Picture This: Processes Prompted by Graphics in Informational Text

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ABSTRACT

Verbal protocols have provided literacy researchers with a strong understanding of what processes readers (both adults and children) use as they read narrative and informational text. Little is known, however, about the comprehension processes that are prompted by the graphics in these texts. This study of nine second graders used verbal protocol methodology to investigate what processes were prompted by the graphics in the context of two informational texts. Open coding revealed 17 comprehension processes (*label; describe; gains information; infers information; 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*) prompted by the graphics in the texts. Many of these processes are similar to those identified by research on the reading of written text, though others are unique to graphical reading. Comparative analysis of the verbal protocols across texts also revealed that the texts themselves appeared to influence what processes were prompted. Finally, comparisons of students by ability and by classroom suggest that reading ability and teacher factors may be related to the comprehension processes prompted by the graphics in informational text, pointing to important areas of future research.

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Looking through most primary school classroom libraries and bookstores, the prominence of graphics in children's books becomes apparent. These graphics have accompanied children's stories for over 350 years (Moss, 2008), with one of the first acknowledged uses of children's graphics appearing circa 1650 in *Orbis Pictus* by Comenius. More recently the presence of graphics in children's books has increased, as indicated by researchers in the 1970s (Concannon, 1975), 1980s (Harber, 1980), 1990s (Simons & Elster, 1990), and 2000s (Carney & Levin, 2002), and their purpose has become more important to the texts as they now carry as much, if not more, meaning as the written text (Kiefer, 2008; Moss; Sipe, 2008). Researchers debate whether graphics benefit children's reading of narrative and informational text, but not about the prominence of the graphics in texts. Therefore, it is important to investigate the comprehension processes these graphics prompt and consider the implications of this for texts and readers.

UNDERSTANDING GRAPHICS

Benefits of Graphics

Many educators (Fang, 1996; Miller, 1938) and researchers (Fang, 1996) view graphics (any photograph or illustration in narrative or informational text including but not limited to diagrams, maps, graphs, and tables) as integral parts of narrative children's books. Although not all researchers agree that graphics are helpful to children, several researchers have conducted studies that indicate that they are. At the word level, graphics can help children decode and understand words they do not recognize (Arlin, Scott, & Webster, 1978–1979; Denburg, 1976). At the text level, narrative graphics can motivate children to read (Brookshire, Scharff, & Moses, 2002; Fang; Simons & Elster, 1990) and help them predict what will occur next (Fang; Omaggio, 1979). Also, they can provide mental scaffolds to facilitate students' recall of what happened in the book (Fang; Gambrell & Jawitz, 1993). Many educators and researchers believe that informational graphics can also improve learning because such graphics may require deeper processing (Hannus & Hyona, 1999) and may help to clarify confusing material (Levin, 1981).

Functions of Graphics

Researchers (Bishop & Hickman, 1992; Carney & Levin, 2002; Fang, 1996; Levin, 1981; Levin, Anglin, & Carney, 1987; Nikolajeva & Scott, 2000) have identified various functions graphics play in children's books. These functions range from merely decorating the page, to assisting the reader in organizing and interpreting the text, to providing additional information not stated directly in the text. Table 1 provides explanations of six common functions of graphics:

Table 1. Functions of Graphics in Text

Function	Description	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	use as mnemonics to help readers remember the written text by making it more concrete and meaningful	the word *bed* with the *b* and *d* as headboard and footboard
Extension	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."

decoration, representation, organization, interpretation, transformation (Carney & Levin; Levin; Levin et al.), and extension (Bishop & Hickman; Fang; Nikolajeva & Scott).

Graphics in Informational Text

Informational books contain many graphics (Hannus & Hyona, 1999; Moss, 2008) and students must decide to which graphics they should pay attention and what information they should glean from them. These graphics are usually realistic (e.g., a life-like drawing of frog) or are photographs (Purcell-Gates, Duke, & Martineau, 2007). They also include diagrams, tables, charts (Purcell-Gates et al., 2007), maps, and bar-, circle-, and picto-graphs (Davis, 1968),

among others. Because graphics are prominent and serve many functions in informational text, it is important to investigate the comprehension processes prompted by the graphics as students read informational text. This information will assist researchers and classroom teachers in designing and implementing instructional interventions and lessons that teach students to utilize the graphics more proficiently as they read informational text, as similar information has with the comprehension of written text (see Duke & Pearson, 2002).

PRIOR RESEARCH ON COMPREHENSION OF WRITTEN TEXT AND GRAPHICS

Comprehension of Written Text

In order to understand the comprehension processes prompted by the graphics, it is important to understand those processes prompted by written text. Prior research has provided great insight into these comprehension processes readers use as they read narrative and informational text (National Institute of Child Health and Human Development, 2000; Pressley, 2000; Pressley & Afflerbach, 1995). Good readers are strategic and flexible (Duke & Pearson, 2002; Pressley & Afflerbach; Tierney & Cunningham, 1984). Often, they are aware of what strategies they use as they read, and they choose strategies depending on the type of text they are reading. If one strategy fails, they attempt a different strategy in order to facilitate their comprehension. Good readers rely on their prior knowledge of the subject (Pressley & Afflerbach), as well as of text features (Englert & Hiebert, 1984). Furthermore, they question, summarize, visualize, predict, infer, set goals, react affectively (Lorch & van den Broek, 1997; Pressley, 1997, 2000; Pressley & Afflerbach), and much more. Research on comprehension processes with students as young as second grade (Alvermann, 1984; Brown, Pressley, Van Meter, & Schuder, 1996; Hilden, 2006, 2008; Wade, 1990) has found that they can be flexible and strategic as they read as well.

Comprehension of Graphics

Much less is known about the comprehension of graphics in texts. In fact, while some studies suggest that graphics are beneficial to students' overall comprehension (Gambrell & Jawitz, 1993; Rusted & M. Coltheart, 1979), others report that they have either neutral (Brookshire, Scharff, & Moses, 2002; Rose & Robinson, 1984) or detrimental (Harber, 1983; Rose, 1986) effects. Moreover, most previous research investigated graphics as they relate to overall comprehension of text as indicated by administering a posttest, rather than how readers use them as they read as shown by measures administered while reading the text (with the exception of Schnotz, Picard, & Hron, 1993) or how readers comprehend graphics with and without the support of text.

Graphics assist in comprehension

Even researchers who agree that graphics are beneficial cannot agree for whom. Some researchers have found that graphics aid all readers in recalling illustrated (Haring & Fry, 1979) and unillustrated text (Small, Lovett, & Scher, 1993), and in making inferences and connections (Bromley, 2001). Others have found that they only assist good readers, presumably because integrating graphics and written text is too intellectually demanding for poor readers (Hannus & Hyona, 1999). Still others have shown that graphics provide scaffolds for lower ability and learning disabled readers, allowing them to better access the content, and thus improving their comprehension (Rusted & M. Coltheart, 1979). In summary, all one can determine is that *some* researchers have found that *some* graphics assist *some* students' comprehension under *some* circumstances, and others have found just the opposite.

Much of this inconsistency may be attributable to the various designs of the studies. The researchers used different genres of passages. For example: narrative (Brookshire et al., 2002) and informational (Watkins et al., 2004), styles of graphics (Rusted & V. Coltheart, 1979), color drawings (Rusted & M. Coltheart, 1979), bright and subdued colors (Brookshire et al., 2002), maps (Watkins et al.), partial pictures (Guttmann, Levin, & Pressley, 1977). Modes of presentation also differed. For example: read to (Small, Lovett, & Scher, 1993), oral reading (Rusted & V. Coltheart), silent reading (Gambrell & Jawitz, 1993). Also, the studies assessed comprehension in different ways, ranging from retelling (Rusted & V. Coltheart) to explaining what one liked about the story (Walsh, 2003).

