The Influence of Prereading and Recall Instructions on Attention and Memory for Scientific Seductive Text

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Dedication

For Rachel.

Abstract

The question of how interesting but irrelevant textual information (i.e., seductive details) in a multi-topic scientific text influences the processes and products of comprehension was explored in three experiments. In Experiment 1, participants read a multi-topic informational text on lightning and tornado formation and rated each sentence for importance and interest. In Experiment 2, participants read the text with or without seductive details and completed a free recall. Participants who received the seductive details version of the text demonstrated a *seductive details effect* (e.g., Harp & Mayer, 1998; Peshkam, Mensink, Putnam, & Rapp, 2011), in which they recalled significantly less important information compared to controls. In Experiment 3, participants read the seductive details version of the text while wearing a head-mounted eye tracker. Prior to reading the text, participants also received prereading questions designed to focus their attention on one topic (e.g., lightning formation) over the other (e.g., tornado formation). In addition, participants completed a test of their working memory capacity (WMC) in the form of a reading span test (RSPAN), and recieved either a general instruction to freely recall the text or two specific recall instructions for each topic. In terms of online processes, the results indicated that participants allocated additional attention to information introduced by the prereading instructions, in the form of increased reinspections and look-backs. However, attention to seductive details was not reduced by these instructions. In terms of offline products, participants recalled significantly more information from the text that was introduced by the prereading instructions, compared to information that was not mentioned in those instructions. Seductive details were also well recalled for participants receiving free recall instructions. Yet, production of seductive details was significantly reduced when participants received specific recall instructions. In addition, participants with high working memory capacities also produced significantly less seductive content as compared to participants with low working memory capacities. These findings suggest that although seductive details are irresistibly alluring during comprehension, that allure might not be similarly demonstrated upon recall-driven reflection.

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Chapter I: Overview

Authors commonly add salacious and off-topic information to informational texts in order to increase reader engagement. Such additions are referred to in the research literature as *seductive details* (e.g., Garner, Gillingham, & White, 1989). A substantial amount of research evidence now exists to support the notion that the presence of seductive details induces a *seductive details effect*: Readers who encounter seductive details in instructional materials spend less time reading, have poorer recall, and do worse on transfer tasks involving important content, compared to readers who receive the same instructional content without seductive details (e.g., Garner, Brown, Sanders, & Menke, 1992; Garner et al., 1989; Harp & Mayer, 1997, 1998; Lehman, Schraw, McCrudden, & Hartley, 2007; Schraw, 1998). To date, this effect has been obtained with a variety of media forms and types of seductive details.

Previous experimental attempts to reduce the detrimental influence of seductive details on readers' comprehension of informational texts have produced mixed results. Prereading instructions vaguely warning readers about seductive details appear to reduce the amount of seductive content produced (Peshkam, Mensink, Putnam, & Rapp, 2011), yet no increase in the production of important content was observed. In addition, some readers appear naturally more resistant than others to the seductive details effect, while some readers even appear to benefit from the presence of seductive details (e.g., McCrudden & Corkill, 2010; Sanchez & Wiley, 2006). However, previous experiments examining the seductive details effect have generally left unexamined how specific prereading or recall instructions focused on important content might influence readers' comprehension processes and products. In addition, prior research has also left unexamined how readers' working memory capacity might influence how they deal with seductive scientific text.

The current experiment sought to examine these issues, and had three complimentary purposes. The first purpose was to conduct an investigation of the seductive details effect that takes into consideration the multiple factors inherent to dynamic text comprehension; specifically how readers' cognitive processes during comprehension (as indicated by eye-movements) and offline products (as indicated by recalls) would be influenced by text content (i.e., seductive details), task instructions (i.e., topic focusing instructions and recall cues), and individual differences (i.e., working memory capacity). The second purpose of the experiment was to determine if differences in recall instructional focus on either general or specific information from the text, would lead to differences in readers' recall for texts containing seductive details. The third and final purpose of the experiment was to determine whether prereading instructions focusing readers toward important content could alleviate the seductive details effect.

To address these questions, three experiments were conducted. In Experiment 1, a multi-topic scientific text on lightning and tornado formation (adapted from various internet sources, also Lehman et al., 2007; Peshkam et al., 2011) was developed. Participants then read the text and rated each sentence for interest and importance in order to identify seductive detail sentences. In Experiment 2, participants read the text with or without the seductive details sentences, completed an inventory on their reading strategies, and completed a free recall, the results of which were used to determine if the text elicited a seductive details effect. Experiments 1 and 2 established the multi-topic scientific text that elicited the seductive details effect for use in Experiment 3.

In Experiment 3, participants read the seductive details version of the text while wearing a head-mounted eye tracker. Prior to reading the text, participants received prereading relevance instructions in the form of questions that were designed to focus their attention toward specific lightning or tornado information in the text during comprehension. Participants then completed a reading strategy inventory and a test of working memory capacity (WMC), and then either received one of two recall instruction conditions: A single, general free recall task with an instruction to recall as much as they could from the entire text, or two specific recall tasks with instructions to first recall the topic unmentioned by the prereading instructions (i.e., nonfocused), followed by instructions to recall the topic mentioned by instructions (i.e., focused). Thus, the effects of specific relevance instructions on readers' online processes were compared to the effects of specific and general recall instructions on their offline products.

The primary achievement of this dissertation was to provide additional evidence for the detriment seductive details cause on the processes and products of readers' comprehension of scientific text, in the form of fixation and recall measures, while also providing some important nuance and expansion regarding theories of how seductive details detriment comprehension. The secondary achievement of this dissertation was to demonstrate the utility of combinatorial prereading and recall instructions in increasing readers' attention to and production of important scientific content while reducing the influence of seductive details. The third and final achievement of this dissertation was to integrate these results into a dynamic textual framework and suggest possible future directions for theories of scientific text comprehension that take into account the ways in which readers deal with relevant and irrelevant information.

This dissertation unfolds according to the following organization: The current chapter, titled *Chapter I: Overview*, begins on page 1 and provides a general preview and organizational overview to the reader. *Chapter II: Review of the Empirical Literature on Seductive Details* begins on page 5 and provides a brief review of the empirical literature on the seductive details effect in texts and media, individual differences that may influence the seductive details effect, and previous investigations on ways to mediate the seductive details effect. *Chapter III: Dynamic Text Comprehension as a Research Framework*, beginning on page 27, situates the current experiment and resulting hypotheses within the larger theoretical perspective of dynamic text comprehension. *Chapter IV: The Current Experiment* provides a general overview of the three experimental investigations discussed in this dissertation, beginning on page 32.

Beginning on page 34, the experimental portions of the dissertation are presented, starting with *Chapter V: Experiment 1*, which presents the results of an essential baseline norming study on the scientific stimuli using readers' interest and importance ratings for sentences in the text. *Chapter VI: Experiment 2*, which begins on page 46, presents the results of an investigation into how the presence or absence of seductive details in the scientific stimuli induces a seductive details effect. *Chapter VII: Experiment 3* presents the results of an investigation into the effects of working memory capacity and prereading and recall instructions on participants' eye-movements and recall for the seductive scientific stimuli. Finally, *Chapter VIII: General Discussion*, beginning on page 75 interprets the experimental results and discusses the theoretical implications of the findings as well as future research directions.

Chapter II: Review of the Empirical Literature on Seductive Details

Informative texts such as textbooks contain elements that learners must attend to, the most important of which is the instructional content relevant to the learning goals of the reading experience (for a review, see McCrudden & Schraw, 2007). In addition to this critical text content, authors of instructional materials often add highly interesting factoids or anecdotes that are only tangentially related to the relevant topic in order to increase reader engagement. Previous research has referred to such irrelevant additions as s*eductive details*, a term first coined by Garner, Gillingham, and White (1989).

Importantly, seductive details have been shown to induce a *seductive details effect,* in which learning is significantly reduced for readers who encounter seductive details in instructional materials, compared to readers who receive the same instructional content without seductive details (e.g., Garner, Brown, Sanders, & Menke, 1992; Garner et al., 1989; Harp & Maslich, 2005; Harp & Mayer; 1997,1998; Lehman, Schraw, McCrudden, & Hartley, 2007; Mayer, Griffith, Jurkowitz, & Rothman, 2008; McCrudden, & Corkill, 2010; Peshkam, Mensink, Putnam, & Rapp, 2011; Sanchez & Wiley, 2006; Schraw, 1998; Wade, Schraw, Buxton, & Hayes, 1993). To date, this effect has been obtained with a variety of media forms and types of seductive details. Thus, any analysis of the effect might usefully begin with a review of the literature regarding seductive details and the forms such details might take; I do so to introduce the topic here.

Seductive details and their effect on learning. The impact of adding seductive details to informational materials was first investigated by Garner et al. (1989). The researchers added one highly interesting sentence to each paragraph of an expository text on insects. For example:

> Some insects live alone, and some live in large families. Wasps that live alone are called solitary wasps. A Mud Dauber Wasp is a solitary wasp. Click Beetles live alone. *When a Click Beetle is on its back, it flips itself into the air and lands right side up while it makes a clicking noise.* Ants live in large families. There are many kinds of ants. Some ants live in trees. Black Ants live in the ground. (p. 47)

In a norming study, teachers rated the italicized sentence (and others like it) as very interesting, likely due to the novel fact it presented. However, the seductive detail sentences, despite being interesting, were also identified as failing to contain information of crucial importance to the main idea of the material. Although participants reported that they found the inserted sentences very interesting, their recall of the text material was negatively impacted by the presence of seductive details. Specifically, participants who received seductive details recalled fewer main ideas than participants who had received no seductive details. This effect was even more pronounced when the experiment was replicated using elementary school-aged children, suggesting that younger readers are potentially less able to identify relevant from irrelevant information, more negatively influenced by the presence of seductive details, or both. Garner et al. (1989) concluded that attempts to increase student motivation and comprehension by increasing the degree to which a text is interesting may actually result in impaired recall of important information, again, termed the seductive details effect.

Of course, textual content can be interesting to readers for a variety of reasons. Kintsch (1980) differentiated these reasons into two dimensions: *Cognitively interesting* content is novel to the reader, potentially arousing a desire to learn more about the unknown. The earlier textual example from Garner et al. (1989) would fall into this category (i.e., that a Click Beetle makes a clicking noise when it rights itself). *Emotionally interesting* content relates to the human condition, focusing on topics such as death, power, and sex, which can elicit readers' *absolute interest* in content (Schank, 1979). According to Kintsch, the best informational texts attempt to present content in such a way that it appeals both to readers' cognitive interest as well as their emotional interest.

Using Kintsch's (1980) categories of cognitive and emotional interest, Harp and Mayer (1997) investigated the differential influences of cognitively interesting but relevant illustrations (i.e., summative illustrations) and emotionally interesting but irrelevant illustrations and text (i.e., seductive illustrations and text) on readers' comprehension of an informative text on lightning formation that was created for the purposes of their experiment. The lightning formation text was a 550 word expository text that contained a causal explanation of how lightning forms in the atmosphere, as well as six summative illustrations. To the informational content in the lightning formation document, an additional 11 sentences (150 words) of seductive text as well as six seductive illustrations were added.

Based on a norming study, participants rated seductive illustrations and seductive text segments as high in emotional interest and low in cognitive interest, and the summative illustrations as high in cognitive interest and low in emotional interest. An example of the text appears below, with the italicized, seductive element added to a paragraph providing a causal explanation of lightning formation:

> Lightning can be defined as the discharge of electricity resulting from the difference in electrical charges between the cloud and the ground. *Every year approximately 150 Americans are killed by lightning. Swimmers are sitting ducks for lightning, because water is an excellent conductor of this electrical discharge*. (p. 94)

It should be noted that Harp and Mayer's (1997) summative illustrations did not function as seductive details in their study. Although rated as cognitively interesting by participants, the summative illustrations were actually quite relevant to understanding the main ideas of the overall text. Because of this, participants who received the summative illustrated version of the lightning formation text were considered the control group (i.e., the base text), in that the text closely resembled a science textbook chapter. In the study, participants received either a base text packet on lightning formation, or a text packet containing one of three seductive detail combinations: 1) base text with seductive text, 2) base text with seductive illustrations, or 3) base text with seductive text and seductive illustrations. Participants who received text containing some form of seductive details recalled significantly less information related to the causal explanation of lightning formation as compared to participants who only received base text packets. In addition, although all participants who received texts containing some form of seductive detail performed worse than controls in answering four questions that tested their ability to transfer their knowledge of the passage (e.g., “Suppose you see clouds in the sky, but no lightning. Why not?”), participants who received both seductive text and seductive illustrations produced the fewest solutions in the transfer task, compared to all other groups.

In a follow up experiment, Harp and Mayer (1998) replicated and further investigated the effect of seductive details on readers’ comprehension. Participants were allowed 6.5 minutes to read a text packet containing either a causal explanation of lighting formation (550 words) used previously by Harp and Mayer (1997), or the seductive details version containing the base text (550 words), seductive text (150 words) and seductive illustrations (6 images). Similar to their earlier published results, participants who received seductive details recalled significantly fewer main ideas and generated fewer solutions to a transfer task, as compared to participants who did not receive the seductive details packet (i.e., a seductive details effect). These observations were interpreted as evidence for the *diversion hypothesis*, which posited that readers encountering seductive details would organize their understanding of the text content around irrelevant knowledge cued by the seductive details.

The scope of the diversion hypothesis was further extended and tested by Lehman et al. (2007). In a pre-experiment norming study, the researchers presented an adapted version of the lightning formation text to participants and collected importance and interest ratings for each sentence in the text. Out of the 50 sentences of the lightning formation text, 11 seductive detail sentences were identified as highly interesting and unimportant by participants. In the controlled experiment, participants read the lightning formation text at their own pace on a computer, using a self-paced single sentence reading paradigm. Half of the participants received the base text lighting formation text (39 sentences, 741 words) and half received the base text plus the 11 additional seductive detail sentences (226 words). Participants then completed a free recall and an essay about the causal relations embedded in the lightning formation text.

Lehman et al. (2007) replicated the seductive details effect observed by Harp and Mayer (1997, 1998): Participants that received seductive details recalled significantly less information and demonstrated significantly worse understanding about the causal relations conveyed in the text (as measured by the essay task), as compared to participants that did not receive seductive details. Participants that received seductive details also spent less time reading important information, compared to average reading times for participants that did not receive seductive details. Interestingly, participants also were slower to read base text sentences that followed seductive details (a spillover effect), as compared to reading times for the same sentences obtained from participants that did not read immediately preceding seductive sentences. This slow-down effect was taken as evidence that seductive details may break the coherence of the passage, further hindering a student's ability to form a coherent representation of the content (in this case, lightning formation). Thus, readers encountering seductive details during comprehension potentially establish a less coherent mental representation, compared to controls, which in turn hinders their ability to produce important information from an informational text.

In addition, the seductive details effect is not necessarily bound to textual learning. The effect has also been replicated by Harp and Maslich (2005) in a lecture setting, using the lightning formation text adapted as a recorded lecture and PowerPoint presentation containing the seductive illustrations. Participants heard the lecture with or without seductive details, and were allowed to take notes. Immediately after the lecture, the notes were collected and participants completed a free recall as well as a four question test adapted from earlier experiments (Harp & Mayer, 1997, 1998). As with other experiments using textual materials, participants who heard the lecture with seductive details recalled less information on lightning formation and produced fewer correct answers on the test than control participants. This replicated a similar finding by Kintsch and Bates (1977), who found that students demonstrated superior memory for extraneous information made during a lecture, such as offhand jokes. Seductive details have also been shown to be detrimental to students attempting to recall physical movements and physical activity tips shown in a seductive video lesson, compared to students that watched the same video without the seductive details (Shen, McCaughtry, Martin, & Dillion, 2006). This would suggest that the seductive details effect is not simply a textual effect, but can also influence other learning modalities.

Seductive details can also take a variety of forms within instructional materials. As reviewed earlier, s*eductive text* appears to be the most commonly studied form of seductive details, typically appearing as one or more interesting but irrelevant sentences embedded within a larger informational text (e.g., Garner et al., 1989; Harp & Mayer, 1997, 1998; Hidi & Baird, 1988; Lehman et al., 2007; McCrudden, & Corkill, 2010;

Schraw, 1998). Consider the italicized seductive text example below from Peshkam et al. (2011):

> Ball lightning usually occurs after a cloud-to-ground flash. It appears as a glowing, fiery ball that floats for several seconds before disappearing. *Once, an 8" ball of lightning struck into a dimly lit church in England and burned off the back of a man's head.* There are many theories of how ball lightning forms, but none have been proven by creating ball lightning in a laboratory. (p. 229)

Although the italicized sentence might raise interest in the passage, it does not provide additional useful information that enhances the reader's understanding of lightning formation. Also important is the fact that such information would be unlikely to appear on a later test on the core content, which in this case is the formation of lightning.

