Empirical Results from an Evaluation of the Accessibility of Websites by Dyslexic Users

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Abstract. This paper presents an empirical study on problems encountered by users with dyslexia when using websites. The study was performed by a user evaluation of 16 websites by a panel of 13 participants with dyslexia, each participant evaluating 10 websites. The results presented in the paper are based on 693 instances of accessibility and usability problems. Most frequent problems were related to navigation issues, problems with presentation and organisation of information, lack or misfunctioning of specific funtionality in websites, and issues with language.

Keywords: dyslexia, web accessibility, learning difficulties, user evaluation

1 Introduction

The field of web accessibility has been concerned with the development of techniques to make websites more accessible to people with disabilities. Most of the research in this field, however, has been limited to investigating accessibility issues to people with visual, physical and hearing disabilities. Far less attention has been given to the study of the accessibility of websites to people with cognitive disabilities and specific learning difficulties, such as dyslexia (see McCarthy & Swierenga, 2010).

A number of sets of web accessibility guidelines have been developed. These guidelines involve both general accessibility guidelines for disabled users, such as the Web Content Accessibility Guidelines 1.0 (WCAG) (W3C, 1999) and 2.0 (W3C, 2008) from the World Wide Web Consortium, and other guidelines specific to dyslexic users (British Dyslexia Association, 2011; Bradford, 2005; Kolatch, 2000; Zarach, 2002). However, very little empirical evidence for the kinds of problems dyslexic users face when using websites has been reported.

A large scale user-based evaluation of websites conducted as part of a formal investigation into the accessibility of websites commissioned by the Disability Rights Commision of Great Britain (Disability Rights Comission, 2004) provided empirical information on the problems that dyslexic users encounter with websites. The results of that study have pointed to the need for more indepth empirical studies to better

understand the nature of problems encountered by dyslexic users when using websites.

This paper presents an empirical study involving dyslexic participants with a wide range of websites. The study involved user evaluation of 16 websites by a panel of 13 dyslexic participants. The results show the main problems encountered by these users, and discussions about the nature of the problems and implications for design to be drawn from the findings.

The paper is organised as follows: Section 2 discusses related work connected to dyslexia and web accessibility; Section 3 presents the method used for the empirical study; Section 4 presents the main results obtained; Section 5 presents a discussion of these results, and, finally, Section 6 the main conclusions and future work.

2 Dyslexia and Web Accessibility

In a recent literature survey of web accessibility and dyslexia, McCarthy & Swierenga (2010) reported that there is little work in the literature regarding the study of the accessibility of web sites for dyslexic users. Their findings highlight the fact that most of the research on web accessibility has focused on users with visual disabilities or with severe cognitive disabilities.

Empirical studies with participants with more severe cognitive disabilities have pointed to a lack of inclusion of the problems found in their results in current accessibility guidelines, as reported by Small et al. (2005) and Sevilla et al. (2007).

Small et al. (2005) conducted an empirical study involving the evaluation of two WCAG 1.0-compliant websites with 27 users with developmental cognitive disabilities (corrected vision, cerebral palsy, obsessive-compulsive disorder). They found that users had a substantial number of problems with the websites, which led the authors to argue that the cognitive disabilities analysed in the study were not accounted for in WCAG 1.0.

Sevilla et al. (2007) conducted another empirical study with 20 participants with cognitive disabilities using two different versions of a web interface. A conventional version of a website was evaluated as well as another version with simplified navigation. Besides reporting on improvements in performance with the version with simplified navigation, the authors also argue that the needs of people with cognitive deficits are poorly addressed in WCAG 1.0 and WCAG 2.

With respect to dyslexia in particular, there are few studies that provide rigorous empirical results of dyslexic participants using websites. The majority of the literature on dyslexia and web accessibility is related to guidelines to produce accessible web content to dyslexic users, derived from general guidelines for dyslexia.

A number of sets of guidelines have been produced to help developers produce more accessible web content for dyslexic users (British Dyslexia Association, 2011; Bradford, 2005; Kolatch, 2000; Zarach, 2002), as reported in a review undertaken by McCarthy & Swierenga (2010). Friedman & Bryen (2007) also conducted a review of 20 sets of guidelines from research studies and websites maintained by professonals and advocacy organisations connected to dyslexia and other cognitive

disabilites, and compiled the guidelines most cited by these sources; most guidelines had to do with other cognitive disabilities, but some were applicable todyslexia. Evett & Brown (2005) also performed a analysis comparing guidelines for producing accessible content for dyslexic and blind users, and reported to have found a high degree of overlap between guidelines for these two user groups.

