Do People with Dyslexia Need Special Reading Software?

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Abstract. Around 10% of the population has dyslexia, a reading disability that negatively affects a person's ability to read and comprehend texts. Since certain text alterations can impact the reading performance of people with dyslexia, several specialized reading tools have been developed for this target group. However, there is also evidence that dyslexic-related difficulties do not only overlap with the ones of other groups with special needs but also appear among most people with varying degrees. These facts lead us to question the actual need of specific reading software for people with dyslexia. In this paper we analyze the textual parameters that impact dyslexic reading and compare them with the features of the current reading tools, specialized or not. Our main conclusion is that people with dyslexia are an example to support universal accessibility: the inclusion of their needs match the usability requirements of all other readers. Most of the dyslexic needs are covered through the customization of the text in existing generic reading tools, but to cover all the requirements, specialized software is needed.

Key words: Reading software, dyslexia, readability, universal accessibility.

1 Introduction

From 10 to 17.5% of the population in the U.S.A. [18] and from 8.6 to 11% of the Spanish speaking population [20] have dyslexia. *Dyslexia* is a neurological reading disability characterized by difficulties with word recognition, poor decoding abilities and poor spelling. As side effect, this impedes the growth of vocabulary and background knowledge [19]. Since a great amount of information is presented as text, this condition makes it more difficult to people with dyslexia to use well standard information systems.

On one hand, previous research have shown the importance of the text layout. For example, certain text presentations can make people with dyslexia to read

significantly faster [35, 42, 36]. Hence, a number of specialized reading tools have been developed to support this specific reading disability [37, 13, 21].

On the other hand, there are three facts that question the actual requirement of specialized reading software in favor of universal accessible reading software:

– Dyslexia-related difficulties are also shared by other groups with special needs, such as people with low vision [12].
– Dyslexia symptoms are common among most people to varying degrees [9].
– There is a considerable overlap between the dyslexic-friendly recommendations and more general textual accessibility recommendations [24].

In this paper we aim to find out whether people with dyslexia require specific reading software. First, we analyze the textual parameters that have an impact on their reading (Section 2). Second, we compare these parameters with the features of the most popular reading software as well as with the ones specifically developed for this target group (Section 3). We end drawing some conclusions in Section 4.

2   What do People with Dyslexia Need?

In this section we present the text presentation parameters which have been recommended in previous works regarding people with dyslexia as well as user studies which measure the reading performance. We distinguish the values which have lead to significant effects.

2.1   Font Type

Recommendations Most of the recommendations agree in using sans-serif fonts. Most studies recommend *Arial* [6, 12, 23] and *Comic Sans* [6, 12] or, as alternatives to these, *Verdana*, *Tahoma*, *Century Gothic*, and *Trebuchet* [6]. Other recommended fonts are *Sassoon Primary* [10], *Times New Roman* [16] and *Courier* [1]. Moreover, we found four fonts designed for people with dyslexia: *Sylexiad* [15], *Dyslexie* [22], *Read Regular*[1] and *OpenDyslexic*.

User Studies To the best of our knowledge there are only two user studies that objectively measure the effect of the font type in the reading speed of people with dyslexia. In [22] *Arial* and *Dyslexie* are compared using 21 students with dyslexia. *Dyslexie* did not lead to faster reading, but could help with some dyslexic-related errors. In [39] we compare 12 fonts using eye-tracking (48 participants with dyslexia) being the most readable Sans serif, roman and monospaced fonts, specially *Helvetica*, *Courier*, and *Computer Modern Unicode* [29].

Suggestion for best practice: Sans serif, roman and monospaced fonts are good fonts for people with dyslexia specifically, *Helvetica*, *Courier*, *Arial*, *Verdana* and *Computer Modern Unicode* [29].

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[1] `http://www.readregular.com/`

2.2 Font Size

Recommendations The recommended font size for this target group is 12 or 14 points [2, 5, 6], or bigger [6, 8].

User Studies A study with 22 participants with dyslexia compared font sizes ranging from 10 to 26 points using raw text on the screen. Texts written with 26 points were the fastest to read [35]. However, another study with 28 participants with dyslexia tested the same range of sizes in the context of the Web (Wikipedia) and 18 points resulted to be the most readable size. Beyond 18 points there were no further improvements on reading speed [36].

