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The effect of font width on eye movements during reading

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A R T I C L E I N F O

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A B S T R A C T

Certain font features (e.g., letter width) can change the amount of space occupied by text in published works. Font styles/features are also known to affect reading eye movements (EM); however, few studies have examined these effects – and none used high-resolution displays. We examined the effects of font width on EMs by utilizing four fonts, from the Univers family, which varied in letter-width magnitude. Participants' (n = 25) reading speed, saccade velocity, and the duration/number of fixations and saccades were recorded. The Ultra Condensed font significantly influenced readability and yielded: fewer fixations and saccades; longer fixation durations than the Roman and Extended fonts; and shorter saccade durations, relative to the other fonts. Readers efficiently adjusted their EMs such that no reading-speed differences were observed. The eye-tracking metrics revealed two trade-off effects: (1) fewer and shorter EMs and (2) more and longer EMs, which were revealed by the font-width manipulation.

1. Introduction

The mode of reading has slowly shifted from books to laptops, tablets, and smartphones. These platforms are gaining popularity due to their conveniently portable size and price drop over the past couple of decades. The screens of many smartphones may be too small to provide a comfortable reading experience. Therefore, it is important to identify ways of saving display space for other media types. One way of saving space is to use a narrow font instead of a wider font. If the font is condensed, it will take up less horizontal space, meaning that more text can be fitted within the same spatial area. Empirical research can inform when font condensing starts to impair the reading performance. We know that font style affects reading and font legibility (Beier, 2012). Previous work has shown that font style influences reading speed (Beier and Larson, 2013; Bernard et al., 2016), letter recognition (Beier et al., 2017; Beier and Dyson, 2014; Pelli et al., 2006), and lexical processing (Dobres et al., 2017; Sawyer et al., 2017). (see Table 1)

The advent of variable fonts means that fonts no longer have fixed forms. Instead, variable fonts can vary simultaneously along multiple axes, as extreme font instances may be interpolated and create any intermediate style needed (Hudson, 2016). This gives the developer, and potentially also the user, greater freedom to choose the specific style of font that best suits the reading situation. Similar to variable fonts, a large font family is one that can vary on multiple parameters, the most common ones being weight (Beier and Oderkerk, 2019; Chung and Bernard, 2018) and width. Letter width has previously been investigated in relation to visual acuity, lexical processing and screen rendering (Beier et al., 2021; Dyson and Beier, 2016; Morris et al., 1998; Oderkerk and Beier, 2020; Sawyer et al., 2017; Waller, 2007). Text for ordinary reading is normally set in fonts identified as having regular letter width (see Fig. 1). In spite of the great impact that space-saving fonts can have on the number of pages needed for the production of books and newspapers as well as the possible benefits of fitting more text on a small digital screen, there is still a large research gap in the collective research of passage reading with Condensed fonts. The following are the few studies which we have been able to identify that have researched the influence of font width on eye movements.

1.1. Condensed fonts

In order to measure the effects of covered spatial area and word length, McDonald (2006) scaled the same font on the horizontal axis, so that words of different lengths subtended identical visual angle, and showed that words with more letters (i.e., narrow fonts), required more fixations and longer fixation durations than words of few letters (wider fonts). Hautala et al. (2011) investigated eye movements during sentence reading of two fonts, one having regular-width letters and proportional letter spacing (Arial) and one having wide letter width and monospacing (Courier). They found fewer fixations per word and longer fixation durations with the regular font than with the wider font

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(Hautala et al., 2011). Finally, Kolers et al. (1981) presented text on a CRT monitor and compared a wide-pixel font of 35 characters per line with a narrow-pixel font of 70 characters per line. They demonstrated that the narrow-font condition caused participants to make fewer and longer fixations, which resulted in a faster reading rate. Collectively, this suggested that even though the narrow letters were more difficult to recognize, the participants gathered more information on each fixation while reading the narrow letter font, resulting in fewer fixations (Hautala et al., 2011; Kolers et al., 1981; McDonald, 2006), and in positive outcomes for reading speed (Kolers et al., 1981). This partly corresponds with research of difficult-to-read font stimuli (such as flourishing script fonts or case alterations between upper- and lower-case letters), showing longer fixation durations (Rayner et al., 2006; Reingold and Rayner, 2006; Sanchez and Jaeger, 2015; Slattery and Rayner, 2010) and shorter saccades (Rayner et al., 2006); however, none reported faster reading with the difficult-to-read fonts. In fact, ordinary fonts, such as Times New Roman and Courier, led to a faster reading rate (Rayner et al., 2006; Sanchez and Jaeger, 2015; Slattery and Rayner, 2010).

