

How Serif and Sans Serif Typefaces Influence Reading on Screen: An Eye Tracking Study

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Abstract. This study aims to investigate how serif and sans serif typefaces influence reading from screen. 10 graduate students voluntarily participated in the study. The data were collected in a laboratory setting. Participants were asked to find the misspelled words in two different texts written in serif and sans serif typeface. The participants tried to find the misspelled words in the texts, during the data collection there was no time limitation. Participants' eye movements were recorded by Tobii 1750 eye tracker device. The data were analyzed according to the accuracy and eye behavior metrics. The findings showed that participants read from sans serif typeface faster and more accurate than serif typeface. The findings suggest that participants fixated on the misspelled words more on serif typeface than sans serif typeface, in terms of the total visit duration participants spent more time on serif typeface than sans serif typeface.

Keywords: Reading behavior · Reading from screen · Eye movement · Serif · Sans serif · User interface

1 Introduction

In recent years, there is a transformation in reading habits from print to screen arising from the advent in digital reading devices (Banerjee et al. 2011; Mangen et al. 2013). The change in individuals' reading behavior in digital platforms and why people have difficulties during reading from screen took attention of the researchers (Dyson and Haselgrove 2000; Dyson 2004; Rose 2011; Jeong 2012). As Liu (2005) explained, reading from screen is not a single process, even people starts reading from screen the process usually includes spending time on activities like browsing, scanning and spotting (Liu 2005). Horton et al. (1996) also pointed out that skimming is more frequent while reading from screen than in-depth reading.

In the literature, many studies have been conducted to understand on why people read slower from screen than from a paper (Jorna and Snyder 1991; Gould et al. 1987). The reasons found for reading faster on paper were; poor image quality displayed on the screen (Gould et al. 1987; Dillon et al. 1988), font type as serif and sans serif

(Beymer et al. 2008; Bernard et al. 2001; Mackeben 1999; Tullis et al. 1995), and size which have an influence on readability and legibility of the text (Franken et al. 2015). (Gould et al. 1987) found that with the improvements of the screen resolution, proofreading performance are not differed on paper and screen when the same font used. Although proofreading and reading processes are differed from each other, proofreading studies contribute the reading studies as well (Schotter et al. 2012). Schotter et al. (2012) expressed that proofreading may differ from reading process in terms of the similarity of the nature of the visual search tasks. The proofreading process also differed from reading that during proofreading tasks people tend to skim instead of trying to understand the text. Exploring the reading and other information processing tests by using eye behavior are well researched issues among researchers (Clifton et al. 2007; Rayner 1998; Rayner and Morris 1992; Just and Carpenter 1980). In order to understand reading process and legibility of a block of text, researchers focus on eye movements (Franken et al. 2015; Rello and Marcos 2012; Beymer et al. 2008; Rayner and Pollatsek 1989). Moreover, eye tracker-based method might provide more reliable results for a very precise measurement of reading speed (Franken et al. 2015).

Even the developments in screen resolutions and various research on how reading process occurred, investigating readability of texts and reading process still taking attention of the researchers. Font size and type are the other mostly focused variable for investigating readability in reading process, different findings were found for the preferred font size and type. Bernard et al. (2002a) found that in terms of reading efficiency there was no significant difference between font typeface in different size but in terms of the relation between font type and size there was a difference when considered the font legibility. They explained that people read faster in 12 point size than 10 point size fonts during online reading (Bernard et al. 2002b). According to Banerjee et al. (2011) legibility of the serif fonts (Times New Roman, Georgia and Courier New) is better compared to the sans serif fonts (Arial, Verdana and Tahoma). Moret-Tatay and Perea (2011) mentioned the advantage of texts in sans serif fonts compared to serif fonts during reading. They also mentioned about choosing sans serif typeface while preparing texts in computers screen. On the other hand, Tullis et al. (1995) found no difference between the serif and sans serif fonts considering reading speed in a proofreading task. Interestingly, in the study, the participants preferred sans serif fonts over serif fonts. Similarly, Boyarski et al. (1998) reported that reading speed of sans serif (Verdana) and serif (Georgia and Time New Romans) fonts did not differ for comprehension. Moreover, Bernard and Mills (2000) couldn't find any difference between sans serif (Arial) and serif (Times new roman) fonts regarding reading speed and detection of word errors. In general, serif fonts performed better than sans serif fonts (Banerjee et al. 2011; Beymer et al. 2008; Bernard et al., 2001), not statistically significant however. Most people seem to prefer the sans serif fonts of Arial and Verdana rather than serif fonts (Banerjee et al. 2011; Beymer et al. 2008; Bernard et al. 2002b). However, these preferences as different font size and types may subject to the different age groups and needs (Darroch et al. 2005; Bernard et al. 2002b; Kawasaki et al. 2008; Tullis et al. 1995).

