Web Content Accessibility Guidelines 2.0

A Literature Study Exploring the Effectiveness of WCAG 2.0 for the Visually Impaired

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January 2023

Abstract

Since the introduction of the Web Content Accessibility Guidelines (WCAG) 2.0, there has been an increase in awareness of web accessibility, however, according to the literature, this is not reflected by an increase in accessibility of websites for visually impaired people. The goal of this literature study is to determine to what extent the implementation of the Web Content Accessibility Guidelines (WCAG) 2.0 ensures the accessibility to websites for visually impaired people. The digital library of the Association for Computing Machinery was consulted for finding articles for this literature study. In total sixteen articles were consulted to answer the research question. This study shows that there are three factors which influence the accessibility of websites for visually impaired people. These factors are the problems encountered by the web developers, the testability of accessibility and the coverage of problems by the WCAG 2.0. The factors presented in this paper show an overarching picture of the limitations of the WCAG 2.0, which can serve as a starting point for experimental studies as well as a more elaborate literature study. Future experimental studies could focus on the inclusion of visually disabled people during the development as well as the evaluation process. Future literature studies could replicate this study, however, consulting more digital libraries as well as broadening the accessibility problems to people with disabilities, in general, could demonstrate other factors which could influence accessibility.

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1. Introduction

In the course of the past decade, digital technology has taken a more prominent role within society. This is reflected by the increasing number of implementations of digital technology within education, the government, healthcare and personal finance and administration. The Dutch government for example offers a digital service to request declarations and receive important messages, requesting the advance amount concerning surcharges is even available only as a digital service (Ministerie van Algemene Zaken, 2022).

A problem which may arise due to the increasing reliance on digital services and technology is that certain minorities within society are unable to keep up with the developments or do not have access to the services at all. Those who do not have access to the (solely) digitally available services and information can feel unempowered, and the lack of information and inaccessibility to services can have severe negative consequences. For instance, knowledge of advance surcharges could help avoid negative financial consequences by changing one's energy consumption behaviour.

The division between those who experience digital disablement (difficulty or inability to access digital services and use digital technology) or digital scarcity (the lack of accessible technological and related resources) and those who experience neither of these is called information inequity (Chaudhry & Shipp, 2005). Information inequity is predominantly experienced by visually impaired people, as there is a visual bias toward digital technologies (Chaudhry & Shipp, 2005). Visual impairment can be defined as "A loss of sight that cannot be corrected using glasses or contact lenses." (Disability Resource Centre, n.d.).

Problems which visually impaired people could encounter can vary from being unable to navigate through a website without a mouse to their aids not being able to read the site properly. The accessibility of digital technology for everyone is a challenge, as minorities have different needs compared to those who fall within the general demographics. For instance, alternative textual descriptions and labels are essential to visually impaired people, as they describe those visual aspects of a site they cannot observe (Siu et al., 2021).

The necessity to keep everyone in mind when it concerns accessibility is reflected by the introduction of the Web Accessibility Initiative (WAI) and the formation of the Web Content Accessibility Guidelines (WCAG) since the beginning of the Internet in 1999 by the World Wide Web Consortium (W3C). The WCAG are created, according to the W3C, to have a singular standard which assures the accessibility to sites which will meet the needs of individuals, organisations and governments internationally (World Wide Web Consortium [W3C], n.d.-c). An example of a guideline from the WCAG would be "Provide text

alternatives for any non-text content so that it can be changed into other forms people need, such as large print, braille, speech, symbols or simpler language." (World Wide Web Consortium [W3C], n.d.-d).

The vision of the W3C concerning accessibility is favourable, yet certain complications might occur when the WCAG are adopted. According to Lazar et al. (2004), one of the complications which might occur with the WCAG is that the guidelines are considered confusing by those who want to follow them. This has to do with the ambiguity of the guidelines, as they are descriptive, yet not detailed on how to meet the guideline. Another complication which is described by Lazar et al. (2004) is how the guidelines are considered advice rather than a requirement. This means that they are generally less prioritised by webmasters than the basic design steps, resulting in a less accessible website. Based on these complications, it can be presumed that the guidelines are less effective than the W3C intends them to be. The need for websites to be accessible is reflected as well by the number of foundations besides WAI that are committed to this topic. Some of the foundations offer a service to check the accessibility of a website and offer possible solutions. These solutions, however, are difficult to implement as the needs of different groups vary and are broad.

Based on the previously discussed information, it can be concluded that work needs to be done to make websites accessible and thereby reduce information inequity. The literature revolving around this subject is not able to show the scale of the problem yet, nor where the root of the problem lies. Therefore, there is a need for this literature study, which will offer an overarching picture of the situation. Furthermore, this overarching picture could serve as a starting point to determine how the problem of inaccessibility can be tackled at the roots.

Within this thesis, the focus will be laid on the accessibility of websites to people who are visually impaired, for visually impaired people predominantly experience information inequity as mentioned before. The research question which will be addressed in this study is: To what extent does the implementation of the WCAG 2.0 ensure the accessibility of websites for visually impaired users?

The paper is organised as follows. In the second section, the theoretical framework will be presented, in which the definition of visual impairment, problems visually impaired people can encounter, accessibility versus usability and the Web Content Accessibility Guidelines will be discussed. In the third section, the method that was applied will be discussed, including the search plan as well as the selection process. The fourth section will discuss the results, which will cover the following topics: compliance with the WCAG, testing accessibility based on WCAG, accessibility based on the success criteria and the

impact on the visually impaired. The last section will present the conclusion and discussion of this research.

