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Rebecca R. Norman

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READING THE GRAPHICS: READING PROCESSES PROMPTED BY THE GRAPHICS AS SECOND GRADERS READ INFORMATIONAL TEXT

By

Rebecca R. Norman

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
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ABSTRACT

READING THE GRAPHICS: READING PROCESSES PROMPTED BY THE GRAPHICS AS SECOND GRADERS READ INFORMATIONAL TEXT

By

Rebecca R. Norman

This dissertation is comprised of two manuscripts that resulted from a single study using verbal protocols to examine the reading processes prompted by the graphics as second graders read informational text. Verbal protocols have provided researchers with an understanding of the processes readers use as they read. Little is known, however, about the processes that are prompted by the graphics in these texts. In this study, 30 second graders—designated as below-average, average, and above-average readers based on their comprehension scores on the *Gates-MacGinitie Reading Test* —read two informational texts, were prompted to share their thinking when they looked at a graphic, and completed a free retelling and 8 researcher-designed comprehension questions. These verbal protocols and comprehension scores were used to investigate the research questions: (1) What reading processes are prompted by the graphics as second graders read informational text? (2) In what ways does second graders' reading achievement relate to the processes prompted by graphics as they read informational text? and (3) What is the relationship, if any, between children's processes prompted by the graphics in informational text and their overall comprehension of the same texts according to two outcome-measures? The first and second questions are addressed in manuscript one, while the third is addressed in manuscript two.

With regard to research question one, open-coding of the 60 transcripts revealed 23 reading processes. The number of times any process was prompted by the graphics for

any one child across the two books ranged from 9 to 62 and the number of different processes used by any one child ranged from 1 to 16 different processes.

With regard to research question two, ANOVAs indicated that: (1) there were no statistically significant differences in the sheer number of times any process was prompted among the below-average, average, and above-average readers (2) above-average readers used significantly more different processes than average readers when reading one text, but not the other; (3) the prompting of some individual processes differed by achievement level.

With regard to the third research question, correlations between students' scores on the post-reading comprehension measures and reading processes suggested that: (1) the number of times any process was prompted was significantly correlated with scores on the retelling measure for one book, but not for the other book or for the comprehension question measure for either book; (2) there were no significant correlations between the number of different processes and students' scores on any comprehension measure; (3) a number of individual processes were positively correlated with retelling and/or comprehension question scores.

In conclusion, the graphics in informational text prompted a number of reading processes. Students' reading achievement does appear to relate to the number and type of processes prompted, but perhaps not to the same extent as it does for written text. Furthermore, there is some correlation between processes and students' comprehension scores, but these differ by book and comprehension measure. Finally, some reading processes appear to assist students' comprehension while others do not.

ACKNOWLEDGEMENTS

I have many people to whom I owe thanks for their help in completing this dissertation and my doctoral studies. First and foremost, I would like to thank my advisor and dissertation chair, Dr. Patricia A. Edwards, and my unofficial advisor and dissertation director, Dr. Nell K. Duke. It is because of their mentorship and support that I have grown as a researcher and truly understand how to plan and execute a study from start to finish. Of course, I do not think this dissertation would have been finished without the help of Kate Roberts, Christy Bragg, Meagan Shedd, Laura Jimenez, Nicole Martin, Erin Wibbens, Sarah Little, and Lauren Fingeret. Thank you for answering all questions and learning with me (nothing like the blind leading the blind at times), reading draft after draft, and providing "cheers" when I needed them most. I would also like to thank the other members of my dissertation committee, Dr. Douglas Hartman and Dr. Kimberly Maier for thoughtful suggestions and feedback on the proposal and the dissertation. Finally, I would like to thank my family for being my biggest cheerleaders and supporters. I especially owe my husband for supporting me throughout my studies, for listening to me talk endlessly about comprehension and graphics, for knowing what graphics are included in *Dino Dig* and *Weather Watching* even better than I do, and for making me laugh through it all.

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Introduction

This dissertation is written in an alternative format (Duke & Beck, 1999), consisting of an introduction and two article manuscripts to be submitted to scholarly journals. In this introduction, I will present some of the context and rationale for the study, as well as provide an overview of the study.

Contextualizing the Dissertation

Although I began my doctoral studies with the assumption that I would be studying comprehension and reading processes in a more traditional sense (i.e., of written text), as I began to read more widely, I came across Gambrell's and Jawitz's (1993) article, *Mental imagery, text illustrations, and children's story comprehension and recall,* and Carney's and Levin's (2002) article, *Pictorial illustrations still improve students' learning from text*, and was intrigued as I began to think about my former students and their use of graphics as they read both narrative and informational texts. I remembered differences in their attention to and use of the graphics when reading in different genres. For example, many of them would take a picture walk and make predictions about the book when they read narrative picture books, but not when they read informational text. Also, I recalled teaching them about graphics in narrative text, such as to study the pictures for clues about characters' feelings; in informational text I remembered teaching them to read the captions and labels that accompanied the graphics, but did not remember teaching them to really study the pictures themselves and to see what information they could learn from them. I assumed that their ability to read the accompanying text would lead them to understand the graphics as well, not recognizing the fact that students' abilities to comprehend graphics could vary as much as their ability to comprehend

written text. These realizations led me to question: (1) how are students using the graphics as they read both narrative and informational text? and (2) how are these processes helping them to understand the graphics?

With these questions in mind, I designed my practicum study, which laid the groundwork for the current study, to investigate the processes prompted by the graphics as second graders read informational text. For that initial study, I utilized a verbal protocol design with 9 second graders (3 above-average readers, 3 average readers, and 3 below-average readers) as they read two modified informational texts (i.e., *Animal Look-Alikes* [Griffiths & Clyne, 2005] and *Recycling Adds Up* [Zollman, 2008]). Open coding (Strauss & Corbin, 1998) of the 18 transcripts from the study revealed 17 reading processes (i.e., *label; literal description; inferential description; prediction; infer the author's purpose; confirm-disconfirm text; connection-to-self; irrelevant connection; connection-to-prior knowledge; wonder; knowledge monitoring; affective response; compare-contrast graphics* [renamed graphic-to-graphic connection]*; evaluate; use of running text; use of captions, labels, map key, etc.* [renamed *use of graphical devices*]; and *word identification*) that were prompted by the graphics. Further analysis of the data suggested a number of trends, although the small sample size precluded more in depth statistical analyses. One trend was that students of different reading achievement groups seemed to be prompted to use different processes as they read. For example, only below-average readers were prompted to use the graphics to help them *identify words*. This difference led me to wonder whether students' use of processes differed by achievement group, as research in written-text has suggested (for a review of this research, see Oakhill & Cain, 2004). Another trend noted was the fact that particular books appeared to

differentially influence the processes prompted by the graphics. For instance, *Animal Look-Alikes* was written in a compare-contrast structure (Meyer, 1975) and *Recycling Adds Up* was written in a problem-solution structure (Meyer, 1975). While reading *Animal Look-Alikes* all nine students were prompted to *compare-contrast graphics* a total of 63 times, but only four students were prompted to *compare and contrast graphics* a total of 4 times while reading *Recycling Adds Up.* These differences may partly be explained by the differences in text structure, which led me to wonder whether the use of different books in the study would reveal new reading processes.

Finally, as I continued with my reading about research on reading processes and the comprehension of written text, I noticed that such research has suggested that the use of a greater number of processes is correlated with higher scores on comprehension assessments (e.g., Dermitzaki, Andreou, & Paraskeva, 2008; Samuelstuen & Braten, 2005). In my practicum study, the students' comprehension of the books was not assessed, so I was unable to study whether a relationship existed between the processes prompted by the graphics and students' comprehension of the texts, but wondered whether such a relationship existed. From these findings and questions, I developed my dissertation study.

Overview of the Dissertation

When designing my dissertation study, I had three purposes in mind: (1) to add to our understanding of the processes prompted by the graphics in informational text, (2) to investigate in what ways second graders' reading achievement relates to the processes prompted by graphics as they read informational text, and (3) to investigate what relationship, if any, exists between processes prompted by the graphics in informational

text and children's overall comprehension of those same texts. Therefore, I designed a verbal protocol study in which 30 second graders (10 above-average readers, 10 average readers, and 10 below-average readers) from 8 classrooms in 5 different schools in 5 different school districts read two informational texts (i.e., *Dino Dig* [Odgers, 2008] and *Weather Watching* [Ryan, 2008]) aloud, were prompted to share their thinking whenever they looked at a graphic, and completed two comprehension measures (i.e., free retelling and research-designed comprehension questions) for each text.

Overview of Results

The first manuscript addresses the questions, (1) What reading processes are prompted by the graphics as second graders read informational text? and (2) In what ways do second graders' reading abilities relate to the processes prompted by graphics as they read informational text? Open coding (Strauss & Corbin, 1998) of students' transcripts revealed 25 codes—23 specific reading processes, *no process,* and *uninterpretable.* While 17 of the 23 reading processes had been also coded during my practicum research, six processes (i.e., *create narrative, connection-intertextual* [text-to-text], *connection-graphic-to-written text, name, repeat-paraphrase written text;* and *reading process-other*) were new. In order to investigate the relationship between reading abilities and the processes prompted by the graphics, ANOVAs were run to determine whether there were statistically significant difference in the mean number of times any process was prompted by the graphics, range of processes, and instances of individual processes used for each book and across both books. The results indicated that there were no statistically significant differences in mean number of times any processes was prompted, for range of processes for *Weather Watching* and both books combined, or for

individual processes for *Weather Watching* across the three achievement groups. For *Dino Dig*, however, above-average readers were more likely to use a greater number of processes that average readers, made *graphic-to-graphic connections* more often than average readers and *knowledge monitored* more often than below-average readers. For the two books combined, below-average readers *created narratives* more often than above-average readers while above-average readers made more *intertextual connections* than below-average readers.

The second manuscript focused the question: What is the relationship, if any, between the reading processes prompted by the graphics and children's overall comprehension of the same texts? In order to address this question, correlations were run to determine whether there were statistically significant relationships between (1) the range of processes used by an individual and that child's scores on the book-specific comprehension measures, (2) the number of times any process was prompted by and graphic for an individual and his or her scores on the comprehension measures, and (3) the number of times individual processes were used by a participant and his or her scores on the retelling and the researcher-designed comprehension questions. The results indicated that there were no significant correlations between the range of processes prompted by the graphics and students' retelling or comprehension questions scores for either book, and there was only a significant positive correlation between the number of times any process was prompted and students' retelling scores on *Dino Dig*. Correlations between individual processes and outcome measures indicated that there were statistically significant positive correlations for *graphic-to-graphic connections, irrelevant connection, connection-to-prior knowledge, connection-to-self, intertextual connections,*

label, and *use of graphical devices*. and retelling scores for both books; for *compare-contrast graphics* and comprehension question scores for *Dino Dig*; and for *predicting* and *use of running text* and retelling scores for *Weather Watching.*

Significance of the Study

The results of this study have a number of implications for the field of literacy, but carry three particularly important implications for future research. First, this study adds to our understanding of what reading processes are prompted by the graphics in science informational text, including six new processes that were not revealed in previous research. Just as understanding the reading processes prompted by written text has helped to shape research in reading comprehension and reading instruction, understanding the processes prompted by the graphics is essential to future research on reading graphics and teaching students to better comprehend the graphics. Furthermore, it would appear that the reading processes are not created equal; that is to say, some appear to assist students in retelling and answering comprehension questions more than others do. Knowing which processes prompted by the graphics assist students more in their overall comprehension of the text can help us determine which processes are most important to teach students to use. Finally, in this study the books themselves appeared to influence which processes were prompted by the graphics, as well as the relationship between the processes and reading achievement and between the processes and comprehension scores for that text. This highlights the importance of considering the reader *and* the text as they relate to comprehension of graphics in future research. More research is needed to develop our understanding of reading processes and graphics, but a clearer picture is beginning to appear.

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MANUSCRIPT ONE: GRAPHICAL READING PROCESSES AND READING ACHIEVEMENT: IS THERE A CONNECTION?

Take a moment to consider well-known children's authors and book titles, such as Gail Gibbons' (1995) *The Reasons for the Seasons,* Seymour Simon's (2000) *Destination: Jupiter*, Tomie dePaola's (2001) *26 Fairmount Avenue*, and Kevin Henkes' (1996) *Lilly's Purple Plastic Purse.* These texts are written about different topics, in different genres, and for different reading levels. Yet, they all include a profusion of important graphics, either drawn or photographed, that represent and extend the written text. Visiting a classroom library or local bookstore and looking through the books in the children's section, one again notices the abundance of graphics in children's books.

In some instances graphics—operationalized here as any photograph or illustration in narrative or informational text including but not limited to diagrams, maps, graphs, and tables—add little to the text beyond providing visual appeal to the page (Levin, 1981; Levin, Anglin, & Carney, 1987). In others, the graphics provide additional information, without which the reader could not understand the information provided or the story told (Bishop & Hickman, 1992; Duke et al., in preparation; Fang, 1996). Research has identified six functions of graphics as common: decoration, representation, organization, interpretation, transformation (Carney & Levin, 2002; Clark & Lyons, 2004; Levin, 1981; Levin et al., 1987) and extension (Bishop & Hickman, 1992; Duke et al., in preparation; Fang, 1996) (see Table 1.1). As Donovan and Smolkin (2002) note, it is this latter type of graphics, extension, "these information-bearing units—of various media, colors, and styles—[that] merit special consideration" (p. 510). Previous research has found that the presence of these information-bearing graphics may motivate children

to read a book (Brookshire, Scharff, & Moses, 2002), are what children attend to as they participate in an interactive read-alouds of expository text (Oyler, 1996) and may help children with their comprehension of the text (Norman & Roberts, 2008). The graphics in informational text are particularly important because students must decide to which graphics they should pay attention (Hannus & Hyona, 1999; Moss, 2008), what is most important in the graphic (Duke et al., in preparation) and what information they should learn from them (Duke et al., in preparation; Hannus & Hyona, 1999; Moss, 2008). Little, however, is known about how students are using the graphics in informational text as they read or the reading processes that are prompted by those graphics. In response to these issues, in the study described in this article, I investigated children's reading of two informational texts and the reading processes prompted by the graphics in these two books.

Theoretical Framework

As indicated above, graphics are prominent in books (e.g., Carney & Levin, 2002), and in informational texts in particular (e.g., Fingeret, in preparation; Purcell-Gates, Duke, & Martineau, 2007). They often convey important ideas and carry meaning central to understanding the overall text, especially in informational texts (Duke & Kayes, 1998; Moss, 2008). Therefore, this study is grounded in the belief that being literate is not simply the ability to read and write words; it is the ability to think about, create, and communicate meaning from spoken, written, and *visual* text (e.g., IRA/NCTE, 1996; The New London Group, 1996). When thinking about comprehension and composition, we—as teachers and as researchers—need to think beyond the written word and also consider the comprehension and composition of the graphical elements of text.

Comprehension of visual as well as spoken and written text can be understood through semiotic theory (e.g., Jewitt & Oyama, 2001). It reflects the belief that many graphics (e.g., photographs, diagrams, and pie charts) are meaningful signs that need to be interpreted, just as the print on the page needs to be interpreted, in order to make meaning from the texts (e.g., Jewitt & Oyama, 2001). This meaning is created though interactions between the reader, the context, and the texts (RAND Reading Study Group, 2002). Thus in this study, I investigate students' reading processes prompted by the graphics in two informational texts in the context of one-on-one reading sessions.

