Size Matters (Spacing not): 18 Points for a Dyslexic-friendly Wikipedia

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ABSTRACT

In 2012, Wikipedia was the sixth-most visited website on the Internet. Being one of the main repositories of knowledge, students from all over the world consult it. But, around 10% of these students have dyslexia, which impairs their access to text-based websites. How could Wikipedia be presented to be more readable for this target group? In an experiment with 28 participants with dyslexia, we compare reading speed, comprehension, and subjective readability for the font sizes 10, 12, 14, 18, 22, and 26 points, and line spacings 0.8, 1.0, 1.4, and 1.8. The results show that font size has a significant effect on the readability and the understandability of the text, while line spacing does not. On the basis of our results, we recommend using 18-point font size when designing web text for readers with dyslexia. Our results significantly differ from previous recommendations, presumably, because this is the first work to cover a wide range of values and to study them in the context of an actual website.

Keywords

Dyslexia, text presentation, readability, understandability, font size, line spacing, eye-tracking, Wikipedia.

1. INTRODUCTION

Dyslexia is a neurological reading disability, which impairs a person's ability to read and write. The *Interagency Commission on Learning Disabilities* [19] states that 10 to 17.5% of the population in the U.S.A. have dyslexia. Also, between 7.5 to 11.8% of the Spanish-speaking population has dyslexia [28]. Previous studies showed that at least 0.669% of the errors found in the Web are made by people with dyslexia [3].

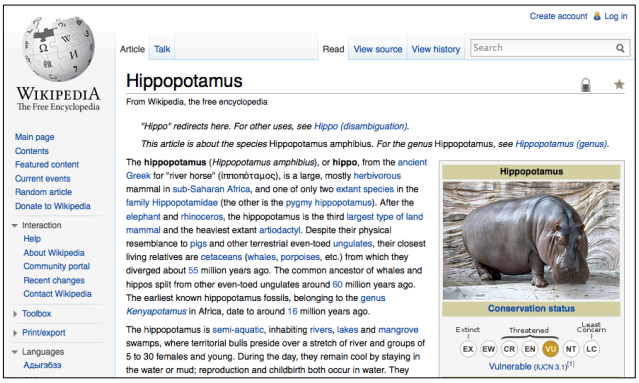

Figure 1: Example of a Wikipedia article that was used in the study.

However, reading is essential for success in our educational system. The most common way of detecting a child with dyslexia is due to her/his low performance in school. Fortunately, thanks to the fact that more and more of this reading involves online resources on the Web, we are able to alter and improve the presentation of educational resources for children with dyslexia. Presenting online text in more dyslexic-friendly ways may not only impact these children's reading performance but also their success in education.

In the *Web Content Accessibility Guidelines* (WCAG) [10], dyslexia is treated as part of a diverse group of cognitive disabilities. They do not contain specific guidelines for text presentation for people with dyslexia. However, previous research has shown that text presentation can be an important factor regarding the reading performance of people with

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dyslexia [20, 31, 16]. Therefore, some recommendations for this target group have appeared in the recent years [21]. However, research related to web accessibility and dyslexia is still scarce compared to other target groups [12].

A common limitation of most previous studies is that they used isolated words and sentences. Yet, most of the text we encounter in the Web is embedded into web sites with navigation bars, images, and side bars containing *e.g.* advertisements or additional links. By ignoring these contextual factors, it is not clear how the results of these studies will generalise to real-world usage [31]. What is missing, is studying the effect of the combination of text presentations parameter on reading and comprehension in context, *i.e.*, of a text that is embedded into a standard web site.

One of the most used websites in education is Wikipedia. According to *Alexa Internet* [2], in February 2013, Wikipedia is the sixth most popular website worldwide, and the most popular website which mainly contains text. Wikipedia is frequently consulted by students to do their exercises and there is growing effort from Wikipedia to support education, such as the *Wikipedia Education Program*.

In this paper, we report from the first study which experimentally compares the effect of 6 font sizes and 4 line spacings on readability and comprehensibility of texts in Wikipedia. We investigated font size and line spacing, since in previous work [31] these parameters had the apparently highest influence on reading performance.

