

Have We Forsaken Reading Theory in the Name of “Quick Fix” Interventions for Children With Reading Disability?

Donald L. Compton
Vanderbilt University

Amanda C. Miller
Regis University

Amy M. Elleman
Middle Tennessee State University

Laura M. Steacy
Vanderbilt University

Our contribution to this special issue on reading theory questions the effectiveness of the prevailing interventions intended to improve word-reading and reading comprehension skills in children with reading disability (RD). Our hypothesis is that we as a field may have inadvertently diluted reading theory in ways that compromise the power of intervention programs. For both word reading and reading comprehension we argue that current intervention programs target instruction at a knowledge level below that which is necessary to foster reading skill development that is “generative” in children with RD. Further, we contend that current interventions for children with RD fail to mimic and promote the inductive learning mechanisms that characterize typical reading development. Thus, we return to reading theory in an attempt to identify ways that current interventions may be reconceptualized to treat word-reading and reading comprehension deficits. In doing so, we call for the development of a new generation of reading interventions that target the fundamental knowledge structures and learning mechanisms known to support typical reading development.

Reading disability (RD) occurs in 5% to 10% of the school-age population constituting a serious public health problem, leading to lifelong difficulty in school and the workplace, and creating financial burdens on society (Fletcher, Lyon, Fuchs, & Barnes, 2006). Over the last several decades intense research efforts have been aimed at developing and disseminating validated intervention programs designed to improve the long-term reading development of children with RD. The motivation behind this effort arises from an understanding of the negative cognitive and social consequences associated with poor reading skills (Cunningham & Stanovich, 1998) and

the increased demands on literacy skill in our ever-evolving information-driven society (Snow, Burns, & Griffin, 1998).

Unfortunately, our best attempts at developing potent interventions to treat RD can best be described as producing limited successes. For instance, our most powerful researcher delivered code-based interventions aimed at ameliorating early word-reading problems leave as much as 10 to 15% of the population of children emerging from treatment with inadequate word-reading skills (O'Connor & Fuchs, 2013; Torgesen, 1998, 2000). In addition, many individuals identified as poor readers in high school or as adults still have significant word-reading difficulties (Barnes et al., 2012; Brasseur-Hock, Hock, Kieffer, Biancarosa, & Deshler, 2011; Bruck, 1992). Children who are “unresponsive” to our best word-level reading interventions pose serious challenges to our educational system (Perfetti, 2007; Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001). Moreover, there is growing skepticism among researchers over our present prescription of strategy-based instruction to improve the comprehension skill of children with RD (e.g., Hirsch, 2006; McKeown, Beck, & Blake, 2009; Solis et al., 2012). Kamhi (2009) recently argued that reading comprehension is not a skill but instead that it comprises a set of complex higher level mental processes that include thinking, reasoning, imagining, and interpreting. He takes this view to the extreme by offering a “narrow” view of reading that restricts the scope of reading development to only the learning of word recognition skills. Even those with more mainstream views on reading comprehension development have argued that instructional approaches targeting general strategies have only limited impact on measures of reading that include diverse content domains (see Willingham, 2006).

Is this the best we can do in developing intervention programs with the power to make significant long-term changes in the developmental trajectories of children with RD, or have we abandoned (or perhaps watered down) theory in order to produce interventions that are relatively fast and easy to implement? In this article we explore the idea that, as a field, we may have inadvertently diluted reading theory in ways that compromise the power of intervention programs to improve the reading skills of children with RD. Furthermore, we respond to our own criticisms of the intervention literature by proposing a set of theoretically derived alternatives to the word-reading and reading comprehension intervention approaches that currently dominate the field. Our suggestions for alternative approaches are not wholly supported by empirical evidence but instead are intended to serve as a heuristic for how we might return to reading theory to identify new approaches that can significantly improve the power of interventions to affect reading trajectories of children with RD.

We begin by adopting a view of reading development in which word-reading and comprehension skills are partially independent (e.g., Catts, Hogan, & Fey, 2003; Oakhill & Cain, 2012; Perfetti, Marron, & Foltz, 1996) allowing us to postulate a set of theoretically and empirically derived RD subtypes that have unique intervention needs in word reading, comprehension, or both. We then examine current practices in treating word-reading and comprehension deficits in light of Perfetti's component model of reading (Perfetti, 1992; Perfetti & Stafura, 2014 [this issue]; Perfetti, Landi, & Oakhill, 2005). We hypothesize that current code-based interventions designed to treat significant word-reading deficits rely too heavily on routines designed to foster “context-independent” decoding rules that inadvertently starve the evolving lexicon of fully specified orthographic representations (i.e., word representations) that help drive the development of advanced “context-dependent” decoding relationships (see Perfetti, 1992). We then move to reading comprehension, where we call into question what we believe to be an overreliance on

instruction designed to foster active engagement with text. We focus specifically on strategy instruction and argue that in its truest form this type of instruction ignores the fundamental role of reader knowledge in constructing the situation model.