In many instances, seductive text might also appear with *seductive illustrations*, which are highly interesting but irrelevant images (e.g., Harp & Mayer, 1997, 1998; Park, Kim, Lee, Son, & Lee, 2005; Sanchez & Wiley, 2006). For example, in conjunction with the earlier textual example, a picture of lightning striking a church might be added to the material. Seductive illustrations have been used to further increase the allure of seductive text, resulting in a concomitant increase in the seductive details effect (i.e., Harp & Mayer, 1997, 1998). Seductive illustrations have also been shown to induce a seductive details effect in the absence of seductive text, for example, by increasing the amount of time readers spend looking at irrelevant illustrations and decreasing the amount of time readers spend on important text in informational materials (Park et al., 2005; Sanchez &

Wiley, 2006). This suggests that seductive illustrations can cause similar damage to readers' comprehension of learning materials as seductive text.

Finally, *seductive augmentations* appear as interesting but irrelevant details embedded within instructional multimedia materials (Moos & Marroquin, 2010; Park et al., 2005). For example, learners may be presented with a video interview of an individual who has been struck by lightning, as an introduction to a larger lesson on lightning formation (Park & Lim, 2007; Schraw & Lehman, 2001). While influencing learners in a manner similar to seductive text and illustrations, seductive augmentations tend to appear as combinations of interactive seductive text and seductive illustrations, as well as irrelevant animations, video, and sound embedded within instructional multimedia (Deimann & Keller, 2006; Mayer, 2003; Mayer, Dow, & Mayer, 2003; Mayer, Heiser, & Lonn, 2001).

As the reviewed literature should indicate, the seductive details effect appears ubiquitous across a wide variety of learning experiences and contents (Harp & Maslich, 2005; Mayer et al., 2003, 2008; Moos & Marroquin, 2010). But despite the well-documented effects of these details, several important questions remain, not the least of which is: Why, precisely, are seductive details so attractive to learners? Thankfully, the extant literature provides some insight into potential answers. First, the content of seductive details appears to be irresistibly alluring to readers during comprehension. As noted by Kintsch (1980), information to be learned is generally more interesting when it is story like and appeals to aspects of emotional interest. Readers are typically interested in topics that reflect or depict emotionally interesting content involving aspects of the human condition like sex, death, power, and money.

One reason such topics appeal to readers might be due to a memory-based survival response that has been tuned by years of evolution. Research evidence has shown that participants given surprise recall tests after reading word lists demonstrated superior memory for survival-oriented terms (i.e., finding food, avoiding death) when compared to non-survival terms (Nairne & Pandeirada, 2008; Nairne, Pandeirada, & Thompson, 2008). This effect has been referred to as survival processing (Nairne, Thompson, & Pandeirada, 2007) in which information important to an organism's survival enjoys memory benefits over survival-irrelevant information. Indeed, evaluation of previous seductive detail stimuli shows that the most detrimental seductive details are related to sex and death, and also tend to be rated as the most interesting by participants (Harp & Mayer, 1997, 1998; Mayer et al., 2008).

Secondly, when embedded within potentially dry expository texts, seductive details tend to stand out as novel segments when compared to the content of the larger document. First described by von Restorff (1933), psychologists have long been aware of the bizarreness effect (also referred to as the von Restorff effect, novelty effect or isolation effect) on both attention and recall (e.g., Hunt, 1995). In essence, highly novel stimuli receive more attention and are better remembered then non-novel stimuli. For example, McDaniel and Einstein (1986) had participants learn a series of 10 triplet word combinations (i.e., dog, bicycle, and street) from sentences. Participants received either a list of 10 bizarre sentences (i.e., "The dog rode the bicycle down the street."), 10 common sentences (i.e., "The dog chased the bicycle down the street.") or one of two combination lists (i.e., 5 bizarre and 5 common sentences). There were no differences in the between-list design; participants that received only bizarre sentences recalled the same number of words (*M* = .52) as compared to participants that received only common sentences (*M* = .55). But a seductive-details like effect was observed for participants who received mixed sentence lists; that is, participants recalled more words from bizarre sentences (*M* = .62) then common sentences (*M* = .38). Thus it appeared that, in the presence of both bizarre and common sentences, recall was enhanced for bizarre information and reduced for common information.

Individual differences and the seductive details effect. Due to their novelty and attention-grabbing properties, seductive details interfere with comprehension during reading and reduce the recall of important content. However, is it the case that seductive details cause the same detriments to comprehension for every reader? Might some readers actually benefit from the presence of seductive details in informational texts? Conversely, are some readers more susceptible to the seductive details effect then others? As mentioned earlier, young children appear to be especially sensitive to the seductive details effect (e.g., Garner et al., 1989), however, are there other groups of readers that might be similarly detrimented by seductive content? Examinations of readers' individual differences might offer some potential answers to these questions.

For instance, McCrudden and Corkill (2010) hypothesized that a readers' verbal ability might influence their comprehension of a science text containing seductive details. In their experiment, participants read the seductive details version of the lightning formation text on a computer, after which they completed a free recall. High verbal ability participants (HVA), as compared to low verbal ability participants (LVA), demonstrated better comprehension of the text; HVAs were faster to read the text and recalled more important content as compared to LVAs. Interestingly, there was no observed difference in the amount of seductive details recalled, which might suggest that seductive details caused a greater impairment to LVAs in their recall of important content from the text; that is, while both groups recalled the same amount of seductive details, LVAs recalled fewer base elements than HVAs did. Although this experiment demonstrated that seductive details are more damaging for some readers than others, it did not consider the fact that in some instances, seductive details might actually benefit certain readers.

The notion that some readers might benefit from seductive details was explored in an experiment that examined the influence of seductive illustrations and working memory capacity (WMC). In their study, Sanchez and Wiley (2006) had participants read a 2,700 word multimedia lesson on the causes of ice ages on a computer. In addition to the important base text, participants received one of three versions of the lesson, containing no illustrations, 12 conceptual illustrations, or 12 seductive illustrations. After reading the passage, participants were instructed to write an argumentative essay on the causes of ice ages, as well as complete an inference verification task. Participants with low working memory capacity (LWMC) revealed the standard seductive details effect: The presence of seductive illustrations resulted in significantly fewer causal explanations in LWMC's explanatory essays, as compared to LWMCs who read the lesson containing no illustrations or conceptual illustrations. In addition, LWMCs performed similarly to participants with high working memory capacity (HWMC) in the no illustrations and conceptual illustration groups. However, HWMCs generated significantly more causal explanations when they received seductive illustrations, as compared to all other conditions. Inference verification tasks also showed a seductive details effect for LWMCs, compared to HWMCs who were unaffected by seductive illustrations.

Of course, the fact that HWMC readers appeared to *benefit* from seductive illustrations seems counterintuitive. In order to explain this unexpected result, Sanchez and Wiley (2006) conducted a second experiment that relied on an eye-tracking methodology to evaluate differences in how HWMC and LWMC participants processed the lesson. Based on this analysis, it appears that participants relied on different attentional strategies as they comprehended the ice age content that also contained seductive illustrations. Specifically, HWMCs spent less time overall looking at the seductive illustrations and more time reading the important base text, as compared to LWMCs. Participants with LWMC in contrast, continued to look at the seductive illustrations throughout the experiment, which in turn led them to spend less time on the important base text.

Although Sanchez and Wiley (2006) did not expound on the potential reasons HWMC readers demonstrated a benefit from seductive illustrations, one possible explanation is present in the experimental literature. Referred to as the *reverse-cohesion effect*, high prior-knowledge readers actually recall more information when presented with texts that contain coherence breaks, compared to low prior-knowledge readers reading the same texts (McNamara, Kintsch, Songer, & Kintsch, 1996; McNamara & Kintsch, 1996). The experimental observations offered by Sanchez and Wiley demonstrate similar patterns, and are also supported by previous claims that seductive details function as coherence breaks within informational texts (e.g., Lehman et al., 2007). However, this proposed explanation has yet to be experimentally investigated.

Mitigating the seductive details effect. Seductive details are commonly added to informational texts with the best intentions: Learners generally view informational texts as uninteresting and boring (e.g., Lorch, Lorch, & Klusewitz, 1993), and learners who are more interested in what they read demonstrate higher task motivation, persistence, and learning (e.g., Ainley, Hidi, & Berndorff, 2002; Hidi, 2006). Thus, any extra material that increases attention and interest to learning materials is likely to be viewed by authors as a worthwhile addition. An important question related to this issue is how readers' understanding of important content might or might not be enhanced for educational texts that contain seductive details. Typically, investigations into this question have focused on adjusting three main factors involved in reading experiences: Textual factors, reader factors, and situational factors.

The easiest and most commonly studied way to improve learning outcomes from a text containing seductive details is to adjust textual factors. One example of this is to simply remove all seductive detail sentences from an informational text (e.g., Garner et al., 1989; Harp & Mayer, 1998). Indeed, as earlier reviewed, readers receiving texts without seductive details demonstrate better recall and transfer for important content (e.g., Lehman et al., 2007). However, preparing materials of this type in the real world is problematic: Teachers typically don't have the ability to edit the informational texts used in their classes, and even if they do so, they are potentially left with a document that is less interesting and motivating to their students.

Other forms of textual alteration have also been explored, including highlighting main ideas, inducing learning objectives, or signaling the presence of seductive details in the text (e.g., Harp & Mayer, 1998). Yet, none of these changes significantly enhanced the learning of important content. Only one textual manipulation to date has appeared to help mitigate the effect: When seductive detail sentences were clustered into the last paragraph of the lightning formation passage, participants recalled more important base text as compared to readers who received the text with the seductive details dispersed throughout. Yet, the seductive details effect was not eliminated completely, as these readers still recalled significantly less important base text compared to controls. Conversely, for participants who read the text with the seductive details grouped into the first paragraph, the seductive details effect became even stronger, and participants recalled significantly less important content compared to the other text versions.

Other researchers have also suggested, as previously mentioned on page 17, that seductive details break the coherence of informational texts, making it difficult for readers to construct coherent causal representations of the scientific information conveyed in the material (Lehman et al., 2007; Schraw, 1998). According to this view, if seductive details were edited to be more cohesive or causally related with the larger content of the informational text, then the seductive details effect might be reduced. Although this type of textual alteration has not been fully explored, this perspective is also problematic. As with simply removing seductive details, it is also greatly difficult for instructors to rewrite informational texts. In addition, previous research has suggested that it is the emotionally interesting content of seductive details, not just their coherence with the passage, which induces a seductive details effect (e.g., Harp & Mayer, 1997).

As textual editing is likely too difficult and costly, a second possibility is to account for reader factors, such as individual differences, when selecting an informational text or lesson. As described earlier on page 16, working memory resources influence the seductive details effect in important ways: HWMC readers may have a better ability to successfully comprehend a text containing seductive details as compared to LWMC readers (Sanchez & Wiley, 2006). Based on this finding, a teacher might provide a text with more seductive details to HWMC readers and a text with fewer seductive details to LWMC readers. Another related option might be to reduce the cognitive load of the learning materials. In one experiment investigating this question, a multimedia lesson about biology was presented on a computer to a group of high-school students who either received the lesson as on-screen text to be read (i.e., high-cognitive load), or a spoken narrative to be listened to (i.e., low-cognitive load; Park, Moreno, Seufert, & Brünken, 2011). The seductive details effect was significantly reduced for the auditory, low-cognitive load group, suggesting that when the materials are delivered in such a way as to minimize working memory load, readers may in fact perform better even when encountering seductive details.

Finally, a third potential option is to make use of reading instructions that influence how readers approach a given reading situation. For example, readers may be assigned a specific task or goal when reading an informational text. These goals might take the form of a teacher asking students to read a text from a particular perspective (e.g., “Consider this scene in *Hamlet* from the perspective of Ophelia.”) or to answer specific questions (e.g., “While reading this chapter on weather formation, be preprared to answer the question, ‘How do tornados form during thunderstorms?’.”). Due to the efficiency with which they can be designed and implemented in the classroom by teachers, task instructions have the potential to be an effective way to reduce the seductive details effect; especially when compared to textual alterations or attempts to account for reader factors. In the experimental literature, task instructions that are designed to directly influence the processes and products of the reading situation are typically referred to as *relevance instructions*.

Relevance instructions and the seductive details effect. In practice, relevance instructions are typically prereading instructions (developed by teachers or experimenters) given to readers to assist them in selecting textual content during reading that will be of use on a later application (e.g., McCrudden & Schraw, 2007). For example, a teacher may instruct a student to study a textbook chapter about weather with the goal of understanding how tornados occur. In practice, relevance instructions are designed to alert and guide readers toward *relevant information* in a passage while potentially avoiding *irrelevant information* (e.g., Kaakinen & Hyönä, 2008; McCrudden, Schraw, & Kambe, 2005). Relevant information in this case is text content that has an intended use on a later task (e.g., Schraw, Wade, & Kardash, 1993). In the earlier example, tornado content within the larger weather chapter is deemed relevant by the prereading instructions, as readers are instructed to focus on learning tornado content to answer a question on a later test. Conversely, irrelevant information (also termed incidental or non-focused content) typically consists of the remaining textual material that is not focused on by the prereading instructions. This category can also include information that is unimportant to understanding the main idea of the passage – a classification to which seductive details belong (for a review, see McCrudden & Schraw, 2007).

When properly utilized, prereading relevance instructions can alter readers' comprehension strategies, as indicated by an increase in attention to relevant material compared to irrelevant material. Although the instructions given to readers can take a wide variety of forms, prereading instructions have been categorically defined in the research literature according to whether they target specific or general content in a text (e.g., McCrudden & Schraw, 2007; Peshkam et al., 2011). *General relevance instructions* typically instruct readers to take a broad, non-specific approach to a text while using their prior knowledge to guide their strategic reading behaviors. For example, readers may be instructed to read a text for study or entertainment (e.g., Narvaez, van den Broek, & Ruiz, 1999; van den Broek, Lorch, & Linderholm, 2001), with the purpose of discussing or elaborating on the text (e.g., Bråten & Samuelstuen, 2004), or to read the text from a particular perspective (e.g., Kaakinen & Hyönä, 2008; Schraw, et al., 1993).

A seminal study by Pichert and Anderson (1977) provides an exemplar for the effects of general relevance instructions on comprehension. In their experiment, participants read a narrative text about two boys playing in a house. The text also contained information about the house's condition as well as valuables contained within the house. Prior to reading the text, participants received instructions to imagine they were viewing the house from the perspective of either a potential home buyer or a burglar. Compared to control participants who did not receive such instructions, participants in the home buyer condition tended to recall more information relevant to a home buyer (leaky basement) and participants in the burglar condition tended to recall more information relevant to a burglar (expensive jewelry left out). Since the participants only received general instructions, they were required to rely on their prior knowledge of what a burglar or home buyer would attend to in a house to determine the relevance of the textual information they were reading.

Conversely, s*pecific relevance instructions* direct readers to focus on specific terms or sentences in the larger text, and often appear as questions that readers should expect to answer after reading the text. Such instructions might potentially ask readers to study a set of questions with the intention of answering them after comprehension (e.g., McCrudden & Schraw, 2010; McCrudden, Schraw, & Hartley, 2006) or even to ignore specific seductive detail sentences contained within a text (e.g., Peshkam, et al., 2011). Unlike general relevance instructions, specific relevance instructions typically provide a preview of some of the specific content readers should focus on during comprehension.

A seminal study by Rothkopf and Billington (1979) provides an exemplar of specific relevance instructions. In their experiment, participants' eye-movements during comprehension were measured as a function of specific prereading instructions. Both general sentence reading times (obtained via self-advanced slides) and eye movements (obtained via physiological recordings) were collected from participants who read an informational text about the National Oceanographic Data Center. Prior to reading the text, participants memorized either specific prereading questions (e.g., "What is the name of the scale used by oceanographers when recording the color of water?") or were provided with control instructions that did not indicate any particular information to be studied within the text (e.g., "Learn as much from the passage as you can."). Participants receiving specific prereading questions spent more time reading relevant than irrelevant text, and also recalled more relevant-focused text, as compared to participants receiving control instructions. In addition, participants that received specific prereading questions appeared to slow down and re-read relevant text, while only skimming irrelevant text (see also Rothkopf & Bisbicos, 1966, 1967).

