

Web Accessibility and People with Dyslexia: A Survey on Techniques and Guidelines

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ABSTRACT

Although the dyslexia has significant occurrence in the global population, ranging from 15 to 20%, not much is known about how developers, designers, and content producers should respect differences and consider people with dyslexia in the Web. In this paper we present a survey regarding the state of the art on dyslexia and Web Accessibility. From the results, we present a set of 41 guidelines that may support website stakeholders (*i.e.*, people directly involved with the design, development, and content) in phases involving design, coding, and Web content insertion. Moreover, we propose a mapping of these guidelines considering the responsibilities of different roles of websites stakeholders. Informed by this survey we expect development teams to objectively consider abilities of people with dyslexia in order to remove accessibility barriers.

Categories and Subject Descriptors

H.5.2 [Information Interfaces and Presentation]: User Interfaces – Evaluation/methodology. D.2.2 [Software Engineering]: Design Tools and Techniques – User interfaces.

General Terms

Design, Human Factors.

Keywords

Web Accessibility, Dyslexia, Guidelines, Reading Disability, Learning Disability, Legibility

1. INTRODUCTION

Content sharing in the Web is growing significantly in the last decades (just for a glimpse, Facebook reported 5 billion shared

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items on January 2010¹). This fact has impacted on cultural changes in the worldwide population. When people start sharing or consuming content through information systems, accessibility is a key term to be taken into account.

Accessibility can be considered in a number of contexts, for example, architecture, communication, services, among others. Web Accessibility means that all people, regardless the different kinds of limitations, can perceive, understand, navigate, interact, and contribute to the Web. An accessibility barrier is defined as anything that makes harder or impossible for people with disability to use the Web [27].

For the organizations, accessibility is a key factor to be considered in their websites, since it is directly related to profit, legislation, and the image that the organization has within society. Considering the users' point of view, Abascal and Nicolle [1] say that computers potentially contribute increasing the social inclusion and autonomy of people with disability, since they provide access to education, work, information, communication, leisure, etc.

Being a citizen is becoming more and more dependent on the fact of being digitally literate and of having access to the Web. In addition, different modern cultures depend on ICT (Information and Communication Technologies). Example of this dependence is that several government, educational, and entertainment services are offered only online. Moreover, working positions that do not require the use of ICT are becoming rare. Unfortunately, efforts to guarantee accessibility of websites are not yet growing accordingly.

When thinking of Web Accessibility, issues that arise first are commonly related to visual disabilities, since common barriers are related to how to present visual information in a non-visual way. Questions related to other types of disability are hardly considered (*e.g.*, reading disability). Dyslexia is not often included in studies involving Web Accessibility.

According to the *Diagnostic and Statistical Manual of Mental Disorders-IV* (DSM-IV) [3], the dyslexia (or reading disorder) is

¹<http://www.insidefacebook.com/2010/02/15/new-facebook-statistics-show-big-increase-in-content-sharing-local-business-pages/>

characterized by an inferior ability in reading in comparison to the expected for the chronological age.

Regarding the incidence of dyslexia in the population, the International Dyslexia Association (IDA) [13] asserts that from 15 to 20% of the world population have some symptom of dyslexia as slow reading, imprecise reading, difficulty when spelling, low proficiency in writing, or tendency of exchanging similar letters.

Beyond presenting percentages as motivators to highlight the need for actions regarding dyslexia in the Web, this work has as main basis the Universal Design principles. This means that we aim at dealing with dyslexia in such a way that solutions do not segregate this group of users.

McCarthy and Swierenga [15] highlight that much work has been done in order to relate dyslexia to Web Accessibility, but there is no significant number of works yet aiming at the articulation of both, Web Accessibility and dyslexia. Most efforts are focused on how to support users that are blind or have low vision.

The objective of this work is to present a survey regarding the state of the art on accessibility and people with dyslexia, aiming at removing or avoiding barriers that they may face in the Web. Based on this survey involving literature results, techniques, and guidelines, we compiled guidelines according to actions and responsibilities of developers, designers, or content producers. This role-based organization of the guidelines was inspired by the work presented in [22] and aims at providing filters so that website stakeholders can easily apply guidelines that are closely related to their roles.

