

Title

Dyslexia and Web Accessibility: Meta-Analysis of user insights.

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Purpose

The purpose of this paper is to inform the World Wide Web Consortium (W3C) Cognitive Accessibility Roadmap and Gap analysis for the Cognitive Accessibility User Research initiative. This is a meta-analysis paper to gain insight on specific Dyslexia and Web Accessibility issues. A thematic analysis of 11 studies from 2011 to 2018 was undertaken to provide user information, to support the W3C, Cognitive and Learning Disabilities Accessibility Task Force (COGA TF). The meta-analysis contributes additional information to the Cognitive Accessibility Issue Papers, W3C editors' working draft, 2019.

Methodology

Thematic analysis was undertaken using the Braun and Clarke (2006) method to identify semantic themes and patterns within the Empirical studies (Alholjailan, 2012; Clarke & Braun, 2013). Inclusion criteria was defined as follows: i) studies from 2011 to 2018, ii) Dyslexia and Web Accessibility, iii) diverse accessibility challenges. The analysis comprised of four stages of thematic coding to capture the reflections of the end users.

Results

In 2014, Dr Sally Shaywitz emphasised that the lack of high-quality scientific research on dyslexia was not 'the' problem, stating "... our current understanding of dyslexia is not being fully utilized in either policy or practice-" (Shaywitz, 2014) therefore explicitly, placing the inadequacies in the action gap not in the knowledge gap. However, Rello (2015) argues the real difficulty with Dyslexia and Web Accessibility is not the lack of academic research on this complex subject but more the repetitive study of the same issues (Rello, 2015). However, unlocking the potential of knowledge transfer from harvested data requires the development of 'meaningful use' initiatives supported by end user insight (Viola and Mookencherry, 2012)- in supporting this knowledge transfer. Table 1 identifies significant challenges faced by dyslexic users with search engine accessibility. Users with dyslexia find challenges at all stages of the

information seeking process, including query formulation, search result triage, and information extraction (Morris et al., 2018). Table 2 outlines the difficulties in using CAPTCHA, for example, the difficulty of identifying the numbers within the images (de Santana et al., 2013). Suggestions of a game-based CAPTCHA test may overcome the difficulties for dyslexic users (Gafni and Nagar, 2017). However, the W3C cautions the use of CAPTCHA and accessibility solutions, simply stating at present no ideal fit exists (W3C, 2019). Table 3 text design include; font without serifs; avoid small text; short simple text to assist with readability; text size 12 to 14px for reading and printing and using white spacing to help with readability, for example, Sokolik (2018), Berget et al., (2016), Rello (2015), Freire et al., (2011). In addition, the British Dyslexia Association (BDA), Dyslexia Style Guide 2018, recommended inter-word spacing be not less than 3.5 times the inter-letter spacing (British Dyslexia Association, 2018).

Table 4 describes the need for clear affordance for the improvement of functionality design. For example; alt tags that conveys information about the image; appropriate URLs to assist screen readers, algorithms ranking; unclear content links, and the discontinuation of hyperlinks that display “click here” Sokolik (2018), Morris et al., (2018), Habib et al., (2012), de Santana et al., (2012), Freire et al., (2011). Table 5 and Table 5.1 delineates the content design barriers present for people with dyslexia. Design opportunities for content design include autocomplete and spellchecker features specifically directed at Dyslexic users (Morris et al., 2018). However, acknowledging spelling mistakes are potentially outside the remit of (WCAG) (Berget et al., 2016). Furthermore, the BDA recommends using dark coloured text not on a white background but on a light background as white can appear too glaring (British Dyslexia Association, 2018).

Table 6 indicates that designers of web-learning material in Slovenia were largely aware of the standard guidelines for accessibility, readability, and usability (Radovan and Perdih, 2018)- however, emphasising accessibility as the area that required the most attention in web-based learning. Table 7 illustrates the impact inaccessibility design features have on the user. Challenges included anxiety of writing, social stigmatization and low tolerance of spelling errors, potentially, ending with enforced constraints and loss of social capital. In addition, the most perceived negative impact for users with dyslexia was writing on Facebook for fear of inadvertently disclosing their disability to the wider community by publicly displaying spelling and writing errors, (Reynolds and Wu, 2018). However, additional anxiety is caused in the visible nature of the editing history of posts, for the correction of spelling and writing errors, therefore, limiting user interaction due to stigmatization.

