THE EFFECTS OF MULTIPLE COLUMN ONLINE TEXT ON READING SPEED, READING COMPREHENSION, AND SATISFACTION

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I have examined the final copy of this Dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirement for the degree of Doctor of Philosophy with a major in Psychology/Human Factors.

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ABSTRACT

This study examined the effects of the number of columns and type of justification on reading speed, reading comprehension, and satisfaction for online text. Sixty-six participants read a single narrative passage of approximately 2200 words presented in one of six conditions: one, two, or three columns and full- or left-justification. Results from this study found that reading speeds for the two-column full-justified condition and one-column left-justified condition were fastest overall. Fast readers performed best under the two-column full-justified condition, and slow readers performed best under the one-column left-justified condition. No significant differences were found for overall satisfaction or comprehension. Further studies are needed to examine the importance of individual difference in reading ability on online reading performance.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION AND PURPOSE OF STUDY

Introduction

As of April 2003, 148 of the top-selling 150 newspapers in the United States were available online (Berger, 2003) and the number of students using online textbooks was projected to reach 2.2 million that same year ("Another on-traditional option," n.d.). Currently universities are offering up to ten times more journals in online versions than in print (De Groote & Dorsch, 2003). The University of Michigan and Columbia University distribute electronic versions of textbooks to students (Epstein, 1999). Decreases in the cost of hosting online journals and the cost of software to develop them has also skyrocketed the number of online newsletters and Internet "e-zines" (Marcus, 1997). Wired News (1999) reports that Microsoft has joined with publishing firms and electronics manufacturers to set technical standards for e-books used with its Microsoft Reader™ program.

A joint survey by Market Fact and MSNBC.com found that employees report they spend more time reading news and information online than they do through media such as television, newspapers, radio, or magazines (Pruitt, 2003). Thirty-five percent of the 351 respondents reported using the Internet for news and information gathering during the day. Thirty-seven percent reported that the Internet is their choice for gathering national news, compared with 25% who use newspapers. Respondents also reported that the Internet is their choice for gathering national news; 37% reported going online for that purpose. Twenty-five percent get national news from cable television and 18% from broadcast television. Respondents indicated that local news, weather information, and stock quotes were the most popular search topics.

While these studies demonstrate the increase in the amount of online reading, it does not explain *why* an individual would choose to read materials online rather than using traditional paper media. Shaikh (2004a) surveyed 330 individuals of various backgrounds for the reasons why they read online (as opposed to printing documents). The major reasons listed were *size* (smaller documents being more likely to be read online), *navigation* (those documents easier to navigate were more likely to be read online), *entertainment value* (materials read for pleasure were more likely to be read online than research articles, presentations, etc., which were more likely to be printed) and *convenience*.

Other sources also give reasons as to why individuals choose electronic versions of documents over hard copies. A Yahoo! Internet Life article (2002) reports that some individuals prefer reading e-books to avoid the thickness of their hardcopy counterparts; this "obliviousness to length" encourages some readers who might otherwise turn away from a hefty book. Goldsborough (1999) mentions that being able to use the "find" tool available in Internet browsers can also be a benefit of reading online, as it allows one to quickly search for specific topics or passages within a document.

Research on the optimization of online reading currently focuses on issues related to the presentation and layout of text, such as the length of lines in an online document, the size and type of font used, the amount of whitespace in a document, and whether an online document consists mainly of paging or scrolling. The present study will investigate the first of the above issues: the optimal line length for multiple-column text.

Bundesen's Theory of Visual Attention

Bundesen's (1990) Theory of Visual Attention (TVA) is based on the assumption that visual recognition and attentional selection consist in making perceptual categorizations

(such as of the type "item *x* belongs to category *i*"). TVA uses two levels of representations, the perceptual level, or recognized features of a given item, and the conceptual level, which is the categorization of the item and its features. These two representations are used to determine the evidence for membership into a given category that come from the item. The greater the number of features an item has in common with a category, the more likely the item is a member of that category.

Perceptual categories, according to TVA, can take several different forms including categories based on color, shape, or location. A perceptual category is made if and when it enters the limited capacity of the short-term memory store. When a perceptual category is made, the item must first be selected and then be recognized as a member of a particular category. The item can then enter the short-term memory store if a categorization is represented within the store, if enough space is available. Space is available for making categorizations if 1) the item is already represented in the store or, 2) there is space available in the store. If neither of these conditions is made, the representation of the item is lost.

Visual Attention and Reading Comprehension

Research in the area of reading suggests that automating visual word choice through recognition is important for novice readers. Non-automated, or effortful, word recognition takes up attentional resources that can be more useful for higher-level comprehension and memory storage (Brown, Gore, & Carr, 2002). Cognition research suggests that highly literate adults have reached the level of automated word recognition, and this assumption of automated word recognition for adults is a standard view of cognitive research. It should also be noted that the tendency to read words is not easily eliminated with practice (MacLeod, 1991; Reisberg, Baron, & Kemler, 1980).

There is a strong positive link between visual attention and reading comprehension. McConkie, Reddix, and Zola (1992) suggest that there is a stark distinction between perceptual processes that make information available from the visible text and cognitive processes that use information in language processing, while Henderson (1992) notes that covert shifts of attention and overt movements of the eye are functionally related. Visual attention is the medium that links perception to cognition; through perception, the visual information is available while through cognition, the visual information can be utilized.

Researchers believe the selection of information from visual displays can be controlled in two distinct ways. Goal-directed selection is based on the observer's ability to control what regions or objects in the visual field are to be selected for further visual processing, given a set of goals and beliefs about the current task (Yantis, 1993). This is also known as top-down or endogenous control. In stimulus-directed selection, certain properties of the stimulus may capture attention independently of the observer's goals and beliefs (known as bottom-up or exogenous control).

There are two separate types of attention primarily used when researching visual attention in the context of reading comprehension. These two different types of attention – working memory and selective attention – are important because they illustrate the distinct cognitive processes individuals utilize when reading (Yantis & Johnson, 1990).

The role of working memory is to choose which goals a person wishes to pursue, make decisions, select responses to be carried out, and maintain task critical information at a readily available level of activation. Selective attention chooses the sources of sensory input from the external world during perceptual processing, as well as maximizing the speed and

accuracy at which selected input is encoded (Mirsky, 1996). Sensory input is visual during word recognition, so the type of selective attention used is visual attention.

In researching working memory, dual-task demands are typically used, which assumes a focus on word recognition as the primary task, such as speeded pronunciation or lexical decision tasks. Secondary tasks in working memory studies are usually reaction time or memory load related. Studies using these tasks show interference with secondary reaction time, as well as interference from maintaining the memory load (Brown, Gore, & Carr (2002). These effects are larger for low frequency words, suggesting that past experience with the word reduces the load on working memory. These studies seem to support familiarity-sensitive models that suggest practice is the crucial component determining how quickly a word can be processed in short-term memory and activated from the long-term memory store (Logan, 1988). Such models hypothesize that in working memory, word recognition approaches automaticity with the limitation that some words are not frequent enough to reach such a high level of automation.

Research on the other primary attentional mode, selective visual attention, reveals a frequent finding of a "word superiority effect", in which participants identify letters with greater accuracy in words presented in isolation than in non-word letter strings presented under the same conditions (Carr & Pollatsek, 1985). This effect can be eliminated in tachistoscopic forced-choice recognition tasks by cueing participants to a particular position to focus on, in which the next letter can be expected. Results such as these suggest that visual attention must be distributed across entire letter strings for the letters to interact and become specific, distinct words rather than unrelated letters processed independently.

Visual attention studies appear to favor familiarity-sensitive models. Familiarity-sensitive models argue that the amount of attention required to successfully identify stimuli depends on practice. This was applied to the role of spatial attention in word processing by LaBerge & Brown (1989). In this model, the spatial attention filter aligns the visual processing channel with the features of familiar objects, so that relatively unfamiliar, lower-frequency words are identified through the repeated identification of familiar subunits, such as letters or morphemes (linguistic units consisting of a word, or word element, such prefixes or suffixes, that cannot be divided into smaller meaningful parts) (Henderson, 1992).

The need for sustained visual attention can be offset by familiarity. Madden (1992) states that visual-attentional information processing research reliably finds that the reaction time for visual search performance during correct decision tasks is reduced when a cue is given as to the probable location of a target within the display.

As well, Sieroff & Posner (1985) cued participants to visually attend to either the left or right end of a target stimulus. This cue increased performance in tachistoscopic whole reports when the stimulus was a random letter string, but not when the stimulus was a high-frequency word. In the case of high-frequency words, a ceiling effect reduced the impact of any increase in performance by participants. Thus, Sieroff & Posner hypothesize that visual attention is needed for encoding novel material, but as familiarity increases, the need for sustained visual attention can diminish or even disappear. The relationship between working memory and visual attention seems to be that familiarity from previous exposure reduces the demand on both of these components of the attentional system. Word recognition becomes more automated as familiarity increases, coming close to automaticity for words that are encountered with a great deal of frequency.

Online Reading Research

Line Length and Reading Speed

Bailey (2002) reports that the influence of line length on reading speed has been measured since the 1880s. In the first empirical study of the effect of line length on reading, Weber (1881) recommended that the ideal line length for books, magazines, and newspapers using a 10-point font, with black letters on a white background was 100 millimeters (3.9 inches), and that lines should never exceed 150 mm (5.9 inches). Javel (1881) reported that line lengths should not exceed 90 mm (3.5 inches). Cohn (1883) validated Javel's findings of 90 mm (3.5 inches) and suggested that line length should not exceed 100 mm (3.9 inches). Several decades later, Tinker and Paterson (1929) found that line lengths ranging from 75 to 90 mm (2.9 inches to 3.5 inches) showed faster reading speed than line lengths of 185 mm (7.3 inches). Since then, researchers have proposed that longer line lengths reduce reading speed because the number of lateral eye movements required is increased, in turn increasing the likelihood that users would become lost within the text.

More recently, in studies of online reading, researchers have found the reverse: longer line lengths facilitate faster reading speeds. Duchnicky and Kolers (1983) found that a "full screen" line length of 187 mm (7.4 inches) resulted in a 28% increase in reading time over a "one-third" line length of 62 mm (2.4 inches). Both the full-screen and one-third screen lengths were read faster than the "two-thirds" screen length of 124 mm (4.8 inches). From this, Ducknicky and Kolers concluded that longer line lengths are more efficient for reading from computer screens than narrow line lengths.

Dyson and Kipping (1997) found that a line length of 140 mm (5.5 inches) was read faster than a narrow line length of 46 mm (1.8 inches). A follow-up study by Dyson and

Kipping (1998) found the same increase in reading speed as line length increased. A 7.3 inch line length was read more quickly than a line length of four inches. Users preferred the four-inch line length, however.

Youngman and Scharff (1999) found that with 12.5 cm margins, the fastest reading times were for short 4-inch line lengths over the 6- and 8-inch lengths. The 4-inch lengths were also preferred over the other lengths. With no margins, the 8-inch line lengths had the fastest overall reading times. Dyson and Haselgrove (2001) found that a 4-inch line length was read more quickly than a short line length of 1.7 inches. Shorter line lengths are typically not recommended because shorter line lengths increase either the amount of scrolling required on a page, or the number of pages in the text.

However, several studies do come out in favor of shorter line lengths. Huey (1968) found that readers returned to the next line more accurately with line lengths of approximately 100 mm (4 inches) than with longer line lengths. Gregory and Poulton (1970) found that people with poor reading ability performed better when the line length was approximately seven words. This suggests that readers who have little experience with online reading, as well as readers who have vision deficits, may benefit the most from narrower line lengths.

Some hypothesize that smaller lines allow for more chunking, and less stress on short-term memory load (Lam, Lam, Liu, & Shin, 2000). Assuming that readers take in a line of text at a time, a single column of very long text would create more short-term memory load than a short line. Short line lengths also ease the transition from one end of a line to the beginning of the next. However, wide columns allow for faster reading rates and fewer disruptions from transitioning from one line to the next.

Some research finds that line length has little effect on reading speed. Bernard, Fernandez, and Hull (2002) found no differences in adult reading speed between line lengths of 245 mm (9.6 inches), 145 mm (5.5 inches), or 85 mm (3.3 inches). Subjects reported a preference, however for the shorter line lengths of 5.5 inches and 3.3 inches.

Dillon (2004) notes that reading speed can be reduced by interference from text on adjacent lines because the number of characters available in a given fixation is also reduced. Bailey (2002), summarizing the line length research, suggests that users read faster if a line length is long (up to 10 inches), and that short line lengths of 2.5 inches or less results in decreased reading speed. Bailey also notes that research has shown that users prefer moderate line lengths of between 4 and 5 inches. Rayner & Pollatsek (1989) have also interpreted the confusing and seemingly conflicting results of online reading research: if line lengths are too long, return sweeps to the beginning of the next line are difficult for readers to make. If the lines are too short, readers cannot take in as much information at each fixation. Eye movement studies show that readers decrease their saccade length, make more fixations, and increase fixation durations when short lines are used (Masson, 1985). Reading short lines seems to be "particularly inefficient" in terms of these studies (Dyson & Haselgrove, 2001).

Line Length and Comprehension

Research investigating the effect of line length on comprehension has also been conflicting. For print reading, Tinker (1963) suggests that shorter line lengths produce higher comprehension. For online reading, de Brujin, de Mal, & van Oostendorp (1992) also suggest shorter lines promote better comprehension. However, Dyson and Haselgrove (2001) found that a line length of 55 characters per line facilitated better overall comprehension and Dyson and Kipping (1998) found line length to have no effect on comprehension.

The Dyson & Haselgrove (2001) study used a comprehensive set of questions that required the reader to use higher order thinking (termed "*title"* questions), remember the order of items (*structure*), recall main facts (*main factual*) and ideas *(main idea*), recall incidental facts about the passage (*incidental*), and indicate if a line was in the passage or not (*recognition*). Using this methodology for measuring comprehension, they found that 55 CPL (characters per line) facilitated better overall comprehension. This better performance was attributed to the ability of the eye to easily locate the start of the next line when reading at this line length, possibly reducing distractions. Using a sensitive measure of comprehension may have also influenced these results (Shaikh, 2004b).

Dyson & Haselgrove (2004) also reported that factual questions were easiest to answer and the structure questions were most difficult to answer across all line lengths. Questions assessing recall of main ideas are commonly accepted as being easier and requiring lower thinking levels. Hansen and Haas (1988) found similar results for questions relating to the structure of passages. In their studies, they found subjects had better spatial recall when reading from paper than from reading from a screen. The researchers theorized that the lack of spatial orienting cues (as commonly found in printed material) might have resulted in poorer performance on the questions pertaining to order. This lack of spatial cues was attributed to the scrolling required by the method of the study. Scrolling through a long page increases the likelihood of readers losing information regarding place within documents rather than reading on an unchanging page.

Carver (1990) explains the apparent contradiction between slow reading times resulting in increased comprehension and fast readers typically having better comprehension. Both negative and positive correlations between reading rate and comprehension have been

reported as these studies have measured two different types of correlations: between-individual and within-individual. When an individual increases his or her reading rate, comprehension, a within-individual characteristic, decreases. However, those who are naturally fast readers generally have high levels of comprehension, a between-individual characteristic.

Characters Per Line

Several sources state that 10 to 12 words per line (50 to 70 CPL) is the optimum line length for print materials (Nord & Tanner, 1993; Felker, 1981; Tinker, 1963). The reasons cited for this are similar to the reasons cited for online materials – long lines increase the difficulty for lateral eye movements to stay on track and return to the next line without the need to reread.

There are conflicting results as to what the optimal number of CPL should be for documents to be read online. Many online sources use the line length recommended for print, approximately 52 CPL, (Tinker, 1963) when designing their materials. However, a wide variety of "optimal" passage lengths are presented in the literature. Typically, a "middle of the road" approach is used, with medium line lengths (e.g. 50-70 CPL) being favored in many studies. Some research suggests line lengths of approximately 60 CPL are most efficient for online reading (Horton, 1989; Mills & Weldon, 1987). Horton (1989) reports that longer line lengths are more tiring to read and recommends limiting line lengths to around 40 to 60 CPL, while Grabinger (1993) found that lines of 45-60 CPL were most preferred. Other research has led to recommendations that line lengths should not exceed approximately 70 CPL (Spencer, 1963), as both very short and very long lines disrupt the normal eye movement patterns.

In order to determine difference in reading performance between short and long line lengths, Dyson and Kipping (1998) had participants read six documents with line lengths of 25, 40, 55, 70, 85, and 100 CPL. They found that long lines of approximately 75-100 characters per line (CPL) were read more quickly than narrow lines of 25 CPL. However, the 55 CPL condition was rated easiest to read, while the 100 CPL condition was rated least easy to read. No differences were found in perceptions of reading efficiency.

In an ensuing study, Dyson & Haselgrove (2001) compared comprehension and reading speed at different line lengths between normal readers and readers trained to read fast. No interaction was found between reading speed and line length, but the 100 CPL line length was read more quickly than the 55 CPL lines. A line length of 25 CPL showed reading rates between the 55 CPL and 100 CPL conditions. Comprehension was higher with medium line lengths (55 CPL) than longer lines (100 CPL). Dyson and Haselgrove propose that there does not seem to be an advantage for shorter lines of 25 CPL when reading fast.

A study by Bernard, Fernandez, and Hull (2002) found no significant differences for either children or adults for mean reading time when compared across line lengths of 45, 76, or 132 CPL. The “full length” condition, with text across the entire screen, was perceived by adults as being more optimized for scrolling when compared to the “medium” and “narrow” lengths, filling about half and a quarter of the screen, respectively. However, they found that the adults preferred the short and medium length to the full length condition. From this, they suggest that full-screen line lengths should be avoided for online documents, particularly for large amounts of text, and recommend a medium line length of approximately 65-75 CPL.

Paging vs. Scrolling

Line length typically has a direct relationship with the amount of paging and/or scrolling required for online reading. Dyson & Kipping (1997) found that users who used paging rather than scrolling navigated through a web document more quickly. In a second study, Dyson & Kipping (1998) presented subjects with three different layouts for reading online text: a one-column layout using scrolling, a one-column layout using paging, and a three-column layout using paging. Reading speed for the one-column paging condition was faster than for either the one-column scrolling or three-column paging conditions. No significant differences in comprehension for the conditions were found. Participants preferred the three-column layout to the other two conditions, however. From this, Dyson & Kipping concluded that paging is faster than scrolling for reading online text, and that a single wide column is read faster than three narrow columns when paged.

A study by Baker (2003) also investigated paging vs. scrolling. Subjects were presented with three different layouts: a "paging" condition, in which one paragraph of text was presented at a time, with participants forced to page to see the next screen, a "full" condition, in which the entire screen was filled with text and users paged to the next screen with no scrolling involved, and a "scrolling" condition, with the entire document presented on one scrollable page, with no paging whatsoever. After reading each passage participants were given five comprehension questions related to the text, and five search tasks.

Baker found that the paging condition resulting in a slower reading time than the scrolling condition, while there were no differences in comprehension for the two conditions. Baker also found a trend for the paging condition to lead to longer search task completion times than the "full" or scrolling condition.

The results of this experiment are somewhat surprising given that Dyson & Kipping (1998) found paging to be typically faster than scrolling. However, Baker reports that users commented that they were more accustomed to scrolling when reading documents on the web. It may be that since participants had more exposure to scrolling they were able to read through the documents more quickly using that mode of navigation.

Hansen & Haas (1988) and Piolat, Roussey, & Thunin (1997) note some disadvantages of scrolling to paging. Cues to the location of information are lost when text is scrolled within a window. However, scrolling is now commonly used when reading or scanning web pages (Dyson & Haselgrove, 2001). It is difficult to accommodate a paged format in web browsers, as the amount of text per page is not fixed.

Passage length

The content used in most line length studies has been nonfiction in nature, such as SAT passages. The passages have typically ranged from 300-1000 words in length. Few studies have investigated the effect of line length on material commonly found on the Internet such as narrative passages, which may be much longer than the one or two pages presented in previous studies. Surber (1992) notes that participants read longer passages twice as fast as shorter passages. Commander and Stanwyck (1997), suggest that slower reading times for shorter passages may be due to readers spending more time comprehending the material in preparation for the pending questions.

A recent study by Shaikh (2004b), using the same comprehension question structure as the Dyson & Haselgrove (2001) study, investigated the effects of line length on reading performance and reader satisfaction of long narrative passages with approximately 2500 words and short news stories of about 350 words. Four line lengths were examined (35, 55,

75, and 95 CPL), and participants were measured on their speed of reading, comprehension, and preference for each of the line lengths. A main effect of speed was found, with 95 CPL being read faster than any of the other three line lengths, but no differences for reading efficiency (reading speed x percent correctly comprehended) were found. In general, the long passages were read more quickly than the short passages. Participants showed higher levels of comprehension for structure questions when reading long narrative passages at 35 CPL than short passages at the same length. Preference was evenly split between 35 and 95 CPL, an interesting result, given the fact that medium length lines commonly found in paper media should have been more familiar to readers than either the short or long line lengths. It is possible that the variety of line lengths now present on the Web may have influenced reader preference.

Rayner (1983) showed that skilled readers can obtain useful visual information up to fifteen characters to the right of a fixation. Shaikh (2004b) notes that at 35 CPL, approximately half of a line can be taken in with each fixation. Shaikh also suggests that, due to regressive eye movements to previous portions of a line, a line length of 35 CPL may allow for increased rehearsal of information. Hansen & Haas (1988) suggest that shorter lines are more conducive to learning than longer lines, because long line lengths increase fatigue. The findings in the Shaikh (2004b) study do not agree with those in the Dyson and Haselgrove (2001) study, which found that a line length of 55 CPL resulted in faster reading times than a line length of 100 CPL. This study does support the finding of Dyson and Kipping (1998) that a longer line length of 100 CPL resulted in higher reading speed, as well as Duchnicky and Kolers (1983) who recommended a line length of 75-100 CPL.

Multiple-Column Displays

Large high-resolution displays can now have resolutions of over 1900 pixels, resulting in extremely long lines of text. One way to resolve the problem of very long text lines is to divide the text into multiple columns, thus decreasing the width of each individual line. Some sites even allow users to customize pages into one, two, or three columns (for examples, see: http://www.grandcanyonlodges.com, and http://www.travelyellowstone.com). In general, the longer lateral eye movements become, the lower comprehension rates become (Andreyev & Martynov, 2000). Long lines increase the difficulty of finding new lines of text after long lateral eye movements, especially when lines are vertically spaced close together. Bouma (1980) has suggested that two-columns be used for high-density text. Williamson (1966) and Pinelli, Cordle, & McCullough (1986) found that two-column layouts improved reading performance, and were most preferred for printed scientific and technical material. Dyson & Kipping (1997) found a difference in comprehension when readers were divided into fast and slow groups. Faster readers performed better in a three-column paged condition, while slower readers showed worse performance.

