

An Examination of Eye Movements, Reading Skills and the Impact of Seductive Details on  
Students' Learning

by

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## Abstract

This dissertation consists of three separate studies. The purpose of the first study was to examine whether junior high students' eye movement patterns are sensitive to differences in reading skills and/or general developmental changes as well as whether junior high students' eye movement patterns are related to text comprehension. Forty junior high students completed a variety of reading tasks, one with an eye-tracker. Results revealed that age and sight word reading were not associated with eye movement measures. Phonemic decoding efficiency was a marginally significant predictor of the number of saccades, and passage comprehension predicted first and gaze fixation durations as well as saccade amplitudes. Percentage of regression and first fixation durations were both predictors of text comprehension. In sum, the first study provided general information about the eye movements of young adolescent readers while reading a complex text.

The purpose of the second study was to examine how seductive details in scientific text impact (a) online processing of text, (b) emotional and cognitive interests, and (c) learning outcomes of junior high school students. Eye movements of 58 junior high students were monitored while they read a scientific text (with or without seductive sentences and/or with informative or seductive images), adapted from Lehman et al. (2007) and Harp and Mayer (1997). The students' cognitive and emotional interests were assessed separately for each screen. After the participants finished reading the text, they answered recall and comprehension questions to measure their learning. Overall, results showed that the presence of different types of seductive information has different impact on how much the participants remember and comprehend the important information. In general, the added seductive sentences and images did not affect students' cognitive or emotional situational interest; however, seductive sentences

were attended to and those exposed to screens containing seductive text gave higher cognitive interest ratings for these screens. Results also indicated that the additional information significantly increased student processing time and that students processed base sentences faster when only base information was presented. Little time was spent examining the images and no differences were found between informative and seductive images. These findings suggest that including irrelevant additional information, either as text or pictures, may not have the desired effect of improving students' interest, and could be detrimental by increasing information processing time.

The purpose of the third study was to expand on the second study by including two additional conditions and assessing older students. Undergraduate students read on a computer a scientific text with or without seductive details. The participants' eye movements were tracked and their cognitive and emotional interest was assessed separately for each screen. Immediately after reading the text, participants answered recall and comprehension questions. Results showed that enhancing factual text with seductive information did not improve learning outcomes, but it did increase the text processing time. Neither the additional seductive sentences, seductive images, nor informative images affected the students' emotional or cognitive interest. Similar to the second study, these findings suggest that adding seductive details, whether in the form of additional text or as images, may not have the desired effect of improving interest, and may be harmful for learning by increasing the time needed to process the text.

## Preface

This thesis is an original work by Krystle-Lee Turgeon with the collaboration of Dr. Rauno Parrila at the University of Alberta. The research projects received research ethics approval from the University of Alberta Research Ethics Board, Project Name “Seductive detail effect in scientific texts”, No. Pro00040636, approved August, 2013; Project Name “Reading of scientific text-study3”, No. Pro00053483, approved January, 2015.

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## Chapter I: General Introduction

Reading plays a crucial role in the learning process at every age. Students are often asked to read out of a textbook as part of a lesson. The text being read by students can help foster learning in many different ways. For example, a text can be beneficial to enhance a topic that is being learned or when used as a reference tool. Being able to read the words is essential, but understanding the information is imperative to students' learning outcomes. Not only do students need to learn to read and comprehend information presented in a text, they must also be able to decipher what is important from what is not important. Not all texts are created the same. Some texts may contain a mixture of pertinent and non-pertinent information for a lesson. For example, a text may contain information relating to the topic but not to the instructional goal of the text. When presented with such a text, students need to be able to identify what is important so they can comprehend the information. A student's ability to retain the right information and comprehend from text should develop with age and practice. Being able to distinguish different types of information can become challenging when the information presented can be very persuasive and interesting. Reading skills are an important asset to develop, and for this reason, it is a topic that continues to be studied.

The current dissertation consists of five chapters. The first provides an introduction to eye movements, containing information on some of its measures, importance, and developmental changes. Further, theoretical explanations of the seductive detail effect will be identified followed by a review of empirical findings of seductive details in both text and images. The second chapter focuses on junior high school students' eye movement patterns in order to gain information on the developmental aspects of reading skills and eye movements. The third chapter examines the inclusion of seductive information (in text and images) in a scientific text and its impact on junior high school students' emotional and cognitive interest, text processing time, and reading

behaviours. The fourth chapter examines how university students interact with learning material that includes informative text with or without seductive sentences as well as with or without informative or seductive images. The impact of the inclusion of seductive information on students' emotional and cognitive interest as well as their learning outcomes are also addressed. The final chapter (Chapter V) of the dissertation concludes with a general discussion of the main findings and their implications.

### **Definition of Terms**

*Fixation:* When the eye pauses on a word or image to capture the information.

*Personal interest:* A learner's enduring preference of certain content, subject areas, or activities (Schiefele, 1991).

*Reading comprehension:* A complex process of extracting and understanding meaning of a written language (Snow, 2002).

*Reading speed:* The rate at which someone reads words within a text.

*Regression:* A backward saccade (movement from right to left) made by the eye.

*Retention:* The ability to recall the information read in a text.

*Saccade:* A forward movement made by the eye.

*Seductive details:* Additional materials that are interesting but irrelevant to the instructional goal of the text (Garner, Gillingham, & White, 1989; Harp & Mayer, 1997, 1998).

*Situational interest:* A learner's response to the environmental information presented that can last over time or be short-lived (Schraw & Lehman, 2001).

*Transfer:* The ability to apply information to a different context.

*Working memory:* The ability to coordinate processing and storage functions of information (Daneman & Carpenter, 1980).

## Eye Movements in Reading

Eye tracking has become a highly utilized method to examine cognitive processing (Rayner, 1998). Eye tracking techniques and research have been expanding over the years with the use of new technology that has also made it more accessible. A brief overview of the history of eye movement research can be divided in four eras. During the first era, Huey (1908) provided us with the basic concepts for describing eye movements, such as saccades and fixations. Buswell (1922) and Tinker (1958) were among those who started to study eye movements from a behavioural point of view. Not much research was done in the second era due to the behaviourist movement. In the third era (starting around 1975), new improved methods of recording eye movements were introduced with the use of computers. Theories started to be developed in regards to language and cognitive processes that included eye movement research. Keith Rayner, one of the most influential researchers in the eye movement and reading field, also started his work during this era. Now in the fourth era, eye movement methods have evolved and are more precise. Quantitative models of eye movements in reading are being created and the knowledge has expanded tremendously.

Assumptions are often made on what an individual is looking at and processing. The only way to confirm an assumption is to track and measure his/her eye movements. For example, eye movements have been studied to determine where and how individuals look at a variety of stimuli. Some researchers have used eye tracking to study how individuals with autism look at a human face when detecting emotion (e.g., Leung, Ordqvist, Falkmer, Parsons, & Falkmer, 2013) or what a child examines on a page from a storybook when listening to a story (e.g., Roy-Charland, Perron, Turgeon, Hoffman, & Chamberland, 2016). Eye movements can also provide information about how individuals process meanings of words and sentences (e.g., Frazier & Rayner, 1982). Eye tracking is a technique that can further assist in explaining reading

difficulties. For instance, it has allowed researchers to find differences in the eye movements between individuals with dyslexia and skilled readers in a reading task (e.g., Prado, Dubois, & Valdois, 2007). In sum, we have learned and continue to learn from eye movement research.

Through the study of eye movements in reading, many different eye movement measures have been developed and are widely utilized. These measures will provide different information regarding the reading process of a reader. First, as an individual reads a text, their eyes are making rapid movements, which are referred to as saccades, from one word to another. For a fluent reader, the mean length of a saccade in reading can vary from 7 to 9 characters (Rayner, 1998). The role of a saccade is simply to allow the eye to move, as no information can be taken in during the movement. Following a saccade, the eye will pause to gain information. The pause is called a fixation. Fixations allow for the visual information of the word to be captured and then processed (Rayner, 1998). Fixation durations can vary based on many different factors such as word length or reading ability. The mean fixation duration of a fluent reader is around 200-250 ms (Rayner, 1998). The duration of a fixation can give information on how an individual is processing a word. For instance, longer fixation durations can reflect a deeper processing, which in turn can be indicative of the reader struggling to either recognize or identify a word (e.g., Rayner & Duffy, 1986). Not every word is fixated on and some words can be fixated on more than once. For these reasons, four different fixation duration measures have been created to capture word processing more accurately. When words contain multiple fixations, the duration of the very first fixation made on a word can be reported. The *first fixation duration* indicates the initial duration of the word processing (Rayner & Pollatsek, 1989). If a word was only fixated on once, a *single fixation* duration will be reported. In this case, the first fixation and single fixation duration will be of equal value. This measure is used to indicate that a reader was able to recognize and process the word with only a single fixation (Rayner & Pollatsek, 1989). When

multiple fixations are made on a single word before the eye leaves the word, the sum of the fixations are calculated to represent *gaze duration*. This measure indicates that multiple fixations were required to process a word (Just & Carpenter, 1980). The last fixation measure includes the duration of all fixations made on a word, including those that are returning. This measure is named *total fixation duration*, and is used as a way to identify that a reader has made multiple fixations and may have also returned to the word after having passed it (Rayner & Pollatsek, 1989). Total fixation duration and gaze fixation duration can be equal or different. Differences will be observed when a reader has left the word to continue reading and then decided to go back to reread the same word. When a reader returns to a word, they are making a backward saccade, or a *regression*. The role of a regression is to allow the reader to reread information they may have missed or misunderstood. Regressions are one measure that researchers struggle to explain since they can be made for many different reasons and are difficult to manipulate in experiments (Schotter, Tran, & Rayner, 2014). For example, a regression can be made due to an oculomotor issue, such as having overshoot a saccade, which could cause the reader to go past a word that they then need to regress back to. Or a regression can be a result of confusion or difficulty processing a word (Rayner & Pollatsek, 1989). In general, about 10 to 15% of a reader's saccades will be regressions (Rayner, 1998). Many factors such as age and reading ability can impact the eye movements of a reader.

The perceptual span is the area within which readers obtain information during a fixation. The span extends to about 14 to 15 characters to the right of a fixation (e.g., McConkie & Rayner, 1975; Rayner, 1998). The span consists of the foveal area where visual acuity is good (approximately 6 to 8 characters around the fixation), the parafoveal area where acuity diminishes (extends up to 15 characters), and the perifoveal area where no information can be extracted, as it cannot be detected. The perceptual span allows readers to get information about

word length, and letter features and identities, and this information is used to help program saccades (e.g., McConkie & Rayner, 1975).

According to Rayner (1998), reading ability will influence the size of the perceptual span. Beginning and struggling readers tend to have a smaller span in comparison to advanced readers due to the fact that they have more difficulties processing words in the foveal region and therefore are not able to use information provided in the parafoveal region. For example, at the end of the first grade, a span will typically be around 11 characters to the right of a fixation (Rayner, 1986).

Variability is shown in many eye movement measures, including the readers' fixation durations that can vary from 100 ms to over 500 ms with saccade lengths ranging from 1 letter space to 15 letter spaces (Rayner, 1998). Variability can be found between readers as well as within readers. Variability for a reader can range within a text. When the level of difficulty of a text increases, so will the fixation durations as well as the number of saccades and regressions, and the length of the saccades will diminish (Rayner, 1998). Eye movements can also vary based on the quality of the text, such as quality of the font, the length of the lines, and the space between letters (Rayner, 1998; Rayner & Pollatsek, 1989). Many studies have shown that if the font used appears to be more difficult, the reader will make more fixations that tend to be longer, and, as a result, this will lead to a slower reading speed (Slattery & Rayner, 2009). Spacing between words will influence eye movements given that no spacing brings the first landing position closer to the beginning of the word and will slow down the reader (Rayner, 1998).

Developmental changes can also be observed in eye movement measures. Children's eye movements tend to differ from those of adults. While reading, beginner readers make more and longer fixations (350 ms), have shorter saccade lengths (2 to 5 characters), and make more regressions (e.g., Buswell, 1922; McConkie et al., 1991; Rayner, 1998; Taylor, 1965). As

children develop their reading abilities, their eye movement patterns start to change and become more like the average reader's eye movement patterns. Changes may relate to the ability of being able to quickly and accurately identify words; therefore, children's longer fixations durations may reflect slower or less efficient lexical identification (Huestegge, Radach, Corbic, & Huestegge, 2009). As previously mentioned, the amount of information children extract from a fixation also increases with age and with more developed skills (Rayner, 1986). Hence, when more information gets extracted from a fixation, a reader will start making longer saccades and plan following saccades and fixation location at a faster rate. Buswell (1922) found that children's eye movement in reading becomes stable by the fifth grade, and the number of regressions is the only aspect left that will continue to change until the end of high school (Huestegge et al., 2009; Rayner & Pollatsek, 1989). In sum, as reading skills increase, changes will be found in the measurement of eye movements in reading. However, a significant amount of the research on eye movements in reading has focused on skilled adult readers and only a few studies have investigated younger beginner readers.

### **Theoretical Explanations of the Seductive Detail Effect**

Additional materials that are interesting but irrelevant to the instructional goal of the text are known as *seductive details* (e.g., Garner, Alexander, Gillingham, Kulikowish, & Brown, 1991; Garner et al., 1989; Moreno & Mayer, 2000). One of many theoretical explanations used to understand the effects of seductive details is the cognitive theory of multimedia learning (CTML) (e.g., Harp & Mayer 1998; Lehman, Schraw, McCrudden, & Hartley, 2007). The CTML explains the seductive detail effect in terms of the working memory that becomes crowded by the presence of seductive details. One or both channels of the system, such as the visual or auditory channels, can become overloaded by seductive details. If a student chooses to process the seductive details presented to them, they may be unable to engage in the processing of important information

(Mayer, 2005; Mayer, Griffith, Jurkowitz, & Rothman, 2008). As a result, students learn the material poorly. Within the CTML, the seductive detail effect is similar to the coherence principle, which states that people learn more deeply when seductive details are excluded from the material rather than included. This is due to the fact that seductive information competes for cognitive resources in working memory and can also divert attention away from the important information. The process of organizing the information is subsequently disrupted, and students integrate the information with an inappropriate theme (Mayer, 2003, 2009).

The seductive detail effect can also be explained by three additional hypotheses postulated by Harp and Mayer (1998): the distraction hypothesis, the disruption hypothesis, and the diversion hypothesis. According to the *distraction hypothesis*, seductive details reduce learning outcomes by distracting attention from important information (Harp & Mayer, 1998). Harp and Mayer (1998) assumed that seductive details require less attentional effort and can be understood easily compared to important information. Sanchez and Wiley (2006) used a different explanation of the distraction hypothesis, where seductive details harm learning outcomes only for learners with a low working memory capacity that have more trouble focusing their attention on the important information. In Sanchez and Wiley's (2006) explanation, working memory is viewed from a controlled attention perspective. According to the *disruption hypothesis*, seductive details interrupt the construction of a coherent mental representation of the important ideas (Harp & Mayer, 1998). When seductive details are present, readers have difficulties building a coherent mental representation of the content while reading. In contrast, the *diversion hypothesis* states that the seductive detail effect occurs during the integration of information with existing knowledge if the seductive details prime inappropriate prior knowledge as the organizing schema of the material (Harp & Mayer, 1998; Lehman et al., 2007). As a result, the reader builds a representation of the text around the seductive details rather than around the important ideas.



A few other possible explanations of the seductive detail effect, such as motivation, interest, perceptual load, and cognitive load, can be found but the majority of these explanations tend to partly overlap with one another. The cognitive load theory, for example, assumes that learning depends on the efficiency of the use of available cognitive resources. This theory has three components: intrinsic cognitive load that depends on the amount of elements that need to be simultaneously processed in working memory to learn the information; the extraneous cognitive load that is caused by the unnecessary cognitive demands imposed by instructional design; and the germane cognitive load, or the load that results from engaging in a learning activity, that fosters schema acquisition (Park, Moreno, Seufert, & Brünken, 2011). Seductive details will impose an extraneous cognitive load by having students spend their limited resources in processing materials that are not beneficial to learning.

### **Empirical Findings of Seductive Details**

Research on seductive details has produced a series of studies with mixed results. Some have reported a negative seductive detail effect (e.g., Harp & Mayer, 1997, Exp.1; Lehman et al., 2007), while others have produced mixed results (e.g., Garner et al., 1989; Mayer et al., 2008), and others have found no effects (e.g., Garner & Gillingham, 1991; Hidi & Baird, 1988). To examine the seductive detail effect, measures of retention and transfer are typically used, since remembering and understanding are two major goals of learning. A typical retention test asks for a recall of information presented in the passage. This kind of test measures the quantity of learning, or how much is remembered. The transfer test involves answering some problem-solving questions about the text. This kind of test reflects the ability to use what has been presented in a new situation. This test will ask learners to solve problems that were not explicitly given in the material. A transfer test will evaluate the quality of learning.

Written seductive details are typically found in general instructional texts (Garner et al., 1989), but studies with narrative text have also shown that the inclusion of seductive details can interfere with learning (e.g., Garner et al., 1989; Wade & Adams, 1990). The studies that showed a negative effect of the seductive details have illustrated that students who do not receive seductive details outperform those who do on both retention and transfer measures (e.g., Lehman et al., 2007). Harp and Mayer (1998, Exp.1, 2, 3) examined the effect of seductive illustrations in a multimedia text on the process of lightning. College students read an illustrated base text passage (550 words) with six black and white captioned illustrations, while other students read the same passage with an additional seductive detail text (150 words) and six captioned colour photographs describing the risk of lightning for humans. Results of this study suggest a negative seductive detail effect: the students who received the illustrated base text outperformed those who received the seductive illustrations in all three experiments on both retention and transfer measures. In the same study, Harp and Mayer (1998) postulated and tested the *distraction*, *disruption*, and *diversion* hypotheses. They concluded that their study supported the diversion hypothesis that suggests seductive details interfere with learning because the participants activate inappropriate schemata, which cause them to form mental representations around the seductive details rather than around the main ideas. These results suggest a combined seductive detail effect for text and illustrations, but do not provide evidence for a clear effect for seductive illustration alone.

Lehman et al. (2007) took Harp and Mayer's (1997) materials, including their lesson on the process of lightning, and modified them in order to increase the comprehensibility. A total of 741 words for the base text describing the process of lightning was used and 226 additional words for the seductive detail text was used describing the risk of lightning for humans. University students read either the base or seductive detail text on a computer screen one

sentence at a time without any time limit. A seductive detail effect was found for retention and for two deeper processing measures, holistic understanding (understanding of the cause and effect relationships in the text) and total claims (number of causal explanations and inferences made in the holistic understanding task). Lehman et al. also calculated time per word by dividing sentence reading time by the number of words in the sentence. The results indicated that students who read the seductive details text read the base sentences faster than those who read only the base text. In this study, Lehman et al. (2007) modified the three hypotheses (distraction, disruption, and diversion) postulated by Harp and Mayer (1998) by articulating the factors that affect online processing: attention, text coherence, and schema activation. The results of Lehman et al.'s study support the distraction and the disruption hypotheses and partially support the diversion hypothesis. All three processes appear to work in conjunction and interact with one another (Lehman et al., 2007). Lehman et al. (2007) concluded that seductive details interfere with comprehension and processing because the attention to the base text is reduced, the coherence of the text is disrupted, and there is a possible construction of inappropriate schema.

Other studies have found mixed results with the presentation of seductive details in text (e.g., Mayer et al., 2008; Rey, 2011). For example, Mayer et al. (2008) examined the seductive detail effect during a written and narrated animation explaining how a cold virus infects the human body. In the first experiment, college students either received an illustrated booklet, a PowerPoint presentation, or a narrated animation. Two versions of the PowerPoint presentation and two versions of the narrated animation were created: a seductive detail text version and a low-interest text version. The base text contained 500 words, and participants were given either the seductive detail text of 762 words or the low-interest text of 749 words. Results of this experiment showed that students who received the low-interest text significantly outperformed those who received the seductive detail text on transfer but not on retention measures. The results

of Mayer et al.'s (2008) study also contributed to the CTML. The results are consistent with the idea that the reader will engage in more extraneous processing for lessons that contain high interest seductive details than those with low interest seductive details, which then leaves less cognitive capacity for deep processing of the essential material.

Harp and Mayer (1997, Exp.1) examined seductive details in illustration and a comparison was made between four conditions: base text explaining the process of lightning with six captioned black and white illustrations, the same base text and black and white illustrations plus seductive text, base text with an addition of six captioned color photographs (seductive illustrations), and a base plus seductive text and color photographs. Results of this study suggest a mixed seductive detail effect: College students who received the base illustrations significantly outperformed those who received the seductive illustrations on retention and marginally on transfer performances. For the transfer test, differences were found between conditions; the base condition significantly outperformed the base plus seductive text and the base plus seductive text and seductive illustrations conditions, although the base condition did not significantly outperform the base plus seductive illustrations condition, which explains why the results are said to be mixed.

No support for the seductive detail effect has also been reported (e.g., Garner & Gillingham, 1991; Schraw, 1998). For example, Garner and Gillingham (1991) tested university students who either read the base text (400 words) about Stephen Hawking and his scientific work or read the same passage with an additional seductive detail text (100 words) about a wager between Kip Thorne and Stephen Hawking. The retention measure used in this study asked the student to recall only important information instead of asking for a general recall of information. Students who read the seductive detail text did not differ on the retention and transfer measures from the students who read the base text. A possible reason for the absence of the seductive detail

effect is that the seductive detail text was not as interesting as it needed to be in order to produce an effect (Garner & Gilligham, 1991).

Rey (2011), in turn, found no support for the seductive detail effect in illustrations. This study contained both text and illustrations: a base text of 700 words, a seductive text passage containing 1148 words, and 19 seductive illustrations showing decorative astronomic photographs (no control illustrations were used). Participants either received the base text with or without seductive illustrations or the seductive text with or without illustrations. No differences were found between the students who had and had not received the seductive detail illustrations on retention or transfer measures. It is important to note that this study compared seductive illustrations to no illustration instead of comparing seductive illustrations to base illustrations. Such results do not provide enough information about seductive illustrations since these were not compared to other illustrations. The results of the study do not fully confirm the coherence principle of the CTML, particularly for the seductive illustrations. The illustrations did not impair learning performance and the author believed that they did not overload the working memory (Rey, 2011). However, it is also possible that students did not look at the illustrations.

Taken together, the studies that found a seductive detail effect suggest that seductive detail sentences take longer to read than other sentences, and that different reading strategies may be used when encountering seductive detail sentences (Lehman et al., 2007; Schraw, 1998). Seductive detail sentences are also better recalled than other types of sentences and can interfere with the retention of the main ideas (Harp & Mayer, 1997; Lehman et al., 2007; Rowland-Bryant et al., 2009). Rey's (2012) meta-analysis revealed overall significant effect sizes for retention (small to medium effect size) and transfer (medium effect size) performances, supporting the seductive detail effect. The studies that produced mixed effects either found a difference for retention but not for transfer performances or vice versa, or found partial effects. Finally, several

studies failed to find any seductive detail effect (Hidi & Baird, 1988 Garner et al., 1991; Garner & Gillingham, 1991; Park & Lim, 2007; Schraw, 1998; Rey, 2011). In sum, conflicting results have been found for all types of seductive details.

### **Current dissertation**

The current dissertation consists of three studies in which different aspects of reading are examined in university and junior high school students. The first study examines whether eye movement patterns in junior high school students are sensitive to differences in reading skills and/or general developmental changes. Specifically, age, word reading, and passage comprehension were examined to see if they predicted eye movements during a reading task. The study also inspects if reading behaviour relates to text comprehension. Results suggest that age does not predict eye movement measures, but reading comprehension and non-word reading do. When examining if the eye movement measures predict text comprehension, first fixation duration and percentage of regression were both found to be good predictors.

The second study also includes junior high school students and focuses on the impact of seductive details (in sentences or images) on the online processing of text, learning outcomes, and cognitive and emotional interest. Results indicate some differences in text comprehension and processing when seductive information is presented. The results do not support the use of seductive information in non-fiction texts aimed at junior high school students. No mean interest rating differences between the four conditions were found, although the seductive details were noted for those exposed to the seductive text. Base sentences tend to be read faster when only base information is presented. Results from eye tracking revealed, not surprisingly, that more time is needed to examine material containing more information.

The third study also focuses on the impact of seductive details (in sentences or images) on the online processing of text, but this time we focused on how their inclusion can affect

university students' emotional and cognitive interest along with their learning outcomes. Overall, neither the seductive text nor the seductive images affected the students' cognitive or emotional interest. The inclusion of seductive information did not improve learning outcomes and it increased the text's processing time.

In general, this dissertation provides us with information about different impacts that researchers, textbook writers, and teachers can expect when presenting specific types of information to students. The first study provides some general information concerning the eye movements of young adolescent readers. It indicates that reading comprehension and word reading predict variance in eye movement measures. The other two studies suggest that including seductive information in learning material is not necessarily beneficial. Instead, including seductive information will increase the time the reader needs to learn the information and the purportedly seductive information may not even be viewed as seductive, and in return, the student will not be more interested in the material. The findings of the second and third studies contribute to the research of seductive details as they highlight the importance of online evaluation of the reader's level of interest.

