

World knowledge Driving Young Readers' Comprehension Difficulties

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Abstract: Our goal in this project is to develop a better understanding of young readers' difficulties in comprehending text, and how those difficulties vary as a function of reader aptitudes and text genre. Therefore, we examined the effects of reading decoding abilities and world knowledge (assessed using the Woodcock–Johnson III Tests of Achievement) on 61 third-grade readers' comprehension of narrative and expository texts. The children read a narrative (445 words) and an expository (464 words) text. Comprehension of each text was assessed with 12 multiple-choice questions. Comprehension of the narrative text improved as a function of decoding ability. In contrast, expository text comprehension was driven by world knowledge. The latter result indicates that the low-knowledge children were not able to make the knowledge-based inferences required by the expository text, replicating previous work conducted with adult populations (e.g., McNamara, 2001). Potential solutions to facilitate comprehension from expository texts, such as increased text cohesion and reading strategy instruction are discussed.

Keywords: Young readers, reading comprehension, learning from text, fourth-grade slump

Introduction

Texts are used as educational tools from the onset of schooling in the elementary school years. Therefore, understanding and learning from written material is of paramount importance to academic success. Of course, children's reading competency develops throughout the school years. However, a critical period in reading development seems to occur between the third and fifth grades. An emergence of comprehension difficulties around the middle of this period is sometimes referred to as the *fourth-grade slump* (Meichenbaum & Biemiller, 1998; Sweet & Snow, 2003). Our study explored children's reading comprehension near the beginning of this period, in the third grade. We considered the demands children face when comprehending school-based texts (narrative or expository) and, accordingly the importance of two reader-based competencies (prior knowledge level and reading decoding ability) in the comprehension of narrative and expository texts. We anticipate that our research will be of crucial educational importance; that is if we understand factors that drive the comprehension of school-based texts, we are in a better position to remedy comprehension problems among struggling young readers.

Our interest in investigating reading comprehension in young readers stemmed from the observation that the fourth-grade slump may be related to a change in reading requirements around the third and fourth grade levels. Prior to the third grade, most reading activities are geared toward the goal of learning how to read. Subsequently, children are increasingly required to read to learn. To learn new topics such as science, children are exposed to increasingly difficult texts and, perhaps for the first time, expository texts. The increased exposure to expository texts has important implications for third and fourth grade students. In particular, these students face critical comprehension challenges from expository texts, particularly those covering scientific material (Bowen, 1999; Snow, 2002).

Successful reading comprehension requires the efficient coordination and integration of a number of underlying processes (Snow, 2002), which include word decoding abilities (Perfetti, 1985) and the utilization of world knowledge (Kintsch, 1988). Science texts present a special case for comprehension because they introduce many new concepts (Carey, 1986), which are oftentimes abstract and esoteric (Meyerson, Ford, Jones, & Ward, 1991). Accordingly, the reader's prior knowledge plays a vital role in the integration and assimilation of new content-based information; readers with greater knowledge are more likely to link new concepts with their existing knowledge schemas. However, often students do not have enough knowledge to succeed in their courses in the United States (Snow, 2002). Content difficulty is compounded by the unique style in which expository texts are written. For example, science texts typically adopt an 'objective' method of writing, which contrasts to the narrative-style, to which young children are frequently exposed. Children's stories usually follow a uniform structure,

comprising a sequence of causally related events (Cain, 1996). These events are oftentimes familiar to young children (e.g., going out to dinner). Overall, narrative texts place fewer demands on the child than expository texts in terms of information density and complexity.

Thus far, we have claimed that scientific texts present difficulty for the young reader because of the style in which they are written and the complexity of the content. A principal difference between narrative and expository texts concerns the knowledge demands placed on the child needed for the comprehension of scientific material. As such, one driving factor for the comprehension of expository texts in contrast to narrative texts is readers' knowledge. A great deal of research has shown that readers' prior knowledge facilitates and enhances comprehension and learning from expository texts, such as science texts (e.g., Afflerbach, 1986; Chi, Feltovich, & Glaser, 1981; Chiesi, Spilich, & Voss, 1979; Lundeberg, 1987; Means & Voss, 1985). Readers who have greater domain knowledge about the topic of text have better memory for the text and develop a deeper understanding of the information conveyed (e.g., McNamara & Kintsch, 1996; McNamara, Kintsch, Songer, & Kintsch, 1996). Moreover, the influence of readers' knowledge on expository text comprehension can be greater than that of reading abilities (e.g., Chiesi, Spilich, & Voss, 1979; O'Reilly & McNamara, 2002).

