SIE 2015
6th International Symposium on Industrial Engineering
24th-25th September 2015
FACULTY OF MECHANICAL ENGINEERING
STEINBEIS ADVANCED RISK TECHNOLOGIES
INNOVATION CENTER FME

REVIEW OF THE ON-SCREEN READABILITY RESEARCHES

Ljiljana D. Ristić
Ph.D. candidate, Faculty of Mechanical Engineering, Belgrade, Serbia

Abstract: *Since that the computer has become a common platform for the dissemination of information, it is very important, how are those information presented on VDT screens. In this regard, improvement of the readability can significantly enhance the quality of represented information. This review considers certain crucial characteristics that define the successful application of the readability concept.*
Key words: *readability, tipeface, computer display.*

INTRODUCTION

There are three main concepts that define the quality of presentation of symbols on VDT screens. These are the visibility, legibility and readability (Klarin and Zunjic, 2007; Zunjic, 2013). Mentioned concepts posses certain similarities and differences. Visibility is an important characteristic that influences on the possibility of detection of objects displayed on a VDT screen (Zunjic et al, 2012a). In the broadest terms, legibility can be described as the convenience of reading, with regard to the differentiation between alphanumeric characters (Zunjic, 2004). Readability is what makes some texts easier to read from others. It is often confused with legibility. Kember and Varley maintain that readability is reflected in the reading process, while legibility relates to the capability to differ the individual characters. Zunjic (2013) gives the precise rules for making distinctions between the mentioned concepts. The importance of these concepts is widely recognized. They have been found the appropriate applications in certain global VDT checklists (for example Zunjic et al, 2012b), as well as in standards (for example ISO). Application of such standards can provide efficient user experience (Zunjic, 2012c). However, the accent of this paper is on certain characteristics that determine the readability.

"George Klare (1963) defines readability as the ease of understanding or comprehension due to the style of writing. This definition focuses on writing style as separate from issues such as content, coherence, and organization. In a similar manner, Gretchen Hargis and her colleagues at IBM (1998) state that readability, the ease of reading words and sentences, is an attribute of clarity. The creator of the SMOG readability formula G. Harry McLaughlin (1969) defines readability as: the degree to which a given class of people find certain reading matter compelling and comprehensible. This definition stresses the interaction between the text and a class of readers of known characteristics such as reading skill, prior knowledge, and motivation. Edgar Dale and Jeanne Chall's (1949) definition may be the most comprehensive: The sum total (including all the interactions) of all those elements within a given piece of printed material that affect the success a group of readers have with it. The success is the extent to which they understand it, read it at an optimal speed, and find it interesting."

THE READABILITY FACTORS

There are several important factors which influence the on-screen text readability:

a) Font type („serif" – Times New Roman and „sans serif"- Arial).
b) Type size
c) Screen resolution
d) Format (dot-matrix, anti-alians).

Font type

There are thousands of fonts and font variations that could potentially be used on a web site, but the vast majority of these fonts will not work for most users on the web because computers can display only the fonts installed on the computer, and not all computers have the same fonts installed.

Two categories are often „serif" – Times New Roman and „sans serif"- Arial. Serif fonts are characterized by the flared extensions, or strokes, on the tips of such letters as f, l, and i, as can be seen in

the Figure 1. An example of the serif fons are presented in Figure 2.

Figure 1. Serif fonts

Serif fonts also usually have a combination of thick and thin strokes, as seen in the curve of the letter "f" above. Examples of serif fonts include Times New Roman, Georgia, and Book Antiqua.

Times New Roman (AaBbCc...MmNn...WwXxYyZz)
Georgia (AaBbCc...MmNn...WwXxYyZz)
Book Antiqua (AaBbCc...MmNn...WwXxYyZz)

Figure 2. Examples of serif fonts.

Sans-serif fonts have plain endings, and appear blockier than serif fonts. They do not have the flared extensions, strokes, or other kinds of ornamentation (Figure 3).

Figure 3. Sans serif fonts.

"Sans" means *without*, and "serif" refers to the extra *strokes*, or *lines*. Sans-serif fonts include Arial, Tahoma, Trebuchet MS, and Verdana (Figure 4).

