Factors that influence skilled and less-skilled comprehenders' inferential processing during and after reading: exploring how readers maintain coherence and develop a mental representation of a text

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FACTORS THAT INFLUENCE SKILLED AND LESS-SKILLED COMPREHENDERS' INFERENTIAL PROCESSING DURING AND AFTER READING

Exploring How Readers Maintain Coherence and Develop a Mental Representation of a Text

ABSTRACT

This study examines factors that influence readers' cognitive processing (i.e., inference generation) and the development of a mental representation of text: comprehension skill and working memory (WM). Elementary students ($N = 61$) participated in causal questioning conditions with narrative texts to examine text- and knowledge-based inferences generated when probed during versus after reading. Recalls were examined to assess readers' mental representations of texts after-reading and answering questions. Skilled comprehenders generated more goal- and subgoal-related text-based inferences during and after reading and included more original text information and less background knowledge in their recalls of texts than did less-skilled comprehenders. Skilled comprehenders with high WM also generated more goal-related text-based inferences than did those with low WM. Findings support and extend previous research regarding how readers struggle with inference generation and may further inform the development of causal questioning interventions to help improve struggling readers' comprehension of narrative texts.

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COMPREHENSION of text requires the reader to engage in a complex set of cognitive processes such as thinking about the text, judging the text, and potentially problem-solving while reading. When the cognitive processing of reading becomes more automatic, readers begin to transition from learning to read (i.e., focusing on decoding) to reading to learn (i.e., focusing on understanding connected text and then as a whole, and learning from the information presented in the text; Chall, 1996). Readers develop their understanding of connected and whole text through developing a coherent representation of text or a coherent situation model (Graesser & Clark, 1985). One important aspect of the development of a coherent representation of a text is through the generation of inferences. Inference generation includes making connections from one part of a text to another or making connections from the text to the reader's background knowledge, and, often, a combination of the two (Graesser et al., 1994).

Generating inferences can also help a reader develop and maintain coherence throughout reading (Graesser & Clark, 1985). However, previous research has shown that some readers struggle with generating the types of inferences needed to maintain coherence during reading to develop a coherent representation of a text after reading (e.g., Bowyer-Crane & Snowling, 2005; Cain & Oakhill, 1999; Laing & Kamhi, 2002; Rapp et al., 2007). Yet, it is still unclear why some readers struggle with this process and whether or not difficulties are due to individual differences (e.g., reading comprehension skills, working memory [WM]), type of text (e.g., narrative), type of inference (e.g., connections within a text or to background knowledge), timing of when an inference is generated (i.e., during reading to fill a gap, or after reading to wrap up or create a representation of the text), or a combination of these factors.

Thus, the purpose of this study was to explore skilled and less-skilled comprehenders' (i.e., readers who struggle less from word-reading abilities and more from comprehension skills) inference generation during and after reading, as well as the types of inferences generated (i.e., within the text and to background knowledge). To do so, we first describe the types of inferences that have been shown to be successful for maintaining coherence and developing a coherent representation of a narrative text. Narrative text is the focus of this article because of its natural components and quality to encourage inference generation of connecting to other parts of the text (e.g., characters, goals, action; van den Broek et al., 1999), as well as a readers' background knowledge to help fill in the gaps not provided by the text. Second, we discuss the differences in skilled and less-skilled reading comprehenders' inference generation, and the contribution of WM. Finally, we report findings from a causal questioning activity used to monitor inference generation during and after reading, and the types and quantity of inferences generated used to maintain coherence. Findings will be used to inform a better understanding of why some readers struggle with the cognitive processing of inference generation during reading to maintain coherence during reading, as well as what is needed after reading to develop a coherent representation of a text. This understanding will also help inform the use of interventions that encourage inference generation during and after reading to help improve cognitive processing for struggling comprehenders.

Cognitive Processing of Narrative Texts

Previous research has demonstrated that when reading narrative texts, readers generate inferences that connect to previously read goal-driven information in the text and

background knowledge that is beneficial for constructing a coherent representation of text (e.g., Trabasso & van den Broek, 1985). Much of this evidence has come from examining skilled adult comprehenders' inference generation, and more recent research has shown that children who are considered skilled comprehenders compared with their peers also demonstrate successful generation of goal-driven inferences (e.g., McMaster et al., 2012; Rapp et al., 2007). In addition, children who are considered less-skilled comprehenders compared with their peers have shown difficulty in generating inferences and, instead, use other types of cognitive processes (e.g., paraphrasing, associations, elaborations; Carlson, Seipel et al., 2014; McMaster et al., 2012; Rapp et al., 2007) that can be useful for comprehension but not sufficient. Although these cognitive processes are not inaccurate to use when comprehending text, previous research suggests that less-skilled comprehenders may overuse them more often than other processes and do so less strategically, which has resulted in the development of a less coherent representation of the text after reading (e.g., Carlson, Seipel et al., 2014; McMaster et al., 2012; Rapp et al., 2007; Seipel et al., 2017). This previous work also suggests that overusing and being less strategic in the types of cognitive processes used during reading may impede the ability to maintain coherence during reading.

Developing and Maintaining Coherence

To develop a coherent representation of a narrative text (i.e., a combination of main ideas, as well as goals, subgoals, outcomes of characters, and emotions), readers often develop what is called a situation model. A situation model is part of the mental representation that is composed of the situations that take place in the text, which include (but are not limited to) time, space, and causality (van Dijk & Kintsch, 1983; Zwaan et al., 1995). In addition, to develop a situation model of a text, readers rely on two types of coherence to maintain during reading: local and global coherence (Casteel, 1993; Graesser & Clark, 1985; Graesser et al., 1994; Kintsch, 1998; McNamara et al., 1996). Local coherence is achieved when the reader connects currently read information to immediately preceding text information. Global coherence is achieved when the reader connects currently read information to much earlier text information and/or to their background knowledge.

Inferences Generated during Coherence

These connections can be achieved through a variety of inferences generated during and after reading. Generally speaking, these inferences can be text- or knowledge-based, and both can be goal-driven. Consider the following example: "Jenny wanted to get an 'A' on her test. She needed to study for hours."

In this example, one connection a reader could make is from information in the second (i.e., "currently read") sentence to the preceding sentence to infer that Jenny needed to study for hours because she wanted to get an "A" on her test (i.e., wanting to get an "A" is her goal). In this example, generating a text-based inference could help a reader achieve local coherence (e.g., Graesser & Clark, 1985; Kintsch, 1988; McNamara, 2007).

Readers also generate inferences to construct global coherence. Consider a slightly longer example: "Jenny wanted to get an 'A' on her test. She needed to study for hours. Jenny studied hard and took the test the next day. She got 100%. Jenny was really happy."

After reading this text, a reader could connect information from the end of the text (i.e., "currently read") to an earlier goal statement (she wanted to get an "A" on the test), for instance, or connect to relevant background knowledge (an "A" or "100%" is an excellent grade); and thus, these are reasons Jenny would be happy. Generating these types of text- and knowledge-based inferences would help the reader construct global coherence. However, although it has been demonstrated that generating these inferences can help readers construct local and global coherence, it is still unclear how readers maintain this coherence throughout reading to develop a coherent representation of a text. That is, are there particular skills that skilled comprehenders have that enable the ability to maintain coherence? Previous research has shown that when inference generation is difficult for a reader and the reader is unable to maintain local and/or global coherence, the situation model developed after reading may be less coherent; and, thus reading comprehension may tend to be poor (e.g., Long et al., 1994, 1997). However, what specific characteristics are related to this difficulty that less-skilled comprehenders experience, as well as those related to the easy skilled comprehenders experience. Furthermore, does WM play a stronger role than previously identified? Previous research has consistently found high correlations between WM and reading comprehension skill, and inference generation (e.g., Cain et al., 2004; Oakhill & Cain, 2000; Seigneuric et al., 2000; Swanson et al., 1989); however, it is not clear how these relationships explain the ability that readers have to maintain coherence throughout reading. Thus, these are the next areas that we address to help support the exploration study in the current article.