Hartley, Burnhill, & Fraser (1974) and Burnhill, Hartley, & Young (1976) found that multicolumn layouts that are too narrow can slow the reading rate of fast readers by up to 200 words per minute. However, Hartley & Trueman (1983) found no significant difference between a single and two-column format on reading comprehension and reading rate. Based on the findings of the Dyson & Kipping (1998) study, Andreyev & Martynov (2000) hypothesized that for very wide screens, reading speed and comprehension would improve when the text was divided into multiple columns. Using science passages for the text, they

controlled the width of the columns by varying the size of the text window between 600, 800, and 1000 pixels.

Andreyev and Martynov found no significant differences for reading speed, comprehension time or the number of comprehension errors made in either the one-column or three-column condition. Satisfaction for the three-column display was higher than for the single-column.

Andreyev and Martynov also found that satisfaction ratings for the single-column display decreased as the width of the text window increased. The three-column display was rated more satisfactory than the single-column for both the 800 and 1000 pixel windows. No differences in satisfaction were found for the 600 pixel window for either the one- or three-column conditions. Andreyev and Martynov attribute this to the line length being more manageable for the reader in a small window, no matter how it is displayed. They also suggest one direction for future research is to measure reading performance with two-column displays in addition to one- and three- column displays.

Lam, Lam, Liu, & Shin (2000) found that participants reading a one-page science-related document had a 28% faster reading time in a three-column condition than reading the same passage with only one-column. They found no differences for comprehension or preference for either condition. However, they do note that several participants commented that the three-column display "seemed" shorter than the single-column format. Interestingly, Lam et al. also report that subjects would often use their finger to point to the screen while reading from the one-column condition, but rarely did this in the three-column format, suggesting that subjects had a difficult time of keeping their place in the text in the one-column condition.

Whitespace

The amount of "whitespace," or open space, presented in a document performs an important role in facilitating both reading and organizing text. Mullet & Sano (1995) notes that whitespace directs reader attention to areas where important information will be provided, and is useful for organizing information on a page. White (1974) states that whitespace helps to tie successive pages together through the repetition of "identifiable areas." The most current recommendation by the National Cancer Institute (2003) is to limit the amount of white space on pages that are used for scanning and searching. Few recommendations, however, are provided for the amount of white space for online text passages such as short stories, news articles, or online novels.

Some researchers propose that large amounts of whitespace are not good for online reading. Spool (1997) reports that users were less successful in finding information on websites with large amounts of whitespace than with page layouts that were very dense. Participants in this study reported lower perceptions for high whitespace sites on "ease of reading", "ease of searching", and "finding things easily."

Chaparro & Bernard (2001) showed participants three different whitespace layouts (low, medium, and high) and asked them to perform five search tasks using each of the layouts. Results from this study showed that while participants showed no differences in the time to find the information, they did report more satisfaction with the medium whitespace condition over the low whitespace condition. Comments from participants described the low whitespace condition as being "too cramped" white the high whitespace condition looked "empty" and necessitated more scrolling to see all of the text.

A recent study by Chaparro, Baker, Shaikh, Hull, & Brady (2004), manipulated the amount of whitespace on a page by adjusting *margins* (the amount of whitespace on either end of a line) and *leading* (defined as the vertical distance from the baseline of one line of text to the baseline of the next line, or space between lines of text). Results from this study showed that participants read text with margins more slowly than text with no margins, but showed higher levels of comprehension. While leading did not seem to have an impact on reading performance, participants reported lower levels of satisfaction and higher levels of eyestrain when paired with a "no margins" condition.

Cognitive Issues

A common resolution to dividing online passages across multiple pages is to separate paragraphs mid-sentence across consecutive pages. However, researchers have proposed three different basic components of reading comprehension: propositions, sentences, and paragraphs (Kintsch, 1974; Just & Carpenter, 1980; Mandler & Johnson, 1977). This division, then, can affect cognition in two ways. The first is that information from the preceding page is no longer available on the current page (Dillon, 2004).

Second, the load time for pages may be slow, straining readers' short-term memory load for the information on the previous page. Separating sentences across screens may interfere with comprehension by placing burden on working memory to "hold the sense of the current conceptual model" while moving on to the next screen (Dillon, 2004). Ellis (1983) reports that between ten and twenty percent of eye movements during reading are regressions to words already fixated on by the reader, and that long eye-movement pauses occur at the end of sentences, also suggesting that the separation of sentences between pages may impede comprehension.

Dillon (1990) and de Brujin, de Mal, and van Oostendorp (1992) found that participants reread text more often when divided across pages than when the text was not divided. Although they report there was no difference in comprehension, participants did often remark that the divided text was a nuisance. Dillon (2004) suggests that text splitting should be avoided for interfaces using paging.

Eye Tracking

The Poynter Institute (2000) has conducted a series of studies using eye tracking to detect where people are looking while performing various tasks on the Internet, including reading internet newspapers. Results from these studies show that among users' first three eye-fixations, 78% were directed towards text on a page. The study also found that the typical pattern for reading on the web is to mainly skim over text, while occasionally reading the text more closely. These results seem to support Nielsen's (1994; 1997) suggestion that readers usually scan, rather than read, online.

Text Justification

The conventions of paper magazines and newspapers often require text to be full-justified (Schwier & Misanchuk, 1993). Even some software such as Microsoft Reader™, a program that allows users to read online books, full justify the text. Several studies suggest, however, that for paper documents, ragged right text (left-justified) can be read more quickly (Muncer, Gorman, Gorman, & Bibel, 1986).

Priestly (1991) and Hartley (1986) suggest that printed materials should be left-justified because the intra-word spacing remains constant, which helps slower readers identify words more quickly. However, Priestly notes that a debate continues in the curriculum and education sphere on whether instructional material is best presented in a full-

justified or left-justified format. Full justification requires that both margins be aligned. To accomplish this, large spaces must be made between words, or words must be hyphenated, both of which can reduce reading speed and comprehension. Left-justified text is generally preferred because it removes the need for hyphenated words.

Williamson (1966) and Fabrizio, Kaplan, & Teal (1967) both suggest that left-justified margins in printed materials do not adversely affect legibility, but found no benefit for left-justified text over full-justification. Pinelli, Cordle, & McCollough (1986) state that left-aligned margins provide visual points of reference that guide the eye smoothly down the page from one line to the next. Because each line differs in length, the eye is cued from one line to the next and can find its way to the next line easily. In full-justified text, all lines are of equal length, which can diminish a visual cue that promotes speeded reading.

Mathes & Stevenson (1976), Bain (1970), and Hawken (1966) all state that full-justified text is more difficult for poor readers to read and comprehend. Gregory & Poulton (1970) found poor readers had lower comprehension scores when reading from full-justified text on paper than from left aligned text with a line length of approximately seven words. Recommendations for paper are typically to *not* use full justification of text when sustained reading is the primary goal of the document (Schwier & Misanchuk, 1993; Muncer, et al., 1986).

However, Campbell, Marchetti, & Mewhort (1981) found that full-justified text aided in faster reading for skilled readers than left-justified text, and that left-justified margins in printed material reduced reading speed by diminishing eye movement control because of the lack of predictability of where the line will end. Craig (1982) notes that full-justified margins are best suited for sustained reading comfort.

There is surprisingly little research on the impact of text justification on online reading. A recent study by the Software Usability Research Lab (SURL) (2004) looked at the effects of justification on reading online documents. In this study, participants read SAT-type passages presented in three different formats: an "enhanced justified" condition that utilized Microsoft ClearType™, a "full-justified" condition, and a "left-justified" condition. They found the "enhanced justified" condition was read more slowly than the "full-justified" condition, but found no differences for comprehension. Participants also preferred the "full-justified" text to the other conditions.

Review

Currently, there are a number of issues related to online reading that are unresolved. Whether shorter or longer line lengths result in more efficient reading has yet to be determined. Longer line lengths typically result in faster reading times (Duchnicky and Kolers, 1983; Dyson and Kipping, 1997; Dyson and Kipping, 1998; Dyson and Haselgrove, 2001), but research suggests medium to short line lengths typically result in higher comprehension (Tinker, 1963; de Brujin, de Mal, & van Oostendorp, 1992; Chaparro et al., 2004).

The optimal number of columns in a multi-column online display is also unknown as the research on reading speed supports both long single columns of text (Dyson and Kipping, 1998), and multiple short columns (Lam et al., 2000) while preference seems to lie towards multiple short columns (Bouma, 1980; Dyson and Kipping, 1998; Andreyev & Martynov, 2000).

There has been little research done on the impact of text justification on online reading. Currently, it is unknown whether full-justified or left-aligned text results in more

efficient online reading, though one recent study has shown support for full-justified text (SURL, 2004).

In summary, the major findings regarding line length, justification, and multi-column displays and online reading have been:

- Longer line lengths generally facilitate faster reading speeds.
- Shorter line lengths result in increased comprehension.
- The optimal number of characters per line is between 45 and 65.
- Paging through online text generally results in better comprehension than scrolling.
- Reading speed is faster for both single and multiple columns, but preference is for multiple short columns.
- Left-justified text is read faster than full-justified text. One study shows a preference for full-justified text.

Purpose and Hypotheses

This study seeks to examine the impact of multiple-column text displays and text justification on reading speed and comprehension of a narrative passage. Three multiple-column conditions (one-column, two-column, and three-column) and two justification conditions (left and full) will be examined.

Based on the previous research, it is hypothesized that:

I. *Reading speed will be faster for a single (90 cpl) column condition than shorter two- or three-column conditions (45 cpl, 30 cpl, respectively).*

II. *Comprehension will be higher for the three-column condition than the one- or two-column conditions.*

III. *Reading speed will be faster for left-justified text than full-justified text across all column conditions.*

IV. *Satisfaction will be higher for full-justified text than left-justified text across all column conditions.*

CHAPTER II

METHOD AND RESULTS

Method

In this study, participants read text displayed either as a single column (90 CPL), a 2-column format (45 CPL each), or 3-column format (30 CPL each) presented using either Full or Left Justification.

Participants

Sixty-six undergraduate Wichita State University students with normal or corrected vision participated in the study. Participants had an average age of 22.8 years.
Data were collected on the participants' amount of online reading experience and types of materials read online. Eighty-nine percent reported using the Internet a few times per week or more. Forty-eight percent of participants indicated that they read online for two to six hours per week, 15% reported reading online for seven to fourteen hours per week, and nine percent reported reading online for fifteen hours or more per week.

Materials

H.H. Munro's ("Saki") short story "The Lumber Room," a passage of 2191 words was used as the reading material. The story had a readability score of 9.6 on the Flesch-Kincaid Grade Level statistic. Six versions of the story were created: a single column with a width of 90 CPL, a 2-column format with column widths of 45 CPL, and a 3-column format with column widths of 30 CPL, each presented in either a Full or Left Justification format (See Figures 1 – 6).

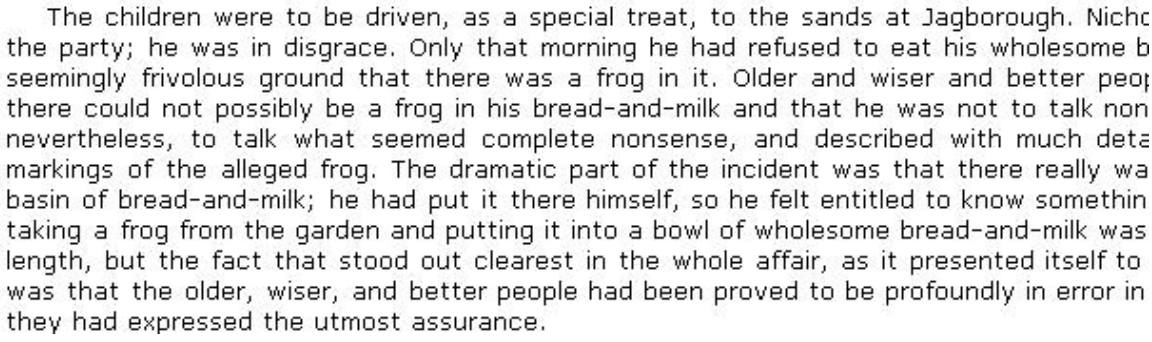

Figure 1. One-Column Full-Justified Condition

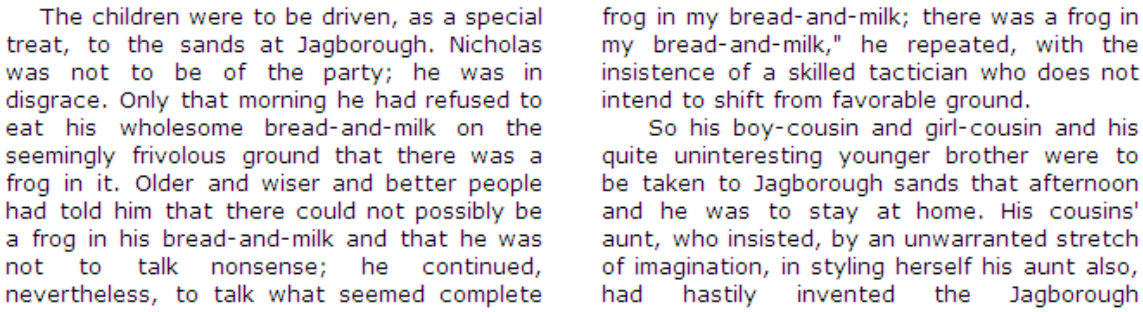

Figure 2. Two-Column Full-Justified Condition

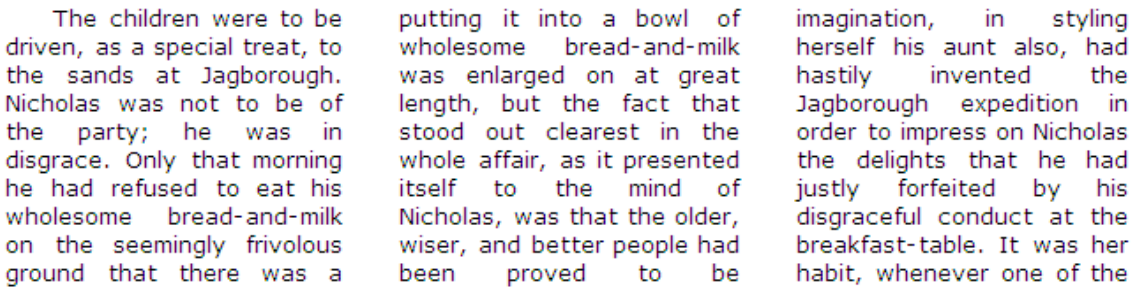

Figure 3. Three-Column Full-Justified Condition

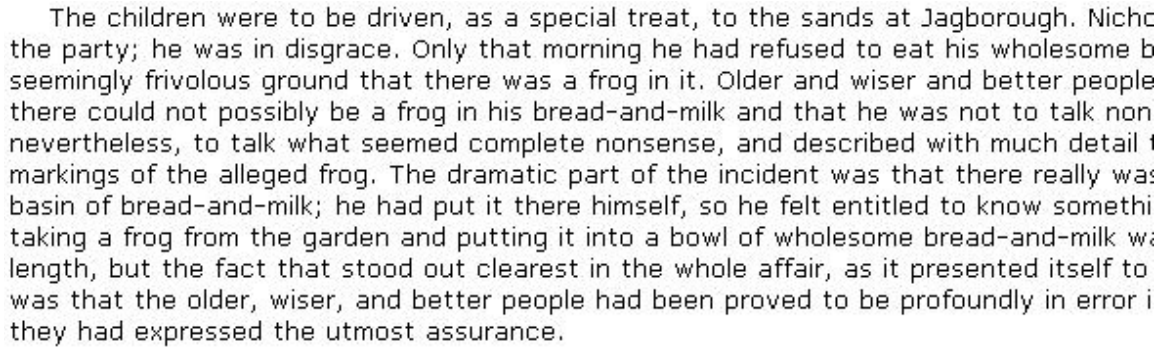

Figure 4. One-Column Left-Justified Condition

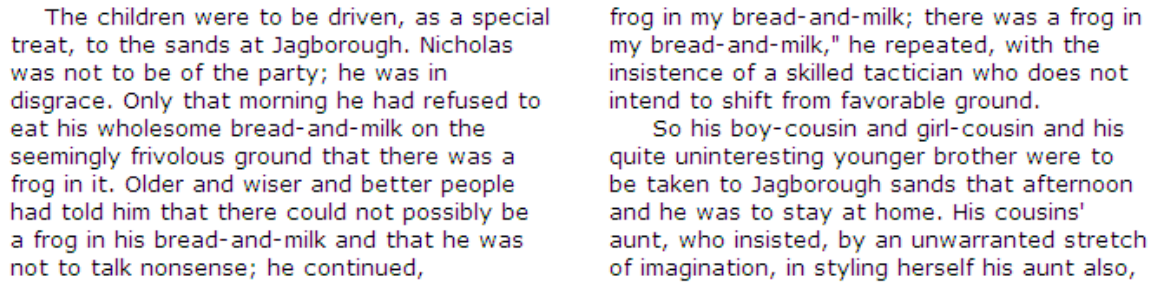

Figure 5. Two-Column Left-Justified Condition

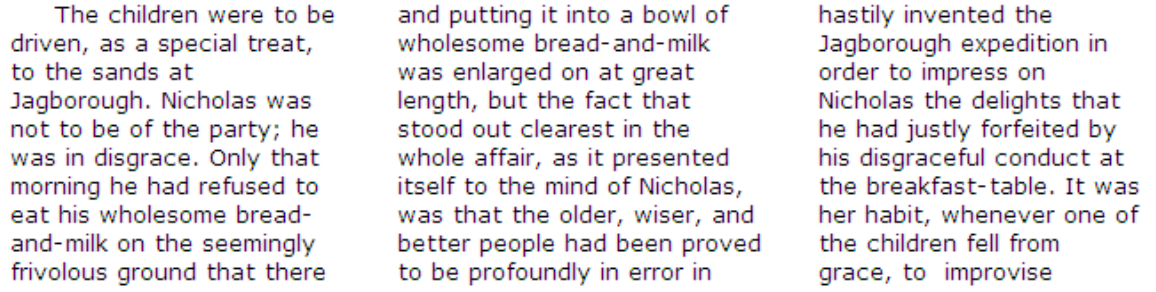

Figure 6. Three-Column Left-Justified Condition

Passages were presented on Dell Dimension 4600C desktop with a 17” display running 1024 x 768 screen resolution. Each of the passages was presented on six consecutive pages; users clicked on an arrow at the bottom of each page to advance to a subsequent page

or return to a previous page. No scrolling was required. Users read the passages at a distance of approximately 60 cm. Passages were displayed in 10pt Verdana font.

Four questionnaires were used to gather participant background information, comprehension of the texts, and satisfaction for each of the passage layouts (See Appendices A - D).

Procedure

The design of this study was a 2 x 3 randomized block design with matched subjects. Column format (single, 2-column, and 3-column) and Justification (Full, Left) were the independent variables.

Participants were matched on reading speed using a modified online version of the one-minute Comprehension portion of the Nelson-Denny Reading Test Form F. Participants read the passage for one minute. The number of the line each participant was reading at the end of one minute was recorded. This number is an approximation of the reading speed of the reader. That line number was then used to match subjects with similar reading times to the six layouts, with eleven participants in each condition (see Table 1). A one-way ANOVA confirmed that there were no differences in Nelson-Denny reading speed between any of the groups ($F(5,60)= 0.006$, $p = 1.000$).

Participants were then asked to read a short story, taking approximately 15 minutes to complete, displayed in one of the six different column conditions (one, two, or three columns, in either a Full or Left-justified format). After reading the story, participants answered sixteen comprehension questions (fifteen multiple-choice and one recall question with ten units) about the story, modeled after those used by Dyson and Haselgrove (2001). The multiple-choice questions included one title question, one main idea question, three main

factual questions, four structural questions, and six incidental questions. Participants then completed a nine-item questionnaire (with a 1 to 7 range) regarding their reading satisfaction regarding the layout of the passage they read.

Table 1
Matched-subject reading speed using Nelson-Denny Reading Test Form F

	Full-Justified One-Column	Full-Justified Two-Columns	Full-Justified Three-Columns	Left-Justified One-Column	Left-Justified Two-Columns	Left-Justified Three-Columns
Group #1	184	184	172	184	184	184
Group #2	195	195	195	195	195	195
Group #3	209	209	209	209	209	209
Group #4	215	215	215	215	215	215
Group #5	215	215	215	215	215	215
Group #6	220	220	220	220	220	220
Group #7	232	232	232	232	232	232
Group #8	247	247	247	247	247	247
Group #9	262	262	262	262	262	262
Group #10	276	288	276	288	288	276
Group #11	314	314	314	314	314	314

Dependent Variables

- *Reading speed*, measured by the amount of time taken to read each story (converted to words per minute);
- *Reading comprehension*, measured by the number of questions about each passage answered correctly, as well as the type of questions answered correctly;
- *Reading efficiency*, measured by multiplying words per minute by the percentage correct on overall comprehension;
- *Satisfaction*, measured by participant response to a satisfaction questionnaire.

Results

A 2 x 3 randomized block ANOVA was used to evaluate *reading speed, reading comprehension, reading efficiency* and *reading satisfaction.*

Reading Speed and Reading Efficiency

Because the assumption for homogeneity of variance was not met, a reciprocal transformation was performed on reading speed data. A 2x3 randomized block ANOVA found no significant main effects for either justification, $F(1,10) = 1.816$, $p = .207$ or number of columns, $F(2,20) = 1.787$, $p = .193$ for reading speed. A significant interaction for justification x number of columns was found, $F(2,20) = 3.812$, $p = .040$. $\eta^2 = .276$, $1 - \beta = .624$ (see Table 2).

Post-hoc Tukey's HSD comparisons showed that reading speed was significantly faster for *two-column full-justified* (M=269.33) than for *one-column full-justified*, (M=224.31), and significantly faster for *one-column left-justified* (M=266.43) than for *one-column full-justified* (M=224.31), or *three-column full-justified* (M=227.60) (see Figure 7).