Outcome versus concurrent measures

Most previous research on visual literacy investigated whether the presence of graphics have facilitative effects on comprehension. The results were based on postreading tests, such as free (Gambrell & Jawitz, 1993) or cued (Small et al., 1993) recall and specific comprehension questions (Harber, 1983). Few studies used measures that were collected during the reading process, such as verbal protocols (Pressley & Afflerbach, 1995), to examine whether and how students used the graphics, or engaged in the comprehension processes prompted by the graphics, as students read the text. In fact, only one study (Schnotz, Picard, & Hron, 1993) attempted to investigate how participants were using the graphics as they read.

Schnotz and colleagues (1993) studied 26 college students as they read and learned from a 32-paragraph passage about time and date changes as one passes through time zones. The passages were accompanied by a map of the different time zones. The students were first asked to describe the information they could extract from the map. They then participated in a "learning phase" for which they were given 11 questions and were asked to think aloud about how

they answered the questions by using the passage and the map. Finally, students were given 25 complex test questions 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 many times successful and unsuccessful learners (as determined by performance on the 25-question test about time in different areas of the world) referred to the graphics and found that successful learners referred to the graphics significantly more often (an average of 21.3 times and 12.5 times respectively). Moreover, successful learners interpreted more sections of the map and used the map to determine more spatial and temporal differences. Schnotz and colleagues concluded that the successful learners were using the graphics to develop mental models and used the written text to add to these mental models.

This research was conducted with college-aged students. Whether and how elementary-aged children, whose books contain many graphics (Carney & Levin, 2002), use the graphics as they read has not been studied.

Reading of written text versus reading of graphics

Although the previous research on graphics and comprehension examined situations in which the written text and graphics were completely redundant (Guttmann, Levin, & Pressley, 1977), the written text contained information not in the graphics (Rusted & M. Coltheart, 1979), or the graphics contained information not in the written text (Styles & Arizpe, 2001), the focus for most—if not all—was on whether graphics helped or hindered comprehension of written text. As discussed above, graphics can and often do extend the text. Therefore, it is important to understand students' abilities to read graphics with and without supporting text, as well. The current study of comprehension processes prompted by the graphics in informational text begins to investigate students' reading of graphics that represent and extend the written text.

THEORETICAL FRAMEWORK

This research study is situated within a sociocognitive perspective of literacy (Bandura, 1986). Being literate is not simply the ability to read and write; it is the ability to think about, create, and communicate meaning. Therefore, when reading, a person cannot simply find meaning in the text. The meaning is created though the interactions between the reader, the situation, and the texts (RAND Reading Study Group, 2002), with text in this case defined more broadly to include "…not only to printed text, but also to spoken language, *graphics*, and technological communications" (IRA/NCTE, 1996, p. 2, emphasis added). Therefore, understanding what processes are prompted by the graphics is an important next step to understanding how students think about, create, and communicate meaning.

PURPOSE OF RESEARCH AND RESEARCH QUESTION

The purpose of this exploratory study was to begin to fill some of the gaps in the literature on comprehension and graphics. Previous literature on graphical comprehension has devoted very little focus to reading measures collected during reading, the comprehension processes prompted by the graphics, and comprehension of the graphics that represent and extend text. In light of the paucity of research in these areas, this study investigated what processes were prompted by the graphics as second graders read informational text, with a variety of graphics, at their grade level. As they read, students were asked to think aloud, and these verbal protocols were analyzed to determine what processes were prompted by the graphics in order to address the research question: What processes are prompted by the graphics as second graders read informational text?

METHOD

Design

To address this research question, an exploratory study using verbal protocols (Afflerbach, 2000; Pressley & Afflerbach, 1995; Pressley & Hilden, 2004) of students reading informational text was conducted. During verbal protocols, participants are asked to think aloud as they read. Participants report the contents of their short-term or working memory (Pressley & Hilden). Moreover, as Ericcson and Simon (1980) point out, verbal reports do not affect the participants' cognitive processes as long as they are asked to report exactly what they are thinking and not asked to hypothesize about their thoughts. The researcher then analyzes the verbal protocol to ascertain the strategies participants used to make sense of what they were reading (see Olshavsky, 1976–1977).

Verbal protocols were well suited to this research question because they allow us to investigate the reading processes and strategies readers employ. Past studies for which verbal protocols have been used have focused on single aspects of reading (Afflerbach, 2000). This study continued that tradition by using verbal protocols to focus specifically on the comprehension processes that are prompted by the graphics in informational text. To my knowledge, there are no published verbal protocol studies with this focus.

Participants

This study was conducted with nine (five male and four female) second graders enrolled in three schools in a small northeastern state. Second graders were chosen for two reasons. First, books designed for use by primary-aged students (defined here as Grades K–3) contain a significant number of graphics (Carney

& Levin, 2002). Second, verbal protocols have been found to be effective with students as young as second grade (Alvermann, 1984; Brown et al., 1996; Hilden, 2006, 2008; Wade, 1990), but have not been tested with younger students. There is some concern that younger students are unable to verbalize their thinking (Afflerbach & Johnston, 1984), but previous verbal protocol research has shown that second graders can do so.

These students were chosen from three different classrooms from three different schools in three different school districts so as to decrease the likelihood that the results would be unduly affected by one district, school, or classroom teacher placing a greater emphasis on graphics. The classrooms, schools, and districts were a convenience sample, however, none of the teachers had received special training in teaching students to use graphics as they read.

In each participating classroom, the teacher was asked to nominate three students based on in-class performance and school assessments. More specifically, the teacher was asked to nominate one student who read at a level considered below average, one who was an average reader, and one who read above average for that point (May and June) in the school year. These students represented a range of reading levels in the classroom but did not include English language learners or special education students.

After each of the teachers had nominated the three students from her classroom, the decoding and comprehension subtests of the Gates-MacGinitie Reading Test (GMRT) (MacGinitie, MacGinitie, Maria, & Dreyer, 2000) were administered in two of the three classrooms. In the third classroom, the test had been administered the previous month, and, with parent permission, test scores were provided by the teacher. The scores on these assessments indicated that the teachers' nominations of students as low, middle or high reader were fairly accurate.

Materials

Students read two information books, *Recycling Adds Up* (Zollman, 2008) and *Animal Look-Alikes* (Griffiths & Clyne, 2005). Two different books were used to help diminish the likelihood that the results are due to book-specific characteristics. Both books were part of the Pearson Learning Group's second grade *iOpeners* series, which were designed to include high-interest informational content and graphics (Pearson Education Group, 2004). The *iOpeners* series was modeled after authentic trade books, but with some characteristics of educational materials (e.g., comprehension questions at the end) for instructional use in elementary classrooms.

In *Recycling Adds Up*, Zollman explains how garbage has become a problem, what type of garbage is thrown away each year, the impact it has on the earth, and how we can reduce the amount of garbage through recycling. This book is an example of a problem-solution structured informational text (Meyer,

1975). *Animal Look-Alikes* examines different animals that look alike (e.g., frog and toad) and explains how they are similar and different. It is written in the compare-contrast structure (Meyer). Both books are written at a reading level at which second graders are expected to read independently in the second half of the school year (level L for *Recycling Adds Up* and level K for *Animal Look-Alikes*) (New Standards Primary Literacy Committee, 1999).

Both texts include numerous graphics. These graphics are relevant to the written text, and some provide additional information not included in the text (Carney & Levin, 2002; Levin et al., 1987; Nikolajeva & Scott, 2000). For example in *Recycling Adds Up*, Zollman wrote: "Each day a person throws away about four-and-a-half pounds of garbage" (p. 3) and the accompanying photograph on the page depicts two girls throwing away trash. This graphic is a representational photograph (Carney & Levin; Levin et al.) and represents what is stated in the text. A pie graph found later on in the book, however, provides additional information about garbage, identifying what percentage of garbage is made up of paper, grass clippings, metals, glass, plastic, food scraps, and other materials; information that is not included in the written text. This is an example of a graphic that is not redundant with the text, providing only additional information that cannot be found in the text. Additionally, across the two books, the graphics represent many of the types of graphics children encounter when reading informational books. Both books include photographs with captions and labels, flow charts, diagrams, cross sections, maps, and graphs.

