TYPOGRAPHY
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Typography in Publication Design

The use of eye-tracker technology to evaluate typefaces, Greek fonts and publication design for screen.

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Abstract: The aim of this paper is to present how the technology of eye-tracker can be used to research typography and publication design for screen applications. Various studies have already been done on the ways that the eyes pause—and for how long on words—nonetheless using an eye-tracker to explore the role of letterform characteristics on screen still encourages further investigation, especially for fonts in Greek, where similar evaluation research was not found. The present study sets two major screen-based typefaces, Verdana and Georgia in Greek, and examines as well as it compares reading-speed and viewers' preferences between the two. Using a within-subjects design, data were collected from 28 participants who read sentences and paragraphs set in different typographic parameters. Significant speed differences were found for lower-case paragraph-texts set in Georgia and upper-case single line sentences set in Verdana. The experiment provides a platform for further research by incorporating additional typographic and demographic variables to investigate.

Key words: eye-tracking, typography, Greek typefaces, publication design for screen.

1. Introduction

With the advent of online-technologies, a great deal of publication design has transferred from print to screen and the traditional print-medium is redefined. Books, magazines, newspapers, commercial or social catalogs, flyers—and much publication design are asked to be viewed on screen-based platforms. From television and computer screens to the mobile and tablet interfaces, Typography needs to be constantly researched and adjusted in new digital screen based environments where viewers are rapidly increasing and have access everyday.

In this paper we present a study that deals with a comparison between two typefaces, Verdana and Georgia set in Greek letterforms. Specifically, our aim is to investigate and derive typographic conclusions regarding their legibility and use for screen publication design. We have selected these two typefaces because both were specifically designed for screen-use, as well as for the reason that Verdana is without serifs and can be compared with Georgia that has. Additionally both typefaces are found by default on Mac and Pc platforms and users are already familiar with them. Designed by Matthew Carter, they were released in 1996 for major use on computers. In particular we ask two questions: (a) which of the two typefaces and size is better in upper-case form?—display typography and (b) which of the two typefaces and size is better in lower-case form?—running text. The contribution of this study lies on the investigation of legibility in Greek letterforms using eye tracking technology. In doing so, it extends in scientifically looking at reading speed in relation with upper or lower case fonts as well as different size values.

As the medium is changing from print to screen, more typographic research questions arise within this context. When designing an interface several parameters need to be considered like proper size for text, reading distance, screen size and resolution, contrast between text and background, consistency, content of information, who the viewers are, usability, scrolling, interface design and human interaction.

Figure.1 Eye tracker fixations and saccades on upper case Verdana text

Eye tracking is the process of measuring and analyzing the navigation of the viewer's gaze on visual stimuli, in our case typography (figure.1). It is an excellent tool that can be used to observe where, the way, and for how long the eyes move on specific visual information. When dealing with typographic research on screen, we can fascinatingly investigate macro and micro typographic parameters in respect of navigation and reading speed. Of course the hypothetical research questions are unlimited as minor interface changes can influence the overall readability and legibility experience on screen. For example, we can alter, compare and examine font type, size, colour, leading, line-width, tracking, kerning, contrast, grid or any other layout variables. An extra asset of this type of research is that studies can be done in addition to specific demographic variables such as ethnicity, people with special needs, different educational background, gender and various age groups.

Horton (1990) refers to significant factors for on-screen readability; namely the visual perception of the user and how the text is read (skimmed lightly, read word for word, or character by character), colour of the characters and the angle form which it is viewed. Geske (1996) tested the legibility of Helvetica type in three different sizes and in three different faces. He found no significant differences for legibility of 9, 10 and 12-point type in the regular face; however he noted that Helvetica bold increases legibility in comparison to Helvetica italics which were less legible. Forlizzi, Neuwirth, Boyarski and Regli (1998) remarked that Georgia was considerably easier to perceive and read being sharper than Times and Verdana. They compared serif and san serif fonts (on screen) and found that Georgia (serif) was more easily comprehended as opposed to Verdana (sans serif) but as regards to speed there was no difference.

