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LEGIBILITY ANALYSIS OF SELF-DESIGNED TYPEFACE WITH EYE-TRACKING DEVICE

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Abstract: *Typography appears in every aspect of our lives. It is closely intertwined with the representation of information, communication, and our cultural and national identity. Until the invention of computer in printing, only a few typefaces were in use. Then, almost overnight, a flood of new typefaces appeared in different type styles or in their combinations. Nowadays, a vast number of tools is available for designing typefaces, enabling almost anyone to do it. Nevertheless, not every typeface is well designed and useful, i.e. legible. A successful type design requires following the established aesthetic and technical principles. Moreover, it should follow perceptual principles. This study was concerned with evaluating the legibility of various useful typefaces in comparison to a self-designed typeface. The self-designed typeface was not based only on the principles of good legibility. Its design was based also on the paintings by the Slovenian Art Nouveau and later Impressionist painter Matija Jama, whose 150th birthday is celebrated this year. The Impressionist painter's typeface should not only have the qualities of artistic style, but also be usable, i.e. legible, for a longer text. To determine which type size is optimal for such a text, the test of legibility was conducted. The legibility of the self-designed typeface was analysed along with three other well-known and useful typefaces, i.e., an old style typeface (Minion), a transitional typeface (Bentham) and a sans serif typeface (Gill Sans). The reading speed and number of fixations were analysed using a Tobii 120X eye-tracking device. Different texts in all four typefaces in three different type sizes (i.e. 16, 21 and 26 px) were displayed on a 24-inch LCD display. The twenty tested individuals were aged between 19 and 23 years. The results showed that the choice of a particular type size affected the reading speed and legibility. It was also found that for some typefaces, different type sizes, when read, require more fixations. The results of our study show that a self-designed typeface is useful, i.e. legible, at larger type sizes. An appropriate type style and size can improve legibility on displays.*

Keywords: eye-tracking technology, LCD display, legibility, typeface, type size

1. INTRODUCTION

Typography appears in every aspect of our lives. It is closely intertwined with the representation of information, communication, and our cultural and national identity. Until the invention of computer in printing, only a few typefaces were in use. Then, almost overnight, a flood of new typefaces appeared in different type styles or in their combinations. Nowadays, a vast number of tools is available for designing typefaces, enabling almost anyone to do it. Nevertheless, not every typeface is well designed and useful, i.e. legible. A successful type design requires following the established aesthetic and technical principles. Moreover, it should follow perceptual principles. The communication through a page or display requires from the reader to translate symbols into meaning. Legibility refers to how easily this process is performed. To make reading possible, the text must be visible and recognisable; however, visibility and recognition are influenced by the typographical choice (Reynolds, 1988; Možina, 2001). Legibility and the reading process can be studied by tracking eye movement. Reading does not occur as a continuous movement of eyes along the lines of a text, but rather as a sequence of rapid eye movements (saccades) and individual fixations (cf. Figure 1). Fixations are short stops on individual words or groups of words which enable the brain to process information. They last between 200 and 250 ms (Rayner et al., 2001; Abadi, 2006), between 200 and 300 ms (Rayner, 1998), or even more (Feng, 2009). Saccades are extremely quick eye movements with which we change the direction of our gaze in a moment and align the image of the object of interest with the macula of retina. When reading, saccades move over groups of letters (Burr et al., 1982). Saccades are the most common type of eye movement; their speed can exceed 500°/s and an individual saccade may last from approximately 25 to 75 ms (Rayner, 1998; Leigh et al., 2015).