2. Theoretical framework

2.1 Visual impairment

There are several definitions of the term visual impairment in scientific literature. As this study focuses on the effectiveness of the WCAG, it is of importance to determine which definition will be used within this study. The Disability Resource Centre (n.d.) uses the following definition: "A loss of sight which cannot be corrected using glasses or contact lenses". Even though this definition entails the main point of visual impairment, it is too broad to test the effectiveness of the WCAG. Another definition which could be used is the definition formulated by the World Health Organisation (WHO). According to the WHO (2022), vision impairment can be divided into two groups, distance and near vision impairment. Distance vision impairment has four levels: mild, moderate, severe and blindness. Near vision impairment is described as "… when the near visual acuity is worse than N6 or M.08 at 40 cm." Even though the definitions of the WHO are more elaborate than the one of the Disability Resource Centre, it could be more difficult to understand what it entails. To establish a comprehensible definition of visual impairment, a definition inspired by the definitions of the WHO and Disability Resource Centre has been formulated. Visual impairment within this paper is defined as follows: "Limited to no vision, which cannot be corrected by aids, such as glasses and contact lenses." This definition is inclusive towards the gradation in which vision impairment can occur.

2.2 Problems visually impaired people can encounter

People who are visually impaired are likely to encounter problems while trying to access a website. These problems arise while trying to navigate through a site, as well as trying to find the relevant information they need. As a result, visually impaired users are more likely to experience stress and reduced information processing efficiency, and comprehend the information less well (Machulla et al., 2018).

Visually impaired people often use aids which are HTML dependent, meaning they retrieve the information that is requested from the HTML code that websites are built with. The most well-known aids are screen readers and refreshable Braille displays. According to Alves et al. (2018), those who rely on a screen reader experience limited navigation possibilities when visiting a website, as navigation is mostly based on visual cues. A person who has normal vision can navigate through a site by filtering the information based on

visual cues, done by simply glancing (Giraud et al., 2018). Filtering is almost impossible to do for visually impaired people, as the HTML-dependent aids read the code line by line. This means that visually impaired people have to listen to an extensive amount of content until the relevant information is read. The longer it takes for the relevant information to be read, the more likely information overload will be experienced (Reid & Snow-Weaver, 2008). According to Giraud et al. (2018) distracting information, such as an advertisement or irrelevant information, has a negative effect on the cognitive load of the visually impaired user. This means when more distracting information is embedded within the HTML code, the available capacity of the user's working memory is more likely to be exceeded, resulting in a cognitive overload.

When a visually impaired person can access and navigate a website, it does not guarantee other problems will not be encountered. For instance, important information, like contact information, could be solely shown in an image instead of in a text. This means when the alt text (a tag that can be added to the image in the HTML code) is not describing the information which is mentioned in the image, the information is inaccessible to visually impaired users. As a result, visually impaired users will be unable to find this information. This is an example of the phenomenon 'not knowing what you do not know' described by Bigham et al. (2017). According to Bigham et al. (2017), this occurs when a (visually impaired) user encounters a problem during the process of completing a task, without knowing where the root of the problem lies. They are uncertain if the information is difficult to access or if the information is existent at all.

Visually impaired users are able to partially compensate for the problems they encounter. Research has shown that two compensation strategies were applied by visually impaired users when confronted with the lack of proper ways to navigate through a site (Machulla et al., 2018). The first compensation strategy is letting their screen reader read the entire website linearly at an increased speed. The second compensation strategy is filtering the information cognitively. Both of these compensation strategies demand a great focus from the user, costing a lot of cognitive energy. This means the available capacity of the working memory is more likely to decrease, resulting in a higher chance of cognitive overload (Machulla et al., 2018).

Some of the problems visually impaired users encounter have been discussed. Compared to people with normal or corrected to normal vision, visually impaired users are more likely to encounter problems and difficulties while trying to access websites. Even

though tools such as screen readers increase the usability of the internet for visually impaired users, it does not guarantee the accessibility of the internet to this fraction of society.

2.3 Accessibility vs. usability

The terms accessibility and usability overlap significantly in scientific literature. As the W3C is responsible for the WCAG and the Web Accessibility Initiative (WAI), as well as they are experts within this field, the necessity to define both terms properly is crucial. First usability will be defined, then accessibility. As usability is an important aspect for (web)design, the International Standards Organisation (ISO) created a definition which is precise and widely accepted (Petrie & Kheir, 2007). The International Standards Organisation [ISO]. (n.d.). defines usability in 9241-11 as: "The extent to which a product can be used by specified users to achieve specific goals with effectiveness, efficiency and satisfaction in a specified context of use". The concept of accessibility does not have a precise and widely accepted definition, as accessibility depends a lot on the context. Within this thesis, the context of accessibility concerns the extent to which visually impaired users are able to access the web. Therefore, the definition of the World Wide Web Consortium [W3C] (n.d.-a) is applied, which defines accessibility as follows: "people with disabilities can equally perceive, understand, navigate, and interact with websites and tools. It also means that they can contribute equally without barriers." To clarify the distinction between accessibility and usability, usability concerns specified users who could be disabled but do not have to be, while accessibility concerns disabled people specifically. As both terms have been defined properly, it is possible to look at what exists to assure accessibility to the web.

