ABSTRACT

Title of Document: EFFECTIVENESS OF FALSE CORRECTION STRATEGY ON SCIENCE READING COMPREHENSION

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False-correction reading strategy theoretically prompted college students to activate their prior knowledge when provided false statements linked to a portion of their biology textbook. This strategy is based in elaborative interrogation theory, which suggests that prompting readers to answer interrogatives about text students are reading increases their comprehension of that text. These interrogatives always asked "why" statements pulled from a text, one sentence in length, were "true." True statements in this study based on a text were converted by the experimenter into false statements, one sentence in length. Students were requested to rewrite each statement (n=12) on average every 200 words in a text as they were reading, converting each false statement into a true statement. These students outperformed other students requested to reread the same biology text twice (an established placebo-control strategy). These students, in turn, outperformed still other students reading an unrelated control text taken from the same textbook used only to establish a prior knowledge baseline for all students included in this study. Students participating in this study were enrolled students in an undergraduate introductory general biology course designed for non-majors. A three-group, posttest-only, randomized experimental control-group design was used to prevent pretest activation of students' prior knowledge thus increasing chances of producing evidence of false-correction effectiveness and to begin augmenting potential generalizability to science classrooms. Students' (n=357) general biology knowledge, verbal ability, and attempts to use the false correction strategy were collected and analyzed. Eight of the participants were interviewed by the researcher in a first attempt in this domain to collect data on participants' points of view about the strategy. The results of this study are not yet recommended for use in authentic school settings as further research is indicated.

EFFECTIVENESS OF FALSE CORRECTION STRATEGY ON SCIENCE READING COMPREHENSION

By

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Dedication

To my wonderful family for being so supportive; my husband Bryan for waiting for so long for me to complete this; my children Matthew and Chrysta for giving me the reason to finish; and to all my supportive friends who have cheered me on.

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Finally, I would like to thank the students who participated in this study. This study was not possible without their participation and I hope these finding will someday improve science learning.

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CHAPTER 1: INTRODUCTION

This study sought to investigate the effects of using a new reading comprehension strategy on the comprehension of science text. No studies were located that investigated the use of correcting a false statement as a reading comprehension strategy. This was an experimental study drawn from basic and applied research in educational psychology on the effectiveness of elaborative interrogation strategies on reading comprehension. Elaborative interrogation strategy theory suggests that if students are presented with an interrogative, that is, a question, then the students are more likely to activate prior knowledge, resulting in increased learning (Callender & McDaniel, 2007). Why questions, that is, elaborative interrogations, are questions that prompt the reader to ask "Why is this true?" This strategy was applied in experimental studies about reading science text recently (Cain, 2004; Smith, 2002). For reading science text at the undergraduate biology level, this strategy was shown to be effective (Smith, 2002).

A goal of the present study was to extend research of elaborative interrogation strategies with a novel form of elaborative interrogation, called false correction, which, in essence, can be thought of as "why-not" questions. This study included student students enrolled in an undergraduate introductory biology course and used text from a common textbook used for nonmajors' introductory biology courses. A methodological strength of this study was that it more closely resembled the conditions of a science classroom in comparison to earlier educational psychological studies, which took place under laboratory conditions.

When students arrive at college, they are often not prepared for the challenges they are about to face in their academic classes (Simpson, Olejnik, Tam & Supattathum, 1994). Many of these students do not have a tool kit of strategies that they can use to help them complete their assigned learning tasks (Pressley, 2002b). Undergraduates have heavy reading loads and, therefore, reading strategies are very important cognitive tools (Simpson & Nist, 2002). At the college level, it seems that students spend little time reading the textbooks, which is in part a lack of reading strategies (Pressley & McCormick, 1995; Pressley, 2006). This is especially true of science classes. Science textbooks can be difficult to read and understand (Best, Rowe, Ozuru & McNamara, 2005). This fact is complicated when the reading in a science course, which uses dense technical text and unfamiliar vocabulary, is more cognitively demanding and difficult to comprehend compared to more often read non-school texts (Simpson & Nist, 2002).

Science texts generally require readers to make inferences while they read, which can be difficult for many students (Wiley & Myers, 2003). One reason may be due to students' lack of knowledge of effective reading comprehension strategies or failure to use those strategies (Villaume & Brabham, 2002). When the text is complicated, as in the case of science, the cognitive load is heavier and using strategies successfully allows for easier understanding of difficult expository text. Unsuccessful students too often merely memorize textbook information (Pressley, 2006) rather than use reading strategies that work (Woloshyn, Willoughby, Wood, & Pressley, 1990). When students are aware of their study strategies and use them while reading, they theoretically are more successful at comprehending the science text they read. This is especially true when students have some background knowledge about the content.

Having some domain knowledge, or prior knowledge, allows for easier comprehension of such text (Best, Rowe, Ozuru & McNamara, 2005). This prior knowledge may or may not be available for students at the college level as they approach a task of learning from science texts. When students approach this task with effective strategies, their comprehension of the text may be increased.

There is an increasing interest in reading comprehension in schools, but little research has been reported in the area of science reading dealing with science textbooks. In recent years, the number of experimental research studies in science education has increased. Finding and investigating novel reading comprehension strategies is an important research focus and is extremely valuable to practicing teachers. This project was designed to help understand and extend the research on using an established reading comprehension strategy on science textbook materials. Whether science textbooks are good for students is a separate question not assessed in this study. Regardless, they are widely used, including at middle and high schools, according to surveys of science teachers (Weiss, 2001).

The present experimental study was based on findings from research dealing with elaborative interrogation strategies on reading comprehension. Such strategies require students to answer why questions that are strategically placed adjunct to text (Pressley & McCormick, 1995). Why questions are questions that prompt the reader to answer the question about a short statement pulled from a text: "Why is this true?" This why-question strategy has been applied to at least one previous experimental study examining reading biology text at the undergraduate level. The strategy was effective even after verbal ability and prior knowledge were accounted for using a regression approach (Smith, 2002). Smith (2002) found that the use of why questions improved comprehension of biology textbooks compared with the placebo-control group rereading the same text. This finding was consistent with prior basic research studies investigating relatively short texts and typically measuring verbal recall.

When the why-question strategy is applied to college science textbook materials, statements pulled from the students' textbook at regular internals are placed on a sheet of paper, always followed by the same recurring interrogative, "Why is this true?", as was done by Smith (2002). The current study differs. Instead of asking students why batches of text-derived statements are true, students were asked why modified (falsified) statements were not true. In the present study, modified meant each pulled statement (i.e., pulled from students' textbook) was reworded so that it was converted into a false statement. The students' task was to write on a sheet of paper why each modified false statement was false by rewriting the false statement as a true statement. One methodological difference also exists, including the use of a second control group used to establish a prior knowledge baseline.

The current study extends the range of elaborative interrogation to include a form of why questioning called false-correction, which, in essence, can be thought of as "why-not" questions: "Why is this not true?" This modified form of why questions theoretically requires students to process their relevant prior knowledge in a more complete fashion compared to asking students why a correct statement pulled directly from their text is true.   Whether purely why questions and false correction questions differ in learning effectiveness was not a research goal in the present. Instead, a research goal in this study was to investigate an alternative interrogative.

Pressley, McDaniel, Turnure, Wood, and Ahmad (1987), who developed the elaborative interrogation strategy linked to a hypothesis with the same label, found that students felt more prepared for tests when adjunct questions were added to a text. In 1988, Pressley and colleagues (Pressley, Symons, McDaniel, Snyder, & Tenure, 1988) determined that using why questions increased learning of facts better than did rereading. Woloshyn, Willoughby, Wood, and Pressley (1990) found that using why questions based in the elaborative interrogation rationale -- encouraging students to elaborate on pulled statements by asking students to answer the same question, "Why is the statement true?" -- worked with dense technical text for adult learners. But these studies did not measure comprehension or problem-solving.

Evidence from elaborative interrogation research on the why-question strategy effectiveness suggests that the main reason such interrogatives work is because they activate students' prior knowledge rather than merely focusing students' attention on the selected parts of presented textual information. Prior knowledge affects how well people learn (Donovan, Bransford, & Pellegrino, 1999). Prior knowledge used effectively allows new related text materials to be more easily assimilated into a reader's schema (Pressley, 2006). Thus readers without much prior knowledge on a topic they have read have to use more cognitive working memory, retrieving and activating prior knowledge and linking it to new information. Prior knowledge brought to students' working memory, theoretically by encouraging them to answer why questions, helped readers to access relevant information embedded in their schema (Martin & Pressley, 1991). One possible explanation for the effectiveness of answering interrogatives may be that, in terms of schema theory, prior knowledge allows the reader to understand the presented information in such a way as to better fill the slots in the appropriate schema. This explanation hypothetically also explains the effectiveness of correcting false correction, which can be thought of as why-not questions. Answering false-correction questions theoretically engages students in relatively more information processing of this type compared to answering why a true statement is true, and thus theoretically enables students to comprehend a science text they have read. The experimental testing of this particular hypothesis in the context described in the next section was the main purpose of this study.

This was an experimental study of science reading comprehension using a randomized three-group posttest only control group design. All students were registered students in the same non-majors introductory biology course and were assigned randomly to one of three treatment groups: (i) reading unrelated text (control), (ii) rereading experimental text (placebo-control), or (iii) correcting false statements while reading experimental text (treatment). After completing a prior knowledge test, a verbal ability test, a demographic questionnaire and a self-efficacy assessment, the students read text and used the study strategy to which they were assigned. Once the reading with study strategy was completed, the students were administered a comprehension posttest, covering the relevant experimental text. The time on task for the reading and study session was recorded. Scores on the prior knowledge test, verbal ability test, posttest and false correction statements were calculated and analyzed. Eight of the volunteers were interviewed by the researcher to obtain data about students' thoughts while engaged in the study tasks.

Operational Definitions of Key Terms

Adjunct question: Adjunct questions are questions that are embedded in text, enhancing comprehension of text (Pressley & McCormick, 1995; Holliday, Whittaker & Loose, 1984).

Elaborative Interrogation (EI): The elaborative interrogation hypothesis states that when readers elaborate in question form on information they read, they comprehend better by activating prior knowledge (Pressley & McCormick, 1995). This hypothesis uses the reading strategy known as why questioning.

Why question: Why questions are precise elaborative interrogations about a specific statement (Pressley and Bryant, 1982). Generally, the precise elaboration is in the format, “Why is this true?” (Smith, 2002).

False correction statement: False correction statements were statements that were taken from students required course textbook and rewritten so that they were false. Readers corrected these false statements as they read. These were, in essence, a form of why questions, designed to have the reader ask, “Why is this not true?” The intent of the false correction statement was to have readers assimilate information from the text as they read to allow them to correct a false statement that related directly to the text. The false statement was not a statement that was a verbatim sentence from the text with some words changed to make the statement false. Instead, the false statement was an incorrect statement that included information from the text, paraphrased in such a way as to make that statement false, without directly mimicking the text in a verbatim fashion. In other words, the false statements were not asking readers to recall or recognize exact words or phrases from the text, but to apply the information from the text to correct the false statement. This application was established years ago in a seminal article as a form of comprehension (Anderson, 1972).

Comprehension: Comprehension has been defined in many ways. Generally, comprehension refers to what is remembered during a learning task (Pressley &

McCormick, 1995) for recall (Amlund, Kardash & Kulhavy, 1986) or for deeper understanding (Colburn, 2003). Comprehension has also been defined as gaining meaning from text (Best, Rowe, Ozuru & McNamara, 2005). For the purpose of this study, comprehension is defined as understanding of information from text as evidenced by posttest scores and in line with Anderson's position (1972).

Self-efficacy: Self-efficacy is the belief about one's ability to complete a specific task (Bandura, 1994). In this study, self-efficacy is defined as the belief of the students about their ability to successfully complete the reading task and associated posttest.

Think aloud: Think aloud is a research strategy where subjects verbalize their thinking during an activity (Ericsson & Simon, 1998). The think aloud research strategy was modified for the purposes of this study so that students were asked to verbalize their thinking as they engaged in a reading comprehension study strategy.

Summary

A major goal of this study was to investigate the effectiveness of using false-correction strategy while reading to increase comprehension of science text. The three-group, posttest only control group design was used to determine the impact of prior knowledge on learning from text and to establish baseline learning of the placebo-control group. The posttest scores of the false correction group were then analyzed and compared to the rereading placebo-control group posttest scores.

CHAPTER 2: LITERATURE REVIEW

This study investigated the effectiveness of a study strategy called false correction. The strategy was developed based on prior research in the fields of elaborative interrogation and reading comprehension. False correction is a modified form of elaborative interrogation that has readers ask themselves, “Why is this not true?” as they are reading text and the associated false statements. This literature review will begin with a discussion of reading comprehension research, followed by a discussion of elaborative interrogation. In addition, several factors, such as prior knowledge, and self efficacy, have been shown to affect reading comprehension and will be discussed where appropriate.

Reading comprehension research

According to Barr (2001), there are four themes around which reading research clusters: emergent literacy, early reading instruction, facilitating comprehension, and teaching situated in classrooms. Based on a review by Barr (2001), studies in facilitating comprehension focus on strategy use and development. Much reading research has been focused on using strategies such as think aloud, use of imagery, increasing metacognition, and highlighting important vocabulary (Barr, 2001). There are also many studies about summarizing, outlining, and use of graphic organizers as comprehension strategies (Baker & Brown, 2002). In recent years, there has been a focus on using a combination of reading comprehension strategies in general, as well as reading comprehension in specific content areas, like science.

Undergraduates have an extremely heavy reading load (Stahl & King, 2000) and, therefore, reading strategies become very important. Even so, it seems that college students spend little time reading the textbooks, which may be a result of lacking the reading skills that are necessary in demanding courses with high volume reading (Pressley & McCormick, 1995; Pressley, 2002a). This fact is complicated when the reading is in a science course, which not only has dense technical text and specific vocabulary, but also is more cognitively difficult to comprehend (Simpson and Nist, 2002; Best, Rowe, Ozuru & McNamara, 2005). Metacognitive skills become important at the college level and, in a paper presented to AERA in 1999, Nist and colleagues suggested that successful undergraduate students studying history and biology were aware of their understanding and thinking, and developed a reading plan to supplement the concepts they did not fully understand. Unsuccessful students, however, tended to memorize and only used reading to find specific information, rather than as a comprehension tool. Indeed, Simpson and Nist (2002) encourage the use of metacognition for college students and suggest ways to foster that skill: encourage students to think about their theories of learning; teach students megacognitive and cognitive skills for reading; use direct instruction; show students how to synthesize information from multiple sources; and be flexible in strategy use.

Strategy use can be complicated and students need practice to develop their strategies (Wood, Motz, & Willoughby, 1998). The most common strategy used is that of rereading (Rawson, Dunlosky & Thiede, 2000; Cordon and Day, 1996; Pearson and Fielding, 1991) which has been shown to increase recall of information (Millis & King, 2001), and therefore is commonly used as a control situation in research of reading strategy effectiveness. In fact, Amlund, Kardash & Kulhavy (1986) showed that adult readers, in this case, graduate students, remembered better after reading a passage twice as opposed to reading once or three times.

In addition to rereading, questioning is a reading comprehension strategy that is becoming more common, as evidenced by an increasing number of experimental studies on that topic.

Questioning as a strategy

The ability to monitor learning while reading is essential for comprehension (Lin, Moore & Zabrucky, 2000) especially at the college level, where reading places a high demand on cognitive processing (Taraban, Rynearson & Kerr, 2000). College students, when normally classified as good readers, tend not to use metacognitive skills to determine their understanding levels, even though most good readers constantly assess their understanding, which enables them to enact strategies when necessary (Pressley, Snyder, Levin, Murray & Ghatala, 1987). Questioning, either teacher-generated or reader-generated, can increase understanding of text, especially when higher level questions are used (Andre & Anderson, 1978). The benefit of such a reading comprehension strategy may be to increase cognitive processing, which can generate a deeper understanding of the text (Best, Rowe, Ozuru & McNamara, 2005). The questions used to increase reading comprehension can be of several varieties, one of which is adjunct questioning.