Table 2
Reading Speed Means and Standard Deviations

	Columns		
	One	Two	Three
Full Justification	224.31 (39.76)	269.33 (61.43)	227.60 (41.77)
Left Justification	266.44 (40.52)	242.87 (35.14)	246.29 (70.31)

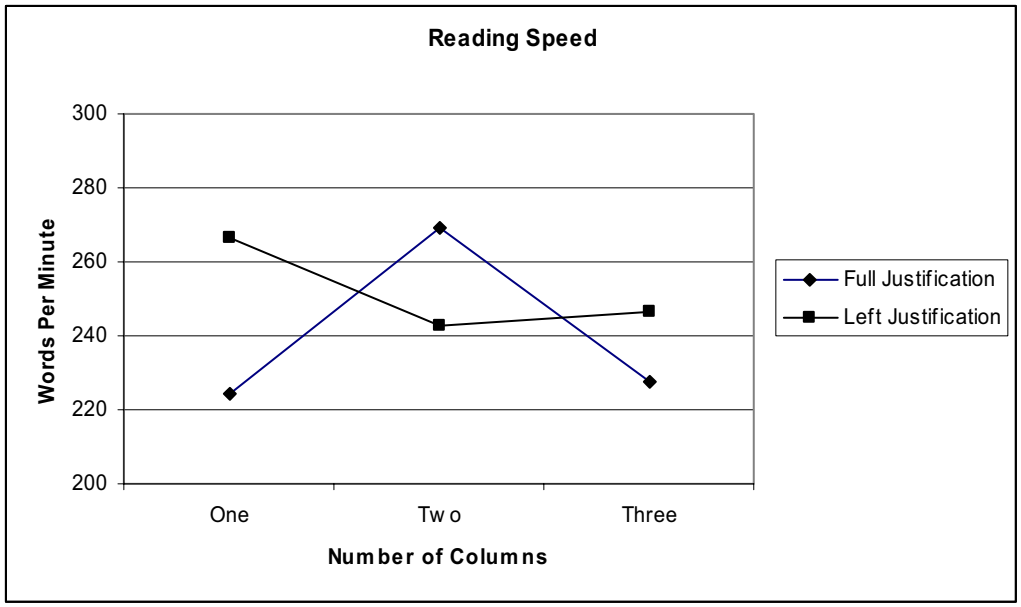

Figure 7. Participant Reading Speed

Because the assumption of homogeneity of variance was not met, a reciprocal transformation was performed on reading efficiency data. A 2x3 randomized block ANOVA found no significant main effects for either justification, $F(1,10) = 1.103$, $p = .727$ or number of columns, $F(2,20) = 1.815$, $p = .477$ for reading efficiency. An interaction approaching significance for justification x number of columns was found, $F(2,20) = 3.124$, $p = .066$. $\eta^2 = .238$, $1 - \beta = .534$ (see Table 3).

Post-hoc Tukey's HSD comparisons showed higher reading efficiency for *two-column full-justified* (M=196.26) than for *three-column full-justified* (M=151.18), or *two-column left-justified* (M=154.47), and higher reading efficiency for *one-column left-justified* (M=191.65) than for *two-column left-justified* (M=154.47) (see Figure 8).

Table 3
Reading Efficiency Means and Standard Deviations

	Columns		
	One	Two	Three
Full Justification	169.53 (28.87)	196.26 (78.80)	151.18 (48.62)
Left Justification	191.65 (61.79)	154.47 (50.70)	166.61 (64.61)

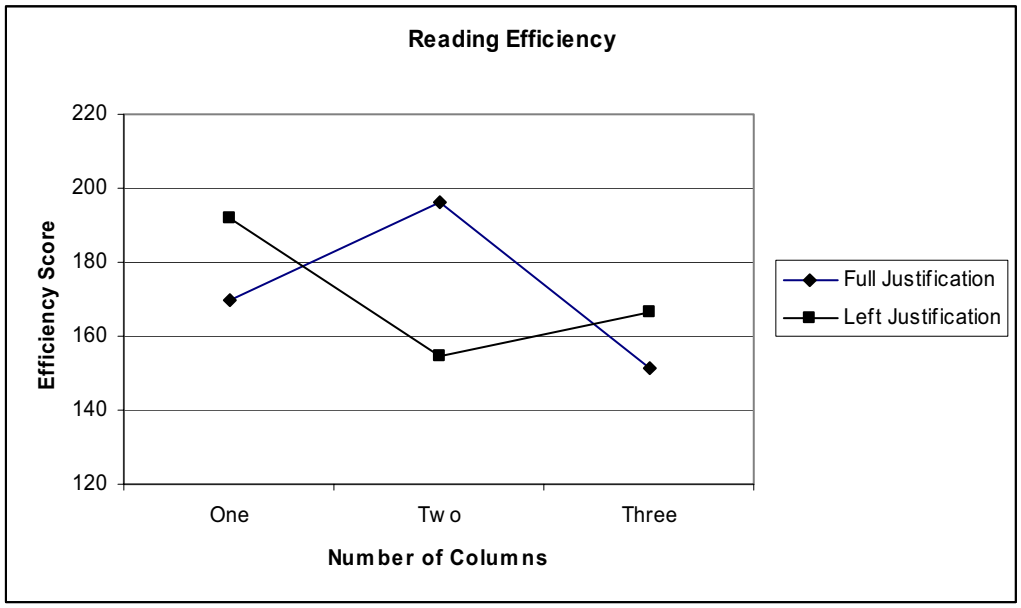

Figure 8. Participant Reading Efficiency Score

Reading Comprehension

Comprehension scores were calculated by dividing the number of questions answered correctly for each type by the total number of questions for each type. The means and standard deviations for each of the question types are displayed in Table 4.

Table 4. Comprehension Means and Standard Deviations for All Question Types

	One-Column Full-Justified	Two-Column Full-Justified	Three-Column Full-Justified	One-Column Left-Justified	Two-Column Left-Justified	Three-Column Left-Justified
Total	4.64 (0.92)	4.25 (0.90)	3.99 (1.01)	4.28 (1.17)	3.77 (0.95)	4.14 (1.08)
Title	0.91 (0.30)	0.73 (0.47)	0.64 (0.50)	0.73 (0.47)	0.45 (0.52)	0.64 (0.50)
Main Idea	0.36 (0.50)	0.36 (0.50)	0.55 (0.52)	0.18 (0.44)	0.55 (0.52)	0.36 (0.50)
Main Factual	0.79 (0.50)	0.77 (0.08)	0.77 (0.18)	0.82 (0.12)	0.86 (0.13)	0.75 (0.25)
Structural	0.78 (0.27)	0.84 (0.23)	0.75 (0.21)	0.66 (0.36)	0.66 (0.33)	0.81 (0.23)
Incidental	0.81 (0.34)	0.79 (0.18)	0.75 (0.17)	0.77 (0.20)	0.78 (0.24)	0.75 (0.24)
Recognition	0.79 (0.11)	0.75 (0.16)	0.72 (0.11)	0.75 (0.14)	0.83 (0.08)	0.83 (0.16)

A 2x3 randomized block ANOVA found no significant main effects for either justification, $F(1,10) = 1.003$, $p = .450$, number of columns, $F(2,20) = 1.089$, $p = .356$ or for a justification x column interaction, $F(2,20) = 1.101$, $p = .398$ (see Table 5) for total comprehension.

Table 5
Total Comprehension Means and Standard Deviations

	Columns		
	One	Two	Three
Full Justification	4.64 (0.92)	4.25 (0.90)	3.99 (1.01)
Left Justification	4.28 (1.17)	3.77 (0.95)	4.14 (1.08)

A 2x3 randomized block ANOVA found no significant main effects for either justification, $F(1,10) = 2.119$, $p = .176$, number of columns, $F(2,20) = 1.458$, $p = .256$ or for a justification x column interaction, $F(2,20) = 0.515$, $p = .605$ (see Table 6) for title comprehension.

Table 6
Title Comprehension Means and Standard Deviations

	Columns		
	One	Two	Three
Full Justification	0.91 (0.30)	0.73 (0.47)	0.64 (0.50)
Left Justification	0.73 (0.47)	0.45 (0.52)	0.64 (0.50)

A 2x3 randomized block ANOVA found no significant main effects for either justification, $F(1,10) = 1.036$, $p = .506$, number of columns, $F(2,20) = 1.129$, $p = .306$ or for a justification x column interaction, $F(2,20) = 1.112$, $p = .391$ (see Table 7) for main idea comprehension.

Table 7
Main Idea Comprehension Means and Standard Deviations

	Columns		
	One	Two	Three
Full Justification	0.36 (0.50)	0.36 (0.50)	0.55 (0.52)
Left Justification	0.18 (0.44)	0.55 (0.52)	0.36 (0.50)

A 2x3 randomized block ANOVA found no significant main effects for either justification, $F(1,10) = 1.204$, $p = .561$, or number of columns, $F(2,20) = 1.361$, $p = .297$ or for a justification x column interaction, $F(2,20) = 1.673$, $p = .118$ (See Table 8) for main factual comprehension.

Table 8
Main Factual Comprehension Means and Standard Deviations

	Columns		
	One	Two	Three
Full Justification	0.79 (0.15)	0.77 (0.08)	0.77 (0.18)
Left Justification	0.82 (0.12)	0.86 (0.13)	0.75 (0.25)

A 2x3 randomized block ANOVA found no significant main effects for either justification, $F(1,10) = 1.208$, $p = .560$, or number of columns, $F(2,20) = 1.204$, $p = .763$ or for a justification x column interaction, $F(2,20) = 1.554$, $p = .213$ (See Table 9) for structural comprehension.

Table 9
Structural Comprehension Means and Standard Deviations

	Columns		
	One	Two	Three
Full Justification	0.78 (0.27)	0.84 (0.23)	0.75 (0.21)
Left Justification	0.66 (0.36)	0.66 (0.33)	0.81 (0.23)

A 2x3 randomized block ANOVA found no significant main effects for either justification, $F(1,10) = 1.113$, $p = .701$, or number of columns, $F(2,20) = 1.191$, $p = .640$ or for a justification x column interaction, $F(2,20) = 1.073$, $p = .721$ (See Table 10) for incidental comprehension.

Table 10
Incidental Comprehension Means and Standard Deviations

	Columns		
	One	Two	Three
Full Justification	0.81 (0.34)	0.79 (0.18)	0.75 (0.17)
Left Justification	0.77 (0.20)	0.78 (0.24)	0.75 (0.24)

A 2x3 randomized block ANOVA found no significant main effects for either justification, $F(1,10) = 2.041$, $p = .184$, or number of columns, $F(2,20) = 1.154$, $p = .864$ or for a justification x column interaction, $F(2,20) = 2.730$, $p = .090$ (See Table 11) for recognition comprehension.

Table 11
Recognition Comprehension Means and Standard Deviations

	Columns		
	One	Two	Three
Full Justification	0.79 (0.11)	0.75 (0.16)	0.72 (0.11)
Left Justification	0.75 (0.14)	0.83 (0.08)	0.83 (0.16)

Satisfaction

A 2x3 randomized block ANOVA found no significant main effects for either justification, $F(1,10) = 1.951$, $p = .193$ or number of columns, $F(2,20) = 1.304$, $p = .524$ for the statement "I found the passage easy to read". An interaction approaching significance for justification x number of columns was found, $F(2,20) = 2.967$, $p = .074$. $\eta^2 = .229$, $1 - \beta = .512$ (see Table 12).

Post-hoc Tukey's HSD comparisons showed greater satisfaction for *two-column full-justified* (M=6.09) than for *one-column left-justified* (M=5.09), or for *two-column left-justified* (M=4.82) (see Figure 9).

Table 12
Means and Standard Deviations for Satisfaction Question "I found the passage easy to read."

	Columns		
	One	Two	Three
Full Justification	5.09 (1.76)	6.09 (0.94)	5.73 (1.01)
Left Justification	5.09 (1.45)	4.82 (1.25)	5.27 (1.74)

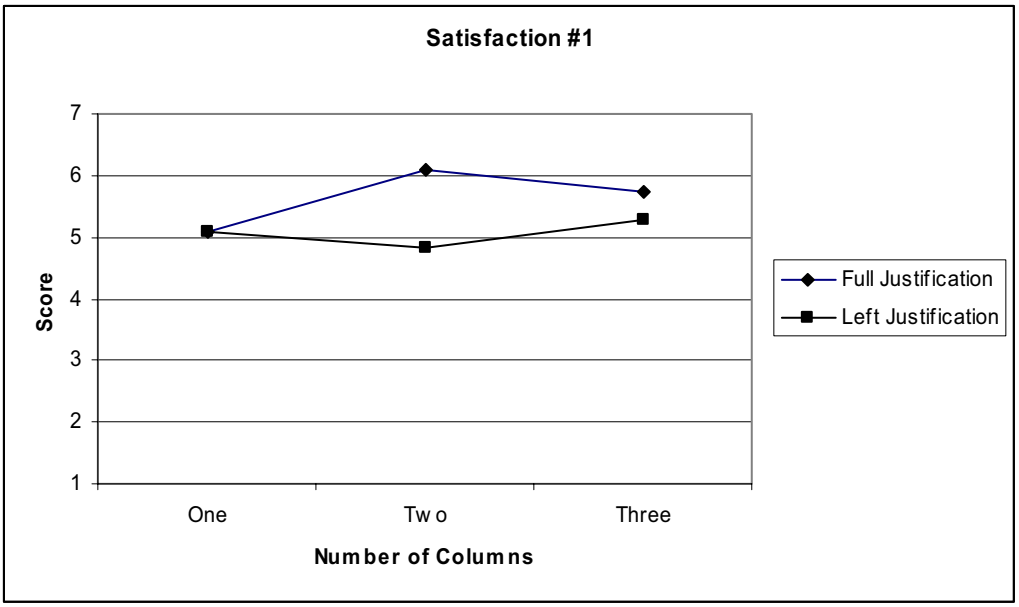

Figure 9. Satisfaction for "I found the passage easy to read."

A 2x3 randomized block ANOVA found no significant main effects for either justification, $\underline{F}(1,10) = 1.294$, $\underline{p} = .573$ or number of columns, $\underline{F}(2,20) = 1.589$, $\underline{p} = .229$ for the statement "I was able to concentrate on the passage". A significant interaction for justification x number of columns was found, $\underline{F}(2,20) = 5.123$, $\underline{p} = .016$. $\eta^2 = .339$, $1 - \beta = .760$ (see Table 13).

Post-hoc Tukey's HSD comparisons showed greater satisfaction for *two-column full-justified* (M=6.36) than for *one-column full-justified* (M=4.82), *three-column full-justified* (M=5.18), *one-column left-justified* (M=5.27), or *two-column left-justified* (M=5.09) (see Figure 10).

Table 13
Means and Standard Deviations for Satisfaction Question "I was able to concentrate on the passage."

	Columns		
	One	Two	Three
Full Justification	4.82 (1.33)	6.36 (0.81)	5.18 (1.47)
Left Justification	5.27 (1.56)	5.09 (1.14)	5.36 (1.43)

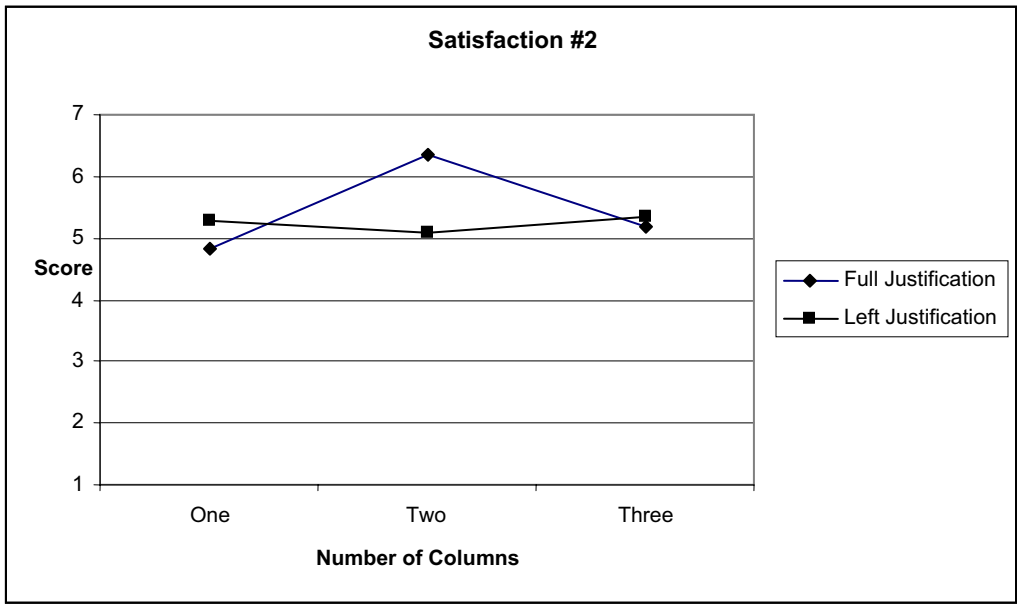

Figure 10. Satisfaction for "I was able to concentrate on the passage."

A 2x3 randomized block ANOVA found no significant main effects for either justification, $F(1,10) = 1.234$, $p = .624$, or number of columns, $F(2,20) = 1.113$, $p = .785$ or for a justification x column interaction, $F(2,20) = 1.243$, $p = .789$ (see Table 14) for the statement "Physically, how do you feel after reading this passage?".

Table 14
Means and Standard Deviations for Satisfaction Question "Physically, how do you feel after reading this passage?"

	Columns		
	One	Two	Three
Full Justification	4.55 (1.04)	5.09 (1.22)	5.09 (1.14)
Left Justification	4.64 (0.81)	4.73 (1.27)	4.91 (1.45)

A 2x3 randomized block ANOVA found no significant main effects for either justification, $F(1,10) = 1.678$, $p = .224$ or number of columns, $F(2,20) = 1.847$, $p = .184$ for the statement "Mentally, how did you feel while reading this passage?". An interaction

approaching significance was found for justification x number of columns, $\underline{F}(2,20) = 3.452$, $\underline{p} = .052$. $\eta^2 = .257$, $1 - \beta = .579$ (see Table 154).

Post-hoc Tukey's HSD comparisons showed greater satisfaction for *two-column full-justified* (M=6.27) than for *one-column full-justified* (M=4.45), *one-column left-justified* (M=5.09), or for *two-column left-justified* (M=4.91) (see Figure 11).

Table 15
Means and Standard Deviations for Satisfaction Question "Mentally, how did you feel while reading this passage?"

	Columns		
	One	Two	Three
Full Justification	4.45 (1.21)	6.27 (1.01)	5.55 (1.21)
Left Justification	5.09 (1.58)	4.91 (1.22)	5.00 (1.79)

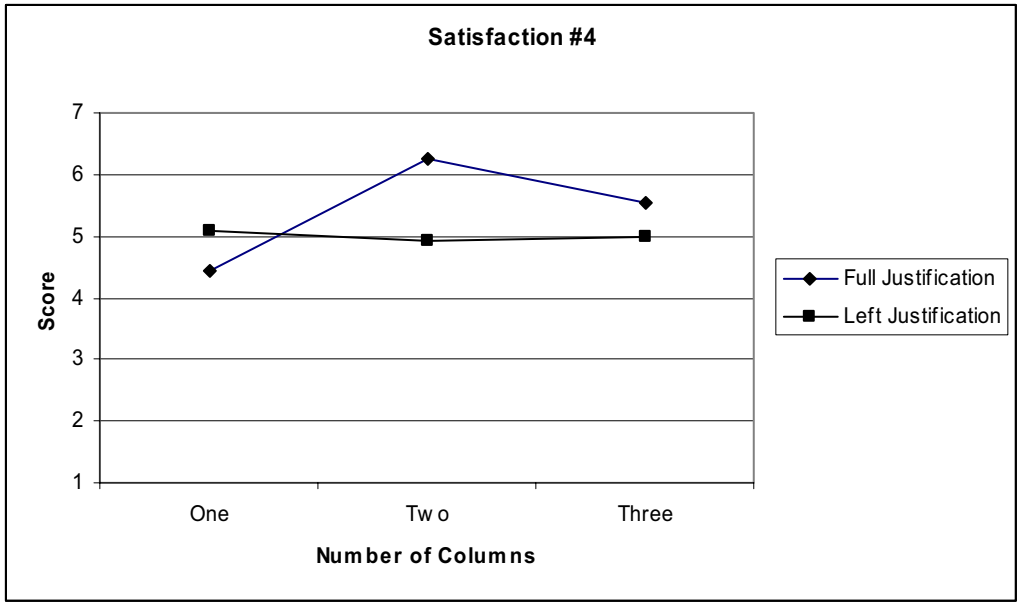

Figure 11. Satisfaction for "Mentally, how did you feel while reading this passage?"

A 2x3 randomized block ANOVA found no significant main effects for justification, $\underline{F}(1,10) = 1.448$, $\underline{p} = .224$ for the statement "I am confident that I comprehended all the relevant information." A main effect approaching significance was found for number of

columns, $\underline{F}(2,20) = 3.033$, $\underline{p} = .071$. $\eta^2 = .223$, $1 - \beta = .522$. No significant interaction for justification x number of columns was found, $\underline{F}(2,20) = 1.534$, $\underline{p} = .420$ (see Table 16).

Post-hoc Tukey's HSD comparisons showed higher satisfaction for *two-column full-justified* (M=5.81) than for *one-column full-justified* (M=4.64) (see Figure 12).

Table 16
Means and Standard Deviations for Satisfaction Question "I am confident that I comprehended all the relevant information."