The effects of knowledge on the comprehension of expository texts led us to the hypothesis that the fourth grade slump may be related, at least in part, to knowledge required for the successful comprehension of scientific texts. In other words, the shift in reading materials in the third and fourth grades (i.e., greater emphasis on expository texts) is predicted to have an important bearing on declining levels of comprehension in the fourth grade. If this is the case, we should find that world knowledge is a major driving force in children's comprehension of expository texts. In contrast, we should find that the comprehension of narrative texts is less dependent on prior knowledge, and rather related more to other reading-related factors, such as reading decoding skills. Thus, it may be that a child who shows little difficulty reading a narrative text may have sudden comprehension problems when faced with expository text. Such a finding would provide evidence that the skill sets that are necessary for understanding narratives are different from that of expository texts.

In terms of the theoretical positions of reading comprehension, the "simple view" of reading similarly proposes that reading comprehension is the product of two variables: reading decoding and linguistic comprehension (Gough, Hoover, & Peterson, 1996; Hoover & Gough, 1990). Reading decoding represents the ability to apply letter-sound correspondence rules when reading words and non-words. Many individuals fail to develop proficient reading decoding ability, which limits their reading for understanding (Perfetti, 1985; Lyon, 2002; Vellutino, 2003). Linguistic comprehension represents the process by which the components of language (i.e., words, sentences, or discourse) are understood. Linguistic comprehension, as measured by tests of listening comprehension, word knowledge, and world knowledge, relate conceptually to the deeper-level understanding constructed by the reader. In addition, correlational and factor analytic evidence provide further support for the relations between linguistic comprehension and world knowledge (McGrew, 1997; McGrew & Woodcock, 2001).

Another related theoretical notion regards levels of comprehension, as described by Kintsch's Construction-Integration model of text comprehension (1988; 1998). His theory of comprehension distinguishes between the *surface code*, the propositional *textbase*, and the *situation model*. The *surface code* preserves the exact wording and syntax of clauses, and rapidly fades from memory. The *textbase* contains explicit propositions that preserve the meaning but not the exact wording and syntax. The *situation model* is the general or global content of the text. For expository text, the situation model refers to the integration of the textbase with the reader's knowledge about the text's subject matter and world knowledge. For narrative text, it refers to the reader's understanding of the characters, settings, actions, and events in the reader's mental representation of the story. This representation is constructed inferentially through interactions between the explicit text, world knowledge, and the comprehension goals of the reader (Graesser, Singer, & Trabasso, 1994; Johnson-Laird, 1983; Kintsch, 1998).

Most relevant to our current question is the importance placed on the activation and use of prior knowledge to form a coherent situation model of the text. Moreover, the availability of prior knowledge while reading becomes particularly important when the reader is faced with less cohesive text. Research by McNamara and colleagues (McNamara, 2001; McNamara, in press; McNamara et al., 1996; McNamara & Kintsch, 1996) has indicated that knowledge deficiencies are aggravated by less cohesive texts. For example, McNamara et al. (1996) examined the

effects of text cohesion and prior knowledge for middle-school students' comprehension of a science text about heart disease. The authors found that increased text cohesion benefited low-knowledge readers across various measures of comprehension, including free recall, open-ended comprehension questions, and a keyword sorting task. Essentially, low-knowledge readers cannot easily fill in gaps in low-cohesion texts because they do not have the knowledge to generate the necessary inferences. Therefore, low-knowledge readers need a high-cohesion text to understand and remember the content. In contrast, high-knowledge readers are less affected by text cohesion, and often benefit from low-cohesion texts because they possess the knowledge needed to generate inferences and fill cohesion gaps. Moreover, inference processing induced by low-cohesion text can increase active processing thereby facilitating deeper-level processing. This, in turn, enhances comprehension.

Our analyses of cohesion for texts used in schools during this critical period indicate that text cohesion is a particular problem. Though many texts at those grade levels may use short sentences, and sometimes even stick to relatively familiar words, they often lack the cohesive devices that young readers need to make sense of text (Graesser, McNamara, & Louwerse, 2003). For example, texts for this age level contain very few connectives such as *although*, *because*, *consequently*, and so on. Connectives are essential for allowing a reader with less knowledge to know what type of relationship exists between successive ideas. These types of cohesion gaps in their learning materials would render readily apparent any knowledge deficiencies that a child may have. And, those knowledge deficits will most likely to appear when the child is asked to read the more knowledge demanding material that appears in expository texts.