1.2. Hypotheses

None of the previous experiments regarding letter width and eye-movements employed test stimuli with multiple fonts from the same font family presented on high-resolution monitors (3000 by 2000 pixels). By using professionally developed stimuli fonts that gradually increase in letter width (c.f., Section 2.2 – Stimuli Fonts), we can better identify the letter-width threshold for changes in eye movement patterns while reading on modern screens. One can then identify the optimal letter width that saves space without causing performance-based measurable reading difficulties. This led us to the following hypotheses.

H1. Reading time will vary as a function of font width because the spatial areas occupied by the different font widths will lead to faster reading times, which should occur in narrow font-width conditions, relative to wide font-width conditions.

H2. Number of fixations will vary as a function of font width, such that more fixations will be found in wide font-width conditions, relative to narrow font width conditions.

H3. Fixation durations will vary as a function of font width, whereby narrow font width conditions will have longer fixation durations relative to wide font width conditions.

H4. Number of saccades will vary as a function of font width, such that wide font width conditions will require more saccades to read the entire text relative to narrow font width conditions.

H5. Saccade duration will vary as a function of font width, in that wide font width conditions will have longer saccade durations relative to narrow font width conditions.

2. Method

2.1. Participants

A total of 25 participants took part in the experiment, ranging in age from 18 to 35 years ($M = 24.32$ years, $SD = 4.26$ years, 11 women). The balanced Latin-square design required 24 participants for 6 repetitions of the design; however, an extra individual was recruited, and the results remained the same. Participants were recruited through the website forsoegsperson.dk (convenience sample) and were compensated with a gift card of DKK 100 ($16) for participation. Inclusion criteria were that participants had normal or corrected-to-normal vision and considered Danish their native language. The study followed the Declaration of Helsinki and The Danish Code of Conduct for Research Integrity.

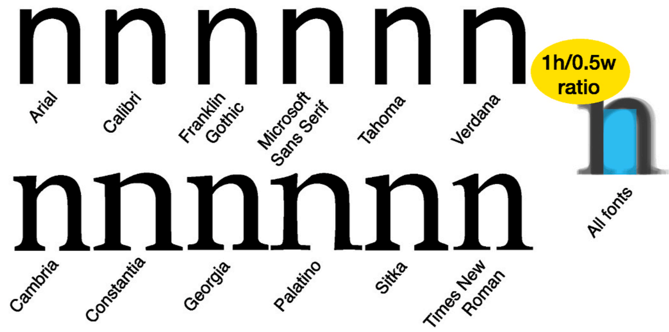

Fig. 1. Superimposing the regular-width fonts style of a selection of the fonts available in Microsoft Word demonstrates that an average height/width ratio of the internal space of the lower-case letter 'n' is about 1h/0.5w.

2.2. Stimuli – fonts

The four test fonts that were used originated in the Univers font family (see Fig. 2), a family designed by Adrian Frutiger in 1957 that was one of the largest font families of its time (Osterer and Stamm, 2014). We chose this font family as it is widely used and includes multiple variations in the letter width between fonts. As the fonts belong to the same family, the stroke width and letter structure are approximately identical between fonts. Fonts of different widths also tend to vary on inter-letter spacing (the space between the letters of a word) and inter-word spacing (the space between words). This is also the case in the Univers family. In the typographic literature, it is generally recommended that the space between two neighbouring 'n's should be slightly less than the space between the vertical stems (Tracy, 1986), so that the space between letters has the same optical value as the space within letters (Smeijers, 1996). Further, the recommendation is that the space between words

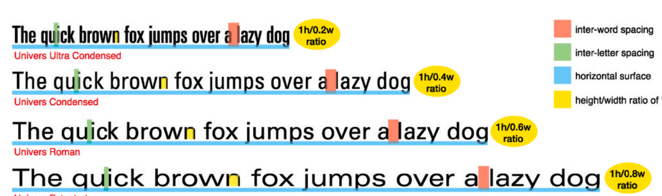

Fig. 2. The four text fonts. From the top: Univers Ultra Condensed, Univers Condensed, Univers Roman and Univers Extended.