The contribution of the paper is as follows:

- Font size has a significant effect on objective and subjective readability and comprehensibility, while line spacing has not.
- Reading improves up to a font size of 18 points, beyond, we do not see further improvements.

The next section reviews the related work, Section 3 explains experimental methodology. Section 4 presents the results, which are discussed in Section 5. In Section 6, we derive guidelines for dyslexic-friendly websites.

2. RELATED WORK

We divide previous work into general guidelines, and previous studies related dyslexic readers and font size & line spacing.

2.1 General Guidelines

In his article on the *Top 10 Mistakes in Web Design*[1], Jakob Nielsen stresses that providing text in the right font size is crucial for the usability of any web page. However, previous studies come to different conclusions about the ideal font size. Nielsen recommends to use at least 10 points. Other recommendations include 12 points [5] and 14 points [4, 6]. Others simply suggest to allow users to adjust the font size [23, 16].

Yet, Nielsen also points out that users are typically too lazy to change fonts when viewing web sites. Consequently, to ensure good readability, it is essential for web sites to provide their text in an appropriate font size by default.

[1] `http://www.nngroup.com/articles/top-10-mistakes-web-design/`, 2011, last visited Feb 21, 2013.

2.2 Font Size and Dyslexia

Too small font sizes is one of the key problems experienced by people with dyslexia [21]. According to [1, 7, 8], the recommended font size for this target group is 12 or 14 points. According to [8, 13], some readers with dyslexia prefer larger font sizes. Reporting from the first study that used eye-tracking to determine the most readable text parameters for on-screen reading, [31] found 26 points to be the most readable found size. The general finding that repeats throughout previous work is that people read and comprehend texts better with increasing font sizes. Guidelines typically suggest font sizes ranging from 10 to 26 points. However, it remains unclear from which point on increasing font size is no longer beneficial.

2.3 Line Spacing and Dyslexia

Another key factor of legibility for people with dyslexia is line spacing [17]. Line spacing can be given in various units. In the web context, we often find values without units, such as 1.0. These values are factors which describe the line spacing relative to the default spacing. For example, for a default line spacing of 16px, the factor 1.5 produces a line spacing of 24px. Recommendations in previous work comprise line spacings of 1.3 in [25], 1.4 [31], 1.5 [8], and 1.5 to 2 lines [26]. In [31], line spacing was strongly correlated with reading performance: the narrower the space between the lines, the slower the participants read.

2.4 What is Missing

All previous studies, including the ones which use eye-tracking, study the effect of text presentations parameters (1) independent from each other, *i.e.,* combinations of text parameters are not assessed, and (2) independent from the context, *i.e.,* the text is studied isolated without the other content that typically appears on web pages.

3. METHODOLOGY

To study the effect of font size and line spacing on readability and comprehensibility of websites, we conducted an experiment. 28 participants had to read six Wikipedia entries related to animals with varying font sizes and line spacings. We chose Wikipedia, since it is the most-visited text-heavy website.[2] Readability and comprehensibility were analyzed via eye-tracking, comprehension tests, and subjective feedback.

3.1 Design

In our experimental design, *line spacing* and *font size* served as independent variables with 4 and 6 levels, respectively.

- For *font size*, we used the levels 10, 12, 14, 18, 22, and 26 points (pt). We chose to study *font size* because it is the only text presentation parameter which had a significant reading texts with participants with dyslexia [31]. We chose 10 pt because it is suggested as minimum font size in standard usability guidelines. The other font sizes were chosen because they are recommended in previous work: 12 pt in [5], 14 pt in [6, 4], and 18, 22, 26 points in [31].

[2] Other, more visited websites, such as `google.com`, contain almost no text and are hence not useful for this study.

– For *line spacing* we tested the levels 0.8, 1.0. 1.4, and 1.8 lines. We chose *line spacing* because of its strong correlation with reading performance [31]. Recommendations for people with dyslexia are: 1.3 in [25], 1.4 [31], 1.5 [8], and 1.5 to 2 lines [26]. Since line spacing has never been studied in comparison with font size, we chose to study the browser's default line spacing (1.0) in comparison with 0.8 and 1.4 and 1.8, in order to cover the space of values that are recommended in the literature.