With respect to empirical studies with dyslexic participants using websites, the largest study to date reported in the literature was conducted by the Disability Rights Commission of Great Britain in 2004 (Disability Rights Commission, 2004). The study involved tests on 100 websites, performed by a panel of 50 participants, which included participants with dyslexia, visual, hearing and physical disabilities. Out of the 50 participants, 12 had dyslexia (Petrie, Hamilton, & King, 2004). The study resulted in a total of 585 accessibility problems. In particular, the study found that the most recurring problems encountered by dyslexic users were: confusing page layout, unclear navigation, poor colour selections, graphics and text too small and complicated language.

The DRC study helped to provide empirical evidence to problems that people with dyslexia have when using websites. Further studies in line with this study could provide more detailed analyses of the types of problems dyslexic users find when using websites. In particular, in the DRC study only 22% of the tasks in the study were performed in a laboratory environment, whilst the remainder 78% of them were performed remotely with self-reports provided by the participants. Petrie, Hamilton, King and Pavan (2006) compared the data from the two methods of data collection and found that the quality of the data was not compromised, but the quantity of data provided by the remote evaluations was lower. Thus the data from the DRC study may have underestimated the problems that disabled, including dyslexic, users were having with the web. A study performed in the laboratory allows for the identification of more problems that users would not necessarily report on, and also provides richer details about the nature of the problems.

Other small-scale studies have also reported on experiences of dyslexic users when using websites. Harrison & Petrie (2007) conducted a study of six websites involving six participants, of whom two were visually disabled and two were dyslexic. In their study, they analysed the relationship between the severity ratings of accessibility problems given by users with the ratings given by accessibility experts and with the priority of related issues set in guidelines. The results showed that there was no correlation between ratings given by users and by experts with the priorities of problems in accessibility guidelines in WCAG 1.0.

Al-Wabil et al. (2007) conducted a study investigating navigation issues faced by dyslexic users. Their study comprised interviews with 10 participants with dyslexia. The participants were shown examples of web pages and asked to discuss about their experiences with navigation elements in web sites. Results pointed to how dyslexic users use search features, breadcrumb trails and other navigation resources. Although the study provided good insight from users' opinions, there was no empirical evidence from participants using real websites.

Studies on problems encountered by dyslexic users have reported interesting findings, and have pointed to a clear need for broader empirical studies. This paper

presents an indepth study of dyslexic people using a range of websites accessibility to provide more insight into the nature of the problems dyslexic users have when using websites, and will provide important contributions to implications for design of websites.

3 Method

3.1 Participants

The participants were recruited from the University of York Students' Union mailing list and from personal contacts of the authors.

A total of 13 participants with dyslexia took part in the study, of whom 6 were male and 7 were female. Their ages ranged from 19 to 49 years (median = 20). The majority of the participants (12 out of 13) had English as their first language; one participant had Persian as first language, but was fluent in English. All participants had been diagnosed with dyslexia either by the University of York's Disability Office or by other appropriate professionals. Each participant was reimbursed with £15 per hour of their time.

With respect to their experience with computers, the participants rated their experience in a scale from 1 (not at all) to 7 (extensive). Their ratings of computer experience ranged from 3 to 7, with 84% of the participants with experience rated as 5 or above. All the participants had been using the Internet for 7 years or more. The participants spent between 1 and 20 or more hours per week on websites; 6 out of 13 reported to spend more than 20 hours a week using websites.

Participants were asked to provide details about their dyslexia, in terms of how severe it was and in what aspects they were affected by it. Most participants reported to have been assigned a severity level in a severity scale that ranged from "mild", "moderate", "severe" and "profound". In the sample of participants, 3 reported to have mild dyslexia, 3 mild-moderate dyslexia, 2 moderate dyslexia, 1 moderate-severe dyslexia, and 4 were not able to inform their level of dyslexia.

The aspects in which they were affected by their dyslexia were very broad, and varied considerably from participant to participant. The issues reported and the numbers of participants affected by each of them are as follows:

- Difficulties with spelling (8 participants)
- Difficulties with reading and comprehension (7 participants)
- Difficulties with reading text with black printing on white background (7 participants)
- Limited short-term memory (4 participants)
- Low writing speed (2 participants)
- Difficulties with processing of verbal information (2 participants)
- Speech difficulties (2 participants)
- Difficulties with motor coordination (1 participant)
- Limited spatial awareness (1 participant)
- Asperger's syndrome (1 participant)

Only 5 participants reported using some kind of assistive technology: 2 participants reported using Dragon Dictate and 2 participants use Dictaphone, both for speech recognition; 1 participant reported using TextHelp as a speech synthesizer software for reading texts on a computer. Regarding their enhancements, 6 participants reported changing the background colour of text in order to be able to read it comfortably, and 1 participant reported often increasing font size in websites to read text comfortably.