Arial (AaBbCc...MmNn...WwXxYyZz)
Tahoma (AaBbCc...MmNn...WwXxYyZz)
Trebuchet MS (AaBbCc...MmNn...WwXxYyZz)
Verdana (AaBbCc...MmNn...WwXxYyZz)

Figure 4. Examples of the sans-serif fonts.

By far two of the most common typefaces currently being used within electronic mediums such as the World Wide Web (Web), are Times New Roman (Times) and Arial (Ramsden, 2000). The popularity of these two typefaces is ostensibly caused by the fact that most computer operating systems today are pre-configured to have Times as the default serif typeface, whereas Arial has generally served as a popular sans serif alternative to Times.

Tipe size

Typically, the presentation of Times and Arial has been displayed in either 10- or 12-point sizes on the Web. The size that is used is often determined at least in part by the x-height (the height of the torso for lower-case letters, or simply the height of a lowercase 'x') of that particular typeface. For example, Arial, which has a proportionally larger x-height than Times, is often displayed in a smaller text size—such as a 10-point size—whereas Times is often displayed in a 12-point size, giving them approximately the same x-height and general appearance in height. To a certain degree, larger text sizes are considered more readable than smaller sizes (Bouma, 1971; Rudnicky and Kolers, 1984) for print-based research and Mills and Weldon, 1987 for screen-based research). Yet the differences between text sizes are often not significantly apparent until the size differences become quite large (Tinker,1963).

Screen resolution

The few studies that have examined online reading have generally found that commonly used typefaces of around 11-point sizes or more, are generally readable on screen resolutions as small as 1024_768 pixels. For example, in examining the readability of different type sizes on computer screens with this size resolution, Tullis et al. (1995) found no significant differences between 9-point Arial, 9.75-point MS Serif and MS Sans Serif, and 9-point Arial typefaces. However participants reading the smaller, 6-point Small Fonts and 7.5-point Arial were found to be less accurate in detecting typographical errors than when reading the larger, 9 and 9.75-point Arial and 9.75-point MS Sans Serif typefaces.Moreover, using a lower screen resolution of 640x480, Boyarski et al. (1998) found that 10-point serif (Times and Georgia) and sans serif (Verdana) typefaces were equally readable (a 10-point typeface has a character height close to 4 mm at this resolution, which is similar to a 12-point size at1024x768 pixels).

Format

One such display characteristic is the aliasing or 'stair-casing' phenomenon that is associated with the dot-matrix characters on computer screens which, in effect, can make letters look jagged on medium to low-resolution screens. Efforts to lessen the aliasing effects associated with dot-matrix characters have been accomplished through the use of anti-aliasing techniques, which produce 'smoothed' text within a graphical image (such as JPEG or GIF files) or use formats such as AdobeTM Portable Document Format (PDF) files (Figure 5). Anti-aliased formats are designed to make text more readable by adding several shades of darker contrast—such as gray—to the aliased area as a means to reduce the contrast differences between the background and the characters. However, this type of smoothing can blur the letterforms somewhat, possibly making anti-aliased text less readable for particular typefaces and sizes of text than the equivalent in a dot-matrix format. To date, little research has been conducted that examines the impact of antialiased versus dot-matrix formats on text readability; the few studies that compared text in these formats were met with mostly inconclusive results. For example, Gould et al. (1987) found no evidence of any effect on reading for anti-aliased text compared to dot-matrix text, but

participants generally preferred the anti-aliased text (consisting of a 10-point serif typeface with a character height of 3.5mm at a resolution of 1024x768 pixels). A more recent study by Boyarski et al. (1998) compared anti-aliased text to dot-matrix text and also found no significant differences in readability. Their results concerning the perceived readability of the two formats were inconclusive as well. The results indicated that a Microsoft antialiased text, but not Adobe anti-aliased text, was considered more readable than the compared dot-matrix text. The Boyarski, et al. study used a 16-point, anti-aliased serif typeface at a screen resolution of 640x480 pixels. These studies did not, however, examine typeface and size differences within dot-matrix and anti-aliased formats. Today it is quite common for computer displayed documents—particularly within web-sites—to have medium-sized (10 and 12-point) dot-matrix and antialiased text.