Suggestion for best practice: Sizes raging from 18 points [36] to 26 points [35] lead to to faster readings.

2.3 Brightness and Colors

Recommendations Suggestions broadly agree that people with dyslexia normally prefer lower brightness and color differences among text and background compared to the average reader [25, 5, 6, 38], although not lower than then minimum color luminosity ratio prescribed by the W3C[2] [7, 27]. In [38] light grey is recommended for the font color.

User Studies Previous user studies showed that specific text and background colors could be beneficial for reading on the screen. The color pairs which lead to a better readability were: cream and black [35], yellow/blue [35, 14], light mucky green/dark brown [35, 14], grey (25%) in the background with white font and in grey font (25%) with white background [35].

Suggestion for best practice: Since no effects were found in previous studies we do not make any specific recommendation.

2.4 Character, Line and Paragraph Spacing

Recommendations In [25] it is recommended to create a slightly larger distance between individual words and reduce letter-spacing slightly so that the letters within a word lie closer together while [26] suggests to have clear spacing between letter combinations. Recommendations in previous work comprise line spacings of 1.3 in [25], 1.4 [35], 1.5 [6], and 1.5 to 2 lines [26]. According to [5], paragraphs –even when they have a single line– should always be spaced out with an empty line between each paragraph. According to [26, 5] justified text alignment shall not be used since it produces an irregular spacing between words and that it is harder to read.

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[2] To avoid brightness differences less than 125 and color differences less than 500 [7].

User Studies Extra-large letter spacing was found to lead to faster reading (74 children with dyslexia) [42]. However, in [35] none of the character, line and paragraph spacings tested lead to significant effects (22 participants with dyslexia, 12 of them adults). However, line spacing was found to be strongly negatively correlated with reading performance: the narrower the space between the lines, the slower the participants read [35]. In [36] the effect of line spacing and font size is measured in combination, but only font size lead to significant differences on the reading performance.

Suggestion for best practice: Larger letter spacings were found to lead to faster reading [42].

2.5   Column Width

Recommendations The recommendations suggest that lines should not be too long [6, 26, 5] –60 to 70 characters – and narrow columns should be avoided [6].

User Studies In a user study (22 participants with dyslexia) no significant differences on reading speed were found regarding column width, although most users preferred columns from 44 to 66 characters per line [35].

Suggestion for best practice: Since no effects were found we do not make any specific recommendation.

2.6   Language Content

Recommendations The use of complicated language has been extensively pointed out as one of the key problems for this target group [24, 38]. Recommendations agree in using plain language, that is, clear, concise, jargon-free texts is recommended. According to [3] plain language benefits all users. Very long sentences shall be avoided [6, 5, 26, 41].

User Studies User studies have shown that people with dyslexia read better more frequent and shorter words [17, 31]. Also numerical expressions written as digits lead to a better readability than numbers written in letters [34]. However, the lexical quality of the text [28], the addition of graphical schemes to the text (mind maps) [33] or the performance of syntactic simplification of the text throughout verbal paraphrases [32] did not lead to significant effects. However, the only user study that tested a lexical simplification algorithm for Spanish [4] showed that performing automatic lexical simplifications (substituting complex words but a simpler synonyms) did not improve the readability of the texts. However, when this synonyms were presented on-demand to the user the texts are perceived as simpler [30].

Suggestion for best practice: We recommend to show synonyms on demand since this strategy was found to be beneficial regarding the perception of the complexity of the text [30].

3   Current Tools

In this section we compare the two most popular reading applications –*Kindle* and *iBooks*– and five specific reading software for people with dyslexia. The only ones designed on the basis of user studies with this target group are *Firefixia*, *SeeWord*, *IDEAL eBook Reader* and *Text4All*.

- **Kindle reading software**.[3] A reading software introduced by Amazon for various devices and platforms.
- **iBooks**.[4] An e-book application by Apple for the iOS operating system used by its devices.
- **ClaroRead**.[5] A software for various platforms to support reading and writing. It includes an extra package for people with dyslexia such as *ClaroView* which a color tool. We did not find evidence of user studies performed for the design or testing of this tool.
- **Firefixia**. A Mozilla Firefox extension, especially designed to apply predefined features supporting people with dyslexia. It was designed and tested on the basis of research done with participants with dyslexia [37].
- **IDEAL eBook Reader**.[6] An ebook reader for Android which includes specific settings for displaying books for people with dyslexia. Those settings are based on user studies [21].
- **SeeWord**. A software that provides customization capabilities to improve Microsoft Word. It was also specifically tested with people with dyslexia [13].
- **Text4All**.[7] A web service which allows users to adapt text from existing web pages [40]. It has an option for modifying the text layout for people with dyslexia based on user studies using eye-tracking [35, 36].