	Columns		
	One	Two	Three
Full Justification	4.64 (1.12)	5.82 (1.17)	5.45 (1.51)
Left Justification	4.55 (1.51)	5.00 (1.48)	5.45 (1.29)

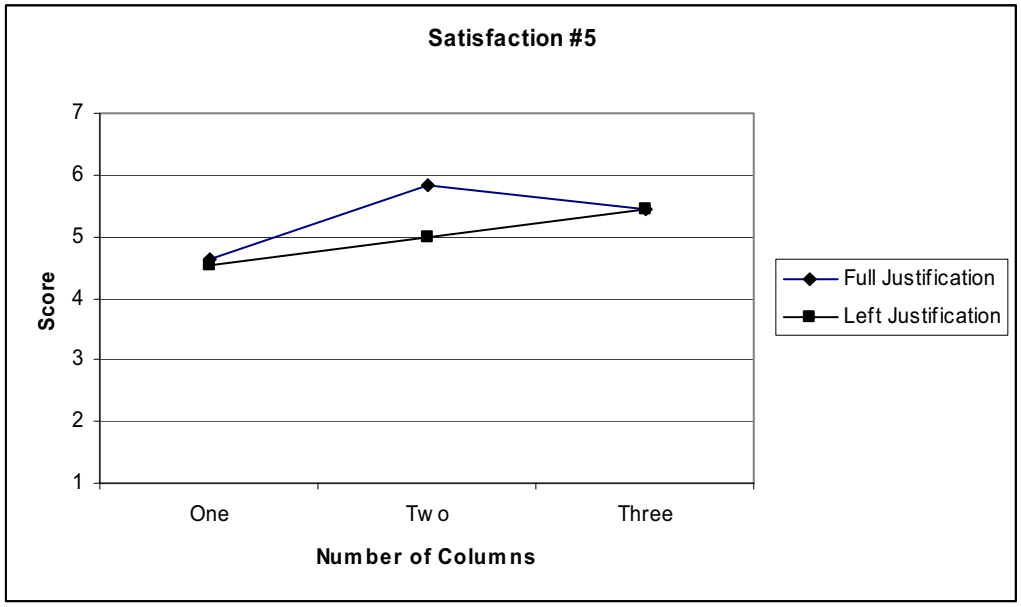

Figure 12. Satisfaction for "I am confident that I comprehended all the relevant information."

A 2x3 randomized block ANOVA found no significant main effects for either justification, $\underline{F}(1,10) = 1.103$, $\underline{p} = .602$, or number of columns, $\underline{F}(2,20) = 1.014$, $\underline{p} = .747$ or for a justification x column interaction, $\underline{F}(2,20) = 1.289$, $\underline{p} = .752$ (see Table 17) for the statement "How would you rate the level of eyestrain while reading this passage?".

Table 17
Means and Standard Deviations for Satisfaction Question "How would you rate the level of eyestrain while reading this passage?"

	Columns		
	One	Two	Three
Full Justification	4.73 (1.79)	5.64 (1.63)	5.27 (1.49)
Left Justification	5.00 (1.55)	5.18 (1.60)	4.73 (1.95)

A 2x3 randomized block ANOVA found no significant main effects for either justification, $F(1,10) = 1.202$, $p = .734$, or number of columns, $F(2,20) = 1.117$, $p = .756$ or for a justification x column interaction, $F(2,20) = 1.068$, $p = .804$ (see Table 18) for the statement "I would like to read college textbook material presented in this type of format.".

Table 18
Means and Standard Deviations for Satisfaction Question "I would like to read college textbook material presented in this type of format."

	Columns		
	One	Two	Three
Full Justification	3.82 (1.47)	5.00 (1.41)	3.73 (2.05)
Left Justification	3.64 (1.50)	3.82 (1.94)	4.55 (2.07)

A 2x3 randomized block ANOVA found no significant main effects for either justification, $F(1,10) = 1.197$, $p = .300$, or number of columns, $F(2,20) = 1.223$, $p = .315$ or for a justification x column interaction, $F(2,20) = 2.569$, $p = .102$ (see Table 19) for the statement "I would like to read leisure material presented in this type of format."

Table 19
Means and Standard Deviations for Satisfaction Question "I would like to read leisure material presented in this type of format."

	Columns		
	One	Two	Three
Full Justification	4.36 (1.43)	5.55 (1.04)	4.00 (1.95)
Left Justification	4.82 (1.17)	3.55 (2.21)	3.82 (2.60)

A 2x3 randomized block ANOVA found no significant main effects for either justification, $F(1,10) = 1.204$, $p = .753$, or number of columns, $F(2,20) = 1.604$, $p = .653$ or for a justification x column interaction, $F(2,20) = 1.947$, $p = .118$ (see Table 20) for the statement "I would like to read newspaper or magazine articles presented in this type of format."

Table 20
Means and Standard Deviations for Satisfaction Question "I would like to read newspaper or magazine articles presented in this type of format."

	Columns		
	One	Two	Three
Full Justification	3.91 (1.64)	4.82 (1.47)	4.55 (1.86)
Left Justification	4.00 (1.41)	3.82 (2.18)	5.00 (2.32)

A 2x3 randomized block ANOVA found no significant main effects for either justification, $F(1,10) = 1.302$, $p = .334$, or number of columns, $F(2,20) = 1.721$, $p = .204$ or for a justification x column interaction, $F(2,20) = 1.821$, $p = .118$ (see Table 21) for total satisfaction.

Table 21
Means and Standard Deviations for Satisfaction Total

	Columns		
	One	Two	Three
Full Justification	40.36 (7.29)	50.64 (6.55)	44.55 (10.84)
Left Justification	42.09 (8.71)	40.91 (9.70)	44.09 (14.20)

Examination of Fast versus Slow Readers

Originally, reading speed was not considered as an independent variable in this study. Dyson & Kipping (1997) propose that fast and slow readers use different reading strategies that may impact comprehension. They suggest that faster readers are able to scan narrow columns more efficiently and increase their comprehension. Based on this proposal, the five fastest groups of readers (N=5) in this study were compared to the five slowest groups of readers (N=5), with the middle reading speed group (Group #6, see Table 1.) removed. Reading speed, reading comprehension, reading efficiency, and reading satisfaction were then analyzed using a 2 x 2 x 3 split-plot ANOVA.

Reading Speed and Reading Efficiency

Because the assumption of homogeneity of variance was not met, a reciprocal transformation was performed on reading speed data. A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction for justification x speed, $F(1,8) = 1.543$, $p = .528$, column x speed, $F(2,16) = 1.945$, $p = .145$, or justification x column x speed, $F(2,16) = 1.880$, $p = .185$ for participant reading speed. A main effect approaching significance was found for speed, $F(1,8) = 4.486$, $p = .067$, $\eta^2 = .359$, $1 - \beta = .462$ (see Table 22).

Post hoc Tukey's HSD comparisons showed faster reading speed for *fast readers* than for *slow readers* (see Figure 13).

Table 22
Reading Speed Means and Standard Deviations for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	247.59 (48.75)	322.31 (45.74)	233.92 (51.36)
Full Justification (slow)	201.51 (15.73)	233.31 (20.42)	234.64 (22.33)
Left Justification (fast)	288.91 (43.71)	255.54 (34.42)	264.16 (66.29)
Left Justification (slow)	245.04 (31.35)	234.88 (38.54)	241.71 (80.22)

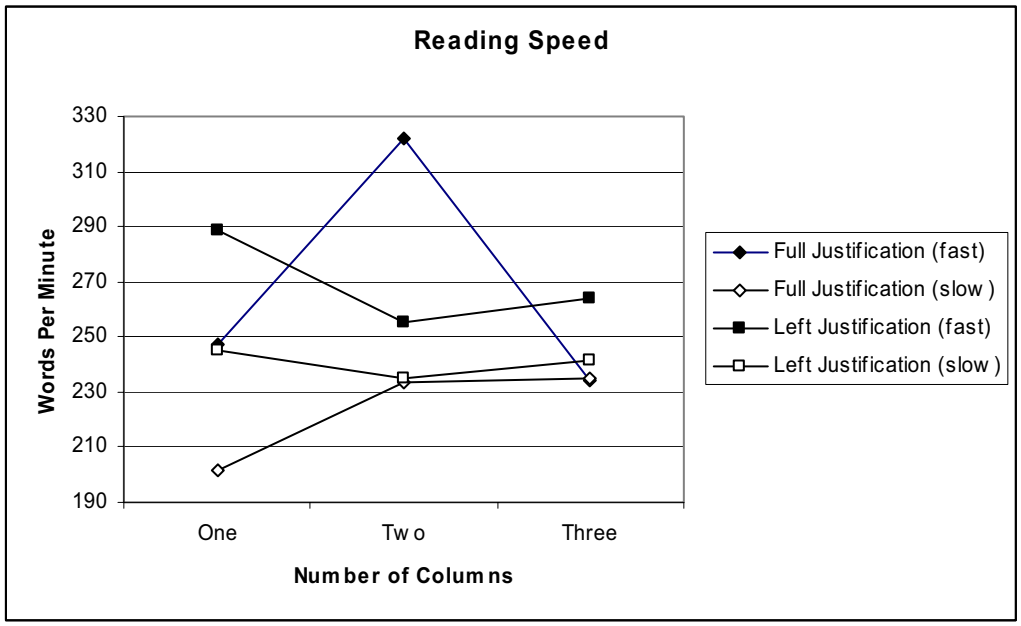

Figure 13. Average Reading Speed for Fast and Slow Readers

Because the assumption of homogeneity of variance was not met, a reciprocal transformation was performed on efficiency data. A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction for justification x speed, $F(1,8) = 1.673$, $p = .626$ or column x speed, $F(2,16) = 1.552$, $p = .360$ for reading efficiency. A significant interaction was found for justification x column x speed, $F(2,16) = 4.262$, $p = .033$, $\eta^2 = .348$, $1 - \beta = .658$. A significant main effect was found for speed, $F(1,8) = 8.620$, $p = .019$, $\eta^2 = .519$, $1 - \beta = .730$ (see Table 23).

Post-hoc Tukey's HSD comparisons showed higher reading efficiency for *fast readers* (M=198.69) than for *slow readers* (M=147.19). Higher reading efficiency was found for fast readers at the *two-column full-justified* condition (M=259.15) than for slow readers at the *one-column full-justified* condition (M=158.12), slow readers at the *one-column left justified* condition (M=147.56), slow readers at the *two-column full-justified* condition (M=152.91), slow readers at the *two-column left-justified* condition (M=124.26), slow readers at the *three-column full-justified* condition (M=148.90), and slow readers at the *three-column left-justified* condition (M=151.43).

Higher reading efficiency was found for fast-readers at the *one-column left-justified* condition (M=225.90) than for slow readers at the *one-column left-justified* condition (M=147.56), slow readers at the *two-column full-justified* condition (M=152.91), slow readers at the *two-column left-justified* condition (M=124.26), slow readers at the *three-column full-justified* condition (M=148.90), and slow readers at the *three-column left-justified* condition (M=151.43) (see Figure 14).

Table 23
Reading Efficiency Means and Standard Deviations for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	176.34 (34.70)	259.15 (65.42)	163.38 (55.18)
Full Justification (slow)	158.12 (22.98)	152.91 (39.58)	148.90 (45.35)
Left Justification (fast)	225.90 (12.95)	178.71 (44.19)	188.71 (92.37)
Left Justification (slow)	147.56 (69.83)	124.26 (48.73)	151.43 (26.56)

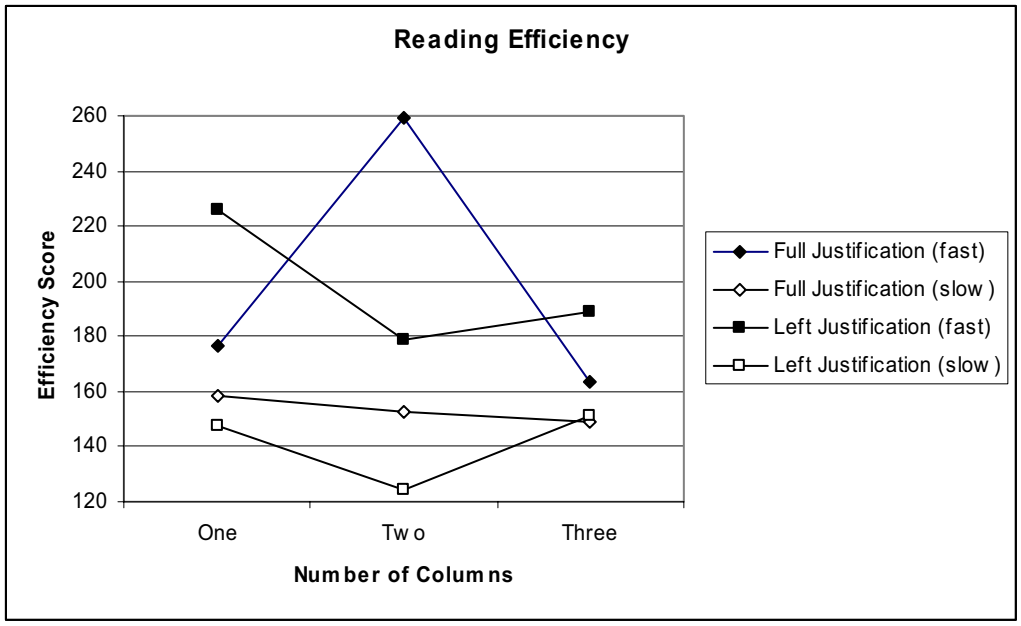

Figure 14. Average Reading Efficiency for Fast and Slow Readers

Reading Comprehension

A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction for justification x speed, $F(1,8) = 1.504$, $p = .454$, column x speed, $F(2,16) = 1.309$, $p = .677$, or justification x column x speed, $F(2,16) = 1.592$, $p = .319$ for total comprehension. A significant main effect for speed was found, $F(1,8) = 6.841$, $p = .031$, $\eta^2 = .461$, $1 - \beta = .631$ (see Table 24).

Post-hoc Tukey's HSD comparisons showed higher total comprehension for *fast readers* (M=4.42) than for *slow readers* (M=3.87) (see Figure 15).

Table 24
Total Comprehension Means and Standard Deviations for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	4.46 (1.32)	4.79 (0.75)	4.19 (0.93)
Full Justification (slow)	4.70 (0.48)	3.92 (0.84)	3.84 (1.26)
Left Justification (fast)	4.75 (0.52)	4.16 (0.69)	4.17 (1.07)
Left Justification (slow)	3.55 (1.34)	3.13 (0.81)	4.06 (1.33)

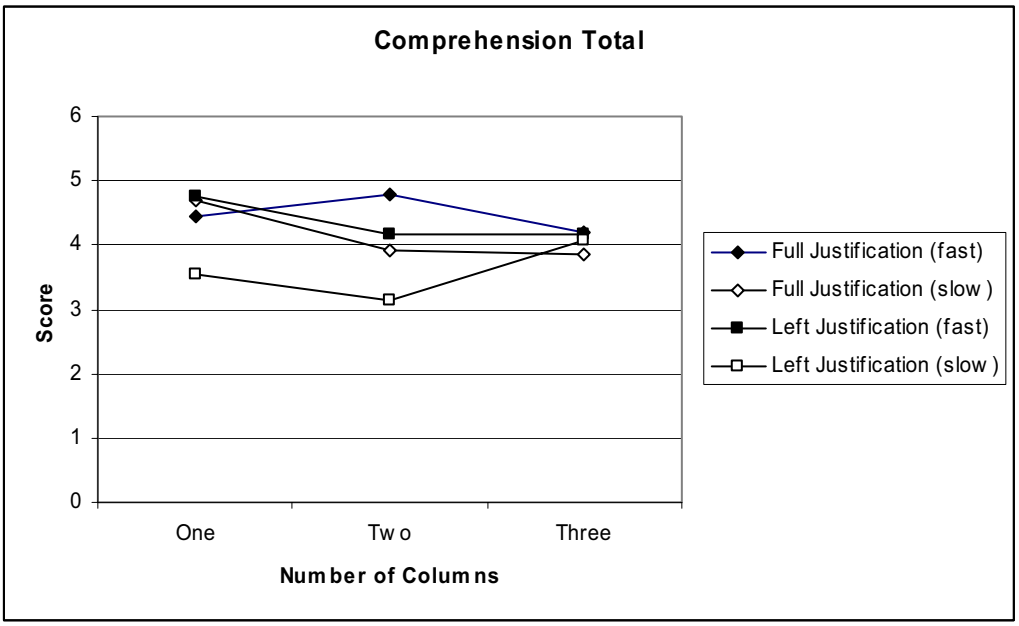

Figure 15. Average Total Comprehension for Fast and Slow Readers

A 2x3x3 mixed design ANOVA found no significant interaction for justification x speed, $F(1,8) = 1.882$, $p = .207$, column x speed, $F(2,16) = 1.252$, $p = .433$, or justification x column x speed, $F(2,16) = 1.209$, $p = .452$ for title comprehension. No main effect was found for speed $F(1,8) = 2.323$, $p = .166$ (see Table 25, Figure 16).

Table 25
Title Comprehension Means and Standard Deviations for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	0.83 (0.41)	0.83 (0.41)	0.67 (0.52)
Full Justification (slow)	1.00 (0.00)	0.60 (0.55)	0.60 (0.55)
Left Justification (fast)	1.00 (0.00)	0.67 (0.52)	0.67 (0.52)
Left Justification (slow)	0.40 (0.55)	0.20 (0.45)	0.60 (0.55)

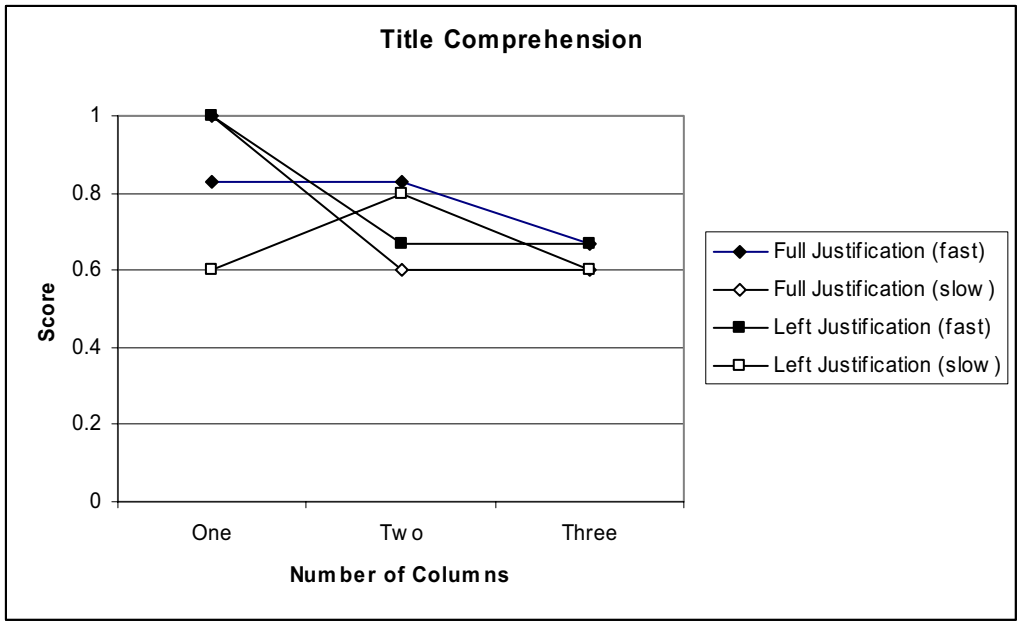

Figure 16. Title Comprehension for Fast and Slow Readers

A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction for justification x speed, $F(1,8) = 1.564$, $p = .203$, column x speed, $F(2,16) = 1.265$, $p = .603$, or justification x column x speed, $F(2,16) = 1.462$, $p = .375$ for main idea comprehension. No significant main effect was found for speed, $F(1,8) = 2.970$, $p = .123$ (see Table 26, Figure 17).

Table 26
Main Idea Comprehension Means and Standard Deviations for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	0.60 (0.55)	0.60 (0.55)	0.60 (0.55)
Full Justification (slow)	0.20 (0.45)	0.20 (0.45)	0.40 (0.55)
Left Justification (fast)	0.20 (0.45)	0.60 (0.55)	0.40 (0.55)
Left Justification (slow)	0.00 (0.00)	0.40 (0.55)	0.40 (0.55)

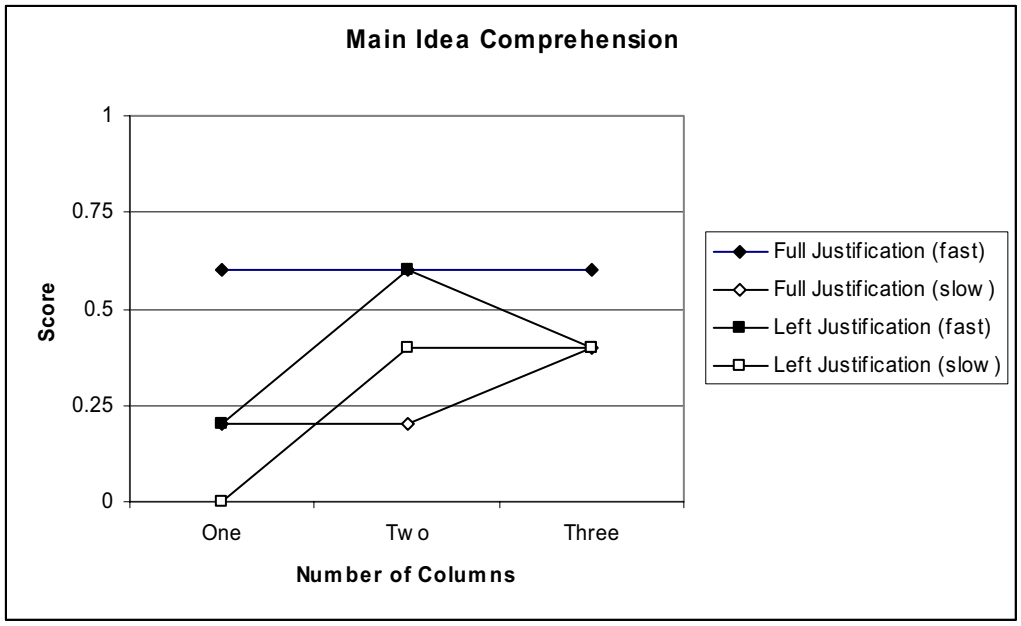

Figure 17. Main Idea Comprehension for Fast and Slow Readers

A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction for justification x speed, $F(1,8) = 1.138$, $p = .742$, column x speed, $F(2,16) = 1.813$, $p = .461$, or justification x column x speed, $F(2,16) = 1.806$, $p = .464$ for main factual comprehension. No main effect was found for speed, $F(1,8) = 1.100$, $p = .760$ (see Table 27, Figure 18).

