

## Effects of Comprehension Skill on Inference Generation during Reading

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The purpose of this study was to investigate differences between readers with different levels of comprehension skill when engaging in a causal questioning activity during reading, and the varied effects on inference generation. Fourth-grade readers ( $n = 74$ ) with different levels of comprehension skill read narrative texts aloud and were asked causal questions at specific points during reading. Responses to questions were examined for the types of inferences the readers made during reading. There was no main effect of comprehension skill in terms of readers' text-based inferences made in response to the causal questions. However, readers differed in their use of knowledge-based inferences in response to the causal questions, and in particular knowledge-based inferences that connected to related text information. Results are discussed in terms of individual differences that can influence attempts at maintaining coherence during reading.

**Keywords:** causal questioning; coherence; comprehension processes; comprehension skills; individual differences; inference generation

### Introduction

A primary goal in reading research is to understand how readers build a coherent representation of a text. A coherent representation of a text is formed by the construction of an internal model that is consistent with the text, often called a situation model, and is a marker of successful comprehension (Graesser & Clark, 1985; Graesser, Singer, & Trabasso, 1994; Kintsch, 1998; McNamara, Kintsch, Songer, & Kintsch, 1996). A large body of research has indicated that readers' situation models of texts can include events that take place in the story or description along the dimensions of time, space, characters, character goals, events, and causality (van Dijk & Kintsch, 1983; Zwaan, Langston, & Graesser, 1995; Zwaan, Magliano, & Graesser, 1995). Encoding story elements along these dimensions can help a reader track what is important in a text for successful comprehension.

Researchers have examined the dimensions of developing situation models (Bohn-Gettler, Rapp, van den Broek, Kendeou, & White, 2011; Zwaan et al., 1995) and the cognitive factors underlying the successful encoding of coherent text representations

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into memory. In addition, text representations have been examined after reading to assess the quality of a reader's memory for text, and to identify whether different types of instructional techniques are more or less effective at encouraging readers to develop coherent text representations in memory (for example, McMaster et al., 2012). But despite this growing body of work, additional research is needed to identify particular instructional techniques that can promote the construction of coherent text representations for struggling readers with insufficient comprehension skills. Thus, this study examines one type of activity—inference generation—that has been shown to be critical for building and maintaining a coherent situation model during reading and to be amenable to instruction (for example, Graesser & Clark, 1985; Graesser et al., 1994). In our examination, we first sought to examine relations between inference generation and comprehension by evaluating the types of inferences that readers with different levels of comprehension skill use during reading. Second, we specifically examined whether an instructional activity focused on encouraging consideration of causality through questions might encourage inference generation, and hence support comprehension.

### **Maintaining Coherence through Inference Generation**

During reading, readers attempt to track and understand dimensions of a text (e.g., characters, character goals, events, causality) to maintain coherence (for example, Graesser et al., 1994; Trabasso & van den Broek, 1985). Inferences that are constructed to maintain causal coherence, for example, include those made when readers attempt to understand that *A* happened because *B* took place. Thus, readers will encode and interpret causal relationships in the text to assist in maintaining coherence during reading.

Furthermore, inferences rely upon information that is intended to establish local and/or global coherence (Casteel, 1993; Graesser & Clark, 1985; McNamara et al., 1996). Local coherence is exemplified when a reader connects currently read information with immediately preceding text information; global coherence is maintained by connecting currently read information to earlier text information beyond the immediately preceding information, as well as building associations with prior understandings (Albrecht & O'Brien, 1993; Graesser et al., 1994; McKoon & Ratcliff, 1992). These activities serve a critical purpose for building a mental representation that encodes and connects explicitly stated text information with background knowledge (i.e., a situation model).

Because readers can track events along a variety of text dimensions (for example, Bohn-Gettler et al., 2011; Zwaan et al., 1995) and readers can rely on various sources of input (i.e., the current text, the previous text, and prior knowledge) to build causal relations in a text, there are several types of inferences that could be generated. Even so, inferences can be grouped into two broad categories: text-based and knowledge-based. *Text-based inferences* include connections that readers make to specific ideas presented earlier in a text. Such inferences can connect to information from immediately preceding text (i.e., near text information; local coherence), or can connect to information from earlier sections of text (i.e., distant text information; global coherence). *Knowledge-based inferences* include connections that readers make to information in background knowledge (i.e., global coherence) that can be explanatory, associative, and/or predictive. These inferences can also be integrated with related or unrelated background knowledge when compared with the text (Carlson, Seipel, & McMaster, 2014; McNamara, 2007; Rapp, van den Broek, McMaster, Kendeou, & Espin, 2007).

