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Third Graders' Strategy Use and Accuracy on an Expository Text: An Exploratory Study Using Eye Movements

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The data that support the findings of this study are available from the corresponding author upon reasonable request.

Abstract

Background: Of the myriad of reading comprehension (RC) assessments used in schools, multiple choice (MC) questions continue to be one of the most prevalent formats used by educators and researchers (Ferrer et al., 2017). Outcomes from RC assessments dictate many critical factors encountered during a student's academic career, and it is crucial that we gain a deeper understanding of the nuances of these assessments and the types of skills needed for their successful completion. The purpose of this exploratory study was to examine how different component skills (i.e., decoding, word recognition, reading fluency, RC, and working memory [WM]) were related to students' response accuracy as they read a text and responded to MC questions. **Methods:** We monitored the eye movements of 73 third graders as they read an expository text and answered MC questions. We investigated whether the component skills differentially predicted accuracy across different question types and difficulty levels. **Results:** Results indicated that readers who answered MC questions correctly were able to identify when they needed to re-read the text to find the answer and were better able to find the relevant area in the text compared to incorrect responders. Incorrect responders were less likely to re-read the text to find the answer and generally had poorer precision when attempting to locate the answer in the text. Finally, the component skills relied upon by readers to answer RC questions were related to the type and difficulty of the questions. **Conclusions:** Results of the present study suggest that comprehension difficulties can arise from a myriad of sources, and that reading abilities together with test-taking strategies impact RC test outcomes.

Keywords: compensatory reading strategies, eye movements, multiple-choice questions, reading comprehension, response accuracy

Abbreviations: RC = Reading Comprehension, WM = Working Memory, MC = Multiple Choice, RM = Reading Motivation

Implications for Practice

What is already known about this topic?

- RC is a multi-faceted concept containing lower- and higher-level component skills.
- RC assessments, and particularly those in the MC format, have a long history of debate throughout the literature as to their accuracy, reliability, and what they are truly measuring.

What this paper adds.

- The data presented were collected as part of a larger project in which eye movement data were collected from third, fifth, and eighth graders as they read passages of varying genre and length. Readers also responded to inferential and literal MC questions. An initial review of the accuracy data from the larger study yielded an interesting finding: for one specific third-grade expository text, the accuracy rate was only about 50%. This accuracy rate is uniquely low, providing us with an opportunity to examine the behaviors of readers when they answered a question correctly versus when they answered the question incorrectly. Although exploratory, we found these data compelling, and with our array of eye movement data, were able to more deeply explore differences between correct and incorrect responders on this expository text. Thus, we would like to report the results out to the wider community as it is likely the case that others encounter item- or passage-specific nuances in which eye movement behaviors can provide more detail. In addition, these results will help inform future avenues of research, as well as the designing and validating of RC assessments.
- The majority of existing research related to test-taking relies on self-report or other unnatural methods of observation (e.g., "point to where you are reading"). Despite the

increase in popularity in eye-tracking methodology, we are unaware of any published studies examining online reading behavior and accuracy on MC questions.

- We found that many factors influence success on MC RC assessments. Specifically, lower-level components, such as word recognition, higher-level components, such as WM, and the type and difficulty level of the questions all affect student performance and interact in different ways.

Implications for practice or policy.

- Explicit instruction and opportunities for practice in the classroom are critical to teach students how to effectively utilize compensatory reading strategies and develop the comprehension skills necessary to succeed on RC assessments.

Third graders' strategy use and accuracy on an expository text: An exploratory study using eye movements

Effective reading comprehension (RC) is a necessary skill for success in school and in life, and it is often measured using norm-referenced assessments. The results of these assessments can determine many outcomes for students, such as classroom placement and access to special services. However, it remains unclear whether these assessments measure overall comprehension ability, or if instead individual questions assess specific components of comprehension. The present exploratory study utilized eye-tracking technology to investigate how item-level characteristics (e.g., inferential vs. literal) and student component skills (e.g., decoding, word recognition, reading fluency, RC, and working memory [WM]) were related to third graders' accuracy on multiple choice (MC) questions. More specifically, we examined (a) students' reading of an expository text and its accompanying MC questions, (b) which component skills were related to response accuracy, and (c) how question type and difficulty-level influenced the use of RC strategies when answering MC questions.

Processes Involved in Reading Comprehension (RC)

The RAND Reading Study Group defines RC as a process wherein readers interpret and apply meaning to text by actively interacting with it (Snow, 2002). This suggests that to be considered a "good comprehender," readers must master a variety of skills beyond simply recognizing and decoding individual words. Best et al. (2008) argue that good comprehenders must be able to combine the meanings of individual words into sentences, draw inferences, and build a coherent situation model to understand the text. Additionally, good comprehenders tend to monitor their understanding during reading and know how to address lapses in comprehension (Garner, 1981). As a result of these characteristics, good comprehenders are more likely to form a deeper understanding of the text and correctly answer comprehension questions, as compared to poor comprehenders.