Review of the Literature

Comprehension and Written Text

Much of what we know about successful comprehension comes from decades of research on what skilled readers do as they read. We know that skilled readers construct meaning using a wide variety of strategies (e.g., activating prior knowledge, questioning, monitoring their comprehension) purposefully and flexibly (e.g., Duke & Pearson, 2002; Pressley & Afflerbach, 1995). Furthermore, they consider the genre and the reason for reading the text (Duke, 2005; RAND Reading Study Group, 2002); thus, skilled readers will read mystery books for pleasure much differently than they will read the instructions on how to program their DVD players (Duke & Roberts, in press).

Poor readers, on the other hand, use fewer processes and are less skilled at using these processes strategically (see Cain & Oakhill, 2004; Oakhill & Cain, 2007; Pressley & Hilden, 2006). For instance, Cain and Oakhill (1999) found that poor comprehenders made fewer inferences than skilled comprehenders, and Dermitzaki, Andreou, and

Paraskeva (2008) reported that poor readers were less able to distinguish between important and unimportant information and to monitor and repair errors.

Although less research has been conducted on what younger, less skilled readers do as they comprehend, we do have a window into their mental processes as they read. Verbal protocol or think-aloud research that has been conducted to date demonstrates that even young readers can articulate what they do as they read (e.g., Alvermann, 1984; Brown, Pressley, Van Meter, & Schuder, 1996; Hilden, 2008; Norman, in press; Purcell-Gates et al., 2007; Wade, 1990). The research reveals that young children are using a variety of strategies and processes as they read, and to varying degrees as they read informational (e.g., Hilden, 2008; Norman, in press) or narrative texts (e.g., Alvermann, 1984; Brown, et al., 1996).

Importantly, not only can young children report comprehension strategies and processes, but teachers can affect these strategies and processes even in young children (Roberts & Duke, 2009; Stahl, 2004). These strategies and processes include, but are not limited to, predicting, activating prior knowledge, using text structure, questioning, summarizing, identifying important ideas, and visualizing (see Roberts & Duke, 2009 and Stahl, 2004 for reviews of strategy instruction research). Knowing more about the processes young children use, or do not use, while reading written and graphical text and how this varies by child and by reading achievement will help us to decide what processes we need to teach, and to whom, to help all students be successful readers.

Comprehension and Graphics

While the research on comprehension of written text is abundant, the comprehension of graphics has been less researched, and has usually been studied in the

context of how the graphics influence the overall comprehension of the text, rather than whether and how the graphics themselves are comprehended. Moreover, the research that does exist has produced inconsistent results, with some researchers finding that graphics have no effect on overall comprehension (e.g., Brookshire et al., 2002; Miller, 1938; Rose & Robinson, 1984) and others finding that the graphics have either negative (e.g., Harber, 1983; Rose, 1986; Watkins, Miller, & Brubaker, 2004) or positive (e.g., Bromley, 2001; Hannus & Hyona, 1999; Small, Lovett, & Scher, 1993) influences on comprehension (see Norman & Roberts, in preparation for a detailed discussion of graphics and comprehension). For those who have found that the presence of graphics has assisted students in comprehending the overall text, some researchers (e.g., Rusted & Coltheart, 1979) report that it assists below-average readers more, perhaps because the graphics provide them with support for the reader and allow them access to information they could not glean from the written text. Other researchers (e.g., Hannus & Hyona, 1999) posit that graphics help the comprehension of above-average readers due to the fact that students need to integrate information from the written text and graphics in order to benefit from the graphics, which only high-achievement readers appear to be capable of doing. Specifically, Hannus and Hyona asserted that above-average readers recalled and comprehended more from the illustrated texts because they were better able to understand four key ideas: (1) when to examine the graphics while reading; (2) which graphics they should examine; (3) what information they should obtain from the graphics; and, 4) how to combine information in the written text and the graphics into one mental representation. However, neither Rusted and Coltheart (1979) nor Hannus and Hyona (1999) used verbal protocols, think-alouds, or retrospective interviews to study whether

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and how students of different reading achievement groups were using the graphics differently, but rather derived their conclusions as logical and theoretical extensions of their data. This study uses verbal protocols to specifically investigate whether there are differences in the number and type of processes prompted by the graphics for second graders of different achievement groups.

In summary, the research conducted with children thus far has investigated whether graphics improve children's comprehension of written text, but the results have been inconsistent with some researchers finding them to have neutral effects, others finding them to have negative effects, and still others finding that they have beneficial effects. Furthermore, even those researchers who agree that they are beneficial to students' comprehension do not agree for whom or for what reasons.

Outcome versus Concurrent Measures

Most of the previous research on graphics and comprehension explored whether the presence of graphics had beneficial effects on participants' overall comprehension. The results were based on outcome measures, such as free (e.g., Gambrell & Jawitz, 1993) or cued (e.g., Small et al., 1993) recall and specific comprehension questions (e.g., Harber, 1983). Few studies (i.e., Norman, in press; Schnotz, Picard, & Hron, 1993) have used verbal protocols or other concurrent reading measures (e.g., think alouds or embedded questions) to study whether and how students used the graphics, or what reading processes were prompted by the graphics as students read the text. Only one study (i.e., Schnotz et al., 1993) has attempted to investigate how participants used the graphics to assist in their comprehension of informational text through the use of verbal

protocols, and one study (i.e., Norman, in press) examined the processes prompted by the graphics in informational text.

Processes prompted by the graphics. Norman (in press) used verbal protocols to study the processes prompted by the graphics as 9 second graders of varying reading achievement groups (i.e., 3 above-average, 3 average, and 3 below-average readers) from 3 classes read two informational texts (i.e., *Animal Look Alikes* [Griffiths & Clyne, 2005] and *Recycling Adds Up* [Zollman, 2008]). In this study, whenever students looked at the graphics, they were asked what they were thinking and their responses were recorded and transcribed. Using grounded theory (Strauss & Corbin, 1998), their verbal protocols were analyzed to reveal 17 reading processes that were prompted by the graphics as students read these two texts (i.e., *label; literal description; inferential description; prediction; infer the author's purpose; confirm-disconfirm text; connection-to-self; irrelevant connection; connection-to-prior knowledge; wonder; knowledge monitoring; affective response; compare-contrast graphics; evaluate; use of running text; use of captions, labels, map key, etc.;* and *word identification).*

Comparative analysis of the verbal protocols across texts also revealed that the texts themselves appeared to influence what processes were prompted. For example, *Animal Look-Alikes* (Griffiths & Clyne, 2005) is written using a compare/contrast text structure (Meyer, 1975), in which the written text and graphics compare and contrast two animals that could be confused, explicating their similarities and differences. Therefore, it was not surprising that students made more comparisons between and amongst graphics in this book than in *Recycling Adds Up* (Zollman, 2008) which is written in a problem and solution text structure (Meyer, 1975) and in which the content and the graphics do

not lend themselves as readily to the comparisons. For example while reading *Animal Look-Alikes,* one reader studied the crocodile and alligator and noted that "Well, (traces around the picture of crocodile and alligator snouts as talking), ...I found out that the crocodiles snout has more pointy (makes a pointy snout coming out of his face with his hands) and then the alligator has a more (points at alligators snout and traces it) circular snout."

Finally, comparisons of students' verbal protocols suggested that the child's reading achievement may be related to the processes prompted by the graphics in informational text. On average, the graphics prompted twice as many processes for the below-average reader as for the above-average reader. Because of the small number of participants, however, inferential statistics could not be run, and further research is needed to explore what, if any, differences exist in processes prompted by graphics from different reading achievement groups.

Research Questions

The purpose of this study was to extend our understanding of the reading processes prompted by the graphics in informational text. More specifically, I investigated the reading processes prompted by the graphics as second graders of below-average, average, and above-average reading achievement read two informational texts, with a variety of graphics, at their grade level. In this way, I sought to address the research question: What reading processes are prompted by the graphics as second graders read informational text?

In addition, given the importance of graphics for reading comprehension and results of previous research suggesting a relationship between reading achievement and

the processes prompted graphics, I address the question: In what ways, if any, do second graders' reading achievement relate to the processes prompted by graphics as they read informational text?

Methods

Design

To address the research questions, I conducted a study using verbal protocols (Afflerbach, 2000; Pressley & Afflerbach, 1995; Pressley & Hilden, 2004) of second graders reading two informational texts. First, the students were identified as below-average, average, and above-average readers based on their comprehension scores on the *Gates-MacGinitie Reading Test (GMRT)* (MacGinitie, MacGinitie, Maria, & Dreyer, 2000). Then, while reading two informational books, students were asked to think aloud about the text whenever they were so inclined, and were also prompted to comment whenever they looked at a graphic. These verbalizations were analyzed using modified grounded theory (Strauss & Corbin, 1998) (described in more detail below) in order to identify the reading processes prompted by the graphics in informational text. Finally, ANOVAs were run to determine whether there were differences in the reading processes prompted by the graphics by reading achievement group.

Participants

The study was conducted with 30 second-grade students (17 males and 13 females) enrolled in 8 classrooms in 5 schools in 2 states in the Northeastern United States. The 5 school districts from which schools were selected were purposively chosen in order to provide a diverse sample of students based on socioeconomic status and ethnicity. Within each school district, 1 school consented to participate in the study. Two

second-grade classrooms from each school were randomly selected from all consenting classrooms. Subsequently, within each classroom, all consenting students were administered the decoding sub-test (for which students must choose, from a list of similar looking words, the one word that fits a picture) and comprehension subtest (for which students must read a narrative or informational passage and choose which picture illustrates a segment of or answers a questions about that passage) of the *GMRT*, Form T (MacGinitie et al., 2000). Students were selected based on their comprehension scores so that one reader from each class was randomly selected from between the 1st and 30th percentile, one from between the 40th and 60th percentile, and one from between the 70th and 100th percentile. Two classrooms had to be eliminated from the study because they lacked a range of readers as indicated by the *GMRT*. In these two schools, all six students were selected from the other classroom. Selecting only 3 to 6 children per classroom reduced the likelihood that study findings would be affected by any one teacher's reading instruction. Students who received special education services or were English Language Learners were eliminated from the study prior to selection of students in order to eliminate any language and learning disability factors.

The participants were diverse in terms of socio-economic status, which was measured using maternal education level (Entwisle & Astone, 1994) and ethnicity. For the sample, 6% of mothers reported completing 8th grade but not high school, 23% reported completing high school, 6% reported holding associates degrees, 30% reported a bachelors or other four-year degree, 20% reported masters degrees, and 3% reported doctorates; four declined to respond. In terms of ethnicity, per parent report, 6% of the

children were Asian-American, 10% African-American, 50% Caucasian, 20% Hispanic/Latino, and 10% other; and the parents of two students did not respond.

Materials

Students read two informational texts, *Dino Dig* (Odgers, 2008) and *Weather Watching* (Ryan, 2008). Both books are part of the Weldon Owen Publishings' stage two *Top Readers* series, which includes books that are designed with simple sentences, specialized vocabulary, and graphics that provide support, and that contain a range of graphics (Odgers, 2008, back cover; Ryan, 2008, back cover). *Dino Dig* describes how dinosaurs become fossils and how scientists find and use these fossils to learn about dinosaurs. *Weather Watching* explains different types of weather and why they occur. Both books are written at a reading level appropriate for second graders to read independently in the second half of the school year (Chall, 1996).

The graphics included in the books are relevant to the text and provided additional information not included in the text (Duke et al., in preparation; Nikolajeva & Scott, 2000). For example, on pages 6 through 7 of *Dino Dig* (Odgers, 2008), a flow chart illustrates two dinosaurs' bodies being covered by sand, layers of dirt building up on top of the bodies, the bodies turning to stone, and scientists uncovering the fossils. This graphic extends the accompanying written text, which reads "Dinosaur bodies lay under the group for millions of years. As time passed, the bones were replaced by minerals and turned to stone. They became fossils." There were also representational graphics, such as a drawing of a skeleton hanging in a museum (p. 20-21) which represents what is stated in the text: "The fossil skeletons are put on display in a museum" (p. 20). Both texts

include photographs and drawings with captions and labels, diagrams, maps, and flow charts (see Table 1.2).

Because children this young should not be asked to think aloud for too long a period of time, specific sections of the book were removed, with three sections and five pages removed from each book. Any section removed met the following criteria: (1) the exclusion of those pages would not diminish the range of graphics in the text, and (2) the removal of those sections would not impact the comprehension of later sections. Within sections that met these criteria, I gave priority to removing sections that (1) contained vocabulary or concepts deemed difficult or confusing for second grade students and (2) that were not typical of informational text.

Finally, as in Norman (under review), to more easily track when students were looking at the written text and when they are looking at the graphics, the books were modified in a number of ways. Specifically, the original books, measuring 6 inch by 9 inch (15.24 cm by 22.86 cm), were cut apart and glued onto construction paper, measuring 12 inches by 18 inches (30.48 cm by 45.72 cm), so that the distance between the main text and the graphics was increased. The labels and titles of graphics were not cut apart from the image and headings and connected text remained intact; relative position of graphics and texts on the page was kept the same.

Data Collection Procedures

Sessions one and two. The first two sessions occurred within the classroom as all students with parental consent completed the decoding and comprehension subtests of the *GMRT*, Form T, Level 2 (MacGinitie et al., 2000). These sessions were also used to

introduce myself to the students and explain the study to them. All students who were not participating in the study read quietly at their seats during this time.

Sessions three and four. The third and fourth session were held on a one-to-one basis in a quiet place outside of the classroom. During these sessions, the students read either *Dino Dig* (Odgers, 2008) or *Weather Watching* (Ryan, 2008). The order of presentation was counterbalanced within achievement group and classroom.

Students read each book aloud. The readings were not corrected. When students asked for help identifying a word they were encouraged to try their best. In a few instances, when students refused to continue reading, they were supplied with a word. As students read, they were asked to verbalize what they are thinking as described below.

Verbal protocols. To determine the processes prompted by the graphics, verbal protocols (Pressley & Afflerbach, 1995; Pressley & Hilden, 2004) were used. As is recommended in verbal protocol methodology books and chapters, the directions provided to students for sharing their thinking were general:

> Today, you are going to be reading a book for me. The book is going to look a little funny (show students book), so don't worry about that. As you read, I cannot help you with any of the words. If you come to a word you don't know, try your best and keep reading. When you are done reading, I am going to ask you to retell the book to me [retellings are not analyzed for this manuscript]. I am also going to ask you some questions about the book. As you read, I want to know what you are thinking. Sometimes, I am going to stop you to ask you to tell me what you are thinking. If you have nothing to say, you can tell me that too. You can also talk

about the book at other times when I don't ask if you want to. Is it okay to tell me you have nothing to say? Is it okay to talk about the book whenever you want?

As students read, I watched continuously in order to determine where the participants' eyes were looking, the text or the graphics. When I noticed that they were looking at a graphic, participants were prompted to share their thinking with, "What are you thinking?" If students had not looked at any graphics after four pages, they were also prompted.

Videotaping. All interactions with the students during the two reading sessions were videotaped. Videotaping was used instead of audiotaping in order to capture when students were pointing at different parts of the book as they were talking about what they were thinking. In this way, I was able to determine to which graphic or block of written text students were referring during their think-alouds.

Data Analysis

In order to address the two research questions, two forms of analysis were used. Each form of analysis is described in detail in the following sections.

