.html

Rowe, K. (2005). *Teaching reading: National inquiry into the teaching of literacy*. Department of Education, Science and Training, Australian Council for Educational Research. Retrieved from https://research.acer.edu.au/tll_misc/5/

Rozin, P., Scott, S., Dingley, M., Urbanek, J. K., Jiang, H., & Kaltenbach, M. (2011). Nudge to nobesity I: Minor changes in accessibility decrease food intake. *Judgment and Decision Making*, *6*, 323–332. doi:10.1111/j.1753-4887.2009.00206.x

Samuels, S. J. (2007). The DIBELS tests: Is speed of barking at print what we mean by reading fluency? *Reading Research Quarterly*, *42*, 563–566.

Schober, M., Rapp, D., & Britt, M. (2018). *The Routledge handbook of discourse processes* (2nd ed.). New York, NY: Routledge.

Schotter, E., Bicknell, K., Howard, I., Levy, R., & Rayner, K. (2014). Task effects reveal cognitive flexibility responding to frequency and predictability: Evidence from eye movements in reading and proofreading. *Cognition*, *131*, 1–27. doi:10.1016/j.cognition.2013.11.018

Seidenberg, M. (2017). *Language at the speed of sight: How we read, why so many can't, and what can be done about it*. New York, NY: Basic Books.

Seidenberg, M. S., Waters, G. S., Barnes, M. A., & Tanenhaus, M. K. (1984). When does irregular spelling or pronunciation influence word recognition? *Journal of Verbal*

Learning and Verbal Behavior, *23*, 383–404. doi:10.1016/S0022-5371(84)90270-6

Sesma, H. W., Mahone, E. M., Levine, T., Eason, S. H., & Cutting, L. E. (2009). The contribution of executive skills to reading comprehension. *Child Neuropsychology*, *15*, 232–246.

Seymour, P. H. K., Aro, M., & Erskine, J. M. (2003). Foundation literacy acquisition in European orthographies. *British Journal of Psychology*, *94*, 143–174. doi:10.1348/000712603321661859

Seymour, P. H. K., & Elder, L. (1986). Beginning reading without phonology. *Cognitive Neuropsychology*, *3*, 1–36. doi:10.1080/02643298608252668

Shapiro, L. R., & Solity, J. (2008). Delivering phonological and phonics training within whole class teaching. *The British Journal of Educational Psychology*, *78*, 597–620. doi:10.1348/000709908x293850

Shapiro, L. R., & Solity, J. (2016). Differing effects of two synthetic phonics programmes on early reading development. *British Journal of Educational Psychology*, *86*, 182–203. doi:10.1111/bjep.12097

Share, D. L. (1995). Phonological recoding and self-teaching: Sine qua non of reading acquisition. *Cognition*, *55*, 151–218. doi:10.1016/0010-0277(94)00645-2

Share, D. L. (1999). Phonological recoding and orthographic learning: A direct test of the self-teaching hypothesis. *Journal of Experimental Child Psychology*, *72*, 95–129. doi:10.1006/jecp.1998.2481

Share, D. L. (2004). Orthographic learning at a glance: On the time course and developmental onset of self-teaching. *Journal of Experimental Child Psychology*, *87*, 267–298. doi:10.1016/j.jecp.2004.01.001

Share, D. L. (2008). On the Anglocentricities of current reading research and practice: The perils of overreliance on an "outlier" orthography. *Psychological Bulletin*, *134*, 584–615. doi:10.1037/0033-2909.134.4.584

Sharratt, N., & Tucker, S. (2004). *The three billy goats gruff*. London, England: Macmillan.

Shaywitz, B., Shaywitz, S., Pugh, K., Einar Mencl, W., . . . Gore, J. C. (2002). Disruption of posterior brain systems for reading in children with developmental dyslexia. *Biological Psychiatry*, *52*, 101–110. doi:10.1016/s0006-3223(02)01365-3

Simons, D. J., Boot, W. R., Charness, N., Gathercole, S. E., Chabris, C. F., Hambrick, D. Z., . . . Stine-Morrow, E. A. L. (2016). Do "brain training" programs work? *Psychological Science in the Public Interest*, *17*, 103–186.