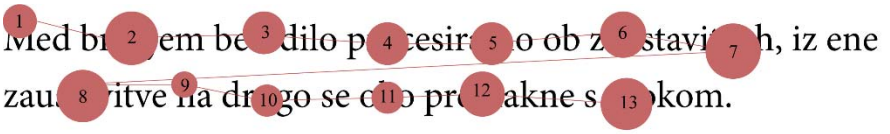

Figure 1: Eye movements (saccades) and fixations

A large number of studies on legibility points to its importance. There are some typographic characteristics to be observed to make a text more legible. For a small type size, it is known that differences in stroke weight and typographic tonal density (TTD) are significant (Rat et al., 2011; Možina et al., 2019), since they influence text legibility. Furthermore, a number of other typographic characteristics needs to be observed in order to make a text more legible, i.e. distinctive character features (counter shape), x-height, ascender, descender, serifs, contrast (stroke weight), set width, type size, leading (i.e. space between lines) etc. (Reynolds, 1988; Tracy, 2003; Franken et al., 2015).
For better visibility of information, colour can be of use as well (White, 1996). Most typefaces are designed to be read as black letters on a white background and they, in this manner, achieve optimum legibility. When reading large amounts of type, the contrast of black and white is what readers are most accustomed to (Carter, 1997; Možina, 2001). The legibility study (Franken et al., 2020) of different typefaces in different light-dark contrasts with different backgrounds displayed on an LCD display showed that a better contrast (however, not maximum, i.e. black on white) increases the reading speed.
The aim of this study was to examine the legibility of various useful typefaces in comparison to a self-designed typeface. The self-designed typeface was not based only on the principles of good legibility. Its design was based also on the paintings by the Slovenian painter Matija Jama, whose 150th birthday is celebrated this year. Matija Jama (1872–1947) studied painting at a private art school in Munich. After his Art Nouveau period, his work was influenced by the Italian and French Impressionists. The majority of his 450 well-known paintings are in oil technique. Jama was recognised for his landscape paintings; however, *vedute* and portraits are also greatly featured in his art. During his later years, he leaned more towards figuralism (Kocjan et al., 2015). The Impressionist painter's typeface should not only have the qualities of artistic style, but also be usable, i.e. legible, for a longer text.

2. EXPERIMENTAL PART

For the purposes of our research, we first analysed the self-designed typeface, entitled Mila (cf. Figure 2) and categorised it according to the classification of typefaces. Legibility was then tested in comparison to three established typefaces with similar design features. The old style typeface Minion, the transitional typeface Bentham and the humanistic sans serif typeface Gill Sans were used (McLean, 1996; Možina, 2003) (cf. Figures 3–5). The study was conducted by analysing texts in the Slovenian language from the book *Ernijeva kuhinja* (by Zoran Hočevar), using an eye-tracking device. Lastly, we analysed the results of the study.

Figure 2: Typeface Mila

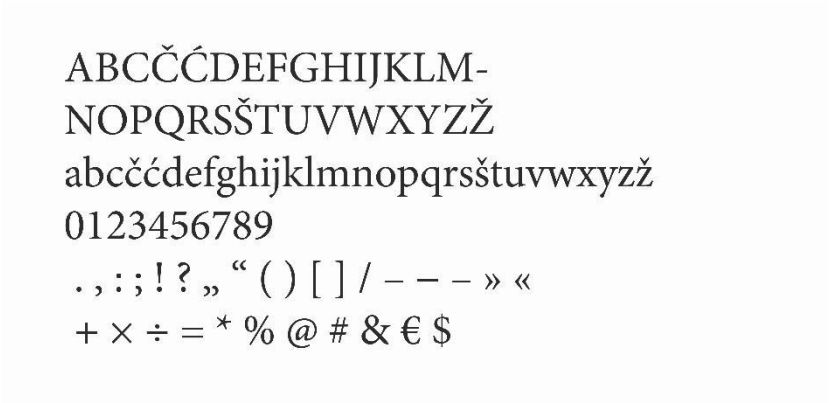

Figure 3: Typeface Minion

Figure 4: Figure Bentham

Figure 5: Typeface Gill Sans

In controlled laboratory conditions (*ISO 3664*, 2009), the reading speed, fixations and saccades were analysed with an eye-tracking device Tobii 120X. The texts in all four typefaces at 16, 21 and 26 px, were displayed on a 24-inch LCD display with the resolution of 1900 × 1200 pixels at a 120 Hz refresh rate. In each typeface, a different text was presented to tested individuals. We used 12 different texts with the length of around 70 characters per line (cf. Table 1). The texts were displayed in dark characters on light backgrounds (text colour #000000, background colour #EEEEEE).