Discourse Analysis of Processes. In order to address research question 1: What reading processes are prompted by the graphics as second graders read informational text?, as well as to provide some of the data to address research question 2: In what ways, if any, do second graders' reading achievement relate to the processes prompted by graphics as they read informational text?, students' verbal protocols were transcribed verbatim, including references to where the students were looking or pointing as they thought aloud. The transcription of their readings and that of their thinking was done in different colors in order to make it easier to distinguish the two sections

First, verbalizations were analyzed to determine whether the comment was about the written text without reference to the graphic (e.g., "That's a really hard word"), the graphic without reference to the written text (e.g., "Deserts are right here, here, here, here [keeps pointing to different parts of the map]" as the students studies a map of different climate zones around the word), both the written text and the graphic (e.g., while studying a picture of clouds, "It's sort of interesting the clouds are made of water," an idea stated in the text), or was an unrelated comment (e.g., "Her phone [a teacher] is ringing and she's outside"). Only comments that pertained in whole or in part to the graphics were coded further.

Second, the verbalizations about the graphics were coded as prompted or unprompted. Prompted comments were defined as any verbalizations a participant made after I asked the student what they were thinking, while unprompted comments were those responses that the student made spontaneously.

Third, modified grounded theory (Strauss & Corbin, 1998) was used to identify the processes prompted by the graphics in informational text. I began by analyzing for the 18 codes developed during previous research (i.e., *label; literal description; inferential description; prediction; infer the author's purpose; confirm-disconfirm text; connection-to-self; irrelevant connection; connection-to-prior knowledge; wonder; knowledge monitoring; affective response; compare-contrast graphics; evaluate; use of running text; use of captions, labels, map key, etc.; word identification;* and *no process*), which were in turn developed through grounded theory (Norman, in press). I created new codes for any verbalizations that could not be coded using any of the 18 previous codes. Codes were described with a short phrase that explained the process prompted by the graphic.

These phrases were compared continuously to ensure that none of them could be collapsed. Seven new codes were developed (i.e., *names, intertextual connection, graphic-to-written text connection, create narrative, repeat-paraphrase written text, reading process-other,* and *uninterpretable*). All codes are discussed in more detail in the *Results* section below.

Because the graphics occasionally prompted more than one process, the decision was made that verbalizations could be coded as more than one process in order to preserve the integrity of the data. For example, while reading *Dino Dig* (pp. 16-17), one student studied a photograph of a head of a mummified dinosaur fossil found in Montana and a drawn picture of the entire fossil and commented, "I think they are going to tell us what they found. I think they're going to tell us what this weird thing is (points to photograph) and this (points to drawing.) Hey, I think, (looks back and forth between the two graphics) it looks like they're the same thing." The first and second sentences were coded as *prediction* because the student verbalized a prediction about what the page would talk about. The third sentence was coded as *graphic-to-graphic connection* because the student is looking at both pictures and commenting that they are different representations of the same fossil.

A graduate student familiar with reading processes of written text, but unfamiliar with the verbal protocols collected for this study, was trained to code the verbal protocols using six of the transcripts. She then coded a random sample of 16 of the transcripts, stratified by text. Inter-rater reliability was 86.7% or 320 out of 369 codes. This inter-rater reliability compares to the reliability in other verbal protocol studies (e.g., Brown et al., 1996).

Statistical analysis.

What reading processes are prompted by the graphics as second graders read informational text? After all verbalizations were coded to determine what processes were prompted by the graphics, descriptive statistics were calculated. First, the number of times each process was prompted for each student and each achievement group was calculated separately for each book (as processes might differ by book). Second, for each process, the number of students for whom that process was prompted at least once was calculated separately for each book.

In what ways do second graders' reading achievement relate to the processes prompted by graphics as they read informational text? To investigate the relationship between students' reading achievement and the processes prompted by graphics as they read informational text, ANOVAs (α=0.05) were run. First, an ANOVA was run to determine whether there was a statistically significant difference in the mean number of total processes by achievement group. Second, an ANOVA was run to determine whether there was a statistically significant difference in the mean number of different processes by achievement group. Finally, ANOVAs were run to determine whether there were statistically significant differences in the mean number of instances for individual processes by achievement group. All ANOVAs were run for each book separately and for the two books combined.

Because ANOVAs are fairly robust to violations of the normality and variance of heterogeneity assumptions when the group sizes are equal (Donaldson, 1968; Field, 2009) and all achievement groups in this sample were equal, these assumptions were not examined.

Results

What Reading Processes are Prompted by the Graphics as Second Graders Read Informational Text?

The modified open-coding of the transcripts resulted in 25 codes—23 reading processes (i.e., *affective response; confirm-disconfirm text; intertextual connection; graphic-to-graphic connection; graphic-to-written text connection; irrelevant connection; connection-to-prior knowledge; connection-to-self; evaluate; infer author's purpose; inferential description; knowledge monitoring; label; literal description; name; prediction; repeat-paraphrase written text; reading process-other; use of graphical devices; use of running text; wonder;* and *word identification), no process,* and *uninterpretable.* See Table 1.3 for a complete description of each process as well as student comments that exemplify each process.

Table 1.4 displays the number of total times each process was prompted and the number of students for whom each process was prompted. Due to space considerations, only three processes are discussed in more detail. The processes chosen include the process prompted the fewest number of times (*infer author's purpose*), the greatest number of times (*wonder*), and for the greatest number of students (*literal description*).

As indicated in Table 1.4, *infer author's purpose* was only prompted by the graphics once, for an above-average reader reading *Weather Watching*. After reading about rain and snow (pp. 14-15), the student looked back and forth between the picture of gray clouds and a picture of a snowman and explained that the author had put them on the same page because "they're the same sometimes. Sometimes the rain is bad weather and sometimes snow is bad weather."

On the other hand, *wonder* was prompted by the graphics a total of 125 times (53 for *Weather Watching* and 72 for *Dino Dig*) by 20 of the 30 students (12 for *Weather Watching* and 16 for *Dino Dig*). The students *wondered* between 0 and 26 times across the two books (M=4.17 and *SD*=7.419). These *wonders* included asking about what was occurring in the picture (e.g., "I wonder what he's doing to that animal" as a below-average reader studied a picture of a man welding a dinosaur together [pp. 18-19]), as well as critiquing the author (e.g., "Why do they [the author] tell us that it's frozen in the lake, but they don't show the lake and my teacher said that you...shouldn't write things down in the book if it doesn't go, if doesn't have a picture of it" as a below-average reader studied a winter scene to accompany the explanation of ice and frost [pp. 16-17]).

Literal description was used by the most students—27 of the 30 students (14 for *Weather Watching* and 16 for *Dino Dig*) for a total of 79 times (28 for *Weather Watching* and 51 for *Dino Dig*). When comments were coded as *literal description*, students described what was explicitly depicted in the graphic (but not simply with a label or name, in which case it would be coded *label* or *name*). The descriptions could be general (e.g., when an above-average reader looked at the wind cycle [pp. 12-13] and commented, "That looks like a cycle.") or could specifically describe what was occurring in the graphic (e.g., while looking at the picture of scientists discovering a dinosaur fossil in rock and sand [the fourth picture on pp. 6-7] an average reader stated the scientists were "digging for a fossil"). It was prompted between 0 and 8 times across the two books (M=2.63 and *SD*=2.092).

In What Ways Does Second Graders' Reading Achievement Relate to the Processes Prompted by Graphics as They Read Informational Text?

Number of times any process was prompted by the graphics. The number of times any process was prompted by the graphics across the two books ranged from 9 (by an average reader who *repeated-paraphrased the written text* eight times and *knowledge monitored* once) to 62 (by an above-average reader who used 15 different processes and often spoke about the graphics without being prompted) (M=12.045 for all 30 students) (see Table 1.5). On average, the graphics in *Weather Watching* prompted an equal number of processes for below-average and above-average readers (M=12.80), which was greater than the number of times any process was prompted for average readers. Additionally, when reading *Dino Dig,* the number of times any process was prompted by the graphics was greatest for above-average readers (M=18.90) and least for average readers (M=12.50) (the mean for below-average readers was 14.90). The ANOVA, however, indicated that no statistically significant difference in mean number of total processes existed among the three achievement groups.

Number of different processes prompted by the graphics. The number of different processes prompted by the graphics across both books ranged from 1 process (an average reader who used only wondering) to 16 processes (two above average readers, one of whom used *affective; connection-to-prior knowledge; connection-to-self; graphic-to-graphic connection; graphical-to-written text connection; irrelevant connection; inferential description; create narrative; knowledge monitoring; label; literal description; names; reading process-other; prediction; repeat-paraphrase written text;* and *use of graphical devices*; and the other of whom used *affective; connection-to-*

prior knowledge; connection-to-self; intertextual connection; irrelevant connection; infer author's purpose; inferential description; create narrative; knowledge monitoring; label; literal description; reading process-other; prediction; repeat-paraphrase written text; use of graphical devices and *wonder*) (see Table 1.5). There was no statistically significant difference in the mean number of different processes by achievement group for *Weather Watching* (M=6.80 for below-average readers, M=3.629 for average readers, and M=3.683 for above-average readers) There was a statistically significant difference for *Dino Dig (F=4.931, p=0.015, r* [of the contrast]*=0.52)* and the difference in means approached significance for both books combined *(F=2.631, p=0.09, r=0.40).* Tukey's Post Hoc tests showed the difference to be between average readers and above-average readers *(p=0.011* for *Dino Dig* and *p=0.075* for both books) with the above-average readers (*M*=9.1 for *Dino Dig* and *M*=11.9 for both books) more likely to use a greater number of different processes than the average readers (*M*=5.2 for *Dino Dig* and *M*=7.8 for both books). The means for below-average readers was between above-average and average readers for *Dino Dig* and both books (M=7.30 and M=10.10 respectively).

Number of instances of individual processes prompted. ANOVAs were run to determine if there was a statistically significant difference for the mean number of times an individual process was prompted by the graphics among the three achievement groups (see Table 1.6). No statistically significant differences were found among achievement groups at the book level for *Weather Watching*, though *create narrative* approached significance (*F=3.277, p=0.053, r=0.44)*, with a Tukey Post Hoc test (*p=0.046*) showing that below-average readers (*M*=1.00) were more likely to use the process *create*

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narrative than average readers (M=0.10) (above-average readers [M=0.40] *created narratives* more often than average readers, but less often than below-average readers).

For *Dino Dig*, statistically significant differences were found for *graphic-to-graphic connection* (F=3.500, p=0.045, r=0.43) and *knowledge monitoring* (F=3.738, p=0.037, r=0.46). A Tukey Post Hoc test indicated that the above-average readers were prompted to make *graphic-to-graphic connections* more often than average readers (M= 0.50 and 0.00 respectively, p=0.023) and were prompted to *knowledge monitor* more often than below-average readers (M=1.30 and 0.30 respectively, p=0.03). Although not statistically significantly different from either above-average or below-average readers, the mean number of times average readers *knowledge monitored* was in between the other two achievement groups (M=0.70). Three processes, *connection-to-self, create narrative,* and *label,* approached significance (F=3.291 p=0.053, F= 2.930 p=0.071, and F=2.854 p=0.075 respectively). Tukey Post Hoc tests showed that above-average readers (M=0.8) made more *connections to themselves* than average (M=0.10) and below-average readers (M=0.10) (p=0.085, r=0.39) and *labeled* the graphics more often than average readers (M=1.5 and .3 respectively, p=0.084, r=0.39), but *created* fewer *narratives* than below-average readers (M=0.8 and 2.5 respectively, p=0.061, r=0.42).

When ANOVAs were run on the number of instances of individual processes across the two books, statistically significant differences were found for *graphic-to-graphic connection (F=3.5, p=0.045), create narrative* (F=4.370, p=0.023) and *intertextual connections* (F=3.822, p=0.035). A Tukey Post Hoc test showed that average readers (M=0.00) made *graphic-to-graphic connections* less often than above average readers (M=0.50) (p=0.048, r=0.43), below-average readers (M= 3.5) *created*

narratives more often than above-average readers (M=1.20) (p=0.029, r=0.46), and above-average readers (M=0.60) made *intertextual connections* more often than below-average readers (M=0.00) (p=0.04, r=0.44).

Discussion and Implications

This study investigated the processes that were prompted by the graphics as second graders read two informational texts and whether there were any differences in these processes by reading achievement. To address these two questions, 60 verbal protocols from 30 second-graders (10 above-average, 10 average, and 10 below-average readers) reading two informational texts were collected and analyzed. The findings from and implications of this study are discussed below.

Graphical Reading is Active Reading

The protocols revealed that 23 reading processes (i.e. *affective response; connection-to-prior knowledge; connection-to-self; graphic-to-written text connections; graphic-to-graphic connections; intertextual connection; irrelevant connection; evaluate; infer the author's purpose; inferential description; create narrative; knowledge monitoring; label; literal description; name; prediction; use of graphical devices; use of running text; confirm-disconfirm text; repeat-paraphrase written text; wonder; reading process-other;* and *word identification)* were prompted by the graphics in these two informational texts. The number and diversity of processes suggest that, like the reading of written text, the reading of graphics is an active endeavor. Students do not merely glance at the graphics or view them as decorations on the page. Instead, they use the graphics, for instance, to help them *predict* the topic of the book or the page, make *connections*, and *wonder* about the topic. Students also integrate information from the

graphics and the written text, such as when they *use the running text* to clarify the graphic or use the graphic to *confirm or disconfirm* information from the written text.

Not all students, however, are as active when reading the graphics as others. For one average reader, only nine processes were prompted across the two books. That is less than one process for every three graphics. He did look at most of the other graphics, but when asked what he was thinking replied, "Nothing," 21 times. Indeed, the results from this study suggest that some students actively use the graphics while others do not. Assuming that active processing of graphics improves comprehension of any given informational text (Norman, in preperation), research is needed to determine how to help all students become active and strategic processors of the graphics.

Different Books, Different Processes

As in previous research (i.e., Norman, in press), the books read by the students appear to influence what processes are prompted by the graphics. Despite being similar—each book was published by the same company for the same series, contained 10 sections and 26 pages (after modification), and contained similar styles of graphics—*Weather Watching* prompted a total of 365 processes for all 30 students, while *Dino Dig* prompted a total of 463. This difference could be due, in part, to a difference in interest. Research on students' use of strategies while reading informational text suggests that students use more strategies as they read written text identified as highly interesting to them than when they read written text of low interest to them (Jimenez, in preparation). In retrospect, it appears that these second-graders may have been more interested in reading about dinosaurs than in reading about weather; therefore, they were prompted to think more actively about the graphics in a book about dinosaurs.

Some processes, however, were prompted more often for *Weather Watching* than for *Dino Dig.* For example, students used the process *connection-to-self* more when reading *Weather Watching* than *Dino Dig* (15 to 10 respectively). Many of these *connections* referenced the rain, thunder, and lightning outside on the days they were reading the *Weather Watching* book, an experience all of the students shared. With *Dino Dig* some students *connected* to visits to dinosaur museums and dinosaur camps, but not all of the children have attended these places, and, therefore, could not make personal connections to the books. When reading a book about which they have more personal experiences they are more likely to make *connections-to-self.*

Additionally, while seventeen of the processes had also been found in previous research (see Norman, in press), *create narrative, graphic-to-written text connection, name, repeat-paraphrase written text; intertextual connection,* and *reading process-other* were new processes revealed. These additional processes could be a product of the increased number of students in the present study or the fact that two different books, written about different topics, in a different graphical styles, and for a different series and publisher, were used in that study. One notable difference between the books used in this study and those used in Norman (under review) is the fact that most of the graphics in the previous study—with the exception of a map in *Animal Look-Alikes* and a cross-sectional diagram and pie chart in *Recycling Adds Up*—were photographs, while many of the graphics in *Dino Dig* and *Weather Watching* were drawn illustrations. These drawn illustrations appear to prompt students to *create narratives* more often than the photographs in the same book which perhaps explains why *create narrative* was not prompted by the largely photographic graphics in the previous study.