## References

- Buswell, G. T. (1922). *Fundamental reading habits*. Chicago: The University of Chicago.
- Daneman, M., & Carpenter, P. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior*, *19*, 450–466. doi: 10.1016/S0022-5371(80)90312-6
- Frazier, L., & Rayner, K. (1982). Making and correcting errors during sentence comprehension: Eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology*, *14*, 178–210. doi: 10.1016/0010-0285(82)90008-1
- Garner, R., Alexander, P. A., Gillingham, M. G., Kulikowich, J. M., & Brown, R. (1991). Interest and learning from text. *American Educational Research Journal*, *28*, 643–659. doi: 10.3102/00028312028003643
- Garner, R., & Gillingham, M. G. (1991). Topic knowledge, cognitive interest, and text recall: A microanalysis. *Journal of Experimental Education*, *59*, 310–319. doi: 10.1080/00220973.1991.10806569
- Garner, R., Gillingham, M. G., & White, C. S. (1989). Effects of “seductive details” on macroprocessing and microprocessing in adults and children. *Cognition and Instruction*, *6*, 41–57. doi:10.1207/s1532690xci0601\_2
- Harp, S. F., & Mayer, R. E. (1997). The role of interest in learning from scientific text and illustrations: On the distinction between emotional interest and cognitive interest. *Journal of Educational Psychology*, *89*, 92–102. doi: 10.1037/0022-0663.89.1.92
- Harp, S. E., & Mayer, R. E. (1998). How seductive details do their damage: A theory of cognitive interest in science learning. *Journal of Educational Psychology*, *90*, 414–434. doi: 0.1037/0022-0663.90.3.414



- Hidi, S., & Baird, W. (1988). Strategies for increasing text-based interest and students' recall of expository texts. *Reading Research Quarterly*, 23, 465–483. doi: 10.2307/747644
- Huestegge, L., Radach, R., Corbic, D., & Huestegge, S. M. (2009). Oculomotor and linguistic determinants of reading development: A longitudinal study. *Vision Research*, 49(24), 2948–2959. doi: 10.1016/j.visres.2009.09.012
- Huey, E.B. (1908). *The psychology and pedagogy of reading*. New York: Macmillan.
- Just, M. A., & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review*, 87(4), 329–354. doi: 10.1037/0033-295X.87.4.329
- Lehman, S., Schraw, G., McCrudden, M. T. & Hartley, K. (2007). Processing and recall of seductive details in scientific text. *Contemporary Educational Psychology*, 32, 569–587. doi: 10.1016/j.cedpsych.2006.07.002
- Leung, D., Ordqvist, A., Falkmer, T., Parsons, R., & Falkmer, M. (2013). Facial emotion recognition and visual search strategies of children with high functioning autism and Asperger syndrome. *Research in Autism Spectrum Disorder*, 7, 833–844. doi: 10.1016/j.rasd.2013.03.009
- Mayer, R. E. (2003). The promise of multimedia learning: Using the same instructional design methods across different media. *Learning and Instruction*, 13, 125–139. doi:10.1016/S0959-4752(02)00016-6.
- Mayer, R. E. (2005). Cognitive theory of multimedia learning. In Mayer, R. E. (Ed), *The Cambridge handbook of multimedia learning* (pp. 31–48). New York: Cambridge University Press.
- Mayer, R. E. (2009). *Multimedia learning* (2<sup>nd</sup> edition). Cambridge: Cambridge University Press.

- Mayer, R. E., Griffith, E., Jurkowitz, I. T. N., & Rothman, D. (2008). Increased interestingness of extraneous details in a multimedia science presentation leads to decreased learning. *Journal of Experimental Psychology, 14*, 329–339. doi: 10.1037/a0013835
- McConkie, G.W., & Rayner, K. (1975). The span of the effective stimulus during a fixation in reading. *Perception and Psychophysics, 17*, 578–586. doi: 10.3758/BF03203972
- McConkie, G. W., Zola, D., Grimes, J., Kerr, P. W., Bryant, N. R., & Wolff, P. M. (1991). Children's eye movements during reading. In J. F. Stein (Ed.), *Vision and visual dyslexia, 13*, (pp. 251–262). London: Macmillan Press
- Moreno, R., & Mayer, R. E. (2000). A coherence effect in multimedia learning: The case for minimizing irrelevant sounds in the design of multimedia instructional messages. *Journal of Educational Psychology, 92*, 117–125. doi:10.1037/0022-0663.92.1.117
- Park, B. & Lim. J. (2007). Promoting positive emotion in multimedia learning using visual illustrations. *Journal of Educational Multimedia and Hypermedia, 16*, 141–162.
- Park, B., Moreno, R., Seufert, T., & Brünken, R. (2011). Does cognitive load moderate the seductive details effect? A multimedia study. *Computers in Human Behavior, 27*, 5–10. doi:10.1016/j.chb.2010.05.006
- Prado, C., Dubois, M., & Valdois, S. (2007). The eye movements of dyslexic children during reading and visual search: Impact of the visual attention span. *Vision Research, 47*, 2521–2530. doi:10.1016/j.visres.2007.06.001
- Rayner, K. (1986). Eye movements and the perceptual span in beginning and skilled readers. *Journal of Experimental Child Psychology, 41*, 211–236. doi: 10.1016/0022-0965(86)90037-8
- Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin, 124*, 372–422. doi: 10.1037/0033-2909.124.3.372

- Rayner, K., & Duffy, S. A. (1986). Lexical complexity and fixation times in reading: Effects of word frequency, verb complexity, and lexical ambiguity. *Memory & Cognition, 14*(3), 191–201. doi: 10.3758/BF03197692
- Rayner, K., & Pollatsek, A. (1989). *The psychology of reading*. Englewood Cliffs, N.J.: Prentice Hall.
- Rey, G. D. (2011). Seductive details in multimedia messages. *Journal of Educational Multimedia and Hypermedia, 20*, 283–314.
- Rey, G. D. (2012). A review of research and a meta-analysis of the seductive detail effect. *Educational Research Review, 7*, 216–237. doi: 10.1016/j.edurev.2012.05.003
- Rowland-Bryant, E., Skinner, C. H., Skinner, A. L., Saudargas, R., Robinson, D. H., & Kirk, E. R. (2009). Investigating the interaction of graphic organizers and seductive details: Can a graphic organizer mitigate the seductive details effect? *Research in the Schools, Mid-South Educational Research Association, 16*, 29–40.
- Roy-Charland, A., Perron, M., Turgeon, K. L., Hoffman, N., & Chamberland, J. A. (2016). The link between text difficulty, reading speed and exploration of printed text during shared book reading. *Reading and Writing, 29*, 731–743. doi: 10.1007/s11145-016-9624-1
- Sanchez, C. A., & Wiley, J. (2006). An examination of the seductive details effect in terms of working memory capacity. *Memory & Cognition, 34*, 344–355. doi: 10.3758/BF03193412
- Schiefele, U. (1991). Interest, learning, and motivation. *Educational Psychologist, 26*, 299–323. doi: 10.1207/S15326985ep2603&4\_5
- Schotter, E. R., Tran, R., & Rayner, K. (2014). Don't believe what you read (only once) comprehension is supported by regressions during reading. *Psychological Science, 25*(6), 1218–1226. doi: 10.1177/0956797614531148

- Schraw, G. (1998). Processing and recall differences among seductive details. *Journal of Educational Psychology, 90*, 3–12. doi: 10.1037/0022-0663.90.1.3
- Schraw, G., & Lehman, S. (2001). Situational interest: A review of the literature and directions for future research. *Educational Psychology Review, 13*, 23–52. doi: 10.1023/A:1009004801455
- Slattery, T. J., & Rayner, K. (2009). The influence of text legibility on eye movements during reading. *Applied Cognitive Psychology, 24*, 1129–1148. doi: 10.1002/acp.1623
- Snow, C. E. (2002). *Reading for understanding: Toward an R&D program in reading comprehension*. Santa Monica, CA: Rand Corporation.
- Taylor, S. E. (1965). Eye movements in reading: Facts and fallacies. *American Educational Research Journal, 2*, 187–202. doi: 10.3102/00028312002004187
- Tinker, M. A. (1958). Recent studies of eye movements in reading. *Psychological Bulletin, 55*, 215–231. doi: 10.1037/h0041228
- Wade, S. E., & Adams, R. B. (1990). Effects of importance and interest on recall of biographical text. *Journal of Reading Behavior, 22*, 330–53. doi: 10.1080/10862969009547717

## Chapter II: Young adolescents' reading skills and eye movements

### Introduction

Being able to extract information presented on a page and comprehend its meaning is an important skill to develop, as most information in educational settings is presented in this format. For these reasons, reading has been studied in many different ways for many years with a range of different readers in order to gain knowledge about this crucial skill. One important technique used to study reading is eye-tracking (Rayner & Pollatsek, 1989). Researchers have been able to show how cognitive processes can be examined with the use of eye movement data (e.g., Just & Carpenter, 1984; Rayner, 1995, 1998). Measuring one's eye movement in a reading task allows for a direct investigation of reading by capturing behavioural data (eye movement patterns) in reading. We know, for example, that our eyes **do not** make random movements on a page filled with text. Our eyes move in the direction of the words being presented but can sometimes go in the opposite direction in order to reread. We know that not all words are looked at directly and that we do not look at all words for the same amount of time (Rayner, 1998). Eye movement monitoring can also provide us with details about how individuals process words and sentences, and where in a text they may struggle. Based on a reader's characteristics we know that a beginner reader will generate different eye movement data than a skilled reader (McConkie, Zola, Grimes, Kerr, Bryant, & Wolff, 1991). Although we have learned a lot from reading studies, we still have significant gaps in our knowledge of reading. The purpose of this study was to examine whether eye movement patterns in junior high students are sensitive to differences in reading skills and/or general developmental changes. In addition, we were also interested in examining if reading behaviours, as measured by eye movements, were related to text comprehension. This study can help us gain knowledge about the developmental aspects of young adolescents' reading skills and eye movement.

## Eye movement measures

Various eye movement measures have been developed and utilized in reading research. Each measure provides slightly different information about the reading process. During reading our eyes are constantly making movements from one word to another. These movements are known as *saccades*. For a fluent reader, the mean length of a saccade varies from 7 to 9 characters (Rayner, 1998). In between the saccades, the eye pauses to fixate on a word; fixations are required as we are unable to gain information during saccades. Fixations allow us to obtain visual information of the word to start processing it (Rayner, 1998). Fixation durations are typically a good indicator of the extent of the processing done by a reader. While reading, a fluent reader's mean fixation duration is around 200-250 msec (Rayner, 1998). Longer fixation durations reflect a deeper processing that could indicate difficulty in identifying or reading a word (e.g., Rayner & Duffy, 1986).

There are four different fixation measures that are frequently used. These measures were created because the average fixation duration does not provide sufficient information about word processing (Rayner & Pollatsek, 1989). If the word only receives one fixation, the *single fixation* measure is used and captures the duration of the one fixation on a word. This measure indicates that a reader was able to process the word with a single fixation (Rayner & Pollatsek, 1989). If multiple fixations appear on a word, the *first fixation duration* provides the duration when the reader first started to examine the word. Thus, this measure signifies the initial duration of the word processing (Rayner & Pollatsek, 1989). The next measure, *gaze duration*, also pertains to multiple fixations on a single word. Gaze duration is the sum of all fixation durations and indicates the total time spent on a word before the eye moves onto something else (another word, picture, etc.). Gaze duration indicates that more than one fixation was required to finish processing a word (Just & Carpenter, 1980). The last measure is *total fixation duration*, which

includes the duration of fixations (whether forward or backward) made on a word. This measure can indicate that a reader returned to the word to finish processing it or was connecting new and prior information (Rayner & Pollatsek, 1989). Total fixation duration and gaze duration can be the same. While we read, our eyes not only move forward but backward, a phenomenon known as *regression*. Regression can occur for different reasons. For example, if the reader has made a longer saccade, either because he/she initially skipped a word or had an issue with oculomotor control, a regression is needed to obtain the information required to understand the sentence (Rayner & Pollatsek, 1989; Schotter, Tran, & Rayner, 2014). A reader who has difficulty processing a word or comprehending text can also make regressions. Approximately 10-15% of a typical reader's saccades are regressions (Rayner, 1998).

Researchers have reported age-related changes in eye movement patterns during reading. For instance, as age increases, so do the saccade amplitudes and word skipping probability. A decrease is observed for the number of fixations, fixation durations and refixation probability (Blythe & Joseph, 2011; Buswell, 1922; McConkie et al. 1991; Rayner, 1985, 1998; Taylor, 1965). For example, Rayner (1989) found a reduction in the number of fixations and the mean fixation durations until Grade 5. McConkie et al. (1991) noted a difference between children from Grade 1 to Grade 5 and adults in the frequency in which words were refixated before the eyes moved to another word. As noted by Blythe and Joseph (2011), age-related changes in eye movement patterns may be caused by the ease of identification of words within a sentence. Hence, differences between elementary schoolchildren and adults likely reflect the children's slower or less efficient lexical identification (Huestegge, Radach, Corbic, & Huestegge, 2009). It has also been reported that as reading skills improve, the amount of information one can extract from a fixation increases (Rayner, 1986). Many studies have found that the perceptual span is typically 3-4 characters less for younger and less-skilled readers than for those with more

developed skills (e.g., Rayner, 1986; Sperlich, Meixner, & Laubrock, 2016). If more information is extracted from a fixation and the processing of the next word starts in the parafoveal view, a reader can start making longer saccades and more optimally plan the following saccade and fixation location. Rayner and Pollatsek (1989) reported that regressions seem to decrease until the end of high school. Buswell (1922) did not find the same result. In sum, as reading skill increases changes in eye movement will reflect the decrease in cognitive processing difficulty associated with word identification and text comprehension.

### **Reading ability**

Efficient word recognition, meaning construction, generation of inferences and comprehension monitoring are some of the skills that contribute to overall reading comprehension (Oakhill & Cain, 2007). Reading comprehension develops as a child develops better reading abilities and skills (Kendeou, van den Broek, White, & Lynch, 2007). For example, some of the literature has suggested that beginning readers have deficits in reading comprehension strategies. In some cases poor reading comprehension occurs when children are more focused on reading as a decoding process and do not focus on making sense of the text (Baker & Brown, 1984). In other cases, children may struggle with the lexical process; if many unfamiliar or difficult words are included in a text, children will not be able to fully understand the text (Perfetti, 1985). As children age, their reading vocabulary expands and they are able to identify words more quickly and accurately. Because most adolescents can read words accurately, a lack of comprehension is often assumed to relate to comprehension strategies used to understand the text (Shankweiler, Lundquist, Dreyer, & Dickinson, 1996). However, difficulties in reading nonwords and irregular words can still affect high school students' comprehension (Shankweiler et al., 1996). If adolescents struggle when reading nonwords, they are also likely to struggle when reading new words, which impacts their comprehension. The



ability to construct a coherent mental representation of a story and to identify different types of connections also develops with age. As children grow older they are able to focus more deeply on a story and make connections within the text and between the text and their background knowledge (Kendeou et al., 2007). In short, younger children do not comprehend as much as older children. If younger adolescents are still developing these reading skills they may have less comprehension than older adolescents. These comprehension differences can also be reflected in their eye movement patterns. For example, if an adolescent is struggling to read words or to comprehend a sentence this can lead to longer fixation durations and more regressions, as they may need to reread words or the whole sentence in order to fully comprehend the information.

### **Current study**

A great deal of the research on eye movement in reading has focused on skilled adult readers, with only a few studies investigating younger, beginning readers, and even fewer investigating adolescent readers. For this reason, we will focus on adolescent readers and examine how age and reading skills impact their eye movement. To better understand the developmental aspects of reading and eye movement, it is important to examine eye movement patterns of students of all ages. Gaining data and information from adolescents will enable us to understand how to help them improve their reading skills. It will also help us to support and improve their learning outcomes.

First, the present study measured the eye movement of adolescents while they were reading a text. Single word analysis was conducted in order to obtain basic fixation duration measures such as first, gaze and total fixation durations. We also collected information about saccades as well as regressions. We focused on these measures, as they are the measures typically used in reading research; they provide information about word and text processing. Thus, the first goal of the present study is to investigate how different eye movement measures are related to

both word reading skills and to reading comprehension ability as measured by standardized tests. The same eye movement measures are then used to examine how they impact comprehension of the experimental text used to obtain them.

This study will address the following two research questions:

1. Do age, word reading ability and passage comprehension predict eye movement during a reading task?
2. Do the eye movements predict comprehension of the text that the students read?

For the first question, we consider age a predictor of eye movement in a reading task if any biological changes are still occurring during the first years of adolescence. If this is the case, we expect to find results similar to those in previous studies, indicating a decrease in the number of fixations, regressions, saccades and fixation durations and an increase in saccade amplitudes as age increases (Blythe & Joseph, 2011; Buswell, 1922; McConkie et al., 1991; Rayner, 1985, 1998; Taylor, 1965). If no changes are occurring during this time period, age will not predict the eye movement in the reading task. Age can also relate to word reading and comprehension skills.

If word-reading skills are still poor during adolescence, they could be associated with more fixations made on words as well as more time needed to read them correctly. If students are having difficulty reading the words, they may also make shorter saccades, as they will be unable to capture and process all of the information presented in the parafoveal view (e.g., Rayner, 2009). We would expect that passage comprehension, as measured by a standardized reading comprehension test, be a good predictor of the eye movement measures that are known to reflect cognitive processes (e.g., Rayner, 2009). Hence, the expectation is that lower passage comprehension scores will be associated with longer fixation durations since the reader needs more time to process the information (Chance, Rayner & Well, 2005). Better passage comprehension should also be associated with more regressions made by the reader as the reader

takes the time to reread the information he/she is struggling with in order to comprehend (e.g., Schotter et al., 2014).

For the second research question, we expect that the eye movements observed in reading a text are associated with comprehension of that same text. This assumption is based on the fact that eye movement measures are not random but controlled by the reader. Consequently, we expect once again that longer fixation durations indicate either difficulty with the words themselves or with integrating new information with what has already been read. As for saccades and regressions, we can expect that fewer and longer saccades are associated with poorer comprehension. However, if they are accompanied by more regressions made to reread the information that was skipped, this effect may not occur.

## **Methods**

### **Participants**

Forty junior high students from a public school (kindergarten through to grade 9) in Edmonton, Alberta took part in this study. The sample was composed of 13 students from grade 7, 15 students from grade 8 and 12 students from grade 9. Students varied in age from 12 to 14, with the mean age of 13. All the students had normal or corrected-to-normal vision. Participants and their legal guardian read and signed a consent form.

### **Measures**

**Reading abilities.** The participant's word and nonword reading fluency was assessed with the TOWRE-II (Torgesen, Wagner, & Rashotte, 2012). The participants had to read lists of sight words (Sight Word Efficiency (SWE)) and nonwords (Phonological Decoding Efficiency (PDE)) out loud for 45 seconds. The correct number of words and nonwords read in that time was recorded. The reported test-retest reliability coefficient for the sight word efficiency is 0.84 and for phonemic decoding efficiency is 0.90.

Reading comprehension was measured with the Woodcock Reading Mastery Tests-Revised Passage Comprehension task (WRMT-R; form H; Woodcock, 1998). Participants had to silently read sentences that had missing words and fill in the missing word by saying the word out loud. The test was administered in the recommended standardized format and the session ended after six consecutive errors. The score was the number of correctly named missing words. The reported split-half reliability for this age group is 0.92.

**Sentences.** A set of 15 sentences (331 words) adapted from Lehman et al. (2007) was presented on a computer screen and used to collect information about adolescents' eye movement patterns. The sentences were presented in the context of a text that explained the causal chain involved in the formation of lightning. The font was 17-point Times New Roman. The text was presented in columns, similar to information found in textbooks.

**Text comprehension questions.** The students were presented with nine text comprehension questions assessing the information recalled and understood from the text. Some of these questions were taken from Mayer's (2009) set of questions that corresponded with the text. The following are two examples of different questions that students were asked to answer: (1) What two types of particles are needed to create the electrical charge? (2) Imagine you see a cloud with an extended top. Explain what is happening.

Once students were done reading the text they were asked to write down their answers and to try to answer as many questions as possible based on the information they had just read. Students were encouraged to try their best to answer all questions and were not given any time limits.

The performance of each student was scored by adding up the number of correct answers given for each question. A maximal total of 17 points could be given. A marking rubric containing the amount of information required for each answer was used to score the answers.

Two independent raters scored the responses. One rater scored all protocols while another scored 20% of randomly selected protocols. Kappa statistics were computed to determine inter-rater reliability. Reliability was computed for each question and ranged from 0.48 to 1 with a mean of 0.73.

Eye movements were recorded using the SR Research Ltd EyeLink 1000 Plus system. The EyeLink 1000 Plus has a high degree of accuracy (0.5°) and a sampling rate of 1000 Hz. This system has a camera and an infrared sensor; the camera was placed at the bottom of the computer screen facing the participant. The system tracks the dominant eye. The participants placed their chin on a chin rest 60 cm in front of the computer screen to minimize head movements. A nine-point calibration procedure was used.

### **Procedure**

Each participant was tested individually in one session lasting approximately 35 minutes. This session was completed in a room at the junior high school. Participants completed the reading tasks and the eye-tracking task in a randomly assigned order. For the eye-tracking task, participants were informed that a text would be presented on the computer screen and they needed to read the text as they would read any other text presented in a textbook. To ensure that the camera was properly calibrated, a fixation point appeared in the left corner of the screen before each page was presented. After completing the session, participants were debriefed, thanked and dismissed.

### **Eye-tracking data**

Eye movement data were coded with the EyeLink Data Viewer software. This program presents the pages of the text and superimposes the positions of the fixations made by the participant. The eye movement measures of interest for this study are presented in Table 1.1. All

eye movement measures were taken for each word. Saccades and regressions amplitudes were not counted for words appearing at the end or start of a line. Saccades and regressions are both within-word and between-word measures.

Table 1.1

*Summary of Eye Movement Measures as Dependent Variables*

<b>Eye movement measures</b>	<b>Description</b>	<b>Code</b>
Number of fixations	Total number of fixations made on all words	NFix
Fixation duration (msec)		
Average first	Average duration of the first forward fixation on the word	First
Average gaze	Average summed duration of all forward fixations on the word before leaving the word	Gaze
Average total	Average summed duration of all fixations on the word	Total
Saccades		
Total number	Summed number of saccades made on words	NSacc
Average amplitude (character length)	Average length of a saccade on a word	SaccAmp
Regressions		
Regression frequency	Amount of regressions made on words	RegFeq
Percentage of regression	Percentage of saccades that are regressions	PerReg
Average amplitude (character length)	Average length of a regression on a word	RegAmp

## Results

### Descriptive

Descriptive statistics for all standardized variables, eye movement variables, and text comprehension are presented in Table 1.2. Distributional properties were examined for each variable. An inspection of the data plots showed an outlier on the First, Gaze, and Total fixation duration measures, one each on SaccAmp and text comprehension, and three on the NFix measure. The outlying scores were changed to one unit above the highest score in the sample that was not an outlier (see Tabachnick & Fidell, 2007). No violations of the assumptions of

normality, heteroscedasticity or linearity were observed. As indicated in Table 1.2, values of skewness and kurtosis fell in the acceptable range of -1.0 and 1.0 (Tabachnick & Fidell, 2007).

Table 1.2.

*Descriptive Statistics for all Measures*

	Mean	SD	Minimum	Maximum	Skewness	Kurtosis
Age	13.18	0.75	12	14	-.30	-1.11
PC <sup>a</sup>	105.50	9.12	85	123	-.07	-.58
SWE <sup>a</sup>	109.38	15.63	85	137	.37	-1.09
PDE <sup>a</sup>	104.35	12.07	81	131	.31	-.37
Txt Comp	3.87	1.68	1.50	8.00	.59	-.50
First	160.01	38.58	82.31	243.70	.10	-.03
Gaze	202.76	64.25	82.80	341.91	.47	-.02
Total	286.40	100.43	103.21	492.70	.49	-.14
NFix	382.90	94.43	171	548	-.06	-.25
RegFreq	20.25	9.95	4.81	43.54	.73	-.30
PerReg	16.75	5.63	7.62	29.25	.48	-.82
RegAmp	6.98	1.59	4.74	11.38	.86	.26
Nsacc	318.25	78.44	149	487	.43	.46
SaccAmp	9.62	1.48	7.00	13.48	.64	.13

Note. PC = Woodcock Reading Mastery Tests-Revised Passage Comprehension task; SWE = Sight Word Efficiency; PDE = Phonemic Decoding Efficiency; Txt Comp = Text comprehension; First = Average first fixation duration; Gaze = Average gaze fixation duration; Total = Average total fixation duration; Nfix = Number of fixations; Nsacc = Total number of saccades; SaccAmp = Average saccade amplitude; PerReg = Percentage of regressions; RegFreq = Regression frequency; RegAmp = Average regression amplitude. <sup>a</sup>Standardized score.