2.4 Web Content Accessibility Guidelines

The Web Content Accessibility Guidelines (WCAG) are developed by the World Wide Web Consortium (W3C), to make the web accessible to all. To start, some background information will be given concerning the history of the WCAG, then the setup of the WCAG will be explained, after which some examples of guidelines will be given and finally the most recent developments will be discussed shortly.

The W3C was established in 1994 by Tim Berners-Lee, the innovator and founder of the World Wide Web. As the World Wide Web finds its origin in code, it was important that standards were established. Therefore, the W3C was established, which develop international standards for the web, including HTML and CSS (World Wide Web Consortium [W3C], n.d.-b). A few years later, in 1997 the Web Accessibility Initiative (WAI) was established, with its main goal to make the internet accessible to people with disabilities (A11y Project,

2022). According to the World Wide Web Consortium [W3C] (n.d.-b), the WAI is responsible for developing standards and support materials that help with the understanding and implementation of accessibility on the web. One of their responsibilities is the development of the WCAG. According to the World Wide Web Consortium [W3C] (n.d.-c), the goal of the WCAG is as follows: "Cooperation with individuals and organizations around the world, with a goal of providing a single shared standard for web content accessibility that meets the needs of individuals, organizations, and governments internationally". The first version of the WCAG was used until 2008, as WCAG 2.0 was introduced. Several big changes were made when 1.0 and 2.0 are compared. One of the most prominent changes is the introduction to the ability to test accessibility with the help of guidelines, success criteria and quality levels (Fogli et al., 2010).

The WCAG 2.0 consist of four principles, also known as the four pillars. Those are: Perceivable, operable, understandable, and robust. Table 1 shows the descriptions of the pillars, what these pillars mean and examples of guidelines which fall within the specific pillar.

Table 1

The four pillars of WCAG

Pillar	Description	What it means for the user	Guideline example
Perceivable	Information and user interface components must be presentable to users in ways they can perceive	Users must be able to perceive the information being presented (it cannot be invisible to all of their senses).	All non-text content that is presented to the user has a text alternative that serves the equivalent purpose.
Operable	User interface components and navigation must be operable.	Users must be able to operate the interface (the interface cannot require interaction that a user cannot perform)	All functionality of the content is operable through a keyboard interface without requiring specific timings for individual keystrokes, except where the underlying function requires input that depends on the path of the user's movement and not just the endpoints.
Understandable	Information and the operation of user interface must be understandable	Users must be able to understand the information as well as the operation of the user interface (the content or	The default human language of each Web page can be programmatically determined.

		operation cannot be beyond their understanding)	
Robust	Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies.	Users must be able to access the content as technologies advance (as technologies and user agents evolve, the content should remain accessible)	In content implemented using markup languages, elements have complete start and end tags, elements are nested according to their specifications, elements do not contain duplicate attributes, and any IDs are unique, except where the specifications allow these features.

According to the World Wide Web Consortium [W3C] (n.d.-d) following the guidelines will make the content accessible to more people, especially to those with disabilities, such as visual impairments. To show to what degree a website conforms with the WCAG, three different quality levels were introduced: A, AA and AAA (World Wide Web Consortium [W3C], n.d.-e). When a website conforms to all the success criteria that are listed within the first level, they meet the requirements to receive an A-level status. When a website meets more success criteria their status can improve to AA or AAA level, of which AAA is the highest attainable level.

Following the guidelines and meeting the success criteria could increase the usability of web content to users in general. However, there are some problems concerning the WCAG. First of all, the guidelines are often considered to be advice rather than a requirement, resulting in those who create web content not following the guidelines (Lazar et al., 2004). This means that not all web content is accessible to all users. When the guidelines are implemented, they are considered confusing to those who need to follow them (Lazar et al., 2004). This means it is more difficult to implement and follow the guidelines. This is a result of the ambiguity of the guidelines, as they are formulated as guidelines and not as rules that need to be followed. Besides the fact that the guidelines are difficult to follow, Aizpurua et al. (2013) mention that conforming to the guidelines does not equal accessibility of the web content to the user. For example, the WCAG do not cover the use of wide space between related information (Calvo et al., 2016). This means that when the guidelines are followed, it does not guarantee the web content to be accessible to all. A few issues which are not covered by the WCAG are: not hiding information properly for assistive aids, the size of buttons and fonts and the usage of custom components. Hereby it is expected that the implementation of the WCAG 2.0 does not ensure the accessibility of websites for visually impaired users.

3. Method

3.1 Search plan

For this literature study, two search methods have been used, a database search and the snowball method. For the database search method, this study has limited itself to the Association for Computing Machinery Digital Library (ACM DL). The ACM DL focuses exclusively on the field of computing, meaning their database consists solely of relevant literature to this specific field. Computing has been selected as the focus of this study as it covers different disciplines for which the Web Content Accessibility Guidelines (WCAG) are relevant and important, such as computer engineering, information technology and software engineering.

ACM DL is favourable compared to Google Scholar, as Google Scholar includes literature from other fields besides computing as well, resulting in a larger number of articles to be filtered and analysed. The database from ACM DL, therefore, serves the purpose of pre-filtering the literature based on its relevance to the field of computing. Another benefit of utilising ACM DL is the greater number of options concerning filter criteria compared to Google Scholar. ACM DL offers for example the option to filter by content type. As this literature study focuses on scientific literature, it is beneficial to have this filter option. By selecting filter criteria, the number of irrelevant papers included within the search will be reduced. By selecting this library, it can be ensured that the consulted articles are relevant and of proper quality.