Factors That Influence Inferential Generation Needed to Maintain Coherence during and after Reading

Comprehension Skill and Inference Generation

On the surface, the local and global coherence examples above are simple illustrations of how effortless generating an inference can be for a skilled comprehender; however, a growing body of research shows that less-skilled comprehenders (readers who exhibit little or no difficulties with lower-level reading skills such as decoding or fluency, but instead show difficulties with comprehension based on their end-of-year standardized reading proficiency scores) often experience difficulties in engaging in these types of processes (e.g., Cain & Oakhill, 1999; Cain et al., 2001; Carlson, Seipel et al., 2014; McMaster et al., 2012; Rapp et al., 2007). Specifically, less-skilled comprehenders have been shown to vary considerably in the types of text- and knowledge-based inferences and other cognitive processes they use to try to maintain local and global coherence, the efficiency with which they use such processes, and when this occurs (during or after reading; e.g., Cain & Oakhill, 1999; Cain et al., 2001; Carlson, van den Broek et al., 2014; Laing & Kamhi, 2002). This variability has been found with less-skilled comprehenders generating fewer knowledge-based inferences than skilled comprehenders during reading but have been shown to not differ in their generation of text-based inferences during reading (e.g., Laing & Kamhi, 2002). In addition, the knowledge-based inferences less-skilled comprehenders generate have been shown to be often based on irrelevant background knowledge (Carlson, Seipel et al., 2014; McMaster et al., 2012; Rapp et al., 2007). To confuse the matters further, other research has shown

that less-skilled comprehenders generate fewer text- and knowledge-based inferences than do skilled comprehenders during reading, but in this case, it has been detected after reading (e.g., Cain & Oakhill, 1999; Cain et al., 2001).

Thus, this evidence suggests that differences in inference generation for skilled and less-skilled comprehenders may be due to when they occur (i.e., during vs. after reading). However, it is not clear if these inference generation differences are a function of comprehension skill or some other cognitive factor. Furthermore, it is not clear if perhaps the difference lies in the ability to maintain coherence through generating these inferences throughout the entire reading task (during to the end of reading). Thus, we suggest a need for a direct comparison of inference generation both during and after reading to be made to determine how skilled and less-skilled comprehenders differ in the types and number of inferences generated when maintaining local and global coherence and if there are other cognitive factors (e.g., WM capacity) that may be influencing readers' ability to maintain coherence.

WM and Inference Generation

Working memory (WM), a component of the memory system that includes the ability to hold and use active information from memory in the present moment, has been shown to be important for generating inferences during and after reading (e.g., Seigneuric et al., 2000; Swanson et al., 1989). WM has also been shown to be an important contributor to individual differences associated with reading comprehension (Baddeley & Hitch, 1974; Daneman & Carpenter, 1980; Just & Carpenter, 1992). That is, researchers have consistently found high correlations between WM and reading comprehension performance in adults (e.g., Daneman & Carpenter, 1980), as well as relations between WM, reading comprehension skill, and inference generation in children (Cain et al., 2004; Oakhill & Cain, 2000; Seigneuric et al., 2000; Swanson et al., 1989; Yuill et al., 1989). For example, Cain et al. (2004) found younger readers' inferencing and reading comprehension skills to be moderated by WM. Specifically, less-skilled comprehenders who performed poorly on a vocabulary knowledge task that required students to generate different types of text- and knowledge-based inferences also performed poorly on a WM task, perhaps because of higher WM processing demands placed on the students during both tasks (Cowan, 1999; Gernsbacher, 1990).

These findings are informative for understanding the relationships among inference generation, comprehension skill, and WM. However, further investigations are needed to understand how WM influences the generation of specific types of inferences and if they are more or less prominent at certain points during the activity of reading (i.e., during versus after reading), and how WM may play a role in maintaining coherence from the beginning to the end of the task. Understanding the role of WM between skilled and less-skilled comprehenders' inference generation that takes place during and after reading can help determine whether particular instructional activities are more or less taxing on a reader and could further influence the development of new interventions.

Study Purpose and Research Questions

In this study, we explore the relationships among inference generation, comprehension skill, and WM, using questioning tasks to monitor the generation of goal-driven

text-based inferences and goal-driven knowledge-based inferences during versus after reading, for readers in grades 3–5. The encouraging of goal-driven inference generation is important for comprehending and developing a coherent situation model of narrative texts (van den Broek et al., 1999). Specifically, we ask causal "why" questions at specific points during two questioning tasks—one during and one after reading—to encourage goal-driven inference generation that were deemed important for helping readers build causal connections (i.e., local and global coherence) throughout a text, as well as form a coherent representation or situation model of a text (e.g., Kendeou et al., 2008; Trabasso & van den Broek, 1985).

The current study also extends previous research in three ways. First, we use a similar method of questioning activities to facilitate inference generation; however, the method used in the current study was modified to be administered both during and after reading (two conditions; Carlson, van den Broek et al., 2014; McMaster et al., 2012). Second, high and low WM was used to explore how WM capacity influences skilled and less-skilled comprehenders' inference generation during and after reading, and how WM capacity plays a role in the ability of maintaining local and global coherence throughout reading. Finally, we examine how the inferences that readers generate in response to causal questions asked during and after reading influence the development of a coherent representation of a text.

Thus, the following questions were asked for this exploratory study: (*a*) Do skilled and less-skilled comprehenders differ in the types and number of inferences generated during and after reading with a causal questioning task? (*b*) Does WM influence the inferences generated by skilled versus less-skilled comprehenders to maintain local and global coherence when answering causal questions during and after reading? (*c*) Do skilled and less-skilled comprehenders differ in the quality of text representations (recall) after generating different goal-driven inferences to answer causal questions during and after reading?

Method

Participants

Participants with parental consent were selected from three Midwestern suburban elementary schools in the United States. Sixty-one (38 female) third-, fourth-, and fifth-grade students participated in this study. Because of the exploratory nature of this study, we were concerned with obtaining enough power to detect an appropriate effect size; thus, we conducted a power analysis to determine an appropriate sample size needed. Specifically, power was estimated based on two effect sizes from previous research (0.235 and 0.47: the first value is half of the original η^2; see Bowyer-Crane & Snowling, 2005) to estimate the sample size needed. The smaller value for effect size was used to err on the side of caution or to be conservative and to ensure a large enough sample size. Sample size was estimated using G*power, a program that can be used to estimate optimal sample sizes and effect sizes based on alpha levels and power values (Erdfelder et al., 1996). For this study, the statistical test entered in G*power was an *F* test for ANOVA: fixed effects, special, main effects, and any interactions (see below). The information entered for the input parameters included effect size η^2; α error probability ($\alpha = 0.05$); power 1-β error probability (power = 0.95);

and numerator degrees of freedom (group A = 2 comprehension skills; group B = 2 treatment groups; and 1 interaction/moderator variable). The final result for G*power is the calculation of total sample size (i.e., total sample size over all groups), critical *F*, noncentrality parameter λ, denominator degrees of freedom, and actual power that would be obtained. Thus, this power analysis using both effect sizes mentioned above indicated a sample size of 45–50 total students needed, which was further broken down to 25 skilled and 25 less-skilled comprehenders. A slightly larger sample size was selected to ensure enough participants were included in each skill group (see details below).

The mean age of participants was 9 years, 9 months (range: 9–11 years); 1 was Native American, 8 Asian/Pacific Islander, 10 Black/African American, 12 Hispanic, and 30 White/Caucasian; and 28 received free or reduced meals. English was the first language for the majority of the participants (47 native English speakers), and 9 were diagnosed with specific behavioral or learning disabilities.