Table 1
The unit values are extracted from the font files.

Units of the font family Univers				
	Inter-word Spacing width	Inter-letter spacing value between the letters of the letter pair 'ii'	The sum of horizontal spatial area of all lowercase letters from 'a' to 'z'	Height/width ratio of the internal space of the letter 'n'
Ultra Condensed	186 units	74 units	7.963 units	1/0.2
Condensed	222 units	130 units	11.608 units	1/0.4
Roman	278 units	165 units	13.889 units	1/0.6
Extended	370 unit	198 units	17.021 units	1/0.8

should be equal to the width of the letter 'i' (including the space surrounding it) (Tschichold, 1985), or slightly less than the width of the letter 'o' (Johnston, 1913). Univers is a sans serif family, which is traditionally more tightly spaced (Beier, 2017). Nevertheless, as wider fonts have greater internal space than narrow fonts within the letter counters, the inter-letter and inter-word spacing will be greater in wider fonts than in narrower fonts. Adrian Frutiger knew this and found that in his design of Univers "the white of the counters must bear a certain relation to the white of the side-bearings[1]" (Frutiger, 1962, p. 265).

2.3. Stimuli – text and layout

The stimulus text was taken from the Danish novel "Begyndelsen: fire historier" by Thomas Thurah. We selected four paragraphs of text, each with 1815–1820 characters in total. The order of both the font type and the paragraph texts was counterbalanced with a full Latin-square design between participants, so that each font condition was read first by the same number of participants. This way each participant read all four paragraphs once, and each font condition was read 24 times in total (e.g., Paragraph 1 was read 6 times for each font condition). The column width was 1500 pixels, while the column height of the Extended condition was 1700 pixels. As Extended fonts of wider letters take up a larger horizontal spatial area than Condensed fonts of narrow letters, the covered spatial area varied between font conditions in the following way: Extended took 32 lines of text; Roman took 26 lines of text; Condensed took 23 lines of text; and Ultra Condensed took 16 lines of text.

2.4. Apparatus

An HP laptop with 8 GB of RAM, Intel (R) Core i5-6300U 2.5 CPU GHz CPU, and a 64-bit, Windows 10 operating system was utilized; the screen resolution was 3000 by 2000 pixels. A chin rest was centred to the computer screen, and participants used it throughout the experiment. The experiment scripts were written in MATLAB using the Psychophysics Toolbox (Brainard, 1997; Kleiner et al., 2007; Pelli, 1997); thus, the timing of the stimuli was computer-controlled. A pair of Pupil Labs Core glasses was used (Kassner et al., 2014; two infra-red illuminated eye cameras with a sampling rate of 200 Hz per eye), which was also equipped with a world-view (participant's view) camera. The eye tracking glasses were operated using the Pupil Capture application (v 2.0), which was used to calibrate each participant's gaze before the experiment. The eye tracking data were preprocessed using the iMotions (2020) platform.

2.5. Procedure

The participants were greeted upon arrival, informed about the experiment, and asked for their written informed consent to participate. Next, participants were asked to place themselves in front of the computer such that they were comfortably seated and to use the chin rest, which was affixed to the table.

Before the beginning of the experiment, the participants were asked to wear the head-mounted eye-tracker and were calibrated to the laptop screen via the Pupil Capture software in a 5-point calibration sequence. Then, the participants completed a practice session where they were asked to read a single paragraph and answer yes/no questions regarding the reading content. Following this, the experiment was started, which lasted between 10 and 15 min depending on the individual participant's reading speed. To ensure that participants read the paragraphs and paid attention to the content, they were instructed to answer two yes/no questions regarding the text content after each paragraph; however, the question responses only served as a manipulation check.

[1] Side-bearings are the white space on the left and right of a letter.

2.6. Eye-tracking analysis

Eye-tracking data were imported to the iMotions platform and processed with a velocity-threshold identification (I-VT) method. The I-VT filter was set with a 20 ms (ms) window length, the velocity threshold was 30° per second, the minimum duration of a fixation was 100 ms, and the minimum spatial separation of fixations was 0.5° visual angle.