This work is organized as follows: Section 2 summarizes the concept of dyslexia and questions involved in dyslexia diagnosis. Section 3 shows the background to the work. In the sequence, Section 4 presents related works and details the literature review. Following, Section 5 summarizes and discusses the guidelines and techniques compiled. Lastly, Section 6 discusses the survey and Section 7 concludes and indicates further work.

2. UNDERSTANDING DYSLEXIA

The term dyslexia has a Greek origin in which "*dis*" means disorder and "*lexia*" language. Thus, dyslexia is a language disorder [11]. The concept of the dyslexia is controversial even among the specialists in the field [20]. The currently more accepted neurological model has the dyslexia as a neurological disorder of genetic origin with persistence throughout life [19].

The World Federation of Neurologists [30] defines dyslexia as a disorder in which a child does not develop the skills of reading, writing, and spelling expected according to their age and intellectual performance, despite having access to regular schooling.

According to the neuropsychological approach, the difficulties are understood as a consequence of one or more dysfunctional brain systems involved in learning [21]. Sternberg and Grigorenko [26] proposed a definition that became one of the most used. It is a multiple causes approach that suggests that the reading difficulties are the result of an interaction between biological, genetic and neuropsychological, cognitive, and social skills as well. Thus, authors understand dyslexia as etiologically heterogeneous phenomenon.

In relation to etiological factors related to reading difficulties there are two main lines of discussion: a biological (genetic and

neuropsychological) and a functional (memory, phonological awareness, connection of written form to the spoken form, learning and recognition of rules/exceptions, and linguistics inferences) [11], [20].

According to the DSM-IV, people with dyslexia have difficulties to understand written words and sentences in such a way that these difficulties interfere significantly in the accomplishment of common tasks that require reading abilities. Dyslexia is more commonly found in men, representing from 60 to 80% of the population that has this disability [3].

The IDA [12] defines dyslexia as a language learning disability of neurological basis that results in linguistic difficulties, especially those related to reading, but it may also interfere in other abilities such as orthography, writing, and pronunciation. The effects of dyslexia vary depending on the level of disability and the intervention offered to the person.

However, this disability should not be directly related to intellectual levels. Dyslexia is not related to low intelligence or educational attainment. Dyslexia is not itself a disease, it is a dysfunction of the brain related to language processing. It is a specific impairment in reading accompanied by a normal development in other areas that are not related to the disability. Some authors understand it as a different way of thinking instead of a disease [16], [25].

In order to have a dyslexia diagnosis the person must present the following characteristics [3]:

“A) Reading achievement², as measured by individually administered standardized tests of reading accuracy or comprehension, is substantially below that expected given the person's chronological age, measured intelligence, and age-appropriate education. B) The disturbance in Criterion A significantly interferes with academic achievement or activities of daily living that require reading skills. C) If a sensory deficit is present, the reading difficulties are in excess of those usually associated with it.”

There are several characteristics employed to refer to people with dyslexia. This way, we are talking about a group that is united by the diagnosis of dyslexia, but, at the same time, is separated by the complexity that the diagnosis itself involves. We can not consider people with dyslexia as a homogeneous group due to lack of consensus regarding a precise diagnosis. Finally, the literature does not count on efficient tools to attest the exact cause of learning disabilities.

When interacting with computers, people with dyslexia can benefit from using assistive technologies as screen readers, voice recorders, and voice synthesizers [24]. Other categories of tools as spell checkers [9] and screen magnification are also valuable³.

² Reading achievement is measured using standardized tests, performed individually, that measure reading comprehension and correct interpretation.

³ For an example consult:
<http://www.dyslexic.com/AtoZdisplay.asp?Type=01&TpData=>

3. METHODOLOGICAL STANCE

Universal Design (UD) consists in the design of products and environments that are usable by everyone, in the widest possible extension, without the need for adaptation or specialized design [8]. The difficulty in fulfilling the UD proposal is clearly due to a number of factors including technological and methodological limitations. Nevertheless, UD is considered a goal to be pursued because it motivates the development and design of solutions that respect different necessities without discriminating.