Adjunct questions as a comprehension strategy

According to Rowe (1986), using adjunct questions as purpose questions (questions designed to focus the reader on the main purpose of the text) tends to activate cognitive processes and in turn enhance learning. Adjunct questions in general focus attention on specific information so as to increase understanding of that material (Holliday, 1981; Holliday, Whittaker & Loose, 1984). This attention is central to cognitive processing of text. For readers with poor comprehension ability, the presence of adjunct questions compensates for problems in cognitive processing (Rickards & Hatcher, 1977). In contrast, readers who have good comprehension ability tend to have automaticity of schema activation, resulting in less allocation of conscious attention, requiring less cognitive effort on the part of the reader (Walczyk, 2000).

One issue that is associated with adjunct questions is whether the questions focus the reader only on specific segments of the text to the exclusion of the rest of the sections. Holliday, Whittaker & Loose (1984) found this to be true, especially for low verbal ability learners. The goal of adjunct questioning, then, is to focus attention on the text in such a way as to enhance understanding, but not to focus so tightly on that specific information so that the rest of the text is lost. Also, the nature of the adjunct questions is critical and should avoid being verbatim restatements of the text being read, which tends to overprompt the reader (Holliday, 1983).

In 1987, Pressley, Snyder, Levin, Murray & Ghatala found that students felt they were more prepared for comprehension tests when adjunct questions were added to text. Pressley investigated the use, as well as placement of adjunct questions. The adjunct questions used were similar to the questions that would appear on a posttest. The hypothesis was that making students answer these adjunct questions during reading may signal the importance of the information. In one version of a reading, the adjunct questions were placed at the end of the reading and in the other version, the adjunct questions were interspersed throughout the reading. The presence of adjunct questions increased student perception of readiness for testing and, although the presence of adjunct questions did facilitate learning, the position of those questions did not seem to make a significant difference in learning (Pressley, Snyder, Levin, Murray, & Ghatala, 1987).

One type of adjunct questioning, elaborative interrogation, has been well studied in terms of effectiveness on increasing comprehension of text. This strategy uses researcher or teacher generated questions that prompt the readers to ask themselves why a particular statement they are reading is true.

Elaborative Interrogation as a comprehension strategy

The strategy now known as elaborative interrogation, or using why questions, was originally used by Pressley (Pressley, McDaniel, Turnure, Wood, & Ahmad, 1987). In this initial research, the students were asked to read man sentences taken from previous research (Stein, Bransford, Franks, Owings, Vye, & McGraw, 1982). A man sentence is a short statement about a man that students were asked to learn. For example: "The angry man went to the restaurant." This research showed that learning arbitrary facts was difficult, unless the learners connected those arbitrary facts to other significant and memorable topics, using elaboration. In other words, the man sentence, "The angry man went to the restaurant" was easier to remember if there was an elaboration added, such as, "because there was no food at home." In Stein's work, the elaborations were researcher provided. Pressley, McDaniel, Turnure, Wood, & Ahmad (1987) took this one step further by asking students to self-generate the elaborations. This was accomplished by using why questions. These why questions were designed to elicit answers about the relationships that existed in the man sentences used by Stein and colleagues. The results showed that using elaborative interrogation, or why questions, as a strategy improved learning.

In 1988, Pressley, Symons, McDaniel, Snyder, & Tenure determined that using why questions increased learning of facts better than did rereading. This is especially true when the readers are reading prose (Seifert, 1993), but also true when the reading is of an expository nature (Ozgungor & Guthrie, 2004). Wood, Pressley, & Winne (1990) found that children who used why questions were prompted to think about the relationships that are present in the material to be learned, thus facilitating learning. Simpson and colleagues (1994) found that adults do not spontaneously engage in elaboration during reading and studying, which is a critical problem for college students. Learning facts from dense prose is an important skill for adults, particularly college students. Wood, McDermott, Motz, Willoughby, Kaspar & Ducharme (1999) found that adults who engage in elaboration while studying have higher learning gains than adults who were not encouraged to elaborate while they studied. Woloshyn, Willoughby, Wood, & Pressley (1990) found that consciously using elaborative interrogation as a strategy to learn from dense technical text was a successful strategy for adult learners. In fact, their data supported the contention that the actual answers to the why questions were less important than simply the use of the strategy.

Using elaborative interrogation is more cognitively challenging than reading or rereading and the process generates lasting associations (Martin and Pressley, 1991), which is a major goal of undergraduate education. Adults, such as college students, can benefit from using elaborative interrogation as a reading comprehension strategy. Indeed, when college students are science majors, this strategy may be very valuable, as the reading at the college level is highly demanding, mainly consisting of dense expository text (Pugh, Pawan & Antommarchi, 2000). One college program that is rife with dense technical prose is that of science, specifically biological science. Students studying biology at the college level should benefit from using elaborative interrogation.

Elaborative Interrogation Strategy for Science Reading

Elaborative interrogation increases comprehension of adults reading about basic science concepts (McDaniel & Donnelly, 1996), but this investigation was not conducted in a setting that was authentic for learning science. Two recent dissertations (Smith, 2002; Cain, 2004) were completed investigating the effects of using elaborative interrogation, or why questioning, in a science course at the undergraduate level. These studies were looking at studying science in an authentic setting, namely a college classroom, using authentic students, namely students enrolled in a college science course. One focused on the use of why questions to enhance understanding, and drawing, of Lewis structures, a basic chemistry concept. Lewis structures are diagrams that illustrate the fundamental concept of electron positions and therefore bonding. Cain (2004) hypothesized that using why questions, or elaborative interrogation, as a strategy would not produce higher gains in learning about how to draw Lewis structures than using rereading as a strategy. This is interesting in that the presence of diagrams adjunct to science text usually aids in comprehension of that text (Ainsworth and Loizou, 2003).

In this research, elaborative interrogation was not shown to be a significantly better strategy than rereading, which was contrary to most research in the area (such as Pressley, McDaniel, Turnure, Wood, & Ahmad 1987; Pressley, Symons, McDaniel, Snyder, & Tenure, 1988). This may be due to the learning task involved, namely learning how to draw a chemical structure from reading instead of the classic experiments where students were trying to increase comprehension of text, either alone or with adjunct diagrams. Apparently, this strategy does not transfer to a task such as learning to draw chemical structures. Without any procedural information, the presence of why questions seemed to be detrimental to learning the structures. Asking why a structure makes sense may have been difficult to determine from the reading, and therefore may have given the students in this group less time to spend looking at the specific structures. Also, the text used in this study, taken from a common college chemistry textbook, was not a typical of the text that has been used in many elaborative interrogation studies. Normally, the text used is one of narrative or declarative sentences. The text in this case consisted of sentences describing the procedure to draw Lewis structures. This type of text is commonly seen in college textbooks for this type of task.

A second recent dissertation on this topic (Smith, 2002) focused on the use of why questions to improve students' comprehension of biology text at the college level. Smith's hypothesis was that students using why questions as a reading comprehension strategy would outperform students using a rereading strategy on a test for comprehension. Both the experimental why question group and the rereading control group received the same text to read, photocopied from an authentic college introductory biology textbook. The readings consisted of both text and diagrams of the human digestive system. The diagrams were included to simulate the authentic learning situation of introductory biology students, who read textbooks that include diagrams on most pages. The treatment group, which used the elaborative why-questioning strategy, significantly outperformed the control group, which used the rereading strategy.

Overall, Smith found that elaborative interrogation was a better strategy for students when learning material from an undergraduate biology textbook. This finding is consistent with prior studies on elaborative interrogation. When asked, "Why is this true?" during reading, students generally performed better on posttest items. This can be taken to show that this strategy, using why questions, can increase comprehension of undergraduate level biology content. There are other factors, such as prior knowledge and high verbal ability, that affect levels of comprehension, but answering why questions seems to benefit most groups in gaining comprehension.

Other Factors Affecting Reading Comprehension

In addition to the factors mentioned above, reading comprehension may also be affected by other factors such as prior knowledge and self-efficacy. Based on research findings, each of these factors play a role in the ability of students to comprehend text they read.

Prior knowledge

There is an abundance of data to support the idea that prior knowledge of a topic increases comprehension of text (eg. Woloshyn, Paivio & Pressley, 1994; Afflerbach, 1990). Prior knowledge affects how well people learn (Afflerbach, 1990; Pressley, Wood, Woloshyn, Martin, King & Menke, 1992) and allows new related material to be more easily assimilated into present schema. Also, prior knowledge makes the chunking of information easier, since content knowledge makes the reader familiar with the topic (Willoughby, Wood & Khan, 1994). Larger chunks occupy less cognitive space and are usually easier to retrieve from working memory. Prior knowledge can be used to facilitate vocabulary access as well as identification of main idea and allows readers to have automaticity of certain strategies, since present schema are easily accessed. Readers without prior knowledge of the topic have to use more cognitive space, because they need to make conscious use of strategies. However, conscious strategies are generally better than no strategies at all.

When students wee asked to learn specific facts, as in a school setting, having a certain amount of prior knowledge can facilitate that learning (Woloshyn, Paivio & Pressley, 1994). Using elaborative interrogation, however, does not depend on the students having large amounts of prior knowledge (Woloshyn, Pressley, & Schneider, 1992). Even students with low prior knowledge can benefit from this strategy. Since prior knowledge can affect performance, investigations of reading comprehension strategies should account for prior knowledge (Johnston, 1984). Students in reading comprehension studies should be tested for prior knowledge and the results should be accounted for as a possible influence or bias.

Self-efficacy

Self-efficacy, defined by Bandura (1994) as personal belief about ability, has a positive effect on performance (Lawson, Banks & Logvin, 2007). Self-efficacy results from prior experience performing the task, observation of the task performed by others, insistence by a professional about one's ability to perform the task, and level of interest in the task (Baldwin, Ebert-May & Burns, 1999). In terms of learning science, many students have low self-efficacy levels and enter these classes with some trepidation. Having a high level of self-efficacy for science learning may increase students' performance outcomes, which in turn should increase their level of self-efficacy. Self-efficacy can be promoted by motivation (Guthrie & Wigfield, 1999) and students with high self-efficacy may be more motivated and persistent in reading and may perform better than students with lower self-efficacy. In addition, Bouffard-Bouchard, Parent & Larivee (1991) found that students with low self-efficacy tend to reject correct hypotheses more than students with higher self-efficacy. For these reasons, self-efficacy was deemed important enough to investigate during this study to determine the role self-efficacy may play in reading comprehension. However, this research factor was considered secondarily to the main-effects comprehension achievement question dealing with the false-correction strategy.

Self-efficacy, gender and science

Self-efficacy plays an important role in learning, but research has shown that gender also plays a role (Golombok & Fivush, 1994). There exist stereotypes in American culture that impact the self-efficacy of girls about science (Howe, 2002) and, since data show that self-efficacy impacts achievement in science (Britner & Pajares, 2006), it is important to be aware of the potential differences that exist in learners based on gender connected beliefs.

Other Considerations

One aspect of this research asked volunteers from the student pool to "study aloud" during an interview. The theoretical background of this research strategy is grounded in the think aloud research strategy, which is used to investigate the thinking of students as they complete tasks (Ericsson & Simon, 1998).

Think Aloud Protocol

Think aloud protocols are a form of self-explanation, an approach to investigating self-regulation (Bielaczyc, Pirolli & Brown, 1995). Think aloud is a research strategy where subjects verbalize their thinking during an activity (Ericsson & Simon, 1998). For this study, the think-aloud strategy was modified to a study-aloud protocol. The study-aloud strategy asked readers to verbalize their thinking as they were reading text and using a study strategy to achieve comprehension of the text.

Test and question type

One other aspect of the experiment must be addressed. In similar experiments investigating the effectiveness of using why-question strategy, the question type used for many of the assessments were multiple choice, but the posttest assessment for the current study consisted of true-false questions. According to Mehrens (1992), multiple-choice tests are very appropriate for testing declarative knowledge but can also test for higher order thinking (Burton, 2005; Mehrens, 1992), and not just recall, a major criticism of such questions. True-false tests, when constructed well, are also effective assessment tools (Ebel, 1970; Ebel & Frisbie, 1991; Downing, 1992). The advantage for using true-false questions on the posttest is one of efficiency. Also, as long as they are crafted to be as precise and unambiguous as possible, the true-false questions can easily be constructed to test higher order thinking (Ebel & Frisbie, 1991). For these reasons, the tests and questions used are assumed to be appropriate. Each test item assessed an application of knowledge presented in the text or required students to understand true-false statements derived from paraphrased statements taken from their experimental text.

Summary

The precise reason for the instructional effectiveness of using elaborative interrogation strategies is a question that cognitive psychologists have not yet answered, but it has been well documented that when students use why-question strategies as they read, there is a resulting increase in their reading comprehension. The specific use of elaborative interrogation reading strategy for certain aspects of reading in college science to increase comprehension of text has also been documented. There are additional factors that must be considered when discussing reading comprehension, such as the role of prior knowledge, especially in science. Motivation and self-efficacy of the reader are extremely important components of reading and have an impact on comprehension of text. The intent of the novel reading comprehension strategy discussed in this study was to increase comprehension of the text in a way that prompted interest in the content to be read, since this was a new way of studying, which, in turn, potentially engaged the reader with higher motivation.

Statement of Research Questions

The research questions focus on testing the effectiveness of the experimental strategy known as false correction on reading comprehension of science text by undergraduate students in an introductory biology course. This strategy was developed from the basis of research data collected from studies on elaborative interrogation, both in the domain of science and general reading comprehension. The following hypotheses were tested in this study:

1. Students in an introductory college biology course, when provided with false correction statements adjunct to a reading, will outperform students provided with a reading and asked to read twice on a posttest based on that reading.

    1a: Students using the rereading strategy will outperform the students using the unrelated reading strategy on a posttest.

2. Of the false correction strategy users, students with high prior knowledge will outperform students with low prior knowledge on the posttest.

3. Of the false correction strategy users, students with high verbal ability will outperform students with low verbal ability on the posttest.

4. The false correction strategy treatment, along with prior knowledge, verbal ability, and self-efficacy, will be significant predictors of higher posttest scores.

CHAPTER 3: METHODOLOGY

A goal of this study was to investigate the effectiveness of a novel reading strategy, false-correction, when used by undergraduate students studying science. The effectiveness of the false correction study strategy was determined by comparing the posttest performance of students in the three groups: experimental false correction, placebo control rereading, and control group reading unrelated biology text. A three-group, posttest-only, randomized experimental control-group design was used to prevent pretest activation of prior knowledge and to augment potential generalizability to science classrooms. According to a review of experimental studies about reading comprehension strategies, many studies fail to account for threats to validity in design or methodology (Lysynchuk, Pressley, d'Ailly, Smith & Cake, 1989), so care was taken to limit threats to validity for this study. In the present study, it was deemed important not to active students' prior knowledge because why- and false-correction questions theoretically helped learners by activating their prior knowledge. Since pretests activate prior knowledge yet are not typically used in science classrooms, a study using a pretest design might reduce the chances of identifying learning effects of why- or false-correction questions. This study used students which were a sample of a population of interest, namely college students who were not science majors.

To lessen threats to internal validity, the study used separate treatment groups that were given treatments in a comparable manner in comparable environments, namely their normal course meeting room during their regularly scheduled sessions. Also, the students were members of a similar group, in that they were all registered students in the same non-majors introductory biology course. In addition, the students were randomly assigned to one of the treatment groups: (i) reading unrelated text, (ii) rereading experimental text, and (iii) correcting false statements while reading the experimental text.

The experimental design is represented in Figure 1. The design shows that a sample of the target population, college undergraduates, was randomly assigned to a treatment group. A random number generator was used to provide a list of the numbers 1 through 24 (the maximum number of students in each course section). Folders were set up and included instructions to the student, the text to be read and, when necessary, a page containing the false correction statements. The folders were numbered as follows: 1-8 were set up for the group reading unrelated text (the text was about ecology); 9-16 were set up for the group who were rereading (text was about animal behavior); 17-24 were set up for the group doing the false correction (the same text about animal behavior). The folders were stacked according to the random number list generated for that course section. The students were asked to take an envelope from the stack as they entered the room, thus creating a random distribution of the treatments to the students.