To provide an initial investigation of these ideas, we examined here the effects of text genre, world knowledge, and word decoding abilities third-graders' text comprehension. In terms of text genre, we focus on narrative and science (expository) texts. The texts that we have chosen for this study are typical passages from third grade textbooks. Our hypotheses are that the children's comprehension of the narrative passage will be superior to the expository passage. Also, the reader abilities associated with the comprehension of the two passages will differ; while the comprehension of the science passage will be primarily driven by children's level of world knowledge, the comprehension of the narrative text will primarily be driven by reading decoding abilities. While such results will certainly not close the book on the question we are pursuing, we believe that it will provide evidence as to whether knowledge is an important consideration when comprehension problems are observed during this developmental period.

Method

Participants

Participants were 61 children enrolled in the third grade at two public schools in a large metropolitan school district. Children ranged in age from 8 years, 4 months to 10 years, 7 months ($M = 109.7$ months, $SD = 6.0$ months). Girls formed 52% of the sample ($n = 32$), and boys formed 48% of the sample ($n = 29$). Approximately, 57% of children were Black ($n = 35$), 28% were White ($n = 17$), 7% were biracial ($n = 4$), and 3% were Asian-Pacific Islanders ($n = 2$).

Materials

Texts. The children read two texts, one narrative and one expository (see Table 1). The narrative text, *Orlando*, was obtained from Addison Wesley's *Phonics Take-Home Reader, Grade 2*. The expository text, *Needs of Plants*, was obtained from McGraw-Hill's *Science, Grade 2*. Due to time constraints, only one text was selected for each genre.

Table 1. Select Characteristics of the Narrative and Expository Texts

Text	Number Words	Number Sentences	Flesch-Kincaid grade level
Narrative (Orlando)	445	67	3.6
Expository (Needs of Plants)	464	45	4.4

Multiple-choice questions. Twelve multiple-choice questions for each text measured textbase and situation model levels of understanding (Givón, 1993; Louwerse, 2002; Kintsch, 1998; McNamara et al., 1996). Each

question and three possible answers were presented orally and visually, and the children were required to vocalize the correct answer.

Four of the 12 questions from the narrative text were answered correctly by more than 85% of the sample. In a conservative attempt to eliminate question level ceiling effects and to facilitate a normally distributed total score for the narrative text, these 4 questions were omitted. Therefore, 8 questions were used to create the total score. From the expository text, the response patterns to all 12 questions did not demonstrate ceiling effects. For each child and each text, the proportion of correct answers to the total number of acceptable questions (8 or 12) was calculated.

Aptitude Measures. Children completed three tests from the Woodcock–Johnson III Tests (WJ III) of Achievement (Woodcock, McGrew, & Mather, 2001). The WJ III standardization sample, containing 8,818 individuals, was formed using a stratified sampling plan that controlled for 10 individual and community variables. Test items stemmed from extensive analysis of item content, and item scaling was accomplished through application of Rasch analyses.

The tests completed from the WJ III included the Word Attack test, Picture Vocabulary test, and Academic Knowledge test. The Word Attack test measures reading decoding ability. Participants are required to pronounce phonically regular non-words. The WJ III Picture Vocabulary test measures word knowledge and requires participants to name familiar and unfamiliar pictured objects. The WJ III Academic Knowledge test measures knowledge about the biological, physical, and social sciences and the humanities. It comprises three subtests, Science, Social Studies, and Humanities, which are summed to produce a test raw score.

For each WJ III test, age-based standard scores ($M = 100$, $SD = 15$) were obtained. For the Word Attack test, the standard score represents *decoding ability*. The standard scores for the Picture Vocabulary and Academic Knowledge tests were averaged together to represent *world knowledge*.

Procedure

Recruitment of children consisted of sending letters of invitation to parents of third-grade children through the children's school classrooms. The letters provided information about the study and requested that parents contact the researchers to schedule a testing session. Testing sessions were conducted on four Saturdays during February, March, and May, 2003. After completion of the testing, children were provided a \$20 gift card to a department store, coupons from merchants, and school supplies.

A large assessment battery was completed in a 1-hour testing session, but only information relevant to this study is reported here. Children first silently read a narrative or expository text within a 5-minute period. After the text was removed from view, children answered 12 multiple-choice questions about the text. This process was repeated with the remaining text (using a counterbalanced ordering). The children then completed the aptitude measures for decoding ability and knowledge. Graduate students who successfully completed a graduate course covering the administration of standardized tests completed all testing.

Results

The analysis compared children's performance on the multiple-choice questions relating to the narrative text and expository text. A $2 \times 2 \times 2$ mixed analysis of variance (ANOVA) was performed on the proportion correct scores obtained from the narrative and expository texts. The ANOVA included the between-subjects variables of *decoding ability* (*high, low*), and *world knowledge* level (*high, low*), and the within-subjects variables of *text type* (*narrative, expository*). Both between-subjects variables were formed by grouping all participants who obtained a score below the median in the *low* group and all participants who obtained scores at or above the median in the *high* group. For all effects, alpha was set to .05.

