

Studying Journal Articles under Time Pressure

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

The purpose of this dissertation is to understand how students distribute their attention while reading academic journal articles under time pressure. Given that most of the reading done in university is commonly time-sensitive and task-dependent, this dissertation explores how students actually shift their attention across the discrete sections of a journal article in the available time to identify and extract task-relevant information. Addressing gaps in the literature, the experiments in this dissertation observe the impact of the following three factors on strategic shifts in attention during study: (1) varied time conditions; (2) the presence/absence of summary information; and (3) the experience of the reader in terms of education level.

The experimental methods used in this series of studies are consistent across all three chapters. Participants are given two 5-page academic journal articles to read on cognitive psychology for an impending test. Participants' eye movement data are analyzed for the total adjusted viewing time the eyes spend in each section of the article, i.e., viewing time in each section was divided by the number of words in each section.

The experiments in Chapter 2 examine overt attention when studying with and without a time constraint. Participants were given either 2 minutes of study time or unlimited study time. Analyses of the eye movement data reveal a *reduced reading effect* both when study time is restricted and unlimited. Specifically, the results showed that as time progresses, participants tend to read less and skim more, with the largest amount of adjusted time being spent on the Abstract. Chapter 3 examines further the apparent importance of the

Abstract when reading under time constraint. It investigates whether people allocate more attention to the Abstract relative to other sections of the journal article based on its position or its summary content. Also, Chapter 3 explores whether the presence of an Abstract impacts what people read next in the article. Participants are given a limited time in which to read one of two versions of the articles to read, one version with an Abstract, the other without. The findings show that position, rather than summary content, seems to explain the amount of adjusted viewing time on the Abstract. Additionally, the summary information contained in an Abstract impacts what people read next in the article. Chapter 4 examines the extent to which participants' education level impacts their use of a skimming strategy for studying. Here, participants form three different groups based on their year of study: graduates, senior undergraduates (3rd and 4th year), and junior undergraduates (1st and 2nd year). Overall, the results suggest that, when studying journal articles under time pressure, skimming behaviour changes from a primarily linear-skimming strategy (reading from beginning to end) to a more targeted-skimming strategy with increased education level. Finally, in the General Discussion in Chapter 5, a summary of the findings of this dissertation is considered in light of the literature on complex factors that impact attention and information-gain. The chapter also outlines hypotheses for future testing of overt attention while reading journal articles under time pressure.

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Dedication

This thesis is dedicated to two special people:

Rita and Joseph Meschino, whose faith, love, and personal support helped me to realize my long-time dream of completing my PhD.

Table of Contents

AUTHOR'S DECLARATION	ii
Abstract	iii
Acknowledgements	v
Dedication	vi
Table of Contents	vii
List of Figures	ix
List of Tables	x
Chapter 1 Introduction.....	1
1.1 OVERT ATTENTION	4
1.2 READING	7
1.2.1 Time Available for Reading	8
1.2.2 The Presence of a Summary	10
1.2.3 Properties of the Reader	11
1.3 THE PRESENT EXPERIMENTS	12
Chapter 2 The Role of Available Reading Time in Studying from Journal Articles.....	15
2.1 Study 1.....	17
2.1.1 Method.....	18
2.1.2 Results	21
2.1.3 Discussion	27
2.2 Study 2.....	28
2.2.1 Method.....	29
2.2.2 Results	31
2.2.3 Discussion	39
2.2.4 Summary and Conclusion.....	40
Chapter 3 The Role of the Abstract in Studying Journal Articles under Time Pressure	42
3.1.1 Method.....	50
3.1.2 Results	52
3.1.3 Discussion	61
Chapter 4 The Role of Experience in Skimming Journal Articles under Time Pressure	64
4.1.1 Method.....	68

4.1.2 Results.....	70
4.1.3 Discussion.....	76
Chapter 5 General Discussion.....	79
5.1 Future Directions	83
Appendix A Memory Task Questionnaire for <i>Search</i> Article (Lleras, Rensink & Enns, 2005).....	91
Appendix B Memory Task Questionnaire for <i>Vision</i> Article (Lee & Vecera, 2005)	93
Appendix C Opening Pages for Abstract Absent Condition (Chapter 4)	95
References.....	97

List of Figures

Figure 2.1. The average adjusted time (ms/word) spent reading each section of the journal articles with 2 minutes of study time.....	22
Figure 2.2. The average number of fixations (per word) and average fixation duration in milliseconds for each section of the journal articles with 2 minutes of study time.....	25
Figure 2.3. The average adjusted time (ms/word) spent reading each section of the journal articles with unlimited study time and an explicit linear reading strategy.....	34
Figure 2.4. The average number of fixations (per word) and average fixation duration in milliseconds for each section of the journal articles with unlimited reading time and an explicit linear reading strategy.. ..	37
Figure 3.1. The average adjusted time (ms/word) spent viewing the opening and second paragraphs as a function of Presence of Abstract (Present; Absent) and Study Time (2 minutes; 5 minutes).. ..	54
Figure 3.2. The average scores for the memory task (as a percentage) as a function of Presence of Abstract (Present; Absent) and Study Time (2 minutes; 5 minutes)	60
Figure 4.1. The average adjusted time (ms/word) spent viewing each section of the journal articles as a function of education level (Junior Undergraduates, Senior Undergraduates & Graduates).....	71
Figure 4.2. The average number of fixations per word and average fixation duration (in ms) for each section of the journal articles as a function of education level with 2 and 5 minutes of study time.. ..	74

List of Tables

Table 2.1. Mean reading time (in seconds) averaged across participants for each article and collapsed across articles.....	32
Table 3.1. Position of opening and second paragraphs across Abstract conditions.	48

Chapter 1

Introduction

One of the effects of living with electric information is that we live habitually in a state of information overload. There's always more than you can cope with.

Marshall McLuhan, *The Best of Ideas*, CBC Radio, 1967

With a well-written book I only read the right-hand page and allow my mind to work on the left-hand page. With a poorly written book I read every word.”

Marshall McLuhan

Information overload is a familiar experience for many university students, often coinciding with the pressure of a deadline. At one time or another, most students find themselves in a time crunch and having to read articles before a seminar, skim notes to prepare for a test, or browse through resources for written assignments. A prime example would be a student who is unprepared for a quiz on the week’s readings in an upcoming class. Without enough time to carefully read the entire article before the start of class, the student will likely read only what they think is going to be on the quiz. Indeed, much of the reading that university students do is typically time-sensitive and task-specific in this way. They read to gain information necessary for completing a task within a specific time-frame.

The purpose of this dissertation is to understand how students distribute their attention in one such common, real-life situation: reading academic journal articles under time pressure for an impending test. Both the information source (journal articles) and the task (studying for a test) were chosen for being widely representative of students’ experience with literacy at the higher education level. There are two broad literatures on which the present research is based: (1) visual attention and (2) reading. In the visual attention literature, research has developed along three key lines of inquiry, investigating (1) the

internal cognitive mechanisms of attention or, in other words, covert attention (e.g., Kahneman & Treisman, 1984; Pashler, 1984; Posner, 1980; Posner, Snyder & Davidson, 1980; Triesman, 1982); (2) the neural mechanisms of attention (e.g., Anderson, Essick & Siegel, 1985; Danckert, Maruff, Kinsella, de Graaff & Currie, 1999; Desimone & Duncan, 1995; Kelley & Yantis, 2010); and (3) overt eye movements or, in other words, overt attention (e.g., Findlay & Gilchrist, 2004; Friesen & Kingstone, 1998; Henderson, Weeks and Hollingworth, 1999; Rensink, O'Reagan & Clark, 1998; Underwood, Jebbett & Roberts, 2004). This dissertation primarily focuses on overt attention, examining where in journal articles people direct their eyes as they read.

In the reading literature, broadly speaking, research has investigated six key issues: individual word recognition (e.g., Brown, Stolz & Besner, 2006; Mulatti, Reynolds, & Besner, 2006), how the eyes fixate on individual words and sentences (e.g., Rayner, 1978; see Rayner, 1998 for review); memory for material read and reading comprehension (e.g., Kintsch & van Dijk, 1978; Kintsch, 1988); integrating pictures and text (e.g., Carroll, Young & Guertin, 1992; Hegarty, 1992; Rayner, Rotello, Stewart, Keir & Duffy, 2001); reading extended texts e.g., (Dee-Lucas & Larkin, 1995; Holmqvist, Holsanova, Barthelson & Lundqvist, 2003); and reading under time pressure (e.g., Duggan & Payne, 2009, Reader & Payne, 2007). The present research focuses specifically on the last two areas, i.e., reading an extended text (journal articles) under time pressure. In keeping with the lines of inquiry that emerge from the two broad literatures, the present research examines people's eye movements to the different sections of the journal article as they read under time pressure.

Before reviewing the relevant literature on overt attention and reading in more detail, it is important to discuss the overall approach taken in this dissertation. A common approach in experimental psychology is to generate hypotheses based on a theory and then to test those hypotheses. Departing from this hypothesis-driven approach of experimental psychology, the present research adopts a distinctive approach in attention research known as *cognitive ethology* (Kingstone, Smilek, Ristic, Friesen & Eastwood, 2003; Kingstone, Smilek, & Eastwood, 2009). This approach focuses on embodied aspects of cognition, such as overt attention, and primarily focuses on *observing* how people behave in naturally occurring situations as a starting point for investigating complex cognitive processes.¹ Grounding research in observations of everyday behaviour can guide further, more controlled experimentation and provide steps toward new theories of cognitive processes. In this way, a cognitive ethology approach avoids making the kind of *a priori* assumptions about the invariance of cognitive processes across contexts that fail to fully explain the more variable characteristics in real-life situations (Kingstone, et al., 2009).

Informed by a cognitive ethological approach, then, the overarching goal of this dissertation is: (1) to observe students' behaviour (eye movements) as they study for a test from academic journal articles; (2) to describe the nuances of behaviour in terms of complex factors that impact attention and information-gain in this context; and (3) to make theoretical conclusions and generate hypotheses for further testing based on these observations of what

¹ The term *cognitive ethology*, as defined by Kingstone et al. and the present research, takes its inspiration but remains distinct from the well-developed discipline of the same name that studies non-human animal cognition.

people attended to during reading. By observing people's behaviours in the naturalistic task of reading articles under time pressure for a test, this dissertation is able to take an observational approach in the laboratory. Indeed, that students often read articles sitting at a desk in a room, often on the computer, provides the present research with a unique opportunity to apply the cognitive ethology approach while remaining in a lab setting.

The following section discusses the relevant work on overt attention and eye movements, highlighting the main terminology and measurements used in this thesis. Next, the literature on reading will be examined with a focus on recent work on reading under time pressure. Lastly, this chapter will outline in greater detail the experiments that appear in subsequent chapters of this dissertation.

1.1 OVERT ATTENTION

The way the eyes move when engaging with the world has been extensively studied, by researchers such as, Yarbus (1968), Henderson, Weeks and Hollingworth (1999), Underwood, Jebbett & Roberts (2004) to name a few. As a basic description, Findlay and Gilchrist (2003) provide a summary of the principles underlying overt attention, linking them to the mechanics of eye movements. Traditionally, attention involves the selection of part of a dense visual array. That is, when we pay attention to an object, it receives more processing and stronger representation in perception than other objects around it. According to Findlay and Gilchrist, selection of an object in a particular location of the visual array can occur either by directly looking at the object or more indirectly by focusing on the location of the object and catching it out of the corner of one's eye. While much of the research has

emphasized the latter form of covert attention, they argue that selection is best achieved by moving the gaze to fixate an item so that it can be processed by the fovea. They argue that it is this type of direct visual selection that characterizes *overt attention*. That is, overt attention is the ability to move one's eyes to align the fovea with an object in a visual array. Because direct fixation is the main method by which objects are selected, overt visual attention is an *active* function of vision. With this logic, Findlay and Gilchrist step outside the dominant paradigm in the literature that puts covert attention at the centre of attentional selection.

As a measure of overt attention, eye movements have been examined in a large number of naturalistic contexts. Examples include playing chess (Reingold, Charness, Pomplun, & Stampe, 2001), reading weather maps (Heagerty et al., 2010), sports (Harle & Vickers, 2001), driving (Land & Lee, 1994; Underwood, Chapman, Berger & Crundell, 2003), scene-viewing (Henderson, 2003; Rensink, O'Reagan & Clark, 1997; Yarbus, 1967), studying x-rays (Nodine & Kundel, 1987) and browsing advertisements (Rayner et al., 2001). Based on these studies, several fundamental principles have emerged: (1) the eyes move in characteristic patterns; (2) the eyes move based on characteristics of the object(s) being observed; and (3) the eyes move based on goals of the observer.

Regarding the first principle, the basic pattern of visual sampling involves the short rapid movement of the eyes (*saccades*) separated by pauses (*fixations*). During the time of each fixation, the cognitive system processes new information. The *duration* of fixations can vary depending on the amount or complexity of information being processed at any given moment, with longer durations indicating more processing. For example, the average fixation duration during silent reading is between 200-250 milliseconds, while for scene-

viewing, it is around 330 milliseconds (Findlay & Gilchrist, 2003; Rayner, 1998). Regions that contain important or task-relevant information require more attention and, therefore, would receive a greater number of fixations. By contrast, sensitivity to visual input tends to be reduced during a saccade, with no new information being obtained (*saccadic suppression*). Frequent saccades are necessary due to variable degrees of clarity and sharpness in the visual field. The visual field consists of three regions: the fovea (the central 2 ° of vision), the parafovea (extending 5 ° on either side of a fixation), and the periphery (extending beyond the parafovea). Through saccadic movements, we foveate the visual input we want to see clearly.

Regarding the second and third principles mentioned above, eye movements based on characteristics of the object and goals of the observer are elegantly demonstrated by Yarbus (1967). Regarding the characteristics of the object, Yarbus shows how the observer attends to what is of central interest over what is of peripheral interest when looking at pictures. For instance, when the object being viewed is a portrait of a human face, the observer usually pays particular attention to the eyes, lips, and nose, with other parts receiving only cursory consideration. He reasons that these features, being the most expressive, are most likely to hold important information, such as the mood or attitude (Yarbus, 1967).

With regard to the goals of the observer, Yarbus shows that people's eye movements vary with the nature of the information required by a task. For instance, when having to estimate the material circumstances of the family members portrayed in Repin's painting, "An Unexpected Visitor", the observer's eyes fixated mainly on the clothing and furniture in

the scene. However, when instructed to give the ages of the people shown in the picture, attention was concentrated on the faces (Yarbus, 1967).

Because the eyes move in these characteristic ways, the following shifts in eye movements are expected to be found when reading journal articles. First is a pattern of fixations based on decisions about what is of central over peripheral interest. That is, the investigation of eye movement behaviour ought to show which sections of the journal articles people identify as important for extracting task-relevant information. Second, decisions about what is of central interest ought to be dictated in part by the format of the stimulus itself. For instance, the standardized sections of the journal article format, such as the Abstract, contain specific information that might impact where people look (see Chapter 2). Last, it is expected that the goals of the observer are going to be important in extracting information. Furthermore, those goals may depend on characteristics of the observer. For example, a goal of optimizing information-gain might be influenced by participants' education level (see Chapter 4).

1.2 READING

The second main area of focus in this dissertation is how people shift their attention when reading extended texts and when reading under time pressure. In order to prioritize and extract task-relevant information from text-based sources in these conditions, readers can use various strategies. For example, in their studies of how people research and write business documents such as newsletters and reports, Pirolli and Card (1999) draw an analogy between readers' information-seeking strategies and the foraging behaviour of animals. The

researchers observe that participants adapted their time and resources when navigating information-rich environments. Similarly, studies on skimming an online magazine article (Duggan & Payne, 2009), sampling multiple online texts (Hoernbaek & Frokjaer, 2003; Reader & Payne, 2007) and scanning newspaper spreads for entry points to items of interest (Holsanova, Rahm & Holmqvist, 2006) suggest that in order to optimize information gain, readers adapt their allocation of attention. In the context of reading journal articles under time pressure, this literature offers insight into several factors that influence the development and adaptation of attentional strategies during reading. Those factors are as follows: (1) time available for reading; (2) the presence of a summary; and (3) characteristics of the reader.

1.2.1 Time Available for Reading

The allocation of time during reading has been studied across several text formats, such as short excerpts of online text (Reader & Anderson, 1980; Reader & Payne, 2007), popular science articles (Duggan & Payne, 2009), newspaper spreads (Holmqvist, Holsanova, Barthelson & Lundqvist, 2003; Holsanova, Rahm, & Holmqvist, 2006), and excerpts from a physics text (Dee-Lucas & Larkin, 1997). Despite format differences, the studies support the adoption of some form of selective reading strategy, such as skimming. For example, when given either 7 or 15 minutes and instructed to read several text excerpts for information to write an essay, people will skim each excerpt for just enough information to perform the required task (Reader & Payne, 2007). The primary pattern of skimming found at both time constraints was characterized by reduced reading of the later parts of the

text excerpts. According to Reader and Payne, the two time limits were used to provide some generality to the findings, with 7 minutes being the extreme.

One issue that arises, though, is whether the skimming pattern is unique to reading under time pressure or whether it is a more general pattern of reading. Although 15 minutes may be sufficient for gathering much of the task-relevant information, the researchers do not know if or how people's browsing pattern would change with unlimited time and explicit instructions to read each excerpt from beginning to end. It is worth noting that other studies assessing reading strategies under time pressure have typically not compared performance to a condition in which people are given both unlimited reading time and an explicit linear reading strategy.

