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Search, Read and Write: An Inquiry into Web Accessibility for People With Dyslexia

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Abstract. Universal design in context of digitalisation has become an integrated part of international conventions and national legislations. A goal is to make the Web accessible for people of different genders, ages, backgrounds, cultures and physical, sensory and cognitive abilities. Political demands for universally designed solutions have raised questions about how it is achieved in practice. Developers, designers and legislators have looked towards the Web Content Accessibility Guidelines (WCAG) for answers. WCAG 2.0 has become the de facto standard for universal design on the Web. Some of the guidelines are directed at the general population, while others are targeted at more specific user groups, such as the visually impaired or hearing impaired. Issues related to cognitive impairments such as dyslexia receive less attention, although dyslexia is prevalent in at least 5-10% of the population. Navigation and search are two common ways of using the Web. However, while navigation has received a fair amount of attention, search systems are not explicitly included, although search has become an important part of people's daily routines. This paper discusses WCAG in the context of dyslexia for the Web in general and search user interfaces specifically. Although certain guidelines address topics that affect dyslexia, WCAG does not seem to fully accommodate users with dyslexia.

Keywords. Universal Design, dyslexia, Web accessibility guidelines, WCAG, search

1. Introduction

Browsing and searching comprise the fundamental means of navigating Web content [1]. This behaviour is in accordance with the suggestions by Berners-Lee and Cailiau [2] when they introduced the Web, namely that searchable indexes should be added to the hypertext model. Search has become an integrated part of people's daily routines [3]. However, information retrieval may be difficult, especially for users who struggle

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with spelling and reading, such as people with dyslexia [4-5]. Consequently, accessible search user interfaces are necessary to ensure all users equal access to online content.

Universal design promotes equality and fairness, and entails that the society should be accessible for all users without the need for any adaptation or specialised design [6]. An important aspect of universal design is that users are not considered one homogenous group. Although most people share basic physiological and psychological characteristics, differences occur. Universal design incorporates variations in physical and cognitive abilities in addition to differences in gender, age and cultural background.

The UN Convention on the Rights of Persons with Disabilities states that information and communication technologies should be universally designed [7]. Universal design is also included in the EU eAccessibility programme [8] and in national legislations. A challenge related to legislation is *how* to define products or services as universally designed, and a lack of formal regulations may make it difficult to enforce the law. Consequently, WCAG has been applied in the legislation of several countries, such as Norway [9], Canada [10] and Australia [11].

According to Huffaker [12], WCAG is now the most recognised framework for accessibility rating. The guidelines are developed by the World Wide Web Consortium (W3C) and address the needs of a wide range of users. W3C [13] mentions for example blindness and low vision, deafness and hearing loss, learning disabilities, cognitive limitations, limited movement, speech disabilities, photosensitivity and a combination of these impairments. An overall aim is equal and barrier free access for all. Dyslexia is not mentioned specifically, but is a part of the broader terminology applied, namely «*cognitive, language and learning disabilities*» and «*print disabilities*» [13].

Accommodating a wide range of users may be difficult, for instance due to conflicting needs or because certain users may have difficulties expressing their needs [14]. This issue is also addressed in the WCAG introduction, which states: «*Note that even content that conforms at the highest level (AAA) will not be accessible to individuals with all types, degrees, or combinations of disability, particularly in the cognitive language and learning areas*». Dyslexia is an example of a common learning disorder which falls under the category described by W3C in their emphasis on potential shortcomings in WCAG. This cognitive impairment is mainly characterised by reading and writing difficulties [15] and is prevalent in 5-10% of the population [16].

It is claimed that the Web is not accessible for users with dyslexia, and that Web content may be inaccessible for people with dyslexia despite compliance with WCAG [17-18]. The Disability Rights Commission [19] reported that users with dyslexia failed on 17% of the tasks in a Web usability test. Two issues related to navigation, mainly unclear and confusing layout and confusing and disorienting navigation mechanisms. Two difficulties involved design, and were caused by insufficient contrast and too small graphics or text. The last issue involved complicated language and terminology.

Online search systems have been reported to be particularly inapproachable for people with dyslexia, especially systems with a low tolerance for spelling errors [5,17,20]. Inaccessible search systems represent a challenge in a digitalised society, where access to online information has become an integrated part.

This paper discusses WCAG in relation to dyslexia, and questions whether WCAG sufficiently accommodates people with dyslexia. Accessibility is discussed in the context of the Web in general, and with a particular focus on search user interfaces. The paper is structured as follows: First, related research on dyslexia and Web accessibility is presented, followed by a description of WCAG and how people with dyslexia are accommodated. Then, the guidelines are discussed according to dyslexia.