With such a wide array of necessary skills, it is unsurprising that poor comprehension can be the result of deficiencies in a number of areas. Many researchers agree that these skills can be broken down into lower-level and higher-level processes. Lower-level processes, such as decoding, are so influential that Blanchard (1980) found that simply exposing readers to unfamiliar words before they encountered them in a text increased overall RC. This improvement in comprehension, even without being taught the meaning of unfamiliar words, is indicative of the importance of lower-level skills and the burden that their absence can place on the efforts of struggling readers. In fact, research indicates that when readers must expend effort on decoding individual words, WM capacity and RC suffer due to a lack of cognitive resources to devote to higher-level processes (Basaraba et al., 2013; Best et al., 2008).

Once readers master lower-level processes, they can begin to ascertain the meaning of a text (i.e., higher-level processes) and familiarize themselves with its structure (van der Schoot et al., 2008). Indeed, Seigneuric and Ehrlich (2005) found that although decoding and vocabulary skills were significant contributors to RC in first and second grades, WM only began to contribute to RC in the third grade. Successful comprehension requires readers to identify important concepts in a text, generate inferences about what is or is not being said, and connect new information with knowledge already possessed, all of which rely upon an accessible mental representation of the text that the reader can refer to and update as needed (Cain et al., 2004). Poor comprehenders have been shown to struggle with discerning relevant information in a text (Carretti et al., 2005), as well as retaining and updating information contained in their WM in the face of incoming content (Palladino et al., 2001). In contrast, good comprehenders are better able to use a text to reinforce their mental representation of it (Murray & Kennedy, 1988) as well as successfully locate and apply important information contained within (Cataldo & Oakhill, 2000). Cataldo and Oakhill (2000), for example, asked participants to verify their answers to comprehension questions by locating the corroborating content in a previously-read text and indicating with their finger where they were reading. The researchers found that good comprehenders spent less time searching for the answer and were more likely to go directly to the relevant area. Additionally, Murray and Kennedy (1988) found that good comprehenders made more large, sweeping eye movements to specific areas in a text when answering a question about the content contained therein, whereas poor comprehenders resorted to backtracking with shorter, choppier eye movements, indicating a much less direct search for information. These findings suggest that when readers are better able to comprehend a text, they can more easily build a mental model of it to hold in their WM, allowing them to revisit key areas of the text much more quickly and efficiently than poor comprehenders. It is reasonable to assume, then, that poor comprehenders, who may still be struggling to master lower-level skills, would not yet be able to successfully integrate, retain, and access important information from their WM stores when their cognitive resources are otherwise taxed by decoding the letters and words in front of them.

In addition to cognitive factors, reading motivation (RM) also affects performance on comprehension assessments. Prior research assessed both intrinsic RM (reading for enjoyment) and self-efficacy (beliefs in one's abilities) and found that stronger readers tend to exhibit higher levels of positive RM, whereas poorer readers tend to score lower on RM assessments (Guay et al., 2019). Additionally, lower levels of intrinsic RM and self-efficacy can curtail persistence on reading tasks and lead to frustration and a sense of failure (Cartwright et al., 2016). This, in turn, may lead to fewer interactions with the text as patience runs out, ultimately contributing to a less thorough understanding of the text and poorer performance on comprehension assessments.

Even if a reader is considered a "good comprehender," the use of compensatory mechanisms, or reading strategies, is sometimes necessary to compensate for a lack of background knowledge or a lapse in comprehension. These compensatory reading strategies can include re-reading sections of text (van der Schoot et al., 2008), searching the surrounding text for contextual clues as to the meaning of a word or idea (Paris & Flukes, 2005), and activating background knowledge (Schreiber, 2005). Kletzien (1991) found that more difficult texts place higher demands on lower-level comprehension skills, such as word recognition, negatively impacting higher-level components that facilitate deeper understanding. Additional research implies that good comprehenders are not only better at recognizing when they need to utilize a compensatory reading strategy (Cataldo & Cornoldi, 1998), but they are also more willing to try a variety of strategies, such as searching for contextual clues, re-reading, and making inferences, when their current approach proves unsuccessful (Kletzien, 1991). Interestingly, however, Walczyk et al. (2004) found that poor comprehenders use more compensatory reading strategies than good comprehenders, but only after encountering a comprehension question they are unable to answer. It appears that although poor comprehenders utilize more retroactive compensatory reading strategies, good comprehenders actively monitor their comprehension as they read (Jian, 2017; Joseph, 2005).

Metacognition can be thought of as one's awareness of their cognitive processes (Flavell, 1979). The concepts of monitoring and repairing comprehension during reading, important aspects of metacognition, involve readers' awareness of their understanding of a text, or lack thereof, and their ability to employ appropriate strategies to repair confusion. Although one's ability to monitor and repair their comprehension increases with age and proficiency (Pintrich & Zusho, 2002), research indicates that children as young as first grade monitor their RC (Kinnunen et al., 1998). Kinnunen et al. (1998) found that first graders with more developed decoding abilities were better at monitoring their comprehension while reading, and were more likely to employ more advanced strategies, such as looking back to previously-read areas of the text, than less proficient readers. Kinnunen and Vauras (2010) also examined differences in comprehension monitoring and repair in fourth graders through eye-tracking and found that more efficient readers looked back to re-read sections of a text describing an unfamiliar topic more often than less efficient readers, and they also recalled more main ideas from the text. Prior research suggests that better readers across age groups are more aware of lapses in their comprehension (Hare, 1981; Wagoner, 1983), and are more likely to actively use strategies to alleviate any confusion (Hare, 1981). Kinnunen et al. (1998) conclude that more efficient decoding facilitates an increased frequency of active strategy use as the burden on higher-level processes, such as WM, are reduced.