In Table 1 we compare the features of the tools for dyslexic-related needs. Even if it is not a text layout parameter, we include Text-to-Speech (TTS) among the features. People with dyslexia may benefit from this technology due to the multi sensory experience of seeing and hearing.

ClaroRead also includes a feature called 'homophones' which detects words that are pronounced the same, coloring them in the document to make these words less confusable. Similarly, *SeeWord* colors differently similar looking letters such as 'd' and 'b' [13]. The rationale behind these features is that people with dyslexia specifically encounter problems with words that are phonetically or orthographically similar [11].

Firefixia also includes the option of eliminating italics and other features for web text such as choosing the color of the links [37].

Even if *SeeWord* does not allow to customize the column width, it uses another strategy to reduce the visual clutter in the interface. It uses a masking

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[3] `www.amazon.com/kindle`

[4] `https://itunes.apple.com/en/app/ibooks/id364709193?mt=8`

[5] `http://www.clarosoftware.com/index.php?cPath=333`

[6] `https://play.google.com/store/apps/details?id=org.easyaccess.epubreader`

[7] `http://www.text4all.net/dyswebxia.html`

Table 1. Summary feature comparison of the reading tools. The asterisk ('*') means that the feature is under development, "yes" means that the feature can be adjusted meeting the recommendations and "no" means the lack of that feature in the application. Required features, the ones which lead to significant results, are marked in bold.

| Software | **Font** | **Size** | Bright-ness | **Color** | Spacing | | | | Column Width | **Syno-nym** | TTS |
					Chac.	Word	Line	Parag.			
Kindle	yes	yes	yes	yes	no	no	yes	no	yes	no	yes
iBooks	yes	yes	yes	yes	no	no	no	no	no	no	yes
ClaroRead	yes	yes	no	yes	yes	no	yes	yes	no	no	yes
Firefixia	yes	yes	no	yes	yes	no	yes	no	yes	no	no
IDEAL	yes	yes	yes	yes	yes	yes	yes	yes	no	yes*	yes
SeeWord	yes	yes	no	yes	yes	no	yes	no	no	no	no
Text4All	yes	yes	no	yes	yes	no	yes	no	no	yes*	no

window which leaves only part of the text visible, reducing the problem of visual stress and memory.

The feature for adjusting the brightness contrast is integrated in the reading software of the mobile devices (*Kindle*, *iBooks* and *IDEAL eBook reader*). For the rest, such feature is part of the operating system, not in the reading software itself.

None of the tools include the feature of displaying synonyms on-demand for complex words. Nonetheless, such feature is being currently developed for the *IDEAL eBook Reader* and in *Text4All*.

There are other applications for people with dyslexia that we did not consider because they are not reading softwares *per se* such as *ScreenRuler*,[8] an application that provides an overlay rule to support reading tasks, or *Colour Explorer*,[9] a software to change the colors in the *Windows* operating system.

4   Conclusions

According to the state of the art, there is a set of parameters which lead to significant effects on reading for people with dyslexia. These are:

– font type,
– font size,
– colors (font and background),
– character spacing, and
– presenting synonyms on-demand.

Hence, these parameters must be included in the reading tools for people with dyslexia if we want to have accessible text.

[8] http://www.clarosoftware.com/index.php?cPath=348
[9] http://colour-explorer.software.informer.com/9.0/

The most popular tools, *Kindle* and *iBooks*, allow to customize most of these crucial text presentation parameters, with the exception of character spacing and the presentation of synonyms on-demand. That is, universal accessibility is supported by these main stream tools and with some additional features (which at the moment are only on specialized software for dyslexia) could provide greater accessibility, leading to a more inclusive design for all where additional software would not be needed for people with dyslexia.

Nowadays, specialized reading software is still needed to cover all features that lead to a more accessible reading for people with dyslexia. However, using the principles of universal accessibility would easily bridge the gap between specialized and non-specialized reading software for people with dyslexia, without making any differences for this target group of people and empowering their inclusion.

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