In order to more easily track when students were looking at the written text and when they were looking at the graphics, the books were modified to extend the distance between the main text and the graphics. Based on pilot work, each book was modified in a number of ways. The books, originally 7-inch by 9-inch (17.78-cm by 22.86-cm), were cut apart and remounted on yellow construction paper so that written text and the graphics were separated, with the modified book pages measuring 12 inches by 22 inches (30.48 cm by 55.88 cm). Connected text and graphics with labels and titles remained intact (e.g., the cross-section of the landfill, its title, and the labels were cut as one section), while captions were positioned away from the corresponding graphic because they could be understood without the graphic. Relative positioning of the written text and graphics on the page was not altered.

Data Collection

Sessions one and two

In two of the schools, the decoding and comprehension subtests of the GMRT were administered during the first two sessions. For these sessions, all three students from a classroom met with the researcher outside of the classroom in a quiet place for about 30 minutes. These sessions were also used to get to know

the students through informal conversations and to help the students feel more comfortable with the researcher.

In the third classroom, the students had already taken the GMRT the month before. They were also familiar with the researcher because of her presence in the classroom on other occasions (unrelated to instruction in or investigation of graphics in text). Therefore, the first two sessions were not conducted with these students.

Sessions three and four

Two subsequent sessions were conducted one-to-one in a quiet spot outside of the classroom. During each of these individual sessions, the students read either *Recycling Adds Up* or *Animal Look-Alikes*. The order of presentation of the books was counterbalanced by random assignment.

Students read each book aloud, independently. Their readings were not corrected. When students asked for help, they were encouraged to try their best. On a few occasions words were supplied for students because they would not continue to read. As students read, they were asked to verbalize what they were thinking as described below. The directions for eliciting verbal protocols were as follows:

> 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 want to know what you are thinking. Occasionally, I am going to be stopping you to ask you 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 if you want to. Any questions?

These directions are consistent with the recommendations of methodological pieces of verbal protocol studies in reading.

As students read, they were prompted to think aloud about the graphics and written text each time they looked at a graphic. At these times, they were prompted with, "I notice you are looking at this picture. What are you thinking?" If participants did not look at any graphics for four pages, they were prompted to share their thinking with the prompt, "What are you thinking?" These parameters were chosen because research on verbal protocols (Pressley & Afflerbach, 1995) has demonstrated that the more time that elapses between thinking and reporting the more likely the report will be embellished (Afflerbach, 2000; Pressley & Afflerbach), thus compromising the validity of the report. Students were not prompted more often to help diminish the "talking to talk" phenomenon (Hilden, 2006, 2008).

Videotaping

All interactions with the students during sessions three and four were videotaped. Videotaping was used instead of audiotaping in order to record whether students were pointing at different parts of the book as they were talking about what they were thinking. Also, because the graphics and text were separated on the reconstructed books, the videotape allowed the researcher to differentiate between when the participants were looking at the graphics versus the text without eye-tracking equipment. Transcripts were made of the students' reading and verbalizations of their thinking, and also indicated the images at which the participants were looking.

Data Analysis

Students' readings and verbal protocols were transcribed verbatim. The transcripts were color-coded so that students' readings were in black, their verbalizations were in pink, and the researcher's verbalizations were in green.

First, the transcripts were analyzed to determine when students were discussing the graphics (e.g., "…they're showing you how much garbage they put in the dump" in response to a photograph of a landfill in *Recycling Adds Up* [p. 4]), and when they were discussing the texts independently of the graphics (e.g., "I can't read that" or "Is aluminum a type of rock that is like has bad stuff in it or something?") or an unrelated topic (e.g., when a student noticed a piece of lint in the book, she asked, "How did this get in there?"). Of the 530 student verbalizations coded, only 434 were included in the analyses; the remaining 96 verbalizations, which were not related directly to the graphics, were not analyzed further.

Next, students' verbalizations about graphics were coded as prompted or unprompted. Prompted verbalizations were defined as those verbalizations that were responses made when the researcher asked the participants what they were thinking. Unprompted verbalizations were spontaneous verbalizations made by the students without any prompting from the researcher. This distinction was thought to be important because prompted verbalizations may have been more influenced by the researcher than unprompted, or spontaneous, verbalizations.

Finally, open coding (Strauss & Corbin, 1998) was used to develop categories for the comprehension processes prompted by the graphics. Although the transcripts drove the identification of categories, prior knowledge of written text comprehension processes undoubtedly influenced the coding of these graphical comprehension processes. Each verbalization was described in a word or short phrase (e.g., *compare-contrast graphics*) to explain what process had been prompted by the graphic. Because students' verbalizations could contain more than one idea, many were coded as more than one category. For example, when looking at a sculpture of the buffalo made out of recycled material in

Recycling Adds Up, one student commented, "Um, it looks like it's made out of newspaper. The nose is made out of newspaper. Uhh, this looks like a screw here. I'm thinking if everyone recycles we could have more trees." The first three lines were coded as *literal description* because they describe what is found in the buffalo mask, while the last line was coded as *inferential description* because the student's statement pieces different parts of the book together to infer information about recycling.

The short descriptions/categories (named and defined in Results) were continuously compared to determine if any could be collapsed into one category (Strauss & Corbin, 1998). Though no categories were combined during the initial phase of coding, after interrater reliability analysis of scoring (described below) had been conducted, two categories—*describes* and *gains information*—were further collapsed into one category because they could not be reliably distinguished. The resulting collapsed category was renamed *literal description*.

Interrater reliability

A graduate student familiar with written text reading processes, but unfamiliar with the verbal protocols collected in this study, was trained by the author to code the protocols using two of the transcripts collected. She then scored a random sample of eight transcripts (four transcripts from each book). Initial interrater reliability was 77%. As mentioned above, however, many of the discrepancies in scoring were due to lack of agreement on whether a verbalization should be coded *describes* or *gains information*. When these codes were collapsed the interrater reliability reached 82%, or an agreement on 304 out of 370 codes. The graduate student then coded a second set of eight transcripts (four per book) using the revised coding system. Interrater reliability was again 82%.

Examining process frequency

The number of times each process was prompted by the graphics for each student was tallied for each book individually in order to determine if there were differences in the types or frequency of comprehension processes prompted between books. Next, percentages were calculated to determine (a) the percentage of total processes prompted by the graphics each individual process represented across students, and (b) the percentage of total processes prompted by graphics each individual process represented for each student. Finally, the number of different processes used by each student was calculated.

RESULTS

As discussed above, 18 categories—17 comprehension processes (*label; describe; gains information; infers information; 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*) and *no process*—resulted from the open-coding of the transcripts. Each of these 18 categories is described, with examples, in Table 2 (following pages). Descriptive statistics for number of students who used each process and number of times each process was prompted are displayed in Table 3 (following Table 2).

In this section, I first discuss similarities and differences found between these processes and processes identified in previous research with written text. I then compare the comprehension processes prompted by the graphics in the two different books. Finally, I explicate the differences in processes prompted across ability levels and classrooms. Space considerations do not allow for a complete description of the findings on each process. Therefore, for each section, specific processes will be used to illustrate the ideas.

Comparisons of Written and Graphical Text Processes

As described at the outset of the paper, previous research on good readers has found that their processes are strategic and flexible, and that they employ a range of comprehension processes to assist with their comprehension (Duke & Pearson, 2002; Pressley & Afflerbach, 1995; Tierney & Cunningham, 1984). Some of the comprehension processes prompted by graphics in this study mirror those prompted by narrative and informational written text (l*iteral description, connections to prior knowledge, predictions, inferring, wondering, knowledge monitoring, evaluating, affective responses*), while others appear to be unique processes prompted only by graphics (*use of captions, labels, map keys, etc., confirm-disconfirm text*), and are not discussed in the literature on informational text comprehension.

Processes Consistent with Written Text Research

As indicated above, many of the comprehension processes prompted by the graphics were consistent with the comprehension processes prompted by written text. In this section, three of these processes are discussed in further detail.