In those instances where the available time was more than sufficient for reading, people were often not provided with all the available material (;Duggan & Payne, 2009; Holsanova, Rahm, & Holmqvist, 2006). For example, Holsanova, Rahm, & Holmqvist (2006) gave participants a choice of one of 12 newspaper excerpts to read with unlimited time. The newspaper stimuli appeared in two-page, open-spread format and included columns of text, headlines or pictures with picture captions. It would seem that any pattern observed would be specific to browsing a page of a newspaper, leaving open the question of how behaviour might generalize to browsing a whole newspaper with unlimited time. Furthermore, in a related study in which participants were given unlimited reading time and complete paper and online versions of newspapers, no explicit linear reading strategy was required (Holmqvist, Holsanova, Barthelson & Lundqvist, 2003). Based on the literature review, there are gaps in the research regarding the applicability of these findings to new and

different text formats and time conditions. The present research will address some of these gaps by exploring a different format in a naturalistic context, i.e., how students actually distribute their attention when studying journal articles under time pressure for a test. Critically, the present research also aims to go beyond the current literature and examine any changes in those patterns of attention when students have *unlimited* study time and an explicit reading strategy.

1.2.2 The Presence of a Summary

A review of the literature finds several studies that examine the impact of summaries on how people distribute their attention while reading. Moreover, these studies examine summaries in different text formats. For example, the front page provides the overview for the subsequent section and article pages of a newspaper (Holmqvist, Holsanova, Barthelson & Lundqvist, 2003). A hierarchical organizational chart and a menu-like list of headings provide outlines for an electronic text on physics (Dee-Lucas & Larkin, 1995), and a single-page list of summary sentences pulled from the body of the main text provide the overview for several short educational text excerpts (Reader & Payne, 2007). This research on such summary sections has demonstrated two important findings. The first is that summary sections receive more attention relative to other parts of text. For instance, a study of scanning patterns while reading newspapers (Holmqvist, Holsanova, Barthelson & Lundqvist, 2003) shows that the first page of a newspaper is fixated more frequently and for longer than subsequent pages.

Second, summary sections can influence further reading of a text. For example, Reader and Payne (2007) gave participants four text excerpts to read for the purpose of writing an essay. Some participants received outlines in addition to the four excerpts. Reader and Payne observed that the summary information of the outlines enabled readers to more quickly evaluate and select the most task-relevant excerpt for reading.

One format that lends itself to such investigation of summary information, but has yet to be studied in this context, is the academic journal article. The modular format of journal articles is designed to standardize the areas of central and peripheral interest. Furthermore, with an Abstract section that contains both summary and organizational content, the journal article is a novel text format that is well-suited for studying the impact of summary information on further reading.

1.2.3 Properties of the Reader

For various naturalistic tasks that involve information-gathering, studies have demonstrated that individuals bring certain high level factors that can systematically impact overt attention. For example, Reader and Payne (2007) show that individuals' varying degrees of background knowledge influenced how they allocated their time when reading text excerpts on the human heart under time constraint. The results showed that more knowledgeable readers spent more time reading the more difficult excerpts relative to less knowledgeable readers. Similarly, other studies show the influence of factors such as an individual's goals on the evaluation of print advertisements (Rayner, Rotello, Stewart & Duffy, 2001), prior domain and format knowledge on reading weather maps (Canham &

Hegarty, 2010; Hegarty, Canham & Fabrikant, 2010) and expertise on performance in a field of interest (e.g., Grant & Spivey, 2003; Harle & Vickers, 2001; Reader & Payne, 2007).

Taken together, the evidence from the literature suggests that properties of the individual are important for discerning and attending to the task-relevant information. Moreover, the literature provides insight into the kind of properties that ought to be considered when examining other information-gathering contexts, such as the education level of students in the present research on reading journal articles under time pressure.

1.3 THE PRESENT EXPERIMENTS

Given the review of the literature, the development of attentional strategies for optimizing information-gain during reading would depend on the time for the task in a different format, the presence of summary information, and the properties of the reader. The purpose of this dissertation is to understand how students distribute their attention while reading academic journal articles under time pressure for an impending test. In doing so, the experiments will contribute critical new findings to the reading and attention literature by investigating: (1) a new format (journal articles) and *different* time conditions (2 minutes, 5 minutes, or unlimited time); (2) the influence of summary information on overt attention during journal article reading; and (3) the influence of properties of the reader, such as education level.

Chapter 2 of this dissertation explicitly looks at how behavioural patterns of overt attention observed in the literature might change with different time constraints and a different format such as journal articles. The modular format of journal articles was designed

with redundancy of content in mind, standardizing areas of central and peripheral interest. In this way, journal articles lend themselves well to the study of the distribution of attention over time. Given that most of the reading done in university is time-sensitive, this chapter explores how students actually distribute their attention across the discrete sections of the journal article when studying for an impending test under time pressure. It also evaluates whether the skimming pattern of decreased viewing to later parts of a text shown by Duggan and Payne (2009) applies to journal articles. Furthermore, it addresses a gap in the literature, examining how the behavioural pattern might change when that pressure is lifted and students have *unlimited* study time, as well as an explicit strategy for reading from beginning to end in linear fashion. Specifically, it examines whether the pattern of decreased viewing is unique to reading under time pressure or whether it is a more general principle of reading.

Chapter 3 of the dissertation addresses the importance of summary information to the distribution of attention during reading. The experiment presented in Chapter 3 manipulates the presence of the Abstract in the journal format, making use of that section's unique position and summary content. In this way, the chapter explores whether people allocate more attention to the Abstract relative to other sections of the journal article (a finding that emerges in Chapter 2) based on its position or its summary content. In addition to the importance of Abstract position and summary content, the further question of whether the presence of an Abstract impacts what people read next in the article is examined.

Finally, Chapter 4 gives more explicit consideration to the properties of the reader when studying from journal articles under time pressure. This chapter examines what strategies readers use to extract information in the time available and whether those strategies

depend on the reader's experience with reading journal articles. In higher education, journal articles are a primary source for scientific literacy. As students move through their degree program, they are increasingly exposed to this format of reading material. In light of this experience with the format, this chapter considers how reading strategy can be influenced by a reader's education level and all the factors that change with higher education, such as greater content knowledge and more experience with time-sensitive tasks.

Chapter 2

The Role of Available Reading Time in Studying from Journal Articles

The following series of studies evaluates how students distribute their attention when studying from journal articles for an impending test. Journal articles are one of the more common types of texts that university students rely on for discipline-specific information. The sections of the journal article format standardize distinct content areas, making it useful for students to extract task-relevant information quickly when studying for a test or preparing presentations. This modular format also makes journal articles well-suited for evaluating students' reading behaviour. Given that most of the reading done in university is time-sensitive, how do students actually distribute their attention across the discrete sections of the journal article when studying for a test under time pressure? Furthermore, how does the behavioural pattern change, if at all, when that pressure is lifted and students have *unlimited* study time?

In their research on the effectiveness of skimming strategies for longer texts, Duggan and Payne (2009) examined how people read magazine articles when given insufficient reading time. In their first experiment, participants were given an article from a popular science magazine, as well as either the first or second *half* of a second article. In each condition, participants were given just over 5 minutes for reading. By holding viewing time constant across experimental conditions, the researchers manipulated participants' discretion in allocating the available time. Each reading task was followed by two memory tasks: a true-false test for meaning and a test to identify sentence location. In the full-article condition,

participants were instructed that there was not enough time to read through the text at normal speed and that they should allocate time so as to maximize their performance on the test. The scarcity of time meant that participants would need to skim for task-relevant information. The results revealed a strategy of allocating attention across the extent of a text, with reading time per page decreasing over the course of the text. The implication was that this pattern was due to the time pressure.

By contrast, the half-article conditions function as a control for reading under time pressure, with the shorter text affording the participants ample reading time. Participants were instructed to read the half-article in linear fashion and at normal speed. It was emphasized that they did not have to finish reading all the visible text. The results showed that, even with less time pressure, a similar pattern of decreasing reading time per page emerges as in the full-text condition. This finding might suggest that the pattern is characteristic of all reading, not just reading under time pressure. However, without access to the whole article and without having to read *all* the visible text, the observed participant behaviour may not be an accurate reflection of reading magazine articles. Therefore, it remains unclear from Duggan and Payne's study whether the decrease in reading time (per page) is a general pattern of all reading.

New insights into this pattern could be gained from: (1) an examination of reading under time pressure using other types of reading materials; and (2) an evaluation of whether such a pattern would emerge even when people are given *unlimited* reading time and instructed to use a *linear reading strategy* (i.e., reading all the material from beginning to end in linear fashion). With regard to the second point, it is worth noting that other previous

studies assessing reading strategies under time pressure have typically not compared performance to a condition in which people are given unlimited reading time (Reeder & Anderson, 1980; Reader & Payne, 2007). In cases in which the available time was more than sufficient for reading, people were either not given all the available material (Holsanova, Rahm & Holmqvist, 2006), or given no explicit strategy for reading in linear fashion (Holmqvist, Holsanova, Barthelson & Lundqvist, 2003; Hornbaek & Frokjaer, 2003).

The present studies examine how people allocate their attention using: new reading material (i.e., academic journal articles); manipulation of time constraint (Study 1); and conditions of unlimited reading time and the explicit instruction to read from beginning to end in linear fashion (Study 2). The expectation is that the pattern of decreased time across a text shown by Duggan and Payne will be found when people are reading journal articles under time constraint (Study 1). Study 2 (linear reading strategy with no time constraint) assesses whether the observed pattern is specific to skimming under time pressure, or whether it is a more general pattern of reading with no restrictions on time. One possibility is that with unlimited time and access to all the information, individuals might read more and skim less. Accordingly, instead of a pattern of decreased viewing time, then, the expectation would be an equal amount of viewing time across each section of the article.

2.1 Study 1

Study 1 evaluates how much viewing time (adjusted by the number of words in each section) participants actually spent at each section of the journal article format when given an extremely constrained amount of study time, i.e., 2 minutes. Participants were presented

with two journal articles from *Psychological Science* and instructed to get as much information as they could in the available time to prepare for an impending test. Eye movements were monitored to assess how much time individuals spent looking at each major section of the articles (i.e., Abstract, Introduction, Method, Results and Discussion). Unlike the Duggan and Payne study, the visual displays for my stimuli were not modified to create uniform units of information per page. Rather, in an attempt to observe how students actually engage with a text in their day-to-day studies, I opted to preserve the variable lengths and font sizes featured in the standard sections of the journal article format in our visual displays and adjust for any differences in section size during data analysis. Ultimately, if Duggan and Payne's finding is a general pattern of skimming under time pressure, then a similar pattern should be evident in viewing time across the sections of the journal article format.

2.1.1 Method

Participants. Eighteen undergraduate students from the University of Waterloo participated in a 60-minute session for course credit. Students were recruited from various psychology courses over two terms of the academic year. Each participant reported normal or corrected-to-normal vision. Participants who calibrated poorly were replaced to maintain counterbalance (see Procedure section for details on calibration). In total, the data from 2 participants were replaced.

Stimuli. Displays for the study were created from two cognitive psychology articles from the academic journal, *Psychological Science* (Volume 16, 2005). One article was on

Search (Lleras, Rensink, & Enns, 2005) and the other on *Vision* (Lee & Vecera, 2005).

These articles were chosen for their similarity in format and difficulty level.²

The format in both articles was consistent, containing the same clearly demarcated regions of: Abstract, Introduction, Methods, Results, and Discussion. In both articles these regions of interest spanned 5 pages. Although consistent in overall format, there were some minor differences between the articles regarding the number of words per section, as well as the number of figures and tables. The total number of words was 2929 for the *Vision* article and 2780 for the *Search* article, with the *Vision* article containing lengthier Abstract, Introduction, Methods, and Discussion sections. The *Search* article contained no tables and 4 relatively small figures, each about a quarter of a page in size. The *Vision* article contained a large figure of about a half-page in size and a short table (quarter page).

A forced-choice memory test was created for each article to be completed following each trial. The test was a pen and paper task, with each test consisting of 15 true/false statements. In the *Vision* article, 9 statements were true and 6 were false. In the *Search* article, 5 statements were true and 10 were false.³

Apparatus. Location and frequency of eye-movements were tracked using an SR Research Eyelink 1000 system. Only the eye which calibrated most accurately was tracked.

² A Gunning-Fox index was used to assess difficulty level of articles. This index calculates an estimate of readability based on the number of years of formal education required to understand the text on first reading. According to this index, the readability scores for the articles were comparable, with the *Search* article scoring 15.8 years of education and the *Vision* article 15.7.

³ The present questionnaires were used in a previous pilot study. I used the same questions, in order to maintain consistency. In retrospect, it would have been optimal to have an even number of True and False questions. However, the questionnaires were not intended to be a critical component of the study. Rather, they function primarily as incentive for participants to read the articles.

Pages were displayed in single-page format on a DELL Precision 390 computer with Intel® Core Duo CPU at 1.86 GHz processing speed and a 19” LCD screen oriented in portrait-mode, running Experiment Builder 1.3.40 experimental software. At any point during the experiment, participants could access any part of the article by pressing one of two buttons on a Microsoft Sidewinder Plug and Play game pad to turn pages, one for turning the pages forward in the article and the other for turning pages back.

Procedure. Participants were tested individually in a small office with a researcher present. The experiment consisted of two study and test sessions, one for each article. The assignment of article to session was counterbalanced across participants.

During the study phase of each session, participants were given 2 minutes to silently read a 5-page journal article from *Psychological Science*. While informed of the time constraint prior to starting the task, participants were not provided with further information about the time remaining once the study phase commenced. Participants were informed that each article would be followed by a memory test of 15 true/false questions on the content of what they read. Participants were also given the following scenario to keep in mind during the reading task: *Imagine it is 2 minutes before your psychology class. You realize that you have not read the readings for the week. But you know that your professor likes to give surprise quizzes on the readings. With only 2 minutes before class, you need to get as much information as you can from the readings to prepare for the possibility of a quiz.* The test phase was administered immediately after the study phase.

The eye monitoring system was calibrated at the beginning of each study phase. A random 13-dot calibration pattern was used, with average accuracy being .50 degrees visual

angle. The eye monitoring system was set to track either the left or the right eye, based on accuracy of calibration. Because maintaining consistent calibration across a full-screen display can be difficult over lengthy periods of time, calibration was assessed again by visual inspection of the eye movement record at the end of the experiment. A participant's data was excluded from analysis if there was a major change in fixation accuracy over the course of reading a passage (e.g., a shift in fixations off the passage of text being read).

2.1.2 Results

2.1.2.1 Adjusted Viewing Time

Given evidence from the literature for the prioritization of text over graphics (Carroll et al., 1992; Hegarty & Just, 1993; Rayner et al., 2001; Wedel et al., 2009), this study is specifically interested in how people are reading the text. Therefore, the analyses were restricted purely to the main text regions of the journal articles. Figure 2.1 shows the mean adjusted viewing times averaged across articles for each participant. In order to place the article sections on a more equal playing field, the viewing time for each section was assessed on a per word basis. Total viewing time in each section was divided by the number of words in each section (see Dugan and Payne, 2009; see also Smilek, Birmingham, Cameron, Bishof & Kingstone, 2006). The average word counts for each section averaged across articles were: Abstract = 158, Introduction = 537, Methods = 451, Results = 1314, Discussion = 394.5. This measure is hereafter simply referred to as *adjusted viewing time*.

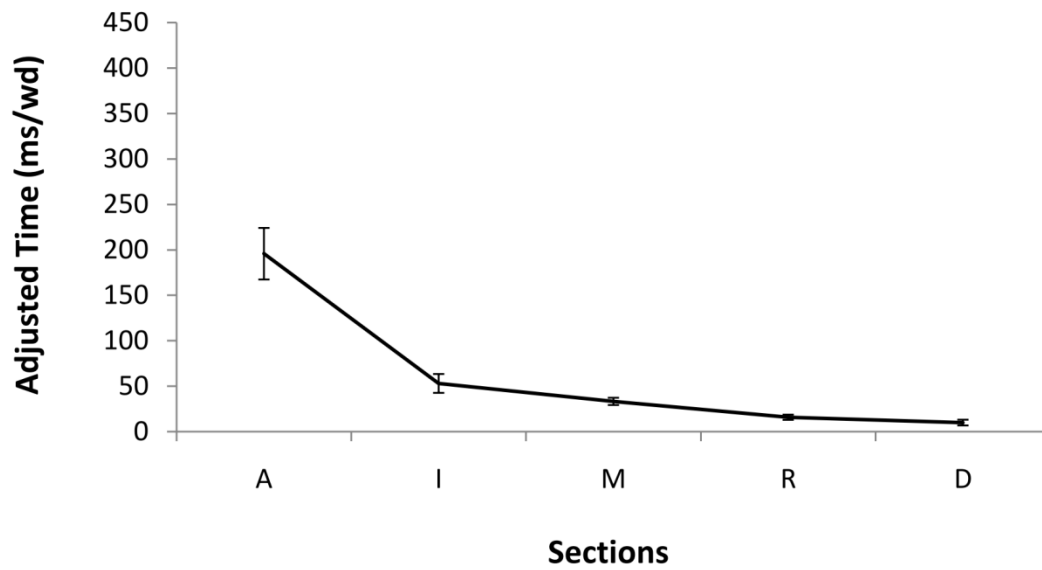


Figure 2.1. The average adjusted time (ms/word) spent reading each section of the journal articles (A = Abstract, I = Introduction, M = Methods, R = Results, D = Discussion) when given 2 minutes of study time. Error bars depict one standard error of the mean.