Further research is needed in order to investigate the influence of graphical style, the book topic, and genre on the processes prompted by the graphics. Also, research is needed to determine whether there is a relationship between interest and prior knowledge and the processes prompted by the graphics.

Reading Achievement and Graphical Reading Processes

As discussed above, previous research on written text has indicated that skilled readers use more strategies and use them more strategically than less-skilled readers (Anastasiou & Giva, 2009; Cain & Oakhill, 2004; Oakhill & Cain, 2007; Pressley & Hilden, 2006). In this study, however, no statistically significant differences were found for the number of times any process was prompted by the graphics by achievement group. There were statistically significant differences in the number of different processes prompted between average readers and above-average readers only when reading *Dino Dig*, with above-average readers using more different processes than average readers. Although not significant, below-average readers also used a greater number of different processes when reading *Dino Dig* than average readers, although fewer than above-average readers. The pattern of graphics prompting a greater number of different processes for above-average and below-average readers than for average readers was also seen in *Weather Watching*, though these differences were not statistically significant.

Perhaps the disparity between below-average and above-average readers that has been suggested by previous research on written-text does not exist to the same extent with graphics because written text reading achievement, which was the primary basis on which these students' achievement was classified, does not influence students' abilities to comprehend and talk about graphics in the same way it would influence their

comprehension and discussion of written text. Instead their ability to gain information from and to determine the main idea of the graphic might play a greater role in the number and range of processes prompted by the graphics. Further investigation and considerable assessment development work is needed to determine whether there are below-average, average, and above-average graphical comprehenders, as there are for written text.

Finally, statistically significant achievement group differences were observed for the mean number of times four specific processes (i.e., *graphic-to-graphic connection, intertextual connection, create narrative,* and *knowledge monitoring*) were prompted by the graphics. This difference in the use of specific processes by achievement groups is consistent with previous research on written text (e.g, Braten & Stromso, 2003; Samuelstuen & Braten, 2005). Three of the specific processes were used more often among above-average readers. Their greater use of *graphic-to-graphic connections* may be related to the fact that above-average readers are more likely to attend to text-structure (Englert & Thomas, 1987), and the fact that they made more *intertextual connections* could be attributed to the fact that above-average readers often read more (Cunningham & Stanovich, 1998) and, thus, have a greater number of texts with which they can connect. Above-average readers also *knowledge monitored* (Hilden, 2008, 2009) more often than the below-average and average readers. When students engaged in *knowledge monitoring*, they were determining whether or how new knowledge from the text or graphics fit with their existing knowledge, and, thus, is another type of monitoring of comprehension and use of prior knowledge. This finding is consistent with research on written-text that has found that below-average readers are less capable of self-regulating

and monitoring their understanding of the text than above-average readers (e.g., Anasatiou & Griva, 2009; Drmitzaki, Andreou, & Paraskeva, 2009; and see Pressley, 2002) and that students who activate and use prior knowledge are better able to comprehend written text (Hansen, 1981; Pressley et al., 1994) Some research does exist on students' use of *knowledge monitoring* while reading informational text (see Hilden, 2008; 2009), but more research is needed that explores students' *knowledge monitoring* while reading graphics and how this relates to their overall graphical comprehension.

Finally, *create narrative* was prompted more often for below-average readers than for above-average and average readers. These students ascribed actions and feelings to, and at times even provided dialogue between, the animals and people in the graphics. This process would appear to be genre-inappropriate and may not facilitate in comprehending the graphic (Cervetti, Bravo, Hiebert, Pearson, & Jaynes, 2009). Again this difference could be due to the fact that above-average readers read more (Guthrie, 2004); therefore, they may have a greater exposure to and greater knowledge of informational text (Duke & Kays, 1998), which discourages them from *creating narratives*. More research is needed to investigate why this process is prompted and whether it helps or hinders comprehension of graphics and the accompanying text.

Limitations

While precautions were taken to maintain the validity of this study, as in any study, a few remain. First, verbal protocols rely on students' self-reporting of their thinking. Therefore, students' verbal abilities may have impacted their reporting of their thinking (Afflerbach & Johnston, 1984). Second, although students were allowed to talk about their thinking at any time and were allowed to say that they were not thinking about

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anything, the fact that students were prompted whenever they looked at a graphic may have influenced the number of time students studied the graphics, possibly encouraging some to look at the graphics more often and discouraging others from looking at the graphics. Although students were not told that they would be asked to share their thinking after looking at a graphic, some did figure out the pattern and began to report their thinking as they looked at each graphic (one student even commented on it). Third, students were classified as above-average, average, and below-average readers based on one subtest of one reading assessment given on one day. Students may have been classified differently if other assessments had been chosen, or even if they had been tested on a different day or at a different time. Fourth, only 10 students from each achievement group participated in this study. Perhaps a larger sample size would have revealed different processes and other differences between the achievement groups. Finally, because a large number of ANOVAs were run, there could be issues with Type 1 errors.

Conclusions

As with written text, the reading of the graphics is an active process for many students. Is there a connection between the graphical reading processes and reading achievement, as the title of this paper asks? These processes do not seem to differ as much by achievement as they do for written text, but some differences do appear to exist. Perhaps this is due, in part, to differences in the affordances and constraints of reading graphics, or graphics and written text combined, instead of reading written text alone. Exploration of students' graphical comprehension and how written-text comprehension and graphical

comprehension relate may assist us in better understanding differences in written and graphical text comprehension processes.

Table 1.1

Functions of Graphics in Text

Function of Graphic	Definition	Example
Decoration*	appear as an ornament on the page without adding to or relating to the written text	an acorn accompanying an autumn poem
Representation*	support the plot and content of the written text by portraying the characters, setting, and events in narrative text or depicting the information presented in informational text	a photograph of a salmon making a nest with its tail accompanying the text, "Female salmon make nests with their tails."
Organization*	supply a framework for classifying information from the written text	a timeline in a biography
Interpretation*	explain abstract ideas by depicting them in a more concrete fashion	an illustration of the circulatory system as plumbing (Levin, 1981)
Transformation*	Represent mnemonics to help readers remember the written text by making it more concrete and meaningful	the word *bed* with the b and d as head and footboards

Table 1.1 (cont.)

Extension[t]	provide extra details not directly stated in the text	a labeled diagram of a fruit fly's eye to accompany the text, "A fruit fly's eye is very complex."

[*] Levin, Anglin, and Carney (1987)

[t] Bishop and Hickman (1992), Duke et al. (in preparation) and Fang (1996)

Table 1.2

Number of instances of each graphic type in Weather Watching *and* Dino Dig

Type of Graphic	Number of instances in *Weather Watching*	Number of instances in *Dino Dig*
Total number of photographs	5	5
Labeled photograph	1	0
Total number of drawn illustrations	9	12
Labeled drawn illustration (not cross-sectional diagram or flow chart)	1	6
Cross-sectional diagram	1	1
Graphic with key	3	0
Map	1	0
Flow chart	1	1

Note: Some graphics are counted more than once. For example, the map in *Weather Watching* is counted as both a map and a graphic with key.

Table 1.3

Definitions and Examples of All Processes Prompted by the Graphics

Affective response	Student expresses an emotion based on the graphic.	Example 1: I like rainbow (traces rainbow). Example 2: That it's cool to fly kites in the sky (affective), but they need to know, like, what the weather is like (evaluate). Example 3: That's weird.
Connection – graphic-to-written text	Student makes a connection between a graphic and the written text in another part of the same book.	Example: It shows like it said before in the book that if you find one fossil you probably find more cause it looks like more than one dinosaur.
Connection-graphic-to-graphic	Student compares different graphics in order to better understand both graphics and/or to gain new information/ meaning.	Example 1: Hey, I think (looks back and forth between the two graphics), it looks like they're the same thing.
Connection-intertextual	Graphic prompts student to make a connection to another text (e.g., book, movie, TV show, etc)	Example: In a show I saw they called them *carnivores*, the dinosaurs.

Table 1.3 (cont.)

Connection-to- prior knowledge	Student references prior knowledge related to the graphic. Prior knowledge may be inaccurate.	Example: Our teacher did tell us that you can memorize the colors (pointing to list of colors in rainbow) by Roy G. Biv. R, O, Y, G, B, I, V, as in a name.
Connection-to -self	Graphic prompts student to make a connection to the student's own life.	Example: (Looking at picture of storm clouds and umbrellas) I'm thinking about right now because look outside (it is raining)...it was like before it was only like poom, poom, poom.
Connection-Irrelevant	The connection made is topically connected, but is not relevant to the author's intent.	Example: (looking at a rainbow) I'm thinking of sunlight and happiness and rainbows and dandelions and pots of gold on the other side of the rainbow. I don't really think there is another side of a rainbow. Hmmm...Bet there isn't.
Create narrative	The graphic prompts student to create a narrative. Student ascribes feelings, thoughts, and actions to the people or	Example 1: He's like (points to larger dinosaur, in a low voice) "Where are you?" (then in a really high voice) "Let's play hide and

Table 1.3 (cont.)

	animals in the pictures. The actions are not present in the graphic and/or not reasonably inferred from the graphic and the words.	seek. Ahhhhh!" (Runs fingers across the page.)
Evaluate	Student judges or forms an opinion based on the information presented in the graphic and/or his or her background knowledge.	Example: I don't think it's really good because lightning can like shock you for electricity.
Knowledge monitoring	Student recognizes absence of prior knowledge or recognizes that the text or graphic confirms previous thinking	Example 1: I know lightning can go up (points to picture) or lightning can come down. And then there is another thing that lightning can go like it can either go up out of nowhere and just form. It can go up out of nowhere and just form. And it can come from clouds. And that's how it forms. That's what my mom told me. Example 2: I never knew that.

Table 1

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Table 1.3 (cont.)

Label	Student labels something in the picture while pointing to the objects being labeled. Labels may or may not be correct.	Example: snow (points to snow)
Names	Student names or lists items found in the picture without pointing to the objects in the picture. Names may or may not be correct.	Example: I'm thinking like lightning (looking at picture, but not pointing).
Literal description	The graphics prompt student to describe (not simply name or label) what is explicitly depicted in the graphic. Student may be gaining information, or may be stating what they see in the graphic. Information may or may not be correct.	Example 1: I'm thinking, for this picture (points to picture of lightning hitting tree), I think that it really I'm thinking about how when lightning comes it kind of affects, um, buildings and trees. Example 2: Mmm...their bones like all squiggly (points to bottom part of the bones on the tail), like, like all...the bones like this side is all sticking out, like pointy (points to bottom parts) and this side (points to top parts) is not.

Table 1.

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Table 1.3 (cont.)

Inferential description	The graphic prompts student to infer information. The information is implied in the graphic or by combining information from the graphic and the words, but is not explicitly depicted. Information may or may not be correct.	Example: I'm thinking that these are guys who throw a (sic) airplane up in the sky when the wind blows.
Infer author's purpose	Student infers the author's purpose for including a graphic, what the author wanted you to learn from the graphic, or why author placed a graphic in a specific spot.	Example: It's kind of like rain and snow are on the same page because they're the same sometimes. Sometimes the rain is bad weather and sometimes snow is bad weather.
Prediction	Student uses the graphic to predict what will be on the page/in the book.	Example: Um, I think this is goin...this page is going to tell us about like about like what's on the land like where deserts are and where like tropical rainforests are.
Use of graphical	Student uses graphical text features (e.g., labels, captions,	Example 1:... I did notice that these (points to map key) match there

Table 1.3 (cont.)

devices	map keys, arrows in flow chart, graphics' titles) to understand graphic. Student is not just restating or rephrasing the caption or label.	(pointing to map) so that would be a desert, that would be a tropical piece. The colors match. (Continues pointing to map key and matching areas on map.)
Use of running text	Student uses the text to better understand and gain information from the graphic. Student is not just restating or rephrasing the running text.	Example: (After reading running text) Oh...I just learned that's (points to graphic) a kite.
Repeat-paraphrase text	While looking at the graphic, student repeats or attempts to repeat text verbatim or paraphrases or attempts to paraphrase text using own words. The text can be the running text, captions, or labels (if the label is a phrase).	Example 1: Text: Bolts of lightning flash when the electricity builds up. Student: That lightning can build up... Example 2: Label: Clouds move with the wind. Student: That, like, clouds can like, like the wind can move the clouds...
Confirm-disconfirm text	Student uses the graphic to confirm/disconfirm what was stated in the text.	Example: Text: They then add muscle tissue and skin to the skeleton. This makes the dinosaur

Table 1.3 (cont.)

		look like it did when it was alive. Student: That does not look like it did when it was alive (point to dino). Only the skin (points to skin) would be there (circles around dinosaur).
Wonder	Student uses the graphics to question or wonder about topic. The wonders can be said as statements or questions. They may include words such as *if* or *wonder* but do not have to.	Example: Are there tons of the polars or not? Or if there's, like most deserts in most states or places? And, and how how (sic) are the temperature in like Afr, in like Australia, Africa, Europe, and South America?
Word identification	Student uses the graphic to decode word or comprehend meaning of word.	Example: I'm trying to see if the picture will help me figure out the word (mutters to self, repeats sentence).
Reading Process-Other	Comment does not fit into any of the other processes listed.	Example: Have you ever seen a wooly mammoth or a saber tooth statue in museums, hm? (Student is asking the researcher a question)

Table 1.4

Total Number of Times and for How Many Students Each Process was Prompted

Process	*Weather Watching*		*Dino Dig*		*Both Books*	
	No. of times prompted (% of total processes)	No. of students (% of students)	No. of times prompted (% of total processes)	No. of students (% of students)	No. of times prompted (% of total processes)	No. of students (% of students)
Affective response	19 (5.21)	9 (30.00)	23 (4.97)	9 (30.00)	42 (5.07)	12 (40.00)
Confirm-disconfirm text	5 (1.37)	4 (13.33)	5 (1.08)	5 (16.67)	10 (1.21)	7 (23.33)
Create narrative	15 (4.11)	10 (33.33)	47 (10.15)	17 (56.67)	62 (7.49)	20 (66.67)
Intertextual connection	4 (1.10)	3 (10.00)	3 (0.65)	2 (6.67)	7 (0.85)	5 (16.67)
Graphic-to-graphic connection	0 (0.00)	0 (0.00)	6 (1.30)	5 (16.67)	6 (0.72)	5 (16.67)

Table 1.4 (cont.)

Graphic-to-written text connection	0 (0.00)	0 (0.00)	5 (1.08)	3 (10.00)	5 (0.60)	3 (10.00)
Irrelevant connection	7 (1.92)	5 (16.67)	12 (2.59)	8 (26.67)	19 (2.29)	11 (36.67)
Connection-to-prior knowledge	33 (9.04)	15 (50.00)	23 (4.97)	14 (46.67)	56 (6.76)	20 (66.67)
Connection-to-self	15 (4.11)	10 (33.33)	10 (2.16)	6 (20.00)	25 (3.02)	13 (43.33)
Evaluate	5 (1.37)	3 (10.00)	2 (0.43)	2 (6.67)	7 (0.85)	5 (16.67)
Infer the author's purpose	1 (0.27)	1 (3.33)	0 (0.00)	0 (0.00)	1 (0.12)	1 (3.33)
Inferential description	27 (7.40)	14 (46.67)	47 (10.15)	22 (73.33)	74 (8.94)	24 (80.00)
Knowledge monitoring	24 (6.58)	12 (40.00)	23 (4.97)	15 (50.00)	47 (5.68)	20 (66.67)
Label	19 (5.21)	11 (36.67)	23 (4.97)	13 (43.33)	42 (5.07)	18 (60.00)
Literal description	28 (7.67)	14 (46.67)	51 (11.02)	16 (53.33)	79 (9.54)	27 (90.00)

Table 1.4 (cont.)