Table 27
Main Factual Comprehension Means and Standard Deviations for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	0.80 (0.11)	0.75 (0.00)	0.80 (0.21)
Full Justification (slow)	0.80 (0.21)	0.80 (0.11)	0.80 (0.11)
Left Justification (fast)	0.75 (0.00)	0.90 (0.14)	0.80 (0.21)
Left Justification (slow)	0.90 (0.14)	0.85 (0.14)	0.70 (0.33)

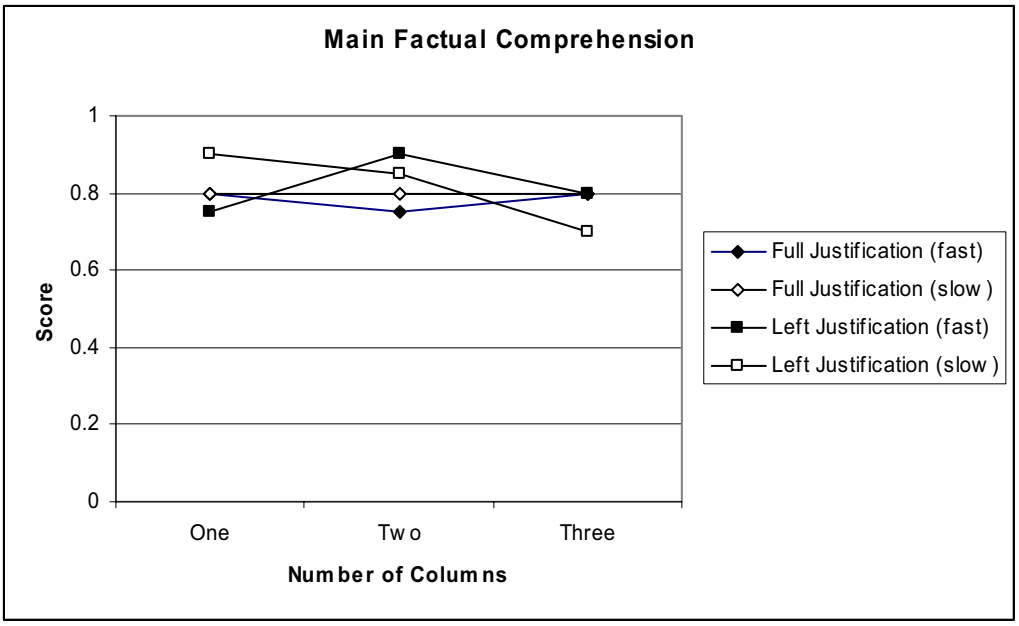

Figure 18. Main Factual Comprehension for Fast and Slow Readers

A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction for justification x speed, $F(1,8) = 3.470$, $p = .100$, column x speed, $F(2,16) = 1.134$, $p = .608$, or justification x column x speed, $F(2,16) = 1.357$, $p = .286$ for structural comprehension. No main effect was found for speed, $F(1,8) = 1.505$, $p = .634$ (see Table 28, Figure 19).

Table 28
Structural Comprehension Means and Standard Deviations for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	0.66 (0.33)	0.79 (0.29)	0.73 (0.28)
Full Justification (slow)	0.86 (0.18)	0.86 (0.18)	0.79 (0.18)
Left Justification (fast)	0.79 (0.18)	0.73 (0.43)	0.79 (0.18)
Left Justification (slow)	0.46 (0.44)	0.59 (0.28)	0.79 (0.29)

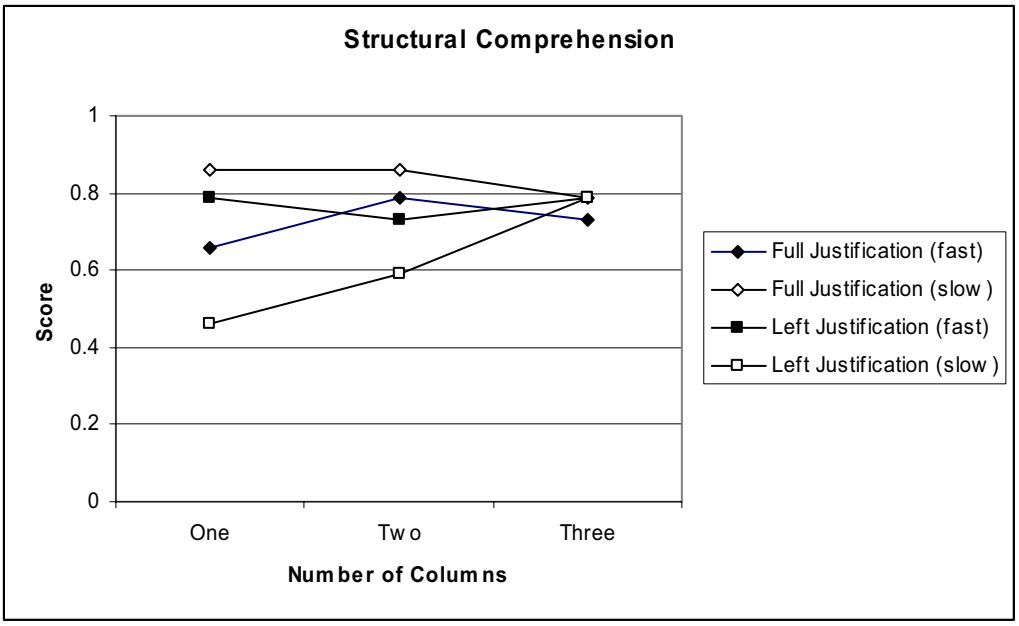

Figure 19. Structural Comprehension for Fast and Slow Readers

A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction for justification x speed, $F(1,8) = 1.557$, $p = .247$, column x speed, $F(2,16) = 1.533$, $p = .267$, or justification x column x speed, $F(2,16) = 1.303$, $p = .624$ for incidental comprehension. No significant main effect was found for speed $F(1,8) = 2.626$, $p = .144$ (see Table 29, Figure 20).

Table 29
Incidental Comprehension Means and Standard Deviations for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	0.79 (0.14)	0.86 (0.14)	0.76 (0.19)
Full Justification (slow)	0.86 (0.14)	0.76 (0.22)	0.73 (0.19)
Left Justification (fast)	0.83 (0.17)	0.89 (0.09)	0.79 (0.22)
Left Justification (slow)	0.66 (0.20)	0.66 (0.31)	0.73 (0.30)

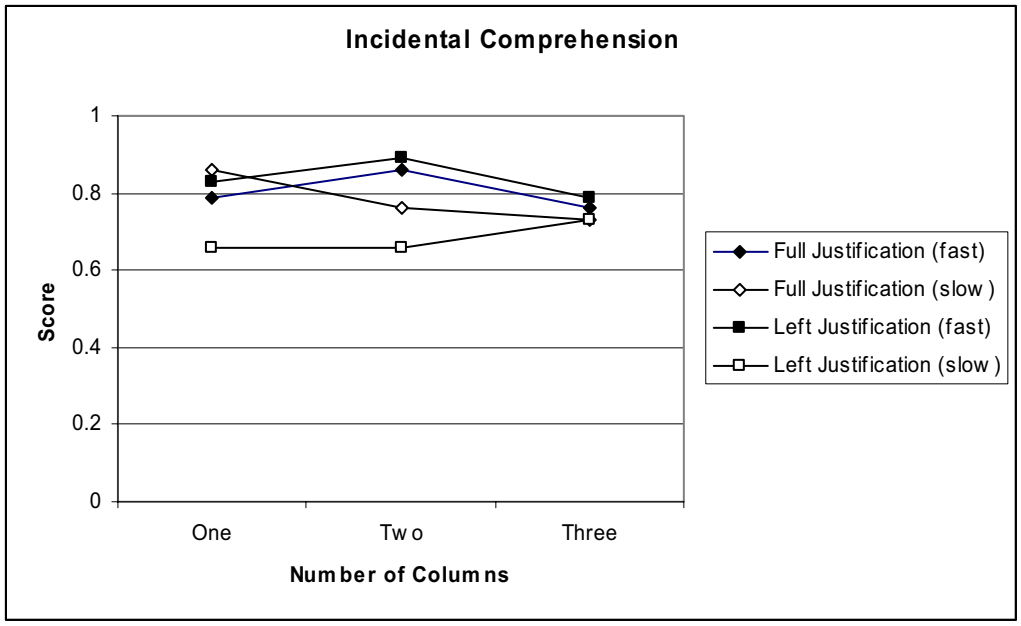

Figure 20. Incidental Comprehension for Fast and Slow Readers

A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction for justification x speed, $F(1,8) = 1.103$, $p = .627$, column x speed, $F(2,16) = 1.533$, $p = .587$, or justification x column x speed, $F(2,16) = 1.201$, $p = .648$ for recognition comprehension. No significant main effect was found for speed, $F(1,8) = 1.973$, $p = .487$ (see Table 30, Figure 21).

Table 30
Recognition Comprehension Means and Standard Deviations for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	0.80 (0.16)	0.78 (0.15)	0.70 (0.10)
Full Justification (slow)	0.78 (0.08)	0.70 (0.20)	0.72 (0.13)
Left Justification (fast)	0.78 (0.13)	0.84 (0.05)	0.78 (0.18)
Left Justification (slow)	0.72 (0.16)	0.82 (0.11)	0.84 (0.13)

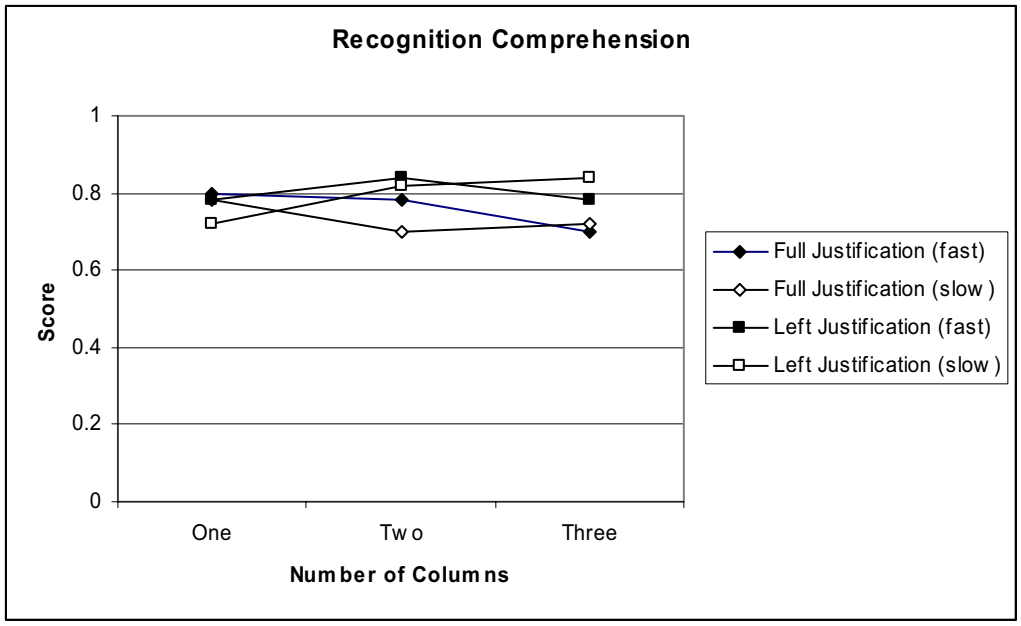

Figure 21. Recognition Comprehension for Fast and Slow Readers

Satisfaction

A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction for justification x speed, $F(1,8) = 1.678$, $p = .657$, column x speed, $F(2,16) = 1.442$, $p = .266$, or justification x column x speed, $F(2,16) = 1.594$, $p = .557$ for the statement "I found the passage easy to read". A significant main effect was found for speed, $F(1,8) = 7.577$, $p = .025$, $\eta^2 = .486$, $1 - \beta = .675$ (see Table 31).

Post-hoc Tukey's HSD comparisons showed higher satisfaction for *fast readers* (M=5.80) than for *slow readers* (M=4.83) (see Figure 22).

Table 31
Means and Standard Deviations for Satisfaction Question "I found the passage easy to read." for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	6.00 (0.71)	6.40 (0.55)	5.80 (1.09)
Full Justification (slow)	4.00 (2.12)	6.00 (1.22)	5.60 (1.14)
Left Justification (fast)	6.00 (1.22)	4.80 (1.09)	5.80 (0.45)
Left Justification (slow)	4.20 (1.30)	4.40 (1.14)	4.80 (2.59)

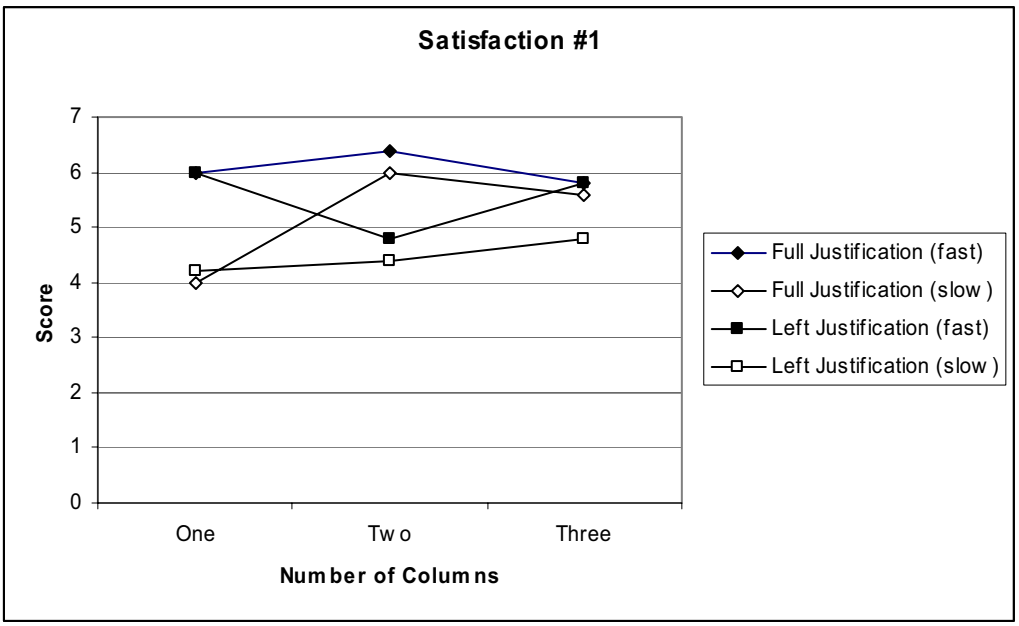

Figure 22. Satisfaction for "I found the passage easy to read" for Fast and Slow Readers

A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction for justification x speed, $F(1,8) = 1.686$, $p = .521$, column x speed, $F(2,16) = 2.648$, $p = .101$, or justification x column x speed, $F(2,16) = 1.672$, $p = .524$ for the statement "I was able to concentrate on the passage". No significant main effect was found for speed, $F(1,8) = 1.806$, $p = .216$ (see Table 32, Figure 23).

Table 32
Means and Standard Deviations for Satisfaction Question "I was able to concentrate on the passage." for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	5.40 (1.14)	6.60 (0.55)	4.80 (1.92)
Full Justification (slow)	4.20 (1.48)	6.40 (0.89)	5.40 (1.14)
Left Justification (fast)	6.20 (1.30)	5.00 (1.41)	5.60 (0.89)
Left Justification (slow)	4.20 (1.30)	5.00 (1.00)	5.00 (2.00)

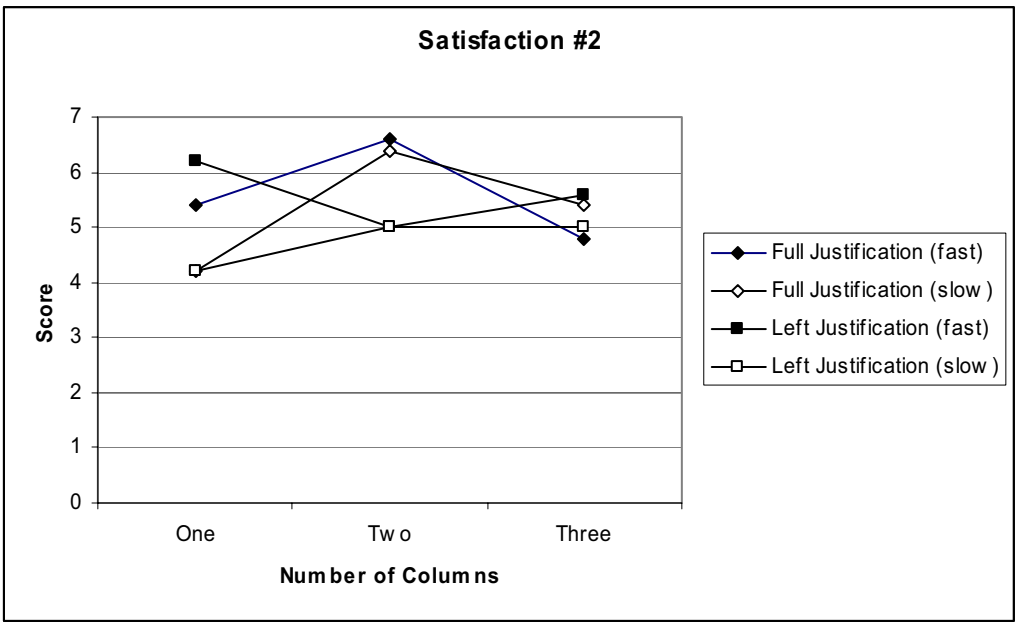

Figure 23. Satisfaction for "I was able to concentrate on the passage for Fast and Slow Readers

A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction for justification x speed, $F(1,8) = 1.274$, $p=.292$, or column x speed, $F(2,16) = 1.493$, $p = .254$ for the statement "Physically, how do you feel after reading this passage?". A significant interaction was found for justification x column x speed, $F(2,16) = 4.455$, $p = .029$, $\eta^2 = .358$, $1 - \beta = .679$. No significant main effect was found for speed, $F(1,8) = 1.010$, $p = .921$ (see Table 33).

Post-hoc Tukey's HSD comparisons showed satisfaction was higher for slow readers at the *three-column full-justified* condition (M=6.00) than for slow readers at the *one-column left-justified* condition (M=4.00) (see Figure 24).

Table 33
Means and Standard Deviations for Satisfaction Question "Physically, how do you feel after reading this passage?" for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	4.60 (0.89)	5.40 (1.34)	4.40 (0.89)
Full Justification (slow)	4.40 (1.34)	5.00 (1.22)	6.00 (0.71)
Left Justification (fast)	5.20 (0.84)	4.20 (1.09)	5.40 (0.55)
Left Justification (slow)	4.00 (0.00)	4.80 (1.09)	4.80 (1.92)

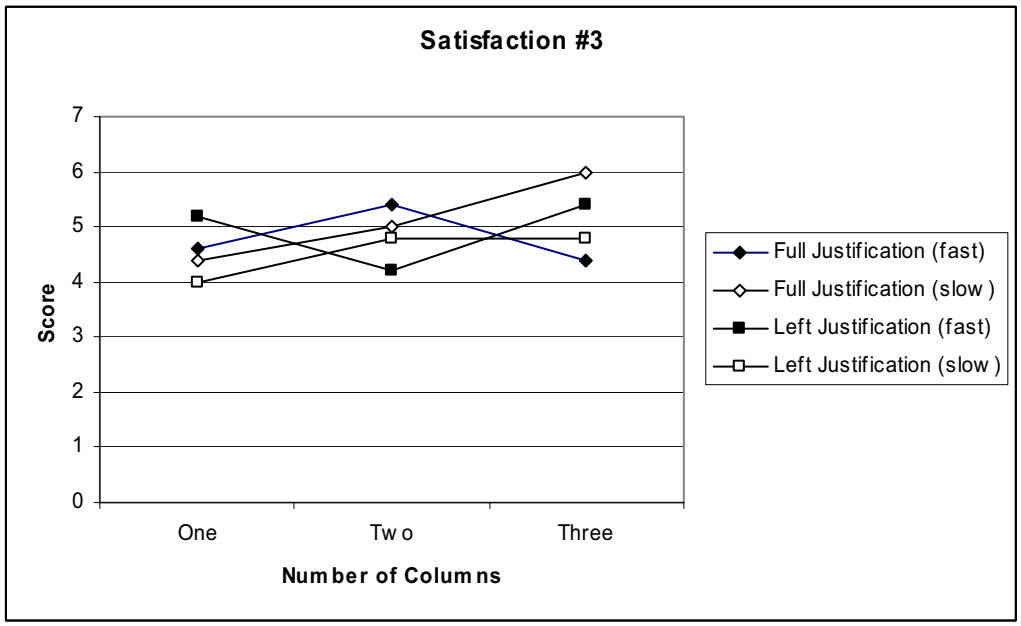

Figure 24. Satisfaction for "Physically, how do you feel after reading this passage?" for Fast and Slow Readers

A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction for justification x speed, $F(1,8) = 1.478$, $p = .551$, column x speed, $F(2,16) =$

1.895, p = .183, or justification x column x speed, $F(2,16) = 2.413$, p = .121 for the statement "Mentally, how did you feel while reading this passage?" No significant main effect was found for speed, $F(1,8) = 3.422$, p = .102 (see Table 34, Figure 25).