Within the UD domain Abascal and Azevedo [2] define inclusive design as the one which aims at considering the needs of all the users in mainstream applications and not only in the systems especially designed for people with disabilities. This work is aligned with the inclusive design stance.

The inclusive design is presenting signals of overcoming the welfarist view of products design. Now, when one refers to social inclusion also refers to wishes, emotions, autonomy, and social rights of people. Regarding affectivity, it means considering also the individual happiness as a criterion for the definition of citizenship [23]. Thus, this work follows the UD's philosophy and considers the inclusive design in the process of applying this philosophy, since the main goal presented is the design of products and environments that are usable by everyone. Moreover this goal may be achieved by considering the needs of all users in the mainstream application, including people with dyslexia.

Regarding organization of guidelines, in [22] the authors proposed an integrated an objective way of presenting references involving website accessibility and usability. In addition, in that work three roles associate actions to responsibilities of different professionals: developers, designers and content producers, as follows:

- **Developers:** are people with expertise in Web technologies and programming. Their responsibilities are within modeling/coding systems and algorithms;
- **Designers:** are people with expertise in designing user interface (UI) solutions involving User Experience and Information Architecture. Their responsibilities are within designing UI, defining color schemes, defining layout, among others;
- **Content Producers:** are people in charge of writing and publishing content into websites. Their responsibilities are within updating Web pages' content and writing new content for the website.

It is worth mentioning that these roles are not strictly defined and, in small teams, one stakeholder may assume more than one of these roles (*e.g.*, designer and developer, content producer and designer). Some evidences were shown that such structuring helps stakeholders to quickly reach relevant information regarding website maintenance [22].

In this work, outcomes and guidance provided by different associations, academic papers, reference websites, and specialized magazines were summarized and organized to form an objective and straightforward to use set of guidelines.

The method used in the literature review was the following: 1) we first identified and extracted guidelines, results, outcomes, and techniques presented in the academic papers mentioning dyslexia and Web Accessibility; 2) then we grouped all the extracts found

according to the papers' sections where they appeared, terms used, and goals; 3) finally we compiled all extracts and rewrote them in a guideline style in order to facilitate their use, placing them under the groups identified. The groups were formed according to the UI element that the guidelines are referring to and are detailed in the guidelines mapping section.

It is noteworthy to mention that the groups found are not a definitive set and they may grow as the study of dyslexia and Web Accessibility evolves. Next we present a summarized view of the related work.

4. RELATED CONTRIBUTIONS

The next subsections present works that aimed at studying dyslexia and Web Accessibility. The first subsection presents works of organizations that support people with dyslexia, in the sequence a subsection counts on academic research papers, and then a subsection details existing guidelines.

4.1 Organizations that support people with dyslexia

The British Dyslexia Association (BDA) [5] is an institution that has as a main vision a society that is aware of people with dyslexia so that these people can reach their whole potential. The institution promotes initiatives that aim at promoting sound changes that bring benefits to people with dyslexia. Moreover, BDA also offers support to people with dyslexia and supports people that have direct contact with them, looking for innovative solutions and promoting best practices in national and international levels. In this work we refer to the guide offered by the institution that deals with text, accessible formats, and Web design.

Rainger [18] presents a perspective on content production in the Web aiming at the accessibility regarding people with dyslexia. The referred work was published at JISC Techdis⁴, a British website that offers consulting services about technology and social inclusion. The service supports educational institutions and enterprises via knowledge sharing concerning accessibility, stimulating the innovation and offering counseling about technology and disability. The author focus his work on content accessibility and concludes that there is a need for developers to be aware of the diversity of perceptions of content, learning styles, cognitive limitations and learning strategies.

Bradford [7]'s concerns are related to how to design Web pages for people with dyslexia. His work is published in the Dyslexia Parents⁵ website that counts on the Dyslexia Online Magazine. The website has the objective of supporting parents of children and teenagers by providing information and counseling. The website also provides resources that deal with dyslexia from different perspectives including, parents, students, and teachers. The author concludes his work pointing out that the main goal to be achieved in order to cope with dyslexia is to promote understanding of textual content.