Initially, I analyzed the data for adjusted viewing time using a repeated measures ANOVA with Article (Search; Vision) and Section (Abstract; Introduction; Methods; Results; Discussion) as within-subjects factors as a between-subjects factor. The results showed a significant main effect of section, $F(4, 68) = 27.8, MSE = 7572, p < .05, \eta^2 = .62$, but no difference as a function of Article and no interaction between Article and Section, all F 's < 2.5 , all p 's $> .05$. In order to keep an already complex analysis clear and simple, I decided to collapse data across the Search and Vision articles. To be consistent, I collapsed the (adjusted) viewing time data across articles for all remaining analyses in this dissertation.

The data for adjusted viewing time averaged across articles were analyzed using a repeated measures analysis of variance (ANOVA) with Article Section (Abstract, Introduction, Methods, Results & Discussion) as a within-participant factor. The analysis revealed a significant difference in adjusted time spent as a function of section, $F(4, 68) = 28.3, MSE = 3755, p < .001, \eta^2 = .63$. Inspection of Figure 2.1 indicates that the greatest amount of adjusted viewing time was spent on the Abstract. A post hoc pair-wise comparison of adjusted viewing times between sections (using a Bonferroni correction of 10 pairwise comparisons with alpha set to .005) shows significant decreases in adjusted time between the Abstract and all subsequent sections, all t -values > 4.4 , all p 's $< .005$. Other noteworthy differences include a significant decrease in adjusted time between the Introduction and Discussion, $t(17) = 3.6, p < .005$, the Methods and Results, $t(17) = 3.9, p < .005$ and the Methods and Discussion $t(17) = 4.0, p < .005$. None of the other comparisons reached significance, all p 's $> .005$. These findings are consistent with Duggan and Payne's observation that people read less as they move through a document. Looking at the trends

for this decrease reveals a large linear trend, $F(1, 17) = 48.9$, $MSE = 6148$, $p < .001$, $\eta^2 = .74$, as well as smaller quadratic $F(1, 17) = 19.0$, $MSE = 5143$, $p < .001$, $\eta^2 = .53$ and cubic trends, $F(1, 17) = 8.5$, $MSE = 2645$, $p < .05$, $\eta^2 = .33$. The quartic trend did not reach significance, $F < 4.0$, $p > .05$.

2.1.2.2 Number of Fixations and Average Fixation Duration

Given the overall decline in adjusted viewing time, I considered *how* participants are viewing the different article sections during their 2 minutes of study time. The frequency and duration of fixations across sections were inspected, adjusting for discrepancies in section length. I expected that the decrease in viewing time could be a function of the fact that (1) people are sampling fewer words as they read, which would lead to a decreased number of fixations per section; and/or (2) there is a reduction in their processing of the sampled words, leading to decreased fixation durations across sections. In order to control for the different lengths of article sections, the number of fixations in each section was divided by the number of words in each section. Figure 2.2 shows the adjusted number of fixations and average fixation duration for each article section.

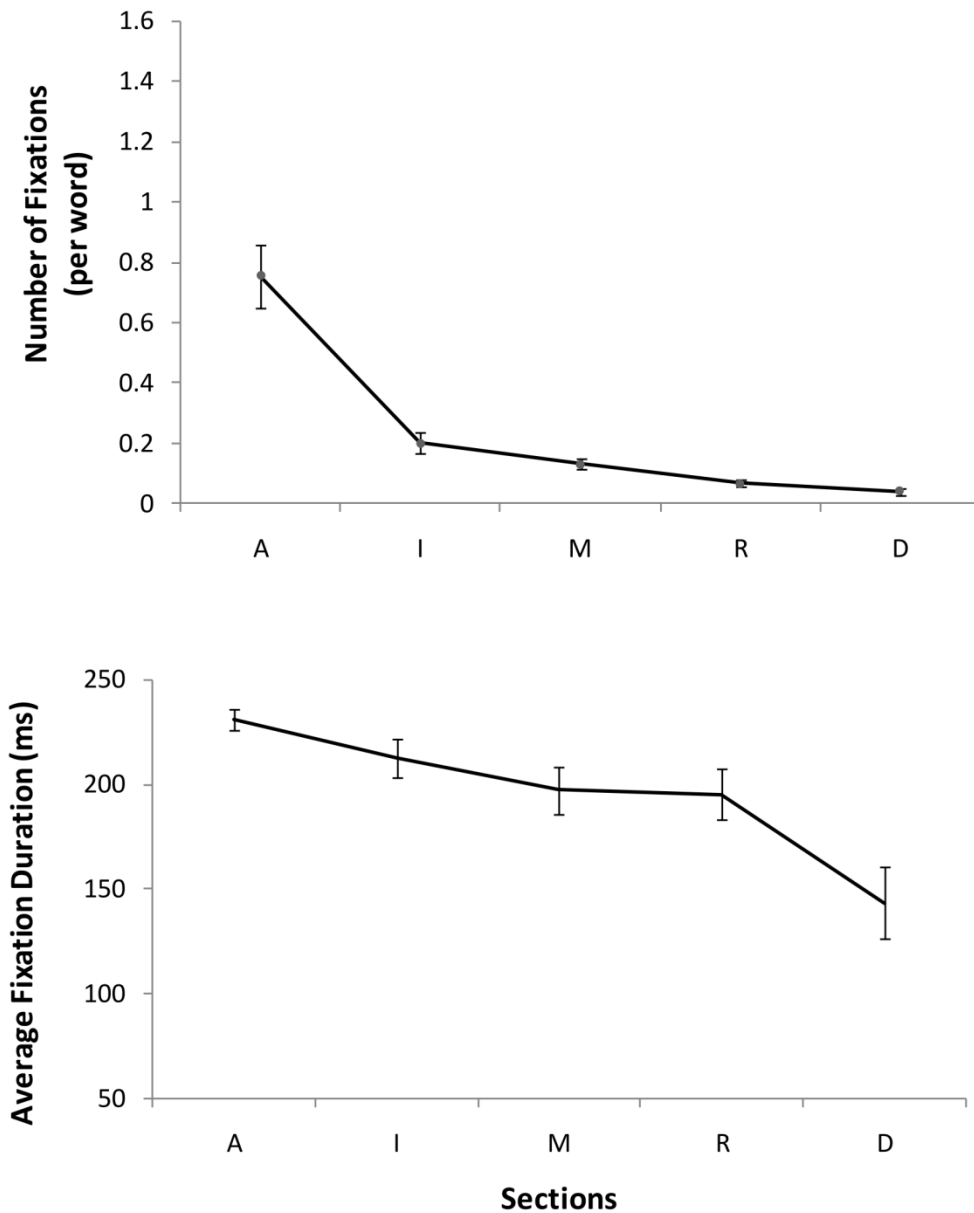


Figure 2.2. The average number of fixations (per word) and average fixation duration in milliseconds for each section of the journal articles (A = Abstract, I = Introduction, M = Methods, R = Results, D = Discussion) when given 2 minutes of study time. Error bars depict one standard error of the mean.

The data for the adjusted number of fixations were analyzed using a repeated measures analysis of variance (ANOVA) with Article Section (Abstract, Introduction, Methods, Results & Discussion) as a within-participant factor. The analysis revealed a significant decrease in number of fixations per word across sections, $F(4, 68) = 30.7$, $MSE = .05$, $p < .001$, $\eta^2 = .64$. Inspection of Figure 2.2 indicates that the greatest adjusted number of fixations was made to the Abstract. This significant decrease in the adjusted number of fixations between the Abstract and subsequent sections of the articles is supported by a post hoc pair-wise comparison of adjusted viewing times between sections (using a Bonferroni correction with alpha set to .005), all t -values > 4.5 , all p 's $< .005$. Other posthoc comparisons reveal a significant difference between the Introduction and Discussion, $t(17) = 3.7$, $p < .005$, between the Methods and Results, $t(17) = 3.9$, $p < .005$, and between the Methods and Discussion, $t(17) = 4.0$, $p < .005$. None of the other comparisons reached significance, all p 's $> .005$.

A similar repeated measures ANOVA was conducted with the fixation duration data, with Article Section (Abstract, Introduction, Methods, Results, & Discussion) as a within-participant factor. The analysis revealed a significant effect of section, $F(4, 40) = 10.8$, $MSE = 1145$, $p < .001$, $\eta^2 = .52$. An inspection of Figure 2.2 shows that the longest fixation durations were for the Abstract. Post hoc pair-wise tests comparing the adjusted viewing times between sections (using a Bonferroni correction with alpha set to .005) show a significant difference between the Abstract and Discussion, $t(10) = 5.5$, $p < .005$. Other post hoc comparisons reveal significant differences between the Methods and Discussion, $t(10) = 4.7$, $p < .005$, and the Results and Discussion, $t(10) = 4.8$, $p < .005$. None of the other

comparisons reached significance. It is evident from Figure 2.2 that, although they were below the average durations for reading, these fixation durations were still within normal range (i.e., 100-500ms) for processing new information from texts (Findlay & Gilchrist, 2003; Rayner, 1998). Indeed, the shorter than average durations are not surprising given the overall 2-minute time constraint. These eye movement data showed a reduction in the sampling and processing of words as participants progress through the article.

2.1.2.3 Memory Performance

The task of the memory test contributed to creating a familiar context of study and incentivized students to read the articles. Participants' performance on the memory task, averaged across articles for each participant, resulted in a maximum percentage score of 76.7, and a minimum score of 46.7. The overall mean percentage score was 60, with a standard deviation of 8.1. A single-sample t-test shows a significant difference between the overall mean score and chance, where chance is 50%, $t(17) = 5.2, p < .001$. This result indicates that participants on average had reasonable memory for the content.

2.1.3 Discussion

The present study examined the viewing pattern of university students while reading journal articles for an impending test under time constraint. Analyses of adjusted viewing times, number of fixations per word, and average fixation durations in each section of the article revealed a decrease in all three measures over the course of the article. Indeed, the number of fixations per word, average fixation duration, and adjusted viewing times were greatest for the Abstract and decreased in a linear fashion for subsequent sections. These

results suggest that people tend to read less and skim more as time decreases. In the context of a new format of academic journal articles, the skimming behaviour observed in the Duggan and Payne study (2009) seems to be a more general pattern of reading under time pressure.

2.2 Study 2

Study 2 aims to address an outstanding question from the literature on reading under time pressure. That is, is there a pattern of decreased viewing time when reading in the absence of time pressure and with a clear instruction to read the text from beginning to end? A general assumption implicit in the skimming literature is that, with unlimited time and access to all the information, individuals will spend an equal amount of time viewing each section (adjusted by the number of words in each section). The present study examines how much viewing time per word participants actually spent at each location in the journal article format when given *unlimited* reading time and an explicit *linear reading strategy*.

Participants read the same two journal articles from *Psychological Science* used in Study 1 for an impending test. Participants were explicitly instructed to read the article from beginning to end and to inform the researcher when they had finished. While they read the journal articles, their eye movements were monitored to assess how much time individuals spent looking at each major section of the articles (i.e., Abstract, Introduction, Method, Results and Discussion). Giving participants an explicit linear reading strategy ought to reveal how much time overall is required to read these articles from beginning to end. Also, it allows for testing the implicit assumption of a more equal amount of adjusted viewing time

in each section. Alternatively, the outcome might be a reduction in reading time per section over the course of the article, despite instructions to read word for word from beginning to end. This would mean that such a pattern is not uniquely characteristic of reading under time pressure.

2.2.1 Method

Participants. Sixteen undergraduate students from the University of Waterloo participated in a 60-minute session for course credit. Students were recruited from various psychology courses for course credit over two terms of the academic year. Each participant reported normal or corrected-to-normal vision. Participants who calibrated poorly were replaced to maintain counterbalance (see *Procedure* section for details on calibration). In total, the data from 5 participants were replaced.

Stimuli. Displays were generated from the same two *Psychological Science* articles (Volume 16, 2005) used in the previous study, one on *Search* (Lleras, Rensink, & Enns, 2005) and the other on *Vision* (Lee & Vecera, 2005).

The same forced-choice memory test was used for each article as for Study 1. The memory test was to be completed following each study session. The test was a pen and paper task, with each test consisting of 15 true/false statements.

Apparatus. The location and frequency of eye-movements were tracked using an SR Research Eyelink 1000 system, as described for Study 1. Only the eye which calibrated most accurately was tracked. Pages were displayed in single-page format on a DELL Precision 390 computer with Intel® Core Duo CPU at 1.86 GHz processing speed and a 19" LCD

screen oriented in portrait-mode, running Experiment Builder 1.3.40 experimental software. At any point during the experiment, participants could access any part of the article by pressing one of two buttons on a Microsoft Sidewinder Plug and Play game pad to turn pages, one for turning the pages forward in the article and the other for turning pages back.

Procedure. As with the first study, participants were tested individually in a small office with a researcher present. The experiment consisted of two study and test sessions, one for each article. The assignment of article to session was counterbalanced across participants.

During the study phase of each session, participants were given an unlimited amount of time to silently read a 5-page journal article from *Psychological Science*. While informed of the unlimited length of study time prior to starting the task, participants were not informed of how much time had passed during the study phase. They were informed that, following each article, there was a memory test of 15 true/false questions on the content of what they read.

Additional specific instructions were given to the participants. Participants were instructed at the start of each study phase as follows: *Please read the entire article from beginning to end. Please tell the researcher when you reach the end of the article so that she can record the time.* The test phase was administered immediately after the study phase.

As in the previous study, the eye monitoring system was calibrated at the beginning of each study phase. A random 13-dot calibration pattern was used, with average accuracy being .50 degrees visual angle. The eye monitoring system was set to track either the left or the right eye, based on accuracy of calibration. Once again, a participant's data were

excluded from analysis if there was a major change in fixation accuracy over the course of reading a passage (e.g., a shift in fixations off the passage of text being read).

2.2.2 Results

2.2.2.1 Overall Reading Time

Table 2.1 shows the individual reading times and the mean total reading time for each article and averaged across articles. For participants with unlimited time, I found that the Search article required an average of 666 seconds or 11 minutes of reading time, whereas the Vision article required 800 seconds or 13 minutes overall. When averaged across articles for each participant, 733 seconds or 12 minutes was sufficient reading time for this type of academic journal article.

Table 2.1. Mean reading time (in seconds) averaged across participants for each article and collapsed across articles.

Article	Mean	Std. Deviation
Search	666.06	171.46
Vision	800.13	162.47
Combined	733.09	135.47

2.2.2.2 Adjusted Viewing Time

Given the overall reading time, the spread of viewing time across the article was examined more closely. Figure 2.3 shows the average adjusted viewing times for each article section. Once again, the mean adjusted viewing times were averaged across articles for each participant, and viewing time for each section (adjusted by the number of words) was assessed.

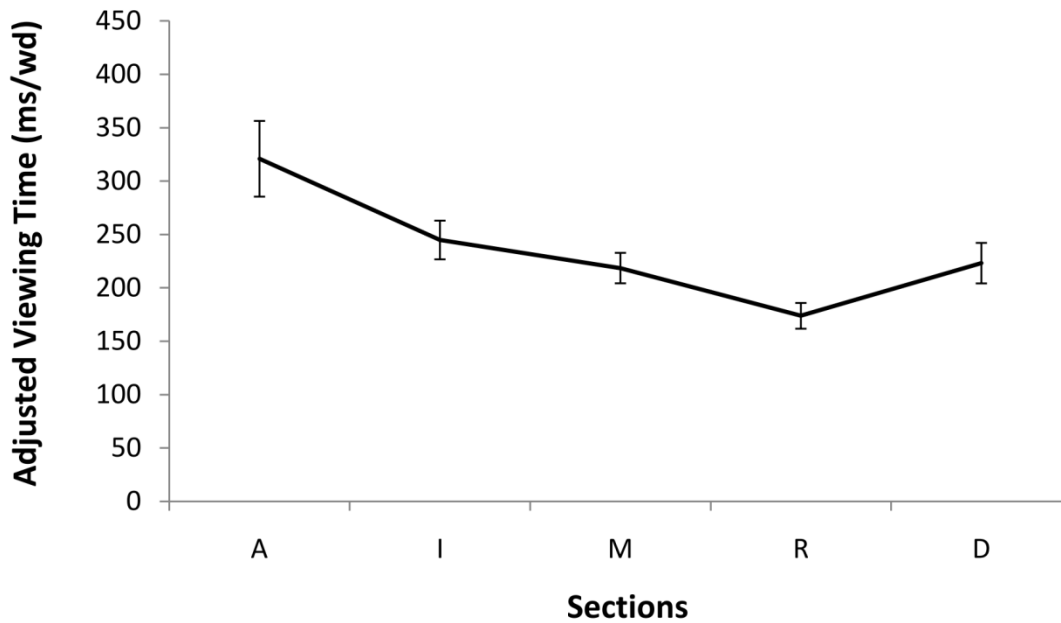


Figure 2.3. The average adjusted time (ms/word) spent reading each section of the journal articles (A = Abstract, I = Introduction, M = Methods, R = Results, D = Discussion) when given unlimited study time and an explicit linear reading strategy. Error bars depict one standard error of the mean.