Table 34
Means and Standard Deviations for Satisfaction Question "Mentally, how did you feel while reading this passage?" for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	5.00 (1.00)	6.60 (0.55)	5.40 (0.89)
Full Justification (slow)	3.80 (1.30)	6.20 (1.30)	5.80 (1.64)
Left Justification (fast)	6.00 (1.22)	4.40 (1.52)	6.00 (1.22)
Left Justification (slow)	4.20 (1.64)	5.20 (0.84)	4.40 (1.95)

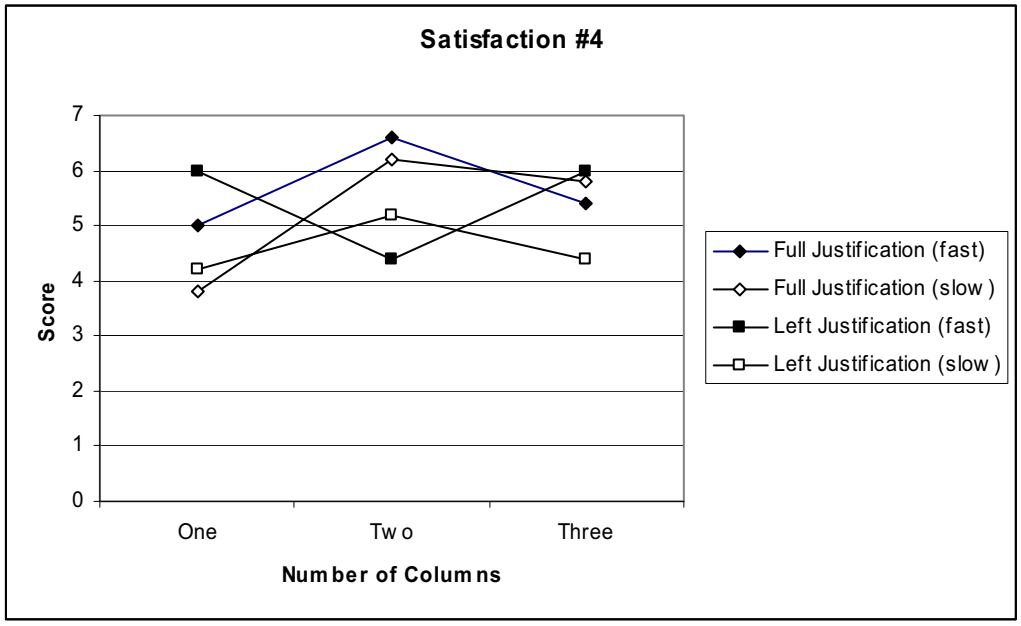

Figure 25. Satisfaction for "Mentally, how did you feel while reading this passage?" for Fast and Slow Readers

A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction for justification x speed, $F(1,8) = 1.040$, $p = .949$, column x speed, $F(2,16) = 1.197$, $p = .328$, or justification x column x speed, $F(2,16) = 1.232$, $p = .318$ for the statement "I am confident that I comprehended all the relevant information." No significant main effect was found for speed, $F(1,8) = 1.254$, $p = .674$ (see Table 35, Figure 26).

Table 35
Means and Standard Deviations for Satisfaction Question "I am confident that I comprehended all the relevant information." for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	4.80 (1.00)	6.00 (0.55)	5.40 (0.89)
Full Justification (slow)	4.40 (1.30)	5.80 (1.30)	5.80 (1.64)
Left Justification (fast)	5.20 (1.22)	4.20 (1.52)	5.60 (1.22)
Left Justification (slow)	4.00 (1.64)	5.40 (0.84)	5.20 (1.95)

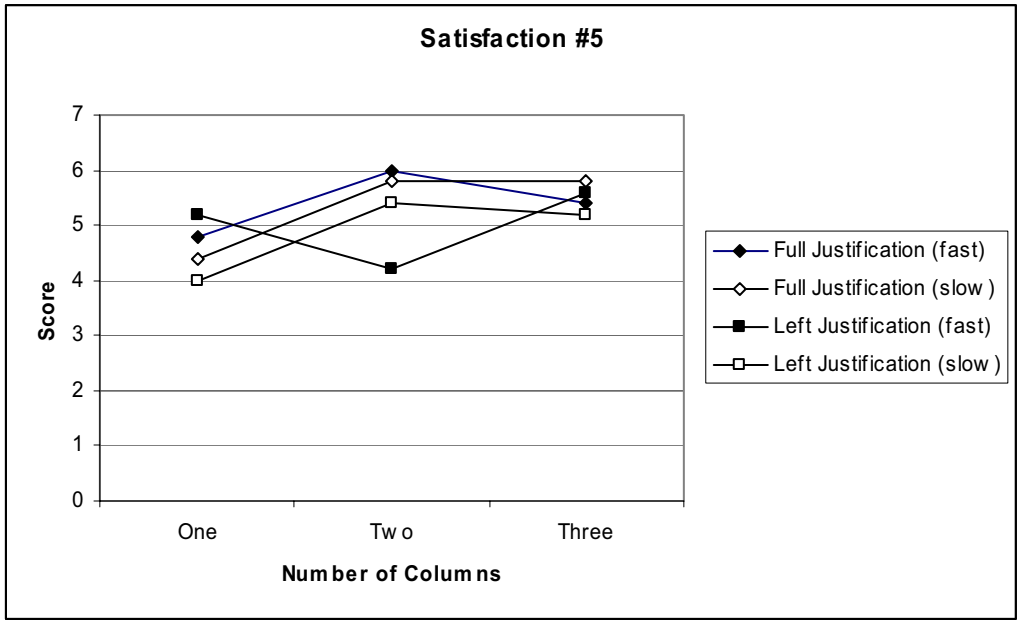

Figure 26. Satisfaction for "I am confident that I comprehended all the relevant information" for Fast and Slow Readers

A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction was found for justification x speed, $F(1,8) = 3.472$, $p = .099$, column x speed, $F(2,16) = 1.178$, $p = .695$, or justification x column x speed, $F(2,16) = 3.275$, $p = .064$ for the statement "How would you rate the level of eyestrain while reading this passage?" No significant main effect was found for speed, $F(1,8) = 3.275$, $p = .064$ (see Table 36, Figure 27).

Table 36
Means and Standard Deviations for Satisfaction Question "How would you rate the level of eyestrain while reading this passage?" for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	3.80 (2.05)	6.20 (1.30)	4.60 (1.82)
Full Justification (slow)	5.80 (1.09)	5.00 (2.00)	5.80 (1.09)
Left Justification (fast)	5.80 (1.09)	5.20 (1.92)	5.60 (1.52)
Left Justification (slow)	4.00 (1.58)	5.60 (1.14)	4.00 (2.35)

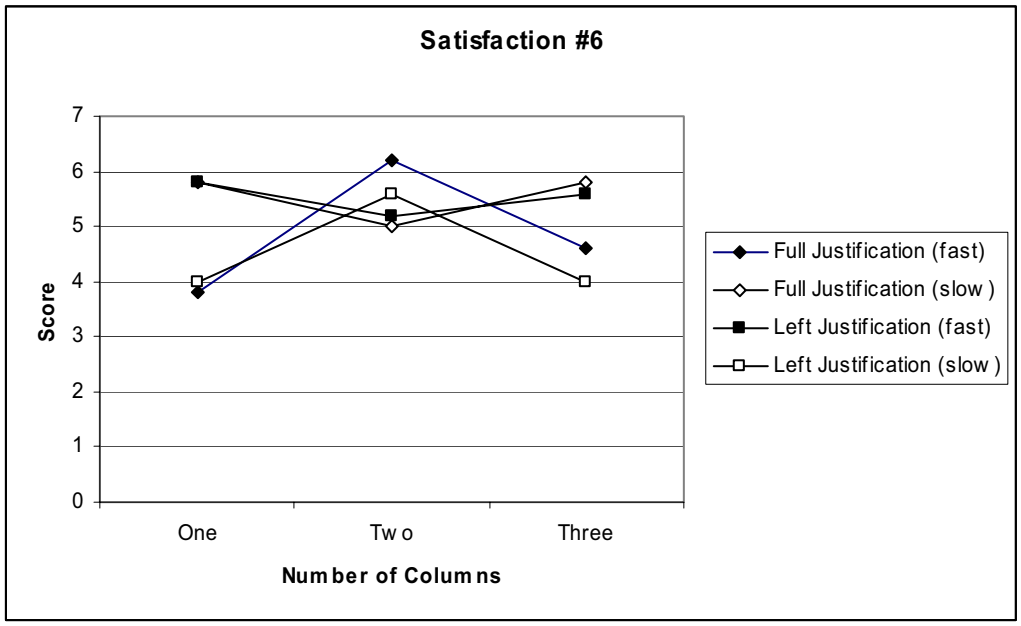

Figure 27. Satisfaction for "How would you rate the level of eyestrain while reading this passage?" for Fast and Slow Readers

A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction for justification x speed, $F(1,8) = 1.118$, $p = .647$, or column x speed, $F(2,16) = 1.547$, $p = .595$ for the statement "I would like to read college textbook material presented in this type of format" A significant interaction was found for justification x column x speed, $F(2,16) = 4.841$, $p = .023$, $\eta^2 = .377$, $1 - \beta = .717$. No significant main effect was found for speed, $F(1,8) = 1.347$, $p = .650$ (see Table 37).

Post-hoc Tukey's HSD comparisons found that satisfaction was higher for fast readers at the *two-column full-justified* condition (M=6.00) than for fast readers at the *one-column full-justified* condition (M=3.60), slow readers at the *one-column left-justified* condition (M=3.20), fast readers at the *two-column left-justified* condition (M=2.60), and fast readers at the *three-column full-justified* condition (M=2.80) (see Figure 28).

Table 37
Means and Standard Deviations for Satisfaction Question "I would like to read college textbook material presented in this type of format." for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	3.60 (2.07)	6.00 (1.00)	2.80 (1.64)
Full Justification (slow)	4.00 (1.00)	4.20 (1.30)	4.80 (2.28)
Left Justification (fast)	4.20 (1.64)	2.60 (1.52)	5.00 (1.58)
Left Justification (slow)	3.20 (1.48)	5.00 (1.87)	3.80 (2.59)

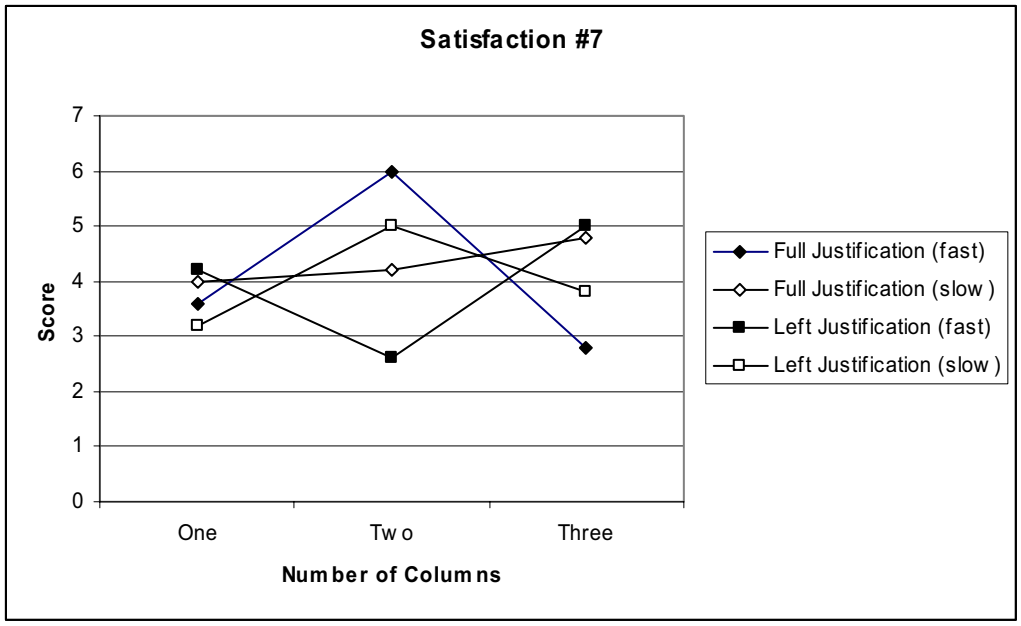

Figure 28. Satisfaction for "I would like to read college textbook material presented in this type of format" for Fast and Slow Readers

A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction for justification x speed, $\underline{F}(1,8) = 1.114$, $\underline{p} = .674$, or column x speed, $\underline{F}(2,16) = 1.784$, $\underline{p} = .521$ for the statement "I would like to read leisure material presented in this type of format." A significant interaction was found for justification x column x speed, $\underline{F}(2,16) = 6.514$, $\underline{p} = .009$, $\eta^2 = .449$, $1 - \beta = .843$. No significant main effect was found for speed, $\underline{F}(1,8) = 1.357$, $\underline{p} = .546$ (see Table 38).

Post-hoc Tukey's HSD comparisons showed satisfaction was higher for fast readers at the *two-column full-justified* condition (M=6.20) than for slow readers at the *one-column full-justified* condition (M=4.40), fast readers at *the two-column left-justified* condition (M=2.80), fast readers at the *three-column full-justified* condition (M=3.20), and slow readers at the *three-column left-justified* condition (M=3.00) (see Figure 29).

Table 38
Means and Standard Deviations for Satisfaction Question "I would like to read leisure material presented in this type of format." for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	4.00 (1.87)	6.20 (0.84)	3.20 (1.30)
Full Justification (slow)	4.40 (0.89)	5.00 (1.00)	5.00 (2.35)
Left Justification (fast)	4.60 (0.55)	2.80 (1.79)	5.00 (2.45)
Left Justification (slow)	5.20 (1.64)	4.80 (2.17)	3.00 (2.73)

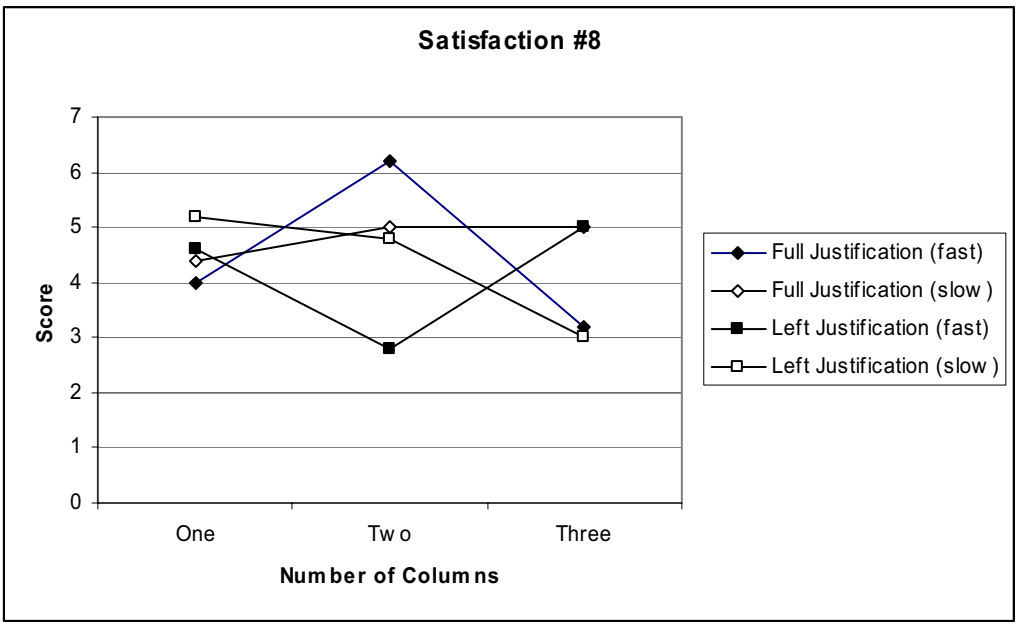

Figure 29. Satisfaction for "I would like to read leisure material presented in this type of format" for Fast and Slow Readers

A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction was found for justification x speed, $F(1,8) = 1.355$, $p = .554$, column x speed, $F(2,16) = 1.578$, $p = .544$, or justification x column x speed, $F(2,16) = 1.924$, $p = .178$ for the statement "I would like to read newspaper or magazine articles presented in this type of format." No significant main effect was found for speed, $F(1,8) = 1.112$, $p = .846$ (see Table 39, Figure 30).

Table 39
Means and Standard Deviations for Satisfaction Question "I would like to read newspaper or magazine articles presented in this type of format." for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	4.20 (1.92)	5.00 (2.00)	4.40 (1.52)
Full Justification (slow)	3.40 (1.52)	4.60 (1.14)	5.00 (2.35)
Left Justification (fast)	3.80 (1.64)	3.40 (2.30)	5.80 (1.79)
Left Justification (slow)	4.40 (1.34)	4.80 (1.79)	4.00 (2.83)

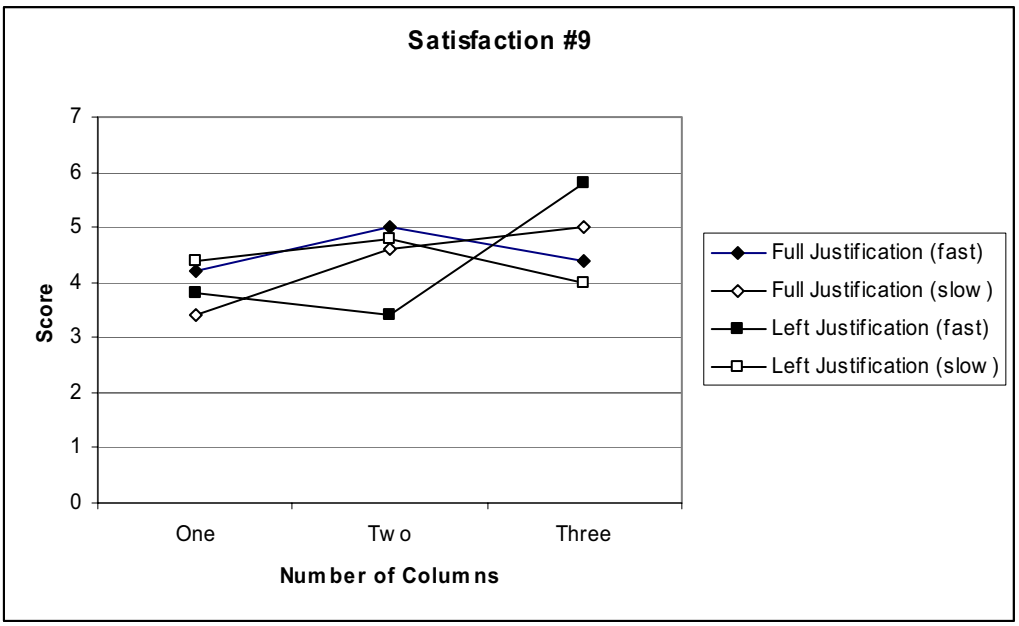

Figure 30. Satisfaction for "I would like to read newspaper or magazine articles presented in this type of format" for Fast and Slow Readers

A 2x2x3 (speed x column x justification) mixed design ANOVA found no significant interaction for justification x speed, $\underline{F}(1,8) = 1.337$, $\underline{p} = .584$, or column x speed, $\underline{F}(2,16) = 1.960$, $\underline{p} = .404$ for total satisfaction. A significant interaction was found for justification x column x speed, $\underline{F}(2,16) = 4.009$, $\underline{p} = .039$, $\eta^2 = .334$, $1 - \beta = .630$. No significant main effect was found for speed, $\underline{F}(1,8) = 1.617$, $\underline{p} = .455$ (see Table 40).

Post-hoc Tukey's HSD comparisons found that satisfaction was higher for fast readers at the *two-column full-justification* condition (M=54.40) than for slow readers at the *one-column full-justified* condition (M=38.40), slow readers at the *one-column left-justified* condition (M=37.40), fast readers at the *two-column left-justified* condition (M=36.60), slow readers at the *three-column left-justified* condition (M=39.00), and fast readers at the *three-column full-justified* condition (M=40.80) (see Figure 31).

Table 40
Total Satisfaction Means and Standard Deviations for Fast and Slow Readers

	Columns		
	One	Two	Three
Full Justification (fast)	41.40 (7.16)	54.40 (5.03)	40.80 (7.98)
Full Justification (slow)	38.40 (8.38)	48.20 (6.76)	49.20 (13.42)
Left Justification (fast)	47.00 (7.55)	36.60 (9.76)	49.80 (8.64)
Left Justification (slow)	37.40 (8.65)	45.00 (9.77)	39.00 (18.81)

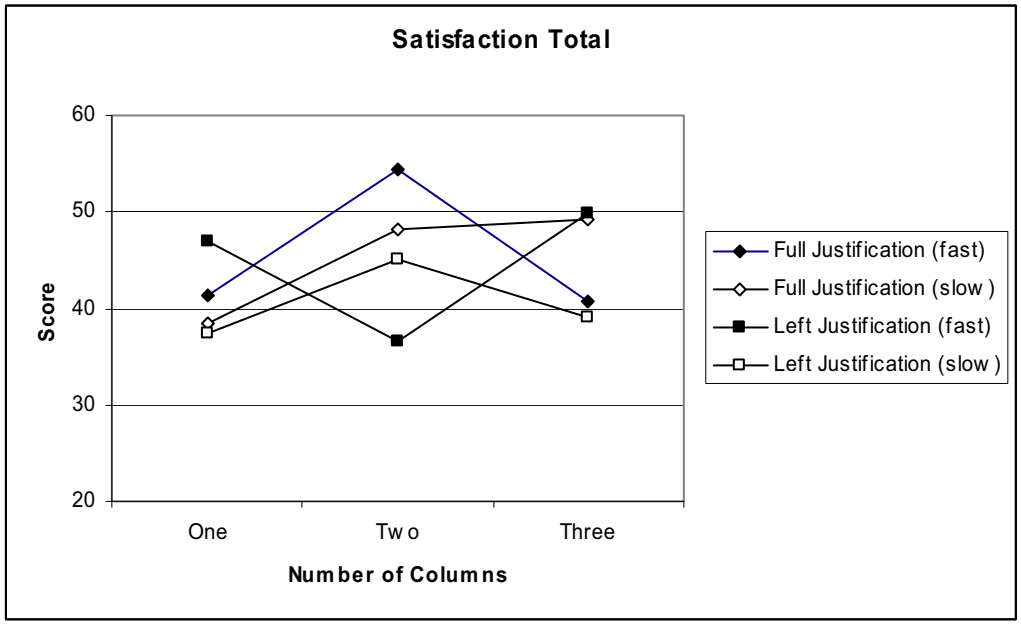

Figure 31. Total Satisfaction for Fast and Slow Readers

Hypotheses Analysis

Hypothesis I. *Reading speed will be faster for a single column condition than shorter two- or three-column conditions.* This hypothesis was not supported. Reading speed was fastest at the two-column full-justified condition, significantly faster than the one-column full-justified condition. The one-column left-justified condition was read significantly faster than one-column full-justified or three-column full-justified conditions.

Hypothesis II. *Comprehension will be higher for the three-column condition than the one- or two-column conditions.* This hypothesis was not supported. No significant differences were found for reading comprehension.

Hypothesis III. *Reading speed will be faster for left-justified text than full-justified text across all column conditions.* This hypothesis was not supported. Reading speed was fastest for full-justified text when presented in two columns, followed by left-justified text in one column.

Hypothesis IV. *Satisfaction will be higher for full-justified text than left-justified text across all column conditions.* This hypothesis was partially supported. No significant differences were found for total satisfaction across all column conditions. However, the individual questions "*I found this passage easy to read*," "*I was able to concentrate on the passage*," "*Mentally, how did you feel while reading this passage?*," "*I am confident that I comprehended all the relevant information*," and "*I would like to read leisure material presented in this type of format"* showed higher satisfaction for the two-column full-justified condition than the other conditions.