Literal descriptions

In this study, *literal descriptions* were the most-common type of comprehension process prompted by the graphics. All nine students made *literal description* comments, for a total of 79 reports or 18.2% of all reading processes prompted by the graphics. The number of times students made *literal description* comments ranged from two for Ted (an average reader based on teacher ratings) to 14 for Melinda (a high reader). For Melinda, the 14 verbalizations accounted

Table 2.1 Inventory of Comprehension Processes

Processes	Examples
Literal description Student described what was explicitly depicted in the graphics. As students made literal description comments, they may have been learning new literal information or merely describing what they saw in the graphic. Often an action or explanation of the graphic accompanied the description. When the reader merely named the items in the graphic, cases were not labeled as literal description.	*Animal Look-Alikes*, pp. 14-15: While reading about the differences between frogs and toads, Melinda, a high reader, looked at the two pictures and commented, "They this the toad looks all bumpy and dry. The frog looks all wet and um slippery." *Recycling Adds Up*, p. 5: Malcolm, a low reader, examined the pie chart of items that make up garbage. "Well, it like shows us how many are there of like paper, food scraps, plastic, glass, grass clippings, but mostly they have lots of paper."
Label Student named the items in the graphic without discussing any actions or elaborating beyond the names of the objects.	*Animal Look-Alikes*, p. 4: Examining the two diagrams, one of a butterfly, and one of a moth, Reginald, a low reader, pointed to each labeled item on the butterfly and the moth, stating, "There's the wings (points to wings), the butterfly and the antenna (points to antennae). Wings, moth, antenna, again." *Recycling Adds Up*, p. 13: Ted, an average reader, labeled the items found in the buffalo sculpture, but did not discuss the buffalo sculpture itself. "There's newspaper and that's newspaper and that's probably like a metal thing."

Table 2.2 Inventory of Comprehension Processes

Processes	Examples
Inferential descriptions Student inferred information from or about the graphic. This information is implied in the graphic, but is not explicitly depicted. An inferential description may also be made by combining information in the text and the graphic. Inferred information may or may not be correct.	*Animal Look-Alikes*, p. 12: Observing the frog climbing a plant that looks similar to bamboo, Maggie, a low reader, noted, "I'm actually noticing how this tree is, so I'm…thinking that they live where the pandas live, like in China and stuff, because the…red-eyed tree frog looks…like it's actually climbing like what pandas eat." *Recycling Adds Up*, p. 13: After describing the use of newspaper to make the buffalo mask, Tammy, a high reader, inferred that "…if everyone recycles we would have more trees."
Prediction Student predicted what would be on the page/ in the book, or what actions might be taken by the subjects of the graphics.	*Animal Look-Alikes*, p. 8: When beginning the section on alligators and crocodiles, Ted, an average reader, glanced at the photographs and commented, with prompting, "It's about crocodiles and alligators." *Recycling Adds Up*, p. 3: Sean studied the girls on page three who were touching garbage bags in a garbage can. He predicted that "and, um, they probably going to take it like bag by bag."
Infer author's purpose Student explained why they believed an author included a graphic, what the author wanted you to learn from the graphic (with reference to the author), or why the author placed a graphic in a specific place on the page or in the book.	*Animal Look-Alikes*, pp. 14-15: Malcolm, a low reader, studied the page with a frog and a toad, stating, "I guess they (the authors) were um talking about a toad (points to toad) first since the toads on this picture." *Recycling Adds Up*, p. 4: Sean, a middle reader, studied the photograph of the garbage dump and commented, "they're (the author) showing you (points to picture) how much garbage [is] put in the dump."

Table 2.3 Inventory of Comprehension Processes

Processes	Examples
Confirm-disconfirm text Student used the graphic to substantiate or unsubstantiated what was stated in the text.	*Animal Look-Alikes*, p. 18: Upon reading "However, seals have tiny ears ear holes, who while seals sea lions have ear flippers flaps on the sides of their heads," she examined the photographs of the seal and sea lion, noting, "Um you can like on the sea lion (looking at the sea lion) you can kind of like see the ear flap a little bit and on the seal you can kind of see like a hole next to the eye." *Recycling Adds Up*, p. 5: After studying the pie chart, George began reading the text at the bottom of the page, "A little more than 4 after 10 of garbage is paper." After he read about each fraction of garbage, he returned to the pie chart and traced the corresponding section on the chart.
Use of running text Student referred back to the text to help them understand the graphic.	*Animal Look-Alikes*, p. 10: Trying to decide if a photograph depicted an alligator or a crocodile, Tammy explained that it must be a crocodile, "because in here it said (points to text) that the crocodile teeth stick out of their closed mouth. It makes them look like the crocodile is smiling and it looks like this one is (points to photograph) smiling because the teeth are sticking out."

Table 2.4 Inventory of Comprehension Processes

Processes	Examples
Use of captions, labels, map key, etc. Student referred to captions, labels, map keys, the graphic's title, or other graphical features (e.g., arrows in a flow chart) to assist in their comprehension of the graphic.	*Animal Look-Alikes*, p. 7: Ted, an average reader, read the caption that stated, "It is hard to see this moth because it is almost the same color as the tree bark." He then studied the other photographs of moths and butterflies, commenting, "So it's talking about camouflage right there. This one's (pointing to the Cleopatra butterfly) disguised as like a flower." *Recycling Adds Up*, p. 15: Maggie studied the photograph of the compost pile. Originally, she responded affectively (see below) "because it doesn't look good how they're doing that because they're mixing the things together…." She then read the caption to learn, "In a compost pile, worms and bacteria help turn grass clippings and food scraps into rich soil." She looked back at the picture, commenting, "Oh, so they turn into rich soil."
Connection-to-self Student made a connection to his or her own life.	*Animal Look-Alikes*, p. 12: Reginald, a low reader, remarked after looking at the photographs of frogs and toads, "I see toads at my house." *Recycling Adds Up*, p. 9: Tammy studied the photograph of the girl sorting recyclables. "At my house, we, we keep buckets at the bottom of the cellar, and we sort newspapers, magazines, and then we have um, we have a bag… we put like plastic and cans."

Table 2.5 Inventory of Comprehension Processes

Processes	Examples
Irrelevant connection Student made a connection prompted by the graphics that was not relevant to the book.	*Animal Look-Alikes*, p. 11: While reading about where alligators and crocodiles lived, Reginald, a low reader, studied the map, commenting, "My mom and dad have been to Australia. And, they've been in a limo when they got married. And they went to Australia when they got…after they got married."
Connections-to-prior knowledge Student referenced his or her prior knowledge after studying a graphic.	*Animal Look-Alikes*, p. 4: Ted, an average reader, commented, "we're studying butterflies so I know that this one's (points to moth) a moth because its wings (traces wings) because its body (traces body) are kind of furry." *Recycling Adds Up*, p. 7: Tammy, a high reader, looked at the cross-section diagram of the landfill. "In library we read a book and it was about how um it was about landfills… it showed how they put um they put a pile of garbage and then they cover it with more dirt."
Wonder Student asked a question or wondered about a topic.	*Animal Look-Alikes*, p. 6-7: While studying the photographs of different moths and butterflies, Maggie, a low reader, commented, "I'm actually thinking, how they get their colors?" *Recycling Adds Up*, p. 9: When he noticed the diaper, George, a high reader, wondered, "Why would a diaper be on a book?"

Table 2.6 Inventory of Comprehension Processes

Processes	Examples
Knowledge monitoring Student recognized the absence of prior knowledge or recognized that the graphics confirmed previous thinking.	*Animal Look-Alikes*, p. 21: Melinda, a high reader, commented, "Rabbit and the hare, I thought they were just the same animal, but they're not." *Recycling Adds Up*, p. 9: George, a high reader, studied the photograph of the girl sorting the recycling and said, "I never knew a recycling can be a collection."
Affective response Student expressed an emotion based on the graphic.	*Animal Look-Alikes*, pp. 6-7: Upon seeing the different butterflies and moths, Malcolm, a low reader, expressed awe by saying, "Oooo…" When asked why he had said that, he replied, "because of all the kinds of moths and butterflies and color." *Recycling Adds Up*, p. 13: Diane studied the photograph of the buffalo head, and pronounced "Scary! Because it's looking mean."
Compare-contrast graphics Student referred to two or more graphics in the text as he or she compared or contrasted them.	*Animal Look-Alikes*, p. 10: Sean, an average 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." *Recycling Adds Up*, p. 8: Tammy studied the recycling triangle on the recycling area sign and printed alone, remarking, "That's the little triangle (as she points from the recycling area to triangle printed alone)."