### Correlations

Pearson correlation coefficients among the variables are displayed in Table 1.3. As shown in Table 1.3, age did not correlate with any other variable. Passage Comprehension (PC) was significantly correlated with the fixation duration variables (First, Gaze, and Total), as well as

with the saccade variables (NSacc, and SaccAmp). Sight Word Efficiency (SWE), a subtest of TOWRE-II, only correlated with the Phonemic Decoding Efficiency (PDE) subtest of the same test. The PDE correlated significantly with all fixation duration variables (First, Gaze, and Total) as well as with the two saccade variables (NSacc and SaccAmp). Three of the dependent variables (NFix; RegFreq; RegAmp) did not correlate with any of the independent variables. The text comprehension variable was significantly correlated with the average First variable as well as the PerReg. The correlations between the reading and the eye movement measures can be considered moderate (Tabachnick & Fidell, 2007).



Table 1.3.

*Correlations of Standardized Reading Tests, Text Comprehension and Dependent Variables*

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Age	–												
2. PC	.070	–											
3. SWE	-.098	.304	–										
4. PDE	-.132	.359*	.787**	–									
5. Txt Comp	.069	.167	-.145	.090	–								
6. First	-.114	-.461**	-.155	-.329*	-.355*	–							
7. Gaze	-.146	-.465**	-.223	-.398*	-.309	.963**	–						
8. Total	-.138	-.366*	-.206	-.353*	-.141	.868**	.930**	–					
9. NFix	-.118	-.269	-.216	.303	.039	.743**	.825**	.932**	–				
10. NSacc	-.057	-.338*	-.281	-.392*	-.077	.817**	.891**	.917**	.921**	–			
11. SaccAmp	.131	.431**	.204	.370*	.300	-.810**	-.824**	-.730**	-.741**	-.835**	–		
12. PerReg	-.174	.066	.040	.098	.357*	-.010	.020	.295	.372*	.053	.132	–	
13. RegFreq	-.157	-.043	-.067	-.054	.269	-.355*	.443**	.701**	.783**	.538**	-.272	.842**	–
14.RegAmp	-.165	.136	.194	.262	.149	-.119	-.177	-.110	-.098	-.163	.248	.144	.052

*Note.* PC = Woodcock Reading Mastery Tests-Revised Passage Comprehension task; SWE = Sight Word Efficiency; PDE = Phonemic Decoding Efficiency; Txt Comp = Text Comprehension; First = Average first fixation duration; Gaze = Average gaze fixation duration; Total = Average total fixation duration; NFix = Number of fixations; NSacc = Total number of saccades; SaccAmp = Average saccade amplitude; PerReg = Percentage of regressions; RegFreq = Regression frequency; RegAmp = Average regression amplitude.

\* $p < .05$ ; \*\* $p < .01$

### **Hierarchical regression analyses**

To determine the effects of word reading ability and reading comprehension on eye movement measures, a series of nine hierarchical regression analyses were conducted. Age was not included in these analyses since it was not associated with any dependent variable. Further, as the two TOWRE-II measures were highly correlated, and only PDE correlated significantly with the dependent variables, PDE was chosen to represent word reading/decoding skills. Standardized scores from PDE and PC were then used to predict the eye movement measures. PDE and PC did not jointly explain significant variance in the NFix, PerReg, RegFreq, and RegAmp, and for this reason we do not report the results of these analyses. A summary of the remaining analyses can be found in Table 1.4.

When PDE and PC were entered to predict first fixation durations, the model explained 24% of the variance  $F(2, 39) = 5.94; p = .006$ . PC was the only significant predictor ( $\beta = -.187, p = .014$ ). The model for Gaze explained 28% of the variance  $F(2, 39) = 7.12; p = .002$ , and again only PC was significant ( $\beta = -.370, p = .018$ ). When PDE and PC were entered to predict Total, the model explained 19% of the variance,  $F(2, 39) = 4.35; p = .020$ , but neither predictor was significant after controlling for the other. In terms of the NSacc, the model explained 20% of the variance,  $F(2, 39) = 4.58; p = .017$ . PDE was a marginally significant predictor ( $\beta = -.311, p = .056$ ). When PC and PDE were entered to predict SaccAmp, the model explained 24% of the variance  $F(2, 39) = 5.81; p = .006$ . Again, PC ( $\beta = .342, p = .035$ ) was the only significant predictor.

Table 1.4.

*Summary of Hierarchical Multiple Regression Predicting Eye Movement Measures*

	<i>R</i>	<i>R</i> <sup>2</sup>	<i>B</i>	<i>SE</i>	<i>t</i>
First	.493	.243**			
PDE			-.599	0.490	-1.23
PC			-1.665	0.648	-2.57*
Gaze	.527	.278**			
PDE			-1.414	0.796	-1.78
PC			-2.605	1.054	-2.47*
Total	.436	.190*			
PDE			-2.115	1.318	-1.60
PC			-3.025	1.745	-1.73
NSacc	.446	.199**			
PDE			-2.022	1.024	-1.97
PC			-1.946	1.356	-1.44
SaccAmp	.489	.239**			
PDE			0.030	0.019	1.61
PC			0.055	0.025	2.22*

*Note.* PC = Woodcock Reading Mastery Tests-Revised Passage Comprehension task; PDE = Phonemic Decoding Efficiency. First = Average first fixation duration; Gaze = Average gaze fixation duration; Total = Average total fixation duration; NSacc = Total number of saccades; SaccAmp = Average saccade amplitude.

\* $p < .05$ ; \*\* $p < .01$

### **Eye movements and text comprehension**

A multiple regression was calculated to evaluate whether eye movement measures predict the comprehension of the text that students were reading. Because the fixation measures (first, gaze, total and number of fixation) were all highly correlated, first fixation duration was chosen

to be included in the model as it was highly correlated with text comprehension. As for the saccade measures, saccade amplitude was chosen to be included as it was the only saccade measure that correlated with text comprehension. As for the regression measures, the percentage of regressions was selected as it correlated significantly with text comprehension. The first model included First, SaccAmp, and PerReg and showed that when all three variables were entered to predict text comprehension, the model explained 25% of the variance  $F(3, 39) = 4.08; p = .014$ . Percentage of regressions ( $\beta = 0.365, p = .018$ ) was the only significant unique predictor. Next, SaccAmp was removed, as it was the least significant variable in the model. The second model with First and PercReg as predictors was significantly related to text comprehension  $F(2, 39) = 6.19; p = .005$ , and explained 25% of the variance. Both First ( $\beta = -.351, p = .018$ ) and PerReg ( $\beta = 0.353, p = .018$ ) were significant predictors. A summary of the analysis can be found in Table 1.5.

Table 1.5.

*Summary of the Regression Analyses*

	<i>R</i>	<i>R</i> <sup>2</sup>	<i>B</i>	<i>SE</i>	<i>t</i>	VIF
Model 1	.504	.254**				
First			-.019	0.011	-1.718	2.99
SaccAmp			-.107	0.285	-0.377	3.04
PerReg			.109	0.044	2.479*	1.05
Model 2	.501	.251**				
First			-.015	0.006	-2.467*	1
PerReg			.217	0.162	1.344*	1

*Note.* First = Average first fixation duration; SaccAmp = Average saccade amplitude; PerReg = Percentage of regression.

\* $p < .05$ ; \*\* $p < .01$ .

## Discussion

Eye movement measures of junior high students were recorded in order to investigate their association with differences in reading skills and developmental changes. The first research question was whether age, word reading ability and reading comprehension ability would predict eye movements during a reading task. Results revealed that age was only weakly correlated with all of the outcome variables. The fact that age did not correlate with the eye movement measures indicates that relevant biological changes are either not occurring between the ages of 12-14 or they are not sufficient to impact eye movement control. This finding aligns with those stating that as of age 11, a child's eye movements in reading are relatively stable (Blythe & Joseph, 2011).

In terms of word reading, SWE (measured by the TOWRE SWE test) was not significantly correlated with any of the outcome variables. Hence, the ability to identify words quickly did not predict how young adolescents moved their eyes while reading the test text. However, PDE (as measured by the TOWRE PDE test) and PC (as measured by WRMT-R) were positively correlated to one another and negatively correlated with the fixation duration variables (First, Gaze; PDE was also negatively correlated with Total) and with the NSacc, and positively correlated with SaccAmp: better decoding and comprehension ability were associated with shorter fixations on words before moving onto the next, and with fewer but longer saccades. Regression analyses indicated that students with higher PC scores spent less time processing the word when they first looked at it (First fixation duration). Because no association was found between eye movement measures and SWE, quick word recognition is likely not the key factor. Instead, this pattern of results suggests that the eye movement measures were determined by the adolescents' ability to integrate the new information with what they had already read, a significant task, as the text was conceptually complex.

In addition, when comprehension ability was controlled, decoding ability remained a marginally significant predictor for the NSacc. This result recognizes that good phonemic decoding ability will have some influence on how many forward movements the eyes will make in a reading task. Nonword reading can relate to the ability to read new words efficiently, perhaps in chunks, which would result in fewer movements within the word and earlier previewing of the following word (e.g., Balota, Pollatsek, & Rayner, 1985).

Thus, our results indicate that decoding and comprehension abilities predict some eye movement measures, with comprehension ability, as measured by WRMT-R's passage comprehension test, being a significant unique predictor of the majority of the measures. In an earlier study, Kuperman and Van Dyke (2011) reported that word reading accuracy was a robust predictor of eye movement measures for their 16-to 24-year-old participants in a sentence-reading task. In contrast, our results showed that for students ranging from 12 to 14 years old, the ability to identify words efficiently did not predict eye movement while reading a text. Further, in Kuperman and Van Dyke's study, reading comprehension, measured with the Peabody Individual Achievement Test-Revised, had a significant effect on their participants' eye movement measures. This result is in line with ours. This suggests that an adolescent's reading comprehension score can predict the time spent on one word before moving onto another and can also predict the size of the adolescent's eye movements. This result does not come as a surprise as it has been shown in the past that reading ability is one factor that can impact eye movements (e.g., Rayner, 1998). Additionally, our result also emphasizes the importance of comprehension ability rather than word reading skill. It is possible that the results reported here reflect the fact that the text was conceptually challenging but did not include many complex words—if the text contains many difficult or unfamiliar words, it is possible that word recognition becomes more important.

The second research question examined whether the eye movement measures predicted comprehension of the text being read, as opposed to general reading comprehension ability. The results show that the percentage of regressions and first fixation durations both predicted text comprehension. The amount of variance explained by these two measures was 25%. First fixation durations were negatively correlated with text comprehension, indicating that students who needed less time identifying and reading the word during their first encounter with the word had better comprehension scores. This result is similar to the one found in the first question when examining PC; the ability to generally and specifically comprehend a text are both related to first fixation duration. Thus, if an adolescent spends more time on a word when he/she first fixates on it, this likely indicates a struggle with the word to text integration.

Next, a positive correlation was found between the percentage of regressions and text comprehension: students who made more backward saccades comprehended this particularly difficult text better than the students who made fewer regressions. Given that reading comprehension ability (as measured by WRMT-R) was not correlated with the percentage of regressions, this result likely reflects a strategy choice: students who were more motivated to comprehend the text decided to reread the text or parts of it in order to understand it better. This finding adds to the literature suggesting that regressions are important for comprehension as they help in obtaining the information needed to accurately comprehend the text (e.g., Schotter et al., 2014). Our results also emphasize the fact that the reader controls his/her eye movements during a reading task. A certain percentage of saccades will be regressions, not simply because of an oculomotor error but because the reader decides to review the information to increase his/her understanding (Bicknell & Levy, 2011).

## **Limitations**

A limitation of our study that is worth mentioning is the small sample size and the use of single measures of decoding, word reading and comprehension. A much larger sample and wider variety of measures are required to increase validity and power. Consequently, this study is more of an exploratory study that will require replication. A second limitation lies in the eye movement measures, more specifically in the regression and saccade measures. More refined measures, such as type of regression and saccade (within or between words), are needed in order to better understand how regressions and saccades are related to reading ability and text comprehension. A third limitation worth mentioning is that students were unable to return to a previously read screen. Regressions are an important aspect of reading comprehension and the fact that students were only able to make regressions on the screen they were reading and not go back to a previous screen may have impacted their overall comprehension of the text. Access to previous screens needs to be considered in future studies.

## **Conclusion**

This study was conducted in the interest of acquiring information about junior high students' eye movements in a reading task, as little research can be found about this age group. Age and sight word efficiency did not relate to the eye movement measures, but PDE and PC did. When examining how eye movement measures predicted text comprehension, first fixation durations and percentage of regressions were both found to be predictors. We suggest that the first captures the word-to-text integration processes and the second relates to strategic decisions to reread information.



## References

- Baker, L., & Brown, A. L. (1984). Metacognitive skills and reading. In P. D. Pearson, R. Barr, M. L. Kamil, & P. Mosenthal (Eds.), *Handbook of reading research* (pp. 353–394). Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.
- Balota, D. A., Pollatsek, A., & Rayner, K. (1985). The interaction of contextual constraints and parafoveal visual information in reading. *Cognitive Psychology*, *17*, 364–390. doi: 10.1016/0010-0285(85)90013-1
- Bicknell, K., & Levy, R. (2011). Why readers regress to previous words: a statistical analysis. *Proceedings of the Annual Meeting of the Cognitive Science Society*, *33*, 931–936. Retrieved from <https://escholarship.org/uc/item/7jf4w8sv>
- Blythe, H. I., & Joseph, H. S. S. L. (2011). Children's eye movements during reading. In S. P. Liversedge, I. D. Gilchrist, & S. Everling (Eds.), *The Oxford handbook of eye movements* (pp. 643–662). New York: Oxford University Press.
- Buswell, G. T. (1922). *Fundamental reading habits: A study of their development*. Chicago: University of Chicago Press.
- Chace, K. H., Rayner, K., & Well, A. D. (2005). Eye movements and phonological parafoveal preview benefit: Effects of reading skill. *Canadian Journal of Experimental Psychology*, *59*, 209–217. doi: 10.1037/h0087476
- Huestegge, L., Radach, R., Corbic, D., & Huestegge, S. M. (2009). Oculomotor and linguistic determinants of reading development: A longitudinal study. *Vision Research*, *49*(24), 2948–2959. doi: 10.1016/j.visres.2009.09.012
- Just, M. A., & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review*, *87*(4), 329–354. doi: 10.1037/0033-295X.87.4.329

- Just, M. A., & Carpenter, P. A. (1984). Using eye fixations to study reading comprehension. In D. E. Kieras & M. A. Just (Eds.), *New methods in reading comprehension research*, (pp.151–182). Hillsdale, NJ: Erlbaum.
- Kendeou, P., van den Broek, P., White, M.J., & Lynch, J. (2007). Comprehension in preschool and early elementary children: Skill development and strategy interventions. In D. S. McNamara (Ed.), *Reading comprehension strategies: Theories, interventions and technologies* (pp. 27–45). New York: Lawrence Erlbaum Associates.
- Kuperman, V., & Van Dyke, J. A. (2011). Effects of individual differences in verbal skills on eye-movement patterns during sentence reading. *Journal of Memory and Language*, *65*, 42–73. doi: 10.1016/j.jml.2011.03.002
- Mayer, R.E. (2009). *Multimedia learning* (2<sup>nd</sup> edition). Cambridge: Cambridge University Press.
- McConkie, G. W., Zola, D., Grimes, J., Kerr, P. W., Bryant, N. R., & Wolff, P. M. (1991). Children's eye movements during reading. In J. F. Stein (Ed.), *Vision and visual dyslexia*, *13*, (pp.251–262). London: Macmillan Press.
- Oakhill, J., & Cain, K. (2007). Issues of causality in children's reading comprehension. In D. S. McNamara (Ed.). *Reading comprehension strategies: Theories, interventions and technologies*, (pp. 47–71). New York: Lawrence Erlbaum Associates.
- Perfetti, C. A. (1985). *Reading ability*. New York: Oxford University Press.
- Rayner, K. (1985). The role of eye movements in learning to read and reading disability. *Remedial and Special Education*, *6*, 53–60. doi: 10.1177/074193258500600609
- Rayner, K. (1986). Eye movements and the perceptual span in beginning and skilled readers. *Journal of Experimental Child Psychology*, *41*, 211–236. doi: 10.1016/0022-0965(86)90037-8

- Rayner, K. (1995). Eye movements and cognitive processes in reading, visual search, and scene perception. In J. M. Findlay, R. W. Kentridge, & R. Walker (Eds.), *Eye movement research: Mechanisms, processes and applications* (pp. 3–22). Amsterdam: Elsevier.
- Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, *124*, 372–422. doi: 10.1037/0033-2909.124.3.372
- Rayner, K. (2009). Eye movements and attention in reading, scene perception, and visual search. *Quarterly Journal of Experimental Psychology*, *62*, 1457–1506. doi: 10.1080/17470210902816461
- Rayner, K., & Duffy, S. A. (1986). Lexical complexity and fixation times in reading: Effects of word frequency, verb complexity, and lexical ambiguity. *Memory & Cognition*, *14*(3), 191–201. doi: 10.3758/BF03197692
- Rayner, K., & Pollatsek, A. (1989). *The psychology of reading*. Englewood Cliffs, NJ: Prentice Hall.
- Schotter, E. R., Tran, R., & Rayner, K. (2014). Don't believe what you read (only once) comprehension is supported by regressions during reading. *Psychological Science*, *25*(6), 1218–1226. doi: 10.1177/0956797614531148
- Shankweiler, D., Lundquist, E., Dreyer, L. G., & Dickinson, C. C. (1996). Reading and spelling difficulties in high school students: Causes and consequences. *Reading and Writing*, *8*, 267–294. doi: 10.1007/BF00420279
- Sperlich, A., Meixner, J., & Laubrock, J. (2016). Development of the perceptual span in reading: A longitudinal study. *Journal of Experimental Child Psychology*, *146*, 181–201. doi: 10.1016/j.jecp.2016.02.007
- Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5<sup>th</sup> ed). Boston: Pearson Education, Inc.

- Taylor, S. E. (1965). Eye movements in reading: Facts and fallacies. *American Educational Research Journal*, 2, 187–202. doi: 10.3102/00028312002004187
- Torgesen, J., Wagner, R., & Rashotte, C. (2012). Test of Word Reading Efficiency (TOWRE 2). Austin, TX: Pro-Ed.
- Wittrock, M. C., Marks, C., & Doctorow, M. (1975). Reading as a generative process. *Journal of Educational Psychology*, 67, 484-489. doi: 10.1037/h007017
- Woodcock, R. W. (1998). *Woodcock Reading Mastery Tests - Revised*. Circle Pines, MN: American Guidance Service.

### Chapter III: Examining the impact of seductive details on junior high students' learning

#### **Introduction**

There have been diverse attempts to increase students' interest in textbook reading in order to help with their learning (e.g., Hidi, 2001; Lehman, Schraw, McCrudden, & Hartley, 2007; Schraw, 1998). The argument is that the material presented in textbooks needs to be enjoyable and emotionally engaging for the students, and in order to achieve this goal, textbooks often include additional information in the format of text and/or images. This is commonly seen in science education where additional images and illustrations can depict the same information that is explained in the text and thus be informative (Mason, Tornatora, & Pluchino, 2013), or they can depict something interesting, but irrelevant for the comprehension of the text (Wade & Moje, 2000). Information that is supposedly interesting but irrelevant for the comprehension of the content is known as seductive details (Garner, Alexander, Gillingham, Kulikowish, & Brown, 1991; Garner, Gillingham, & White, 1989; Harp & Mayer, 1997; 1998; Moreno & Mayer, 2000; Sanchez & Wiley, 2006). The purpose of this study was to examine how including seductive text and images affects junior high students' emotional and cognitive interest, text processing time, and reading behaviours, including comprehension.

#### **Seductive details and interest**

Several studies have identified a relationship between interest, attention and learning (Park & Lim, 2007; Schraw & Lehman, 2001). Interest can be temporarily stimulated in a learning task (situational interest) or it can reflect students' personal preferences toward something (individual interest; Hidi, 2006). Based on Hidi and Renninger's (2006) interest model, teachers can help students to increase their interest levels in a given subject by triggering and maintaining their situational interest, which should eventually lead to an increase in their individual interest in the subject. For example, presenting a text containing elements of surprise,

originality, and personalization can have a positive effect on situational interest (Flowerday, Schraw, & Stevens, 2004; Iran-Nejad, 1987) and increase the level of comprehension and recall of information (Park & Lim, 2007). Similarly, images can help improve cognitive interest if they help students to comprehend the explanation presented in the text or they can increase emotional interest. If the level of emotional interest is increased, it is expected to cause the student to continue to pay attention to the information, which will in return help them learn (Kintsch, 1980).

A few studies have examined seductive details and interest (e.g., Harp & Mayer, 1997; Magner, Schwonke, Alevén, Popescu, & Renkl, 2014; Park, Flowerday, & Brünken, 2015). These studies have used different types of interest rating scales presented to participants at different points in the experiment. For example, Harp and Mayer (1997) conducted two experiments examining seductive details' impact on emotional and cognitive interests with the use of an illustrated scientific text. For their first experiment, university students were assigned to one of five conditions where they were asked to read an illustrated passage on the process of lightning. All conditions included a base text (550 words) alongside six captioned informative illustrations. Additional information was added to other conditions that included six captioned seductive illustrations and/or seductive text (150 words). Once the passage was read, students filled out an interest inventory, examining emotional (e.g., while reading the passage I felt interested) and cognitive interest (e.g., I found the information to be useful) with four Likert scale questions. No significant differences were found in the interest levels between conditions and Harp and Mayer hypothesized that students were unable to distinguish between emotional and cognitive interest.

Harp and Mayer's (1997) second experiment examined the levels of interest further with a new, more refined, interest survey containing six items on a 10-point Likert scale. University students read the passage with seductive details used in Study 1. Next, the interest survey with a

booklet containing the same passage they had read was given to them with seductive text, base illustrations and captions, and seductive illustration and captions highlighted in different colors and the students were asked to rate each highlighted section separately. Students did not have to answer any recall or transfer questions. Seductive text and illustrations were rated high in emotional interest and low in cognitive interest. Base text and illustrations and all captions were rated high in cognitive interest and low in emotional interest.

Other studies have also found positive effect of seductive details on situational interest (cognitive and emotional) (Park et al., 2015; Park, Moreno, Seufert, & Brünken, 2011; Schraw, 1998). For example, Park et al. (2015) conducted an experiment with university students containing a multimedia science lesson. Modality (narration vs. text) of the lesson and the presence of seductive details were manipulated. Situational interest was measured with an interest questionnaire (looking at emotional and cognitive interest), containing 10 items and a five-point Likert scale, given to the students after they had finished the lesson. The results indicated that the students rated their situational interest higher for the narrated seductive details condition than the other conditions. In fact, the narrated seductive details significantly improved students learning and situational interest.

Magner et al. (2014) examined the impact of seductive illustrations on situational interest in a computer-based learning environment. The seductive illustrations were rated higher on emotional interest than on cognitive interest during a pre-study with a 6-item 9-point Likert scale. Grade 8 students then participated in a geometry lesson containing a variety of problems shown with or without seductive illustrations. Once a problem was completed the students were asked to rate their level of emotional and cognitive interest on a 9 point-Likert scale; thus, interest was measured as the students moved along the lesson to examine if situational interest could be

triggered and maintained by the illustrations. Results showed that the illustrations triggered but did not maintain neither emotional nor cognitive situational interest during the task performance.

### **Seductive details and learning**

Research on the effects of seductive details on learning has mostly focused on university students and produced mixed results with some studies reporting negative effects (e.g., Harp & Mayer, 1997, Exp.1; Lehman et al., 2007, Exp.2; Rowland, Skinner, Davis-Richards, Saudargas, & Robinson, 2008; Rowland-Bryant et al., 2009), others reporting mixed effects (e.g., Garner et al., 1989, Exp.1, 2; Garner et al., 1991, Exp.1, 2; Mayer, Griffith, Jurkowitz, & Rothman, 2008, Exp.1, 2; Rey, 2011), and yet others reporting no effects (e.g., Garner & Gillingham, 1991; Hidi & Baird, 1988; Schraw, 1998; see Rey, 2012, for a review).

A possible reason for differences in results in existing empirical studies is the lack of control for potential confounding variables. Several studies have suggested variables that can moderate the effects of seductive details, such as the age, reading ability, and working memory capacity of the participants (e.g., Mayer, Heiser, & Lonn, 2001; McCrudden & Corkill, 2010; Park et al., 2011; Park et al., 2015; Rey, 2012). For example, even university students show variability in reading skills (e.g., Deacon, Cook, & Parrila, 2012) that can influence the seductive detail effect. A skilled reader has strategies (such as comprehension monitoring, e.g., Oakhill & Cain, 2007) that could negate the seductive details' impact on their overall comprehension and learning. In addition, students with less working memory capacity may experience difficulties in integrating new information with their background knowledge into a coherent mental model (McVay & Kane, 2012). Thus, students with less working memory capacity could be affected more by the inclusion of seductive details in comparison to those with more working memory capacity. Related to working memory, the ability to control attention can impact learning outcomes in general (Sanchez & Wiley, 2006) and may be particularly important in learning



situations where some of the presented material is of lesser or no importance to the learning task. Finally, the ability to construct a coherent mental representation of the story and to identify different types of connections develops with age. As children grow older they are able to focus more deeply on the story and use their background knowledge to make connections within the text and between the text and their existing knowledge (Kendeou, van den Broek, White, & Lynch, 2007). Younger students may also find seductive details more interesting than older students and this alone can affect their recall. Thus, age is one reader characteristic that is likely to mediate the seductive detail effect.