Sara Quinn (2005) explains why Verdana, Georgia and Trebuchet work well on-screen. She claims they work because:

> *"… (1) their lowercase characters are slightly larger than the average typeface. This larger 'x-height' makes the character look bigger overall. The open spaces are slightly larger than average, so they don't seem to 'fill in'; (2) to limit jagged edges the curves are reduced to a minimum in the open spaces of the letters; (3) the letters are spaced further apart, in a more regular way, so they don't seem to touch; (4) some combinations of letters that might bump or overlap, like 'ft,' and 'fl,' are specifically drawn so that they have extra space between them; (5) Verdana, Georgia, and Trebuchet are installed both on Windows and Apple operating systems, making them universally available for use on any web page. Some people call these 'web-safe' fonts, because most users have them…."*

It would be interesting to examine with eye tracking the legibility of the Greek alphabet in various letterforms/ligatures respectively. Reading speed, typographical variables and accompanying pictures on screen were investigated by Beymer, Russell and Orton (2007), who under the overall speed metric found that Georgia was read 8.45% faster than Helvetica, although this difference was not marked down as significant. They also studied the distracting influence of pictures on reading speed and how images caught the reader's eyes. Larson (2007) remarked that the low resolution of computer screens is particularly unsuitable for fonts with serifs because low resolution screens cannot render serif type in small sizes, and that sans serif fonts render more cleanly onscreen since they have less fine detail.

Josephson (2008) studied the way in which a reader can conceive information, and concluded that it was perceived during the fixations and that no useful information was perceived while the eyes are moving. In addition, he found that the location of a fixation is not random and that fixation does not apply to all words, for instance short words such as "the" and "a" are commonly skipped. The same study concludes that the eyes can only read three to four letters, from left and right of a fixation during normal reading. He also points out that readers use information on the right of a fixation and do not use any letters on the left of the word that is currently being fixated on.

Beymer *et al* (2008), in a between-subject design study with 82 participants have found that there are significant differences of eye tracking measurements in respect of age and the participant's first language comprehension. Additionally they observed that smaller sizes are read slower and found no significant differences between serif and san-serif fonts after comparing Georgia and Helvetica on screen, even though serif reading was recorded to be moderately faster. Several researchers and typographers have explored the legibility of typefaces on screen using eye-tracking, and many studies have already taken place with various Latin fonts and less in Arabic. Al-Wabil and Remya (2010) examined Arabic Fonts at 12, 14 and 16pt sizes and found that participants read easier and faster the larger fonts than the recommended 12pt font in English texts.

In this study we set up an experiment using eye tracking to examine the reading performance between Verdana and Georgia set in Greek texts. We investigate font size, lower and upper case, single sentences and paragraph formats. Additionally we compare eye tracking findings with participants' aspects on given questionnaires.

2. Methodology

The study was set-up in two phases: an eye tracking experiment and a questionnaire. During the first phase we used a 3x2x3 within-subjects design and we collected data from 28 participants as shown in table 1. They were all graduate students at Cyprus University of Technology, age between 18-25 years old, 13 male and 15 female, all having Greek as their first language. We asked the participants to be seated approximately at a distance of 60-70cm from the computer screen and read separately in Verdana and Georgia: (a) single line sentences in lower and upper case and (b) various paragraphs set only in lower case for three different font sizes 10pt, 12pt and 14pt. Each text-format was presented in succession to avoid scrolling; the text used was taken from the university's web site profile and was never kept the same in any case. The line width was reserved between 70-

75 characters per line whether set in one sentence or paragraph whilst tracking and leading were adjusted automatically by default for each size and study. There was no hyphenation in the text and justification was left. The typefaces' colour was black on white screen.

	Verdana			Georgia		
	10	12	14	10	12	14
Lower case One-line text	lower case			lower case		
Upper case One-line text	UPPER CASE			UPPER CASE		
Lower case Paragraph-text	Paragraph text			Paragraph text		

Table 1. N=28, Typographic Parameters and Typeface design

The eye tracker that we used is SMI/iViewX system and we always calibrated its settings separately for each participant. Our eye tracker was automatically calculating the information using the SMI BeGaze™ 2.5 software which simplifies monocular and binocular tracking data analysis by structuring the information on experiments and subjects, as well as displaying the results as meaningful graphs—all in one advanced application.