Table 1. Thematic Area 1. Search Engine

Search Engine	Design affordance for users with dyslexia	Design challenges for users with dyslexia
Search engine design	<ul style="list-style-type: none"> • Simplifying the page so that it is less dense • Searching for the etymology of words • Allow users to opt in (or out) 	<ul style="list-style-type: none"> • Finding information through web search
Search engine triage	<ul style="list-style-type: none"> • Separated successful from unsuccessful searches 	<ul style="list-style-type: none"> • Finding information in all three stages of the search process • Determining which websites listed in the SERP they should click on
Query formulation	<ul style="list-style-type: none"> • A button to play back an audio pronunciation of the query terms • Placing images or icons representing a word next to the query 	<ul style="list-style-type: none"> • Could not understand why the search engine returned the page for the query • Difficulties with spelling and reading made query formulation particularly challenging
Information extraction	<ul style="list-style-type: none"> • Quickly identify pages whose reading level matched their abilities • Pages with short sentences, short paragraphs, short line lengths, ample whitespace between lines • Adding visual information such as webpage thumbnails next to the SERP 	<ul style="list-style-type: none"> • Dyslexic and non-dyslexic users have different search result scanning patterns • Find websites that were more “friendly” to dyslexic users
Voice search	<ul style="list-style-type: none"> • Adding a speech input button next to the search box across all nonmobile platforms 	<ul style="list-style-type: none"> • A means to circumvent spelling challenges
Information search	<ul style="list-style-type: none"> • (Sans serif fonts), font size (with larger sizes facilitating reading) 	<ul style="list-style-type: none"> • Reading challenges made navigating the SERP challenging
	<ul style="list-style-type: none"> • Color and contrast of the page’s visual scheme 	<ul style="list-style-type: none"> • Locating the sought piece of information within that page
	<ul style="list-style-type: none"> • More multimodal options in the SERP, such as the ability to highlight words and hear them read aloud 	<ul style="list-style-type: none"> • Difficulties in recognizing domain names or URLs
Search user interface	<ul style="list-style-type: none"> • Searchable indexes should be added to the hypertext model 	
Internal search	<ul style="list-style-type: none"> • Self-completion, and orthographic verification to point errors and ease correction 	

Table 2. Thematic Area 1. Search Engine. Descriptive meta-analysis of challenges and opportunities from primary research on Dyslexia and Web Accessibility Morris et al., (2018), Berget et al., (2016), de Santana et al., (2012).

Table 2. Thematic Area 2: CAPTCHA.

CAPTCHA	Design affordance for users with dyslexia	Design challenges for users with dyslexia
Difficulties decipher text		<ul style="list-style-type: none"> • Text display unclear • Understanding distorted text • Know and read Latin letters • Identify the numbers contained in the image
Role of emotions in user experience		<ul style="list-style-type: none"> • Frustration • Decreased motivation • Threatened by the test
Best CAPTCHA experience	<ul style="list-style-type: none"> • Game based CAPTCHA • Move small pictures with accuracy 	
CAPTCHA familiarity	<ul style="list-style-type: none"> • More familiar with arithmetic based test 	<ul style="list-style-type: none"> • Less familiar with No CAPTCHA
CAPTCHA interface design issues		<ul style="list-style-type: none"> • Poor user experience • Test slows them down • User abandonment • Decline in website conversion rates

Table 3. Thematic Area 2: CAPTCHA. Descriptive meta-analysis of challenges and opportunities from primary research on Dyslexia and Web Accessibility Gafni and Nagar, (2017), de Santana et al., (2013).

Table 3. Thematic Area 3: Text.

Text	Design affordance for users with dyslexia	Design challenges for users with dyslexia
Dyslexic-Friendly Test	<ul style="list-style-type: none"> • Sans-serif fonts • Increased letter-spacing may improve reading performance but line spacing has no significant effect • Prefer left-justified text with a ragged right edge • Clear and readable text • Font size may also have a significant effect on readability • Using frequent words increased the reading speed • Shorter words enhanced the understanding of the content • Text should be possible to resize up to 200% without losing functionality, content or require horizontal scrolling 	<ul style="list-style-type: none"> • Avoid italics
Text design	<ul style="list-style-type: none"> • Font size (larger than the current recommendations, around 18 points for a 17-inches screen) and typeface (more specific than the current recommendations, sans serif and non-italic typefaces) • Customize the text 	<ul style="list-style-type: none"> • Default presentation of text is not adequate • Inadequate spacing between lines and paragraphs
Text presentation	<ul style="list-style-type: none"> • Avoid small text sizes • Use white spaces to ease reading 	<ul style="list-style-type: none"> • Do not use justified text alignment, since it counts on irregular spacing between words and it is harder to read

Table 4. Thematic Area 3: Text. Descriptive meta-analysis of challenges and opportunities from primary research on Dyslexia and Web Accessibility Sokolik, (2018), Berget, et al., (2016), Rello, (2015), de Santana et al., (2012), Freire et al., (2011).

Table 4. Thematic Area 4: Functionality.