CHAPTER III

Discussion

The purpose of this study was to examine how multiple columns and text justification impact online reading in terms of reading speed, comprehension, and satisfaction of a narrative passage. Results from this study showed that reading speed was significantly faster for two-column full-justified text than for one-column full-justified text. Reading speed was also significantly faster for one-column left-justified text than for one-column full-justified or three-column full-justified text. The two-column full-justified condition had the highest overall reading speed. This result is somewhat surprising given that previous research has found that longer line lengths result in increased reading rates (Duchnicky and Kolers, 1983; Dyson and Kipping 1997, 1998; Dyson and Haselgrove, 2001). There are some possible explanations for this result: it may be that participants had more familiarity with the two-column full-justified condition than the other layouts because it is common in newspapers, magazines, and textbooks. It may also be that both the very long lines and very short lines decreased the ability to make an optimal number of fixations. Participant reading ability may also be a factor in the reading speed differences. All of these explanations will be explained in more detail when discussing fast versus slow readers.

Reading efficiency was also found to be highest for the two-column full-justified text than for three-column full-justified or two-column left-justified text, and higher reading efficiency was found for one-column left-justified text than for two-column left-justified text.

No differences were found for comprehension between any of the groups. Participants in the two-column full-justified condition showed highest satisfaction for the statements, "*I found this passage easy to read*," "*I was able to concentrate on the passage*," "*Mentally, how*

did you feel while reading this passage?," "*I am confident that I comprehended all the relevant information,*" and *"I would like to read leisure material presented in this type of format."* These results suggest that the two-column full-justified text aided readers' concentration on the passage. Campbell et al. (1981) and Craig (1982) both suggest that full-justified text can aid readers when reading for extended periods of time because the fixed edges give cues to where each line will end, and readers can predict how much further to read across the line.

Rayner & Pollatsek (1989) note that both very long and very short line lengths increase reading difficulty. Because the one-column conditions in this study had very long line lengths, the number of lateral eye movements required to read each line increased, increasing the difficulty of keeping one's place in those conditions. In the three-column conditions, very short line lengths may have impeded readers' ability to take in an optimal amount of information at each fixation. The time required to go from line to line may have also decreased reading speed.

Fast vs. Slow Comparison

The reading rate of participants in this study was generally very high compared to other studies of online reading. This study used narrative text as the reading material, while previous line length studies have typically used academic materials such as SAT passages or textbook chapters. This difference in content may have had an impact in a number of ways. The average reading speed of participants in this study was 246 words per minute for literature, higher than the online reading rate reported in other studies of 220 words per minute for expository text. In an investigation of Microsoft's ClearType™ text, Gugerty, Tyrrell, Aten, & Edmonds (2004) similarly found an average reading speed of approximately

250 words per minute when reading the novel Dracula. Because the passage was meant to be entertaining, rather than informational, readers across all conditions may have been more engaged in the text, thus increasing the overall reading rate.

When separated into fast and slow readers, fast readers showed their fastest reading, highest reading efficiency, and highest satisfaction at the two-column full-justified condition. Slow readers showed their fastest reading and highest reading efficiency at the one-column left-justification condition. Faster readers also showed higher total comprehension than slow readers. Slow readers tended to be *dis*satisfied with the one-column left-justified condition, although they showed best performance under that condition.

It is not fully understood why fast readers performed best under the two-column full-justified condition, or why slow readers had better performance with one-column left-justification. Mayer (1981) suggests that fast readers change their reading strategies based on the current reading purpose, but slow readers do not quickly or easily change strategies. Mayer suggests that careful design can aid readers in selecting the optimal strategy for reading a given text. Pinelli, et al. (1986) report that readers have difficulty in reading justified text because words at the ends of lines are often hyphenated, slowing their ability to recognize words. However, in the present study, none of the lines ended with a hyphenated word. This may have impacted the fast readers' ability to scan the lines more quickly in the two-column full-justified condition.

Effective cognitive processing strategies are necessary to ensure reading comprehension (Gaskins & Elliot, 1991). These strategies may include mental manipulations of text at word, sentence, paragraph, or whole text levels to enhance reading comprehension (Paris, Lipson, & Wixson, 1983). These processing strategies differ from comprehension

skills in that the latter are taught as automatized procedures to be applied as tasks out of context from the text. For example, a teacher may ask students to match prefixes to root words isolated from real text (Duffy & Roehler, 1987). Effective readers have knowledge about good reading strategies, as well as knowledge about how and when to use them effectively (Paris, Cross, & Lipson, 1984).

A crucial cognitive component of effective reading is metacomprehension, or awareness of one's own comprehension or lack of it (Paris et al., 1983). The degree of awareness varies from reader to reader. Effective readers show high degrees of metacomprehension by demonstrating that they know when they understand or do not understand part of a text.

Slow readers showed their best performance at the single-column condition. This may be because, as mentioned earlier, the very short lines impeded slow reader's ability to take in an optimal amount of information at each fixation. Gutherie & Wigfield (2000) assert that a slow reader may lose all information about the beginning of a sentence from short-term memory before he or she has read to the end. Slow readers may also have had difficulty "keeping their place" with the multiple line length conditions for this same reason.
Some studies suggest that slow readers read word for word (Hardin, 2001; Smith, 1994; Paris et al., 1983), rather than scanning text to gather main ideas. Nielsen, (1997) however, notes that the majority of text on the web is taken in by scanning rather than reading. Because slow readers typically read word for word and do not utilize scanning techniques, it may have been easier for them to read across one single long line rather than have the text divided into columns.

It should also be noted that the effect size of the significant results in this study ranged from .25 to .40, suggesting a moderately small to modest effect can be attributed to these results by the independent variables. Although the effect sizes were not large, these results do suggest that layout is an important factor in determining reading speed and reading efficiency for fast and slow readers.

Future research

Additional research on line length, multiple-column displays, and justification should focus on a number of areas. Perhaps most importantly, it is important to see if the individual differences between readers, such as reading ability, helps to show a distinction between fast and slow readers on other areas of online reading, including, but not limited to, the use of whitespace, font size and type, and finding the optimal line length for fast and slow readers. This research could have a large impact on the design of educational websites and software. Currently, no other study in this area has divided readers into naturally fast and slow groups. The differences between these two groups may yield important information about the way these types of readers take in information presented in different formats.

A more sensitive measure between fast and slow readers may also yield beneficial results. The reading speed of all participants in this study was relatively high. Measuring those who read more slowly may find more distinct differences in reading performance.

Future research should also examine flexible software that allows users to adjust text layout in order to best suit their current reading needs. Although participants in this study saw only one layout, future studies could have participants read several different layouts to find within-subject differences for speed, comprehension, and satisfaction.

Conclusion

Numerous factors contribute to the ease of online reading. As more types of documents become digital, and more people read from online sources, finding the optimal presentation of these materials will become critical in the near future. Reading and comprehension tests are moving into the digital domain and studies such as this one can help researchers and designers know which types of layouts are best for their audience. A two-column full-justified format is best for situations where fast readers are the primary audience. However, for more a more equalized setting, a layout with no strong advantages or disadvantages would be best.

The results of this study suggest that there is not one best way to present text online. Although fast readers performed best at the two-column full-justified condition, slow readers benefited from other presentations. Users should have the option to customize web pages to suit their reading needs. There are very few sites that allow users to tailor information displays into multiple columns or adjust justification styles or font types. Giving users these options can help increase their reading speed and satisfaction with the text, and eventually may lead to better comprehension.

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APPENDICES

Appendix A: Consent Form

WICHITA STATE UNIVERSITY
Department of Psychology
Fairmount College of Liberal Arts and Sciences

Consent Form

Since you are 18 years of age or older, you are invited to participate in a study investigating website usability. We hope to learn more about website design. You were selected as a possible participant in this study because you fit the criteria of the population we are interested in studying.

If you decide to participate, you will be asked to complete several tasks with a website. Your participation in this study will take approximately half an hour.

Any information obtained in this study in which you can be identified will remain confidential and will be disclosed only with your permission. At the beginning of your participation, you will be given a participant number. This number will be used to keep track of your data, your name will not be associated with any of the data collected.

Participation is entirely voluntary. Your decision whether or not to participate will not affect your future relations with Wichita State University. If you decide to participate, you may withdraw from the study at any time without affecting your status with Wichita State University.

If you have any questions about this research, please ask me. If you have additional questions during the study, I will be glad to answer them. If you have questions pertaining to your rights as a research subject, or about research-related injury, you can contact the Office of Research Administration at Wichita State University, Wichita, KS 67260-0007, telephone (316) 978-3285.

You will be offered a copy of this consent form to keep.

You are making a decision whether or not to participate. Your signature indicates that you have read the information provided above and have voluntarily decided to participate.

_____ _____
Signature of Participant Date

_____ _____
Signature of Investigator Date

Wichita State University, Wichita Kansas 67260-0034 Telephone: (316) 978-3170 Fax: (316) 978-3086
www.wichita.edu

Appendix B: Background Questionnaire

Background Questionnaire

1. How frequently do you visit web sites (on the World Wide Web or internet)?

___Daily
___A few times per week
___A few times per month
___Less than once per month
___Never (If never, skip the rest of the questions)

2. On average, how many hours a week do you USE the Internet?

___ 0 to 1 hours per week
___ 2 to 6 hours per week
___ 7 to 14 hours per week
___ 14 to 24 hours per week
___ 25 to 40 hours per week
___ Over 40 hours per week

3. On average, how many hours a week do you spend READING text longer than one page (i.e., articles, documents, electronic books) on the Internet?

___ 0 to 1 hours per week
___ 2 to 6 hours per week
___ 7 to 14 hours per week
___ 14 to 24 hours per week
___ 25 to 40 hours per week
___ Over 40 hours per week

4. Which of the following activities have you done on the Internet?

(Please check the frequency box that best describes your activity level.)

E-mail:					
❑ hourly	❑ daily	❑ weekly	❑ monthly	❑ few times	❑ never
Instant messaging:					
❑ hourly	❑ daily	❑ weekly	❑ monthly	❑ few times	❑ never
Searched for information using a search engine (such as Google, Lycos, MSN):					
❑ hourly	❑ daily	❑ weekly	❑ monthly	❑ few times	❑ never
Buy a product from an online store:					
❑ hourly	❑ daily	❑ weekly	❑ monthly	❑ few times	❑ never
Compare information or prices using a comparison website (webbot):					
❑ hourly	❑ daily	❑ weekly	❑ monthly	❑ few times	❑ never
Buy something at an online auction (such as eBay or Ubid):					

❑ hourly	❑ daily	❑ weekly	❑ monthly	❑ few times	❑ never
Bank online:					
❑ hourly	❑ daily	❑ weekly	❑ monthly	❑ few times	❑ never
Apply for a loan:					
❑ hourly	❑ daily	❑ weekly	❑ monthly	❑ few times	❑ never
Play a game:					
❑ hourly	❑ daily	❑ weekly	❑ monthly	❑ few times	❑ never
Gamble at an online casino:					
❑ hourly	❑ daily	❑ weekly	❑ monthly	❑ few times	❑ never
Send an e-card:					
❑ hourly	❑ daily	❑ weekly	❑ monthly	❑ few times	❑ never
Listen to or download online music:					
❑ hourly	❑ daily	❑ weekly	❑ monthly	❑ few times	❑ never
Join a newsgroup:					
❑ hourly	❑ daily	❑ weekly	❑ monthly	❑ few times	❑ never
Participate in chat room:					
❑ hourly	❑ daily	❑ weekly	❑ monthly	❑ few times	❑ never
Pay bills:					
❑ hourly	❑ daily	❑ weekly	❑ monthly	❑ few times	❑ never
Browse the Internet for fun:					
❑ hourly	❑ daily	❑ weekly	❑ monthly	❑ few times	❑ never

5. For each of the following, please indicate whether you typically read on the Internet (online) or on paper:

News stories	**Online**	**Paper**
Product information	**Online**	**Paper**
Product comparison info	**Online**	**Paper**
Home page of a web site	**Online**	**Paper**
Research Articles	**Online**	**Paper**
PDF documents	**Online**	**Paper**

6. What do you find to be the biggest problems in using the Internet in general?
(Please check all that apply.)
___ Not being able to find the information I am looking for
___ Not being able to efficiently organize the information I gather
___ Not being able to return to a page I once visited
___ Not being able to determine where I am (i.e., lost in hyperspace)
___ It takes too long to view/download pages
___ It costs too much
___ Encountering links that do not work
___ Other (please specify) _____

7. How often have you bought items from the Internet in the last year?
___ Never
___ Once
___ 2 to 5 times
___ 6 to 15 times
___ 15 to 30 times
___ Over 30 times in the last year

8. My gender is
___ Male
___ Female

9. My age is _____

10. English is my native language
___ Yes
___ No

Appendix C: Comprehension Questions

1. Which of the following titles best fits the text?
a. Battle of the Wills
b. Exploring the Garden
c. A Trip to the Beach

2. What type of garden was Nicholas told not to enter?
a. raspberry garden
b. gooseberry garden
c. blackberry garden

3. In the story, what happened right before Nicholas found a book of exotic birds?
a. He hid from his aunt.
b. He found an important looking key.
c. He found a hanging tapestry.

4. What type of jam was to be served with tea?
a. strawberry jam
b. blackberry jam
c. gooseberry jam

5. Which of Nicholas's cousins was named in the story?
a. Bobby
b. Billy
c. Ben

6. How many jars of jam did Nicholas say were in the cupboard?
a. 4
b. 3
c. 2

7. What was the name of the beach the children took a trip to?
a. Jagborough
b. Janborough
c. Jarborough

8. Why was Nicholas not allowed to go to the beach?
a. lying to his aunt
b. putting a frog in his breakfast
c. being "in disgrace"

9. Why did Nicolas's cousin cry before going to the beach?
a. She scraped her knee.
b. She missed her cousin.
c. Her boots were too tight.

10. What was the main idea of this story?
a. Children should obey adults.
b. Punishment should fit the crime.
c. Children should have their imaginations fostered.

11. What type of bird did Nicholas assign a “life history” to?
a. pigeon
b. toucan
c. duck

12. Where did Nicholas go after being told he was “in disgrace”?
a. the cupboard
b. the lumber room
c. the gooseberry garden

13. Which of the following best describes Nicholas’s aunt?
a. insightful
b. stern
c. childish

14. In the story, what event is mentioned just before Nicholas spoke to “the Evil One”?
a. His aunt falling into the rain-water tank.
b. Nicholas hiding the key to the lumber-room.
c. Nicholas finding a picture-book of exotic birds.

15. How is Nicholas’s aunt related to him?
a. She is Nicholas’s mother’s sister.
b. She is Nicholas’s father’s sister.
c. The text does not say.

Indicate with a check which of the following appeared in the text.

____ "Aunt will be down presently, in the meantime you must try and put up with me."
____ “Why didn’t he tell me they were hurting?” asked the aunt with some sharpness.
____ She was a woman of few ideas, with immense powers of concentration.
____ “Aunt often tells me that the Evil One tempts me and that I always yield.”
____ A quantity of crinkly paper shavings was the first thing that met the view when the lid was removed…
____ The children had explored the gardens thoroughly before they were caught.
____ There were only few wolves that lived in this part of the forest, he thought.
____ …with the insistence of a skilled tactician who does not intend to shift from favorable ground.
____ “You wicked boy, do you mean to say you'll leave me here alone?”
____ …he did not believe in trusting too much to luck and accident.

Appendix D: Satisfaction Questionnaire

Reading Satisfaction Questionnaire

Please answer these statements with respect to the reading you have just finished.

1. I found the passage easy to read.

Not at all Completely
1 2 3 4 5 6 7

2. I was able to concentrate on the passage.
Not at all Completely
1 2 3 4 5 6 7

3. Physically, how do you feel after reading this passage?
Exhausted Full of energy
1 2 3 4 5 6 7

4. Mentally, how did you feel while reading this passage?
Completely confused Everything made sense
1 2 3 4 5 6 7

5. I am confident that I comprehended all the relevant information.
Not at all confident Very confident
1 2 3 4 5 6 7

6. How would you rate the level of eyestrain while reading this passage?
A great deal None
1 2 3 4 5 6 7

7. I would like to read college textbook material presented in this type of format.
Not at all Completely
1 2 3 4 5 6 7

8. I would like to read leisure material presented in this type of format.
Not at all Completely
1 2 3 4 5 6 7

9. I would like to read newspaper or magazine articles presented in this type of format.
Not at all Completely
1 2 3 4 5 6 7

Appendix E: Short Story “The Lumber Room”

The children were to be driven, as a special treat, to the sands at Jagborough. Nicholas was not to be of the party; he was in disgrace. Only that morning he had refused to eat his wholesome bread-and-milk on the seemingly frivolous ground that there was a frog in it. Older and wiser and better people had told him that there could not possibly be a frog in his bread-and-milk and that he was not to talk nonsense; he continued, nevertheless, to talk what seemed complete nonsense, and described with much detail the coloration and markings of the alleged frog. The dramatic part of the incident was that there really was a frog in Nicholas's basin of bread-and-milk; he had put it there himself, so he felt entitled to know something about it. The sin of taking a frog from the garden and putting it into a bowl of wholesome bread-and-milk was enlarged on at great length, but the fact that stood out clearest in the whole affair, as it presented itself to the mind of Nicholas, was that the older, wiser, and better people had been proved to be profoundly in error in matters about which they had expressed the utmost assurance.

"You said there couldn't possibly be a frog in my bread-and-milk; there was a frog in my bread-and-milk," he repeated, with the insistence of a skilled tactician who does not intend to shift from favorable ground.

So his boy-cousin and girl-cousin and his quite uninteresting younger brother were to be taken to Jagborough sands that afternoon and he was to stay at home. His cousins' aunt, who insisted, by an unwarranted stretch of imagination, in styling herself his aunt also, had hastily invented the Jagborough expedition in order to impress on Nicholas the delights that he had justly forfeited by his disgraceful conduct at the breakfast-table. It was her habit, whenever one of the children fell from grace, to improvise something of a festival nature from which the offender would be rigorously debarred; if all the children sinned collectively they were suddenly informed of a circus in a neighboring town, a circus of unrivalled merit and uncounted elephants, to which, but for their depravity, they would have been taken that very day.

A few decent tears were looked for on the part of Nicholas when the moment for the departure of the expedition arrived. As a matter of fact, however, all the crying was done by his girl-cousin, who scraped her knee rather painfully against the step of the carriage as she was scrambling in. "How she did howl," said Nicholas cheerfully, as the party drove off without any of the elation of high spirits that should have characterized it.

"She'll soon get over that," said the self-styled aunt; "it will be a glorious afternoon for racing about over those beautiful sands. How they will enjoy themselves!"

"Bobby won't enjoy himself much, and he won't race much either," said Nicholas with a grim chuckle; "his boots are hurting him. They're too tight."

"Why didn't he tell me they were hurting?" asked the aunt with some sharpness.

"He told you twice, but you weren't listening. You often don't listen when we tell you important things."

"You are not to go into the gooseberry garden," said the aunt, changing the subject.

"Why not?" demanded Nicholas.

"Because you are in disgrace," said the aunt loftily.

Nicholas did not admit the flawlessness of the reasoning; he felt perfectly capable of being in disgrace and in a gooseberry garden at the same moment. His face took on an expression of considerable obstinacy. It was clear to his aunt that he was determined to get

into the gooseberry garden, "only," as she remarked to herself, "because I have told him he is not to."

Now the gooseberry garden had two doors by which it might be entered, and once a small person like Nicholas could slip in there he could effectually disappear from view amid the masking growth of artichokes, raspberry canes, and fruit bushes. The aunt had many other things to do that afternoon, but she spent an hour or two in trivial gardening operations among flower beds and shrubberies, where she could watch the two doors that led to the forbidden paradise. She was a woman of few ideas, with immense powers of concentration.

Nicholas made one or two trips into the front garden, wriggling his way with obvious stealth of purpose towards one or other of the doors, but never able for a moment to evade the aunt's watchful eye. As a matter of fact, he had no intention of trying to get into the gooseberry garden, but it was extremely convenient for him that his aunt should believe that he had; it was a belief that would keep her on self-imposed sentry-duty for the greater part of the afternoon. Having thoroughly confirmed and fortified her suspicions, Nicholas slipped back into the house and rapidly put into execution a plan of action that had long germinated in his brain. By standing on a chair in the library one could reach a shelf on which reposed a fat, important-looking key. The key was as important as it looked; it was the instrument which kept the mysteries of the lumber-room secure from unauthorized intrusion, which opened a way only for aunts and such like-privileged persons. Nicholas had not had much experience of the art of fitting keys into keyholes and turning locks, but for some days past he had practiced with the key of the schoolroom door; he did not believe in trusting too much to luck and accident. The key turned stiffly in the lock, but it turned. The door opened, and Nicholas was in an unknown land, compared with which the gooseberry garden was a stale delight, a mere material pleasure.

Often Nicholas had pictured to himself what the lumber-room might be like, that region that was so carefully sealed from youthful eyes and concerning which no questions were ever answered. It came up to his expectations. In the first place it was large and dimly lit, one high window opening onto the forbidden garden being its only source of illumination. In the second place it was a storehouse of unimagined treasures. The aunt-by-assertion was one of those people who think that things spoil by use and consign them to dust and damp by way of preserving them. Such parts of the house as Nicholas knew best were rather bare and cheerless, but here there were wonderful things for the eye to feast on. First and foremost there was a piece of framed tapestry that was evidently meant to be a fireplace.

To Nicholas it was a living, breathing story; he sat down on a roll of Indian hangings, glowing in wonderful colors beneath a layer of dust, and took in all the details of the tapestry picture. A man, dressed in the hunting costume of some remote period, had just transfixed a stag with an arrow; it could not have been a difficult shot because the stag was only one or two paces away from him; in the thickly growing vegetation that the picture suggested it would not have been difficult to creep up to a feeding stag, and the two spotted dogs that were springing forward to join in the chase had evidently been trained to keep to heel till the arrow was discharged. That part of the picture was simple, if interesting, but did the huntsman see, what Nicholas saw, that four galloping wolves were coming in his direction through the wood? There might be more than four of them hidden behind the trees, and in any case would the man and his dogs be able to cope with the four wolves if they made an attack? The man had only two arrows left in his quiver, and he might miss with one or both of them; all one knew about his skill in shooting was that he could hit a large stag at a

ridiculously short range. Nicholas sat for many golden minutes revolving the possibilities of the scene; he was inclined to think that there were more than four wolves and that the man and his dogs were in a tight corner.