We used a hybrid-measures design. Each participants read six texts with one *line spacing* and six different *font sizes*. Hence, for *font size*, we collect repeated measures, while for *line spacing*, we obtain between-group data. The order of conditions was counter-balanced to cancel out sequence effects.

For quantifying readability and understandability, we used the following dependent measures:

Fixation Duration: We used fixation duration as objective approximation of readability. When reading a text, the eye does not move contiguously over the text, but alternates saccades and visual fixations, that is, jumps in short steps and rests on parts of the text. *Fixation duration* denotes how long the eye rests still on a single place of the text. Fixation duration has been shown to be a valid indicator of readability. According to [27, 18], shorter fixations are associated with better readability, while longer fixations can indicate that processing loads are greater.

Comprehension Score: To measure text comprehension, we used both literal and inferential questions. Inferential items are questions that require a deep understanding of the text content, because the question that cannot be answered straight from the text. Literal questions, in contrast, can be answered directly from the text. We used multiple-choice questions with four possible choices, one correct choice, two wrong choices and one "I don't know". To compute the text comprehension score, the correct choice counted 100% and the rest 0%.

Perception Rating: In addition, we asked the participants to provide their subjective perceptions. For each of the six texts, the participants rated on a five-point Likert scale, how easy they found the text to read and to understand in the given presentation format. An example of the items is given in Figure 2.

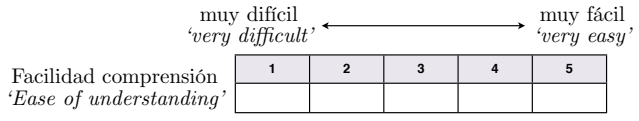

Figure 2: Comprehension rating item

3.2 Participants

28 people (15 female, 13 male) with a confirmed diagnosis of dyslexia took part in the study. Their ages ranged from 14 to 38 ($\mu = 21.36$, $s = 7.49$) and they all had normal vision. All of them presented official clinical results to proof that dyslexia was diagnosed in an authorized center or hospital.[3]

[3]In the Catalonian protocol of dyslexia diagnosis [11], the different kinds of dyslexia, extensively found in literature, are not considered.

Except from 3 participants, all of the participants were attending school or high school (14 participants), or they were studying or had already finished university degrees (11 participants).

3.3 Materials

To isolate the effects of the text presentation, the texts themselves need to be comparable in complexity. In this section, we describe how we designed the texts that were used as study material.

3.3.1 Wikipedia Entries

Since Wikipedia entries are heterogeneous, it is challenging to find sufficiently similar entries. We decided against modifying text, because otherwise the experiment does not show readability and comprehension in real context of the Web. Thus, we went through the articles of the Spanish Wikipedia related to animals and chose 24 articles which share the following comparable characteristics:

(a) All texts used in the experiment cover the same *genre* and the same *topic*, namely animals.

(b) They all have a similar number of words in the first and the second paragraphs, ranging from 40 to 60 words for each of the paragraphs.

(d) They have a similar discourse structure: title, the first paragraph presents the animal and the place where the animal lives, the second and paragraph gives more information which differs depending on the entry, the third paragraph explains more details.

(e) The layout was always the same: the paragraphs were located in roughly the same position of the screen. Each article contained one image on the top-right of the content pane (see Figure 1).

(f) We looked for texts with low frequencies of numerical expressions [30], acronyms, and foreign words, because people with dyslexia specially encounter problems with such words [18, 29].

For each of the selected Wikipedia articles, we obtained the HTML source code. To alter the websites, we used a browser (Chrome) plug-in (StyleBot) to modify the style sheet (css) to change font size and line spacing.

3.3.2 Comprehension Questionnaires

Each of the questionnaires was composed of six multiple-choice questions, one for each of the Wikipedia articles. An example of each type of items is given in Figure 3.