2.7. Analysis

The dependent measures of the experiment were reading time, number of fixations, fixation duration, number of saccades, and saccade duration. A one-way, repeated-measures ANOVA was implemented with font width as the independent variable, and the data from the five dependent variables were submitted to this same procedure. A Bonferroni correction was implemented to mitigate the effects of a Type-1 error being found in the pair-wise comparisons, which are considered "atheoretical" comparisons between conditions. Planned comparisons (i.e., theory-driven comparisons) were also executed between the baseline font width (Roman) against the other font-width conditions. Estimated omega squared (ω^2) – the percentage of variance in the dependent variable that is accounted for by the font width independent variable – was used to interpret any significant main effects. Cohen's d, which is an estimate of the population parameter's effect size, was used to interpret the post hoc paired-sample t-tests. Cohen's d has the following meaningfulness cut-offs: very small 0.00–0.01; small 0.02–0.20; medium 0.21–0.50; large 0.51–0.80; very large 0.81–1.20; and huge 1.21–2.0. In order to ensure that the assumption of sphericity was not violated, for the repeated-measures ANOVA, a Huynh-Feldt correction was reported.

3. Results

3.1. Behavioural manipulation check

Participants answered a total of eight questions (i.e., two yes/no questions for each of the four paragraphs). The grand mean of mean number of correct responses was 1.74. The estimated marginal means were as follows: Ultra Condensed (M = 1.79 correct, SD = 0.41 correct); Condensed (M = 1.84 correct, SD = 0.37 correct); Roman (M = 1.79 correct, SD = 0.41 correct); and Extended (M = 1.52 correct, SD = 0.65 correct). No significant main effect of font width on mean number of correct responses was found, F (3, 72) = 2.74, $p > .05$.

3.2. Reading time

The grand mean of reading time was 91.38 s (secs). The estimated marginal means were as follows: Ultra Condensed (M = 92.59 s, SD = 18.03 s); Condensed (M = 91.67 s, SD = 17.59 s); Roman (M = 90.45 s, SD = 19.08 s); and Extended (M = 86.43 s, SD = 21.27 s). No significant main effect of font width on reading time was found, F (3, 72) = 1.65, $p > .05$.

3.3. Number of fixations

The grand mean of number of fixations was 329. From most to fewest mean number of fixations, Ultra Condensed yielded 308 fixations (SD = 75 fixations), followed by Condensed, which yielded 345 fixations (SD = 77 fixations), then Roman, which resulted in 348 fixations (SD = 64 fixations), and, finally, Extended, which yielded 355 fixations (SD = 70 fixations). We found a significant main effect of font width on the number of fixations (see Fig. 3), F (3, 72) = 4.11, p = .019, ω^2 = 0.042. However, after applying the Bonferroni correction, none of the comparisons remained statistically significant.

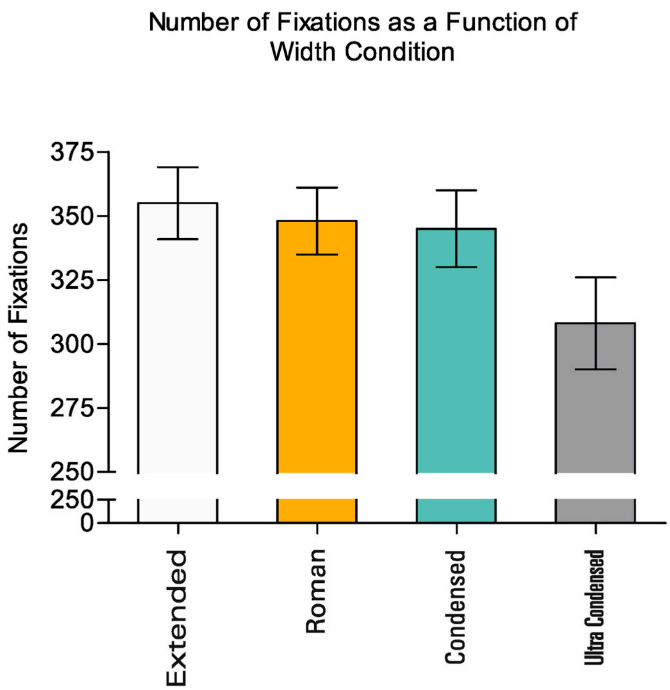

Fig. 3. Mean number of fixations as a function of font-width condition. Error bars depict the standard error of the mean.