Table 2.7 Inventory of Comprehension Processes

Processes	Examples
Evaluate Student formed an opinion based on the information presented using his or her background knowledge.	*Animal Look-Alikes*, p. 11: Maggie read the map of where "Places where alligators and crocodiles live." "I'm glad if we live in North America. They're not really close to us because they only can live in one area." *Recycling Adds Up*, pp. 6-7: Sean, an average reader, studied the photograph of the landfill (p. 6) and the cross-sectional diagram of a landfill (p. 7), and began to evaluate if it is better to have landfills above or below ground. "Well, (looks at photograph on p. 6) I'm thinking about the dump. How much garbage they put there, and then what they (looks at cross-section on p. 7) do with the most trash. They put it… they bury it underground, and then plant grass or something to make a playground or a house on top. I think that's a good idea, but not much of a good idea. It's a little bit of a good idea. It shouldn't be underground (inaudible); trash shouldn't be underground though. I don't, and (looks at photograph on p. 6) over ground and on the ground in the place it will make it smell really bad and it will… it's going to waste a lot of land. Like, you could make a big town with a bunch of houses where a dump is instead of pouring a bunch of trash there."

Table 2.8 Inventory of Comprehension Processes

Processes	Examples
Word identification Student used the graphics to decode or comprehend the meaning of a word.	*Animal Look-Alikes*, p. 8: Malcolm looked at the picture to decode reptile. "It kind of like gave me more time to think of what they crocodiles look like (points to pictures) what reptiles look like and stuff with their scales." *Recycling Adds Up*, p. 13: Maggie looked at the photograph of the buffalo to decode buffalo, "Well, I was just like wondering what that word wondering what the word would be if I looked at the picture it might tell me what that word might be and it would be much more easier because whenever I get stuck on words I look over at the picture and it helps me."
No process Student said he or she did not know what he or she was thinking or did not respond.	"Nothing." "I don't know."

Table 3. Descriptive Statistics for the Comprehension Processes

	Number of Students Who Used Process at Least Once	Total Times Coded for *Recycling Adds Up*	Percentage of Total Processes Coded for *Recycling Adds Up*	Total Times Coded for *Animal Look-Alikes*	Percentage of Total Processes Coded for *Animal Look-Alikes*	Total Times Coded Across Both Books	Percentage of Total Processes Coded Across Both Books
Literal description	9	46	31.08	33	11.54	79	18.20
Label	8	5	3.38	13	4.55	18	4.15
Inferential description	8	13	8.78	15	5.24	28	6.45
Prediction	5	3	2.03	20	6.99	23	5.30
Infer author's purpose	3	3	2.03	7	2.45	10	2.30
Confirm-disconfirm text	8	3	2.03	30	10.49	33	7.60
Use of running text	3	0	0.00	3	1.05	3	0.69
Use of captions, labels, etc.	7	6	4.05	17	5.94	23	5.30
Connections-to-self	4	2	1.35	9	3.15	11	2.53
Irrelevant connections	2	0	0.00	3	1.05	3	0.69
Connections-to-prior knowledge	8	14	9.46	17	5.94	31	7.14
Wonder	3	4	2.70	7	2.45	11	2.53
Knowledge monitoring	5	7	4.73	29	2.45	36	8.29
Affective response	4	8	5.41	3	1.05	11	2.53
Compare-contrast	9	4	2.70	63	22.03	67	15.44
Evaluate	5	11	7.43	4	1.40	15	3.46
Word identification	2	1	0.68	2	0.70	3	0.69
No process	6	18	12.16	11	3.85	29	6.68

for half of all comprehension processes prompted by the graphics in both of the books.

This abundance of *literal descriptions* is consistent with research on reading processes in narrative text. For example, in a study of second graders reading basal stories, Alvermann (1984) found that, overall, students reported more literal strategy use than use of inferences, personal identification (connection-to-self), image, or self-interrogation.

Prediction

Prediction is another process prompted by graphics as well as written text. In this study, the graphics prompted five students to predict, for a total of 23 comments or 5.3% of all comments prompted by the graphics. Three of the students (Sean, a middle reader; Ted, a middle reader; and Malcolm, a low reader) predicted six times each. For Ted, *prediction* was prompted more often than any other comprehension process and accounted for a total of 18.18% of all comprehension processes prompted by the graphics. Anecdotally, Sean, Ted, and Malcolm mentioned that they liked to look at the graphics first because they give clues to the information that would be contained on the page.

In Brown and colleagues' (1996) and Hilden's (2006, 2008) studies, the second graders also made predictions as they read either narrative (Brown et al., 1996; Hilden 2006) or informational (Hilden, 2008) texts. In fact, Brown and colleagues' found that making *predictions* was the most-commonly used process. Furthermore, Hilden (2008) reported that the second graders in her study made predictions based on the text, as well as the graphics.

Knowledge monitoring

Another instance of similar processes being prompted by the text and the graphics in informational text is the prompting of *knowledge monitoring*, which was coded whenever a student recognized the absence of prior knowledge or recognized that the graphics confirmed previous thinking. Five students made 36 comments, or 8.28% of processes prompted by the graphics, that were categorized as *knowledge monitoring*. For example, Tammy (a high reader) commented, "Well I always thought sea lions and seals are the same thing just they can be called different things just like crocodiles and alligators. But when you show two of them together they look different" (Griffiths & Clyne, 2005, p. 16). Furthermore, Melinda (a high reader) noted that she "...didn't know that people throw away that much garbage in just one day" (Zollman, 2008, p. 3) as she studied the photograph of two girls throwing away garbage. Hilden (2008) also found that students were prompted to knowledge monitor as they had informational text read to them ("I never knew. I only thought there was one type of salmon. I didn't know there were all of these types" [p. 74]). Those students who knowledge monitored in Hilden's study were often deemed bet-

ter comprehenders on the Concepts of Comprehension Assessment (Billman, Duke, Hilden, Zhang, Roberts, Halladay, et. al., 2008). Similarly, in this study, all three high readers monitored their knowledge as they studied the graphics.

Processes inconsistent with written text research

Other processes, however, did not appear in the literature on written text comprehension processes. *Use of captions, labels, map keys, etc.* is one process that appears to be unique to graphics. Verbalizations were coded with this label whenever a student referred to captions, labels, map keys, the graphic's title, or other graphical features (e.g., arrows in a flow chart) to assist in their comprehension of the graphic. Seven students used this process a combined total of 23 times, or 5.3% of total processes. For example, Maggie (a low reader) studied the photograph of a compost pile on page 12 of *Recycling Adds Up* and initially reported an *affective response*, "Well, the some…some of that picture doesn't really look good and I think I just lost my appetite…because it doesn't look good how they're doing that because they're mixing the things together like they're mixing the food scraps, the grass clippings, and these like um these wooden things." She then read the caption accompanying the graphic and remarked, "Oh, so they turn into rich soil." By reading the caption, Maggie was better able to comprehend the photograph.