The results of the ANOVA analysis are reported below in Table 2. In terms of main effects, the ANOVA yielded a main effect for text genre, $F(1,57) = 27.82$, $p < .001$, $MSE = .0304$, reflecting better comprehension of the narrative ($M = .68$, $SD = .21$) than the expository text ($M = .50$, $SD = .15$). Thus, as expected, children comprehended the narrative text more successfully than the expository text. Furthermore, there was a main effect of world knowledge, $F(1,57) = 5.17$, $p = .03$, $MSE = .028$. Thus, children with high levels of world knowledge better comprehended the texts ($M = .62$) than did the children with low levels of world knowledge ($M = .55$). The main effect of decoding ability was not reliable.

Turning to interaction effects, we predicted that there would be an interaction between genre, reading decoding skill and world knowledge, with world knowledge being associated with the comprehension of the expository text and reading decoding skill being associated with the comprehension of the narrative text. However, this 3-way interaction between decoding ability, world knowledge, and text genre was not reliable, $F < 2$. There was, however, a significant 2-way interaction between decoding ability and text genre, $F(1, 57) = 11.84, p = .001$. Children with high decoding ability scored higher on comprehension questions from the narrative text ($M = .75, SD = .16$) than the expository text ($M = .49, SD = .16$), $t(59) = -3.42, p = .001$. In contrast, children with low decoding ability scored similarly when comprehending the narrative text ($M = .58, SD = .22$) and the expository text ($M = .51, SD = .15$). Thus, there was an effect of decoding ability for the narrative but not the expository text.

Finally, the interaction between world knowledge and comprehension of different text genres was marginal, $F(1, 57) = 3.25, p = .08$. Nonetheless, subsequent analyses confirmed that children with high world knowledge scored significantly higher than the children with low world knowledge when comprehending the expository text, $t(59) = -3.11, p = .003$, but there was no significant difference between the children with high and low world knowledge when comprehending the narrative text. In sum, there was an effect of world knowledge for the expository but not the narrative text.

Table 2. Proportion Correct on Comprehension Questions as a Function of Decoding Ability, World knowledge, and Text Genre

Decoding ability	World knowledge	Text Genre	
		Expository Proportion (SD)	Narrative Proportion (SD)
Low	Low	.48 (.12)	.57 (.22)
	High	.57 (.19)	.61 (.24)
High	Low	.36 (.14)	.76 (.21)
	High	.55 (.12)	.75 (.14)

Discussion

The study was designed to investigate factors that drive the comprehension of school-based texts in the third grade, as children are entering the period known as the fourth-grade slump. Specifically, we investigated the importance of two reading skills (world knowledge and reading decoding skill) in the comprehension of expository and narrative texts. Our findings confirm our hypotheses that (1) narrative texts are comprehended more successfully than expository texts and (2) different reader skills (prior knowledge and reading decoding skills) are important for the comprehension of expository and narrative texts. With regard to the latter point, our analysis has emphasized the importance of reader knowledge in the comprehension of expository texts. Comprehension success was affected by the level of readers' prior knowledge; low-knowledge readers were less likely to comprehend the expository text than were high-knowledge readers. Conversely, comprehension of narrative text was most strongly supported by reading decoding skills.

Our results indicate that decoding ability is the driving force for the comprehension of narrative texts. Efficient and automatic word decoding may free up working memory space, which can be used for memory of the text base and inference making (Perfetti, 1985; Seigneuric, Ehrlich, Oakhill, & Yuill, 2000). Most children likely have the necessary knowledge from life and educational experiences to form a sound situation model for the typical narrative text. In addition, the contribution of decoding ability may be more apparent because knowledge plays a less central role.

As hypothesized, our findings also implicate knowledge as important for comprehending expository texts. As indicated in the introduction, previous research has shown that there are large effects of knowledge on reading comprehension for adults and older school students (e.g., Afflerbach, 1986; McNamara & Kintsch, 1996). Indeed, the effects of knowledge often override effects of reading decoding and comprehension abilities (Chiesi, Spilich, & Voss, 1979). This study confirms that when children are confronted with expository texts, such as science texts, their ability to understand what they read is greatly affected by prior knowledge. Thus, just as studies with young adult readers have shown, young children with less prior knowledge will struggle to form a coherent situation model when reading expository texts because they are not able to generate the necessary inferences.

