A Research Review of Cognitive Skills, Strategies, and Interventions for

Reading Comprehension

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Reading Comprehension: Cognitive Skills, Strategies, and Interventions

The purpose of this paper is to provide an overview of the research on reading comprehension, including the cognitive processes employed during comprehension of text, the cognitive deficits associated with poor comprehension, and the research-based characteristics of interventions for improving reading comprehension skills.

Overview of Reading Comprehension

Comprehension is the essence of reading and the active process of constructing meaning from text (Durkin, 1993). Reading comprehension is a complex interaction among automatic and strategic cognitive processes that enables the reader to create a mental representation of the text (van den Broek & Espin, 2012). Comprehension depends not only on characteristics of the reader, such as prior knowledge and working memory, but also on language processes, such as basic reading skills, decoding, vocabulary, sensitivity to text structure, inferencing, and motivation. Comprehension also requires effective use of strategic processes, such as metacognition and comprehension monitoring. As readers mature in their comprehension skills, they are able to progress efficiently from the stage of learning to read to the ultimate goal of reading to learn (Yovanoff, Duesbery, Alonzo, & Tindal, 2005).

The National Assessment of Educational Progress (NCES, 2012) revealed that 24% of eighth graders and 33% of fourth graders tested below basic in reading skills in 2011. Further, on the International Assessment of Adult Competencies Literacy Scale (USDE, 2012), adults in the United States achieved an average literacy proficiency score of 270 on a scale of 0 to 500—3 points below the international average score of 273! These results indicate a need to examine

current practices in reading comprehension instruction. Because comprehension is so complex and requires multiple cognitive skills and stored memory, several barriers to improving comprehension must be overcome. First, we must be able to identify weaknesses in specific cognitive skills. Further, we must also have procedures for enhancing those specific skills rather than general interventions that target a limited number of skills without regard for identified strengths or weaknesses. Finally, we have to recognize that several components of comprehension—such as prior experience and vocabulary—are acquired over time, making them difficult targets for training and intervention. Therefore, the next section highlights research that identifies the cognitive skills and processes required for the development of reading comprehension ability, followed by research supporting effective interventions for reading comprehension development.

The Role of Cognitive Skills in Reading Comprehension

Fluency. Fluency is a prerequisite skill to comprehension. It is the automatic recognition of words that frees up the cognitive capacity required for comprehending the meaning of the words (Pressley, 2002). Considered a bridge between decoding and comprehension (Pikulski & Chard, 2005), reading fluency took center stage after the results from the National Reading Panel (2000) were published. Although early studies recognized decoding as the skill that predicted differences in comprehension skills between children (Stanovich, 1986), a landmark study of struggling readers revealed that only those who practiced reading the words until they automatically recognized them were able to accurately answer comprehension questions about the text (Tan & Nicholson, 1997). A study of at-risk second graders also revealed that accuracy and rate of oral reading uniquely predicted comprehension ability

(Berninger, Abbott, Vermeulen, & Fulton, 2006). However, fluency appears to be a larger influence in developing reading comprehension skills for younger readers compared to older ones. As text becomes more challenging with each grade level, fluency becomes less predictive of reading comprehension and, instead, gives way to vocabulary (Yovanoff, Duesbery, Alonzo, & Tindal, 2005). In a multivariate study of Florida students' reading comprehension scores, Schatschneider et al. (2005) discovered that oral reading fluency did explain the differences in comprehension among third grade students while vocabulary emerged as a major factor among older students. In the section that follows, research on the role of vocabulary in comprehension development is discussed.

Vocabulary and Semantic Processing. In order to extract meaning from text, a strong sense of semantics is required. That is, children have to understand what words mean before they can construct understanding of text passages. The first empirical study of the correlation between word knowledge and reading comprehension was published over 70 years ago (Davis, 1942), and has been replicated in decades of research consistently identifying knowledge of vocabulary as a primary predictor of reading comprehension development (Thorndike, 1973; Beck, Perfetti, & McKeown, 1982; Carroll, 1993; Torgeson et al., 1997; de Jong & van der Leij, 2002; Braze, Tabor, Shankweiler, & Mencl, 2007). In one longitudinal study of children from kindergarten through second grade, Roth, Speece, and Cooper (2002) discovered that vocabulary skills, such as oral definitions and word retrieval, were the best predictors of reading comprehension development. A similar study of at-risk second graders revealed that verbal IQ was a statistically significant predictor of reading comprehension in both the beginning and end of school year assessments (Berninger, Abbott, Vermeulen, & Fulton, 2006). Further,

vocabulary knowledge is a consistent predictor of reading comprehension from fourth through eighth grades as well (Bos & Anders, 1990; Yovanoff, Duesbery, Alonzo, & Tindal, 2005).