The data were analyzed using a repeated measures analysis of variance (ANOVA) with Article Section (Abstract, Introduction, Methods, Results & Discussion) as a within-participant factor. The analysis revealed a significant difference in adjusted time spent as a function of section, $F(4, 60) = 8.8, MSE = 5295, p < .001, \eta^2 = .37$. As Figure 2.3 shows, the greatest amount of adjusted viewing time was spent on the Abstract, with a slight increase on the Discussion. A post hoc pair-wise comparison of adjusted viewing times between sections (using a Bonferroni correction with alpha set to .005) reveals a significant decrease in adjusted time between the Abstract and Results, $t(15) = 4.0, p < .005$, and between the Abstract and Discussion, $t(15) = 3.5, p < .005$. Other notable differences exist between the Introduction and Results, $t(15) = 5.0, p < .005$, and between the Methods and Results, $t(15) = 8.2, p < .005$. None of the other comparisons reached significance, all p 's $> .005$. The results depart from the assumption that participants would distribute their adjusted time equally across all regions of the article and that the line graph would look fairly flat. Even with ample study time, access to the complete text, and a specific study strategy (i.e. to read the article from beginning to end), there is a *reduced reading effect* where the pattern in adjusted viewing time generally decreases over the course of the article. Looking at the trends for this effect revealed a large linear trend, $F(1, 15) = 18.1, MSE = 6295, p < .001, \eta^2 = .60$, and slightly smaller quadratic, $F(1, 15) = 5.0, MSE = 12449, p < .05, \eta^2 = .30$, and quartic trends, $F(1, 15) = 8.5, MSE = 875.3, p < .05, \eta^2 = .36$. The cubic trend did not reach significance, $F < 2.0, p > .05$.

2.2.2.3 Number of Fixations and Average Fixation Duration

Given this reduced reading effect in adjusted time, I wanted to examine *how* participants were viewing the different article sections during that time. As in Study 1, an inspection of the frequency and average duration of fixations across sections would indicate whether the reduced reading effect was a function of sampling and/or of processing fewer words over time (*see Figure 2.4*).

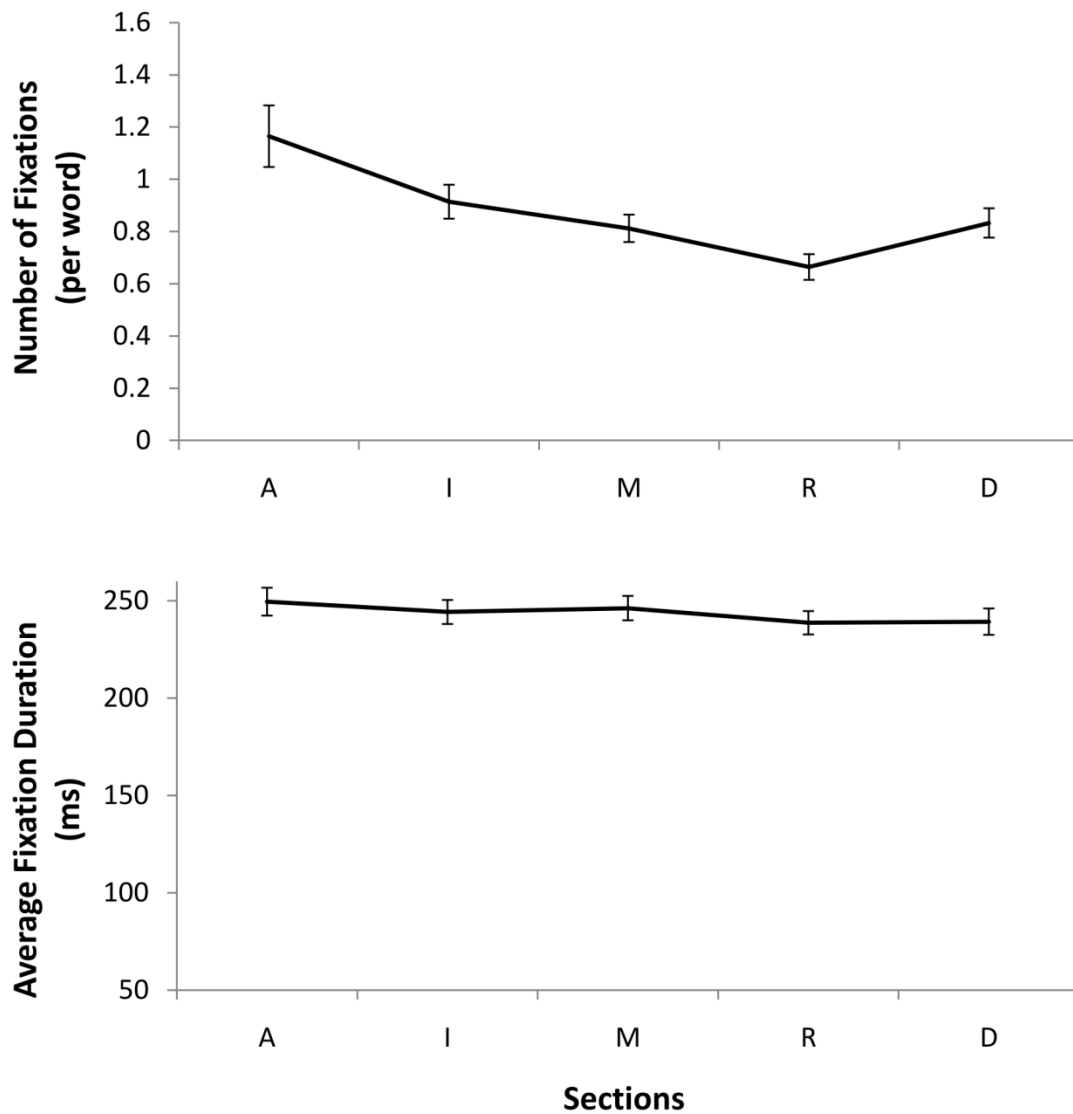


Figure 2.4. The average number of fixations (per word) and average fixation duration in milliseconds for each section of the journal articles (A = Abstract, I = Introduction, M = Methods, R = Results, D = Discussion) when given unlimited reading time and an explicit linear reading strategy. Error bars depict one standard error of the mean.

The data for the adjusted number of fixations were analyzed using a repeated measures analysis of variance (ANOVA) with Article Section (Abstract, Introduction, Methods, Results & Discussion) as a within-participant factor. The analysis revealed a significant difference in number of fixations per word across sections, $F(4, 60) = 9.0$, $MSE = .06$, $p < .001$, $\eta^2 = .38$. Figure 2.4 indicates that the greatest number of fixations per word was made on the Abstract. Post hoc comparisons of adjusted viewing times between sections (using a Bonferroni correction with alpha set to .005) reveals a significant decrease in number of fixations per word between the Abstract and Results, $t(15) = 4.1$, $p < .005$. (Interestingly, the comparison between the Abstract and Discussion was marginally significant, $p = .006$). Other comparisons show a significant difference between the Introduction and Results, $t(15) = 5.1$, $p < .005$, and the Methods and Results, $t(15) = 8.9$, $p < .005$. None of the other comparisons reached significance, $p > .005$.

A similar repeated measures ANOVA was conducted with the fixation duration data, with Article Section (Abstract, Introduction, Methods, Results, & Discussion) as a within-participant factor. The analysis revealed a small significant effect of section, $F(4, 60) = 2.7$, $MSE = 126.7$, $p < .05$, $\eta^2 = .15$. Post hoc comparisons of adjusted viewing times between sections (using a Bonferroni correction with alpha set to .005) reveals that this difference seems to be driven by a decrease from the Methods to Results, $t(15) = 4.6$, $p < .005$. None of the other comparisons reached significance, all p 's $> .005$. Similar to the eye movement results in Study 1, it is evident from Figure 2.4 that average durations fall within the typical range for reading texts, i.e., 200-250ms (Rayner, 1998). These data suggest that there is a

reduction in the sampling and processing of words as participants progress through the article.

2.2.2.4 Memory Performance

Participants' performance on the memory task was averaged across articles for each participant. Data for one participant were removed due to incorrect completion of the questionnaire. Performance of the remaining 15 participants resulted in a maximum percentage score of 90 and a minimum score of 56.7. The overall mean percentage score was 73%, with a standard deviation of 10.2. A single-sample t-test shows a significant difference between the overall mean score and chance, where chance is 50%, $t(14) = 8.7, p < .001$. This result indicates that participants on average had reasonable memory for the content. Compared to performance under the time constraint of Study 1, these scores indicate a significant improvement in memory performance when study time is unconstrained, $t(31) = 4.0, p < .001$.

2.2.3 Discussion

The present study examined the viewing pattern of university students while reading journal articles for an impending test without the constraint of time pressure. Analyses of adjusted viewing times, number of fixations (per word), and average fixation durations in each section of the article revealed an overall decrease in adjusted viewing time across sections, with the largest amount of adjusted time spent on the Abstract and, to a lesser extent, on the Discussion. Even with unlimited time and an explicit linear reading strategy,

participants will: (1) read less and skim more as time progresses; and (2) prioritize the Abstract.

Taken together, these results of the eye movement and viewing time data show that sustaining reading over time and across a journal article is difficult. As time progresses, linear reading degrades and participants start to skim more. More critically, the results extend those of Study 1, implying that this pattern is evident not only when skimming articles under time pressure, but also, when reading from beginning to end in linear fashion with unlimited time. I refer to this general pattern as the *reduced reading effect*.

There could be a number of reasons for this reduced reading effect. Perhaps participants simply experience fatigue over time. Alternatively, there may be redundancy in the content of some sections so that people reach a threshold of having enough information, at which point they start skimming (Duggan & Payne, 2009; Pirolli & Card, 1999; Reader & Payne, 2007). Manipulations of motivation (i.e., overcoming fatigue) or task (i.e., changing the threshold) may help tease apart some of the reasons for the reduced reading effect, but will not be pursued further in this thesis. Rather, the interest of the present research is the role of the Abstract and the role of reader's experience with journal articles.

2.2.4 Summary and Conclusion

The present studies explored: 1) reading under time pressure using other types of reading materials and (2) reading when given unlimited time and asked to read all of the material from beginning to end. Study 1 evaluated how much adjusted viewing time participants spent when studying a journal article when given only 2 minutes of study time.

Study 2 tested whether the decreasing pattern that characterizes reading under time pressure would emerge when participants had unlimited reading time and an explicit linear reading strategy. In both studies, analyses of adjusted viewing times, number of fixations (per word), and average fixation durations in each section of the article revealed a reduced sampling of words, a more subtle reduction in the processing of words, and an overall reduction in adjusted reading time across article sections.

These findings step beyond the work of Duggan & Payne (2009) on skimming under time pressure in an important way. Duggan and Payne found that, when given less than sufficient time to read an article, reading time per page decreased over the course of the article as people adopted a skimming strategy. What remained unclear from their study was whether this decreasing pattern is unique to skimming under time pressure or whether it is a more general pattern of reading without time restrictions. The findings from Studies 1 and 2 show that this decreasing pattern is consistent not only with extremely limited amounts of reading time on the one hand, but also with unrestricted reading time and explicit instructions for reading the entire article in linear fashion on the other. Since this is a general pattern of behavior spanning various contexts, I refer to this pattern as a *reduced reading effect*.

Chapter 3

The Role of the Abstract in Studying Journal Articles under Time Pressure

When reading journal articles for research or study purposes, the Abstract stands out as an important feature. It is visually unique in that it is often set apart from the body of the main text by spacing and smaller font size. Also, it is always the first paragraph of text on the opening page. In terms of content, the Abstract provides a general overview of both the content and the organization of that content within the journal article. Given these unique features, what is unclear is whether people allocate more attention to the Abstract relative to other sections of the journal article based on its position or its summary content. Furthermore, does the presence of an Abstract impact what people attend to next in the journal article?

In Chapter 2, I showed that the Abstract is prioritized as a specific task-relevant section of journal articles when skimming under time pressure. Participants were divided into two groups based on study time and given two journal articles to study under time pressure for an impending quiz. One group was given only 2 minutes to study the articles, whereas the other was given an unlimited amount of study time to create a baseline for comparison. To assess skimming behaviour, we monitored participants' eye movements and examined how much time individuals spent looking at each major section (i.e., Abstract, Introduction, Method, Results and Discussion) averaged across articles. Given that the sections of the article differed in length, the viewing times were adjusted by dividing the total viewing time in each section by the number of words in each section. Analysis of adjusted viewing times

showed an overall tendency for people to read less of each section as they moved through the article regardless of group. More critically, all participants regardless of group spent the most adjusted viewing time on the Abstract relative to other sections of the articles. This finding seems to suggest that there was something special about the Abstract. However, what was unclear was whether the Abstract is special because it appears first in the text or because it contains important summary information. Would the Abstract receive more attention in terms of adjusted viewing time if the fact that it appears first was controlled? In other words, would the Abstract receive any more attention than a paragraph that does not contain summary information but occurs in the first position?

Studies have shown that people tend to focus primarily on initial components of documents (Duggan & Payne, 2009; Holsanova, Holmqvist & Rahm, 2006; Kieras, 1980; Masson, 1982; Reader & Payne, 2007; Wartenberg & Holmqvist, 2005; Wilkinson & Payne, 2006). If position order matters in this way, then the opening paragraph of an article ought to receive greater attention than subsequent paragraphs in the text simply by virtue of its primary position in the article. For example, Wartenberg and Holmqvist (2005) examined how the position of items in a newspaper spread impact people's attention during reading. Participants read spreads from 17 local newspapers over an unlimited period of time. Participants' eye movements were tracked for the amount of time and order in which specific areas of interest were scanned. The researchers found that items at the top of the page were looked at earlier and for longer than items lower down on the page. These findings suggest that, among different design and format considerations, position order matters.

Similarly, Wilkinson and Payne (2006) examined how readers effectively allocate their attention across multiple texts under time pressure. In the first of two experiments, participants were given limited time to study four separate online text excerpts about the human heart for the purpose of writing a test. Assessing time allotment in terms of the number of visits and duration of time spent per page and text, analysis revealed that readers adopt a “satisficing” approach (Pirolli & Card, 1999). That is, they started at the top of the first text excerpt and read until they become satisfied they have enough information. At this point, reading trails off and resumes at the beginning of the next excerpt. According to Wilkinson and Payne, the text that appears first is read first; text is not evaluated for relevance prior to reading. Consequently, position of information tends to take priority over relevance of content in the allotment of attention. In the context of skimming journal articles, this evidence for the primacy of position would suggest that the opening paragraph of a journal article would receive greater attention irrespective of whether it was an Abstract.

There is reason to believe, however, that position might not be the whole story when it comes to the importance of the Abstract. The Abstract provides a summary of the content as well as an overview of the organization of that content. Research demonstrates that summaries play a role in the selective identification and extraction of relevant information from a text (Dee-Lucas et al., 1995; Holmqvist, Holsanova, Barthelson & Lundqvist, 2003; Holsanova, Holmqvist & Rahm, 2006; Reader & Payne, 2007). For example, Holmqvist et al. (2003) showed that people’s scanning and reading patterns of online newspapers are influenced by the content and organization of the first page. Participants’ eye movements were tracked as they read two “net papers”. The proportion of fixation time spent in each

area of interest was calculated. Participants spent more time scanning the first page before reading articles on other pages of the paper. Also, participants tended to return to the front page in the course of reading the articles. Based on these results, Holmqvist et al. (2003) suggest that the first page functions as a reliable overview of entry points for reading the rest of the paper. Unlike other pages in the newspaper spread, the first page provides a summary that can guide further reading. In the context of journal articles, then, the abstract might be attended more than other sections not only because it appears first, but also because it contains important summary information

Apart from whether the Abstract draws more attention based on its position or summary content, there is the further question of whether the presence of an Abstract impacts what people read next in the article. Reader and Payne (2007) provide some insight to this question in demonstrating the importance of a summary outline to people's browsing behaviour. Participants were given four separate online text excerpts about the human heart to read under time pressure for the purpose of writing a brief essay on the topic. In the second experiment, though, participants were divided into two groups; one had access to an outline of each of the four texts in addition to the full text excerpts, whereas the other group did not. The outlines consisted of the first sentence of every 3rd paragraph which the researchers deemed sufficiently representative of each entire text. Analysis of the number of visits and time spent per page and text revealed that readers adopted an "outline-sampling" strategy when an outline was present. That is, readers visited each of the four outlines briefly to obtain a preview of all texts before visiting the first text. By contrast, readers that did not have the outlines proceeded with a satisficing strategy, starting at the top of the first text

excerpt and reading until they become satisfied they have enough information before skipping to the start of the next excerpt. Based on these results, Reader and Payne suggest that readers rely on the outline to more quickly evaluate and select text excerpts with the most task-relevant information. In other words, after an outline, readers go directly to information that is best, whereas, without an outline, they sequence through a text, gathering information that is sufficient. Given this evidence, summaries seem to impact what a reader will attend next.

Based on the literature review, two lines of inquiry emerge regarding the potentially unique status of the Abstract in journal articles. The first concerns whether the Abstract receives more attention in terms of adjusted viewing time based on its primary position in the journal article or its important summary content. The second line of inquiry concerns whether the summary content of the Abstract affects what people will attend next in the journal article.

In the present study, undergraduate university students read one of two versions of two journal articles from Psychological Science for an impending test. One version of the articles contained the Abstracts, whereas the other version did not. Also, participants were given either 2 or 5 minutes to read each article to assess the generality of their attentional strategies across time constraints. To assess the impact of the Abstract, participants' eye movements were monitored. Also, the pattern in viewing time was considered for the first two paragraphs, averaged across articles, when (1) the opening paragraph of the article is the Abstract (Abstract Present condition) and (2) when the opening paragraph of the article is the first paragraph of the Introduction (Abstract Absent condition). Table 3.1 identifies the first

and second paragraphs of text for each of the Abstract Present and Abstract Absent conditions. As in the previous studies of Chapter 2, the viewing times were adjusted to accommodate differences in paragraph length (see Results section for details on adjusted time).