3.4 Equipment

The eye-tracker used was the Tobii 1750 [33], which has a 17-inch TFT monitor with a resolution of 1024x768 pixels. The time measurements of the eye-tracker has a precision of 0.02 seconds. The eye-tracker was calibrated for each participant and the light focus was always in the same position. The distance between the participant and the eye-tracker was constant (approximately 60 cm. or 24 in.) and controlled by using a fixed chair.

Segun lo que acabas de leer en la Wikipedia *'According to what I just read on Wikipedia:'*

- El gorila tiene un ADN muy similar al de los humanos. *'The gorilla's DNA is similar to the human's.*
- El gorila vive en los bosques del sur de África. *'The gorilla lives in the forests of southern Africa'.*
- El gorila es un primate carnívoro. *'The gorilla is a carnivorous primate'.*
- No lo sé, creo que lo no ponía o al menos yo no lo recuerdo. *'I do not know, I think it was not in the text, or at least I do not remember it'.*

Figure 3: Comprehension item example.

3.5 Procedure

The sessions were conducted at the *Universitat Pompeu Fabra, Barcelona (Spain)*, and lasted around 20 minutes. Each session took part in a quiet room, where only the interviewer (first author) was present, which ensured that the participants could concentrate. Each participant performed the following four steps.

First, we began with a questionnaire that was designed to collect demographic information. Second, to assure the engagement of the participants, we asked them if they would like to read some Wikipedia articles about animals[4]. Third, the participants were asked to read the texts in silence and complete the comprehension questionnaires. They were asked to read only the first 3 paragraphs of the article. The reading was recorded by the eye-tracker. Finally, each participant was asked to provide his/her perception ratings, which were issued on paper while they could see again the Wikipedia articles to be rated.

4. RESULTS

In this section, we present the analysis of the data from the eye-tracker (fixation duration), the comprehension tests, and the perception ratings. A Barlett's test showed that all data sets were homogeneous. Hence, we used two-way ANOVA and pairwise t-tests with Holm-correction to test for significant effects.

4.1 Fixation Duration

4.1.1 Font Size

Figure 4 shows the average fixation duration for each of the *font size* conditions. There was a significant main effect of *font size* on *fixation duration* ($F(1,156) = 15.506, p < 0.001$).

For 10pt font size, participants had significantly longer fixation durations than 14pt ($p = 0.018$), as well as 18pt, 22pt, and 26 pt ($p < 0.001$, each).

For 12pt font size, participants had significantly longer fixation durations than 18pt, 22pt, and 26 pt ($p < 0.001$, each).

For 14pt font size, participants had significantly longer fixation durations than 18pt, 22pt, and 26 pt ($p < 0.001$, each).

For the font sizes 18pt, 22pt, and 26pt, we could not find significant differences between the fixation durations.

This data indicates that until 18pt font size, the fixation duration decreases with increasing font size. Beyond 18pt, increasing the font size led to no significant improvement in our data. Hence, our results provide evidence that bigger font sizes lead to better readability. However, from 18pt font size on, no improvement of the readability could be found.

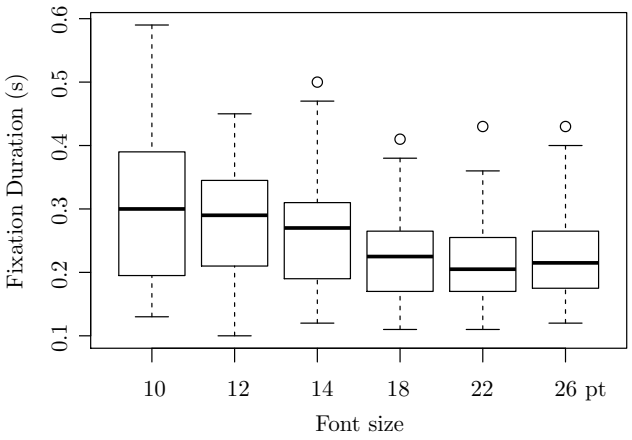

Figure 4: Mean fixation duration by font size. (Lower fixation durations indicate better readability.)