Functionality	Design affordance for users with dyslexia	Design challenges for users with dyslexia
Alt tags	<ul style="list-style-type: none"> • Use an 'alt tag' to describe and image that carries information 	
URLs	<ul style="list-style-type: none"> • Include a URL in its full form in a document, using a "TITLE" tag in the HTML can help those using screen readers 	<ul style="list-style-type: none"> • Screen readers read out everything on the screen, including full URLs requires the user to listen to those URLs being read letter by letter
Ranking algorithms	<ul style="list-style-type: none"> • Ranking algorithms based on our participants' experiences • Factoring reading level, page structure, and visual clarity, into ranking algorithms 	
Problematic functions of Virtual Learning Environments	<ul style="list-style-type: none"> • Call for a more individualized set-up 	<ul style="list-style-type: none"> • Upload function far from straightforward • Remember 'where to click' and in what order • Unclear destination of a link • Overload of irrelevant information
Hyperlinks	<ul style="list-style-type: none"> • Content links must indicate which pages were accessed • Use underline only for links and avoid links involving big blocks of text • Use links in the beginning or at the end of phrases in order to ease the reading 	<ul style="list-style-type: none"> • Unspecific text such as 'read more' or 'click here' are quite common • Use of screen readers, these labels do not provide the user with sufficient information to make a decision on which hyperlink to select
Chat functions		<ul style="list-style-type: none"> • Both within and outside the VLE, are awkward to use • Keep up with the speed of communication both as far as writing and reading
"Auto-complete" feature	<ul style="list-style-type: none"> • "Auto-complete" feature for input fields 	

Table 5. Thematic Area 4: Functionality. Descriptive meta-analysis of challenges and opportunities from primary research on Dyslexia and Web Accessibility Sokolik, (2018), Morris et al., (2018), Habib et al., (2012), de Santana et al., (2012), Freire et al., (2011).

Table 5. Thematic Area 5: Content Design.

Content Design	Design affordance for users with dyslexia	Design challenges for users with dyslexia
Inappropriate design choice		<ul style="list-style-type: none"> • Extraneous content made it more difficult for them to read effectively • Ads were distracting
Spelling features	<ul style="list-style-type: none"> • Toggle between a single choice for spelling autocorrection (the status quo) and a n-best list • Iconography may benefit users with dyslexia • Orthographic correction 	<ul style="list-style-type: none"> • Misspellings of query terms were so far off from the correct spelling that search engines' • Challenging for them to verify whether automatic spelling correction had helped or hindered their query
Markup	<ul style="list-style-type: none"> • Guarantee that the markup is valid, provide alternative text, avoid unnecessary tables, and use semantic markup wherever use tables • Use the tag to explain abbreviations and acronyms • Mark up a page via highlighting or underlining may also be valuable to people who are taught to employ active reading techniques on paper for enhanced comprehension 	
Misspelling		<ul style="list-style-type: none"> • Frequently occurs during query formulation
Images and charts	<ul style="list-style-type: none"> • Images and pictures should complement textual information • Images have significant alternative text • Avoid moving or blinking images 	
Colour customisation	<ul style="list-style-type: none"> • Kurniawan and Conroy reported increased reading speed when users with dyslexia were allowed to select colour schemes (Berget et al., 2016) • Nielsen, who claims that users do not always prefer customisation (Berget et al., 2016) 	<ul style="list-style-type: none"> • Rello, Kanvinde & Baeza-Yates found that there was no coherence between preferences regarding colour schemes and performance (Berget et al., 2016)
Navigation	<ul style="list-style-type: none"> • 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 • Breadcrumb trails 	

Table 6. Thematic Area 5: Content Design. Descriptive meta-analysis of challenges and opportunities from primary research on Dyslexia and Web Accessibility Morris et al., (2018), Berget et al., (2016), Freire et al., (2011), de Santana et al., (2012; 2013).

Table 5.1. Thematic Area 5: Content Design.

Content Design	Design affordance for users with dyslexia	Design challenges for users with dyslexia
Web page layout	<ul style="list-style-type: none"> • Use a simple design. avoid large columns of text • Use fluid design so that the width of the columns can be adjusted 	<ul style="list-style-type: none"> • Confusing page layout • Strictly avoid horizontal scrolling • Expected functionality not present • Functionality does not (or appear not to) work correctly • Too much irrelevant content before task content • Avoid using mechanisms that interfere with back and forward buttons functioning
Site map planning	<ul style="list-style-type: none"> • Use of hierarchical trees containing clear texts 	
Index page	<ul style="list-style-type: none"> • Structure logical order involving tasks sequence or structure, without requiring exclusively the alphabetical ordering 	
Writing	<ul style="list-style-type: none"> • Use short, simple direct sentences, with small number of chunks of information • Give instructions clearly. avoid long explanation phrases. use active voice instead of passive 	<ul style="list-style-type: none"> • Do not write text all in capitals (without proper tag) because screen readers may spell it out instead or reading it sequentially
Reading	<ul style="list-style-type: none"> • Inclusion of a feature to help the indication of the line being read 	
Headers and highlighting	<ul style="list-style-type: none"> • Consider using boxes, border, and background color to call users attention 	
Lists	<ul style="list-style-type: none"> • To improve comprehension of list item, use white space to separate marker from text and between items use double spacing • Use ordered lists (or numbered lists) 	
Spacing	<ul style="list-style-type: none"> • Use a spacing line to separate paragraphs and use space between lines of 1.5 to 2 lines of spacing 	
Graphic size		<ul style="list-style-type: none"> • An increased number of objects may cause a negative effect on cognitive load and performance measures
End user customisation	<ul style="list-style-type: none"> • Users can configure color scheme (background color, text color, and printing colors), font type, and text size 	