### **Reader Differences during Inference Generation**

Good readers generate relevant text-based and knowledge-based inferences during reading (for example, Graesser & Clark, 1985; Graesser et al., 1994; McNamara, 2007; van den Broek, Tzeng, Risdén, Trabasso, & Basche, 2001). However, struggling readers often exhibit difficulty doing so (Cain & Oakhill, 1999; Cain, Oakhill, Barnes, & Bryant, 2001; Oakhill, 1984). These differences may stem from lack of sufficient memory resources or relevant knowledge, and less practice or skill in integrating newly acquired knowledge with information in the text (Cain, Oakhill, & Bryant, 2004).

But despite these informative findings, the methods used to assess differences in inferencing skills between different groups of younger readers might limit the kinds of claims to be derived from the data. For example, younger readers' generation of text-based inferences (after one or more sentences) and knowledge-based inferences (integrating the text and prior knowledge) are usually assessed *after* a reading task is completed (i.e., offline). Younger readers actually may generate these kinds of inferences *during* reading (i.e., online), with the previously mentioned tasks insufficiently sensitive to capture such activity. Identifying the types of inferences that younger readers generate during their attempts at comprehension can be useful for outlining how they rely on them for comprehension.

### ***Improving Reading Comprehension Skills***

The aforementioned studies provide insight into the differences that younger readers with different skill levels exhibit when generating inferences offline. However, examining inference generation during comprehension can provide information about whether younger readers of different comprehension skills are more or less likely to make inferences online. For example, examining the kinds of inferences constructed during reading could reveal further information about whether younger readers of varying skills exhibit difficulty integrating information from previously read text, background knowledge, or both as they read. In addition, it is less clear whether younger struggling readers who have difficulty with decoding and other resource issues attempt to construct online inferences when compared with their good reader peers. Thus, assessing the role of reading comprehension skills can help determine whether inferencing during reading is more or less influential in the performance of different groups of readers.

### ***Assessing Inference Generation during Comprehension***

Differences in the kinds of inferences that people regularly generate as they read have been shown between different groups of readers, and with particular respect to the comprehension of struggling readers. The obtained differences have typically been identified using think-aloud tasks in which readers are asked to read a text one sentence at a time and articulate aloud the thoughts that come to mind during reading (Ericsson & Simon, 1993). Their verbal responses are then coded for types of inferences (e.g., text-based and knowledge-based), repetitions of the text (e.g., paraphrases), comprehension monitoring, affective statements, evaluations of the text, and questions about the text. Findings from think-aloud studies have revealed differences in these codings between different kinds of struggling readers, and in particular younger struggling readers. For example, one categorisation has identified younger struggling readers as either paraphrasers (readers who mostly repeated the ideas conveyed in the text) or elaborators

(readers who mostly generated knowledge-based inferences, but also made connections to background knowledge that were not appropriately related to the text) (Carlson et al., 2014; McMaster et al., 2012; Rapp et al., 2007). These findings illustrate that different groups of younger struggling readers may be processing the text in different ways, utilizing different types of cognitive strategies. Although think-aloud tasks have been useful for identifying specific cognitive processing (e.g., constructing inferences) during reading (Ericsson & Simon, 1993), it would prove informative to extend these findings with different types of tasks during reading (e.g., questioning tasks) to determine the strength of such findings. Furthermore, additional findings from other tasks such as questioning could inform whether particular types of instructional techniques are more or less effective for encouraging readers to use different processing strategies to improve comprehension.

For instance, van den Broek et al. (2001) presented fourth-graders, seventh-graders, 10th-graders and college-aged readers with inferential questions (either during reading or after reading), or asked no questions. The questions asked were causal (why a character performed an activity), literal (what goal was attained), and connecting (how the goal was attained). Participants were asked to recall information after completing the question task, and those recalls were assessed for general information (i.e., general or gist meaning of the text) or specific information (i.e., target information in the questions). Questioning during reading interfered most with the youngest readers' recall, especially target information associated with the questions (specific information). In addition, more skilled readers were able to recall more targeted information after engaging in this question task, as compared with readers who did not do so. The authors concluded that inferential questioning interfered with younger readers' comprehension; however, it is unclear why and how such questioning interfered with their comprehension. In addition, the readers' responses were not assessed for specific cognitive processes (e.g., constructing inferences) used to answer the questions. Thus, further research should be conducted to understand the cognitive processes that readers use when also answering questions during reading.