2. Background

Dyslexia exists in different forms and degrees. Some users with dyslexia are slow but accurate readers, while others are fast but inaccurate readers [21]. Nevertheless, difficulties with word decoding and reading comprehension are commonly found in both types of readers [22]. Other common characteristics are reduced short-term memory capacity, concentration difficulties and reduced naming skills [15, 23-25].

Dyslexia may affect the use of computers in several ways. Some struggle using keyboards due to reduced motor skills and coordination [26]. Frequent misspellings may cause difficulties using Web pages that require textual input from the user, such as search systems or other types of forms [5]. Slow reading, reduced decoding skills or reduced short term memory capacity can cause difficulties understanding textual content, such as menus or instructions and also affect result list assessment [27].

2.1 Web Accessibility and People with Dyslexia

Several researchers have addressed dyslexia and Web accessibility. Al-Wabil, Zaphiris & Wilson [17] interviewed ten people with dyslexia about their navigation behaviour. They revealed significant navigational barriers online. Kurniawan and Conroy [28] reported increased reading speed when users with dyslexia were allowed to select colour schemes. Rello, Kanvinde & Baeza-Yates [29] found that there was no coherence between preferences regarding colour schemes and performance. This finding is in accordance with Nielsen [30], who claims that users do not always prefer the solution in which they perform the best.

It has been suggested that people with dyslexia prefer fonts without serifs [31], and that italics should be avoided [32]. Font size may also have a significant effect on readability [31, 33]. Increased letter-spacing may improve reading performance [34], but line spacing has no significant effect [33]. Further, it is reported that users with dyslexia prefer left-justified text with a ragged right edge [35].

Graphics have also been discussed, for instance the accessibility of graphics in technical documentation [36] and how people with dyslexia interpret graphs [37]. Others have discussed whether including graphic content in text interfaces are useful [38-40]. The issue of clear and readable text in relation to users with dyslexia or low-proficiency readers has also been addressed. Rello, Baeza-Yates, Dempere-Marco and Saggion [41] found that using frequent words increased the reading speed of people with dyslexia, while shorter words enhanced the understanding of the content. The importance of using plain language is also suggested to increase Web accessibility for all users [42-43].

2.2 Accessible Search and People with Dyslexia

Information search is a common activity, and millions of searches are conducted on a daily basis [3]. Al-Wabil et al. [17] reported general difficulties with search among users with dyslexia, and specifically in internal search systems with high demands for spelling. The finding was supported by Habib et al. [20]. MacFarlane et al. [4] reported that students with dyslexia exhibited fewer search iterations, reviewed less documents and took longer per search than people without dyslexia. MacFarlane, Albrair, Marshall and Buchanan [27] investigated how impaired short-term memory affected information search, and found a correlation between short-term memory and the ratio of documents

classified as irrelevant. MacFarlane et al. [27] reported that users with a high phonological memory capacity judged more documents as irrelevant compared to people with reduced capacity.

Berget and Sandnes [5] investigated the usability of an online search system with no query-building aids or tolerance for spelling errors. Dyslexia had a negative effect on search performance. It was suggested that search systems should compensate for misspelled queries to adequately accommodate users with dyslexia. This finding was supported in a second study by Berget and Sandnes [44] on query formulation in Google, a system with several query-building aids and a high tolerance level for errors. Users with dyslexia did not apply query-building aids significantly more than controls. However, the high tolerance for errors counteracted the negative effect of dyslexia.

3. WCAG 2.0

WCAG 2.0 has become the de facto standard for Web accessibility among developers, designers and legislators [45]. The first version was endorsed as a W3C recommendation in 1999 [46], but was replaced by WCAG 2.0 in 2008 [13], which is now defined as the international standard ISO/IEC 40500:2012 [47]. WCAG has been criticised, among others for placing too much responsibility on the end-users and require that they are aware of technologies that may best accommodate their needs [48].

Four principles constitute the basis for WCAG, namely that Web content should be perceivable, operable, understandable and robust. A total of 12 guidelines are formulated, one to four per principle. Each guideline is divided into success criteria, which are more specific, testable and platform independent requirements [13]. One of three conformance levels are defined for each criterion, from A to AAA, where AAA is the highest level. Guidelines accommodating people with dyslexia are found in all the principles. However, robustness is not discussed herein as it applies to assistive technology. Table 1 displays the main criteria that may particularly relates to dyslexia.

3.1 Navigation

Navigation is addressed in two guidelines, 2.4 and 3.2. Guideline 2.4 requires navigable content. The success criteria address how content is presented to support navigation, by allowing users to bypass blocks that are repeated on several Web pages (2.4.1) or by providing descriptive titles, headings and labels (2.4.2, 2.4.6 and 2.4.10). These measures may reduce the text that must be read, by either skipping repeated blocks, or by reading headings only, to locate the correct content. Other criteria address the need to provide information about the user's location within a Web site (2.4.8) and consistent navigation (3.2.3). Such measures may be especially important for users with dyslexia, who are reported to get confused when navigating Web pages [17,19]. Only criteria 2.4.1 (bypass blocks) and 2.4.2 (titles) are at the lowest conformity level.