3.4. Fixation duration

The grand mean of mean fixation duration was 174 ms (ms). From the shortest mean fixation duration to the longest, Ultra Condensed yielded a mean of 187 ms (SD = 25 ms), followed by 174 ms (SD = 23 ms) for Condensed, then 168 ms (SD = 19 ms) for Condensed, and a mean of 166 ms (SD = 21 ms) for Ultra Condensed. There was a significant main effect of font width on mean fixation duration (see Fig. 4), $F\,(3, 72) = 9.68, p < .0001, \omega^2 = 0.065$. Ultra Condensed showed significantly longer fixation durations than both Extended and Roman, $p < .001$ and $p = .03$, respectively. The planned comparison between Roman and Ultra Condensed was significant, $t\,(24) = 3.06, p = .003, d = 0.611$.

3.5. Number of saccades

The grand mean of mean number of saccades was 677. From the smallest to the greatest mean number of saccades, Ultra Condensed yielded a mean of 569 saccades (SD = 39 saccades), followed by 672 saccades (SD = 42 saccades) for Condensed, then 719 saccades (SD = 43 saccades) for Roman, and a mean of 747 saccades (SD = 37 saccades) for Extended. There was a significant main effect of font width on the number of saccades (see Fig. 5), $F\,(3, 72) = 12.55, p < .001, \omega^2 = 0.093$. Ultra Condensed had fewer saccades than Extended and Roman, $p = .001$. The planned comparison between Roman and Ultra Condensed was significant, $t\,(24) = 4.43, p < .006, d = 0.886$.

3.6. Saccade duration

The grand mean of mean saccade duration was 50 ms. From the shortest to the longest mean saccade duration, Ultra Condensed yielded a mean of 46 ms (SD = 9 ms), followed by 51 ms (SD = 12 ms) for Condensed, then 51 ms (SD = 10 ms) for Roman, and a mean of 52 ms (SD = 9 ms) for Extended. There was a significant main effect of font width on mean saccade duration (see Fig. 6), $F\,(3, 72) = 7.08, p = .001, \omega^2 = 0.045$. Ultra Condensed had significantly shorter saccade durations than all the other conditions, $p = .012, p = .012$,

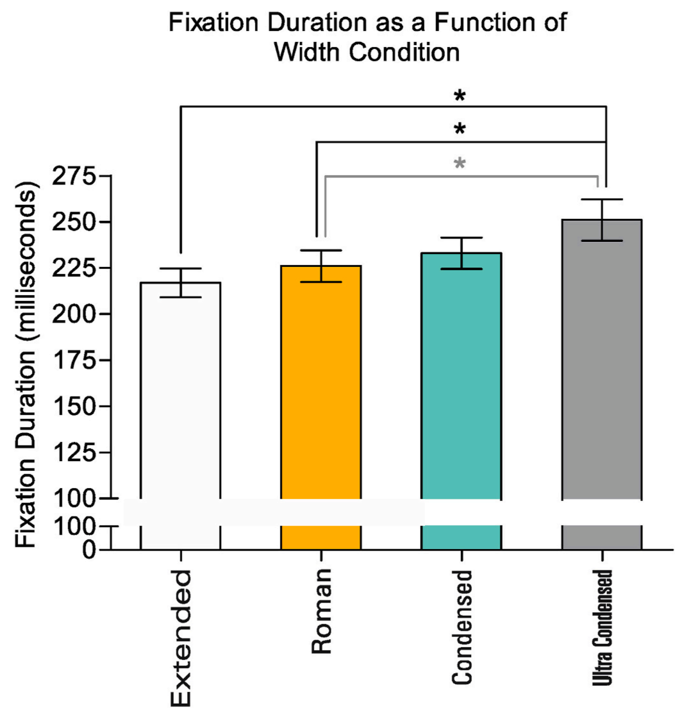

Fig. 4. Mean fixation duration in milliseconds as a function of font-width condition. Error bars depict the standard error of the mean. A black star indicates a significant pairwise comparison, while a grey star indicates a significant planned comparison. All significant comparisons had a p-value below .05.