Singson, M., Mahony, D., & Mann, V. (2000). The relation between reading ability and morphological skills: Evidence from derivational suffixes. *Reading and Writing*, *12*, 219–252. doi:10.1023/A:1008196330239

Smith, F. (1971). *Understanding reading: A psycholinguistic analysis of reading and learning to read*. New York, NY: Holt, Rinehart and Winston.

Smith, S. A., & Murphy, V. A. (2015). Measuring productive elements of multi-word phrase vocabulary knowledge among children with English as an additional or only language. *Reading and Writing*, *28*, 347–369. doi:10.1007/s11145-014-9527-y

Snow, C. (2002). *Reading for understanding: Toward an R&D program in reading comprehension*. Santa Monica, CA: RAND Education.

Snow, C. E. (2017). The role of vocabulary versus knowledge on children's language learning: A fifty-year perspective. *Journal for the Study of Education and Development*, *40*, 1–18.

Snow, C. E., & Juel, C. (2005). Teaching children to read: What do we know about how to do it? In J. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 501–520). Malden, MA: Blackwell. doi:10.1002/9780470757642.ch26

Snow, P. (2017, May 12). Balanced literacy: An instructional bricolage that is neither fish nor fowl [Blog post]. Retrieved from http://pamelasnow.blogspot.com.au/2017/05/balanced-literacy-instructional.html

Solity, J., & Vousden, J. (2009). Real books vs reading schemes: A new perspective from instructional psychology. *Educational Psychology*, 29, 469–511. doi:10.1080/01443410903103657

Spencer, L. H., & Hanley, J. R. (2004). Learning a transparent orthography at five years old: Reading development of children during their first year of formal reading instruction in Wales. *Journal of Research in Reading*, *27*, 1–14. doi:10.1111/j.1467-9817.2004.00210.x

Spencer, M., Quinn, J. M., & Wagner, R. K. (2017). Vocabulary, morphology, and reading comprehension. In K. Cain, D. L. Compton, & R. K. Parrila (Eds.), *Theories of reading development* (pp. 239–256). Amsterdam, The Netherlands: John Benjamins.

Stanovich, K. E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly*, *21*, 360–407. Retrieved from http://www.jstor.org/stable/747612

Stanovich, K. E., & West, R. F. (1989). Exposure to print and orthographic processing. *Reading Research Quarterly*, *24*, 402–433. doi:10.2307/747605

Stuart, M., Masterson, J., Dixon, M., & Quinlan, P. (1999). Inferring sublexical correspondences from sight vocabulary: Evidence from 6- and 7-year-olds. *The Quarterly Journal of Experimental Psychology A*, *52*, 353–366. doi:10.1080/027249899391106

Stuart, M., & Stainthorp, R. (2015). *Reading development and teaching*. Thousand Oaks, CA: SAGE.

Suggate, S. (2016). A meta-analysis of the long-term effects of phonemic awareness, phonics, fluency, and reading comprehension interventions. *Journal of Learning Disabilities*, *49*, 77–96. doi:10.1177/0022219414528540

Taft, M. (1994). Interactive-activation as a framework for understanding morphological processing. *Language & Cognitive Processes*, *9*, 271–294.

Taft, M., & Forster, K. I. (1975). Lexical storage and retrieval of prefixed words. *Journal of Verbal Learning and Verbal Behavior*, *14*, 638–647. doi:10.1016/S0022-5371(75)80051-X

Taylor, J. S. H., Duff, F. J., Woollams, A. M., Monaghan, P., & Ricketts, J. (2015). How word meaning influences word reading. *Current Directions in Psychological Science*, *24*, 322–328. doi:10.1177/0963721415574980

Taylor, J. S. H., Rastle, K., & Davis, M. H. (2013). Can cognitive models explain brain activation during word and pseudoword reading? A meta-analysis of 36 neuroimaging studies. *Psychological Bulletin*, *139*, 766–791. doi:10.1037/a0030266

Tong, X., Deacon, S. H., Kirby, J. R., Cain, K., & Parrila, R. (2011). Morphological awareness: A key to understanding poor reading comprehension in English. *Journal of Educational Psychology*, *103*, 523–534. doi:10.1037/a0023495

Torgerson, C., Brooks, G., & Hall, J. (2006). *A systematic review of the research literature on the use of phonics in the teaching of reading and spelling* (Research Report RR711). U.K. Department for Education and Skills. Retrieved from http://dera.ioe.ac.uk/14791/1/RR711_.pdf

Treiman, R., & Bourassa, D. C. (2000). The development of spelling skill. *Topics in Language Disorders*, *20*, 1–18.