Additionally in our experiment we utilized an extra tool of eye tracking equipment in order to collect our experimental data; the Reading Statistics which demonstrates in depth results, such as time aspect, when a participant spends a certain time period on reading a character, word, sentence or paragraph. Generally, the tool Reading Statistics indicates in detail, readability information extracted directly from the event properties, with average/max/min as the main statistic measurements.

In the second phase of the study, participants were asked to answer close-type questions regarding the readability and legibility of the typefaces used in the eye tracking experiment. The answers were compared with the scientific outcomes.

3. Results and discussion

The extracted results of the experiment derived from the following four parameters: (a) Fixation duration—the reading time on character, word, sentence or paragraph, for example longer fixation duration is often associated with the deeper and more effortful cognitive processing, measuring unit millisecond (b) Saccade duration—the distance-time between two fixations, measuring unit: millisecond (c) Fixation count—the number of

fixations on character, word, sentence, paragraph and (d) Saccade count—the number of saccades between fixations. Due to the fact that we wanted to gain the total readable time a subject spends on a character, word, sentence or paragraph, we summarized the results, filtered out from the two parameters (fixation duration and saccade duration) and therefore gather the overall time for each participant.

We then run paired samples T-tests to investigate any significant differences between the two typefaces.

Table 2 shows the average (M) of reading time, fixation and saccade counts for Verdana and Georgia set in lower case for one-line sentence of 70-75 characters. From the 3 different sizes investigated we can observe a significant difference on reading time for 10 pt Verdana being read faster than Georgia $p < 0.05$. Although there are time, fixation and saccade counts differences in 12 and 14 sizes as well, there was no any significant indication. In general it seems that lower-case Verdana is read faster when set in one line of 70-75 characters sentence text; however only for 10pt size this was evident.

Reading Statistics	Size	Verdana	Georgia	Significant difference?
Reading time (ms) (fixation and saccade duration)	10	3795,1613	4685,6871	yes
	12	3817,7484	4108,8290	no
	14	4002,4226	3883,3226	no
Fixation count	10	10,8710	11,8710	no
	12	11,9677	11,6129	no
	14	12,4839	11,9032	no
Saccade count	10	10,1935	10,8710	no
	12	11,2258	10,5161	no
	14	11,8065	10,8065	no

Table 2. Reading statistics examining type size between Verdana and Georgia set in one-line sentence of 70-75 characters **lower case** Greek text

In table 3 we examined possible differences for one-line sentences of 70-75 characters set in upper-case Verdana and Georgia. In this instance the results are more consistent in predisposing that Verdana capital is read faster than Georgia capital, however, significant

differences were found only on averages (M) for sizes 10pt and 14pt, $p < 0.05$. There were also differences in fixation and saccade counts but they were only significant for 14pt size.

Reading Statistics	Size	Verdana	Georgia	Significant difference?
Reading time (ms) (fixation and saccade duration)	10	4213,3871	4752,0742	yes
	12	3595,2065	4099,1645	no
	14	3709,1452	4863,1032	yes
Fixation count	10	12,8710	12,6129	no
	12	12,2258	12,5484	no
	14	13,0645	15,4194	yes
Saccade count	10	12,5484	11,7419	no
	12	11,8387	11,6774	no
	14	12,3548	14,7097	yes

Table 3. Reading statistics examining type size between Verdana and Georgia set in one-line sentence of 70-75 characters **upper case** Greek text

In table 4 we investigated the reading performance using text set in paragraph format and we compared lower-case Verdana and Georgia in 3 different sizes. Interestingly we found significant average (M) differences suggesting that Georgia is read faster in 10pt and 14pt, sizes, $p < 0.05$ but not in 12 pt. Fixation and saccade counts were always less for Georgia over Verdana but they were found to be significant only for 10pt and 14pt sizes.