⁴ http://www.jisctechdis.ac.uk/techdis/resources/detail/learnersmatter/Jan03_Dyslexia

⁵ <http://www.dyslexia-parent.com>

4.2 Academic research papers

Al-Wabil et al. [4] present an exploratory study about the experience of people with dyslexia when surfing the Web. The results were obtained from semi-structured interviews conducted with 10 individuals with dyslexia. The research subjects were from 18 and 49 years old. The study investigated needs, challenges, and difficulties faced by the participants. All subjects had been diagnosed with dyslexia and 3 of them also had dyspraxia⁶ (one of these 3 participants also had sensorial defensiveness⁷). In the study, researchers also observed with special interest the use of assistive technologies. The referred work contributed by informing about techniques and types of accessibility barriers the subjects face. The authors conclude that they had interviewed a relatively small group of individuals, but the study suggested the presence of patterns in navigation and scanning of Web pages for information by dyslexic users. In addition, the authors point out that despite the existence of websites conforming to accessibility standards, the Web suffers from many problems in supporting navigation and content consumption, particularly for users with specific learning difficulties.

McCarthy and Swierenga [15] contributed with a literature review considering published works dealing with dyslexia and accessibility in order to determine the knowledge produced until 2010. They investigated available information regarding user experiences of people with dyslexia within the Web. They also considered disabilities that can interfere in the overall understanding on how people with dyslexia use the Web. The authors associated dyslexia with disabilities in general, especially the low vision. The paper has objectives similar to ours, but the referred work presents mainly pointers, without showing objectively how to apply guidelines or remove barriers for people with dyslexia. In addition, the work places dyslexia in the background of other disabilities, fact that may hide specificities on how people with dyslexia interact with the Web.

4.3 Guidelines

Zarach [31] presents 10 guidelines that were published in the CETIS⁸ (Center for Educational Technology and Interoperability Standards) website. The CETIS provides advices referring to technology and education to educational institutions of United Kingdom. The objective of the website is to contribute to the debate about the use of technology in the field of education. Zarach concluded that the presented guidelines aim at enhancing readability and accessibility for people with dyslexia, but they also benefit people without dyslexia, since focus on improving simplicity, clarity, and usability. This is very much in accordance with the UD paradigm.

The WARAU⁹ (Websites Adapted to Requirements of Accessibility and Usability) is a reference website where website stakeholders can discuss norms, guidelines, techniques, and good

⁶ Dyspraxia can be defined as the difficulty in motor control

⁷ Sensorial Defensiveness is the tendency of reacting negatively or in an alarming way to an inoffensive or non-annoying sensorial input [14].

⁸ <http://jisc.cetis.ac.uk>

⁹ <http://warau.nied.unicamp.br> (in Brazilian Portuguese)

practices for the development of accessible and usable Web code. WARAU's target audience is composed of websites stakeholders that already have some knowledge in coding Web pages (*e.g.*, HTML, CSS, and JavaScript) and that want to learn how to build valid, accessible, and usable websites. In the website there are discussion areas to a number of topics involving accessibility and usability, from assistive technologies to guidelines and standards provided by organizations such as the World Wide Web Consortium (W3C). Although presenting an objective approach, with references and code examples, the website does not present any guideline or technique specifically addressing dyslexia.

Sets of guidelines for the elaboration of accessible Web content contribute significantly to the wide adoption of actions towards the promotion of Web Accessibility. Examples of available sets of guidelines are the Web Content Accessibility Guidelines (WCAG) [29] and the Section 508 [10]. The WCAG is the most adopted set of guidelines and currently it is in the 2.0 version.

When investigating how WCAG deals with dyslexia, one can observe that two external references [6], [18] were used in order to elaborate guidelines. Moreover, dyslexia is directly mentioned in one success criterion (*i.e.* 3.1.5 Reading Level). The theme of dyslexia is indirectly considered in some guidelines, but, without a direct reference, reading disabilities may be neglected by WCAG readers.

We argue that the lack of explicit consideration of dyslexia specificities in the guidelines make the needs of users with dyslexia unfulfilled, making them more and more unmotivated in using the Web. This fact is significant when considering autonomy, since difficulties in making common tasks also raises preconceptions and stigmatization of people with dyslexia, bringing negative impacts to their self-esteem, making symptoms even worse.