Table 3.1. Position of opening and second paragraphs across Abstract conditions.

	<i>First Paragraph</i>	<i>Second Paragraph</i>
<i>Abstract Present</i>	Abstract	Introduction paragraph 1
<i>Abstract Absent</i>	Introduction paragraph 1	Introduction paragraph 2

Regarding the first main issue of why the Abstract received more attention than other sections in our previous studies, the following predictions were made. If the opening article paragraph receives equivalent viewing time irrespective of the presence or absence of the Abstract, then the Abstract is not unique apart from being the first paragraph of text. In other words, the reason the Abstract received greater adjusted viewing time than other sections in our previous studies is more a matter of its position as a first paragraph and less some other aspect, such as its summary content. Conversely, if the Abstract is attended longer than some other opening article paragraph (e.g., the first paragraph of the introduction), then the implication is that the Abstract is unique for reasons other than its primary position in the text, such as its summary content.

Regarding the second main issue of whether the presence of the abstract affects viewing of further text by virtue of its summary content, the following prediction was made. If the presence of the Abstract influences further viewing, then there ought to be a difference in how people view the second paragraph, depending on whether it follows an Abstract or a paragraph that is not the Abstract. Such a difference in the viewing time of second paragraphs would be most meaningful if there were no difference in how much time people spend viewing the first paragraph across the Abstract Present and Absent conditions. In this way, any differences in viewing the second paragraph could not be attributed to differences in viewing the first paragraph.

3.1.1 Method

Participants. Forty undergraduate students from the University of Waterloo participated in a 60-minute session for course credit. Students from either 1st or 2nd year of their undergraduate studies were recruited from various psychology courses for course credit over two terms of the academic year. Each participant reported normal or corrected-to-normal vision. Participants were randomly assigned to 4 groups of 10 students based on two factors: modifications to the journal format (Abstract Present or Abstract Absent) and amount of study time (2 or 5 minutes). Participants who calibrated poorly were replaced to maintain counterbalance (see *Procedure* section for details on calibration). In total, the data from 16 participants were replaced.

Stimuli. The same two cognitive psychology articles (i.e., one on *Search* and one on *Vision*) from the previous chapter were adapted for the present study. Participants read one of two versions of both articles. In one version, the articles contained all the original, clearly demarcated regions of the journal format (i.e., Abstract, Introduction, Methods, Results, and Discussion). This version will hereafter be referred to as the *Abstract Present condition*. In the alternate version, the Abstract was removed and its position on the page left blank. This version will hereafter be referred to as the *Abstract Absent condition*.

In both format conditions, these regions of interest spanned 5 pages for each article. However, given the obvious modification in the Abstract region, the total number of words differed between versions. The total number of words for each article was 2929 for *Vision* and 2780 for *Search* in the Abstract Present condition and 2759 for *Vision* and 2634 for *Search* in the Abstract Absent condition.

As in the methods for Chapter Two, the same forced-choice memory test of 15 true/false statements for each article was to be completed following each study phase. The memory task did not vary across the Abstract Present and Abstract Absent versions of the articles.

Apparatus. All apparatus for monitoring eye movements and for displaying and accessing article pages is the same as that used in previous studies of Chapter 2.

Procedure. The procedure also replicates that of the 2-minute study in Chapter Two. The experiment consisted of two study and test sessions, one for each article. The assignment of article format (Abstract Present or Abstract Absent) and length of study time (2 or 5 minutes) to session was counterbalanced across participants.

During the study phase of each session participants were given either 2 minutes or 5 minutes to silently read a 5-page journal article from *Psychological Science*. Although informed of the length of study time prior to starting the task, participants were not provided with further information about the time remaining once the study phase commenced. Participants in both the Abstract Present and Abstract Absent versions were given the following scenario to keep in mind during the reading task: *Imagine it is 2 (5) minutes before your psychology class. You realize that you have not read the readings for the week. But you know that your professor likes to give surprise quizzes on the readings. With only 2 (5) minutes before class, you need to get as much information as you can from the readings to prepare for the possibility of a quiz.* Participants in the Abstract Absent version were not informed of the missing Abstract. The test phase was administered immediately after the study phase.

The eye monitoring system was calibrated at the beginning of each study phase. A random 13-dot calibration pattern was used, with average accuracy being .50 degrees visual angle. The eye monitoring system was set to track either the left or the right eye, based on accuracy of calibration. Since maintaining consistent calibration across a full-screen display can be difficult over lengthy periods of time, calibration was assessed again by visual inspection of the eye movement record at the end of the experiment. A participant's data were excluded from analysis if there was a major change in fixation accuracy over the course of reading a passage (e.g., a shift in fixations off the passage of text being read).

3.1.2 Results

As in the previous studies, any discrepancies in section length were accounted for in the measure of adjusted viewing time. That is, the viewing time for each paragraph was assessed as a ratio score, dividing the total viewing time in each paragraph by the number of words in each paragraph (see Chapter 2 for the word counts for each section).⁴

Figure 3.1 shows the average adjusted viewing times for the first two article paragraphs as a function of Presence of Abstract (Abstract Present or Abstract Absent) and Study Time (2 or 5 minutes). Recall that, in the Abstract Present condition, the first paragraph of the article is the Abstract and the second is the opening paragraph of the Introduction. In the Abstract Absent condition, the first and second paragraphs of the article are the first and second paragraphs of the Introduction (see Table 3.1). Based on the

⁴ The most informative way to address the question of the Abstract was through an analysis of the first couple of article paragraphs, as opposed to article sections. I excluded an analysis as a function of section because it was not necessary to make the point of this study. Indeed, when the data were analyzed as a function of section, the results for the 2-minute condition showed a similar pattern to the one observed in the Study 1 of this dissertation, where participants had 2 minutes of study time. Similarly, the results for the 5-minute condition revealed a similar pattern to the one observed in Study 4, where participants have 5 minutes of study time.

pertinent literature (Duggan & Payne, 2009; Holsanova & Holmqvist, 2006; Kieras, 1980; Masson, 1982; Reader & Payne, 2007), people tend to focus primarily on initial components of documents. Given its primary position in the article, then, the opening article paragraph ought to receive greater attention than subsequent paragraphs irrespective of whether that opening paragraph was an Abstract.

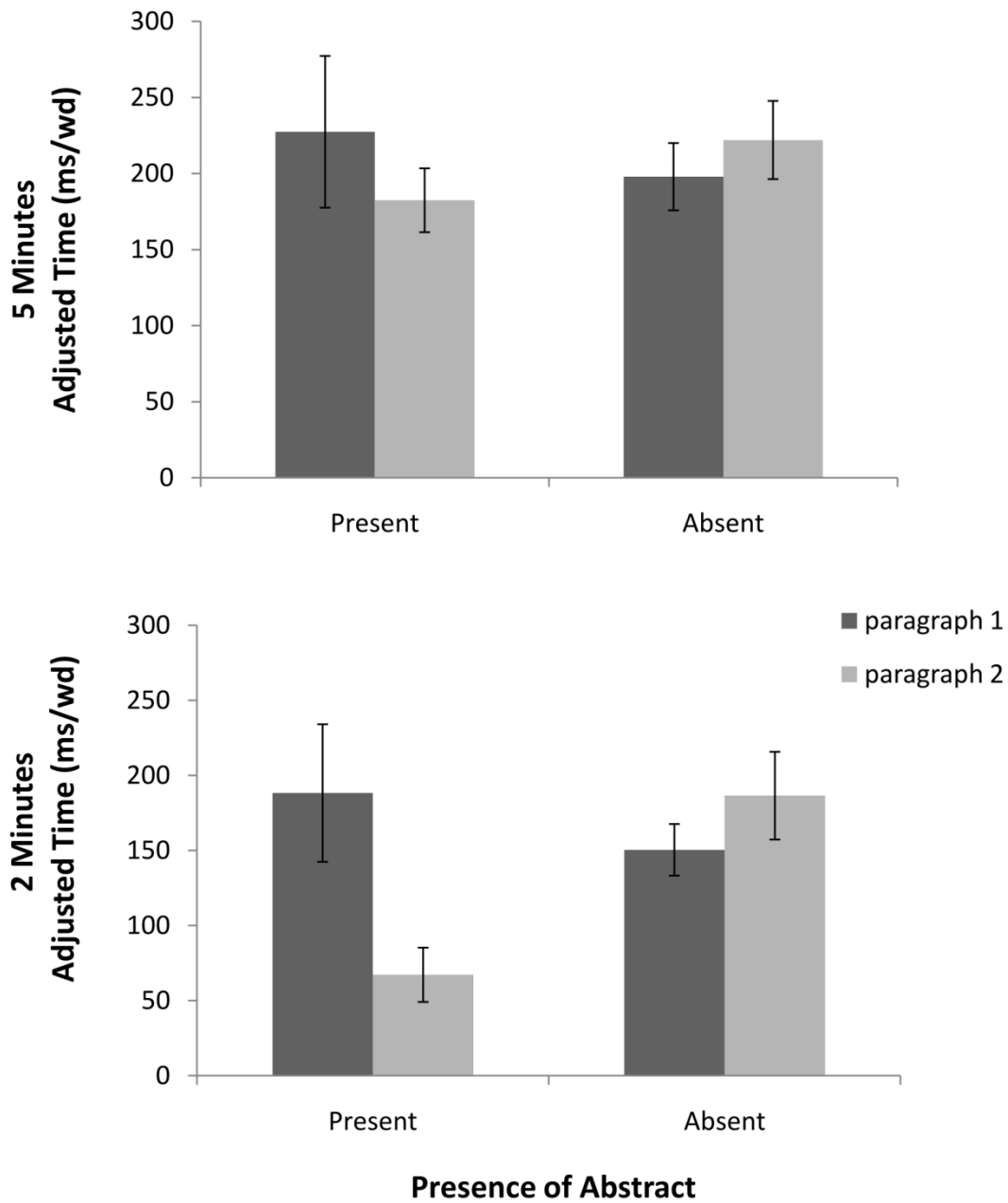


Figure 3.1. The average adjusted time (ms/word) spent viewing the opening and second paragraphs as a function of Presence of Abstract (Present; Absent) and Study Time (2 minutes; 5 minutes). Error bars depict one standard error of the mean.

To test this hypothesis, the data were analyzed using a repeated measures ANOVA with a within-subjects factor of Paragraph Position (First and Second) and between-subjects factors of Presence of Abstract condition (Present and Absent) and Study Time (2 and 5 minutes). The analysis revealed no significant main effect of Paragraph Position, $F(1, 18) = 1.6$, $MSE = 8560$, $p > .05$, $\eta^2 = .04$ and no significant interactions of Paragraph Position and Study Time or Presence of Abstract and Study Time, all F 's < 1 , all p 's $> .05$. There was a significant main effect of Study Time, $F(1, 18) = 6.6$, $MSE = 10569$, $p < .05$, $\eta^2 = .2$, with more adjusted viewing time spent in the 5-minute than the 2-minute condition. More critically, there was a significant interaction of Paragraph Position with Presence of Abstract, $F(1, 18) = 7.5$, $MSE = 8560$, $p < .05$, $\eta^2 = .1$. That is, there is a difference in the amount of adjusted time spent on the first and second paragraphs of the articles when the Abstract is present compared to when the Abstract is absent. This interaction suggests that the presence of the Abstract does influence how people direct their attention when studying from journal articles. To understand more precisely the nature of the interaction, I analyzed the difference in time spent on the opening and second paragraphs across Presence of Abstract conditions.

3.1.2.1 Analysis of Article Opening Paragraphs

To more closely examine the interaction between Paragraph Position and Presence of Abstract conditions, I examined the amount of adjusted time spent viewing the opening article paragraph for both the Abstract Present and Absent conditions. The data were analyzed using a univariate ANOVA with Presence of Abstract (Present and Absent) and Study Time (2 and 5 minutes) as between-subjects factors. The analysis revealed that the

amount of time spent on the opening paragraph did not differ reliably between Present/Absent conditions, $F < 1, p > .05$, or study time, $F(1, 36) = 1.4, MSE = 13382, p > .05, \eta^2 = .04$. As anticipated, it seems that participants spend the same amount of adjusted time on the opening paragraph, despite the presence or absence of the Abstract. The analysis also did not reveal any significant interactions of Abstract condition with study time, $F < 1, p > .05$. This finding alone suggests that the opening paragraph of the article is important to readers, regardless of whether it is an Abstract or not. So far, it would seem that the Abstract's position, as opposed to its summary content, impacts readers' viewing patterns. However, I consider this finding further in light of an analysis of second paragraphs.

3.1.2.2 Analysis of Second Paragraphs

Next, I examined the amount of adjusted time spent in the second paragraph of the articles across both Abstract Present and Absent conditions. There appears to be an increase in time spent on the second paragraph in the Absent condition relative to the Present condition. The data were analyzed for the amount of adjusted time spent in the second paragraphs in both the Present and Absent conditions using a univariate ANOVA with Presence of Abstract (Present and Absent), and Study Time (2 and 5 minutes) as between-subjects factors. The analysis revealed a significant difference in adjusted time for the second paragraph as a function of Present/Absent condition, $F(1, 36) = 11, MSE = 5747, p < .05, \eta^2 = .23$. This suggests that participants spent more time on second paragraphs when the Abstract was absent from the article. Also, the time spent viewing the second paragraph was greater when participants had 5 as opposed to 2 minutes of study time, $F(1, 36) = 9.9, MSE = 5747,$

$p < .05$, $\eta^2 = .22$. The analysis did not reveal any interactions of Abstract condition with Study Time, $F(1, 36) = 2.7$, $MSE = 5747$, $p > .05$, $\eta^2 = .07$. These findings suggest that, over and above its position in the article, the presence or absence of the Abstract has an impact on the viewing patterns of the second paragraph. I consider this further with an analysis of the interaction between first and second paragraphs.

3.1.2.3 Analysis of Abstract Present Condition

The data from the Abstract present and Abstract absent conditions were analyzed separately. For each of the Abstract present and Abstract absent conditions, a repeated measures ANOVA was used with a within-subjects factor of Paragraph Position (First and Second) and a between-subjects factor of Study Time (2 and 5 minutes).

In the Abstract present condition, the data revealed significant main effects of Paragraph Position, $F(1, 18) = 4.5$, $MSE = 15390$, $p < .05$, $\eta^2 = .2$ and Study Time, $F(1, 18) = 5.2$, $MSE = 11454$, $p < .05$, $\eta^2 = .84$. There was no significant interaction, $F < 1$ and $p > .05$. Based on Figure 3.1, it is evident that these data support a decrease in adjusted time from the first to second paragraphs. In other words, when the abstract is present, people will spend more time on the opening article paragraph than on the subsequent paragraph.

3.1.2.4 Analysis of Abstract Absent Condition

For the Abstract Absent condition, the data revealed a significant main effect of Paragraph Position, $F(1, 18) = 5.2$, $MSE = 1729$, $p < .05$, $\eta^2 = .23$. There was no other significant main effect or interaction, all F 's < 1 and all p 's $> .05$. These data support an increase in adjusted time from the first to the second article paragraphs that is evident in

Figure 3.1. That is, when the abstract is absent, people will spend more time on the second paragraph than on the opening paragraph of the article. Furthermore, having less overall time to study makes a difference in adjusted time spent on the paragraphs when the Abstract is present. More critically, however, when the abstract is absent, a reversal is seen in the pattern of adjusted time that was observed when the Abstract is present. Based on these findings, the presence or absence of the Abstract impacts how participants distribute their viewing time in the subsequent paragraph of the article.

It is important to note that a comparison of paragraph positions entails a comparison of different paragraph content. For example, the comparison of second paragraphs examines the first paragraph of the introduction in the Abstract Present condition and the second paragraph of the Introduction in the Abstract Absent condition. The implication is that the observed effects in adjusted time across Paragraph Position and Presence of Abstract conditions may be impacted by the difference in the content of those paragraphs. By convention, the paragraphs of the Introduction are written to contain more general information at the start and increasingly specific information at the end. One approach would be to compare paragraphs with the same content. One possibility would be to compare the first paragraph of the Introduction (I1) across Abstract Present and Absent conditions. However, in the Abstract Absent condition, I1 appears as the first paragraph which is confounded with the presence/absence of the Abstract. For this reason, I chose to compare I2 across Abstract Present and Absent conditions.

Taking the different content into consideration, then, the data for adjusted time spent on the second paragraph of the Introduction (I2) was analyzed using a univariate ANOVA

with Presence of Abstract (Present and Absent), and Study Time (2 and 5 minutes) as between-subjects factors. The analysis revealed a significant effect of Presence of Abstract, $F(3, 36) = 5.8, MSE = 7859, p < .05, \eta^2 = .14$. The mean adjusted time for I2 was 210.1 ms/wd in the Abstract Present condition (and 222 ms/wd in the Abstract Absent condition) when given 5 minutes of study time. The mean adjusted time for I2 was 63.0 ms/wd in the Abstract Present condition (and 186.5 ms/wd in the Abstract Absent condition) when given 2 minutes of study time. In terms of the amount of adjusted time spent on subsequent paragraphs, I2 behaves similarly to I1 in the Abstract Present condition. Therefore, even when taking content into account, the observed effect of presence and absence of an Abstract in subsequent paragraphs is similar as shown by the previous analyses.