4.1.2 Line Spacing

Figure 5 shows the average fixation duration for each of the *line spacing* conditions. We did not find a significant effect of *line spacing* on *fixation duration* ($F(1,156) = 0.896, p = 0.345$). Hence, in contrast to font size, line spacing did not have an effect on readability.

4.1.3 Interactions

The interaction plot in Figure 6 shows that for increasing font size the fixation duration decreases similarly for all line spacings. Only for a line spacing of 1.4, we can see an increase at 26pt font size, which may indicate the these two values in combination decrease readability.

4.2 Comprehension Score

4.2.1 Font Size

Figure 7 shows the comprehension scores for each of the *font size* conditions. There was a significant effect of *font size* on the comprehension score ($F(1,165) = 9.370, p = 0.003$).

For 10pt font size, participants had significantly lower comprehension scores than for 18pt, 22pt, and 26 pt ($p < 0.01$, $p < 0.01$, $p < 0.05$, respectively).

For 12pt font size, participants had significantly lower comprehension scores than 18pt and 22pt ($p < 0.05$, each).

[4]Note this experiment was optional, the participants came to the study for another experiment. Out of 56 participants, 28 were willing to read articles about animals using Wikipedia.

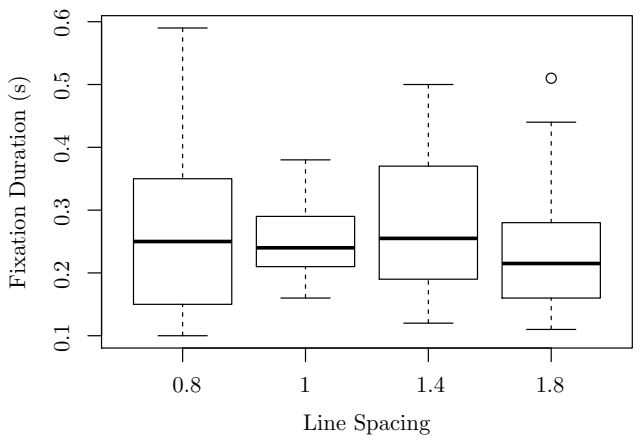

Figure 5: Mean fixation duration by line spacing. (Lower fixation durations indicate better readability.)

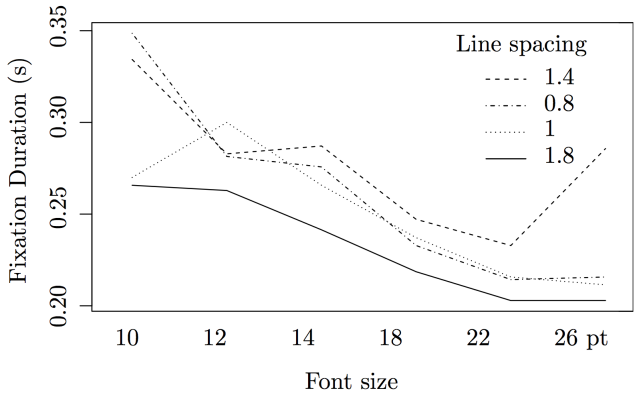

Figure 6: Interaction between font size and line spacing. (Lower fixation durations indicate better readability.)

For the font sizes 14pt, 18pt, 22pt, and 26pt, we could not find significant differences between the comprehension scores.

Similarly, we could not find significant differences between the comprehension scores for the font sizes 10pt and 12 pt.

These results indicate that the comprehension is significantly better for the larger font sizes (18, 22, 26 pt) than for the smaller font sizes (10, 12 pt) that we tested.

4.2.2 Line Spacing

Figure 8 shows the comprehension scores for each of the *line spacing* conditions. There was a significant effect of *line spacing* on the comprehension score ($F(1, 165) = 4.214, p = 0.042$). The comprehension score was significantly higher for 0.8 line spacing than 1.8 line spacing ($p < 0.05$). These results indicate that smaller line spacing leads to better understanding of the text.