Finally, research suggests that students with poor comprehension exhibit a lack of semantic awareness characterized by an inability to attach meaning to words (Sencibaugh, 2007). In a comprehensive review of research, the National Reading Panel (2000) concluded that vocabulary instruction facilitates the development of reading comprehension, especially when students are repeatedly exposed to vocabulary words. Further, the Panel recommended explicit instruction in vocabulary through a variety of active learning methods and contexts. Indeed, the preponderance of research indicates that vocabulary is a key contributor to reading comprehension development.

Visualization. Another key component of reading comprehension is the active construction of a mental image of the text. These mental images are fluid and change as the reader continually assimilates new text (Woolley, 2010). Visualization is an application of the dual-coding theory of reading (Sadoski & Paivio, 2004), the concept that readers process both visual representations of verbal information and of objects to create meaning. Also referred to as mental imagery, research suggests that this skill contributes to comprehension (Pressley, 2002; National Reading Panel, 2000) and enhances memory of the text (Romeo, 2002).

Instruction in visualization is supported by research as well. In a large-scale study of Pueblo County Schools, third through fifth graders trained in mental imagery while reading made greater reading comprehension gains than their matched control group (Sadoski & Wilson, 2006). In addition, Center et al. (1999) and Brown et al. (1995) found statistically significant correlations between visualization training and reading comprehension scores of students when used as part of a multiple-strategy instruction intervention.

Working Memory. Working memory has also been identified as an integral part of reading comprehension. Working memory is defined as an executive function responsible for keeping and updating information in the mind (Rothlisberger, Neuenschwander, Cimeli, & Roebers, 2013). Further, working memory is responsible for managing the process of extracting information from text and integrating it with prior knowledge to create meaning (Garcia-Madruga et al., 2013). Sequences of text-based information are held in working memory and integrated with new incoming text and with prior knowledge held in long-term memory. Research has established a correlation between working memory and comprehension (Cain, Oakhill, & Bryant, 2004). In two studies, Seigneuric (2000, 2005) and his colleagues found working memory to be a direct predictor of reading comprehension scores among third and fourth graders, although not significant for first and second graders. Further, a similar result emerged from a study of 8 to 16 year olds, identifying working memory as a statistically-significant predictor of reading comprehension (Christopher et al., 2012). The findings from these three studies suggest that as text complexity increases with grade level, a greater amount of working memory is needed for assimilating longer sentences with new vocabulary into rapidly changing mental images. However, recent research indicates that composite executive function scores are statistically significant predictors of reading comprehension scores in pre-kindergarten through third grade as well (Rothlisberger, Neuenschwander, Cimeli, & Roebers, 2013). Indeed, working memory seems to play a critical role in reading comprehension across age groups.

Reasoning and Inference. Inferential reasoning is the ability to use information in the text to determine additional information that is only implied by the text. In a review of studies on inference skills for reading, researchers at the National Foundation for Educational Research

(2008) discovered that the ability to draw inferences is directly related to reading comprehension ability. In unrelated studies, Cain and Oakhill (1999, 2007) reported that students' inferencing skills contribute to future comprehension skills; and Bowyer-Crane and Snowling (2005) discovered that students with poor comprehension also lack inferencing ability.

The process of inferential reasoning requires both short-term and long-term memory, acting on retrieval of background knowledge combined with the text to arrive at the implicit information from the text (NFER, 2008). In a study of the factors that contribute to reading comprehension among Florida students, Schatschneider et al. (2005) discovered that in addition to verbal knowledge, reasoning ability was the dominant factor among 10th grade students' reading comprehension scores. The growing body of research continues to acknowledge the role of reasoning and inferencing abilities in reading comprehension.