Treiman, R., & Cassar, M. (1996). Effects of morphology on children's spelling of final consonant clusters. *Journal of Experimental Child Psychology*, *63*, 141–170. doi:10.1006/jecp.1996.0045

Treiman, R., & Kessler, B. (2014). *How children learn to write words*. Oxford, England: Oxford University Press.

Tunmer, W. E., & Chapman, J. W. (2012). Does set for variability mediate the influence of vocabulary knowledge on the development of word recognition skills? *Scientific Studies of Reading*, *16*, 122–140. doi:10.1080/10888438.2010.542527

U.K. Department for Education. (2014). *National curriculum in England: English programmes of study (Appendix 1, Spelling)*. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/239784/English_Appendix_1_-_Spelling.pdf

U.K. Department for Education. (2017). *Statistics on national curriculum assessments at key stage 1 and phonics screening check results*. Retrieved from https://www.gov.uk/government/statistics/phonics-screening-check-and-key-stage-1-assessments-england-2017

U.K. Department for Education and Skills (2007). Letters and sounds: Principles and practice of high quality phonics. Notes of guidance for practitioners and teachers. Nottingham, UK: DfES Publications. Retrieved from https://www.gov.uk/government/publications/letters-and-sounds

U.S. Department of Education. (2015). *National Center for Education Statistics, National Assessment of Educational Progress (NAEP)*. Retrieved from https://datacenter.kidscount.org/data#USA/2/8/10,11,12,13,15,14,2719/char/0

van den Broek, P., Bohn-Gettler, C. M., Kendeou, P., Carlson, S., & White, M. J. (2011). When a reader meets a text: The role of standards of coherence in reading comprehension. In M. T. McCrudden, J. P. Magliano, & G. Schraw (Eds.), *Text relevance and learning from text* (pp. 123–139). Charlotte, NC: Information Age Publishing.

Van Dyke, J. A., Johns, C. L., & Kukona, A. (2014). Low working memory capacity is only spuriously related to poor reading comprehension. *Cognition*, *131*, 373–403. doi:10.1016/j.cognition.2014.01.007

van Orden, G. C. (1987). A ROWS is a ROSE: Spelling, sound, and reading. *Memory & Cognition*, *15*, 181–198. doi:10.3758/BF03197716

Veldre, A., & Andrews, S. (2015). Parafoveal lexical activation depends on skilled reading proficiency. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *41*, 586–595. doi:10.1037/xlm0000039

Veldre, A., & Andrews, S. (2016). Is semantic preview benefit due to relatedness or plausibility? *Journal of Experimental Psychology: Human Perception and Performance*, *42*, 939–952. doi:10.1037/xhp0000200

Vinckier, F., Dehaene, S., Jobert, A., Dubus, J. P., Sigman, M., & Cohen, L. (2007). Hierarchical coding of letter strings in the ventral stream: Dissecting the inner organization of the visual word-form system. *Neuron*, *55*, 143–156.

Vousden, J., Ellefson, M., Solity, J., & Chater, N. (2010). Simplifying reading: Applying the simplicity principle to reading. *Cognitive Science*, *35*, 34–78. doi:10.1111/j.1551-6709.2010.01134.x

Walker, M., Sainsbury, M., Worth, J., Bamforth, H., & Betts, H. (2015). *Phonics screening check evaluation*: *Final report*. National Foundation for Educational Research, U.K. Department for Education. Retrieved from https://www.nfer.ac.uk/publications/YOPC03/YOPC03.pdf

Wang, H., Castles, A., & Nickels, L. (2012). Word regularity affects orthographic learning. *The Quarterly Journal of Experimental Psychology*, *65*, 856–864. doi:10.1080/17470218.2012.672996

Wang, H., Castles, A., Nickels, L., & Nation, K. (2011). Context effects on orthographic learning of regular and irregular words. *Journal of Experimental Child Psychology*, *109*, 39–57. doi:10.1016/j.jecp.2010.11.005

Webster, N. (1787). *The American spelling book: Containing an easy standard of pronunciation. Being the first part of a grammatical institute of the English language*. Philadelphia, PA: Young and M'Cullough.