In a follow-up study, McMaster et al. (2012) used different questioning techniques to assess the effect of questions on the comprehension of narrative texts presented to fourth-grade readers. Specifically, three different types of questioning activities were used with good, average, and struggling readers to assess whether certain types of questioning activities administered during reading helped improve readers' understanding of narrative texts. These questioning activities asked readers literal questions (i.e., "who, what, where, when" questions), prompted readers to make general connections (i.e., "how does what you just read connect to earlier text information?"), or prompted readers to make specific causal connections (i.e., "why did Annie pass the time watching wild dolphins swim?") during reading. The causal questioning activity asked causally based "why" questions (i.e., cause-effect relationships) during reading to encourage readers to make causal inferential connections between text and background knowledge that, as previously described, proves important for maintaining a coherent representation of a text (for example, Graesser et al., 1994). The general questioning activity asked generic questions during reading to encourage readers to make general inferential connections with no direction specified in the questions. Finally, the literal questioning activity asked basic questions during reading to encourage readers to recall specific information from the text.

While McMaster et al. (2012) found no observable effects of questioning activity as a function of reading skill, with struggling, average, and good readers performing

similarly, differences were obtained specifically within the struggling group, and in line with previous articulations of younger readers as paraphrasers and elaborators (Cain & Oakhill, 2006; Rapp et al., 2007). Paraphrasers appeared to benefit more from the general questioning activity, and elaborators appeared to benefit more from the causal questioning activity. This makes sense because elaborators may be trying to make causal connections during reading, in line with what these readers have been shown to do when assessed with a think-aloud task (i.e., connecting to background knowledge by making knowledge-based inferences); in contrast, paraphrasers may be trying to make general connections during reading, yet by doing so may only be repeating the text, which has been observed in think-aloud data. These findings show that different kinds of questions may be more helpful during reading for different types of struggling readers. However, the findings were based on differences between pre-recall and post-recall scores collected after reading, as the authors did not assess whether specific processes (e.g., construction of inferences) were more or less effective when answering the questions. So again, the findings are informative but speak more to post-reading consequences of potential inferential activities rather than to what readers might have been doing during their reading of the texts and attempts to answer the questions.

### **Purpose**

In this study, we assessed readers' cognitive processing, and specifically the types of inferences they constructed during reading, using a causal questioning activity. This activity is particularly informative because the specific "why" questions that were used differed from those used in other tasks. That is, instead of using methods such as a think-aloud task, which generally assesses cognitive processing without specific questioning, the approach adopted in the current experiment involved asking causal questions at specific points throughout the texts deemed important for helping participants build causal connections during reading. Answers to these questions could provide evidence for the cognitive processing that readers do to build coherence during reading when also answering questions that assess comprehension (for example, McMaster et al., 2012; van den Broek et al., 2001). In addition, answers to these questions can provide a useful way of examining the types of inferences generated during reading.

In this study, we also examined reader differences in the types of text-based and knowledge-based inferences they generated when answering causal questions during reading. Previous research has indicated that struggling readers have more difficulty generating these inferences than do good readers when the questions are asked after reading is completed (for example, Cain & Oakhill, 1999; Oakhill, 1984). However, more recent findings indicate that some of these differences do not emerge during reading; that is, struggling readers may exhibit difficulty integrating relevant background knowledge with the text (i.e., knowledge-based inferencing), but do not struggle with connecting to previous text (i.e., text-based inferencing) when compared with their skilled peers (for example, McMaster et al., 2012). Thus, participants' answers to the causal questions could provide additional insight into the kinds of text and background knowledge integration differences that might emerge for different readers.

The purpose of this study was thus to address the following questions: are there quantitative differences in text-based versus knowledge-based inferences generated by readers with different levels of comprehension skill; and are there qualitative differences in the text-based (local vs. global) and knowledge-based (related vs. unrelated) inferences generated by readers with different levels of comprehension skill when their

reading also involves answering causal questions? We were interested in examining causal questions because they may encourage readers to use text-based and knowledge-based inferences to support comprehension of the text. In addition, we were interested in extending previous research findings regarding inference generation differences between readers by assessing inference generation during reading with a specific questioning activity to extend beyond methods that have regularly been employed in the extant literature (e.g., think-aloud tasks). Findings for the current study may provide further insight into the patterns of inferencing observed between readers when they are asked questions during reading, thus identifying whether readers at different levels of comprehension skill differ in the inferencing activities they engage in.

