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# The Interaction Between The Reader And The Reading Situation: The Roles Of Text Cues, Reading Tasks, And Individual Differences In Reading Ability

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# THE INTERACTION BETWEEN THE READER AND THE READING SITUATION: THE ROLES OF TEXT CUES, READING TASKS, AND INDIVIDUAL DIFFERENCES IN READING ABILITY

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First, I would like to dedicate my dissertation to my parents for all their love and support, especially for believing in me. Second, I would like to dedicate my dissertation to my major professor Rick Wagner for all his positive comments and support. I really respect and admire him. I would also like to thank my committee for their valuable time. Lastly, I would like to dedicate my dissertation to all my friends and family members who never gave up on me, especially Tash who gave me a kick in the pants when I needed it and Aunt Mary for all the cards and commiseration. I will "dare to let myself be the woman I am becoming."

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## ABSTRACT

Text cues indicate to the reader where and how to direct his or her reading-related processing. Findings in the text cue literature are mixed. The reading task and individual differences in reading ability might account for these results. A dichotomous view of the reader's ability to actively process text has been prevalent for many years. Some researchers see the reader as passive and some see the reader as active. A new view has emerged in the last few years: the view of the reader as interactive. Proponents of this view think that all aspects of the reader, such as individual differences, and the reading situation, including the reading task, influence text processing. The present experiment examined these three views using the methodology of the text cue literature, as well as an on-line measure of text processing. If readers are interactive, then they should process target information according to the presence of cues, the type of information contained within the target sentence, and aspects of the reading task, such as comprehension question type.

College students read experimental texts and answered comprehension questions after each text. Embedded within the texts were summary target sentences and importance target sentences from which reading time data was collected. These sentences contained information that was conceptually important to the texts. There were two versions of each text. In one version of a text half the target sentences were preceded

by a text cue sentence and half were not. In the other version of the same text, the text cue sentences were placed before the target sentences that had not been preceded by text cue sentences in the other version. Only one type of text cue sentence ever preceded a target sentence. Importance text cue sentences preceded importance target sentences, and summary text cue sentences preceded summary target sentences. What made a sentence important or a summary was the type of information contained with in the sentence.

After reading each text the participants' task was to answer either summary comprehension questions or importance comprehension questions. The type of comprehension question participants answered was the aspect of reading task manipulated. Participants answered only one type of question throughout the experiment.

How the quantity of a participant's reading situation knowledge influenced their cognitive processing was assessed by comparing the reading times and comprehension question from the first text participants read to the second text they read. During the first text participants had no idea what type of comprehension question they were to answer, so they only had previous experience with comprehension questions to guide their processing decisions. During the second text, participants had knowledge of the type of question that they were most likely going to be asked. This variable was titled text presentation order.

Finally, an aspect of the reader was measured. Participants were grouped by Individual differences in reading comprehension. The participants were divided into two reading level groups, good and poor readers, by use of the VSAT test.

The results of this study support the view of the reader as interactive. For the first text, the type of target sentence and the presence or absence of text cue sentences did not make a significant difference. However, after having answered comprehension questions for the first task, participants knew what to expect of from their reading task and could use this information to guide their cognitive processing while reading the second text. Results from the second text show that there were processing differences between participants in the importance question condition and participants in the summary question condition. Surprisingly, there was no effect of individual differences in reading ability, and only one variable was significant for the comprehension question data. These findings could be due to the measure of individual differences in reading ability chosen for this experiment. Question type was the only variable that influence the number of correct comprehension questions. No differences in the total number of correct answers to comprehension questions fits with some text cue research that has found no general differences in the remembrance of text cued and non text cued information. These results indicate a complex interaction between the reader, the reading situation, and the reading task.

# INTRODUCTION

How well a reader understands a text depends on the interaction between the reader and the reading situation. A reading situation is "a specific type of text read for a specific purpose" (Lorch, Klusewitz & Lorch, 1993, p. 375). Elements of the reading situation can create connections between information and act as cues to accessing relevant networks of knowledge in memory. Text cues are "information in the text that does not add new content on a topic, but points out aspects of the structure of the text or gives emphasis to certain aspects of the topic content" (Meyer, 1984, p. 19). Text cues indicate to the reader where and how to direct his or her reading-related processing. The extent to which text cues can facilitate reading comprehension may depend on characteristics of the reader and aspects of the reading situation. It may also depend upon the reading task. The reading task might help shape the goal and/or expectations of the reader, and in doing so, influence the search for text cues and the processing of cued information. To understand the interaction between the reader and the reading situation, this dissertation will investigate how text cues, reading tasks, and individual differences in reading comprehension ability interact to influence text processing and the reader's mental representation. Specifically, how these factors interact to assign importance to to-be-processed textual information, how that designation influences text processing, and how that processing influences the outcome of comprehension.

The end product of reading comprehension processes can be characterized as a coherent mental representation of written text in long term memory (Ericsson & Kintsch, 1995). The more connections there are among the elements in the mental representation, the more coherent the representation (Graesser, Singer, & Trabasso, 1994). The more coherent a mental representation is the more understandable and memorable a text is to the reader (Graesser et al., 1994).

For years researchers have debated the extent to which readers search for cues, and under what circumstances they create a coherent mental representation. Some researchers believe that readers are passive processors (e.g. McKoon & Ratcliff, 1992). They claim that unless text cues are present, readers do not try to create a coherent mental representation. Other researchers believe that readers are active processors (e.g. Goldman, Saul, & Coté, 1995; Graesser et al., 1994; McNamara, Kintsch, Songer, & Kintsch, 1996; Pressley, El-Dinary, & Brown, 1992; Pressley, Wharton-McDonald, Rankin, El-Dinary, Brown, Afflerbach, et al., 1997). According to this view, readers are always seeking to create a coherent mental representation, even in the absence of text cues. These two views are limited in the scope of reading processes and outcomes that they can explain. There is an alternate view that explains the interaction between the reader and the reading situation across a variety of circumstances, and including the effects of reading tasks and individual differences in reading comprehension. This position describes the reader as interactive (van den Broek, Young, Tzeng, & Linderholm, 1999).

Only a few experimental measures have been employed by researchers in the text cue literature. Researchers primarily use off-line measures such as recall protocols and comprehension questions to determine the effect of text cues (e.g. Golding & Fowler, 1992; Lorch & Lorch, 1995; Meyer, Brandt, & Bluth, 1980; Yuill & Joscelyne, 1988; see Lorch, 1989 for a review). These measures do not quantify the processing of textual information, only the outcome of such processing. On-line measures such as reading times can begin to quantify the interaction between text cues, individual differences, and reading task as readers process textual information. Together on-line and off-line measures can capture the scope of reading processes and outcomes. In this way a complete picture of reading comprehension can be obtained.

## Reading Comprehension: The Roles of Text Cues, Reading Tasks, and Individual Differences

Aspects of the reader and the reading situation constrain the reader's cognitive processes, and in doing so, shape the reader's mental representation of a text. However, whether the reading task and individual differences in reading comprehension ability constrain the selection of text cues and the processing of cued information is not clear. Most researchers in the text cue literature have not studied the interaction between text cues, reading tasks, and individual differences in reading comprehension ability.

There are many types of cues (see Lorch, 1989 for a review). Text cues can be *lexical* (e.g. the use of the words first or important), *typographical* (e.g. underlined), or *semantic* (e.g. explicit statements about the topic of a paragraph). Different text cues signal different types of information, they vary in the scope of information they signal (e.g. a sentence versus a paragraph), they differ in the ambiguity of which textual elements that they cue (e.g. an underlined sentence is less ambiguous than a heading preceding a sentence), and some cues are more visually distinctive than others (e.g. a typographical cue is more visually distinctive than a lexical cue) (see Lorch, 1989 for a review).

The role that all cues share is that of directing the reader's attention to specific information, either to the text content that is most important to the text or to the text structure (Lorch, 1989). Text structure is the organization that binds the text together. The result is that nearly all types of cues in a text produce better memory for cued information and better memory for information consistent with a coherent mental representation of a text (Lorch, 1989). Text cues influence both the distribution of ideas recalled (i.e. information is accessed about more topics) and the organization of recall (i.e. recall more closely follows the top-level and conceptual structure of the text) (Lorch, 1989; Lorch & Lorch, 1996; Meyer & Rice, 1989). Less is known about how text cues directly affect readers cognitive processing, but typical results show that cued information is read more slowly than information that is not cued (e.g. Lorch, 1989; Lorch & Lorch, 1986; Lorch, Lorch & Klusewitz, 1995).

Individual differences in reading comprehension ability may influence the reader's processing of cued information. There are mixed results in the text cue literature. Some studies have reported that a reader's accuracy in picking out text cues and his or her understanding of what those cues imply for cognitive processing depends on characteristics of the reader (e.g. Lorch & Lorch, 1986; Meyer & Rice, 1989; Yuill & Joscelyne, 1988). The forms these differences have taken vary across studies. Some studies have reported that better recallers are more affected by text cues (e.g. Lorch, 1985), but other studies show that better recallers are less affected by text cues (e.g.

Lorch & Lorch, 1986). Other text cue studies have reported little or no differences between the text cue use of good and poor readers (e.g. Loman & Mayer, 1983).

These mixed results suggest that either the type of individual differences measurement employed makes an impact on the results, or some other factor is influencing the effect of individual differences. For example, in Lorch and Lorch's (1986) first experiment, they examined the contribution of three measures of individual differences: a test of vocabulary skills, a measure of reading speed, and a recall score. Both the measure of reading speed and the recall score had independent effects on the magnitude of text cue results (Lorch & Lorch, 1986). However, the reading task may be the other factor that is interacting with text cues and individual differences. If readers don't understand a task or don't know how to apply their understanding, they will not recall the same type of information as those who do (Winograd, 1984). For example, Winograd (1984) instructed poor readers to write a summary of a text. Winograd found that poor readers knew a summary should contain important elements from a text, but they had different views than good readers about which ideas in a text were important. Furthermore, poor readers were also not as likely as good readers to include what they thought was important in their summaries.

Although text cue research has not clarified the role of reading tasks, research in other areas of the reading literature shows that reading tasks helps assign importance to textual information just as text cues do (de Jong & Ferguson-Hessler, 1996; Schmalhofer & Glavanov, 1986). However, unlike the assignment of importance by text cues that is based on text constraints, the assignment of importance conferred upon information by reading tasks is based on task constraints. So, if a task constraint highlights the importance of certain text segments, readers use task-relevant information to selectively process those segments at encoding (Schraw et al., 1993). Furthermore, some researchers have reported that readers process information in a text according to the reading comprehension task, regardless of whether the information is of high text-based importance (e.g. Schraw, Wade, & Kardash, 1993). When task demands necessitate that readers process information differently, or when it is necessary to look for different types of information to fulfill a task, there is a difference in outcomes, even though the text is the same. For example, in Schmalohofer & Glavanov's (1986) experiment, as a consequence of different encoding instructions, the type of processing and the type of cognitive product changed for their participants. Readers under summarization instructions focused more on the meaning of the text and remembered propositional information better. Readers under knowledge acquisition instructions focused more on the situation in the text and retrieved more situational information. Only if information is irrelevant or no task is given, do readers rely primarily on text-based importance (e.g. Schraw et al., 1993).

Because text cues signal the importance of information to the text structure, the research of Schraw and others (e.g. Schmalohofer & Glavanov, 1986; Schraw et al., 1993) would imply that task constraints supercede the influence of text cues. The reading task might shape the reader's expectations and goals, and in doing so, influence both the selection of cues and the processing of cued information. However, researchers disagree over the extent to which readers are motivated to search for cues and engage in reading-related processes to create and update their mental representations (Lorch & Lorch, 1995).

**Reading Comprehension: The Activity Level of the Reader**

All readers are necessarily processing information in a text in some way or another, but the extent to which readers are actively doing so and the outcome of their reading-related activities has been the focus of much research and debate. A dichotomous view of the reader's ability to actively process text has been prevalent for many years. Some researchers claim that readers are passive processors. Other researchers claim that reading is an active process (e.g. Goldman et al., 1995; Graesser et al., 1994; Lorch & Lorch, & Mathews, 1985; Lorch et al., 1993; McNamara et al., 1996; Pressley et al., 1992; Pressley et al., 1997). A new viewpoint has emerged in the past few years, the two purposes of which are to integrate on-line and off-line aspects of reading and to promote the view that reading is an interaction between the reader and the reading situation (van den Broek et al., 1999).

According to the view of the reader as passive, readers create the most minimal representation that they can (e.g. McKoon & Ratcliff, 1992). Proponents of this view claim that unless readers are forced to engage in more complex processes (i.e. if the text does not "make sense"), or unless they are guided to do so by text cues embedded in the text, readers will not engage in these processes so on their own. These researchers believe that under most circumstances readers are too passive to do more than encode a text as a temporally organized list of facts or events to be memorized (e.g. Loman & Mayer, 1983; Meyer et al., 1980; Meyer & Rice, 1989). They do, however, propose that when text cues are present, readers focus their attention on the top-level or conceptual structure of the text to which text cues usually point (e.g. Loman & Mayer, 1983; Meyer et al., 1980; Meyer & Rice, 1989). This is accompanied by reading information that follows text cues slower, than when the same information is not preceded by a cue. Proponents of this view assert that any differences in recall that might occur between readers reflect corresponding differences in how the text was encoded when text cues were present versus when they were absent from the text. At recall, readers who do not see text cues in their text would not remember top-level or conceptual information as well as those who did have text cues, nor would any text cues relating to the top-level or conceptual structure help them because the mental representations of both groups would be structured differently.

According to proponents of the active reader view, all readers are highly motivated to create a coherent mental representation of a text based on the conceptual and structural nature of a text, regardless of whether or not text cues are present. Proponents of an active reader suggest that cued information is read slower than uncued information because readers know to devote more elaborate processing to cued information. If text cues are present, readers use them to pinpoint the hierarchical and conceptual structure of the text and organize their mental representations accordingly. If text cues are not present, readers still try to create a coherent mental representation based on the structure of the text. However, they have to use other methods to help them identify important conceptual and structural information, and they have to create their own retrieval cues to that information. Therefore, readers without text cues try to create a similar mental representation to readers that do have text cues, one based on the text, but their successfulness at a creating such a representation would depend on how accurately they identify conceptual and structural information and how accurately they create retrieval cues to that information. The closer a reader's retrieval cues were to the conceptual structure of a text, the better he or she would do at recalling conceptual information.

Readers who see text cues at encoding are presumed to recall more conceptual and structural information than readers who did not see text cues at encoding because their accessibility to that information at retrieval is greater, but this may not be true in all cases. Readers who see text cues at encoding should have better retrieval cues, the text cues present in the text. However, according to some proponents of the active reader position (e.g. Lorch & Lorch, 1995), if the text cues the one group of readers saw at encoding were also presented to the group of readers who read the same text without cues, the text cues would help both groups. In fact, proponents of this idea suggest that the results for the two groups would be similar; they would recall a similar amount and the same kind of information. This would be due to the fact that both groups should be trying to retrieve the same information, the information that is important to the conceptual and structural nature of the text. The only difference between those who did and those who did not have text cues at processing would be in the accessibility of information. Providing text cues would close the gap between the two groups so that important textual information would supposedly be equally accessible to both groups.

Proponents of both views assume that when text cues are present all readers are trying to create a similar coherent mental representation. Furthermore, proponents of both views believe readers are creating mental representations with the same strategy, the "structure strategy" proposed by Meyer (e.g. Meyer & Rice, 1989). Readers use the structure strategy to build an integrated representation that reflects the hierarchical organization of the text and the relative importance of its conceptual content. However, these assumptions do not address individual differences in strategy use or that aspects of the reading situation and/or reading task might supercede the effects of the hierarchical structure of the text.

Recent research proposes a view of the reader as interactive (van den Broek et al., 1999). The emphasis of this research is on patterns of activation and how those patterns result in a coherent mental representation (van den Broek et al., 1999). As the reader progresses through a text, his or her mental representation is progressively refined and constrained. With each new reading cycle new concepts are activated, some old ones are retained, and others are removed from the focus of attention. In this way concepts are activated to different degrees depending on the current state of the interaction between the reader and the reading situation and the reading task. The implication of this view is that a wide variety of mental representations are possible, even when readers are reading the same text. So, the importance of text cues could vary across readers.

According to proponents of this view, more than just text cues influence text processing. Aspects of the reading situation and the reading task may act as assigners of importance and be used as retrieval cues to textual information. The benefit of readers recognizing cues in the reading situation and the reading task is that doing so may simplify decision-making about the importance of information and may reduce the number of inferences they would otherwise have to make (Goetz, Alexander, & Schallert, 1987; Lorch, 1989). This would result in faster processing of irrelevant or less important information, and slower processing of important information. The importance of text information would depend on the reader, the reading situation, and the reading task.

According to the interactive reader viewpoint, the focus of research into individual differences between readers would not be on the activity level of readers so much as on the types of cognitive processing decisions that they make. These decisions would then determine which aspects of the reader, the reading situation, and the reading task were the most important influences on text processing. These decisions would be limited by differences in attentional capacities, knowledge, and cognitive processing (van den Broek et al., 1999). Therefore, the difference between good and poor readers may be the result of the good reader being better able recognize and apply aspects of the reading situation and the reading task. They may have a better conception of the type of processing different materials and different reading situations require, and they could, therefore, make better processing decisions. This would lead to good readers more accurately, effectively, and efficiently guiding their text processing and creating their mental representations. However, poor readers also try to process text information, and some times they are as successful as good readers. This would explain why significant individual differences in reading comprehension ability do not always occur in the text cue literature. The type of reading situation may determine the extent to which individual differences impact text processing. For example, individual differences may be more apparent when the reading task is demanding or the text is difficult (e.g. Goldman et al., 1995).

Although readers may not consciously know the concept of information processing, they do know that some materials require different processing than others (McDaniel & Einstein, 1989). They seem to base their processing decisions, at least in part, on aspects of the reading situation and the reading task. For example, Lorch, Klusewitz, and Lorch (1995) investigated readers' ability to make distinctions among different reading situations. They presented participants with several reading situations each of which specified a reading material and a purpose for reading the material. The participants were asked to sort the examples of reading situations into their own categories according to the strategies they used in each reading situation. The data from this study produced seven categories of school reading situations and six personal reading situations. One reading category for school situations is "reading to memorize" (Lorch et al., 1995, p. 282). Under this type one goal is to "read a chemistry text to prepare for a lab exam on identifying components" (Lorch et al., 1995, p. 282). An example of a type of personal reading is "reading to apply" (Lorch et al., 1995, p. 288). Readers place the goal, "read a hobby magazine to learn about a particular pastime" (Lorch et al., 1995, p. 288) under the category "read to apply." On the other hand, if a reader reads without a specific purpose, and with the expectation that they will not be held accountable for the material, they read superficially (Lorch et al., 1995). This research suggests that the more specific the goal, the more selective the reader is in processing a text. Assuming that their goal is to accomplish their reading task, readers should pay more attention to text cues that lead to task-relevant information than those that don't.

The viewpoint of the interactive reader indicates that a wide spectrum of coherent mental representations is possible. Researchers would have to take into consideration all aspects of the reading situation and reading task when conducting research. The fact that these variables have not been thoroughly investigated or controlled for in the text cue literature may explain the mixed results in this area.

## Text Cue Literature: The Good, the Mixed, and the Confounded

Analysis of previous research in the text cue literature lends credence to the idea that aspects of the reader, the reading situation, and the reading task interact with text cues. Aspects of the reading task have both intentionally and inadvertently been investigated in the text cue literature. The reader's expectations about their task, the type of information necessary to fulfill their task, and the cognitive demands of their task all seem to make an impact on the processing of cued information. Individual differences also play a role. However, whether text cues and aspects of the reader and the reading task conflict with one another, or one supercedes the others, or they work in concert to shape the reader's mental representation is debatable.