Comparisons Across Books

Across the two books, 434 total processes were coded (see Figure 1 for number of occurrences of comprehension processes across both texts). Of these, 286 processes (65.9% of total codes) were prompted by the graphics in *Animal Look-Alikes*, while 148 processes (34.1% of the total codes) were prompted by graphics in *Recycling Adds Up*. (See Figure 2 for comparisons of total number of comprehension processes prompted between texts.) Although all processes were prompted at least once by at least one student while reading *Animal Look-Alikes*, nobody made *irrelevant connections* or *used the running text* to better understand a graphic while reading *Recycling Adds Up*. Many other comparisons

Figure 2. Comparison of Total Number of Comprehension Processes Between Two Books

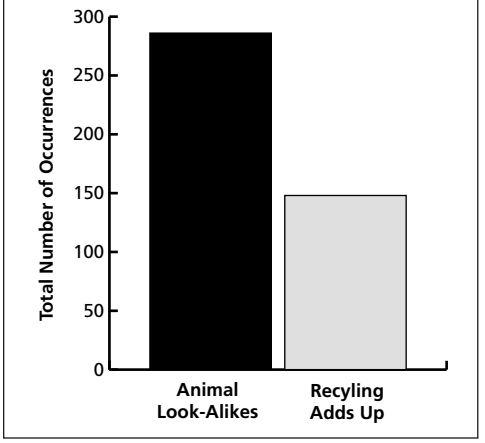
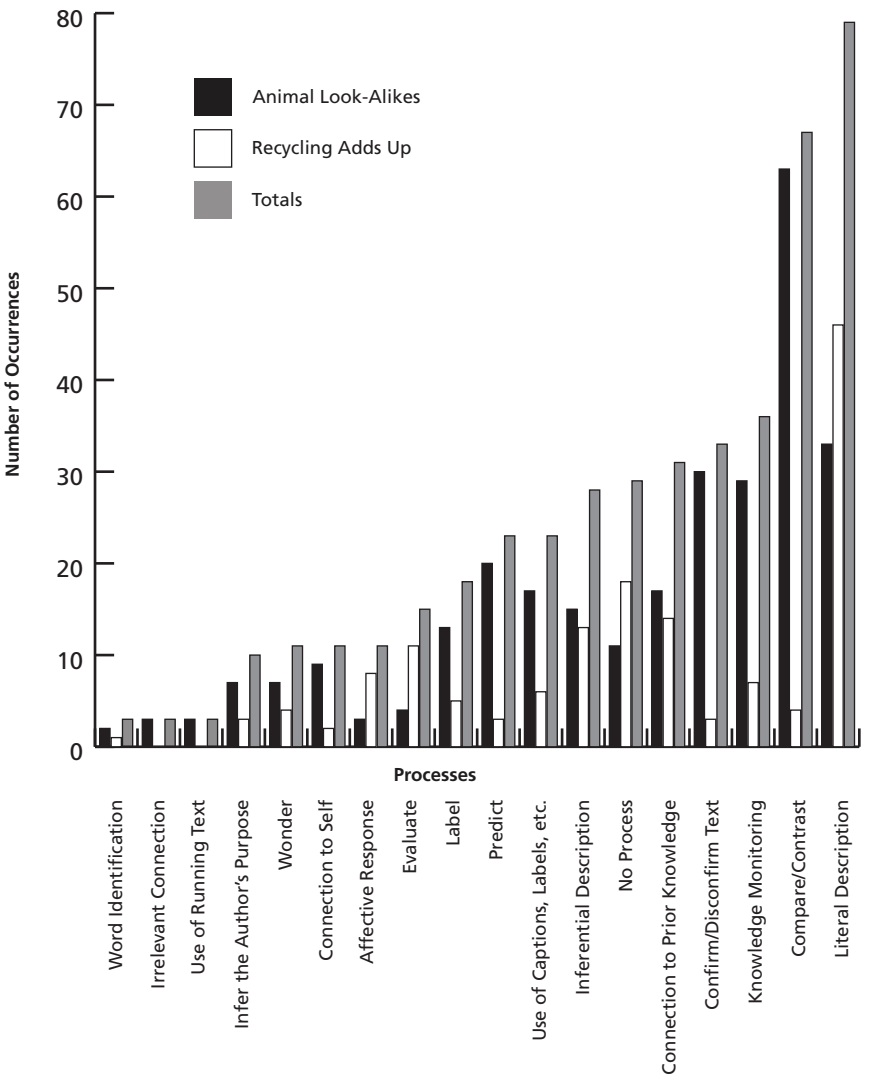


Figure 1. Number of Occurrences for Each Process Across Both Texts



can be made about the comprehension processes prompted by the graphics while reading the two books. Comparisons of the differences between books in three particular codes (*literal description, compare-contrast graphics,* and *affective response*) are explicated below as examples.

Literal description

As mentioned earlier, *literal description* was the most commonly prompted process. Although more processes were prompted by the graphics in *Animal Look-Alikes* than in *Recycling Adds Up*, the graphics in the latter book prompted *literal description* more often (33 to 46 occurrences respectively). In the state in which this study occurred, studying animals, their habitats, and life cycles is required in kindergarten, first, and second grades (Connecticut State Department of Education, 2008) while recycling is not introduced until third grade. Furthermore, reviewing the informational texts available to students in the local bookstores and libraries reveals that more books are available on animals than on recycling. Therefore, I hypothesize that students in this study were more familiar with animals than with recycling. This, in turn, would make it more likely that students would be capable of using the other processes (*prediction* and *connections to prior knowledge*) when examining *Animal Look-Alikes*, and would not have to rely on literal description as frequently.

Additionally, about 84% of the *literal description* comments during the readings of *Recycling Adds Up* were made after being prompted to explain their thinking. Therefore, I hypothesize that when prompted to explain their thinking, students who had little prior knowledge or experiences with the subject of recycling and landfills were more likely to describe what they saw in the graphic because they needed to understand the graphic on a literal level before they could process it on a deeper level.

Compare-contrast graphics

All nine participants compared and contrasted between four (Melinda, a high reader and Ted, a middle reader) and ten (Sean, a middle reader and Malcolm, a low reader) times. Students compared and contrasted more often while reading *Animal Look-Alikes* than *Recycling Adds Up* (63 to 4 respectively).

Animal Look-Alikes is written using a compare-contrast text structure (Meyer, 1975) in which the text and graphics compare and contrast two animals that could be confused, explicating their similarities and differences. Therefore, it is not surprising that students made more comparisons between and amongst graphics in this book than in *Recycling Adds Up* which is written in a problem-solution text structure and in which the content and the graphics do not lend themselves as readily to the comparisons.

Affective response

Affective responses were coded more often for *Recycling Adds Up* than *Animal Look-Alikes* (8 to 3 respectively). Four students (Maggie, Diane, George, and Malcolm) representing the full range of reading abilities reported affective processes prompted by the graphics. Five of these reports were unprompted and six were prompted.

Interestingly, the types of affective responses students had differed between the two books. Two of the three affective responses to *Animal Look-Alikes* were positive (e.g., upon seeing the different butterflies and moths [pp. 6-7], Malcolm, a low reader, expressed awe by saying, "Oooo…" When asked why he had said that, he replied, "because of all the kinds of moths and butterflies and color"). In *Recycling Adds Up*, the affective responses were more of a visceral response to unpleasant attributes of the graphics (e.g., after studying the compost pile [p. 12], Maggie, a low reader, commented, "Well…some of that picture doesn't really look good, and I think I just lost my appetite").

Comparisons Across Readers by Ability and Classroom

When comparing the comprehension processes used by readers at the reading ability (see Figure 3) and classroom levels (see Figure 4), differences in number and type of comprehension processes were noted. These differences, however, should be treated as only suggestive in light of the small numbers of students in each ability level and in each classroom. Furthermore, it should be noted that there were many differences based on individual students as well (Norman, 2009). For example, Tammy, a high reader, reported the use of 11 processes, while Melinda, also a high reader, reported the use of only six different processes. Additionally, Diane, from Classroom Two, *affectively responded* and *wondered* about the text while neither of the other students from Classroom Two did so.

Comparison across ability

In two of the classrooms, the graphics prompted twice as many comprehension processes for the low readers (Reginald and Maggie) as for the high readers (Melinda and Tammy); in the third classroom the number of comprehension processes prompted for the low (Malcolm) and high (George) reader was very similar (46 to 49 respectively). For all but three processes (*prediction, literal description,* and *knowledge monitoring*) and *no process*, low readers reported the comprehension processes more often than middle or high readers. Middle readers reported *predictions* more often than the other two ability groups, and high readers reported *literal descriptions* and *knowledge monitoring* most often. Three processes are discussed in more detail below.