3.2 Websites evaluated

This study involved the evaluation of a sample of 16 websites, comprising websites at different conformance levels with the Web Content Accessibility Guidelines 1.0 and 2.0. The selection of websites included both websites from the private and public sectors, and involved local and central government websites, public services, non-profitx organisations and commercial websites.

One of the goals of the selection was to have a varied range of websites and conformance to WCAG 1.0 and 2.0. This was envisaged to enable further analysis comparing the problems found by disabled users and problems identified in accessibility audits performed with the guidelines.

In order to obtain a wide range of websites in different conformance levels, around 400 home pages of websites were analysed with automatic accessibility evaluation tools. Websites that had some potential level of conformance were further analysed using manual accessibility audits with WCAG 1.0. The websites were drawn from a sample of 100 websites evaluated in the formal investigation conducted by the Disability Rights Commission of Great Britain (Disability Rights Commission, 2004) and other websites found by search procedures.

The selection was performed soon after the WCAG 2.0 were published. At that point there was very little support available to perform accessibility audits with the new guidelines. Due to this, the selection was initially based on conformance of the home pages to WCAG 1.0. A follow-up evaluation of the home pages of the websites with WCAG 2.0 was performed using the archived web pages that had been evaluated with WCAG 1.0, so the evaluation was on exactly the same home page.

Table 1 shows the list of websites selected and information about their level of conformance to WCAG 1.0 and WCAG 2.0. For each website, the level of conformance (A, AA, or AAA) is shown, as well as the numbers of instances of violations of checkpoints/success criteria and the number of different checkpoints/success criteria violated. If a web page contains five images that do not have alternative text associated to them, this would count as five instances of violations of checkpoint 1.1 in WCAG 1.0 and success criterion 1.1.1 in WCAG 2.0, but would count as only one checkpoint/success criterion violated.

Table 1 List of websites with WCAG 1.0 and WCAG 2.0 conformance levels

Website	Type	WCAG 1.0 - instances of violations	WCAG 1.0 - Different checkpoints violated	WCAG 1 Conformance Level	WCAG 2.0 - instances of violations	WCAG 2.0 - Different success criteria violated	WCAG2 Conformance Level
Lflegal – Law Office www.lflegal.com	Private	5	2	AA	0	0	AAA
Green Beast Design www.green-beast.com	Private	23	3	AA	9	3	AA
York City Council www.york.gov.uk	Public	16	4	AA	7	5	-
NHS – National Services for Scotland www.nhsnss.org	Public	30	6	AA	31	9	-
Copac - Libraries network www.copac.ac.uk	Private	21	8	A	6	2	A
The Automobile Association www.theaa.com	Private	68	9	A	58	9	-
Department of Health www.dh.gov.uk	Public	91	9	A	31	6	A
Digizen www.digizen.org.uk	Private	80	9	A	46	12	-
JISC www.jisc.ac.uk	Public	58	12	A	216	13	-
Royal Mail www.royalmail.com	Private	50	15	A	103	7	-
Pret www.pret.co.uk	Private	184	16	A	141	21	-
Trades Union Congress www.tuc.org.uk	Private	146	23	A	97	17	-
British Museum www.britishmuseum.org	Public	130	8	-	86	8	-
NHS Direct www.nhsdirect.nhs.uk	Public	30	10	-	163	20	-
Ford www.ford.co.uk	Private	124	27	-	244	33	-
TicketMaster www.ticketmaster.co.uk	Private	757	29	-	1118	35	-

The selection of websites contains websites with a range of conformance levels, instances of violations and number of different checkpoints/success criteria violated. In relation to WCAG 1.0, there are 4 level-AA conformant websites, 8 level-A conformant websites, and 4 websites not conformant to WCAG 1.0. In relation to WCAG 2.0, there is one level-AAA conformant, 1 level-AA conformant, 2 level-A conformant and 12 non-conformant websites. Despite having a larger number of websites that are not conformant to WCAG 2.0 in the sample, it is worth noting that these websites have a wide variability in the number of instances and of individual checkpoints/success criteria violated, which will enable future analyses of coverage of problems found by user evaluation by WCAG 1.0 and WCAG 2.0.