Glynn and DiVesta (1979) presented readers with adjunct questions that corresponded to particular statements in a text that were either underlined or not. Underlining is a typographical cue. Sometimes the experimental questions explicitly referred to the underlined material and sometimes not. They found that there was only a facilitative effect of underlining on memory when the adjunct questions matched the underlined material. This research would seem to indicate that the readers' expectations and understanding of their task made underlined material irrelevant when it did not fit the task. However, this experiment has some problems with a potential uncontrolled variable; the instructions implicitly rendered non-underlined information irrelevant (Lorch et al., 1995). Thus, it is no wonder that recall of unsignaled information was depressed.

Golding and Fowler (1992) also investigated the interaction between task and underlining. Some participants were told that they would be asked questions about details of a text and others were told that they would be asked to list general information (Experiment 1) or outline the text (Experiment 2). All participants were only tested on details of the text. So, some participants received the same test about which they were initially informed, but the other participants received a test other than the one they were expecting. In both experiments text cues only increased recall performance when a reader's expectation about a subsequent test matched the cued information that was tested. The results of this study do not support a general facilitative effect of cues.

According to more recent research by McNamara, Kintsch, Songer, and Kintsch (1996), there may be an alternate explanation for Golding and Fowler's (1992) results than the match between reader expectation and text cues. Their findings might be an artifact of the type of information measured, the type of task, and/or the type of cue present in the text. The detail questions focused on information from the microstructure of the text, but the other tasks focused upon information from the macrostructure of the text. McNamara, Kintsch, Songer, and Kintsch (1996) found that the benefit of text cues depended on whether or not the microstructure or macrostructure was measured and which type of cue, macro cues (e.g. topic headers) or micro cues (e.g. sentence connectives) were present in the text. Unfortunately, there is no mention of the types of cues present in Golding & Fowler's materials.

McNamara and her colleagues found that in general readers recalled more macro-propositions than micro-propositions. However, the presence or absence of macro cues did influence the number of propositions recalled. For text containing macro cues, macro-propositions were recalled more often than micro-propositions. For texts without macro cues, even if there were micro cues present, there was no difference in recall between macro-propositions and micro-propositions. Plus, there was very little difference in the recall of micro-propositions across the four text conditions (macro and micro cues present, macro and micro cues absent, or only one type of cue present).

Therefore, Golding and Fowler (1992) might have found different results depending on their treatment of several confounding variables in their experiment. If they had measured macro-propositions, instead of, or in addition to, micro-propositions, they may have thought that cues have a general facilitated effect on text processing. However, this conclusion would depend upon the type of text cues present in the texts, macro or micro. Differences in the type of tasks readers were told to expect also confounded the experiment. Participants in the general and outline groups would likely have recalled more macro-propositions than the detail group because the tasks of the general and outline groups were conducive to remembering macro-propositions, perhaps regardless of the types of cues present. The facilitative effect of cues would depend upon the type of information measured, the type of measure, and the type of cue present in the text.

Richgels and his colleagues (Richgels, McGee, Lomax, & Sheard, 1987) conducted research that supports the influence of reading task and type of information measured. These researchers found that participants showed a varying level of awareness of text structures depending on the task (e.g. recall) and text structure type (e.g. problem/solution). All else being equal, the awareness of different text structures changed depending on the task used to measure that awareness, and which structure was recalled the most depended on the task. Written recall is one of the most prevalent off-line measures in text cue research, but Richgels and his colleagues discovered that it is the least informative measure of text structure awareness, compared to organization of compositions and responses to interviews about text structure (Richgels et al., 1987).

Richgels and his colleagues (Richgels, McGee, Lomax, & Sheard, 1987) suggest that the differences in text structure awareness among the three tasks result from the different cognitive demands the three tasks placed upon the participants. The recall task was the least demanding of the three tasks. The other two tasks required more initiative on the part of the participants. The suggestion to use text structure to organize their responses was less concrete. Plus, the third task, answering interview questions about passage structure, required the ability to analyze the reader's own performance. This study indicates that researchers need to be more aware of the cognitive demands of their experimental tasks and the degree to which participants need to show initiative to be successful at them. Because text cues point to text structure, it is likely that the way in which task influences the remembrance of text structure is by how text cues are selected and applied during processing.

Lorch and Lorch (1986) inadvertently tested how task demands and expectations influence text cue selection, and how cued information is processed differently depending on aspects of the reading task. Participants read two experimental texts and answered comprehension questions after each text. Reading times were collected from the texts. The questions for each text were two summary questions and several detail questions. None of the questions highlighted importance information. Lorch and Lorch did not analyze the comprehension question data. The only purpose of the questions was to confirm that the participants had read the texts, but the participants were unaware that the comprehension questions were not going to be analyzed. Therefore, it is reasonable to assume they had expectations about their task of answering comprehension questions.

Lorch and Lorch's experimental texts contained two types of text cues, importance and summary. Importance cues directed participants to information important to the conceptual structure of the text, and summary cues pointed to information that summarized information important to the conceptual structure of the text. Lorch and Lorch did not differentiate between summary and importance cues in their analysis, meaning that type of cue was not a variable under investigation, until they found unexpected results. At that time they analyzed the combined data from the two texts, but still did not analyze the comprehension questions.

There were several unexpected findings. Lorch and Lorch's data showed that there was an effect of summary cues on reading times. Target sentences preceded by summary cues were read slower than when they were not preceded by summary cues. This is consistent with previous research. However, there was no effect of importance cues on reading times. This research also shows an interaction between text cues and individual differences. Lorch and Lorch found that better recallers were less affected by summary cues than poor recallers. Interestingly, this is inconsistent with later research by Lorch and Lorch. Later, they found that better recallers were *more* affected by task (Lorch & Lorch, 1987).

Lorch and Lorch (1986) suggest that the reason for the lack of an effect for importance cues is because more attention was paid to summary cues than importance cues. However, separate analysis was conducted on summary and importance cues, and Lorch and Lorch did not analyze comprehension questions, so there is no direct way to tell from Lorch and Lorch's study whether or not more attention was paid to summary than importance cues. The question is why would summary cues have received more attention?

There are a few possible explanations for a difference in attention. Perhaps, there were more summary cues than importance cues. This pattern might have attracted more attention to the summary cues. However, there were four per text for the summary cues and six and eight for texts one and two respectively for the importance cues. So, according to this line of reasoning, participants of this experiment should actually have paid more attention to the *importance* cues. Another reason could be that the participants treated the importance cues the same way uncued information is treated. If this is true, what characteristics would some cues have that others don't that would cause them to be mentally grouped with uncued information?

If readers are aware of their cognitive processing needs, they might make the decision to ignore or pay less attention to cues that are not conducive to their task. Therefore, Lorch and Lorch's (1986) participants may not have given importance cues as much attention as summary cues because they were not as helpful or relevant to their task of answering comprehension questions. The questions directly related to summary information and micro-propositions, not information. Readers may have thought that importance cues and importance information were irrelevant, or not as important, as summary cues and summary information because summary information was so essential to their task, and importance information was not. If this is the case, readers may not have processed both types of cues and cued information in the same way. The readers might have processed summary information differently than importance information, due to the demands of the reading comprehension task or due to expectations about the reading comprehension task. As a result of their processing decisions, summary information would be remembered better than importance information. So, this research supports the idea that the assignment of importance is, at least in part, based on aspects of the reading task.

Readers in Lorch and Lorch's (1986) experiment may have had certain expectations about their task due to the type of comprehension questions presented to them. After the first experimental text and set of summary and detail questions, the participants might have expected to have the same types of questions after the second experimental text. So, based on the types of questions participants read for the first text, readers may have assigned more importance to information signaled by summary cues. Lorch and Lorch's (1986) experiment might have shed light on the issue of reader expectations and the assignment of importance, but they analyzed the first and second texts together, so can not compare when participants would not have had any expectations about the comprehension questions they would receive (while reading the first text) to when they might have had expectations about the type of questions they would receive (while reading the second text).

On the other hand, there is some support for text cues being processed in the same manner, regardless of other variables. Lorch and Lorch (1995) compared three text cues: headings, overviews, or summaries. There were three versions of an article, each version containing one type of cue. The twelve subsections of the text either did or did not contain text cues. All three types of text cues communicated the same information about a text's topic structure. At recall readers were provided with the names of the twelve text topics to aid recall, or they were not given any aid. Providing the names of the twelve text topics aided recall of participants when a text cue had preceded a particular topic at encoding, but it did not make a difference if no cue had preceded the topic. Although there was a general difference in recall between cued and uncued information, there were no differences in the effects of the three cues. Lorch and Lorch (1995) suggest that their participants may have encoded the text content similarly across the three text cue conditions. However, in this study they do not offer any substantive reasons why this might have occurred.

There are several explanations for these findings. The text cues in Lorch and Lorch's (1995) experiment were all typographical. The key could be that the three text cues communicated the same information about the text's topic structure. If different types of cues are used, rather than different varieties of the same type of cue, there may be variation in how cued information is processed. This could be due to either the nature of the cued information to-be-processed or some aspect or aspects of the text cues. Also, all participants had the same instructions: to read the texts in preparation for a memory test. They were all in the same reading situation. The only differences between readers would have been individual differences in reading ability. These differences were not measured in Lorch and Lorch's (1995) experiment.

Other research shows that the assignment of importance to text information is mediated by individual differences beyond the impact of the reading task and the reading situation. Lorch, Lorch, and Mogan (1987) examined how task influences the identification and recall of a text's topics. The topics were designed to have text-based importance to recall. If the type of task mediates the importance of text topics, there will be a difference in recall of text's topics between the two types of tasks used to measure the participants' comprehension. If text-based importance is more important than task, there should be no difference. One group of participants read the text with the goal of doing a true-false sentence verification task. A second group read with the goal of providing an outline for the text. The verification task is a recognition memory task that requires little or no macro processing, whereas the outline task emphasizes retention of topic information and does require macro processing. The outline group also did the verification task after reading the practice text, so both groups were familiar with this task. Then, after reading the experimental texts, both groups were given the verification task, the outline task group without prior warning. That is to say, they were not expecting that task. There was no effect of task on reading times. So, according to this analysis task does not mediate the importance of text topics. These results would seem surprising. However, because the task used to measure recall of topics was one that required little, if any macro processing, the outcome is no surprise, according to the results of McNamara and his colleagues (1996) and Richgels and his colleagues. The task most likely did not place high cognitive demands on the readers nor did it measure the type of information asked for in the case of the outline group.

When individual differences in reading ability were added to the analysis a different story emerged. In the same experiment Lorch, Lorch, and Mogan (1987) performed a second analysis with the addition of an individual differences (in recall score) variable. The recall score was the number of macro-propositions recalled from a practice text. The dependent variable was reading times. With the addition of the individual difference variable, there were two significant effects of task. There was an interaction between task (verification and outline), topic (minor topic sentences and major topic sentences), and recall score. The tendency for the Topic effect to be larger in the Outlining task than in the Verification task was greater for better recallers than for poorer recallers. There also was an interaction between task, topic, shift (minor change-one change in attribute, major change-two changes in attribute), and recall score. The shift effect on topic sentences was larger for the outline condition than the verification condition. This pattern was more pronounced for good recallers than poor recallers. The reading times of the good recallers also varied more across tasks than poor recallers.

The results of this second analysis fit with the findings of McNamara, Richgels, Schmalhofer, Glavanov and their colleagues (McNamara et al.,1996; Richgels et al., 1987; Schmalhofer & Glavanov, 1986). The processing demands were different for the two tasks and the information measured was different, resulting in different outcomes. However, these outcomes were only discovered with the inclusion of the individual differences variable. This study shows that individual differences in the reader are important factors in the interaction between the reading task and text structure, and perhaps text cues. This study indicates that there are individual differences in how good and poor readers apply their knowledge of reading tasks and text structure, and perhaps, of text cues, to assign importance to text elements.

More questions have been raised than answered in the study of text cues. It would seem that knowing whether text cues and aspects of the reader and the reading task conflict with one another, or one supercedes the others, or they work in concert to shape the reader's mental representation depends upon knowing all the factors in the reading situation, aspects of the reading task, and characteristics of the reader. However, no one study has attempted to manipulate and/or control for all these factors.

## The Present Study

In previous research, experimenters did not isolate which aspect or aspects of the reading task actually contributed to their results. From an analysis of the literature, it would seem that the type of information necessary to fulfill a reader's task is the key to understanding the interaction among reading tasks, text cues, and individual differences. Advocates of the three views of reader cognitive processing have different predictions about this interaction and about how readers assign importance to textual information and process that information. If type of information to-be-processed is the key, then this aspect of the reading task needs to be isolated. Other aspects of the reading situation were controlled as much as possible in this experiment.

One aspect of the reading task was manipulated, question type. All participants were given the same instructions at the beginning of the experiment, to read for understanding and to expect comprehension questions. However, they were not told what type of questions to expect. Therefore, all readers started with the same general task, answering comprehension questions, but when tested, each participant completed only one type of comprehension question for all texts. They answered either summary questions or importance questions. Consequently, although their task was the same, the type of information they needed to fulfill that task was different. The participants needed either summary information or importance information, but not both, to fulfill their reading task. Manipulating only one aspect of the reading task controlled for problems previous experiments encountered. Target sentences in the text contained the information necessary to answer the comprehension questions.

Two aspects of the experimental texts were manipulated. First, there were two target type conditions: summary targets and importance targets. All the target sentences were approximately equally important to the conceptual and top-level structure of the text. Therefore, if readers only use the structure of the text to process information, all the target sentences had a similar chance of being processed more or less the same way. Each target sentence was associated with one of two types of text cues embedded in a text cue sentence. A text cue sentence contained words that indicated that it was a text cue sentence and which type of text cue was represented. Importance text cue sentences appeared before target sentences containing importance information and summary text cue sentences appeared before target sentences containing summary information. Therefore, text cue itself was not a variable manipulated. That is to say importance cues never occurred before summary target sentences and vice versa. Instead, the second text variable manipulated was cue occurrence, the appearance of cues before a target sentence. There were two types of cue occurrence conditions: cued or uncued. There were two versions of each text. If a particular target sentence was cued in one version, it was not cued in the other so each target sentence has and equal chance of being cued and being uncued. Participants saw only one version of each text, but all participants read both summary and importance text cue sentences and target sentences.

Due to the general nature of the instructions given, readers only knew which type of information would best fulfill their reading task *after* they answered the first set of comprehension questions. This circumstance was devised to ascertain how readers select text cues and process textual information in the absence of specific knowledge about the type of information that would best fulfill their task, compared to when aspects of the reading task were more identifiable. While reading the first text, readers had to rely on previous experience with comprehension questions to guide their processing decisions. After answering the first set of comprehension questions, assuming that readers expected all the comprehension questions they were to receive to be the same; they should have used their newfound knowledge of their reading task to refine their processing decisions. If readers used this knowledge to their advantage, then they should have read sentences that fit their reading task slower than sentences that did not fit their reading task. If they only followed the general instructions given to them at the beginning of the experiment, then processing of sentences for the first and second text should have been similar.

The argument could be made that any differences between questions answered after the first text and questions answered after the second text was simply due to presentation order. People typically perform differently as they gain more experience with a task. However, what exactly drives the difference between presentation order, but an increase in knowledge about the reading situation facing the reader. Furthermore, readers should already be experienced with comprehension questions. If knowledge of the most useful type of information does not influence the reader's processing decisions, then that knowledge should not influence how readers process information from the second text. However, to maintain the focus of this experiment on the roles of text cues, reading task, and individual differences as thus far described, the potential conflict between presentation order and situation knowledge was not directly investigated. Rather, the name presentation order was conferred upon the measurement of reader experience with their reading task. There were two text presentation order conditions: the first text presented and the second text presented.

Finally, individual differences in reading comprehension ability were investigated. Verbal SAT scores were used as an indication of reading comprehension ability. This measure has been frequently used in reading comprehension literature. Participants were categorized as either good or poor readers depending on their VSAT score

Proponents of the passive reader view believe that readers need to be explicitly shown what information is relevant to creating a coherent mental representation. The author of the text is the one who confers importance on information by his or her placement of text cues. Advocates of the passive reader position claim that the type of cue in a text should not make a difference to the cognitive processing of a reader who is passive because all text cues should be equally important to them. Proponents of the passive reader position would not predict the reader to spontaneously use aspects of the reading task and/or reading situation to determine the importance of information because this information is not relevant to the importance conferred by the author. Therefore, the reader having more or less knowledge of his or her task should not alter the importance of cued information. Advocates of the passive reader view claim that only if given specific instructions to do so, will readers rely on aspects of the reading situation and reading task to confer importance upon information.

Proponents of the passive reader position predict that cued information will always be processed slower and remembered better than uncued information, regardless of its conceptual and top-level relevance and regardless of its importance to the reading task or situation. They claim that readers do not use the conceptual structure of a text to process information, unless text cues specifically point to that structure. Therefore, any uncued information, regardless of its importance to the conceptual and top-level structure of the text, will not be added to the reader's mental representation. This is because without a text cue a reader who is passive would not know how to determine the relevancy of information. Proponents of the passive reader view would also predict that good readers read information faster and answer more questions correctly than poor readers, but poor readers are helped more by the presence of cues than good readers.

Advocates of the active reader position claim that readers always use the hierarchical structure of a text and the importance that structure places on units of information to guide their comprehension and recall of information. Proponents of the active reader position assert that any top-level information is remembered, but its accessibility at recall depends on the strength of its cues. These researchers claim that an active reader can spontaneously use aspects of the reading task or reading situation to help them create a coherent mental representation, but cues of textual importance always supercede cues from the reading task or reading situation. Because in this experiment all target sentences are composed of top-level and conceptual information, advocates of the active reader view would predict that uncued target sentences would also be added to the reader's mental representation. However, there will still be a main effect of cue occurrence on reading speed: cued information will be read slower than uncued information. This is due to the fact that text cues still give cued information an advantage over uncued information in how much attention is paid by the reader. However, advocates of the active reader position predict that because the comprehension questions can act as retrieval cues, readers should be able to answer comprehension questions based on cued and uncued target sentences equally well.

These predicted outcomes are mediated by individual differences. Advocates of an active reader predict individual differences in reading speed, good reader will read faster than poor readers, and individual differences in the number of correctly answered comprehension questions, good readers will answer more correctly than poor readers. They also predict a larger difference in speed between cued and uncued sentences for good readers than poor readers. Advocates of the active reader position claim that this will occur because good readers are more aware of the purpose of text cues and how to allocate their resources accordingly. However, they claim that there would be little or no difference in the total number of correct answers to comprehension questions for cued and uncued information for good readers. Because both the cued and uncued information is conceptually important, good readers would have added both types of information to their mental representations. When answering the comprehension questions, good readers would be better able to use cues in the comprehension questions to retrieve both cued and uncued target information than poor readers. For poor readers there would be a small difference between cued and uncued information.

Proponents of an interactive reader claim that this type of reader's understanding of a reading situation might change over time, or the circumstances of the reading situation might change across texts. This will change the relevance of information to a reader's mental representation, and therefore the assignment of importance to that information. Advocates of the interactive reader view predict that, in general, information cued by text cues will be read slower than uncued information. However, other variables will modify the assignment of importance to cued information. Advocates of an interactive reader predict that participants will read target sentences in the first text in this experiment slower than target sentences in the second text. For the duration of the first text, some aspects of the reading situation and reading task are vague, and therefore confer little if any importance upon textual information.  During the second text more aspects of the reading task and reading situation are clarified and readers have a better idea of what information will help them complete their reading task, so they can narrow the focus of their attention. Therefore, they should ignore or pay less attention to information which aspects of the reading situation and the reading task deem as less important and pay the most attention to target sentences preceded by task-matching text cue sentences.  Proponents of an interactive reader predict a larger speed difference between when a cue precedes a target sentence and when it does not, for when task and cue type matches (e.g. summary cue and summary task), than when task and cue type does not match (e.g. importance cue and summary task).  Proponents of the interactive reader position would not predict an interaction between cue type, reading task, and occurrence for comprehension questions because of the design of this experiment.