Table 1: Selected texts for legibility analysis

Text number	Typeface	Type size (px)	Number of characters
1	Bentham	16	575
2	Bentham	21	569
3	Bentham	26	560
4	Mila	16	532
5	Mila	21	519
6	Mila	26	546
7	Minion	16	574
8	Minion	21	599
9	Minion	26	559
10	Gill Sans	16	611
11	Gill Sans	21	578
12	Gill Sans	26	566

The tested individuals were positioned 60 (±1) cm from the screen according to the recommendations of the ISO 9241-303 standard (2012). The texts were set in a CSS style sheet and displayed as an HTML document. In this way, we ensured a precise display of texts in the chosen size. The texts were displayed in the middle of the screen. Consecutive texts were invoked by successive mouse clicks.
There were 20 participants, 5 male and 15 female, aged from 19 to 23, with an average of 20.60 years; all participants had normal or corrected-to-normal vision. The participants read the same texts. We used the so-called Latin square design to vary the display sequence in order to prevent the possible fatigue effect with texts displayed towards the end of the experiment. The time required to read texts of different length, the number of fixations, saccades and the length of saccades (in number of characters) (cf. Table 2) were later calculated for 500 characters.

Table 2: Measurement data

Text number	Number of characters	Reading time (s)	Number of fixations	Number of saccades	Length of saccades (no. of characters)
1	575	32.02	353.80	352.80	2.23
2	569	32.62	349.25	348.25	2.13
3	560	30.58	331.75	330.75	2.07
4	532	33.85	330.70	329.70	2.34
5	519	30.82	288.00	287.00	2.33
6	546	32.04	352.10	351.10	1.92
7	574	31.49	322.60	321.60	2.30
8	599	32.50	360.05	359.05	2.00
9	559	32.71	368.55	367.55	1.79
10	611	35.45	397.55	396.55	1.92
11	578	31.92	370.70	369.70	1.90
12	566	31.51	351.30	350.30	1.91

3. RESULTS

When presenting the results, we focused on *reading time*, *number of fixations* and *saccade length*.

3.1 Reading time

The results (cf. Figure 6) showed the speed of reading for each of the tested typefaces (Bentham, Mila, Minion, Gill Sans). The reading speed for the typeface Bentham was the lowest at the type size 21 px. The texts displayed in the type size 26 px were read the fastest. The difference between the reading times for the type sizes 16 px and 26 px was 0.55 s. For the typeface Mila, the reading time descended proportionally with an increase in type size. The texts in the type size 16 px were read the slowest and in

the type size 26 px the quickest. For the typeface Minion, the reading time was the shortest when the presented texts were displayed in the type size 21 px and the longest for the type size 26 px. Nevertheless, the difference between the two reading times was relatively small, i.e. 0.3 s. The results for the typeface Gill Sans showed that the texts in the type size 21 px were read the fastest and the texts in the type size 26 px were read by 0.23 s (0.83%) more slowly. The longest reading time was recorded for the type size 16 px.

As showed in Figure 6, the average reading time was the longest for the typeface Mila (in all type sizes). The texts displayed in the type size 16 px were read the quickest when set in the typeface Minion and the same outcome can be observed for the type size 21 px. At the size 26 px, the shortest reading time was measured for the typeface Bentham. On average, the shortest reading time was recorded for the texts displayed in the size 21 px (28.27 s). For the size 26 px, the average reading time was 28.43 s. The participants spent the most time reading the texts displayed in the type size 16 px (29.03 s). On average, the reading time was the shortest for the typefaces Minion and Bentham, both of which had an average of 27.94 s for all type sizes.