3.1.2.5 Memory Performance

Finally, I also assessed performance on the memory test that followed each article using a univariate ANOVA with Presence of Abstract and Study time as between-subjects factors. The analysis revealed that memory performance increased as study time increased, $F(1, 36) = 6.7, MSE = 87, p < .05, \eta^2 = .2$. Interestingly, there was no main effect of Presence of Abstract and no interaction of Presence of Abstract and Study Time, all F 's < 1 , p 's $> .05$. As Figure 3.2 shows, increased study time enhances memory performance, but the presence of the Abstract has no impact on performance at these highly restricted times.

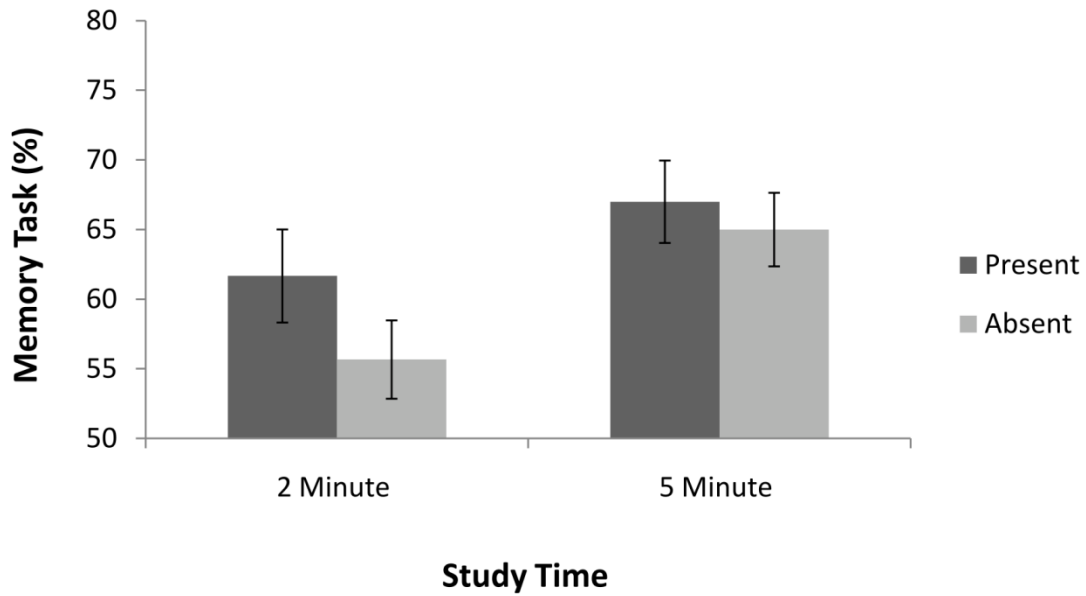


Figure 3.2. The average scores for the memory task (as a percentage) as a function of Presence of Abstract (Present; Absent) and Study Time (2 minutes; 5 minutes). Error bars depict one standard error of the mean.

3.1.3 Discussion

The two issues investigated in the present study concerned: (1) whether the Abstract receives more attention in terms of adjusted viewing time based on its primary position in the journal article or its important summary content; and (2) whether the summary content of the Abstract affects what people will attend next in the journal article. Regarding the first issue, I predicted that if the opening article paragraph receives equivalent viewing time irrespective of the presence or absence of the Abstract, then the importance of the Abstract is more a matter of its position as a first paragraph and less some other aspect, such as its summary content. Alternatively, if the Abstract is attended longer than some other opening article paragraph (e.g., the first paragraph of the introduction), then the implication is that the Abstract is unique for reasons other than its primary position in the text, such as its summary content. These findings demonstrate that people do not spend any more adjusted viewing time on the Abstract than another first paragraph (e.g., first paragraph of the introduction). In this sense, position seems to explain the amount of adjusted viewing time on the Abstract. This finding is consistent with the literature that demonstrates that people tend to focus primarily on initial components of documents (Duggan & Payne, 2009; Holsanova, Holmqvist & Rahm, 2006; Kieras, 1980; Masson, 1982; Reader & Payne, 2007; Wilkinson & Payne, 2006).

Regarding the second issue, it was predicted that, if the summary content of the Abstract influences further viewing, then there ought to be a difference in how people view the second paragraph, depending on whether it follows an Abstract or a paragraph that is not the Abstract. The results demonstrate that, in the absence of the kind of summary information

an Abstract provides, people do spend more time on the subsequent paragraph than the opening paragraph when skimming journal articles under time constraint. Such a difference in the viewing time of second paragraphs is especially meaningful given that I found no difference in how much time people spend viewing the first paragraph across the Abstract Present and Absent conditions. In this way, the differences in viewing the second paragraph cannot be attributed to differences in viewing the first paragraph. In keeping with research on text summaries and skimming behaviour (Dee-Lucas et al, 1995; Holmqvist, et al., 2003; Holsanova, et al., 2006; Reader & Payne, 2007), this finding suggests the summary content of the Abstract influences what readers do next in terms of the distribution of adjusted viewing time to subsequent paragraphs. Taken together, the results demonstrate the importance of the Abstract is a matter not only of its primary position in the journal article format, but also of its role as a *summary* section.

One potential concern of our study is that the comparison of first paragraphs in the Abstract Present condition crosses a section boundary. The Abstract Present condition compares position order of paragraphs in the context of the article as a whole, i.e., paragraphs 1 and 2 of the article. However, if I consider the position order of paragraphs at the level of section, then the Abstract Present condition can be considered to be comparing two “first paragraphs” of two different sections, the Abstract and the Introduction. However, I would argue that reframing an analysis in terms of section boundaries does not change our interpretation of the results. If I consider the Abstract Present condition as a comparison of first paragraphs between sections, then, based on the literature supporting the primacy of first parts, the first paragraph of the Introduction ought to yield little or no difference in adjusted

viewing time relative to the Abstract paragraph. However, I find that the first paragraph of the Introduction receives less adjusted viewing time than the Abstract. Furthermore, in the Abstract Absent condition, I ought to see an increase in adjusted viewing time on the first compared to the second paragraph of the Introduction. Instead, I find exactly the opposite effect, with there being an increase in adjusted viewing time for the second paragraph. Therefore, a consideration of section boundaries serves to highlight rather than detract from the interpretation of our results.

Through monitoring participants' eye movements, the present study demonstrates the moment-to-moment distribution of attention across the opening paragraphs of academic journal articles when summary information is present in the form of an Abstract. Furthermore, it extends and uniquely contributes to the literature on summaries in a specific, but everyday context for university students, i.e., studying for a test under time constraint.

Chapter 4

The Role of Experience in Skimming Journal Articles under Time Pressure

Imagine for a moment that you are a student preparing for a quiz in an upcoming class. The class begins in 5 minutes and you still have to read a five-page journal article that might be covered on the quiz. Clearly you do not have enough time to carefully read the entire article. What strategy will you use to extract as much information from the article as you can in the time available? And, critically, would your strategy depend on your education level?

Research on reading for information-gain has evaluated how effective people are at selecting relevant information and the strategies that are employed (Duggan & Payne, 2009; Kieras, 1980; Masson, 1982; Reader & Payne, 2007). For instance, in examining how people read magazine articles under time pressure, Duggan and Payne (2009) observe systematic patterns of skimming. Analyses of the participants' eye movements revealed that when people are not given information about where important information is located in a document, they prioritized the initial parts of the text with later parts receiving progressively less attention. As observed in Chapter 2, this pattern characterizes a more general *reduced reading effect*, in which people tend to read less and skim more over time. Duggan and Payne (2009) characterize the particular type of skimming under time pressure as a 'satisficing' approach. That is, they start at the beginning of the document and read until they become satisfied they have enough information, at which point reading trails off and resumes at the beginning of the next part of the document (also see Pirolli & Card, 1999; Reader & Payne,

2007). In light of the reduced reading effect, I interpret this pattern here as a *linear-skimming strategy* because it generally involves skimming a document in linear fashion from beginning to end, allocating progressively less attention to later parts of text.

There are several good reasons to believe, however, that the linear-skimming strategy might not always be applied. One reason is that readers might be able to strategically allocate attention based on how efficiently they can acquire new information from the text being read (Reader & Payne, 2007). Specifically, Reader and Payne (2007) have shown that as expertise with a topic increases, individuals spend more time on more difficult passages describing the topic than on simple passages.

A second reason that a linear-skimming strategy may not be applied, and the one I would like to focus on in this article, is that many types of written communication follow formatting and structure conventions that can inform readers about where different types of information are likely to be found. Articles published in scientific journals clearly meet this constraint. Most articles in the field of Psychology include an Abstract, Introduction, Methods, Results and Discussion sections. As such, there is often an explicit agreement among authors and readers of journal articles about where in the article the important information should be found (American Psychological Association, 2009; Northey, Tepperman & Albanese, 2009; Strunk & White, 1979). In most journal articles, important summaries are at the beginning of articles, in the Abstract, but also at the end in the Discussion. Given these writing conventions, it seems possible that readers will be able to seek out these sources of information when skim reading. When reading a journal article people might not just focus on beginnings (using a linear-skimming strategy), but rather

selectively focus on sections that contain important summary information even if these sections are at the end of the document (e.g., the Discussion). Indeed, I observed such a trend in Chapter 2, when people were given unlimited time and an explicit linear reading strategy. In the context of skimming under time pressure, I refer to this strategy as the *targeted-skimming strategy*.

Of course, a targeted-skimming strategy presupposes that the individual would know roughly where in the text important information ought to be found. In the context of reading scientific journal articles, the amount of experience with the format increases with the level of university education. In Psychology, many university programs explicitly target improving scientific literacy, which involves increasing exposure to primary sources such as journal articles as students move through their degree program. In first and second year classes this may consist of explicit instruction in the writing conventions (i.e., APA format) and the exposure to the occasional research article as part of a seminar. In third and fourth year classes, assignments will often explicitly require that journal articles be used and seminar courses may only use journal articles as their readings. In graduate level courses, journal articles are the primary source of reading material, and students are often involved in writing articles for publication in scientific journals. Of course, there are other factors that change with higher education that might affect skimming strategy. For instance, by the time students have reached the graduate level they should have more prior knowledge of the content and greater experience with reading under time constraints. Given all of these reasons, I expect that as the level of university education increases, students would be more likely to use a

targeted-skimming strategy, whereas those with less experience would approximate the simple linear-skimming strategy.

In the present study I evaluated how journal articles are read under time pressure and whether education level affects this process. In this study, three groups of university students at different levels of education – Junior Undergraduates (1st and 2nd year undergraduates), Senior Undergraduates (3rd and 4th year undergraduates), and Graduate students – were asked to read two journal articles from *Psychological Science* for an impending test. Participants were only given 5 minutes to read each article so that I could evaluate how they prioritize various components of the journal articles under time constraint. While they read the journal articles I monitored their eye movements. To assess whether observers used a linear- or targeted-skimming strategy, I examined how much time individuals spent looking at each major section of the articles (i.e., Abstract, Introduction, Method, Results and Discussion).

I reasoned that if students employ a linear-skimming strategy, then the viewing time in each section should be largely determined by the order in which a section appears in the text (with later sections receiving progressively less attention). In contrast, a targeted-skimming strategy would be distinguished by a pattern in which viewing times are less dependent on the order of sections and instead rely more on conventions about where summary information should be located. In particular, I expected that individuals using a targeted-skimming strategy would be distinguished by increased viewing times in the Abstract and Discussion sections. Critically, I expected that a linear-skimming strategy would mostly characterize the viewing behavior of junior undergraduates with this strategy progressively giving way to a targeted-skimming strategy at higher levels of education.

4.1.1 Method

Participants. Data from a total of 64 students from the University of Waterloo were included in the analysis. All students reported normal or corrected-to-normal vision and participated in a 60-minute session. Participants formed three different groups based on their year of study: a group of 20 undergraduates in 1st and 2nd year (Juniors); a group of 20 undergraduates in 3rd and 4th year (Seniors); and a group of 24 graduate students (Graduates), ranging from MA to first year postdoctoral studies in psychology. Undergraduate students were recruited from various psychology courses for course credit at various times throughout the academic year. Graduates were recruited from the Department of Psychology and did not receive remuneration. Participants who calibrated poorly on the eye-tracking device were replaced to maintain proper counterbalance (see *Procedure* section for details on calibration). In total, the data from 7 undergraduates and 5 graduates were replaced.

Stimuli. Displays for the present study consisted of the same two cognitive psychology articles (i.e., one on *Search* and one on *Vision*) from the previous chapters. The articles contained clearly demarcated regions of the journal format, i.e., Abstract, Introduction, Methods, Results, and Discussion. In both articles, these regions of interest spanned 5 pages.

As in the methods for the previous two chapters, the same forced-choice memory test of 15 true/false statements for each article was to be completed following each study phase.

Apparatus. All apparatus for monitoring eye movements and for displaying and accessing article pages are the same as those used in previous studies reported in this dissertation.

Procedure. The procedure replicates that of the studies from the previous two chapters. Participants were tested individually in a small lab room with a researcher present. The experiment consisted of two study and test sessions, one for each article. The assignment of article to session was counterbalanced across participants.

During the study phase of each session participants were given 5 minutes to silently read a 5-page journal article from *Psychological Science*. Participants were given a similar scenario as in Chapter 3 to keep in mind during the reading task: *Imagine it is 5 minutes before your psychology class. You realize that you have not read the readings for the week. But you know that your professor likes to give surprise quizzes on the readings. With only 5 minutes before class, you need to get as much information as you can from the readings to prepare for the possibility of a quiz.* As in the previous studies, participants were free to navigate forward and backward through the article while studying, but they were not provided with information about how much time was remaining. The test phase was administered immediately after the study phase.

As in the previous studies, the eye monitoring system was calibrated at the beginning of each study phase. A random 13-dot calibration pattern was used, with average accuracy being .50 degrees visual angle. The eye monitoring system was set to track either the left or the right eye, based on accuracy of calibration. Again, calibration was assessed by visual inspection of the eye movement record at the end of the experiment. A participant's data was excluded from analysis if there was a major change in fixation accuracy over the course of reading a passage (e.g., a shift in fixations off the passage of text being read).

4.1.2 Results

4.1.2.1 Adjusted Viewing Times

Given that the sections of the article differed in length (i.e., word count) I adjusted the viewing times as in the previous studies, i.e., by creating a ratio score, dividing the total viewing time in each section by the number of words in each section. This allowed me to place the article sections on a more equal playing field by assessing the viewing time for each section on a per word basis. Figure 4.1 shows the average adjusted viewing times for each article section as a function of education level. Once again the data were analyzed using a mixed model ANOVA, with Article Section (Abstract, Introduction, Methods, Results and Discussion) as a within-participant factor and Education Level (Junior Undergrad, Senior Undergrad and Graduate) as a between-group factor.

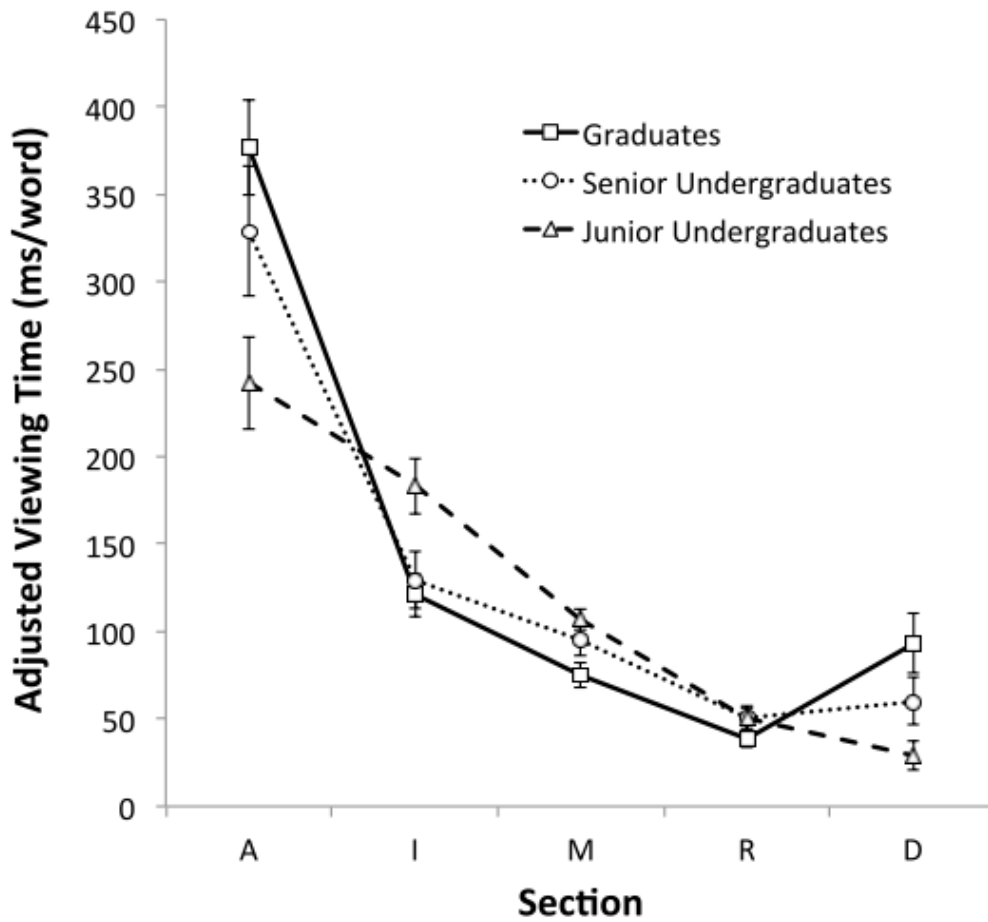


Figure 4.1. The average adjusted time (ms/word) spent viewing each section of the journal articles (A = Abstract, I = Introduction, M = Methods, R = Results, D = Discussion) as a function of education level (Junior Undergraduates, Senior Undergraduates & Graduates). Error bars depict one standard error of the mean.