3.2 Colours and Contrasts

Three success criteria (1.4.3, 1.4.6 and 1.4.8) address colours or contrasts, and are at level AA and AAA. Although visually impaired and colour blind users are specifically mentioned in the documentation [49], sufficient contrasts are also suggested to accommodate users with dyslexia [31].

3.3 Fonts and Graphics

WCAG does not give advice on the choice of fonts. However, two success criteria at level AA and AAA regard font size (1.1.4 and 1.4.8). Text should be possible to resize up to 200% without losing functionality, content or require horizontal scrolling. Most criteria addressing graphics emphasise that such content should not be the only source for information, but applied as decoration. Graphic size is barely mentioned in the supporting documentation for 1.1.4, with an emphasis on challenges related to images that may not rescale as well as text [50]. Criterion 1.4.8 mentions layout and discusses text width and line spacing, which may affect readability for users with dyslexia [35].

Table 1. Guidelines and success criteria relevant for users with dyslexia

Topic	Guideline	Success criteria	Description	Level
Navigation	2.4 Navigable	2.4.1	Bypass Blocks	A
		2.4.2	Page Titles	A
		2.4.6	Headings and Labels	AA
		2.4.8	Location	AAA
		2.4.10	Section Headings	AAA
	3.2 Predictable	3.2.3	Consistent Navigation	AA
Colours/contrasts	1.4 Distinguishable	1.4.3	Contrast (Minimum)	AA
		1.4.6	Contrasts (Enhanced)	AAA
		1.4.8	Visual Presentation	AAA
Font	1.4 Distinguishable	1.4.4	Resize Text	AA
		1.4.8	Visual Presentation	AAA
Layout	1.4. Distinguishable	1.4.8	Visual Presentation	AAA
Language	3.1 Readable	3.1.5	Reading Level	AAA
Timing	2.2 Enough Time	2.2.1	Timing Adjustable	A
		2.2.3	No Timing	AAA
Errors	3.3 Input Assistance	3.3.1	Error Identification	A
		3.3.3	Error Suggestion	AA
		3.3.5	Help	AAA
		3.3.6	Error Prevention	AAA

3.4 Language

Guideline 3.1 requires readable and understandable text. According to 3.1.5, a AAA criterion, the reading level should not exceed lower secondary education level [13]. This may be the criterion most clearly directed at users with dyslexia, who in addition to reading disabilities are specifically mentioned in the supporting document [51]. A short explanation of the difficulties experienced by people with dyslexia during reading are also provided.

3.5 Timing

Guideline 2.2 concerns timing. Several people with dyslexia have reduced writing or reading speed [15], which may cause difficulties when filling out forms or reading text if the user is not provided enough time. Two criteria address this issue. One criterion demands that users should be able to turn off or extend time limits (2.2.1, level A), while another states that there should be no timing (2.2.3, level AAA). The justification

for this demand is, among others, to allow users with cognitive impairments enough time to read and understand text [52].

3.6 Errors

Guideline 3.3 deals with input assistance and errors where user input is required. One criterion (3.3.1) demands error identification, and suggests to provide users with information about required fields that has no input, or if input errors are detected. Other criteria concern error suggestions (3.3.3), context-sensitive help (3.3.5), error prevention and that data entered by the user is checked for errors (3.3.6). Users with reading disabilities are mentioned in the support document for the latter [53]. All the criteria are at a medium or high conformance level, except for 3.3.1.

4. Dyslexia-Specific Guidelines

In contrast to WCAG, guidelines directed at particular user groups exist, such as users with visual impairments [54], elderly people [55] or people with dyslexia [35, 56]. Friedman and Bryen [57] reviewed 20 guidelines directed at users with cognitive impairments, where three of these specifically addressed dyslexia. The most frequently appearing guideline (75% of the guidelines) regarded inclusion of graphic content in addition to text. Other commonly addressed topics were consistent design (60%) and clear text (60%). None of the 22 most frequently appearing guidelines addressed search systems, except for a general point regarding alerting users on possible errors.

Santana et al. [58] reviewed and summarised 41 dyslexia-specific guidelines. These guidelines covered navigation, colours, text presentation, writing, layout, images and charts, end user customization, mark-up, videos and audios. In these guidelines internal search and writing aids were included. Further, Santana et al. [58] includes a guideline stating that images and pictures should complement textual information. The justification for this guideline is that people with dyslexia consider images over words. However, the impact of adding graphic to text is disputed in the research literature [39].