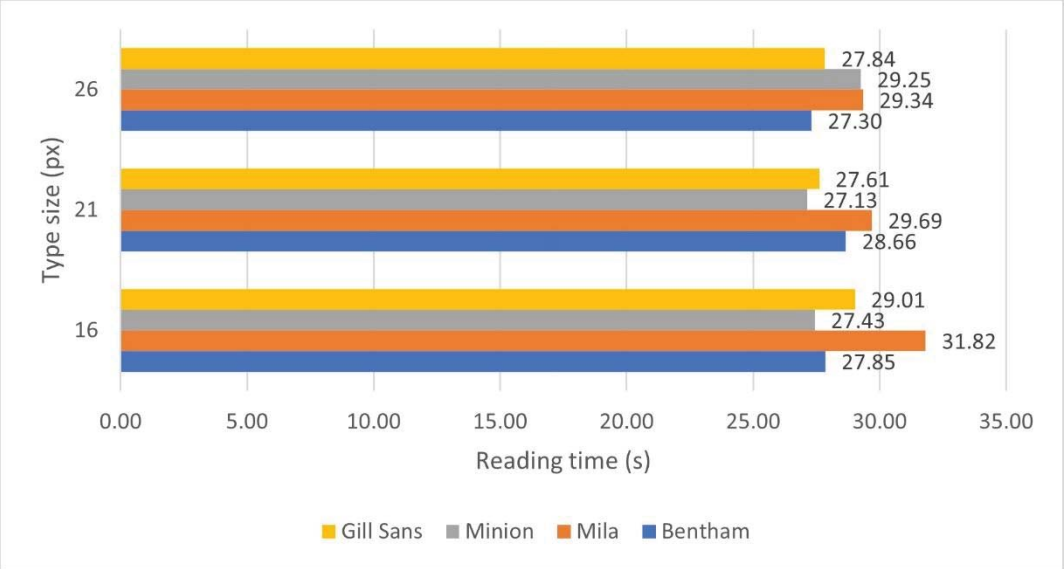

Figure 6: Comparison of average reading time (s) for all typefaces, depending on type size

3.2 Number of fixations

Figure 7 shows the number of recorded fixations for each type size. For the typeface Bentham, the most fixations were recorded at the type size 16 px. An increase in type size resulted in fewer fixations, meaning that at the size 26 px, the fewest fixations were made. The participants made the largest number of fixations for the typeface Mila at the type size 26 px. At the type size 16 px, by 3.42% fewer fixations were made. The smallest number of fixations was recorded for the type size 21 px, i.e. on average by 13.98% fewer fixations than for the type size 16 px. For the typeface Minion, the number of fixations ascended proportionally with an increase in type size. For the type size 16 px, the number of fixations was by 7.12% lower than for the type size 21 px and by 17.44% lower than in the texts displayed in the type size 26 px. The typeface Gill Sans had the most fixations recorded at the smallest type size. For the type size 21 px, there were by 1.23% fewer fixations made. The smallest number of fixations was made at the type size 26 px, i.e. by 4.62% fewer than at the type size 16 px.

On average (cf. Figure 7), the fewest fixations for all type sizes were made when reading the texts displayed in the typeface Bentham. For the type size 16 px, the typeface Minion had the smallest number of fixations, followed by the typefaces Bentham and Mila. Relatively more fixations were made for the texts in the typeface Gill Sans. For the type size 21 px, the smallest number of fixations was recorded for the typeface Mila, followed by the typeface Minion with on average by 8.66% more fixations. The highest number of fixations occurred with the texts in the typeface Gill Sans. The typeface Bentham had the smallest number of fixations at the type size 26 px. In comparison to other type sizes, there were fewer fixations for the typeface Gill Sans. The highest number of fixations was measured for the typeface Minion, the typeface Mila had on average by eight fixations less.

On average, the type size 21 px had the smallest number of fixations (301.39). For the type size 16 px, the average number was 306.20. The most fixations were made at the type size 26 px, on average 314.66. When compared, the typefaces Bentham, Mila and Minion had a similar average number of fixations (303.57–303.73). The typeface Gill Sans had a noticeably higher number, i.e. 318.78.