Name	15	6	17	11	32	14
	(4.11)	(20.00)	(3.67)	(36.67)	(3.86)	(46.67)
Prediction	15	6	19	5	34	9
	(4.11)	(20.00)	(4.10)	(16.67)	(4.11)	(30.00)
Repeat-	35	17	46	18	81	22
paraphrase	(9.59)	(56.67)	(9.94)	(60.00)	(9.78)	(73.33)
written text						
Use of	28	18	4	3	32	18
graphical	(7.67)	(60.00)	(0.86)	(10.00)	(3.86)	(60.00)
devices						
Use of	4	4	2	2	6	5
running text	(1.10)	(13.33)	(0.43)	(6.67)	(0.72)	(16.67)
Wonder	53	12	72	16	125	20
	(14.52)	(40.00)	(15.55)	(53.33)	(15.10)	(66.67)
Word	6	5	9	6	15	7
identification	(1.64)	(16.67)	(1.94)	(20.00)	(1.81)	(23.33)
Reading	7	6	14	9	21	12
process-	(1.92)	(20.00)	(3.02)	(30.00)	(2.54)	(40.00)
other						

Table 1.5

Descriptive Statistics and ANOVA Test Results for Number of Different Processes Prompted and Number of Times Any Process was Prompted

		Total Sample		Below-average Readers		Average Readers		Above-average			
		M	Range	M	Range	M	Range	M	Range	F	df
Number of Times Any Process	*Weather Watching*	12.17	4-28	12.80	4-23	10.90	3-21	12.80	3-28	.284	2, 27
	Dino Dig	15.43	6-36	14.90	6-33	12.50	6-18	18.90	9-34	2.344	2, 27
	Both Books	27.60	9-62	27.70	10-56	23.40	9-36	31.70	14-62	1.204	2, 27
Number of Different Processes	*Weather Watching*	6.20	1-13	6.8	3-10	4.50	1-11	7.30	2-13	2.089	2, 27
	Dino Dig	7.2	1-13	7.3	5-11	5.20	1-9	9.10	4-13	4.931*	2, 27
	Both Books	9.93	1-16	10.10	7-15	7.80	1-5	11.90	5-16	2.631	2, 27

*Significant at $p<.05$

Table 1.6

Number of Times Each Process was Prompted by Reading Achievement

	Weather Watching			*Dino Dig*			Both Books		
	BAR	AR	AAR	BAR	AR	AAR	BAR	AR	AAR
Affective response	5	6	8	1	8	14	6	14	22
Confirm-disconfirm text	3	1	1	1	1	3	4	2	4
Connect-irrelevant	1	2	4	2	2	8	3	4	12
Connection-intertextual	0	1	3	0	0	3	0	1	6
Connection-graphic-to-written text	0	0	0	2	0	3	2	0	3
Connection-graphic-to-graphic	0	0	0	1	0	5	1	0	5
Connection-to-prior knowledge	14	11	8	8	5	10	22	16	18
Connection-to-self	2	7	6	1	1	8	3	8	14
Create narrative	10	1	4	25	14	8	35	15	12
Evaluate	0	3	2	1	1	0	1	4	2
Infer the author's purpose	0	0	1	0	0	0	0	0	1
Inferential description	12	6	9	21	9	17	33	15	26
Knowledge monitoring	11	5	8	3	7	13	14	12	21

Table 1.6 (cont.)

Label	8	3	8	5	3	15	13	6	23
Literal description	13	3	12	18	13	20	31	16	32
Name	3	7	5	3	4	10	6	11	15
Prediction	2	0	13	3	1	15	5	1	28
Repeat-paraphrase written text	9	17	9	15	20	11	24	37	20
Reading process-other	1	2	4	4	2	8	5	4	12
Use of graphical devices	11	6	11	1	0	3	12	6	14
Use of running text	1	0	3	0	1	1	1	1	4
Wonder	19	25	9	27	31	14	46	56	23
Word identification	3	3	0	7	2	0	10	5	0

BAR=Below-average Reader

AR= Average Reader

AAR= Above Average Reader

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MANUSCRIPT TWO: GRAPHICAL READING PROCESSES AND COMPREHENSION: IS THERE A RELATIONSHIP?

"A picture is worth a thousand words," but only if one can comprehend it. Otherwise, it is just a page decoration at best and a waste of space at worst. Considering how many graphics are found in textbooks and other non-fiction texts for children and adults and the amount of information they contain, it is important to understand what readers are doing when they see these graphics, how they are processing them, how they are understanding them, and whether these graphics are contributing to their overall comprehension of the text. This study begins to address some of these questions by investigating: What is the relationship, if any, between children's processes prompted by the graphics in informational text and their overall comprehension of those texts?

Theoretical Framework

This study is grounded in semiotic (e.g., Jewitt & Oyama, 2001) and multiple literacies (The New London Group, 1996) theories and in recognition of previous research on the importance of informational text and graphics in today's society. In the twenty-first century, reading and writing printed words is not enough—one must be able to read and communicate meaning with spoken, written, and visual text (e.g., IRA/NCTE, 1996; The New London Group, 1996). Therefore, the graphics in text, which I define as any photograph or illustration in narrative or informational text including but not limited to diagrams, maps, graphs, and tables, are meaningful signs that need to be understood in order to make meaning (e.g., Jewitt & Oyama, 2001).

These graphics are particularly important in informational text, where they can help to organize ideas (e.g., a flow chart explaining how fossils are made), make abstract ideas more concrete (e.g., an illustration of the circulatory system as plumbing [Levin,

1981]), and provide extra information not included in the written text (e.g., photographs of fish fossils, plant fossils, and insect fossils to accompany the written text, "There are many types of fossils"). Research has identified 6 common functions of graphics in informational text (Carney & Levin, 2002; Clark & Lyons, 2004; Duke et al., in preparation; Levin, 1981; Levin, Anglin, & Carney, 1987):

- decoration, which appear as an ornament on the page without adding to or relating to the written text;
- representation, which depict the information presented in informational text;
- organization, which supply a framework for classifying information from the written text;
- interpretation, which explain abstract ideas by depicting them in a more concrete fashion;
- transformation, which represent mnemonics to help readers remember the written text by making it more concrete and meaningful; and
- extension, which provide extra details not directly stated in the text.

Younger students particularly need to learn to read and understand these graphics because their informational texts contain many graphics (Duke & Kays, 1998; Fingeret, in preparation) and because children often have difficulty reading informational texts (Langer, 1983; Park, 2008). Perhaps if children better understood how to gain information from the graphics in informational text, these texts would be less of a struggle (Moss, 2008).

Review of the Literature

Comprehension of Written Text

Research over the past half century has provided us with a well-developed picture of what skilled readers are doing and thinking as they read narrative and informational text. Skilled readers use many and varied reading processes (e.g., prediction, inferring, summarizing, visualizing, comprehension monitoring) strategically and flexibly (e.g., Duke & Pearson, 2002; National Institute of Child Health and Human Development, 2000; Pressley & Afflerbach, 1995). Furthermore, they utilize their prior knowledge of the topic and of the genre and consider their purpose for reading the text to assist them in their comprehension (e.g., Duke, 2005; RAND Reading Study Group, 2002).

Not only has it been found that skilled readers use more strategies than less proficient readers, but utilization of these strategies has been found to be correlated with better comprehension (e.g., Braten & Stromso, 2003; Dermitzaki, Andreou, & Paraskeva, 2008; Samuelstuen & Braten, 2005). For example, Dermitzaki and colleagues (2008) found that third graders' use of strategies such as planning and monitoring of learning processes were highly correlated with their performance on a comprehension assessment related to the same text. Moreover, Samuelstuen and Braten (2005) found that 10th graders who were poor decoders but used many strategies while reading two expository texts scored better on a comprehension assessment about the text than good decoders who did not use many strategies. While these findings speak to the importance of strategy use to comprehension of written text, the question remains: does this correlation between strategy use and comprehension carry over to the reading of graphics?

Comprehension of Graphics

Although research on comprehension of graphics does exist (and will be discussed next), it is not as robust as the research on comprehension of written text. Furthermore, the findings have been inconsistent, with some researchers finding that the inclusion of graphics has no effect on participants' comprehension, others finding detrimental effects, and still others finding beneficial effects. Representative studies are discussed below.

Graphics have no effect on comprehension of written text. A number of studies (e.g., Brookshire, Scharff, & Moses, 2002; Miller, 1938; Rose & Robinson, 1984) conducted with children found that the presence of graphics had no effect on the participants' comprehension. For example, Brookshire and colleagues (2002) randomly assigned first and third grade students to one of three conditions for reading a narrative text designed specifically for the experiment: text-only, text plus illustrations, and illustrations-only (for which the students were told the names of the characters and instructed to make up a story). After reading (in third grade) or hearing (in first grade) the text, students were asked 15 comprehension questions. Five of the questions' answers could be found in the written text, five could be found in the graphics, and five could be found in both the written text and the graphics. They found that the presence of graphics did not significantly increase students' comprehension scores on the questions whose answers could be found in the written text only (which was not surprising) or in the text and the graphics, and slightly decreased their comprehension scores of illustration-only questions.

Graphics have negative effects on comprehension of written text. Other studies on graphics and comprehension of connected text, however, have concluded that graphics negatively impact the reading process (Harber, 1983; Rose, 1986; Watkins, Miller, & Brubaker, 2004). For instance, Rose (1986) researched the effects of illustrations on the comprehension of students with learning disabilities. Thirty-two learning disabled elementary students (age 9 years, 3 months to 12 years, 8 months) read passages, at their reading level, in both illustrated and unillustrated conditions. Within-subject analyses indicated that the students' comprehension of unillustrated passages was significantly higher than their comprehension of the illustrated passages.

Graphics have beneficial effects on comprehension of written text. Other researchers (e.g., Hannus & Hyona, 1999; Rusted & Coltheart, 1979; Small, Lovett, & Scher, 1993) have concluded from their research that graphics actually aid in students' comprehension. Yet these researchers do not agree for whom or in what ways.

Graphics benefit ALL readers. For example, in one study, Small and colleagues (1993) studied 33 first and 33 third graders of varying reading abilities learning about three unfamiliar animals. Students were randomly assigned to one of three conditions: description-only (listened to passages), picture-only (examined graphics), and description-plus-picture condition (listened to passage and examined graphics). After listening to each passage and/or examining each graphic, the students answered 12 comprehension questions about the animal--four of the answers could be found in the description, four in the graphic, and four in both. Students were encouraged to guess or make up answers if they were unsure. Students in the description-plus-picture condition recalled more information presented only in the text and more information presented in

the text and the graphics than those students in the description-only condition. Thus, the results of the study suggested that the presence of graphics facilitated recall of information, even if the information had not been presented in the graphics, for *all* students in the study.

Graphics benefit GOOD readers more. In contrast to the findings above, based on their study of fourth graders' comprehension of biology textbook passages, Hannus and Hyona (1999) concluded that the graphics assisted *good* readers more than others. The participants in this study, 108 fourth graders from two urban elementary schools in Finland, were exposed to three illustrated passages and three unillustrated passages. After reading, they answered ten or eleven comprehension questions for each passage. The questions assessed the students' recall of specific details as well as their comprehension of biological principles. The results indicated that graphics led to better recall of detail information for all students, but only better comprehension of biological principles for the stronger readers. They asserted that this difference was due to the fact that students needed to integrate information from the written text and graphics in order to benefit from the graphics, which only high-ability readers appeared to be capable of doing. Furthermore, they hypothesized that better readers recalled and comprehended more from the illustrated texts because they were better able to understand four key ideas: (1) when to examine the graphics while reading; (2) which graphics they should examine; (3) what information they should obtain from the graphics; and, 4) how to combine information in the written text and the graphics into one mental representation.

Graphics benefit POOR readers more. Still other studies have found that, while graphics may help all students, they especially improve the reading comprehension of

poor readers and readers from disadvantaged populations. For instance, Rusted and Coltheart (1979) found that graphics improved the comprehension of poor readers more than that of good readers. In this study, thirty-six 9- and 10-year olds (half good and half poor readers) were randomly assigned two sets of six informational passages about unusual animals, with one set of passages containing graphics of the animals and the other not containing any graphics. The passages included information about the physical characteristics of the animals, as well as their living and eating habits. Before reading, students were told to remember what they read and to pay attention to graphics if they were present. The students then read each passage aloud two times. Immediately after the second reading of each passage, students told the researcher everything they remembered about the passage. The results of the study suggested that the presence of graphics improved the general recall of all students, but *poor* readers actually recalled more illustrated features than good readers, thus improving their comprehension as a whole. Furthermore, the researchers reported that the poor readers appeared to study the graphics more often and use them more intentionally than the good readers.

Conclusion. In summary, the research conducted with children thus far has investigated whether graphics improve children's comprehension of written text, but the results have been inconsistent, with some researchers finding them to have neutral effects, others finding them to have negative effects, and still others finding that they have beneficial effects. Even those researchers who agree that they are beneficial to students' comprehension do not agree for whom or for what reasons.

Outcome versus concurrent measures. Most of the previous research on graphics and comprehension explored whether the mere presence of graphics had effects

on participants' overall comprehension of the texts presented to them. Few studies used think alouds (e.g., Norman, in press; Schnotz, Picard, & Hron, 1993) to examine what they were doing with those graphics, and what relationship that had to participants' comprehension of the text. In fact, only one study (i.e., Norman, in press) has research the specific reading processes that were prompted by the graphics and only one study (i.e., Schnotz et al., 1993) has attempted to investigate how participants used the graphics to assist in their comprehension of informational text through the use of verbal protocols.

Reading processes prompted by the graphics in informational text. In Norman's (in press) study, 9 second graders read two informational texts and were prompted to think aloud whenever they studied a graphic. These think-alouds revealed that 17 reading processes (i.e., *label; literal description; inferential description; prediction; infer the author's purpose; confirm/disconfirm text; connection-to-self; irrelevant connection; connection-to-prior knowledge; wonder; knowledge monitoring; affective response; compare-contrast graphics; evaluate; use of running text; use of captions, labels, map key, etc.;* and *word identification*) were prompted by the graphics in these two texts. This study did not utilize any outcome measures, however, so it was not possible to determine whether or not a relationship existed between the reading processes prompted by the graphics and students' comprehension of those same texts.

Use of graphics in informational text. Schnotz and colleagues (1993) studied 26 college students as they read a passage, accompanied by a map of the time zones, about time and date changes as one passes through the different time zones in order to determine whether there were differences in how successful and unsuccessful learners used the graphics (i.e., the map). After reading, the students first described what

information they could extract from the map; then thought aloud as they answered 11 questions using a map; and finally took a 25 question test for which they had to apply the information in the written text and the map to figure out times in different areas of the world. Schnotz and colleagues compared how often successful and unsuccessful learners—as determined by the 25 question test about the material—referred to the map during the think-alouds, finding that successful learners referred to the map significantly more often than their less successful counterparts (i.e., an average of 21.3 times and 12.5 times respectively). Moreover, successful learners interpreted more sections of the map during their think-alouds and used the map to determine more spatial and temporal differences as indicated by their think-alouds. Schnotz and colleagues hypothesized that the successful learners were using the graphics to develop mental models, and used the written text to add to these mental models.

In sum, Norman's (in press) study provides us with an understanding of what processes are prompted by the graphics as children reading informational texts, but no outcome measure was used so it is unknown how well students comprehended the texts or whether the use of reading processes as they studied the graphics improved or hindered the students' comprehension of the overall text. Schnotz and colleagues' (1993) study indicated that successful learners—those students who comprehended the text more—used the graphic more often, but did not investigate the specific reading processes that were prompted by the graphic. Therefore more research is needed in order to investigate specifically the relationship between the reading processes prompted by the graphics and students' comprehension of the same texts.