The specific search that has been used is: (“WCAG 2.0” OR “WCAG 2.1”) AND (“vis* impair*” OR blind). The first part of the search concerns the WCAG and its version. As this literature study places the current effectiveness of the WCAG at the heart, the most recent versions have been selected. Moreover, the difference between WCAG 1.0 and the revised WCAG 2.0 and 2.1 is substantial. At the same time, WCAG 1.0 is not excluded from occurring within the results, as it is likely that relevant papers have consulted or referred to papers which discuss WCAG 1.0. As this search term is rather broad, the majority of the filtering process was done manually. The reason why more specific keywords, such as effectivity or effectiveness, were not included in the search, was to ensure papers which did not specifically cover effectivity or effectiveness still could be included. The relevance to the paper is not solely determined by the inclusion of the term effectivity or effectiveness.

Executing this search query on the ACM DL returned 273 results in total for this search. The results included several content types, such as research articles, short papers,

posters, extended abstracts and opinions. As this study concerns scientific literature, with the focus on longer, peer-reviewed articles, the content type *Research Article* was selected. After applying this filter, 195 results remained. Due to the number of results and the chance of filtering out an important article no other filter, such as publication year, has been applied. Furthermore, all scientific articles which have been consulted were written in English, to ensure the original source is available to those who read this thesis.

The second method which has been used to search for relevant literature is the snowball method. The snowball method has been applied in two different ways. First of all, by identifying relevant articles which have been cited in articles found through the database search method. The second way is by including relevant articles which are connected strongly to the original paper introducing the WCAG 2.0 (World Wide Web Consortium [W3C], n.d.-d). These are found with the help of Connectedpapers[1]. Connectedpapers creates a visual graph based on the paper that has been entered. The graph shows with visual cues which papers are connected strongly, the most recent and how often they have been cited. This second form of the snowball search method functions as a check to ensure the most relevant papers have been consulted and incorporated. Additionally, this tool can show connections to other relevant papers which otherwise might have been overlooked. To bring clarity regarding which articles have been collected through the database search method and which have been collected through the snowball search method, an asterisk (*) has been added to the end of the reference in the reference list when the reference has been collected through one of the snowball search methods. There was only one research article which has been added through the snowball method.

3.2 Filtering the results

After the automatic filtering was done by the ACM DL, 195 results remained. As it would be unlikely that all of the results would be of added value to this literature study, the remaining 195 results were filtered manually. Before the filtering process started, an Excel file was created in which the following was noted per article: the title, the link to the article (DOI) and the abstract. Besides these descriptives, four columns were added. In these columns the following inclusion criteria were written down: visual impairment focused, accessible, (when applicable) which version of WCAG was discussed and usefulness for this literature study. One more column was added in case there was a need to take notes, summarise the core of the paper or write down possibly relevant quotes. After the Excel was

[1] Connectedpapers.com

created, all the articles were manually added to the file. As the articles were sorted by relevance by the ACM DL, this order was preserved while adding the articles to the file. To ensure the original order could be retrieved easily, the articles were numbered. After the descriptives were added, the abstracts of the articles were analysed to assess if they met the selection criteria or not. Per selection criterion, there were several options to note to what extent the article met the criterion.

The options for *Visual Impairment focussed* were limited to “yes”, “no” and “yes, among others”. During the selection process there were some abstracts which discussed visual impairment as well as others, therefore the option “yes, among others” was included. If this option was not included, relevant papers could be excluded, which could result in a less accurate representation of the information within this paper.

The *accessible* selection criterion had two options, “yes” and “no”. An article was considered not accessible when written in another language than English or when the full text was not available for free after the VPN of Tilburg University was active.

The selection criterion concerning the *WCAG version* was noted, if applicable, by selecting one of the following options: “1.0”, “2.0”, “2.1”, “both” and “n.s.” (not specified). This information could be of use when comparing different results of different articles. Not only is a comparison between results, but between WCAG versions possible.

The last inclusion criterion concerned the usefulness of the article. As usefulness is a rather broad term, it was mainly based on the previously mentioned criteria if the inclusion of a paper would be considered. There were three options which could be selected, “yes”, “no” and “maybe”. The “maybe” option was included as there were some articles which could be of use based on the abstract, however, it would depend on what the rest of the article would discuss.

Out of the 195 results, 86 were considered usable. As these 86 articles included several articles which were possibly usable but not certain enough, a second selection process was initiated. As the first selection was solely focused on the abstract, the second selection focused on the abstract, introduction and discussion sections of the articles. This would make the selection process more accurate as well as simpler, as there would be more information on which the selection could be based. The same selection criteria were applied as in the first selection process. To organise all information related to the selection processes, the second selection was done in a new tab within the same Excel file. While reading the articles more in-depth, some of the articles seemed to be more relevant to another section of this literature study than the results section. One article was for example focussed on a specific tool which

was developed for people with visual impairment or discussed what kind of problems the visually impaired could encounter. These papers were not considered relevant for the result section as they were too broad or too specific, however, they could be relevant for another section of this literature study. Therefore, a new column was created in which this could be written down. In this column, the following options could be filled in: “Introduction”, “Theoretical framework”, “Results” and “Discussion”. As the links between the different articles became increasingly clear while reading the articles in more depth, the selection process, including which article would be the most relevant to which section, became easier. Out of the 86 articles, 41 articles were considered useful for this thesis, meaning they were considered useful for one of the several parts of this literature study. Out of these 41 articles, 16 articles were considered usable for the results section.