The Role of Cognitive Strategies and Metacognition in Reading Comprehension

Although cognitive skills are indeed prerequisites for reading comprehension, cognitive strategies are also required. Cognitive strategies differ from cognitive skills because they are active, rather than passive, processes. Metacognition is commonly referred to as thinking about thinking. In reading, metacognition refers to control of cognitive strategies that help the reader process new information from text (Kuhn, 2000). Based on a comprehensive review of research, the National Reading Panel (2000) identified several strategies that contribute to successful reading comprehension: prediction, activating prior knowledge, questioning, visualizing, monitoring and clarifying, and drawing inferences. Further, the Panel identified 38 studies that indicated that the coordination of multiple cognitive strategies while reading improves reading comprehension and text memory.

A study conducted with 45 third graders found statistically significant differences in cognitive strategy used between high achieving and low achieving students; further, metacognitive use of strategies was positively correlated with reading comprehension scores (Dermitzaki, Andreou, & Paraskeva, 2008). Pressley (2002) also asserts a correlation between students' metacognition and reading comprehension scores; and Oakhill and Cain (2007) discovered that students' ability to monitor their comprehension at age eight significantly predicted their reading comprehension skill at age 11.

Research continues to identify metacognition and cognitive strategies as key contributors to reading comprehension development. Conversely, a primary deficit in poor comprehenders is the inability to employ metacognitive strategies during reading. Dermitzaki, Andreou, and Paraskeva (2008) identified a lack of planning, comprehension monitoring, analyzing, and prioritizing important text as key deficits among third graders with low reading comprehension achievement. While many poor comprehenders lack metacognitive strategies, others are simply unable to select or use strategies effectively (Horner & Shwery, 2002). Therefore, reading comprehension requires knowledge of cognitive strategies as well as effective use and control over them.

The Role of Background Knowledge in Reading Comprehension

As described in the prior section, the ability to activate prior knowledge is a cognitive strategy needed for effective reading comprehension. More specifically, background knowledge is necessary for generating inferences (Cain et al., 2001; Pressley, 2000). Background knowledge is a compilation of prior learning, as well as prior mental images of text that are stored in long-term memory. Cromley and Azevedo (2007) discovered that background

knowledge is a significant contributor to comprehension, as is vocabulary. Students who lack prior knowledge about the content they are reading will struggle to make sense of it. Background knowledge is developed through exposure to a variety of books, particularly trade books (Headley & Dunston, 2000), as well as through general life experiences (Gill, 2008).

Characteristics of Effective Interventions for Reading Comprehension

Explicit Strategy Instruction. Meta-analyses of research indicates that reading comprehension interventions are effective only when they are accurate, consistent, and intensive (Division for Learning Disabilities of the Council for Exceptional Children, 2014; Sencibaugh, 2007), as well as explicit and recursive (Mastropieri, Scruggs, & Graetz, 2003). In a comprehensive review of research, the Institute of Education Sciences (2010) found a preponderance of evidence that explicit strategy instruction is associated with improved reading comprehension outcomes. This finding aligns with the recommendations from the National Reading Panel (2000) review of reading comprehension strategies (see also Pressley et al., 1989; Rosenshine & Meister, 1997; Rosenshine, Meister, & Chapman, 1996). Recent research also supports this assertion. For example, Wang (2007) reported that explicit instruction in comprehension strategies to third and fourth graders enhanced their comprehension for both narrative and expository text. In another study, Dube, Dorval, and Bessette (2013) also reported statistically significant improvements in reading comprehension following explicit strategy instruction to third and fourth grade students with learning difficulties. Indeed, the evidence for explicit instruction in reading comprehension strategies continues to mount.

Text and Word Structure Instruction. Text structure refers to how ideas or facts are related on the printed page, such as in a sequence, a comparison, a question and answer, or a

cause and effect. Following a review of existing research, the Institute of Education Sciences (2010) recommended explicit instruction to students in text structure for improving comprehension. Consistent with this recommendation, current research suggests that training in strategies based on text structure produces significant reading comprehension outcomes for students (Sencibaugh, 2007). The research indicates that even students in primary grades achieve reading comprehension improvement from explicit instruction in text structure (Hall, Sabey, & McClellan, 2005; Stevens, Van Meter, & Warcholak, 2010).