A set of 3 tasks was developed for each website (except for NHS Direct, with two tasks). The tasks involved typical activities that would be performed in the websites, such as consulting council tax charges, buying tickets online, finding a local health service, find a used vehicle, and others. We attempted to have tasks with different difficulty levels for all the websites.

3.3 Design

The study consists of observing disabled users while using the selected websites and registering information about the way they experience the websites. Participants were asked to use a concurrent think aloud protocol, to "speak aloud" what they were thinking as they were carrying out their tasks. The main variables to be analysed regarding the tests were:

- Problems encountered by users and their severity
- Task completion
- Difficulty to complete each task (measured in a scale from 1 – 5)
- Time to complete tasks
- User satisfaction with the website

All the variables to be analysed are important to help understand whether disabled users can use the websites or not. Special attention was given to the problems found and how users rate the severity of the problems. During the study, users were asked to rate the severity of each problem found on a website while attempting to perform a given task using the following scale, adapted from the severity rating scale defined by Nielsen (1993). The severity of each problem should be rated according to the following scale:

1 – **Cosmetic** – an irritation that is unlikely to cause serious interruption in completing the task.

2 – **Minor** – a problem that is likely to interrupt the users for a short period of time or from which they can recover easily

3 – **Major** – a problem that is likely to interrupt the users for a long period of time or from which they will recover but with some difficulty.

4 – **Catastrophe** – a problem which will stop the user from completing their task.

Problems coded by the researchers during the analysis of the videos were also assigned severity levels according to this same scale.

3.4 Procedure

Evaluations took place in the Interaction Labs in the Department of Computer Science at the University of York. Participants were briefed on the nature of the study and then asked to sign an informed consent form. Participants then were asked to make any adjustments they needed to do in their preferred internet browser. Participants were also instructed about how they should proceed during the study, including instructions about talking aloud as they did the tasks, and reporting on any problems they would find while attempting to do the tasks. An explanation of the scale they should use to rate the severity of problems was also given. After this, participants were asked to open the first website and were given the tasks they would do.

3.5 Data preparation and coding

The analysis process comprised an initial phase to establish a categorization of accessibility problems and adequate levels of inter-coder reliability. The second phase was the main coding of all the problems.

In order to gather a representative set of problems, the selection of videos for the initial phase included a range of different websites. Each video was initially coded independently by three different coders, who identified accessibility problems and gave them an initial classification and severity rating.

After the independent coding of the videos, the three coders met to compare their initial identifications and classifications. During these meetings, a unified list of problems identified by all the coders is produced, a mutually agreed classification, and a classification scheme itself is built up.

The second phase, comprising the main coding of the full corpus of data, involved the analysis of approximately 45 hours of video recordings of dyslexic participants. This phase was performed by one coder.

4 Results and Discussion

A total of 693 instances of problems encountered by dyslexic participants were identified in the 16 websites. Each website was evaluated by 10 different participants. The mean number of problems per participant on each website was 4.33.

Table 2 shows the websites with the total number of instances of problems encountered by all participants. The total number of instances of problems ranged from 13 on the Digizen website to 70 on the Department of Health's website, with a mean of 43.25 problems per website.

Table 2 - Total number of instances of user problems per website

Website	Type	WCAG 1 Conformance Level	WCAG 2 Conformance Level	Instances of user problems
Lflegal – Law Office	Private	AA	AAA	49
Green Beast Design	Private	AA	AA	32
York City Council	Public	AA	-	63
NHS – National Services for Scotland	Public	AA	-	46
Copac - Libraries network	Private	A	A	29
The Automobile Association	Private	A	-	37
Department of Health	Public	A	A	70
Digizen	Private	A	-	13
JISC	Public	A	-	46
Royal Mail	Private	A	-	49
Pret	Private	A	-	18
Trades Union Congress	Private	A	-	57
British Museum	Public	-	-	57
NHS Direct	Public	-	-	44
Ford	Private	-	-	52
TicketMaster	Private	-	-	30

The problems encountered by users during the evaluation were also categorised according to how they affected the user when trying to perform their tasks. Table 3 presents a list of the categories with most problems assigned to them. It is worth noting that fifteen categories of problems accounted for 80% of instances of problems encountered by users.