To assure there were no articles overlooked, a final check was done by using Connectedpapers. The graph which was created based on the papers connected to the WCAG 2.0 article, showed there were several strong connections. The majority of these papers were within the dataset and therefore have been filtered on relevance to this literature study. Some of the papers which did have a strong connection to the WCAG 2.0 article, were not within the data set. However, based on the title and the abstract of these articles, they would not have been relevant to this literature study. They were not focussed on visual impairment, on other disabilities or were not accessible as payment was needed.

3.3 From separate articles to the results

After selecting the 16 articles, the reading process started. A word document was created in which the APA notations of all the articles were written down. Underneath each APA notation, the most important information, such as findings, information which showed the context as well as the applied methods were written down. During the reading process, there were four main categories which showed up the most often. These four categories were: compliance with WCAG, testing accessibility, accessibility based on compliance with the WCAG and the impact on disabled people. After finishing the reading process, the document was printed. Four different coloured markers were used to mark which information could be relevant to which category. Based on these coloured sections, the results section was written.

4. Results

After the selection process, a total of 16 papers remained to be incorporated within the results section. Among these papers, the majority were empirical studies. Even though the empirical studies focus on a specific target group or aspect concerning accessibility, they

discuss several topics which are relevant to different sections of the results. In table 2, shown below, an overview is presented concerning the following topics: type of article, type of impairment focussed on, type of study and WCAG version. Based on these demographics, the content of the paper and the coloured sections, the papers were divided among the different sections of the results.

Table 2

Overview of the demographics of the articles

Article	Type of article	Type of impairment focussed on	Type of study	WCAG version
Alonso et al. (2010)	Research article	Not specified	Experiment	2.0
Bittar et al. (2011)	Research article	Not specified	Prototype evaluation	2.0
Brajnik (2011)	Research article	Not specified	Review of research	2.0
Calvo et al. (2016)	Research article	Various disabilities	Reviews	2.0
Clegg-Vinell et al. (2014)	Research article	Various disabilities	Preliminary investigation	2.0
Crabb et al. (2019)	Research article	Various disabilities	Focus groups (workshop)	2.0
Fogli et al. (2010)	Research article	Various disabilities	Preliminary evaluation	2.0
Hanson & Richards (2013)	Research article	Various disabilities	Case study	2.0
Henry et al. (2014)	Research article	Various disabilities	Communications paper	2.0
Kelly et al. (2008)	Research article	Various disabilities	Case study	1.0 and 2.0
Koutsabasis et al. (2010)	Research article	Not specified	Case study	2.0
Moreno et al. (2018)	Research article	Low vision	Exploratory study	2.0
Nogueira et al. (2019)	Research article	Blind	Experiment	2.0
Petrie & Wakefield (2020)	Research article	Visually impaired	Remote evaluation	2.0
Power et al. (2012)	Research article	Blind	Empirical study	2.0
Vigo et al. (2013)	Research article	Not specified	Empirical study	2.0

The results will consist of four different sections, of which the first one will concern compliance with the WCAG. While analysing the results, it became clear that correctly applying the WCAG is not straightforward, and therefore this section will focus on what factors have an influence on the degree of compliance with the WCAG. The second section will discuss the testability of accessibility and the different methods which can be applied. The third and fourth sections will focus on the effectiveness of the WCAG if applied correctly. The third section concerns the success criteria of the WCAG. The last section will address the impact of (in)accessibility on the visually impaired.

4.1 Compliance with the WCAG

The WCAG have been incorporated within the laws and governmental policies across the globe to serve as a guide to web accessibility (World Wide Web Consortium [W3C], 2023). Regardless of the increasing awareness concerning accessibility, there has not been an

increase in web accessibility according to Power et al. (2012) and Koutsabasis et al. (2010). The degree to which websites meet the success criteria is really low, as less than 4% of 30 million web pages met the success criteria which could be tested automatically (Lopes et al., 2010, as cited in Power et al., 2012). According to Power et al. (2012) the inaccessibility of websites to disabled people has been increasing. Several articles present different factors which could explain the phenomenon of the increasing inaccessibility of websites.

The first factor concerns the developers of the websites, as they experience difficulties while trying to apply the guidelines (Bittar et al., 2011). The findings of Crabb et al. (2019) show that there is a lack of knowledge among the developers, especially on how to implement techniques as well as how accessibility can be increased. When they do apply the guidelines, however, they also experience difficulties which can be connected to several aspects of the WCAG. The first aspect of the WCAG is that it strives to make the web accessible to all and to do so, the guidelines are thorough. This thoroughness, however, could be an explanation as to why implementation is more difficult according to Hanson and Richards (2013). The study done by *Clark et al. (2006), which was explained in Kelly et al. (2008), compared WCAG 2.0 to its preceding version 1.0 and concluded that the document of WCAG 2.0 is double the size. The thoroughness, as well as the increasing complexity of websites, explains the size, resulting in more information which needs to be considered by the developers. This makes the implementation of the guidelines more difficult, as found by Hanson and Richards (2013). The second aspect of the WCAG is specified by Clegg-Vinell et al. (2014), as the guidelines can be quite abstract and some can be subject to an evaluator effect. The evaluator effect is explained in Clegg-Vinell et al. (2014) according to the definition by Hornbaek and Frøkjær (2008), which means that evaluators present different problems while evaluating the same application with the same evaluation technique. The abstractness of the guidelines as well as the evaluator effect can explain the difficulties encountered by developers. When a guideline is abstract, there is room for multiple interpretations. Furthermore, the evaluator effect has a negative effect on the implementation of the WCAG, as it can be influenced by the prior knowledge and experiences of the developer.