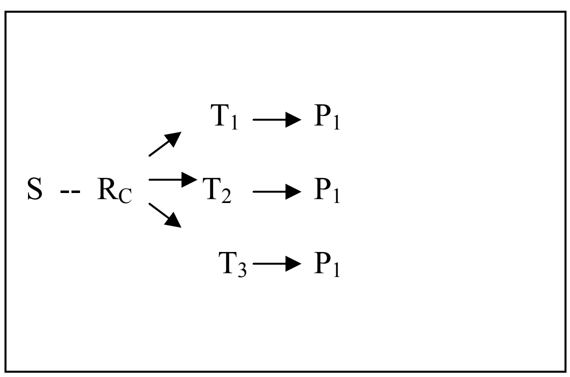


Figure 1: Graphic of Posttest only control group design. S=sample; R_C = complete randomization of students; T_n = treatment; P_1= posttest

In addition to the treatment envelope, each student completed a prior knowledge test, to assess their understanding of basic concepts about the animal kingdom, and a verbal ability test. Students also completed a demographic questionnaire and a self-efficacy assessment, which were administered prior to the treatments. The three treatments (T_1 - reading unrelated text; T_2 – reading animal behavior text twice; and T_3 – correcting false statements) were implemented at the same time to all students in that course section. The start time was recorded and all students were asked to open their envelopes and follow the directions inside. As each student completed the study task they were assigned, students' recorded the time they completed the study task and returned the envelope to the instructor. Students were then administered the same comprehension posttest (P_1). The posttest scores of each group were compared to determine effectiveness of the false correction strategy.

Research Setting &Students

The study took place at a comprehensive university in the Mid-Atlantic region, which has a diverse student body. The university has a general education program that requires all students to take at least one laboratory science course at the university in order to graduate. The course from which students were recruited was a general education non-majors' introductory biology course. This course is designed for students not pursuing a major in biological, physical or health science programs. Enrolled students from several laboratory course sections were asked to participate in the study, but none were required to participate as part of their course grade. Any student not wishing to participate in the investigation was given the opportunity of completing an alternate activity for that class period, which would have allowed them to earn the same grade for that day as those who choose to participate. Even though the alternate assignment was offered, no student chose to complete the alternate assignment; all students present during the testing days chose to participate in the study.

Students were asked to participate in the study that took place during their regularly scheduled course period, lasting 110 minutes. All students participated in the study during the same week of the semester. Initially, there were a total of 357 voluntary students; 130 in the group reading unrelated text; 130 in the group reading about animal behavior twice; 97 in the group correcting false statements. The reason for the unusual distribution of participants is explained later in the study. Regardless, all participants were randomly assigned.

Research Design

The design of this study was a modified randomized posttest-only equivalent group design. After listening to an explanation of the research intent and signing the consent form, students were administered a vocabulary test to measure verbal ability and a biology prior knowledge assessment to measure their understanding of the biology of animals. The students were randomly assigned to either the experimental false-correction group or one of two control groups (i) rereading treatment, a commonly used control treatment in elaborative interrogation experiments, serving as the placebo control group or (ii) unrelated reading treatment, where students read a different biology passage on ecology. This latter group, reading unrelated text, was included to establish whether learning occurred without using a pretest in the experimental design as is more typically done. This group was faced with answering posttest items on a subject they had not just read about, thus completing the task without having their prior knowledge theoretically activated by their assigned reading.

Since the posttest was administered immediately following the study session, care was taken to avoid creating a testing effect on posttest scores, so the experimental design did not include a pretest. Students were asked to read an excerpt taken from a commonly used undergraduate general biology textbook (Krogh, 2005). Students were told that the study was trying to find out the effectiveness of different reading comprehension strategies, or study strategies, on the comprehension of reading authentic science text. The students were supplied with written instructions about the study strategy they were asked to use, based on their treatment group. Students were told they would take a posttest at the end of the study session. In other words, all students were told that the study session was intended to be an intentional learning session in preparation for an assessment on the content of the reading.

Materials

The materials used included text excerpts, a verbal ability test, a test of prior knowledge, a short demographic questionnaire, a short self-efficacy questionnaire, and false correction statements, which were administered only to the false correction group. Each course section in the study received the same instructions, also printed on a transparency and shown to the group by overhead projection at the beginning of the session. The students were also asked to volunteer for short fifteen minute interview sessions that would take place in the weeks following the study.

Text

The reading excerpts consisted of photocopies from a chapter on animal behavior (2633 words) and a chapter on ecology (5872 words), taken from a commonly used undergraduate biology textbook (Krogh, 2005). The false correction group and the rereading control group both read text on animal behavior, specifically about reflexes, action patterns, and social behavior. The unrelated reading control group read text from the same basic biology textbook, but from a different section on ecology.

The readings did not include diagrams, visuals, or references to figures. These non-text displays were removed from the text which were read by the students. This differed from recent studies of elaborative interrogation in science (Smith, 2002; Cain, 2004). This approach was deliberately chosen to assure that the students were not learning information from the adjunct visuals. One study of elaborative interrogation, although in the content area of psychology, was found where the investigators removed visuals (Callender & McDaniel, 2007). Although diagrams may have an effect on reading comprehension, this is a separate empirical question and is not part of the research question investigated in this study.

Instructions

Each session began with the administrator reading the instructions to the students while simultaneously projecting the transcription of the instructions by overhead projector. The following is the transcription of those instructions.

> Each person in the room should have an envelope. Do not open it until the instructor says to open it. In this experiment, we are looking at different ways students study. Different people in the room will be doing different kinds of studying during this research experiment. We do not know which strategy is better and hope this experiment will give us some answers. You will have two pages to fill out before you can open your envelope. One has questions about your thoughts on how you will do during this study and some demographic information. The second is a vocabulary test designed to assess your verbal ability. After you have completed the

study, bring your packet to the front of the room and you will be administered a test that covers the material you have read.

An important point to make here is that this is a true placebo control group design where the students did not have knowledge about which strategy was potentially better in increasing comprehension of text. This design is common in medical research. By telling the students that the researchers were investigating several study strategies and that the intent of the study was to find out if any of these strategies increase reading comprehension, the students were not lead to believe that the researchers felt any single strategy was better at facilitating comprehension. The advantage of this type of control is to prevent student bias. It was assumed that the students did not believe that one strategy might be better than another while they were reading the science text. An experimental design including a placebo control group suggests that the researchers attempted to remove any potential unconscious bias on the part of the students as described by Ruxton & Colgrave (2006). The course section instructors also did not know which students would receive which specific treatment and were not told the hypotheses of the study, to prevent any administrator bias.

In addition to the instructions to the students, each course section instructor received instructions for administering the study, the transcript of which follows.

> Have students pick up the top envelope and one each of the following papers: consent form, prior knowledge test, verbal ability test, demographic questionnaire. Explain that this study is being conducted by two science education researchers who are interested in learning about the

effectiveness of different study strategies used while reading about science. Tell the participants that they are not required to participate, that participation will not have any effect on their course grade, and if they choose to not participate, they will be administered an alternate activity for that laboratory session. Have the willing participants sign the consent form. Instruct the class to answer the questions on both sides of the verbal ability test and both sides of the prior knowledge test. Have the students fill out the demographic questionnaire, which includes the self-efficacy questions. These first four papers can then be put inside the envelope. Read the instructions to the students while showing the transparency of the statement. Have them record the start time on their envelope and then remove the text and instruction page. The students should follow the directions they have been given in their envelope. Instruct the students to place all papers back in the envelope when they are finished with the activity. Have students record their end time on the envelope. When all papers are in the envelope, the student should come to the front and get the posttest. The posttest should be taken without any other papers visible. When the posttest is complete the student should put it in the envelope and turn in the entire packet to the front. Leave all papers in a pile to be picked up at end of day.

Verbal Ability Test

The vocabulary test used to measure verbal ability, taken from the *Kit of Reference Tests for Cognitive Factors* (French, Ekstrom, & Price, 1963) and used by other researchers, e.g. Dennis, Sternberg & Beatty, (2000). This instrument was shown to be predictive of science comprehension (Holliday, Brunner & Donais, 1977; Holliday, 1976; Smith, 2002). It was designed for use for research purposes only. The test consisted of a series of 48 multiple-choice questions where students are asked to select the correct synonym for the administered word. See Appendix 3 for examples from the verbal ability assessment. The intention of this ETS-published test was to assess the verbal ability of each student.

Prior Knowledge Test

The prior knowledge test consisted of questions about general knowledge of animal biology, not including topics in the reading. These questions were modified from test bank questions provided by several well-known publishers of college level biology textbooks. The test bank questions were used to construct items used in the prior knowledge test because they are of comparable level to the reading and posttest items; that is, they are college level material. The prior knowledge questions were multiple-choice in format and asked the students to select the best option to either answer the question or finish the statement. See Appendix 2 for example questions from the prior knowledge test. The intention of these questions was to determine students' level of understanding of animal biology. However, the prior knowledge test did not include questions about animal behavior covered in the experimental text being read for the study. This was to prevent the threat to validity based on pre-testing, where students can be cued in by pre-test questions prior to the experiment (Crawford & Impara, 2001), resulting in activation of their knowledge of the specific information presented in the experimental reading. It was assumed that the assessed basic knowledge of the animal kingdom and animal behavior not covered in the experimental reading would indicate knowledge about other types of animal behavior. To assess the quality of questions contained in the posttest, the questions were examined by a tenured professor with a specialization in animal behavior, who determined that the questions would indeed determine levels of prior knowledge of basic animal behavior and general knowledge of animal biology. It was predicted, of course, that this prior knowledge test would predict comprehension test scores of students reading the experimental text.

Demographic questionnaire

The demographic questionnaire was designed to ensure that the groups were indeed random representations of the population of interest, namely college biology students who are not science majors. The questionnaire included questions about age, gender, ethnicity, and prior coursework, including college level and high school level biology coursework. These data played an important role in this study and included questions to assess the following demographic data:

a) Gender: In science classes, there may be an impact of gender on performance and overall interest in read topics (Pajares, 2002; Britner & Pajares, 2006). Since the setting was a science class, it was important to have gender information available to help determine if there was a correlation between gender and performance.

b) Age: There may be an interaction between age and performance, so this data was collected. Certain life experiences may impact understanding of the information being read. Evidence from prior elaborative interrogation research supports the idea that readers of all ages may benefit from using this type of reading comprehension strategy (Wood, Pressley & Winne, 1990; Woloshyn, Willoughby, Wood & Pressley, 1990).

c) Previous college level biology courses: If the students had already taken a college level biology course, they may have been exposed to this information in college coursework and perform better on the posttest despite the study strategy being used. This allowed us to determine whether these individuals were included in the data set.

d) Previous high school level biology course: Even though high school biology may not cover this material, we wanted to determine which students had biology instruction in the past. This may or may not affect performance on the posttest.

e) Status in college: This may impact performance and we wanted to determine whether or not students in the later parts of their college careers may have developed study skills that allow them to earn higher grades on the posttest.

f) College GPA: We want to determine if there is a relationship between overall college GPA and performance on the posttest. We used a self report of this, which may or may not be exactly accurate, but should be close enough for us to determine whether a relationship exists.

g) Race/ethnicity (not required): There are data that supports the idea that there is a difference in performance based on socio-economic background and that there is also a relationship between certain ethnic groups and performance in urban school settings, especially for primary and secondary grades (Dills, 2006). Race/ethnicity categories were taken from the US Department of Labor, Bureau of Labor Statistics website (http://www.bls.gov/bls/glossary.htm#R).

Self-efficacy questionnaire

The self-efficacy questionnaire included questions about how each student believes he or she will perform during their using the research learning material. A link between self-efficacy and persistency at task has been shown in high school students (Bouffard-Bouchard, Parent, and Larivee, 1991) and between self-efficacy and performance (Bouffard-Bouchard, 1990). Self-efficacy is described as an individual's belief about their level of ability to perform specific tasks or events. The intent of this self-efficacy questionnaire was to collect data to evaluate students' perceptions of how they will do during the study impact their scores on the posttest. Studies have shown that students with higher self-efficacy tend to be more motivated and thus have higher assessment outcomes. This was included in the study to determine whether there was a correlation between self reported self-efficacy and scores on posttest for this study population. Students were asked to rate how they feel about certain statements on a scale of 1 to 7, with 1 being not at all true and 7 being very true. This questionnaire was adapted from a questionnaire used in a recent doctoral dissertation, directed by Dr. Roger Azevedo. See Appendix 4 for example questions from the self-efficacy questionnaire.

False-correction Strategy Statements

The false-correction strategy statements administered to the false correction group were generated from the experimental text covering reflexes, action patterns and social behavior. Specifically, the false statements were prepared from the text by paraphrasing the existing text and then changing true segments to false segments. The following is a portion of the experimental text read by the students:

> Reflexes are very simple actions. Looking beyond them to more complex behaviors, it is possible to see *patterns* of action in animal behavior that seemingly are as stereotyped as reflexes. The time-honored example of such a pattern is the egg-rolling behavior of the graylag goose, which was studied by both of the founders of animal behavior research, Niko Tinbergen and Konrad

Lorenz. For a female graylag trying to hatch chicks, an egg *outside* the nest is a matter of great importance, because eggs that are not properly incubated won't hatch. As such, females have a very specific means of getting wayward eggs back inside the nest's perimeter. They reach just beyond the egg with their bills and roll the egg back toward the nest until it is safely retrieved. Now, here's the interesting part. Any small, round object placed just outside the greylag's nest will elicit this behavior. Tinbergen and Lorenz constructed "eggs" much larger than any the goose would ever have laid, and they used beer bottles to boot. No matter; placed just outside a greylag's nest, these objects will elicit this behavior. Indeed, no object at all needed to be present for the goose to carry out this action. Tinbergen and Lorenz snatched eggs away from geese that were in the middle of their rolling, and they still continued the behavior right through to the end (meaning until they got their beaks inside the nest).

At one time, an important concept in animal behavior research was that of a *fixed action pattern*, meaning a stereotyped behavior that, once triggered by a stimulus, is always carried through to its conclusion. The graylag's egg-retrieval behavior is a paradigm of the fixed action pattern in that geese can do it on their first try, it is stereotyped (all graylags do it the same way), and it is always carried through to its conclusion. A more informative way to state this last phrase might be: It is always carried through to its conclusion *regardless of sensory input*. Remember it doesn't matter whether the goose's senses tell her an egg is under her bill or not.

The false correction strategy statement linked to the above text was:

> When a female greylag goose is presented with a stray object outside of her nest, she reaches out with her wing and rolls the object back into the nest.

Students using the false correction strategy were asked, as they were reading, to find the information in the text about that false statement and use it to correct the false statement on the paper provided. The single sentence false statement was written to cover concepts from the entire passage and the student had to comprehend the basic information and make inferences from the text to correct the false statement.

For example, the text "For a female graylag trying to hatch chicks, an egg *outside* the nest is a matter of great importance, because eggs that are not properly incubated won't hatch," must be understood to correct the false statement, as it is the underlying reason behind the female goose's behavior. To correct the false segment of the false statement, "…she reaches out with her wing …", the student must assimilate the information contained in the text, "…females have a very specific means of getting wayward eggs back inside the nest's perimeter. They reach just beyond the egg with their bills and roll the egg back toward the nest until it is safely retrieved."   It is also important to note that the segment of the false statement, "When a female greylag goose is presented with a stray object outside of her nest,…" is not false. Students' had to read the following text,

> "Any small, round object placed just outside the greylag's nest will elicit this behavior. Tinbergen and Lorenz constructed "eggs" much larger than any the goose would ever have laid, and they used beer bottles to boot. No matter; placed just outside a greylag's nest, these objects will elicit this behavior. Indeed, no object at all needed to be present for the

goose to carry out this action. Tinbergen and Lorenz snatched eggs away from geese that were in the middle of their rolling, and they still continued the behavior right through to the end (meaning until they got their beaks inside the nest)”,

to understand that the shape of the stray object is less important than the fact that it is outside of the nest. Students’ should not have corrected this part of the false correction statement if they really comprehended the text they were reading.

It is also important that the student understand the statement from the second paragraph, “The graylag’s egg-retrieval behavior is a paradigm of the fixed action pattern in that geese can do it on their first try, it is stereotyped (all graylags do it the same way)…” so they can make the assumption that all females will behave in the same way when faced with this specific situation, namely an egg outside the nest. In other words, the student reading the text was not searching for single words from the text that had been changed, but instead was asked to understand the reading and apply the read information in such a way as to correct the false statement.