Reading Statistics	Size	Verdana	Georgia	Significant difference?
Reading time (ms) (fixation and saccade duration)	10	12044,3581	8760,4161	yes
	12	9422,9774	9746,8839	no
	14	11139,5258	6267,5710	yes
Fixation count	10	33,4194	23,3871	yes
	12	29,0323	27,3871	no
	14	33,8065	18,9677	yes
Saccade count	10	32,2581	22,0968	yes

	12	27,4516	25,7742	no
	14	32,4194	18,2903	yes

Table 4. Reading statistics examining type size between Verdana and Georgia set in **paragraph format** lower case Greek text

In the second phase of the study we asked the participants to fill in an online questionnaire, once they were done with the eye tracking experiment. Our aim was to compare our scientific indications with the viewers' opinion on the Typographic variables examined. For this reason we have shown them a series of sentences, again using text from the University's web site (figure.2) and we asked then what they think regarding their legibility.

οι σημαντικές τεχνολογικές εξελίξεις των τελευταίων χρόνων έχουν επιφέρει	(verdana lower case)
σημαντικές μεταβολές στους τρόπους επικοινωνίας και διάδοσης πληροφοριών	(georgia lower case)
ΜΕ ΑΠΟΤΕΛΕΣΜΑ Η ΧΡΗΣΗ ΤΩΝ ΠΟΛΥΜΕΣΩΝ ΚΑΙ ΤΩΝ ΓΡΑΦΙΚΩΝ ΤΕΧΝΩΝ ΝΑ ΕΧΕΙ ΕΔΡΑΙΩΘΕΙ	(VERDANA UPPER CASE)
ΑΝΑΜΕΣΑ ΣΤΟΥΣ ΠΙΟ ΑΠΟΤΕΛΕΣΜΑΤΙΚΟΥΣ ΤΡΟΠΟΥΣ ΔΙΑΔΟΣΗΣ ΜΗΝΥΜΑΤΩΝ ΚΑΘΗΜΕΡΙΝΑ	(GEORGIA UPPER CASE)

Figure.2 One-line, 70-75 character sentences used in the questionnaire and the experiment

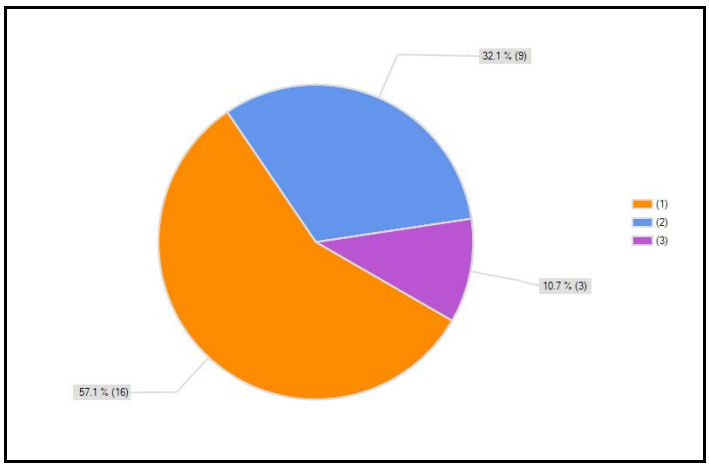

Figure.3 Pie chart showing participants' preferences between Verdana & Georgia set in lower case

Figure 3 shows that 57.1% thought that text set in Verdana 12pt, lower case, single-line of 70-75 characters is more legible compared to 32.1% of Georgia respectively. A 10.7% of the participants did not notice any reading difference or preferences between the two.

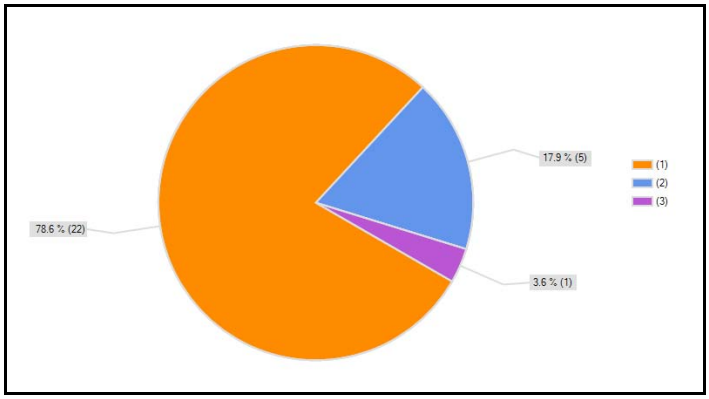

Figure.4 Pie chart showing participants' preferences between Verdana & Georgia set in upper case