Advocates of the interactive reader position believe that the same text may be processed, interpreted, and remembered very differently, not only by different individuals, but also very differently by the same individual in a different reading situation and/or with a different reading task.  During the first text, nothing in the reading situation makes one of the text cues more relevant than the other to either group of readers, and they don't know at this point what type of information they need to answer the comprehension question task.  According to this view, good readers should read sentences faster and answer more questions correctly than poor readers.  For the second text, good readers will read target information faster than poor readers and answer more questions correctly, but aspects of the reading situation and reading task will have more effect on good readers. There should be a larger speed difference between cued and uncued textual information, when reading task and text cue type matches, than when it does not match. This is because good readers are more likely to know which cues fit the reading task and situation, and then be more likely to ignore or pay less attention to target information preceded by a non-matching text cue. On the other hand, the reading time results of poor readers should look similar for both texts. According to the interactive reader position, poor readers are less likely to use aspects of the reading situation to determine the relevance of textual information. Plus, they should have a harder time ignoring or paying less attention to irrelevant textual information that fits the conceptual structure of the text (Gernsbacher, 1990). So, there should be a smaller speed difference in reading times between when a text cue does and does not match for poor readers. Results of the comprehension questions should show that good readers answer more comprehension questions correctly than poor readers, as they did for the first set of questions. However, for the second set, good readers should correctly answer more questions that required using cued information than questions that required using uncued information.

# METHOD

## Participants

Participants were 78 undergraduate psychology students at Florida State University over the age of eighteen. Six participants were removed due to not having a VSAT score. Fifteen participants were removed because of the number of outliers contained within their data. Their average reading times were either above or below an outlier cutoff that is described subsequently in the results section. Therefore, the data from 57 participants were analyzed. Participants were tested in groups of 8-12 students in an experimental session lasting approximately 45 minutes. Participants were randomly assigned to the respective conditions. They received course credit for their participation. High and low ability reader groups were formed using a median split, which corresponded to a score of 550.

## Materials

All texts were expository texts. The practice text was from Biology (Alcamo, 1995). One experimental text, the "Energy Problems" text, was adapted from Lorch and Lorch's (1986) study (see Appendix A and B for two versions of this text). This text was originally from The People's Almanac # 2 (Wallechinsky & Wallace, 1978). The second experimental text, "The Earth" was adapted from Concepts of the Cosmos: An Introduction to Astronomy (1984) (see Appendix C and D for two versions of this text).

Which of the two experimental texts were shown first was counterbalanced.

Included within each of the experimental texts were text cue sentences (see Appendices A and B for the text cue sentences that appeared in “Energy Problems” text and Appendices C and D for the text cue sentences in “The Earth” text, respectively. Text cue sentences appear in bold in the appendix, but did not appear that way during the experiment.). A text cue sentence contained words that indicated that it was a text cue sentence and which type of text cue was represented. There were two different text cue types: summary and importance. Summary cues are function indicators, and importance cues are relevance indicators. However, both types indicate information important to the conceptual and top-level structure of the text. There were twelve text cue sentences written for each text, six importance and six summary. An example of an importance text cue sentence is “the following sentence is important to know.” An example of a summary text cue sentence is “the following sentence summarizes the preceding section.”

Each text included twelve target sentences (see Appendices A and B for the target sentences that appeared in “Energy Problems” text and see Appendices C and D for the target sentences that appeared in “The Earth” text, respectively. Target sentences are underlined in the appendix, but did not appear that way during the experiment.). Six target sentences were associated with summary cues. These target sentences had to contain summary information for a paragraph. An example of a summary target sentence is “gathering fossil fuels and creating nuclear power are dangerous.” Six target sentences were associated with importance cues, and the nature of the information contained within these sentences was importance information. A sentence was considered “important” if (1) it contained information linked to the theme and top-level structure of the text, (2) it contained information that explains why actions, events, and states are mentioned in a text, and (3) its removal from the text caused a coherence break. A coherence break occurs when connections between text elements do not make sense (Graesser et al., 1994). An example of an importance target sentence is “the mantle contains little iron and nickel, hence its much lower density than the core.” When cued, summary target sentences were always signaled by summary cues and importance target sentences were always signaled by importance cues.

The twelve target sentences were randomly chosen from each text with a few caveats. First, they all had to be macropropositions. A sentence was considered a macro-proposition if it contained information relevant to the theme and top-level structure of the text. The theme and top-level structure was determined by the text’s topics. Second, summary target sentences usually appeared at the end paragraphs. This is due to the nature of sentences that contain summary information, and not due to any particular design by the author. Third, the first sentence in a paragraph could not be a target sentence. It would not be ecologically valid to have a paragraph start out with the sentence "the following sentence is important" or “the following sentence summarizes the preceding section.” Fourth, the importance sentence could not be the main idea of a paragraph. This is because the main idea of a paragraph has special prominence above and beyond the importance conferred by a text cue (Goldman et al., 1995). So, six summary target sentences were randomly chosen from a pool of sentences that fit the characteristics of a summary sentence, and six importance sentences were randomly chosen from a pool of sentences that fit the characteristics of an importance sentence.

The twelve text cue sentences were divided into two sets to create two versions of each text. In one version of a text six text cue sentences, three summary and three importance, appeared before six target sentences, three summary and three importance, and the other six sentences were not preceded by a cue. In the second version of a text the six text cue sentences, three summary and three important, appeared before the six previously uncued target sentences and the previously cued sentences were not preceded by a cue. Therefore, the only difference between the two versions of each text was whether or not a particular target sentence was cued or uncued. The number of cued sentences in each text was limited to six because previous research has shown that over-cueing can be detrimental to the processing and remembering of cued information (Lorch & Lorch, 1996).

There were two sets of comprehension questions for each story, one set for the importance comprehension question condition and one set for the summary comprehension question condition (see Appendices E-H for importance and summary comprehension questions from each text). There were eight questions for each reading task. The first question shown to participants in the importance question condition required a one-sentence statement listing the most important point in the text, and the last question asked participants to list the important points they would use to write a conclusion about the text. The middle six questions tested recall of information contained within the importance target sentences. A sample general importance question from "Energy Problems" text is "Why are we confronted by immense energy problems?" (See Appendix E). The summary comprehension question condition followed the same format as the importance comprehension question condition. The first summary question shown to participants required a one-sentence summary of the text and the final question asked for a one-sentence summary of the text's conclusion. The middle six questions tested recall of information contained within the summary target sentences. A sample summary question from the "Energy Problems" text is "Why should we worry about the health threats of fossil fuels and nuclear power?" (See Appendix F). Which set of comprehension questions participants received was counterbalanced with the caveat that they answer the same type of comprehension questions for both texts.

The researcher scored the comprehension questions. The researcher was blind to whether cued or uncued information was being tested when scoring the comprehension questions. Participants were given one point for each correct answer. A correct answer required that participants write in all the propositions of the target sentence that answers a particular comprehension question. If they got at least one proposition correct per target sentence, but any other wrong, or if they wrote only one correct proposition and more were necessary to answer the question, they received half a point. If the information was generally correct, but the propositions were from another sentence or sentences in the text, then participants received half a point. If they did not answer the question or answered with all incorrect propositions, they received a zero for that question.

## Design

The experiment is a 2 (target type: summary, importance) X 2 (cue occurrence: cued, uncued) X 2 (question type: summary questions, importance questions) X 2 (text presentation order: first text, second text) X 2 (individual differences in reading comprehension ability: good, poor) repeated measures mixed model ANOVA design. There were two dependent measures. The on-line dependent variable was reading times of target sentences. The off-line dependent measure was number of correct answers to comprehension questions. Each of these dependent variables was analyzed using a mixed-model ANOVA.

**Procedure**

All participants were given the same general instructions: to read for understanding (see Appendix J for the exact instructions). Participants read three texts, one practice and two experimental texts. The practice text did not follow the format of any version of the experimental texts. The practice text did not contain any summary or importance text cues. The participants did not answer any comprehension questions for the practice text so that there would not be any questions to influence how participants read the first experimental text. The purpose of the practice text was to familiarize the participants with the procedure of reading texts during the experiment and to give them an opportunity to ask procedural questions before they read the experimental texts.

Each participant read one version of each experimental text. Half of the participants saw one version and the other half saw the other version of each text. Which version of each text the participant read and the order in which at text was presented was counterbalanced. In this way each version of a text and each of the two experimental texts had an equal chance of being read first.

Participants read all texts using an IBM computer. Reading times were collected using a computer program designed by e-prime (Schneider, Eschman, & Zuccolotto, 2002). Participants were informed that their reading times were to be recorded, and they should read at a comfortable pace without stopping to rest. Participants read one sentence of a text at a time on a video display. Participants controlled text presentation by pressing the space bar on the computer's keyboard to proceed to the next sentence. When a participant pressed the space bar, the current sentence was immediately erased and replaced by the next sentence after an extremely short delay.  Sentence reading times were measured from sentence presentation until the space bar was pressed.  Each sentence was presented left justified at the same horizontal location on the display screen. Target sentences always fit on one line of the display screen.  Paragraph boundaries were not indicated visually.

A concern with not having paragraph boundaries could be that this format of presenting a text does not have ecological validity.  However, Goldman, Saul, and Coté (1995) conducted an experiment investigating the interaction between paragraphing, type of sentence, and reading task.  They report that paragraphing did little to change the fact that main ideas were generally processed longer (i.e. had longer reading times) and were recalled better than sentences containing elaborative information.  When the paragraph cue and the semantic information coincided, main idea sentences were read longer, processed more frequently, and recalled better than sentences containing elaborative information.  When the semantic and structure cues did not converge (i.e. when sentences containing elaborative information appeared at the beginning of a paragraph), sentences containing main points were still read longer and recalled better, but readers did look back more frequently to the elaborations that begin the paragraph than other elaborations. These results indicate that being the first sentence in a paragraph does not automatically give a sentence an advantage or cause readers to believe it is a main idea.  This experiment indicates that readers do not need to see paragraph boundaries in order to distinguish between main idea sentences and other sentences important to the theme of a paragraph.

After participants read each experimental text, comprehension questions were administered. Each participant answered either summary comprehension questions or importance comprehension questions for both texts. Which type of question a participant received was counterbalanced so that half the participants received summary comprehension questions and half received importance comprehension questions. After the last set of comprehension questions was answered, the experiment was over, and participants received a debriefing form.

See Figure 1 on the next page for a flow diagram of the experimental procedure. A sample procedure for a participant would be that he or she read the practice text, read Version 1 of the "Energy Problems" text, answered importance comprehension questions for the "Energy Problems" text, read Version 1 of "The Earth" text, and answered importance comprehension questions for "The Earth" text.

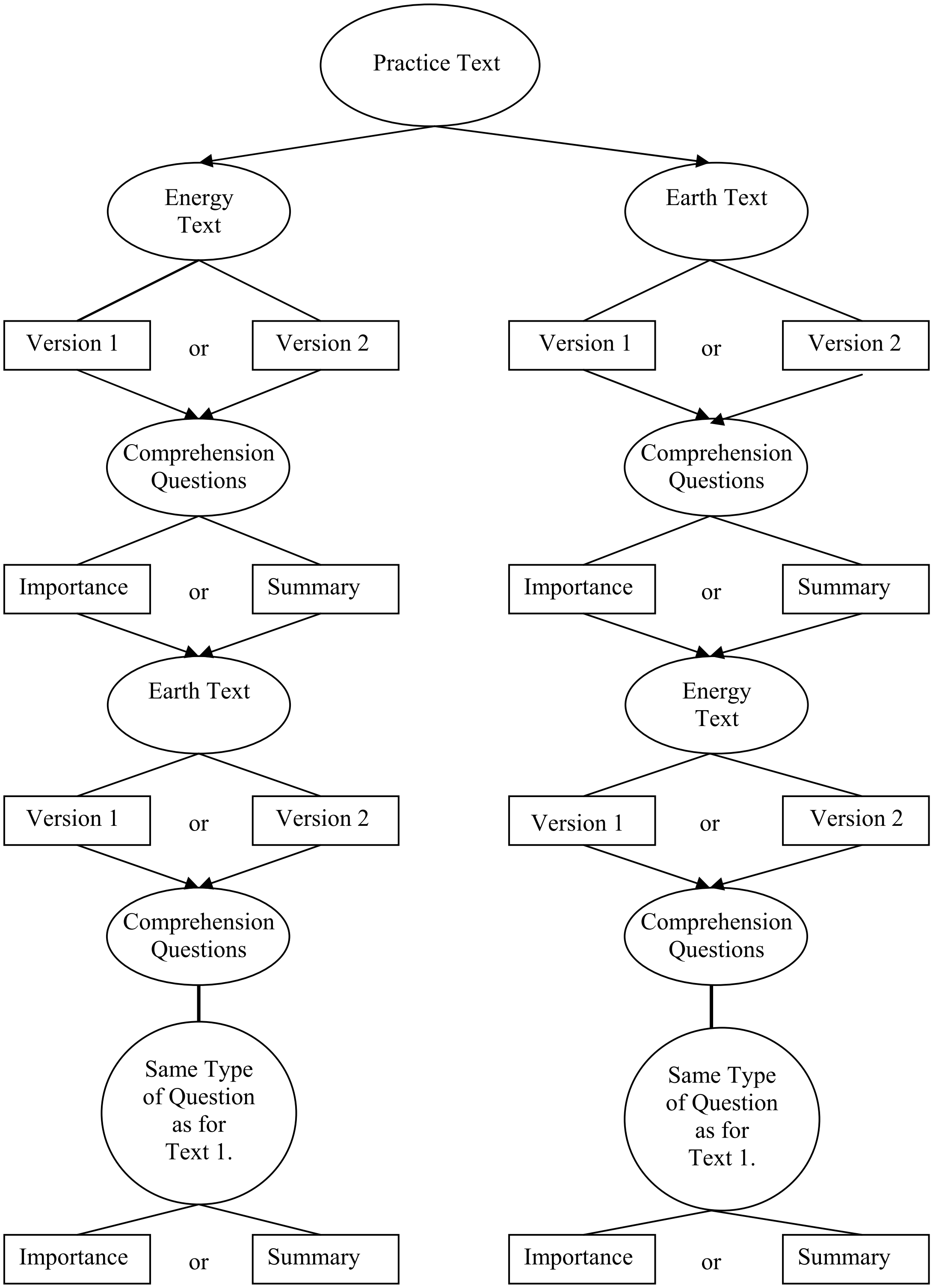


Figure 1. Diagram of Experimental Procedure

## RESULTS

Reading times for target sentences and number of correct responses to comprehension questions were the two dependent variables. The same target sentences that were present in the two texts and for which reading time data were collected contained the information necessary to answer the comprehension questions correctly. The following results for both reading times and correct answers to comprehension questions are based upon two separate Analysis of Variances (ANOVA) and follow-up planned comparisons using t-tests. Means for summary cued, summary not cued, importance cued, and importance not cued target sentences were calculated separately. The $F_1$ and $t_1$ refers to tests against an error term based on participant variability and $F_2$ and $t_2$ refers to tests against an error term based on item variability. All effects were tested at a significance level equal to .05.

Each participant saw one version of each experimental text. Which text they read first and which version of that text they saw was counterbalanced. There was no effect of counterbalancing order, $F_1 (3, 41) = 2.06$, $p = .12$, $F_2 (3, 20) = 2.68$, $p = .07$ . Therefore, all results are collapsed across counterbalancing order

Outliers for the reading time data were handled in the following manner. Outliers above two standard deviations from the participant's mean reading times for target sentences were brought to the fence, except in the case where a data point was above 50,000 ms. In this case, the data point was removed before the target sentences data was averaged. The average reading speed for non-target sentences was calculated. This was to make sure that participants read the texts in a timely manner. Some participants were removed because their entire data (target sentences plus the rest of the sentences from a story) contained 20% or more outliers. The outliers were either ones that were faster than the average reader can read a sentence and still make sense of it (< 500ms), suggesting that they were rushing through the experiment without trying to understand the sentences, or they were ones that were very slow (> 50,000ms). There was not a significant difference between participants who were rejected and those who were in the analyses, along the individual differences variable, $t_1(75) < 1$, $p > .05$.

**Reading Times of Target Sentences**

The significant main effects and interactions for analysis of participants' variability are listed in Table 1. Both significant and non-significant results from analysis of participants' variability are listed in Table 11 in Appendix J. There were three main effects, two second-order interactions, one third-order interaction, and one fourth-order interaction. The fourth-order interaction among cue occurrence, target type, question type, and text presentation order qualifies the other interactions and main effects, but the other interactions and main effects will still be discussed.

The three variables that had main effects were cue occurrence, target type, and text presentation order. The cue occurrence main effect was congruent with previous research. Participants read cued target sentences slower (M = 8458.67, SD = 4426.31, SS = 57) than uncued target sentences (M = 5947.15, SD =2019.29, SS = 57). There was a significant main effect of target type. Participants read importance target sentences (M = 10200.96, SD = 6440.33, SS = 57) slower than summary target sentences (M = 6716.30, SD = 3806.25, SS = 57). There was a significant main effect of text presentation order. Participants read target sentences in the first text (M = 7687.88, SD = 3122.57, SS = 57) slower than target sentences in the second text (M = 6717.790, SD = 3218.1, SS = 57).

Table 1
Significant Results for Analysis of Participant Variability for Reading Speed of Target Sentences

| Source | $df_1$ | $F_1$ | $\eta^2_1$ | $p_1$ |
|---|---|---|---|---|
| Occurrence (Oc) | 1 | 29.98 | .36 | .00* |
| Target Type (TT) | 1 | 55.34 | .51 | .00* |
| Order (Or) | 1 | 10.83 | .17 | .00* |
| TT X Question Type (QT) | 1 | 23.94 | .31 | .00* |
| Or X QT | 1 | 7.61 | .13 | .01 |
| Oc X TT X QT | 1 | 4.02 | .07 | .05 |
| Oc X Or X TT X QT | 1 | 4.64 | .08 | .04 |
| Within Group Error | 53 | | | |

* $p < .01$

There were two significant main effects for item variability. Both significant and non-significant main effects and interactions for analysis of item variability are listed in Table 12 in Appendix K. There was a significant main effect of cue occurrence. Cued target sentences (M = 8319.17, SD = 2828.44, SS = 12) were read slower than uncued target sentences (M = 5970.86, SD= 2400.50, SS = 12). There was a main effect of target type. Importance target sentences (M = 8735.60, SD = 1906.3, SS = 12) were read slower than summary target sentences (M = 5554.43, SD = 1824.39, SS = 12). There was no main effect of text, so it would seem that the differences in reading speed were not due to idiosyncratic characteristics in the two experimental texts.

There was an interaction between question type and target type for both participant and item variability. Cell means, standard deviations, sample sizes, and t-tests for participants' and item variability are in Table 2. Participants in the summary question type condition read summary target sentences (M = 6238.56) slower than participants in the importance question type condition (M = 4873.56). Conversely, participants in the importance question type condition read importance target sentences (M = 10379.42) slower than participants in the summary question type condition (M = 7349.33). The item analysis showed a similar pattern of results for the interaction between question type and target type. As with the analysis of participant variability, summary target sentences (M = 10112.05) were read slower when participants had to answer summary questions then when participants had to answer importance questions. Importance target sentences were read slower when participants had to answer importance questions (M = 6200.68) than when they had to answer summary questions (M = 4908.18).