Assessing Reading Comprehension (RC)

Researchers have used a variety of techniques to assess reading strategies. Cataldo and Oakhill (2000) asked participants to point to where they were reading. Vidal-Abarca et al. (2010) used Read&Answer technology to record reading behaviors as participants manually revealed areas of text to read. Others have used eye-tracking technology to record eye movements while students read and responded to MC questions (e.g., Ardoin et al., 2019; Zawoyski & Ardoin, 2019). Eye-tracking allows for careful analysis of real-time, moment-by-moment reading when comprehension is potentially taking place (Rayner, 1998). According to van der Schoot et al. (2008), eye-tracking may offer a more "ecologically valid" (p. 205) glimpse into how readers process text as they read, whereas methods such as self-reporting can affect the natural mental processes of reading or bias participants' responses (Kirk & Ashcraft, 2001).

Eye-tracking methodology is not only useful for analyzing RC skills; it also offers a glimpse into how those skills are utilized in the face of differing types and difficulty levels of assessments. Prior research indicates that the type of question, or the type of knowledge the question requires the reader to utilize, can affect response accuracy. Literal comprehension questions require the reader to locate information explicitly stated in the text and are considered to be easier than inferential ones (Basaraba et al., 2013; Eason et al., 2012), whereas inferential questions require the reader to make connections within the text to understand a critical, yet not explicitly stated, concept (Basaraba et al., 2013). Since literal comprehension relies on the ability to decode and comprehend words explicitly stated in a text, researchers argue that this can be thought of as the "first level" of comprehension (Basaraba et al., 2013; p. 353). As inferential comprehension is the next, more complicated, level of comprehension, it follows that efficient literal comprehension facilitates successful inferential comprehension (Eason et al., 2012). If readers cannot identify words explicitly stated in a text, their global comprehension of the text, and thus, their capacity to draw inferences, may suffer.

Applegate et al. (2002) further differentiate the types of knowledge assessed by comprehension questions. Specifically, they argue that there can be both low-level and high-level inferential items. Low-level inferential items, they claim, "are not stated verbatim in the text but may be so close to literal as to be obvious" (p. 176). High-level inferential items, in contrast, "call for the reader to link experience with the text and to draw a logical conclusion." (p. 176). Consequently, one could argue that there could also be sub-levels within literal items. For example, a lower-level literal question could simply require the reader to remember something that was stated verbatim in the text, whereas a higher-level literal item can be found in the text, but not stated verbatim. The present study included two inferential comprehension questions and two literal comprehension questions, each tapping into different skill sets of the reader: a lower-level skill set and a higher-level skill set. Research implies that the various levels and components of comprehension are so interconnected that comprehension questions can pose additional, unintended obstacles for struggling readers, and may not solely measure overall RC (Magliano et al., 2007; McNamara & Kendeou, 2011). Students who lack mastery of any number of these skills may struggle more on a particular type of question than another. It is important to identify how and where these obstacles can occur so that RC tests can accurately assess the comprehension skills of the reader, rather than inadvertently tapping into their test-taking abilities or a deficit in a lower-level component.

The Current Study

The purpose of this exploratory study was to examine how different component skills (i.e., decoding, word recognition, reading fluency, RC, and WM) were related to students' RC strategy use and response accuracy as they read an expository text and responded to MC questions. The text examined here was part of a larger study in which we used eye movements to investigate how children (third, fifth, and eighth graders) process texts of varying type (narrative and expository) and length (short, medium, and long) and respond to MC RC assessments. In the present study, we monitored third graders' eye movements as they read an expository text and answered MC questions. The question type was manipulated (literal vs. inferential; low-level vs. high-level). Because the overall response accuracy across the four questions was 50%, we were able to examine the reading and response patterns of the students when they answered correctly versus incorrectly. We addressed the following questions in this exploratory project:

(a) How did students' reading strategies, as determined using eye-movement data, differ across items they answered correctly versus incorrectly? Additionally, were there differences in the precision with which students were able to locate information in the text?

(b) Do component skills differentially predict accuracy across different question types?

Method

Participants

Participants in this study were 78 typically developing third grade students without a special education identification and whose first language was English. Participating schools used their universal screening data (e.g., FastBridge, Measures of Academic Progress) to select an equal number of students across achievement levels for inclusion in the study. The third grade students were one of three grades included in the larger study from which these data originated. The larger study involved third, fifth, and eighth graders, as those grades span the range of grade levels where English Language Arts testing is required, with state-mandated testing generally starting in the third grade. Five third graders were excluded from analyses due to eye-tracking data loss. The remaining 73 third graders attended one of five public elementary schools across three school districts located in the southeastern United States. Free and reduced lunch percentages for the five schools ranged from 16.15% - 91.98%.

Of the 73 participants, 49.32% identified as White, 30.14% identified as Black, 9.59% identified as Hispanic, 5.48% identified as Asian, and the remaining 5.48% identified as multiracial. Participants' ages ranged from 8.58 years to 9.67 years (M = 9.11 years, SD = 0.30) and 56% were female. Written parental consent, as well as written participant assent, were obtained for all participants.