The analysis revealed that people had the largest adjusted viewing times in the Abstract, with adjusted times then declining in subsequent sections, $F(4, 244) = 115.2$, $MSE = 6616$, $p < .001$, $\eta^2 = .65$. This suggests that people tended to be less thorough in their reading of the sections as they moved through the articles. This is consistent with Duggan and Payne's (2009) observation that people read less as they move through a document.

Importantly, the adjusted viewing times also yielded a significant interaction between Article Section and Education Level, $F(8, 244) = 5.42$, $MSE = 6616$, $p < .001$, $\eta^2 = .15$. In order to understand this interaction further, I examined the within-subject contrasts. I hypothesized that if students could not take advantage of conventions about where summary information is located in the journal article format, then their adjusted reading times should decrease linearly with section order (linear skimming). In contrast, being able to take advantage of the journal format conventions should yield a significant non-linear component to this relationship due to increased viewing time in the Abstract and Discussion.

For Junior Undergraduates, analysis revealed that adjusted viewing times linearly decrease over successive sections, $F(1,19) = 86.1$, $MSE = 7292$, $p < .001$, $\eta^2 = .82$. None of the higher level components (e.g., quadratic, cubic) reached significance, F 's < 2.0 , p 's $> .05$. This pattern is consistent with the use of a linear-skimming strategy. In contrast, the Graduates showed not only a large linear trend, $F(1,23) = 84.6$, $MSE = 11953$, $p < .001$, $\eta^2 = .79$, but also a large and reliable quadratic trend, $F(1,23) = 83.7$, $MSE = 8135$, $p < .001$, $\eta^2 = .78$, as well as significant cubic and quartic trends (F 's > 9.15 , p 's $< .01$). Moreover, the results of the Graduate Students showed longer adjusted viewing times for the Discussion section than for the preceding Results section, $t(23) = 2.73$, $p < .05$. Such a pattern is not

expected from a linear-skimming strategy. Rather, this pattern suggests Graduate students are using a targeted-skimming strategy, reserving time to process important information in the Discussion section. The Senior Undergraduates showed a pattern in between those observed for the Juniors and Graduates, with significant linear, quadratic, cubic and quartic trends, all F 's > 5.78 , all p 's $< .03$. When considering these trends, it is important to note that a qualitative inspection of the data revealed that all but two participants moved through the article sections in the order of appearance.

4.1.2.2 Number of Fixations and Average Fixation Duration

To investigate further how participants were viewing the different article sections during the study time, analyses of the frequency and duration of eye movements was also examined for the groups. To account for discrepancies in section size, the number of fixations in each section was divided by the number of words for those sections. Decreases in the frequency and average duration of fixations across sections would indicate if people were sampling and processing fewer words across sections (see Figure 4.2).

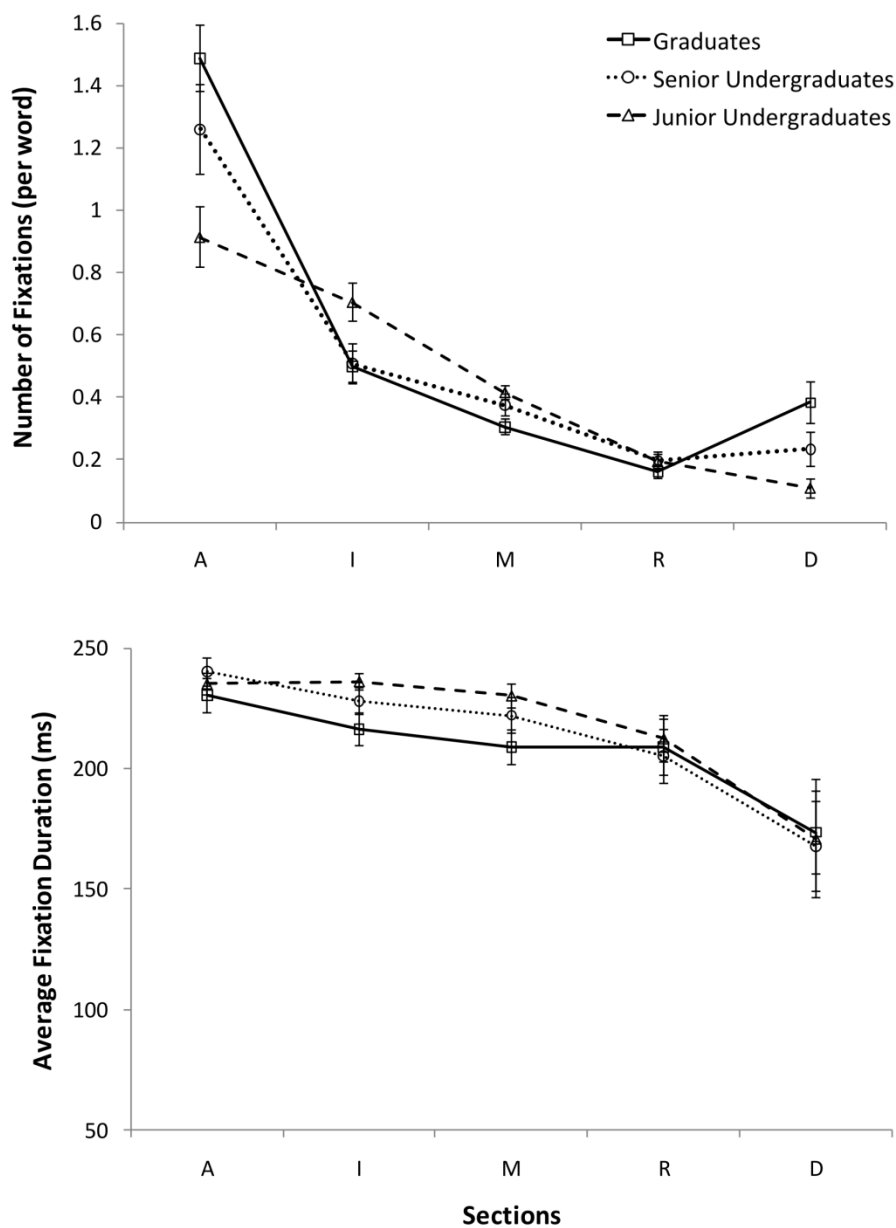


Figure 4.2. The average number of fixations per word and average fixation duration (in ms) for each section of the journal articles (A = Abstract, I = Introduction, M = Methods, R = Results, D = Discussion) as a function of education level when given 2 and 5 minutes of study time. Error bars depict one standard error of the mean.

The findings of a mixed measures ANOVA (with Section as within-subject factor and Education level as between-group factor) for number of fixations per word show a significant main effect of section, $F(4, 244) = 115, MSE = .01, p < .001, \eta^2 = .65$, and a significant interaction of section and education level, $F(8, 244) = 5.9, MSE = .01, p < .001, \eta^2 = .16$. The pattern in the adjusted number of fixations for Junior Undergraduates decreases linearly with section order, reflected in the large linear trend, $F(1,19) = 93.5, MSE = .10, p < .001, \eta^2 = .83$. None of the higher level components (e.g., quadratic, cubic) reached significance, F 's $< 2.0, p$'s $> .05$. By contrast, the Graduates showed not only a large linear trend, $F(1,23) = 94.1, MSE = .16, p < .001, \eta^2 = .80$, but also a large and reliable quadratic trend, $F(1,23) = 78.8, MSE = .13, p < .001, \eta^2 = .77$, as well as significant cubic and quartic trends (F 's $> 6.2, p$'s $< .05$). The Senior Undergraduates showed a pattern in between those observed for the Juniors and Graduates, with significant linear, quadratic, cubic and quartic trends, all F 's $> 5.78, all p$'s $< .03$. These trends in the adjusted number of fixations reflect the trends observed in the adjusted viewing time for each education level and can be seen in Figure 4.2. As in the analysis of adjusted viewing time, these patterns are consistent with the use of a linear-skimming strategy for the Junior Undergraduates and a non-linear, more targeted skimming strategy for the Graduates.

A similar mixed measures ANOVA for average fixation duration reveals significant main effect of section, $F(4, 173) = 18.7, MSE = 1448, p < .001, \eta^2 = .30$, but no significant interaction between section and education level, $F < 1, p > .05$. As Figure 4.2 shows, there is a decrease in fixation duration across sections for all groups, with a steeper decrease in processing for the Discussion section. For Junior Undergraduates, this is reflected in the

large significant linear, quadratic, cubic, and quartic trends, all F 's > 4.9 , all p 's $< .05$. For Senior Undergraduates, there were significant linear, quadratic, and cubic trends, all F 's > 5.3 , all p 's $< .05$, but the quartic trend did not reach significance, $F < 1$, $p > .05$. For the Graduate group, there was a reliable linear trend, $F(1, 22) = 10.7$, $MSE = 2600$, $p < .05$, $\eta^2 = .33$, and a cubic trend, $F(1, 22) = 5.1$, $MSE = 1164$, $\eta^2 = .19$, but neither the quadratic nor the quartic trends reached significance, all F 's < 1.3 , all p 's $> .05$. Taken together, the pattern of a decreasing number and duration of fixations for all groups suggests a reduction in the sampling and processing of words as participants progress through the article, with the steepest decrease occurring in the Discussion section.

4.1.2.3 Memory Performance

Finally, I also assessed performance on the memory test that followed each article. The mean accuracy scores for each group were: Junior Undergraduates = 65%, Senior Undergraduates = 68%, and Graduates = 76%. A one-way ANOVA revealed that memory performance increased as education level increased, $F(2, 61) = 7.3$, $MSE = 108.8$, $p < .05$, $\eta^2 = .19$. A single-sample t-test shows that the overall mean score for each group differs significantly from chance (where chance is 50%), all t 's > 6.2 , all p 's $< .001$.

4.1.3 Discussion

The present study examined eye movements while university students with different levels of education read journal articles under time pressure. Analyses of viewing times in each section of the article revealed that the pattern of viewing times across sections differed with changes in education level, such that increases in education level were associated with

greater time in the Abstract and Discussion. When viewing times were adjusted for section length (i.e., word count) it became evident that undergraduate students were exhibiting a linear-skimming strategy. In contrast, graduate students exhibited several deviations from linear-skimming, consistent with a targeted-skimming strategy. The senior undergraduate students fell in between the juniors and the graduates. Taken together, these results suggest that different skimming strategies – linear and targeted – were used by the junior, senior, and graduate groups.

Our results are consistent with the satisficing framework (e.g., Duggan & Payne, 2009), and suggest several avenues of future exploration. Although I have shown that graduates and undergraduates use different skimming strategies, our groups likely differ on several other unmeasured characteristics (e.g., age, prior knowledge of the content, experience with reading under time constraints, IQ, or ability to focus their attention on the task at hand). It is possible that this particular group of graduate students would have used a targeted skimming strategy at any education level, perhaps even when they were undergraduates. In this study any of these factors could lead to different skimming strategies, and I cannot easily disentangle these various potential factors in the present study. While the starting point for the present study is the general experience of education level, future research could focus on determining the relative contribution of these factors to the difference in skimming strategies.

The present findings also highlight the importance of considering text format when evaluating reading characteristics. Much of the textual media we consume is presented in formats that have well-accepted structures with clearly delineated summary sections, such as

textbooks, newspapers, or magazine articles. To the extent that a reliable format is available and known to readers, it is likely that reading strategies will deviate from a pure linear-skimming model to reflect these consistencies.

On a broader note, our findings build on a growing number of studies showing that people are able to selectively attend to what is of central importance over what is of peripheral importance (e.g., Carrol, Young, & Guertin, 1993; Hegarty & Just, 1992; Holsanova, Rahm, & Holmqvist, 2006; Rayner et al., 2001; Reingold, Charness, Pomplun, & Stampe, 2001; Yarbus, 1967). In addition, our work extends previous studies showing that in various naturalistic tasks such as scene viewing, weather map reading and playing sports, overt attention is systematically influenced by high level factors such as task demands (e.g., Nodine & Kundel, 1987; Smilek, Birmingham, Cameron, Bischoff & Kingstone, 2006; Wedel et al, 2008), an individual's goals (Rayner et al, 2001), schema knowledge (see Henderson, 2003 for a review), domain knowledge (Hegarty, Canham & Fabrikant, 2010; Canham & Hegarty, 2010) and expertise (e.g., Grant & Spivey, 2003; Harle & Vickers, 2001).

Chapter 5

General Discussion

This dissertation aims to understand how students distribute their attention when studying from journal articles for an impending test. Central to the literature on overt attention is the principle that the eyes move in specific patterns based on characteristics of the object being observed and on the goals of the observer. Evidence of this principle in the reading literature demonstrates that shifts in attention during reading to areas of central importance can be influenced by several factors, most critically: (1) available time for reading; (2) the presence of summary information; and (3) properties of the reader. Building on insights from the overt attention literature and the reading literature, the present investigation observes the influence of these three factors in the context of a new format (journal article) and varied time conditions. The resulting observations will be discussed in light of the particular objectives of the experiments in this dissertation.

Chapter 2 of this dissertation examined the influence of available reading time on overt attention. Given that most of the reading done in university is time-sensitive, this chapter explored how students actually distribute their attention across the discrete sections of journal articles when studying for an impending test under time pressure. Furthermore, it addressed a gap in the literature, examining how the behavioural pattern changes when that pressure is lifted and students have *unlimited* study time, as well as an explicit strategy for reading from beginning to end in linear fashion.

The studies in the chapter were, in part, a response to Duggan and Payne's finding of a pattern of decreasing attention across the extent of the text when skimming under time

pressure (2009). The studies explored: (1) reading under time pressure using a new type of text (journal articles) and (2) reading when given unlimited time and instructions for an explicit linear reading strategy. Study 1 evaluated how much adjusted viewing time participants spent when studying a journal article with only 2 minutes of study time. Study 2 tested whether the pattern of decreased time across a text generalized to reading without time restrictions by giving participants unlimited reading time and an explicit linear reading strategy.

In both studies, analyses of adjusted viewing times, the adjusted number of fixations and average fixation durations in each section of the article revealed a *reduced reading effect*. That is, there was reduced sampling and processing of words and an overall reduction in adjusted reading time across article sections. In Study 1, the adjusted number of fixations, average fixation duration, and adjusted viewing times were greatest for the Abstract and decreased in a linear fashion for subsequent sections. These results suggested that people tend to read less and skim more as time decreases. In this way, Study 1 extends the finding of Duggan and Payne (2009) to the academic journal article format.

In Study 2, the analyses of adjusted viewing times, adjusted number of fixations, and average fixation durations in each section of the article revealed an overall decrease in adjusted viewing time across sections, with the largest amount of adjusted time spent on the Abstract and, to a lesser extent, on the Discussion. Even with unlimited time and an explicit linear reading strategy, participants would: (1) read less and skim more as time progresses; and (2) prioritize the Abstract. In other words, the *reduced reading effect* generalized across different time conditions.

Chapter 3 addressed the second influential factor, the importance of summary information to the distribution of attention during reading. The experiment reported in Chapter 3 manipulated the presence of the Abstract in the journal format, making use of that section's unique position and summary content. In this way, the chapter explored whether people allocate more attention to the Abstract relative to other sections of the journal article based on its position or its summary content. In addition to the importance of Abstract position and summary content, the further question of whether the presence of an Abstract impacts what people read next in the article was examined.

Regarding the first issue, it was predicted that if the opening article paragraph received equivalent viewing time irrespective of the presence or absence of the Abstract, then the importance of the Abstract would be more a matter of its position as a first paragraph and less some other aspect, such as its summary content. Alternatively, if the Abstract was attended longer than some other opening article paragraph (e.g., the first paragraph of the introduction), then the implication was that the Abstract is unique for reasons other than its primary position in the text, such as its summary content. The results demonstrated that people did not spend any more adjusted viewing time on the Abstract than another first paragraph (e.g., first paragraph of the introduction). In this sense, position seemed to explain the amount of adjusted viewing time on the Abstract.

On the second issue, it was predicted that if the summary content of the Abstract influences further viewing, then a difference ought to be seen in how people viewed the second paragraph, depending on whether it follows an Abstract or a paragraph that is not the Abstract. The results demonstrated that, in the absence of the kind of summary information

an Abstract provides, people spent more time on the subsequent paragraph relative to the opening paragraph when skimming journal articles under time constraint.

Finally, Chapter 4 carefully considered the impact of properties of the reader on overt attention when studying from journal articles under time pressure. This chapter contributed to understanding the strategies readers used to extract information in the time available, linear-skimming or targeted-skimming. Furthermore, the chapter contributed to how those strategies are influenced by the readers' experience with reading journal articles, comparing the strategies of graduates, 3rd and 4th year undergraduates (seniors) and 1st and 2nd year undergraduates (juniors). In the context of reading scientific journal articles, the amount of experience with the format seemed to differ with varying levels of university education.

Analyses of viewing times in each section of the article revealed that the pattern of viewing times across sections differed with changes in education level, such that increases in education level were associated with greater time in the Abstract and Discussion. When viewing times were adjusted for section length (i.e., word count), it became evident that junior undergraduate students were exhibiting a linear-skimming strategy. In contrast, graduate students exhibited several deviations from linear-skimming, consistent with a targeted-skimming strategy. The senior undergraduate students fell in between the juniors and the graduates. Overall, these results suggest that when studying journal articles under time pressure, skimming strategy changes from a primarily linear-skimming strategy to a partly targeted-skimming strategy with increased education level.