Table 2
Mean (SD, SS) for Reading Speed in Milliseconds for Target Sentences and t-test Analysis of Cell Means as a Function of Question Type and Target Type for both Participant and Item Variability

| | Question Type | | |
|---|---|---|---|
| Target Type | Summary | Importance | t-test values* |
| | Participant Variability | | |
| $\text{Summary}_1$ | 6238.56 (2613.58, 29) | 4873.56 (2205.56, 28) | $t_1(55) = 2.13$*** |
| $\text{Importance}_1$ | 7349.33 (2011.38, 29) | 10379.42 (5523.04, 28) | $t_1(55) = -2.77$** |
| t-test values* | $t_1(28) = -2.51$*** | $t_1(27) = -7.20$** | |
| | Item Variability | | |
| $\text{Summary}_2$ | 10112.05 (2089.64, 12) | 7359.15 (2425.21, 12) | $t_2(11) = 3.91$** |
| $\text{Importance}_2$ | 4908.18 (1491.42, 12) | 6200.68 (2335.40, 12) | $t_2(11) = -3.13$** |
| t-test values* | $t_2(22) = 7.02$** | $t_2(22) = 1.19$+ | |

* All t-tests are two-tailed tests. ** $p < .01$ *** $p < .05$ + $p > .05$

There was a significant interaction between text presentation order and question type for participant variability. There was not a significant interaction between text presentation order and question type for item variability. Cell means, standard deviations, and t-tests for participants' variability are in Table 3. Participants who were in the summary question type condition read target sentences from the first text slower than target sentences read during the second text. However, there was little difference in reading speed between target sentences read during the first text and those read during the second text for the participants in the importance question type condition. Furthermore, there was not a significant difference in reading speed between participants in the summary question type condition and participants in the importance question type for both the first and second texts.

| Table 3<br>Mean (SD, SS) Reading Speed in Milliseconds for Target Sentences and t-test Analysis of Cell Means for Participant Variability as a Function of Reading Task and Text Presentation Order | | | |
|---|---|---|---|
| | Question Type | | |
| Presentation Order Of Texts | Summary | Importance | t-test values* |
| First | 7672.16 (2531.32, 29) | 7704.16 (3684.79, 28) | $t_1(55) = -.38+$ |
| Second | 5915.70 (2024.28, 29) | 7548.75 (3977.80, 28) | $t_1(55) = -1.96+$ |
| t-test values * | $t_1(28) = 4.26$** | $t_1(27) = .39+$ | |
| * All t-tests are two-tailed tests. ** $p < .01$ + $p > .05$ | | | |

There was a significant interaction between cue occurrence, target type, and question type for participants' variability. There was not a significant interaction between cue occurrence, target type, and question type for item variability. Cell means, standard deviations, and t-tests for participants' variability are in Table 4. The difference between cued and uncued target sentences was significant regardless of the question type and target type. Participants in both the summary question type condition and the importance question type condition read cued summary target sentences slower than uncued summary target sentences. Participants in both the summary question type condition and the importance question type condition read cued importance target sentences slower than uncued importance target sentences.

Table 4
Mean (SD, SS) Reading Speed in Milliseconds for Target Sentences and t-test Analysis of Cell Means for Participant Variability as a Function of Cue Occurrence, Target Type, and Question Type

| | Question Type | |
|---|---|---|
| Type of Target and Occurrence | Summary | Importance |
| Summary Cued | 7362.19 (3534.08, 29) | 6047.33 (4022.90, 28) |
| Summary Uncued | 5114.88 (2595.33, 29) | 3699.66 (1241.51, 28) |
| t-test values* | $t_1(28) = 3.63$** | $t_1(27) = 3.12$** |
| Importance Cued | 7966.60 (2617.90, 29) | 12515.11 (8246.52, 28) |
| Importance Uncued | 6732.05 (2183.95, 29) | 8243.73 (3790.47, 28) |
| t-test values* | $t_1(28) = 2.5$*** | $t_1(27) = 3.46$ ** |

* All t-tests are two-tailed tests. ** $p < .01$ *** $p < .05$

When just the cued target sentences were analyzed with t-tests, a pattern similar to the target type and question type interaction emerged. Cell means, standard deviations, and t-tests for participants' variability are in Table 5. Participants who were in the importance question type condition read cued importance target sentences slower than cued summary target sentences. There was a different pattern for participants in the summary question type condition. Participants who were in this condition read cued summary target sentences and cued importance target sentences at about the same rate.

The summary and importance question type conditions were compared for the two cued target types. There was a significant difference between summary and importance question type conditions, when participants read cued importance target sentences. Participants in the importance question type condition read cued importance target sentences slower than participants in the summary question type condition. However, there was not a significant difference in reading speed between participants in the two question type conditions when participants read cued summary target sentences.

Table 5
Mean (SD, SS) Reading Speed in Milliseconds for Cued Target Sentences and t-test Analysis of Cell Means for Participant Variability as a Function of Target Type and Question Type

| | Question Type | | |
|---|---|---|---|
| Target Type | Summary | Importance | t-test values* |
| Summary Cued | 7362.19 (3534.08, 29) | 6047.33 (4022.90, 28) | $t_1(55) = 1.31+$ |
| Importance Cued | 7966.60 (2617.90, 29) | 12515.11 (8246.52, 28) | $t_1(55) = 2.83**$ |
| t-test values* | $t_1(28) = -.854+$ | $t_1(27) = 5.67**$ | |

* All t-tests are two-tailed tests. ** $p < .01$ + $p > .05$

Furthermore, whether the target type and question type matched each other made a significant difference in how participants read target sentences. Cell means, standard deviations, and t-tests for participants' variability are in Table 6. Participants read cued target sentences that matched their question type slower than cued target sentences that did not match their question type. They also read uncued target sentences that matched their question type slower than uncued target sentences that did not match their question type. When participants read target sentences that contained information matching their question type, regardless of which question type condition they were in, the difference in reading speed between cued and uncued target sentences was greater than the difference between cued and uncued target sentences that did not contain information matching their question type.

Table 6
Mean (SD, SS) Reading Speed of Cued and Uncued Target Sentences in Milliseconds and t-test Analysis of Cell Means for Participant Variability as a Function of Cue Occurrence and Question Type Matching

| | Question Type Matching | | |
|---|---|---|---|
| Cue Occurrence | Matched to Question Type | Not Matched to Question Type | t-test values* |
| Cued | 9893.47 (6766.65, 57) | 7023.87 (3488.06, 57) | $t_1(57) = 3.54$** |
| Uncued | 6651.86 (3575.68, 57) | 5242.46 (2338.19, 57) | $t_1(57) = 2.37$*** |
| Difference between Cued-Uncued | 4024.6 | 2283.51 | $t_1(56) = 3.14$** |

* All t-tests are two-tailed tests. ** $p < .01$ *** $p < .05$

To discover how the reading speed of target sentences matched to a participant's question type compares to target sentences unmatched to a participant's question type, these two types of sentences were analyzed for both task conditions. Cell means, standard deviations, and t-tests for participants' variability are in Table 7. There were unexpected results. Participants in the importance question type condition read uncued importance target sentences slower than cued summary target sentences. Participants in the summary question type condition read cued importance target sentences slower than uncued summary target sentences.

Table 7
Mean (SD, SS) Reading Speed in Milliseconds for Cued Target Sentences and t-test Analysis of Cell Means for Participant Variability as a Function of Question Type and Target Type (with Cue Occurrence)

| | Question Type | |
|---|---|---|
| Target Type (With Cue Occurrence) | Summary | Importance |
| Importance Uncued | | 8243.73 (3790.47, 28) |
| Summary Cued | | 6047.33 (4022.90, 28) |
| t-test values* | | $t_1(27) = 3.46$** |
| Summary Uncued | 5114.88 (2595.34, 29) | |
| Importance Cued | 7966.60 (2617.90, 29) | |
| t-test values* | $t_1(28) = -5.95$** | |

* All t-tests are two-tailed tests. ** $p < .01$

There was a significant interaction between text presentation order, cue occurrence, target type, and text for item variability. Therefore, whether the passage was presented first or second, which text was being read, whether a cue was present or not, and which type of target sentence was read made a difference in the speed with which items were read. This interaction was not significant for participant variability. Cell means and standard deviations are in Table 8.

Table 8
Mean (SD, SS) Reading Speed in Milliseconds for Item Variability as a Function of the Text Presentation Order of Texts, Cue Occurrence, Target Type, and Text

| | Text Presentation Order | | | |
|---|---|---|---|---|
| Cue Occurrence | First Text | | Second Text | |
| and Target Type | Earth Text | Energy Text | Earth Text | Energy Text |
| Summary Items Cued | 11166.93/ (3470.99, 6) | 10169.47/ (3357.48, 6) | 8740.81/ (1879.33, 6) | 9758.56/ (3372.84, 6) |
| Summary Items Not Cued | 8217.88/ (3137.79, 6) | 7005.08/ (1641.83, 6) | 7772.74/ (1162.05, 6) | 7053.33/ (1779.35, 6) |
| Importance Items Cued | 7167.38/ (3185.85, 6) | 6880.85/ (2231.90, 6) | 7347.51/ (1279.68, 6) | 5321.83/ (1820.04, 6) |
| Importance Items Not Cued | 5906.49/ (2554.63, 6) | 3362.26/ (1084.78, 6) | 4750.11/ (1859.65, 6) | 3699.00/ (1263.43, 6) |

There was a significant interaction between reading question type, text presentation order, target type, and cue occurrence for participant variability. There was not a significant interaction for these variables for item variability. Cell means, standard deviations, and t-tests for participants' variability for this interaction are listed in Table 9 and Table 10. For the first text, cued sentences were read significantly slower than uncued sentences. As predicted, the size of the difference between cued and uncued target sentences did not depend upon whether the target type matched what was to be the participant's question type. For the second text the overall difference between cued and uncued target sentences was significant, as it was for the first text, but a different pattern emerged for the second text when matched and unmatched target sentences were compared. Regardless of the question type, the difference between cued and uncued target sentences was larger when the type of information matched the question type than when the type of information did not match the question type.

Table 9
Mean (SD, SS) Reading Speed in Milliseconds and t-test Analysis of Cell Means for participant Variability as a Function of Text Presentation Order, Cue Occurrence, and the Match between Target Type and Question Type

| Cue Occurrence and Matching | Text Presentation Order: First Text | Second Text |
|---|---|---|
| Cued | 8782.2 (4422.00, 57) | 8135.03 (5162.46, 57) |
| Uncued | 6593.54 (2727.14, 57) | 5300.77 (1778.57, 57) |
| t-test values* | $t_1(56) = 4.27$** | $t_1$ 56) = 5.02** |
| Matched | 4538.97 (4780.31, 57) | 4597.78 (5960.96, 57) |
| Not Matched | 3098.56 (3563.56, 57) | 2541.04 (2958.21, 57) |
| t-test values* | $t_1(56) = 1.96$+ | $t_1(56) = 3.08$** |

* All t-tests are two-tailed tests. ** $p < .01$ + $p > .05$

The difference between cued and uncued target sentences was compared for each target type and cue occurrence for the second text. When participants were in the importance question type condition, there was a larger difference between cued and uncued importance target sentences than cued and uncued summary target sentences. When participants were in the summary question type condition, the differences were in the predicted direction; the difference between cued and uncued target sentences was greater for summary target sentences than for importance target sentences, but this difference was not significant. The difference in reading speed between cued and uncued target sentences was compared for the two question types. The degree of difference in reading speed between cued and uncued importance target sentences was significantly different for the two question types. The difference was larger for participants who answered the importance question type. However, the degree of difference between cued and uncued summary target sentences was not significantly different for participants in the two question type conditions.

Table 10
Mean difference (SD, SS) in Target Sentence Reading Speed in Milliseconds between Cued and Uncued Target Sentences and t-test Analysis of Cell Means for Participant Variability as a Function of Question Type and Target Type for the Second Text

| | Question Type | | |
|---|---|---|---|
| Target Type | Summary | Importance | t-test Values* |
| Summary Cued-Uncued | 3190. 04 (3352.90, 29) | 2666.47 (3677.70, 28) | $t_1(55) = .56+$ |
| Importance Cued-Uncued | 2382.03 (2097.73, 29) | 6055.80 (7596.50, 28) | $t_1(55) = -2.47$*** |
| t-test Values* | $t_1(28) = -1.15+$ | $t_1(27) = 3.06$** | |

* All t-tests are two-tailed tests. ** $p < .01$ *** $p < .05$ + $p > .05$

Further analyses were conducted on target sentence data from the second text to discover which target sentence type and cue occurrence were read the fastest and the slowest for each reading question type. See Figure 2 for means. Four categories were compared: cued summary target sentence, uncued summary target sentence, cued importance target sentence, uncued importance target sentence. The slowest mean reading speed for both question types were the same for the cued importance target sentences. The fastest mean reading speed for both question types was for the uncued summary target sentences. However, the range between the fastest and the slowest categories was significantly different for the two question types. The difference between the cued importance target sentences and the uncued summary target sentences was larger for participants in the importance question type condition (M =10222.10, SD = 2447.94, SS = 28), than for participants in the summary question type condition (M = 3503.85, SD = 10179.83, SS = 29), $t_1$ (55) = 3.45, $p < .01$.

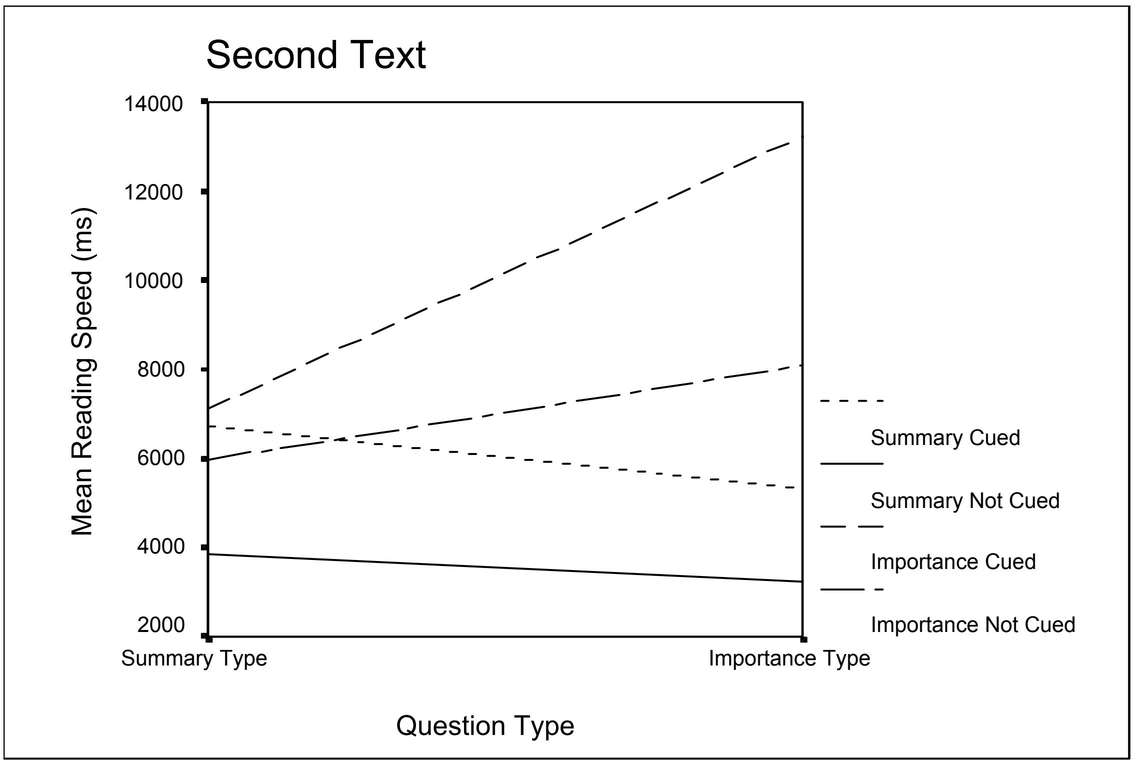


Figure 2. Mean Reading Speed in Milliseconds (ms) for Target Sentences in the Second Text for participant Variability as a Function of Type of Task, Type of Target and the Occurrence of Cues

Surprisingly, there was no effect of the individual differences variable (VSAT). There was no main effect of VSAT, although the means were in the predicted direction. Good readers (M = 6592.60, SD = 2520.73) read sentences faster than poor readers (M = 7752.2, SD = 3242.73). There were no interactions between VSAT and any of the other variables. The individual difference variable was not present in the item variability analysis.

### Comprehension Questions

There was only one significant main effect for the participant variability analysis of total number of correctly answered comprehension questions. There was a significant difference between the two question types in the number of comprehension questions participants answered correctly $F_1$ (1, 53) = 10.13, $p < .01$. Participants in the summary question type condition (M = 7.43, SD = 1.48, 29) answered more comprehension questions correctly for the two experimental texts than participants in the importance question type condition (M = 5.79, SD = 2.30, 28). The insignificant main effects and interactions for participants' variability are listed in Table 13 in Appendix L. The insignificant main effects and interactions for item variability are listed in Table 14 in Appendix M. A reliability analysis was conducted and shows that the comprehension questions were sufficiently reliable (a = .60). However, when observed power was calculated the statistics were low, from .05 to .25. These figures cast doubt that there was sufficient power to detect significant differences, if those differences were small.

# DISCUSSION

The present study investigated the interaction between aspects of the reader, the reading task, and the reading situation using both on-line and off-line measures. The purpose of the study was threefold: to isolate as much as possible the effects reading tasks and text cues have on the reader's processing and remembrance of information, to uncover the extent to which readers actively search a text for task-related information, and to ascertain any differences between good and poor readers. The findings from this experiment support the hypotheses that the processing of textual information is mediated by a combination of text cues and the reading task. Readers do actively search for task-relevant information and pay less attention to task-irrelevant information, even if it is conceptually and structurally important. The variable that has had the most inconsistent effects in text cue literature, individual differences, did not play a role in this experiment. None of the individual differences-related effects were significant. There are three viewpoints that could explain the results of this experiment: the passive reader view, the active reader view, and the interactive reader view. The view that readers are interactive best fits the data. These results help explain some of the conflicting findings in the text cue literature and broaden our understanding of the cognitive processing that occurs during reading.

There was a significant main effect of cue occurrence on reading speed of target sentences. Cued target sentences were read more slowly than uncued target sentences. This result dovetails with previous research and supports the idea that readers dedicate more cognitive processing to information that is cued. However, this main effect is qualified by interactions between cue occurrence and target type, question type, and text presentation order.

There was a significant main effect of target type on reading speed of target sentences. Importance target sentences were read slower than summary target sentences. This suggests that there may be cognitive processing differences between these two types of information. The research of McNamara, Kintsch, Songer, and Kintsch (1996) and Richgels, McGee, Lomax, and Sheard (1987) supports this result. Although these researchers did not specifically test the difference between summary and importance information, their research does support the idea that different types of information are processed in different ways. This difference could also be due to the way in which participants assigned significance to importance and summary information. Importance information might have been significant to participants in both the importance and summary question type conditions causing it to be read slowly by both groups. Later discussion on the interaction between target type and cue occurrence, question type, and text presentation order gives credence to this idea.

There was a significant main effect of text presentation order on reading speed of target sentences. Participants read target sentences in the first text slower than target sentences in the second text, despite the fact that both texts were from the same genre and had a similar structure; they were both science texts. Which text participants saw first or second was orthogonally controlled so this difference in reading speed of targets cannot be due to idiosyncratic characteristics of the two texts. The significant effect of presentation order supports the claim that a reader's knowledge about the reading situation is continually being updated, at least between texts. In the present experiment, participants knew more about the reading situation before beginning the second text than they did before reading the first text because they had the experience of answering comprehension questions after the first text. Participants could have used their knowledge and/or previous knowledge about similar reading situations to increase the speed of their processing of textual information while reading the second text. However, this experiment was not designed to distinguish between these two possibilities. This main effect is qualified by the interaction between text presentation order and target type, cue occurrence, and question type.

There was a significant interaction between target type and question type for reading speed of target sentences. Participants in the importance question type condition read importance target sentences slower than summary target sentences. However, participants in the summary question type condition also read importance sentences slower than summary sentences. This result was contrary to the predictions made by advocates of all three views. However, when the two question types were compared for each target type, the data followed the interactive view. Participants in the summary question type condition read summary target sentences slower than participants in the importance question type condition. Participants in the importance question type condition read importance target sentences slower than participants in the summary question type condition. These findings support the idea that question type-matching information is processed more carefully than information that does not directly match a question type. The unexpected results for the summary question type substantiates the idea that some information is relevant to more than one type of reading task, and/or the relative importance of different types of information may vary, depending upon aspects of the reading task.

The target type and question type interaction should be interpreted with caution for two reasons. First, a higher-order interaction qualifies this interaction. Second, text presentation order must be present in any interaction with question type for the results to be meaningful. Because participants were not aware of the exact nature of the comprehension questions that they would face while reading the first text, they only had their general knowledge of comprehension questions to guide them to important information in the text, the difference between the two question types, summary and importance, can only have influenced readers *after* they answered questions for the first text.