Methods

Research Design

I conducted a study using verbal protocols (Afflerbach, 2000; Pressley & Afflerbach, 1995; Pressley & Hilden, 2004). As the students read, they were prompted to think aloud whenever they studied a graphic; students were also encouraged to share their thinking at any other time during the reading. After each reading, the students retold the book and answered eight researcher-designed comprehension questions. I then analyzed the verbal protocol transcripts using modified open coding (Strauss & Corbin, 1998) and scored the retellings and researcher-designed comprehension questions. Finally, correlations were run between students' scores on the retelling and research-designed comprehension questions and the number of times any process was prompted, the number of different processes, and the number of instances of individual processes to answer the question: What is the relationship, if any, between children's processes prompted by the graphics in informational text and their comprehension of the same texts?

Participants

The study was conducted with 30 second-grade students (17 males and 13 females) from 8 classrooms in 5 schools in 5 school districts in 2 Northeastern states. In order to provide a diverse sample of students based on ethnicity and socioeconomic status, the school districts were selected purposively. Within each school district, 1 school agreed to participate; within each of these schools, 2 classrooms were randomly selected from all consenting classrooms. Two of the selected classrooms (1 in each of two schools) had to be eliminated from the study because they lacked a range of readers as indicated by the Gates MacGinitie Reading Test (GMRT) (MacGinitie, MacGinitie,

Maria, & Dreyer, 2000) comprehension subtest. In these 2 schools, all 6 students were randomly selected from one classroom. Including only 2 classrooms from each school and 3 to 6 students from each classroom help to decrease the likelihood that the results of the study would be influenced by any one school or teacher placing a greater emphasis on the graphics in text.

The decoding and comprehension sections of the GMRT, Form T, Level 2 were administered to all consenting students from each classroom, and students were identified as below-average readers (i.e., they scored between the 1st and 30th percentile), average readers (i.e., they scored between the 40th and 60th percentile), and above-average readers (i.e., they scored between the 70th and 100th percentile). Those students who did not score between these percentile ranges were eliminated from the study. Additionally, in order to better control for any language or learning disability factors, students who received special education services or were English Language Learners were eliminate from the possible participant pool prior to selection (i.e., below-average, average, and above-average). Once all students had been identified or eliminated, randomized cluster sampling was used to select one reader from each class in each achievement group so that one was a below-average reader, one was an average reader, and one was an above average reader.

The participants were diverse in terms of ethnicity and socio-economic status, which was measured using maternal education level (Entwisle & Astone, 1994). For the sample, per parent report, 6% of the children were Asian-American, 10% African-American, 50% Caucasian, 20% Hispanic/Latino, and 10% other; and the parents of two students did not respond. In terms of socio-economic status, 6% of mothers reported

completing 8th grade but not high school, 23% reported completing high school, 6% held associates degrees, 30% reported holding a bachelors or other four-year degree, 20% reported holding a masters degree, and 3% reported holding a doctorate; four declined to respond.

Materials

Students read *Dino Dig* (Odgers, 2008) and *Weather Watching* (Ryan, 2008), two informational texts that are part of Weldon Owen Publishings' stage two *Top Readers* series, a series of books that are designed with simple sentences, specialized vocabulary, and graphics that provide support (Odgers, 2008, back cover; Ryan, 2008, back cover) and contain a range of graphics. *Dino Dig* explains the process by which dinosaurs become fossils and how scientists discover and use these fossils to learn about dinosaurs. *Weather Watching* describes different types of weather and how scientists study weather. Both of the books are written for second graders to read independently in the second half of the school year according to Chall's (1996) *Qualitative Assessment of Text Difficulty*.

The graphics in both books represent many of the prototypical graphics found in informational texts, such as photographs and realistic drawings with captions and labels, maps, flow charts, and cross-sectional diagrams (Fingeret, in preparation; Purcell-Gates, Duke, & Martineau, 2007). (See Table 2.1 for number of instances of each graphic type.) Also, these graphics represent many of the communicative properties of graphics (e.g., representation, organization, and extension) identified by Levin and colleagues (Carney & Levin, 2002; Levin, 1981; Levin et al., 1987), Clark and Lyons (Clark & Lyons, 2004), and Duke and colleagues (in preparation).

Because the length of the books was a concern, three sections (five pages) were removed from each book. All sections removed met the following criteria: (1) the exclusion of those pages would not diminish the range of graphics in the text, and (2) the removal of those sections would not impact the comprehension of later sections. Within sections that met these criteria, I gave priority to removing sections that (1) contained vocabulary or concepts deemed difficult or confusing for second grade students and (2) that were not authentic to informational text.

Finally, in order to more easily track where the students were looking as they read (i.e., the running text, the captions, or the graphics), the books were modified (as in Norman, in press). The original books, which measured 6 inches by 9 inches (15.24 cm by 22.86 cm), were cut apart and glued onto construction paper, which measured 12 inches by 18 inches (30.48 cm by 45.72 cm), so that the distance between the main text and the graphics was increased. The labels and titles of graphics were not cut apart from the image, and headings and the accompanying running text remained intact; the relative position of graphics, written text, and captions on the page was kept the same.

Data Collection and Analysis

Sessions one and two. During the first two sessions, which occurred within the classroom, I introduced myself to the students and explained the study to them. Then, all students with parental consent completed the decoding and comprehension subtests of the GMRT, Form T, Level 2 (MacGinitie et al., 2000).

Sessions three and four. During the third and fourth sessions, which were held on a one-to-one basis in a quiet place outside of the classroom, the students read aloud either *Dino Dig* (Odgers, 2008) or *Weather Watching* (Ryan, 2008). As the students read,

they were not corrected and were provided with little assistance in the decoding of words. When students asked for help, they were encouraged to try their best. In a few instances, students were supplied with words because they refused to continue reading. As students read, they were asked to verbalize what they were thinking (procedures for this are described below). The order of presentation of the two books was counterbalanced within ability group and classroom.

Verbal protocols. Verbal protocols were used to determine the readings processes prompted by the graphics. As students read, they were prompted to think aloud about the text when they looked at a graphic. As is recommended in methodological pieces on verbal protocols (i.e., Pressley & Afflerbach, 1995; Pressley & Hilden, 2004) the directions to students for sharing their thinking were general:

> Today, you are going to be reading a book for me. The book is going to look a little funny (show students book), so don't worry about that. As you read, I cannot help you with any of the words. If you come to a word you don't know, try your best and keep reading. When you are done reading, I am going to ask you to retell the book to me. I am also going to ask you some questions about the book. As you read, I want to know what you are thinking. Sometimes, I am going to stop you to ask you to tell me what you are thinking. If you have nothing to say, you can tell me that too. You can also talk about the book at other times when I don't ask if you want to. Is it okay to tell me you have nothing to say? Is it okay to talk about the book whenever you want?

As students read, I watched continuously in order to determine where their eyes were looking, the text or the graphics. When I noticed that they were looking at a graphic,

I prompted them to share their thinking with, "What are you thinking?" If students had not looked at any graphics after four pages, they were also prompted with "What are you thinking?"

In order to identify the processes prompted by the graphics, students' verbal protocols were transcribed verbatim. The transcription of their readings and that of their thinking was done in different colors in order to make it easier to distinguish the two kinds of verbalization.

First, verbalizations were analyzed to determine to what the student was referring: the written text without reference to the graphic (e.g., "D-I-G [underlines word as spells it out]"); the graphic (e.g., "Oh, I see a bones [sic] [student points to bones in picture]"); the graphic and the written text (e.g., "So in here they would have to put a replica [points to spot on the skeleton where a piece is missing]" after reading that scientists make replicas to fill in missing piece of a fossil); or an unrelated comment (e.g., "I need to go to the bathroom"). Only those comments that pertained to the graphics, either because they directly related to the graphic or because the student was looking at the graphic as they spoke, were coded further. Second, modified grounded theory (Strauss & Corbin, 1998) was used to reveal the reading processes prompted by the graphics in each of the texts. Because previous research (i.e., Norman, in press) using grounded theory had already identified 18 codes, I began by analyzing for these processes (i.e., *label; literal description; inferential description; prediction; infer the author's purpose; confirm/disconfirm text; connection-to-self; irrelevant connection; connection-to-prior knowledge; wonder; knowledge monitoring; affective response; compare-contrast graphics; evaluate; use of running text; use of captions, labels, map key, etc.; word*

identification) and *no process*. Any verbalizations that did not fit one of the 18 previous codes were then described with a short phrase that explained the process prompted by the graphic. These phrases were compared continuously to ensure that none of them could be collapsed. In this way, six new codes were developed (i.e., *names, graphic-to-written text connection, intertextual* [across texts] *connection, creates narrative, repeat-paraphrase written text,* and *other*). (Please see results section below for further discussion of these codes.)

In some instances, the graphic prompted more than one reading process; therefore, the verbalizations could be coded using multiple processes. For example, while reading *Dino Dig* (pp. 22-23) and studying a cross-sectional diagram of a dinosaur, one student commented, "That looks gross (points to dinosaur)! I think maybe they're going to tell us, like (points to muscle), the layers of a dinosaur, maybe." The first sentence in this verbalization was coded as an *affective response* because the student was reacting to the graphic; the second sentence was coded a *prediction* because the student explained what he thought the page would discuss.

A literacy expert familiar with reading processes of written text was trained to code the verbal protocols using six of the transcripts. She then coded a random sample of the transcripts (n=16 or more than 25%), stratified by book. Inter-rater agreement was 86.7% or 320 out of 369 codes, which is comparable to inter-rater agreement in other verbal protocol studies (e.g., Brown, Pressley, Van Meter, & Schuder, 1996).

Retellings. When students had finished reading the book, they were asked to retell the text. For this study, directions for retelling were adapted from previous research on

younger children's retellings of expository text (e.g., Romero et al., 2005), but were modified to utilize the fact that the session was videotaped.

> Another second grader hasn't read this book and wants to know about it. She (He) will watch the video to hear the retelling. Can you retell the book using your words and the words in the book as you remember them? Try to include as many details as you can.

Retellings have been used in previous research on the influence of graphics on students' comprehension of the written text (e.g., Gambrell & Jawitz, 1993). They have also been successfully used to assess young children's comprehension of narrative (e.g., Baumann & Bergeron, 1993; Morrow, 1985; Roberts, in preparation) and expository text (e.g., Moss, 1997; Romero, Paris, & Brem, 2005).

Retellings were scored based on protocols developed for each book. The protocol scoring procedure is based on that used by Meyer, Brandt, and Bluth (1980) in their study of the use of top-level text structures and by Taylor (1980) in her study of children's memory for expository text. To develop retelling protocols, an expert in designing retelling protocols and I analyzed each book independently, identifying superordinate and subordinate ideas from the running text and captions and developing a checklist to be used in scoring the retellings. Next, we compared checklists and found three discrepancies—two for *Dino Dig* and one for *Weather Watching.* These disagreements were resolved through discussion and consultation with another literacy expert.

Finally, we assigned points to each idea. Superordinate ideas received two points, and subordinate ideas received one point. Students could also receive half a point for retelling the topic of a superordinate idea (e.g., it talked about rainbows) or for retelling

part of a subordinate idea (e.g., the sun makes rain). At times a superordinate idea for one page was discussed as a subordinate idea on another page. In these instances, students received two points (see Appendix A for retelling protocol for *Dino Dig).* Finally, in order to equate the two retellings, the students' scores on the retelling were divided by the total possible points (i.e., 45 for *Weather Watching* and *49* for *Dino Dig)* and multiplied by 100 to determine their scores on the retelling.

A literacy expert familiar with scoring retellings was trained to score the retellings using 2 transcripts and then scored 10 transcripts for *Weather Watching* and 10 transcripts for *Dino Dig*. First, I looked at whether or not a student mentioned a main idea or supporting detail; interrater agreement was 96.2%, or 885 ideas out of 920. Then, I compared our final retelling scores for each protocol to see if they were within 1 point; 80%, or 16 out of 20, were within 1 point.

Book-specific comprehension questions. Finally, students were asked 8 book-specific comprehension questions about the text. All questions were open-ended and students were asked to respond verbally. Students' answers were recorded and later transcribed.

Researcher-designed comprehension questions have also been used as comprehension assessments in the study of graphics (e.g., Harber, 1983), as well as in assessing children's comprehension of narrative (e.g., Paris & Paris, 2003) and expository text (e.g., Purcell-Gates, Duke, & Martineau, 2007). To construct the questions, I developed a concept map of the written text to illustrate the macro- and microstructures (Kintsch & van Dijk, 1978). I then wrote open-ended questions that tapped both concepts at the macro- and micro-level of the text. These questions were

designed to assess the three levels of comprehension recommended by the 2009 National Reading Framework (National Assessment Governing Board, 2008): locate/recall (for which students must identify information explicitly stated in the text), integrate/interpret (for which students must make inferences within and across texts), and critique/evaluate (for which students must assess the quality of the text, decide what is most important in the text, or judge the plausibility of an argument). Eight experts in the field of literacy reviewed and suggested revisions for the questions. After questions were refined, the experts identified whether each question assessed a macro- or micro-level idea, and whether it assessed literal, inferential, or critical comprehension skills to ensure this distribution was met. Based on their expert review, it was. (See Appendix B for questions from *Weather Watching*.)

On the comprehension questions, students could receive up to two points for each correct answer. To develop a scoring protocol, an expert in literacy and I answered each question with what we thought would be considered two-point and one-point answers for second grade students. These answers were compared to each other and to a random sample of six transcripts. From these transcripts, sample 0-point, 1-point, and 2-point answers were selected to include in the scoring protocol. Once all answers were scored, students' comprehension question scores for each book were divided by the number of points scored by the total number of points possible (i.e., 16, though for two students, one question was missed so their possible points were out of 14 instead of 16) and multiplied by 100.

A literacy expert familiar with scoring comprehension questions was trained to score the comprehension questions using 2 transcripts. She then scored 10 transcripts for

Weather Watching and 10 transcripts for *Dino Dig*. Interrater agreement was 87.5%, or 140 out of 160 questions.

Videotaping. The 2 one-on-one reading sessions were videotaped in order to record where students were looking and pointing (e.g., running text, caption, label, graphic) as they discussed their thinking. The transcriptions included references to where the students were looking or pointing as they read and verbalized.

Statistical analysis. After all verbalizations pertaining to the graphics, retellings, and comprehension questions were analyzed, a number of statistical analyses were run. First, the number of times each process was prompted for each student was calculated separately for each book. Second, the number of different processes prompted for each student was calculated separately for each book. Third, correlations were run to determine whether and if so, to what degree, there was a statistically significant relationship between (a) retelling scores and (b) comprehension question scores and (1) the range of processes used by children (2) the number of times any process was used by children, and (3) the number of times each individual process was used by children.

Results

The Reading Processes

The modified open-coding of the transcripts resulted in 25 codes—23 reading processes (i.e., *affective response; confirm-disconfirm text; intertextual connection; graphic-to-graphic connection; graphic-to-written text connection; irrelevant connection; connection-to-prior knowledge; connection-to-self; create narrative; evaluate; infer the author's purpose; inferential description; knowledge monitoring; label; literal description; name; prediction; repeat-paraphrase written text; reading*

process-other; use of graphical devices; use of running text; wonder; and *word identification), no process,* and *uninterpretable.* Table 2.2 provides complete descriptions of and student comments that exemplify each process.