## Method

### *Participants/Setting*

The study was conducted in three Midwestern suburban elementary schools in the United States. A total of 74 fourth-grade students (32 male) participated in this study. The mean age of the students was nine years, four months (range: 8–10 years); six students were African American, 60 students Caucasian, two students Asian, four students Hispanic, and two students other. All students spoke English as their first language, and students with developmental or intellectual disabilities or English-language learners were not selected to participate.

Participants were screened and divided into good, average, and struggling readers using percentile scores from two group-administered standardised reading measures: the Curriculum-Based Measurement (CBM) Maze Task (Deno, 1985; Espin & Foegen, 1996; Fuchs & Fuchs, 1992); and the Gates–MacGinitie reading comprehension test (MacGinitie & MacGinitie, 1989). Specifically, we used scores from the CBM Maze Task to determine the groups, similar to methods used in previous research (McMaster et al., 2012; Rapp et al., 2007). Struggling readers ( $n=34$ ) scored at the 46th percentile (at or below three correct maze choices); average readers ( $n=22$ ) scored between the 50th and 76th percentiles (between four and eight correct maze choices); and good readers ( $n=18$ ) scored above the 78th percentile (above 11 correct maze scores). Scores from the Gates–MacGinitie test were used to corroborate scores from the CBM Maze.

### *Measures and Materials*

#### *Screening Measures*

Participants were screened for reading skill with the CBM Maze task, a modified cloze task used to measure overall reading proficiency (Deno, 1985; Espin & Foegen, 1996; Fuchs & Fuchs, 1992). The Maze is a group-administered test in which participants are asked to silently read three passages, one passage at a time. For each text, every seventh word is deleted and replaced with three options to choose from; participants are required to choose the word that best completes the text as they read. Participants are given one minute to read and complete as many selections as possible from each text. Accuracy scores are averaged across the three passages. CBM Maze correlations with other reading measures range from  $r=0.60$  to  $r=0.80$  for elementary-aged students (Wayman, Wallace, Wiley, Ticha, & Espin, 2007).

Participants' reading performance, as measured by the CBM Maze, was corroborated with scores from the Gates–MacGinitie reading comprehension test. This is a

paper-and-pencil, group-administered measure, composed of 11 texts and 48 multiple-choice questions, that measures comprehension for literal information, inferential information, and vocabulary.

### *Experimental Texts and Questions*

Six narrative texts were used for the causal questioning activity in this study. These texts were developed in previous research (Rapp et al., 2007). Specifically, each narrative text was designed with a similar goal structure (plot, nature of events, and tense of language) with a main goal that motivated sub-goals and events in the text. These goal organisations were substantiated based on causal analyses (Trabasso & van den Broek, 1985; Trabasso, van den Broek, & Suh, 1989), which involved articulating a causal network model for the propositions described in each of the texts. The texts differed in terms of their included characters, setting, and events. The topics of the texts were designed to be age appropriate and interesting to children (e.g., “going to the beach to collect sea shells”), and similar in terms of length, coherence, and grade levels. The average number of words per text was 259.67; the average number of sentences per text was 23.67; and the average Flesch Kincaid reading level (Kincaid, Fishburne, Rogers, & Chissom, 1975) per text was 4.53.

Participants were randomly assigned to read two narrative texts from a total of six for the causal questioning activity. The order of texts was counterbalanced to ensure that each text was administered an equal number of times and to prevent ordering effects. Each text was single-spaced and printed on 8-inch × 11-inch card stock paper in a size 14 Times New Roman font. An example of the student version of the texts used in this study is presented in Appendix 1.

The causal questions for the questioning activity were also developed for previous research (Rapp et al., 2007). There were five or six questions for each text. The questions were about specific text information deemed important for developing local and global coherence during reading. Furthermore, the questions were causal in that they were based on our causal analysis of each text, with the content of each question designed to encourage a causal inference supporting a coherent understanding of the text. Answers to the questions were examined for the type of inference generated (i.e., text-based and knowledge-based inference). The experimenter version of the causal questions included the correct causal response for each question to assist in providing feedback to participants for each question (i.e., if correct, participants were told to continue reading; if incorrect, participants were asked the question again). The experimenters determined the appropriateness and relevance of each participant’s response to each question in a just-in-time fashion during the questioning activity. An example of the experimenter version (i.e., text with questions and exemplar responses) used in this study is presented in Appendix 2.