A significant body of literature now supports so-called *relevance effects*, in that prereading instructions increase attention to and recall of the textual information made relevant by prereading instructions, while potentially decreasing attention to irrelevant information, as indicated by eye-fixations, reading times, and various recall protocols (e.g., Hyönä, Lorch, & Kaakinen, 2002; Kaakinen & Hyönä, 2005, 2007, 2008; Kaakinen, Hyönä, & Keenan, 2001, 2002; McCrudden et al., 2005; 2006; McCrudden, Magliano, & Schraw, 2010; McCrudden & Schraw, 2007; Peshkam, et al., 2011). Two important findings on relevance effects and informational texts, directly pertinent to the current project, can be derived from the results of these studies.

First, prereading relevance instructions influence readers' online attentional processes during comprehension, in that they orient readers toward relevant content and away from irrelevant content. However, although both general and specific relevance instructions tend to increase readers' attention to relevant content, they may also instantiate different reading strategies for texts. For example, general instructions necessitate that readers examine each sentence in to determine its instructionally designated relevance. In making this determination, readers must typically rely on their prior knowledge or strategic awareness to designate sentences as relevant or irrelevant. Conversely, specific relevance instructions provide a preview of the relevant sentences that will be encountered during reading (e.g., McCrudden & Schraw, 2007), thus potentially requiring less cognitive effort from readers to identify relevant sentences (a no-increased effort effect; e.g., McCrudden et al., 2005).

The second important finding derived from the literature on relevance effects is that readers' offline products reflect their previous increased attention to information. Essentially, readers recall more information relevant to the prereading instructions as compared to information that was unmentioned in the instructions. Thus, any experiment investigating potential relevance effects must generally demonstrate that readers are increasing their attention to relevant content as well as increasing their production of the relevant content on a later task.

Recent research has directly compared how general or specific prereading instructions might reduce the seductive details effect. In their experiment, Peshkam et al. (2011) had participants read an informational text on lightning formation or space travel that also contained seductive details. Prior to reading, participants were provided with one of four types of prereading instructions that asked them to focus on specific seductive details, asked them to ignore specific seductive details, offered a general warning about the problematic effects of seductive details, or offered no instructions at all. The seductive details effect was mitigated only after readers received general instructions that vaguely warned about the effects of seductive details on comprehension. In this condition, participants recalled less seductive content compared to the other three instructional conditions, although recall of important base text was not influenced by prereading instructions.

Although Peshkam et al.'s (2011) research demonstrated the potential benefits for prereading instructions in reducing the seductive details effect, few studies have investigated how readers might similarly benefit from targeted recall instructions. Importantly for the current experiment, recall instructions can potentially provide additional information that readers can use to produce additional information at retrieval. In a follow up experiment from their earlier research, Anderson and Pichert (1978) found that participants who read the home-buyer text from one perspective (i.e., burglar) could recall additional information when asked to consider what they had earlier read from the alternative perspective (e.g., if they were asked to read from a burglar perspective, they were later asked to take the homebuyer perspective at recall). Thus, not only did the prereading instructions influence readers during comprehension, but instructions at recall also fostered readers' memory for or reconstructions of the text with respect to additional information. In this way, recall instructions potentially provided cues that enhanced some information at recall, which allowed readers to produce additional information (see also Baillet & Keenan, 1986).

Chapter III: Dynamic Text Comprehension as a Research Framework

Because seductive details appear to exert a negative influence on many aspects of learning and there are potentially several avenues to pursue in terms of mitigation, the current project considers the seductive details effect from the theoretical perspective of dynamic text comprehension (Rapp & van den Broek, 2005; Sparks & Rapp, 2010). From this perspective, researchers must consider the influence of the *online cognitive processes* that are active during reading as well as the *memory products* that result from the implementation of those processes (e.g., van den Broek, Rapp, & Kendeou, 2005; Rapp & Kendeou, 2007; 2009). According to this framework, successful comprehension of a text is the result of a dynamic and interactive process between text characteristics (e.g., genre, overall passage coherence), reader characteristics (e.g., prior knowledge, working memory capacity), and the reading situation (e.g., reading goals and instructions). The seductive details effect may be viewed as a product of these dynamic factors, whereby potential reader characteristics (i.e., working memory capacity) may interact with textual aspects inherent in the document (i.e., interesting factoids) within a given reading situation (i.e., to understand the important content).

In addition to the consideration of the previously mentioned factors, investigations involving a dynamic text perspective must also make use of measures that can potentially indicate changes to the cognitive processes involved in reading (i.e., online processes) and their memory products after the text has been read (i.e., offline products). During reading, readers' online processes can be measured via computer or eye tracker technologies which collect reading times or fixation durations for the words or sentences within texts. When readers demonstrate slower reading times for the words or sentences in the texts, with reference to particular comparison conditions, researchers can make inferences about the cognitive processes involved. For example, a reader that receives prereading instructions to focus on lightning information in an informational text might demonstrate slower reading times or longer fixations for lightning content, as compared to other content. Such slowdowns can potentially indicate additional attention allocation, encoding effort, or critical evaluation of content (e.g., Rapp & Mensink, 2011).

Offline memory products are measured through tasks that ask readers to produce or apply their mental representation of the text after comprehension. Examples include free recalls, recognition tasks, argumentative essays, or question and answer tests. In many instances, online processes and offline products align, in that a reader who demonstrates longer reading times for content is likely to encode that information and produce it on a subsequent recall. However, in some cases readers might not need to linger on content during comprehension in order to produce high amounts of content at recall.

Instances in which readers' online processes and offline products diverge can potentially illuminate periods during which readers' comprehension processes might be altered or influenced (e.g., Rapp & Mensink, 2011). As an example, the attention readers allocate to seductive details might not necessarily correlate with their recall for seductive content. In fact, as some previous research has suggested, attempts to reduce readers' attention to seductive details prior to reading might not provide a beneficial reduction in the seductive details effect (e.g., Peshkam, et al., 2011). Thus, an alternative intervention might need to focus instead on influencing readers' recall of important content, either through prereading instructions, recall instructions, or a combination of both.

In addition, previous experiments on the seductive details effect have generally investigated text, reader, and task factors separately. For example, because the seductive details effect is inherently driven by textual characteristics, several studies have investigated how the presence of seductive details within a text influences readers' online processes and offline products (e.g., Lehman et al., 2007; McCrudden & Corkill, 2010; Peshkam et al., 2011; Sanchez & Wiley, 2006) as indicated by reading time measures and recalls. From a dynamic perspective, these analyses provide an important comparison of how a textual factor may influence readers' online and offline processes.

Additionally, individual differences such as working memory capacity (Sanchez & Wiley, 2006) or verbal ability (McCrudden & Corkill, 2010) may moderate the seductive details effect. The results of these studies suggest that readers with high WMC and/or high VA generally demonstrate better comprehension of texts containing seductive details, as compared to readers with lower abilities. However, although these studies utilized investigations with measures of both online and offline processes, they did not address the potential influence of the reading situation, again focusing on only one element (i.e., readers) associated with a dynamic comprehension model (i.e., readers, text, tasks).

Finally, the importance of the reading situation, as manipulated through reader goals or tasks, may also play a role in influencing readers' attention to and recall of a text containing seductive details. For example, Peshkam et al. (2011) found that the seductive details effect was mitigated only by general prereading instructions warning readers about the detrimental effects of seductive details. Although this study employed reading time measures that provided insights into readers' cognitive processing of texts, the experiments did not address potential individual differences inherent in the reading situation nor did the prereading instructions direct readers toward relevant content. Rather, the prereading instructions concentrated on the seductive content, instructing readers to focus on the seductive sentences, specifically ignore them, or, in a vague way, warning of their detrimental impact. Yet, readers appear to have great difficulty in disregarding or ignoring content when they are specifically instructed to do so (e.g., Peshkam, et al.; Wegner, Schneider, Carter, & White, 1987). In addition, it is typically easier for readers to increase their attention to relevant content rather than decrease attention to irrelevant content (e.g., McCrudden et al. 2005; 2006; Kaakinen & Hyönä, 2008).

Thus, successful mitigation of the seductive details effect might occur only with full consideration of the dynamic factors involved in text comprehension and instructions focused on relevant content. For example, readers might better resist the seductive details effect if the textual aspects of seductive details are rigorously controlled, the potential influence of readers' individual differences are accounted for, and the reading task is created in such a way as to enhance attention and recall of relevant textual content, rather than intended to encourage avoidance of the irrelevant seductive content.

To summarize this review of the literature, the addition of seductive details to informational text and media results in learners recalling less important content, as compared to learners receiving the same content with seductive details removed (i.e., a seductive details effect; Garner et al., 1989; Harp & Maslich, 2005; Harp & Mayer, 1998;

Lehman, et al., 2007; Schraw, 1998). Although some individuals may benefit from seductive details (e.g., Sanchez & Wiley, 2006; McCrudden & Corkill, 2010), researchers have investigated a variety of ways to reduce the negative effect seductive details have on most readers. Yet these interventions have often involved alterations to learning practices, materials, and environments that teachers are unable to easily achieve (e.g., Harp & Mayer, 1997).

Thankfully, prereading relevance instructions have shown some promise in reducing the amount of seductive content that learners produce at recall (e.g., Peshkam, et al., 2011). However, to date, no experiment has investigated the influence of prereading instructions focused on relevant content to be learned. In addition, the claims offered by views of dynamic text comprehension (e.g., Rapp & van den Broek, 2005; Sparks & Rapp, 2011) would suggest that, while prereading instructions might influence readers' online comprehension processes, recall instructions might have similar effects on readers' memory products.

Chapter IV: The Current Experiment

The current experiment had three complimentary purposes. The first purpose was to conduct an investigation of the seductive details effect that takes into consideration the multiple factors inherent to dynamic text comprehension; specifically how readers' cognitive processes during comprehension (as indicated by eye-movements) and offline products (as indicated by recalls) would be influenced by text content (i.e., seductive details), task instructions (i.e., topic focusing instructions and recall cues), and individual differences (i.e., working memory capacity). The second purpose of the experiment was to determine if differences in recall instructions, focusing on either general or specific information from the text, would lead to differences in readers' recall for texts containing seductive details. The third and final purpose of the experiment was to determine whether prereading instructions focusing readers toward important content could potentially alleviate the seductive details effect.

To address these questions, three experiments were conducted. In Experiment 1, a multi-topic scientific text on lightning and tornado formation (adapted from various internet sources, also Lehman et al., 2007; Peshkam et al., 2011) was developed. Participants then read the text and rated each sentence for interest and importance in order to empirically identify seductive detail sentences. In Experiment 2, participants read the text with or without the seductive details sentences, completed an inventory on their reading strategies, and completed a free recall, the results of which were used to determine if the text elicited a seductive details effect. Experiments 1 and 2 thus ultimately served as important norming investigations that allowed for a multi-topic scientific text that elicited the seductive details effect for use in Experiment 3.

In Experiment 3, participants read the seductive details version of the text while wearing a head-mounted eye tracker. Prior to reading the text, participants received prereading relevance instructions in the form of questions that were designed to focus their attention toward specific lightning or tornado information in the text during comprehension (e.g., Kaakinen & Hyönä, 2005; 2008; McCrudden & Schraw, 2007; McCrudden et al., 2005; 2006; Peshkam et al., 2011). Participants then completed a reading strategy inventory and a working memory capacity (WMC) test that measured their reading span (RSPAN). After completion of the WMC task, which also served as a distracter, participants then either received one of two recall instruction conditions: A single, general free recall task with an instruction to recall as much as they could from the entire text, or two specific recall tasks with instructions to first recall the topic unmentioned by the prereading instructions (i.e., nonfocused), followed by instructions to recall the topic mentioned by instructions (i.e., focused). Thus, the effects of specific relevance instructions on readers' online processes were compared to the effects of specific and general recall instructions on their offline products.

Chapter V: Experiment 1

The goal of Experiment 1 was to develop and norm a dual-topic scientific text that also contained highly interesting but unimportant sentences (i.e., seductive details). In Experiment 1, participants received a rating packet which contained a text titled *Severe Weather Formation* (see Appendix B on page 102). The text described lightning and tornado formation in the Midwest. Participants read the text a total of three times. Participants initially read the three-page text for comprehension at their own pace, with no other assigned task. Participants then read the text a second time, rating each sentence for interest or importance, depending on their packet version. Finally, participants read the text a third time, and completed the interest or importance rating task they did not perform during their second reading. Participants also completed a short reading questionnaire designed to assess their awareness of specific comprehension strategies, as well as their interest in the text.

Method

Participants

Twenty University of Minnesota undergraduates participated in the experiment for either course credit or a gift certificate. Participants ranged in age from 19 – 22 (M = 19.58, SD = 1.07) and nine were female. All participants were native speakers of English.

Materials

The text was a 66 sentence, 1,384 word text which described how tornadoes and lightning form during inclement weather conditions (see Appendix B on page 102). The passage was adapted and constructed from the *Lightning Formation* text used in previous seductive detail experiments (i.e., Harp & Mayer, 1998; Lehman et al., 2007; McCrudden & Corkill, 2010; Peshkam et al., 2010) as well as from various internet sources. The passage contained an introduction and conclusion paragraph (167 words), five paragraphs on lightning formation (484 words) and five paragraphs on tornado formation (458 words). When it did not disrupt the overall coherence of the text, the paragraphs alternated between lightning and tornado information in order to discourage skimming through a particular topic. In addition, the dual-topics were selected in order to increase the scientific nature of the content, as well to be combined into a larger overall document topic that could be referred to in the general recall instructions used in Experiment 3 (i.e., the formation of severe weather; Kaakinen & Hyönä, 2005; 2008; McCrudden et al., 2005, 2006; 2010; Peshkam et al., 2011).

Across the text, lightning-specific sentences averaged 21.04 words in length ($SD = 6.29$) and tornado-specific sentences averaged 21.81 words in length ($SD = 6.29$); a t-test revealed that these averages did not differ significantly ($t < 1$). Six lightning-specific seductive details (139 words total, $M = 23.17$, $SD = 5.19$) were inserted across the lightning paragraphs (see Table 1 on page 40) and six tornado-specific seductive detail sentences (136 words total, see Table 2 on page 41) were inserted across tornado paragraphs ($M = 22.83$ words, $SD = 10.19$). A t-test revealed no significant differences in average seductive detail sentence length ($t < 1$). Where possible, lightning and tornado seductive detail sentences were inserted as to appear in analogous positions within lightning and tornado paragraphs. In total, seductive detail sentences represented approximately 18% of the total text content, or 12 out of 66 total sentences.

The interest and importance rating tasks were adapted from previous experiments on seductive details by Lehman et al. (2007). The interest scale for the text appeared as a 6-point, Likert-type scale (1 = Very Uninteresting, 2 = Uninteresting, 3 = Slightly Uninteresting, 4 = Slightly Interesting, 5 = Interesting, 6 = Very Interesting). Each sentence appeared on the interest rating page as it appeared in the text, with alternating sentences appearing on a light gray background for visual clarity. Participants received the following instructions: "Some sentences in a text are more interesting than others. Please rate each one of the following sentences from the passage titled *Severe Weather Formation* according to how interesting you found each sentence in the text. Use the 6-point scale below to rate the relative interest of each sentence in the passage. Circle one number for each sentence."

The importance rating for the text also appeared as a 6-point, Likert-type scale (1 = Very Unimportant, 2 = Unimportant, 3 = Slightly Unimportant, 4 = Important, 5 = Slightly Important, 6 = Very Important). Participants received the following instructions, adapted from Lehman et al. (2007): "Some sentences in a text are more important than others. Please rate each one of the following sentences from the passage titled *Severe Weather Formation* according to how important the sentence is to the text's overall meaning. Use the 6-point scale below to rate the importance of each sentence in the passage. Circle one number for each sentence." As with the interest ratings, each sentence also appeared on the importance rating pages as in the text, with alternating sentences appearing on a light gray background.