In the case of both word reading and reading comprehension we argue that current intervention programs target knowledge structures that fail to foster reading skill development that is “generative” in children with RD. Furthermore, we contend that the knowledge structures targeted in current interventions for children with RD fail to mimic and promote the inductive learning mechanisms that characterize typical reading development (e.g., Harm & Seidenberg, 1999; Kintsch, 1998). We conclude the sections on word reading and reading comprehension with a general discussion of how current theory might be used to strengthen the reading interventions designed for children with RD by targeting knowledge structures and learning mechanisms that better promote inductive learning that characterize typical word reading and comprehension development. In doing so, we call for the development of a new generation of reading interventions that target the fundamental knowledge structures and learning mechanisms known to support skilled reading development.

SUBTYPES OF READING DISABILITY

Comprehension of written material requires the coordination of a complex set of skills. Thus, there are multiple sources of comprehension failure (e.g., Cain, Oakhill, & Bryant, 2000; Perfetti et al., 1996). Word-reading skills are strongly associated with comprehending text, particularly in the early stages of reading development (Rayner et al., 2001). Yet developmental studies provide evidence of significant independence between reading comprehension and word recognition (Catts, Adlof, Hogan, & Weismer, 2005; Florit & Cain, 2011; Olson, Keenan, Byrne, & Samuelsson, 2014 [this issue]), particularly as children become older. Specifically, the correlation between word identification and reading comprehension skills shifts around fourth grade when word-reading accuracy and reading comprehension are influenced by different skill sets (Johnston, Barnes, & Desrochers, 2008), leading to stronger correlations between reading comprehension and language skill (e.g., listening comprehension) and weaker correlations between reading comprehension and word identification (Stanovich, Cunningham, & Feeman, 1984). This partial independence between reading comprehension and word recognition skills that changes across development allows for three major subtypes of RD: children with word-reading problems only, comprehension problems only, and mixed word-reading and comprehension problems. These three subtypes can present during initial reading development (early-emerging RD) or after a phase of typical development (late-emerging RD; see Catts, Compton, Tomblin, & Bridges, 2011). Separate subtypes in word reading and comprehension indicate the need for effective intervention in each of these areas.

We further delineate the cognitive/linguistic and knowledge constituents that contribute to reading using a modified version of the component model of reading comprehension developed by Perfetti and colleagues (Perfetti, 1992; Perfetti et al., 2005). Figure 1 represents a trimmed-down version of the Perfetti model in which a situation model is constructed through the interactive building of representations influenced by various linguistic and knowledge sources. Consistent with the simple view of reading, two major levels of processing exist: (a) the identification of words via a visually accessible orthographic lexicon, and (b) the engagement of language processing mechanisms that assemble these words into messages. It is important to note that the

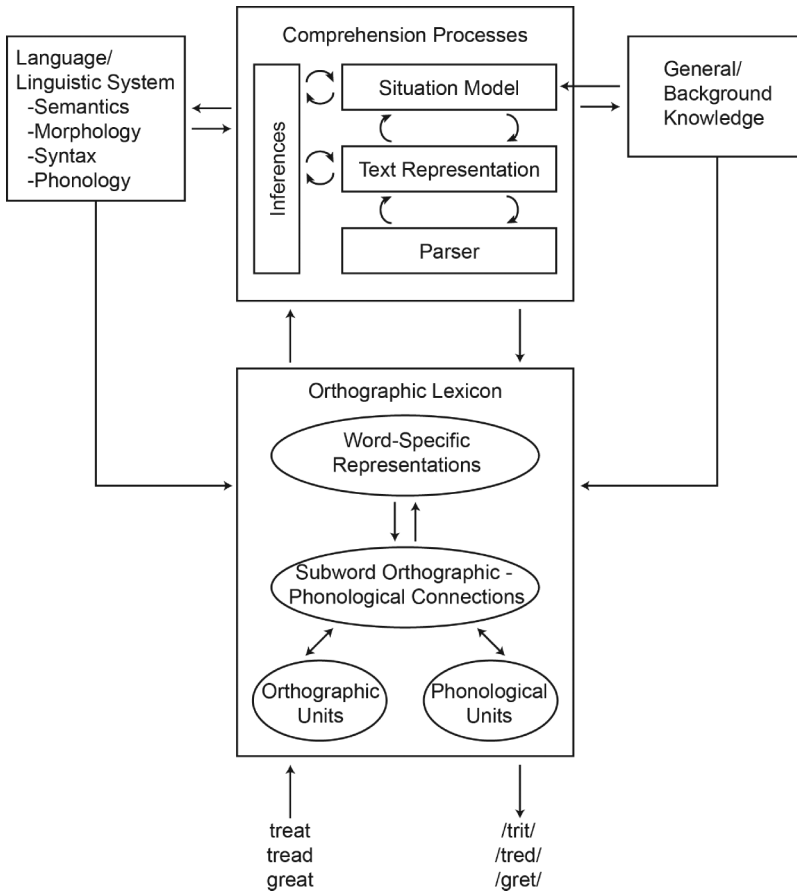


FIGURE 1 Modified version of the Perfetti et al. (2005) component model of reading comprehension.

resulting representations are not the result of exclusively linguistic processes but are critically enhanced by other knowledge sources (e.g., context dependent orthographic-phonological representations in the case of the orthographic lexicon and general/background knowledge in the case of comprehension processes). In the following sections we focus on the knowledge structures required to build high-quality lexical representations required for automatic word recognition (represented by the box labeled “orthographic lexicon” in Figure 1) and those that contribute to the building of a coherent situation model during reading (represented by the box labeled “comprehension processes” in Figure 1).