The false statements followed the order of the reading. The following instructions were included with the false statements administered to the students:

All the following statements are **false**.

Read the false statement. Find the corresponding material in the passage. Ask yourself: "Why is this false?" Underline / circle the incorrect words or phrases.

Rewrite the statement so that it is true. (You should use complete sentences.)

Again, it is important to note that the false correction statement was a falsified statement that paraphrased information from the text and was not a verbatim sentence taken from the text and changed to be false. This theoretically asked readers to make inferences about what they have read, which can be evidence of comprehension (Best, Rowe, Ozuru & McNamara, 2005). Using the information contained in the text, one possible correction of the false statement might be, "When a female greylag goose is presented with a stray object outside of her nest, she reaches out with her bill and rolls the object back into the nest."

Posttest

The posttest consisted of true-false items on the text about reflexes, action patterns and social behavior. The students were asked to indicate, by circling either the word true or the word false on the answer sheet, whether each statement was true or false, based on what they had just read, using the provided reading strategy. To show how one posttest item was linked to the reading and one of the false correction strategy statements, the following example is provided. The entire posttest is reproduced in Appendix 7.

> 12. When a female greylag goose sees an object outside of her nest, she often ignores it.
>
> (Correct answer: False)

The portion of the text that relates to this topic, "For a female graylag trying to hatch chicks, an egg *outside* the nest is a matter of great importance, because eggs that are not properly incubated won't hatch. As such, females have a very specific means of getting wayward eggs back inside the nest's perimeter. They reach just beyond the egg with their bills and roll the egg back toward the nest until it is safely retrieved." contains information to answer the posttest item. The posttest item does not refer to a single specific sentence in the text, but asks the student to understand the concept behind the behavior of the female graylag goose when confronted with a stray object, which is described in the text. Great care was taken to generate the posttest items so that they were not testing recall or recognition. Instead, whenever practical, the words were rearranged, different modifiers were used, or entire sentences were paraphrased. In science, it is impossible to change all nouns and verbs to produce pure paraphrased statements, but the researchers tried to avoid verbatim restatements of material from the text in the posttest items, while maintaining the integrity of the content as it relates to the validity of the posttest items. There was no reason to believe that the student students in this study were aware of the graylag goose behavior described in the text prior to the reading activity. It was assumed that the students read the text and made inferences about the material in order to answer this posttest item

There were 65 posttest true-false items based on the text covering reflexes, action patterns and social behavior of animals. These questions were of higher-order thinking, in that they required the students to comprehend and apply the information they had read (Pressley & McCormick, 1995). The test items were not recall items, because we were interested in investigating the effectiveness of a reading strategy on comprehension, which required students to use and apply what they had learned from reading text. Previously laboratory studies examining elaborative interrogation assessed lower-order thinking (Pressley & McCormick, 1995).

Interviews

Students were asked to volunteer to be interviewed following their participation in the study. The volunteers were interviewed by the researcher in a faculty office. Each interview was audiotaped using a digital voice recorder and the resulting audio file was transferred to a computer and stored. At the beginning of the interview, each student was asked a few common questions about the study strategy they used during the study. Sample questions used during the beginning of the interviews are shown below:

What reading strategy, if any, do you usually use when studying?

Which reading strategy did you use during the study?

How effective do you think the strategy is that you used during the study?

Would you use this strategy when studying in the future?

Following these questions, asked of each volunteer, the students were administered the first section of the experimental reading to read again. As the student read, they were asked to "study aloud". Study alouds may be thought of as a form of think alouds, which required students to verbalize their thinking as they were engaged in a task (Ericsson & Simon, 1998). This study aloud protocol was a modified think aloud where the student was asked to verbalize their thoughts as they read the passage, using the same study strategy they used in the original experiment. If students were in the rereading control group, they were asked to study aloud as they read and reread the section of text. If they were in they false-correction experimental group, they were asked to correct the associated false questions that correspond to the section they were reading.

Procedure

Students volunteering to participate completed the study materials during their regularly scheduled course session, lasting approximately 110 minutes. Upon entering the room, the students were asked to take the top envelope from the stack, and one of each of the consent form, verbal ability test, prior knowledge test, and questionnaire. The administrator introduced the study to the students and all volunteers were asked to sign a letter of consent, approved by each university IRB committee. Subsequently, students completed the verbal ability test, then the prior knowledge test. After these two assessments, the students completed a short demographic questionnaire and a short self-efficacy questionnaire. This information provided a profile of the students in the study. After both of these were completed, a set of instructions were read to all students, as described earlier in this chapter. The students were then told to open their envelope, which contains one of the two texts (experimental or other text) and instructions for a specific reading comprehension strategy. The reading comprehension strategies were either read the passage once, read and reread the passage, or read and correct the false statements. After finishing the reading activities, each student was administered a posttest. The posttest was not timed. Reading task completion times were recorded. Students were not limited in terms of reading or test taking time.

Data Analysis

Data collected were in the form of numerical scores from the posttest and written answers for the corrected false statements. Collected data also included scores from the verbal ability test and the prior knowledge test as well as information from the demographic questionnaire and self-efficacy assessment, as mentioned earlier. The numerical scores were subjected to descriptive statistics (means and standard deviations) both as a whole group and for the subgroups, prior knowledge and verbal ability. Prior knowledge and verbal ability scores were used to divide the group into high and low categories for both, using the median score as the cut score (Crawford & Impara, 2001; Ebel & Frisbie, 1991). An analysis of variance was used to determine differences between groups based on posttest scores.

In addition to these analyses, the corrected false statements were analyzed. A rubric for grading the level of correctness for each statement was constructed and the resulting scores were analyzed for correlation to posttest scores. The levels of correctness were adapted from similar research investigating the effectiveness of why questioning during reading (Smith, 2002; Cain 2004; Seifert, 1993) and were used to score the false correction answer as one of the following:

0 - incorrect or no response

1 - partial correct but some incorrect or missing

2 - all acceptable correct

3 - exceptional correct

A regression analysis was performed to determine the strength of predictive value for each hypothesized predictor, namely verbal ability, prior knowledge, false correction study strategy, and self-efficacy score. An item analysis of the posttest items was performed to determine the level of discrimination for each posttest item and for each false correction statement (Ebel & Frisbie, 1991) to show that the questions used were appropriate for this investigation. In addition, correlations and effect sizes were calculated.

Chapter IV

RESULTS

Discussion of strategy groups

The focus of this investigation was to provide evidence as to whether using the novel strategy, false correction, by undergraduate students in a non-majors biology course increased comprehension of a text read during the study. Three groups read biology text followed by a posttest that covered animal behavior. One group, the unrelated reader group, read text about ecology, which did not match the material on the posttest. This group was designed to serve as a baseline control against the impact of prior knowledge on posttest score. The other two groups read the experimental text on animal behavior from their required course textbooks. The rereader group was asked to read the text and then reread it. This is a common placebo-control design used in reading comprehension research (Rawson, Dunlosky & Thiede, 2000) and also a common student practice (Pressley, 2006). The false-correction treatment group was asked to read the text once and correct false statements about the text as they were reading.

Before analyzing the data, all data were subjected to quality control. In other words, even though the students were supervised, not all completed the requested task. Some students refused to cooperate with the researcher, perhaps because there were no negative consequences for nonparticipation. The only direct evidence for this was for the false correction group in that they completed a written task, while the other groups were completing reading only tasks. To determine compliance in the false correction group, the number of blanks present on the correction page was used. Any student not completing more than half the task was removed from the sample. This was the standard used to assess cooperation. It is more difficult to determine compliance for the read only groups, but all students appeared to be reading the text as required by their task assignment. When the times for reading of the unrelated reader group (text length 5872 words) where the students were asked to read once ($M=25.14$ min, $SD=7.06$min) were compared with the times for reading of the rereader group (text length 2633 words) where the students were asked to read the text twice ($M=23.18$ min, $SD=7.27$ min), the reading time difference was significant ($F(1,248)=4.7$, $p=0.03$). The unrelated reader group took slightly longer than the rereader group, which may be accounted for the fact that the unrelated reader text was slightly longer in word length compared to the length of the experimental text, when read twice. This led to the assumption that the students in the two read-only groups, i.e. the unrelated readers and the rereaders, were apparently complying with the task demands. In addition, no evidence was found suggesting that these participants were not cooperating.

At the onset of the study, students were randomly assigned to one of the three groups, unrelated reading, rereading, or false correcting. After quality control was completed, there were 357 students. Of these, 130 were in the unrelated reading group, 130 were in the rereading strategy group, and 97 were in the false correcting strategy group. That is, 33 students failed to provide any responses to six of the twelve false-correction statements.

As a whole, the students were 66% female and 34% male; 74% aged 19 or younger, 24% aged 20-24, and the remaining 2% aged 25 or older. Almost all of the students (99.5%) had taken a biology course in high school, most of whom had taken that high school course within the last four (4) years. Only 12% had taken a college level biology course (not including the current course). There were 31% freshmen, 48%

sophomores, 13% juniors and 8% seniors in the student group. Of those students who gave ethnicity data, 1% were American Indian, 3% were Asian, 7.5% were Black or African American, 2% were Hispanic or Latino, 0.3 % were Native Hawaiian or Other Pacific Islander, and 81% were White or Caucasian.

Random Assignment of Students

Students were randomly assigned to a strategy as they entered the classroom. This occurred prior to the assessment of prior knowledge and verbal ability. An analysis of variance (ANOVA) was used to assure that the groups were balanced in terms of verbal ability and prior knowledge (See Table 1 for the descriptive statistics of the verbal ability and prior knowledge tests).

Table 1: Descriptive Statistics and ANOVA results for Verbal Ability and Prior Knowledge scores

Strategy Group	Verbal Ability Scores	Prior Knowledge Scores
Unrelated reading	M=20.33 SD=5.60	M=14.13 SD=3.16
Rereading	M=21.10 SD=5.48	M=14.02 SD=2.84
False Correcting	M=21.81 SD=5.84	M=14.71 SD=2.52
Df	2,352	2,353
F	1.93	2.24
Significance	0.147	0.108

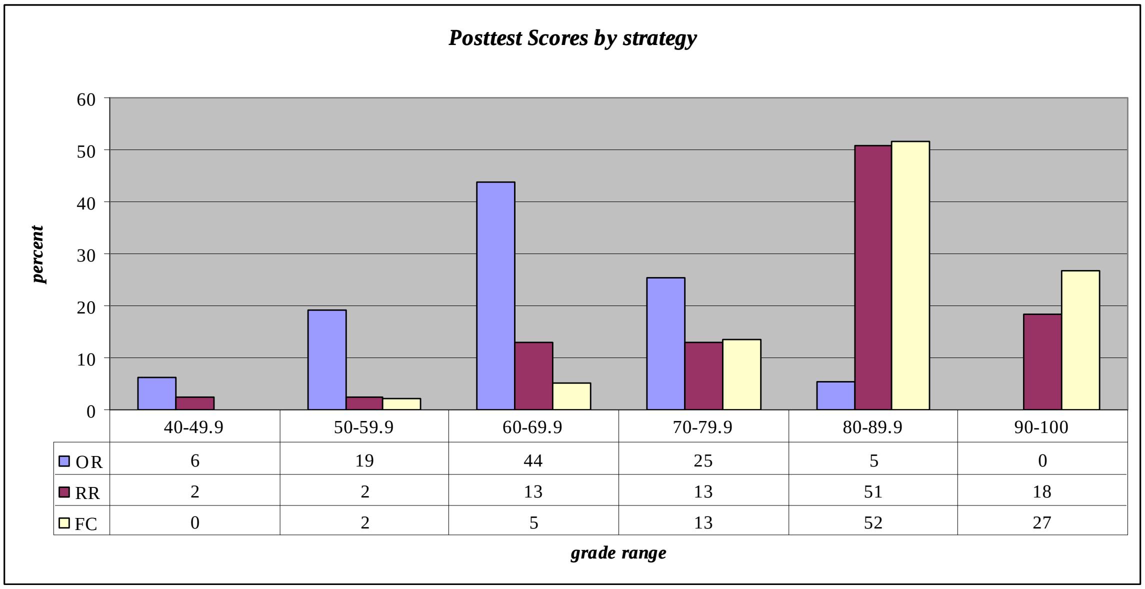
Table 1 shows that there was no significant difference in verbal ability (p=0.15) for the unrelated reading control group (M=20.33, SD=5.60), the rereading control group (M=21.10, SD=5.48), and the false corrector group (M=21.81, SD=5.84). Likewise, there was no significant difference in prior knowledge (p=0.11) for the unrelated reading control group (M=14.13, SD=3.16), the rereading control group (M=14.02, SD=2.84) and the false correction group (M=14.71, SD=2.52). This suggests that the three groups did not differ because of random assignment of students to the three groups.

Posttest score

When separated by group, there was a marked difference in students' posttest scores. The posttest scores for the rereading group had a mean value of 80.9% and the posttest scores for the false correcting group had a mean value of 85.5%. When the posttest scores were separated into grade categories (fig 2), the results were interesting. In the false correcting group, the highest percentage of scores was in the 80-90% range but there were no members of this group who scored in the lowest range (40-50%). In addition, only 7% of the students in the false correcting group had a posttest score below 70%. Of the unrelated reading group, most of the scores (69%) were below 70%, which in many situations is a failing score. In addition, the unrelated reading group did not have any students scoring in the 90-100% range. In the rereading strategy group, the highest percentage of scores (51%) was in the 80-90% range. This group had members score in all grade ranges, with 17% scoring below the 70% score.

To assess the reliability of the posttest as an instrument to measure comprehension of the text that was read, a Cronbach's alpha was calculated. This measures internal consistency of the instrument based on the number of items in the instrument and the average correlation of the items to each other (Groves, Fowler, Couper, Lepowski, Singer & Tourangeau, 2004). For the posttest used in this study, the Cronbach's alpha value was calculated as 0.86.

Figure 2: Posttest scores by strategy



OR: Unrelated reading group; RR: rereading group; FC: false correction group

Correlations of variables

There was a significant correlation (Table 2) between verbal ability and posttest score ($r=0.32$, $p<0.001$) as well as between prior knowledge and posttest score ($r=0.26$, $p<0.001$). Verbal ability and prior knowledge also showed a significant correlation ($r=0.36$, $p<0.001$).

Table 2: Correlation Among Variables

Variable	By Variable	Correlation
Posttest	Prior Knowledge	0.26*
Verbal Ability	Prior Knowledge	0.36*
Verbal Ability	Posttest	0.32*

* $p<0.001$

In addition, a correlation coefficient was calculated to determine if a relationship existed between time on task and posttest score. For the unrelated reading group, there was no significant correlation between time on task and posttest score ($r=0.108$, $p=0.230$). There was no significant correlation between time on task and posttest score ($r= -0.17$, $p=0.874$) for the false correction strategy group. For the rereading strategy group, there was a significant correlation between time on task and posttest score ($r=0.355$, $p<0.001$). .

Setting Cut Scores for Dividing Groups

To evaluate some of the hypotheses of this experiment, groups were divided into high and low categories for that variable. To determine the cut score, or the score where the division would take place, both the median score and the mean score were used (Ebel & Frisbie, 1991). The main delineation was by median score and where students scored exactly at the median, the mean score was used to place those students into either the high or low category. (Table 3) For prior knowledge, the median score was 14 and the mean score was 14.13, so students who scored 14 or below were placed in the low prior knowledge group and students scoring 15 or higher were placed in the high prior knowledge group. For verbal ability, the median score was 21 and the mean score was 18.6, so students who scored 20 or lower were placed in the low verbal ability group and students scoring 21 or higher were placed in the high verbal ability group.

Table 3: Cut Scores for Prior Knowledge and Verbal Ability Grouping

Variable	Median Score	Mean Score	High group	Low group
Prior Knowledge	14	14.3	≥ 15	≤14
Verbal Ability	21	18.6	≥21	≤20

Evaluation of Hypotheses

All hypotheses were evaluated using one-way ANOVA calculations. Each hypothesis is discussed in turn.