A 16-item, experimenter-designed reading questionnaire was also included at the end of the packet, the items for which can be found in Table 4 on page 44. Participants completed the questionnaire after all other tasks and were instructed to answer the questions based on their first reading of the text. The questionnaire contained items intended to measure participants' awareness of their understanding, interest, strategy use, and general effort during the initial reading.

Procedure

Participants completed the experiment individually in sessions that included one to eight participants in each session. Each participant received a text packet that contained all information and tasks for the experiment, and read the text a total of three times. Participants were instructed to read the text carefully at their own pace in order to understand it, and that they would complete three tasks related to the text after reading. Participants then read through the text the first time at their own pace for comprehension, without completing any other tasks. After reading the text for comprehension, participants then read through the text a second time, and rated each sentence in the text for either interest or importance. In order to avoid order effects, participants were randomly assigned to complete the interest rating task first or the importance rating task first. After completing the initial interest or importance rating task, participants then read through the text a third time and completed the remaining rating task. Once the rating tasks were finished, participants completed the 16-item reading questionnaire, were debriefed on the experiment, and excused from the laboratory. The entire experimental session took no longer than 40 minutes.

Results

Classification of seductive detail and base text sentences. During stimuli creation, sentences were inserted into the text that were anticipated to be rated by participants as highly interesting yet unimportant to their understanding of the text. This taxonomy has been used in previous research (i.e., Harp & Mayer, 1998; Lehman et al., 2007; Wade et al., 1993), defining seductive details as highly interesting but unimportant sentences in the text, as compared to highly important and highly interesting, highly important and uninteresting, or unimportant and uninteresting sentences. In the current experiment, seductive sentences were constructed based on previously identified sentence topics that are commonly viewed as highly interesting to readers (Harp & Mayer, 1997; Kintsch, 1980).

Sentences were first classified as lightning, tornado, or other content based on the topic of the paragraph in which they appeared. All sentences in the introduction and conclusion paragraph were classified as other content. Within lightning and tornado paragraphs, sentences were then further identified as either seductive detail or base text sentences based on a difference score calculation performed on all sentences. The difference score was calculated by subtracting the interest score from the importance score for each sentence. In this way, highly interesting but unimportant sentences appear as large positive integers, while highly important but uninteresting sentences appear as large negative integers. Likewise, sentences generally equal in terms of interest and importance average around zero.

When averaged across the entire text, the mean interest and importance difference score was -0.19 (*SD* = .95), suggesting that sentences were generally rated by participants as equal in terms of interest and importance. As shown in Table 1 on page 40 and Table 2 on page 41 respectively, six sentences included as lightning seductive details and six sentences as tornado seductive details appeared to operate as such, based on the criteria that they: 1) had positive difference scores, indicating higher interest ratings compared to importance ratings and 2) were also at least one standard deviation or more from the mean difference score. All seductive details in this case received calculated difference scores of .76 or greater. Of the intended seductive sentences created by the experimenter, only one did not exhibit the characteristics of being highly interesting but unimportant (i.e., "Hazardous and potentially lethal objects that could easily impale a human such as pitchforks, knives, forks, and axes have been found imbedded in trees and buildings after tornadoes have dissipated."); for the remainder of the project, this sentence was left in the text but not categorized as a seductive detail.

Finally, as an additional validity measure, paired t-test contrasts between interest and importance ratings were conducted for each of five sentence categories (i.e., lightning base text, lightning seductive details, tornado base text, tornado seductive details, or other). As summarized in Table 3 on page 42, both lightning and tornado seductive details were rated as significantly more interesting than important, while lightning and tornado base text, as well as other text, were rated as significantly more important than interesting.

Table 1: ***Mean Interest and Importance Ratings for Lightning Seductive Details***

		Interest		Importance		Difference
Sent.	Text	*M*	*SD*	*M*	*SD*	--
11	Understanding how lightning forms is also important; approximately 80 Americans are killed and 300 injured by lightning every year.	5.05	*1.00*	4.20	*1.15*	0.85
14	Once, an 8' ball of lightning struck into a dimly lit church in England and burned off the back of a man's head.	5.80	*0.42*	2.80	*1.14*	3.00
16	In the early 1980s, scientists created a specially developed plane that was flown through thunderstorms in order to better understand how lightning strikes aircraft.	4.35	*1.09*	3.30	*1.22*	1.05
17	Lightning does strike modern commercial airplanes, but this rarely causes damage as airplane nose-cones are built to diffuse lightning strikes.	4.85	*1.18*	3.25	*1.37*	1.60
28	For example, in 2000, a nineteen-year-old from Texas died after being hit in the head by a softball sized hailstone.	5.25	*.79*	3.60	*1.00*	1.65
47	For example, witnesses in Maryland watched as a bolt of lightning tore a hole in the helmet of a high school football player during practice, burning his jersey and blowing his shoes off.	5.55	*0.83*	3.75	*1.07*	1.80

Table 2: ***Mean Interest and Importance Ratings for Tornado Seductive Details***

		Interest		Importance		Difference
Sent.	Text	*M*	*SD*	*M*	*SD*	--
06	Understanding how tornadoes are formed is important because approximately 70 Americans are killed and 1500 injured by tornadoes yearly.	5.10	*0.91*	4.35	*1.18*	0.76
08	Individuals have also been killed by being carried aloft by tornadoes and then dropped from a great height.	5.05	*1.15*	4.00	*1.30*	1.05
21	In 2006, filmmaker Sean Casey created the Tornado Intercept Vehicle out of an armored 1997 Ford F-450 diesel pickup that weighed over 17,000 pounds.	4.85	*1.63*	3.05	*1.23*	1.80
22	The vehicle contained numerous meteorological instruments and was designed to be driven directly into a tornado's most destructive zone.	4.25	*1.52*	3.20	*1.00*	1.05
39	In 2006, Matt Suter of rural Missouri was carried 1307 feet (398 m) by a tornado, according to National Weather Service measurements.	5.35	*0.81*	3.50	*1.10*	1.85
41	In rare cases the tornado can be more than one mile (1.6 km) across.	5.25	*0.85*	4.05	*1.40*	1.20

Table 3: ***Contrast of Sentence Interest and Importance Ratings by Topic and Sentence Type.***

	Interest		Importance					*Cohen's*
Variable	*M*	*SD*	*M*	*SD*	*t*	*df*	*p*	*d*
Lightning topic								
Base text	3.62	*0.49*	4.06	*0.38*	- 4.53	22	< .001	- 0.96
Seductive details	5.14	*0.52*	3.48	*0.48*	5.38	5	.003	2.19
Tornado topic								
Base text	3.61	*0.64*	4.11	*0.44*	- 4.80	22	.000	- 1.06
Seductive details	4.98	*0.39*	3.69	*0.52*	7.07	5	.001	3.02
Other text	3.61	*0.29*	4.74	*0.33*	- 9.00	7	.000	- 3.17

Interest ratings for all sentences. Using the sentence classifications described on page 38, mean ratings for interest were calculated for each sentence type across the text, as shown in Table 3 above. The overall mean for interest ratings across all sentences in the text was 3.88 (*SD* = .67). The mean interest ratings for all lightning formation sentences (excluding seductive details) was 3.62 (*SD* = .49) and for all tornado formation sentences (excluding seductive details) was 3.61 (*SD* = .64). A t-test revealed no significant differences in interest ratings between the lightning and tornado formation sentences ($t < 1$).

Importance ratings for all sentences. Mean ratings for importance were also calculated for each sentence and across topics and are also shown on Table 3. The overall mean for importance ratings across all sentences in the text was 4.07 (*SD* = .52). The mean importance ratings for all lightning formation sentences (excluding seductive details) was 4.06 (*SD* = .38) and for all tornado formation sentences (excluding seductive details) was 4.11 (*SD* = .44). A t-test revealed no significant differences in importance ratings between lightning and tornado formation sentences ($t < 1$).

Reading questionnaire results. Mean ratings and items from the reading questionnaire are shown on page 44 in Table 4. Overall, participants reported high ratings of understanding the text (*M* = 5.90, *SD = .72)* and moderate ratings for interest (*M* = 4.40, *SD* = 1.31) for the text as a whole.

Table 4: ***Means For Reading Questionnaire Items by Experiment and Text Version***

		Exp. 1		Exp. 2				Exp. 3	
		Seductive details		Control		Seductive details		Seductive details	
	Item	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1.	Overall, I understood what I read.	5.90	*0.72*	5.50	*0.94*	5.67	*0.95*	5.29	*1.10*
2.	I used a specific reading strategy to understand the text.	3.80	*1.28*	3.64	*1.39*	4.33	*1.03*	4.07	*1.21*
3.	I read every sentence carefully	5.20	*0.83*	4.86	*1.17*	4.67	*1.38*	4.69	*1.21*
4.	I anticipated what was coming next in the text.	3.75	*1.52*	4.43	*1.40*	4.67	*1.44*	4.02	*1.35*
5.	I paid attention to how well I understood what I was reading.	5.40	*1.14*	5.21	*1.19*	5.50	*0.97*	5.35	*0.97*
6.	I skimmed parts of the text.	3.10	*1.41*	3.86	*1.35*	3.92	*2.39*	3.76	*1.65*
7.	I was interested in what I was reading.	4.40	*1.31*	4.79	*1.19*	4.33	*1.90*	4.36	*1.48*
8.	I made connections between the text and information I already knew.	5.45	*1.10*	6.00	*1.04*	5.83	*1.24*	5.43	*1.28*
9.	I tried to reframe the information from the text so that it made sense to me.	4.80	*1.54*	4.79	*1.25*	5.25	*1.24*	4.73	*1.14*
10.	I made connections back to information that had been previously mentioned in the text.	5.30	*1.08*	5.14	*1.17*	5.33	*1.04*	4.81	*1.19*
11.	I slowed down my reading speed to better understand the text.	5.05	*1.32*	5.07	*1.44*	5.25	*1.60*	5.53	*1.16*
12.	I read the text carefully.	5.10	*0.97*	5.29	*0.83*	5.25	*0.95*	5.06	*0.98*
13.	I put a lot of effort into understanding the text.	4.75	*0.97*	4.36	*1.08*	4.67	*1.25*	4.60	*1.09*
14.	I thought about things that were not in the text.	4.80	*1.40*	5.00	*0.78*	4.50	*1.90*	4.38	*1.58*
15.	I paid more attention to some information than I did other information.	5.90	*0.79*	6.14	*0.66*	5.92	*0.95*	5.82	*1.03*
16.	I felt an emotional response to the text.	3.30	*1.69*	3.14	*1.66*	3.00	*1.50*	3.19	*1.45*
17.	I paid attention to the instructions presented before the text.	--	--	--	--	--	--	5.72	*1.02*
18.	The instructions presented before the text changed how I read the text.	--	--	--	--	--	--	5.06	*1.45*

Discussion

Based on the results from Experiment 1, the constructed text contained sentences that were identified by participants as highly interesting yet unimportant to understanding the text. However, although the text contained potential seductive details, it remained unclear as to whether the seductive detail sentences would function as such during comprehension. An essential element of the seductive details effect is the observation that participants receiving seductive details in texts recall significantly fewer main ideas as compared to participants that do not receive seductive details in the same text (e.g., Harp & Mayer, 1998; Lehman et al., 2007; McCrudden & Corkill, 2010). The purpose of Experiment 2 was to implement the constructed text to evaluate whether sentences identified as seductive details would elicit a seductive details effect from participants, as compared to participants who read a text that omitted those details. Thus, Experiment 2 applied the normed materials to assess whether they would suitably obtain measures that exemplify the seductive details effect, which is crucial for employing the materials to reveal whether manipulations can reduce any such effect.

Chapter VI: Experiment 2

In Experiment 2, the text developed in Experiment 1 was tested for its effectiveness at eliciting a seductive details effect at recall. Two versions of the text were employed – a version that was identical to the text used in Experiment 1 and a version with the seductive detail sentences removed. Participants were randomly assigned one of the text versions to read, completed a math distracter task, a free recall of the text, and then the reading strategy questionnaire used in Experiment 1. Generally, we predicted that participants receiving the seductive details text would recall significantly less important content from the text, as compared to participants receiving the control version (i.e., a seductive details effect; Harp & Mayer, 1998; Lehman et al., 2007; Peshkam et al., 2011).

Method

Participants

Twenty-seven University of Minnesota undergraduates participated in the experiment for either course credit or a gift certificate. Participants ranged in age from 18 – 29 (M = 20.08, SD = 2.24) and 15 were female. All participants were native speakers of English.

Materials

Two versions of the text on lightning and tornado formation were used in the experiment. One version, referred to as the *seductive details version*, was identical to the text used in Experiment 1 (see Appendix B). It contained all 12 of the seductive detail sentences. The second version, referred to as the *control version,* omitted the 12 seductive detail sentences that are shown in Table 1 on page 40 and Table 2 on page 41.

The sentences specifically removed included six tornado-specific (136 words) and six lightning-specific (139 words) sentences, resulting in a final text length of 1109 words for the control version. With the exception of the exclusion of the seductive detail sentences, the control version was identical to the original text. In addition to the text, participants received packets that also contained a page of four complex math problems as a distracter, a free recall page, and the reading questionnaire used in Experiment 1, as shown in Table 4 on page 44.

Procedure

Participants completed the experiment individually in groups of one to eight participants per session. Participants received a packet that contained all information and tasks for the experiment. Prior to reading the passage, participants were instructed to read the text carefully at their own pace in order to understand it, and then to complete two tasks related to the text after reading. Participants read through the text once at their own pace. After reading the text, participants were instructed to correctly answer the four math problems, showing their work on the page. After completing the math distracter task, participants turned to the free recall page which included the following instructions: "We would now like you to recall everything you can about the passage you just read entitled *Severe Weather Formation*. Don't worry about spelling and punctuation. Try to remember as much as you can. If you can only remember some of the meaning from a sentence, include that too. There is no time limit, so write down as much as you can. Use the additional pages if necessary. Do not look back at the text!" Once participants finished the free recall of the text, they completed the reading questionnaire, were debriefed on the experiment and excused from the laboratory. The entire experiment was finished by all participants within 40 minutes.

Recall scoring. A recall protocol was created that allocated all sentences into a rubric of 155 idea units. Individual idea units were separated from sentences by identifying separate verb-noun phrases or propositions within the sentences. Idea units were further identified by the topic of the original sentence, so that the rubric contained 51 lightning formation main idea units, 55 tornado formation main idea units, 16 lightning-specific seductive detail idea units, 15 tornado-specific seductive detail idea units, and 18 introduction-conclusion idea units. Recalls were scored by the experimenter and a trained coder who each coded half of the recalls.

Participant recalls were evaluated based on whether a participant's provided recall segment matched or paraphrased an idea unit contained within the original text. Recall proportions were then calculated by dividing the total number of idea units recalled per topic by the total number of possible idea units the participant could have recalled, based on the text they were given (i.e., total recall proportions were calculated only for the 51 lighting main idea units, 55 tornado main idea units, and 18 introduction-conclusion idea units for participants who did not receive the seductive details version). In addition, 25% of the recalls were randomly selected to be coded in common between the experimenter and a trained coder as a reliability measure. For the in common recalls, agreement was reliably high ($\alpha = .87$) between the experimenter and the trained coder. Disagreements were resolved by discussion.

Results

Recalls. Participants' mean recall proportions were analyzed using a 3 (Sentence Topic: Lightning, Tornado, Introduction-Conclusion) X 2 (Text Version: Control vs. Seductive details) multivariate ANOVA. Two participants' data were removed from analysis due to failure to follow instructions.

The results, presented in Table 5 on page 50, supported the prediction that the seductive details version of the text would elicit a seductive details effect. Participants that received the seductive details version of the text recalled fewer lightning formation main idea units (M = .11, SD = .07) as compared to participants who received the control version (M = .19, SD = .10; F(1,24) = 4.80, MSe = .01, p = .03, η^2 = .17). Participants that received the seductive details version also recalled fewer tornado formation main idea units (M = .09, SD = .06) as compared to participants that received the control version (M = .16, SD = .08; F(1,24) = 6.44, MSe = .01, p = .01. η^2 = .22). A paired t-test revealed no significant difference between the amount of important lightning and tornado formation content each participant produced (t < 1). Interestingly, participants did not significantly differ in the amount of introduction-conclusion information they recalled (F < 2.00). However participants who received the seductive details version of the text recalled a slightly lower proportion of the text overall (M = .13, SD = .06) as compared to participants who read the control text (M = .18, SD = .08; marginally significant, F(1,24) = 3.32, MSe = .01, p = .08, η^2 = .13).