Only a few studies have examined how seductive details affect younger students (Garner et al., 1989; Hidi & Baird, 1988; Magner et al., 2014; Park et al., 2011; Shen, McCaughtry, Martin, & Dillion, 2006; Wang & Adesope, 2016) and they have produced conflicting results as well. For example, in Magner et al. (2014) study reviewed above, learning outcomes were poorer for the students exposed to the seductive illustrations who had low prior knowledge of geometry, whereas students with high prior knowledge learned more when seductive illustrations were present. Shen et al. (2006), in turn, used video lessons about net games in physical education with Grade 6 to 8 students to test the seductive detail effect. The students were presented either the original video, which was 6 minutes long and had approximately 1000 spoken words containing seductive details, or a revised video that was 5 minutes long and had approximately 840 words. A seductive detail effect was found for both retention and transfer scores: Students who viewed the video with seductive details recalled fewer main ideas of the lesson and obtained lower scores on the transfer measure than those in the control condition. No grade effect was found for retention, but it was found for the transfer measure with Grade 8 students having higher scores than Grade 6 and 7 students (Shen et al., 2006). This result supports Hidi and Baird's (1988) assumptions that developing general comprehension strategies could be associated with age and cognitive

development. Garner et al. (1989) examined the effect of seductive details in two experiments, one with adults and one with Grade 7 students. In both experiments, participants read either a base text (162 words) or a text with seductive details (225 words) about insects. A third condition in the second experiment included signaling the important facts in the base text by an explicit macroproposition, with the use of a label, or graphically by changing the appearance of the font. In Grade 7, the seductive detail group and the group with signaling differed on the recall task performance, with those in the seductive detail group recalling less information. The second post-task asked participants to match pictures on the basis of differences presented in the text; for Grade 7, students in both the base text group and the signaling group outperformed the seductive detail group on this task.

In contrast, Hidi and Baird (1988) and Park et al. (2011) did not find any effects of seductive details. In Hidi and Baird's (1988) study, Grade 4 and 6 students read a base text (44 sentences in Grade 4 and 58 sentences in Grade 6) about famous inventors and their inventions or the same text with additional seductive details in text (58 sentences in Grade 4 and 77 sentences in Grade 6). A third condition included a modified version of the seductive details text with the need to find a resolution (63 sentences in Grade 4, 84 sentences in Grade 6). No differences were found on the immediate and delayed recall of either important or unimportant information. In sum, with only a few studies showing mixed results, the effect of seductive details on younger readers is still unclear and more research is needed.

### **Current Study**

In the current study, we presented Grade 7 to 9 students a text with images that have been previously found to be interesting as well as having produced a negative seductive detail effect (Harp & Mayer, 1997, 1998; Lehman et al., 2007). We chose to use materials from existing studies in order to ensure that the selected materials were indeed rated as informative or

seductive. Four different conditions were created: (1) base text with five informative images, (2) base text with five seductive images, (3) seductive text with five informative images, and (4) seductive text with five seductive images. Further, we controlled for multiple reader characteristics – prior knowledge, reading ability, working memory, and attention – that could moderate the influence of seductive details. These four reader characteristics could account for some of the inconsistencies in existing research.

In order to expand our understanding of how information is perceived during the reading task, we evaluated the students' interest throughout the experiment. Students were asked to evaluate multiple times during their reading how interesting and important the text presented on the screen was to them. This method allowed us to capture the level of interest experienced by the students as they were processing the information. Furthermore, it allowed us to examine whether seductive details – that had been rated in previous studies as interesting *a priori* or without the demand of learning the text – were indeed perceived as interesting during the learning task. Very few studies have examined participants' level of interest online when presenting seductive information and this can be a critical component to help us understand the conflicting results of previous studies.

We included both text and images to inspect whether different combinations of materials can influence students' interest, text comprehension, and text processing time, and used eye-tracking to investigate where on the presented information students' focus their attention and for how long. In this study, attention allocation is measured by the total time spent fixating (looking) at the different types of information (base and seductive sentences, base and seductive images). We speculated that students may choose to ignore or not attend to the seductive details (whether in text or images), and this could influence their interest and overall text comprehension. We expected that (a) if attention is not allocated to the seductive details, their presence should not

impact situational interest as it would not get triggered, and, consequently, comprehension of the text would not be affected. This may have been the case in prior studies where no seductive detail effect was found. In contrast, we expected that (b) if seductive details are attended to and situational interest is triggered and maintained, the students in seductive detail conditions should show better recall and comprehension than those who only receive base information. It is also possible that seductive information is attended to, but this information does not impact interest. We expected that (c) if seductive details are attended to but fail to increase interest, they would have a negative effect on recall and comprehension.

Finally, we examined how long the students processed the material presented to them. Besides the obvious (d) increase in processing time resulting from seductive details making the text longer, we speculated that the inclusion of seductive sentences may break the flow of information and create difficulties in building a coherent representation of the base text. If this is the case, we expected that (e) the reading speed of base sentences could differ between the conditions.

## **Method**

### **Participants**

Fifty-eight junior high students (23 boys and 35 girls; mean age = 13 years,  $SD = 0.79$ ) from a public school in Edmonton, Alberta, took part in this study. The sample was composed of 17 students from Grade 7 (9 boys, 8 girls, mean age: 12 years), 19 students from Grade 8 (6 boys, 13 girls, mean age: 13 years), and 22 students from Grade 9 (8 boys, 14 girls, mean age: 14 years). All the students had normal or corrected-to-normal vision and low knowledge of meteorology as indicated by their score on the weather questionnaire (see below). The school district, parents and participating students all gave permission to conduct the study.

## Measures

**Questionnaire.** A knowledge of weather questionnaire, from Harp and Mayer (1997), was given prior to testing. This questionnaire was used to make sure students did not have prior knowledge that would interfere with the results of the study. The questionnaire asked students to rate their knowledge of meteorology (weather) on a five-point scale ranging from 1 = *very little* to 5 = *very much*. Students also had to indicate if they knew 6 specific aspects of meteorology, such as knowing what a cold front or a low-pressure system is.

**Reading ability.** The students' word and nonword reading fluency was assessed with TOWRE-II (Torgesen, Wagner, & Rashotte, 2012). The students had to read out loud lists of sight words (Sight Word Efficiency; SWE) and nonwords (Phonological Decoding Efficiency; PDE) for 45 seconds. The correct number of words and nonwords read in 45 seconds was recorded. The reported test-retest reliability coefficient for the sight word efficiency is 0.84 and for phonemic decoding efficiency is 0.90 (Torgesen et al., 2012).

Reading comprehension was measured with the Woodcock Reading Mastery Tests-Revised Passage Comprehension task (WRMT-R; form H; Woodcock, 1998). Students had to silently read sentences that had a word missing and fill in the missing word by saying the word out loud. The test was administered in the standardized format and the presentation was discontinued after six consecutive errors. A participant's score was the total number of correct responses. The reported split-half reliability for this age group is 0.92 (Woodcock, 1998).

**Working memory.** Working memory was assessed with the Reading Span task from Singer, Andrusiak, Reisdorf, and Black (1992). Students silently read fourteen sets of unrelated sentences presented on a computer screen one sentence at a time. There were four sets of two sentences, and three sets of three, four and five sentences each. At the end of each set the students were asked to name the last word of the sentence in the same order they read the sentences.

Following the recall task, a sentence from the set that was just presented was shown a second time, but now with two missing words and the students were asked to say what the two missing words were. All sentences were presented for seven seconds. Both the total number of last words and the total number of missing words recalled was recorded. The maximum score was 42 for the recalled words and 24 for the missing words. Cronbach's alpha for this sample was 0.78 for the last words and 0.71 for the missing words.

**Attention.** Attention was measured with the Expressive Attention task (EA) from the Cognitive Assessment System (Naglieri & Das, 1997). This measure consisted of three cards in which the students had to read or name as quickly and accurately as possible the stimuli presented. The first card required the students to read a list of words (names of colors), the second card required them to name colors of rectangles and the last card required them to name the color of the ink in which names of colors were presented. All cards were timed. The expressive attention score is determined with the use of completion time and number of correct answers on the last card. The task has a reported reliability coefficient ranging from 0.71 to 0.93 for these age groups (Naglieri & Das, 1997).

**Emotional and cognitive interests.** Students were asked to respond to two questions at the bottom of each screen to indicate their situational interest of the text they were reading (Magner et al., 2014). The questions asked them to rate how interesting they found the text to be (emotional interest) and how important the information was (cognitive interest). The rating was done with a Likert scale that ranged from 1 = *totally disagree* to 6 = *totally agree*. Students rated each screen by fixating on a number on the Likert scale for 5 seconds.

**Text.** A text, on the process of lightning, adapted from Lehman et al. (2007), was presented on a computer screen in four different formats: base text (656 words) plus base images (5 images), base text (656 words) plus seductive images (5 images); seductive details text (966

words) with base images (5 images); and seductive details text (966 words) with seductive images (5 images). The base text explained the causal chain involved in the formation of lightning and contained seven paragraphs. The seductive text contained the base text with the additional seductive sentences intended to make the passage more interesting (e.g., *Understanding how lightning is formed is important because approximately 150 Americans are killed by lightning every year*). The seductive sentences were incorporated throughout the base text. The seductive text contained a total of seven paragraphs. Both texts were presented in columns, similar to information found in textbooks. Five base illustrations were black and white illustrations, approximately 10 x 15cm in size, supporting the information found in the text. Each illustration had a caption below it that included information found in the base text. These illustrations were taken from previous studies (e.g., Harp & Mayer, 1997). Five seductive images were found in the National Geographic article on lightning (Newcott, 1993). These images captured seductive information found in the seductive text and were also used in previous studies (e.g., Harp & Mayer, 1997). The seductive images were color photographs that also included a caption that highlighted information found in the seductive text (e.g., a picture of a football player struck by lightning and his burned uniform). Each image was approximately 10 x 15cm in size.

**Retention and comprehension questions.** A set of retention questions was created for this study with some taken from Mayer (2009). Five retention questions for the base information were: (1) What is created from differences in electrical charges between a cloud and the ground? (2) What does air temperature have to do with lightning? (3) What two types of particles are needed to create the electrical charge behind lightning? (4) What occurs as a result of the movement between updrafts and downdrafts inside a cloud? (5) What causes lightning? The four comprehension questions were: (1) Suppose you see clouds in the sky, but no lightning. Why

not? (2) Imagine you see a cloud with an extended top. Explain what is happening. (3) Why do you think some thunderstorms produce hailstones and others do not? (4) What could be done to decrease the intensity of a lightning storm? Students were asked to write down their answers as soon as they were done reading the text. The retention questions were presented first followed by the comprehension questions. Students were told to try to answer as many questions as possible based on the information they had just read. If they did not recall information they were asked to guess. For the comprehension questions they were also given the instruction to use the knowledge they had just learned and try to apply this knowledge to the different situations. Students were encouraged to try their best to answer all questions and were not given any time limits.

Two independent raters blind to the conditions scored the responses. The retention performance of each student was scored by adding up the number of correct answers given for each question. A maximal total of 7 points for the retention of the base information could be given. The answers for the comprehension questions were also added up for a possible total of 8 points. A marking grid was created to help raters score the answers based on the amount of information found in each answer. One rater scored all protocols and a second rater scored 20% of randomly selected protocols. Kappa statistics were computed to determine inter-rater reliability. Reliability was computed for each retention question and ranged from 0.66 to 1 with a mean of 0.84. The inter-rater reliability for the raters of the comprehension questions ranged from 0.47 to 0.64 with a mean of 0.58. The reliability for the comprehension questions indicates a moderate agreement (Landis & Koch, 1977; McHugh, 2012).

Eye movements were recorded using the SR Research Ltd EyeLink 1000 Plus system. The EyeLink 1000 Plus has a high degree of accuracy (0.5°) and a sampling rate of 1000 Hz. This



system has a camera and an infrared sensor; the camera is placed at the bottom of the computer screen facing the participant. The system tracks the dominant eye. The students placed their chin on a chin rest 60 cm in front of the computer screen to minimize head movements.

### **Procedure**

Each student was tested individually in one session lasting approximately 90 minutes. The students were randomly assigned to one of the four conditions. Students completed the questionnaires, reading tasks, working memory tasks, attention tasks and the eye tracking task in a randomly assigned order. Students answered the retention and comprehension questions as soon as they were done reading the text. After completing the session the students were debriefed, thanked and dismissed.

### **Data analysis**

Eye movement data were coded with the EyeLink Data Viewer software. This program presents the pages of the text and superimposes the positions of the fixations made by the participant. The eye movement measures of interest for this study are reading time for base and seductive sentences and fixation duration (in milliseconds) for base and seductive images.

### **Statistical Analysis**

Distributional properties were examined separately for the four conditions. Assumptions of normality were violated on the attention measure for base text and images (BT+I) and retention scores for seductive text and seductive images (ST+SI) conditions. Outliers were winsorized following guidelines given in Tabachnick and Fidell (2007). The box plots were examined to identify the outliers. The data was analyzed first using the untransformed scores followed by the second analysis with the transformed scores. When no differences between the transformed and untransformed scores were found, the results with raw scores are reported.

## Results

### Control measures

Descriptive statistics for the control, retention and comprehension measures are presented in Table 2.1 separately for the four conditions. A multivariate analyses of variance (MANOVA) was conducted with reading tasks (TOWRE and WRMT-R) as the dependent variables and condition as the independent variable. The overall effect of condition was not significant (Wilk's  $\lambda = 0.899$ ;  $F(9, 124) = .620$ ;  $p = .778$ ).

Table 2.1.

#### *Means and Standard Deviations of the Control Tasks*

	BT+I (n=14)		BT+SI (n=14)		ST+I (n=15)		ST+SI (n=15)		<i>F</i>	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
<i>TOWRE (standard score)</i>										
SWE	110.79	11.26	105.93	13.59	105.93	15.60	108.67	20.63	.32	
PDE	102.79	9.72	102.36	13.87	100.67	12.10	103.40	14.14	.13	
WRMT-R (standard score)	102.36	9.89	102.93	12.53	103.86	8.40	102.33	14.29	.98	
<i>RSPAN</i>										
Last words	24.36	8.49	24.36	5.17	26.93	7.14	25.93	7.09	.47	
Missing words	6.36	3.57	6.86	3.04	5.93	3.97	5.33	3.35	.66	
EA (ratio score)	65.79	13.77	58.00	11.81	60.40	13.39	63.93	17.86	.83	
Retention (/7)	2.68	1.14	2.61	1.27	2.83	0.79	1.73	1.15	3.03	
Comprehension (/8)	1.61	0.86	1.82	1.15	1.07	0.86	0.97	0.83	2.85	

*Note.* BT+I = base text with base images; BT+SI = base text with seductive images; ST+I = seductive text with base images; ST+SI = seductive text with seductive images; WRMT-R = Woodcock Reading Mastery Tests-Revised Passage Comprehension task; RSPAN = Reading Span; EA = Expressive Attention

Several univariate analyses of variance (ANOVAs) were conducted next in order to examine whether the students in different conditions differed on reading span, working memory and attention measures. The ANOVAs revealed no significant differences between the conditions on any of the measures.

### Situational Interest

Two questions presented at the bottom of each screen of the eye tracking display screen measured the participant's situational interest on the text they were reading (level of interest and importance) on a scale ranging from 1 to 6. The mean score of the situational interest for each participant and condition was computed to examine differences across conditions. Table 2.2 presents the means and standard deviations of the situational interest for each condition separately for the screens that included no seductive information (base screens) and that included seductive text or images (seductive screens).

Table 2.2.

#### *Descriptive Statistics of the Situational Interest per Condition and Type of Information*

	BT+I		BT+SI		ST+I		ST+SI	
	(N=14)		(N=14)		(N=15)		(N=15)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Base screens								
Emotional	3.87	0.87	3.98	1.21	3.86	0.79	3.29	0.93
Cognitive	3.66	1.07	3.50	0.88	3.69	0.25	3.30	1.05
Seductive screens								
Emotional			3.76	1.27	4.09	0.63	3.88	0.76
Cognitive			3.40	0.90	3.82	0.96	5.72	1.07

*Note.* BT+I = base text with images; BT+SI = base text with seductive images; ST+I = seductive text with base images; ST+SI = seductive text with seductive images

Two ANOVAs were computed to examine if differences could be found between the mean levels of interest and the four conditions. The main effect of condition was not significant for the cognitive interest (level of importance),  $F(3, 57) = 0.563$ ;  $p = .642$ ,  $\eta_p^2 = 0.030$ , or the emotional interest,  $F(3, 57) = 0.312$ ;  $p = .817$ ,  $\eta_p^2 = 0.017$ .

Repeated measures ANOVA was conducted to examine if cognitive or emotional interest differed for screens showing base versus seductive information in ST+I and ST+SI conditions.<sup>1</sup> Significant differences were found for cognitive,  $F(1, 29) = 23.865$ ,  $p < .001$ ,  $\eta_p^2 = 0.451$ , and emotional,  $F(1, 29) = 5.341$ ,  $p = .028$ ,  $\eta_p^2 = 0.156$ , interest as well for their interaction  $F(1, 29) = 12.442$ ,  $p < .001$ ,  $\eta_p^2 = 0.300$ . The means in Table 2.2 indicate that screens with seductive information received higher ratings than the base screens in ST+I and ST+SI conditions, and the difference was particularly large for cognitive interest ratings in the ST+SI condition. However, because of the low base screen ratings, the overall mean interest ratings were not higher.

### **Retention and comprehension**

To examine differences in retention and comprehension scores, a MANOVA was conducted with the winsorized scores. The main effect of condition was significant, Wilk's  $\Lambda = .740$ ,  $F(6, 106) = 2.87$ ,  $p = .013$ , as were both univariate effects: retention,  $F(3, 54) = 3.034$ ;  $p = .037$ ,  $\eta_p^2 = 0.144$ , and comprehension,  $F(3, 54) = 2.848$ ;  $p = .046$ ,  $\eta_p^2 = 0.137$ . The means in Table 2.1 indicate that students in ST+SI condition had poorer retention than students in the other three conditions; however, *post hoc* pairwise comparisons (Tukey-HSD) indicated that only the difference between the ST+I and ST+SI conditions was significant ( $p = .040$ ). For comprehension, Table 2.1 indicates that the two BT conditions performed better than the two ST conditions, but *post hoc* pairwise comparisons (Tukey-HSD) revealed no significant differences

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<sup>1</sup> BT+SI condition was excluded from the analysis as the images and their captions were examined only very briefly.

between the four conditions (the difference between BT+SI and ST+SI approached significance at  $p = .077$ ).

We then repeated the MANOVA with cognitive and emotional interest as covariates. These analyses showed that only emotional interest had a significant main effect, Wilk's  $\Lambda = .846$ ,  $F(2, 51) = 4.651$ ,  $p = .014$ , and only for the comprehension score,  $F(1, 52) = 6.082$ ,  $p = .003$ ,  $\eta_p^2 = 0.153$ . Pairwise comparisons of comprehension scores showed that BT+SI performed significantly better than both ST conditions; other results remained the same as above.

Next, two separate ANOVAs were conducted to compare the two text types (base vs. seductive). The main effect of text type was not significant for the retention questions,  $F(1, 56) = 1.181$ ,  $p = .282$ ,  $\eta_p^2 = 0.021$ , but was for the comprehension questions,  $F(1, 56) = 8.317$ ,  $p = .006$ ,  $\eta_p^2 = 0.129$ . Students who read the base text obtained on average higher comprehension scores than did those who read the seductive text.

Finally, separate ANOVAs were conducted to investigate if the images would impact the retention and comprehension scores. Two conditions were created for the two types of images (base and seductive). The main effect of condition was not significant for the comprehension scores  $F(1, 56) = 0.040$ ;  $p = .842$ ,  $\eta_p^2 = 0.001$ , but was for the retention scores,  $F(1, 56) = 4.173$ ;  $p = .046$ ,  $\eta_p^2 = 0.069$ . Students presented with base images achieved on average higher retention scores than did students who saw seductive images. This finding is clearly driven by the ST+SI group's poor retention performance.

### **Eye movement data**

**Text processing time.** To examine the students' text processing time, we compared the time spent on the screens (excluding the time spent answering the interest questions) by the type of text presented (base or seductive). The main effect of text type was significant,  $F(1, 57) = 12.68$ ,  $p < .001$ ,  $\eta_p^2 = 0.185$ ; as expected, more time was spent looking at the screens with the

additional seductive details (6 minutes, 06 seconds) than with the base text (4 minutes, 36 seconds).

**Reading speed.** Reading rate was calculated by dividing the number of words by reading time in minutes. Means and standard deviations of reading speed are presented in Table 2.3. An ANOVA showed that the main effect of condition approached significance,  $F(3, 57) = 2.702$ ,  $p = .055$ ,  $\eta_p^2 = 0.131$ . Post-hoc test (Tukey-HSD) showed that the difference between BT+I and BT+SI approached significance ( $p = .054$ ).

Table 2.3.

*Reading Speeds for Each Condition*

	BT+I		BT+SI		ST+I		ST+SI	
	(N=14)		(N=14)		(N=15)		(N=15)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Base sentences	274.7	130.5	185.1	51.3	216.6	81.4	197.8	81.9
Seductive sentences					215.4	74.8	229.6	74.7

*Note.* BT+I = base text with images; BT+SI = base text with seductive images; ST+I = seductive text with base images; ST+SI = seductive text with seductive images

A second comparison was made between reading rate of base sentences and type of information presented (base vs. seductive),  $F(1, 57) = 7.358, p = .009, \eta_p^2 = 0.012$ . Students read base sentences faster (274.73 words per minute) when only base information was presented (BT+I) than when seductive information was added either to the text or as images (BT+SI, ST+I, ST+SI) (200.13 words per minute).

Next, a repeated measures ANOVA was conducted to examine if any differences could be found within the reading speed of the two types of sentences presented (base vs. seductive) for the conditions containing both types of sentences (ST+I and ST+SI). Significant differences were found for sentence type  $F(1, 29) = 6.391, p = .017, \eta_p^2 = 0.181$ . Students read seductive sentences faster (222.46 words per minute) than base sentences (207.17 words per minute).

**Images.** Mean time spent on images as well as the number of images fixated per condition is presented in Table 2.4. ANOVA indicated no significant main effect of condition,  $F(3, 57) = 1.646, p = .190, \eta_p^2 = 0.084$ . When base versus seductive images were contrasted, the difference was not significant,  $F(1, 57) = 0.229, p = .634, \eta_p^2 = 0.004$ . In general, students did not spend much time fixating on the images.

Table 2.4.

*Mean Time Spent on Images (seconds) and Number of Images Fixated*

	BT+I (N=14)		BT+SI (N=14)		ST+I (N=15)		ST+SI (N=15)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Time	4.09	1.87	5.20	2.16	6.40	4.69	4.63	2.02
Number of images fixated (/5)	4.71	0.47	4.07	1.14	4.33	1.05	4.40	0.91

*Note.* BT+I = base text with images; BT+SI = base text with seductive images; ST+I = seductive text with base images; ST+SI = seductive text with seductive images

### Discussion

Research concerning seductive details has often targeted university students, focusing on how the inclusion of seductive details impact their learning outcomes. The present study targeted younger students without any atypical reader characteristics to further investigate if and how the inclusion of seductive details affected emotional and cognitive interests, text comprehension and retention, along with text processing times. Our group of students was matched on a range of measures in order to control for factors that may have contributed to differences found in previous studies. We presented seductive details, found to be seductive in earlier studies, in two formats, sentences and images. A non-fiction text on the formation of lighting was presented with or without the inclusion of seductive details.

We were first interested in whether the students attended to the seductive information. The eye-tracking data shows that students did in fact attend to all seductive information. Seductive sentences were never skipped and on average four out of five seductive images were looked at, albeit very briefly. Since attention was allocated to seductive details, we can validly examine whether they affect interest, comprehension, recall, and text processing. Further, our



results are not in line with an argument that lack of attention to seductive details could account for negative findings in previous studies.

Our second question was whether seductive details would impact situational interest, either emotional or cognitive. We expected that attention to seductive information would trigger and maintain situational interest (hypothesis b). The online examination of interest showed that in general, students' mean interest levels were not different between the four conditions. This result suggests that our group of students may not have found the materials to be sufficiently seductive, although the same materials had been rated as seductive in other studies (e.g., Harp & Mayer, 1997, Exp.2; Lehman et al., 2007). A possible explanation for the non-seductive rating can be that students in the current study may have rated their interest on the basis of how they grasped the information and less on how entertaining it was to them. A second possibility is that the students may have been influenced by the fact that they knew they would be tested on the material and this knowledge played a role in their interest rating. This result resembles the one obtained in Experiment 1 of Harp and Mayer (1997) where university students read a text knowing they would be tested afterwards. These participants were also asked to rate their interest after having read the text and did not rate conditions with seductive information differently than the conditions without seductive information. Interest ratings only changed once students were asked to rate specific information in the text and did not answer questions about it (Harp & Mayer, 1997, Exp.2). Taken together, these studies suggest that, in order to have a more accurate view of the material, it is critical to measure participants' level of interest as they are being exposed to the text under the learning condition.