Hypothesis 1: Students in an introductory college biology course, when provided with false correction statements adjunct to a reading, will outperform students provided with a reading and asked to read twice on a posttest based on that reading.

Hypothesis 1a: Students using the rereading strategy will outperform the students using the unrelated reading strategy on a posttest.

Table 4: ANOVA Summary Table for Posttest Scores of Rereading Group to False Correction Group

ANOVA

Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	701.4938	1	701.4938	6.419294	0.011969	3.88312
Within Groups	24587.77	225	109.279			
Total	25289.26	226				

5: ANOVA Summary Table for Posttest scores of Unrelated Reading Group and Rereading Group

Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	15885.67	1	15885.67	149.9611	1.74E-27	3.877754
Within Groups	27330.45	258	105.932			
Total	43216.12	259				

Of central importance, the results of the ANOVA (Table 4) show a significant difference between the false correction strategy group and the rereading strategy control group, $F(1,225) = 6.42, p=0.012$. The false correctors ($M= 84.49$, $SD = 9.15$) outperformed the rereaders ($M= 80.93$, $SD = 11.33$) on the posttest. The results of the ANOVA (Table 5) show a significant difference between the rereading group and the unrelated reading group, $F(1,258) = 149.96$, $p=<0.001$. The rereaders ($M= 80.93$, $SD = 11.33$) outperformed the unrelated readers ($M=65.30$, $SD=9.14$).

> Hypothesis 2: Of the false correction strategy users, students with high prior knowledge will outperform students with low prior knowledge on the posttest.

Using information from the two groups reading the animal behavior text, the false corrector group and the rereader group, posttest scores were compared using an ANOVA analysis. The difference was significant, $F(1,226) = 7.42$, $p <=0.01$, with the high prior knowledge group ($M=84.43$, $SD=9.91$) outperforming the low prior knowledge group ($M=80.67$, $SD=10.85$) on the posttest.

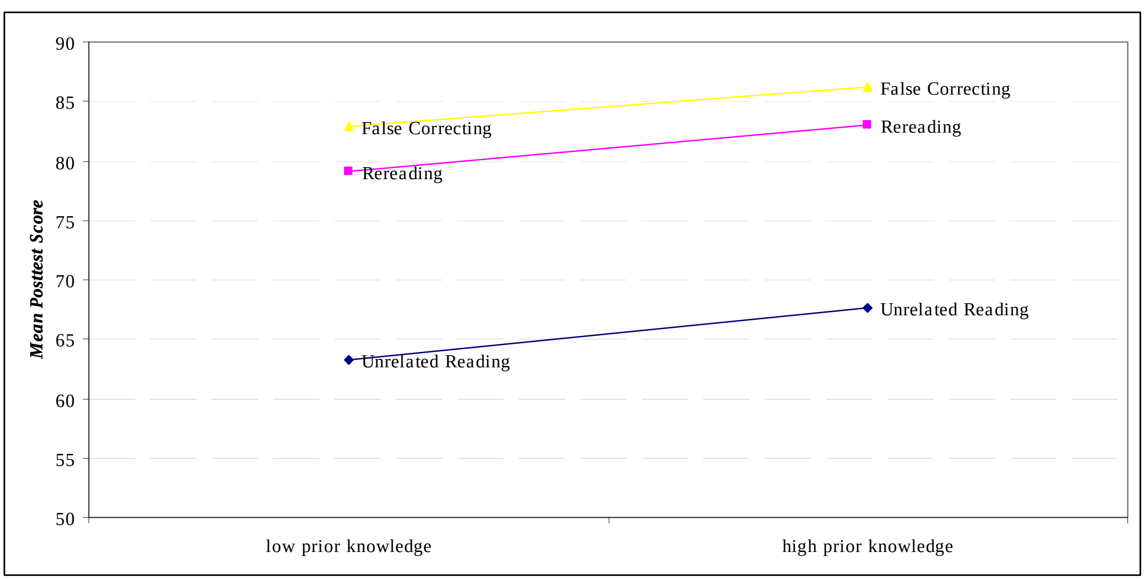
In addition, the results of the ANOVA for the comparison of the posttest scores of the students with high prior knowledge to the posttest scores of the students with low prior knowledge showed a significant difference, $F(1,356) = 10.30$, $p=0.0015$. The students with high prior knowledge ($M=78.55$, $SD=12.47$) outperformed the students with low prior knowledge ($M=74.19$, $SD=13.18$) on the posttest. These data are for all three groups. In other words, for this analysis, all of the high prior knowledge student posttest scores, regardless of assigned reading group, were grouped together and compared to the low prior knowledge student posttest scores, also grouped together.

When the individual groups are analyzed separately (Table 6), high prior knowledge groups outperformed low prior knowledge groups except for the false correction group, where the differences in posttest scores approached significance.

Table 6: ANOVA results for high prior knowledge v low prior knowledge

Strategy	High prior knowledge	Low prior knowledge	Significance Comparing high to low groups
All	M=78.55 SD=12.47 n=167	M=74.19 SD=13.18 n=190	p=0.001
Rereading	M=83.03 SD=11.01 n=61	M=79.09 SD=11.36 n=69	p=0.047
False Correction	M=86.22 SD=8.08 n=47	M=82.86 SD=9.79 n=50	p=0.068

Figure 3: Estimated Posttest Scores for Each Strategy Group, for High Prior Knowledge and Low Prior Knowledge Groups.



As shown in fig. 3, prior knowledge had an impact on posttest score. Students with lower prior knowledge scored lower on the posttest than students with higher prior knowledge.

> Hypothesis 3: Of the false correction strategy users, students with high verbal ability will outperform students with low verbal ability on the posttest.

Using data from the two groups reading the animal behavior text, the false corrector group and the rereader group, the posttest scores were analyzed using an ANOVA. The difference was significant, $F(1,225) = 25.44$, $p<0.001$, with the high verbal ability group ($M=85.38$, $SD=8.46$) outperforming the low verbal ability group ($M=78.61$, $SD=11.80$) on the posttest.

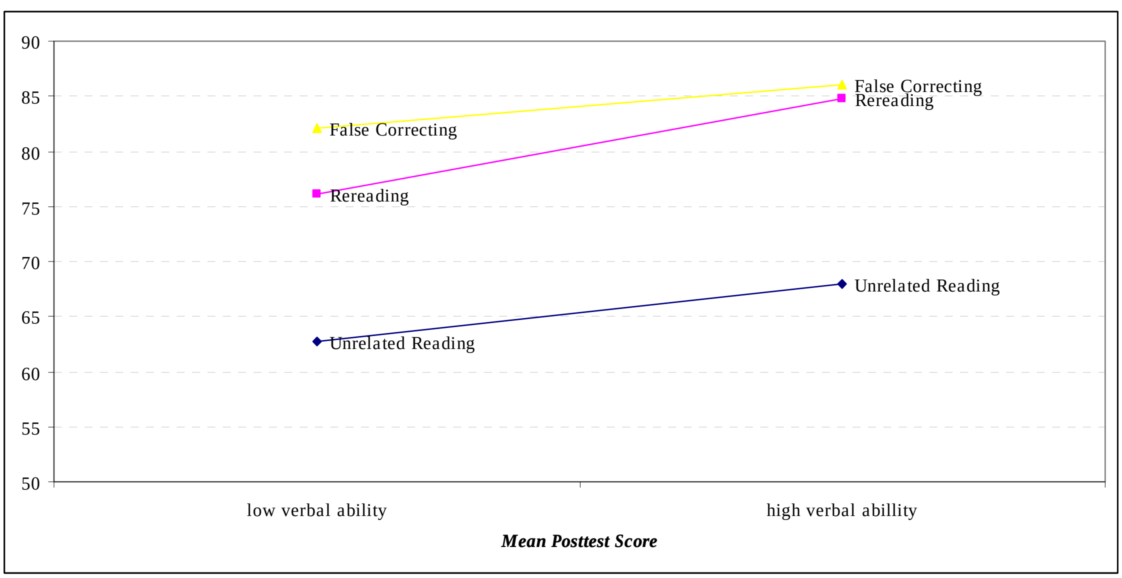
Overall, the results of the ANOVA for the comparison of the posttest scores of the students with high verbal ability to the posttest scores of the students with low verbal ability showed a significant difference, $F(1,353) = 39.84$, $p<0.001$. The students with high verbal ability ($M=80.15$, $SD=11.95$) outperformed the students with low verbal ability ($M=71.83$, $SD=12.86$) on the posttest. These data are for all three groups combined. In other words, for this analysis, all of the verbal ability student posttest scores, regardless of assigned reading group, were grouped together and compared to the low verbal ability student posttest scores, also grouped together.

When individual groups were analyzed, high prior knowledge groups significantly outperformed low prior knowledge groups in all three strategy situations (see Table 7). As shown in the figure 4, verbal ability had an impact on posttest scores. Students with low verbal ability scored lower on the posttest than students with high verbal ability. These data make sense because students with high verbal ability are more able to decode the text as they read, leaving more cognitive space for comprehension of content ideas, rather than for understanding of unfamiliar vocabulary.

Table 7: ANOVA data for high verbal ability v low verbal ability

Strategy	High verbal ability	Low verbal ability	Significance Comparing high to low groups
Unrelated Reading	M=68.02 SD = 9.87 n=59	M=62.77 SD=7.56 n=71	p=<0.01
Rereading	M=84.83 SD=8.50 n=73	M=76.15 SD=12.57 n=57	p<0.001
False Correction	M=86.06 SD=8.42 n=58	M=82.13 SD=9.69 n=39	p=0.035

Figure 4: Estimated Posttest Scores for Each Strategy Group, for High Verbal Ability and Low Verbal Ability Groups.



Hypothesis 4: The false correction strategy treatment, along with prior knowledge, verbal ability, and self-efficacy, will be significant predictors of higher posttest scores.

A stepwise regression analysis was used to determine how much variance was attributable to each potential predictor variable as added each was added to the equation. The first variable to be entered into the regression model was strategy, specifically, the rereading strategy compared to the false correction strategy. The next potential predictor variable entered into the equation was verbal ability, followed by prior knowledge. The final variable entered was self-efficacy. Table 8 shows the results of the regression analysis for each variable as entered into the regression model.

Table 8: Stepwise Regression Analysis for Potential Predictor Variables

Variable	R^2	ΔR^2	B	t
Strategy	0.022^*	0.022	0.148	2.232
Verbal ability	0.163^*	0.141	0.296	6.131
Prior knowledge	0.205^*	0.042	0.209	3.215
Mean self-efficacy	0.210	0.005	0.071	1.160

* Significant at $p<0.001$

Strategy (rereading versus false correction) was a significant predictor of posttest score. Verbal ability and prior knowledge were significant predictors of posttest score, but mean self-efficacy was not a significant predictor of posttest score. Strategy contributed accounted for 2.2% of the variance in posttest score $\Delta R^2=0.022$, F change (1,224) = 4.984, p=0.027. When verbal ability was entered into the equation, it accounted for an additional 14% of variance in posttest score $\Delta R^2=0.141$

F change (1,223) = 37.586, $p<0.001$. The addition of prior knowledge into the regression equation accounted for an additional 4% of variance in posttest score $\Delta R^2=0.042$, F change (1,222) = 11.753, $p<0.001$. All three variables significantly contributed to variation in the regression model with the exception of mean self-efficacy score, which did not significantly predict posttest score.

Effect size was calculated for strategy by dividing the difference of mean posttest scores for the rereading control group and the false correction group by the standard deviation of the rereading control group. This effect size shows how many standard deviations separate the posttest scores of the two treatment groups. The effect size was determined to be 0.46. According to Cohen (1992), an effect size of 0.50 is considered a medium difference. In other words, a medium difference occurs when the two means of central interest are separated by half a standard deviation.

Assessment of False Correction

The false correction statements for all students in the false correction group were scored by the author. There were two additional scorers, who scored a total of 20 false correction papers. The papers scored by the additional scorers were chosen using a random number generator. All the false correction papers were stacked numerically and then the selected papers were pulled from the pile according to the random number list. These were photocopied and the additional scorers were asked to grade them using the rubric they were given. The additional scorers were trained in the scoring process, so they understood the levels of scoring for the false correction papers. The additional scorers were given, as a reference for scoring, a false correction paper with the false portions highlighted along with the corresponding section of text that dealt with that topic. They were asked to score the student generated corrections using a zero to three

(0-3) scoring scale. A score of zero (0) was administered for incorrect responses or blanks. A score of one (1) was administered for partially correct responses, but with either some incorrect information or missing correct information. A score of two (2) was administered for an acceptable all correct response and a score of three (3) was administered for an exceptionally correct response. The scores from the additional scorers were compared to the scores determined by the author to calculate inter-rater agreement. There were high levels of agreement, 94% with scorer #1 and 85% with scorer #2.

Each false correction paper had twelve false statements, with an average of two false sections per statement. Each of the twelve responses was administered a score ranging from zero to three, depending on the level of correctness of the response. Scores for the false correction responses ranged from 15 to 26, with a mean score of 19.7 ($M=19.7$, $SD=2.61$). Sample answers are provided in Table 9.

To assess the impact of the false correction score on posttest score, a correlation was calculated. There was a positive correlation between false correction score and posttest score ($r = 0.54$, $p < 0.001$). There was a negative correlation between number of blank responses and posttest score ($r = -0.51$, $p < 0.001$). These correlations are significant and suggest a relationship between the posttest score and the correction activity in that the not only completing the correction activity, but completing it well gives a greater probability of being successful in comprehension of text. In other words, leaving statements uncorrected or not correcting them completely is apparently a detriment to comprehension, whereas successful correction leads to greater comprehension gains.

Table 9: Sample false correction responses for each level of scoring

Score	False statement (with false portions highlighted)	Associated Text	Response from Student
0	Circadian rhythms follow a monthly pattern and function apart from environmental cues, but noise level is the major environmental cue for entraining circadian rhythms.	Internal cycles, such as those of the cricket's, that last about a day are called circadian rhythms, from the Latin *circa*, meaning "about" and *dies*, meaning "d day". More formally, **circadian rhythms** are biological cycles that function independently of environmental cues and that are roughly synchronized to Earth's 24-hour rotation. Sunlight (or its absence) is the most important environmental cue in entraining circadian rhythms, but various types of biological rhythms are entrained by such factors as temperature, tides, and even the phase of the moon.	Annual clocks follow a seasonal pattern and function apart from environmental cues but they do stay in a state of "migratory restlessness" (student 33-18)
1	Biological rhythms, external clocks for behavior, are seen when chirping crickets conform to a yearly pattern.	Biological Rhythms: The Internal Clock The male *Telegryllus* cricket, when confined to a lab where temperature is held constant and light kept on around the clock, will still chirp almost 11 hours per day, and will begin each new bout of a calling about 25 or 26 hours after the end of the previous bout. The first lesson here is that the chirping is prompted by an internal clock; chirping will continue in a fairly fixed way in the absence of any environmental cues.	Biological rhythms, internal clocks for behavior, are seen in chirping crickets. (student 32-22)
2	A territorial robin will fight to keep rabbits out of its territory because rabbits eat the same food.	**Territoriality** can be defined as the effort an animal makes to keep other animals out of an administered area. In general, territoriality refers to efforts to keep members of one's *own* species from entering an area. Why would a robin be more concerned about another robin than about a rabbit? Because fellow robins will be competing for the same resources – food, nesting space, and mating partners.	A territorial robin will fight to keep robins out of its territory because robins eat the same food. (student 18-24)
3	The female mason wasp lives with a mate and after her eggs hatch, she lives with her offspring until she dies.	Animals vary greatly in their living arrangements. Some live lives of almost complete isolation, while others are in constant contact with other members of their species. At one extreme, consider the female mason wasp (genus *Manobia*), which in her few weeks of life has exactly one moment of contact with another adult member of her species – the moment in which she mates with a male wasp. Other than this, she spends her whole life working alone in the service of her offspring. She lays eggs in hollowed-out plant stems, paralyzes caterpillars (which will serve as food for her young). You might think this would leave her with at least the possibility of having some contact with her offspring once they have matured, but she will die before they emerge from their plant-stem homes.	The female mason wasp had one moment of contact with an adult wasp in her life, she lays her eggs in a hollowed out plant stem but dies before they hatch. (student 1-18)

Time on Task

The length of time each student took while completing their assigned study strategy was recorded and analyzed. In an analysis of variance for time on task for all strategy groups, there was a significant difference in time, $F(2,340) = 35.07$, $p<0.01$. When comparing each strategy to all other strategy groups, there was a small significant time difference between the unrelated reading group compared to the rereading group, $F(1,248) = 4.706$, $p =0.031$. There was a significant difference in time on task for the false correction group compared to both the rereader group, $F(1,215) = 62.15$, $p <0.01$ and the unrelated reader group, $F(1,217) = 37.84$, $p <0.001$. In addition to analyzing the time on task by strategy group, Pearson correlation coefficients were calculated from the gathered time on task data (Table 10) to determine if there were correlations between time on task and posttest score

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Table 10: Analysis of Time on Task for Each Strategy Group

	Unrelated Reading	***Rereading***	***False Correcting***
length(words)	5872.00	2512.00	2512.00
Mean	25.14	23.18	31.57
Standard Deviation	7.06	7.27	8.37
Correlation with Posttest score	0.108	0.355	-0.017
Significance	0.230	<0.001	0.874

The rereading strategy group ($r =0.355$, $p <0.001$) showed a significant but small correlation between time on task and posttest score. There was no significant correlation between time on task and posttest score for the false correction strategy group ($r =-0.017$, $p =0.874$).