Despite the developments in the screen resolution and attempts on making the screens more readable, making the screens more preferable than printed versions is yet not a solved issue for researchers and designers. Since, nonetheless, there was not a

definite assent regarding using serif or sans serif in electronic environments, improving the reading performance still is a concern for designers. In this regard, the purpose of this study is to investigate speed and accuracy of participants while proofreading texts written in serif and sans serif with misspelled words on computer screen. Participants' eye behavior patterns during reading the misspelled text were compared in serif and sans serif typefaces during the proofreading process and task completion period and accuracy of the participants were compared. The research questions of the study as follows:

- Do participants' eye movement behavior changes in the serif and sans serif font styles while detecting the misspelled words?
- Is there any difference in the accuracy of finding the misspelled words with serif and sans serif typeface?
- Is there any difference in task completion time of the participants of finding the misspelled words with serif and sans serif font styles?

2 Method

A case study design was used to explore how participants' eye behavior differed according to the serif and sans serif typeface during proofreading task. 10 graduate students (4 female and 6 male) from Computer Education and Instructional Technology department participated to the experiment voluntarily. The participants' age was ranging from 21 to 43 ($M = 27.5$). Each participant proofread two six-page articles written in Serif and Sans Serif typeface for finding the misspelled words from screen. Researchers informed the participants about the ethical issues by a consent form including information regarding the process. In addition, all participants were informed about they are free to end the session whenever they feel uncomfortable or disrupted. Before starting the data collection, pilot study which consists of two pages text with misspelled words was conducted before the experiment to enable participants familiar with the apparatus and the experiment.

2.1 Apparatus and Procedure

During the experiment, each participant proofread two six-page articles taken from a novel for finding the misspelled words while reading from an LCD screen. The articles selected from the novel include 1548 to 1694 words. While determining the articles, it was our concern to find articles including no digital number or symbols. Each participant proofread one article in Serif typeface (Times New Roman) and one article in Sans Serif (Arial) typeface. Each article has about 24 lines for both font styles, 12-point version, and double space line spacing option was used. The proofreading sessions were recorded and each session took approximately 15 min. The main task in this study was to proofread the pre-determined misspelled words in the text to compare the speed and accuracy of the participants. Participants were informed that there were one to ten misspelled words in the texts and they would be evaluated by their accuracy and speed

during the proofreading. In the experiment, four types of misspellings were used in each article; letter omissions, letter substitutions, letter transpositions and letter additions. Eye movements were measured by using Tobii 1750 eye tracker device in a laboratory setting, which has voice and video recording equipment. The data analyzed by Tobii Studio 3.2.1 software. The reading distance was set to 60 cm by the researchers for providing the best eye movement catching ability to the eye tracker device. Participants were informed about keeping the distance from screen as much as possible to prevent the eye behavior lost. Before the experiments each participant's eye movements were calibrated. For each experiment instead of scrolling, participants were asked to press any button for continuing the next page to keep the similarity as much as possible. During the experiment, the participants were asked to tell the misspelled word aloud to the researcher. There was no time limitation in the experiment and were tracked by using a stopwatch and recorded by the cameras settled in the laboratory setting (Fig. 1).

Böyle dersen pek bir keyiflenir, çiçeklenirler." Asya başka soru sormadan boyamasına geri döndü. Palyaçosunun elbiselerini turuncuya, dişlerini yeşile boyadı. Tam ayakkablarını kan kırmızıya boyayacakken aniden durup, şımarık bir edayla anneannesini taklit etmeye başladı. "Canım canım! Aman da aman! Toprak annen, su baban. "Gülsüm Nine'nin kaşları çatıldıysa da bir müddet durumu fark etmemit gibi davrandı. Bu kayıtsızlıktan cesaret bulan Asya taklitçiliğinin dozunu artırdı.

Süpermarketler asabı bozuk ve kafası karışık kadınlar için tuzaklarla dolu tehlikeli yerlerdir. En azından Rose gibi kadınlar için. Ne zaman süpermarkete girse ihtiyacı olmayan bir sürü ıvır zıvır sepetine dolduruyor Rose. Ama bu sefer aynı hatayı tekrarlamamaya kararlı. Bu kez hakikaten ihtiyacı olan şeylerden başkasını almayacak. Söz verdi kendine. Bu kararlılıkla bebek bezlerinin bulunduğu koridora yollandı. Hem oyalanmanın zamanı değildi.

Fig. 1. Screenshot from the texts written in serif and sans serif typefaces

3 Findings

Before the experiment, demographic information regarding the computer, internet usage experience and reading preferences were gathered. The results showed that all participants have at least 5 years of experience on computer usage ($M = 12.8$, $SD = 3.45$) and using the internet at least 4 h in a day ($M = 8.5$, $SD = 3.26$). Most of the participants ($N = 8$) did not take a training for speed reading. Participants were also

asked about their preferences in which environment they were feeling more focused during reading. Most of the participants ($N = 7$) expressed that they were focusing better on paper than screen. They were also asked to compare the screen and paper medium in terms of non-stop reading activity, most of the participants ($N = 6$) preferred paper than screen ($N = 1$). Some participants ($N = 3$) explained that both medium are the same for them during non-stop reading activity (See Table 1). Participants' reading experiences and their mostly preferred media (screen and paper) for reading (newspaper, article, and books) were explored. Most of the participants ($N = 7$) preferred to read books from paper instead of screen. On the other hand, they preferred to read articles ($N = 6$) and newspaper ($N = 8$) from screen than paper (Fig. 2).