WORD-READING SKILL ACQUISITION

Acquiring a lexical system of representations that permits efficient word recognition is an essential part of learning to read in any language. In this article we have taken a decidedly

“English-centric” approach to the establishment of high-quality orthographic representations in the lexicon. However, we believe the problem of establishing these representations in children with RD is similar across all alphabetic orthographies; it’s just the manifestation of the symptoms that differ (e.g., accuracy issues in opaque orthographies and speed issues in transparent orthographies). A typically developing reader’s orthographic lexicon contains approximately 10,000 word specific representations (excluding inflectional forms) by eighth grade (Ehri, 2005; Harris & Jacobson, 1982). This requires a lexical system that can quickly establish and reliably retrieve word specific spellings that activate pronunciation, meaning, and syntax. As depicted in Figure 1, the orthographic lexicon comprises four major components (i.e., knowledge sources): word-specific representations, orthographic units, phonological units, and subword orthographic-phonological connections. Here we focus exclusively on just two of these knowledge sources: word-specific representations and subword orthographic-phonological connections.

As children learn to read, the orthographic lexicon changes in two important ways (Ehri, 2014 [this issue]; Perfetti, 1992). First, there is a continuous increase in the absolute number of orthographically addressable entries, referred to as “word-specific” representations. Word-specific representations are considered to be less dependent on phonological processes because these representations have been supplanted by specific connections linking spelling directly to pronunciations (Perfetti, 1992; Share, 1995). Several studies have reported that relatively few successful exposures to a word are required for the acquisition of word-specific representations in typically developing readers (e.g., Brooks, 1977; Ehri & Saltmarsh, 1995; Reitsma, 1983). This implies that word-specific representations form relatively rapidly as children develop reading skills and likely depend on individual differences in the frequency and richness of text reading (Cunningham & Stanovich, 1998).

The second developmental change in the orthographic lexicon associated with reading development is an increase in the overall quantity and quality of subword orthographic-phonological connections (Perfetti, 1992). Subword connections between orthographic and phonological codes exist at multiple levels: for instance, individual letter-phonemes, letter cluster-phonemes, letter cluster-rimes, letter cluster-syllables, and letter cluster-morphemes (Berninger, 1994). Early connections between orthography and phonology are initially based on simple one-to-one correspondences that are relatively insensitive to orthographic context (see Share, 1995). With reading development, initially incomplete and oversimplified representations become sophisticated context-dependent connections. These subword connections between orthographic and phonological units form what Gough, Juel, and Griffith (1992) referred to as the *cipher*. The cipher is best conceptualized as a set of *abstract* context-dependent relationships between orthography and phonology that are “implicit, very numerous, and very fast” (Gough et al., 1992, p. 38).

During reading development context-dependent subword connections evolve to represent the probabilistic co-occurrences and constraints that exist between orthographic and phonological units that resemble rule-like behavior (Perfetti, 1992). As a result, skilled readers come to realize that position within a word and surrounding letters affect correspondence between orthography and phonology. For example, *gh* occurs almost exclusively in initial and final positions and in the letter cluster *ght*. In the initial position *gh* is invariant and corresponds to /g/ as in *ghost*, in the final position *gh* varies between silent as in *though* and /f/ as in *cough*, and is silent when part of the *ght* cluster (see Venezky, 1999). Such knowledge affords flexibility in mapping variant associations and allows the reader to better match the letter string pronunciation

with a known vocabulary word. Although skilled readers process words rapidly without conscious employment of these context-dependent correspondences, they are knowledgeable of such relations upon reflection and can call upon them when confronted with the task of pronouncing unfamiliar words (Perfetti, 1992). We maintain that skilled readers develop and rely on complex “context-dependent” decoding rules to build fully-specified lexical representations, whereas children with RD tend to develop and rely on simplistic “context-independent” decoding rules that fail to promote fully specified lexical representations. We define context-independent connections as subword orthographic-phonological connections that are insensitive to word position and surrounding letters, less implicit, and slow and arduous to apply.

Thus, two lexical acquisition systems are at work as a child learns to read—the addition of word-specific entries and the expansion of context-dependent subword orthographic-phonological connections. These acquisition systems are mutually facilitative: “The more powerful the context-sensitive decoding rules (or analogic capabilities), the more entries the learner can acquire. And the more entries, the more powerful the decoding rules” (Perfetti, 1992, pp. 161–162). Disruptions in either of the two acquisition systems should compromise the system and affect reading development. To illustrate the relationship between word-specific knowledge, context-dependent subword connections, and instruction in children with word-reading RD, we explore the possibility that focused decoding instruction (or the lack of it) may result in lexical asymmetry. We argue that asymmetry occurs when one of the lexical subsystems grows without concomitant growth in the other system, resulting in disruption of orthographic lexicon development and word-reading impairment.