Materials

Component Skill Measures. The Woodcock Reading Mastery Test – Third Edition (WRMT-III; Woodcock, 2011) was used to assess students' reading skills. The WRMT-III is a norm-referenced reading achievement measure suitable for ages 4 to 79 years old. We administered the Word Identification, Word Attack, Word Comprehension, Passage Comprehension, and Oral Reading Fluency subtests of the WRMT-III. The Word Identification subtest required participants to accurately identify and pronounce individual words of increasing difficulty and has a split-half reliability of .91-.94 (Woodcock, 2011). The Word Attack subtest required participants to decode nonwords of increasing difficulty, all of which followed the allowable orthographic rules of English, and has a split-half reliability of .92-.94 (Woodcock, 2011). The Word Comprehension subtest required participants to provide antonyms or synonyms to individual words, as well as being presented with pairs of words and having to provide a one-word response to complete a similar word pair. This task has a split-half reliability of .94 (Woodcock, 2011). The Passage Comprehension subtest required participants to read sentences or short texts of increasing difficulty and identify missing words. It has a split-half reliability of .93-.95 (Woodcock, 2011). Finally, the Oral Reading Fluency subtest measured participants' ability to read texts with accuracy and speed, and has a split-half reliability of .90-.96 (Woodcock, 2011).

To assess students' WM abilities, we administered the Word Recall and Pattern Recall subtests of Lucid Recall (Lucid Innovations Limited, 2013), a computerized assessment of WM. Lucid Recall is designed for individuals between 7 and 16 years of age. Word Recall presented participants with sequences of words and asked them to recall the words in the same order in which they were presented. Pattern Recall presented participants with a grid of squares and required them to correctly recall the pattern of squares once the image disappeared from the screen. Test-retest reliability for these subtests ranged from .68-.71 and .69-.77, respectively (Lucid Innovations Limited, 2013).

The Motivation to Read Profile (MRP; Gambrell et al., 1996) was administered to participants to assess their self-concept in reading and how much they value reading. The 20-question survey required participants to answer items such as "*When I read out loud I am a* _______" using a 4-point scale. The scale for this item included the responses "*poor reader*," "*OK reader*," "*good reader*," and "*very good reader*." Test-retest reliability for this assessment ranged from .68-.70 for third grade students (Gambrell et al., 1996).

Text. The text examined in this study was part of a larger study where analyses revealed an interesting finding of unusually low accuracy on the MC questions for this particular text. It was a short, expository text appropriate for third graders. The text was selected from a widely used standardized achievement measure and contained two paragraphs, seven sentences, 88 words, and 486 characters. Although the Spache score for this text was above the third grade reading level (4.37), it was still determined to be most similar to the other texts chosen for the larger project. Since the other third grade texts were of similar difficulty, it seems unlikely that the fourth grade reading level would explain the low accuracy observed here, as participants did not perform poorly on the other texts in the larger study.

There were two literal and two inferential MC questions associated with this text, each of which assessed a lower-level and a higher-level of comprehension, respectively. The easiest of the four questions was the lower-level literal question (low literal; question #2), which simply required readers to either remember or locate a single piece of information that was presented verbatim in the text. The higher-level literal item (high literal; question #1) explicitly stated the answer in the text, but it was not presented verbatim. Participants had to interpret what was stated in a single phrase in the text and match it to the correct answer option. The lower-level inferential item (low inferential; question #4) required participants to draw an inference about information not explicitly stated in the text. They were to do this, though, by connecting two neighboring sentences that resembled the answer so closely that it could almost be considered a literal question. Finally, the higher-level inferential item (high inferential; question #3) required participants to recognize the necessity of drawing an inference rather than finding an answer in the text, locate two key areas of the text that were separated by three unrelated sentences, and apply their knowledge of the calendar system to identify the correct answer option.

Apparatus

Eye movement data were collected using an SR Research EyeLink 1000 system (SR Research Ltd.), which has a sampling rate of 1000 Hz, a resolution of 0.01 degrees of visual angle, and a range of 32 degrees horizontally and 25 degrees vertically. Eye movements were recorded via the right eye; however, participants' viewing was binocular. The text and questions were displayed on a 24-in. Asus VG248 monitor.

The eye-tracking program was constructed using SR Research's Experiment Builder. On each display screen, participants could see the text and two of the MC questions. Upon encountering the text for the first time, participants saw the text as well as the first two MC questions simultaneously. When participants were ready to move on to the next two MC questions, they could click a button to progress to the next screen. The passage would remain on the screen, but the accompanying MC questions would change to the final two items, allowing readers access to the text as they answered each question. "Next" and "back" buttons were available for participants to move between the question screens; however, they could not move to the next stimuli text until all questions were answered for the present text. No time limit was imposed on participants, allowing them to spend as much time as they felt was necessary to read the passage and answer the MC questions.