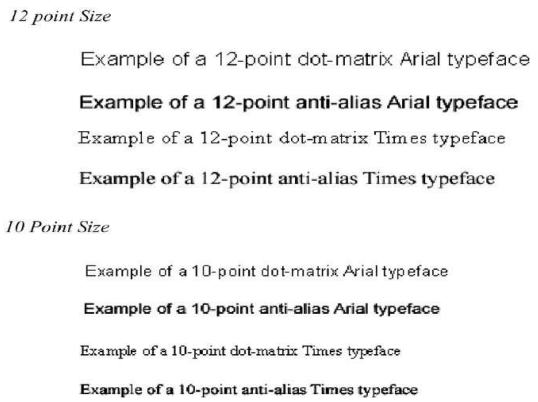

Figure 5. Examples of dot-matrix and anti-aliased text.

It is apparent there is a need for a better understanding of the relationship between typeface, size, and format.

RESEARCHES OF READABILITY

Bernand (2003) was one of his empirical research studies comparing these factors in terms of subjective and actual readability. The question addressed was: what typeface (serif, Times or sans serif, Arial), size (10 or 12-point), and format (dot-matrix or anti-aliased) are most readable (objectively and subjectively), and are most preferred for reading on a computer display?

The study included thirty-five undergraduate and graduate students. Most participants (86%) reported reading from computer screens a few times or more per week. For the experiment, was used a Pentium II based PC computer, using a 60 Hz, 96dpi 17-in high-resolution RGB monitor with a resolution of 1024x768 pixels was used. This resolution was chosen in order to reflect the current trend towards higher resolution settings (Georgia Tech Research Corp., 1998). The light sources were located overhead and to the participants' side in order to reduce glare on the screen. The format of the presented text was presented as an HTML web page. The browser used was Microsoft's Internet Explorer 5.0, which was configured to display only the URL address bar.

The text variations used were the 10- and 12-point Times and Arial proportional typefaces that are typically included within Microsoft's Office software suites. At the resolution used in that study, the 10 and 12-point typefaces had a point height of 3.5 and 4.2 mm, respectively. Times had an approximate x-height of 1.8 and 2.0mm for the respective 10 and 12-point sizes. Arial had an approximate x-height of 2.0 and 2.5mm for the respective 10 and 12-point sizes. To create anti-aliased text, Adobe Acrobat's PDF was used because it is currently the most widely used anti-aliased text document format file.

Their task was assigned to read eight passages as accurately and as quickly with the replacement of words that were presented in random passages. Reading time was measured by the recording in seconds the time taken to read each passage. A stopwatch registered the time taken to read each passage.

Objective text: analyzing the percentage of detected substituted words for each typeface/size/format combination revealed no significant differences ($p > 0:05$) in accuracy for typeface, size, or format. A possible explanation for this outcome is that participants did, in fact, slow their rate of reading for a less readable text combination to achieve roughly the same level of accuracy. To test this, the participants' adjusted accuracy scores were examined.

Subjective text: a significant main effect of type size [$F(1, 34) = 20.34$; $p<0:001$] was found for perceived sharpness. Pairwise comparisons revealed that text at the 12-point size ($M = 4:6$) were perceived as being sharper than at the 10-point size ($M = 3:9$). This is probably due to the greater perception of text readability at the larger, 12-point size.

Participants were asked to rank each text combination from the most to the least preferred. The most preferred type was 12-point dot-matrix Arial ($M = 5:7$), followed by both 12-point dot-matrix Times and 12-point anti-aliased Arial text ($M = 5:4$ for both). Together these text conditions were significantly preferred over the other conditions [$w2(7;N = 35) = 137$; $p< 0:001$]. In addition, 10-point antialiased Times ($M = 0:6$) was significantly less preferred than all of the text conditions except 12-point anti-aliased Times and 10-point dot-matrix Times. Examining only the participants' first and second preference choices reveal the overall tendency for 12-point dot-matrix and anti-aliased Arial, as well as 12-point dot-matrix Times to be most preferred. Overall, 87% of the participants

chose one of them as their first or second choice. Neither the 10-point dot-matrix nor anti-aliased Times was ranked first or second by any participant.