## **Procedures**

### *Screening*

The group-administered screening measures (i.e., CBM Maze and Gates–MacGinitie) were recorded during one class period by trained project staff. Teachers remained in the classroom during the test administration and provided support for organisational or behavioural problems that occurred.

### Questioning Activity

Trained project staff individually administered the causal questioning activity during regular school hours. Participants were seen for one session of 20–30 minutes during the spring semester at their elementary schools. The causal questioning activity included practice and experimental phases. For the activity, participants read a text out loud and paused when they reached a red dot printed in the text. At that point an experimenter asked a causal question (e.g., “Why did Annie pass the time watching wild dolphins swim along the shore?”). Correct answers to each question could be found in earlier text information before the question appeared.

Sessions were tape-recorded for later transcription and coding. Participants received a US\$5.00 gift card from a local store for participating in the study, and participating teachers were also compensated for their time.

### Question Response Coding

The transcriptions of each session were coded to assess the types and quantity of inferences generated in the participants’ responses to the questions. These inferential responses were potentially categorised into one of two different types—text-based and knowledge-based inferences—based on previously utilised categorisations (i.e., think-aloud activities) (for example, van den Broek, Lorch, Linderholm, & Gustafson, 2001). Although the causal questions were designed to evoke attention to specific causal text information that would support text understanding, knowledge-based inferences were also coded because readers typically use their background knowledge to maintain coherence during reading (for example, Graesser et al., 1994; McNamara, 2007) and may generate knowledge-based inferences to help answer the questions.

Text-based inferences were coded as a combined group of inferences that connected the current text to local and global text information. Knowledge-based inferences were coded as a combined group of inferences that integrated the current text to related and unrelated background knowledge (McMaster et al., 2012; Rapp et al., 2007). Examples of the text-based and knowledge-based inferences that readers generated are presented in Table 1.

All question responses were coded by two independent judges, with one blind to the experimental conditions. Inter-rater percent agreement was calculated for 20% of the participants’ transcripts. There was an average of 91% agreement between the judges. Disagreements between judges were resolved by discussion.

Table 1. Inferential response type definitions and examples used during coding of the causal questioning activity.

Inferential response	Definition	Example of response
Text-based	Connections made to near and distant (i.e., local and global) text information	“Because Annie was watching dolphins and they were always in groups and never swimming alone” (Q3, Annie story)
Knowledge-based	Connections made to background knowledge that was related or unrelated to the text information	“She was worried and scared for her friend” (Q5, Beach story)



## Results

### *Types of Inferences Generated during Reading*

We compared the types of inferences generated by good, average, and struggling readers during reading that also involved answering causal questions. Descriptive statistics (mean and standard deviation [SD]) for text-based and knowledge-based inferences by reader type are presented in Table 2.

### *Quantity of Inferences Generated during Reading*

To determine whether there were differences between the three groups of readers, we conducted a  $2 \times 3$  repeated-measures analysis of variance with inference type (text-based and knowledge-based inferences) as the within-subjects variable and reading comprehension skill (good, average, and struggling) as the between-subjects variable.

### *Text-based versus Knowledge-based Inferences*

There was no main effect of comprehension skill,  $F(1,71) = 0.03$ ,  $p = 0.97$ ,  $\eta_p^2 = 0.001$ , or interaction of inference type and comprehension skill,  $F(1,71) = 0.37$ ,  $p = 0.69$ ,  $\eta_p^2 = 0.01$ . That is, good, average, and struggling readers did not differ overall in the total number of inferences generated when assessed during reading that involved also answering causal questions.

There was, however, a significant main effect of inference type,  $F(1,71) = 74.81$ ,  $p < 0.001$ ,  $\eta_p^2 = 0.51$ . Specifically, all readers generated more text-based inferences (mean = 13.30; SD = 4.01) than knowledge-based inferences (mean = 6.55; SD = 5.19) during reading that involved causal questioning.

### *Quality of Inferences Generated during Reading*

As noted earlier, previous research has indicated that struggling readers have more difficulty generating both text-based and knowledge-based inferences than do good readers when those inferences are queried after reading is completed; however, the assessment of whether these differences occur during reading has been more limited in the methods used to assess such differences. The above findings provide initial evidence that good, average, and struggling readers do not differ in the number of text-based and knowl-

Table 2. Descriptive statistics (mean and SD) for total number of text-based and knowledge-based inferences generated during a causal questioning activity by comprehension skill.