Procedure

Parent permission forms were sent home with students describing the study. Students received a small prize for returning the parent permission forms regardless of whether parent permission was provided. Written assent was also obtained from students for whom parental permission was received. At the beginning of the eye-tracking session, participants were informed that they would be reading stories on a computer screen and answering questions as a camera tracked their eye. They were given no guidance regarding how to read or answer the questions, allowing them to choose their own reading strategies. Participants sat at a table with their chin on a chinrest and their forehead resting against the top bar of the chinrest. The 24-in. monitor and eye-tracking camera were positioned approximately 93 cm and 55 cm from the participant, respectively. Eye-tracking and component skill assessments were conducted in quiet spaces provided by the schools (e.g., conference rooms and libraries). The eye-tracking portion of the larger study was conducted in a single session that lasted approximately 20 minutes depending on the speed of the participant. All remaining testing was conducted across one to two additional sessions.

Results

Analytic Plan

The purpose of this paper is descriptive and exploratory. We have rich eye movement data that reflect the reading strategies third graders used when reading a passage and answering MC questions. Since students answered four different types of MC questions, and their accuracy varied across the questions, we will present the data for each question, as well as for the correct versus incorrect responders, separately. First, we examined the different strategies students used when they answered the question correctly versus incorrectly. For example, we coded whether students engaged in re-reading behavior after encountering the question, but prior to responding to it, and how many times they re-read the text. Re-reading of the text was operationalized as two or more successive fixations from left to right after having already read the text and encountered the question. Each time readers looked back to the question and then returned to the text and met the preceding criteria was coded as an additional re-read. We also coded the precision with which students re-read the text to find the relevant material that would help them answer the question. *High precision* was defined as (a) immediately regressing back to the sentence containing the question relevant text that would allow them to answer the question, or (b) regressing to one sentence prior to or following the question relevant text before reading the actual sentence containing it. *Low precision* was defined as regressing to more than one sentence prior to or following the question relevant text before reading it. *No precision* was defined as re-reading the text but never looking at the question relevant text. Additionally, we examined how students differed on the component skill variables (i.e., reading achievement sub-scales, WM, and RM) when they correctly or incorrectly answered each question. See Table 1 for descriptive statistics and Table 2 for the correlations between the component skill variables. We conducted logistic regressions using response accuracy as the outcome variable and component skills as the predictors.

Low Literal Question

The low literal question was the only question in which the answer was presented verbatim in the text. This question had the highest accuracy rate at 71% correct. The majority of correct responders (58%) did not re-read the text, and they often chose the correct answer immediately upon reading it from the list of options. Additionally, of those who did re-read, the majority (68.2%) did so with high precision, only 13.6% had low precision, and 18.2% had no precision. When the students re-read, they varied in the number of times they went back to consult the text. Of the correct responders who re-read, 77.3% found the question relevant text on the first re-read, 4.5% found the question relevant text on the second re-read, and 18.2% never found the information in the text.

The majority of incorrect responders (62%) also refrained from re-reading. Of those who did re-read, though, 50% had no precision, 37.5% re-read with low precision, and 12.5% located the question relevant text with high precision. For the few students who did re-read, 37.5% re-read the relevant section on the first re-read, 12.5% re-read it on the second re-read, and 50% never re-read the question relevant text during re-reading.

Prior to running the logistic regression to examine which component skill measures explained variance in response accuracy, point-biserial correlations between the individual predictors and response accuracy were examined. See Table 3 for the correlations across the four questions. The component skill measures were significant predictors of response accuracy, χ^2 (9) = 20.01, p = .02, with the Nagelkerke R^2 = .39. See Table 4 for regression statistics. Word Attack, Oral Reading Fluency, and the RM tasks were independent contributors to the model.

Additionally, response accuracy for this question, along with both of the inferential questions, was negatively correlated with Value of Reading. Possible explanations for this are explored in the Limitations section.

High Literal Question

The high literal question asked when a specific event detailed in the text occurred, and although the exact wording of the question was not written verbatim in the text, the relevant information to answer the question was presented in the text, making this a literal item that required higher-level processing. This question had accuracy of only 34%. Eye movement observations showed that the vast majority of correct responders (92%) re-read the text when answering this question, and of the students who re-read, 73.9% had high precision and 26.1% had low precision. When they did re-read, 78.2% of students re-read the question relevant text during their first re-read, and the remaining 21.7% correctly located the question relevant text on their second re-read. Thus, all correct responders who re-read found the question relevant text.

The majority of incorrect responders (73%) re-read the text when answering the question. When they did re-read, 34.3% re-read with high precision, 42.9% re-read with low precision, and 22.9% had no precision. Additionally, 51.3% read the relevant information during their first re-read, 20% read that information on their second return to the text, and 5.7% took three returns to the text to locate the question relevant information.

The component skill measures were significant predictors of response accuracy in the logistic regression for this question, too, χ^2 (9) = 23.84, p = .005, with the Nagelkerke R^2 = .42. Even though nearly all predictor variables correlated significantly with response accuracy (see Table 3), the only unique predictor was Self-Concept.

Low Inferential Question

The low inferential question required that students integrated information from two different, but neighboring, sentences from the last paragraph of the text. Accuracy for this question was 62%. The majority of correct responders (57.7%) re-read parts of the text when answering the question, but there was a variety of precision levels amongst them. Of the students who did re-read, 42.3% re-read with high precision, 42.3% re-read with low precision, and 15.4% did not read the question relevant text when searching for the answer. When revisiting the text, 69.2% found the relevant information on the first re-read and 15.4% found it on the second re-read.