4.3 Perception Ratings

4.3.1 Font Size

There was a significant effect of *font size* on subjective readability rating ($F(1, 135) = 72.191, p < 0.001$). Figure 9 shows the subjective readability ratings by *font size*. Pairwise post-hoc comparisons showed significant differences between almost all conditions.

For the font sizes 10pt, 12pt, 14pt, and 18pt, readability ratings increase significantly with increasing font size. This means that the readability ratings for the conditions are: $10pt < 12pt < 14pt < 18pt$ ($p < 0.01$, each).

For the font sizes 18pt and 22pt, we found no significant difference in the ratings ($p = 0.324$).

For 26pt font size, the readability ratings are significantly lower than for 22pt ($p < 0.01$).

These results indicate that subjective readability increases with increasing font size, but that it hits a plateau around 18pt - 22pt, and decrease beyond 22pt.

Analog to the effect on subjective readability, there was a significant effect of *font size* on subjective comprehension

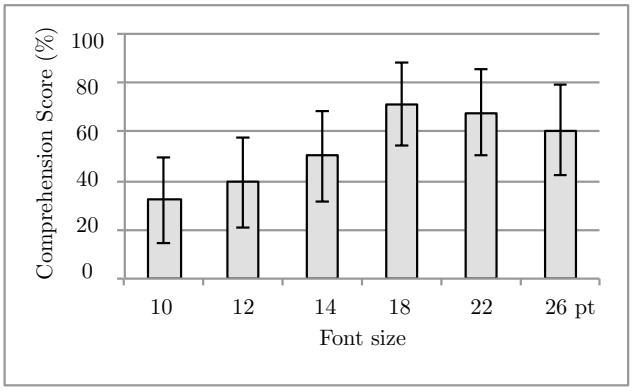

Figure 7: Mean comprehension score by font size.

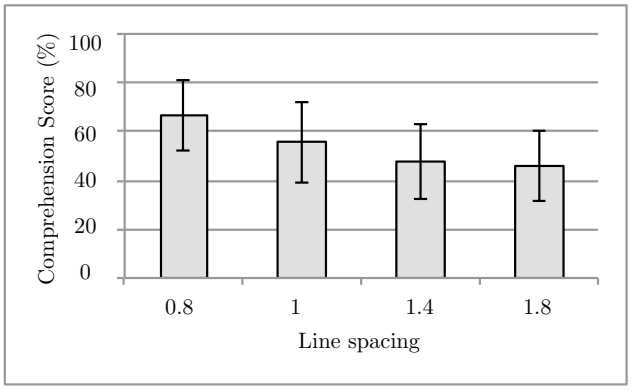

Figure 8: Mean comprehension score by line spacing.

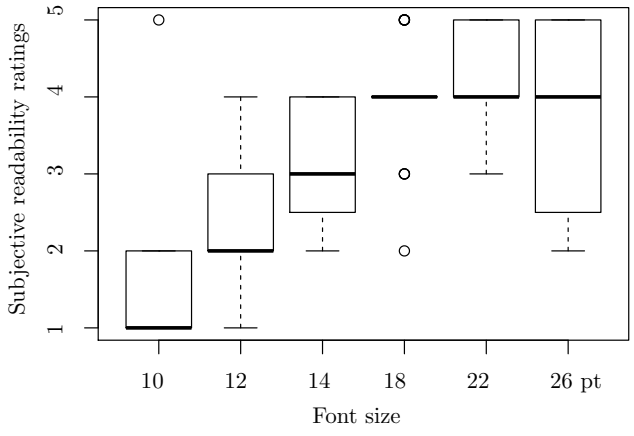

Figure 9: Subjective readability ratings increase with increasing font sizes, and hit a plateau around 18pt, 22pt.