Word identification. Two students, both low readers (Malcolm and Maggie), used this strategy for a total of three times (two by Malcolm and one by Maggie), or less than 1% of the comprehension processes. Both of these students commented that they look at pictures to help them figure out words. Reginald, the other low reader, looked around the page as he was attempting to decode the word *examples* on page 8 of *Recycling Adds Up*. However, when asked what he was thinking, he quickly denied that he had looked at any of the graphics, and his tone of voice and posture appeared defensive.

Figure 3. Comparisons of Comprehension Processes Across Ability Levels

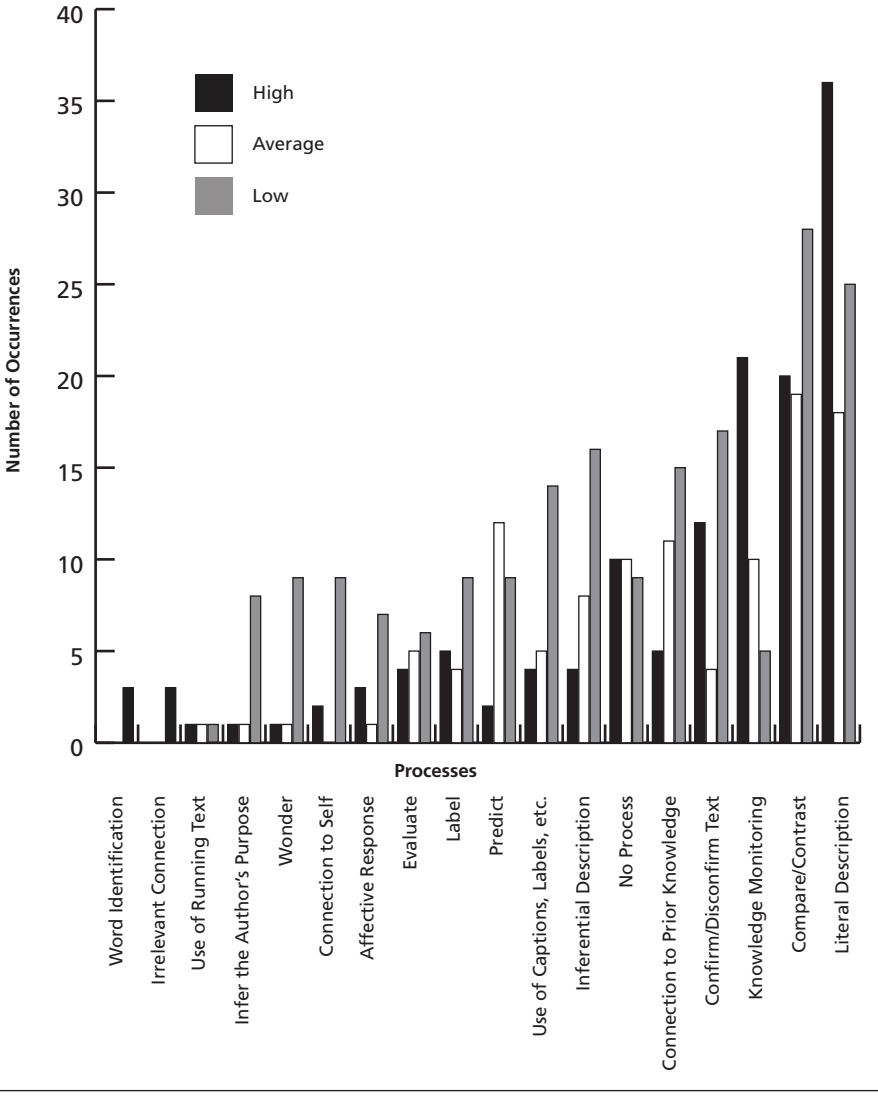
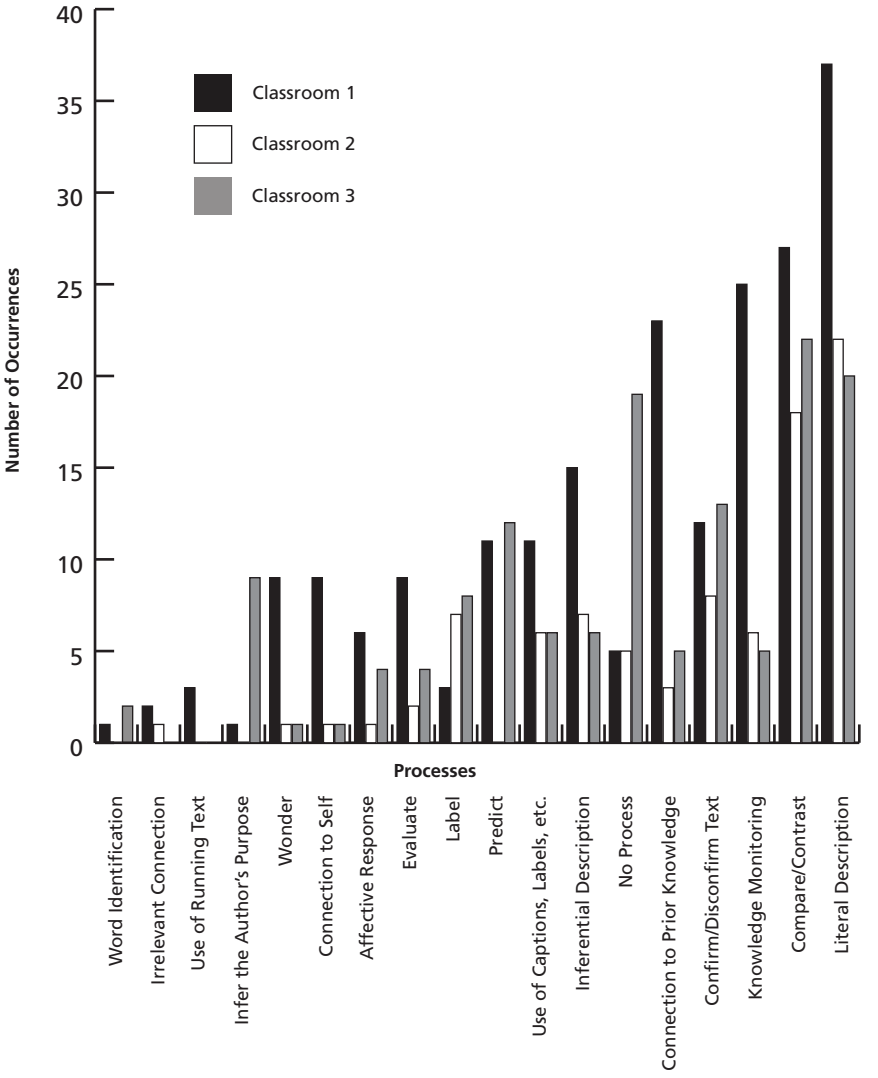


Figure 4. Comparisons of Comprehension Processes Across Classrooms



Irrelevant connections. Three times, or less than 1% of the comprehension processes, the connections prompted by the graphics were not relevant to the book, and, thus, were coded as *irrelevant connections*. Low readers made all three of these *irrelevant connections* (two by Maggie and one by Reginald). While the average and high readers made *connections-to-self* and *connections-to-prior knowledge*, none of their connections were irrelevant.

Interestingly, two of the *irrelevant connections* were prompted while studying the map describing where alligators and crocodiles live in *Animal Look-Alikes* (p. 11). Reginald commented, "My mom and dad have been to Australia. And, they've been in a limo when they got married. And they went to Australia when they got…after they got married." Maggie also made an *irrelevant connection* as she studied this map, stating, "My family actually made up this country game where we have to name a country so if I said Australia my brother would have to name a country with A. So that's how we do it." Although Australia is labeled on the map, the students' comments about their families do not pertain to the habitats of alligators and crocodiles or to animal look-alikes, and thus were irrelevant to the book. In contrast, high-level readers responded to the map by *literally describing* where crocodiles lived (Melinda) and *confirming/disconfirming the text* (George).