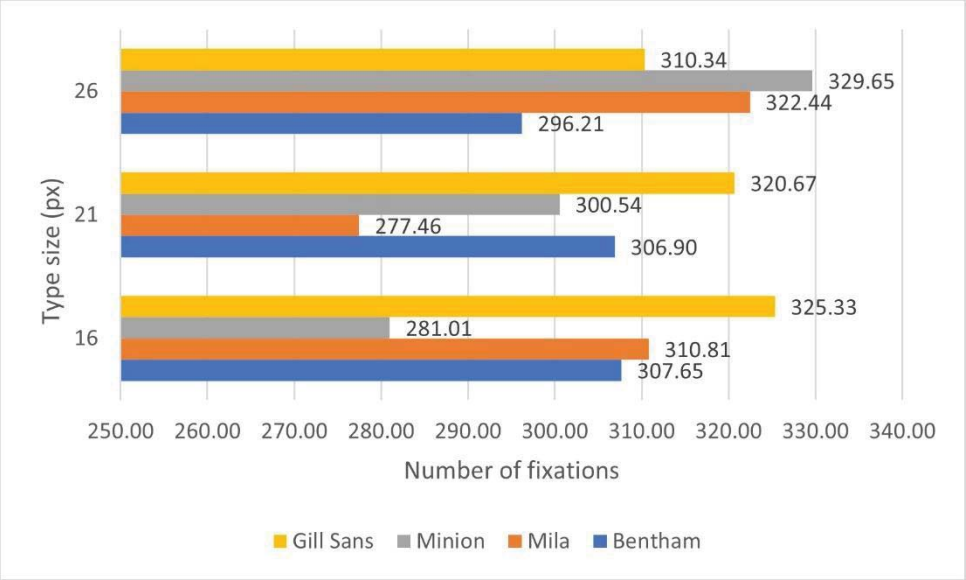

Figure 7: Comparison of average number of fixations for all typefaces, depending on type size

3.3 Saccade length

The results (cf. Figure 8) show the average length of a saccade, expressed in the number of characters recognised in different typefaces and different type sizes.

The saccade length for the typeface Bentham descended proportionally with an increase in type size. The saccades were the longest for the type size 16 px and the shortest for the type size 26 px.

For the typeface Mila, the saccades were the longest for the text displayed in the type size 16 px, somewhat shorter for the type size 21 px and the shortest (by 15.32%) for the type size 26 px. The saccade length also descended with an increase in type size for the typeface Minion. For the type size 16 px, by 9.09% more characters were recognised than for the type size 21 px and by 24.24% more than for the type size 26 px. The saccades had similar lengths in all type sizes for the texts displayed in the typeface Gill Sans. For the type size 21 px, by 0.53% fewer characters were recognised than in the biggest type size, i.e. 26 px. The difference between the type sizes 16 px and 26 px was 0.52%, where the smallest type size had the longest saccadic movements recorded.

On average (cf. Figure 8), the length of saccades was the longest for the typeface Bentham. For all type sizes, they were the shortest for the texts displayed in the typeface Gill Sans. For the type size 16 px, the saccadic movements were the longest for the typeface Minion, followed by the typeface Bentham. The typefaces Mila and Bentham had matching results and the longest saccades in the type size 21 px. Additionally, the typeface Bentham had the longest recorded saccades for the type size 26 px, followed by the typefaces Mila and Minion.

The length of saccades was the longest for the type size 16 px, where the length of a saccade was on average 2.40 characters. For the type size 21 px, the average saccade length was 2.29 characters. The shortest length recorded was for the type size 26 px, where the average saccade length was 2.08 characters. The typeface Bentham had the average saccade length of 2.43 characters. The typeface Minion had the length of 2.35 characters, followed by the typeface Mila (2.33 characters). The shortest saccade length, i.e. 1.91 characters, was recorded in the texts presented in the typeface Gill Sans.