Despite the fact that there were no mean interest rating differences between the four conditions, seductive details did get noted by those exposed to the seductive text. When taking a closer examination of the interest ratings of the seductive text, we found that the screens with

seductive details, specifically for the ST+SI condition, received higher interest ratings than did the screens containing only base information. Further, the ratings were higher for cognitive interest than for emotional interest. This result indicates that the seductive information presented in text plays a role in triggering levels of interests but it may not be enough to maintain it. Together, these results could indicate that seductive details may have a negative effect on the level of interest for screens containing only base information or that interest wasn't maintained throughout the text. Another possible explanation is that students may have compared screens rather than rate them for the information it contained.

Third, we examined the impact of seductive details in text and images on students' text comprehension. A set of retention and comprehension questions allowed us to evaluate how much information they were able to retain as well as their level of comprehension of the material they were examining. We hypothesized that if attention is paid to the seductive details but situational interest is not maintained, this would have a negative effect on both retention and comprehension (hypothesis c). Although our junior high students in general found the text difficult, some differences between conditions were found for both comprehension and retention of the information. Retention scores were negatively affected for students in the ST+SI condition, and presence of seductive images in particular seemed to affect retention but not comprehension. In contrast, comprehension scores, but not retention scores, tended to be lower for those who read the seductive text. Therefore, the presence of different types of seductive information can have different impact on how much the participants remember and comprehend the important information.

We expected to find better retention and comprehension scores if seductive information was attended to and interest triggered. Our results indicate that seductive information was attended to but situational interest did not vary between conditions and both comprehension and

retention scores were generally poor. When an effect was found, it was negative and could be attributed to the combined condition that saw both seductive sentences and seductive images. To further our findings, we examined retention and comprehension while controlling for interest. The effects of condition on comprehension seem to depend on emotional situational interest. These findings provide some support for the idea that situational interest plays a role in the comprehension (Kintsch, 1980; Park & Lim, 2007). The negative effect of the ST+SI condition could indicate that the two types of seductive information jointly focus attention on the unimportant information whereas having only one type of seductive information (as in BT+SI and ST+I conditions) is not enough to direct attention on the unimportant information.

Results from eye-tracking confirmed our most obvious hypothesis (hypothesis d) that more time is needed to examine material containing more information. When students are presented a text that includes seductive sentences, more time is needed to look at the screen (6 minutes, 6 seconds) compared to when a text only has base sentences (4 minutes, 36 seconds). Given that students who were exposed to the base text only obtained better comprehension scores than those exposed to the text containing seductive sentences, it is possible that either the additional time required or the inclusion of seductive details disrupt the mental model building of the information presented. The fact that students processed the base sentences faster when only base information was presented suggests that the likely culprit were the seductive details. In sum, these results indicate that the possible increase in interest triggered by seductive details is negated by added processing time and complexity.

Time spent examining informative and seductive images did not differ. Our group of junior high students did look at most of the images when presented but they did not spend much time examining them. Despite the fact that not much time was spent examining the images, they still seemed to have some impact on learning behaviors and outcomes, mainly on the retention of

information. Base images had a positive effect on the retention of the information regardless of the type of text presented with them. In terms of the overall retention results, those in the ST+I condition achieved the highest score out of the four conditions. If students are exposed to seductive information in a text, an informative image may help them focus on important information. Such a result indicates that incorporating images in a scientific text can help highlight the important information needed to be retained. For example, base sentences in the BT+I condition were read faster than in the BT+SI condition. This could be due to an interference caused by the seductive images or by the benefit derived from the informative images. Unfortunately, we did not include a base text only condition that would have allowed differentiating the two possible explanations. It would be of great interest for future studies to include a text only condition.

Future studies should manipulate the presentation of the task (reading and rating) to see if interest ratings would differ. An additional questionnaire could also be given in order to understand how participants decided to rate the information and if any of the information given to them prior to the task, such as knowing a test would follow, had any influence on their rating of the text. Lastly, future studies could also examine the ability to recall the information at a later time, such as a month a later. The inclusion of seductive details may have long-term effects where only the seductive information is remembered or where seductive information provides a cue to the actual information.

### **Limitations**

This study has some notable limitations. First, our overall sample size is small. This limits the generalizability of our results and a replication with larger number of participants is necessary before any conclusions can be drawn. A second limitation can be found within the length of the two texts and in the fact that students could not return to a previous screen. Both may have

impacted the results negatively. Providing students' with the ability to return to previously viewed screen could have impacted their retention and comprehension scores as most students commented on needing to review the material more in order to have better answers or to answer all questions properly. As a result, the learning situation was somewhat unnatural to the participants. Further, the base text contained fewer words than the seductive text since the seductive sentences were added to the base text. However, it is very difficult to avoid this situation without compromising the integrity of the base text.

### **Conclusion**

In conclusion, we identified some differences in text comprehension and processing when seductive information is presented. Most of the effects were negative and our results do not support the use of seductive information in non-fiction texts aimed for junior high students. If seductive information is presented to students, it seems likely that including it in the text has a better impact than adding seductive images. This study also stresses the importance of measuring interest throughout the task during the performance if the goal is to make arguments about interest and comprehension. Considering that our group of students did not necessarily perceive the materials presented in this study as seductive, the effects of indisputably seductive details on learning remains unclear.

## References

- Deacon, S. H., Cook, K., & Parrila, R. (2012). Identifying high-functioning dyslexics: Is self-report of early reading problems enough? *Annals of Dyslexia*, *62*, 120–134. doi: 10.1007/s11881-012-0068-2
- Flowerday, T., Schraw, G., & Stevens, J. (2004). The role of choice and interest in reader engagement. *The Journal of Experimental Education*, *72*, 93–114. doi: 10.3200/JEXE.72.2.93-114
- Garner, R., Alexander, P. A., Gillingham, M.G., Kulikowich, J. M., & Brown, R. (1991). Interest and learning from text. *American Educational Research Journal*, *28*, 643–659. doi: 10.3102/00028312028003643
- Garner, R., & Gillingham, M. G. (1991). Topic knowledge, cognitive interest, and text recall: A microanalysis. *Journal of Experimental Education*, *59*, 310–319. doi: 10.1080/00220973.1991.10806569
- Garner, R., Gillingham, M. G., & White, C. S. (1989). Effects of “seductive details” on macroprocessing and microprocessing in adults and children. *Cognition and Instruction*, *6*, 41–57. doi:10.1207/s1532690xci0601\_2
- Harp, S. F., & Mayer, R. E. (1997). The role of interest in learning from scientific text and illustrations: On the distinction between emotional interest and cognitive interest. *Journal of Educational Psychology*, *89*, 92–102. doi: 10.1037/0022-0663.89.1.92
- Harp, S. E., & Mayer, R. E. (1998). How seductive details do their damage: A theory of cognitive interest in science learning. *Journal of Educational Psychology*, *90*, 414–434. doi: 10.1037/0022-0663.90.3.414
- Hidi, S. (2001). Interest, reading, and learning: Theoretical and practical considerations. *Educational Psychology Review*, *13*, 191–209. doi: 10.1023/A:1016667621114

- Hidi, S. (2006). Interest: A unique motivational variable. *Educational Research Review, 1*, 69–82. doi: 10.1016/j.edurev.2006.09.001
- Hidi, S., & Baird, W. (1988). Strategies for increasing text-based interest and students' recall of expository texts. *Reading Research Quarterly, 23*, 465–483. doi: 10.2307/747644
- Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist, 41*, 111–127. doi: 10.1207/s15326985ep4102\_4
- Iran-Nejad, A. (1987). Cognitive and affective causes of interest and liking. *Journal of Educational Psychology, 79*(2), 120–130. doi: 10.1037/0022-0663.79.2.120
- Kendeou, P., van den Broek, P., White, M. J., & Lynch, J. (2007). Comprehension in preschool and early elementary children: Skill development and strategy interventions. In D. S. McNamara (Ed.), *Reading comprehension strategies, Theories, interventions and technologies* (pp. 27–45). New York: Erlbaum.
- Kintsch, W. (1980). Learning from text, levels of comprehension, or: Why anyone would read a story anyway. *Poetics, 9*(1–3), 87–98. doi: 10.1016/0304-422X(80)90013-3
- Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33*, 159–174. doi: 10.2307/2529310
- Lehman, S., Schraw, G., McCrudden, M. T., & Hartley, K. (2007). Processing and recall of seductive details in scientific text. *Contemporary Educational Psychology, 32*, 569–587. doi: 10.1016/j.cedpsych.2006.07.002
- Magner, U. I. E., Schwonke, R., Alevén, V., Popescu, O., & Renkl, A. (2014). Triggering situational interest by decorative illustrations both fosters and hinders learning in computer-based learning environments. *Learning and Instruction, 29*, 141–152. doi: 10.1016/j.learninstruc.2012.07.002
- Mayer, R. E. (2009). *Multimedia learning* (2<sup>nd</sup> edition). Cambridge: Cambridge University Press.

- Mayer, R. E., Griffith, E., Jurkowitz, I. T. N., & Rothman, D. (2008). Increased interestingness of extraneous details in a multimedia science presentation leads to decreased learning. *Journal of Experimental Psychology, 14*, 329–339. doi: 10.1037/a0013835
- Mayer, R. E., Heiser, J., & Lonn, S. (2001). Cognitive constraints on multimedia learning: when presenting more material results in less understanding. *Journal of Educational Psychology, 93*, 187–198. doi:10.1037//0022-0663.93.1.187
- Mason, L., Tornatora, M. C., & Pluchino, P. (2013). Do fourth graders integrate text and picture in processing and learning from an illustrated science text? Evidence from eye-movement patterns. *Computers & Education, 60*, 95–109. doi: 10.1016/j.compedu.2012.07.011
- McCrudden, M. T., & Corkill, A. J. (2010). Verbal ability and the processing of scientific text with seductive detail sentences. *Reading Psychology, 31*, 282–300. doi: 10.1080/02702710903256486
- McVay, J. C., & Cain, K. (2012). Why does working memory capacity predict variation in reading comprehension? On the influence of mind wandering and executive attention. *Journal of Experimental Psychology: General, 141*, 302–320. doi: 10.1037/a0025250
- Moreno, R., & Mayer, R. E. (2000). A coherence effect in multimedia learning: The case for minimizing irrelevant sounds in the design of multimedia instructional messages. *Journal of Educational Psychology, 92*, 117–125. doi: 10.1037//0022-0663.92.1.117
- Naglieri, J., & Das, J. P. (1998). *Das-Naglieri Cognitive Assessment System (CAS)*. Itasca, IL: Riverside.
- Newcott, W. (1993). Lightning: Nature high-voltage spectacle. *National Geographic, 184*, 80–103.



- Oakhill, J., & Cain, K. (2007). Issues of causality in children's reading comprehension. In D. S. McNamara (Ed.), *Reading comprehension strategies: Theories, interventions, and technologies* (pp. 47–71). New York: Erlbaum.
- Park, B., Flowerday, T., & Brünken, R. (2015). Cognitive and affective effects of seductive details in multimedia learning. *Computers in Human Behavior, 44*, 267–278. doi: 10.1016/j.chb.2014.10.061
- Park, S., & Lim, J. (2007). Promoting positive emotion in multimedia learning using visual illustrations. *Journal of Educational Multimedia and Hypermedia, 16*, 141–162.
- Park, B., Moreno, R., Seufert, T., & Brünken, R. (2011). Does cognitive load moderate the seductive details effect? A multimedia study. *Computers in Human Behavior, 27*, 5–10. doi:10.1016/j.chb.2010.05.006
- Rey, G. D. (2012). A review of research and a meta-analysis of the seductive detail effect. *Educational Research Review, 7*, 216–237. doi:10.1016/j.edurev.2012.05.003
- Rey, G. D. (2011). Seductive details in multimedia messages. *Journal of Educational Multimedia and Hypermedia, 20*, 283–314.
- Rowland, E., Skinner, C. H., Davis-Richards, K., Saudargas, R., & Robinson, D. H. (2008). An investigation of placement and type of seductive details: The primacy effect of seductive details on text recall. *Research in the Schools, 15*, 80–90.
- Rowland-Bryant, E., Skinner, C. H., Skinner, A. L., Saudargas, R., Robinson, D. H., & Kirk, E. R. (2009). Investigating the interaction of graphic organizers and seductive details: Can a graphic organizer mitigate the seductive details effect? *Research in the Schools, Mid-South Educational Research Association, 16*, 29–40.
- Sanchez, C. A., & Wiley, J. (2006). An examination of the seductive details effect in terms of working memory capacity. *Memory & Cognition, 34*, 344–355. doi:

10.3758/BF03193412

Schraw, G. (1998). Processing and recall differences among seductive details. *Journal of Educational Psychology, 90*, 3–12. doi: 10.1037/0022-0663.90.1.3

Schraw, G., & Lehman, S. (2001). Situational interest: A review of the literature and directions for future research. *Educational Psychology Review, 13*, 23–52. doi: 10.1023/A:1009004801455

Shen, B., McCaughtry, N., Martin, J., & Dillion, S. (2006). Does “Sneaky Fox” facilitate learning? Examining the effects of seductive details in physical education. *Research Quarterly for Exercise and Sport, 77*, 498–506. doi: 10.1080/02701367.2006.10599384

Singer, M., Andrusiak, P., Reisdorf, P., & Black, N. L. (1992). Individual differences in bridging inference processes. *Memory and Cognition, 20*, 539–548. doi:10.3758/BF03199586

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5<sup>th</sup> ed). Boston: Pearson Education, Inc.

Torgesen, J., Wagner, R., & Rashotte, C. (2012). *Test of Word Reading Efficiency (TOWRE 2)*. Austin, TX: Pro-Ed.

Wade, S. E., & Moje, E. B. (2000). The role of text in classroom learning. In M. L. Kamil, P. B. Mosenthal, P. D. Pearson, & R. Barr (Eds.), *Handbook of reading research* (Vol. III, pp. 609–627). Mahwah, NJ: Erlbaum.

Wang, Z., & Adesope, O. (2016). Does learners’ prior knowledge moderate the detrimental effects of seductive details in reading from text? A 2 by 3 study. *International Journal of Instruction, 9*, 35–50. doi: 10.12973/iji.2016.923a

Woodcock, R. W. (1998). *Woodcock Reading Mastery Tests - Revised*. Circle Pines, MN: American Guidance Service.

## Chapter IV: Do seductive details in scientific text affect interest and learning?

### Introduction

In the past decades, several research groups have studied how to improve students' learning from text. Enhancing factual texts with illustrations or with highly interesting and entertaining information has been suggested as a way to increase students' interest and, subsequently, recall of the text (Mayer, 2009). Additional materials that are interesting but irrelevant to the instructional goal of the text are called *seductive details* (e.g., Garner, Alexander, Gillingham, Kulikowish, & Brown, 1991; Garner, Gillingham, & White, 1989; Moreno & Mayer, 2000). Teachers, textbook writers, and instructional multimedia designers like to incorporate seductive details to keep the reader's attention on the instructional material and to foster learning outcomes by increasing their curiosity and level of interest (e.g., Korbach, Brünken, & Park, 2016; Rey, 2012). However, evidence for this practice is mixed. Some studies have found a positive effect of seductive details suggesting that seductive information was beneficial for learning (e.g., Schraw & Lehman, 2001; Thalheimer, 2004), whereas others have shown that including seductive details can decrease learning (e.g., Garner et al., 1991; Harp & Mayer 1997, 1998). Further, these positive and negative effects of seductive details are not always present (e.g., Garner & Gillingham, 1991; Schraw 1998), and when and why the seductive detail effect is present is unclear. We will extend the research on seductive details' impact on online processing of text by measuring eye movements to help understand how university students with normal reading ability interact with learning materials that include informative and seductive text with or without informative and seductive images, and how inclusion of seductive information affects students' emotional and cognitive interest as well as their learning outcomes.

### Seductive Detail Effect

Rey (2012) reviewed 39 experimental studies examining seductive details. Fourteen out

of the 39 studies examined the effect of seductive details in text; four out of these 14 studies showed negative effects of seductive details in text (Harp & Mayer, 1997, Exp.1; Lehman, Schraw, McCrudden, & Hartley, 2007, Exp.2; Rowland-Bryant et al., 2009; Rowland, Skinner, Davis-Richards, Saudargas, & Robinson, 2008). Harp and Mayer (1997, Exp.1), for example, examined the effect of seductive details during a textbook lesson on the process of lightning. College students read an illustrated base text passage (550 words) explaining the process of lightning while others read the same passage with additional seductive details (total of 700 words) describing the risk of lightning for humans. While the overall text recall was poor in both groups, students who read the base text significantly outperformed those who read the seductive detail text both on retention and transfer questions.

Others have found mixed results with the presentation of seductive details in text (e.g., Garner et al., 1989, Exp.1, 2; Garner et al., 1991, Exp.1, 2; Mayer, Griffith, Jurkowitz, & Rothman, 2008 Exp.1, 2; Rey, 2011). For example, in Mayer et al.'s (2008) study, students who read the base text significantly outperformed those who read the seductive detail text on transfer but not on retention questions. In addition, no impact for the inclusion of seductive details has been reported (e.g., Hidi & Baird, 1988; Garner & Gillingham, 1991; Schraw, 1998). In Garner and Gillingham's (1991) study university students read a base text (400 words) about Stephen Hawking and his scientific work or the same text with an additional seductive detail text (100 words). No differences were found in the groups' structured and unstructured recall scores.

Despite the conflicting results, Rey's (2012) meta-analysis revealed overall significant effect sizes for retention (small to medium effect size) and transfer (medium effect size) performances, supporting the negative seductive detail effect. Further, texts with seductive detail sentences take longer to read, and different reading strategies may be used when encountering these sentences (Lehman et al., 2007; Schraw, 1998). Seductive detail sentences may also be

better recalled than other types of sentences and can interfere with the retention of the main ideas (Harp & Mayer, 1997; Lehman et al., 2007; Rowland-Bryant et al., 2009). Taken together, these results suggest that a strong increase in interest and engagement is needed to justify the inclusion of seductive details.

## **Interest**

The main premise behind including seductive details is that learners will be engaged and interested in the information, which will then affect their learning outcomes. Researchers have found that a learner's level of interest can influence their attention, goals and overall learning of the material (e.g., Hidi & Harachiewicz, 2000). Hence, interest is known to influence a learner's cognitive and affective functioning (e.g., Ainley, Hidi, & Berndorff, 2002; Renninger, 2000). Interest itself can be divided into two different dimensions: situational and personal (e.g., Hidi, 2000; Magner, Schwonke, Alevan, Pospescu, & Renkl, 2014). Situational interest (SI) reflects the learner's response to the environmental information presented and can last over time or be short-lived. Three main categories can be found within the SI research: text-based SI (aspects of the text affecting interest, such as text coherence, vividness and seductiveness), task-based SI (task manipulations or encoding instructions), and knowledge-based SI (learner's prior knowledge) (Schraw & Lehman, 2001). Personal interest, in turn, refers to a learner's enduring preference of certain content, subject area or activities and can be divided into two components: value-related or cognitive interest (the information is seen as important) and feeling-related or emotional interest (the information is seen as entertaining) (e.g., Schiefele, 1991).

Situational and personal interest has been related to reading comprehension (e.g., Hidi, 1990; Schraw, Bruning, & Svoboda, 1995), although the relationship between them is not clear. Multiple factors have been proposed to explain the relation, such as the level of text engagement (Mitchell, 1993), relevance of information to the learner's goal (Schraw & Dennison, 1994),

coherence and completeness (Lehman & Schraw, 2002), seductiveness (Sanchez & Wiley, 2006; Schraw, 1998), and value-related feelings (Schiefele, 1991).

Hidi and Renninger (2006) proposed a four-stage model of interest development in which SI becomes the basis for developing personal interest. The first phase starts with a triggered SI, that is activated with environment or text features (Hidi & Renninger, 2006; Linnenbrink-Garcia et al., 2010). Phase 2 represents the maintained-SI, which refers to a triggered state where a learner's attention is focused and held on the information over an extended amount of time or reoccurrences. This maintained interest is typically sustained by meaningfulness or importance of the information (cognitive interest) for the learner. Phase 3 is the emerging personal interest as a result of the maintained SI. At this phase the learner can engage with content with or without external support. The last phase is the well-developed personal interest, where the learner will seek opportunities to reengage with the material. Personal interest in this case can be viewed as the deepening of a learner's knowledge of a subject that is valued and that will motivate curiosity and further exploration of the domain (Linnenbrink-Garcia et al., 2010). In order to develop both interest components, a maintained SI is needed.

When seductive information is presented to learners it is assumed that the learner's SI would be triggered. However, measures of interest are typically absent in seductive detail research or completed in a pilot study or a posteriori (e.g., Lehman et al., 2007; Plass, Heidig, Hayward, Homer, & Um, 2014), as opposed to during the learning phase, which seems critical to Hidi and Renninger's model. In one exception, Magner et al. (2014) examined the effect of the inclusion of seductive illustrations in a computer-based learning environment on triggered and maintained SI. The illustrations were tested in a pilot study to be highly interesting; however, the results showed that during the task performance the illustrations triggered SI but did not maintain it. Further, the seductive illustrations resulted in poorer learning outcomes for students with low

prior knowledge but not for those with high prior knowledge. Thus, situational interest should be assessed before, during, and after the learning task when investigating seductive details in order to better understand the mixed effects of seductive details reported in existing studies.

### **Current Study**

The current study builds on existing research by using a text and images that have been found interesting in prior research and have produced a negative seductive detail effect (Harp & Mayer 1998; Lehman et al., 2007). We expand on previous studies by including online measures of interest, modified comprehension questions, as well as an examination of online processing of different parts of the text and images. In order to compare different texts and images (base and seductive), six conditions were created: base text, base text with five informative images, base text with five seductive images, seductive text, seductive text with five informative images, and seductive text with five seductive images.

Further, we controlled for various reader characteristics that may moderate the influence of seductive details. First, student's prior knowledge was controlled by only including those with limited knowledge, as we did not want prior knowledge to interfere with the learning task. Second, as readers with a lower working memory capacity tend to have less capacity to integrate the information they are reading with their background knowledge into a working mental model (e.g., McVay & Cain, 2011), it is possible that they would be affected by the presence of seductive details more than readers with more working memory capacity. In order to avoid working memory capacity confounding the results, we administered the Reading Span task (see below) to all participants. Third, one's ability to control attention during a reading task can impact learning (Sanchez & Wiley, 2006). Hence, we controlled for possible attention problems.

We evaluated the learners' interest throughout the experiment to better understand how the information is perceived during the task performance (is it interesting and important to the

reader). Measuring interest multiple times allowed us to investigate if the presented information was viewed as seductive during the task (as opposed to a priori). We also assessed the participants' emotional status prior to and after they had completed the experiment to assess the overall effect of the task. This can help us better understand how seductive details impact a learner's emotional status beyond situational interest. Very few studies have examined participants' level of interest when presenting seductive information. This can be a critical component to help us understand the conflicting results.

Finally, we included both text and images to examine how different combinations of materials (e.g., seductive text with informative images) influence interest and learning. Images and illustrations that are found in textbooks can be decorative (showing little or no relation to the content of the text) or informative (supporting comprehension of the text). Depending on the types of images their function may vary; some can focus on cognitive aspects (helping to create a better mental model) while others focus attention (directing learners' attention toward a specific aspect) or affect (enhance interest and emotion). Therefore, time spent on seductive and informative images will be inspected.

On the basis of interest theories, we expected that seductive information in a sentence or image would trigger situational interest if it were attended to. Further, we expected that if situational interest is triggered and maintained, students who receive seductive information should perform better on the retention and transfer questions than students who do not receive seductive information. However, if seductive details fail to increase interest despite being attended to, their impact on performance on recall and transfer questions will be negative.



## Methods

### Participants

A total of 127 undergraduate university students (27 males and 100 females; mean age 22.6 years,  $SD = 4.17$ ) who reported English as their first language were recruited from the subject pool program of the Department of Educational Psychology at a large Canadian university and received course credit as compensation for their participation. All participants had low to no knowledge of meteorology as indicated by the knowledge of weather questionnaire (see below) and normal or corrected-to-normal vision.

### Measures

**Questionnaires.** A knowledge of weather questionnaire, adapted from Harp and Mayer (1997), was administered prior to testing to make sure participants did not have prior knowledge that would interfere with the results of the study. The questionnaire asked participants to rate their knowledge of meteorology on a five-point scale ranging from 1 = *very little* to 5 = *very much*. Participants also had to indicate if they knew six specific aspects of meteorology, such as what a cold front or a low-pressure system is.

**Reading ability.** The participant's word and nonword reading fluency was assessed with TOWRE-II (Torgesen, Wagner, & Rashotte, 2012). The participants read out loud as many words (Sight Word Efficiency; SWE) or nonwords (Phonological Decoding Efficiency; PDE) as possible in 45 seconds. The correct number of words and nonwords read in that time was recorded. The reported alternate forms reliability coefficient of the sight word efficiency and phonemic decoding efficiency for this age group is 0.92 (Torgesen et al., 2012).

Reading comprehension was measured with the Woodcock Reading Mastery Tests-Revised Passage Comprehension task (WRMT-R; form H; Woodcock, 1998). Participants read silently sentences with missing words and provided the missing word orally. The test was

administered in the recommended standardized format and the session ended after six consecutive errors. The number of correct missing words named was the score. The reported split-half reliability for this age group is 0.82 (Woodcock, 1998).