The total number of processes prompted by the graphics across the two books ranged from 9 to 62 (M=28, SD=12.625). The number of different processes prompted by the graphics across both books ranged from 1 to 16 (M=9.93, SD=4.226). Table 2.3 provides descriptive statistics for the total number of times each process was prompted for each book, and Table 2.4 provides descriptive statistics for the number of times any process was prompted and number of different processes prompted by the graphics for each book. For further discussion of these processes see Manuscript 1.

Correlations between the Reading Processes and Retelling Scores

Out of a score of 100, students' scores on the retellings ranged from 1.02 to 22.45 (M=9.03, SD=5.65) for *Dino Dig* and from 1.11 to 26.67 (M=8.00, SD=5.72) for *Weather Watching.* The correlation between retelling and number of times any process was prompted by the graphics was statistically significant for *Dino Dig* (r=0.403, p=0.027), but not for *Weather Watching.* This statistically significant correlation indicates that, for *Dino Dig*, a greater use of any process prompted by the graphics was associated with higher retelling scores. In fact, about 16.25% of the variation in students' retelling scores for *Dino Dig* can be explained by the number of times any process was prompted. Neither for *Weather Watching* nor for *Dino Dig* was the correlation between the number of different processes and retelling scores statistically significant. See Table 2.5 for means, standard deviations, and ranges of scores on the retellings for the two

books, correlations between retelling scores and total number of processes, and correlations between retellings and number of different processes.

Several individual reading processes were also associated with higher retelling scores for each book, For *Dino Dig,* seven processes (i.e., *connection-to-prior knowledge* [r=0.417, p=0.022], *connection-to-self* [r=0.395, p=0.031], *intertextual connection* [r=0.363, p=0.049], *label* [r=0.517, p=0.003], *graphic-to-graphic connection* [r=0.436, p=0.016], *irrelevant connection* [r=0.382, p=0.037] and *use of graphical devices* [r=0.439, p=0.015]) were significantly correlated with retelling scores and one processes (i.e., *names* [r=0.310, p=0.095]) approached significance. The effect sizes for these processes were all moderate to strong, ranging from 0.096 (*names)* to .267 (*label*). See Table 2.6 for means, standard deviations, and correlations between retelling scores and individual processes.

For *Weather Watching*, students' scores on the retelling were significantly correlated with *predicting* (r=0.702, p<0.001) and *use of running text* (r=0.382, p=0.037). Finally, the correlation with *connection-to-prior knowledge* approached significance (r=-0.357, p=0.053). Interestingly, this correlation was negative, indicating that more *connections-to-prior knowledge* were associated with lower retelling scores for *Weather Watching.* The effect sizes for *connection-to-prior knowledge* and *use of running text* were moderate (r^2=0.127 and 0.146 respectively), while the effect size for *predicting* was very strong (r^2=0.493). (Please see Table 2.7.)

Correlations between the Reading Processes and Researcher-Designed Comprehension Question Scores

Students' scores on the researcher-designed comprehension questions ranged from 15.63 to 81.25 (M=47.43, SD=16.83) out of a score of 100 for *Dino Dig* and from 3.13 to 62.5 (M=41.38, SD= 18.09) out of a score of 100 for *Weather Watching.* No correlations between these scores and number of times any process was prompted or number of different processes used were statistically significant, although the correlation between number of different processes prompted while reading *Weather Watching* and the score on comprehension questions did approach significance (r=0.309, p=0.097), indicating that the number of different processes accounted for about 9.5% of the variation in students' scores on the comprehension questions. Again, see Table 2.5 for means, standard deviations, and ranges of scores on the comprehension questions for the two books, correlations between comprehension scores and the number of times any process was prompted, and correlations between comprehension scores and the number of different processes.

Correlations run between the number of times individual reading processes were prompted by the graphics and students' scores on the comprehension questions indicated that only *graphic-to-graphic connection* was significantly correlated with comprehension scores (r=0.528, p=0.003) for *Dino Dig.* The prompting of *intertextual connections* also approached significance (r=0.326, p=0.079) for *Dino Dig.* The effect sizes of these processes on their comprehension question score were moderate (r^2=0.106 for *intertextual connections*) to strong (r^2=0.279 for *graphic-to-graphic connection*) There were no significant correlations between any specific reading processes and the

comprehension questions for *Weather Watching*. See Table 2.6 and 2.7 for means, standard deviations, and correlations.

Discussion

This study investigated what relationship, if any, existed between the processes prompted by the graphics as second graders read informational text and their scores on two comprehension measures for that text: retelling and researcher-designed comprehension questions. A discussion of these findings follows.

Sheer Number of Processes May Not Always Help

As discussed above, research on reading processes and the comprehension of written text has shown that students who employ a greater number of total processes score higher on comprehension assessments (e.g., Braten & Stromso, 2003; Dermitzaki et al., 2008; Samuelstuen & Braten, 2005). In this study, the number of times students used any process while studying the graphics in *Dino Dig*—but not *Weather Watching*—was significantly correlated with the retelling measure. Previous research has also found that good readers use a greater range of processes with written text (e.g., Dermitzaki et al., 2008). With respect to the visual elements of text that were the focus of this study, there were no significant correlations between range of different processes used and scores on either of the comprehension measures for either of the books.

Why do these differences exist between the relationship of how students process written text and graphical text and subsequent comprehension? I propose three possible reasons: (1) the designs of the studies differed, (2) it is possible that not all processes are created equal—that is to say that the use of some are associated with improved comprehension, while the use of others are not, and (3) students are being taught to

strategically use processes when reading written text, but not when reading graphics (if they are taught to read graphics, at all).

The studies' designs. The design of this study differed from the designs of the studies investigating reading processes prompted by written text and comprehension. In this study, students' reading processes were revealed through verbal protocols and modified open-coding. Students were not asked to identify specific processes, but instead shared their thinking about the graphics in general. In Samuelstuen & Braten (2005), students were asked to indicate how often they had used specific processes by selecting (1) *not at all* to (10) *very often* on a Likert-type scale. Perhaps some students over- or under-represented their use of these processes. Additionally, previous research on the relationship between reading processes and comprehension have not included as many different reading processes as were included in this study. For example, Samuelstuen and Braten's (2005) investigated the use of only three types of reading processes—elaboration, organization, and monitoring. They did not include many of the reading processes included in this study, such as *word identification*, *predicting*, or *irrelevant connections*. However, this does not necessarily mean that fewer processes were present, but could mean that the level of analysis was less refined than in the present study, with several micro-processes mapping onto one macro-process. Limiting the number and type of reading processes investigated in this study or consolidating processes may have lead to different results.

Not all processes are created equal. When looking at the correlations between reading processes and comprehension scores, it appears that not all reading processes contribute to a readers' overall comprehension equally. For example, students who used

the graphics to assist them in w*ord identification* did not necessarily score better or worse on the comprehension measures—it helped them to decode the text, but was not necessarily related to better recall.

Students' *use of graphical devices* (positively statistically significantly correlated with retellings about *Dino Dig*) and *use of the running text* (positively statistically correlated with retellings about for *Weather Watching*), on the other hand, appear be associated with better retelling scores (for *Dino Dig* and *Weather Watching* respectively). Perhaps this is partially due to the fact that the graphical devices and the running text helped them to comprehend the graphic better. For example, *Weather Watching* discusses the fact that, long ago, scientists used kites to study the weather. When first looking at the accompanying graphic, a number of students thought it was a picture of the Wright brothers and their airplane. Only after reading the running text did some of them comment, "I just learned that that's a kite." Understanding that the graphic showed scientists flying a kite may have cleared up misconceptions and helped students to remember how scientists studied weather long ago so that they could correctly include this in their retellings. Qualitative analysis of students' answers to the question "How did people study weather long ago?" indicates that students who used the running text to revise their understanding of this graphic were more likely to respond correctly than those students who did not use the running text to revise their thinking. These latter students were more likely to reply that they used airplanes.

Greater use of *labeling* a graphic was also associated with higher retelling scores, but not with higher comprehension question scores. This could be due in part because *labeling* the pictures made them more memorable to the children, and thus made them

more likely to mention them in their retellings. Just restating items did not necessarily assist them in answering comprehension questions, however, because many of the comprehension questions asked them to go beyond simply recalling specific items included in the text. One exception was a question about *Dino Dig* which asked students to "Tell me as many things as you can from this book that were turned into fossils." Qualitative analysis of this question suggests that students who labeled the photographs and illustrations of the different types of fossils were able to include more different types of fossils.

Reading instruction. Currently, many students (likely including those in this study) have been taught to predict, summarize, make inferences, make connections, and use other processes strategically as they read *written* text. In fact, this strategy instruction is emphasized in research-based programs, such as those based on transactional strategy instruction (Brown et al., 1996) and reciprocal teaching (Palincsar & Brown, 1994), as well as popular books written for teachers, such as *Strategies that Work* (Harvey & Goudvis, 2007) and *Mosaic of Thought* (Keene & Zimmermann, 2007). Importantly, this instruction does focuses on the quality of the use of these processes. That is to say, teachers spend time teaching the difference between a helpful and an unhelpful prediction or connection. By comparison, less emphasis appears to be placed on the reading and processing of graphics as no research exists whether or not teachers are teaching students to read and process graphics or to suggest effective ways in which to teach students how to read and process these graphics. Therefore, students are not learning how to effectively use these reading processes when studying graphics and it would appear that quality, strategic use of processes while reading written-text may not transfer to quality, strategic

use of processes while reading the graphics.

The Curious Case of Prior Knowledge

In looking at specific processes, previous research has found that prior knowledge of a subject assists in students' comprehension of the topic (e.g., McNamara & Kintsch, 1996). In this study, the graphics prompted 20 students to make *connections-to-prior knowledge* for a total of 56 times (33 for *Weather Watching* and 23 for *Dino Dig).* Interestingly, these *connections-to-prior knowledge* were positively correlated to retelling scores for *Dino Dig,* but negatively correlated to retelling scores for *Weather Watching,* though the latter only approached statistical significance. In some cases, it seems that children's connections relating prior knowledge to *Dino Dig* were of greater quality or were more accurate, thus assisting them in their comprehension of the text. For example, one above-average reader was prompted to make *connections-to-prior knowledge* while reading *Dino Dig* and *Weather Watching.* For *Dino Dig,* one of his *connections-to-prior knowledge* was about mummies while studying a photograph of Leonardo, a dinosaur fossil that was a mummy. In his retelling, he discussed Leonardo and received three out of the four possible points he could have received for that page, which was almost half of his *Dino Dig retelling* points. While reading *Weather Watching,* his *connection-to-prior knowledge* was incorrect—while studying a photograph of lightning, he stated that lightning could come from the sky or the ground. In his retelling, he did not mention lightning at all. Accurate and relevant prior knowledge likely assists students in their comprehension more than inaccurate or less relevant prior knowledge.

Limitations

Precautions were taken to maximize the validity of this study, but a few limitations remain. First, because verbal protocols rely on participants self-reporting of their thinking and the comprehension measures were dependent upon students verbalizing their answers, students' verbal abilities may have impacted their reporting of their thinking (Afflerbach & Johnston, 1984) and their ability to retell or answer the comprehension questions. Second, the fact that students were prompted to share their thinking whenever they looked a graphic may have affected how often students studied the graphics. Some students may have been studied them more often because of this prompting, while others may have looked at them less often in order to avoid prompting. In fact, although never specifically told that they would be asked to share their thinking when they looked at a graphic, some students appeared to figure out the pattern and began to report their thinking as they looked at each graphic.

Implications and Conclusions

Previous research on comprehension and graphics has been inconsistent with regard to whether or not the presence of graphics is beneficial to students' overall comprehension of the text. None of these previous studies investigated how students were processing these graphics. The present study indicates that the use of *certain processes* when reading graphics in informational text are associated with a better overall understanding of that same text. Some possible reasons are discussed above, but more research is needed to investigate how and why these processes are contributing to the students' comprehension. Additionally, neither the quality of students' processes nor the relationship between the quality and students' comprehension scores were analyzed in

this study. Future research should study whether such a relationship exists. Furthermore, research indicates that students are being taught to use processes as they read written text, but no research exists to indicate they are being taught to use these processes as they read graphical text; survey and observational studies are needed to investigate whether and how teachers are instructing students to use processes as they read the graphics in text. Finally, because this research suggests that the use of specific processes is associated with better comprehension, intervention studies that teach students how to strategically use these processes and comprehend graphics are needed. We are developing our understanding of the use and comprehension of the graphics in informational text, but we have a long road before we have a complete picture.

Table 2.1

Number of instances of each graphic type in Weather Watching *and* Dino Dig

Type of Graphic	Number of instances in *Weather Watching*	Number of instances in *Dino Dig*
Total number of Photographs	5	5
Labeled photograph	1	0
Total number of drawn illustrations	9	12
Labeled drawn illustration (not cross-sectional diagram or flow chart)	1	6
Cross-sectional diagram	1	1
Graphic with key	3	0
Map	1	0
Flow chart	1	1

Note: Some graphics are counted more than once. For example, the map in *Weather* counted as both a map and a graphic with key.

Table 2.2

Definitions and Examples of All Processes Prompted by the Graphics

Affective response	Student expresses an emotion based on the graphic.	Example 1: I like rainbow (traces rainbow). Example 2: That it's cool to fly kites in the sky (affective), but they need to know, like, what the weather is like (evaluate). Example 3: That's weird.
Connection – graphic-to-written text	Student makes a connection between a graphic and the written text in another part of the same book.	Example: It shows like it said before in the book that if you find one fossil you probably find more cause it looks like more than one dinosaur.
Connection-graphic-to-graphic	Student compares different graphics in order to better understand both graphics and/or to gain new information/ meaning.	Example 1: Hey, I think (looks back and forth between the two graphics), it looks like they're the same thing.
Connection-intertextual	Graphic prompts student to make a connection to another text (e.g., book, movie, TV show, etc)	Example: In a show I saw they called them *carnivores*, the dinosaurs.

Table 2.2 (cont.)

Connection-to- prior knowledge	Student references prior knowledge related to the graphic. Prior knowledge may be inaccurate.	Example: Our teacher did tell us that you can memorize the colors (pointing to list of colors in rainbow) by Roy G. Biv. R, O, Y, G, B, I, V, as in a name.
Connection-to –self	Graphic prompts student to make a connection to the student's own life.	Example: (Looking at picture of storm clouds and umbrellas) I'm thinking about right now because look outside (it is raining)…it was like before it was only like poom, poom, poom.
Connection-Irrelevant	The connection made is topically connected, but is not relevant to the author's intent.	Example: (looking at a rainbow) I'm thinking of sunlight and happiness and rainbows and dandelions and pots of gold on the other side of the rainbow. I don't really think there is another side of a rainbow. Hmmm…Bet there isn't.
Create narrative	The graphic prompts student to create a narrative. Student ascribes feelings, thoughts, and actions to the people or	Example 1: He's like (points to larger dinosaur, in a low voice) "Where are you?" (then in a really high voice) "Let's play hide and

Table 2.2 (cont.)

	animals in the pictures. The actions are not present in the graphic and/or not reasonably inferred from the graphic and the words.	seek. Ahhhhh!" (Runs fingers across the page.)
Evaluate	Student judges or forms an opinion based on the information presented in the graphic and/or his or her background knowledge.	Example: I don't think it's really good because lightning can like shock you for electricity.
Knowledge monitoring	Student recognizes absence of prior knowledge or recognizes that the text or graphic confirms previous thinking	Example 1: I know lightning can go up (points to picture) or lightning can come down. And then there is another thing that lightning can go like it can either go up out of nowhere and just form. It can go up out of nowhere and just form. And it can come from clouds. And that's how it forms. That's what my mom told me. Example 2: I never knew that.

Table 2.2 (cont.)