5. GUIDELINES MAPPING

This section presents the integration of guidelines, and techniques resulted from the conducted study. The guidelines are grouped according to the topics addressed, aiming at the easy reuse and implementation. Considering the stakeholders' roles presented in [22], Table 1 presents groups of guidelines and the respective relevance for the roles considered.

The mapping is intended to serve as an index to guide actions considering the mentioned stakeholders' roles. Thus, for example, content producers could easily know where they should focus their actions and which techniques to use to improve Web Accessibility considering people with dyslexia.

The relevance level was attributed to each guideline according to the following rules:

- If the application of guidelines of a certain group (G) depends strictly on responsibilities of a certain role (R), then the relevance level for this group is set as high;
- Else, if the application of guidelines of G depends highly on a role different than R, but also depends on the participation of the R, then the relevance level is set as medium;
- In other cases, *i.e.*, when the application of guidelines of G has minimum or no dependence on R, then the relevance level for R is set as low.

For example, when referring to end user customization, developers are highly involved in applying such guidelines because the development of customization features involves modeling and programming. Moreover, designers are also involved, since they are responsible for defining the proper design of customization features, UI elements, and colors. Finally, content producers have little participation on applying such guidelines, since they have almost no content to be produced. Hence, the guidelines presented at the end user customization group have low level of relevance for content producers.

Table 1. Relationship among groups of guidelines and relevance level according to stakeholders' roles.

Guidelines group	Relevance		
	Developer	Designer	Content producer
Navigation	High	High	Medium
Colors	Medium	High	Medium
Text presentation	Medium	High	Medium
Writing	Low	Low	High
Layout	Medium	High	Low
Images and charts	Medium	High	Medium
End user customization	High	Medium	Low
Markup	High	Low	Medium
Videos and audios	Medium	High	Medium

The guidelines surveyed are organized according to the following groups:

1. **Navigation:** involves recommendations related to menu structuring, breadcrumbs, index pages, site map, internal search, links, lists, and how to highlight headlines, sections, and key terms;
2. **Colors:** involve recommendations related to the combination concerning foreground and background colors;
3. **Text presentation:** recommendations related to text sizes and font types, as well as alignment and animation;
4. **Writing:** recommendations concerning content writing style that makes easier for people with dyslexia to read content in the Web;
5. **Layout:** overall recommendations about how to structure the Web page layout;
6. **Images and charts:** recommendations about whether charts/images are important to support the understanding of the text and in which cases they should be avoided;
7. **End user customization:** recommendations about UI elements that are customized by users and that have positive results when offered to users with dyslexia;
8. **Markup:** recommendations related to techniques of markup languages (*e.g.*, HTML and XHTML) that improve accessibility considering people with dyslexia;

9. **Videos and audios:** recommendations considering the use of multimedia as videos and audios.

5.1 Navigation

5.1.1 Navigation menu

N1 – Navigation must be consistent, visible all the time, and must contain simple lists of links avoiding the need of scrolling pages to see all listed items. Difficulties related to the sense of direction are usual for users with dyslexia [4], [7], [15].

N2 – Avoid dynamic menus or menus that use transparency, because users with dyslexia may find hard to contrast them with the background partially visible [4].

N3 – Whenever using images in navigation, since they facilitate the use for people with dyslexia, make sure that images have significant alternative text (*via alt* attribute) adding a textual description to textually represent images function [31].

5.1.2 Breadcrumb

N4 – Textual breadcrumbs should have text size that allows comfortable reading. Considering redundant information, breadcrumbs can also have snapshots¹⁰ helping in the task of contextualizing and remembering. People with dyslexia prefer using the back button, especially when there are snapshots of visited Web pages [4].

5.1.3 Index page

N5 – Whenever possible, structure index pages considering a logical order involving tasks sequence or structure (*e.g.*, when involving information that can be structured as part-whole), without requiring exclusively the alphabetical ordering. Most of dyslexic people use index page, but they may have difficulties with alphabetic sequences [4].