Table 1. Demographics of the participants

		N
Internet usage (day/hour)	3–5 h	1
	5–7 h	3
	More than 7 h	6
Training for speed reading	Yes	2
	No	8
Focusing better during reading	Screen	3
	Paper	7
Non-stop reading time comparison	Screen	1
	Paper	6
	Same	3

Asya Kazancı, bazı insanların doğum günlerine neden bu kadar bayıldığını bilmiyordu ama en azından o tür insanlardan olmadığını biliyordu. Dergi günlerinden nefret ederdi. Belki bu derin hoşnutsuzluğunun nedeni, küçüklüğünden beri her yaş gününde aynı lezzetsiz pasta

Fig. 2. A gaze plot from the misspelled word search process

In terms of the accuracy between these two typefaces during proofreading, participants found more misspelled words in total in sans serif ($M = 16,4$) than the serif typeface ($M = 14,7$). Moreover, they had completed the tasks in sans serif in a shorter period of time ($M = 9,10$) than the serif typeface ($M = 9,96$) (See Table 2).

The eye behavior analysis showed that participants fixated more on serif typeface texts ($M = 264, 55$, $SD = 58$) than sans serif typeface text ($M = 241, 66$, $SD = 43$). In that vein, participants spent more time on serif typeface text ($M = 91, 97$, $SD = 23, 33$) while proofreading the document than sans serif typeface text ($M = 85,23$, $SD = 18,2$) (See Table 3).

Participants' accuracy in finding different types of misspelled words was also explored. In serif typeface participants found the "letter transposition" (70 %) and letter addition (67 %) types of misspelling more than the other types. In sans serif typeface,

Table 2. Mean proofreading rate (words/min) and accuracy (% hits) in serif and sans serif typeface.

	Serif (TNR)		Sans serif (Arial)	
	M	SD	M	SD
Accuracy	14,7 (61 %)	3,5	16,4 (68 %)	3,71
Task completion time	9,96*	3,73	9,10*	4,96

Table 3. Eye movement parameters comparison for Serif and sans serif typefaces

		Fixation count		Total visit duration		Fixation duration	
		M	SD	M	SD	M	SD
Serif	Misspelled AOI (all)	264,55	58	91,97*	23,33	0,25	0,02
Sans serif	Misspelled AOI (all)	241,66	43	85,23*	18,2	0,25	0,03

*sec

letter addition and letter substitution types were mostly recognized misspelled words in the text than the other misspelled words. The eye behavior metrics showed that in specific types of misspelled words fixation count numbers were differed in serif and sans serif typeface (See Table 4).

Table 4. Accuracy (% hits) and fixation counts on the misspelled words AOI for serif and sans serif typeface.

	Serif (TNR)			Sans serif (Arial)		
	(% hits)	Fixation count		(% hits)	Fixation count	
	N	M	SD	N	M	SD
	Letter substitution	26 (43 %)	60	26	45 (75 %)	70,8
Letter addition	40 (67 %)	81	26	45 (75 %)	61,5	24
Letter omission	37 (61 %)	56,5	14	34 (57 %)	56,5	21
Letter transposition	42 (70 %)	67	28	39 (65 %)	52,8	19

4 Discussion and Conclusion

In this study, reading electronic text in serif and sans serif typefaces were compared. In general it was found that participants read from sans serif typeface faster and more accurate than serif typeface. According to findings, there was no difference in participants' fixation duration in serif and sans serif typeface while proofreading task. This might be a result of the limited number of participants, which could not provide a significance among these two typefaces. Even though the total fixation durations on the whole texts were not differed, the fixation duration values for misspelled words and fixation counts on misspelled word AOI and in the whole document differed. The longer fixation durations might be related with having trouble or difficulty in eliciting

information (Just and Carpenter 1980). Accordingly, the difference in total fixation duration also might be an indicator for revealing the cognitive process (Salvucci 2001). On the other hand, the total visit durations and fixation count numbers of the participants differed in serif and sans serif typefaces. The increase in fixation count number is considered as an interest to a specific area or cognitive processing (Holmqvist et al. 2011; Doherty et al. 2009). Accordingly, the total visit duration during the proofreading was higher in serif typeface than sans serif typeface. This might be a result of the struggle in the serif typeface while recognizing the misspelled words. Of course this single study cannot prove that one typeface is definitely better than other. However, the findings show some similarities with the previous recent studies (Tullis et al. 1995; Boyarski et al. 1998). So, practitioners may use those user performance scores to make decisions on their typeface selections for electronic text. The major limitation in eye-tracking research is the limited number of participants and lack of demographic diversity. This study may be replicated with a larger number of participants from various demographic diversity and reading experiences to compare the reading patterns through electronic environments. Additionally, different parameters like reading from different media can be another future study to explore how people read from environments like mobile phone and tablets.

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