The British Dyslexia Association [35] style guide consists of three parts: dyslexia friendly text, accessible formats and Website design. The first two address font types and sizes, and emphasise short and simple text. The third section accentuates clear navigation, and the use of graphics, images and pictures to break up text. A similar set of ten guidelines has been presented by Zarach [56]. These guidelines suggest using images alongside text, sans-serif fonts, includes a recommended font size, emphasise clear text, navigation and customisation of colours.

5. Discussion

WCAG seems to include many guidelines that may accommodate people with dyslexia (see Table 1). Several of the criteria are in accordance with difficulties reported by The Disability Rights Commission [19], such as navigation, colours and language. These issues are quite general, and may therefore also apply to people without dyslexia. Clear navigation, properly sized content and clear language will most likely positively affect the usability for all users. This is in accordance with previous findings, that measures

which will improve accessibility for users with dyslexia can also enhance the usability for users without dyslexia [43].

Although several important topics for users with dyslexia are addressed in WCAG, a shortcoming is in the conformance levels. Only 23.5% of the success criteria in Table 1 are at the lowest level, while 29.4% are AA and 47.1% are AAA. Only certain criteria related to navigation, timing and errors are at the lowest conformance level. The criterion most clearly directed towards users with dyslexia, namely 3.1.5 regarding a clear and simple language, is classified as level AAA. Consequently, if jurisdictions and specifications of requirements do not apply the strictest conformance level, a high number of Web sites claiming to be in accordance with WCAG may be inaccessible for people with dyslexia. It may therefore be a need to rethink the classification of certain criteria, unless the highest level is always applied as formal requirements.

Existing guidelines directed at people with dyslexia focus on similar issues as WCAG, for instance colours, navigation and simple text. Fonts and images however, are not addressed in WCAG. Tolerance levels for misspelling are not included in any of the guidelines, although demands for correct spelling seem to impact people with dyslexia, particularly during search [5]. It may be argued that content guidelines are most clearly directed at the information made available online and not on user inputs. Consequently, misspellings made by users may be outside the scope of WCAG. However, the Web has become highly interactive, and most Web sites have some sections that require user input, such as forms for ordering products or tickets, systems for paying online or search on a Web page or in another type of search user interface.

Font typefaces and font characteristics have been discussed in the research literature. It has been reported that font types affect reading performance [32], that people with dyslexia prefer fonts without serifs [31] and that italics should be avoided [32]. Consequently, it may be useful to include a criterion regarding fonts, since WCAG now only seems to address font size. However, there may be conflicting needs with other user groups, so this must be discussed in a wider user diversity context.

The suggestion to include graphics in addition to text is not included in WCAG, but are mentioned in dyslexia-specific guidelines [35,56,58]. However, scholars do not agree upon the usefulness of dual-modality displays because an increased number of objects may cause a negative effect on cognitive load and performance measures [59].

It has been suggested that people with dyslexia struggle with information retrieval [4-5, 27]. Berget and Sandnes [5] found that search systems with no tolerance for errors are inaccessible to users with dyslexia. This finding is in accordance with Al-Wabil et al.'s findings [17]. Consequently, this is an important issue that should addressed.

WCAG should more explicitly incorporate search. Guideline 3.3 regards input assistance, but is mostly directed at filling out forms, and that feedback should be given when required fields are empty or if the inputted data does not seem correct. Nothing is mentioned about spelling errors in general, which are commonly made by users with dyslexia [15] and frequently occurs during query formulation [5]. Spelling errors in queries are reported to be common among users without dyslexia [60], which indicate that a guideline related to spell checking may also accommodate these users.

6. Conclusion

Dyslexia is rarely mentioned in WCAG, which may lead to neglect of the needs of users with reading disabilities [58]. W3C are aware of shortcomings regarding dyslexia

in the introduction to the guidelines [13]. Consequently, more effort should be put into accommodating users with cognitive impairments. Much relevant research has been carried out regarding the needs of users with dyslexia. This platform of knowledge should constitute a suitable starting point for a discussion of the revision of WCAG.

WCAG should be revised to better accommodate people with dyslexia. The conformance levels should be altered to ensure that at least the criterion regarding clear language is at level A. It may also be useful to include criteria regarding font typefaces and text decoration. Search systems should be incorporated in WCAG more explicitly, including a guideline addressing the need for more assistance in user interfaces that require user input such as queries. Ideally, there should also be a demand for a certain tolerance level for misspellings in user input. Such criteria may be included in the existing guideline 3.3, and would not require a major revision of WCAG structure.

One may argue that by applying a combination of WCAG and a set of dyslexia-specific guidelines the accessibility increases. However, one of the purposes behind WCAG is to counteract the need to fulfil requirements in several guidelines. The overall aim is to develop one common standard which accommodates as many users as possible, and thus to achieve universal design. In this context, WCAG is a good starting point. Since dyslexia is such a widespread impairment, it seems reasonable to accommodate this user group better in future versions of WCAG.

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