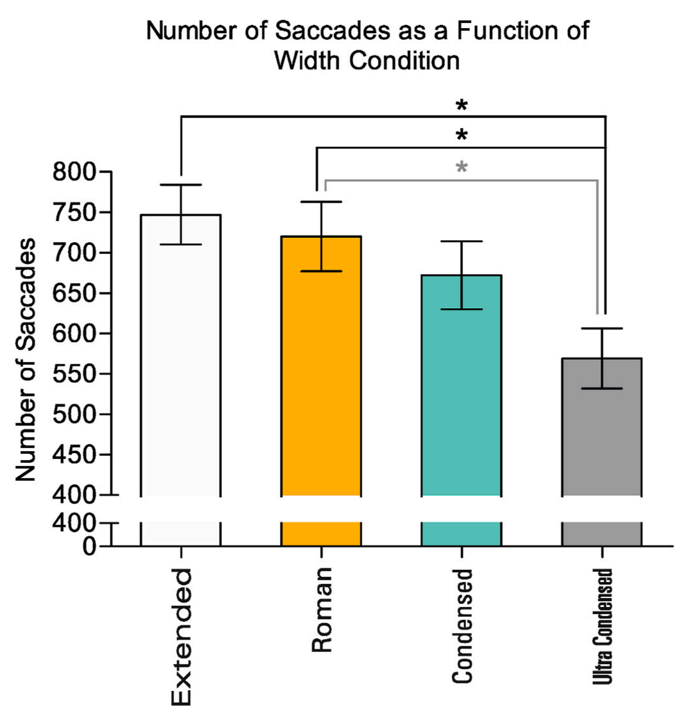

Fig. 5. Mean number of saccades as a function of font-width condition. Error bars depict the standard error of the mean. A black star indicates a significant pairwise comparison, while a grey star indicates a significant planned comparison. All significant comparisons had a p-value below .05.

and $p = .012$, respectively. The planned comparison between Roman and Ultra Condensed was significant, $t\,(24) = 3.41, p = .012, d = 0.682$ (see Fig. 7).

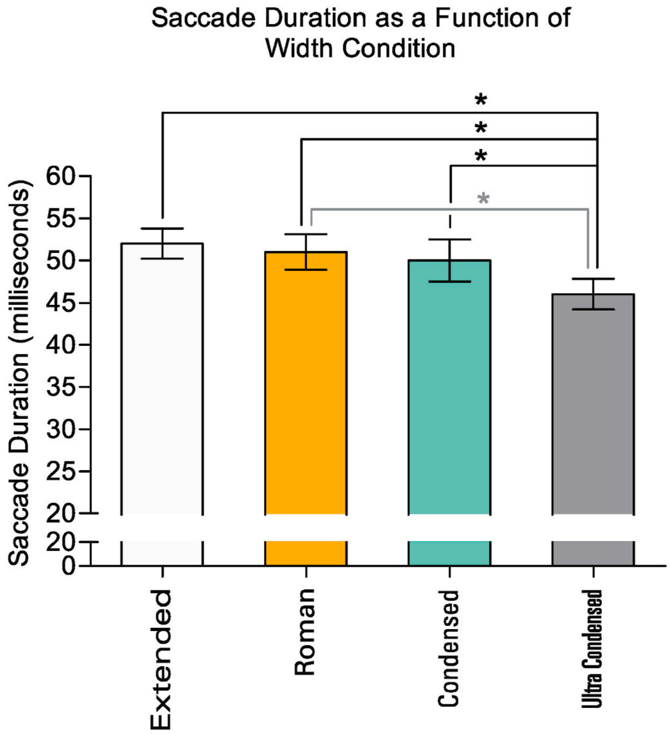

Fig. 6. Mean saccade duration in milliseconds as a function of font width condition. Error bars depict the standard error of the mean. A black star indicates a significant pairwise comparison, while a grey star indicates a significant planned comparison. All significant comparisons had a p-value below .05.