Weekes, B. S. (1997). Differential effects of number of letters on word and nonword naming latency. *The Quarterly Journal of Experimental Psychology*, *50*, 439–456. doi:10.1080/713755710

Willingham, D. T. (2006). The usefulness of brief instruction in reading comprehension strategies. *American Educator*, *30*(4), 39–50.

Willingham, D. T. (2017a). *The reading mind: A cognitive approach to understanding how the mind reads*. San Francisco, CA: Jossey-Bass.

Willingham, D. T. (2017b, March 27). What happens when you teach children to make inferences while reading? [Blog post]. Retrieved from http://www.danielwillingham.com/daniel-willingham-science-and-education-blog/what-happens-when-you-teach-children-to-make-inferences-while-reading

Wolf, M. (2007). *Proust and the squid: The story and science of the reading brain*. New York, NY: HarperCollins.

Wonnacott, E., Joseph, H., Adelman, J. S., & Nation, K. (2016). Is children's reading "good enough"? Links between online processing and comprehension as children read syntactically ambiguous sentences. *The Quarterly Journal* *of Experimental Psychology*, *69*, 855–879. doi:10.1080/17470218.2015.1011176

Woollams, A. M., & Patterson, K. (2012). The consequences of progressive phonological impairment for reading aloud. *Neuropsychologia*, *50*, 3469–3477.

Woollams, A. M., Ralph, M. A. L., Plaut, D. C., & Patterson, K. (2007). SD-squared: On the association between semantic dementia and surface dyslexia. *Psychological Review*, *114*, 316–339. doi:10.1037/0033-295X.114.2.316

World Literacy Foundation. (2015). *The economic and social cost of illiteracy: A snapshot of illiteracy in a global context*. Retrieved from https://worldliteracyfoundation.org/wp-content/uploads/2015/02/WLF-FINAL-ECONOMIC-REPORT.pdf

Wright, T. S., & Cervetti, G. N. (2017). A systematic review of the research on vocabulary instruction that impacts text comprehension. *Reading Research Quarterly*, *52*, 203–226. doi:10.1002/rrq.163

Yeari, M. (2017). The role of working memory in inference generation during reading comprehension: Retention, (re) activation, or suppression of verbal information? *Learning and Individual Differences*, *56*, 1–12. doi:10.1016/j.lindif.2017.04.002

Zevin, J. D., & Seidenberg, M. S. (2002). Age of acquisition effects in word reading and other tasks. *Journal of Memory and Language*, *47*, 1–29. doi:10.1006/jmla.2001.2834

Ziegler, J., Perry, C., Jacobs, A., & Braun, M. (2001). Identical words are read differently in different languages. *Psychological Science*, *12*, 379–384. doi:10.1111/1467-9280.00370

Ziegler, J. C., Bertrand, D., Tóth, D., Csépe, V., Reis, A., Faísca, L., . . . Blomert, L. (2010). Orthographic depth and its impact on universal predictors of reading: A cross-language investigation. *Psychological Science*, *21*, 551–559.

Ziegler, J. C., Jacobs, A., & Klüppel, D. (2001). Pseudohomophone effects in lexical decision: Still a challenge for current word recognition models. *Journal of Experimental Psychology: Human Perception and Performance*, *27*, 547–559.

Ziegler, J. C., Perry, C., & Zorzi, M. (2014). Modelling reading development through phonological decoding and self-teaching: Implications for dyslexia. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *369*, Article 20120937. doi:10.1098/rstb.2012.0397

Zoccolotti, P., De Luca, M., Di Pace, E., Gasperini, F., Judica, A., & Spinelli, D. (2005). Word length effect in early reading and in developmental dyslexia. *Brain and Language*, *93*, 369–373. doi:10.1016/j.bandl.2004.10.010

Zwaan, R. A., & Radvansky, G. A. (1998). Situation models in language comprehension and memory. *Psychological Bulletin*, *123*, 162–185. doi:10.1037/0033-2909.123.2.162