Knowledge monitoring. The graphics prompted *knowledge monitoring* for five of the nine students, including all three high readers. For Tammy and Melinda, both high-ability readers, *knowledge monitoring* was the second most-common process that was prompted by the graphics, 21.28% and 21.43% of the comprehension processes respectively; for George, also a high reader, it accounted for 8.93% of the comprehension processes. While reading *Animal Look-Alikes*, the students often realized that similar animals were not actually the same animal. For example, Melinda commented, "Rabbit and the hare, I thought they were just the same animal, but they're not" (p. 21). Additionally, George commented that he could use the new information that he had gained, "Well, now I can tell the difference if I catch a frog or a toad in my backyard." Sean, a middle reader, and Maggie, a low reader, were the only other students who used *knowledge monitoring* (16.13% and 5.00% respectively).

Comparisons across classrooms

As indicated above, differences between the classrooms were noted. For instance, the students in Classroom Two (Melinda, Diane, and Reginald) used fewer different processes (a range of 6 to 9 different processes) than the students in the other two classrooms (a range of 11 to 16 for Classroom One and 8 to 13 for Classroom Three). Furthermore, two of the students in this classroom, Melinda and Diane, never verbalized their thinking unless prompted to do so. By comparison, all other students spoke about their thinking both when prompted and spontaneously.

On the other hand, Classroom One was unique in that students in this class reported the greatest number of total processes, the greatest range of comprehension processes, and reported comprehension processes that no students from other classrooms indicated. For example, all three instances of *use of running text* came from students in this classroom while reading *Animal Look-Alikes* and trying to decide whether a photograph depicted an alligator or a crocodile. Tammy, Sean, and Maggie, from Classroom One, each referred back to the running text to find information that would help them decide. Tammy, for instance, explained that it must be a crocodile, "because in here it said (points to text) that the crocodile teeth stick out of their closed mouth. It makes them look like the crocodile is smiling and it looks like this one is (points to photograph) smiling because the teeth are sticking out." Additionally, as indicated above, although all three high readers demonstrated *knowledge monitoring*, the only average- and low-ability readers who *knowledge monitored* were Sean and Maggie, from Classroom One.

DISCUSSION AND IMPLICATIONS FOR FUTURE RESEARCH

The purpose of this study was to investigate the comprehension processes prompted by the graphics as second graders read informational text. I collected 18 verbal protocols from nine students as they read two informational texts written at a level appropriate for the end of second grade. These protocols revealed 17 comprehension processes prompted by the graphics and no process. Many of these processes were consistent with processes identified in research of comprehension processes prompted by narrative and informational written text, while others were found to be unique to the reading of graphics. When comparing the comprehension processes prompted by the two texts, I found differences in the quantity and types of comprehension processes prompted. Differences were also noted for the different students, reading abilities, and classrooms, though the differences across abilities and classrooms findings are only suggestive because of the small number of participants for each ability level and for each classroom. Implications for future research are discussed below.

Comparisons of Written and Graphical Text Processes

As stated above, previous research demonstrates that good readers are strategic, flexible, and use a wide range of comprehension processes (Duke & Pearson, 2002; Pressley & Afflerbach, 1995; Tierney & Cunningham, 1984). When studying second graders as they read (or listen to) narrative (Brown et al, 1996; Hilden, 2006) and informational text (Hilden, 2008), researchers have found that even young readers employ a wide range of comprehension processes. In this study of comprehension processes prompted by graphics, many of the same

processes were found, (*prediction* and *knowledge monitoring*). Other processes, however, were only found in this study, and perhaps are uniquely prompted by graphics (*use of captions, labels, map keys*, etc.).

Research in comprehension processes prompted by written text has led to practitioner literature encouraging instruction of comprehension processes (Keene & Zimmermann, 2007; Miller, 2002) and to intervention studies on teaching comprehension processes or strategies (see Duke & Pearson, 2002; National Institute of Child Health and Human Development, 2000; Roberts & Duke, 2009 for reviews of strategy instruction research). These studies have found that direct instruction of comprehension processes improves students' use of the comprehension processes and their comprehension of written text. Therefore, an important next step in research on graphics and reading processes is to investigate whether and how students can be instructed to better comprehend the abundant graphics that accompany informational text.

Comparisons Across Books

Comparisons of the two books suggest that the graphics in different informational texts may prompt comprehension processes differently. For example, while reading *Animal Look-Alikes* students were more likely to *compare and contrast* the graphics; these comparisons mirrored the compare-contrast structure (Meyer, 1975) of the text. *Recycling Adds Up*, on the other hand, had a problem/solution structure (Meyer), and students reported *comparing/contrasting graphics* less often with this text. The differences elicits the question: What is the relationship between text structure and comprehension processes prompted by the graphics and written text?

Furthermore, *Recycling Adds Up* prompted students to give *literal descriptions* more often. This could be due to the fact that the students possessed less prior knowledge about recycling, and therefore spent more time describing what they saw in the graphics, and less time using higher-level comprehension processes (*knowledge monitoring* and *prediction*) to comprehend the graphics. However, without a prior knowledge assessment and a greater number of texts, this cannot be determined. Therefore, another question raised by this work is: What is the relationship between interest/prior knowledge and processes prompted by the graphics in informational text?

Comparison Across Readers by Ability and Classrooms

Comparisons of readers suggest differences across readers, as well as trends across reading abilities and classrooms. The lower-ability readers were the only students who used the graphics to help with *word identification* and to make *irrelevant connections*. On the other hand, the higher-ability students *monitored*

their knowledge more often than the middle- or lower-ability readers. The fact that differences exist amongst ability levels is consistent with previous research on text comprehension, which has found that good and poor readers process text differently (see Oakhill & Cain, 2004). While there were suggested trends across reading ability, because of the small number of participants it is impossible to determine whether there is any relationship between reading ability and processes prompted by the graphics. Replication of this study with more participants would be advisable in order to investigate whether such a relationship exists.

As with reading ability, comparisons of classrooms suggest that the number and type of comprehension processes prompted by the graphics differs among classrooms. It can be noted that the graphics prompted more processes for students from Classroom One than for students from either of the other classrooms. In contrast, students in Classroom Two were the least likely to look at the graphics and rarely made any comments that were not prompted by the researcher. Moreover, all students from Classroom One *monitored their knowledge* (compared to only the high readers from the other two classrooms) and *used the running text*, and no students from Classroom Two made any *predictions* based on the graphics. These variations may be due to differences in instruction or to the emphasis placed by the teachers or schools on the use of graphics while reading aloud. After all, prior research has shown that read alouds can vary greatly depending on the teacher (Dickinson & Keebler, 1989). No data was collected, however, on whether and how the teachers in these classrooms discussed the graphics while reading informational text with the students. This suggests another important research question to address in future research: Whether and what type of a relationship exists between teacher instructional practice and student use of graphics?

LIMITATIONS

While steps were taken to eliminate as many limitations as possible, a few remain. First, students self-reported their thinking. It is possible that processes were prompted by the graphics, but students failed to report these processes. Conversely, it is possible that some children may have been more willing or more able to discuss their thinking than other students. Additionally, the prompting may have impacted how often and in what ways students thought about the written text and the graphics. They may have begun to think more about the written text and graphics than they would during independent reading. Also, because I prompted them when they were looking at the graphics, the amount of time or attention students devoted to the graphics may have increased or decreased as they read. Furthermore, the students only read informational text, and two specific informational texts. The comprehension pro-

cesses prompted by the graphics as second graders read these specific informational texts may be different than those prompted by the graphics contained in other genres or other instantiations of informational text (Cakir, 2008). Finally, the separation between the graphics and the text were exaggerated, which is not authentic to most book readings and may have increased or decreased the student's attention to the graphics, and thus the comprehension processes prompted by the graphics.

CONCLUSION

Past verbal protocol research has provided us with a robust picture of the comprehension processes prompted by the written text as students read both informational and narrative texts. However, there has been a dearth of research on the comprehension processes prompted by the graphics in such texts. This study has begun to develop potential answers for informational text. We now know that, in a group of second graders reading end-of-second-grade-level informational texts, the graphics prompt at least 17 comprehension processes (*literal description, label, inferential description, prediction, infer 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*). This and future research will lead to a more-complete picture regarding the types and nature of comprehension processes prompted by texts in their entirety.

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