Skilled and less-skilled comprehender groups were identified using scores from the Computerized Achievement Levels Tests (CALT; Northwest Evaluation Association, Lake Oswego, OR, 2001), a district-administered reading achievement test in which scores were provided by the school administration. The skilled comprehender group scored between the 51st and 83rd percentiles on the CALT, and the less-skilled comprehender group performed between the 3rd and 38th percentiles. The skilled comprehender percentile range was chosen to ensure that this group did not include extremely good readers, of which there were a fair number. The less-skilled comprehender group range was chosen to oversample the participants given the larger number of good readers at the schools in this district. The range for the less-skilled comprehender group was also chosen to ensure the students did not have any decoding issues and reading comprehension was the targeted skill of interest to investigate.

The comprehender groups were further verified using their scores from a Curriculum-Based Measurement (CBM) Maze Task (Fuchs & Fuchs, 1992) and the Oral Reading Fluency (ORF) test from the Dynamic Indicators of Basic Early Literacy Skills, 6th ed. (DIBELS; Good & Kaminski, 2002), also provided by the school district. Specifically, the criteria included using the top scores from the 75%–90% to form the skilled comprehender group and the bottom scores from the 0%–40% to form the less-skilled comprehender group. Students who did not fit these criteria were not selected for this study because their scores fit in between the above ranges and did not clearly fit in one comprehender group.

WM capacity was assessed by the researchers as the total words recalled correctly (28 total possible words) on a sentence-span measure (Swanson, 1999). Across participants, word recall scores ranged from 0 to 24. We used a median-split cut-off (seven words recalled correctly) to identify participants as having high or low WM capacity.

Based on the above identifiers, and after receiving parental consent and student assent, $n = 30$ skilled comprehenders (20 with high WM and 10 with low WM) and $n = 31$ less-skilled comprehenders (12 with high WM and 19 with low WM) participated in this study. Separate analyses of variance (ANOVAs) with comprehension group as the independent variable and CALT, CBM Maze average correct words read per min, DIBELS ORF, and WM total words scores as dependent variables confirmed the differences between skilled and less-skilled comprehender groups. Means, *SD*s, *F*-values, and effect sizes for each of these analyses by comprehender group are provided in Table 1.

Table 1. Means, *SD*s, *F*-values, and Effect Sizes for the Grouping Measures by Comprehension Skill

	Skilled Comprehenders ($n = 30$)		Less-Skilled Comprehenders ($n = 31$)			
Screening Measures	*M*	*SD*	*M*	*SD*	*F* (1, 59)	Partial η^2
Certified Academic Language Therapists	218.20	3.22	195.42	7.07	259.00***	.81
Curriculum-Based Measurement Maze average words correct	11.06	2.47	7.47	2.98	26.04***	.31
Dynamic Indicators of Basic Early Learning Skills Oral Reading Fluency	137.53	23.31	94.06	25.16	48.91***	.45
Working memory words	10.13	6.25	5.77	5.42	8.48**	.13

** $p < .01$.
*** $p < .001$.

Measures and Materials

Measures. *CALT.* The CALT (Northwest Evaluation Association, 2001) is a standardized computer-adapted reading achievement test (based on the Northwest Achievement Levels Test [NALT]) that students were required to take one or two times per year at their school at the time of this study. The CALT reading subtests measure literal, inferential, and vocabulary components of reading comprehension. The CALT has a reported reliability range of $r = 0.76$–0.87 (Northwest Evaluation Association, 2001).

DIBELS ORF. The DIBELS ORF test (Good & Kaminski, 2002) is an individually administered standardized measure used to identify readers who may need additional instructional support and to monitor progress in ORF and was collected three times per year at the school at the time of the study. DIBELS ORF consists of a set of standardized passages in which participants read aloud for 1 minute. Words omitted, substituted, or hesitated upon for longer than 3 seconds are counted as errors. The number of words read accurately in 1 minute is counted as the fluency score. Reported reliability coefficients for DIBELS ORF range from $r = 0.65$ to 0.98 (Good & Kaminski, 2002).

CBM Maze. The CBM Maze task is a modified cloze task designed to assess overall reading proficiency (Fuchs & Fuchs, 1992). The task is group administered. Participants silently read three texts, in which every seventh word is deleted and replaced with three options, only one of which makes syntactic and semantic sense. Participants choose the words that best fit each sentence. Participants are given 1 minute to read each text silently and select as many words as possible. Each selected word is scored as correct or incorrect, and the total number of correctly selected words is summed. Skipped words are scored as incorrect. Scores from the three passages are averaged. The CBM Maze has a reported reliability range from $r = 0.60$ to 0.80 for elementary-aged participants (Wayman et al., 2007).

Sentence span. To measure WM capacity, participants were individually administered a sentence-span task (Swanson, 1999), which measures the storage and processing components of WM. Participants listen to sets of two to five sentences read aloud by an experimenter. After each set, participants are asked a comprehension question about one of the sentences. After answering the question, participants are instructed

to recall the last words from the sentences they just heard in order of presentation. All components (recall of the last words and question) need to be answered correctly to continue to the next difficulty level. There is a total of six practice sentences and 28 test sentences that range between six and 10 words long. The final words and answers to the comprehension questions are nouns; none of the words are repeated in any of the sets. Words recalled, and question answers are scored for accuracy. In addition, the level of trials is scored; that is, the level the participant completed all items recalled accurately and all comprehension questions were answered accurately is scored. This task lasts approximately 10–15 minutes. This sentence-span task has strong correlations with other comprehension tasks that range from $r = 0.72$ to 0.90 (e.g., Daneman & Carpenter, 1980; Swanson, 1999; Swanson et al., 1989).

Materials. *Narrative texts.* Four narrative texts were used, two for each questioning condition in this study. The texts for each condition were counterbalanced to ensure that each text was administered first or second an equal number of times. The texts used in the current study were modifications of texts used in previous research (e.g., Carlson, van den Broek et al., 2014; McMaster et al., 2012; Rapp et al., 2007). In addition, the texts used for the two different questioning conditions (i.e., during and after reading) were parallel in that they were highly similar in terms of goal structure (plot, nature of events, and tense of language) with a main goal that motivated subgoals and events in the text; however, they differed in terms of characters, setting, and events. For example, one text used for the questioning condition during reading was about a character named Annie who watched dolphins to pass the time; and the parallel text used for the questioning condition after reading was about a boy named Sam who watched squirrels in the park. The topics of the texts were designed to be age appropriate and interesting to children. The average number of words per text was 243.75 and the average Flesch Kincaid (Kincaid et al., 1975) reading level was grade 4.2. Each text was printed, single-spaced, on 8" × 11" card stock paper in size 14 Times New Roman font. Examples of the texts with questions for the methods are presented in the appendix.

Causal questions. The two questioning conditions were designed to compare the generation of inferences between skilled and less-skilled comprehenders during and after reading. Both conditions employed causal questions, used to monitor local and global coherence by encouraging connections in the text and to background knowledge (i.e., goal-driven inference generation) that contribute to the construction of a coherent representation of text (Carlson, van den Broek et al., 2014; McMaster et al., 2012; Rapp et al., 2007). Target connections were identified by conducting causal analyses for each text (Trabasso & van den Broek, 1985; Trabasso et al., 1989).

Each participant took part in a during-reading and an after-reading questioning condition at different time points, at least 2 weeks apart from the other. The order of the questioning conditions was counterbalanced such that all participants received both questioning conditions, but half received the "during-reading" questions first and half received the "after-reading" questions first.