The second factor which could explain the phenomenon of increasing inaccessibility of websites to disabled people is described by Power et al. (2012) based on the study of Petrie et al. (2005), as the overstatement of conformance to the WCAG. Their research showed that 30% of the analysed websites overstated their compliance with the WCAG 1.0. According to Power et al. (2012) studies have shown that the changes between 2.0 and 1.0 did not

guarantee that problems found in 1.0, likely including the overstatement of compliance, were addressed in 2.0.

The third and last factor which could explain this phenomenon is specified by Clegg-Vinell et al. (2014), as they found a disharmony between their findings concerning the severity of problems and those of the WCAG. According to Hanson and Richards (2013), the WCAG have ordered the success criteria among different A-levels (A, AA and AAA) based on the possible workarounds of authors. Clegg-Vinell et al. (2014) researched the severity rating given by disabled people when a guideline was not being followed. When comparing the two severity ratings, disharmony was found, which means the disabled people considered certain success criteria more important to be followed than the WCAG insinuated by categorising it in a different A-level. According to Clegg-Vinell et al. (2014), this disharmony could cause confusion among developers. However, when confronted with confusion, Clegg-Vinell et al. (2014) recommend listening to the severity ratings of users rather than those of the WCAG.

4.2 Testing accessibility based on the WCAG

According to Bigham et al. (2010, as cited in Bittar et al., 2011), guidelines and standards are formulated to serve as an entry point to accessibility. It is important that when guidelines are implemented, conformance to the guidelines can be tested, to determine if accessibility is guaranteed. The goal of testing the accessibility of the websites for those who are disabled can be achieved by testing and evaluating to what degree the websites meet the success criteria incorporated within the WCAG. There are three methods which can be applied to test the accessibility of websites based on the WCAG. These methods are automated tools, automated tools in combination with manual testing and manual testing.

The first method consists of applying automated tools, which analyse to what degree a website meets the success criteria of the WCAG 2.0. Brajnik (2011) describes the appeal of using automatic evaluation tools as they are easy to use and interpret, and efficient.

However, there are some limitations to the automated evaluation tools, as described by Vigo et al. (2013). Vigo et al. (2013) showed that the coverage of the success criteria by the automated evaluation tools was very narrow, as at most 50% of the success criteria were covered. Furthermore, the choice of the right tool is crucial, as Vigo et al. (2013) showed that the results concerning the coverage would be worse if not the best tool was applied for the specific type of success criteria. Even if several tools would be used, it does not guarantee the coverage would increase. Besides the degree to which the success criteria are covered,

Brajnik (2011) shows a limitation to applying automated tools as well. Brajnik (2011) shows that there is uncertainty concerning what is measured exactly by the automated evaluation tools. An example that is given concerns the failure rate. Failure-rate solely shows to what extent the developers were able to address accessibility features, however, it does not reflect on the severity of the accessibility barriers (Brajnik, 2011).

The second method consists of combining automated tools with manual testing. Because it was shown by Vigo et al. (2013) that automated evaluation tools are limited concerning the coverage of the success criteria, manual testing could fill in the gaps. Including manual evaluation, however, does not go without any problems according to Brajnik (2011). Brajnik (2011) shows that along the different steps of evaluation, errors and subjectivity can slip through. For example, during the assessment of accessibility problems, one fifth of the ratings might be wrong (Brajnik, 2011).

The third and last method consists solely of manual testing. As shown before by Brajnik (2011), manual evaluation is vulnerable to errors and subjectivity. According to Alonso et al. (2010) and Brajnik (2011), the degree of expertise of the person conducting the tests influences the success of manual testing. However, there is a great shortage of experts according to Fogli et al. (2010), which introduces an additional limitation to reliable manual testing.

According to Alonso et al. (2010), the goal of WCAG 2.0 was that it should be machine testable or reliably human-testable. To test if the WCAG 2.0 could be considered human testable, Alonso et al. (2010) researched to what extent the success criteria of level-A could be tested by beginners. Their analysis after having students (beginners) conduct manual testing, showed that out of the 25 success criteria, 13 were rated incorrectly, or there was no consensus among the students. Alonso et al. (2010) compare their findings with a similar study done by Brajnik (2009), which found similar results. A cause Alonso et al. (2010) identify is the difficulties that were experienced by the beginners concerning the interpretation of the WCAG 2.0. The study of Alonso et al. (2010) shows that the WCAG 2.0 are not testable for beginners.

As the WCAG 2.0 are not testable for beginners according to Alonso et al. (2010, manual testing should be done by experts. The testing by experts however does not guarantee all problems will be reported or are actual problems according to Power et al. (2012). Brajnik (2011) shows that of all the problems reported by experts, 20% were false positives and 32% of actual accessibility problems were missed by the experts. Besides the false positives and

missing accessibility problems, Brajnik (2011) shows that even if evaluators are experts, experts only reached or exceeded 75% of agreement for half of the success criteria.

4.3 Accessibility based on the success criteria

As the testability of the accessibility of the websites has some complications, it is difficult to conclude if a website meets the success criteria. Assuming a website does implement the guidelines and meet the success criteria, the question is, would this guarantee accessibility? More specifically, to what extent does meeting the success criteria guarantee accessibility to those who are visually impaired? "As previously mentioned, the success criteria are not ordered based upon the severity ratings, but rather according to the possible workarounds by the developers (Clegg-Vinell et al., 2014; Hanson & Richards, 2013). However, assuming it is possible to comply fully with the WCAG, the question is whether it would cover all the problems that could be encountered by people with a disability, specifically the visually impaired.