But there were other objects of delight and interest claiming his instant attention; there were quaint twisted candlesticks in the shape of snakes, and a teapot fashioned like a china duck, out of whose open beak the tea was supposed to come. How dull and shapeless the nursery teapot seemed in comparison! And there was a carved sandalwood box packed tight with aromatic cotton-wool, and between the layers of cotton-wool were little brass figures, hump-necked bulls, and peacocks and goblins, delightful to see and to handle. Less promising in appearance was a large square book with plain black covers; Nicholas peeped into it, and, behold, it was full of colored pictures of birds. And such birds! In the garden, and in the lanes when he went for a walk, Nicholas came across a few birds, of which the largest were an occasional magpie or wood-pigeons. Here were herons and bustards, kites, toucans, tiger-bitterns, brush turkeys, ibises, golden pheasants, a whole portrait gallery of undreamed-of creatures.

And as he was admiring the coloring of the mandarin duck and assigning a life-history to it, the voice of his aunt in shrill vociferation of his name came from the gooseberry garden without. She had grown suspicious at his long disappearance, and had leapt to the conclusion that he had climbed over the wall behind the sheltering screen of the lilac bushes: she was now engaged in energetic and rather hopeless search for him among the artichokes and raspberry canes.

"Nicholas, Nicholas!" she screamed, "you are to come out of this at once. It's no use trying to hide there; I can see you all the time."

It was probably the first time for twenty years that any one had smiled in that lumber-room.

Presently the angry repetitions of Nicholas's name gave way to a shriek, and a cry for somebody to come quickly. Nicholas shut the book, restored it carefully to its place in a corner, and shook some dust from a neighboring pile of newspapers over it. Then he crept from the room, locked the door, and replaced the key exactly where he had found it. His aunt was still calling his name when he sauntered into the front garden.

"Who's calling?" he asked.

"Me," came the answer from the other side of the wall; "didn't you hear me? I've been looking for you in the gooseberry garden, and I've slipped into the rain-water tank. Luckily there's no water in it, but the sides are slippery and I can't get out. Fetch the little ladder from under the cherry tree--"

"I was told I wasn't to go into the gooseberry garden," said Nicholas promptly.

"I told you not to, and now I tell you that you may," came the voice from the rain-water tank, rather impatiently.

"Your voice doesn't sound like aunt's," objected Nicholas; "you may be the Evil One tempting me to be disobedient. Aunt often tells me that the Evil One tempts me and that I always yield. This time I'm not going to yield."

"Don't talk nonsense," said the prisoner in the tank; "go and fetch the ladder."

"Will there be strawberry jam for tea?" asked Nicholas innocently.

"Certainly there will be," said the aunt, privately resolving that Nicholas should have none of it.

"Now I know that you are the Evil One and not aunt," shouted Nicholas gleefully; "when

we asked aunt for strawberry jam yesterday she said there wasn't any. I know there are four jars of it in the store cupboard, because I looked, and of course you know it's there, but she doesn't, because she said there wasn't any. Oh, Devil, you have sold yourself!"

There was an unusual sense of luxury in being able to talk to an aunt as though one was talking to the Evil One, but Nicholas knew, with childish discernment that such luxuries were not to be over-indulged in. He walked noisily away, and it was a kitchenmaid, in search of parsley, who eventually rescued the aunt from the rain-water tank. Tea that evening was partaken of in a fearsome silence. The tide had been at its highest when the children had arrived at Jagborough Cove, so there had been no sands to play on--a circumstance that the aunt had overlooked in the haste of organizing her punitive expedition. The tightness of Bobby's boots had had a disastrous effect on his temper the whole of the afternoon, and altogether the children could not have been said to have enjoyed themselves. The aunt maintained the frozen muteness of one who has suffered undignified and unmerited detention in a rain-water tank for thirty-five minutes. As for Nicholas, he, too, was silent, in the absorption of one who has much to think about; it was just possible, he considered that the huntsman would escape with his hounds while the wolves feasted on the stricken stag.

Appendix F: Source Tables

Table 41

Analysis of Variance Source Table for Matched-Subject Nelson-Denny Comprehension Line Numbers

Source	Sum of Squares	df	Mean Square	F	Sig.
Just	8.727	1	8.727	2.222	.167
Error(just)	39.273	10	3.927		
Col	30.545	2	15.273	1.892	.177
Error(col)	161.455	20	8.073		
just * col	4.364	2	2.182	1.476	.628
Error(just*col)	91.636	20	4.582		

Table 42

Analysis of Variance Source Table for Reading Speed

Source	Sum of Squares	df	Mean Square	F	Sig.
JUST	2162.365	1	2162.365	1.201	.299
Error(JUST)	18008.358	10	1800.836		
COLUMN	4054.546	2	2027.273	1.258	.306
Error(COLUMN)	32227.200	20	1611.360		
JUST * COLUMN	13371.641	2	6685.821	4.347	.027
Error(JUST*COLUMN)	30763.409	20	1538.170		

Table 43

Analysis of Variance Source Table for Reading Efficiency

Source	Sum of Squares	df	Mean Square	F	Sig.
JUST	1186.875	1	1186.875	1.013	.911
Error(JUST)	901069.410	10	90106.941		
COLUMN	203077.958	2	101538.979	1.815	.457
Error(COLUMN)	2491748.888	20	124587.444		
JUST * COLUMN	488523.810	2	244261.905	4.921	.018
Error(JUST*COLUMN)	992783.229	20	49639.161		

Table 44
Analysis of Variance Source Table for Total Comprehension

Source	Sum of Squares	df	Mean Square	F	Sig.
JUST	.876	1	.876	1.618	.450
Error(JUST)	14.174	10	1.417		
COLUMN	2.574	2	1.287	1.089	.356
Error(COLUMN)	23.641	20	1.182		
JUST * COLUMN	1.208	2	.604	1.965	.398
Error(JUST*COLUMN)	12.521	20	.626		

Table 45
Analysis of Variance Source Table for Title Comprehension

Source	Sum of Squares	df	Mean Square	F	Sig.
JUST	.379	1	.379	2.119	.176
Error(JUST)	1.788	10	.179		
COLUMN	.636	2	.318	1.458	.256
Error(COLUMN)	4.364	20	.218		
JUST * COLUMN	.212	2	.106	1.515	.605
Error(JUST*COLUMN)	4.121	20	.206		

Table 46
Analysis of Variance Source Table for Main Idea Comprehension

Source	Sum of Squares	df	Mean Square	F	Sig.
JUST	.006061	1	.006061	1.476	.506
Error(JUST)	1.273	10	.127		
COLUMN	.485	2	.242	1.159	.334
Error(COLUMN)	4.182	20	.209		
JUST * COLUMN	.485	2	.242	1.784	.470
Error(JUST*COLUMN)	6.182	20	.309		

Table 47
Analysis of Variance Source Table for Main Factual Comprehension

Source	Sum of Squares	df	Mean Square	F	Sig.
JUST	.001515	1	.001515	1.327	.580
Error(JUST)	.464	10	.004640		
COLUMN	.003977	2	.001989	1.265	.304
Error(COLUMN)	.314	20	.001572		
JUST * COLUMN	.003598	2	.001799	1.590	.564
Error(JUST*COLUMN)	.610	20	.003049		

Table 48
Analysis of Variance Source Table for Structural Comprehension

Source	Sum of Squares	df	Mean Square	F	Sig.
JUST	.106	1	.106	1.208	.298
Error(JUST)	.875	10	.008745		
COLUMN	.003960	2	.001980	1.260	.773
Error(COLUMN)	1.521	20	.007606		
JUST * COLUMN	.172	2	.008580	1.672	.213
Error(JUST*COLUMN)	1.026	20	.005132		

Table 49
Analysis of Variance Source Table for Incidental Comprehension

Source	Sum of Squares	df	Mean Square	F	Sig.
JUST	.0006680	1	.0006680	1.154	.703
Error(JUST)	.434	10	.004342		
COLUMN	.002088	2	.001044	1.292	.750
Error(COLUMN)	.714	20	.003570		
JUST * COLUMN	.0005845	2	.0002923	1.082	.921
Error(JUST*COLUMN)	.711	20	.003553		

Table 50
Analysis of Variance Source Table for Recognition Comprehension

Source	Sum of Squares	df	Mean Square	F	Sig.
JUST	.004379	1	.004379	2.041	.184
Error(JUST)	.215	10	.002145		
COLUMN	.0002727	2	.0001364	1.066	.936
Error(COLUMN)	.411	20	.002053		
JUST * COLUMN	.006.576	2	.003288	2.730	.090
Error(JUST*COLUMN)	.241	20	.001205		

Table 51
Analysis of Variance Source Table for Satisfaction Question "I found the passage easy to read."

Source	Sum of Squares	Df	Mean Square	F	Sig.
JUST	5.470	1	5.470	1.951	.193
Error(JUST)	28.030	10	2.803		
COLUMN	2.212	2	1.106	1.505	.611
Error(COLUMN)	43.788	20	2.189		
JUST * COLUMN	4.576	2	2.288	2.967	.074
Error(JUST*COLUMN)	15.424	20	.771		

Table 52
Analysis of Variance Source Table for Satisfaction Question "I was able to concentrate on the passage."

Source	Sum of Squares	Df	Mean Square	F	Sig.
JUST	.742	1	.742	1.300	.596
Error(JUST)	24.758	10	2.476		
COLUMN	5.303	2	2.652	1.589	.229
Error(COLUMN)	33.364	20	1.668		
JUST * COLUMN	9.485	2	4.742	5.123	.016
Error(JUST*COLUMN)	18.515	20	.926		

Table 53
Analysis of Variance Source Table for Satisfaction Question "Physically, how do you feel after reading this passage?"

Source	Sum of Squares	df	Mean Square	F	Sig.
JUST	.379	1	.379	1.240	.635
Error(JUST)	15.788	10	1.579		
COLUMN	2.030	2	1.015	1.685	.515
Error(COLUMN)	29.636	20	1.482		
JUST * COLUMN	.576	2	.288	1.242	.787
Error(JUST*COLUMN)	23.758	20	1.188		

Table 54
Analysis of Variance Source Table for Satisfaction Question "Mentally, how did you feel while reading this passage?"

Source	Sum of Squares	df	Mean Square	F	Sig.
JUST	2.970	1	2.970	1.678	.224
Error(JUST)	17.697	10	1.770		
COLUMN	7.485	2	3.742	1.847	.184
Error(COLUMN)	40.515	20	2.026		
JUST * COLUMN	11.121	2	5.561	3.452	.052
Error(JUST*COLUMN)	32.212	20	1.611		

Table 55
Analysis of Variance Source Table for Satisfaction Question "I am confident that I comprehended all the relevant information."

Source	Sum of Squares	df	Mean Square	F	Sig.
JUST	1.515	1	1.515	1.448	.518
Error(JUST)	33.818	10	3.382		
COLUMN	10.394	2	5.197	3.033	.071
Error(COLUMN)	34.273	20	1.714		
JUST * COLUMN	2.212	2	1.106	1.642	.537
Error(JUST*COLUMN)	34.455	20	1.723		

Table 56
Analysis of Variance Source Table for Satisfaction Question "How would you rate the level of eyestrain while reading this passage?"

Source	Sum of Squares	df	Mean Square	F	Sig.
JUST	.970	1	.970	1.274	.612
Error(JUST)	35.364	10	3.536		
COLUMN	3.545	2	1.773	1.115	.347
Error(COLUMN)	31.788	20	1.589		
JUST * COLUMN	2.212	2	1.106	1.289	.752
Error(JUST*COLUMN)	76.455	20	3.823		

Table 57
Analysis of Variance Source Table for Satisfaction Question "I would like to read college textbook material presented in this type of format."

Source	Sum of Squares	df	Mean Square	F	Sig.
JUST	.545	1	.545	1.187	.674
Error(JUST)	29.121	10	2.912		
COLUMN	5.182	2	2.591	1.115	.348
Error(COLUMN)	46.485	20	2.324		
JUST * COLUMN	11.000	2	5.500	1.086	.357
Error(JUST*COLUMN)	101.333	20	5.067		

Table 58
Analysis of Variance Source Table for Satisfaction Question "I would like to read leisure material presented in this type of format."

Source	Sum of Squares	df	Mean Square	F	Sig.
JUST	5.470	1	5.470	1.197	.300
Error(JUST)	45.697	10	4.570		
COLUMN	6.394	2	3.197	1.223	.315
Error(COLUMN)	52.273	20	2.614		
JUST * COLUMN	17.848	2	8.924	2.569	.102
Error(JUST*COLUMN)	69.485	20	3.474		

Table 59
Analysis of Variance Source Table for Satisfaction Question "I would like to read newspaper or magazine articles presented in this type of format."

Source	Sum of Squares	df	Mean Square	F	Sig.
JUST	.379	1	.379	1.166	.692
Error(JUST)	22.788	10	2.279		
COLUMN	7.394	2	3.697	1.501	.247
Error(COLUMN)	49.273	20	2.464		
JUST * COLUMN	6.303	2	3.152	1.798	.464
Error(JUST*COLUMN)	79.030	20	3.952		

Table 60
Analysis of Variance Source Table for Total Satisfaction

Source	Sum of Squares	df	Mean Square	F	Sig.
JUST	131.045	1	131.045	1.032	.334
Error(JUST)	1269.788	10	126.979		
COLUMN	237.091	2	118.545	1.721	.204
Error(COLUMN)	1377.909	20	68.895		
JUST * COLUMN	406.909	2	203.455	1.821	.188
Error(JUST*COLUMN)	2234.758	20	111.738		

Table 61
Analysis of Variance Source Table for Reading Speed for Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	935.316	1	935.316	1.455	.519
Error(just)	16443.532	8	2055.441		
column * speed	5322.681	2	2661.340	1.930	.177
Error(column)	22058.672	16	1378.667		
just * column * speed	5579.457	2	2789.729	1.880	.185
Error(just*column)	23739.047	16	1483.690		
SPEED	20414.610	1	20414.610	4.486	.067
Error	36408.856	8	4551.107		

Table 62
Analysis of Variance Source Table for Reading Efficiency for Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	14550.298	1	14550.298	1.167	.694
Error(just)	698546.345	8	87318.293		
column * speed	269777.658	2	134888.829	1.118	.351
Error(column)	1929594.775	16	120599.673		
just * column * speed	292154.968	2	146077.484	4.262	.033
Error(just*column)	548343.459	16	34271.466		
SPEED	1432343.827	1	1432343.827	8.620	.019
Error	1329354.211	8	166169.276		

Table 63
Analysis of Variance Source Table for Total Comprehension for Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	.794	1	.794	1.569	.472
Error(just)	11.168	8	1.396		
column * speed	1.342	2	.671	1.505	.613
Error(column)	21.245	16	1.328		
just * column * speed	1.945	2	.972	1.644	.224
Error(just*column)	9.461	16	.591		
SPEED	4.574	1	4.574	6.841	.031
Error	5.349	8	.669		

Table 64
Analysis of Variance Source Table for Title Comprehension for Fast and Slow Readers

Source	Sum of Squares	Df	Mean Square	F	Sig.
just * speed	.267	1	.267	1.882	.207
Error(just)	1.133	8	.142		
column * speed	.400	2	.200	1.857	.443
Error(column)	3.733	16	.233		
just * column * speed	.533	2	.267	1.391	.277
Error(just*column)	3.067	16	.192		
SPEED	.600	1	.600	2.323	.166
Error	2.067	8	.258		

Table 65
Analysis of Variance Source Table for Main Idea Comprehension for Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	.150	1	.150	1.385	.273
Error(just)	.867	8	.108		
column * speed	.133	2	.067	.267	.769
Error(column)	4.000	16	.250		
just * column * speed	.000	2	.000	1.462	.375
Error(just*column)	4.933	16	.308		
SPEED	.817	1	.817	2.970	.123
Error	2.200	8	.275		

Table 66
Analysis of Variance Source Table for Main Factual Comprehension for Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	.001	1	.001	1.018	.896
Error(just)	.458	8	.057		
column * speed	.040	2	.020	1.188	.330
Error(column)	.267	16	.017		
just * column * speed	.052	2	.026	1.806	.464
Error(just*column)	.517	16	.032		
SPEED	.0001042	1	.0001042	1.100	.760
Error	.008333	8	.001042		

Table 67
Analysis of Variance Source Table for Structural Comprehension for Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	.261	1	.261	3.470	.100
Error(just)	.603	8	.075		
column * speed	.025	2	.013	1.142	.869
Error(column)	1.430	16	.089		
just * column * speed	.142	2	.071	1.357	.286
Error(just*column)	.835	16	.052		
SPEED	.0007260	1	.007260	1.055	.820
Error	1.053	8	.132		

Table 68
Analysis of Variance Source Table for Incidental Comprehension for Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	.066	1	.066	1.557	.247
Error(just)	.340	8	.042		
column * speed	.045	2	.023	1.544	.591
Error(column)	.661	16	.041		
just * column * speed	.025	2	.012	1.329	.724
Error(just*column)	.603	16	.038		
SPEED	.118	1	.118	2.626	.144
Error	.358	8	.004478		

Table 69
Analysis of Variance Source Table for Recognition Comprehension For Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	.001	1	.001	1.056	.818
Error(just)	.213	8	.027		
column * speed	.024	2	.012	1.527	.600
Error(column)	.369	16	.023		
just * column * speed	.007	2	.004	1.249	.783
Error(just*column)	.225	16	.014		
SPEED	1432343.827	1	1432343.827	8.620	.019
Error	1329354.211	8	166169.276		

Table 70
Analysis of Variance Source Table for Satisfaction Question "I found the passage easy to read." for Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	.150	1	.150	1.044	.839
Error(just)	27.333	8	3.417		
column * speed	6.633	2	3.317	1.442	.266
Error(column)	36.800	16	2.300		
just * column * speed	.700	2	.350	1.646	.537
Error(just*column)	8.667	16	.542		
SPEED	14.017	1	14.017	7.577	.025
Error	14.800	8	1.850		

Table 71
Analysis of Variance Source Table for Satisfaction Question "I was able to concentrate on the passage." for Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	1.350	1	1.350	1.488	.505
Error(just)	22.133	8	2.767		
column * speed	8.033	2	4.017	2.648	.101
Error(column)	24.267	16	1.517		
just * column * speed	1.300	2	.650	1.672	.524
Error(just*column)	15.467	16	.967		
SPEED	4.817	1	4.817	1.806	.216
Error	21.333	8	2.667		

Table 72
Analysis of Variance Source Table for Satisfaction Question "Physically, how do you feel after reading this passage?" for Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	2.017	1	2.017	1.274	.292
Error(just)	12.667	8	1.583		
column * speed	3.733	2	1.867	1.493	.254
Error(column)	20.000	16	1.250		
just * column * speed	6.533	2	3.267	4.455	.029
Error(just*column)	11.733	16	.733		
SPEED	.001667	1	.001667	1.010	.921
Error	12.800	8	1.600		

Table 73
Analysis of Variance Source Table for Satisfaction Question "Mentally, how did you feel while reading this passage?" for Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	.817	1	.817	1.387	.551
Error(just)	16.867	8	2.108		
column * speed	7.233	2	3.617	1.895	.183
Error(column)	30.533	16	1.908		
just * column * speed	6.433	2	3.217	2.413	.121
Error(just*column)	21.333	16	1.333		
SPEED	6.017	1	6.017	3.422	.102
Error	14.067	8	1.758		

Table 74
Analysis of Variance Source Table for Satisfaction Question "I am confident that I comprehended all the relevant information." for Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	.017	1	.017	1.004	.949
Error(just)	31.000	8	3.875		
column * speed	4.300	2	2.150	1.197	.328
Error(column)	28.733	16	1.796		
just * column * speed	4.033	2	2.017	1.232	.318
Error(just*column)	26.200	16	1.638		
SPEED	.150	1	.150	1.157	.703
Error	7.667	8	.958		

Table 75
Analysis of Variance Source Table for Satisfaction Question "How would you rate the level of eyestrain while reading this passage?" for Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	10.417	1	10.417	3.472	.099
Error(just)	24.000	8	3.000		
column * speed	.633	2	.317	1.170	.845
Error(column)	29.733	16	1.858		
just * column * speed	20.633	2	10.317	3.275	.064
Error(just*column)	50.400	16	3.150		
SPEED	.417	1	.417	1.137	.721
Error	24.267	8	3.033		

Table 76
Analysis of Variance Source Table for Satisfaction Question "I would like to read college textbook material presented in this type of format." for Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	.067	1	.067	1.019	.893
Error(just)	27.867	8	3.483		
column * speed	1.433	2	.717	1.259	.775
Error(column)	44.333	16	2.771		
just * column * speed	37.233	2	18.617	4.841	.023
Error(just*column)	61.533	16	3.846		
Speed	.267	1	.267	1.225	.648
Error	9.467	8	1.183		

Table 77
Analysis of Variance Source Table for Satisfaction Question "I would like to read leisure material presented in this type of format." for Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	.067	1	.067	1.013	.912
Error(just)	40.533	8	5.067		
column * speed	1.033	2	.517	1.180	.837
Error(column)	46.000	16	2.875		
just * column * speed	30.833	2	15.417	6.514	.009
Error(just*column)	37.867	16	2.367		
Speed	1.067	1	1.067	1.328	.582
Error	26.000	8	3.250		

Table 78
Analysis of Variance Source Table for Satisfaction Question "I would like to read newspaper or magazine articles presented in this type of format." for Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	.267	1	.267	1.100	.760
Error(just)	21.333	8	2.667		
column * speed	3.033	2	1.517	1.552	.587
Error(column)	44.000	16	2.750		
just * column * speed	13.433	2	6.717	1.924	.178
Error(just*column)	55.867	16	3.492		
Speed	.067	1	.067	1.010	.922
Error	52.000	8	6.500		

Table 79
Analysis of Variance Source Table for Total Satisfaction for Fast and Slow Readers

Source	Sum of Squares	df	Mean Square	F	Sig.
just * speed	52.267	1	52.267	1.344	.574
Error(just)	1215.333	8	151.917		
column * speed	143.433	2	71.717	1.960	.404
Error(column)	1195.600	16	74.725		
just * column * speed	729.433	2	364.717	4.009	.039
Error(just*column)	1455.467	16	90.967		
Speed	68.267	1	68.267	1.617	.455
Error	884.800	8	110.600		