The following instructions were read to the participants in both conditions: "Many readers connect ideas from different parts of a story to help them better understand what they are reading. Today, I will be asking you questions as you read (for questioning during reading)/after you read (for questioning after reading) to help you connect main ideas in the story." Participants were then instructed to read the texts out loud and to pause when they came to a red dot in the text (questions during

reading) or at the end of the text (questions after reading). At these points, participants were asked the causal questions. Five questions with a parallel structure were asked for each text. For example, the first question for a story about the girl named Annie described above (questions asked during reading) was "Why did Annie pass the time watching wild dolphins swim?" and the first question for the parallel story about the boy named Sam (questions asked after reading) was "Why did Sam pass the time watching squirrels gather nuts?" Participants were provided with a practice text and questions before reading the experimental texts for each condition. Participants had two chances to answer each question correctly and were allowed to look at the text during the question answering during both conditions.

Correct answers for both questioning conditions could be found in the text, specifically in local and global areas (i.e., goals and subgoals of the narratives) before the question content. Only these answers provided the correct causal explanation for the question. Correct answers for each question were included on a protocol to aid the experimenters in providing feedback while working with the participants. However, participants were never told if their answer was "correct" or "incorrect" during either questioning condition. Rather, feedback consisted of telling participants, "Okay, continue reading" (during reading) when they answered correctly, or consisted of repeating the question if a participant answered incorrectly (during and after reading). Participants were provided with a repeated question one time if answered incorrectly and were told the correct answer in a complete sentence if answered incorrectly twice. This type of feedback was provided to ensure that participants were not spending an inadequate amount of time on any one question and still heard the correct answer in the form of a sentence. After reading and answering questions, participants were asked to recall the narratives. Each session was audio recorded and lasted approximately 20–30 minutes.

Procedures

Scores from the CALT and DIBELS ORF were provided by the school district. The CBM Maze was administered during scheduled group sessions in class periods, and individually administered assessments (sentence-span task, questioning tasks, recall) took place during regular school hours or during an after-school program. Teachers of participating students helped arrange administration schedules according to availability. Each student received a $5.00 gift card to a local store for participating. Teachers were compensated for their time and class interruption with Amazon.com gift cards to supplement their classroom libraries.

Project staff members were trained to administer and code each task with each other and with project supervisors until they were 100% accurate. They then administered all activities during two sessions that lasted approximately 20–30 minutes each. The sessions with the questioning conditions were conducted at least 2 weeks apart (if not longer), to prevent any immediate recall of the parallel texts. Each session took place in a designated location in the participants' schools. Individual sessions were audio recorded for later transcription and coding.

Coding the question responses. Coding of the question responses was done similarly for responses from both the during- and after-reading conditions. Specifically, first, responses were coded as correct or incorrect. Responses were correct if

they were coded as connecting back to local and global areas in the text prior to the question content in the story (i.e., goals and subgoals) related to causal information that was deemed important for constructing a coherent situation model. Responses were incorrect if they were coded as connecting to local and global areas in the text before or after the question content that was not related to the goals and subgoals of the story. Responses were also incorrect if they were coded as connecting only to background knowledge because the causal questions were developed to assess readers' connections to specific goals and subgoals in the story.

Second, responses were coded as text- or knowledge-based inferences (cf. Linderholm, 2002; Linderholm & van den Broek, 2002; van den Broek et al., 2001). In addition, knowledge-based responses were coded as related if they connected to background knowledge related to a situation in text, and unrelated if they were not related to a situation in the text. Text-based inferences were also coded as local if they connected to text information immediately before the target sentence for the question, and global if they connected to distant text information prior to the target sentence for the question. Finally, during coding, we discovered that some readers generated global text-based inferences that connected to text information after the target sentence for the question and that were out of temporal order. However, readers only generated these inferences in the after-reading questioning condition because they had read the entire text and had access to connect back to any portion of the text when answering the questions and tried to make connections, but such connections were further along in the text from where the question content was provided in the text. Thus, we coded these text-based inferences as global/after text-based inferences. The definition and example of each of these types of correct/incorrect and text/knowledge-based inferences are provided in Table 2.

Coding the recall protocols. Recall protocols for the texts read during the two questioning conditions were parsed into main idea units (e.g., including a subject and a verb) and coded as follows (cf. Kendeou & van den Broek, 2005; Linderholm & van den Broek, 2002; McMaster et al., 2012): conservative if the idea unit matched the gist of an original text unit; liberal if the idea unit was close to the gist of an original text unit and highly constrained by the information in the text; no-match consistent if the idea unit did not match directly with the gist of an original text unit but was valid in the context of the text; and no-match inconsistent if the idea unit did not

Table 2. Inferential Response Types Developed for Questioning Conditions: Text- and Knowledge-Based Inferences

Inferential Response	Definition	Example of Response
Correct combined text-based	Combined both the correct local and global text-based inferences.	"Because Annie was watching dolphins AND they were always in groups and never swimming alone." (Q3, Annie)
Correct local text-based	Connected to correct text information in the immediately preceding sentence.	"He told them about safety in the forest." (Q2, Camping)
Correct global text-based	Connected to correct text information—prior text information, not in the immediately preceding sentence.	"To get kindling." (Q4, Camping)

Table 3. Recall Response Definitions and Examples

Coding Response	Definition	Example
Conservative	Idea unit matched the gist of the original text unit.	"So it's about Annie and her father, who just moved to an island." (story unit/ sentence 1)
Liberal	Idea unit was close to the gist of the original text unit; was highly constrained by the information in the text.	"So they did some research."
No-match inconsistent	Idea unit could not be matched directly to the gist of an original text unit; was invalid or unconstrained by the text.	"And she went to see wild dolphins at the park."
No-match consistent	Idea unit could not be matched directly with the gist of an original text unit; was valid and moderately constrained by the text.	"Sue, they both talked about more dolphins."

Note.—All examples were taken from a recall transcript after reading the text *Annie Moves to the Island*.

match the gist of an original text unit and was invalid or unconstrained by the text. Definitions and examples for each recall code are provided in Table 3.

Scoring. Twelve trained undergraduate research assistants and the primary researcher for this study transcribed the participants' question responses and recall protocols, and then coded participants' question responses and recalls in pairs. Interrater agreement was calculated based on coding from pairs for a randomly selected 20% of the question response and recall transcripts. Average agreement for coded question responses was 93% for during-reading and 92% for after-reading questioning conditions. Average agreement for coded recalls was 80% for during-reading and 81% for after-reading questioning conditions. Disagreements between raters were resolved by discussion.

Data Analysis

Inference generation by comprehension skill. We compared the types and number of text- and knowledge-based inferences generated during and after reading by skilled and less-skilled comprehenders in response to causal questions. We also examined correct/incorrect local and global text-based inferences separately and in combination to determine whether skilled and less-skilled comprehenders connected to near (local) and distant (global) areas in the text, as well as to background knowledge. To do so, we conducted 2 × 2 repeated-measures analyses of variance (RM-ANOVAs) with questioning condition (during vs. after) as the within-subjects factor and comprehension skill (skilled vs. less-skilled) as the between-subjects factor for each type of inference coded (correct and incorrect local and global text-based inferences; related and unrelated knowledge-based inferences). A separate ANOVA was conducted using the number of global/after text-based inferences as the dependent variable and comprehension skill as the independent variable. This variable was only found and coded for during the coding of the question responses for the causal questioning condition after reading.

Inference generation by comprehension skill and WM. We ran additional one-way between-subjects ANOVAs to examine the effect of WM (high vs. low) and reading comprehension skill (skilled vs. less-skilled) on inference generation for

the two questioning conditions. The types of inferences mentioned above were used as the dependent variables in these analyses.

Recall. To determine whether skilled and less-skilled comprehenders differed in the quality of text representations developed after answering questions asked during and after reading, recall responses were compared using 2 × 2 RM-ANOVAs with questioning condition (during vs. after) as the within-subjects factor and comprehension skill as (skilled vs. less-skilled) the between-subjects factor. The types of recall variables mentioned above were used as the dependent variables in these analyses.