There was a significant interaction between text presentation order and question type. Participants in the summary question type condition read target sentences in the first text slower than target sentences in the second text. However, for participants in the importance question type condition there was little difference in reading speed between target sentences from the first text and target sentences from the second text. This interaction is qualified by the higher-order interaction between text presentation order, question type, target type, and cue occurrence.

There was a significant interaction among cue occurrence, target type, and question type. The difference in reading speed between cued and uncued target sentences was significant regardless of the question type condition and the type of target sentence.

Participants in both question type conditions read cued summary target sentences slower than uncued summary target sentences, and participants in both question type conditions read cued importance target sentences slower than uncued importance target sentences. These results must be interpreted with caution because text presentation order is not present in this interaction, and a higher-order interaction qualifies these results.

There was a significant interaction among cue occurrence, question type, target type, and text presentation order for reading speed of target sentences. For the first text cued sentences were read slower than uncued sentences. Whether the cue matched or did not match what was to be their question type did not make a significant difference. The general instructions participants received at the beginning of the experiment might have indicated to the participants that a general use of cues would be beneficial. Previous experience might have lead participants to believe that cued information would be helpful to them. That would explain why both cued importance target sentences and cued summary target sentences were associated with a decrease in reading speed for the first text. If participants thought both types of information would help them read for understanding and answer comprehension questions, then they should have spent more time processing cued sentences.

However, the match between question type and target type did make a significant difference when participants read the second text. Regardless of which question type was answered, the difference between cued and uncued target sentences was larger when the type of information matched the participant's question type condition than when the type of information did not match the question type. At this point in the experiment participants had a better idea of what type of information would help them fulfill their task of answering comprehension questions. Therefore, they could apply their knowledge of question type and the cues in the text to differentiate between more or less relevant information, and then spend more time on information that was useful to them.

Further analyses were conducted on target sentence data from the second text to discover which combination of target sentence type and cue occurrence (cued summary target sentence, uncued summary target sentence, cued importance target sentence, uncued importance target sentence) was read the fastest and the slowest for each reading task condition. Participants in both question type conditions read cued importance target sentences the slowest. Participants in both conditions read uncued summary target sentences the fastest. However, the range between the fastest and the slowest combinations was significantly different for the two question types. The difference between the cued importance target sentences and the uncued summary target sentences was larger for participants in the importance question type condition than for participants in the summary question type condition. This results supports the idea that even though participants in both tasks seemed to think that cued importance target sentence were the most significant type of sentence and uncued summary sentences were the least important type of sentence, they processed those sentences in different ways. Furthermore, participants in the two groups processed summary cued and importance not cued target sentences differently. Those in the importance question type condition processed importance not cued sentences slower than summary cued sentences. Those in the summary question type condition processed summary cued sentences slower than importance not cued sentences. Perhaps, the four types of sentences were processed differently due to how the two groups assigned significance to them.

According to proponents of the interactive view, knowledge about reading situations allows the reader to focus more on what is most important to the reading situation, and spend less time on what is not. Recognizing cues in the reading situation and the reading task does seem to simplify decision-making about the importance of textual information. There seems to be faster processing of irrelevant or less important information, and slower processing of important information. The question is what causes readers to assign different levels of importance to the same information?

There are several possible reasons for why the two groups differed in their assignment of importance. First, it could be due to general differences in cognitive processing between participants in the two question type conditions. Considering that the two reading question type conditions were virtually identical except for the type of information necessary to answer the comprehension questions, it is unlikely that this interaction is due to general processing differences. Second, it is more likely that characteristics of the information needed to answer the two types of questions influenced the cognitive demands placed upon participants. Importance information could be more significant to participants in the summary question type condition than summary information is to those in the importance question type condition. This would clarify why participants in both tasks read the target sentences that matched their task slower than the participants in the not-matching task, but participants in the summary condition read cued importance target sentences slower than cued summary target sentences. If something is noteworthy, it is usually part of a summary, so participants in the summary condition might process importance target sentences analogous to, or even read them slower than, summary target sentences. On the other hand, the information contained within a summary target sentence may be considered too general to answer an importance type question. This would explain why participants in the importance question type condition read summary target sentences faster (i.e. spent less time processing), than importance target sentences.

Another reason for the processing differences between the two question type groups is that an increase in task understanding might have benefited one group more than the other. The way in which the reading situation changed from the first to the second text (i.e. participants gained knowledge about their task of answering questions) might have had a greater influence on participants in the summary question type condition, than on those in the importance question type condition. Those in the summary question type condition may have been able to narrow the focus of their cognitive processing to a greater degree while reading the second text, than those in the importance question type condition. Aspects of the reading situation may have provided participants in the summary question type condition with better-defined guidelines for assigning significance to information than participants in the importance condition. First, the chance of a particular sentence in a text being important is more likely than it being a summary sentence. This would give readers in the importance question type condition more sentences to choose from when selecting which information to include in their mental representations than participants in the summary question type condition. Second, a sentence labeled as significant can come at any point in the text. Summary sentences generally come at the end of sections, so participants in the summary question type condition could read sentences at the beginning and middle of sections faster with less worry over missing something relevant to their task, than those participants in the importance question type condition. Third, participants in the summary question type condition might not have to search for details as much as those in the importance task condition. Summaries are created to generalize across sentences, but each importance sentence contains essential information. This interaction indicates that the type of information necessary to fulfill the task can make a difference in how textual information is processed.

Many previous researchers in the text cue literature assumed that the assignment of importance rested mostly with the occurrence of cues, but these results show that more variables are involved. There seems to be fine gradations to the assignment of importance to textual information. When cued and uncued question-relevant target sentences were separately compared to question-irrelevant cued target sentences, different patterns emerged for participants in the two question type conditions. Participants in the importance question type condition read cued importance target sentences slower than cued summary target sentences. However, participants in the summary question type condition read both types of cued target sentences at about the same rate. Participants in the importance question type condition read uncued importance target sentences slower than cued summary target sentences, which is contrary to previous research. On the other hand, participants in the summary question type condition read uncued summary target sentences *faster* than cued importance target sentences. These results indicate a very complicated interaction among aspects of the reading task, textual information, and text cues. These results suggest that the assignment of importance to textual information is dependent upon many aspects of the reading situation and reading task.

There was no main effect of VSAT or interactions with any of the other variables. This result is consistent with some previous research (e.g. Loman & Mayer, 1983), but against the predictions of all three viewpoints. One reason for the lack of results in this dissertation could be the measure of individual differences, VSAT score. Lorch, Lorch, and Mogan (1987), for example, used a recall score as the basis for differentiating between good and poor readers. Their results showed an interaction between individual differences and task. In fact, task was only significant when the individual difference measure was added to the analysis. Furthermore, in Lorch and Lorch's (1986) first experiment, they found that their measure of reading speed and their recall score had independent effects on the magnitude of text cue effects. Although VSAT is a popular choice for differentiating between good and poor readers, it may not tap into what drives the interaction between task, text cues, and individual differences. Future research should try to quantify the disparity between various measures of individual differences and the effect those differences have on the interaction between text cues and reading task.

Only question type had a significant effect on the number of correctly answered comprehension questions. Participants who were in the summary question type condition answered more comprehension questions correctly than participants in the importance question type condition. There are several explanations for these findings. First, it may be due to summary questions being easier to answer because summary information may have been more available than importance information. Second, the information may have been more available because the retrieval cues created by participants in the summary question type condition could have been more accurate than those created by participants in the importance question type condition. Third, summary information may be more distinctive than importance information. There are fewer propositions to remember. Summary information is gleaned from many sentences and condensed into smaller units. However, the present experiment did not investigate these possibilities, so these explanations are only supposition. Further experiments will have to be conducted to distinguish between these explanations.

The null results in this analysis must be interpreted with caution. The analysis of comprehension questions shows the questions were reliable, and the reading speed of sentences suggest that participants were processing some of the target sentences differently. However, even if their processing was different while they read the texts, the outcome for all the participants was a mental representation, and their mental representations would seem to be very similar. Previous research has shown that readers remember more information that is consistent with a coherent mental representation (Lorch & Lorch, 1996; Meyer & Rice, 1989). Because all the target sentences were conceptually important to the experimental texts, there may not have been a big enough difference between the question type conditions to make an impact on the number of correctly recalled comprehension questions. Speed of reading may be a more sensitive dependent measure than the total number of correct answers to comprehension questions, when target sentences are all conceptually important. Other significant effects and interactions might occur, if other aspects of the target sentences were manipulated, such as the conceptual relevance of the sentences. Another explanation for the null results is that the questions might not have been challenging. Furthermore, aspects of the reading situation and task may save time during processing, but not make a difference in the outcome of comprehension as measured by comprehension questions. Finally, there may not have been enough power to detect differences in the variables.

The mixed results in the text cue literature were potentially due to the lack of control over the type of information measured, the type of instructions given across various studies, and/or differences in processing demands of experimental tasks. The present experiment was designed to control for these potential problems. All target sentences were macropropositions, only general instructions to read for understanding were given at the beginning of the experiment, and the cognitive demands of the two question type conditions were equalized as much as possible, except for differences in the type of information necessary to answer the questions. The results of this dissertation would seem to indicate that careful consideration of the various aspects of reading tasks is warranted.

Various aspects of the reading situation and task seem to affect the relevance of information to the reader. Participants spent more time on information relevant to their reading situation and task, and less time on sentences that did not fulfill their task. Aspects of the reading task help assign importance to textual information beyond the importance conferred upon that information by the conceptual structure of the text. According to this assignment of significance, readers modify their comprehension process and in doing so influence the outcome of comprehension. The extent to which the outcome of comprehension is affected by aspects of the reading task was not clarified by this dissertation due to problems with power. However, text cues seem to be selected and the information that follows them is processed based on the type of information the text cues indicate and how that information will fulfill the reader's task. Therefore, the degree to which information after a particular cue will be processed depends upon how it fulfills the reading task. These results also indicate that some types of information fulfill more than one task, but other types of information may be more task-specific. Now, the goals of research seem to be predicting which aspects of the reading situation determine importance in a particular reading situation, and discovering whether there is a hierarchy of importance for the reading situation, as there is in a text.

The view of the reader as interactive best matches the results of the present study. How well a reader comprehends a text depends on the interaction between the reader, the reading task, and the reading situation. Previous research has shown that reader characteristics shape the reader's processing decisions, but this dissertation did not show such an effect. This lack of an effect could be due to the type of measure selected to distinguish between readers. However, this research does show that readers actively seek out cues to how they should spend time processing textual information, and readers also actively seek information that is relevant to their task. In fact, which text cues are selected and how cued information is processed is based on the reading task and reading situation, and not just the conceptual and top-level structure of the text, as previously thought. The reading task helps shape the goals and expectations of readers, and in doing so, shapes their search for cues and the processing of cued and uncued information. Readers seek out information that is important to fulfilling their task and spend more time processing task-relevant than irrelevant information. Even though importance seems to be determined more by the reading task, reader characteristics, and aspects of the reading situation can influence the determination of importance. That is to say, the relevance of information can change from reader to reader, from text to text, and from task to task.

Therefore, how well a reader understands a text is the culmination of many processing decisions constrained by various aspects of readers and their reading situation and reading task.

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APPENDIX A

"Energy Problems"

(Version A)

Since the Industrial Revolution, developed countries have become increasingly reliant on the production of energy to maintain their economies and standards of living.

Primary sources of energy have been oil, coal, natural gas and, more recently, nuclear power.

We are now faced with severe problems created by our dependence on these energy sources.

The fossil fuels of coal, oil, and gas share several important characteristics that helped establish them as favored sources of energy.

They are all relatively abundant natural resources.

They are all relatively accessible natural resources.

They are transportable.

The technology to convert them to energy is widely available and relatively inexpensive.

Since its development beginning in the 1950's, nuclear power has become an important energy source for the same basic reasons that the fossil fuels are so prominent.

In recent years, however, we have witnessed some of the limitations of fossil fuels and nuclear power.

**The next statement is important for understanding this topic.**

Because of our society's addiction to cheap, abundant energy and the dependence on fossil and nuclear fuels that it has created, we are now confronted by immense problems.

Coal, oil, gas, and the minerals supplying nuclear fuel are certainly abundant natural resources.

Fossil fuels are not renewable resources and therefore their supplies are limited.

Given the increasing demands for energy worldwide, we are rapidly approaching the time when these fuel sources will be exhausted.

We are already beginning to experience the effects of the decreasing availability of fossil fuels.

Coal, oil, and gas reserves are not as accessible as they once were.

Although the major methods of coal production remain strip-mining and underground mining, the most accessible veins of coal have long since been exhausted and miners must dig ever deeper into the ground to recover coal reserves.

The deeper and more extensive tunneling operations mean greater danger to the miners.

For similar reasons, drilling for oil and gas has become increasingly dangerous.

Once drilling operations in the continental U.S. were sufficient to meet the demand for oil and natural gas.

However, as demand increased and continental reserves decreased, the search for oil and gas extended to remote and dangerous locations.

One example is the construction of the Alaskan pipeline.

Another example is the construction of drilling platforms in the turbulent North Sea off the coast of Great Britain.

Work in such harsh environments certainly qualifies as hazardous duty.

As demand goes up, the danger in finding continuous sources of energy goes up.

The development of nuclear power received a boost from the realization that fossil fuel supplies are limited.

**However, it is important to know the following point.**

<u>The safety of our nuclear technology -- for both workers in the industry and the general population -- is a major concern.</u>

Throughout the 50's and 60's and into the 70's, the safety assurances of the nuclear power industry and the government were sufficient to assuage any major public doubts.

However, the legitimacy of safety concerns has been well documented over the past decade.

The most striking example is the Chernobyl disaster in which an apparent partial meltdown killed several workers.

It will have environmental and health consequences for years to come.

In our own country, the most prominent symbol of the inadequacies of current nuclear technology is Three Mile Island.

In addition, there has been a long list of safety violations at nuclear power stations across the country in the past several years.

**The paragraph can be summed up in the following sentence.**

<u>Gathering fossil fuels and creating nuclear power are dangerous.</u>

The costs of energy based on fossil fuels and nuclear power are rising.

In the case of fossil fuels, there are two basic reasons for increasing costs.

In a competitive marketplace, the decreasing availability of coal, oil, and natural gas puts the seller in a powerful position.

Anyone old enough to remember the Arab oil embargo and the resulting long lines at gas stations and the hikes in fuel costs understands this principle well.

Also, the decreasing accessibility of fossil fuels makes the production of energy more costly.

This results both because of the expense of accessing remote locations to drill or mine and because of the need for new, sophisticated technologies for drilling and mining.

For example, technologies for drilling for deep deposits of thick oil involve injecting hot water into wells to thin the oil and create pressure to push the oil to the surface.

Also, technologies are being developed to literally squeeze oil from rocks (i.e., shale).

These technologies are expensive.

Plus, the added costs are passed on to consumers.

In the case of nuclear power, costs are escalating because of the need to increase the safety of the technology and because of the need to dispose of radioactive byproducts properly.

Safety violations have occurred at nuclear power plants for a variety of reasons.

Operators often fail to notice potentially dangerous situations or do not follow correct procedures in response to such situations.

This is understandable given the vast array of instrumentation they must monitor.

Efforts are currently underway to redesign instrumentation to make it more compatible with the cognitive abilities of human operators.

Another reason for problems is that the "failsafe systems" at some installations have not worked properly.

Again, equipment redesign is the answer.

The research and implementation of new designs is expensive.

The problem of disposal of radioactive byproducts was not given sufficient attention early in the development of the nuclear power industry.

As a consequence, we failed to fully appreciate the magnitude of this problem until it could no longer be ignored.

Our initial plans for waste disposal proved inadequate.

The resulting search for effective methods of handling waste and for suitable storage sites has also turned out to be costly.

Due to equipment and research, costs have risen.

The heavy use of fossil fuels and nuclear power threatens our environment in many ways.

We are just beginning to understand the magnitude of the environmental problems we have created.

One side effect of industrialization has been known for a long-time.

Many factors contribute to air pollution, but the burning of fossil fuels -- particularly motor vehicle exhaust -- is a major source of such pollution.

Fossil fuels contribute various dangerous particulates to our atmosphere, including sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, and lead.

Nearly half of the U.S. population lives in areas with unhealthy air, according to the Environmental Protection Agency (EPA).

In the case of smog ozone alone, approximately one-third of the population lives in areas where ozone regularly exceeds acceptable levels.

Further, smog ozone is not restricted to urban areas.

At least in the eastern U.S., summer smog ozone levels regularly exceed standards even in rural areas.

The ever-widening search for new sources of fossil fuels has led to the exploitation of environmentally-sensitive areas.

One prominent example is the construction of the Alaskan pipeline.

Environmentalists warn against development in environmentally-sensitive areas for two basic reasons.

Such development directly threatens the ecology of the immediate area.

And damage to local environments may have much more widespread environmental consequences.

A CBS edition of "48 Hours" (July 27, 1989) demonstrated some of the ill effects of oil exploration on the Alaskan wilderness.

Another example is the destruction of wetland ecologies in Louisiana by oil and gas drilling operations.

Hot wastewater from the cooling towers of nuclear plants has been shown to alter the ecologies of the tributaries into which the water is dumped.

While it is easy to demonstrate immediate effects on local ecologies, it is more difficult to establish the widespread environmental consequences of oil and gas exploration.

This is because such effects can generally be expected to occur only over many years.

Also, widespread environmental effects are typically the result of a variety of factors, making the contribution of any specific factor (e.g., one oil-drilling operation) difficult to assess.

However, it is not hard to imagine how the destruction of a major wetland spawning ground could have extensive implications for fish populations.

**The following sentence sums up this paragraph.**

<u>The search for fuels has disrupted the environment.</u>

One of the benefits of oil is that it is transportable.

One of the liabilities of oil is also that it is transportable.

Oil spills by damaged supertankers are so common that we can easily become complacent about them.

However, the spill by the Exxon Valdez in Alaska tragically demonstrates how destructive and costly oil spills can be.

To put the accident into perspective, an equivalent spill along the eastern coast of the U.S. would have affected the entire coastline from Cape Cod in Massachusetts down to the Carolinas.

Perhaps a spill along the eastern U.S. would have been preferable to the Alaskan location because the pristine wilderness of Alaska is likely to suffer more extensive damage than would the eastern coastline.

It is difficult to put a price tag on the immediate or long-term effects of oil spills on wildlife.

However, one indication of the enormous economic implications of the Valdez spill is that the spill threatens the world's largest salmon fishing ground.

In one fishing season alone, the salmon catch from that fishing ground is estimated to be worth $400 million!

The problem of what to do with radioactive waste, or "radwaste," from nuclear power plants is a huge one.

A good idea of the extent of the problem is provided by the example of the $700 million Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico.

The WIPP is a proposed major site for the storage of radwaste from the nation's nuclear weapons plants.

The capacity of the plant is approximately 850,000 drums of waste!

And that is just waste from the processing of nuclear weapons.

It does not include waste from power-generating facilities.

The WIPP consists of 56 rooms carved out of salt deposits located 2,100 feet below ground level.

It is designed so that the rooms of salt will slowly collapse and encapsulate the waste during the next hundred years.

Currently, tests are being conducted to determine whether the facility will meet EPA standards for storing nuclear waste.

The plan had been to start placing waste in the facility in October of 1988 as part of a five-year series of safety tests.

As of August of 1989, loading of waste had not yet begun.

Two serious concerns have surfaced.

One worry is that the salt beds are more saturated with water than had originally been assumed.

If the rooms of salt collapse too slowly, the water may begin to fill the rooms and dissolve the steel drums containing the radwaste.

The resulting radioactive slurry could potentially reach the surface.

Another worry is that gas generated by the radwaste could build pressure and enlarge cracks in the salt.

This might give the waste an exit route to the surface or nearby underground water supply.

The WIPP is designed to handle radwaste produced by the 17 nuclear weapons plants in this country.

A similar, but more ambitious project, is being planned to handle high-level radwaste from the nation's 106 nuclear power plants.

By the turn of the century, those plants will have generated approximately 50,000 metric tons of spent uranium fuel.

The plan to store the waste involves digging into the stone heart of Yucca Mountain in Nevada and building a repository there.