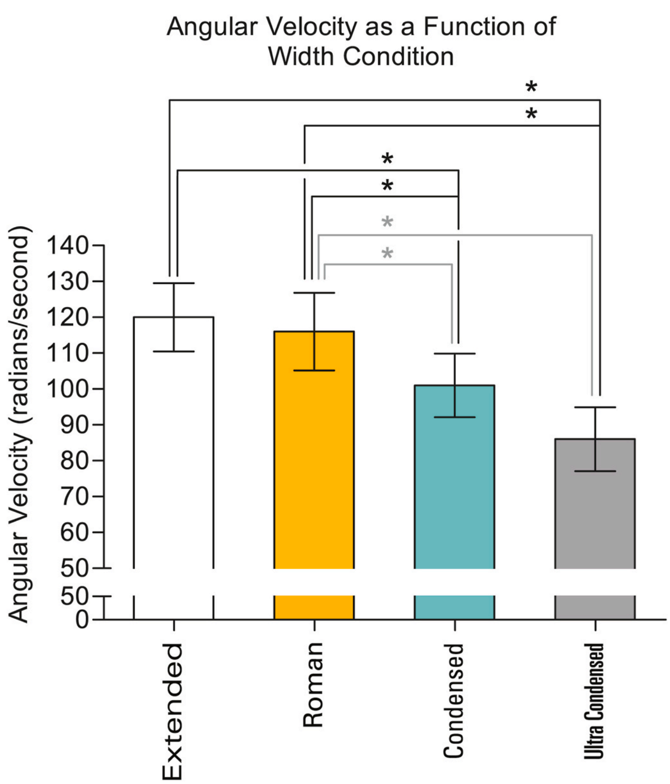

Fig. 7. Mean Angular Velocity in radians per second as a function of font width condition. Error bars depict the standard error of the mean. A black star indicates a significant pairwise comparison, while a grey star indicates a significant planned comparison. All significant comparisons had a p-value below .05.

4. Discussion

Condensing font width may save valuable space in both digital and printed presentation modes. Previous letter-width studies, which compared eye movement behaviour for two fonts with different letter widths (Hautala et al., 2011; Kolers et al., 1981), showed that the narrow condition caused fewer and longer fixations. Our experiment involved four fonts that gradually increased in horizontal letter width, which allowed us to get closer to identifying how narrow the letter widths need to be to influence eye movements. We tested the hypothesis that – compared to Extended and Roman font – narrow-letter fonts (Condensed & Ultra Condensed) would allow for gathering more information during each fixation, and lead to faster reading (Kolers, 1981). However, no benefit of narrow-letter fonts for reading rate was observed. In line with previous studies (Hautala et al., 2011), the large variation in eye-movement patterns between Ultra Condensed and other fonts, did not affect reading time. This interesting reading-time finding suggested that readers are highly efficient at adjusting to the best-suited reading strategy for the utilized font and, thus, end up with similar reading speed between font-width conditions. Font condensing was associated with a trade-off effect of longer fixation durations resulting in fewer fixations and saccades. We will, in the following, discuss the potential mechanism underlying this effect.

4.1. Crowding and visual acuity

Several studies investigating spatial width (Hautala et al., 2011; McDonald, 2006) suggest that visual crowding plays a role in fixation duration. Letters that are placed in close proximity tend to visually merge, this well-described phenomenon (i.e., visual crowding) has been extensively described in the literature (Bouma, 1970; Coates et al., 2013; Marzouki and Grainger, 2014; Montani et al., 2015; Pelli et al., 2016; Yu et al., 2007). Others have investigated effects of spacing on readers with dyslexia (Galliussi et al., 2020; Perea et al., 2012; Zorzi et al., 2012) and low-vision (Beier et al., 2021; Chung, 2014). Several studies investigating inter-letter spacing have reported longer fixation durations (Paterson and Jordan, 2010) and slower reading speed for large inter-letter spacing (Paterson and Jordan, 2010; Van Overschelde and Healy, 2005; Yu et al., 2007). Other studies have also manipulated inter-letter spacing, however, their inter-letter spacing was only slightly increased, which resulted in shorter fixation durations (Perea and Gomez, 2012; Slattery and Rayner, 2013) and more fixations within a sentence (Slattery and Rayner, 2013).

When one designs wide-letter fonts, the inter-letter and inter-word spacing is slightly increased if one follows current typography-design conventions (Beier, 2017). Our test fonts followed these aforementioned design conventions. Hence, we can assume that this inter-letter spacing increase, contributed to the results of our wide font-width conditions (i.e., shorter fixation durations and greater number of fixations). Furthermore, when keeping print area constant, it is possible that narrow-width fonts with multiple letter strokes are more susceptible to the detrimental effects of crowding, when compared to wide-width fonts with fewer letter strokes. Previous work found that smaller visual angles resulted in increased fixation durations (Morrison and Rayner, 1981). We replicated this finding by showing that smaller sizes (projected onto the retina) lead to longer fixation durations, and that this effect can be found when letters are only smaller on the horizontal dimension.

Complex fonts tend to lead to poor legibility and they cause longer fixation durations (Rayner et al., 2006; Reingold and Rayner, 2006; Sanchez and Jaeger, 2015; Slattery and Rayner, 2010). As narrow fonts lead to poor letter recognition (Oderkerk and Beier, 2020), our findings are also in line with these previous studies.