Half of the incorrect responders did not re-read when answering this item, but of those who did, 35.7% did so with high precision, 28.6% did so with low precision, 28.6% did not read the question relevant text while re-reading, and an additional participant (7% of the sample) had no fixations to observe due to a partial eye-tracking loss. Of those who did re-read, only 35.7% located the relevant information on their initial re-read, 14.3% of participants required a second re-read, and an additional 14.3% required a third re-read.

The component skill measures were not significant predictors of response accuracy in the logistic regression for this question, χ^2 (9) = 12.50, p = .19, with the Nagelkerke R^2 = .24. Even though Passage Comprehension and Word Recall were significantly correlated with response accuracy (see Table 3), the regression equation failed to reach significance.

High Inferential Question

The high inferential question required students to locate and connect information from two different parts of the text, and they needed an understanding of the calendar year to match what was written in the text to the correct answer option. This was a difficult question, and it had an accuracy rate of only 37%. Nearly every student (all but 7.4% of correct responders) engaged in re-reading the text when answering the question. For the re-readers, 52% re-read with high precision, 32% re-read with low precision, and 16% did not re-read either of the relevant areas during re-reading of the text. Of the students who re-read and answered the question correctly, 60% found the question relevant information on the first re-read, 20% found the information on the second re-read, and one student (4% of the sample) found it on the eighth re-read of the text.

Eye movement observations of the incorrect responders showed a similar pattern with only 19.6% deciding not to re-read. Of those who did re-read, 54.1% re-read with high precision, 40.5% re-read with low precision, and 5.4% failed to read either of the question relevant areas when searching the text. When students did re-read, 86.5% read the question relevant text on the first re-read and 8.1% read that information on the second re-read.

The component skill measures were significant predictors of response accuracy in the logistic regression for this question, χ^2 (9) = 19.60, p = .02, with the Nagelkerke R^2 = .35. Word Comprehension, Oral Reading Fluency, and Value of Reading were significant unique predictors.

Discussion

To our knowledge, this is the first eye-tracking study that provides an in-depth exploration of response accuracy during a RC test. Our study had three main findings. First, third grade students who answered MC questions correctly generally recognized when they needed to re-read the text to find the answer, and when they did re-read, they were better able to find the question relevant text than incorrect responders. Second, incorrect responders were less likely to re-read the text to find the answer, but when they did, they generally had poor precision and aimlessly searched the text. Finally, the component skills that readers rely upon to answer comprehension questions are related to the type and difficulty of the questions. Certain types of questions require heavier reliance on certain component skills, which can cause difficulties for readers who may be lacking in these underlying processes.

The low literal question was the only item whose answer was presented verbatim in the text, making it the easiest of the four questions. This item required readers to recall what they had previously read, or to return to the relevant area of the text to locate the answer. Word

Attack, Oral Reading Fluency, and the two RM measures uniquely predicted response accuracy outcomes. Word Attack assessed lower-level decoding abilities, and this ability was important for this question. These results suggest that readers who were unable to identify the relevant area of the text or recall what was explicitly stated were impeded by inefficient decoding skills. They were likely unable to tap into higher-level components, such as WM, to build an accessible model of the text. Furthermore, we found that most correct responders either did not re-read the text or located the relevant information with high precision. This supports the importance of higher-level skills in answering this item correctly. As Basaraba et al. (2013) argue, when readers are able to automatically decode words they read, they are better able to utilize higher-level component skills and increase their understanding of the text; thus, they rely less on compensatory reading strategies such as searching the text for answers.

Although Self-Concept was the only unique predictor of response accuracy for the high literal item, nearly all component skill variables were significantly correlated with response accuracy. Of particular interest are the significant correlations between accuracy and the two measures of WM: Word Recall and Pattern Recall. Prior research indicates that good comprehenders are better able to find relevant areas within a text, and that this may be partly due to their better memory of a text's structure and content (Cataldo & Oakhill, 2000). Our data show that the majority of correct responders re-read the text to find or confirm their answer choice, and that most of these responders were able to do so with high precision, suggesting they formed a more accurate mental representation of the text. Interestingly, there was no significant difference between the WM measures for the high inferential item. Like the high literal item, the high inferential item also resulted in poor response accuracy, but did not contain an explicit answer in the text, so readers did not have to rely as heavily on a mental model to recall the structure of the text. This reinforces the importance of WM ability to success on the high literal item.

Despite Passage Comprehension and Word Recall being significantly correlated with response accuracy for the low inferential question, only Word Recall was a unique predictor in the regression analysis. Similar to the high literal question, this item likely also relied heavily on WM ability. Even though this is technically an inferential item, it is so close to being literal that readers simply needed to locate the last paragraph of the text and draw a logical inference. The significant relationships of accuracy with Passage Comprehension and Word Recall suggest that differences between correct and incorrect responders were related to differences in their WM capacity and ability to recall the structure of the text.

Finally, for the high inferential question, the most difficult of the four questions, significant correlations were observed between response accuracy and Word Comprehension, Passage Comprehension, and Oral Reading Fluency. Furthermore, the regression analysis indicated that Word Comprehension, Oral Reading Fluency, and Value of Reading were unique predictors of response accuracy. This item required the reader to infer a connection between two relevant areas in the text. It seems reasonable that those with better overall comprehension abilities would be more successful in identifying and connecting those pieces of text. Less skilled comprehenders, on the other hand, may not recognize that they never read an explicit answer in the text and resort to unsuccessfully searching the text for content that is not there.