Table 5: ***Proportional Recalls by Text Version and Sentence Type***

	Seductive details		Control	
Sentence type	*M*	*SD*	*M*	*SD*
Lightning base text	.11	*.07*	.19	*.10*
Tornado base text	.09	*.06*	.16	*.08*
Other text	.14	*.09*	.24	*.23*
Lightning seductive details	.29	*.15*	--	--
Tornado seductive details	.24	*.15*	--	--
Total	.13	*.06*	.18	*.08*

Participants who received seductive details also demonstrated an overall deficit in their total proportional recall for combined tornado and lightning information (M = .07, SD = .05) as compared to participants who read the control version of the text (M = .12, SD = .06; $F(1,24) = 6.70$, MSe = .003, $p = .01$, $\eta^2 = .23$). Participants who received the seductive details version of the text recalled, on average, 10.83 idea units (SD = 7.28) of tornado and lightning formation information, as compared to control participants who recalled an average of 19.31 idea units (SD = 8.98; $F(1,24) = 6.70$, MSe = 66.89, $p = .01$, $\eta^2 = .23$).

Finally, participants who received the seductive details version of the text recalled high proportions of both lightning-specific (M =.29, SD =.15) and tornado-specific (M = .24, SD = .15) seductive detail idea units. Using a paired t-test, recall proportions of important lightning and tornado information were compared to recall proportions for lightning and tornado seductive details. Participants recalled significantly more lightning seductive details as compared to important lightning information (a .18 difference, $t(11)$= 3.74, $p < .01$), and more tornado seductive details as compared to important tornado information (a .15 difference, $t(11) = 5.18$, $p < .001$). No significant difference between lightning and tornado seductive details was observed ($t<1$).

Reading questionnaire. A one-way ANOVA was used to investigate participants' responses to each of the items on the reading questionnaire, which is shown in Table 4 on page 44. Across all items, participant responses did not differ as a function of the text version they received (all $Fs < 1$).

Discussion

The goal of Experiment 2 was to test whether the constructed text would elicit a seductive details effect at recall. Participants receiving the seductive details version of the text recalled less important content as compared to participants receiving the control version of the text, indicating indeed that the text elicited the seductive details effect at recall. These results were vital to Experiment 3, in which the validated text was used to determine whether instructional guidance might reduce the seductive details effect, as tested with both moment-by-moment and recall methods.

Chapter VII: Experiment 3

The purpose of Experiment 3 was to investigate whether prereading questions focusing participants on important content could reduce the seductive details effect. This examination specifically focused on whether prereading relevance instructions would influence participants' online encoding processes during comprehension, as well as their recall products after comprehension of the text (e.g., McCrudden & Schraw, 2007; Peshkam et al., 2011; Rapp & van den Broek, 2005). In addition, Experiment 3 also investigated how general or specific recall instructions would influence participants' production of relevant and irrelevant (i.e., seductive details) content, as previous research has demonstrated that the type of instructions readers receive at recall can influence their memory products (e.g., Pichert & Anderson, 1978). Finally, the influence of working memory capacity (WMC) was also considered in Experiment 3, as previous research has suggested that individual differences such as working memory may influence readers' susceptibility to seductive details (e.g., McCrudden & Corkill, 2010; Sanchez & Wiley, 2006) as well as their ability to attend to relevance instructions (e.g., McCrudden & Schraw, 2010)

In Experiment 3, participants read the seductive details text version used in Experiments 1 and 2 on a computer while wearing a head-mounted eye tracker. Prior to reading, participants received relevance-focusing instructions in the form of targeted questions (i.e., McCrudden et al., 2005, 2006; McCrudden & Schraw, 2010; Peshkam et al., 2011; Rothkopf, & Billington, 1979) that directed them to focus their comprehension efforts on important lightning or tornado information. For example, a reader might be instructed to read the text in order to answer specific questions regarding lightning formation. In this case, important lightning content would be the focused information, while lightning seductive details, as well as all tornado content, would be defined as nonfocused and therefore irrelevant information. Participants then completed the reading strategy questionnaire used in Experiments 1 and 2, and a test of working memory capacity (WMC). Finally, participants received either general recall instruction to freely recall the entire text, or two specific recall instructions to first recall only the nonfocused topic and then recall only the focused topic.

Theories of dynamic text comprehension posit that readers' comprehension processes and products are influenced by interactions between textual, reader, and situational factors. Thus, the hypotheses and measures of Experiment 3 were developed in order to account for how the textual factors inherent in a seductive, dual-topic text would interact with readers' working memory capacity and the task instructions used in the experiment (i.e., prereading and recall instructions) to influence their online comprehension processes and offline memory products. In terms of online processes, readers spend more time reading seductive details as compared to other text segments, which in turn may reduce the overall amount of time they spend reading important information (Lehman et al., 2007; McCrudden, & Corkill, 2010; Peshkam et al., 2011). In terms of offline products, readers who receive seductive details within informational text, in contrast to those who do not receive them, tend to remember fewer main ideas from the important instructional content but recall seductive details quite well (Garner et al., 1989; Harp & Mayer, 1997, 1998; Lehman et al., 2007; McCrudden & Corkill, 2010).

Thus, one way to mitigate the seductive details effect is through interventions that potentially address both readers' online processes and offline products. Specific relevance instructions in the form of prereading questions have shown promise in increasing readers' attention to relevant content (e.g., McCrudden et al., 2005, 2006; Kaakinen & Hyo; Rothkopf, & Billington, 1979), while general relevance instructions warning readers about seductive details reduced the production of seductive details at recall (e.g., Peshkam, et al., 2011). In addition, recall instructions have also demonstrated some benefit to readers in producing additional relevant content at recall (e.g., Baillet & Keenan, 1986; Pichert & Anderson, 1978).

General hypotheses. Based on these research findings, Experiment 3 investigated the potential benefits of specific prereading instructions focused on relevant content combined with either general or specific recall instructions. The hypotheses for Experiment 3 specifically considered the effects of prereading relevance instructions on readers' online processing of the text and their offline memory products. In addition, the hypotheses were also intended to identify the effects of general and specific recall instructions on readers' offline products, as well as the potential influence of readers' working memory capacity.

Readers' online processes were examined in Experiment 3 using a head-mounted eyetracker, which allowed for the measure of attentional allocation during reading as indicated by readers' eye movements and fixation durations for the text. In regards to these online processes, a *relevance-focusing hypothesis* predicted that prereading instructions directing readers to allocate additional attention to important content would result in a relevance effect, in that readers would demonstrate increased fixation durations for instructionally focused content, as compared to fixation durations for the irrelevant information (i.e., the nonfocused topic and seductive details, Kaakinen & Hyönä, 2005, 2007, 2008; McCrudden & Schraw, 2007). Conversely, a *relevance-seduction hypothesis* predicted that seductive details would be irresistibly alluring to readers during comprehension, regardless of prereading instructions. Data consistent with this hypothesis would consist of increased fixation durations for seductive details, as compared to important focused and nonfocused content, despite the inclusion of targeted prereading instructions.

Readers' offline products were measured via their production of textual content from the text on a recall task. In terms of offline products, the *specificity-enhanced hypothesis* predicted that specific recall instructions should provide readers with additional, useful information in determining the relevance of information they should produce from memory (e.g., Baillet & Keenan, 1986; Pitchert & Anderson, 1978). Indeed, previous research suggests that the use of specific reading instructions may lower the effort required for readers to identify and produce relevant content (McCrudden et al., 2005, 2006). Specific recall instructions could potentially function in a similar way, serving as an additional external recall cue which would potentially enable readers to produce more important content and less seductive detail content, as compared to general free recall instructions.

Alternately, the *generality-enhanced hypothesis* predicted that general recall instructions would prove superior to specific recall instructions. Indeed, previous experiments that have used relevance instructions to reduce the seductive details effect only found a benefit from general warnings about seductive details (i.e., Peshkam et al., 2011). This finding suggests that general instructions, as opposed to specific, might be the most beneficial for readers encountering seductive details in texts. A similar benefit for readers might be obtained through the use of general recall instructions. Support for this hypothesis would be demonstrated if readers produced more important content and fewer seductive details at recall, as compared to the recalls of readers receiving specific recall instructions.

Finally, we also considered the influence of working memory capacity (WMC) on participants' ability to follow the focusing instructions during comprehension, the impact of instructions at recall, and any emergence of the seductive details effect. While individual differences such as WMC and verbal ability (VA) influence general comprehension processes (e.g., Ackerman & Lohman, 2006; Daneman & Carpenter, 1980; Just & Carpenter, 1992), WMC also appears to play an important role in moderating whether and how readers attend to important (i.e., content to be learned) and unimportant text (i.e., seductive details) during comprehension. According to the controlled-attention view of WMC, (e.g., Engle, 2002; Kane, Bleckley, Conway, & Engle, 2001; Lavie, 2005; 2010) the ability to control attention during a variety of cognitive tasks is limited by the capacity of working memory, as well as the demands of the task. Similarly, situations in which readers have to first identify relevant information from irrelevant information, and then delegate additional attention toward relevant information, likely taxes the limited resources of the cognitive system (e.g., Hyönä et al., 2002).

Thus, a WMC measure was included in Experiment 3, in the form of a reading span (RSPAN) test, to assess the potential effects of this individual difference. As a general expectation, we anticipated that participants with a high WMC would be inoculated from the seductive details effect for two reasons. First, individuals with high

WMC are better able to avoid irrelevant content during reading (e.g., Engle, 2002; Sanchez & Wiley, 2006) as compared to low WMC readers. This expectation led to the specific prediction that high WMC readers would spend less time fixating on seductive content during comprehension, and produce less seductive content at recall. Second, we predicted that high WMC readers, as compared to low WMC readers, would better adhere to prereading instructions that focused their attention toward important content (e.g., McCrudden & Schraw, 2010). This expectation led to the specific prediction that high WMC readers, as compared to low WMC readers, would also demonstrate increased fixation durations for important, focused content and would produce more important content at recall.

Method

Participants

One-hundred University of Minnesota undergraduates participated in Experiment 3 for either course credit or a gift card. Participants ranged in age from 18 – 31 (M = 21.67, SD = 2.82) and 61 were female. The data from four participants were excluded from subsequent analysis due to failure to follow instructions. All participants were native speakers of English.

Apparatus

Participants read the text on a 22-in. Dell LCD color monitor while wearing an EyeLink II head-mounted eye tracker (SR Research, Ltd.). Participants advanced through each page of the text at their own pace using a hand-held controller. Sentences appeared in a double-spaced paragraph format as standard black type on a white background. An additional PC running E-Prime software and Microsoft Word was used to collect RSPAN and recall measures respectively.

Materials

Text stimuli and prereading questions. Participants read the seductive details version of the text adapted and normed in Experiments 1 and 2 (see Appendix B). In addition to the text, six targeted-questions were written for lightning content and six for tornado content, in order to focus participants' attention to relevant content (i.e., McCrudden et al., 2005 Kaakinen & Hyönä; 2008). The five non-seductive detail sentences rated as most important for lightning content in Experiment 1 were rewritten as prereading questions. An additional, sixth question about general lightning formation was also included. Five targeted questions and one general question for tornado information were constructed in a similar manner (see Appendix A).

Working memory task. Working memory capacity (WMC) was assessed using an automated reading span (RSPAN) test developed by Unsworth, Heitz, Schrock, & Engle (2005) in order to provide a quick and efficient test of RSPAN. The automated RSPAN test was delivered on a Dell computer running E-prime and participants used the mouse and keyboard to progress through the test. Participants first completed a training block on memorizing letters from the letter set. The full letter set consisted of 12 letters (F, H, J, K, L, N, P, Q, R, S, T, and Y), from which 1 letter was randomly selected to appear for 800 ms, after which a second letter from the set was selected and shown. Participants then used a checklist containing the full letter set to indicate which order the letters appeared in, and received feedback on their responses.

Participants next completed a second training block on the sentence judgment task. Participants read a sentence which either made sense (e.g., "The jogger quickly ran through the park.") or did not (e.g., "The jogger quickly ran through the sky."). After reading the sentence, participants were required to answer either TRUE or FALSE to the question, "Did the sentence make sense?" quickly and accurately. Participants were allowed 2500 milliseconds, on average, to respond to each sentence.

Finally, participants completed a third training block integrating the two earlier tasks. Participants were first presented with a letter from the letter set to memorize, and then read and responded to the sentence task, after which the task repeated (up to 3 times total for practice trials). After the letter-sentence pairs, participants indicated the correct letters and the order in which they appeared using the letter checklist, which also included a blank option for letters they could not recall. Feedback was also provided to participants during this phase. In addition, participants were also instructed that they needed to maintain an 85% accuracy level during the sentence judgment task.

Following the practice blocks, participants completed experimental blocks that varied from 3 – 7 letter-sentence pairs. Throughout the experiment, a participant's accuracy score was displayed in the upper-right corner of the screen. Sentences were scored as incorrect if participants failed to respond within their allotted timeframes. An absolute RSPAN score for each participant was then calculated as the sum of all perfectly recalled letter sets. All participants completed the RSPAN test within 20 minutes, and the test also served as a distracter prior to the recall task.

Procedure

After participants completed informed consent, the head-mounted eye tracker was fitted and calibrated. Participants were then randomly assigned to receive either lightning or tornado prereading questions. All participants received the following instructions: “Prior to reading the passage, please read the six questions below. We want you to focus on these questions as you read the passage. Later, you will be tested on these questions.” Participants then received six prereading questions on either lightning content (e.g., “What is the meteorological definition of lightning?”) or tornado content (e.g., “What is the meteorological definition of a tornado?”; see Appendix A). After participants finished reading the questions, they read the text on severe weather formation at their own pace. The text was presented across 12 screens, appearing as one more or more double-spaced paragraphs per screen. Participants’ eyes were tracked as they read the text. After completing the text, the eye tracker was removed and participants completed a short, 16-item reading strategy questionnaire based on their reading of the text, previously used in Experiments 1 and 2. Two additional items were added to the inventory that measured participants’ awareness of the prereading instructions (see Table 4 on page 44). Participants then moved to a second computer terminal to complete the automated working memory reading span (RSPAN) test and the recall task.

After completing the reading span test, participants were randomly assigned to one of two recall instruction conditions. Participants receiving general recall instructions completed one recall task for the entire text, and received the following recall prompt: “We would now like you to recall everything you can about the passage you read on SEVERE WEATHER FORMATION. Don’t worry about spelling and punctuation. Try to remember as much as you can about SEVERE WEATHER FORMATION. If you only remember some of the meaning from a sentence, include that too. There is no time limit, so type as much as you can below."

Participants receiving the specific recall instructions completed two separate recall tasks that differed in terms of the information they were prompted to produce. For each recall task, the specific recall instructions participants received were the same as above, however the text "SEVERE WEATHER FORMATION" was replaced with either "LIGHTNING FORMATION" or "TORNADO FORMATION". For the first recall task, participants were first instructed to recall as much as they could about the nonfocused topic. After participants signaled to the experimenter that they had produced as much content as they could for the nonfocused topic, participants were then instructed to complete the second recall task, recalling as much as they could about the focused topic. Upon completion of the recall tasks, participants were debriefed and excused from the laboratory.

Coding recalls. Recalls were coded by the experimenter according to the protocol used in Experiment 2. As a reliability measure, 25% of the recalls were randomly selected to be coded in common between the experimenter and a trained coder who was blind to the experimental hypotheses. For the in-common recalls, agreement was reliably high ($\alpha = .83$) between the experimenter and the trained coder.

Results

Fixation time measures. Participants' eye-movements were measured as the duration of fixations made on sentences during comprehension. Additionally, eye-movements were classified as one of three types of fixations: *first-pass fixations* (fixations that landed on unread regions of a sentence for the first time), *first-pass reinspections* (fixations that landed on a previously read segment of the sentence they were currently reading), and *look-backs* (fixations that landed on a previously read sentence then the one they were currently reading; c.f., Hyönä, Lorch, & Rinck, 2003; Kaakinen & Hyönä, 2005; 2008). Fixations across these three categories were also summed to create a *total fixation duration* category. Fixation durations (in ms) for each sentence were calculated by dividing the participants' raw sentence fixation durations by the number of characters contained within the sentence. Fixation durations greater than 3 standard deviations above the mean for each participant were removed, resulting in a loss of 1.33% of the data.