Times New Roman and Arial typefaces in 10 and 12-point, dot-matrix and anti-aliased format conditions were compared for readability (accuracy, reading speed, and accuracy/ reading speed), as well as perceptions of typeface legibility, sharpness, ease of reading, and general preference.

In this staudy proved that Bernand (2003) the 10-point anti-aliased Arial typeface was read slower than the other type conditions. Examining perceptions of typeface legibility, sharpness, and ease of reading detected significant effects for typeface, size, and format. Overall, the 12 point dot-matrix Arial typeface was preferred to the other typefaces. Recommendations for appropriate typeface combinations for computer-displayed text are discussed.

CONCLUSIONS

The rapid development of information technology leads to a massive use of various media with display screen (computers, phones, ect) and therefore a growing need to test.

The effect of size, type and format on the perceptions of reading performance, did however, produce significant differences. Text at the 12-point size produced significantly greater subjective readability (perceptions of text legibility and sharpness) and had lower levels of perceived difficulty in reading than text at the 10-point size. Text at the 12-point size was also significantly preferred to text at the 10-point size. Participants also perceived Times at both 10- and 12-point sizes as significantly more difficult to read than Arial, even though 10-point Arial and 12-point Times have approximately the same x-height. It is possible the serifs and the narrow character spacing of Times affected its perceived readability.

Future studies could extend this research by examining a greater number of typefaces or sizes in both aliased and anti-aliased formats. In addition, as with all studies that examine reading performance with different typefaces, caution should be made in generalizing these outcomes to other typeface combinations. Many factors should be taken into account, such as style and size of text, the line and character spacing, the computer settings and the user characteristics, such as age and reading ability.

REFERENCES

1. Klarin, M. and Zunjic, A, 2007, Industrial ergonomics (in Serbian), Faculty of Mechanical Engineering, Belgrade, Serbia.
2. Zunjic, A., 2004, Software-generated factors of discrimination of alphanumeric symbols (in Serbian), Proceedings of the Yugoslav scientific symposium on Ergonomics, pp. 49-52, Ergonomics Society of F.R. Yugoslavia, Belgrade.
3. Zunjic, A., Ristic, Lj. and Milanovic, D.D., 2012a, Effects of screen filter on visibility of alphanumeric presentation on CRT and LCD monitors, Work (41), pp. 3553-3559.
4. Zunjic, A., Milanovic, D.D., Milanovic, D.L., Misita, M. and Lukic, P., 2012b, Development of a tool for assessment of VDT workplaces - A case study, Industrial ergonomics (42), pp. 581-591.
5. Zunjic, A., 2012, Some problems of implementation of standards in the field of human - computer interaction, Proceedings of the 5th International symposium on Industrial engineering, University of Belgrade, Faculty of Mechanical Engineering, Belgrade, pp. 241-244.
6. Zunjic, A., 2013, Elements of the interface in human - computer system (monograph), Faculty of Mechanical Engineering, Belgrade.
7. Bernard, M.L., Chapparo, B.S., Mils M.M. and Halcomb, C.G., 2003, Comparing The Effects Of Text Size And Format On The Readibility Of Computer-Displayed Times New Roman And Arial Text, International Journal of Human-Computer Studies (59), pp. 823-835.
8. Ramsden, A., 2000, Annabella's HTML help. From: http://www.geocities.com/annabella.geo/fontface.html.
9. Tinker, M.A., 1963, Legibility of Print, Iowa State University Press, Ames, IA.
10. Georgia Tech Research Corporation., 1998, GVU's WWW User Survey. From: http://www.gvu.gatech.edu/user surveys
11. Boyarski, D., Neuwirth, C., Forlizzi, J., Regli, S.H., 1998, A study of fonts designed for screen display, Proceedings of CHI' 98, pp. 87–94.
12. Bouma, H., 1971, Visual recognition of isolated lower case letters. Vision Research (11), pp. 459–474.
13. Rudnicky, A.I., Kolers, P.A., 1984, Size and case of type as stimuli in reading. Journal of Experimental Psychology in Human Perception and Performance (10), pp. 231–249.