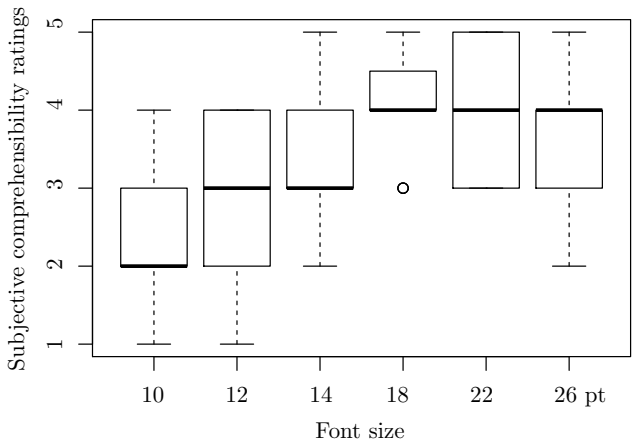

Figure 10: Subjective comprehensibility ratings increase with increasing font sizes, and hit a plateau around 18pt, 22pt.

rating ($F(1, 135) = 48.052, p < 0.001$). Figure 10 shows the subjective comprehension ratings by *font size*. Pairwise post-hoc comparisons showed a similar pattern, as we found on the readability ratings. There were significant differences between almost all conditions.

> For the font sizes 10pt, 12pt, and 14pt, comprehensibility ratings increase significantly with increasing font size. This means that the readability ratings for the conditions are: $10pt < 12pt < 14pt$ ($p < 0.01$, each).
>
> No significant differences were found between 14pt and 26pt ($p = 0.254$), 18pt and 22pt ($p < 0.703$), 18pt and 26pt ($p = 0.088$), and 22pt and 26pt ($p = 0.184$).
>
> Nevertheless, the ratings for font size 14pt are significantly lower than for 18pt ($p < 0.01$) and 22pt ($p < 0.05$).

These results indicate that comprehension is highest for the larger font sizes 18pt, 22pt, and 26pt.

4.3.2 Line Spacing

For *line spacing*, we neither found significant effects on the subjective readability ($F(1, 135) = 0.113, p = 0.737$) nor on the subjective comprehensibility $F(1, 135) = 0.193, p = 0.661$) of the texts.

5. DISCUSSION

Summary of Findings. We found significant effects of font size on fixation duration, comprehension scores, and subjective ratings. Fixation durations decreased with increasing font size until 18pt. Beyond this font size, no significant reduction of the fixation durations could be found. The comprehension scores were significantly higher for the larger font sizes (18pt, 22pt, 26pt) than for the smaller font sizes (10pt, 12pt). Subjective readability increased with increasing font size, being highest at 18pt and 22pt, and stabilizes with further increasing size. Subjective comprehensibility increased, too, with increasing font size, being highest for the larger font sizes (18pt, 22pt, 26pt). For line spacing, the only significant effect we found was that for the largest line spacings (1.8) the comprehension scores were significantly lower than for the lowest (0.8). Other than that, line spacing did not have any significant effect in our setup.

Font Size. Our results regarding font size are not consistent with previous studies and recommendations. Previous studies using eye-tracking with regular readers [6] recommend 14 points (comparing the sizes of 10, 12, and 14 points), while 26 points are recommended with readers with dyslexia (comparing fonts of 14, 18, 22 and 26 points) [31]. Also, the web design recommendations for readers with dyslexia recommend 12 or 14 points [1, 8, 7] or bigger [13, 8].

On the basis of our results, we recommend to use font size of 18 points for text in the Web. 18 points strikes the balance between having the best readability, comprehension, and subjective perception scores. Beyond 18pt, increasing the font size led to no significant improvement in our data, and was even counter-productive for subjective readability.

Pamenter	Value
Font size	18 points

Table 1: Recommended values for web text.

Line Spacing. Existing recommendations regarding lines spacing for readers with dyslexia are heterogeneous. Previous work has suggested 1.3 [25], 1.4 [31], 1.5 [8], and 1.5 to 2 lines [26]. Since in our setup, line spacing hardly had significant effects, we can neither confirm nor disprove these recommendations. The only significant effect of line spacing in our experiment was found on the comprehension scores, which were higher for 0.8 than for 1.8 spacing. This can be seen as indicator, that too much line spacing leads to decreased reading performance. However, from the data we cannot make assumptions about the intermediate line spacings 1.0 and 1.4.