Gender and Self-Efficacy

There were no significant differences in posttest score based on gender, $F(1,349) = 0.64$, $p=0.42$. The female students ($M=76.30$, $SD=12.51$) had a slightly higher mean posttest score than the male students ($M=75.10$, $SD=14.26$), but the difference was not significant. There was a significant difference in self efficacy scores based on gender, $F(1,355) = 15.48$, $p < 0.001$. The male students ($M=4.91$, $SD=1.01$) reported higher self efficacy than the female students ($M=4.46$, $SD=0.99$). The median self efficacy score for the males was 5.1 and the median self efficacy score for the female students was 4.5. There was a small significant correlation between self efficacy score and posttest score ($r = 0.23$, $p < 0.001$) for the entire group. When divided by gender, an examination of the correlation between self efficacy score and posttest score showed differences. For the female students, the correlation was not significant ($r = 0.11$, $p=0.10$), while for the male students, the correlation was significant, though small ($r = 0.29$, $p = 0.0015$). Even though the female students scored slightly higher on the posttest, they were not convinced of their self efficacy in science.

Interview Data

Eight students volunteered for interviews. These interviews took place three weeks after the study and were conducted in the author's office. The interviews were audiotaped and downloaded as audiofiles. Of these eight volunteers, two were from the unrelated reader group, one was from the rereader group, and five were from the corrector group. A standard set of questions was used to begin the interview (Appendix 8) and all standard questions were asked of all interviewees. The first question asked about reading strategies currently used by the volunteers. The most common answer was read or reread, followed by taking or rewriting notes and using flashcards. Several students indicated that they read right before a test day, as opposed to reading for studying in general. The most commonly reported method for reading was skimming, followed by reading just the assigned sections, looking for bold words, and looking at the pictures. All of the interviewees from the false correction group indicated that they liked the strategy, even though it was different from their normal strategy. Two students indicated that while they liked the way they learned from using the strategy, they most likely would continue to use a different, more comfortable strategy. The remainder of the interviewees from the false correction group all felt that there was value in using the strategy.

During the study aloud part of the interview, the students were asked to recreate the beginning of the study strategy while studying aloud. The audiofiles of the interviews were reviewed for themes of how the students studied. Themes can be described as concepts that emerge from data (Ryan & Bernard, 2003). Codes were used to get an overall picture of major themes or categories of types of thoughts, which Bogdan and Biklen, (2003), describe as searching the collected data for reoccurrences or emerging categories and recording specific words to represent those categories. According to Strauss and Corbin (1998), every single word of every page of data does not need to be carefully read for codes to emerge. The major codes that emerged from the interviews were “look for / find”, “realize”, “relate”, “match/change”, “read”, “reread”, “rephrase”, and “notice”.

Table 11: Number of interviewee responses in each category

Categories	Example statements from statements	All strategies (n = 8)	Unrelated reading (n=2)	Rereading (n=1)	False Correction (n=5)
Look for/find	Looking for "reflex" Find difference in reading	10	0	1	9
Realize	Realize new information Just realized that I don't know what it said	8	2	0	6
Relate	Relate to other vocabulary	4	2	2	0
Match/change	Match to a false statement	5	1	0	4
Read	I'm just reading I will read the question first	2	0	0	2
Reread	Need to go back and reread it	3	1	1	1
Rephrase	Let me rephrase that	2	1	0	1
Notice	Notice italics and bold Notices incorrect sections	2	0	1	1

There were eight categories that emerged from the study aloud data (Table 11). When split into strategy groups, the false correction interviewees most often verbalized statements falling into the look for / find category, followed by the rereader interviewee. The unrelated reading interviewees did not verbalize anything fitting this code. For the unrelated reading interviewees, the most common themes that emerged were realized and related. For the rereader interviewee, the most common theme was related. For the false corrector interviewees, the most common theme was look for/find. These data are interesting, but with such small sample sizes, they are only indicators that more research in this area in needed.

Chapter V

DISCUSSION

Summary of Study

This study focused on an instructional problem, rather than the basic cognitive psychology problem of increasing students' reading comprehension of textbook materials. No reported cognitive psychology studies have been located that established that interrogatives such as the ones investigated in this study worked under clinical, much less classroom conditions. As an instructional strategy to increase reading comprehension, elaborative interrogation seems to be useful, even when the reading is in science, which normally consists of difficult or unfamiliar text. Because of the nature of the text that is read at the college level, one of the skills undergraduates need in a science class is reading comprehension, since there is a lot of required reading and students typically have several classes each semester. Regardless of the assigned reading load, many students do not have basic reading comprehension strategies or any metacognitive skills, even at the college level (Best, Rowe, Ozuru & McNamara, 2005), which may put some students at a disadvantage.

In reading, the use of strategies can increase comprehension of text (Pressley & McCormick, 1995). Several reading comprehension strategies are currently used by readers in and out of the classroom and are effective in increasing reading comprehension to differing degrees. This study sought, in part, to determine the effectiveness of a novel reading comprehension strategy, false correction. False correction is an adaptation of the elaborative interrogation strategy known as why questioning, where readers are prompted to ask why a specific part of the reading is true. False correction, however, asks the reader to correct false statements about the text as they read; in essence, the readers are asking themselves why a specific statement about part of the reading is not true, and then correct that statement. The underlying purpose of such a strategy was to engage higher levels of cognitive processing by creating a conflict between a statement that is known to be false and the text, which is assumed to be correct. This type of cognitive conflict may increase motivation to resolve the conflict into one's current body of knowledge (Pressley & McCormick, 1995) and may provide another instructional strategy for learners.

A total of 357 students were asked to read science text using one of three reading comprehension strategies, the distribution of which was determined by random assignment. The unrelated reader group read about ecology, using a read through once strategy. The rereader group read about animal behavior (the experimental text), using a read and then read again strategy. The false correction group read about animal behavior (experimental text), using the experimental false correction strategy. All students were timed during their study session and immediately following the study session, were asked to take a posttest on animal behavior. In other words, the unrelated reader group did not know the posttest was on different material than the reading until they were taking the posttest.

Before engaging in the study strategy, students were administered a prior knowledge test on basic animal knowledge and a verbal ability test. This was to determine levels of high and low abilities for each variable. The students also filled out a demographic questionnaire and a self-efficacy assessment.

Findings

Hypothesis evaluation:

The first three hypotheses were evaluated using a one way ANOVA and the fourth hypothesis was evaluated using a regression analysis. Hypothesis 1 posited that students using the false correction strategy would perform better on a posttest than students using the other strategies. This hypothesis was supported. Students using the false correction strategy significantly outperformed both the unrelated reader group and the rereader group on the posttest. A goal of this study was to investigate an alternative interrogative to the why-question approach to activating prior knowledge. The investigated alternative interrogative in this case was characterized as a false correction strategy. A goal of the study was to determine whether the false correction strategy outperformed the standard rereading control group. There is a lot of parallelism with why question approach between the current study and other elaborative interrogation research. In previous studies, elaborative interrogation took many forms. False correction may be a form of elaborative interrogation and the results agree with prior research.

Hypothesis 2 was concerned with the interaction of prior knowledge with outcome, positing that students with higher prior knowledge would outperform students with lower prior knowledge. The prior knowledge test was assessed by a colleague of the author who is an expert in animal behavior, and deemed appropriate for this situation. The hypothesis was supported for the group as a whole, which is in line with previous research on the subject. It is interesting is that, of the three strategy groups, the false correction group did not show a significant difference in posttest scores, which may be interpreted as support for the effectiveness of the false correction strategy. These results may indicate that students with higher prior knowledge in a domain tend to perform better on academic tasks about information in that domain. In other words, regardless of strategy use, having prior knowledge was an advantage when completing the posttest assessment for most students.

Hypothesis 3 posited that students with higher verbal ability would outperform students with lower verbal ability. This hypothesis was also supported. The verbal ability of the students was determined using a commonly used vocabulary test (French, Ekstrom & Price, 1963; Dennis, Sternberg & Beatty, 2000). Students with high verbal ability significantly outscored students with low verbal ability. These results make sense, since a better knowledge of vocabulary tends to correlate with higher comprehension because there is more automaticity of the reading process and therefore more cognitive space to comprehend the material being read (Sadoski & Paivio, 2007).

Hypothesis 4 stated that false correction as a strategy, along with prior knowledge, verbal ability, and self-efficacy, would be significant predictors of posttest scores using a regression analysis. Most of the score variance was due to the use of the unrelated reading strategy, but verbal ability and prior knowledge were also significant predictors of outcome. Self-efficacy scores were found not to be significant predictors of outcome score. However, when separated by gender, self-efficacy scores significantly predicted posttest score for males, but not for females, who tended to underestimate their ability in science tasks.

<u>False correction answers:</u>

The false correction answers were scored for all students in that group. Each student had twelve false statements to correct, each consisting of an average of two incorrect segments. Additional raters, college professors with experience in science education, were trained in the scoring rubric and scored a total of twenty false correction papers, each with twelve false statements. This amounted to about twenty percent (20%) of the total false correction papers. The additional raters' scores agreed with the author's ratings, who scored all the papers. This interrater agreement helps to ensure internal validity. Overall, there was a correlation between the score on the false correction and score on the posttest, indicating that the better a student did with correcting the false statements, the better their posttest score. Also, there was a negative correlation between number of blanks on the false correction sheet and the posttest score. In other words, the more blanks a student left on the false correction paper, the lower their score tended to be. This may be related to motivational issues in general and is an interesting question. It also may indicate that, with practice, this strategy could be even more effective for diligent students.

Self-efficacy and Gender:

Self-efficacy, the belief about one's ability to be successful, has been looked at for college biology students (Baldwin, Ebert-May & Burns, 1999; Lawson, Banks & Logvin, 2007). Research suggests that self-efficacy is often overestimated when compared to actual outcomes. One major point that may play a factor is one of anxiety level for many students when taking science courses or reading science text. Britner (2008) reports that girls tend to have higher anxiety levels then boys when engaged in science activities. If self-efficacy is negatively affected by psychological or emotional issues, performance most likely will also be negatively impacted. Anecdotal evidence from classroom teaching also supports the idea that girls tend to be more anxious about learning science that boys, even at the college level. Although many young men and women in college report a dislike for science, anecdotally, female students more often report emotional stress than do the male students.

Gender issues in science have been well documented (see AAUW, 2004). Although the gender gap seems to be closing (AAUW, 1998, AAUW, 2004), there are still steps to be made. Stereotypes about gender and science still abound and affect choices students make when choosing coursework and parents still tend to underestimate a daughter's ability to achieve in science (Pajares, 2002; Beghetto, 2007). Attitudes about science are present early in elementary school and many times are not changed, even by programs designed to increase motivation and attraction to STEM (science, technology, engineering and mathematics) college majors and careers.

Girls tend to be more confident in reading and writing than in math and science and tend to have higher levels of anxiety about science (Britner & Pajares, 2006; Britner, 2008). If a girl's self-efficacy in science is low, then her achievement is most likely affected, as self-efficacy usually is a strong predictor of science achievement (Pajares, 2002). What is interesting in this study is that the self-efficacy scores of the female students did not reflect their achievement scores on the posttest; rather the self-efficacy scores of the female students underestimated their achievement. This corresponds to findings from Britner (2008), who found that, in life science, although the girls earned higher scores than the boys, they did not report higher levels of self-efficacy. If this could have been reported to the female students, there is the chance that their motivation and attitudes about science would improve. Indeed, according to Britner (2008), the major factor in lowering girls' self-efficacy scores was anxiety about perception of failure in science classes, a major social issue.

Comparison to other studies

In a study of the major topics of interest for educational psychologists, studies of reading and literacy were the most common, with studies on motivation and learning theories close behind (Smith, Plant, Carney, Arnold, Jackson, Johnson, Lange, Mathis & Smith, 2003). As reading and literacy are major topics of experimental studies, this research on the effectiveness of a novel reading comprehension strategy is well timed and an appropriate addition to the literature base.

Validity of Study

Lysynchuk, Pressley, d'Ailly, Smith & Cake (1989) reported that many reading comprehension strategy studies had problems with both internal and external validity. Efforts were made in the design of this experimental study to prevent as much error as possible. To preserve internal validity, a posttest only design was used to avoid the Hawthorne effect, interrater agreement was assessed and the posttest items were subjected to analysis. In addition, internal validity was protected by using random assignment of students to strategy group and time spent on task was recorded. Another threat to internal validity, as found by Ridgeway, Dunston & Qian (1993) concerns training administered to students. For this study, all students were administered the same set of instructions for the overall study session, and members of each study strategy group received written instructions about their assigned strategy. To ensure internal validity through statistical analysis, all important statistical information has been included in the results section (namely, test type used, degrees of freedom, F values and probability levels).

In terms of external validity, the population has been well described and the instruments used have been tested and discussed. The setting of the study was authentic, in that it occurred in a normal classroom during a normal course session. This use of an authentic situation, as well as using authentic text, allows for better generalization to practitioners (Ridgeway, Dunston & Qian, 1993). Another major threat to external validity is one of transfer effects (Lysynchuk, Pressley, d'Ailly, Smith & Cake, 1989). Most studies assess short term effects of reading comprehension strategies, but in authentic learning settings, long term effects are very important. Although this study investigated the short term effects of the false correction strategy, one future direction would be to increase the time between the use of the strategy and the posttest.

Compliance of Students

It is not surprising that several students from the false correction strategy group did not complete at least half of the false correction paper. One reason for this noncompliance may have been the realization that the posttest scores would not be considered in their course grade. Students may refuse to exert cognitive effort even when such exertion may result in a learning benefit. The precise reason most students cooperate while others do not remains a matter of conjecture. We do not view the noncompliance of students who refused to engage in the false correction strategy as a limitation of this instructional study in science education. No cognitive strategy that takes learning effort is going to be adopted by all students, especially when the penalty for noncompliance does not exist, and the rewards for students who are uninterested in academic success are either not apparent or perceived as unattainable. Another possible reason for noncompliance of several students in the false correction group may have been that all students could see other students, since the experiment took place during a normal class session. Seeing other students who did not have a writing activity may have played a role in the lower compliance of students who did have the writing activity.

In a recent study of the effectiveness of elaborative interrogation strategy, students were either paid for their time or were given extra credit (Ozgungor & Guthrie, 2004). The students in the current study were not given additional credit or compensation for their participation, to make the study as authentic as possible.

Time on Task

There was a significant difference in time on task when all three strategy groups were compared. The false correction strategy group took significantly more time to complete their task than either of the reading groups, either the unrelated reading group, who read a 5800 word text once, or the rereading group, who read a 2500 word text twice. Ozgungor & Guthrie (2004) found similar results when they compared groups rereading text and using why questions. In their study, the students took longer to read and answer why questions than those who were rereading the text and not answering why questions. They hypothesized that much of that time difference was due to the physical writing activity, but suggested that time effects on reading need more investigation. Indeed, many elaborative interrogation studies do not report time on task statistics. The time it takes to enact a strategy is important, especially when that strategy is used in authentic classroom situations, designed to increase learning.