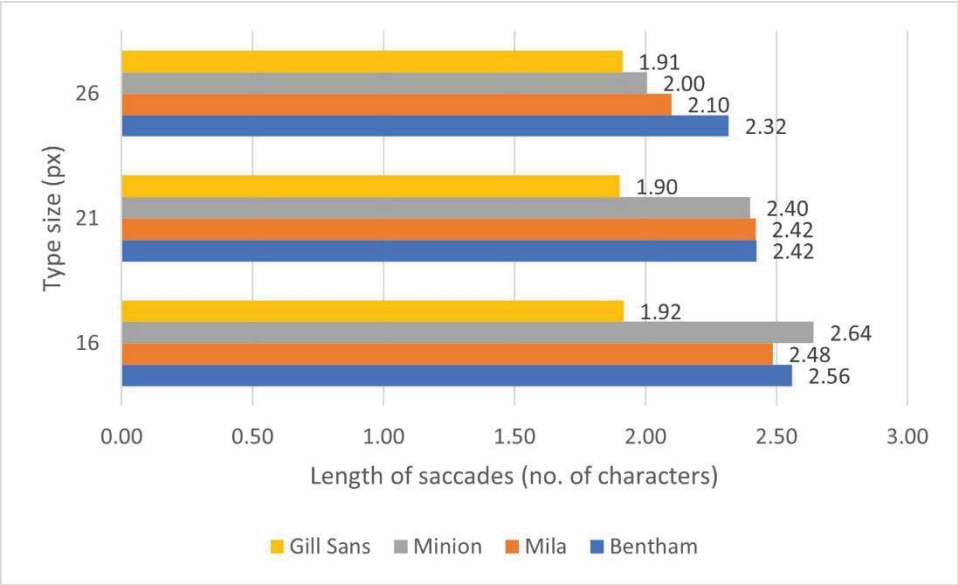

Figure 8: Comparison of average saccade length for all typefaces, depending on type size

4. DISCUSSION

In regard to the results of the study, the speed of reading for the self-designed typeface Mila and typeface Bentham proved to be the fastest for the texts displayed in the type size 26 px. For the typefaces Minion and Gill Sans; however, the reading time was the shortest at the type size 21 px. On average, the longest reading times were measured for the texts in the typeface Mila and the shortest for the typefaces Bentham and Minion, which had similar results. The shortest reading speed was recorded for the type size 21 px and the longest for the type size 16 px. The participants read the texts in the typefaces Bentham and Gill Sans with the smallest number of fixations at the type size 26 px. The texts displayed in the typeface Mila had the smallest number of fixations at the type size 21 px and for the typeface Minion, the fewest fixations were made at the type size 16 px. On average, the smallest number of fixations was recorded for the typeface Bentham and the highest for the typeface Gill Sans. The results indicate that the lowest number of fixations was made at the type size 21 px and the highest at the largest type size, i.e. 26 px. According to the results of saccade lengths, they were the longest at the type size 16 px for all typefaces except for the typeface Gill Sans. The latter had the longest saccade length at the type size 21 px. The participants made on average the longest saccade length when reading the texts displayed in the typeface Bentham and the shortest at the typeface Gill Sans. The lowest number of characters captured simultaneously were at the type size 26 px and the highest at the type size 16 px.

5. CONCLUSIONS

Based on the characteristics of different typefaces and the results of legibility analysis, we came to the conclusion that the typeface Bentham proved to be the most legible. The optimal results were obtained at the type size 26 px, where the length of saccades was the longest. The typefaces Bentham and Minion had the shortest reading times. Among all the studied typefaces, the texts in the typeface Mila were the slowest to read, with the reading times being the longest for all type sizes. The self-designed typeface turned out to be the most legible at larger type sizes. In smaller type sizes, legibility was worse due to thin character strokes and smaller size of serifs. The highest number of fixations and the shortest saccade length measured in texts displayed in the typeface Gill Sans indicate that this typeface is not particularly legible under the selected conditions.

The self-designed typeface Mila was analysed and according to its characteristics categorised into typeface style groups. We successfully reviewed the legibility of the typeface. This study showed interesting results, especially when observing the length of saccades, where all measured values were relatively small. Before starting this study, we assumed the self-made typeface to be useful and legible in larger type sizes, which was proven correct.

The findings and results of the research can contribute to a more appropriate type design in consideration of legibility and, consequently, to the design of more legible typefaces.

6. ACKNOWLEDGEMENTS

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