For the data analysis, each sentence was defined in terms of the topic of the prereading instructions that participants received, and if the sentence was a relevant sentence targeted by the instruction, or a seductive detail. For example, the sentence: "Meteorologists define lightning as the atmospheric discharge of electricity resulting from the difference in electrical charges between the cloud and the ground," would be classified as a focused-targeted sentence for a reader instructed to focus on lightning content, due to the fact that the sentence was specifically targeted by the prereading instructions. For a participant instructed to focus on tornado content, the same sentence would be identified as a nonfocused-targeted sentence.

Thus, for each fixation time measure, the data were analyzed using a 2 (Topic: Focused vs. Nonfocused) X 2 (Sentence Type: Targeted Sentences vs. Seductive Detail Sentences) within-participant, repeated-measures ANOVA.

Table 6: ***Mean Total Fixation Durations by Sentence Type and Topic***

	Focused Topic		Nonfocused Topic	
Sentence type	*M*	*SD*	*M*	*SD*
Targeted	39.87	*11.02*	36.91	*9.02*
Seductive detail	36.40	*8.10*	36.53	*8.65*

A significant interaction between Topic and Sentence Type was obtained for *total fixation duration*, ($F(1,95) = 10.04$, $MSe = 22.89$, $p = .002$, $\eta^2 = .10$), with total duration varying as a result of both the focused topic and the type of sentence, as shown in Table 6. The interaction was driven by the fact that participants slowed down on focused-targeted sentences as compared to nonfocused-targeted sentences (a 2.96 ms difference, $F(1,95) = 15.95$, $MSe = 26.31$, $p < .001$, $\eta^2 = .14$), focused seductive details (a 3.47 ms difference, $F(1,95) = 12.82$, $MSe = 45.10$, $p = .001$, $\eta^2 = .12$), and nonfocused seductive details (a 3.33 ms difference, $F(1,95) = 14.32$, $MSe = 37.26$, $p < .001$, $\eta^2 = .13$). No other sentence comparisons were significant (all *F*s < 1). Additionally, a main effect for Topic was observed, ($F(1,95) = 8.22$, $MSe = 23.21$, $p = .002$, $\eta^2 = .08$) with participants allocating more attention to the focused topic ($M = 38.13$, $SD = 8.43$) as compared to nonfocused topic ($M = 36.73$, $SD = 8.36$). Finally, a main effect for Sentence was also observed, ($F(1,95) = 9.19$, $MSe = 38.66$, $p = .003$, $\eta^2 = .09$), with participants allocating more total attention to targeted sentences (*M* = 38.39, *SD* = 9.40) as compared to seductive details (*M* = 36.46, *SD* = 7.77).

Table 7: ***Mean First-pass Fixation Durations by Sentence Type and Topic***

	Focused Topic		Nonfocused Topic	
Sentence type	*M*	*SD*	*M*	*SD*
Targeted	27.27	*6.15*	27.35	*5.48*
Seductive detail	27.20	*5.73*	27.24	*5.88*

No main effects or interactions were obtained for *first-pass fixation duration* (all *Fs* < 1), as shown in Table 7. This suggests that the attentional differences observed in the total fixation durations were not driven by first-pass fixations, but by other types of fixations.

Table 8: ***Mean First-pass Reinspection Durations by Sentence Type and Topic***

	Focused Topic		Nonfocused Topic	
Sentence type	*M*	*SD*	*M*	*SD*
Targeted	8.22	*5.34*	7.09	*4.19*
Seductive detail	7.43	*4.04*	7.55	*4.45*

As shown in Table 8, a significant interaction was obtained between Topic and Sentence Type for *first-pass reinspection duration*, ($F(1,95) = 4.83$, $MSe = 7.72$, $p = .03$, $\eta^2 = .05$), with reinspections varying as a result of both the focused topic and the type of sentence. The interaction was driven by the fact that participants demonstrated slower reinspections for focused-targeted sentences as compared to nonfocused-targeted sentences (a 1.13 ms difference, $F(1,95) = 6.94$, $MSe = 8.80$, $p = .01$, $\eta^2 = .07$). No other sentence comparisons were significant (all *F*s < 1). Additionally, a marginal main effect for Topic was observed, ($F(1,95) = 3.36$, $MSe = 7.29$, $p = .07$, $\eta^2 = .03$) with participants demonstrating slightly slower reinspections for the focused topic ($M = 7.82$, $SD = 4.04$) than the nonfocused topic ($M = 7.32$, $SD = 3.99$). No main effect for Sentence was observed ($F < 1$).

Table 9: ***Mean Look-back Durations by Sentence Type and Topic***

	Focused Topic		Nonfocused Topic	
Sentence type	*M*	*SD*	*M*	*SD*
Targeted	2.88	*4.14*	1.35	*2.30*
Seductive detail	1.45	*2.32*	1.16	*2.26*

Finally, as shown in Table 9, a significant interaction between Topic and Sentence Type was also obtained for *look-back duration* ($F(1,95) = 7.43$, $MSe = 4.94$, $p = .008$, $\eta^2 = .07$), with look-back durations varying as a result of both the focused topic and the type of sentence. The interaction was driven by the fact that participants spent longer looking back to focused-targeted sentences as compared to nonfocused-targeted sentences (a 1.53 ms difference, $F(1,95) = 13.04$, $MSe = 8.65$, $p < .001$, $\eta^2 = .12$), focused, seductive details (a 1.43 ms difference, $F(1,95) = 14.89$, $MSe = 6.59$, $p < .001$, $\eta^2 = .14$), and nonfocused, seductive details (a 1.73 ms difference, $F(1,95) = 22.92$, $MSe = 6.24$, $p < .001$, $\eta^2 = .19$). No other sentence comparisons were significant (all *F*s < 2.5). Additionally, a main effect for Topic was observed, ($F(1,95) = 13.94$, $MSe = 5.76$, $p <$

.001, $\eta^2 = .13$) with participants allocating more attention to the focused topic (*M* = 2.17, *SD* = 2.82) as compared to the nonfocused topic (*M* = 1.26, *SD* = 1.97). Finally, a main effect for Sentence was also observed, ($F(1,95) = 14.62$, *MSe* = 4.32, $p < .001$, $\eta^2 = .13$), with participants allocating more total attention to targeted sentences (*M* = 2.12, *SD* = 2.63) as compared to seductive details (*M* = 1.31, *SD* = 2.06).

Effects of working memory on fixation durations. Two separate additional analyses were conducted on fixations for Experiment 3 to determine the potential effects of Working Memory Capacity (WMC), as measured by a Reading Span test (RSPAN) on participants' fixations during comprehension of the text. All participants averaged 85% or greater on the sentence judgment task, and across all participants absolute RSPAN scores ranged from 6 - 75 (*M* = 44.15, *SD* = 16.07). Two separate analyses on participants' fixation durations (*total duration*, *first-pass forward duration*, *first-pass reinspection duration, and look-back duration*) were conducted using the obtained RSPAN scores.

The first WMC analysis used a median split of the RSPAN scores (*Mdn* = 45.50), with participants below the median categorized as the low WMC group (N = 48) and participants above the median categorized as the high WMC group (N = 48). All participants were thus included in the WMC median-split analysis. The median WMC recall analysis was conducted using a 2 (Topic: Focused vs. Nonfocused, repeated within-participants) X 2 (Sentence Type: Targeted vs. Seductive Details, repeated-within participants) X 2 (WMC Median Score: High or Low, between-participants) mixed-measures ANOVA. No unique interactions involving WMC score were obtained for any fixation duration types (all *F*s < 2) using the median-split WMC analysis.

The second WMC analysis utilized a quartile designation of participants' RSPAN score and involved 51 of the 96 total participants. The 25th quartile contained all participants with RSPAN scores equal to or less than 32.50 (N = 24). The 75th quartile contained all participants with RSPAN scores equal to or greater than 56.00 (N = 27). The remaining 45 participants were excluded from the quartile WMC analysis. The quartile WMC analysis was conducted using a 2 (Topic: Focused vs. Nonfocused, repeated within-participants) X 2 (Sentence Type: Targeted vs. Seductive Details, repeated-within participants) X 2 (WMC Quartile Score: High or Low, between-participants) mixed-measures ANOVA. As with the median WMC analysis, no unique interactions involving WMC were obtained for any fixation duration types (all *F*s < 2) using the quartile-split analysis.

Recalls. Raw recall scores were converted into proportions for ease of comparison between conditions, as described in Experiment 2. Proportions were then analyzed using a 2 (Topic: Focused or Nonfocused) X 2 (Sentence Type: Targeted Sentences, Seductive Detail Sentences) within-participant, repeated-measures ANOVA.

Table 10: ***Overall Recall Proportions by Sentence Type and Topic.***

	Focused Topic		Nonfocused Topic	
Sentence type	*M*	*SD*	*M*	*SD*
Targeted	.18	*.13*	.13	*.10*
Seductive detail	.18	*.17*	.19	*.16*

As shown in Table 10 on page 67, an interaction between Topic and Sentence Type was obtained (F(1,95) = 8.32, , MSe = .01, p < .01, η^2 = .08), with participants' recalls varying as a result of both the focused topic and the type of sentence. Planned contrasts revealed that participants did not differ in the amount of seductive details they recalled for focused (M = .18, SD = .17) and nonfocused topics (M = .19, SD = .16; F < 1). However, participants did demonstrate superior recall for the targeted sentences for the focused topic (M = .18, SD = .13) as compared to the nonfocused topic (M = .13, SD = .10, F(1,95) = 15.72, MSe = .15, p = .001, η^2 = .14). Additionally, compared to the nonfocused-targeted sentences, participants recalled a higher proportion of both focused (a .06 difference, F(1,95) = 8.63, MSe = .02, p < .05, η^2 = .09) and nonfocused seductive details (a .06 difference, F(1,95) = 11.88, MSe = .02, p < .01, η^2 = .11). However, there was no observed difference in participants' recall of focused and nonfocused seductive details when compared with focused-targeted sentences (all Fs < 1).

A main effect for Topic was also observed, (F(1,95) = 6.124, MSe = .01, p = .01, η^2 = .06), with the finding that participants recalled more of the focused topic (M = .18, SD = .11) as compared to the nonfocused topic (M = .16, SD = .09). A main effect for Sentence Type was also observed, F(1,95) = 3.98, MSe = .03, p < .05, η^2 = .04, as participants recalled a higher proportion of seductive details (M = .19, SD = .14) as compared to targeted sentences (M = .15, SD = .09).

Table 11: ***Recall Proportions by Working Memory Capacity and Sentence Type.***

		Target sentences		Seductive detail sentences	
	n	*M*	*SD*	*M*	*SD*
Working memory by quartile					
HWMC participants	27	.18	*.13*	.13	*.10*
LWMC participants	24	.18	*.17*	.19	*.16*
Working memory by median					
HWMC participants	48	.13	*.08*	.21	*.13*
LWMC participants	48	.16	*.09*	.14	*.12*

Effects of working memory on recalls. Two separate analyses were also conducted on recalls for Experiment 3 to determine the potential effects of WMC on participants' recall of the text, as shown in Table 11. These analyses also used the median split and quartile split analyses described earlier. The first analysis used a median WMC split recall analysis, conducted using a 2 (Topic: Focused vs. Nonfocused, repeated within-participants) X 2 (Sentence Type: Targeted vs. Seductive Details, repeated-within participants) X 2 (WMC Median Score: High or Low, between-participants) mixed-measures ANOVA. No additional unique interactions were observed using a WMC median split (all Fs < 1).

The second WMC recall analysis utilized the quartile designation of participants' WMC scores, and involved a 2 (Topic: Focused vs. Nonfocused, repeated within-participants) X 2 (Sentence Type: Targeted vs. Seductive Details, repeated-within participants) X 2 (WMC Quartile Score: High vs. Low, between-participants) mixed-measures ANOVA. A unique and significant interaction between Sentence and Quartile

Score was obtained ($F(1,49) = 6.53$, $MSe = .02$, $p = .01$, $\eta^2 = .12$). This interaction was driven by the observation that high RSPAN participants recalled significantly more seductive detail content ($M = .21$, $SD = .13$) as compared to low RSPAN participants ($M = .14$, $SD = .12$; $F(1,50) = 3.84$, $MSe = .02$, $p = .05$, $\eta^2 = .07$). Participants did not differ in their recall of targeted sentences ($F < 1.5$). No other unique interactions were obtained (all *F*s < 2).

Effects of general and specific recall instructions. Of particular interest to this experiment was the question of how the production of targeted information and seductive details might differ, based on the type of recall instructions participants received after comprehending the text. To investigate this question, additional planned comparisons were conducted using a 2 (Sentence Type: Targeted vs. Seductive Details) X 2 (Recall Instruction: General vs. Specific) multivariate ANOVA.

Table 12: ***Recall Proportions by Recall Instruction Condition, Sentence Type, and Topic***

	Focused Topic		Nonfocused Topic	
Condition	*M*	*SD*	*M*	*SD*
General recall instructions				
Targeted	.18	*.13*	.14	*.11*
Seductive detail	.22	*.16*	.20	*.14*
Specific recall instructions				
Targeted	.18	*.14*	.12	*.09*
Seductive detail	.14	*.17*	.17	*.17*

As shown in Table 12 on page 70, no difference was observed between targeted sentences and recall instructions ($F < 1$). However, participants that received a general recall instruction recalled significantly more seductive details ($M = .21$, $SD = .12$) as compared to participants receiving specific recall instructions ($M = .16$, $SD = .16$, $F(1,95) = 3.78$, $MSe = .01$, $p = .05$, $\eta^2 = .04$). Recalls for each sentence type were also compared within-participants for each recall instruction condition using a paired samples t-test. For participants receiving the general recall instructions, focused-targeted sentences ($M = .18$, $SD = .13$) were better recalled compared to nonfocused-targeted sentences ($M = .14$, $SD =.11$; $t(48) = 2.26$, $p = .03$). In addition, recall proportions were also significantly higher for seductive details in both the targeted topic ($M = .22$, $SD = .16$; $t(48) = 3.21$, $p = .002$) as well as the non-targeted topic ($M = .21$, $SD = .14$; $t(48) = 2.88$, $p = .006$) when compared to the nonfocused-targeted sentences. No other sentence comparisons were significant for free recall participants (all *t*s < 1.6).

Similarly, paired sample t-tests were also conducted on sentence recalls for participants receiving specific recall instructions. As a reminder, participants were always instructed to recall the nonfocused topic first, followed by the focused topic. As with general recall participants, specific recall participants demonstrated higher recall rates for focused-targeted sentences ($M = .18$, $SD = .14$) compared to nonfocused-targeted sentences ($M = .12$, $SD = .09$; $t(46) = 3.38$, $p = .001$). In addition, targeted topic seductive details ($M = .17$, $SD = .17$) were better recalled compared to nonfocused-targeted sentences ($t(46) = 2.00$, $p = .05$). No other sentence comparisons were significant for cued recall participants (all *t*s < 1.6).

Discussion

The goal of Experiment 3 was to determine if prereading questions focused on important content would influence participants' online processes as measured by eye-tracking measures, and recall products as measured by recall tasks. In addition, the influence of general and specific recall instructions on participants' production of relevant content was also measured. Finally, the influence of WMC was also investigated as a potential influence on reading processes and product measures.

The results of the online measures suggest that readers who received prereading relevance instructions to focus on one topic within a multi-topic scientific text allocated additional attention to relevant content in the focused topic in the form of increased *total fixations*, *reinspections,* and *look-backs,* as compared to the nonfocused topic. However, readers' attention to seductive details did not differ between focused and nonfocused topics. In fact, readers' fixations for seductive details did not differ from their fixations to focused-targeted content, and were significantly longer in duration compared to their fixations to important but nonfocused content. These observations support the *encoding-seduction hypothesis*, which suggests that seductive details are irresistibly alluring to readers during comprehension, and attract attention regardless of prereading instructions designed to focus reading on important content.