Table 3 List of most occurrent problems found in the evaluation by dyslexic users

Category	Instances	Percentage of problems
1. Information not in page where users expected it to be	111	16%
2. Navigation elements do not help the users find what they are seeking	86	12.4%
3. Difficult to scan page for specific item	72	10.4%
4. Default presentation of text is not adequate	43	6.2%
5. Expected funcionality not present	34	4.9%
6. Too much information on page	33	4.8%
7. Organization of content is inconsistent with web conventions or common sense logic	30	4.3%
8. Functionality does not (or appear not to) work correctly/as expected	30	4.3%
9. User cannot make sense of information	29	4.2%
10. User does not perceive that action has had any effect (no/insufficient feedback given to an action)	17	2.5%
11. English too complicated for perceived target audience	16	2.3%
12. Link destination not clear	16	2.3%
13. User cannot understand sequence of interaction in funcionality	16	2.3%
14. User inferred the existence of funcionality where there is not one	13	1.9%
15. Too much irrelevant content before task content	12	1.7%

Navigation and information architecture

The categories with most instances of problems encountered by users were "information not in page where users expected it to be" and "navigation elements do not help the users find what they are seeking", which together account for 28.4% of the instances of problems. These two categories are related with navigation and information architecture issue. The first was occurred when users followed a path that seemed logical to them on the website, but the pages did not contain what they expected them to present. The second category is related to problems when the

elements in the navigation did not help users to decide where to go to find the information they were seeking.

The prevalence of navigation-related problems points to the need of more attention to the design of information architecture in websites. It is important that designers investigate how users find it most logical for the information on websites to be organised.

Highlighting and scanning information

The third most frequent category was "difficult to scan page for specific item", which accounted for 10.4% of the problems. This category is related to problems when the user encounters difficulties scanning for specific items in a web page, often due to lack of structural or visual aids that would make the content they needed stand out from the rest of the web page.

Presentation of text

The fourth most frequent category was "default presentation of text is not adequate", with 6.2% of the problems. Problems in this category involved numerous issues reported in guidelines on how to design text for dyslexic readers (British Dyslexia Association, 2011; Bradford, 2005). Common issues included the use of italics, inadequate spacing between lines and paragraphs, small font size, inappropriate font style, and inappropriate colour background.

The occurrence of complaints about colour background is noteworthy. Many participants encountered problems with black writing on white background. For these users, reading text on white background for a long time causes the text to start forming "visual patterns", or "dancing around". Although most web browsers have features to change the colour background of a website, none of the participants of this study knew about this feature, or if they knew, they found it very difficult to use. In most cases when this problem was reported, participants expected that the websites would provide them with a colour selector feature instead.

Functionality expected

The category "expected funcionality not present" accounted for 4.9% of the problems. This category included issues when a given functionality was not present on the expected page, or not present at the website at all. It also included problems when users expected certain functionalities to be provided by websites, but they were not. Some users considered it a given that websites will provide them with an internal search feature. Another expected functionality noted by some users was the presence of an "auto-complete" feature for input fields. Many users who have difficulties with spelling felt it was beneficial to have this feature in popular search websites, and

expected that other websites would also offer this feature to help them spell words when inputting information.

Amount of information and organisation of content

Users being bombarded with too much information in a page accounted for 4.8% of the total number of problems. Illogical organisation of information within a web page accounted for a further 4.3%. The problems with illogical organisation included issues with related information not being displayed logically along with other related information, illogical ordering of information (not in alphabetical order, for example) and lack of patterns in the way information is listed. A separate category of problems when there was too much irrelevant information before relevant content accounted for 1.7% of the problems.

Misfunctioning

Issues with features not working correctly or in the way users expected accounted for 4.3% of the problems. Many of these problems were related to a lack of proper testing procedures to assure the functionality of the websites is working correctly.

Making sense of content and language

Users not being able to make sense of content accounted for 4.2% of the problems. These problems were related to cases where specific information was displayed out of context, abbreviations with no explanations and nonsense text shown in captchas. A separate category contained problems where the general level of English was too complicated for the perceived target audience, which accounted for 2.3% of the problems.

Other categories included lack of clear feedback that an action has had effect (2.5%), unclear destination of a link (2.3%), users not being able to understand the sequence of interaction in a given functionality (2.3%) and users inferring the existence of functionality where there is not one (1.9%), such as when a text in the imperative mode that looks like a link but is not.

5 Conclusions and Future Work

This paper has presented initial analyses of problems enountered by dyslexic web users on a range of websites with different levels of conformance to WCAG 1.0 and 2.0. Users encountered many problems, which have been categorized into 15 groups. The analysis of these problems will help refine guidelines for the development of

websites to allow dyslexic users to use them easily. Future analysis will investigate to what extent these problems are covered by WCAG 2.0 and guidelines specifically to address the needs of dyslexic web users and the relationship between WCAG 1.0 and 2.0 conformance and the number of problems encountered by dyslexic users.

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