Lexical Asymmetry in Children With RD and the Role of Instruction

Compared with nondisabled children, children with RD require a greater number of successful exposures to a given word to establish a stable and reliable word-specific representation. Ehri and Saltmarsh (1995) hypothesized that children with RD lack sufficient “graphophonic” knowledge (analogous to subword orthographic-phonological connections) to fully analyze matches between orthographic and phonological units in order to store complete word-specific representations. Deficits in phonemic awareness skill likely limit the growth of important subword connections in children with RD and result in a general tendency to process only partial information about words. This is consistent with the view that “unremediated” children with RD may be overreliant on a global processing strategy that accords insufficient attention to individual letters or groupings of letters (Ehri & Saltmarsh, 1995; Frith, 1985). The result is that unremediated children tend to add word-specific representations to the lexicon without associated growth in subword orthographic-phonological connections.

Connectionist models have simulated this asynchrony between word-specific representations and subword orthographic-phonological connections in children with RD. Harm and Seidenberg (1999) simulated phonological dyslexia by impairing the representations of phonological information before training the model to read words. Results showed that in the normal reading system, neighbor words such as *meat*, *treat*, and *eat* showed only small differences in their activation patterns, indicating that the rime pattern represented by *eat* is represented in hidden units of close proximity. However, the phonologically impaired reading system formed divergent representations in which words sharing the same rime were represented in hidden units distributed across a larger space of hidden units. The difference in the distribution of hidden units across the two

models also resulted in qualitatively different performance on nonword reading with only the typical model correctly pronouncing the nonword *geat*. In the case of the impaired model the representations developed for the words containing the rime *eat* did not overlap enough to allow for the correct pronunciation of *geat*.

We maintain that unremediated RD presents itself developmentally as an overreliance on word-specific information at the expense of context-dependent subword orthographic-phonological connections (i.e., graphophonetic knowledge), resulting in an asymmetric lexicon. That is, word-specific entries are added to the lexicon, albeit more slowly, without a corresponding expansion of subword orthographic-phonological connections. It is important to note that Harm and Seidenberg view this dependence on orthographic structure in dyslexia not as a strategy but as a consequence of how the mapping between orthography and phonology is learned.

At the other end of the continuum are RD children who have received explicit and systematic training in “context-free” phonological decoding skills (see Lyon, 1998; Swanson, 1999). We refer to these intervention programs as “context free” because grapheme–phoneme connections are generally taught in isolation without systematically linking these relations to the context of specific words. The rationale for systematic decoding intervention, with associated emphasis on phonological processing, has been that if deficits in phonological-decoding skill can be eliminated through focused instruction, then the acquisition of word-specific representations can commence through successful application of decoding rules (see Share, 1995). Intervention studies designed to improve decoding skills of children with RD (e.g., Foorman et al., 1997; McCandliss, Beck, Sandak, & Perfetti, 2003; Olson, Wise, Ring, & Johnson, 1997; Torgesen et al., 2001) have demonstrated that systematic instruction in phonemic awareness and decoding skills results in significant and lasting improvements in nonword decoding but much less so in real word identification. Results have not supported the efficient transfer of decoding skill gains to word reading via a self-teaching process (see Share, 1995). In fact, there is an evolving literature to suggest that, at the item level, successful decoding of a novel word is not sufficient to guarantee that the word will be added as a word-specific entry in the orthographic lexicon (Nation, Angell, & Castles, 2007; Wang, Nickels, Nation, & Castles, 2013). Torgesen, Wagner, and Rashotte (1997) succinctly summed up the problem as follows:

We have not yet demonstrated that we understand the conditions that need to be in place for children with phonologically-based reading disabilities to acquire the level or type of phonetic reading skills that can be utilized within a self-teaching framework to produce advantages in the development of a rich orthographic reading vocabulary. (p. 230)

We speculate here that the use of context-independent, phonologically based decoding instruction to remediate word-reading deficits may actually encourage the use of smaller orthographic units and promote “letter-by-letter” reading. This is particularly problematic in English where correspondences between orthography and phonology are inconsistent with respect to small reading units (letters or letter clusters corresponding to single phonemes) but more consistent with respect to larger reading units, such as rimes or syllables (Treiman, Mullenix, Bijeljac-Babic & Richmond-Welty, 1995). Psycholinguistic grain size theory (Ziegler & Goswami, 2005) predicts that English-speaking children need to use a variety of recoding strategies, supplementing grapheme–phoneme conversion strategies with the recognition of larger letter patterns and whole word recognition.