**Working memory.** Working memory was examined with the Reading Span task (RSPAN; Singer, Andrusiak, Reisdorf, & Black, 1992). Participants read silently fourteen sets of unrelated sentences one sentence at a time on a computer screen. There were a total of four different sets of sentences, four sets of two sentences, and three sets of three, four and five sentences. At the end of each set the participants were asked to name the last word of each sentence in the order they had occurred. Following the recall task, a sentence from the previous set was shown a second time, but now with two missing words and the participants were asked to say what the two missing words were. All sentences were presented for 7 seconds. Both the total number of last words as well as missing words recalled was recorded. The maximum score was 42 for the recalled words and 24 for the missing words. Cronbach's alpha was 0.69 for the last words and 0.72 for the missing words.

**Attention.** Participants rated their attention by answering an Adult ADHD Self-Report Scale Symptom Checklist (ASRS-v1.1; Kessler et al., 2005). This questionnaire consists of eighteen questions that are rated by the participants using a Likert scale ranging from 1-5. The first part of the questionnaire (Part A) consists of six questions that have been found to be predictive of symptoms of ADHD (Kessler et al., 2005). The checklist is based on DSM-IV-TR criteria. The second part of the questionnaire (Part B) consists of twelve questions that provide additional cues of symptoms. Participants are given a score based on the number of answers found in the shaded boxes of the questionnaire. If four or more answers are in the shaded area of Part A then the participant has symptoms consistent with ADHD. Cronbach's alpha for Part A for

this sample was 0.62.

Attention was also measured with the Expressive Attention task (EA) from the Cognitive Assessment System (Naglieri & Das, 1998). This measure consisted of three tasks in which the participants had to read or name as quickly and accurately as possible the stimuli presented. The first task required for the participants to read a list of words (names of colors), the second task required them to name colors of rectangles and the last task required them to name the color of the ink in which names of colors were presented. All tasks were timed. The expressive attention score is determined based on a scale with the use of completion time and number of correct answers of the last task. It has a reported reliability coefficient of 0.80 (Naglieri & Das, 1998).

**Affective status.** Participants' initial emotional status was evaluated with the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) before they read a text with the eye tracker and again after they answered the comprehension questions at the end of the text. The scale consists of 20 words describing feelings and emotions. Participants are asked to indicate to what extent they are feeling that way at the present moment using a five-point scale from 1 = *very slightly or not at all* to 5 = *extremely*. Cronbach's alpha was 0.93 for the PA scale and 0.87 for the NA scale.

**Emotional and cognitive interests.** Participants were asked to respond to two questions at the bottom of each screen to indicate their situational interest of the text they were reading (Magner et al., 2014). The questions asked them to rate how interesting they found the text to be (emotional interest) and how important the information was (cognitive interest). The rating was done with a Likert scale that ranged from 1 = *totally disagree* to 6 = *totally agree*. Participants rated each screen by fixating on a number on the Likert scale for 5 seconds.

**Text.** A text on the process of lightning, adapted from Lehman et al. (2007), was presented on a computer screen in six different formats: base text with no images (656 words);

base text (656 words) plus informative images (5 images), base text (656 words) plus seductive details images (5 images); seductive details text with no images (966 words); seductive detail text (966 words) with informative images (5 images); seductive detail text (966 words) with seductive images (5 images). The base text explained the causal chain involved in the formation of lightning and contained seven paragraphs. The seductive text contained the base text information with the additional seductive sentences intended to make the passage more interesting (e.g., *Understanding how lightning is formed is important because approximately 150 Americans are killed by lightning every year*). The seductive sentences were incorporated into the text in order to flow within the base information and contained seven paragraphs. Both texts were presented in columns, similar to information found in textbooks. Five informative illustrations, taken from previous studies (e.g., Harp & Mayer, 1997), were black and white illustrations supporting the information found in the text and were approximately 10 x 15cm in size. Each illustration had a caption below it that included information found in the base text. Five seductive images (from the National Geographic article on lightning by Newcott, 1993) were colour photographs that captured seductive information and were also used in previous studies (e.g., Harp & Mayer, 1997). They included a caption highlighting information found in the seductive text. Each image was approximately 10 x 15cm in size.

**Retention and transfer questions.** A set of six retention questions was created for this study. Two example questions were: (1) What is created from differences in electrical charges between a cloud and the ground? (2) What does air temperature have to do with lightning? The six questions are also divided into two types of questions, factual (three questions) and inferential (three questions). The four transfer questions were: (1) Suppose you see clouds in the sky, but no lightning. Why not? (2) Imagine you see a cloud with an extended top. Explain what is happening. (3) Why do you think some thunderstorms produce hailstones and others do not? (4)

What could be done to decrease the intensity of a lightning storm? All four questions represent different question categories, such as troubleshooting, redesign, conceptual and prediction.

Participants were asked to write down their answers as soon as they were done reading the text.

The retention questions were presented first followed by the transfer questions. Participants were told to try to answer as many questions as possible based on the information they had just read. If they did not recall information they were asked to guess. For the transfer questions they were also given the instruction to use the knowledge they had just learned and try to apply this knowledge to the different situations. Participants were encouraged to try their best to answer all questions and were not given any time limits.

Two independent raters blind to the conditions scored the responses. The retention performance of each participant was scored by adding up the number of correct answers given for each question (max = 11). The answers to the transfer questions were also added up for a possible total of 8 points. A marking grid was created to help raters score the answers based on the amount of information found in each answer. One rater scored all protocols and a second rater scored 20% of randomly selected protocols. Kappa statistics were computed to determine inter-rater reliability. Reliability was computed for each retention question and ranged from 0.52 to 1 with a mean of 0.76 for all base questions. The inter-rater reliability for the raters of the transfer questions was found ranging from 0.27 to 0.71 with a mean of 0.50 for all transfer questions.

Eye movements were recorded using the SR Research Ltd EyeLink 1000 Plus system. The EyeLink 1000 Plus has a high degree of accuracy (0.5°) and a sampling rate of 1000 Hz. This system has a camera and an infrared sensor; the camera is placed at the bottom of the computer screen facing the participant. The system tracks the dominant eye. The participants placed their chin on a chin rest 60 cm in front of the computer screen to minimize head movements.

## **Procedure**

Each participant was tested individually in one session lasting approximately two hours with the option of taking a break midway through. The participants were randomly assigned to six conditions: base text (BT) included 22 participants, base text and informative images (BT+I) included 21 participants, base text with seductive images (BT+SI) included 20 participants, seductive text (ST) included 21 participants, seductive text with informative images (ST+I) included 21 participants, and seductive text and images (ST+SI) included 22 participants. Participants completed the questionnaires, reading tasks, working memory tasks, attention tasks and the eye tracking task in a randomly assigned order. The affective status of the participants was always evaluated before they began the eye tracking task and after they answered the retention and transfer questions. After completing the session, the participants were debriefed, thanked, and dismissed.

## **Data Analysis**

Eye movement data were coded with the EyeLink Data Viewer software. This program presents the pages of the text and superimposes the positions of the fixations made by the participant. The eye movement measures of interest for this study are reading time and fixation count for base and seductive sentences, and fixation duration (in milliseconds) and count for informative and seductive images.

## **Statistical Analysis**

Distributional properties were examined separately for the six conditions. Assumptions of normality were violated for TOWRE-II (PDE) in ST, ST+I and ST+SI conditions; RSPAN (number of last words recalled) for ST+SI was negatively skewed, hence reverse score transformations needed to be made (Tabachnick & Fidell, 2007). The following measures were positively skewed WRMT-R for ST; Expressive Attention for ST; PANAS Pre-PA for ST+I as

well as the Pre-NA for BT and BT+SI, the post-PA for ST and ST+I as well as the post-NA for all but BT+SI; Retention scores for BT+I and transfer scores for ST. Square root transformation was used for pre-PANAS, the retention and transfer scores. Next, box plots were examined to identify the outliers and if any outliers remained or if transformation did not work, outliers were winsorized following guidelines given in Tabachnick and Fidell (2007). The procedure includes changing the score of the outlier to the next highest +1 or lowest score -1 that is not an outlier. The data was analyzed first using the untransformed scores followed by the second analysis with the transformed scores. The results with the transformed score are shown below.

## **Results**

### **Control measures**

Descriptive statistics for all variables are presented in Table 3.1 separately for all six conditions. A multivariate analysis of variance (MANOVA) was conducted with reading tasks (TOWRE and WRMT-R) as the dependent variables and condition as the independent variable. The overall effect of condition was not significant ( $Wilks = 0.906$ ;  $F(15, 315) = .761$ ;  $p = .721$ ). Several univariate analyses of variance (ANOVAs) were conducted in order to examine whether the conditions differed on the individual measures. The ANOVAs revealed no differences between the conditions on any of the measures in Table 3.1. Similarly, there were no differences in their pretest positive or negative affect scores as assessed by PANAS. These results indicate that participants in all six conditions were comparable.

Table 3.1.

*Means and Standard Deviations of the Control Tasks*

	BT (n=22)		BT+I (n=21)		BT+SI (n=20)		ST (n=21)		ST+I (n=21)		ST+SI (n=22)		F
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	
TOWRE													
<i>(standard scores)</i>													
SWE	102.61	13.99	104.45 <sup>b</sup>	12.31	101.25	17.08	103.24	14.49	103.24	14.70	102.32	13.70	.41
PDE	105.73	10.82	105.10 <sup>b</sup>	11.81	105.80	10.83	105.24	7.98	104.43	10.88	104.41	7.10	.49
WRMT-R	103.14	8.91	104.29	9.99	109.30	9.61	105.62	13.91	105.06 <sup>a</sup>	8.63	108.80 <sup>b</sup>	9.28	1.28
<i>(standard score)</i>													
RSPAN													
Last words	30.64	4.51	28.71	4.81	29.35	6.18	29.05	6.58	29.57	5.72	31.45	5.57	.75
Missing words	7.05	2.87	7.67	4.34	7.10	3.92	6.71	3.88	7.43	3.64	8.45	4.34	.66
ASRS-v1.1	2.27	1.45	2.67	1.79	2.65	1.57	2.52	1.50	2.57	1.66	2.24 <sup>c</sup>	1.73	.28
<i>(score Part A)</i>													
EA <i>(ratio score)</i>	83.18	14.16	80.71	13.67	79.85	18.09	76.24	23.10	76.90	16.16	76.14	18.20	.58
PANAS													
Pre-PA	22.95	6.65	22.71	6.97	22.95	8.72	22.48	7.17	21.33	6.19	25.23	7.22	.68
Pre-NA	14.41	5.13	13.57	2.38	14.55	4.56	14.33	3.23	14.62	3.51	13.68	2.72	.31
Post-PA	17.27	6.39	18.52	6.93	19.00	6.61	17.33	7.86	16.14	5.41	20.00	8.64	.83
Post-NA	15.41	7.65	15.29	6.90	14.05	2.96	16.38	7.21	15.43	4.32	14.14	4.19	.48
Comprehension													
Retention (/11)	3.45	1.22	3.82	1.27	3.97	2.04	2.83	1.74	3.57	1.51	3.09	1.59	1.81
Transfer (/8)	2.30	1.03	1.50	1.08	1.93	1.25	1.55	1.04	1.64	1.30	1.75	1.27	1.39

*Note.* PANAS was presented before (pre) and after (post) the eye-tracking task, the comprehension questions were presented after the eye-tracking task. BT = base text; BT+I = base text with informative images; BT+SI = base text with seductive images; ST = seductive text; ST+I = seductive text with informative images; ST+SI = seductive text with seductive images; WRMT-R = Woodcock Reading Mastery Tests-Revised Passage Comprehension task; RSPAN = Reading Span; ASRS-v.1.1 = ADHD Self-Report Scale Symptom Checklist; EA = Expressive Attention; PANAS = Positive and Negative Affect Schedule; PA = Positive Affect; NA = Negative Affect. <sup>a</sup>n = 18. <sup>b</sup>n = 20. <sup>c</sup>n = 21



### Retention and transfer scores

To examine differences in retention and transfer scores by all six conditions, two separate ANOVAs were conducted. The main effect of condition was not significant for the retention scores,  $F(5, 121) = 1.812$ ;  $p = .116$ ,  $\eta_p^2 = 0.069$ , or the transfer scores  $F(5, 121) = 1.393$ ;  $p = .232$ ,  $\eta_p^2 = 0.054$ . The same analysis was conducted to investigate if the images would impact the retention and transfer scores. Three conditions were created, no image, informative image, and seductive image. Main effect of condition was not significant for the retention scores,  $F(2, 124) = 1.212$ ;  $p = .301$ ,  $\eta_p^2 = 0.019$ , or the transfer scores  $F(2, 124) = 1.571$ ;  $p = .212$ ,  $\eta_p^2 = 0.025$ .

**Retention scores.** Retention questions were further analyzed based on the question asked (factual vs. inferential) for each condition. The scores are presented in Table 3.2.

Table 3.2.

*Scores of Factual and Inferential Questions of Base Information by Condition*

	BT		BT+I		BT+SI		ST		ST+I		ST+SI	
	(N=22)		(N=22)		(N=19)		(N=21)		(N=21)		(N=22)	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Factual (/3)	1.98	0.66	2.27	0.78	1.84	0.83	1.69	1.03	1.90	0.89	1.91	1.02
Inferential (/10)	1.52	0.98	1.55	0.77	2.24	0.16	1.14	1.03	1.67	1.12	1.18	0.85

*Note.* BT = base text; BT+I = base text with informative images; BT+SI = base text with seductive images; ST = seductive text; ST+I = seductive text with informative images; ST+SI = seductive text with seductive images

ANOVA for the factual questions showed no main effect of condition,  $F(5, 121) = 1.036$ ,  $p = .400$ ,  $\eta_p^2 = 0.041$ . ANOVA with the inferential scores as the dependent variable showed a significant main effect of condition,  $F(5, 121) = 2.659$ ,  $p = .026$ ,  $\eta_p^2 = 0.099$ . Post-hoc pairwise comparisons (Bonferroni) revealed significant differences between the BT+SI and ST conditions ( $p = .028$ ) and between the BT+SI and ST+SI ( $p = .036$ ) conditions.

Next, two separate ANOVAs were conducted to compare the type of questions by type of text presented (base vs. seductive). The main effect of text type was not significant for the factual questions,  $F(2, 124) = 1.127, p = .790, \eta_p^2 = 0.024$ , or the inferential questions,  $F(2, 124) < .001, p = .992, \eta_p^2 = 0.001$ .

Finally, the same two ANOVAs were conducted to compare the type of questions by images (no images vs. informative images vs. seductive images). The main effect of image was not significant for factual questions,  $F(2, 125) = 1.046, p = .354, \eta_p^2 = 0.017$ , or for the inferential questions,  $F(2, 125) = 1.052, p = .352, \eta_p^2 = 0.017$ .

**Transfer scores.** Transfer questions were examined by question type. A maximum of two points were given for each answer. Question categories were the same categories used by Mayer (2009): troubleshooting, redesign, conceptual and prediction. The mean score of each question for each condition can be found in Table 3.3. Since the scores obtained were on average very low, those who did manage to get a higher score skewed the results. To correct for this, scores were treated as categorical with one point for a correct or partially correct answer and zero for an incorrect or no answer.

Table 3.3.

*Mean of Transfer Questions for Each Condition*

	BT		BT+I		BT+SI		ST		ST+I		ST+SI	
	(N=22)		(N=22)		(N=19)		(N=21)		(N=21)		(N=22)	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Troubleshooting	0.36	0.44	0.48	0.49	0.34	0.37	0.41	0.41	0.57	0.46	0.66	0.42
Conceptual	0.50	0.51	0.43	0.39	0.45	0.41	0.33	0.40	0.38	0.38	0.52	0.45
Prediction	0.86	0.47	0.64	0.58	0.74	0.63	0.76	0.63	0.71	0.71	0.96	0.65
Redesign	0.39	0.41	0.21	0.25	0.11	0.27	0.14	0.28	0.14	0.32	0.25	0.37

*Note.* BT = base text; BT+I = base text with informative images; BT+SI = base text with seductive images; ST = seductive text; ST+I = seductive text with informative images; ST+SI = seductive text with seductive images

A series of chi-square tests were performed and no relationship was found between transfer questions and condition: troubleshooting question,  $\chi^2(5, N = 127) = 7.011, p = .220$ ; conceptual question,  $\chi^2(5, N = 127) = 1.852, p = .869$ ; and prediction question,  $\chi^2(5, N = 127) = 4.784, p = .443$ . The redesign question approached significance,  $\chi^2(5, N = 127) = 10.641, p = .059$ . Table 3.3 shows a slightly higher mean for the BT condition than for the other conditions.

**Interest**

**Affective status.** A repeated measures ANOVA was conducted to compare PANAS (PA and NA scales) pre- and post-test scores across conditions. The results showed a significant main effect of Time,  $F(1, 121) = 46.693, p < .001, \eta_p^2 = 0.278$ , and of Scale,  $F(1, 121) = 65.252; p < .001, \eta_p^2 = 0.350$ , as well as a significant interaction of Time by Scale,  $F(1, 121) = 54.92; p < .001, \eta_p^2 = 0.312$ . The main effect of Condition,  $F(5, 121) = 0.314; p = .904$ , was not significant and no significant interactions were found for Time by Condition,  $F(5, 121) = 0.449; p = .813, \eta_p^2 = 0.018$ , Scale by Condition  $F(5, 121) = 1.013; p = .413, \eta_p^2 = 0.040$ , or for Time, Scale by Condition  $F(5, 121) = 0.433; p = .825, \eta_p^2 = 0.018$ . The main effect of Time reflects the fact that

participants were more likely to give a higher rating during the pre-test (18.57) than post-test (16.58). The main effect of Scale reflects higher average PA scores (20.49) than NA scores (14.66). Time by Scale interaction reflects the fact the PA scores dropped from pre to post-test, whereas the NA scores did not change. In sum, across the conditions, the positive affect was reduced by the task while the negative affect remained the same.

**Situational interest.** Two questions presented at the bottom of each screen of the eye-tracking display measured the participant's situational interest on the text they were reading (level of interest and importance) on a scale ranging from 1 to 6. Table 3.4 presents the means and standard deviations of the situational interest for each condition. ANOVAs showed no significant main effect of condition for neither the cognitive interest (level of importance),  $F(5, 121) = 0.273$ ;  $p = .927$ ,  $\eta_p^2 = 0.011$ , nor the emotional interest,  $F(5, 121) = 0.73$ ;  $p = .602$ ,  $\eta_p^2 = 0.029$ .

Table 3.4.

*Descriptive Statistics of the Situational Interest per Condition and Type of Information*

	BT		BT+I		BT+SI		ST		ST+I		ST+SI	
	(N=22)		(N=21)		(N=20)		(N=21)		(N=21)		(N=22)	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
<b>Base</b>												
Emotional	3.50	1.11	3.95	1.51	3.50	0.33	3.41	1.38	3.55	1.17	3.53	0.99
Cognitive	3.25	1.22	3.58	1.03	3.65	0.25	3.54	1.38	3.48	1.09	3.31	0.99
<b>Seductive</b>												
Emotional					3.55	0.24	3.49	1.49	3.87	0.97	3.82	0.94
Cognitive					3.42	0.17	3.57	1.44	3.49	0.95	3.57	0.96

*Note.* BT = base text; BT+I = base text with informative images; BT+SI = base text with seductive images; ST = seductive text; ST+I = seductive text with informative images; ST+SI = seductive text with seductive images

Additional ANOVAs were conducted to examine if cognitive or emotional interest were higher for screens showing base versus seductive information in BT+SI, ST, ST+I and ST+SI conditions. No significant differences were found for cognitive,  $F(5, 121) = 0.273, p = .927, \eta_p^2 = 0.011$ , or emotional,  $F(5, 121) = 0.730, p = .602, \eta_p^2 = 0.029$ , interest.

### Eye Movement Data

**Learning time.** To examine the participants learning time, we compared the time spent on the screens (excluding the time spent answering the interest questions) by the type of text presented (base or seductive). The main effect of text type was significant,  $F(1, 125) = 40.941, p < .001, \eta_p^2 = 0.247$ ; not surprisingly, more time was spent looking at the screens with the additional seductive text (6 minutes, 03 seconds) than with the base text (4 minutes, 06 seconds).

**Reading speed.** Reading rate was calculated by dividing the number of words by reading time in minutes. Means and standard deviations of reading speed are presented in Table 3.5. A first comparison was made between the average reading rate of sentences and condition. An ANOVA showed that the main effect of condition approached significance,  $F(5, 121) = 2.14, p = .065, \eta_p^2 = 0.081$ . Post hoc test (Bonferroni correction) showed that the difference between BT and BT+SI approached significance ( $p = .067$ ).

A second comparison was made between reading rate of base sentence and type of information presented (base vs. seductive),  $F(1, 125) = 4.418, p = .038, \eta_p^2 = 0.034$ . Participants read base sentences faster (313.88 words per minute) when only base information was presented (BT, BT+I) than when seductive information was added to the text (BT+SI, ST, ST+I, ST+SI) (275.53 words per minute).

Table 3.5.

*Reading Speeds (words per minute) for Each Condition*

	BT	BT+I	BT+SI	ST	ST+I	ST+SI
	Mean	M	M	M	M	M
	(SD)	(SD)	(SD)	(SD)	(SD)	(SD)
Base	342.82	283.57	260.32	297.01	259.81	283.88
sentences	(123.28)	(93.79)	(110.20)	(84.80)	(73.67)	(83.45)
Seductive				337.27	291.29	307.78
sentences				(100.34)	(81.56)	(77.17)

*Note.* BT = base text; BT+I = base text with informative images; BT+SI = base text with seductive images; ST = seductive text; ST+I = seductive text with informative images; ST+SI = seductive text with seductive images.

**Images.** Mean time spent on images as well as the number of images fixated per condition is presented in Table 3.6. ANOVA indicated a significant main effect of condition,  $F(3, 79) = 5.02, p = .003, \eta_p^2 = 0.160$ . Post hoc test (Bonferroni) revealed differences between BT+SI and ST+I ( $p < 0.001$ ) as well as between ST+I and ST+SI ( $p < 0.05$ ). Table 3.6 indicates that the participants had longer fixation times on informative images than on seductive images. When informative versus seductive images were contrasted, the difference was significant,  $F(1, 81) = 13.5, p < .001, \eta_p^2 = 0.143$ . In general, participants did not spend much time fixating on the images, but when they did look at the images they spent more time on the informative images.

Table 3.6.

*Mean Time Spent on Images (milliseconds) and Number of Images Fixated*

	BT+I		BT+SI		ST+I		ST+SI	
	(N=21)		(N=20)		(N=20)		(N=22)	
	M	SD	M	SD	M	SD	M	SD
Time	2413.26	1357.06	1426.89	1015.82	2803.33	1578.22	1738.36	1049.52
Number of images fixated (/5)	4.62	0.67	4.20	0.83	4.05	1.09	4.27	0.63

*Note.* BT = base text; BT+I = base text with informative images; BT+SI = base text with seductive images; ST = seductive text; ST+I = seductive text with informative images; ST+SI = seductive text with seductive images

### Discussion

We extended research on the impact of seductive details on online processing of text by measuring eye movements, emotional and cognitive interest, and learning outcomes when students were reading text with or without additional seductive sentences, seductive pictures, or informative pictures. We wanted to understand how university students interact with learning materials and how the inclusion of seductive information affects their learning outcomes and situational interest. We controlled for multiple possible confounding factors such as reading ability, attention and working memory that may have influenced results in the previous studies of the seductive detail effect.

Our main result was that including seductive information did not increase interest or understanding but it did increase the text processing time; not surprisingly, students required more time to examine the material when more information was presented. In addition, when the text included only base sentences, those sentences were read faster than when the text also included seductive sentences. Spending more time reading the base sentences could have led to better comprehension of them, but that did not occur. Hence, including seductive information not

only impacts the total learning time, but also seems to influence text reading rate without any benefit to it. This indicates that the seductive sentences likely incurred an additional processing cost for the participants trying to build a coherent mental model of the text.

As for the seductive images, fixation data indicate that participants looked at images when they were included, but they did not spend a lot of time examining them. To a large extent, both seductive and informative images were ignored by our participants with informative images receiving slightly longer viewing times than seductive images. This indicates that the participants perceived the important information to be in the text itself and did not pay much attention to the images whether they were relevant to the comprehension of the text or not.

Our participants in general did poorly on both the retention and transfer questions regardless of the type of information they received. The retention questions required the participants to remember details presented in the text while the transfer questions required a deeper understanding of the material. Poor performance was not entirely unexpected given previous studies using the same text. Mayer (2009), for example, reported that his participants typically did not perform well when asked to recall the base text and answer transfer question immediately after they read the text. Nevertheless, we expected that the easier to remember seductive information could impact the retention scores of those exposed to seductive information compared to those exposed to base information alone. This was not the case for this group of participants. Similarly, informative images could have helped with deeper understanding of the text as they depicted the same information provided in the text. This did not happen as the participants who saw informative images spent very little time examining them.