5.1.4 Site map

N6 – When building a site map, the use of hierarchical trees containing clear texts is suggested. Site maps are useful, but usually they are used when other search possibilities did not succeed [4], [5], [31].

5.1.5 Back and forward buttons

N7 – Avoid using mechanisms that interfere with back and forward buttons functioning. Users with dyslexia use back and forward browser buttons because they are visible and consistent. They are a solution when a click is done by mistake or if users want to freely go forward or backward when need to read again steps performed in a step-by-step task [4], [18].

5.1.6 Internal search

N8 – When offering internal search in your website, optimize it by aiming for the quality of the results, providing self completion, and orthographic verification to point errors and ease correction [4], [15], [18]. Writing aids are useful for users with dyslexia to correctly perform content searching tasks.

¹⁰ Image representing the screen during the usage of information systems.

5.1.7 Sections header and highlighting

N9 – Avoid using headers all in capitals in order to call users' attention. If the highlight is needed in headers, use text size and bold face for regular capitalized text, since it is easier to read text in regular capitalizing [5], [18].

N10 – Avoid italics because it is harder for people with dyslexia to read italic text if the text size is reduced. Instead of italic text use bold to highlight key concepts. Give preference in using tags that represent semantic information instead of visual, for example, use instead of . The italic text becomes unreadable in comparison to non-italic text. Finally, assure that style sheets do not use italics [5], [7], [18].

N11 – Whenever text highlighting is needed, consider using boxes, border, and background color to call user attention. The reading time is reduced when users with dyslexia easily identify the section related to the text they are reading [9]. In addition, adding colors increase the probability that the information read is retained in a long-term memory [5], [7], [18].

5.1.8 Links

N12 – When writing link labels, structure labels clearly in order to keep them simple. Do not use “click here” [31].

N13 – Content links must indicate which pages were accessed [5]. Presenting clearly what are the visited links improves reading for people with dyslexia and helps on identifying which pages had been visited.

N14 – Use underline only for links and avoid links involving big blocks of text, because it makes harder to read [18].

N15 – Use links in a concise way at the beginning or at the end of phrases in order to ease the reading [5], [18].

5.1.9 Lists

N16 – Use ordered lists (or numbered lists) instead of unordered lists (or bullet list), since ordered lists have additional information of context and people with dyslexia find it easier to follow [31]. Some screen readers speak the number of list items (e.g., list with 10 items), but it is worth mentioning that not all people with dyslexia use screen reader.

N17 – Use white spaces to ease reading. To improve comprehension of list items, use white space to separate marker from text and between items use double spacing [7], [18], [31].

5.2 Colors

5.2.1 Background color

C1 – Avoid pure white as the background color, because the white can obfuscate the text for people with dyslexia. A close alternative is the light gray with the following hexadecimal code #FFFFFFE5. A significant fraction of people with dyslexia is sensitive to the brightness of white background (i.e., scotopic sensitivity) and the text can appear as if it was moving or blurred. Instead of white background use pastel colors in background. For example, dark blue on beige background. Finally, avoid background images and patterns [5], [7], [18].

5.3 Text presentation

5.3.1 Text size

T1 – Avoid small text sizes. Small texts slow reading for people with dyslexia. The smaller text size recommended is from 12 to 14px; for printing it should be from 12 to 14pt [4], [5], [15], [18], [31]. Dickinson [9] reported in an evaluation that people preferred font sizes above 12px (the default in that test case).

T2 – Use mono spaced fonts and without serif. Examples are Arial, Comic Sans, Verdana, Tahoma, Century Gothic, Georgia, and Trebuchet. People with dyslexia, but not only them, consider font without serif easier to read, since that serif fonts are more detailed and, consequently, more complex of reading and identifying letters. For example, in the Times New Roman font the letter ‘g’ appears to be the number 8 [4], [5], [7], [9], [31].

5.3.2 Alignment

T3 – Do not use justified text alignment, since it counts on irregular spacing between words and it is harder to read. It creates visual patterns that are hard to be ignored by people with dyslexia. The different spaces generated distract users and worsen reading [7], [18].