Although we are not aware of studies that have directly examined the effects of context-independent decoding instruction on the size of orthographic units preferred by dyslexic children, serial reading strategies and stronger word length effects have been reported for children with dyslexia (Martens & de Jong, 2006; Ziegler, Perry, & Coltheart, 2003; Zoccolotti et al., 2005), perhaps reflecting impairment in the application of larger orthographic units in parallel when reading unfamiliar words (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001). The characterization of children with dyslexia as using smaller orthographic units during word reading is also supported by studies in which they were found to make more eye movements per word than normal readers (De Luca, Borrelli, Judica, Spinelli, & Zoccolotti, 2002; Hutzler & Wimmer, 2004). However, we are unable to attribute the persistence of letter-by-letter reading in children with RD to be the consequence of a particular intervention strategy. Instead we are left to postulate that the use of context-independent decoding instruction for children with RD has the unforeseen consequence of promoting reliance on a letter-by-letter reading strategy that promotes under reliance on lexical processing (Barca, Burani, Di Filippo, & Zoccolotti, 2006; Coltheart et al., 2001), resulting in a lexicon that develops asymmetrically with subword orthographic–phonological connections being established without a corresponding expansion of word-specific entries.

A Modest Proposal for the Next Generation of Word-Reading Interventions

Our vision for the next generation of word-reading interventions is one that promotes advanced decoding skill and word identification development through explicit instruction in subword orthographic–phonological connections in conjunction with equivalent additions of word-specific entries achieved through mastery word learning, thus promoting symmetric growth of the two orthographic lexicon systems as described by Perfetti (1992). Furthermore, we argue that care be taken in designing the next generation of word-reading interventions so as to promote typical learning mechanisms in children with RD. Connectionist models provide hints about the nature of these learning mechanisms (Foorman, 1994). These models mimic human reading acquisition by using back-propagation as the basic learning mechanism that adjusts the weighted probabilistic relations between orthography and phonology as a function of the training corpus of words. We substitute back-propagations with more traditional teaching methods that promote the simultaneous growth of subword orthographic–phonological connections and word-specific entries in the developing reader. We propose that explicit instruction in subword orthographic–phonological connections along with exposure to well-developed training corpora of words should, in theory, promote subword connections that represent the probabilistic co-occurrences and constraints that exist between orthographic and phonological units. We advocate for the use of mastery learning of items (see Slavin, 1987) within each training corpus to allow for the formation of long-term word-specific representations (see Levy & Lysynchuk, 1997) as well as context-dependent subword orthographic–phonological connections.

It is our hypothesis that the development of context-dependent connections can take place only through deducing the implicit structure of spelling–sound relations across a large pool of words. Thus in adopting a connectionist approach to the development of the orthographic lexicon in children with RD we focus on the creation of skillfully constructed training corpora of words that allow subword orthographic–phonological connections of multiple sizes to be taught in conjunction with the addition of highly useful word-specific entries. We suggest that a focus

on training corpora (i.e., the words to be trained), in conjunction with effective instruction in subword orthographic–phonological connections and word-specific representations, may provide an opportunity for children with RD to induce statistical knowledge of context-dependent orthographic-to-phonological relationships that exist in the English orthography. In this way we hope to mimic a connectionist model’s ability to propagate probabilistic learning through a set of learning experiences that allow the model, in this case the developing reader, to correctly induce statistical knowledge of context-dependent orthographic-to-phonological relations within the learning experiences of individual words. For instance, the vowel combination *ea* when not following *r* is known to be pronounced as /i/ approximately 63% of the time (e.g., *meat*), 27% of the time as /ɛ/ (e.g., *threat*), with the remaining 10% spread across /e/ (e.g., *great*), /ə/ (e.g., *ocean*), and /I/ (e.g. *Chelsea*). Thus, training corpora should reflect this variance in the correspondence between orthography and phonology across important orthographic units. This is similar to Venezky’s (1999) recommendation that “to learn, for example that *c* has one pronunciation before *e*, *i*, *y* and another pronunciation elsewhere, children require lots of words with these patterns” (p. 232). New tools allow for diverse training corpora to be constructed that permit context-dependent decoding rules to be present in a set of words that vary systematically both orthographically and phonologically. For example, the English Lexicon Project (Balota et al., 2007) and Children’s Printed Word Database (Masterson, Stuart, Dixon, & Lovejoy, 2010) allow sets of words to be identified that are in close proximity orthographically and phonologically using a Levenshtein distance generation function while also specifying other important word-level factors (e.g., length, frequency, orthographic structure, etc.). The challenge then is to establish how best to select words for training corpora, control exposures, and vary instruction across whole word and subword units in a way that both lexical systems develop simultaneously in a supportive manner.

READING COMPREHENSION SKILL ACQUISITION

Much of the instructional research on reading comprehension has focused on strategy instruction as a means to engage students with text and help them monitor their comprehension as evident by reviews such as the National Reading Report (National Institute of Child Health and Human Development, 2000). This focus is warranted as evidenced by the effectiveness of strategy instruction especially for struggling readers (Gersten, Fuchs, Williams, & Baker, 2001; National Institute of Child Health and Human Development, 2000). However, it is unclear whether increased comprehension can be attributed to learning specific strategies. In their review of strategy instruction, Rosenshine and Meister (1994) noted that it did not matter which strategies were combined; as long as multiple strategies were used, students’ comprehension increased. In fact, it may not be the strategies themselves that engender changes in comprehension, but possibly some other factors that strategy instruction fosters, such as deeper engagement with the text and awareness of the need to monitor comprehension.