Results of the present study suggest that comprehension difficulties can arise from a myriad of sources. Individual strengths and weaknesses in underlying component skills can vary across readers. In addition, different types and difficulty levels of questions can affect RC scores. As suggested by prior research, readers who are more familiar with compensatory strategies are better able to successfully utilize strategies and often perform better on RC assessments (Cataldo & Cornoldi, 1998). The National Reading Panel [NRP] (2000) argues that readers who do not receive explicit instruction in the use of compensatory reading strategies are unlikely to learn how to use them on their own. Concerningly, though, Ness (2011) reports that only 25% of observed instructional time was dedicated to RC instruction, and that third graders received the least amount of RC instruction, totaling only 11.2% of instruction time. Additionally, Pressley (2002) described his classroom observations as including "a great deal of testing of comprehension but very little teaching of it" (p. 198). If students are not given adequate instruction and opportunities to practice, they will be unable to succeed on assessments that rely heavily on their use of compensatory strategies, thus jeopardizing their academic success.

The present study allowed for a deep, exploratory dive into the strategies young readers utilize while comprehending an expository text. Extensive research exists examining types of strategies readers can use to repair comprehension (e.g., Paris & Flukes, 2005; van der Schoot et al., 2008), but little is known regarding the online processes of engaging in these strategies or how they might vary as a function of individual component skills or test characteristics. A deeper understanding of readers' engagement through real-time monitoring of eye movements is critical for the development of future RC instruction and assessment. Future studies should examine these behaviors in older readers to see if employment of compensatory reading strategies changes as readers gain more experience with this format of testing. Additionally, a common strategy taught in classrooms is to read the MC questions before reading the text. Although our text and questions were presented simultaneously so that readers could have read the questions first if they wanted to, surprisingly, none of them did. All of the participants in this study read the passage before reading the MC questions. Future research should consider specifically instructing participants to read either the text or the questions first to see how this might influence strategy use and comprehension, particularly as it relates to WM abilities. With the prevalence and implications of MC comprehension assessments, more in-depth, real-time measures of reading and answering behaviors are imperative to accurately assess comprehension and instruct beginning and developing readers on effective strategies and interventions.

Limitations

We believe the results reported in the present study to be a valuable source of direction for future research, but due to their exploratory nature, the results reported here should be considered along with their relevant limitations. The present study examined strategy use on a single expository text. Due to this single data set, we cannot be sure how our findings would extend to different types of texts (i.e., narrative or argumentative texts). Additionally, there was only one instance of each type of question. Future studies should examine the interactions of question type and text type to determine whether our findings extend beyond the current study, as well as to provide opportunities for analyses with greater power. Furthermore, because of the structure of the text, the question relevant areas within the text differed for each of the questions in terms of location and length. Future studies may want to consider controlling for length and placement of relevant areas to avoid potential effects of text structure.

Additionally, we suggest including more assessments of individual differences in future studies. Response accuracy for the low literal, low inferential, and high inferential items was negatively correlated with Value of Reading. It is possible that some highly motivated students who recognized that reading is a valuable skill and were perhaps too confident in their abilities did not feel the need to re-read the text to confirm their answer. If, however, they overestimated their performance, without corrective feedback from experimenters, students' high level of RM coupled with poor response accuracy could have persisted and lead to the observed results. Future studies should consider the role of corrective feedback in RC assessments, as well as metacognition and students' perceptions of their performance. Pintrich and Zusho (2002) argue that younger children tend to overestimate their abilities, and as such, are less likely to feel the need to change their strategies assuming what they are currently doing is sufficient. An assessment of metacognition to gain more insight into how young readers assess their comprehension abilities and how they determine their success while reading is critical in future projects.

Summary

Though exploratory, our findings offer directions for future research and suggest that third grade readers who answer MC questions correctly are better at recognizing when they need to use a compensatory reading strategy, such as re-reading the text, and can do so with greater precision and success. Incorrect responders, in contrast, are less likely to utilize compensatory reading strategies, and when they do, they are less precise and less successful than correct responders. We also found that differences in underlying component skills are related to performance on comprehension assessments. Further examination of eye movements during RC assessments is essential to better understand readers' use of compensatory reading strategies, how usage may change depending on individual differences and question characteristics, and what skills are actually being measured by RC assessments, so that instruction and intervention can be tailored to the needs of the students.