5.3.3 Animation

T4 – Avoid moving text, since movement or blinking complicates reading [5], [18].

5.3.4 Print and download versions

T5 – Offer textual version for pages so that users can download it and print it [5], [31].

5.3.5 Spacing

T6 – Use a spacing line to separate paragraphs and use space between lines of 1.5 to 2 lines of spacing [18].

5.4 Writing

5.4.1 Language and writing style

W1 – When writing, be concise. Consider short paragraphs. Avoid complicated language/jargon. Use short, simple, and direct sentences, with small number of chunks of information. Long sentences contain more than one idea and can be divided into shorter phrases. This gives to people with dyslexia the possibility of making a small pause between the sentences [5], [6], [7], [15], [18], [31]. Reading disabilities make hard the recognition of written or printed words and their relations with the correct pronunciation sounds. This process is called text decoding. Decoding must be automatic for people that read fluently. The act of decoding text word by word consumes mental energy needed to understand the text they are reading. Texts that use short and common words and short sentences are easier to decode and usually require a reading ability less advanced than the ability required to read long sentences and uncommon words [29].

W2 – Give instructions clearly. Avoid long explanation phrases. Use active voice instead of passive voice (e.g., use ‘you need to login into the system’ instead of ‘the login is needed in order to use the system’). And avoid double negatives [5], [18].

W3 – When appropriate, use graphics to illustrate complex text or complex ideas [18].

W4 – Do not use hyphenation of words that commonly are presented integrally [18].

W5 – Write considering screen readers because there are people with dyslexia that use this kind of assistive technology. Make good use of punctuation, for example: consider using period at the end of phrases to assist screen readers to perform a small interval; use semicolon, comma, or periods at the end of list items to clearly separate the reading of the items and avoid sequential reading; do not write text all in capitals (without the proper <abbr> tag) because it is possible that screen readers interpret the capitalized text as an acronym and, consequently, spell it out instead of read it sequentially [7], [31].

5.5 Layout

L1 – Prioritize the information. Use simple design. Avoid screens with lots of information. A limited quantity of information should be presented, avoiding scrolling and memory overload. In addition, provide sufficient white space among UI elements [15], [18].

L2 – Avoid large columns of texts. The length of lines may have a big impact in relation to readability considering comfort and comprehension. Consider default width for columns from 60 to 70 characters length (as the ones used in printed newspapers) and use fluid design¹¹ so that the width of the columns can be adjusted to the browsers' window width or different zoom levels [7], [18].

L3 – Strictly avoid horizontal scrolling [18].

5.6 Images and charts

I1 – Use images, charts, and pictures to complement textual information. They divide the Web page in smaller chunks and, for people with dyslexia, provide visual stimuli. However, if they are too big or too small, could make reading more difficult [5], [7], [15], [18].

I2 – Use images and icons throughout the text, particularly in links. People with dyslexia tend to consider more images than words. Include also appropriate descriptions in these images so that screen readers can read them [31].

I3 – Avoid moving or blinking images, because they distract people with disability as well as distract any person [7].

5.7 End user customization

E1 – The website should be easily customizable by users. Provide features so that users can configure color scheme (background color, text color, and printing colors), font type, and text size. These may improve reading speed. In addition, people have different abilities and different preferences regarding colors, types, and sizes [5], [15], [31]. For examples of how to do such

customization, refer to Designing Web Pages for Dyslexic Readers¹² and SeeWord [9].

E2 – Allow users to control presentation using their own style sheets [18].

5.8 Markup

M1 – Assure that the website can be read by screen readers, since some people with dyslexia use this type of assistive technology. Thus, guarantee that the markup is valid, provide alternative text, avoid unnecessary tables, and use semantic markup wherever use tables [22], [31].

M2 – Use the <abbr> tag to explain abbreviations and acronyms [18].

5.9 Videos and audios

V1 – Whenever counting on videos or audios, do not play these media automatically when the page loads. Provide video or audio only under users' requests. In addition, do not rely only on one media to provide content for users [18].