Our intent here is not to argue against the positive role strategy instruction may play in increasing engagement with text but instead to highlight unforeseen consequences associated with this type of instruction. We propose that strategy instruction may result in low-level text representations that embody only what is explicitly expressed in a text but may not transfer to other texts. Low-level representations are likely sufficient to reproduce the text but lack what is necessary to

construct a “deeper understanding” of the meaning of the text (see Kintsch & Rawson, 2005). Deep level understanding of a text, on the other hand, goes beyond the text in nontrivial ways, requiring the construction of meaning through inference making, not just passive absorption of information. Thus, we argue that the probability of promoting deep comprehension in children with RD is maximized through instruction that emphasizes the building and activation of relevant background knowledge as it applies to the text.

Background Information and the Situation Model

Returning to the component model of reading depicted in Figure 1, reading comprehension occurs as the reader builds a mental representation of the text. The building of the mental representation occurs across word, sentence, paragraph, and text and includes processes such as word identification, parsing of word strings into constituents, referential mapping of meaning, and a variety of inference processes all of which interact with the reader’s general/background knowledge and language skills. The majority of comprehension theorists suggest that there are at least two levels of representation: a text-based representation and a situation model (e.g., Kintsch & Rawson, 2005; Perfetti et al., 2005). The text representation conveys the underlying meaning of the text’s explicit information (McNamara & Magliano, 2009). The situation model involves the intertwining of the reader’s background knowledge with the text-based representation to form a deep representation of the text. Thus, the situation model is a more meaningful representation that goes beyond the text-based information (Kintsch, 1988), is cumulative, and evolves as one progresses through the text. Kintsch (2009) argued, “A major problem in school learning is the student’s failure to construct a situation model at all, or the inability to construct an adequate one” (p. 225). Furthermore, we maintain that failure to construct situation models during reading is an acute symptom associated with reading comprehension disability.

A number of studies have reported that individual differences in background knowledge significantly influence the building of a representative situation model (e.g., Chiesi, Spilich, & Voss, 1979; Kendeou & van den Broek, 2005, 2007; McNamara, de Vega, & O’Reilly, 2007; Miller & Keenan, 2011). Accordingly, an increased number of text-based and knowledge-based links allows for the formation of a more coherent mental representation of the text (Kintsch, 1998; McNamara et al., 2007). Readers who possess high levels of knowledge consistently exhibit better comprehension and retention than readers with low levels of knowledge (Chiesi et al., 1979; Langer & Nicolich, 1981). Even something as minimal as knowing the title of a story can completely alter a reader’s situation model (Bransford & Johnson, 1972). It has been suggested that greater activation due to well-connected knowledge structures facilitates retrieval and inference generation (see Kintsch & Rawson, 2005). In fact, Kintsch and Kintsch (2005) argued that most inferences in skilled readers are only a matter of knowledge retrieval, thus implicating the primary role of knowledge in inference making. Increased knowledge may also reduce the demands put on working memory (Ericsson & Kintsch, 1995; McNamara et al., 2007).

The Role of Knowledge in Poor Comprehenders

Poor readers tend to differ from good readers not only in the amount of knowledge they possess but also in how they make use of their knowledge to facilitate comprehension (Bransford, Stein,

Shelton, & Owings, 1981; Oakhill, 1983). For instance, Cain and colleagues have shown that that even when students have the requisite knowledge to make an inference, poor comprehenders do not apply that knowledge when answering inferential questions (Cain & Oakhill, 1999). Further when training students in a knowledge base and then asking literal and inferential questions good and poor comprehenders were equally adept at answering the literal questions, but the good comprehenders were better at answering the inferential questions (Cain, Oakhill, Barnes, & Bryant, 2001). Other studies have also demonstrated that skilled readers are more likely than less skilled readers to generate a topic-related inference during text comprehension, to integrate the text with preceding context, and to answer inferential questions (Long, Oppy, & Seely, 1994; Wilson, 1979).

Compton, Miller, Gilbert, and Steacy (2013) further examined the contribution of knowledge to comprehension processes by asking good and poor fifth-grade readers to read or listen to passages and answer questions. Results indicated that having some knowledge about a passage's topic, which poor readers had less of, was positively associated with the likelihood of correctly answering questions about that passage. In addition, general knowledge and vocabulary knowledge remained significantly associated with correct responses even while controlling for passage specific knowledge. (Again, poor readers possessed less general knowledge and vocabulary knowledge compared to good readers.) Finally, regardless of passage-specific background knowledge, questions about information stated literally in the text were easier to answer than questions that required inference. Results suggest that multiple forms of knowledge, both passage specific and general, are likely required to form coherent and high-quality representations of text.