There was a significant correlation for all students between time on task and posttest score. The only experimental study comparing why-question strategy to rereading in science (Smith, 2002) did not find such a correlation, but did not report individual group time statistics, so it is not known whether there was a significant correlation between time and posttest score for each treatment group. Indeed, in the current study, when the time on task was compared to posttest score for the false correction group, there was no significant correlation. Calendar and McDaniel (2007) discuss the importance of time for elaborative interrogation studies, implying that without information about time on task, it is difficult to determine the impact of the strategy alone. They reported times for strategy groups, but found that the times did not significantly differ between the questioning groups and the rereading group. The reason that this study found time differences between the rereader group and the false corrector group remains a mystery. Perhaps there is an impact of the increased level of cognitive difficulty hypothetically provided by the false correction activity.

Elaborative Interrogation in Science

Recent studies of the use of elaborative interrogation in science have shown that using elaborative interrogation increases comprehension when reading science text. Smith (2002) showed that this was the case for students using elaborative interrogation when reading college level biology. Students answering why questions while reading scored significantly higher than students using rereading as a strategy. This was also the case in most previous elaborative interrogation studies in general reading comprehension of prose. Based on these results, it can be stated that the use of strategies when reading needs to be appropriate to the type of text being read. It would be interesting to see future studies using other reading strategies for comprehension of procedural knowledge in science, as well as studies of the use of elaborative interrogation, both why questioning and false correction, in conjunction with diagrams.

There is evidence from previous research using elaborative interrogation in psychology that supports that using the strategy activates students' prior knowledge (Callender & McDaniel, 2007) and results from this study agree. This study was slightly different in that it showed that even students with low prior knowledge benefited from this strategy. In fact, in this study, there was no significant difference in posttest scores for students using the false correction strategy, regardless of their level of prior knowledge. This is an interesting finding that should be further investigated.

In terms of verbal ability, the findings of this study also agree with that of former research. Students with higher verbal ability outperform students of lower verbal ability in all groups. This makes sense, since the task was a reading comprehension task, where verbal ability, especially when measured by vocabulary test score, is highly germane to task completion.

The quality of answer to the elaborative interrogation was consistent with the findings of Smith (2002), but not of previous research (for example: Martin & Pressley, 1991; Pressley, Wood, Woloshyn, Martin, King & Menke, 1992), where quality of answers to the why questions was less important than using the strategy itself. This may be due to the nature of the text used in these studies. Smith (2002) was using biology text with an audience similar to those used in this study while students of the previous research were reading prose. It is assumed that the intentional writing of the answers to the elaborative interrogations, whether in the form of why questions or false correction statements, requires more cognitive processing, resulting in better learning of the reading. This is supported by data from Smith (2002) and by the current study, where there was a strong correlation ($r=0.54$) between high scores on false correction statements and high score on posttest.

Implications

Special attention needs to be paid to the construction of the false statements. The false statements can be thought of as a type of short answer question and, according to

Ebel & Frisbie (1991), short answer questions should be written as clearly as possible, with the intended answer in mind. In addition, they maintain that test writers should avoid verbatim worded questions as that stimulates the students recall knowledge rather than testing for understanding. The false statements were not simply statements taken directly from the text with one or two words changed to make the statement false. Rather, time was taken to ensure that the false statement, when corrected, would require the corrector to assimilate a passage of text. There is some danger in taking this strategy and using it without forethought and planning of the false statements. Just as all strategies to increase learning should be used judiciously, so should this new false correction strategy.

A second issue to consider is that of textbooks themselves. Science textbooks, especially those at the college level, tend to be difficult to read (Simpson & Nist, 2002). To assist students in comprehending text in these textbooks, it is advisable to encourage the use of reading comprehension strategies, since many students do not spontaneously use strategies as they read (Pressley & McCormick, 1995). Generally, science text requires the readers to infer meaning from several statements (Best, Rowe, Ozuru & McNamara, 2005), which can be difficult for many students. Teachers can use direct instruction methods to teach reading comprehension strategies, which should improve reading comprehension ability. Many textbooks have added questions, either in the margins of the text or as summary questions at the end of chapters. While these questions are useful, it would be helpful to investigate the effectiveness of such questions, especially if used in conjunction with elaborative interrogation questions, such as why questions or false correction statements.

Thirdly, motivation in science achievement must be addressed. For non-science majors, taking a college level science course can be daunting. One important aspect for increasing motivation in a non-majors biology course is that of relevance. Many students are not motivated, seeing no relevance to their own career paths (Glynn, Taasoobshirazi & Brickman, 2007). Both textbooks and instructors have an impact on students' attitudes toward science and, as much as possible, both material from the assigned text and information given by the course instructor are better served when they are couched in relevant societal context. As stated before, motivation can impact self-efficacy, which can impact performance, so motivation, especially in science, is vital.

Future directions

There are several directions for this research to take, such as more support for false correction strategy in science reading, testing false correction strategy in other content areas, testing false correction for other age ranges, and testing false correction strategy with a longer delay time between the study session and the testing session, as well as investigating the impact on long-term retention.

It would be interesting to test the false correction strategy in other levels of biology coursework, specifically for college biology majors and high school biology students. For the college biology majors, it can be assumed that motivation is already present, since the selection of the science major was intentional. This may be an interesting population to use, specifically to determine whether the self-efficacy scores for female students would again be lower than outcome of achievement. For the high school population, it would be interesting to see how self-efficacy scores compared to posttest scores, since this population is required to take the class. Also, at the high school level, societal and peer issues are extremely important factors in self-efficacy image. It would also be interesting to see if there were gender differences in outcomes for this age level.

Another area of future research would be to test the false correction strategy for reading in other content areas. While reading and understanding science content is important, other content areas are just as important and students studying those topics could benefit from using this reading comprehension strategy. Most elaborative interrogation studies were done using prose, so that would be an interesting first choice of text to test the effectiveness of false correction in another content area.

One major issue that needs attention is that of the time delay between studying and testing in an authentic setting. While this study was conducted in an authentic setting with authentic text, the timing between the study session and the testing session was extremely short. In authentic classroom settings, studying usually precedes testing by at least a few hours, or overnight. It would be advisable to test the effectiveness of the false correction strategy in a long term situation, either assigning the false correction as homework or class-work a day or so ahead of the testing session.

Limitations

This study builds on previous studies of elaborative interrogation, especially those using science text. The sample population of the study was adult college students enrolled in a non-majors introductory biology course at a Mid-Atlantic comprehensive university. The reported results may or may not apply to other educational settings.

One thing to note is the absence of a treatment group using the why question strategy. This is not to suggest that why questioning is not an effective strategy for this type of task. The intention of this study is to asses the effectiveness of an alternate strategy, not to compare the effectiveness of the false correction strategy to that of why questioning. That is an interesting empirical question that should be investigated, but is not part of the scope of this study. This study seeks to add to the existing tool kit of effective strategies that students can make use of as they attempt to learn from text.

There were eight volunteers for the interview portion of the study. This section of the study was not extensive and was a first attempt in this domain to collect information about what students thought and felt about the strategy. This portion of the work is underdeveloped and there is no attempt to argue that these data obtained from the interviews represent the rest of the participants' points of view.

Summary

In summary, the elaborative interrogation strategy, false correction, hypothetically activates students' prior knowledge in such a way as to increase reading comprehension in science. The implementation of reading comprehension strategies supports the idea that reading is an active process where the reader is constructing an understanding of the text by assimilating new knowledge with prior knowledge. False correction as a strategy lessens the need for prior knowledge and allows those readers with low prior knowledge about a topic to better comprehend that text. When using false correction, as with other questioning strategies, the reader is prompted to infer meaning from text in order to answer the question or correct the false statement. The potential instructional value of this strategy should suggest more research in this area. Without more investigation, it isn't known whether this strategy will be effective for other educational settings, so these research findings do not support the use of this strategy in a classroom setting yet. While there is evidence for the effectiveness of false correction on increasing reading comprehension, there are still many questions, such as the impact of visuals and the importance of time of assessment (long term effects).

Appendix 1

Consent Form

Initials _______ Date ______

CONSENT FORM

Project Title	Using False-Correction reading comprehension strategy to improve science learning in undergraduate non-science majors.
Why is this research being done?	This is a research project being conducted by Dr. William Holliday at the University of Maryland, College Park and Cynthia Ghent at Towson University. We are inviting you to participate in this research project because you are a student in a non-majors introductory biology course. The purpose of this research project is to determine the effectiveness of correcting false statements during text reading as a strategy to improve comprehension.
What will I be asked to do?	The procedure involves either reading a passage from a biology text or reading the text while correcting false statements. After the reading or reading and correcting sessions, the students will be asked to answer comprehension questions based on the passages just read. This study will take place at Towson University. The study will span one semester, with each participant being asked to take a comprehension test at the end of the study session. There will also be a test of prior knowledge and a vocabulary test administered prior to the start of the study. Each study session will take place during a laboratory class period.
What about confidentiality?	We will do our best to keep your personal information confidential. To help protect your confidentiality, the written work will be stored in a locked file cabinet in an office on the campus of Towson University. If we write a report or article about this research project, your identity will be protected to the maximum extent possible. Your information may be shared with representatives of the University of Maryland, College Park or governmental authorities if you or someone else is in danger or if we are required to do so by law. In accordance with legal requirements and/or professional standards, we will disclose to the appropriate individuals and/or authorities information that comes to our attention concerning child abuse or neglect or potential harm to you or others.
What are the risks of this research?	There are no known risks associated with participating in this research project.
What are the benefits of this research?	This research is not designed to help you personally, but the results may help the investigator learn more about how students learn biology. We hope that, in the future, other people might benefit from this study through improved understanding of learning strategies used at the undergraduate level.

Project Title	Using False-Correction reading comprehension strategy to improve science learning in undergraduate non-science majors.	
Do I have to be in this research? May I stop participating at any time?	Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify. Participation is not a course requirement. You and your class members have other options for earning the same amount of credit. If you do not wish to participate, an alternative laboratory assignment will be administered to you.	
What if I have questions?	This research is being conducted by Dr. William Holliday in the Curriculum and Instruction Department at the University of Maryland, College Park and Cynthia Ghent in the Biology Department at Towson University. If you have any questions about the research study itself, please contact **Dr. Holliday** at: (email) holliday@umd.edu (telephone) 301-405-3135 or **Cynthia Ghent** at**:** (email) cghent@towson.edu (telephone) 410-704-5918. If you have questions about your rights as a research subject or wish to report a research-related injury, please contact: **Institutional Review Board Office, University of Maryland, College Park, Maryland, 20742; (e-mail) irb@deans.umd.edu; (telephone) 301-405-0678** Or Dr. Patricia Alt, Chairperson of the **Institutional Review Board for the Protection of Human Participants at Towson University: (email) palt@towson.edu); (telephone) 410-704-2236**. This research has been reviewed according to the University of Maryland, College Park IRB procedures for research involving human subjects and has also been reviewed according to the Towson University IRB procedures for research involving human subjects.	
Statement of Age of Subject and Consent	*Your signature indicates that:* *you are at least 18 years of age;,* *the research has been explained to you;* *your questions have been fully answered; and* *you freely and voluntarily choose to participate in this research project.* **[*Please note: Parental consent always needed for minors.]***	
Signature and Date	**NAME OF SUBJECT**	
	SIGNATURE OF SUBJECT	
	DATE	

Appendix 2

Prior Knowledge Test

Animal Kingdom   Please put answers on answer sheet

1. Each of the following is a characteristic of at least some animals EXCEPT
a) being single celled
b) being multicellular
c) lack of cell walls
d) being a heterotroph

2. All of the following are advantages of a body cavity EXCEPT
a) providing room for heart expansion
b) allowing the stomach to enlarge during feeding
c) allowing radial symmetry
d) allowing flexibility – organs can slide around relative to one another

3. As a marine zoologist, you discover an animal new to science. It has segmentation, an exoskeleton, jointed appendages, and chelicerae. It might be a form of
a) spider
b) insect
c) horseshoe crab
d) barnacle

4. A starfish is
a) marine
b) carnivorous
c) an echinoderm
d) all of the above

5. Which of the following groups of animals does NOT have any members with amniotic eggs?
a) mammals
b) amphibians
c) snakes
d) birds

6. Which pair of vertebrates are most closely related to each other?
a) coelacanth – mammals
b) amphibians – snakes
c) turtles – *Archaeopteryx*
d) dinosaurs – birds

7. Birds and mammals share all of the following characteristics EXCEPT
a) reptilian ancestry
b) lungs
c) light hollow bones
d) vertebrae

8. All of the following are types of mammals EXCEPT
a) opossum
b) duck-billed platypus
c) kangaroo
d) all are mammals

9. Which of the following is FALSE?
a) Invertebrate animals greatly outnumber vertebrate animals.
b) While all animals are multicellular, some are microscopic.
c) There are many more kinds of marine animals than terrestrial, in part because animals first evolved in the ocean.
d) All modern reptiles are closely related to one another.

10. The study of animals is called
a) botany
b) zoology
c) anatomy
d) ecology

11. Groups of cells that perform a special body function make up
a) organ
b) tissue
c) gland
d) limb

12. Groups of cells with a common function make up
a) organ
b) tissue
c) gland
d) limb

13. Which two systems work together to bring oxygen into your body and deliver it to your cells?
a) urinary and cardiovascular
b) lymphatic and endocrine
c) respiratory and cardiovascular
d) respiratory and digestive

14. A top predator may increase the diversity of species lower on the food chain by
a) decreasing competition
b) increasing competition
c) reducing genetic diversity in prey species
d) only feeding on one type of prey

15. If a caterpillar eats a seedling in your garden, the caterpillar is acting as a
a) predator
b) prey
c) parasite
d) host

16. A very tasty butterfly evolved to have the same coloration of a butterfly that it is not closely related to but has high concentrations of extremely toxic compounds in its wings. This is an example of
a) parasitism
b) mimicry
c) camouflage
d) mutualism

17. A wolf eats a rabbit that eats grass on a prairie in Wisconsin. The wolf is a
a) producer
b) primary consumer
c) secondary consumer
d) prey

18. A seed-eating finch is an example of a
a) producer
b) primary consumer
c) secondary consumer
d) prey

19. Moss in the understory of a forest is a
a) producer
b) primary consumer
c) secondary consumer
d) prey

20. The common ancestor of all animals is likely to have been a(n)
a) colonial flagellated protist
b) colonial ciliated protist
c) colonial flagellated bacterium
d) colonial plant

21. Which of the following statements best reflects what animal behavior research asks?
a) How can the behavior of living things be changed?
b) How does the behavior of animals compare to that of bacteria?
c) What do animals do and why do they do it?
d) What is the nature of the animal genome?