Table 6.1 Thematic Area 5: Content Design. Descriptive meta-analysis of challenges and opportunities from primary research on Dyslexia and Web Accessibility Morris et al., (2018), Berget et al., (2016), Freire et al., (2011), de Santana et al., (2012; 2013).

Table 6. Thematic Area 6: E-Learning Portals

E-Learning Portals	Design affordance for users with dyslexia	Design challenges for users with dyslexia
Readability	<ul style="list-style-type: none"> • Boxes and mind maps are used to summarize important points • Sentence length should be between 15 and 20 words • Material uses the active voice, not the passive 	<ul style="list-style-type: none"> • Material does not contain large chunks of underlined text, which is a not hyperlink
Accessibility	<ul style="list-style-type: none"> • Audio and video recordings and animations can be replayed by the user, paused and/or stopped by the user • Enabling textual description of visual content • The study pinpoints accessibility as the weakest point of the examined web-based learning materials 	<ul style="list-style-type: none"> • Does not contain flashing elements that cannot be stopped
Usability	<ul style="list-style-type: none"> • The site map is hierarchical, and it gives an overview of the complete material • Hyperlinks are descriptive, and we know where they will take us • Textual hyperlinks are coloured when they have been clicked • Navigation of the material remains consistent throughout the material 	<ul style="list-style-type: none"> • No horizontal scrolling

Table 7. Thematic Area 6: E-Learning Portals. Descriptive meta-analysis of challenges and opportunities from primary research on Dyslexia and Web Accessibility Radovan and Perdih, (2018).

Table 7. Thematic Area 7: Social Media.

Social Media	Design affordance for users with dyslexia	Design challenges for users with dyslexia
Spelling and grammar checkers	<ul style="list-style-type: none"> • “An autocorrect feature specifically for a dyslexic person” • Wants a tool that generates text: “it might say ‘here are some suggestions of what you might be trying to say” 	<ul style="list-style-type: none"> • Most spell and grammar checkers tend to miss real-word errors
Using Facebook	<ul style="list-style-type: none"> • Visual content especially appealing • Font colors help with text parsing: “Names are always in blue...non-content that’s just information is in gray and then the text is in black • Font is clear and easy to read • Not needing text-to-speech voiceover software 	<ul style="list-style-type: none"> • Segmenting things in colors is really helpful. “However, the high-contrast color scheme of black text on a white background hindered readability.”
Self-presentation and self-disclosure		<ul style="list-style-type: none"> • Dyslexia interferes with their ability to use Facebook to achieve the self-expression and relationship building goals of self-disclosure (Choi and Bazarova 2015) • Tendency for people to disengage in self-presentation and self-disclosure on social media when writing is a challenge
Writing on Facebook/SNSs	<ul style="list-style-type: none"> • When they cannot effectively communicate and present themselves on SNSs, they miss benefits such as gaining social capital (Ellison, Steinfield, and Lampe 2007) 	<ul style="list-style-type: none"> • Participants found writing on Facebook to be a bigger challenge than reading • Concerns about mis-representing oneself in writing due to quality issues • Due to disinclination towards making their difficulties related to writing known to the outside world • Struggle to express themselves as much and as freely as they want to, ending with self-censorship

Table 8. Thematic Area 7: Social Media. Descriptive meta-analysis of challenges and opportunities from primary research on Dyslexia and Web Accessibility Reynolds and Wu, (2018).

Conclusion

In conclusion, Nielsen advocates for a systematic extraction of design deficits in user interface if one can ‘optimize a series of studies for total gain, rather than spend too much on any one study’ when designing web usability (Nielsen, 2012). Furthermore, Norman promotes gradual innovation for accessibility design as opposed to the in-vogue narrative of radical innovation. ‘The techniques of human-centred design are appropriate to incremental innovation: they cannot lead to radical innovations (Norman, 2013, p. xvii). Therefore, underpinning the concept of closing the knowledge gap and action gap by utilizing the prolific research on Dyslexia and Web Accessibility through incremental design. Findings from this study supports the W3C measures to develop specific Dyslexia Web Accessibility Guidelines.

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