On the basis of our results, we conclude that line spacing does not have much of an effect and can, therefore, be

subordinated to aesthetic considerations or user preferences. We can only hint that small line spacing might make texts easier to comprehend.

Limitations of the Study. One of the limitations of our study is that we provide data on readings of only the first three paragraphs of Wikipedia articles. When using eye-tracking to study reading, it has been found that the initially measured fixation durations are longer, since users are still in a familiarization phase [22, 24]. The heat map in Figure 11 shows that this effect occurred in our setup, too. However, the heat map also shows that the fixation durations normalize when reading on. And, since we assume that people often only read parts of web pages, we conclude that despite the short lengths of the texts, our findings have high ecological validity, *i.e.,* can be generalized to common reading patterns [9].

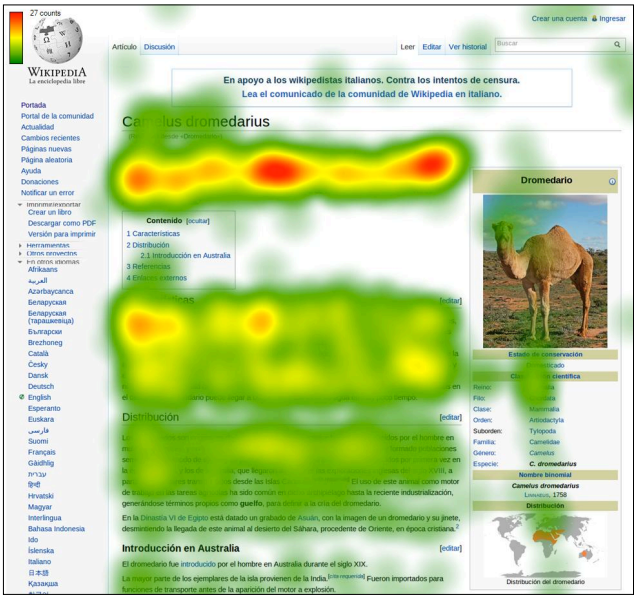

Figure 11: Heatmap.

Another limitation of the study is that we used a fixed line width. The browser window was maximized throughout the study. It could be possible that increasing the line width with increasing the font size would have negated some of the positive effects. However, previous research [32] actually predicts the opposite effect: in a reading study with 20 students, the highest line width led to fastest readings speeds. Therefore, if we had increased line width with font size, we might have even found more pronounced effects. Yet, the typical browser will not change its size when changing the font size. Hence, our design has high ecological validity and allows applying our findings to typical reading patterns.

Applicability Beyond Readers with Dyslexia. Studies on dyslexia and accessibility [20, 14, 21] agree that the application of dyslexic-accessible practices also benefits non-dyslexic readers. Consequently, the guidelines for developing dyslexic-friendly websites [7, 26, 34] usually overlaps with guidelines for low-literacy users [23] or users with low vision [15]. For example, according to Zarach [34], their guidelines for enhancing readability for people with dyslexia also benefit people without dyslexia. Moreover, symptoms of dyslexia are common to varying degrees among most people [14]. Hence, studying optimal reading conditions for people with dyslexia may not only help them to cope with their condition, but it might also benefit a much wider range of users, including those without significant impairments.

6. CONCLUSIONS

We tested the effect of font size and line spacing on objective and subjective readability and comprehensibility of texts of web sites (Wikipedia). The results can be summarized as *size matters, spacing doesn't.* Up to a font size of 18pt, subjective and objective readability and comprehension improved. Beyond 18pt, there were no further increases for the objective measures, and even decreases in the subjective measures. Line spacing, in contrast, had almost no effect. We only found hints that larger line spacings may lead to worse text comprehension.

Therefore, we conclude that a font size of 18pt ensures optimal readability and comprehensibility, subjectively and objectively. For line spacing, we suggest to remain with the default spacing 1.0, since this is what readers are most used to, and since increasing it too much might hamper comprehension.

Future work needs to focus on studying even bigger font sizes. While our results did not show improvements for font sizes beyond 18pt, we did not find conclusive evidence about the point where increasing the font size leads to reduced readability and comprehensibility.

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