22. A toad which eats a bee and is stung, thereafter avoids bees. This is an example of
a) imprinting b) insight
c) trial and error behavior d) instinctive behavior

23. A predator returns to a location where it had recently found food. This is an example of
a) operant conditioning b) insight
c) classical conditioning d) habituation

24. You are on a beach and you see a swimmer being attacked by a shark. Which of the following would be an altruistic act on your part?
a) jumping in the water to save the swimmer
b) using your cell phone to call 911
c) getting a lifeguard
d) grabbing your video camera to tape it for the news

25. A behavior that decreased the reproductive success of one individual to the benefit of another is known as
a) kin selection b) the selfish gene theory
c) altruism d) natural selection

26. Much of the altruism displayed among animals probably can be explained as
a) a genuine concern for one another
b) a lack of understanding of its consequences
c) the reproductive benefits that can come through aiding relatives
d) imprinting on the behavior of others

Appendix 3

Verbal Ability Test

Reading Assessment: Vocabulary Quiz

Name________________ *Circle the best definition or synonym for each word below.*

1. cottontail
   a. squirrel
   b. poplar
   c. boa
   d. marshy plant
   e. rabbit

2. marketable
   a. partisan
   b. jocular
   c. marriageable
   d. salable
   e. essential

3. boggy
   a. afraid
   b. false
   c. marshy
   d. dense
   e. black

4. gruesomeness
   a. blackness
   b. falseness
   c. vindictiveness
   d. drunkenness
   e. ghastliness

5. loathing
   a. diffidence
   b. laziness
   c. abhorrence
   d. cleverness
   e. comfort

6. bantam
   a. fowl
   b. ridicule
   c. cripple
   d. vegetable
   e. ensign

7. evoke
   a. wake up
   b. surrender
   c. reconnoiter
   d. transcend
   e. call forth

8. unobtrusive
   a. unintelligent
   b. epileptic
   c. illogical
   d. lineal
   e. modest

9. terrain
   a. ice cream
   b. final test
   c. tractor
   d. area of ground
   e. weight

10. capriciousness
    a. stubbornness
    b. courage
    c. whimsicality
    d. amazement
    e. greediness

11. maelstrom
    a. slander
    b. whirlpool
    c. enmity
    d. armor
    e. majolica

12. tentative
    a. critical
    b. conclusive
    c. authentic
    d. provisional
    e. apprehensive

13. placate
    a. rehabilitate
    b. plagiarize
    c. depredate
    d. apprise
    e. conciliate

14. surcease
    a. enlightenment
    b. cessation
    c. inattention
    d. censor
    e. substitution

15. apathetic
    a. wandering
    b. impassive
    c. prophetic
    d. hateful
    e. overflowing

16. paternoster
    a. paternalism
    b. patricide
    c. malediction
    d. benediction
    e. prayer

17. opalescence
    a. opulence
    b. senescence
    c. bankruptcy
    d. iridescence
    e. assiduity

18. lush
    a. stupid
    b. luxurious
    c. hazy
    d. putrid
    e. languishing

19. curtailment
    a.expenditure
    b.abandonment
    c. abridgment
    d. improvement
    e. forgery

20. perversity
    a. adversity
    b. perviousness
    c. travesty
    d. waywardness
    e. gentility

21. calumnious
    a. complimentary
    b. analogous
    c. slanderous
    d. tempestuous
    e. magnanimous

22. illiberality
    a. bigotry
    b. imbecility
    c. illegibility
    d. cautery
    e. immaturity

23. clabber
    a. rejoice
    b. gossip
    c. curdle
    d. crow
    e. hobble

24. sedulousness
    a. diligence
    b. credulousness
    c. seduction
    d. perilousness
    e. frankness

Circle the best definition or synonym for each word below.

25. shortcake
    a. condiment
    b. pastry
    c. fruit
    d. sweetmeat
    e. vegetable

26. hardtack
    a. nail
    b. textile
    c. weapon
    d. wood
    e. biscuit

27. commendable
    a. pleasurable
    b. charitable
    c. lucrative
    d. proscriptive
    e. laudable

28. nonchalant
    a. sarcastic
    b. discourteous
    c. noble
    d. unconcerned
    e. unsophisticated

29. coloration
    a. pigmentation
    b. alteration
    c. configuration
    d. prevention
    e. taint

30. aridity
    a. bitterness
    b. surface
    c. sonority
    d. dryness
    e. torridity

31. demoniacal
    a. aloof
    b. mythical
    c. thoughtful
    d. fiendish
    e. eccentric

32. highroad
    a. mountain road
    b. right of way
    c. main road
    d. roadbed
    e. concrete road

33. befog
    a. dampen
    b. forget
    c. whip
    d. mystify
    e. belittle

34. platoon
    a. tableland
    b. bridge of boats
    c. body of soldiers
    d. remark
    e. frigate

35. dullard
    a. peon
    b. duck
    c. braggart
    d. thief
    e. dunce

31. momentously
    a. frivolously
    b. moderately
    c. weightily
    d. momentarily
    e. modishly

37. corroboratory
    a. plausible
    b. anticipatory
    c. confirmatory
    d. explanatory
    e. esoteric

38. figurine
    a. metaphor
    b. wine
    c. poem
    d. organ
    e. statuette

39. rancorous
    a. malignant
    b. jubilant
    c. abashed
    d. inglorious
    e. careless

40. inveteracy
    a. habitualness
    b. migration
    c. bravery
    d. covering
    e. hatefulness

41. choler
    a. anger
    b. chorister
    c. guard
    d. saliva
    e. refrigerator

42. vacillation
    a. purification
    b. wavering
    c. expulsion
    d. tempting
    e. foolishness

43. aggrandizement
    a. theft
    b. impeachment
    c. derision
    d. amazement
    e. enlargement

44. effulgence
    a. prominence
    b. outline
    c. change
    d. radiance
    e. energy

45. aphasia
    a. loss of speech
    b. drunkenness
    c. anemia
    d. loss of memory
    e. rash

46. panoplied
    a. philosophic
    b. armored
    c. panting
    d. frenzied
    e. atavistic

47. sacrosanct
    a. sacrificial
    b. dormant
    c. inviolable
    d. superficial
    e. gullible

48. prurience
    a. modesty
    b. sapience
    c. provender
    d. lust
    e. security

Appendix 4

Demographic and Self-efficacy Instrument

Please circle the number that best describes how you feel for each statement.
1= not at all true 7= very true

I believe I will receive an excellent score on the tests in this study.

1 2 3 4 5 6 7

I am certain I can understand the most difficult material presented in the reading for this study.

1 2 3 4 5 6 7

I am confident I can understand the basic concepts presented in this reading.

1 2 3 4 5 6 7

I am confident I can understand the most complex material presented in this reading.

1 2 3 4 5 6 7

I am confident I can do an excellent job on the tests in this study.

1 2 3 4 5 6 7

I expect to do well on the tests in this study.

1 2 3 4 5 6 7

I am certain I can master the material being presented in this reading.

1 2 3 4 5 6 7

Considering the difficulty of this subject matter and my skills, I think I will do well on the tests in this study.

1 2 3 4 5 6 7

Gender:
___Male ___Female

Age:
___ 19 or younger ___ 20-24 ___ 25-29 ___ 30-34 ___ 35 and older

Taken college biology (not including this class): ___Yes ___No

Taken high school biology: ___Yes (how long ago? ____) ___No

Status in college:
___Freshman ___Sophomore ___ Junior ___Senior ___ Other

College GPA: ___________

Ethnicity: (not required)
_____ American Indian or Alaska Native
_____ Asian
_____ Black or African American
_____ Hispanic or Latino
_____ Native Hawaiian or other Pacific Islander
_____ White or Caucasian

Appendix 5

False Correction Statements

Name ______________

All the following statements are **false**.
Read the false statement. Find the corresponding material in the passage.
Ask yourself: "Why is this false?" Underline / circle the incorrect words or phrases.
Rewrite the statement so that it is true. (You should use complete sentences.)

1. A reflex, a slow intentional response, is stereotyped behavior that is performed in different ways by different individuals of different species.

2. A female graylag goose will retrieve any stray object that is egg shaped and outside the nest by reaching out with her wing and roll the object back to the nest.

3. Any object that is red will trigger the releaser behavior of head down swimming in swordfish.

4. When moths fly toward any loud sound, they are showing positive taxis.

5. Biological rhythms, external clocks for behavior, are seen when chirping crickets conform to a yearly pattern.

6. Circadian rhythms follow a monthly pattern and function apart from environmental cues, but noise level is the major environmental cue for entraining circadian rhythms.

7. Migratory birds that are in captivity exhibit orientations that follow those of insects of the same habitat area.

8. The female mason wasp lives with a mate and after her eggs hatch, she lives with her offspring until she dies.

9. Zebras gather in groups to groom each other but live alone when they travel.

10. Social behavior has many costs but no benefits, as seen when diseases are spread through members of a group very slowly.

11. The caste system of wolves consists of the dominant female, who controls the entire group, and the males who live at the periphery of the group.

12. A territorial robin will fight to keep rabbits out of its territory because rabbits eat the same food.

Appendix 6

Instructions

Instructions to students

Each person in the room should have an envelope. Do not open it until the instructor says to open it. In this experiment, we are looking at different ways students study when they read about biology. Different people in the room will be doing different kinds of studying while they read. We do not know which strategy is better and hope this experiment will give us some answers. There are several pages to fill out before the study begins: a consent form, a page with questions about your thoughts on how you will do during this study and some demographic information, a vocabulary test designed to assess your verbal ability, and a short test to see how much you know about the animal kingdom. Then you will begin the study by following the directions provided with the reading in your packet. After you have completed the study, bring your packet to the front of the room and you will be administered a test that covers the material you have read, to see how much you have learned by using your study strategy.

Instructions to Other Reader Group

Please read the entire text once

Instructions to Rereader Group

Please read the supplied text entirely and then go back and read it again.

False Corrector Group

Instructions to All the following statements are **false**.
Read the false statement. Find the corresponding material in the passage.
Ask yourself: "Why is this false?" Underline / circle the incorrect words or phrases.
Rewrite the statement so that it is true. (You should use complete sentences.)

Appendix 7

Posttest

Answer sheet Name ____________________

1. True	False	23. True	False	45. True	False
2. True	False	24. True	False	46. True	False
3. True	False	25. True	False	47. True	False
4. True	False	26. True	False	48. True	False
5. True	False	27. True	False	49. True	False
6. True	False	28. True	False	50. True	False
7. True	False	29. True	False	51. True	False
8. True	False	30. True	False	52. True	False
9. True	False	31. True	False	53. True	False
10. True	False	32. True	False	54. True	False
11. True	False	33. True	False	55. True	False
12. True	False	34. True	False	56. True	False
13. True	False	35. True	False	57. True	False
14. True	False	36. True	False	58. True	False
15. True	False	37. True	False	59. True	False
16. True	False	38. True	False	60. True	False
17. True	False	39. True	False	61. True	False
18. True	False	40. True	False	62. True	False
19. True	False	41. True	False	63. True	False
20. True	False	42. True	False	64. True	False
21. True	False	43. True	False	65. True	False
22. True	False	44. True	False		

1. Reflexes happen immediately and involuntarily.

2. Reflexes are learned behaviors.

3. When the doctor checks your reflexes by hitting a small rubber hammer on your knee, your leg moves slowly in a fixed action pattern.

4. Reflexes are behaviors that are stereotyped.

5. Stereotyped behavior is seen in some members of a species and is a learned behavior.

6. Egg rolling is a stereotypical behavior in greylag geese.

7. Reflexes happen the same way every time for all members of a species.

8. For female greylag geese, any egg outside of the nest must be collected.

9. Greylag geese carry out the egg retrieval pattern the very first time the try it.

10. When a female greylag goose sees an object outside of her nest, she ignores it.

11. A female greylag goose will retrieve a square shaped object from outside the nest.

12. Female graylag geese only retrieve objects that are outside of the nest if they are eggs.

13. If the female greylag goose loses the egg during the retrieval behavior, she stops the behavior.

14. Releasers are triggers that induce action patterns.

15. An example of a releaser is the open mouths of baby birds that cause the parent birds to feed them.

16. Male stickleback fish tend to swim aggressively and bite when shown the color red.

17. Any object that is painted red, even if it is not fish shaped, will act as a releaser to trigger the head down action pattern in male stickleback fish.

18. Male stickleback fish swim with their heads down when show the color red.

19. The color red on a something other than a fish can induce head down posture in male stickleback fish.

20. Releasers can be visual images, sounds, odors, or even tastes.

21. Orienting behavior occurs in both plants and animals.

22. When plants bend to grow toward a light source, they are exhibiting positive taxis.

23. An example of positive taxis is when moths fly away from high frequency sounds.

24. An example of taxis is seen when a seed is planted upside down, but the roots will twist around to grow down.

25. Taxis occurs when a seed is planted upside down, but the roots twist around to grow down into the soil.

26. Crickets held in a laboratory, will chirp at regular intervals even when there is no information about the outside.

27. When a male cricket in a lab is exposed to a strict cycle of 12 hours of light followed by 12 hours of dark, it will still chirp at random times.

28. Behaviors are influenced by signals from the outside as well as internal clocks.

29. An example of an external cue is when squirrels are entrained by the light-dark cycle.

30. In plants and animals, biological clocks are regulated by external cues like sound.

31. Circadian rhythms are annual clocks.

32. Circadian rhythms can be entrained by cues like sunlight, temperatures or tides.

33. Annual clocks affect migratory birds in the wild, but not those in captivity.

34. Migratory birds have annual clocks.

35. Because of annual clocks, captive birds orient themselves in the same directions as their free-flying relatives.

36. Mason wasps live in social groups except during mating.

37. Zebras are social animals and when herds travel, they set the pace with the fastest animal, and any animals that can't keep up are left behind.

38. Ants and termites are social insects that live in large groups and they benefit from this by having higher survival rates.

39. Migrating birds benefit from flying in formation as a social group because only the leader knows the migration route.

40. Very few animals live in social groups.

41. Since the female mason wasp spends her life preparing for her young, by laying eggs in protected plant stems, and stocking the nests with food, we would consider her a social animal.

42. Animals live in social groups when the benefits outweigh the costs of being in groups.

43. Horses are social herd animals, so they live together during mating and grooming, but not during travel and feeding.

44. Migrating birds benefit from flying in formation as a social group because only the leader knows the migration route.

45. Animals that do not live in social groups are sad and wish they did.

46. Ants and termites are social insects that live in large groups and they benefit from this by having higher survival rates.

47. A cost of social behavior is shown when a group of penguins crowd together during the mating season.

48. When a herd of social animals like gazelle look for water, they travel the speed of the slowest member of the group.

49. Disease is a cost of social grouping because disease spreads more rapidly when the organisms are close together.

50. When musk oxen all turn and face outward when a wolf is nearby, they are gaining a benefit from being in a social group.

51. One benefit of social behavior is seen in prairie dogs when they alert each other when predators are near.

52. Dominance hierarchies exist in all animal populations.

53. Dominance hierarchy is a pattern of power where higher ranked animals have control over the behavior of lower ranked animals.

54. The caste system of wolves is an example of dominance hierarchy.

55. Some birds display dominance hierarchy when all the males get equal access to females during the mating season.

56. An example of dominance hierarchy is when the dominant wolves get food before other members of the pack.

57. Territoriality occurs when animals stake out the boundaries of where they live.

58. Territoriality occurs only in the spring, when animals are finding food.

59. An animal that is territorial attempts to keep animals of different species out of its defined area.

60. Birds aren’t territorial because they are so small.

61. Male songbirds tend to be territorial during mating seasons.

62. Rabbits and robins are territorial towards each other.

63. Animal groups exhibit either territoriality or dominance hierarchies.

64. The size of an animal affects whether groups of that animal show dominance hierarchy or territorial behaviors.

65. Territoriality exists only in large, fierce animals and is directed toward animals of other species.

Appendix 8

Interview Questions

1. You are asked in your course to read an assigned portion of your biology textbook. Let's assume that you will be tested on the assigned portion of the book. Under these conditions, what do ordinarily you do?

2. What reading in your textbook do you do, and how do you read, in preparation for course tests?

3. During the reading experiment, you were asked to study while you read. Describe what you did to study the learning materials in this reading experiment.

4. What was your first impression of the way we asked you to study from the reading material?

5. How do you normally study when using your biology textbook?

6. Did you like the way we helped you to learn from the printed science materials?

7. Did the way that you studied seem to help you learn the science materials?

The next part of the interview is a "study aloud" section. I would like you to repeat a section of the initial science reading study that you participated in earlier. I want you to talk constantly from the time we start this section until the end. You do not need to plan what you say – just say everything that comes to your mind. The most important thing is to keep talking during this part. If you are silent for more than three seconds, I will remind you to keep talking. Do you have any questions? I will give you a practice exercise to get you used to "studying aloud".

Practice exercise (for all)
Please think aloud as you answer the question. Remember to vocalize everything you think. I would like you to name ten animals – I will keep track of the numbers.

For control groups (rereaders and other readers)

Please read the first paragraph of the text from the experiment. As you do so, please "study aloud". This is more than just reading aloud. Vocalize, articulate or say out laud to me anything you think about as you try to learn the material you are reading.

For false correctors: Please read the first paragraph of the text from the experiment along with the first false statement you were administered. As you do so, please "study aloud". This is more than just reading aloud. Vocalize, articulate or say out laud to me anything you think about as you try to learn the material you are reading. Please vocalize what you are thinking as you correct the false statement.

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