Label	Student labels something in the picture while pointing to the objects being labeled. Labels may or may not be correct.	Example: snow (points to snow)
Names	Student names or lists items found in the picture without pointing to the objects in the picture. Names may or may not be correct.	Example: I'm thinking like lightning (looking at picture, but not pointing).
Literal description	The graphics prompt student to describe (not simply name or label) what is explicitly depicted in the graphic. Student may be gaining information, or may be stating what they see in the graphic. Information may or may not be correct.	Example 1: I'm thinking, for this picture (points to picture of lightning hitting tree), I think that it really I'm thinking about how when lightning comes it kind of affects, um, buildings and trees. Example 2: Mmm...their bones like all squiggly (points to bottom part of the bones on the tail), like, like all...the bones like this side is all sticking out, like pointy (points to bottom parts) and this side (points to top parts) is not.

Table 2.2 (cont.)

Inferential description	The graphic prompts student to infer information. The information is implied in the graphic or by combining information from the graphic and the words, but is not explicitly depicted. Information may or may not be correct.	Example: I'm thinking that these are guys who throw a (sic) airplane up in the sky when the wind blows.
Infer author's purpose	Student infers the author's purpose for including a graphic, what the author wanted you to learn from the graphic, or why author placed a graphic in a specific spot.	Example: It's kind of like rain and snow are on the same page because they're the same sometimes. Sometimes the rain is bad weather and sometimes snow is bad weather.
Prediction	Student uses the graphic to predict what will be on the page/in the book.	Example: Um, I think this is goin...this page is going to tell us about like about like what's on the land like where deserts are and where like tropical rainforests are.
Use of graphical	Student uses graphical text features (e.g., labels, captions,	Example 1:... I did notice that these (points to map key) match there

Table 2.2 (cont.)

Devices	map keys, arrows in flow chart, graphics' titles) to understand graphic. Student is not just restating or rephrasing the caption or label.	(pointing to map) so that would be a desert, that would be a tropical piece. The colors match. (Continues pointing to map key and matching areas on map.)
Use of running text	Student uses the text to better understand and gain information from the graphic. Student is not just restating or rephrasing the running text.	Example: (After reading running text) Oh...I just learned that's (points to graphic) a kite.
Repeat-paraphrase text	While looking at the graphic, student repeats or attempts to repeat text verbatim or paraphrases or attempts to paraphrase text using own words. The text can be the running text, captions, or labels (if the label is a phrase).	Example 1: Text: Bolts of lightning flash when the electricity builds up. Student: That lightning can build up... Example 2: Label: Clouds move with the wind. Student: That, like, clouds can like, like the wind can move the clouds...
Confirm-disconfirm text	Student uses the graphic to confirm/disconfirm what was stated in the text.	Example: Text: They then add muscle tissue and skin to the skeleton. This makes the dinosaur

Table 2.2 (cont.)

		look like it did when it was alive. Student: That does not look like it did when it was alive (point to dino). Only the skin (points to skin) would be there (circles around dinosaur).
Wonder	Student uses the graphics to question or wonder about topic. The wonders can be said as statements or questions. They may include words such as *if* or *wonder* but do not have to.	Example: Are there tons of the polars or not? Or if there's, like most deserts in most states or places? And, and how how (sic) are the temperature in like Afr, in like Australia, Africa, Europe, and South America?
Word identification	Student uses the graphic to decode word or comprehend meaning of word.	Example: I'm trying to see if the picture will help me figure out the word (mutters to self, repeats sentence).
Reading Process-Other	Comment does not fit into any of the other processes listed.	Example: Have you ever seen a wooly mammoth or a saber tooth statue in museums, hm? (Student is asking the researcher a question)

Table 2.3

Number of Times Each Process was Prompted

Process	*Weather Watching*	*Dino Dig*	*Both Books*
	No. of times prompted (% of total processes)	No. of times prompted (% of total processes)	No. of times prompted (% of total processes)
Affective response	19 (5.21)	23 (4.97)	42 (5.07)
Confirm-disconfirm text	5 (1.37)	5 (1.08)	10 (1.21)
Create narrative	15 (4.11)	47 (10.15)	62 (7.49)
Intertextual connection	4 (1.10)	3 (0.65)	7 (0.85)
Graphic-to-graphic connection	0 (0.00)	6 (1.30)	6 (0.72)
Graphic-to-written text connection	0 (0.00)	5 (1.08)	5 (0.60)
Irrelevant connection	7 (1.92)	12 (2.59)	19 (2.29)
Connection-to-prior knowledge	33 (9.04)	23 (4.97)	56 (6.76)
Connection-to-self	15 (4.11)	10 (2.16)	25 (3.02)
Evaluate	5 (1.37)	2 (0.43)	7 (0.85)

Table 2.3 (cont.)

Infer the author's purpose	1 (0.27)	0 (0.00)	1 (0.12)
Inferential description	27 (7.40)	47 (10.15)	74 (8.94)
Knowledge monitoring	24 (6.58)	23 (4.97)	47 (5.68)
Label	19 (5.21)	23 (4.97)	42 (5.07)
Literal description	28 (7.67)	51 (11.02)	79 (9.54)
Name	15 (4.11)	17 (3.67)	32 (3.86)
Prediction	15 (4.11)	19 (4.10)	34 (4.11)
Repeat-paraphrase written text	35 (9.59)	46 (9.94)	81 (9.78)
Use of graphical devices	28 (7.67)	4 (0.86)	32 (3.86)
Use of running text	4 (1.10)	2 (0.43)	6 (0.72)
Wonder	53 (14.52)	72 (15.55)	125 (15.10)
Word identification	6 (1.64)	9 (1.94)	15 (1.81)
Reading process-other	7 (1.92)	14 (3.02)	21 (2.54)

Table 2.4

Descriptive Statistics for Number of Different Processes and Number of Total Processes Prompted

		Total Sample		
		M	SD	Range
Number of Times Any Process was Promnted	Weather Watching	12.17	6.406	3-28
	Dino Dig	15.77	7.592	6-36
	Both Books	28.00	12.625	9-64
Number of Different Processes	Weather Watching	6.30	3.385	1-13
	Dino Dig	7.30	3.153	1-14
	Both Books	9.93	4.226	1-16

Table 2.5

Descriptive Statistics for the Comprehension Measures and Correlations between Comprehension Measures and Number of Different Processes and Number of Total Processes Prompted

Book	Comprehension Measure	M	SD	Range	Number of Times Any Processes Was Prompted r	Number of Different Processes r
Weather Watching	Retelling	8.00	5.72	1.11-26.66	.064	-.209
	Comprehension Questions	41.38	18.09	3.13-62.5	-.070	.309[t]
Dino Dig	Retelling	9.03	5.65	1.02-22.45	.403[*]	.171
	Comprehension Questions	47.43	16.83	15.63-81.25	.216	.213
Both Books	Retelling	8.54	4.70	2.13-22.61	.282	.001
	Comprehension Questions	44.01	15.69	14.06-71.88	.083	.325[t]

[*] significant at $p<.05$

[t] significant at $p<.10$

Table 2.6

Descriptive Statistics for Individual Processes and Correlations between Comprehension Measures and Individual Processes for Dino Dig

	Dino Dig				
				Retelling	Comp. Questions
Process	M	SD	Range	R	r
Affective response	.77	1.633	0-7	.067	.051
Confirm-disconfirm text	.17	.379	0-1	-.029	.279
Connection-intertextual	.10	.403	0-2	.363*	.326t
Connection-graphic-to-written text	.17	.531	0-2	.191	.170
Connection-graphic-to graphics	.20	.484	0-2	.436*	.528*
Connection-irrelevant	.40	.968	0-5	.382*	.062

Table 2.6 (cont.)

Connection-to-prior knowledge	.77	1.104	0-5	.417*	.010
Connection-to-self	.33	.758	0-3	.395*	-.049
Create narrative	1.57	1.695	0-5	-.029	-.264
Evaluate	.07	.254	0-1	-.287	-.059
Infer the author's purpose	.00	.000	0	.a	.a
Inferential description	1.57	1.591	0-6	.204	-.050
Knowledge monitoring	.77	.898	0-3	.274	.290
Label	.77	1.278	0-6	.517*	.187
Literal description	1.70	1.236	0-5	.039	.038
Name	.57	.935	0-4	.310t	.062
Prediction	.63	2.735	0-15	-.112	.231

Table 2.6 (cont.)

Reading process-other	.47	.900	0-4	.295	.224
Repeat-paraphrase written text	1.53	2.013	0-6	.003	-.214
Use of graphical devices	.13	.434	0-2	.439*	.078
Use of running text	.07	.254	0-1	.241	.078
Wonder	2.40	4.507	0-16	-.147	.079
Word identification	.30	.837	0-4	-.176	-.027

[a] Correlations could not be run.
* significant at p<.05
[t] significant at p<.10

Table 2.7

Descriptive Statistics for Individual Processes and Correlations between Comprehension Measures and Individual Processes for Weather Watching

	Weather Watching				
				Retelling	Comp. Questions
Process	M	SD	Range	r	r
Affective response	.63	1.245	0-4	-.101	-.188
Confirm-disconfirm text	.17	.461	0-2	.044	-.235
Connection-intertextual	.13	.434	0-2	.111	.104
Connection-graphic-to-written text	.00	.000	0	.a	.a
Connection-graphic-to-graphics	.00	.000	0	.a	.a
Connection-irrelevant	.23	.568	0-2	-.146	.056
Connection-to-prior knowledge	1.10	1.447	0-5	-.357[t]	-.251

Table 2.7 (cont.)

Connection-to-self	.50	.900	0-4	-.186	-.188
Create narrative	.50	.861	0-3	.214	-.094
Evaluate	.17	.531	0-2	-.063	-.115
Infer the author's purpose	.03	.183	0-1	-.154	.090
Inferential description	.90	1.242	0-4	-.018	.035
Knowledge monitoring	.80	1.400	0-5	.171	.086
Label	.63	1.033	0-4	-.167	.004
Literal description	.93	1.363	0-5	.223	.043
Name	.50	1.306	0-5	-.113	-.121
Prediction	.50	1.676	0-9	.702***	.225
Reading process-other	.23	.504	0-2	-.158	.275

Table 2.7 (cont.)

Repeat-paraphrase written text	1.17	1.262	0-5	.154	.186
Use of graphical devices	.93	1.048	0-4	.172	-.054
Use of running text	.13	.346	0-1	.382*	.264
Wonder	1.77	3.159	0-11	-.160	-.074
Word identification	.20	.484	0-2	-.266	-.116

[a] Correlations could not be run.
* significant at p<.05
*** significant at p<.001
[t] significant at p<.10

Appendix A: *Retelling Checklist for Dino Dig*

Page	Main idea Score	Main idea (2 points) (.5 point if names topic of the main idea)	Supporting Idea Score	Supporting ideas (1 point unless indicated as ½ point)	Caption Score	Caption (1 point unless indicated as ½ point)
3	_____	Dinosaurs were reptiles. (1 point)	_____	Almost everything we know about them comes from studying the bones. (1/2 point)		
	_____	They lived long ago.(1 point)	_____	Almost everything we know about them comes from studying their tracks. (1/2 point)		
4-5	_____	Dinos could turn into a fossil when they die. (2 points)	_____	Dinosaur's body lay on the ground. (1/2 point)	_____	Predators sometimes ate its flesh. (1/2 point)
			_____	Dinosaur's body lay in the water. (1/2 point)		

					_____	Dinosarus have predators (or enemies). (1/2 point)
6-7	_____	Dinosaurs became fossils after a long time. (2 points)	_____	Bones are replaced by minerals. (1 point)	_____	Dinosaurs are covered by sand. (1 point)
			_____	Bones turn to stone. (1 point)	_____	Layers of dirt covers the dinosaur's body.(1 point)
					_____	Scientists discover the dinosaur fossils.(1 point)
8-9	_____	Different things can be fossils.	_____	Plant (or leaves) can be fossils. (1 point)	_____	The hard, bony parts are strong enough to make fossils.(1 point)
			_____	Plant fossils form when a leaf falls into clay and makes an impression. (1 point)	_____	Even insects can become fossils.

10-11	_____	Tracks can be fossils. (2 points)	_____	Tracks happen when animals walk in mud. (1 point)	_____	Tracks can be made when animals run from a predator. (1 point)
			_____	Tracks tell us how dinosaurs moved. (1 point)		
12-13	_____	Places with sedimentary rock are good places to look for fossils. (2 points)			_____	Where you find one dinosaur fossil, you might find others. (1 point)
					_____	You can break rocks with a hammer to find fossils. (1 point)
14-15	_____	Scientists uncover fossils in rocks. (2 points)			_____	Scientists have to work carefully. (1 point)
					_____	It may take a long time to uncover the fossil. (1 point)

16-17			_____	Found in Montana. (1 point)	_____	It was a mummy. (1 point)
			_____	Found a brachylophosaurs. (1 point)	_____	Soft tissue has been found as well as bones.(1 point)
			_____	It was named Leonardo. (1 point)		
18-19	_____	Fossil bones are mixed up. (2 points)	_____	Have to put them back together like a puzzle. (1 point)		
20-21	_____	Fossil skeletons are in museums. (2 point)	_____	Skeletons are big. (1 point)	_____	Information and pictures around the displays tell us what animals were like. (1/2 point)
					_____	Information and pictures around the displays tell us how they lived. (1/2 point)

22-23	_____	Bones can be missing from fossil skeletons. (1 point)	_____	The bones are made out of plaster. (1 point)	_____	They add muscle tissue (1/2 point)
	_____	Scientists make bones to fill in the gaps. (1 point)	_____		_____	They add skin to the skeleton. (1/2 point)
					_____	This makes the dinosaur look like it did when it was alive. (1 point)

Appendix B: *Researcher-Designed Comprehension Questions for Weather Watching*

1. What are some different types of climates?

   2 points- hot, cold, and mild (warm) OR desert, tropical, polar, mountain, temperate

   1 point- for naming at least 1 of the above

   0-points- for not naming any of the above

2. Why do you think the author talks about clouds on so many pages?

   2 points- Because most weather comes from clouds like snow and rain and hail and all the weather pretty much has to do with the clouds like you can tell if it's going to rain or it's going to snow or stuff like that from looking at the clouds

   1 point- they are part of the weather and the book is about weather

   0 points- I don't know; he likes clouds

3. What causes wind?

   2 points- the sun heats the earth unevenly

   1 point- moving air; the sun

   0-points- I don't know; a village

4. Why did the author put rain and snow in one section?

   2 points- they are the same thing it is just when rain freezes it turns to snow

   1 point- they are like the same thing; they are similar

   0 points- he had enough room

5. Do you think the author did a good job of explaining what frost is? Why (not)?

   2 points- Well, the writing part didn't explain much about frost but the pictures when you looked at it you could see like the little spikes and like to me it

automatically popped into my head and said, "oh that's how frost looked" and I didn't know how frost looked and that explained its

2 points- Yes, because he told you how water freezes and it forms at night.

1 point- Yes, he used a lot of details

0 points- Yes, I don't know; Yes, because frost is cool.

6. Why does the author write about rainbows?

   2 points- Because rainbows have to do with weather. They have to do with sun and rain like combining

   1 point- because sun makes rainbows OR because rain makes rainbows

   0 points- he thinks rainbows are pretty

7. How did people learn about weather a long time ago? How do they learn about it today?

   2 points- A long time ago they flew kites and today they use satellites to send back pictures

   1 point- answers one part of the question

   0 points- has neither answer

8. Why did the author write this book?

   2-point To teach people about weather like rain, snow, rainbows and how it forms.

   1-point- because weather is important

   0-point- he wanted to, he likes weather, etc.

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