The results of the recall measures suggested that while seductive details were generally well recalled overall, seductive details did not interfere with readers' ability to produce more important information for the topic focused on by prereading instructions, as compared to the nonfocused topic. In both the general and specific recall instruction conditions, readers recalled more important content for the focused topic as compared to the nonfocused topic. However, recalls for focused and nonfocused seductive details did not differ, aligning with the observations of the online measures. Importantly, readers demonstrated a significant reduction in the amount of seductive details they recalled after receiving specific recall instructions as compared to readers receiving general recall instructions. This observation provided partial support for the *specificity-enhanced hypothesis*, in that the specific recall instructions appeared to reduce the amount of seductive details readers recalled. Additionally, this effect did not result in a concomitant reduction in the amount of important information that was provided, as participants' recall of information did not differ between the recall instruction conditions.

Finally, WMC, as measured with the RSPAN, influenced readers' recall of seductive details. Specifically, HWMC readers recalled significantly more seductive details as compared to LWMC readers, although these groups did not differ in the amount of important information recalled. This result was somewhat contrary to previous research findings that high ability readers might potentially be less susceptible to the seductive details effect at recall (e.g., McCrudden & Corkill, 2010). The results were also somewhat contrary to those observed by Sanchez and Wiley (2006), who observed that HWMC readers recalled more important textual content when presented with seductive illustrations, as compared to non-seductive illustrations or controls. However, in the current experiment, HWMC readers did not recall significantly more important content compared to LWMC readers.

It is important to note that the current experiment used seductive text embedded within a larger scientific document, while Sanchez and Wiley (2006) used seductive illustrations. In addition, the current study also utilized prereading instructions as well as a recall instruction manipulation. It is possible that these experimental dissimilarities may have had an influence on the observational discrepancies between the two experiments. Future research will likely be necessary to fully determine if the presence of seductive text or illustrations, or the use of prereading or recall instructions, may influence higher and lower WMC readers' comprehension of scientific texts in different ways.

Chapter VIII: General Discussion

On a daily basis, an estimated 27 million students in the United States navigate the textual landscape of relevant and irrelevant information contained within their scientific textbooks (Weiss, Pasley, Smith, Banilower, & Heck, 2003). In order to succeed academically, these students will need to attend to relevant scientific information to create a coherent mental representation that can then be applied to their learning goals. In addition, students must also avoid the irrelevant information that is present in their textbooks (e.g., McCrudden & Schraw, 2007; Peshkam et al., 2011) – a task with which many students struggle (Rapp, van den Broek, McMaster, Kendeou, & Espin, 2007). Under best-case circumstances, the relevant information is then successfully accessed and applied later, perhaps on a test or essay, or even during conversations or other learning situations. Indeed, most theories of discourse comprehension support the notion that readers strive to create coherent mental representations for any given text (e.g., Kintsch, 1988, 1998; Rapp & van den Broek, 2005; Sparks & Rapp, 2010); representations that they apply later.

However, building coherent representations is not always easy and many texts are not structured to support readers' efforts to do so (e.g., O'Reilly & McNamara, 2007). In many instances, textual factors can even prevent readers' comprehension of a text, rather than foster the construction of coherent understandings. As an exemplar, a large body of previous research has demonstrated that irrelevant but interesting segments embedded within informational texts (i.e., seductive details) interfere with readers' ability to establish a coherent mental representation of an informational text (e.g., Harp & Mayer, 1997; Lehman et al., 2007). A crucial way in which seductive details damage comprehension involves increasing readers' attention to irrelevant content, at the cost of important content (Peshkam et al., 2011; Sanchez & Wiley, 2006). At recall, readers also produce less important content and have more difficulty on transfer and essay tasks (e.g., Harp & Mayer, 1998), indicating that seductive details can negatively impact the products of comprehension. These products, of course, often represent a student's only chance to demonstrate comprehension, such as on exams and essay assignments.

The goal of the current project was to examine how readers' online processes and offline products are impacted by seductive details, reading instructions, and working memory capacity during comprehension of a dual-topic informational text. The current project represents a substantial extension of the work on the seductive details effect for two reasons. First, the current project substantially measured the multiple factors that potentially drive the seductive details effect, including textual factors (i.e., the presence of seductive details) and situational factors (i.e., prereading and recall instructions), as well as individual differences (i.e., working memory capacity) in comprehension proclivities. These factors were selected according to theories of dynamic text comprehension (e.g., Rapp & van den Broek, 2005; Sparks & Rapp, 2010; van den Broek et al., 2005), which posit that factors that include but are not limited to the text and the reader can have important influences on the processes and products of reading (e.g., Rapp & Mensink, 2011). Secondly, the current project also examined how separate instructions influencing readers' processes and products might provide a beneficial reduction in the seductive details effect.

In Experiment 1, a dual-topic text on lightning and tornado formation was created that also contained seductive detail sentences. Importantly, the seductive details were identified not just on the design side of the project, but also based on participants' ratings of importance and interest in each sentence. Experiment 2 was designed to test whether the text would obtain the standard seductive details effect (e.g., Harp & Mayer, 1998). Participants that received the seductive details version of the text recalled significantly less important content as compared to participants receiving a control version of the text that omitted the details (e.g., Harp & Mayer, 1997; Lehman et al., 2007; Peshkam et al., 2011). These two experiments helped to validate the text as a useful means for examining the core questions in this dissertation.

It is worth noting that most projects that examine the seductive details effect do not engage in this level of norming and development to tune and test the validity of the employed materials; but given the goals of examining a potential intervention to reduce the ubiquitous seductive details effect, the first two experiments represent an important set of steps and procedures for moving forward in the project. In addition, previous studies have typically utilized single-topic texts, yet the design of Experiment 3 called for a dual-topic text. Thus, Experiments 1 and 2 provided important observations supporting the notion that the lightning and tornado topics of the scientific text on severe weather formation functioned similarly for readers in terms of importance, interest, and content produced at recall.

Experiment 3 investigated readers' moment-by-moment processing of and memory for the text, while also evaluating whether prereading and recall instructions might substantially reduce the seductive details effect. A head-mounted eye tracker was used to record participants' eye-movements as the material unfolded. Participants received prereading instructions focusing their attention toward one topic within the text (i.e., lighting or tornado content), and received either general or specific recall instructions after reading the text. In addition, participants' WMC was also measured in the form of a RSPAN test. A key observation from Experiment 3 was that participants demonstrated both a relevance effect as well as a seductive details effect: Focused information received longer fixation durations and was better recalled as compared to nonfocused information. Yet, regardless of focusing instructions, readers attended to seductive details equally during reading. In addition, participants produced more seductive details after a single general free recall task instruction as compared to two specific recall task instructions, with no concomitant difference in recall for important content. Finally, HWMC participants recalled significantly more seductive details as compared to LWMC participants.

The observed results provided mixed support for the experimental hypotheses. In terms of online processes, the *relevance-focusing* hypothesis predicted that readers would allocate increased attention to important content and less attention to seductive details in response to prereading instructions. Only partial evidence was obtained for this hypothesis, as readers demonstrated increased fixation durations for important, focused information, but did not differ in their fixation durations for seductive details for either the focused or nonfocused topic. This observation thus also provided partial support for the *relevance-seduction* hypothesis, which predicted that seductive details are irresistibly alluring to readers during comprehension; as prereading instructions focusing readers on important information did not reduce fixation durations for seductive details as compared to other content. However, although no decrease in fixation durations was obtained for seductive details, it should be noted that participants did spend more time reading information that was designated as important by the prereading instructions.

In terms of offline products, the *specificity-enhanced hypothesis* predicted that specific recall instructions would provide readers with improved guidance for identifying relevant information from the text (e.g., McCrudden et al., 2005, 2006; Pitchert & Anderson, 1978), resulting in an increase in the production of important content and a decrease in the production of seductive content. Partial support for this hypothesis was obtained, with readers producing less seductive content in response to specific recall instructions as compared to general free recall instructions. However, the decrease in the production of seductive details for specific recall participants was not realized with a concomitant increase in the production of important content. So while recall instructions were influential in reducing the production of the seductive details effect, there was little in the way of enhancements to learning of core, important content.

Finally, it was predicted that HWMC readers might be inoculated against the seductive details effect as compared to LWMC readers. However, in terms of online processes, no differences were observed between HWMC and LWMC readers for fixation durations on important content and seductive details. Yet, in terms of offline products, HWMC readers did produce significantly more seductive details at recall as compared to LWMC readers. But despite these observations, no effects emerged as a function of WMC on recall for important information. These results provide additional evidence as to how seductive details differentially influence encoding and recall: Readers' recall of seductive details was impacted both when they received more specific recall instructions for each topic, and also as a function of individual differences in their WMC.

This experiment had three goals served by these findings. The first goal was to investigate the seductive details effect from the theoretical perspective of dynamic text comprehension. This perspective informed an experimental exploration that utilized prereading instructions developed to influence readers' online processes during comprehension as well as general and specific recall instructions developed to influence their memory products for the text. In addition, the influence of individual reader factors, in the form of WMC, and textual elements, in the form of seductive details and a dual-topic text, were also considered by the current experiment. Evidence was found to support the perspective that seductive details may cause a dual detriment to readers, drawing additional attention during comprehension and also functioning as highly recallable factoids at retrieval. However, these effects were constrained in important ways, both by the type of recall instructions provided to readers (i.e., general or specific) as well as by readers' individual characteristics (i.e., WMC), thus suggesting a more dynamic process than envisioned by previous research.

The second goal of the experiment was specifically related to this issue, and considered the influence of recall instructions on readers' production of relevant and seductive content. Specific recall instructions reduced the amount of seductive details produced as compared to general free recalls. This observation suggests that, in instances in which readers are given additional and specific recall instructions, their production of seductive content is reduced. It is also important to note that the offline products for participants receiving specific recall instructions stood somewhat in contrast to their online processes, in that seductive details received greater fixation durations yet were produced at low rates.

The third and final goal of the experiment was to examine whether prereading instructions that focused on important content might potentially alleviate the seductive details effect. Previous experiments utilizing prereading instructions that focused readers on seductive details (e.g., general instructions warning readers about seductive details) only resulted in a decrease in the amount of seductive content recalled, as opposed to an increase in the amount of important information produced (Peshkam et al., 2011), while attention to seductive details remained generally unchanged. The results obtained by this experiment extend those of Peshkam et al., in that specific prereading instructions focused on important content also did not significantly increase the recall of important information as compared to seductive details. Likewise, recall instructions only served to reduce the amount of seductive content produced; no change was observed in the amount of important content produced as compared to free recalls.

The current experiment demonstrates that seductive details influence both readers' online processes and offline products, potentially in different ways. Thus, interventions should potentially seek to influence both features in order to provide the most benefit for reducing the seductive details effect. Yet, these observations are constrained by three vital limitations. First, although significantly fewer seductive details were produced at recall following specific recall instructions, the types of processes that were potentially engaged in during retrieval remain unclear. Encoding and retrieval are not necessarily separate, linearly paced processes of knowledge acquisition and application, but are potentially active both during comprehension and at subsequent attempts to access the resulting mental representation (e.g., Hintzman, 2011).

This view of basic memory processes also aligns with those of dynamic views of text comprehension (e.g., Rapp & van den Broek, 2005), whereby the tasks asked of readers during comprehension can potentially influence how readers' access their memory products for a text. Depending on the type of tasks or instructions given to readers, it may be the case that the products produced (e.g., tests, essays, etc.) align with their online processes, or diverge in unanticipated ways (e.g., Rapp & Mensink, 2011). For example, a reader may not demonstrate reading slow-downs for seductive details, yet still produce a large amount of seductive content at recall. In such instances, specific instructions at recall might be more useful for reducing the production of irrelevant information, rather than instructing readers to avoid such elements during reading.

A second limitation of this research also relates to this issue, in that the differences observed between specific and general recall instructions were only tested using a metric based on the amount of content produced. This metric might not necessarily accurately reflect differences in readers' ability to utilize their knowledge of the text in different contexts or after a delay. For example, although previous experiments have demonstrated that seductive details impair readers' abilities to construct arguments or holistic essays (e.g., Lehman et al., 2007; Sanchez & Wiley, 2006), the utility of prereading focusing instructions on a similar application task after a delay has yet to be investigated. The use of prereading questions, and their subsequent additional inclusion on a posttest, could potentially elicit a *testing effect* for participants, whereby the test serves as retrieval practice for important information from the text (e.g., Karpicke & Blunt, 2011; Karpicke & Roediger, 2007, 2008; Karpicke & Zaromb, 2010; Roediger & Karpicke, 2006). Importantly for the testing effect, such results are typically long lasting, in that improved recall for tested content persists after a lengthy delay. Future research might potentially investigate whether the memory benefits obtained by retrieval practice might outweigh the potential problems associated with the seductive details effect.

Finally, a third limitation of these research findings is due in part to the difficulties in ensuring equity between stimuli versions and experimental conditions. For example, participants that received the control text packet in Experiment 2 read a shorter passage compared to participants who received the seductive details version. Although this norming method has been widely used in the research literature (Harp & Mayer, 1997, 1998; Lehman et al., 2007; Peshkam et al., 2011), future research should ensure a full equating of control and seductive details text versions for length. In addition, the recall conditions for Experiment 3 were not equivalent: Participants in the specific instruction condition completed two separate recalls (albeit on the separate topics of the text) while participants in the general recall condition completed only one. While the fact that participants did not differ between conditions in the amount of relevant information they produced may allay this concern somewhat, future research should also investigate how time on task or the number of recall prompts readers receive might influence the content of what readers produce from a seductive text.

Implications. The main findings from this experiment support the notion that seductive details are not only irresistibly alluring to readers during comprehension, but are also a potential distraction at recall as well. Although prereading instructions do not appear to be effective in reducing the amount of attention readers allocate to seductive details, recall instructions can potentially decrease the amount of seductive information produced at recall. In addition, a high WMC potentially enables readers to recall additional seductive content, with no concomitant reduction in memory for important content.

The theoretical implications of these findings support a view of dynamic text comprehension, whereby the cognitive processes that are potentially engaged by readers during reading and at recall are also influenced by reader characteristics and, more importantly, by the task that is required of them. Thus, readers might strategically alter their processes due in part to the task instructions given to them by experimenters, teachers, or authors of learning materials. Importantly, task instructions can also influence readers at different points during the comprehension process. For example, instructions might be given to readers prior to comprehension with the intention of influencing online processes, after comprehension with the intention of influencing how readers access and produce content, or, as in the current experiment, prereading and recall instructions might both be used to further increase their beneficial effects.

Additionally, the results of the current experiment also suggest that working memory capacity constrains the ways in which readers produce seductive content from memory, an important contribution to the existing literature on individual differences and seductive details (e.g., McCrudden & Corkill, 2010; Sanchez & Wiley, 2006). While

HWMC readers ultimately produced more seductive content compared to LWMC readers, no differences between the groups were observed in regards to online effects due to prereading instructions or important information produced at recall. Several explanations exist for this observation. The first is that seductive details function differently for high and low WMC readers at recall, and are more accessible for HWMC readers. Another potential explanation is that the prereading instructions mitigated the potential differences between the two groups during comprehension, resulting in an equal amount of important content produced. Future experiments utilizing more sensitive measures of cognitive processes such as think-aloud paradigms will likely be necessary in order to understand the potential interactions between WMC, relevance instructions, and the seductive details effect.

The findings from this experiment also have important theoretical implications beyond the seductive details literature. Within educational situations, readers must identify and attend to information that is vital for their learning goals while simultaneously identifying and avoiding irrelevant information (e.g., McCrudden & Schraw, 2007). As this project and others have observed, readers have great difficulty in decreasing their attention to highly interesting yet ultimately irrelevant information in texts (e.g., Harp & Mayer, 1998; Lehman et al., 2007; Peshkam et al., 2011). Further understanding of the basic cognitive processes involved in how readers strategically allocate their attention efforts toward relevant information (and away from irrelevant information) can potentially serve to improve learning outcomes for the more complex tasks students are often required to perform with scientific texts.

In the current experiment, readers were only required to perform a relatively simple recall task after reading a single, dual-topic scientific text. Yet, in classroom contexts, students are typically called upon to perform much more cognitively complex activities with texts, like integrating and applying information across multiple documents (Britt, Perfetti, Sandak, & Rouet, 1999; Strømsø, Bråten, & Salmerón, 2011; Rouet, 2006; Rouet & Britt, 2011), critically evaluating sources of scientific information (e.g., Driver, Newton, & Osborne, 2000; Wiley, Goldman, Graesser, Sanchez, Ash, & Hemmerich, 2009), or understanding and producing complex scientific arguments (e.g., Goldman, 2011; Larson, Britt, & Kurby, 2009). Importantly, the basic cognitive processes students must utilize in these tasks are essentially the same: They must select information that is relevant for the task at hand while avoiding irrelevant information both during reading as well as at recall and performance. While not all irrelevant information is seductive, the current experiment provides one attempt at measuring the cognitive processes that underlie how readers select and sort relevant and irrelevant scientific information during comprehension and at recall.