Kelly et al. (2008) describe that with the previous version (1.0) of the WCAG, logos and seals were added at the bottom of a website when they conformed to a certain level of accessibility. Based on these logos, disabled people could assume that the websites would be accessible to them, however apparently this was not the case. Kelly et al. (2008) base this on a previous study by Phipps (2005), where it is pointed out that only 50% of the websites achieved the level that is represented by the seal or logo. The use of these logos could be considered an overstatement of compliance.

By following the WCAG, the assumption is that it would make the website more accessible, however, several studies prove this assumption to be false. The study done by Power et al. (2012) shows that of the encountered problems by visually impaired people, only 50.4% was covered by the WCAG 2.0. In other words, while meeting the success criteria, a website does not prevent visually impaired users from encountering other accessibility problems. A study which is a bit more recent, done by Calvo et al. (2016) found similar findings, as only 32% of the problems that were encountered were covered by the WCAG. Clegg-Vinell et al. (2014) presented similar results as well, as their participants reported accessibility issues which were not covered by the WCAG at all. Hanson and Richards (2013) examined a number of websites that claimed to comply with the level-A success criteria of WCAG, and found that almost none of these websites were considered accessible according to the WCAG.

Kelly et al. (2006) conclude that universal accessibility is seemingly unrealistic,

which is confirmed and acknowledged as well by the WCAG 2.1 guidelines. As stated by the WCAG 2.1: “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.” (World Wide Web Consortium [W3C], 2018)
So far, the discussed literature says that solely compliance with the WCAG is not enough, as accessibility issues still remain.

4.4 Impact on the visually impaired

The previously presented information concerned mostly information about accessibility, to what extent it can be tested as well as the effectiveness of the WCAG. What has not been discussed yet, is what the impact is on the users who are confronted with the barriers to websites when they are not accessible. As shown by Clegg-Vinell et al. (2014), there was a difference between what is considered high priority by the users and what is considered high priority according to the WCAG A-levels. An example of what visually impaired users encounter according to Power et al. (2012) is the misplacement of information. This means that the users follow a link, which does not direct them to the information they expect or the information they need. Another example which visually impaired users encounter is access to buttons (Petrie & Wakefield, 2020). When users, specifically visually impaired users, are confronted with barriers, the study of Nogueira et al. (2019) shows that this has a negative impact on their emotional states. This is specifically found with responsive websites, as non-responsive websites conform more easily to the WCAG (Nogueira et al., 2019). To cope with barriers when they are encountered, visually impaired users have developed different strategies, as described by Moreno et al. (2018). A specific strategy that was found by Moreno et al. (2018), was a navigation strategy, applied by visually impaired people to navigate through a website. This strategy entails the use of screen magnifiers and vertical and horizontal scrolling.

Even though the strategy did help overcome certain barriers, Moreno et al. (2018) showed that there were negative consequences related to the use of the strategy. They found that when the navigation strategy was applied, there was a decrease in legibility and the chance of experiencing a loss of context was higher. This means that the reader was more likely to misunderstand or miss important information. Several causes were given by Moreno et al. (2018), like small font sizes and low contrast between the font colours and background colours.

The results found by Nogueira et al. (2019) concerning experiencing negative

emotions when confronted with barriers, was found as well in people who were not disabled. According to Henry et al. (2014) increasing accessibility could be beneficial as well to people who are not disabled, as they could encounter situational limitations, such as a loud environment and not being able to hear the audio of a video. However, Henry et al. (2014) emphasize that the definition of accessibility should not shift to include people with no disabilities. The reason they present is that it would take away the focus on disabled people and therefore limit the accessibility of the web.

5. Discussion and Conclusion

5.1 Discussion

The goal of this study was to create an overarching picture concerning the situation of inaccessibility of websites, specifically to those who are visually impaired. Especially discovering where the roots of the problems lie, and whether compliance with the WCAG is enough to address these problems were the focus of the study. To create this overarching picture, a literature study has been done, which explored the possible different factors which could be the root of the problem.

The expectation was that the implementation of the WCAG 2.0 would not ensure the accessibility of websites for visually impaired users. As previous research shows, information inequity is experienced by visually impaired people (Chaudry & Shipp, 2005), which can be explained by accessibility problems, such as the lack of alternative textual descriptions (Siu et al., 2021). The results showed that three factors played a role in the inaccessibility of websites for visually impaired people.

First, the results show that compliance with the WCAG is not self-evident. The developers of websites stumble upon several problems, which are mostly connected to WCAG 2.0 itself. As the WCAG is thorough and, compared to its previous version, double the amount of text, the developers have to learn more information. This results in an increase in time to be spent on learning and understanding the WCAG 2.0. Furthermore, the guidelines are described as abstract, meaning that even if the developers do learn everything, the implementation of it can be challenging. The challenging aspects of the implementation, especially the abstractness of the guidelines, could explain the overstatement done by developers concerning compliance with the WCAG 2.0. As the guidelines are abstract, there is no clear agreement among developers when the success criteria are exactly met, which could result in a disagreement whether a website does or does not comply with the WCAG 2.0. This means that the considered accessibility of a website depends on the implementation

of the WCAG as well as the degree to which the developers agree if success criteria are met or not. The difficulties encountered by the developers, as well as the over-compliance, create a framework in which compliance with the WCAG is not self-evident.