Taken together, the observations in the studies of this dissertation contributed to the literature on overt attention and reading by: (1) extending the attentional patterns of reading

under time constraint to the journal article format; (2) extending the patterns of a *reduced reading effect* beyond reading under time constraint to reading in the absence of time pressure; (3) demonstrating the importance of the Abstract in terms of its position *and* its summary information; and (4) showing how a reader's education level impacts skimming strategies for optimizing information-gain under time pressure.

5.1 Future Directions

Along with its contributions to understanding overt attention when reading journal articles for an impending test, this dissertation generates several lines of inquiry for future research. Extending the work in Chapter 2 on reading complex text under time constraint, it would be worth examining how patterns in people's reading behaviour might change when given *more than enough* study time. Since the journal articles in the present research require an average of 12 minutes for reading (see Chapter 2), participants could be given 20 minutes and asked to make use of the full time for studying the material. With a more generous time constraint, would participants change their strategy from skimming to linear reading? Alternatively, would they employ a combined strategy, reading in linear fashion in a first pass of the text and then skimming select parts in a reread? I have already begun exploring such questions on prospective changes in reading behaviour when people are given more than enough time in a second body of research. In this second body of research, I examined how students distribute their attention while studying an excerpt from an introductory sociology textbook for an impending test with ample viewing time.

Like journal articles, textbooks are another primary learning resource for university students. Whereas textbooks organize information into sections, the format conventions are less consistent than with journal articles, with the content written more as a narrative. Using a method similar to that of the present research, the textbook study gave students more than enough time for reading discrete sections of a university textbook. The reading task was followed by a forced choice memory task.

The excerpts contained both text and graphic information and sufficient reading time for the excerpts was determined in a pilot study to be 10 minutes. Participants studied two, four-page sections from an introductory sociology textbook. They were instructed that they would be tested on their knowledge of the material after they finished studying a given section.

In order to evaluate where participants were attending while studying the textbook sections, their eye movements were monitored throughout the task. In monitoring eye movements, the location of fixations, fixation frequency and duration, as well as saccade amplitude were measured. These measures were assessed as a function of several regions of interest. Two general regions of interest were chosen that had been examined in previous studies, namely, the *main text* and *graphics* (Hegarty, 1992; Carroll, Young & Guertin, 1992; Rayner, Rotello, Stewart & Duffy, 2001; Holsanova, Rahm & Homqvist, 2006). I also assessed how the eyes engaged these regions of interest over a ten-minute viewing time. Using this approach it was possible to evaluate (1) the relative amount of attention allocated to each region of the textbook, and (2) how the relative amount of attention allocated to each region changes as a function of time spent studying the textbook.

As with the research on journal articles, an observational approach was taken. Accordingly, participants' scan paths were observed from videos of their eye movement records, focusing on how the eyes engage the regions of interest (i.e., main text and graphics). These initial observations were used to generate specific hypotheses about how people shift attention between the regions of interest over time, which was tested with further observations. When testing specific hypotheses, various aspects of eye movements were evaluated such as total viewing time, number of fixations and saccade amplitudes. The results suggest that, when given more than enough time for reading sections of a textbook, participants engage in three distinct phases of reading: *Orientation*, *Read*, and *Reread*.

The orientation period was observed as being a period of time at the beginning of each trial when participants examined different elements of the chapter section before engaging in systematic reading of the assigned material. Participants spent on average 10 seconds engaged in this orienting activity, with a strong pattern of eye movements to the top left-hand portion of the page within the first 2 seconds, likely a reflexive action driven by reading conventions. An examination of the eye-movement data suggests that this period of orientation served not only as a way for people to determine where to start reading, but also to collect metadata about the assigned readings, such as the different pedagogical features of the chapter.

Following the orientation period, participants engaged in a systematic reading of the assigned chapter sections, consisting of *reading* and *rereading* phases. The *read phase* was defined as a first (or only) pass through the material from beginning to end, without specification of the reading style (e.g., skimming or deep reading). All participants first read

the material *in a general linear fashion* (i.e., starting at the first word of the main text and proceeding to the next with few diversions until reaching the end) prior to rereading. The *reread phase* was any subsequent treatment of the assigned chapter material. All participants reread the chapters in some selective manner.

To further elucidate how attention is being distributed in the two phases of textbook studying, I examined the total time spent viewing the main text and graphics as a function of reading phase (read and reread). Analysis of the (unadjusted) total viewing time data revealed that participants spent substantially more time in the read phase than they did in the reread phase. The amount of time people spent in each of the regions changed substantially across phases, with the majority of their time being spent attending to the main text than the graphics during the read phase. In contrast, participants distributed their attention more evenly during the reread phase between the main text and graphics. Interestingly, the pattern is even stronger when the time per region data is adjusted either by the area of those regions in pixels or a proportion of the total amount of time available in each phase.

Based on these results for shifts in attention between the regions of interest over time when reading textbooks, participants engage in three distinct phases of reading: *Orientation*, *Read*, and *Reread*. Furthermore, readers attended more to the main text during the Read phase, while being less attentive to main text and more inclusive of the graphics during the Reread phase. Considered in the context of journal articles, then, these findings would lead to the prediction that participants employ a combined strategy of linear reading in a first pass of the article, followed by more targeted skimming in a reread.

Extending the work in Chapter 3 on the presence of an Abstract, a further line of inquiry could examine the importance of the Abstract for longer or shorter articles. More specifically, a follow-up study could look at the impact of the Abstract in a lengthier article by examining where participants go next in the article. While Chapter 3 held article lengths constant and manipulated time, a new study could keep time constant and manipulate article length. Retaining the standard sections of the journal article format, the study could examine the transitions made between the Abstract and various other sections during reading. It might be that, with a lengthier article, participants would rely on the Abstract to guide them to the most task-relevant sections. In this instance, participants might return more frequently to the Abstract and/or be more targeted in the sections they move to after reading the Abstract. Alternatively, participants may attempt to simply skim through all sections in a more linear fashion, not returning to the Abstract after initial read. As observed elsewhere in this dissertation, education level played a role in participants' skimming strategies, with Junior Undergraduates skimming in a more linear fashion and Graduates in a more targeted one. In light of this finding, it is conceivable that lengthier journal articles might influence undergraduates to adopt the more targeted skimming strategy of the graduate students. In this way, this follow-up study could manipulate the length of journal articles to test whether the Abstract has greater impact in directing further reading.

An extension of the work in Chapter 4 on education level could focus on expertise. While the main focus of investigation in Chapter 4 was education level, it was acknowledged that participant groups likely differed on several other unmeasured characteristics (e.g., age, prior knowledge of the content, experience with reading under time constraints, or ability to

focus attention on the task at hand). Having shown an effect of education level, in which graduates and undergraduates use different skimming strategies, future research could focus on isolating other factors and the extent to which they might contribute to the difference in skimming strategies. The study could be replicated and extended by examining the allocation of attention by graduate students who have specific content expertise compared to those who do not.⁵ As another variation on the theme of expertise, the study could be replicated and extended by examining the allocation of attention by professors at various stages of their careers or professors both in and out of their area of specialization within psychology. Finally, as a further follow up to the study on the impact of education level, it would be worth disentangling the extent to which other characteristics of the reader could potentially lead to different skimming strategies while reading under time pressure. For example, patterns of attention while reading journal articles could be examined, comparing participants of different ages and genders, or participants with English as a first or second language. Indeed, a version of the study could be run with two participant groups, undergraduates with English as their first language and those with English as a second language (ESL). It is

⁵ As a preliminary look at the possible influence of discipline-specific prior knowledge, a further analysis for this study was conducted comparing the performance of undergraduates who were psychology majors with the existing group of 24 Graduates (who were all psychology majors). Out of the combination of 20 Junior and 20 Senior Undergraduates, only 10 participants were from psychology. Preliminary analyses of patterns in adjusted viewing time across article sections show a marginal interaction between article section and education level, $F < 2$, $p = .09$. The marginal effect might be due to lower power or the fact that 6 of the 10 undergraduate psychology students are Senior undergraduates as well.

I also analyzed adjusted viewing time across article sections for psychology undergraduates ($N = 10$) with other undergraduates from other disciplines ($N = 22$). There was no significant interaction between article section and discipline type, $F < 1$. Although lack of power is a potential issue here, this finding raises the possibility that content-knowledge may not have an impact at this stage in education level. Further study would be required to support this.

reasonable to infer that ESL students may benefit from content that contains more contextual information, such as definitions of key concepts. As such, an analysis of adjusted viewing time across the sections of the articles might reveal a different skimming pattern that prioritizes those sections with greater context information, such as the Introduction or the Methods.

Another noteworthy follow-up to this research would be to examine the viewing time spent on the figures and tables in the journal articles. Although the present dissertation explicitly limited its scope to the main text, the information in the figures and tables of a journal article can provide relevant summary or procedural information in a succinct and visually compelling way. It would be worth examining, first of all, how figures are attended while reading the articles. For example, are they read as they are encountered in the text, or are they examined only after all the text has been browsed? Are they prioritized over certain sections of the article, such as the Methods or Results, or are they ignored completely? A second line of inquiry concerns how people transition between figures and text. That is, do people transition to the figures and tables when cued within the text or do they transition to figures and tables upon immediately turning to a page containing these graphic items? Finally, given the observed differences between undergraduates and graduates in skimming the text of a journal article, it would be worth investigating how the viewing of figures is affected by education level. If, as observed, graduate students tend to focus more on summary sections such as the Abstract and Discussion relative to undergraduates, then the expectation would be that graduates might also prioritize figures (and tables) for their succinct representation of information.

One final suggestion for a follow-up study to the present research would explore the influence of the section headings in the journal format. The headings chunk and label the article content, making the type of information (e.g., summary, procedural) easily identifiable. Would people skim journal articles differently if they were presented with a version of a journal article where all sections, including the Abstract, are not visually distinguished by the specific formatting and labeling characteristics of section headings? Instead of chunked units of information, the text could display information in a continuous linear flow. Evidence from the literature suggests that readers' representations of the main ideas from a more "traditional" linear display of text are more effortful or time-consuming (Kintsch et al, 1986, 1988; van Dijk & Kintsch, 1983, Dee-Lucas & Larkin, 1997), which in turn, might impact their allocation of attention. Indeed, an examination of the viewing time spent on paragraphs might reveal a pattern of more reading and less skimming, in the absence of the visual cues and information labels that headings provide.

Appendix A

Memory Task Questionnaire for Search Article (Lleras, Rensink & Enns, 2005)

1) Humans are not good at resuming a visual search after being interrupted

T F

2) The researchers had 5 experiments.

T F

3) Distracter items were displayed in red and green.

T F

4) Participants were able to resume an interrupted search faster than to start a new search.

T F

5) There was always a target in each trial for all of the experiments.

T F

6) RR effects are greater for displays that have longer durations than displays with shorter durations.

T F

7) RR refers to rapid resumption.

T F

8) RR occurred only when returning to the first search.

T F

9) In these tasks, memory effects last only 1600 ms.

T F

10) Participants' RTs were not influenced when the target was moved between display presentations.

T F

11) The authors' findings are inconsistent with the iterative sequence of hypothesis generation account.

T F

12) The hypothesis generation account suggests that participants compare a hypothesis to the sensory store.

T F

13) The authors use the term "epoch" to refer to the time between the onset of a display and its reappearance.

T F

14) The normalized distribution of RT data is inconsistent with the idea of RR, but is explained by other factors.

T F

15) No theorists have claimed that memory does not play a role.

T F

Appendix B

Memory Task Questionnaire for Vision Article (Lee & Vecera, 2005)

1) The current study examined Visual Short Term Memory in amodal completion

T F

2) Previous studies suggested that prior knowledge has an impact on amodal completion

T F

3) All trials required participants to remember the location of four colours

T F

4) Amodal completion has been considered to be stimulus driven

T F

5) The colour patches did not appear for a long enough duration that participants were conscious of them

T F

6) Participants were faster when doing no-load trials than load trials

T F

7) Visual Short term memory can influence amodal completion

T F

8) Completion of objects depended on the objects physical orientation

T F

9) Whether or not completion occurred has been described in terms of “memory economy”

T F

10) In order for Visual Short Term memory to influence the task used, participants had to use their VSTM

T F

11) Object-based attention can select both occluded and non-occluded objects

T F

12) Amodal completion meets many of the criteria for being a modular process

T F

13) The colour patches were occluded in Experiment 1 and 3 but not in Experiment 2

T F

14) Amodal completion refers to the phenomenon of perceptually filling in an object that occludes another object making the object on top look different.

T F

15) The authors conclude that image-based features remain important for completion.

T F

Appendix C

Opening Pages for Abstract Absent Condition (Chapter 4)

PSYCHOLOGICAL SCIENCE

Research Report

Rapid Resumption of Interrupted Visual Search

New Insights on the Interaction Between Vision and Memory

Alejandro Lleras,¹ Ronald A. Rensink,² and James T. Enns²

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Although visual search has been studied extensively (e.g., Wolfe, 1998), many questions regarding the role of memory remain. Some theorists have claimed memory plays no role; when participants search for a target among a set of distractor items, they shift their attention from one item to the next without any guidance from the items already encountered (Horowitz & Wolfe, 1998, 2001, 2003). Others have argued for implicit memory of item location, because search can be facilitated by repeated display configurations (Chun & Jiang, 1998, 2003; Chun & Nakayama, 2000) and by information regarding the three previously scanned locations (McCarley, Wang, Kramer, Irwin, & Peterson, 2003; Peterson, Kramer, Wang, Irwin, & McCarley, 2001). Yet when explicit memory tasks are performed concurrently with search, performance is unaffected, as if memory

played no role (Woodman, Vogel, & Luck, 2001; but see Oh & Kim, 2004). Consequently, the role of memory in visual search is still uncertain.

Our approach to this question begins with the observation that people rarely perform only one task at a time. For example, while driving, people often perform visual searches, such as looking for a friend they have planned to meet. If memory plays a role, one should see benefits in returning to a search that has been momentarily interrupted. We show here that such benefits are substantial.

Our results point to a hypothesis-testing mechanism in visual perception, one that forms an initial perceptual hypothesis based on a first glance at a scene and then tests this hypothesis in subsequent glances when the scene reappears. Note that this account of perception is not new: Such iteration has been proposed for visual masking (e.g., Di Lollo, Enns, & Rensink, 2000; Enns & Di Lollo, 2000; Lleras & Moore, 2003). Here we show that the initial hypothesis-generation stage can improve performance. If the initial hypothesis is stored in memory for later use, when the display reappears, participants can test it directly against the current sensory information, skipping the initial hypothesis-generation stage, and thereby substantially reducing target-identification time. We present six experiments that provide strong evidence for this proposal.

GENERAL METHOD

Subjects

A total of 110 undergraduate students at the University of British Columbia, Canada, participated for extra course credit. All had normal or corrected-to-normal vision and were naive to the purpose of the experiments.

Task, Equipment, and Stimuli

Participants were required to report the color of a target *T* shape (either red or blue), presented among *L* shapes, by pressing the “z” key for a blue target and the “/” key for a red target.

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Research Report

Visual Cognition Influences Early Vision

The Role of Visual Short-Term Memory in Amodal Completion

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A partly occluded visual object is perceptually filled in behind the occluding surface, allowing the occluded object to appear as a single object that continues behind the occluder. This filling in is known as *amodal completion* (Kanizsa, 1975; Michotte, Thines, Costall, & Butterworth, 1991). Amodal completion occurs early in visual processing (Davis & Driver, 1993; Rensink & Enns, 1998), perhaps before basic Gestalt perceptual grouping processes (Palmer, Neff, & Beck, 1996). Further, amodal

completion is unmodifiable by observers' knowledge or experience (Kanizsa & Gerbino, 1982), which suggests that completion is determined from stimulus properties (e.g., Kellman, Guttman, & Wickens, 2001; Kellman & Shipley, 1991; Takeichi, Nakazawa, Murakami, & Shimojo, 1995). Amodal completion thus meets many of the criteria for being a modular process (Pylyshyn, 1999).

By using indirect measures of completion, recent studies have solidified the view that completion is unaffected by observers' knowledge. Pratt and Sekuler (2001) examined the effect of past experience on amodal completion by using an object-based attention task to assay completion. Observers saw a preview display containing two rectangles and then an occluder covered the middle portions of the rectangles. Next, a peripheral cue summoned attention to an end of one of the rectangles, and then several shapes appeared inside the visible portions of the rectangles. Observers were asked to report the identity of the largest shape.

Performance on such object-based attention tasks reveals a spatial cuing effect: The fastest responses are to targets appearing at the cued location (Egly, Driver, & Rafal, 1994; Vecera, 1994). In addition, responses are faster to uncued (or invalidly cued) targets appearing at the other end of the cued object than to invalidly cued targets appearing in the other, uncued object, revealing the effects of object-based attentional selection. Object-based attention can select both occluded objects (Behrmann, Zemel, & Mozer, 1998; Moore, Yantis, & Vaughan, 1993; Pratt & Sekuler, 2001) and unoccluded objects (Egly et al., 1994; Vecera, 1994).

Interestingly, object-based attentional effects are present even when the preview display contains four distinct objects that are then partially occluded (Pratt & Sekuler, 2001; see Fig. 1a). Such displays contain T-junctions at the intersections of the rectangles and the occluder. These T-junctions trigger completion, overriding observers' knowledge of the objects prior to the

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