The fact that seductive details, whether in the text or in images, did not affect interest is notable. These results seem to indicate that for our participants, the seductive information was



not viewed as seductive. Therefore, our materials neither triggered nor maintained the participants' situational interest. If we assume that maintained situational interest is necessary for the personal interest in the topic to emerge (Hidi & Renninger, 2006), we saw no movement towards it. It is important to note that the materials (both the sentences and the images) we used were chosen because they have been previously viewed and rated as interesting (e.g., Harp & Mayer 1997; Lehman et al., 2007); thus, we expected them to impact the situational interest. This finding emphasizes the importance of measuring the level of interest online while the participants are involved in the learning task. Previous studies examining seductive details have rated the level of interest of the information differently. The majority of the research has asked a different group of participants to rate the information typically in a preliminary study (e.g., Garner et al., 1991; Mayer et al., 2008). Others have asked participants to read the text with purpose but later only needed to rate it (e.g., Lehman et al., 2007) or participants rated and answered some comprehension questions (e.g., Harp & Mayer, Exp.1, 1997; Schraw, 1998). The way that the rating task is presented (just rating, rating and answering comprehension questions) can potentially impact the way the information is viewed and interpreted.

Importantly, what could be seductive in one context may not be in another. When participants are reading a text, they are likely focused on forming a coherent mental model of the text. We suspect that if ratings are done while this process is ongoing, as they were in our study, seductive information is less likely to impact interest ratings than if the rating is completed after reading the text. This may be another explanation of the mixed results involving seductive details – the details were not necessarily seen as seductive while performing the task. In our study, participants were told to read for comprehension and this information might have influenced the way they interpreted the level of importance and interest of the text. This finding can help

explain why no differences were found between conditions on the retention and transfer scores. Participants were able to stay focused on the important information and not let the seductive information influence their learning. If the information would have been more seductive we potentially could have found a significant difference between conditions. Future studies need to assess the level of seductiveness online within the actual learning context to be able to further investigate the effect of seductive information. It would also be worth examining retention of the information at a later time to see if seductive information is remembered better than important information when measured later.

### **Limitations**

Results of the current study should be considered against some of its limitations. As previously mentioned, participants' interpretation of the level of importance of the text and their subsequent interest may have been affected by the instructions emphasizing comprehension. Knowing that their comprehension will be tested might have influenced the way they viewed the text, putting more emphasis on the importance and less on the level of interest, and more on the text and less on the images. Second, the retention and transfer tasks were challenging to answer after one reading of the text – the participants were not able to go back -- and some of the questions could be reworked to make the task more sensitive to learning that takes place. Third, we only measured retention and transfer immediately after the text was read. This allowed us to measure the effect of seductive details in the working memory but not in the long-term memory. There is a possibility that seductive details are better recalled at a later time and used as cues to the important information. However, it is also possible that seductive detail will be the only information remembered; these options require further study. Finally, the length of the two texts may also be seen as a limitation since the seductive text contained more words. We should point

out, however, that this is necessarily always the case when seductive information is added to the text without losing important information. Keeping the word count the same would necessarily lead to losing important information, or replacing it with unimportant irrelevant information that would not be a proper contrast condition if we want to study seductive detail effect.

## **Conclusion**

In conclusion, this study highlights the importance of measuring learner's interest throughout a task since what has been found as interesting for one group of students in one context may not be for another while they are performing a learning task. Understanding how embedded seductive information may influence the students' interest while they are completing a learning task is crucial for understanding how seductive information can or cannot influence their learning outcomes. Since the materials used in this study did not elicit situational interest or, similar to Magner et al. (2014), did not maintain it, we were able to observe only negative effects of including seductive details to informational text. Nevertheless, the results of our study indicate a possible reason as to why previous research on seductive information has shown mixed results. Importantly, they also suggest caution for teachers, textbook writers, and instructional multimedia designers accustomed to including such information under the premise of increasing readers' interest.

## References

- Ainley, M., Hidi, S., & Berndorff, D. (2002). Interest, learning, and the psychological processes that mediate their relationship. *Journal of Educational Psychology, 94*, 545–561. doi: 10.1037/0022-0663.94.3.545
- Garner, R., Alexander, P. A., Gillingham, M. G., Kulikowich, J. M., & Brown, R. (1991). Interest and learning from text. *American Educational Research Journal, 28*, 643–659. doi: 10.3102/00028312028003643
- Garner, R., & Gillingham, M. G. (1991). Topic knowledge, cognitive interest, and text recall: A microanalysis. *Journal of Experimental Education, 59*, 310–19. doi: 10.1080/00220973.1991.10806569
- Garner, R., Gillingham, M. G., & White, C. S. (1989). Effects of “seductive details” on macroprocessing and microprocessing in adults and children. *Cognition and Instruction, 6*, 41–57. doi:10.1207/s1532690xci0601\_2
- Harp, S. F., & Mayer, R. E. (1997). The role of interest in learning from scientific text and illustrations: On the distinction between emotional interest and cognitive interest. *Journal of Educational Psychology, 89*, 92–102. doi: 10.1037/0022-0663.89.1.92
- Harp, S. E., & Mayer, R. E. (1998). How seductive details do their damage: A theory of cognitive interest in science learning. *Journal of Educational Psychology, 90*, 414–434. doi: 0.1037/0022-0663.90.3.414
- Hidi, S. (1990). Interest and its contribution as a mental resource of learning. *Review of Educational Research, 60*, 549–571. doi: 10.3102/00346543060004549
- Hidi, S., (2000). An interest researcher’s perspective: The effects of extrinsic and intrinsic factors on motivation. In C. Sansone & J. M. Harackiewicz (Eds.), *Intrinsic and*

*extrinsic motivation: The search for optimal motivation and performance.* (pp. 309–339). San Diego, CA: Academic Press.

Hidi, S., & Baird, W. (1988). Strategies for increasing text-based interest and students' recall of expository texts. *Reading Research Quarterly*, *23*, 465–483. doi: 10.2307/747644

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, *41*, 111–127. doi: 10.1207/s15326985ep4102\_4

Kessler, R., Adler, L., Ames, M., Demler, O., Faraone, S., Hiripi, E., et al. (2005). The World Health Organization adult ADHD self-report scale (ASRS): A short screening scale for use in the general population. *Psychological Medicine*, *35*, 245–256.

Korbach, A., Brunken, R. & Park, B. (2016). Learner characteristics and information processing in multimedia learning: A moderated mediation of the seductive details effect. *Learning and Individual Differences*, *51*, 59–68. doi: 10.1016/j.lindif.2016.08.030

Lehman, S., & Schraw, G. (2002). Effects of coherence and relevance on shallow and deep text processing. *Journal of Educational Psychology*, *94*, 738–750. doi: 10.1037//0022-0663.94.4.738

Lehman, S., Schraw, G., McCrudden, M. T., & Hartley, K. (2007). Processing and recall of seductive details in scientific text. *Contemporary Educational Psychology*, *32*, 569–587. doi: 10.1016/j.cedpsych.2006.07.002

Linnenbrink-Garcia, L., Durik, A. M., Conley, A. M., Barron, K. E., Tauer, J. M., Karabenick, S. A., & Harackiewicz, J. M. (2010). Measuring situational interest in academic domains. *Educational and Psychological Measurement*, *70*, 1–25. doi: 10.1177/0013164409355699

Magner, U. I. E., Schwonke, R., Aleven, V., Popescu, O., & Renkl, A. (2014). Triggering

situational interest by decorative illustrations both fosters and hinders learning in computer-based learning environments. *Learning and Instruction*, 29, 141–152. doi: 10.1016/j.learninstruc.2012.07.002

Mayer, R. E. (2009). *Multimedia learning* (2<sup>nd</sup> edition). Cambridge: Cambridge University Press.

Mayer, R. E., Griffith, E., Jurkowitz, I. T. N., & Rothman, D. (2008). Increased interestingness of extraneous details in a multimedia science presentation leads to decreased learning. *Journal of Experimental Psychology*, 14, 329–339. doi: 10.1037/a0013835

McVay, J. C. & Cain, K. (2011). Why does working memory capacity predict variation in reading comprehension? On the influence of mind wandering and executive attention. *Journal of Experimental Psychology: General*, 141, 302–320. doi: 10.1037/a0025250

Moreno, R. & Mayer, R. E. (2000). A coherence effect in multimedia learning: The case for minimizing irrelevant sounds in the design of multimedia instructional messages. *Journal of Educational Psychology*, 92, 117–125. doi: 10.1037//0022-0663.92.1.117

Naglieri, J. & Das, J. P. (1998). *Das-Naglieri Cognitive Assessment System (CAS)*. Itasca, IL: Riverside.

Newcott, W. (1993). Lightning: Nature high-voltage spectacle. *National Geographic*, 184, 80–103.

Plass, J. L., Heidig, S., Hayward, E. O., Homer, B. D., & Um, E. (2014). Emotional design in multimedia learning: Effects of shape and color on affect and learning. *Learning and Instruction*, 29, 128–140. doi: 10.1016/j.learninstruc.2013.02.006

Renninger, K. A. (2000). Individual interest and its implications for understanding intrinsic motivation. In C. Sansone & J. M. Harackiewicz (Eds.), *Intrinsic and extrinsic*

*motivation: The search for optimal motivation and performance* (pp. 373–404). San Diego, CA: Academic Press.

- Rey, G. D. (2011). Seductive details in multimedia messages. *Journal of Educational Multimedia and Hypermedia*, *20*, 283–314.
- Rey, G. D. (2012). A review of research and a meta-analysis of the seductive detail effect. *Educational Research Review*, *7*, 216–237. doi: 10.1016/j.edurev.2012.05.003
- Rowland, E., Skinner, C. H., Davis-Richards, K., Saudargas, R. & Robinson, D. H. (2008). An investigation of placement and type of seductive details: The primacy effect of seductive details on text recall. *Research in the Schools*, *15*, 80–90.
- Rowland-Bryant, E., Skinner, C. H., Skinner, A. L., Saudargas, R., Robinson, D. H., & Kirk, E. R. (2009). Investigating the interaction of graphic organizers and seductive details: Can a graphic organizer mitigate the seductive details effect? *Research in the Schools, Mid-South Educational Research Association*, *16*, 29–40.
- Sanchez, C. A., & Wiley, J. (2006). An examination of the seductive details effect in terms of working memory capacity. *Memory & Cognition*, *34*, 344–355. doi: 10.3758/BF03193412
- Schiefele, U. (1991). Interest, learning, and motivation. *Educational Psychologist*, *26*, 299–323. doi: 10.1207/S15326985ep2603&4\_5
- Schiefele, U. (1996). Topic interest, text representation, and quality of experience. *Contemporary Educational Psychology*, *12*, 3–18. doi: 10.1006/ceps.1996.0002
- Schraw, G. (1998). Processing and recall differences among seductive details. *Journal of Educational Psychology*, *90*, 3–12. doi: 10.1037/0022-0663.90.1.3
- Schraw, G., Bruning, R. & Svoboda, C. (1995). Sources of situational interest. *Journal of*

*Reading Behavior*, 27, 1–17. doi: 10.1080/10862969509547866

Schraw, G., & Dennison, R. S. (1994). The effect of reader purpose on interest and recall.

*Journal of Reading Behavior*, 26, 1–18. doi: 10.1080/10862969409547834

Schraw, G., & Lehman, S. (2001). Situational interest: a review of the literature and directions for future research. *Educational Psychology Review*, 13, 23–52. doi: 10.1023/A:1009004801455

10.1023/A:1009004801455

Singer, M., Andrusiak, P., Reisdorf, P. & Black, N. L. (1992). Individual differences in bridging inference processes. *Memory and Cognition*, 20, 539–548. doi: 10.3758/BF03199586

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5<sup>th</sup> ed). Boston: Pearson Education, Inc.

Thalheimer, W. (2004). Bells, whistles, neon, and purple prose: When interesting words, sounds, and visuals hurt learning and performance — A review of the seductive- augmentation research. Retrieved April, 2017, from [http://www.work-learning.com/seductive\\_ augmentations.htm](http://www.work-learning.com/seductive_augmentations.htm)

Torgesen, J., Wagner, R., & Rashotte, C. (2012). *Test of Word Reading Efficiency (TOWRE 2)*. Austin, TX: Pro-Ed.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, 54, 1063–1070. doi: 10.1037/0022-3514.54.6.1063

Woodcock, R.W. (1998). *Woodcock Reading Mastery Tests - Revised*. Circle Pines, MN: American Guidance Service.



## Chapter V: General discussion

This dissertation focused on different aspects of reading in two groups of students, one from a junior high and another from a university. Academic success is often associated with good reading ability. Teachers have multiple reasons for presenting their students with a variety of texts in various disciplines, such as science and history. The texts are a learning tool and also a source to complete for several assignments. The complexity of the texts and language there in increases as the students enter higher grades. To succeed, students need to be able to recognize and decode words efficiently, understand the meaning of the words and the text they are required to read, and make inferences beyond the text (Hulme & Snowling, 2013). However, recent studies have found that not all junior high students are able to read at a proficient level. For example, 12% of Canadian Grade 8 students performed below their expected reading level (O'Grady, Fung, Servage, & Khan, 2016) and 24% of Grade 8 students in the United States performed below the basic level on the reading assessment (NAEP, 2017). Hence, there is a need to further our understanding of the development of young adolescents' reading skills.

In addition, students' reading abilities can also impact their ability to distinguish different types of information shown in the assigned text. Being able to build a proper mental model around what is important is critical for successful comprehension. The success in this task should develop with age and practice, although textbook authors can make this task very challenging by choosing to present information not relevant for the learning task at hand. For example, the authors may choose to include seductive details in an attempt to trigger and maintain students' interest (e.g., Flowerday, Schraw, & Stevens, 2004; Park & Lim, 2007). If the interest is not triggered, the seductive information will require additional time to process material that does not help in building the necessary mental model of the critical information. The age of the reader can

also mediate the impact of seductive details on the learning outcome. As a reader develops the ability to differentiate between the types of information presented, he/she will become capable of focusing on what is important. Therefore younger students may be more vulnerable to having seductive details distract their knowledge acquisition and use. Little research has focused on how seductive information can impact adolescents' learning, yet seductive information is found in most textbooks. There is clearly a need to study adolescents' interactions with seductive information in order to assist with better designs of learning material.

Despite the importance of studying reading at all ages, the bulk of reading research using eye tracking has involved university students (Blythe & Joseph, 2011; Rayner, 1998). The current dissertation presents two studies that focused on junior high students in order to help fill the gap in reading research for this age group. The first study explored junior high students' eye movements in a reading task to examine if they would be sensitive to differences in reading skills and general developmental changes. The second study examined how seductive text and images affected junior high students' emotional and cognitive interest, text-processing time, and reading behaviours. The third study focused on university students to further examine how they interacted and learned with different learning materials, similar to those used in Study 2—that is, materials that contained informative text with or without seductive text, and with or without informative or seductive images.

One of the first study's goals was to investigate if age, word reading skills, and passage comprehension were related to eye movement measures. Two variables, age and word reading efficiency, were not found to be significant predictors. Age has been previously shown to not be a strong predictor past a certain age and level of reading ability (e.g., Blythe & Joseph, 2011). Familiarity with letters, letter combinations, and words increases with age, reading ability, and

exposure (e.g., Blythe, Liversedge, Joseph, White, & Rayner, 2009). Aghababian and Nazir (2000) found that most basic reading skills (as measured by eye movements) were in place by Grade 2, but fixation durations decreased from Grade 1 to Grade 5 for words correctly identified, indicating that age and familiarity will impact how quickly a reader will capture information. Quick, efficient word recognition processes seem to develop as early as age 7 and qualitatively tend to be similar to those of skilled adult readers even if the speed is still developing (Agnababian & Nazir, 2000; Blythe et al., 2009).

An association was found between passage comprehension and eye movement measures and between phonemic decoding efficiency (PDE) and eye movement measures. Passage comprehension was the best predictor of three eye movement measures: first and gaze fixation durations and saccade amplitude. PDE was a significant predictor of the number of saccades. Specifically, a better comprehension and decoding ability were associated with shorter fixations on words as well as with fewer and longer saccades. The fact that passage comprehension was the better predictor of the eye movement measures, followed by decoding, tends to be consistent with the literature indicating that reading ability impacts eye movements (Kuperman, Matsuki, & Van Dyke, 2018; Rayner, 1998).

The second goal was to examine if the eye movement measures predicted the comprehension of the text being read. Results showed that the first fixation duration and percentage of regressions (percentage of saccades being regressions) were both predictors of text comprehension. A negative correlation was found between first fixation duration and text comprehension. Students who identified the words quickly during their first fixation had better comprehension scores. As for the percentage of regressions, results revealed that the more backward saccades students made, the better their comprehension. This finding is consistent with

past studies reporting that regressions are an important aspect of reading comprehension (e.g., Bicknell & Levy, 2011; Schotter, Tran, & Rayner, 2014), and suggests that many of the regressions were done to reread the information to understand it better. Results of the first study provided general information regarding the eye movements of young adolescent readers. The study supports that readers strategically control their eye movements in a reading task and that both general comprehension ability and comprehension monitoring are important factors when it comes to the eye movement measures of young adolescents.

The next step would be to inquire about word characteristics such as word length and frequency for this age group. It has recently been found that word length, frequency, and position can affect later eye movement measures such as total fixation duration and regressions, and that reader characteristics may have more of an impact on the early eye movement measures of undergraduate students (Kuperman et al., 2018). It would be interesting to see if similar results could be replicated with young adolescents.

The second and third study aimed to examine how the inclusion of seductive details, via text and/or images, can impact students' interest and learning from the text. Six conditions were created and presented on a computer screen: base text only (BT), base text and images (BT+I), base text and seductive images (BT+SI), seductive text (ST), seductive text with base images (ST+I) and seductive text and images (ST+SI). In addition, a student's situational interest, both emotional and cognitive, was measured by two questions presented at the bottom of each screen. A set of retention and comprehension questions was presented to the students once they had finished reading and examining the text. In contrast to earlier studies on seductive details, we controlled for attention, working memory, and reading skills, all variables that may account for inconsistencies in the existing research. The time students spent looking at the different types of

information measured attention allocation. Thus, both studies investigated if attention was in fact allocated to the seductive details, if the presence of seductive details would trigger and maintain interest, and finally, how they would impact the students' recall and comprehension of the information.

The second study focused on the impact that seductive details may have on young adolescent readers. Students were randomly assigned to one of four conditions (BT+I; BT+SI; ST+I; ST+SI). First, the study found that junior high students attend to all seductive information that is presented. In general, students' mean interest levels were similar across the four conditions. When only the seductive text conditions were included, screens with seductive details received a higher interest rating than screens with only base information. Specifically, ratings were higher for cognitive, but not emotional, interest. The learning results suggested that the retention scores were affected negatively when seductive images were included, whereas the comprehension scores were slightly lower when the students were presented with the additional seductive text segments. As expected, the processing time results revealed that when students are presented with text containing seductive sentences they need more time to examine the screen compared to when the text is shorter and includes only base sentences. Finally, the time spent examining informative and seductive images did not differ. Seductive images were examined, but time spent examining them was brief.

The third study examined university students' interactions with seductive details. Students were randomly assigned to one of the six conditions (BT; BT+I; BT+SI; ST; ST+I; ST+SI). The main result of this study was that the inclusion of seductive information did not increase interest or understanding but did increase the text processing time, similar to Study 2. Students' affective status indicated that in general, they were more likely to give more positive

ratings during the pre- than the post-test. When a student's situational interest was examined, no differences were found between the conditions. In general, students' learning outcomes were also unaffected by the type of material shown. No differences were found among the six conditions in regards to retention and comprehension. Differences between BT+SI and ST as well as BT+SI and ST+SI were found only with the inferential type questions, suggesting that seductive text may negatively impact inferencing. Further, results revealed that the time spent on the information depends on the type of text presented, as screens containing seductive information were looked at longer. In addition, when a text only included base sentences, the same base sentences were read faster compared to when the text included additional seductive sentences. Finally, when students looked at the images, they spent more time on the informative than on the seductive images.

Taken together, Study 2 and Study 3 shed light on the importance of evaluating students' interest levels while the students are being exposed to the material they are asked to learn. The fact that participants did not generally rate the different texts differently highlights the importance of participants' interpretation of the task at hand. Harp and Mayer (1997) also found that when participants read a text and later answered questions about it, no differences emerged between conditions (presenting seductive details or not) on the interest level ratings. In a second experiment, Harp and Mayer (1997) asked students only to rate specific sentences without having to take a recall or comprehension test. What they found is that the ratings pertaining to the level of interest changed. Combined with our results, these findings strongly suggest that future studies examining the seductive detail effect need to establish that the materials used are indeed "seductive" under the actual testing conditions. Further, the combined results may explain the mixed findings on seductive details in existing studies: it is possible that participants who

were not asked to learn the material may have found it less interesting than those who did have to learn it. In this case, if the text did not appear interesting (i.e., seductive), the participants' level of interest would not have been triggered; to these participants, the text would simply have contained additional information that they perceived would not benefit their learning. For studies with mixed findings (e.g., Rey, 2011), participants' levels of interest may have been partially triggered, but the information was not seductive enough to fully trigger and maintain the levels of interest. For this reason, to fully understand students' interest levels and how or if they were affected by supposedly seductive material, it will be necessary to measure the levels before, during, and after the task. If a participant's level of interest cannot be triggered and/or maintained, then we will not be able to confirm that the information that claimed to be seductive are, in fact, seductive. If the information were not perceived as seductive, the study would not be able to make claims on the impact of seductive details.

The results of the performance of participants in Studies 2 and 3 are not surprising. First, situational interest wasn't triggered or maintained. The insertion of seductive sentences and/or images (described as highly interesting pieces of information irrelevant to the learning outcome) should trigger and maintain interest, which, in turn, should help students retain and comprehend the text. Given that participants in study 2 and 3 had similar levels of interest in all conditions, we would expect them to have similar learning outcomes. Study 2 generated interesting results in this regard. The presence of different types of seductive information seemed to have a distinct impact on the retention and comprehension of important information. Students who read the base text performed better on the comprehension test than those who also read seductive sentences. Students who saw the base images performed better on recall questions than those who saw the seductive images. These specific findings contribute to theories supporting the role of situational

interest in comprehension (Kintsch, 1980). Based on Kintsch's theory, emotional interest (which seductive images supposedly trigger) should increase arousal levels and help students pay attention to the information, which in turn will increase their learning. Study 2 did, in fact, show that emotional, situational interest played a role in the comprehension score as students in the BT+SI condition obtained slightly better scores. The negative effect of the ST+SI condition in Study 2 could indicate that the presence of two types of seductive information impacted younger students by jointly focusing their attention on unimportant information, while the presence of one type of seductive information may not be enough to focus attention on the unimportant information at the expense of the important information.

All participants in Study 2 and Study 3 needed more time to process screens containing seductive information. For conditions presenting only base information, participants in both studies read the sentences faster. For conditions presenting images, differences were only found for university students. University students spent more time looking at base images than at seductive images, whereas junior high students spent about the same amount of time on each image. Jointly, these results indicate that the additional seductive information adds processing time and unnecessary complexity to the task.

The existing research on seductive details suffers from several limitations. For starters, not enough testing has been done on the impact with different age groups, learners and online behaviour measures (e.g., Bartsch & Cobern, 2003; Lee et al., 2005; McCrudden & Corkill, 2010; Rey, 2011, 2012). Also, the existing studies have not controlled for various learner characteristics that could impact the results, such as working memory capacity. The current dissertation included two studies that addressed these shortcomings. Together, the studies extend the existing research by examining how typical readers (with no deficit in reading, attention, or



working memory) interact with seductive details. This allowed us to verify that when differences were found, they were not impacted by possible confounding participant variables.

### **Conclusion**

Seductive details are often incorporated into instructional materials to captivate and motivate students to pay attention and continue reading the text longer than they otherwise would. To further support assumptions made on the basis of motivation theories, research on seductive details needs to start focusing more on participants' interpretation of the information. The so-called seductive information needs to be viewed as seductive by those being tested, as what is interesting for one group in one context may not be for another group in a different context, yet in both situations additional seductive details will increase the time needed to process the information and, perhaps, complicate the recall and comprehension of it. With the help of the present dissertation, future studies will be able to provide some practical benefits, such as advice for teachers as well for textbook and multimedia designers on what kinds of textbooks and online instructional materials will enhance student learning. On the basis of available studies, it is best to avoid adding seductive details in the format of text or pictures to informative texts, as they are more likely to hinder than help learners.