Inferential response	Comprehension skill	Mean (SD)	<i>n</i>
Text-based	Good	13.15 (3.54)	18
	Average	13.18 (4.91)	22
	Struggling	13.72 (3.82)	34
	Total	13.30 (4.01)	74
Knowledge-based	Good	5.83 (3.81)	18
	Average	6.64 (5.73)	22
	Struggling	6.88 (5.56)	34
	Total	6.55 (5.19)	74

edge-based inferences generated during reading that is accompanied by a causal questioning activity. However, we were also interested in whether there were reader differences with respect to the types or quality of text-based and knowledge-based inferences.

As noted in the Methods section, text-based inferences were coded as a combined group of inferences that connected to local and global information in the text; and knowledge-based inferences were coded as a combined group of inferences that integrated the current text to related and unrelated background knowledge. Follow-up repeated-measures analyses of variance were conducted to assess whether good, average, and struggling readers differed in amount of local versus global text-based inferences and related versus unrelated knowledge-based inferences generated during reading. Descriptive statistics (mean and SD) and simple main effects for the types of text-based and knowledge-based inferences generated by reader type are presented in Table 3.

#### *Local versus Global Text-based Inferences*

There was a statistically significant main effect of type of text-based inference,  $F(1,71) = 314.19, p < 0.001, \eta_p^2 = 0.82$ . Specifically, all readers generated more global text-based inferences (mean = 10.31; SD = 3.31) than local text-based inferences (mean = 2.99; SD = 1.66) during reading. However, there was no main effect of comprehension skill,  $F(1,71) = 0.13, p = 0.88, \eta_p^2 = 0.004$ , and no interaction of text-based inference type and comprehension skill,  $F(1,71) = 0.08, p = 0.93, \eta_p^2 = 0.002$ .

#### *Related versus Unrelated Knowledge-based Inferences*

There was a statistically significant main effect type of knowledge-based inference,  $F(1,71) = 15.84, p < 0.001, \eta_p^2 = 0.18$ . Specifically, all readers generated more unrelated (mean = 4.73; SD = 4.95) than related knowledge-based inferences (mean = 1.82; SD = 2.00) during reading. However, there was no main effect of comprehension skill,  $F(1,71) = 0.24, p = 0.79, \eta_p^2 = 0.007$ .

There was a statistically significant interaction of knowledge-based inference type and comprehension skill,  $F(1,71) = 3.18, p = 0.05, \eta_p^2 = 0.08$ . Simple main effects on this interaction revealed that struggling readers generated fewer related knowledge-based inferences than did good readers. There were no other differences found between

Table 3. Descriptive statistics (Means and SDs) and simple main effects for repeated measures analyses of variance for types of text-based and knowledge-based inferences generated during a causal questioning activity by comprehension skill.

		Good ( $n = 18$ )	Average ( $n = 22$ )	Struggling ( $n = 34$ )
Text-based	Local	3.33 <sub>a</sub> (1.75)	2.86 <sub>a</sub> (1.61)	2.88 <sub>a</sub> (1.67)
	Global	10.39 <sub>a</sub> (2.75)	10.32 <sub>a</sub> (4.14)	10.26 <sub>a</sub> (3.08)
Knowledge-based	Related	2.83 <sub>a</sub> (2.55)	1.55 <sub>ab</sub> (1.65)	1.47 <sub>b</sub> (1.72)
	Unrelated	3.00 <sub>a</sub> (2.47)	5.09 <sub>a</sub> (5.49)	5.41 <sub>a</sub> (5.46)

Note: Means in a row that do not share subscripts are significantly different at  $p = .05$  using a Bonferroni adjustment.

struggling, average, and good readers for the types of knowledge-based inferences generated during reading.

## Discussion

This study examined whether fourth-grade readers at different levels of comprehension skill differed in the types of inferences generated during reading while they also completed an embedded causal questioning activity. Readers read narrative texts out loud and were asked causal questions at specific points throughout the text. Text-based and knowledge-based inferences were identified from the verbal responses that participants generated during the activity. There were differences observed between the quantity and quality of text-based and knowledge-based inferences generated during reading between readers with different levels of comprehension skill.

### *Generating Inferences to Maintain Coherence during Reading*

Researchers have given considerable attention to assessing how readers maintain coherence during reading, for which inference generation plays an important role. Readers connect what they read to previous parts of the text and background knowledge in pursuit of constructing a coherent representation of the material (for example, Graesser & Clark, 1985; Graesser et al., 1994). The current study provides additional evidence to support this notion. That is, readers at different levels of comprehension used both text-based and knowledge-based inferences when asked causal questions during reading. The causal questions were designed to facilitate readers' generation of such connections for maintaining coherence during reading.