The repository will be filled with 70,000 tons of waste by the year 2030, then it will be sealed off and its entrance shafts refilled.

The cost is currently estimated at more than $1 billion.

The canisters containing the radwaste will last between 300 and 1,000 years.

The problem is that the radwaste will remain dangerous for more than 10,000 years!

After the canisters have dissolved, it will be up to the mountain to contain the radwaste.

Although current understanding of Yucca Mountain suggests it is an ideal containment site, experience with WIPP demonstrates the necessity for being cautious.

To add to the concern, the 10,000-year time span means that changes in climate and geology could be extensive enough to dramatically change the characteristics of the Yucca Mountain site.

In short, storage of radioactive waste is an expensive and uncertain business.

Due to radioactive waste, nuclear power is a costly method of obtaining power in terms of disposal and the probability of having an accident.

The burning of fossil fuels, particularly coal, causes nitrogen compounds and sulfates to be released into the atmosphere.

These particulates return to the earth in the form of rain with high levels of acidity.

In recent years, environmental scientists have focused a great deal of attention on the effects of acid rain.

It is now clear that acid rain can have devastating effects on lake and forest ecologies.

A study of mountain lakes within the Adirondacks, Poconos and Catskills mountain ranges of the northeastern U.S indicates that acid rain affecting these lakes may have caused the loss of 69 percent of the leeches, 45 percent of the insects, 50 percent of the mollusks (e.g., clams), and 18 percent of the crustaceans.

A study by Canadian researchers has further shown that once these organisms are destroyed, fish cease to reproduce and thus the fish population is endangered.

It is unclear whether such effects are reversible.

An study of spruce trees in a forest in Germany also demonstrates the damaging effects of acid rain.

About 20 years ago, an unhealthy spring yellowing of needles appeared within occasional stands of spruce in a high-elevation Bavarian forest.

Over the next two years, the blight spread and worsened and gave rise to an increase in tree mortality throughout Germany's high-elevation forests.

In 1982, approximately 8 percent of all West German trees were affected.

By 1987, roughly 52 percent of all trees were affected.

Today, about a third of West Germany's trees show heavy damage.

A careful study of the causes of the devastation showed that acid rain initiated a chemical imbalance throughout the ecosystem by acidifying the soil.

The soil changes led to the gradual development of serious deficiencies of essential nutrients for the trees.

The lack of appropriate nutrients, in turn, made the trees much more susceptible to pests and to weather extremes.

The result has been the loss of huge numbers of trees in the space of less than a decade.

The lesson is a sobering one.

The accumulation of the waste (i.e., acid rain) from decades of coal burning had few observable effects for a long time.

When the effects began to be noticed, they were so extensive, so fast to progress, and so poorly understood that nothing could be done to prevent them.

Perhaps the greatest threat to the global economy is global warming due to the greenhouse effect.

The greenhouse effect results when certain gases, particularly carbon dioxide, trap heat that would otherwise radiate into space.

Levels of carbon dioxide have increased more than 23 percent since before the Industrial Revolution and continue to rise roughly 0.4 percent annually.

As the levels of carbon dioxide increase, more and more heat will be trapped and global temperatures will rise.

The 1980s were the warmest decade on record.

The warmest year ever was 1987.

Some weather scientists interpret this evidence to indicate that global warming has begun.

If the greenhouse effect has really initiated a global warming, the implications are widespread indeed.

The overall increase in global temperatures will harm agriculture, industry, and water resources.

In addition to the average increase in temperature, significant shifts in weather patterns and climate can be expected.

Melting of the polar icecaps will cause flooding of low-lying coastal areas worldwide.

Current levels of smog could be greatly exacerbated by the warming.

**One problem is particularly notable.**

<u>Many scientists consider global warming and the resulting changes in the global environment to be the most important problem facing us in the next century.</u>

In the worst possible scenario, the environmental damage resulting from our dependence on fossil and nuclear fuels threatens the survival of life on the planet.

Damage to key links in the food chain, changes in the composition of the atmosphere due to pollution, catastrophic shifts of climate, and other effects of our energy use patterns could certainly cause major changes in life as we know it.

It is impossible, however, to forecast the ultimate consequences of burning fossil fuels and relying on nuclear power.

On the other hand, we can document some serious health problems caused by our use of fossil and nuclear fuels.

Air pollution from the burning of fossil fuels is known to cause respiratory illnesses.

The poisons and irritants spewed into the atmosphere attack the tissue of the lungs and can damage it irreversibly.

For those with respiratory or heart disease, air pollution poses a serious health threat.

In some major cities, it is a routine procedure to warn people with respiratory or heart problems to stay indoors during periods of dangerous smog concentrations.

The stress on the body of poor air quality can be life threatening.

Given the fact that almost half of the U.S. population lives in areas where air pollution regularly exceeds federal standards, the threat to health is a very serious problem.

Perhaps the most prevalent fear people have of nuclear power is its potential for causing cancer through its use of radioactive elements as fuel.

Probably next on the list of health fears from radioactivity is genetic damage.

Post-World War II civilization is well aware of the carcinogenic and mutagenic effects of radiation.

It is unknown what role nuclear power plays in causing cancer and genetic damage (e.g., birth defects) in the general population.

If adequately managed, nuclear power should not increase cancer and genetic damage.

However, reports of accidental release of contaminated wastewater and smoke from nuclear plants are not reassuring to a nervous public.

The more dramatic events of Chernobyl and Three Mile Island are even less comforting. The cancer and genetic threats of nuclear power are well understood by most people. Perhaps less well known is the fact that the burning of fossil fuels also has carcinogenic and mutagenic effects.

In fact, fossil fuels certainly are responsible for more cases of cancer and genetic defects than nuclear fuel.

It is no accident that those areas of the country that are the most heavily industrialized also have the highest rates of cancer and birth defects.

**The following sentence sums up the situation.**

The health threats of fossil fuels and nuclear power are serious and extensive.

APPENDIX B

"Energy Problems"

(Version B)

Since the Industrial Revolution, developed countries have become increasingly reliant on the production of energy to maintain their economies and standards of living.

Primary sources of energy have been oil, coal, natural gas and, more recently, nuclear power.

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The fossil fuels of coal, oil, and gas share several important characteristics that helped establish them as favored sources of energy.

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The technology to convert them to energy is widely available and relatively inexpensive.

**The next sentence should be emphasized.**

<u>Since its development beginning in the 1950's, nuclear power has become an important energy source for the same basic reasons that the fossil fuels are so prominent.</u>

In recent years, however, we have witnessed some of the limitations of fossil fuels and nuclear power.

Because of our society's addiction to cheap, abundant energy and the dependence on fossil and nuclear fuels that it has created, we are now confronted by immense problems. Coal, oil, gas, and the minerals supplying nuclear fuel are certainly abundant natural resources.

**However, the following is an important problem.**

Fossil fuels are not renewable resources and therefore their supplies are limited.

Given the increasing demands for energy worldwide, we are rapidly approaching the time when these fuel sources will be exhausted.

We are already beginning to experience the effects of the decreasing availability of fossil fuels.

Coal, oil, and gas reserves are not as accessible as they once were.

Although the major methods of coal production remain strip-mining and underground mining, the most accessible veins of coal have long since been exhausted and miners must dig ever deeper into the ground to recover coal reserves.

The deeper and more extensive tunneling operations mean greater danger to the miners.

For similar reasons, drilling for oil and gas has become increasingly dangerous.

Once drilling operations in the continental U.S. were sufficient to meet the demand for oil and natural gas.

However, as demand increased and continental reserves decreased, the search for oil and gas extended to remote and dangerous locations.

One example is the construction of the Alaskan pipeline.

Another example is the construction of drilling platforms in the turbulent North Sea off the coast of Great Britain.

Work in such harsh environments certainly qualifies as hazardous duty.

As demand goes up, the danger in finding continuous sources of energy goes up.

The development of nuclear power received a boost from the realization that fossil fuel supplies are limited.

The safety of our nuclear technology -- for both workers in the industry and the general population -- is a major concern.

Throughout the 50's and 60's and into the 70's, the safety assurances of the nuclear power industry and the government were sufficient to assuage any major public doubts.

However, the legitimacy of safety concerns has been well documented over the past decade.

The most striking example is the Chernobyl disaster in which an apparent partial meltdown killed several workers.

It will have environmental and health consequences for years to come.

In our own country, the most prominent symbol of the inadequacies of current nuclear technology is Three Mile Island.

In addition, there has been a long list of safety violations at nuclear power stations across the country in the past several years.

Gathering fossil fuels and creating nuclear power are dangerous.

The costs of energy based on fossil fuels and nuclear power are rising.

In the case of fossil fuels, there are two basic reasons for increasing costs.

In a competitive marketplace, the decreasing availability of coal, oil, and natural gas puts the seller in a powerful position.

Anyone old enough to remember the Arab oil embargo and the resulting long lines at gas stations and the hikes in fuel costs understands this principle well.

Also, the decreasing accessibility of fossil fuels makes the production of energy more costly.

This results both because of the expense of accessing remote locations to drill or mine and because of the need for new, sophisticated technologies for drilling and mining.

For example, technologies for drilling for deep deposits of thick oil involve injecting hot water into wells to thin the oil and create pressure to push the oil to the surface.

Also, technologies are being developed to literally squeeze oil from rocks (i.e., shale).

These technologies are expensive.

Plus, the added costs are passed on to consumers.

In the case of nuclear power, costs are escalating because of the need to increase the safety of the technology and because of the need to dispose of radioactive byproducts properly.

Safety violations have occurred at nuclear power plants for a variety of reasons.

**The following sentence is important.**

Operators often fail to notice potentially dangerous situations or do not follow correct procedures in response to such situations.

This is understandable given the vast array of instrumentation they must monitor.

Efforts are currently underway to redesign instrumentation to make it more compatible with the cognitive abilities of human operators.

Another reason for problems is that the "failsafe systems" at some installations have not worked properly.

Again, equipment redesign is the answer.

The research and implementation of new designs is expensive.

The problem of disposal of radioactive byproducts was not given sufficient attention early in the development of the nuclear power industry.

As a consequence, we failed to fully appreciate the magnitude of this problem until it could no longer be ignored.

Our initial plans for waste disposal proved inadequate.

The resulting search for effective methods of handling waste and for suitable storage sites has also turned out to be costly.

**The next sentence summarizes the preceding section.**

Due to equipment and research, costs have risen.

The heavy use of fossil fuels and nuclear power threatens our environment in many ways.

We are just beginning to understand the magnitude of the environmental problems we have created.

One side effect of industrialization has been known for a long-time.

Many factors contribute to air pollution, but the burning of fossil fuels -- particularly motor vehicle exhaust -- is a major source of such pollution.

Fossil fuels contribute various dangerous particulates to our atmosphere, including sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, and lead.

Nearly half of the U.S. population lives in areas with unhealthy air, according to the Environmental Protection Agency (EPA).

In the case of smog ozone alone, approximately one-third of the population lives in areas where ozone regularly exceeds acceptable levels.

Further, smog ozone is not restricted to urban areas.

At least in the eastern U.S., summer smog ozone levels regularly exceed standards even in rural areas.

The ever-widening search for new sources of fossil fuels has led to the exploitation of environmentally sensitive areas.

One example is the construction of the Alaskan pipeline.

Environmentalists warn against development in environmentally sensitive areas for two basic reasons.

Such development directly threatens the ecology of the immediate area.

And damage to local environments may have much more widespread environmental consequences.

A CBS edition of "48 Hours" (July 27, 1989) demonstrated some of the ill effects of oil exploration on the Alaskan wilderness.

Another example is the destruction of wetland ecologies in Louisiana by oil and gas drilling operations.

Hot wastewater from the cooling towers of nuclear plants has been shown to alter the ecologies of the tributaries into which the water is dumped.

While it is easy to demonstrate immediate effects on local ecologies, it is more difficult to establish the widespread environmental consequences of oil and gas exploration.

This is because such effects can generally be expected to occur only over many years.

Also, widespread environmental effects are typically the result of a variety of factors, making the contribution of any specific factor (e.g., one oil-drilling operation) difficult to assess.

However, it is not hard to imagine how the destruction of a major wetland spawning ground could have extensive implications for fish populations.

The search for fuels has disrupted the environment.

One of the benefits of oil is that it is transportable.

One of the liabilities of oil is also that it is transportable.

Oil spills by damaged supertankers are so common that we can easily become complacent about them.

However, the spill by the Exxon Valdez in Alaska tragically demonstrates how destructive and costly oil spills can be.

To put the accident into perspective, an equivalent spill along the eastern coast of the U.S. would have affected the entire coastline from Cape Cod in Massachusetts down to the Carolinas.

Perhaps a spill along the eastern U.S. would have been preferable to the Alaskan location because the pristine wilderness of Alaska is likely to suffer more extensive damage than would the eastern coastline.

It is difficult to put a price tag on the immediate or long-term effects of oil spills on wildlife.

However, one indication of the enormous economic implications of the Valdez spill is that the spill threatens the world's largest salmon fishing ground.

In one fishing season alone, the salmon catch from that fishing ground is estimated to be worth $400 million!

The problem of what to do with radioactive waste, or "radwaste," from nuclear power plants is a huge one.

A good idea of the extent of the problem is provided by the example of the $700 million Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico.

The WIPP is a proposed major site for the storage of radwaste from the nation's nuclear weapons plants.

The capacity of the plant is approximately 850,000 drums of waste!

And that is just waste from the processing of nuclear weapons.

It does not include waste from power-generating facilities.

The WIPP consists of 56 rooms carved out of salt deposits located 2,100 feet below ground level.

It is designed so that the rooms of salt will slowly collapse and encapsulate the waste during the next hundred years.

Currently, tests are being conducted to determine whether the facility will meet EPA standards for storing nuclear waste.

The plan had been to start placing waste in the facility in October of 1988 as part of a five-year series of safety tests.

As of August of 1989, loading of waste had not yet begun.

Two concerns have surfaced.

One worry is that the salt beds are more saturated with water than had originally been assumed.

If the rooms of salt collapse too slowly, the water may begin to fill the rooms and dissolve the steel drums containing the radwaste.

The resulting radioactive slurry could potentially reach the surface.

Another worry is that gas generated by the radwaste could build pressure and enlarge cracks in the salt.

This might give the waste an exit route to the surface or nearby underground water supply.

The WIPP is designed to handle radwaste produced by the 17 nuclear weapons plants in this country.

A similar, but more ambitious project, is being planned to handle high-level radwaste from the nation's 106 nuclear power plants.

By the turn of the century, those plants will have generated approximately 50,000 metric tons of spent uranium fuel.

The plan to store the waste involves digging into the stone heart of Yucca Mountain in Nevada and building a repository there.

The repository will be filled with 70,000 tons of waste by the year 2030, then it will be sealed off and its entrance shafts refilled.

The cost is currently estimated at more than $1 billion.

The canisters containing the radwaste will last between 300 and 1,000 years.

The problem is that the radwaste will remain dangerous for more than 10,000 years!

After the canisters have dissolved, it will be up to the mountain to contain the radwaste.

Although current understanding of Yucca Mountain suggests it is an ideal containment site, experience with WIPP demonstrates the necessity for being cautious.

To add to the concern, the 10,000-year time span means that changes in climate and geology could be extensive enough to dramatically change the characteristics of the Yucca Mountain site.

In short, storage of radioactive waste is an expensive and uncertain business.

**The following sentence summarizes the situation.**

<u>Due to radioactive waste, nuclear power is a costly method of obtaining power in terms of disposal and the probability of having an accident.</u>

The burning of fossil fuels, particularly coal, causes nitrogen compounds and sulfates to be released into the atmosphere.

These particulates return to the earth in the form of rain with high levels of acidity.

In recent years, environmental scientists have focused a great deal of attention on the effects of acid rain.

It is now clear that acid rain can have devastating effects on lake and forest ecologies.

A study of mountain lakes within the Adirondacks, Poconos and Catskills mountain ranges of the northeastern U.S indicates that acid rain affecting these lakes may have caused the loss of 69 percent of the leeches, 45 percent of the insects, 50 percent of the mollusks (e.g., clams), and 18 percent of the crustaceans.

A study by Canadian researchers has further shown that once these organisms are destroyed, fish cease to reproduce and thus the fish population is endangered.

It is unclear whether such effects are reversible.

A study of spruce trees in a forest in Germany also demonstrates the damaging effects of acid rain.

About 20 years ago, an unhealthy spring yellowing of needles appeared within occasional stands of spruce in a high-elevation Bavarian forest.

Over the next two years, the blight spread and worsened and gave rise to an increase in tree mortality throughout Germany's high-elevation forests.

In 1982, approximately 8 percent of all West German trees were affected.

By 1987, roughly 52 percent of all trees were affected.

Today, about a third of West Germany's trees show heavy damage.

A careful study of the causes of the devastation showed that acid rain initiated a chemical imbalance throughout the ecosystem by acidifying the soil.

The soil changes led to the gradual development of serious deficiencies of essential nutrients for the trees.

The lack of appropriate nutrients, in turn, made the trees much more susceptible to pests and to weather extremes.

The result has been the loss of huge numbers of trees in the space of less than a decade.

The lesson is a sobering one.

The accumulation of the waste (i.e., acid rain) from decades of coal burning had few observable effects for a long time.

**The situation can be summed up as follows.**

When the effects began to be noticed, they were so extensive, so fast to progress, and so poorly understood that nothing could be done to prevent them.

Perhaps the greatest threat to the global economy is global warming due to the greenhouse effect.

The greenhouse effect results when certain gases, particularly carbon dioxide, trap heat that would otherwise radiate into space.

Levels of carbon dioxide have increased more than 23 percent since before the Industrial Revolution and continue to rise roughly 0.4 percent annually.

As the levels of carbon dioxide increase, more and more heat will be trapped and global temperatures will rise.

The 1980s were the warmest decade on record.

The warmest year ever was 1987.

Some weather scientists interpret this evidence to indicate that global warming has begun.

If the greenhouse effect has really initiated a global warming, the implications are widespread indeed.

The overall increase in global temperatures will harm agriculture, industry, and water resources.

In addition to the average increase in temperature, significant shifts in weather patterns and climate can be expected.

Melting of the polar icecaps will cause flooding of low-lying coastal areas worldwide.

Current levels of smog could be greatly exacerbated by the warming.

Many scientists consider global warming and the resulting changes in the global environment to be the most important problem facing us in the next century.

In the worst possible scenario, the environmental damage resulting from our dependence on fossil and nuclear fuels threatens the survival of life on the planet.

Damage to key links in the food chain, changes in the composition of the atmosphere due to pollution, catastrophic shifts of climate, and other effects of our energy use patterns could certainly cause major changes in life as we know it.

It is impossible, however, to forecast the ultimate consequences of burning fossil fuels and relying on nuclear power.

On the other hand, we can document some serious health problems caused by our use of fossil and nuclear fuels.

Air pollution from the burning of fossil fuels is known to cause respiratory illnesses.

The poisons and irritants spewed into the atmosphere attack the tissue of the lungs and can damage it irreversibly.

For those with respiratory or heart disease, air pollution poses a serious health threat.

In some major cities, it is a routine procedure to warn people with respiratory or heart problems to stay indoors during periods of dangerous smog concentrations.

The stress on the body of poor air quality can be life threatening.

Given the fact that almost half of the U.S. population lives in areas where air pollution regularly exceeds federal standards, the threat to health is a very serious problem.

Perhaps the most prevalent fear people have of nuclear power is its potential for causing cancer through its use of radioactive elements as fuel.

Probably next on the list of health fears from radioactivity is genetic damage.

Post-World War II civilization is well aware of the carcinogenic and mutagenic effects of radiation.

It is unknown what role nuclear power plays in causing cancer and genetic damage (e.g., birth defects) in the general population.

If adequately managed, nuclear power should not increase cancer and genetic damage.

However, reports of accidental release of contaminated wastewater and smoke from nuclear plants are not reassuring to a nervous public.

The more dramatic events of Chernobyl and Three Mile Island are even less comforting.

The cancer and genetic threats of nuclear power are well understood by most people.

Perhaps less well known is the fact that the burning of fossil fuels also has carcinogenic and mutagenic effects.