## References

- Aghababian, V., & Nazir, T.A. (2000). Developing normal reading skills: aspects of the visual processes underlying word recognition. *Journal of Experimental Child Psychology*, *76*, 123–150. doi: 10.1006/jecp.1999.2540
- Bartsch, R. A., & Cobern, K. M. (2003). Effectiveness of PowerPoint presentations in lectures. *Computers & Education*, *41*, 77–86. doi: 10.1016/S0360-1315(03)00027-7
- Bicknell, K., & Levy, R. (2011). Why readers regress to previous words: A statistical analysis. *Proceedings of the Annual Meeting of the Cognitive Science Society*, *33*, 931–936.  
Retrieved from <https://escholarship.org/uc/item/7jf4w8sv>
- Blythe, H. I., & Joseph, H. S. S. L. (2011). Children's eye movements during reading. In S. P. Liversedge, I. D. Gilchrist, & S. Everling (Eds.), *The Oxford handbook of eye movements* (pp. 643–662). New York: Oxford University Press.
- Blythe, H. I., Liversedge, S. P., Joseph, H. S. S. L., White, S. J., & Rayner, K. (2009). Visual information capture during fixations in reading for children and adults. *Vision Research*, *49*, 1583–1591. doi: 10.1016/j.visres.2009.03.015
- Flowerday, T., Schraw, G., & Stevens, J. (2004). The role of choice and interest in reader engagement. *The Journal of Experimental Education*, *72*(2), 93–114. doi: 10.3200/JEXE.72.2.93-114
- Harp, S. F., & Mayer, R. E. (1997). The role of interest in learning from scientific text and illustrations: On the distinction between emotional interest and cognitive interest. *Journal of Educational Psychology*, *89*, 92–102. doi: 10.1037/0022-0663.89.1.92
- Hulme, C., & Snowling, M.J., (2013). Learning to read: What we know and what we need to understand better. *Child Development Perspectives*, *7*, 1–5. doi: 10.1111/cdep.12005

- Kintsch, W. (1980). Learning from text, levels of comprehension. *Poetics*, *9*, 87-98. doi: 10.1016/0304-422X(80)90013-3
- Kuperman, V., & Van Dyke, J. A. (2011). Effects of individual differences in verbal skills on eye-movement patterns during sentence reading. *Journal of Memory and Language*, *65*, 42–73. doi: 10.1016/j.jml.2011.03.002
- Kuperman, V., Matsuki, K., & Van Dyke, J.A. (2018). Contributions of reader- and text-level characteristics to eye-movement patterns during passage reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *44*, 1687–1713. doi: 10.1037/xlm0000547
- McCrudden, M. T., & Corkill, A. J. (2010). Verbal ability and the processing of scientific text with seductive detail sentences. *Reading Psychology*, *31*, 282–300. doi: 10.1080/02702710903256486
- National Center for Education statistics. (2013). *The nation's report card: Reading Highlights, (NCES 2014-466)*. Washington, DC: Institute of Education Sciences, U.S. Department of Education.
- O'Grady, K., Fung, K., Servage, L., & Khan, G. (2016). *Report on the Pan-Canadian Assessment of Reading, Mathematics, and Science*. Retrieved from Council of Ministers of Education, Canada: [https://cmec.ca/536/PCAP\\_2016.html](https://cmec.ca/536/PCAP_2016.html)
- Park, S., & Lim, J. (2007). Promoting positive emotion in multimedia learning using visual illustrations. *Journal of Educational Multimedia and Hypermedia*, *16*, 141–162.
- Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, *124*, 372–422. doi: 10.1037/0033-2909.124.3.372
- Rayner, K., Chace, K. H., Slattery, T. J., & Ashby, J. (2006). Eye movements as reflections of

comprehension processes in reading. *Scientific Studies of Reading*, *10*, 241–255. doi: 10.1207/s1532\_799xssr1003\_3

Rayner, K., & Pollatsek, A. (1989). *The psychology of reading*. Englewood Cliffs, N.J.: Prentice Hall.

Rey, G. D. (2011). Seductive details in multimedia messages. *Journal of Educational Multimedia and Hypermedia*, *20*, 283–314.

Rey, G. D. (2012). A review of research and a meta-analysis of the seductive detail effect. *Educational Research Review*, *7*, 216–237. doi: 10.1016/j.edurev.2012.05.003

Schotter, E. R., Tran, R., & Rayner, K. (2014). Don't believe what you read (only once) comprehension is supported by regressions during reading. *Psychological Science*, *25*(6), 1218–1226. doi: 10.1177/0956797614531148

## Bibliography

- Aghababian, V., & Nazir, T.A. (2000). Developing normal reading skills: aspects of the visual processes underlying word recognition. *Journal of Experimental Child Psychology*, *76*, 123–150. doi: 10.1006/jecp.1999.2540
- Ainley, M., Hidi, S., & Berndorff, D. (2002). Interest, learning, and the psychological processes that mediate their relationship. *Journal of Educational Psychology*, *94*, 545–561. doi: 10.1037/0022-0663.94.3.545
- Baker, L., & Brown, A. L. (1984). Metacognitive skills and reading. In P.D. Pearson, R. Barr, M.L. Kamil & P.Mosenthal (Eds.), *Handbook of reading research*, (pp. 353–394). Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.
- Balota, D. A., Pollatsek, A., & Rayner, K. (1985). The interaction of contextual constraints and parafoveal visual information in reading. *Cognitive Psychology*, *17*, 364–390. doi: 10.1016/0010-0285(85)90013-1
- Bartsch, R. A., & Cobern, K. M. (2003). Effectiveness of PowerPoint presentations in lectures. *Computers & Education*, *41*, 77–86. doi: 10.1016/S0360-1315(03)00027-7
- Bicknell, K., & Levy, R. (2011). Why readers regress to previous words: a statistical analysis. *Proceedings of the Annual Meeting of the Cognitive Science Society*, *33*, 931–936.  
Retrieved from <https://escholarship.org/uc/item/7jf4w8sv>
- Blythe, H. I., & Joseph, H. S. S. L. (2011). Children's eye movements during reading. In S. P. Liversedge, I. D. Gilchrist, & S. Everling (Eds.), *The Oxford handbook of eye movements* (pp. 643–662). New York: Oxford University Press.
- Blythe, H. I., Liversedge, S. P., Joseph, H. S. S. L., White, S. J., & Rayner, K. (2009). Visual information capture during fixations in reading for children and adults. *Vision Research*,

49, 1583–1591. doi: 10.1016/j.visres.2009.03.015

Buswell, G. T. (1922). *Fundamental reading habits*. Chicago, Ill.: The University of Chicago.

Chace, K. H., Rayner, K., & Well, A. D. (2005). Eye movements and phonological parafoveal preview benefit: Effects of reading skill. *Canadian Journal of Experimental Psychology*, 59, 209–217. doi: 10.1037/h0087476

Daneman, M., & Carpenter, P. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior*, 19, 450–466. doi: 10.1016/S0022-5371(80)90312-6

Deacon, S. H., Cook, K., & Parrila, R. (2012). Identifying high-functioning dyslexics: Is self-report of early reading problems enough? *Annals of Dyslexia*, 62, 120–134. doi: 10.1007/s11881-012-0068-2

Flowerday, T., Schraw, G., & Stevens, J. (2004). The role of choice and interest in reader engagement. *The Journal of Experimental Education*, 72, 93–114. doi: 10.3200/JEXE.72.2.93-114

Frazier, L., & Rayner, K. (1982). Making and correcting errors during sentence comprehension: Eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology*, 14, 178–210. doi: 10.1016/0010-0285(82)90008-1

Garner, R., Alexander, P. A., Gillingham, M.G., Kulikowich, J.M., & Brown, R. (1991). Interest and learning from text. *American Educational Research Journal*, 28, 643–659. doi: 10.3102/00028312028003643

Garner, R., & Gillingham, M. G. (1991). Topic knowledge, cognitive interest, and text recall: A microanalysis. *Journal of Experimental Education*, 59, 310–319. doi: 10.1080/00220973.1991.10806569

- Garner, R., Gillingham, M.G., & White, C.S. (1989). Effects of “seductive details” on macroprocessing and microprocessing in adults and children. *Cognition and Instruction*, 6, 41–57. doi:10.1207/s1532690xci0601\_2
- Harp, S. F., & Mayer, R. E. (1997). The role of interest in learning from scientific text and illustrations: On the distinction between emotional interest and cognitive interest. *Journal of Educational Psychology*, 89, 92–102. doi: 10.1037/0022-0663.89.1.92
- Harp, S. E., & Mayer, R. E. (1998). How seductive details do their damage: A theory of cognitive interest in science learning. *Journal of Educational Psychology*, 90, 414–434. doi: 0.1037/0022-0663.90.3.414
- Hidi, S. (1990). Interest and its contribution as a mental resource of learning. *Review of Educational Research*, 60, 549–571. doi: 10.3102/00346543060004549
- Hidi, S., (2000). An interest researcher’s perspective: The effects of extrinsic and intrinsic factors on motivation. In C. Sansone & J.M. Harackiewicz (Eds.), *Intrinsic and extrinsic motivation: the search for optimal motivation and performance*. San Diego, CA: Academic Press.
- Hidi, S. (2001). Interest, reading, and learning: Theoretical and practical considerations. *Educational Psychology Review*, 13, 191–209. doi: 10.1023/A:1016667621114
- Hidi, S. (2006). Interest: A unique motivational variable. *Educational Research Review*, 1, 69–82. doi: 10.1016/j.edurev.2006.09.001
- Hidi, S., & Baird, W. (1988). Strategies for increasing text-based interest and students’ recall of expository texts. *Reading Research Quarterly*, 23, 465–483. doi: 10.2307/747644
- Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, 41, 111–127. doi: 10.1207/s15326985ep4102\_4

- Huestegge, L., Radach, R., Corbic, D., & Huestegge, S. M. (2009). Oculomotor and linguistic determinants of reading development: A longitudinal study. *Vision Research*, *49*(24), 2948–2959. doi: 10.1016/j.visres.2009.09.012
- Huey, E.B. (1908). *The psychology and pedagogy of reading*. New York: Macmillan.
- Hulme, C. & Snowling, M.J., (2013). Learning to Read: What we know and what we need to understand better. *Child Development Perspectives*, *7*, 1–5. doi: 10.1111/cdep.12005
- Iran-Nejad, A. (1987). Cognitive and affective causes of interest and liking. *Journal of Educational Psychology*, *79*(2), 120–130. doi: 10.1037/0022-0663.79.2.120
- Just, M. A., & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review*, *87*(4), 329–354. doi: 10.1037/0033-295X.87.4.329
- Just, M. A., & Carpenter, P. A. (1984). Using eye fixations to study reading comprehension. In D.E. Kieras & M.A. Just (Eds.), *New methods in reading comprehension research*, (pp.151–182). Hillsdale, NJ: Erlbaum.
- Kendeou, P., van den Broek, P., White, M.J., & Lynch, J. (2007). Comprehension in preschool and early elementary children: Skill development and strategy interventions. In McNamara, D. S. (Ed), *Reading comprehension strategies, theories, interventions and technologies* (pp. 27–45). New York: Taylor & Francis Group.
- Kessler, R., Adler, L., Ames, M., Demler, O., Faraone, S., Hiripi, E., Howes, M. J., Jin, R., Secknik, K., Spencer, Ustun, T. B., & Walters, E. E. (2005). The World Health Organization adult ADHD self-report scale (ASRS): A short screening scale for use in the general population. *Psychological Medicine*, *35*, 245–256.



- Kintsch, W. (1980). Learning from text, levels of comprehension, or: Why anyone would read a story anyway. *Poetics*, *9*(1–3), 87–98. doi: 10.1016/0304-422X(80)90013-3
- Korbach, A., Brunken, R. & Park, B. (2016). Learner characteristics and information processing in multimedia learning: A moderated mediation of the seductive details effect. *Learning and Individual Differences*, *51*, 59–68. doi: 10.1016/j.lindif.2016.08.030
- Kuperman, V., & Van Dyke, J. A. (2011). Effects of individual differences in verbal skills on eye-movement patterns during sentence reading. *Journal of Memory and Language*, *65*(1), 42–73. doi: 10.1016/j.jml.2011.03.002
- Kuperman, V., Matsuki, K., & Van Dyke, J.A. (2018). Contributions of reader- and text-level characteristics to eye-movement patterns during passage reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *44*, 1687–1713. doi: 10.1037/xlm0000547
- Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*, 159–174. doi: 10.2307/2529310
- Lehman, S., & Schraw, G. (2002). Effects of coherence and relevance on shallow and deep text processing. *Journal of Educational Psychology*, *94*, 738–750. doi: 10.1037//0022-0663.94.4.738
- Lehman, S., Schraw, G., McCrudden, M. T. & Hartley, K. (2007). Processing and recall of seductive details in scientific text. *Contemporary Educational Psychology*, *32*, 569–587. doi: 10.1016/j.cedpsych.2006.07.002
- Leung, D., Ordqvist, A., Falkmer, T., Parsons, R., & Falkmer, M. (2013). Facial emotion recognition and visual search strategies of children with high functioning autism and

- Asperger syndrome. *Research in Autism Spectrum Disorder*, 7, 833–844. doi:  
10.1016/j.rasd.2013.03.009
- Linnenbrink-Garcia, L., Durik, A. M., Conley, A. M., Barron, K. E., Tauer, J. M., Karabenick, S. A., & Harackiewicz, J. M. (2010). Measuring situational interest in academic domains. *Educational and Psychological Measurement*, 70, 1–25. doi:  
10.1177/0013164409355699
- Magner, U. I. E., Schwonke, R., Aleven, V., Popescu, O., & Renkl, A. (2014). Triggering situational interest by decorative illustrations both fosters and hinders learning in computer-based learning environments. *Learning and Instruction*, 29, 141–152. doi:  
10.1016/j.learninstruc.2012.07.002
- Mayer, R. E. (2003). The Promise of Multimedia Learning: Using the same instructional design methods across different media. *Learning and Instruction*, 13, 125–139.  
doi:10.1016/S0959-4752(02)00016-6.
- Mayer, R.E. (2005). Cognitive Theory of Multimedia Learning. In Mayer, R.E. (Ed), *The Cambridge handbook of multimedia learning* (pp.31–48). New York: Cambridge University Press.
- Mayer, R.E. (2009). *Multimedia learning* (2<sup>nd</sup> edition). Cambridge: Cambridge University Press.
- Mayer, R. E., Griffith, E., Jurkowitz, I. T. N., & Rothman, D. (2008). Increased interestingness of extraneous details in a multimedia science presentation leads to decreased learning. *Journal of Experimental Psychology*, 14, 329–339. doi: 10.1037/a0013835
- Mayer, R. E., Heiser, J., & Lonn, S. (2001). Cognitive constraints on multimedia learning: When presenting more material results in less understanding. *Journal of Educational Psychology*, 93, 187–198. doi:10.1037//0022-0663.93.1.187

- Mason, L., Tornatora, M. C., & Pluchino, P. (2013). Do fourth graders integrate text and picture in processing and learning from an illustrated science text? Evidence from eye-movement patterns. *Computers & Education, 60*, 95–109. doi: 10.1016/j.compedu.2012.07.011
- McConkie, G.W., & Rayner, K. (1975). The span of the effective stimulus during a fixation in reading. *Perception and Psychophysics, 17*, 578–586. doi: 10.3758/BF03203972
- McConkie, G. W., Zola, D., Grimes, J., Kerr, P. W., Bryant, N. R., & Wolff, P. M. (1991). Children's eye movements during reading. In J.F. Stein (Ed.), *Vision and visual dyslexia, 13*, (pp.251–262). London: Macmillan Press.
- McCrudden, M. T., & Corkill, A. J. (2010). Verbal ability and the processing of scientific text with seductive detail sentences. *Reading Psychology, 31*, 282–300. doi: 10.1080/02702710903256486
- McVay, J.C. & Cain, K. (2011). Why does working memory capacity predict variation in reading comprehension? On the influence of mind wandering and executive attention. *Journal of Experimental Psychology: General, 141*, 302–320. doi: 10.1037/a0025250
- Moreno, R. & Mayer, R. E. (2000). A coherence effect in multimedia learning: The case for minimizing irrelevant sounds in the design of multimedia instructional messages. *Journal of Educational Psychology, 92*, 117–125. doi:10.1037/0022-0663.92.1.117
- Naglieri, J., & Das, J. P. (1998). *Das-Naglieri Cognitive Assessment System (CAS)*. Itasca, IL: Riverside.
- National Center for Education statistics. (2013). *The nation's report card: Reading Highlights, (NCES 2014-466)*. Washington, DC: Institute of Education Sciences, U.S. Department of Education.

- Newcott, W. (1993). Lightning: Nature high-voltage spectacle. *National Geographic*, *184*, 80–103.
- Oakhill, J., & Cain, K. (2007). Issues of causality in children's reading comprehension. In D.S. McNamara (Ed.). *Reading comprehension strategies: Theories, interventions, and technologies*, (pp. 47–71). Mahwah, NJ: Lawrence Erlbaum Associates.
- O'Grady, K., Fung, K., Servage, L., & Khan, G. (2016). *Report on the Pan-Canadian Assessment of Reading, Mathematics, and Science*. Retrieved from Council of Ministers of Education, Canada: [https://cmec.ca/536/PCAP\\_2016.html](https://cmec.ca/536/PCAP_2016.html)
- Park, B., Flowerday, T., & Brünken, R. (2015). Cognitive and affective effects of seductive details in multimedia learning. *Computers in Human Behavior*, *44*, 267–278. doi: 10.1016/j.chb.2014.10.061
- Park, B., & Lim, J. (2007). Promoting positive emotion in multimedia learning using visual illustrations. *Journal of Educational Multimedia and Hypermedia*, *16*, 141–162.
- Park, B., Moreno, R., Seufert, T., & Brünken, R. (2011). Does cognitive load moderate the seductive details effect? A multimedia study. *Computers in Human Behavior*, *27*, 5–10. doi:10.1016/j.chb.2010.05.006
- Perfetti, C. A. (1985). *Reading ability*. New York: Oxford University Press.
- Plass, J. L., Heidig, S., Hayward, E. O., Homer, B. D., & Um, E. (2014). Emotional design in multimedia learning: Effects of shape and color on affect and learning. *Learning and Instruction*, *29*, 128–140. doi: 10.1016/j.learninstruc.2013.02.006
- Prado, C., Dubois, M., & Valdois, S. (2007). The eye movements of dyslexic children during reading and visual search: Impact of the visual attention span. *Vision Research*, *47*, 2521–2530. doi:10.1016/j.visres.2007.06.001

- Rayner, K. (1985). The role of eye movements in learning to read and reading disability. *Remedial and Special Education, 6*, 53–60. doi: 10.1177/074193258500600609
- Rayner, K. (1986). Eye movements and the perceptual span in beginning and skilled readers. *Journal of Experimental Child Psychology, 41*, 211–236. doi: 10.1016/0022-0965(86)90037-8
- Rayner, K. (1995). Eye movements and cognitive processes in reading, visual search, and scene perception. In J. M. Findlay, R.W. Kentridge, & R. Walker (Eds.), *Eye movement research: Mechanisms, processes and applications* (pp. 3–22). Amsterdam: Elsevier, North-Holland.
- Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin, 124*, 372–422. doi: 10.1037/0033-2909.124.3.372
- Rayner, K. (2009). Eye movements and attention in reading, scene perception, and visual search. *Quarterly Journal of Experimental Psychology, 62*, 1457–1506. doi: 10.1080/17470210902816461
- Rayner, K., Chace, K. H., Slattery, T. J., & Ashby, J. (2006). Eye movements as reflections of comprehension processes in reading. *Scientific Studies of Reading, 10*, 241–255. doi: 10.1207/s1532-799xssr1003\_3
- Rayner, K., & Duffy, S. A. (1986). Lexical complexity and fixation times in reading: Effects of word frequency, verb complexity, and lexical ambiguity. *Memory & Cognition, 14*(3), 191–201. doi: 10.3758/BF03197692
- Rayner, K., & Pollatsek, A. (1989). *The psychology of reading*. Englewood Cliffs, N.J.: Prentice Hall.

- Renninger, K. A. (2000). Individual interest and its implications for understanding intrinsic motivation. In C. Sansone & J. M. Harackiewicz (Eds.), *Intrinsic and extrinsic motivation: The search for optimal motivation and performance* (pp. 373–404). San Diego, CA: Academic Press.
- Rey, G. D. (2011). Seductive details in multimedia messages. *Journal of Educational Multimedia and Hypermedia*, 20, 283–314.
- Rey, G.D. (2012). A review of research and a meta-analysis of the seductive detail effect. *Educational Research Review*, 7, 216–237. doi: 10.1016/j.edurev.2012.05.003
- Rowland, E., Skinner, C.H., Davis-Richards, K., Saudargas, R. & Robinson, D.H. (2008). An investigation of placement and type of seductive details: the primacy effect of seductive details on text recall. *Research in the Schools*, 15, 80–90.
- Rowland-Bryant, E., Skinner, C. H., Skinner, A. L., Saudargas, R., Robinson, D. H., & Kirk, E.R. (2009). Investigating the interaction of graphic organizers and seductive details: can a graphic organizer mitigate the seductive details effect?. *Research in the Schools, Mid-South Educational Research Association*, 16, 29–40.
- Roy-Charland, A., Perron, M., Turgeon, K.L., Hoffman, N., & Chamberland, J. A. (2016). The link between text difficulty, reading speed and exploration of printed text during shared book reading. *Reading and Writing*, 29, 731–743. doi: 10.1007/s11145-016-9624-1
- Sanchez, C. A., & Wiley, J. (2006). An examination of the seductive details effect in terms of working memory capacity. *Memory & Cognition*, 34, 344–355. doi: 10.3758/BF03193412
- Schiefele, U. (1991). Interest, learning, and motivation. *Educational Psychologist*, 26, 299–323. doi: 10.1207/S15326985ep2603&4\_5

- Schiefele, U. (1996). Topic interest, text representation, and quality of experience. *Contemporary Educational Psychology, 12*, 3–18. doi: 10.1006/ceps.1996.0002
- Schotter, E. R., Tran, R., & Rayner, K. (2014). Don't believe what you read (only once) comprehension is supported by regressions during reading. *Psychological Science, 25*(6), 1218–1226. doi: 10.1177/0956797614531148
- Schraw, G. (1998). Processing and recall differences among seductive details. *Journal of Educational Psychology, 90*, 3–12. doi: 10.1037/0022-0663.90.1.3
- Schraw, G., Bruning, R. & Svoboda, C. (1995). Sources of situational interest. *Journal of Reading Behavior, 27*, 1–17. doi: 10.1080/10862969509547866
- Schraw, G., & Dennison, R. S. (1994). The effect of reader purpose on interest and recall. *Journal of Reading Behavior, 26*, 1–18. doi: 10.1080/10862969409547834
- Schraw, G., & Lehman, S. (2001). Situational interest: A review of the literature and directions for future research. *Educational Psychology Review, 13*, 23–52. doi: 10.1023/A:1009004801455
- Shankweiler, D., Lundquist, E., Dreyer, L. G., & Dickinson, C. C. (1996). Reading and spelling difficulties in high school students: Causes and consequences. *Reading and Writing, 8*(3), 267–294. doi: 10.1007/BF00420279
- Shen, B., McCaughtry, N., Martin, J., & Dillion, S. (2006). Does “Sneaky Fox” facilitate learning? Examining the effects of seductive details in physical education. *Research Quarterly for Exercise and Sport, 77*, 498–506. doi: 10.1080/02701367.2006.10599384
- Singer, M., Andrusiak, P., Reisdorf, P. & Black, N.L. (1992). Individual differences in bridging inference processes. *Memory and Cognition, 20*, 539–548. doi: 10.3758/BF03199586

- Slattery, T. J., & Rayner, K. (2009). The influence of text legibility on eye movements during reading. *Applied Cognitive Psychology, 24*, 1129–1148. doi: 10.1002/acp.1623
- Snow, C. E. (2002). *Reading for Understanding: Toward an R&D Program in Reading Comprehension*. Santa Monica, CA: Rand Corporation.
- Sperlich, A., Meixner, J., & Laubrock, J. (2016). Development of the perceptual span in reading: A longitudinal study. *Journal of Experimental Child Psychology, 146*, 181–201. doi: 10.1016/j.jecp.2016.02.007
- Tabachnick, B.G., & Fidell, L.S. (2007). *Using multivariate statistics* (5<sup>th</sup> ed). Boston: Pearson Education, Inc.
- Taylor, S. E. (1965). Eye movements in reading: Facts and fallacies. *American Educational Research Journal, 2*, 187–202. doi: 10.3102/00028312002004187
- Thalheimer, W. (2004). Bells, whistles, neon, and purple prose: When interesting words, sounds, and visuals hurt learning and performance — A review of the seductive- augmentation research. Retrieved April, 2017, from [http://www.work-learning.com/seductive\\_ augmentations.htm](http://www.work-learning.com/seductive_augmentations.htm)
- Tinker, M.A. (1958). Recent studies of eye movements in reading. *Psychological Bulletin, 55*, 215–231. doi: 10.1037/h0041228
- Torgesen, J., Wagner, R., & Rashotte, C. (2012). *Test of Word Reading Efficiency (TOWRE 2)*. Austin, TX: Pro-Ed.
- Wade, S. E., & Adams, R. B. (1990). Effects of importance and interest on recall of biographical text. *Journal of Reading Behavior, 22*, 330–53. doi: 10.1080/10862969009547717



- Wade, S. E., & Moje, E. B. (2000). The role of text in classroom learning. In M. L. Kamil, P. B. Mosenthal, P. D. Pearson, & R. Barr (Eds.), *Handbook of reading research* (Vol. III, pp. 609–627). Mahwah, NJ: Erlbaum.
- Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*, 1063–1070. doi: 10.1037/0022-3514.54.6.1063
- Wang, Z., & Adesope, O. (2016). Does learners' prior knowledge moderate the detrimental effects of seductive details in reading from text? A 2 by 3 study. *International Journal of Instruction*, *9*, 35–50. doi: 10.12973/iji.2016.923a
- Wittrock, M.C., Marks, C., & Doctorow, M. (1975). Reading as a generative process. *Journal of Educational Psychology*, *67*, 484–489. doi: 10.1037/h007017
- Woodcock, R. W. (1998). *Woodcock Reading Mastery Tests - Revised*. Circle Pines, MN: American Guidance Service.