4.2. Saccades

Although Ultra Condensed led to longer fixation durations, it resulted in fewer saccades and shorter saccade durations. Others have found that proportional changes in font size (from larger to smaller visual angles) did not significantly affect the number of characters perceived within a saccade (Miellet et al., 2009; Morrison and Rayner, 1981). Our results showed that condensed fonts lead to a larger number of letters that were perceived within a given saccadic eye movement.

As narrow fonts can fit more letters into each line of text, the saccade pattern for Ultra Condensed was the result of the physical area covered. Despite the narrow letters being more difficult to perceive, the data suggests that the readers processed more letters in a single fixation. As a result, they were able to read more information from their parafoveas, which allowed one to perceive a greater number of letters within each saccade. If we accept this alternative explanation, it would indicate that crowding did not affect fixation duration, as suggested above. Instead, the trade-off effect of fixation duration and number of fixations and saccades was mostly the result of fitting more letters onto the fovea and parafovea during each fixation.

4.3. Implications and limitations

Participants failed to demonstrate full comprehension of the content, although no significant differences between font conditions were found. As comprehension is one of the main factors of successful reading, we see this as an indication that the laboratory setting of the experiment had a negative influence on participants' concentration level. The literature shows that if one practices reading an unfamiliar font style, then reading performance can improve (Beier and Larson, 2013; Zineddin et al., 2003). It is possible that this practice effect would accentuate our Ultra Condensed condition's results, if participants had had the time to practice with the test fonts.

Text set in the Ultra Condensed font would take up less space than the same text set in the Extended, Roman and Condensed fonts. This translates to fewer lines on a given page. There are multiple reading platforms where saving space is important. For example, when the American company AT&T changed the font in their phone books to the space-saving font Bell Centennial, they saved millions of dollars per year due to the fewer pages in each phone book (Dawson, 2013). Small digital devices, similarly, benefit from having the capability to fit more text onto their displays. However, our experiment showed that the Ultra Condensed font caused longer fixation durations, which can be interpreted as yielding longer processing time (Slattery et al., 2016). Hence, fonts with similar letter-width, such as Ultra Condensed (letter 'n' ratio of 1h/0.2w), might not be advisable to use for longer paragraphs of text.

The fixation duration data indicated no difference in processing time between the three widest font-width conditions, which suggests that fonts with a height/width ratio of 'n' between 1h/0.4w and 1h/0.8w are all qualified for setting longer paragraphs of text. This finding is relevant to low-vision reading, where it has been shown that fonts with wider letter shapes improve reading (Beier et al., 2021; Tarita-Nistor et al., 2013; Xiong et al., 2018). We have, thus, demonstrated that designing for low-vision reading does not hamper "good" normal-vision reading, as there were no reading deficits related to the wide font-width letter shapes in our experiment.

The aim of the study was to measure the effects of eye movements in relation to four fonts that gradually increased in horizontal letter width. Another aim was to identify the width "threshold" that would begin to influence changes in eye movements. We did find such changes in eye movements in relation to the width of the Ultra Condensed font and the other font-width conditions (however, performance varied between the different eye-movement measures).

First, in terms of fixation duration and number of saccades, the closest width condition that yielded a significant difference with Ultra Condensed was Roman. Second, in terms of saccade duration, the closest width condition with significant differences to Ultra Condensed was Condensed. Because the threshold was different between these measures, it could be argued that we failed to identify a more general threshold within the range of font widths we implemented. Furthermore, the width increment between neighbouring font conditions was relatively large, which means that we could not identify a more precise value for the width thresholds. To do so, one would need to include fonts of much smaller width increments when compared to our font-width manipulation.

5. Conclusion

The font-width condition Ultra Condensed resulted in longer fixation durations, which suggests that participants needed more time to process information. By taking longer to fixate, participants were able to read more information, which was shown in the data in the form of fewer saccades, and shorter saccade durations. Ultra Condensed stood out the most from the other collective test fonts. With regard to fixation duration, Extended, Roman, and Condensed resulted in very similar reading/processing times. Despite variations in eye movements across font-width conditions, none of the font-width conditions showed a faster reading speed than the others, which suggests that readers are, generally, highly skilled at adapting their reading strategy to fit the utilized font.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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