In this study, we found that all readers generated more text-based than knowledge-based inferences when responding to the causal questions. The questions encouraged readers to build causal relations in order to maintain local and global coherence during reading; thus, our findings suggest that readers at different levels of comprehension can generate inferences that are appropriate for a particular reading situation (e.g., causal questioning activity). However, these findings only focused on causal questions, and thus the claim that this happens more broadly requires more direct testing. Additional research is warranted to assess the types of inferences that can be generated during reading with different types of motivating and focusing questions (e.g., causal vs. general).

The findings from this study also extend previous research showing that good, average, and struggling readers perhaps do not differ in their use of text-based inferences during reading. Previous research has revealed differences in the number of inferences generated between good and struggling readers when those inferences are queried after reading is completed (for example, Cain & Oakhill, 1999; Cain et al., 2001; Oakhill, 1984), and thus the studies for assessing such differences during reading have been more limited. The causal questions asked during reading in the current study may have decreased the difficulty of integrating information from previously read text for struggling readers, encouraging struggling readers to connect to appropriate causal text information by generating the necessary text-based inferences. Although these findings are informative, they should be confirmed in additional research to replicate the findings, which could include both causal questioning and control conditions to compare whether such effects consistently occur as a function of question type.

In this study, good, average, and struggling readers also did not differ in the total number of knowledge-based inferences generated during reading. The findings were

surprising given previous research that indicates struggling readers tend to use fewer knowledge-based inferences than do good readers (for example, Cain & Oakhill, 1999; Oakhill, 1984). But again, the data supporting this finding are based on studies that probed inference responses after reading was completed. After further investigation, we found that different types of knowledge-based inferences, characterised by whether readers integrate the text with related or unrelated background knowledge, may be a source of potential inferential processing differences between readers. Specifically, we found that struggling readers generated fewer related knowledge-based inferences than did good readers when asked causal questions during reading. These findings support previous research that indicates struggling readers may use fewer knowledge-based inferences during and after reading than do their good reader peers (for example, Cain & Oakhill, 1999). However, future research should continue to investigate whether these findings can be replicated with additional methods (e.g., causal questions asked during and after reading) to continue to understand the relationship between the types of inferences that readers with different levels of comprehension skill use to support their comprehension of text.

### ***Assessing Inference Generation***

Our findings also extend previous research by using questioning activities to assess and identify the types of inferences generated during reading, including both text-based and knowledge-based inferences (for example, Cain & Oakhill, 1999; Cain et al., 2001, 2004; McMaster et al., 2012; Oakhill, 1984; Rapp et al., 2007; van den Broek et al., 2001). That is, the task used in the current study differs from tasks used in previous research to identify inference generation (e.g., think-aloud tasks; questioning tasks asked after reading). Findings from this study highlight the need for additional research to develop new questioning methodologies that probe readers to generate both text-based and relevant knowledge-based inferences, since they can be helpful for developing a coherent representation of a text. For instance, perhaps there are other types of questioning techniques that can encourage readers to integrate relevant background knowledge with relevant text during inference generation to support comprehension.

Our findings also extend research that shows readers do not differ with regard to inference generation performance in response to causal questions that are asked during reading (McMaster et al., 2012; Rapp et al., 2007). However, despite these findings, the data do not directly speak to whether the inferences generated assisted or hindered readers' comprehension during the causal questioning activity because we did not collect overall comprehension scores. The focus of this study was to examine inference generation during reading, but a systematic investigation of these kinds of effects on readers' resulting comprehension of the texts (perhaps as measured through recall) is warranted. We might expect that the generation of text-based inferences leads to better comprehension than the generation of knowledge-based inferences, given previous research indicating that inferences based on text content (e.g., causal relations found in text) support the maintenance of local and global coherence, and the development of a coherent representation of a text (for example, Graesser & Clark, 1985; Graesser et al., 1994; van den Broek et al., 2001). Knowledge-based inferences often have a similar effect on supporting readers' attempts at establishing coherence during reading; however, when these inferences are integrated with unrelated background knowledge, they may hinder comprehension (for example, McMaster et al., 2012). Thus, examining whether generating unrelated knowledge-based inferences leads to poorer comprehension than

the generation of related knowledge-based inferences and text-based inferences is also warranted.