6. DISCUSSION

The reviewed guidelines and techniques show convergence, since most of the studied works shares the aim of facilitating the access of dyslexic people to digital information. However, some conflicts still occur. For example, although there is an indication that the fluid design is more accessible, according to BDA [5], stakeholders should avoid starting phrases at the end of the lines. The conflict here is that if the layout is fluid, there is no way of controlling this. Moreover, considering conflict resolution, a promising approach is to consider any fixed configuration pointed by a guideline as a default in conjunction with any other features allowing users to change presentation as they wish.

Among the works reviewed, it was possible to identify that the end user customization plays a central role in accessibility considering dyslexia. Nevertheless, only two guidelines were found regarding this subject. Thus, a deeper study on end user customization is an identified gap that needs to be bridged.

This work focused on guidelines for dyslexia; on the other hand, as we aim at promoting the universal accessibility, we believe that such guidelines should be integrated into general accessibility guidelines as WCAG [29] and Section508 [27]. As WCAG is the most adopted guidelines set and receives diverse contributions from the international community, future work should involve, but should not be restricted to it. At first glance we can identify similarities between WCAG and the reviewed guidelines such as in the case of the WCAG Success Criterion 2.4.8 Location and the reviewed guidelines N4 Breadcrumbs and N6 Site Map. Also, some of the reviewed guidelines, e.g., N1 Navigation menu (partially covered by the WCAG Success Criterion 1.4.8 Visual Presentation) and N8 Internal Search (partially covered by the WCAG Success Criterion 3.3.5 Help), have the potential to improve the WCAG. Potential conflicts between them also require further investigation.

¹¹ Fluid design is obtained when the Web page is structured in such a way that the width of the page follows browser's window width after any resize action.

¹² <http://www.dyslexia-parent.com/mag35.html>

An emerging challenge for the Web Accessibility is the accessibility of Rich Internet Applications (RIA). RIAs offer dynamics comparable to desktop applications with the benefits of being pervasive. On the other hand RIAs break some well-established concepts from websites navigation as, for example, the behavior of back and forward buttons (mentioned in the reviewed guideline N7 Back and Forward Buttons). Despite the fact of some techniques to overcome those barriers, the diversity of behavior scripts languages can provide is enormous and unpredictable. Thus, since the works related to dyslexia on web accessibility are still restricted to traditional Web pages, future research are necessary to identify which of the already reported guidelines are still valid for RIAs and the possible new requirements – specially those related to the dynamic behavior – for accessible RIAs.

It may be hard to convince part of stakeholders about the importance of some issues, such as the question related to contrast between foreground and background colors. There are generic usability guidelines indicating that we should use black on white, as presented by Nielsen in [17]. However, as previously presented by guideline C1, this can be prejudicial for people with dyslexia. This fact reinforces the need for features that provide color scheme customization, font type, spacing, and text size, for screen presentation and for printing.

Moreover, we verified how important is to know about specificities related to different types of disabilities instead of grouping them with “others”, attitude that may move actions away from the real needs and preferences of people with dyslexia. This vision is encouraged by the UD concept – to respect the differences supporting the widest possible audience.

The individual differences are relevant, especially when we refer to dyslexia.

7. CONCLUSION

The dyslexia is still not well understood and even characterized. As a natural consequence, its specificities have hardly been treated by Web Accessibility standards, as other well known disabilities do. This work reviewed existing guidelines and techniques related to dyslexia and presented a compiled set of guidelines to inform the actions of website maintenance professionals and other interested parties. The guidelines, grouped according to UI elements, synthesize outcomes of previous works in such a way that developers, designers, and content producers could understand the limitations of people with dyslexia and remove or avoid accessibility barriers.

Considering the proposed grouping according to stakeholders' roles, developers are more strongly concerned with markup techniques and end user customization features; the designer's work is more sensible to layout and user interface design, as well as the color scheme definition; content producers should pay special attention to the writing style considered and also to guarantying images' alternative texts.

The focus of this work was on specific needs of people with dyslexia as there is a lack in understanding their functional limitations and the Web Accessibility barriers faced by them. However, our intention is to allow this set of guidelines to integrate other sets of guidelines that promote UD principles.

As future work a user study is planned to explore solutions based on the proposed guidelines with a local organization that works with correlated themes.

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