Additionally 78.6% thought that text set in Verdana 12pt, upper case, single line of 70-75 characters is more legible compared to 17.9% of Georgia respectively. A 3.6% of the participants did not notice any reading difference or preferences between the two, and finally,

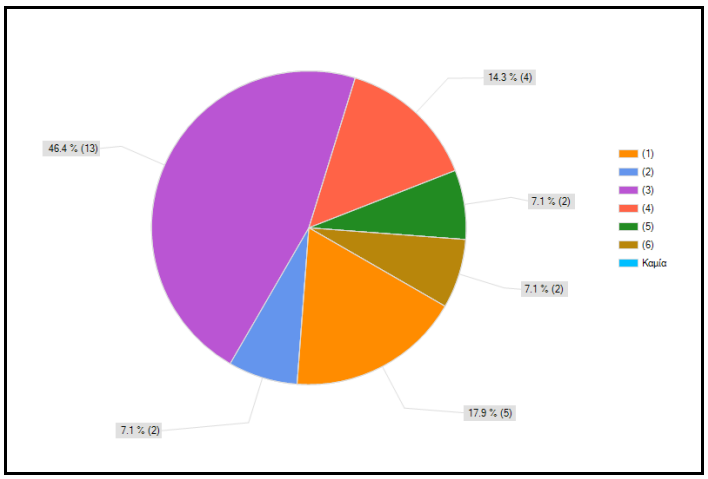

Figure.5 Pie chart showing participants' preferences between Verdana and Georgia set in lower case paragraph texts for 10pt, 12pt and 14pt sizes.

Figure 5 shows that 46.4% thought that text set in Verdana 12pt, lower case, paragraph format is more legible and appropriate for running text on screen, compared to 14.3% of Georgia respectively. A 17.9% thought that text set in Verdana 10pt, lower case, paragraph format is more legible compared to 7.1% of Georgia respectively and finally 7.1% thought that text set in Verdana or Georgia 14pt lower case paragraph format are more legible. Briefly the order of the participants' preference on legibility was Verdana 12pt (46.4%), Georgia 12pt (14.3%), Verdana 10pt (17.9), Georgia 10pt (7.1%), Verdana 14pt (7.1%) and Georgia 14pt (7.1%).

4. Conclusions

It is definitely fascinating to use an eye tracker for evaluating Typographic variables; there are unlimited combinations that a researcher can investigate using this technology. Our aim was to examine how Greek letterforms 'behave' on screen. For this reason we chose Verdana and Georgia, both designed for screen use, and we compared reading speed and various formats between the two.

Specifically, we found that Verdana at 10pt size in lower-case within a single-line sentence of 70-75 characters was read faster than the 10pt of Georgia respectively; all other sizes under these parameters showed no significant differences. Additionally when text was set in upper-case within a single-line sentence of 70-75 characters, Verdana at 10pt and 14pt sizes were read faster than 10pt and 14pt of Georgia respectively, whilst 12pt size had no significant difference. Under the same parameters we have noticed a significant difference on fixation and saccade counts for 14pt size indicating that text set in Georgia requires more cognitive processing at bigger size. Interestingly things changed when we compared these two typefaces in longer lower-case running texts. When we asked the participants to read text within paragraphs, we found that 10pt and 14pt Georgia were read faster than 10pt and 14pt Verdana respectively, whilst 12pt size had no significant difference again. Under the same parameters we have noticed a significant difference on fixation and saccade counts for 10pt and 14pt size indicating that text set in Georgia—when set in lower case—requires less cognitive processing than in Verdana. Finally, from the questionnaires we saw that participants thought Verdana to be in general more legible and preferable than Georgia, however using eye tracking we saw that Georgia was read faster especially in running lower-case text 10pt and 14pt sizes and nothing for 12pt that the 46.4% of the participants had preferred.

The pre-mentioned findings are indicative under the circumstances and parameters set during their investigation. Our outcomes encourage and provide a platform for future research. By using a bigger sample of participants as well as conducting between-subjects experiments we will be able to investigate further demographic and typographic variables within a bigger variety of parametric combinations as well as explore additional interface and screen publication design suggestions.

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