### **Limitations and Future Directions**

One issue for the current study is that the questions asked during the causal questioning activity may have been limited in encouraging readers to generate knowledge-based inferences. The questions were developed to help readers make causal connections in the text. In order to make these causal connections, readers draw on memory from previous texts (e.g., character goals, events, causality). This questioning activity may thus have been more text-based rather than knowledge-based, resulting in fewer knowledge-based than text-based inferences generated when answering the questions. However, readers can still utilise background knowledge to understand the text; and how they do so, beyond the encouragement of causal text-based questions, might provide important information for understanding additional processes that can help or hinder comprehension. Future research that develops additional questioning tasks that are both text-based and knowledge-based focused may provide further information regarding individual processing differences during reading.

In addition, participants were administered only one questioning activity. Collecting data for the types of inferences generated based on responses provided during different questioning activities (e.g., questions asked during vs. after reading; causal vs. general vs. no questions) could lead to comparisons across different types of methodologies. Furthermore, findings across different questioning activities could provide additional evidence and causal explanations for inferential differences between readers with different levels of comprehension skill. For instance, the types of inferences used during and after reading may be a function of a reader's working memory constraints or difficulties allocating attention to connect currently read text to earlier text or to relevant background knowledge (for example, Carlson, 2012).

The type of representation or comprehension of the texts read in the current study was not assessed. Providing evidence about the types of inferences used during reading as a function of answering embedded causal questions to maintain coherence, and how such inferences contribute to the development of a representation of the text (e.g., recall) after reading, are important components of the overall picture of comprehension that warrant additional exploration. For instance, if struggling readers develop less coherent text representations and exhibit less of an understanding of the text material as measured through recall (for example, Long, Oppy, & Seely, 1994, 1997), identifying the types of inferences constructed during reading could prove informative for outlining the processes readers use to construct text representations.

Finally, this study did not assess differences between subgroups of struggling readers as has been reported in previous research; that is, paraphrasers or elaborators (for example, Carlson et al., 2014; McMaster et al., 2012; Rapp et al., 2007). Future research that examines inference generation differences between types of struggling readers could also have implications for determining the types of reading interventions most appropriate for readers who struggle with comprehension in different ways (for example, Cain & Oakhill, 2006; McMaster et al., 2012). For instance, struggling readers who paraphrase or elaborate more often than readers with different levels of comprehension skill may benefit from types of reading interventions that encourage making different text-based or knowledge-based connections in order to maintain coherence during reading (for example, McMaster et al., 2012).

## Conclusions

The purpose of this study was to examine the quantity and quality of inferences generated during reading for younger readers with different comprehension skills in order to better understand how readers maintain coherence during reading. The findings provide evidence that readers with different levels of comprehension skill do not differ in the total number of inferences generated as a function of being asked causal questions during reading. However, good and struggling readers differed in the quality of knowledge-based inferences generated. These results extend our understanding of inference generation and individual differences among readers, as well as provide evidence from an additional method for assessing and identifying inferences generated during reading. The findings have implications for developing additional methods to continue to assess the differences between inference-generation skills for readers with different levels of comprehension.

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**Appendix 1. Student Version for Questioning Activity**

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. ●

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. ● 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. ●

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. ● 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. ● This turned out to be a beautiful day.

**Appendix 2. Experimenter Version of Causal Questions**

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.

**Question 1: Why did Annie pass the time watching wild dolphins swim?**

If Correct Answer(s): ±no friends, lonely continue reading

If Other answer(s): \*bored, lives on island continue with Prompt 1

**Prompt 1: What else does it say in the story about Why did Annie pass the time watching wild dolphins swim?**

If Correct Answer(s): ±no friends, lonely continue reading

If Other answer(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.

**Question 2: Why did Annie and Sue begin to talk about dolphins?**

If Correct Answer(s): ±Annie wanted to make friend continue reading

If Other answer(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 begin to talk about dolphins?**

If Correct Answer(s): ±Annie wanted to make friend continue reading

If Other answer(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.



**Question 3: What made Annie think that dolphins usually swim in groups?**

If Correct Answer(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 Other answer(s): \*she knows that [OR 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 Answer(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 Other answer(s): \*she knows that [OR 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.

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

If Correct Answer(s): +they learned dolphins don't swim alone; continue reading

If Other answer(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 Answer(s): ±they learned dolphins don't swim alone; continue reading

If Other answer(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.

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

If Correct Answer(s): ±because she found a friend; continue reading

If Other answer(s): because they helped the dolphin continue with Prompt 1

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

If Correct Answer(s): ±because she found a friend; continue reading

If Other answer(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.