The current study has provided further evidence for the effect of background knowledge on young readers' expository text comprehension. Specifically, the young readers in our study better understood the more familiar narrative than they did the less familiar science text. Furthermore, their world knowledge was a significant factor influencing their ability to understand the science text. These results are thus indicative of one problem that children may face when they reach the third grade; that is, how to deal with low cohesion, difficult science texts which demand knowledge that these readers may not yet possess. This situation, we expect, could spiral such that the child fails to understand the learning material and thus goes deeper into a knowledge debt. By the fourth grade, the situation would be aggravated and readily apparent. Certainly other factors will come into play, such as changes in the nature of instruction and changes in reader motivation and strategy use (Artelt, Schiefele, & Schneider, 2001; Carroll, 2000; Mokhtari, & Reichard, 2002). However, our purpose here was limited to examining whether knowledge may be a considerable factor for researchers and educators to consider.

One important question that arises regards solutions to remedy this situation. In our laboratory, we are taking two approaches to this problem. First, we are examining the success of teaching reading strategies to students that help them to overcome their knowledge deficits. Research conducted with young adults and high-school students (e.g., Best, Ozuru, & McNamara, 2004; McNamara, in press; McNamara, Best, & Castellano, 2003; McNamara & Scott, 1999) has shown that a reading strategy intervention called Self-Explanation Reading Training (SERT) helps low-knowledge and less strategic readers overcome knowledge deficits. SERT teaches students to self-explain text by using active reading strategies, such as making bridging and elaborative inferences using common sense and logic. The research has shown that SERT facilitates and enhances low-knowledge readers' comprehension of informational texts. An automated system called the Interactive Strategy Trainer for Active Reading and Thinking (iSTART) has been developed to deliver SERT using pedagogical agents and interactive dialog (McNamara, Levinstein, & Boonthum, 2003; O'Reilly, Sinclair, & McNamara, 2004). By using the latest technologies in intelligent tutoring systems, iSTART guides young readers through text by suggesting different reading strategies. Although the techniques and systems that we have developed thus far are targeted at young adults, we believe that a similar system could help younger readers learn strategies that help them navigate difficult text.

Second, we assume that text quality can be improved and that this quality can be tailored to reader ability. For instance, comprehension for low-knowledge readers may be facilitated by more cohesive texts, which contain fewer informational gaps (McNamara et al., 1996; McNamara & Kintsch, 1996). The general approach to increasing text cohesion is to add surface-level indicators of relations between ideas in the text, such as explicit linguistic elements (e.g., words, features, cues, signals and constituents), which guide the reader to the meaning of the text. Thus, signaling causal connections, with terms such as *because* and *consequently*, help the reader interpret and remember relationships between concepts. Accordingly, one way to help readers comprehend texts is to modify cohesion. This can be done in numerous ways, such as adding low-level information (e.g., identifying anaphoric referents, synonymous terms, connective ties, and headers) and supplying background information that was previously left unstated in the text.

However, one roadblock to that avenue has been the lack of automated measures of cohesion. Currently, readers, writers, editors, educators, researchers, and policy makers can only estimate the appropriateness of a text using common readability formulas, such as Flesch Reading Ease and the Flesch-Kincaid Grade Level, which are based on superficial factors such as the number of words in the sentences and the number of letters or syllables per word (i.e., as a reflection of word frequency). It is for that reason that we are developing an automated tool, called Coh-Metrix, which provides measures of text cohesion and text difficulty (McNamara, Louwerse & Graesser, 2003; Graesser, McNamara, Louwerse, & Cai, 2003). Coh-Metrix (version 1.0) automatically analyzes texts on over 50 types of cohesion relations and over 200 measures of language and discourse by applying modules that use lexicons, classifiers, syntactic parsers, shallow semantic interpreters, conceptual templates, latent semantic analysis, and other components widely used in computational linguistics. The ultimate goal is to have a tool that replaces standard readability formulas by being sensitive to a range of cohesion relations, classes of inferences, as well as reader abilities. This tool will allow publishing houses, educators, and researchers to measure the readability of a particular text within a particular text genre tailored at particular reader groups (see <http://coh-metrix.memphis.edu>). A better understanding of the effects of cohesion on readers' comprehension will provide valuable insight and explicit direction on how to improve expository texts while taking into consideration the target readers' aptitudes.

One of our goals in the Coh-Metrix project has been to develop a better understanding of young readers' difficulties in comprehending text, and how those difficulties vary as a function of reader aptitudes and text genre. This study was one step toward that goal. In addition, the study highlights potential considerations that may be made about struggling readers. Specifically, comprehension problems exhibited by young readers may not be reading problems *per se*, but rather knowledge deficits, which can be aggravated by low-cohesion, inconsiderate learning materials.

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