Miller and Keenan (2009) examined the influence of background knowledge on poor readers' ability to recall ideas that were either central or peripheral to the text's overall meaning. They compared the recall performance of good and poor readers with and without background knowledge of the passage topic. Without background knowledge, poor readers showed their greatest deficit relative to good readers in recalling the text's central ideas—a "centrality deficit." However, when aided by background knowledge, poor readers no longer showed a centrality deficit relative to good readers. Results suggest that background knowledge may serve as a compensatory tool and enhance poor readers' ability to recognize and recall the text's most important ideas.

Overall, these studies suggest that various forms of knowledge (i.e., general world knowledge, passage specific knowledge, vocabulary knowledge) allow for inference making, building of a coherent representation, and subsequent recall of text. Studies also suggest that compared to good readers, poor readers tend to have less well-developed knowledge structures as well as problems accessing and using their knowledge to make inferences and build coherent representational models of text. There is some evidence to suggest that providing poor readers with passages containing information in which they possess background knowledge may improve comprehension performance (Miller & Keenan, 2009; Recht & Leslie, 1988; Shapiro, 2004). However, it does not appear that this is sufficient to compensate for inferencing difficulties experienced by children with RD (Cain et al., 2001). In the next section we outline what we believe to be theory-based instructional components that hold potential to improve the reading comprehension skills of children with RD.

An Even More Modest Proposal for the Next Generation of Reading Comprehension Interventions

In suggesting new instructional components for the next generation of reading comprehension interventions for children with RD we focus on three evolving and potentially promising areas: (a) employing a microworld strategy within texts to provide relevant knowledge prior to reading, (b) using latent semantic analysis (LSA) across texts to cluster diverse readings around a relevant theme to build diverse background knowledge, and (c) providing explicit inference making instruction to increase the probability that children will integrate background knowledge into the building of situation models. These three components are intended to build knowledge, improve inferencing, and promote the construction of a coherent situation model. Our view is that these instructional components need to be clustered together into a comprehensive instructional program that allows children with RD to build and utilize new knowledge to improve reading comprehension skills. The focus on the building of a situation model is in keeping with our desires to design interventions that promote typical learning mechanisms in children with RD. In focusing on the construction of the situation model as opposed to strategies that promote access to the text representation we, by necessity, are forced to grapple with how to promote knowledge production and inference making in poor readers.

Microworld knowledge building. There is overwhelming evidence supporting the primary role of prior knowledge in facilitating the construction of a coherent situation model during reading (McNamara & Kintsch, 1996; Rawson & Van Overschelde, 2008). However, poor readers often bring limited or incomplete background knowledge to the task of reading (see Johnston et al., 2008). We advocate for the building of “microworld” knowledge in RD children prior to reading to provide the background knowledge necessary to facilitate inference making and building of the situation model. We borrow the term “microworld” from computational modeling of discourse comprehension (see Frank, Koppen, Noordman, & Vonk, 2008). Microworld knowledge refers to a restricted set of events or situations in the world, extracted from the larger corpora of real-world events, which contain causal knowledge required to understand the text. In a computational model study using microworld knowledge, Frank, Koppen, Noordman, and Vonk (2003) demonstrated that the model was able to make correct temporal inferences when new story statements were added by updating its representation of the story’s situation in accordance with its temporal knowledge of the microworld.

Certainly there are dangers in taking the microworld analogy too far in terms of how it might be used to help instruct children with very poor comprehension skill. The Frank et al. (2003) simulation was based on a very simple story consisting of four consecutive situations. In addition, the microworld approach is limited by the fact that models cannot process text dealing with events outside the microworld. However, the prospect of providing poor readers with a restricted set of events or situations related to the text that increase the probability that correct inferences will be made and a coherent model of text constructed is attractive. It is important to note that we are not equating creating microworld knowledge structures with low-level prereading activities thought to activate readers’ prior knowledge. Instead, we believe that computational modeling techniques should be brought to bear on the problem of determining the type of information and how it should be delivered to poor readers in order to facilitate comprehension. The science of modeling

complex discourse is evolving quickly, and our hope is that at least some of those involved in this work will focus on the problems of poor comprehenders.

General knowledge building. Stanovich, West, Cunningham, Cipielewski, & Siddiqui (1996) argued that individual differences in reading experience (a side effect of differences in comprehension ability) affect both the development of cognitive processes and knowledge bases that support further gains in comprehension growth. Thus, enhancing students' world knowledge through text reading potentially kills two birds with one stone by increasing background knowledge and providing ample opportunity to practice and refine reading comprehension skills. Studies examining the factors involved in extracting information from text suggest that learning from text is the result of a complex interaction of text and reader characteristics (e.g., Clinton & van den Broek, 2012; Linderholm et al., 2000; McNamara, Kintsch, Songer, & Kintsch, 1996).