Follow-up *t* tests. Follow-up *t* tests were conducted for each significant main effect and each main effect that approached significance. Bonferroni adjustments were made so as to decrease the chance of making a Type I error. Adjustments were made by taking the number of comparisons from each section and divided by the standard $\alpha = 0.05$. Thus, the α-level for the *t* tests was adjusted to $\alpha = 0.01$ for the comparisons made for the questioning activities, and $\alpha = 0.03$ for the comparisons made for the recall activities (when compared with the standard $\alpha = 0.05$). Also see Tables 4 and 5 for notes about this adjustment.

Results

Inference Generation during and after Reading

Skilled and less-skilled comprehenders' inference generation. Both skilled and less-skilled comprehenders generated more correct (combined global and local) text-based inferences during reading than they did after reading, RM-ANOVA revealed main effects of questioning condition, $F(1, 59) = 14.31$, $p < .001$, $\eta^2 = 0.20$, and skilled comprehenders generated more correct text-based inferences (combined global and local) during reading and after reading than did less-skilled comprehenders, $F(1, 59) = 9.04$, $p < .01$, $\eta^2 = 0.13$. However, these main effects were not qualified by an interaction of questioning condition and comprehension skill, $F(1, 59) = 0.34$, $p = .56$, $\eta^2 = 0.01$.

When examining only the questions asked after reading, less-skilled comprehenders generated more global/after text-based inferences than did skilled comprehenders, $F(1, 59) = 9.13$, $p < .01$, $\eta^2 = 0.13$. This result provided evidence that less-skilled comprehenders had more of a tendency to connect to sections in the text out of temporal order that were not related to goals and subgoals (i.e., causal information) associated with a coherent representation of the text than did skilled comprehenders, and perhaps providing evidence of difficulty maintaining coherence.

There were no statistically significant main effects or interactions of questioning condition and comprehension skill for the remaining text-based (incorrect local/global) or knowledge-based (related or unrelated) inferences (all $p > .05$). Means and *SD*s can be found for each inference type by comprehender skill in Table 4 (see Total columns).

Influence of WM during inference generation. There was a statistically significant interaction between WM and comprehension skill, $F(3, 57) = 4.00$, $p = .05$, $\eta^2 = 0.07$ on the generation of correct global text-based inferences. A follow-up *t* test on the interaction between WM and comprehension skill revealed that skilled comprehenders with high WM capacity generated more correct global text-based

Table 4. Descriptive Statistics (Means and *SD*s) for Working Memory and Comprehension Skill during the Questioning Conditions

		During Reading						After Reading					
		M (*SD*)						*M* (*SD*)					
Inferential Responses	Comprehender	High WM	*n*	Low WM	*n*	Total	*N*	High WM	*n*	Low WM	*n*	Total	*N*
Correct global	Skilled	7.35 (1.57)*	20	6.30 (1.57)	10	7.00 (1.62)	30	5.65 (1.81)	20	6.40 (1.35)	10	5.90 (1.69)	30
	Less Skilled	5.75 (1.77)	12	6.42 (1.58)	19	6.16 (1.66)	31	5.33 (1.61)	12	5.37 (1.98)	19	5.53 (1.82)	31
Correct local	Skilled	1.65 (1.09)	20	1.40 (1.08)	10	1.57 (1.07)	30	1.80 (1.11)	20	1.70 (1.49)	10	1.77 (1.22)	30
	Less Skilled	1.75 (1.00)	12	1.37 (1.01)	19	1.52 (1.00)	31	1.42 (1.08)	12	0.89 (1.05)	19	1.10 (1.08)	31
Correct combined (local & global)	Skilled	9.00 (1.52)	20	7.70 (1.49)	10	8.57 (1.61)***	30	7.45 (1.96)	20	8.10 (1.66)	10	7.67(1.86)***	30
	Less Skilled	7.50 (1.93)	12	7.79 (1.32)	19	7.68 (1.55)	31	6.75 (1.66)	12	6.26 (2.13)	19	6.45 (1.95)	31
Incorrect global	Skilled	3.10 (2.02)	20	2.80 (1.69)	10	3.00 (1.89)	30	3.60 (2.84)	20	4.20 (2.94)	10	3.80 (2.83)	30
	Less Skilled	4.17 (2.76)	12	4.37 (4.79)	19	4.29 (4.07)	31	3.42 (3.06)	12	2.89 (3.45)	19	2.81 (2.27)	31
Incorrect local	Skilled	1.20 (0.62)	20	.70 (0.82)	10	1.03 (0.72)	30	1.20 (0.83)	20	1.10 (.99)	10	1.17 (0.87)	30
	Less Skilled	1.08 (1.00)	12	1.79 (2.04)	19	1.52 (1.73)	31	0.75 (0.62)	12	1.16 (1.39)	19	1.00 (1.15)	31
Incorrect global/after	Skilled	NA	NA	NA	NA	NA	NA	1.55 (1.43)	20	0.80 (0.92)	10	1.30 (1.32)	30
	Less Skilled	NA	NA	NA	NA	NA	NA	2.08 (1.31)	12	2.74 (1.91)	19	2.48 (1.71)**	31
Related knowledge-based	Skilled	1.35 (1.31)	20	2.20 (2.20)	10	1.63 (1.67)	30	1.50 (1.47)	20	1.10 (2.47)	10	1.37 (1.83)	30
	Less Skilled	1.25 (1.06)	12	1.11 (1.70)	19	1.16 (1.46)	31	1.17 (2.04)	12	2.42 (2.43)	19	1.94 (2.33)	31
Unrelated knowledge-based	Skilled	3.10 (2.38)	20	1.80 (2.70)	10	2.67 (2.25)	30	2.75 (2.48)	20	4.20 (3.01)	10	3.23 (2.69)	30
	Less Skilled	4.33 (3.63)	12	4.16 (3.32)	19	4.23 (3.38)	31	3.67 (2.10)	12	2.89 (3.45)	19	3.19 (2.98)	31

Note.—*p*-values represent follow-up *t* tests at $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$. Incorrect global-after text-based inference was only coded during the questioning condition after reading to capture participants connecting back to areas in the text that were after the question content and not related to goals and subgoals in the text. Also, significance was evaluated with Bonferroni method at $p = .05$ for each main effect and evaluated with Bonferroni method at $p = .01$ for each comparison.

Table 5. Means and Standard Deviations (*SD*) for Recall

		During Reading		After Reading	
Recall Responses	Comprehender	*M* (*SD*)	*N*	*M* (*SD*)	*N*
Conservative	Skilled	16.83 (7.68)**	30	14.80 (7.64)*	30
	Less skilled	11.29 (7.42)	31	9.90 (7.25)	31
Liberal	Skilled	18.20 (5.92)***	30	16.93 (6.14)*	30
	Less skilled	13.35 (7.49)	31	13.68 (6.45)	31
No-match inconsistent	Skilled	2.07 (2.16)	30	2.97 (2.34)	30
	Less skilled	3.45 (3.91)*	31	4.26 (3.30)	31
No-match consistent	Skilled	9.63 (5.08)	30	10.23 (7.30)	30
	Less skilled	10.87 (6.49)	31	10.42 (6.15)	31

Note.—The no-match inconsistent recall responses were responses not related to information found in the text. The *p*-values represent follow-up *t* tests at $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$. Also, significance was evaluated with Bonferroni method at $p = .05$ for each main effect and evaluated with Bonferroni method at $p = .03$ for each comparison.

inferences during reading than did skilled comprehenders with a low WM capacity, $t(57) = -2.53$, $p = .01$.