Finally, this project also offers some practical implications as to how the seductive details effect might be reduced in classroom situations. In circumstances in which instructors are unable to eliminate seductive details from texts, general warnings to avoid irrelevant information (e.g., Peshkam et al., 2011) or specific recall instructions such as those used in this experiment appear to be useful in reducing readers' production of seductive information. In addition, specific prereading instructions focused on important information might also have provided a benefit to readers attempting to learn relevant content. Although readers did not reduce the attention they allocated to seductive details during comprehension, attention did increase for focused content, which may be one necessary aspect in reducing the seductive details effect.

Future directions. The observations of the current project, in addition to the large body of previous research, should leave little doubt that seductive details impede readers' ability to learn from scientific texts (e.g., Harp & Mayer, 1997, 1998; Lehman et al., 2007; McCrudden & Corkill, 2010; Peshkam et al., 2011; Sanchez & Wiley, 2006). However, while the seductive details effect had been previously well documented in the research literature, questions remained in regards to the basic cognitive processes involved. The current project represents an initial attempt to answer the question of how seductive details influence cognitive processes during reading and at recall. In terms of the cognitive processes that were active during reading, readers allocated additional attention to important content in the text in response to specific prereading instructions. Thus, it did not appear to be the case that seductive details interfered with readers' ability to follow relevance instructions. Yet, seductive details remained irresistibly alluring to readers, as prereading instructions did not decrease attention to the seductive details themselves. In order to address this issue, future research will likely require the use of a control text version that lacks seductive details to determine how the presence (or absence) of seductive details might interact with prereading instructions to influence readers' attention to and recall of important information.

In terms of recall products, seductive details appeared easy for readers to recall as compared to other content, at least when readers were allowed to perform a general free recall. However, specific recall instructions significantly reduced the amount of seductive content produced, which would suggest that readers might be able to strategically alter their recall strategies in response to the instructions provided. Future research on the types of differential processing that readers' engage in depending on the type of recall instruction or cue provided would likely provide insight into this effect.

In addition, considering their potential prevalence in educational materials, the question of how to mitigate the seductive details effect is of great importance for educational applications. Textual alterations have been the most commonly explored (Harp & Mayer, 1998) and one under-examined possibility involves consideration of the role textual coherence may play in the seductive details effect (e.g., Lehman et al., 2007). While the current experiment did not control for textual coherence, the observation that HWMC readers produced more seductive content then LWMC readers would suggest that they may have been better able to deal with the coherence breaks that the seductive details caused during comprehension (e.g., Park, et al., 2011; Sanchez & Wiley, 2006). Thus, future investigations might examine how high or low coherence texts that also contain seductive details are understood by readers of different abilities (i.e., prior knowledge or WMC).

Aside from substantial alteration of textual content, few studies have found ways to significantly mitigate the seductive details effect (although, see Peshkam et al., 2011). Indeed, along with the results obtained with the current experiment, it would appear that while focusing instructions are useful for increasing attention to and recall of important information (i.e., a relevance effect; e.g., McCrudden et al., 2010; McCrudden & Schraw, 2007; Kaakinen & Hyönä, 2008;), they do not appear to simultaneously decrease readers' attention to and recall of seductive details. However, future investigations might consider methods of reducing the seductive details effect by carefully considering other well-known effects in cognitive science, as the current project did here with respect to prereading insturctions. For example, retrieval practice (e.g., Karpicke, 2009; Hinze & Wiley, 2011) might potentially prove to be a better way to actually reduce the seductive details effect. There is a vast literature on the benefits to learning that occur when students perform practice tests that require them to retrieve specific information (for reviews, see Pashler, Rohrer, Cepeda, & Carpenter, 2007; Rawson & Dunlosky, 2011; Roediger & Karpicke, 2006). These observations might potentially be leveraged in a future examination of the seductive details effect to determine if retrieval practice would prove a more effective intervention for reducing the seductive details effect.

Although the question of how to mitigate the seductive details effect is an important one, it also begs the question of precisely how common seductive details might be in educational materials that are actually used in classrooms. While seductive details have been investigated across multiple forms of learning materials such as multimedia (e.g., Deimann & Keller, 2006; Mayer et al., 2001, 2003), text (e.g., Harp & Mayer, 1998; Lehman et al., 2007; Peshkam et al., 2011), illustrated materials (e.g., Sanchez & Wiley, 2006) and lectures (e.g., Harp & Maslich, 2005); to date little to no research has been conducted to examine the prevalence of seductive details in educational, non-experimental materials found in classrooms, libraries, and popular press articles.

The lack of research stems from two issues involving seductive details that are difficult to resolve experimentally. First, seductive details are a complex phenomenon to correctly categorize, in that they must be identified and separated from other content in terms of importance as well as interest. Experimental studies, including the current dissertation, have addressed this issue by having readers' rate sentences both for interest and importance. The labor involved in simply norming an experimental text directly relates to the second issue: Although such rating methodologies work for a single experimental text, it would be impractical (and highly subjective) to have coders comb through a large corpus and rate the interest and importance of the instructional content.

One approach, beyond such an inefficient and laborious examination of informational text corpora (e.g., physics or chemistry textbooks), might involve applying Latent Semantic Analysis (Landauer, Foltz, & Laham, 1998) to automatically analyze a large electronic sample of textbook passages and identify potential seductive details. This suggested approach is based on previous research findings demonstrating that seductive details are likely to be emotionally interesting (e.g., Harp & Mayer, 1997) while also breaking the coherence of passages (e.g., Lehman et al., 2007). In an LSA analysis, each sentence from a given textbook chapter could be first evaluated for semantic overlap to a corpus of words rated for emotionality, interestingness, or valence (e.g., death, killed, sex etc.). Sentences identified in the first pass could then potentially be compared in terms of coherence to the larger text (e.g., Foltz, Kintsch, & Landauer, 1998). Thus, the identification of sentences likely to be seductive details in a large number of texts could potentially be performed automatically according to a strict criterion, without the need for importance and interest ratings from participants.

An investigation similar to this one might determine that seductive details are fairly prominent in commonly used learning materials, thus necessitating a wide variety of additional research and interventions. Such interventions could potentially work to design (and redesign) textual materials that accommodate reader characteristics while also increasing the coherence of writing in scientific texts (e.g., McNamara et al., 1996;

McNamara & Kintsch, 1996), or design useful prereading or postreading instructions to be used with existing content (e.g., Peshkam, et al., 2011). However, it might also be the case that seductive details are actually rare in well-designed learning materials, suggesting that the seductive details effect might simply be an experimental artifact that arises from the intentionally developed stimuli utilized by researchers in the laboratory.

Conclusions. The current experiment investigated how seductive details influence the processes and products of comprehension at both encoding and retrieval. These multi-method investigations are of vital interest for both general cognitive models of discourse processes as well as educational practice. The research literature on discourse comprehension and memory contains a substantial amount of evidence as to how readers comprehend and remember texts, including expository and narrative materials. Importantly, the specific genre of scientific text plays a vital role in educational success, as readers must learn to successfully comprehend complex scientific content for success in later academic and societal endeavors (Goldman & Bisanz, 2002).

Yet, while other genres have been well explored, the basic cognitive processes that are involved in comprehending scientific texts remain generally under-examined (van den Broek, 2010). This lack of research is one reason a comprehensive theory of scientific text comprehension has yet to be fully realized by discourse researchers. However, as demonstrated by the current experiment, any comprehensive theory of scientific text comprehension must necessarily account for the processes and products involved when readers comprehend both relevant information that is useful for application to their learning goals, as well as irrelevant information that can damage their understanding of important scientific concepts.

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Appendix A: ***Prereading and Seductive Detail Questions***

Lightning prereading and test questions

1. What is the meteorological definition of lightning?
2. How does ice inside a cloud assist lightning formation?
3. How does the movement of updrafts and downdrafts create a lightning strike?
4. What causes lightning to become visible?
5. What produces the sound wave we call thunder?
6. How does a lightning strike typically form?

Tornado prereading and test questions

1. What is the meteorological definition of a tornado?
2. How do scientists believe tornadoes begin their formation?
3. How long can the mature stage of a tornado last?
4. How does warm, moist air influence a tornado?
5. Why is a tornado still dangerous during the dissipating stage?
6. How do tornadoes typically form?

Lightning seductive detail test questions

1. Approximately how many Americans are killed and injured by lightning each year?
2. What once occurred in a dimly lit church in England?
3. Why did scientists create a specially developed plane in the early 1980s?
4. What purpose do nose-cones serve for modern commercial airplanes?
5. What happened to a nineteen-year-old from Texas in 2000?
6. What did witnesses in Maryland see happen while watching a football practice?

Tornado seductive detail test questions

1. Approximately how many Americans are killed and injured by tornadoes each year?
2. How have individuals been killed by tornadoes?
3. What did filmmaker Sean Casey create in 2006?
4. What was the purpose of Sean Casey's 2006 creation?
5. What happened to Matt Suter of rural Missouri in 2006?
6. In rare cases, how wide can a tornado become?

Appendix B: *Severe Weather Formation Text with Lightning Seductive Details Italicized and Tornado Seductive Details in Bold*

Severe Weather Formation

Dangerous weather phenomena are common to the Midwest, especially in summer months. Lightning strikes and tornadoes are two of the more common dangers that develop from summer storms. Although both lightning strikes and tornadoes can accompany severe thunderstorms, they develop differently and have different outcomes. Due to these differences, individuals living in the Midwest need to be familiar with how lightning and tornadoes develop in order to remain safe during storms.

Meteorologists define a tornado as a violently rotating column of air that is often (but not always) visible as a funnel cloud. **Understanding how tornadoes are formed is important because approximately 70 Americans are killed and 1500 injured by tornadoes yearly.** Most deaths and injuries in tornadoes result from individuals being struck by flying debris or rolled across the ground by the high winds. **Individuals have also been killed by being carried aloft by tornadoes and then dropped from a great height.** For a vortex to be classified as a tornado, it must be in contact with both the ground and the cloud.

Meteorologists define lightning as the atmospheric discharge of electricity resulting from the difference in electrical charges between the cloud and the ground. *Understanding how lightning forms is also important; approximately 80 Americans are killed and 300 injured by lightning every year.* Lightning strikes occur in other forms, including cloud-to-cloud and cloud-to-air, and are accompanied by loud sonic shock waves known as thunder. Ball lightning usually occurs after a cloud-to-ground flash, appearing as a glowing, fiery ball that floats for several seconds before disappearing. *Once, an 8' ball of lightning struck into a dimly lit church in England and burned off the back of a man's head.*

How lightning initially forms is still a matter of debate, and scientists continue to study the root causes ranging from atmospheric perturbations such as wind, humidity, friction, and atmospheric pressure. *In the early 1980s, scientists created a specially developed plane that was flown through thunderstorms in order to better understand how lightning strikes aircraft. Lightning does strike modern commercial airplanes, but this rarely causes damage as airplane nose-cones are built to diffuse lightning strikes.* In addition, ice inside a cloud is thought to be a key element in lightning development, and may cause a forcible separation of positive and negative charges within the cloud, thus assisting lightning formation.

Scientific uncertainty also exists about how tornadoes form, as there are many types of tornadoes, and each type can have different methods of formation. Scientists must make use of ingenious technologies to study tornadoes. **In 2006, filmmaker Sean Casey created the Tornado Intercept Vehicle out of an armored 1997 Ford F-450 diesel pickup that weighed over 17,000 pounds. The vehicle contained numerous meteorological instruments and was designed to be driven directly into a tornado's most destructive zone.** One deployable technology used by scientists is called the TOTO (the TOtable Tornado Observatory), which may help solve the many questions that still plague meteorologists about how tornadoes form.

Inside the cloud, most scientists believe that it is the movement of the updrafts and the downdrafts that cause electrical charges to build and create a lightning strike. Hailstones form as rising and falling air currents within the cloud carry water droplets back up to the cold upper atmosphere. The hailstones in the downdraft then collide with water droplets and tiny ice crystals in the updraft. Hailstones can also grow to enormous size within the storm cloud, causing injury when they fall. *For example, in 2000, a nineteen-year-old from Texas died after being hit in the head by a softball sized hailstone.* Hailstone collisions cause static electricity to develop with the negatively charged particles falling to the bottom of the cloud and positively charged particles rising to the top of the cloud.

Scientists also believe that most tornadoes begin their formation due to updrafts within the atmosphere that occur during thunderstorms. Most tornadoes are formed when a strong updraft acts to concentrate atmospheric rotation, or spin, into a swirling column of air. The resulting swirling column of rising air, perhaps 6 to 12 miles (10 to 20 km) in diameter and only weakly rotating, is called a mesocyclone. Increasing rainfall within the storm cloud drags with it an area of quickly descending air known as the rear flank downdraft, which in turn drags the rotating mesocyclone to the ground. As the mesocyclone approaches the ground, a visible condensation funnel appears to descend from the base of the storm cloud.

As the funnel descends, the rear flank downdraft also reaches the ground. Usually, the funnel cloud becomes a tornado within minutes of the rear flank downdraft reaching the ground. Initially, the tornado has a good source of warm, moist air to power it, so it grows until it reaches the "mature stage". During the mature stage, the strength of the vortex can be very dangerous. **In 2006, Matt Suter of rural Missouri was carried 1307 feet (398 m) by a tornado, according to National Weather Service measurements.** The mature stage can last anywhere from a few minutes to more than an hour, and during that time a tornado often causes the most damage. **In rare cases the tornado can be more than one mile (1.6 km) across.**

The downward movement of electrically charged particles within the cloud plays a similar role in lightning formation. Once static electricity has sufficiently developed within the cloud, a downward stroke towards the ground occurs, called the stepped leader. This first downward stroke is triggered by a spark between the areas of positive and negative charges within the cloud. As the stepped leader nears the ground, a positively charged upward-moving leader travels up from such objects as trees and buildings, to meet the negatively-charged stepped leader. Lightning strikes often hit the tallest object in the area and can be very dangerous. *For example, witnesses in Maryland watched as a bolt of lightning tore a hole in the helmet of a high school football player during practice, burning his jersey and blowing his shoes off.* The upward motion of the current is the "return stroke," and it reaches the cloud in about 70 millionths of a second.

Usually, the upward moving leader from the tallest object is the first to meet the downward moving stepped leader and complete a path between the cloud and earth. The two leaders generally meet about 165 feet above the ground. When this meeting happens, negatively charged particles rush from the cloud to the ground along the path created by the leaders. As the negatively charged particles move, lightning becomes visible. The lightning flash usually consists of an electrical potential of hundreds of millions of volts. The powerful electrical charge of the return stroke causes air along the lightning channel to be heated briefly to a very high temperature. Such intense heating causes the air to expand explosively; producing a sound wave we call thunder.

Meanwhile, the mature tornado begins to recede, as the rear flank downdraft, now an area of cool surface winds, begins to wrap around the tornado, cutting off the inflow of warm air which feeds the tornado. This chokes off the tornado's air supply and the vortex begins to weaken, becoming thin and rope-like. This is the "dissipating stage"; often lasting no more than a few minutes, after which the tornado is contracting into a rope-like tube. However, even during the dissipating stage, high winds can still make the tornado dangerous to individuals on the ground. Hazardous and potentially lethal objects that could easily impale a human such as pitchforks, knives, forks, and axes have been found imbedded in trees and buildings after tornadoes have dissipated. At this point the tornado and associated mesocyclone dissipates due to the removal of the warm air supply. However, new updrafts may also form new mesocyclones deeper within the storm cell, resulting in additional funnel clouds as the storm moves along.

Tornadoes and lightning are common severe weather elements experienced by residents of the Midwest during summer months. During severe weather, individuals are advised to seek shelter and use a battery operated NOAA Weather Radio to receive warnings and advice. Violent storms can be both dangerous and frightening to unprepared residents. Because of this, understanding the complex processes that create inclement weather phenomena can assist individuals to adequately prepare to deal with dangerous weather conditions.