The question then is how to structure text reading opportunities to build diverse world knowledge that will improve the reading comprehension skills of RD children? LSA techniques could potentially be used to select texts that cover diverse topics of interest to the reader that build related world knowledge (see Landauer, Foltz, & Laham, 1998). LSA is a technique for extracting and inferring relations of expected contextual usage of words in passages of discourse (for details, see Landauer & Dumais, 1997; Landauer et al., 1998). LSA represents the words and sets of these words (e.g., a sentence, paragraph, or text) as vectors in multidimensional "semantic space." Complete texts can be represented as a single vector in LSA and the relationship between texts judged by the proximity of text vectors (represented by the cosine values). Thus, LSA could be used to select a diverse set of texts to help build world knowledge across a more varied relational space and theoretically outperform a teacher's ability to select multiple texts on the same topic (see Wolfe et al., 1998). The long-term goal would be to provide poor readers with a choice of high interest texts that systematically build knowledge (see Clinton & van den Broek, 2012). Although there have not been studies attempting to use LSA in this way to cluster texts to build world knowledge, theoretically it seems possible.

Inference making. The literature is clear concerning the importance of inference making in skilled reading and the generally poor inference making skills of poor comprehenders (Cain & Oakhill, 1999; Cain et al., 2001; Elleman, Compton, Fuchs, Fuchs, & Bouton, 2011). We have argued that knowledge building is fundamental to inference making during reading. However, studies suggest that even with relevant topic knowledge some poor readers may still struggle with inference making, and thus we suggest explicit inference training in addition to knowledge building. (We acknowledge that inference-making instruction can be conceptualized as strategy training, but feel it is a necessary component in new intervention programs for many children with reading comprehension difficulties.) Teaching students to "read between the lines" has been found to be effective across age groups ranging across primary (Yuill & Joscelyne, 1988), elementary (Elbro & Buch-Iversen, 2013; Emery & Milhalevich, 1992; Hansen & Pearson, 1983), and secondary students (Spires & Donley, 1998). In addition, although higher order skills are considered difficult to teach, many inference-training studies demonstrate positive effects in relatively short periods (Hansen & Pearson, 1983; Holmes, 1985; Sundbye, 1987). Inference generation has also been shown to be valuable for improving the higher order comprehension of less skilled readers, including those with learning disabilities (e.g., Sundbye, 1987) and poor comprehension (e.g., Yuill & Joscelyne, 1988).

A number of methods have been shown to be effective at improving inferential comprehension, including self-generated elaborations (King, 1994; Spires & Donley, 1988; Stein et al., 1982), activation and use of prior knowledge (e.g., Hansen & Pearson, 1983), practice in answering inferential questions after reading text (Seifert, 1993; Stitt, 1967) or at important junctures within the text (e.g., Carnine, Kameenui, & Woolfson, 1982; Sundbye, 1987), and understanding character perspectives (e.g., Emery & Milhalevich, 1992). One technique that consistently results in positive effects on increasing inferential comprehension in both skilled and less skilled readers is the use of textual clues (Holmes, 1985; Reutzel & Hollingsworth, 1988; Yuill & Joscelyne, 1988; Yuill & Oakhill, 1988). In general, this technique asks readers to identify key words, generate questions, make predictions, and infer setting and consequences. However, because knowledge is requisite for forming many types of inferences (Kintsch & Kintsch, 2005), inference training in the absence of knowledge development will not, in our opinion, result in the coherent building of situation models that characterize skilled reading.

CONCLUSIONS

In this article we question the effectiveness of current intervention approaches designed to ameliorate word identification and reading comprehension deficits in children with RD. In terms of word reading we argue against the long-term effectiveness of context-independent decoding instruction as an approach to efficiently add words to the orthographic lexicon via a self-teaching process. We contend that such an approach may inadvertently starve the evolving lexicon of fully specified orthographic representations (i.e., word representations) that drive the development of advanced “context-dependent” decoding relationships. In its place we advocate for word-reading interventions that promote advanced decoding skill and word identification development through explicit instruction in subword orthographic–phonological connections in conjunction with equivalent additions of word-specific entries achieved through mastery word learning, thus promoting symmetric growth of the two orthographic lexicon systems. The cornerstone of our approach focuses on the creation of carefully constructed training corpora of words that allow subword orthographic–phonological connections of multiple sizes to be taught across multiple words while the words are systematically added to the orthographic lexicon. In this way we hope to promote probabilistic learning of the co-occurrences and constraints that exist between orthographic and phonological units in the English orthography.

In terms of reading comprehension, we maintain that failure to construct situation models during reading is an acute symptom associated with reading comprehension disability. Furthermore, we argue that strategy instruction results in low-level text representations that do not result in the construction of an accurate situation model. Thus we focus on the privileged relationship between knowledge, inference making, and the construction of the situation model. We advocate for the building of passage-specific knowledge using a microworld approach during prereading activities, building of general world knowledge across texts by clustering diverse readings using LSA, and providing inference making instruction to assist children with RD in using knowledge to make correct inferences that result in the construction of the situation model. We hope the approach we have taken in this article will encourage researchers to begin the arduous, but critical and ultimately rewarding, task of developing and testing the next generation of reading interventions for children with RD.

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