In addition, instruction in analysis of word structures, including root words, prefixes, and suffixes, is supported by several preliminary research studies conducted by Baumann and Edwards (Baumann et al., 2002; Baumann et al., 2003). In a follow-up study, Baumann, Ware, and Edwards (2007) discovered that direct instruction in word structures to 20 fifth graders produced a 36% increase in word volume and a 42% increase in the use of low-frequency words in students' writing samples. In addition, vocabulary is improved by learning common prefixes (Graves, 2006) and root words (Henry, 2003). It is clear that instruction in both text and word structure is supported by the reading comprehension research findings.

Individualized Instruction. Along with explicit and intensive instruction, research indicates greater gains in reading comprehension when students are instructed one-on-one. Highlighting the importance of one-on-one reading instruction, Cain and Oakhill (2006) suggest that group measurements obscure individual weaknesses and prevent tailored interventions for individual student needs. Torgesen et al. (2001) studied two intensive one-on-one interventions for reading disabilities and discovered that both programs produced significant improvements across reading skills. In fact, 40% of the students in the study were able to return to the general education classroom from special education. Further, in a study of 47 first-grade classrooms,

students with the most individualized reading instructions achieved the greatest gains in literacy (McDonald Conner et al., 2009). Indeed, research continues to demonstrate the benefit of individualized instruction for reading comprehension.

ComprehendRx for Reading Comprehension

ComprehendRx is a research-based reading comprehension intervention developed by LearningRx. Following the brain training methodology used in all LearningRx programs, ComprehendRx targets the complex network of cognitive skills and strategies used in the comprehension of text. Further, the one-on-one delivery of the individualized program aligns with the research-based characteristics of an effective reading comprehension intervention, including individualized and explicit strategy instruction.

ComprehendRx differs from traditional educational interventions for reading comprehension that tend to target academic skills and may deal with one or two cognitive skills. Instead, the ComprehendRx program targets the most critical cognitive skills that are most deficient and have the greatest impact on comprehension improvement, including reading fluency and speed, core vocabulary, visualization, reasoning, working memory, metacognition, and sequential processing using a set of increasingly challenging mental exercises. As outlined in the prior sections, a preponderance of research identified these cognitive skills as the critical elements in reading comprehension development. This alignment of the ComprehendRx program with the prior research may explain the greater gains achieved so far in the initial pilot studies than typically achieved in reading comprehension interventions.

In addition to enhancing weak cognitive skills, ComprehendRx also develops metacognitive strategies. The research described in the prior sections identified metacognitive

control of cognitive strategies as a significant predictor of reading comprehension success. Research also supports explicit instruction of cognitive strategies—a key component of the ComprehendRx program—for optimum development of reading comprehension skill. See Figure 1 to see the alignment of ComprehendRx with reading comprehension research.

ComprehendRx is delivered one-on-one to students by a cognitive trainer. The results of the individualized training in ComprehendRx is measured by the gold standard in cognitive skills testing, the Woodcock-Johnson III Tests of Cognitive Abilities and Woodcock-Johnson III Tests of Achievement. Although students are trained using all of the ComprehendRx procedures, the scope and sequence is adjusted to address the strengths and weaknesses of the individual. Results have revealed statistically-significant improvements in verbal comprehension, visual and auditory processing, logic & reasoning, working memory, and following directions. These results are consistent with the results of studies on other LearningRx interventions which also demonstrate statistically significant improvements across all cognitive skills following completion of the programs (Luckey, 2007; Carpenter, 2009; Jedlicka, 2012).

The development of LearningRx programs and the delivery of interventions are grounded in decades of research in the fields of education, psychology, and cognitive science. With impressive study results from thousands of students, educators and parents can be confident in the research-based intervention, ComprehendRx, offered at LearningRx Brain Training Centers.

	Comprehension Research	ComprehendRx
COGNITIVE SKILLS		
Fluency/Oral Reading Speed	X	X
Vocabulary	X	X
Visualization	X	X
Reasoning & Inference	X	X
Working Memory	X	X
Cognitive Strategies	X	X
Metacognition	X	X
Background Knowledge	X	
INSTRUCTIONAL CHARACTERISTICS		
Individualized	X	X
Explicit Strategy Instruction	X	X

Figure 1. Alignment of Reading Comprehension Elements: Research versus ComprehendRx

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