There were no statistically significant main effects or interactions between WM and comprehension skill for the remaining text-based (correct local, incorrect local/global) or knowledge-based inferences (related and unrelated) associated with either questioning condition (during and after reading; all $p > .05$). Means and *SD*s can also be found for all inference types by comprehender skill and WM in Table 4.

Text Representations from Recall

Conservative and liberal recall responses. Skilled comprehenders had greater text representations from their recall of the texts than did the less-skilled comprehenders, both for recalled idea units that were coded as conservative during reading and after reading $F(1, 59) = 12.41$, $p = .001$, $\eta^2 = 0.17$, and liberal during reading and after reading, $F(1, 59) = 7.85$, $p = .01$, $\eta^2 = 0.12$. These findings were not qualified by an interaction between questioning condition and comprehension skill when recall main ideas were coded as conservative, $F(1, 59) = 0.07$, $p = .79$, $\eta^2 = 0$, or liberal, $F(1, 59) = 0.89$, $p = .35$, $\eta^2 = 0.02$.

No-match inconsistent and consistent recall responses. Less-skilled comprehenders, on the other hand, made more connections to background knowledge that were inconsistent with the texts in their recall after the during-reading questioning condition than did the skilled comprehenders, $F(1, 59) = 4.39$, $p = .04$, $\eta^2 = 0.07$. This finding was also not qualified by an interaction of questioning condition and comprehension skill, $F(1, 59) = 0.01$, $p = .92$, $\eta^2 = 0$. There were no other main effects of questioning condition and comprehension skill and no interactions between questioning condition and comprehension skill for the no-match consistent recall response variable (all $p > .05$). Means and *SD*s can be found for all recall responses by comprehender skill in Table 5.

Discussion

Reading comprehension is complex and involves several cognitive processes that take place during and after reading. The purpose of this study was to explore and

investigate the factors that influence readers' inference generation during and after reading, and whether such factors help readers maintain coherence throughout reading and develop a coherent representation of a text. To do so, we examined the inferences that skilled and less-skilled comprehenders generated when asked causal questions during and after reading, and the possible effect of WM on inference generation. In addition, we examined skilled and less-skilled comprehenders' recall of the text after each questioning condition. Overall, this study provides added evidence to the field as to why skilled and less-skilled comprehenders may vary in the types of cognitive processes (i.e., inference generation) used to comprehend and maintain coherence of narrative text during and after reading, as well as used to create a representation of a text after reading. Previous research has often provided inconsistent findings regarding how and why readers who struggle with developing and maintaining coherence for successful comprehension also struggle with generating inferences (e.g., Cain & Oakhill, 1999; Cain et al., 2001; Carlson, van den Broek et al., 2014; Laing & Kamhi, 2002). Thus, the evidence from this study points to initial insight as to how different factors may influence inference generation and could help inform the development of new interventions used to improve inference generation skills for struggling comprehenders.

The Effect of Comprehension Skill on Inference Generation during and after Reading

We first found that overall, regardless of comprehension skill, all readers generated more goal-driven text-based inferences to answer the causal questions asked during reading than they did to answer questions asked after reading. The causal questions asked in this study were developed to encourage the generation of goal-driven inferences to achieve and maintain local and global coherence during reading. This finding supports and replicates previous research that has shown that, in general, prompting readers to generate inferences as students read (i.e., during reading) may be more useful for successful comprehension than prompting readers after reading (Carlson, van den Broek et al., 2014; Laing & Kamhi, 2002; McKeown et al., 2009; McMaster et al., 2012; van den Broek et al., 2001). Moreover, generating inferences that help create causal relations has been shown to be useful for maintaining local and global causal coherence during reading (Graesser & Clark, 1985; Graesser et al., 1994) and for creating a coherent representation of a text (Trabasso & van den Broek, 1985). In fact, Kendeou et al. (2009) found that inference generation, especially inferences that represent local and global coherence (i.e., causal inferences), contribute to reading comprehension more so than other basic reading skills such as decoding and vocabulary. The findings in this study support these notions by showing that readers, regardless of comprehension skill, were generating more goal-driven, causally coherent inferences during reading than after reading. Thus, continuing to strengthen the skill of generating goal-driven text-based inferences during reading is important to consider as part of reading comprehension instruction, and specifically by asking goal-driven causal questions instead of other more basic factual questions (e.g., "What" questions) or main idea questions (e.g., "Summarizing" the main idea perhaps is not specific enough). Future research could explore the differences between asking causal questions compared with other types of questions such as factual and main idea or other inferential questions not addressed in the current study.

We also found an effect of comprehension skill on the goal-driven inferences generated during versus after reading. Specifically, skilled comprehenders generated more goal-driven text-based inferences during both questioning conditions than did the less-skilled comprehenders. In addition, less-skilled comprehenders, on the other hand, generated more non-goal-driven text-based inferences (i.e., inferences that connected to text information not related to goals or subgoals) during the after-reading questioning condition than did the skilled comprehenders.

Building off the above finding regarding all readers' inference generation, our investigation of comprehension skill provides a deeper view into the cognitive processes used to maintain coherence. First, our findings support extensive previous research that has shown that skilled comprehenders generate more goal-driven inferences than do less-skilled comprehenders regardless of timing (during or after reading; e.g., Bowyer-Crane & Snowling, 2005; Cain & Oakhill, 1999; Cain et al., 2001; Carlson, van den Broek et al., 2014; Laing & Kamhi, 2002; McMaster et al., 2012; Rapp et al., 2007). Second, our finding further extends how less-skilled comprehenders may be struggling with maintaining coherence throughout reading. That is, we found that less-skilled comprehenders generated fewer goal-driven text-based inferences during and after reading than did skilled comprehenders, and they also generated more non-goal-driven text-based inferences out of temporal sequence after reading than did skilled comprehenders.

These findings expand upon previous research by showing how less-skilled comprehenders exhibited difficulty in generating inferences that connect to text information needed to achieve and maintain coherence (i.e., goals and subgoals), and instead, connected to text out of temporal order in particularly after reading. Specifically, when asked causal questions after reading, less-skilled comprehenders showed more difficulty generating appropriate goal-driven text-based inferences, and instead generated other text-based inferences that may have led to a less causally coherent representation of the text. These differences may be due to poor comprehenders' limited ability to suppress irrelevant information during reading. That is, when prompted with questions after reading, irrelevant information may be more prominent than other more relevant information (i.e., goals and subgoals in the text). Or their ability to maintain coherence after an entire text is hindered because of WM capacity issues. Below we discuss each of these findings in combination with an additional exploratory investigation of the effects of skilled and less-skilled comprehenders' WM on inference generation.

WM capacity during inference generation. In this study, we found that skilled comprehenders with high WM capacity generated more goal-driven text-based inferences during reading that specifically connected to globally coherent information in the text than did comprehenders with low WM capacity. We found no other effects or interactions of WM between skilled and less-skilled comprehenders for the remaining inferences generated during or after reading.

WM was used as an exploratory moderator variable. However, due to the small sample size, findings should be treated with caution. Nonetheless, these findings do support previous research that has shown that WM capacity is related to both children's individual inference generation during reading (e.g., Cain et al., 2004). Readers with high WM have been shown to have more cognitive resources available during reading to generate inferences that connect to text information that helps achieve and maintain local and global causal coherence (i.e., goals, subgoals) than readers

with lower WM. Moreover, readers with high WM have been shown to have a greater ability during reading to suppress information that is not necessary for comprehension and, thus, can filter out information that is not relevant, creating more space to hold relevant information that is needed for successful comprehension (Conway & Engle, 1994; Engle, 1996; Gernsbacher, 1990; Gernsbacher & Faust, 1991; Gernsbacher et al., 1990; Rosen & Engle, 1997, 1998). In her Structure Building Model, Gernsbacher (1990) explains the concept of suppression by stating that skilled comprehenders generate more relevant inferences because irrelevant information is not competing due to the ability to suppress that information. Cowan (1999) also explains that WM resources, such as retrieval, take place during time-sensitive periods during cognitive tasks and may be related to suppression and inference generation abilities as well.