In fact, fossil fuels certainly are responsible for more cases of cancer and genetic defects than nuclear fuel.

It is no accident that those areas of the country that are most heavily industrialized also have the highest rates of cancer and birth defects.

The health threats of fossil fuels and nuclear power are serious and extensive.

# APPENDIX C

## The Earth (Version A)

With the exception of a small amount that has oozed out of deep fissures, we have never seen material from the interior of the earth.

Although we have no direct way of determining the earth's internal structure, we do have indirect methods.

Using our knowledge of its size and mass, for example, we can calculate its average density (mass per unit volume).

In the same way our knowledge of the earth's oblateness indirectly tells us something:

As the earth spins on its axis, its equatorial regions bulge, and the magnitude of this bulge gives us a general indication of its internal makeup.

Of much more value, however, is the study of the waves that are generated by earthquakes: seismic waves.

These tell us that the interior is layered (differentiated), how thick the layers are, and whether they are molten or solid.

Earthquakes occur worldwide.

Most take place 50-100 km below the surface.

A few occur at depths as low as 700 km.

The waves that are generated by these quakes are picked up by seismic stations at many different locations, usually several thousand kilometers apart.

That each of these stations is "seeing" the quake from a different point of view allows us to pinpoint the quake's origin.

For the typical earthquake, the region in which the quake occurs is the focus.

The point on the surface directly above its center is  the epicenter.

The quake sends out two types of waves into the surrounding medium, P- and S-waves.

A third wave, which travels along the surface, will not be discussed.

The P or primary wave, is a longitudinal one.

It creates series of compressions and rarefaction like a sound wave.

The S or secondary wave, is a transverse one, like light.

Its vibrational motion is perpendicular to its direction of propagation.

Both waves travel more rapidly the denser the material through which they are passing.

They also travel at different speeds (the S-wave slower) regardless of the medium.

S- and P-waves also differ in another respect.

The former cannot pass through liquids.

However, P-waves can pass through liquids.

Furthermore, as they pass into a medium of different density, both waves are refracted or bent.

But, like waves of light, not by the same amount.

Early in the study of seismic waves it was noticed that P-waves passed through the core of the earth.

But, S-waves did not.

This implied that the core was liquid.

It was later shown, however, that there is a small solid core inside the liquid one.

Although temperatures are obviously higher in the center, so is the pressure which raises the melting point.

Thus, despite the high temperature the region remains solid.

Seismic waves have been particularly valuable tools in our study of the earth's interior.

Because of them we now know that the earth consists of three main layers: a core (of two parts), a mantle (which surrounds it), and at the surface, a crust.

We know much about the interior of the Earth because of seismic waves.

The diameter of the earth's outer core is approximately 6950 km (4320 mi), about half the diameter of the earth.

The inner, solid core has a diameter of about 2500 km and a density of approximately 10-12 gm/cm3.

This compares to 2.5 gm/cm3 for the material at the surface of the earth and an overall average throughout the earth of about 5.5 gm/cm3.

Because the density near the center is much higher than the average, it is obviously composed of heavier elements.

Geologists believe that it is composed mostly of iron and nickel with perhaps some sulphur and silicon.

This is reasonable: Heavy element such as iron and nickel would have fallen to the core soon after this region became molten.

Surrounding the core is the mantle.

**The following sentence is important.**

The mantle contains little iron and nickel, hence its much lower density than the core.

It is composed primarily of magnesium-rich silicate minerals.

Its inner regions are molten.

But, its outer layers exhibit plastic flow.

They flow slowly.

They are therefore, considered to be a quasi-fluid.

They are referred to as the asthenosphere.

With the goal of examining the mantle directly, Project Mohole was begun in the 1960s.

Its object, to drill through the earth's crust to the mantle, was eventually abandoned because of technical difficulties.

**The following sentence summarizes this section.**

<u>There is no direct way to measure all of the Earth's interior structure.</u>

But, there are ways to do so indirectly.

Surrounding the mantle is the outermost shell of the earth, the crust.

This is composed of the lightest material of the earth-in effect, the slag that floated to the top when the earth was molten.

Under the oceans it is relatively thin (approximately 5 km).

But under the continents, it is much heavier than the oceans.

And, therefore, needing a much thicker layer to support them.

The thickness of this layer averages about 30 km.

Although the crust is the lightest material of the Earth, it has much variation in thickness.

Though the continents are largely of granite, most of the crust is made up of basalt, a volcanic rock consisting of elements such as silicon, oxygen, aluminum, magnesium, and iron.

In the last few years we have learned to date rocks quite accurately.

The techniques have been applied to both earth and moon rocks.

Earth rocks are both relatively old and young.

In fact, many are quite young.

Some, from the Rocky Mountains of North America, for example, are as young as 60 million years.

The oldest known Earth rocks (found in Greenland) are about 3.7 billion years old.

The reasons for this difference in the ages of Earth rocks are considered in the next section.

Shortly after worldwide maps became available, in the early 1600s, Francis Bacon noticed the striking resemblance between the eastern coastline of South America and the western coastline of Africa.

They looked like two adjacent parts of a jigsaw puzzle.

Bacon suggested, on the basis of this, that they might at one time have been part of a single large land mass.

How such a large land mass could break apart, though, was beyond understanding.

The idea was resurrected in 1910 by German meteorologist Alfred Wegener.

In addition to the resemblance between the shorelines of Africa and South America, he noticed similar resemblances between the eastern shores of North America and the western shoreline of Europe.

He also found striking matches in the types of rocks along regions where the continents presumably had once abutted.

Furthermore, fossil types were similar.

**It is important to note the following sentence.**

<u>On the basis of these findings Wegener formulated a theory according to which all of the present continents of the world were, at one time, together in a single super- continent that later broke apart.</u>

But, what force could push continents apart?

There was no known mechanism.

And, as late as 1960, Wegener's ideas were still looked on with considerable skepticism.

But more data were uncovered.

First, a huge underwater chain of mountains was discovered in the middle of the Atlantic Ocean.

Almost midway between the continents and extending their entire length, it is now referred to as the Mid-Atlantic Ridge.

It was also discovered that earthquakes were common along its entire length and that considerable heat was being released along it.

Evidence for the Pangea theory was beginning to accumulate.

H. Hess and R. S. Dietz proposed that magma (liquid rock from the interior of the earth) was flowing out of the ridge, creating in the process a new section of ocean floor.

And, as this section of floor moved away from the ridge, the continents were pushed apart.

Further evidence for this point of view came when the ages of the rocks on the floor were determined.

Near the ridge they were exceedingly young (age here is the time since last molten), and they increased in age with distance from the ridge.

The oldest rocks- about 150 million years old-were found near the edges of the continents.

Another recent piece of evidence has convinced even the most confirmed skeptics.

The magnetic polarity of the earth has reversed many times.

Because iron atoms in molten material orient themselves along magnetic field lines, reversals of polarity can be detected in iron-containing materials that were once molten.

Examination of the floor of the ocean showed evidence of several reversals.

And, of particular interest, the patterns on the two sides of the ridge were identical: Iron at equal distances from and on either side of the ridge always indicated the same polarity.

Iron at equal distances from and on either side of the ridge always indicated the same polarity.

Scientists are now convinced that magma pushing up through the Mid-Atlantic Ridge is indeed pushing the continents apart.

The rate of separation (continental drift) is small, only about 2-4 cm per year.

But, a simple calculation shows that even with this low rate the separation would be substantial in a few million years.

Indeed, it would have taken about 150 million years to move South America as far from Africa as it is today.

According to present theories, about 250 million years ago all the continents of the earth were part of one gigantic continent, called Pangea.

About 8300 km (5000 mi) wide and 16,600 km (10,000 mi) long, it stretched across the earth in a north-south direction.

About 200 million years ago it began to break up along the equator.

Eventually a large sea, now called the Tethys Sea, separated the two parts, which, super-continents themselves, are now referred to as Gondwanaland and Laurasia.

The present continents of South America, Africa, India, Australia, and Antarctica were contained within Gondwanaland, and the continents of North America, Greenland, and Eurasia were contained within Laurasia.

The splitting of Gondwanaland and of Laurasia into these continents, which began about 150 million years ago, was caused by convection currents in the asthenosphere (created by hot material moving upward in some regions and cooler material moving downward in others).

Magma, or liquid rock, ascending through the rifts created new ocean floor, which spread out away from the rift.

Closer to the continents are regions called subduction zones, where the ocean bed disappears down into the mantle again.

Mountain ranges are usually seen in the regions just beyond subduction zones (e.g., the Andes in South America).

Occasionally, continents collide, and exceedingly high mountain ranges are generated.

India, a good example, was at one time completely surrounded by water.

When it joined the mainland, the resulting pressure created the Himalayas.

We now have a fairly good understanding of the process of continental drift.

The surface of the earth is made up of several plates.

There are seven major ones and a few minor ones.

The continents ride on these plates as they move slowly in various directions.

At one edge new material is generate.

At the opposite edge it is disappearing back into the earth.

The surface of the earth is, in effect, being continually recycled.

Earthquake activity is concentrated along the plate edges.

It was this activity, in fact, that allowed us to establish the plate boundaries.

**This information is summarized in the following sentence.**

<u>The Earth is very active.</u>

Planetary atmospheres differ considerably.

The earth's atmosphere is the only one that consists mostly of nitrogen (78.08%) and oxygen (20.95%).

Of the four major regions into which we divide the atmosphere the lowest layer, which reaches to about 8-10 km above the surface, is called the troposphere.

All the Earth's weather occurs in the troposphere.

Extending about 30 km above the troposphere is the stratosphere, within which is a layer that protects us from the ultraviolet rays of the sun: the ozone (03) layer.

This is the layer thought to be endangered by exhausts from high-flying airplanes like the SST (supersonic transport plane) and by various chloro-fluoro-carbons used as propellant in some aerosol spray products.

Destruction or diminution of the layer would permit more ultraviolet light to reach Earth, with a consequent increase in the incidence of skin cancer.

Directly above the stratosphere is the mesosphere, and within it are the various layers of the ionosphere.

The ionosphere is particularly important in radio communications because broadcast waves can be reflected from it.

Since radio waves move in a straight line, this bounce effect is what makes long-distance transmission-around the curve of the earth-possible.

Finally, above the ionosphere, we have the exosphere, the outermost layer, which tapers off to interplanetary space.

An important question to ask is where did the atmosphere come from?

The earth (and other planets) was formed with an atmosphere of hydrogen and helium, which was swept away by the "solar gale."

Many years later an era of vulcanism and outgassing released carbon dioxide, water vapor, and other gases into the region around the earth.

As the earth cooled, the water vapor condensed to the surface, and the oceans began to form.

Some of the carbon dioxide was absorbed by the water of the oceans.

The rest went into the creation of carbonate rocks (limestone).

Water acts as a catalyst in the reactions that create these rocks.

Other gases such as methane and ammonia continued to accumulate.

Eventually, the earth had a second atmosphere.

This atmosphere is composed of many layers of different components.

It consisted of methane, ammonia, nitrogen, and water vapor.

Scientists believe that the basic molecules of life formed in it.

Our present atmosphere evolved from the primitive atmosphere.

The oxygen that we now have is generally believed to have been created by marine vegetation, or algae, in the oceans.

As with plants in general, they absorb carbon dioxide, metabolize the carbon, then expel the oxygen.

It is likely that the ammonia present was absorbed into the oceans, leaving mostly nitrogen and oxygen-the major components of our present atmosphere.

The atmosphere is composed of many layers of different components.

As the name suggests, the magnetosphere is a region- of plasma (charged particles) under the influence of the earth's magnetic field.

Magnetic fields are represented as bundles of lines that emanate from one pole of a magnet and enter the other pole.

**The following information is of note.**

<u>The density, or number of lines crossing a unit area, determines the strength of the field.</u>

The earth's magnetic field is .6 gauss (G) near the surface at the poles

Small toy magnets have field strengths of a few hundred gauss.

A standard laboratory bar magnet has a field strength of several thousand gauss.

The magnetic field of the earth is tilted about 11 degrees with respect to the spin axis.

It will not remain in this direction indefinitely, however.

Over long periods of time it wanders in a random but generally westerly direction.

Every few hundred thousand years or so it completely reverses direction.

We do not understand why this reversal occurs.

We do know what causes the magnetic field: circulating currents in the molten interior of the earth.

Reversal of the field would seem to require reversal of these currents.

The earth's magnetic field extends outward for thousands of miles.

Any charged particles that enter this region will immediately come under its influence.

A source of such particles is the solar wind.

In 1958 instruments aboard the Explorer I rocket indicated that there was a region of considerable radiation above the earth.

Further details obtained with Explorer III showed that there were two radiation regions, now referred to as the Van Allen belts.

When a charged particle enters a magnetic field perpendicular to the field lines, it experiences a side thrust that forces it into a circular orbit.

The radius of the orbit depends on the strength of the field and on the velocity, mass, and charge of the particle.

On the other hand, a particle that enters at an angle to the field (as it is likely to do in the case of the earth) will go into a spiral or helical orbit down along the field lines.

If these lines converge, the radius of the orbit will get smaller and smaller as the particle approaches the region of convergence.

Gradually the pitch, or distance between turns, of the helix will become smaller and smaller, until finally the pitch is zero.

At this point the orbit will be perpendicular to the field lines and the particle will begin to spiral back toward weaker fields-that is, toward the region of divergence (hence, lower density) of lines.

This is called, appropriately, the mirror effect.

Once in a region of divergence, the particle will continue to the region of convergence at the other pole, where it reverses direction again and begins its spiral path back down the field lines.

Because the magnetic field of the earth converges at the poles, many of the charged particles that enter it will experience the mirror effect and, will spiral back and forth along the field lines, being reflected each time they approach a pole.

The particles in this region are, in fact, trapped in the two Van Allen belts.

The inner Van Allen belt begins about 2000 km above the earth's surface and extends to about 3000 km.

It is made up of both electrons and protons, with the protons much the more energetic.

The outer belt begins at 6000 km and extends out to approximately 10,000 km.

It too is made up of both electrons and protons.

In this case it is the electrons that are the more energetic.

As the particles spiral back and forth along the field lines, some are occasionally "dumped" into the upper atmosphere as a result of gusts in the solar wind.

When they strike molecules in this region, they excite them.

The excitation energy is released in the form of a soft glow.

We see it as the northern (aurora borealis) and southern (aurora australis) lights.

**The following sentence summarizes this section.**

<u>Particles charged by magnetic fields become trapped in the Van Allen belts.</u>

# APPENDIX D

## The Earth (Version B)

With the exception of a small amount that has oozed out of deep fissures, we have never seen material from the interior of the earth.

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Using our knowledge of its size and mass, for example, we can calculate its average density (mass per unit volume).

In the same way our knowledge of the earth's oblateness indirectly tells us something:

As the earth spins on its axis, its equatorial regions bulge, and the magnitude of this bulge gives us a general indication of its internal makeup.

Of much more value, however, is the study of the waves that are generated by earthquakes: seismic waves.

These tell us that the interior is layered (differentiated), how thick the layers are, and whether they are molten or solid.

Earthquakes occur worldwide.

Most take place 50-100 km below the surface.

A few occur at depths as low as 700 km.

The waves that are generated by these quakes are picked up by seismic stations at many different locations, usually several thousand kilometers apart.

That each of these stations is "seeing" the quake from a different point of view allows us to pinpoint the quake's origin.

For the typical earthquake, the region in which the quake occurs is the focus.

The point on the surface directly above its center is the epicenter.

The quake sends out two types of waves into the surrounding medium, P- and S-waves.

A third wave, which travels along the surface, will not be discussed.

The P or primary wave, is a longitudinal one.

It creates series of compressions and rarefaction like a sound wave.

The S or secondary wave, is a transverse one, like light.

Its vibrational motion is perpendicular to its direction of propagation.

Both waves travel more rapidly the denser the material through which they are passing.

They also travel at different speeds (the S-wave slower) regardless of the medium.

S- and P-waves also differ in another respect.

The former cannot pass through liquids.

However, P-waves can pass through liquids.

Furthermore, as they pass into a medium of different density, both waves are refracted or bent.

But, like waves of light, not by the same amount.

Early in the study of seismic waves it was noticed that P-waves passed through the core of the earth.

But, S-waves did not.

This implied that the core was liquid.

It was later shown, however, that there is a small solid core inside the liquid one.

Although temperatures are obviously higher in the center, so is the pressure which raises the melting point.

Thus, despite the high temperature the region remains solid.

Seismic waves have been particularly valuable tools in our study of the earth's interior.

Because of them we now know that the earth consists of three main layers: a core (of two parts), a mantle (which surrounds it), and at the surface, a crust.

**The following sentence summarizes this section.**

<u>We know much about the interior of the Earth because of seismic waves.</u>

The diameter of the earth's outer core is approximately 6950 km (4320 mi), about half the diameter of the earth.

The inner, solid core has a diameter of about 2500 km and a density of approximately 10-12 gm/cm3.

This compares to 2.5 gm/cm3 for the material at the surface of the earth and an overall average throughout the earth of about 5.5 gm/cm3.

**It is important to note the following information.**

<u>Because the density near the center is much higher than the average, it is obviously composed of heavier elements.</u>

Geologists believe that it is composed mostly of iron and nickel with perhaps some sulphur and silicon.

This is reasonable: Heavy element such as iron and nickel would have fallen to the core soon after this region became molten.

Surrounding the core is the mantle.

The mantle contains little iron and nickel, hence its much lower density than the core.

It is composed primarily of magnesium-rich silicate minerals.

Its inner regions are molten.

But, its outer layers exhibit plastic flow.

They flow slowly.

They are therefore, considered to be a quasi-fluid.

They are referred to as the asthenosphere.

With the goal of examining the mantle directly, Project Mohole was begun in the 1960s.

Its object, to drill through the earth's crust to the mantle, was eventually abandoned because of technical difficulties.

There is no direct way to measure all of the Earth's interior structure.

But, there are ways to do so indirectly.

Surrounding the mantle is the outermost shell of the earth, the crust.

**The following important sentence should be emphasized.**

<u>The Earth’s crust is composed of the lightest material of the earth-in effect, the slag that floated to the top when the earth was molten.</u>

Under the oceans it is relatively thin (approximately 5 km).

But under the continents, it is much heavier than the oceans.

And, therefore, needing a much thicker layer to support them.

The thickness of this layer averages about 30 km.

**The following sentence summarizes the preceding section**

<u>Although the crust is the lightest material of the Earth, it has much variation in thickness.</u>

Though the continents are largely of granite, most of the crust is made up of basalt, a volcanic rock consisting of elements such as silicon, oxygen, aluminum, magnesium, and iron.

In the last few years we have learned to date rocks quite accurately.

The techniques have been applied to both earth and moon rocks.

Earth rocks are both relatively old and young.

In fact, many are quite young.

Some, from the Rocky Mountains of North America, for example, are as young as 60 million years.

The oldest known Earth rocks (found in Greenland) are about 3.7 billion years old.

The reasons for this difference in the ages of Earth rocks are considered in the next section.

Shortly after worldwide maps became available, in the early 1600s, Francis B acon noticed a striking resemblance between the eastern coastline of South America and the western coastline of Africa.

They looked like two adjacent parts of a jigsaw puzzle.

Bacon suggested, on the basis of this, that they might at one time have been part of a single large land mass.

How such a large land mass could break apart, though, was beyond understanding.

The idea was resurrected in 1910 by German meteorologist Alfred Wegener.

In addition to the resemblance between the shorelines of Africa and South America, he noticed similar resemblances between the eastern shores of North America and the western shoreline of Europe.

He also found striking matches in the types of rocks along regions where the continents presumably had once abutted.

Furthermore, fossil types were similar.

On the basis of these findings Wegener formulated a theory according to which all of the present continents of the world were, at one time, together in a single super- continent that later broke apart.

But, what force could push continents apart?

There was no known mechanism.

And, as late as 1960, Wegener's ideas were still looked on with considerable skepticism.

But more data were uncovered.

First, a huge underwater chain of mountains was discovered in the middle of the Atlantic Ocean.