Second, testing to which degree a website complies with the WCAG is hardly possible. Assuming the websites aim to comply with the WCAG 2.0, it is important to be able to test to what degree they comply. Therefore, testing is crucial, however, the three different methods which can be applied each have their limitations. When applying automated tools, only a portion of all the success criteria can be tested, resulting in a distorted picture of to what extent a website complies with the WCAG 2.0. A combination of an automated tool and manual testing, which could compensate for the uncovered portion by the automated tool, does not seem to be a proper solution either. As manual testing is prone to human errors, it cannot guarantee it shows the correct percentage to which a website complies with the WCAG 2.0. This is an argument as well as why full manual testing is not desirable. The results do show that expertise with the WCAG does have a positive influence when testing to what extent websites comply, however, experts cannot guarantee full coverage of all the success criteria. This has to do with the fact that among experts, as the WCAG 2.0 are abstract, there often is disagreement if success criteria are met or not. So testing if a website is accessible, is difficult due to the previously mentioned limitations.

Third, when assuming a website does fully comply with the WCAG 2.0, it does not guarantee visually impaired users will not encounter any problems or barriers when visiting the website. As Clegg-Vinell et al. (2014) and Calvo et al. (2016) show, meeting the success criteria does not prevent the occurrence of problems for visually impaired people. Less than a third of the problems encountered by visually impaired people are covered by the WCAG 2.0, meaning the WCAG 2.0 is not comprehensive. The limitations of the WCAG 2.0, concerning making the web fully accessible to all, are recognised by the W3C. To conclude, the implementation of the WCAG 2.0 does not ensure websites will be fully accessible to visually impaired users.

The following research question was addressed in this literature study: “To what extent does the implementation of the WCAG 2.0 ensure the accessibility of websites for visually impaired users?”. Based on the presented information in this paper, this research question can be answered. It appears that the WCAG 2.0 cannot ensure the accessibility of websites for visually impaired users. The first problem that arises are the difficulties that are encountered by the developers, meaning the implementation of the WCAG in general cannot be ensured. To test if the WCAG are implemented properly, the methods that are used are not

as reliable, resulting in a distorted picture to what degree a website complies with the WCAG. Even when the assumption is made that a website meets all the success criteria and complies fully with the WCAG, it has been proved by research and acknowledged by the W3C itself that the WCAG cannot guarantee accessibility. The WCAG does not cover all the possible accessibility problems. These accessibility problems have a negative influence on visually impaired people, as expected, emphasizing the need to address these problems.

5.2 Theoretical and practical implications

This literature study shows the problems which arise concerning the accessibility of websites to visually impaired people, as well as the effect of inaccessibility on visually impaired users. When visually impaired users encounter barriers or are confronted with accessibility problems, this has a negative effect on their emotions. Even though the WCAG 2.0 cannot guarantee accessibility to the visually impaired, several researches (Harrison & Richards, 2013; Power et al., 2012; Petrie et al., 2020; Kelly et al., 2008) reached the same conclusion about how accessibility could be more likely to be guaranteed. The involvement of visually impaired people during the process of developing new websites as well as evaluating the existing ones could be beneficial to the accessibility of websites.

This literature study is the first study which brings the existing research together and with that shows the gaps as well as the strengths of the research in this field. Furthermore, the overarching view shows the different factors which influence the accessibility of website for visually impaired users. As the factors are specified, it is possible to formulate different strategies to tackle the influence they have on the accessibility of websites.

5.3 Limitations and suggestions for future research

As the majority of the discussed literature and research was mainly done with developers, researchers and students, the information on how the inaccessibility affects visually impaired users was limited. Therefore, the effects inaccessibility has on the visually impaired can be incomplete. Moreover, this literature study retrieved its research papers from one digital library, which could result in the exclusion of other relevant articles from other fields of research. However, this probability has been minimised by following and describing an elaborate procedure concerning the searching, filtering and selecting of research papers in a replicable way. To ensure no relevant research papers were excluded which were not included in the digital library, the snowball search method with the help of ConnectedPapers was applied. Lastly, this study has been performed by one researcher, meaning there is a probability an unconscious bias could have influenced which research papers were selected.

Based on the limitations as well as the findings of this literature study, several recommendations for future research can be done. For future research it would be recommended to replicate this study on a larger scale, covering more and a greater variety of digital libraries. To ensure there is no probability of an unconscious bias by the researcher, it is recommended to perform this research with multiple researchers, to make it possible to discuss which papers will be included and which will not be included. Another recommendation which can be done is for future empirical studies. The results showed a small number of papers which included disabled people during the development as well as the evaluation stage of websites. By including disabled people during these processes, the results showed that it has a positive effect on the accessibility to the websites.

5.4 Conclusion

This literature study researched to what extent the implementation of the WCAG 2.0 ensures the accessibility of websites for visually impaired users. Based on this literature study it became apparent there are three factors which influence the accessibility of websites for visually impaired people. These factors include the problems encountered by the developers, the testability of accessibility and the coverage of problems by the WCAG 2.0. By establishing these factors, this literature study contributes to a societal as well as a scientific goal. The roots of the problem have been exposed as the three factors, which created an overarching picture. Based on the established factors, research can be done how to decrease the influence of the factors. The established factors can function as a starting point as well, to discover if there are more factors which influence accessibility to websites, for visually impaired people as well as for disabled people in general. This study acquired an overarching view concerning the limitations of the WCAG 2.0 and the complications which may arise when striving for accessibility for the visually impaired.

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