The findings from the current study support the above theories regarding how readers with high WM may be suppressing and retrieving information in memory at the appropriate time to help generate goal-driven inferences during reading to achieve and maintain coherence (Conway & Engle, 1994; Cowan, 1999; Engle, 1996; Gernsbacher, 1990; Gernsbacher & Faust, 1991; Gernsbacher et al., 1990; Rosen & Engle, 1997, 1998). That is, when readers were asked to pause during reading and answer causal questions, readers with high WM may have been able to suppress and retrieve relevant information more easily due to there being little irrelevant information competing (e.g., Cowan, 1999; Gernsbacher, 1990). However, as mentioned above, due to the small sample size in this study, further investigation is needed to confirm this hypothesis with a much larger sample. In addition, having a larger sample size may help provide more power to support an investigation of WM both during and after reading to further understand the role of WM for maintaining coherence throughout the reading task, especially for students who struggle with reading comprehension. The current results, unfortunately, do not differentiate between comprehension skill and WM but would still be worth considering in future studies.

Recall: Comprehension Skill and Text Representations

We also found that skilled comprehenders recalled more story content than did less-skilled comprehenders after both questioning conditions. This finding is consistent with prior findings that skilled comprehenders recall more relevant text information to build a coherent text representation than do less-skilled comprehenders (e.g., Graesser & Clark, 1985; McMaster et al., 2012). In addition, less-skilled comprehenders, in the current study, added more information to their recalls that was inconsistent with the original text information than did the skilled comprehenders. This finding suggests that less-skilled comprehenders may have overly relied on their background knowledge (beyond the text information) during their recalls, which may have in turn caused their recall to be less connected with the text in general and less connected to the causal structures of the text (e.g., McCormick, 1992; McMaster et al., 2012; Trabasso & Suh, 1993; Williams, 1993).

Although the questions in this study were developed to promote causal connections (i.e., goals and subgoals) in the text, we do not know if the information that less-skilled comprehenders recalled is information they perceived to actually come from the text or if they were effortfully trying to pull from information from their background knowledge. Future research could begin to address these potential strategies by asking

readers if they know where the information recalled was from (i.e., the text or background knowledge). Based on the outcomes of this study, researchers could develop interventions that help readers focus on remembering relevant text information to help promote learning from the text rather than rely on previously learned information that did not come from the activity.

Limitations

Although the findings from the current study support and extend previous research in several ways, a few limitations warrant discussion. First, because the sample size was small overall, grade level cannot be addressed in the current study; and thus, generalization of the findings by grade cannot be made. That is, based on these findings, conclusions cannot be drawn as to whether a third grader who is a less-skilled comprehender generates the same type of inferences during or after reading as does a fifth grader who is a less-skilled comprehender. The number of participants in each grade who participated in this study was not equivalent, nor was that an original goal of this study; thus, future research with a larger and equal sized sample of students for each of these grade levels is warranted.

Second, given that this was an exploratory study, the comprehension skill and WM groups were also small. Similar to the above limitation, the findings in this study cannot be generalized regarding how WM functions with regard to comprehension skill and grade level, nor how WM influences how readers maintain coherence during and after reading. However, the exploratory nature of this study provides a direction for the types of future research can take. Thus, using a much larger sample, especially for the WM groups, could provide an opportunity to continue to explore the nature of how WM influences inference generation, comprehension skills, and coherence. In fact, a future study may sample from the very top and bottom quadrants to obtain a reasonable number of participants for both comprehension and WM groups.

Third, the use of questioning prompts (similar to think-aloud activities) used to assess inference generation or other comprehension processing has been criticized because prompting interrupts the reading process and, thus, may interfere with comprehension and the cognitive processes needed for developing successful comprehension (e.g., Kozminsky, 1977). However, if these processes are only assessed after reading as has been previously and numerously used by multiple-choice questions or other offline (i.e., after reading) methods, the processing that happens during reading (i.e., online) would be unknown. Nonetheless, if such methods are used in similar future research, it would be worth making sure the interrupting or prompting is minimized to decrease the chances of disruption and distraction for the reader.

Implications

Although our study does have limitations, our findings also have several practical and research implications for the development of additional interventions and assessments. First, recent research has shown that less-skilled comprehenders benefit from interventions that include questions similar to the types of causal questions asked in the current study, but they also benefit from specific feedback during small group intervention settings when reading narrative texts (McMaster et al., 2015). That

is, McMaster and colleagues have shown that less-skilled comprehenders demonstrated an improved memory of texts, as well as improved oral fluency of narrative texts when placed in small groups of three to five students in which they were provided with immediate feedback after being asked causal questions during and after reading. The findings from the current study support this work and inform additional future research in this area. For instance, it would be fruitful to examine the specific type of feedback students need to generate goal-driven inferences (i.e., causal) during and after reading, thus observing the type of feedback that is most beneficial for struggling comprehenders. Such interventions would also help advance common practice in schools to help support students in making causal connections in text rather than asking other types of questions that may not be challenging enough (e.g., factual, main idea). Doing so may encourage students to use more appropriate cognitive processes and strategies when answering questions, thinking critically, or discussing different parts of the text to maintain coherence. This may also, in turn, help improve comprehension skills.

The findings from the current study also inform the use of appropriate assessments used to identify why students struggle with comprehension where traditional standardized assessments fall short. Carlson, Seipel et al. (2014) have developed such a tool that identifies how struggling readers complete missing information in narrative texts with sentences that mimic the types of inferences and other cognitive processes used during reading. We have found that using such a tool helps identify different reasons for why readers struggle with reading comprehension and could thus help validate current or the development of new interventions.

Conclusion

The purpose of this study was to examine the types of inferences generated during and after reading by children with differing comprehension skills, to understand how young readers develop and maintain local and global coherence and develop a coherent representation of a text, and to understand how WM influences these skills for skilled and less-skilled comprehenders. The findings support and extend the literature in the areas of reading comprehension processing during reading comprehension for late elementary readers. First, in this study we used question prompts to promote connections to causal information in the text deemed important for constructing and maintaining coherence. In this context, we demonstrated that both comprehension skill and WM influence the types of inferences generated and the recalls produced by skilled and less-skilled comprehenders. Second, we found that skilled comprehenders, especially those with high WM, were able to generate more globally goal-driven text-based inferences during and after reading than did comprehenders with low WM. In addition, less-skilled comprehenders were found to struggle with generating appropriate goal-driven text-based inferences during and after reading, and these readers were overly relying on text information out of temporal order to construct a representation of a text in memory. Together, these findings support previous research and provide additional insight into the complexity of cognitive processing that occurs during reading comprehension between readers with different comprehension skills. These findings also provide a better understanding of how examining reading comprehension differences can help improve methods to support successful reading comprehension.

Appendix

Texts Used for Questioning during Reading Condition (experimenter version)

Annie Moves to the Island

Annie and her father recently moved to a small island. Because Annie was new to the island, she had not made any friends. She wanted to meet a new friend soon. To pass the time, Annie watched wild dolphins swim along the shore.

1) **Question: Why did Annie pass the time watching wild dolphins swim?**
   If Correct Response(s): +no friends, lonely *continue reading*
   If Incorrect Response(s): *bored, lives on island *continue with Prompt 1*
   Prompt 1: What else does it say in the story about why Annie passed the time watching wild dolphins swim?
   If Correct Response(s): +no friends, lonely *continue reading*
   If Incorrect Response(s): *bored, lives on island *continue with Prompt 2*
   Prompt 2: Annie had not made any friends so she passed the time watching wild dolphins swim, right?