Almost midway between the continents and extending their entire length, it is now referred to as the Mid-Atlantic Ridge.

It was also discovered that earthquakes were common along its entire length and that considerable heat was being released along it.

Evidence for the Pangea theory was beginning to accumulate.

H. Hess and R. S. Dietz proposed that magma (liquid rock from the interior of the earth) was flowing out of the ridge, creating in the process a new section of ocean floor.

And, as this section of floor moved away from the ridge, the continents were pushed apart.

Further evidence for this point of view came when the ages of the rocks on the floor were determined.

Near the ridge they were exceedingly young (age here is the time since last molten), and they increased in age with distance from the ridge.

The oldest rocks- about 150 million years old-were found near the edges of the continents.

Another recent piece of evidence has convinced even the most confirmed skeptics.

**It is of relevance to note the following sentence.**

The magnetic polarity of the earth has reversed many times.

Because iron atoms in molten material orient themselves along magnetic field lines, reversals of polarity can be detected in iron-containing materials that were once molten.

Examination of the floor of the ocean showed evidence of several reversals.

And, of particular interest, the patterns on the two sides of the ridge were identical: Iron at equal distances from and on either side of the ridge always indicated the same polarity.

Iron at equal distances from and on either side of the ridge always indicated the same polarity.

Scientists are now convinced that magma pushing up through the Mid-Atlantic Ridge is indeed pushing the continents apart.

The rate of separation (continental drift) is small, only about 2-4 cm per year.

But, a simple calculation shows that even with this low rate the separation would be substantial in a few million years.

Indeed, it would have taken about 150 million years to move South America as far from Africa as it is today.

According to present theories, about 250 million years ago all the continents of the earth were part of one gigantic continent, called Pangaea.

About 8300 km (5000 mi) wide and 16,600 km (10,000 mi) long, it stretched across the earth in a north-south direction.

About 200 million years ago it began to break up along the equator.

Eventually a large sea, now called the Tethys Sea, separated the two parts, which, supercontinents themselves, are now referred to as Gondwanaland and Laurasia.

The present continents of South America, Africa, India, Australia, and Antarctica were contained within Gondwanaland, and the continents of North America, Greenland, and Eurasia were contained within Laurasia.

The splitting of Gondwanaland and of Laurasia into these continents, which began about 150 million years ago, was caused by convection currents in the asthenosphere (created by hot material moving upward in some regions and cooler material moving downward in others).

Magma, or liquid rock, ascending through the rifts created new ocean floor, which spread out away from the rift.

Closer to the continents are regions called subduction zones, where the ocean bed disappears down into the mantle again.

Mountain ranges are usually seen in the regions just beyond subduction zones (e.g., the Andes in South America).

Occasionally, continents collide, and exceedingly high mountain ranges are generated.

India, a good example, was at one time completely surrounded by water.

When it joined the mainland, the resulting pressure created the Himalayas.

We now have a fairly good understanding of the process of continental drift.

The surface of the earth is made up of several plates.

There are seven major ones and a few minor ones.

The continents ride on these plates as they move slowly in various directions.

At one edge new material is generate.

At the opposite edge it is disappearing back into the earth.

The surface of the earth is, in effect, being continually recycled.

Earthquake activity is concentrated along the plate edges.

It was this activity, in fact, that allowed us to establish the plate boundaries.

The Earth is very active.

Planetary atmospheres differ considerably.

The earth's atmosphere is the only one that consists mostly of nitrogen (78.08%) and oxygen (20.95%).

Of the four major regions into which we divide the atmosphere the lowest layer, which reaches to about 8-10 km above the surface, is called the troposphere. .

All the Earth's weather occurs in the troposphere.

Extending about 30 km above the troposphere is the stratosphere, within which is a layer that protects us from the ultraviolet rays of the sun: the ozone (03) layer.

This is the layer thought to be endangered by exhausts from high-flying airplanes like the SST (supersonic transport plane) and by various chloro-fluoro-carbons used as propellant in some aerosol spray products.

Destruction or diminution of the layer would permit more ultraviolet light to reach Earth, with a consequent increase in the incidence of skin cancer.

Directly above the stratosphere is the mesosphere, and within it are the various layers of the ionosphere.

The ionosphere is particularly important in radio communications because broadcast waves can be reflected from it.

Since radio waves move in a straight line, this bounce effect is what makes long-distance transmission-around the curve of the earth-possible.

Finally, above the ionosphere, we have the exosphere, the outermost layer, which tapers off to interplanetary space.

An important question is where did the atmosphere come from?

The earth (and other planets) was formed with an atmosphere of hydrogen and helium, which was swept away by the "solar gale."

Many years later an era of vulcanism and outgassing released carbon dioxide, water vapor, and other gases into the region around the earth.

As the earth cooled, the water vapor condensed to the surface, and the oceans began to form.

Some of the carbon dioxide was absorbed by the water of the oceans.

The rest went into the creation of carbonate rocks (limestone).

Water acts as a catalyst in the reactions that create these rocks.

Other gases such as methane and ammonia continued to accumulate.

Eventually, the earth had a second atmosphere.

This atmosphere is composed of many layers of different components.

It consisted of methane, ammonia, nitrogen, and water vapor.

Scientists believe that the basic molecules of life formed in it.

Our present atmosphere evolved from the primitive atmosphere.

The oxygen that we now have is generally believed to have been created by marine vegetation, or algae, in the oceans.

As with plants in general, they absorb carbon dioxide, metabolize the carbon, then expel the oxygen.

It is likely that the ammonia present was absorbed into the oceans, leaving mostly nitrogen and oxygen-the major components of our present atmosphere.

**The following sentence summarizes this section.**

<u>The atmosphere is composed of many layers of different components.</u>

As the name suggests, the magnetosphere is a region- of plasma (charged particles) under the influence of the earth's magnetic field.

Magnetic fields are represented as bundles of lines that emanate from one pole of a magnet and enter the other pole.

The density, or number of lines crossing a unit area, determines the strength of the field.

The earth's magnetic field is .6 gauss (G) near the surface at the poles

Small toy magnets have field strengths of a few hundred gauss.

A standard laboratory bar magnet has a field strength of several thousand gauss.

The magnetic field of the earth is tilted about 11 degrees with respect to the spin axis.

It will not remain in this direction indefinitely, however.

Over long periods of time it wanders in a random but generally westerly direction.

Every few hundred thousand years or so it completely reverses direction.

We do not understand why this reversal occurs.

We do know what causes the magnetic field: circulating currents in the molten interior of the earth.

Reversal of the field would seem to require reversal of these currents.

The earth's magnetic field extends outward for thousands of miles.

Any charged particles that enter this region will immediately come under its influence.

A source of such particles is the solar wind.

In 1958 instruments aboard the Explorer I rocket indicated that there was a region of considerable radiation above the earth.

Further details obtained with Explorer III showed that there were two radiation regions, now referred to as the Van Allen belts.

When a charged particle enters a magnetic field perpendicular to the field lines, it experiences a side thrust that forces it into a circular orbit.

The radius of the orbit depends on the strength of the field and on the velocity, mass, and charge of the particle.

On the other hand, a particle that enters at an angle to the field (as it is likely to do in the case of the earth) will go into a spiral or helical orbit down along the field lines.

If these lines converge, the radius of the orbit will get smaller and smaller as the particle approaches the region of convergence.

Gradually the pitch, or distance between turns, of the helix will become smaller and smaller, until finally the pitch is zero.

At this point the orbit will be perpendicular to the field lines and the particle will begin to spiral back toward weaker fields-that is, toward the region of divergence (hence, lower density) of lines.

This is called, appropriately, the mirror effect.

Once in a region of divergence, the particle will continue to the region of convergence at the other pole, where it reverses direction again and begins its spiral path back down the field lines.

Because the magnetic field of the earth converges at the poles, many of the charged particles that enter it will experience the mirror effect and, will spiral back and forth along the field lines, being reflected each time they approach a pole.

The particles in this region are, in fact, trapped in the two Van Allen belts.

The inner Van Allen belt begins about 2000 km above the earth's surface and extends to about 3000 km.

It is made up of both electrons and protons, with the protons much the more energetic.

The outer belt begins at 6000 km and extends out to approximately 10,000 km.

It too is made up of both electrons and protons.

In this case it is the electrons that are the more energetic.

As the particles spiral back and forth along the field lines, some are occasionally "dumped" into the upper atmosphere as a result of gusts in the solar wind.

When they strike molecules in this region, they excite them.

The excitation energy is released in the form of a soft glow.

We see it as the northern (aurora borealis) and southern (aurora australis) lights.

Particles charged by magnetic fields become trapped in the Van Allen belts.

APPENDIX E

"Energy Problems"

Importance
Questions and Answers

1. Write a one-sentence statement about one of the most important points from the text.
   Answers will vary.

2. What are the two basic reasons for increasing costs of energy based on fossil fuels and nuclear power?
   Decreasing availability and production costs are the two basic reasons.

3. Why are we confronted by immense energy problems?
   We are confronted by problems because of our society's addiction to cheap, abundant energy and dependence on fossil and nuclear fuels that it has created.

4. What are some reasons for safety violations at nuclear power plants?
   Operators fail to notice potentially dangerous situations, and they do not follow the correct procedures in response to such situations.

5. What is a problem with using coal, oil, gas, and the minerals supplying nuclear fuel?
   Fossil fuels are not renewable.

6. What do many scientists consider to be the most important problem facing us in this century?
   Global warming in the environment is considered to be the most important problem.

7. What is a major concern for both workers in the nuclear power industry and the general population?
   The safety of nuclear technology is a major concern.

8. List the important points you would use to write a conclusion for this text.
   Answers will vary.

# APPENDIX F

## "Energy Problems"

### Summary
### Questions and Answers

1. Write a one-sentence summary of the text.
   Answers will vary.

2. Why has energy costs risen?
   Equipment and research are the reason for rising costs.

3. How would the author describe gathering fossil fuels and creating nuclear power?
   Dangerous.

4. Why could nothing be done to prevent the yellowing of needles in the spruce trees of the Bavarian Forest?
   When the effects began to be noticed, they were so extensive, so fast to progress, and so poorly understood that nothing could be done.

5. Why should we worry about the health threats of fossil fuels and nuclear power?
   They are serious and extensive.

6. What has disrupted the environment?
   The search for fuels has disrupted the environment.

7. How is nuclear power costly?
   Due to radioactive waste, nuclear power is a costly method of obtaining power in terms of disposal and the probability of having an accident.

8. List the statements from the text that you would use to write a summary.
   Answers will vary.

APPENDIX G

"The Earth"

Importance
Questions and Answers

1. Write a one-sentence statement about one of the most important points from the text.
   Answers will vary.

2. What has happened to the magnetic polarity of the earth?
   It has reversed many times.

3. How do we know that the center of the earth is composed of heavier elements?
   The density near the center is higher than the average.

4. Of what is the crust composed?
   The crust is composed of the lightest material on earth, the slag that floated to the top when the earth was molten.

5. Why does the mantle have a much lower density?
   It contains little iron and nickel.

6. What is the theory that Wegner formulated?
   All the present continents of the world were, at one time, together in a single super continent that later broke apart

7. What determines the strength of the magnetic field?
   The density of number of times crossing a unit area determines the strength of the field.

8. List the important points you would use to write a conclusion for this text.
   Answers will vary.

APPENDIX H

"The Earth"

Summary
Questions and Answers

1. Write a one-sentence summary of the text.

2. Does the thickness of the crust vary?
   Yes, the thickness does vary.

3. Is there a direct way to measure the Earth's interior?
   No, there is not a direct way.

4. What is the activity level of the Earth??
   It is active.

5. How do we know a lot about the interior of the Earth?
   Research with seismic waves is how we know about the interior of the Earth.

6. In general of what is the atmosphere composed?
   Many layers of different components such as basalt, nickel, and iron.

7. What becomes trapped in the Van Allen Belts?
   Particles charged by magnetic fields.

8. List the statements from the text that you would use to write a summary.

# APPENDIX I

## Instructions

In this experiment it is your task to read the following texts and answer comprehension questions.  You will see the texts one sentence at a time.  Please, move at your own pace. You cannot go back to previous sentences.  Your reading times will be recorded. You will first read a practice text.  You will not have to answer comprehension questions for this text.  Please, press the space bar to begin.

APPENDIX J

Table 11
All Main Effects and Interactions for Analysis of Participant Variability for Reading Times of Target Sentences

| Source | df | F | $\eta^2$ | p |
|---|---|---|---|---|
| Between Subjects | | | | |
| Task (Ta) | 1 | 1.22 | .02 | .27 |
| VSAT | 1 | 2.46 | .04 | .12 |
| Ta X VSAT | 1 | .89 | .02 | .35 |
| Within Subjects | | | | |
| Order (Or) | 1 | 10.83 | .17 | .00* |
| Or X VSAT | 1 | .04 | .00* | .84 |
| Or X Ta | 1 | 7.61 | .13 | .01 |
| Or X Ta X VSAT | 1 | .34 | .01 | .56 |
| Target Type (TT) | 1 | 55.34 | .51 | .00* |
| TT X VSAT | 1 | .01 | .00* | .92 |
| TT X Ta | 1 | 23.94 | .31 | .00* |
| TT X Ta X VSAT | 1 | .22 | .00* | .64 |
| Occurrence (Oc) | 1 | 29.98 | .36 | .00* |
| Oc X Ta | 1 | 3.00 | .05 | .09 |
| Oc X VSAT | 1 | 1.56 | .03 | .22 |
| Oc X Ta X VSAT | 1 | .60 | .01 | .44 |
| Oc X TT X Ta | 1 | 4.02 | .07 | .05 |
| Or X TT | 1 | 3.68 | .07 | .06 |
| Or X TT X Ta | 1 | 1.96 | .04 | .17 |
| Or X TT X VSAT | 1 | .04 | .00* | .84 |
| Or X TT X Ta X VSAT | 1 | .09 | .00* | .77 |
| Or X Oc | 1 | 1.31 | .02 | .26 |
| Or X Oc X Ta | 1 | .05 | .00* | .83 |
| Or X Oc X VSAT | 1 | .12 | .00* | .73 |
| Or X Oc X Ta X VSAT | 1 | .49 | .01 | .49 |
| TT X Oc | 1 | .50 | .01 | .48 |
| TT X Oc X VSAT | 1 | 1.41 | .03 | .24 |
| TT X Oc X Ta X VSAT | 1 | .01 | .00* | .95 |
| Or X TT X Oc | 1 | .17 | .00* | .68 |
| Oc X Or X TT X Ta | 1 | 4.64 | .08 | .04 |
| Or X TT X Oc X VSAT | 1 | .71 | .01 | .40 |
| Or X TT X Oc X Ta X VSAT | 1 | 2.79 | .05 | .10 |

* Number is less than .01 when rounded to the tenths place.

APPENDIX K

Table 12
All Main Effects and Interactions for Analysis of Item Variability for Reading Times of Target Sentences

| Source | df | F | $\eta^2$ | p |
|---|---|---|---|---|
| Between Subjects | | | | |
| Target Type (TT) | 1 | 17.51 | .47 | .00** |
| Text (Te) | 1 | 1.65 | .08 | .21 |
| TT X Te | 1 | .43 | .02 | .52 |
| Within Subjects | | | | |
| Order (Or) | 1 | 3.95 | .17 | .06 |
| Or X TT | 1 | .14 | .01 | .71 |
| Or X T | 1 | .69 | .03 | .42 |
| Or X TT X Te | 1 | 1.02 | .05 | .33 |
| Task (Ta) | 1 | 3.58 | .15 | .07 |
| TT X Task (Ta) | 1 | 27.48 | .58 | .00** |
| Ta X Te | 1 | 3.53 | .15 | .08 |
| Ta X TT X Te | 1 | 1.11 | .05 | .30 |
| Occurrence (Oc) | 1 | 33.28 | .63 | .00** |
| Oc X TT | 1 | .06 | .00* | .81 |
| Oc X Te | 1 | .99 | .05 | .33 |
| Oc X TT X Te | 1 | .04 | .00* | .84 |
| Or X Ta | 1 | .51 | .03 | .48 |
| Or X Ta X TT | 1 | 1.03 | .05 | .32 |
| Or X Ta X Te | 1 | .35 | .02 | .56 |
| Or X Ta X TT X Te | 1 | .46 | .02 | .51 |
| Or X Oc | 1 | 2.44 | .11 | .13 |
| Or X Oc X TT | 1 | .96 | .05 | .34 |
| Or X Oc X Te | 1 | .79 | .04 | .38 |
| Ta X Oc | 1 | 2.3 | .10 | .15 |
| Ta X Oc X TT | 1 | 1.4 | .07 | .24 |
| Ta X Oc X Te | 1 | .00* | .00* | .96 |
| Ta X Oc X TT X Te | 1 | 1.60 | .07 | .22 |
| Or X Ta X Oc | 1 | .00* | .00* | .99 |
| Or X Ta X Oc X TT | 1 | 1.41 | .07 | .25 |
| Or X Oc X TT X Te | 1 | 6.13 | .24 | .02 |
| Or X Ta X Oc X Te | 1 | .12 | .01 | .73 |
| Or X Ta X Oc X TT X Te | 1 | .69 | .03 | .42 |

* Number is less than .01 when rounded to the tenths place. ** $p < .01$

APPENDIX L

Table 13
Non-significant Results for Analysis of Participant Variability for Number of Correctly Answered Comprehension Questions

| Source | df | F | $\eta^2$ | p |
|---|---|---|---|---|
| Between Subjects | | | | |
| Task (T) | 1 | 10.13 | .16 | .00** |
| VSAT | 1 | .03 | .00* | .85 |
| T X VSAT | 1 | .10 | .00* | .75 |
| Within Subjects | | | | |
| Order (Or) | 1 | .08 | .00* | .77 |
| Or X T | 1 | .02 | .00* | .89 |
| Or X VSAT | 1 | .00* | .00* | .96 |
| Or X T X VSAT | 1 | .41 | .00* | .53 |
| Occurrence (Oc) | 1 | 1.67 | .03 | .20 |
| Oc X T | 1 | .00* | .00* | .99 |
| Oc X VSAT | 1 | .45 | .00* | .50 |
| Oc X T X VSAT | 1 | 1.61 | .03 | .21 |
| Or X Oc | 1 | .00* | .00* | .95 |
| Or X Oc X T | 1 | .52 | .01 | .48 |
| Or X Oc X VSAT | 1 | .17 | .00* | .68 |
| Or X Oc X T X VSAT | 1 | .00* | .00* | .98 |

* Number is less than .01 ** $p < .01$

APPENDIX M

Table 14
Non-significant Results for Analysis of Item Variability for Number of Correctly Answered Comprehension Questions

| Source | df | F | $\eta^2$ | p |
|---|---|---|---|---|
| Between Subjects | | | | |
| Text (Te) | 1 | 1.4 | .06 | .24 |
| Within Subjects | | | | |
| Order (Or) | 1 | .65 | .03 | .43 |
| Or X Text (Te) | 1 | 2.6 | .11 | .12 |
| Occurrence (Oc) | 1 | .61 | .03 | .44 |
| Oc X Te | 1 | .54 | .02 | .47 |
| Or X Oc | 1 | 2.19 | .09 | .15 |
| Or X Oc X Te | 1 | 1.33 | .06 | .26 |

* Number is less than .01 ** $p < .01$

# BIOGRAPHICAL SKETCH

I was born July 12, 1972 in Nyack, New York. I moved around a lot as a child due to my Dad's job in the chemical business. But it has been worth it because I have met many wonderful people along the way. Also, I can proudly say I have lived in the North, South, East, and West of the United States. I received my B.A. in Psychology at the University of California, Davis in 1994. I received my M. S. in Psychology in 1997 at Florida State University. Now, I am living in Virginia.

I am interested in the interaction between the reader and the reading situation. Specifically, how the processing conditions under which a reader comprehends affects his or her mental representation. Some influences on the processing conditions in which I am interested are reading strategies, text cues, and reading tasks. Some questions I would like to answer are: how do readers generate, select, and apply strategies, what are the long term consequences of building different types of mental representations, and what types of information does a person have access to under different processing conditions? I would like to apply my research to business and educational settings.