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Table 1

Descriptive Statistics for the Component Skill Measures

Measure	*M*	*SD*	Range
Word Identification	101.95	12.86	68 - 135
Word Attack	100.40	13.23	70 - 129
Word Comp	104.36	11.60	74 - 132
Passage Comp	103.14	14.53	72 - 139
ORF	103.26	11.91	79 - 145
Total Reading Composite	103.41	11.90	77 - 132
Word Recall	106.48	12.52	76 - 134
Pattern Recall	106.94	10.70	72 - 126
SC Motivation	75.59	9.02	52.5 - 97.5
Value of RM	83.23	10.35	60 - 100
Full Survey - Motivation	79.41	8.48	61.25 - 98.75

Note. ORF = Oral Reading Fluency, SC Motivation = Self-Concept Motivation, Value of RM = Value of Reading Motivation

Table 2

Correlations between the Component Skill Measures

	Word Identification	Word Attack	Word Comp	Passage Comp	ORF	Word Recall	Pattern Recall	SC Motivation	Value of RM
Word Identification ($N = 73$)									
Word Attack ($N = 73$)	.650**								
Word Comp ($N = 73$)	.605**	.378**							
Passage Comp ($N = 73$)	.547**	.455**	.599**						
ORF ($N = 70$)	.679**	.510**	.413**	.424**					
Word Recall ($N = 71$)	.533**	.202	.425**	.454**	.332**				
Pattern Recall ($N = 71$)	.219	.207	.412**	.369**	.104	.196			
SC Motivation ($N = 72$)	.107	.189	-.017	.256*	.208	-.051	.076		
Value of RM ($N = 72$)	.211	.154	.190	.163	.375**	.187	-.027	.529**	

Note. * Correlation is significant at $p < .05$; ** Correlation is significant at $p < .01$

Note. ORF = Oral Reading Fluency, SC Motivation = Self-Concept Motivation, Value of RM = Value of Reading Motivation

Table 3

Point-Biserial Correlations between the Component Skill Measures and Response Accuracy for Each Question

	Low Literal	High Literal	Low Inferential	High Inferential
Word Identification	.19	.351**	.17	.18
Word Attack	.32**	.24*	.07	.05
Word Comp	.19	.30*	.07	.32**
Passage Comp	.21	.38**	.24*	.26*
ORF	.23	.33**	.20	.26*
Word Recall	.05	.28*	.32**	.02
Pattern Recall	.20	.23*	.22	.09
SC Motivation	.08	.15	.04	.15
Value of RM	-.08	.18	-.03	-.01
Total RC Accuracy	.62**	.69**	.66**	.58**

Note. * Correlation is significant at $p < .05$; ** Correlation is significant at $p < .01$

Note. ORF = Oral Reading Fluency, SC Motivation = Self-Concept Motivation, Value of RM = Value of Reading Motivation, Total RC Accuracy = Total Reading Comprehension Accuracy

Table 4

Logistic Regression

	B	*SE*	Wald's χ^2	*p* value	*OR*	*CI*
Low Literal						
Word Identification	-.06	.06	1.14	.29	.94	.84-1.05
Word Attack	.08	.04	4.12	.04	1.08	1.00-1.16
Word Comp	.06	.05	1.82	.18	1.07	.97-1.17
Passage Comp	-.02	.03	.43	.51	.98	.92-1.05
ORF	.11	.05	4.07	.04	1.12	1.00-1.24
Word Recall	-.01	.04	.143	.71	.99	.92-1.06
Pattern Recall	.004	.04	.01	.92	1.00	.94-1.08
SC Motivation	.12	.06	3.92	.05	1.12	1.00-1.26
Value of RM	-.16	.06	7.14	.008	.85	.76-.96
High Literal						
Word Identification	.09	.06	2.29	.13	1.10	.97-1.24
Word Attack	-.01	.04	.05	.82	.99	.93-1.06
Word Comp	-.002	.04	.002	.96	1.00	.92-1.09
Passage Comp	.03	.03	1.04	.31	1.03	.97-1.10
ORF	.03	.04	66	.42	1.03	.96-1.11
Word Recall	-.01	.04	.04	.84	.99	.93-1.07
Pattern Recall	.02	.04	.34	.56	1.02	.95-1.11
SC Motivation	.12	.06	4.47	.04	1.14	1.01-1.28
Value of RM	-.05	.05	1.11	.29	.95	.87-1.04
Low Inferential						
Word Identification	-.02	.04	.13	.72	.99	.91-1.07
Word Attack	-.02	.03	.63	.43	.98	.92-1.04
Word Comp	-.04	.04	.87	.35	.97	.90-1.04
Passage Comp	.01	.03	.17	.68	1.01	.96-1.07
ORF	.05	.04	1.79	.18	1.05	.98-1.14
Word Recall	.07	.04	3.92	.04	1.07	1.00-1.15
Pattern Recall	.04	.03	1.62	.20	1.04	.98-1.10
SC Motivation	.02	.05	.21	.65	1.02	.93-1.12
Value of RM	-.04	.04	.74	.39	.97	.89-1.05
High Inferential						
Word Identification	-.02	.05	.16	.69	.98	.90-1.08
Word Attack	-.05	.03	2.57	.11	.95	.90-1.01
Word Comp	.10	.04	5.74	.02	1.11	1.02-1.21
Passage Comp	.01	.03	.19	.66	1.01	.96-1.08
ORF	.08	.04	4.41	.04	1.09	1.01-1.17
Word Recall	-.03	.03	.84	.36	.97	.91-1.03
Pattern Recall	-.04	.04	1.42	.23	.96	.89-1.03

SC Motivation	.10	.05	3.56	.06	1.11	1.00-1.23
Value of RM	-.10	.05	4.78	.03	.90	.82-.99

Note. ORF = Oral Reading Fluency, SC Motivation = Self-Concept Motivation, Value of RM = Value of Reading Motivation, OR = Odds Ratio, CI = 95% Confidence Intervals