One day, Annie and her father went into town. They met a fisherman. Annie also met the fisherman's daughter. Her name was Sue. Both of the girls were shy, but soon Annie and Sue began to talk about dolphins.

2) **Question: Why did Annie and Sue begin to talk about dolphins?**
   If Correct Response(s): +Annie wanted to make friends *continue reading*
   If Incorrect Response(s): *Annie watches/likes dolphins; they like dolphins; that's what they have in common *continue with Prompt 1*
   Prompt 1: What else does it say in the story about why Annie and Sue began to talk about dolphins?
   If Correct Response(s): +Annie wanted to make friends *continue reading*
   If Incorrect Response(s): *Annie watches/likes dolphins; they like dolphins; that's what they have in common *continue with Prompt 2*
   Prompt 2: Annie wanted to meet a new friend so Annie and Sue began to talk about dolphins, right?

Annie told Sue how she liked to watch wild dolphins. Sue told Annie that she thought she saw a dolphin swimming alone just that morning. Annie said that this seemed strange, because she thought that dolphins usually swam in groups.

3) **Question: What made Annie think that dolphins usually swim in groups?**
   If Correct Response(s): +she's been watching dolphins and never saw one swimming alone [if only one of those is included in answer, prompt]; *continue reading*
   If Incorrect Response(s): *she knows that [from any other source than what's provided in the text] *continue with Prompt 1*
   Prompt 1: What else does it say in the story about what made Annie think that dolphins usually swim in groups?

If Correct Response(s): +she's been watching dolphins and never saw one swimming alone [if only one of those is included in answer, prompt]; *continue reading*
If Incorrect Response(s): *she knows that [from any other source than what's provided in the text] *continue with Prompt 2*

Prompt 2: Annie watched wild dolphins swim and probably never saw one swimming alone, right?

Annie and Sue then decided that they needed to learn more about how dolphins behave. They read books about dolphins. They learned that dolphins normally do not swim alone. Annie and Sue wondered if the dolphin that Sue had seen was lost.

4) Question: Why did they wonder if the dolphin that Sue had seen was lost?

If Correct Response(s): +they learned dolphins don't swim alone; *continue reading*
If Incorrect Response(s): *because they read about it; because it was alone *continue with Prompt 1*

Prompt 1: What else does it say in the story about why they wondered if the dolphin Sue had seen was lost?

If Correct Response(s): +they learned dolphins don't swim alone; *continue reading*
If Incorrect Response(s): *because they read about it; because it was alone *continue with Prompt 2*

Prompt 2: They learned that dolphins normally do not swim alone, right?

They decided to call the animal rescue office on the island to ask for help. The next day the rescuers returned the dolphin back to its family. Annie and Sue were happy that they were able to help the dolphin. Annie was really happy that she had met Sue.

5) Question: Why was Annie really happy that she had met Sue?

If Correct Response(s): +because they became friends; *continue reading*
If Incorrect Response(s): * because they helped the dolphin *continue with Prompt*

Prompt 1: What else does it say in the story about why Annie was really happy that she had met Sue?

If Correct Response(s): +because they became friends; *continue reading*
If Incorrect Response(s): * because they helped the dolphin *continue with Prompt 2*

Prompt 2: Annie was really happy she met Sue because she wanted to make new friends, right?

This turned out to be a beautiful day.
RECALL

Texts Used for Questioning after Reading Condition (experimenter version)

Sam Moves to the City

Sam and his mother recently moved to a big city. Because Sam was new to the city, he had not met any other children. Sam wanted to make some new friends soon. To pass the time, Sam watched squirrels gather nuts in the local park.

One day, Sam and his mother went to the mall. They met the owner of a store. Sam also met the owner's son. His name was Ben. Both of the boys were friendly, and soon Sam and Ben began to talk about animals. Sam told Ben how he liked to watch squirrels in the park. Ben told Sam that he had seen a baby squirrel sleeping on the ground outside the mall just that morning. Sam said that this sounded weird, because he thought that squirrels usually slept in trees or other more hidden places.

Ben and Sam decided to find out more about squirrels to figure out if the baby was okay. They called the zoo and asked to speak to an animal expert. The expert told them that squirrels do not usually sleep on the ground. Sam and Ben wondered if the squirrel had been abandoned. They decided to call the zoo again and ask the expert for help.

The next day some zoo workers found the squirrel and brought it to the zoo hospital. Sam and Ben were glad they were able to help the squirrel. Sam thanked Ben, and was very happy they'd met at the mall. Sam's move was turning out great.

1) **Question: Why did Sam pass the time watching squirrels gather nuts?**
   If Correct Response(s): +hadn't met other kids, no friends, lonely *continue reading*
   If Incorrect Response(s): *bored, just moved to the city *continue with Prompt 1*
   Prompt 1: What else does it say in the story about why Sam passed the time watching squirrels gather nuts?
   If Correct Response(s): +hadn't met other kids, no friends, lonely *continue reading*
   If Incorrect Response(s): *bored, lives on island *continue with Prompt 2*
   Prompt 2: Sam had not met any other children so he passed the time watching squirrels gather nuts, right?

2) **Question: Why did Sam and Ben begin to talk about animals?**
   If Correct Response(s): +Sam wanted to make friends *continue reading*
   If Incorrect Response(s): *Sam watches/likes squirrels; they like squirrels; that's what they have in common *continue with Prompt 1*
   Prompt 1: What else does it say in the story about why Sam and Ben began to talk about animals?
   If Correct Response(s): +Sam wanted to make friends *continue reading*
   If Incorrect Response(s): *Sam watches/likes squirrels; they like squirrels; that's what they have in common *continue with Prompt 2*
   Prompt 2: Sam wanted to meet a new friend so Sam and Ben began to talk about animals, right?

3) **Question: What made Sam think that squirrels usually sleep in trees or other more hidden places?**
   If Correct Response(s): +he's been watching squirrels AND never saw a baby squirrel sleeping on the ground [if only one of those is included in answer, prompt]; *continue reading*
   If Incorrect Response(s): *he knows that [from any other source than what's provided in the text] *continue with Prompt 1*
   Prompt 1: What else does it say in the story about what made Ben think that squirrels usually sleep in trees or other more hidden places?

If Correct Response(s): +he's been watching squirrels AND never saw a baby squirrel sleeping on the ground [if only one of those is included in answer, prompt]; *continue reading*

If Incorrect Response(s): *he knows that [from any other source than what's provided in the text] *continue with Prompt 2*

Prompt 2: Sam had been watching squirrels and probably never saw a baby squirrel sleeping on the ground, right?

4) **Question: Why did they wonder if the squirrel that Ben had seen was abandoned?**

If Correct Response(s): +they learned that squirrels don't usually sleep on the ground; *continue reading*

If Incorrect Response(s): *because they wanted to find out more; because it was alone *continue with Prompt 1*

Prompt 1: What else does it say in the story about why they wondered if the squirrel that Ben had seen was abandoned?

If Correct Response(s): +they learned that squirrels don't usually sleep on the ground; *continue reading*

If Incorrect Response(s): *because they wanted to find out more; because it was alone *continue with Prompt 2*

Prompt 2: They learned that squirrels don't usually sleep on the ground, right?

5) **Question: Why was Sam really happy that he had met Ben?**

If Correct Response(s): +because they became friends;*continue reading*

If Incorrect Response(s): *because they helped the squirrel *continue with Prompt 1*

Prompt 1: What else does it say in the story about why Sam was really happy that he had met Ben?

If Correct Response(s): +because they became friends; *continue reading*

If Incorrect Response(s): * because they helped the squirrel *continue with Prompt 2*

Prompt 2: Sam was really happy he met Ben because he wanted to make new friends, right?

RECALL

Note

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