

SOLENT UNIVERSITY

Faculty of Business, Law and Digital Technologies.

MSc (Hons) MSC COMPUTER ENGINEERING

INTERRELATION OF USER EXPERIENCE AND WEB  
DEVELOPMENT

RESEARCH PROJECT (MAA112)

Academic Year 2021-2022

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## 0. Abstract

This literature illustrates the lack of use of WCAG standards in web development. This study focuses on improving user experience regardless of their visual disabilities. We learn that regardless of the multitude of regulations and standards at an international and national level, web content is mostly unusable for the visually impaired. This dissertation presents the evaluation and results for 11 websites, including 4 of the most used websites in the United Kingdom (UK). A handy extension called “AXE coconut web-accessible” will be used to access each website. Overall, the findings show low usage of WCAG 2.0 standards and numerous accessibility and usability issues, even for sighted people. Adopting a user-centred approach during web design can eliminate many accessibility barriers, according to the assessment data analysis.

Further to this, we learn how the WCAG standards can be used to increase user experience. Web developers have modern options such as Chrome extensions and CSS injections to counter pre-existing web accessibility issues. Thereby, leading this study to create a Chrome extension that will help combat the disregard of “WCAG” standards by web developers. The extension altered the website to fit the “WCAG standard” more. Then the extension was further tested with surveys and found that the users found it very useful, especial if they had a visual impairment.

## 1. Introduction

The modern world is constructed around the internet; it connects people, and websites are the main interfaces between people and the internet. Such interaction between people and the internet is dictated by web developers and designers. This interaction is called user experience (UX). It is there to make everything as easy and flawless as possible for all types of users with any disabilities or circumstances in using the internet. The importance of better designs can be seen in the increasing complexity of websites over the years. (Nate Nead 2021)

The modern world wide web is arguably one of the world's most complex pieces of technology. It has the accumulated knowledge of all the previous generations, and it can also hold the understanding of any future generation. Modern society is highly reliant on this massive technological structure and all the utility it provides. In today's day and age, anything we imagine can be done through the internet, from running a company to paying our bills, buying our groceries, etc. This shows how the internet is quintessential for modern humans and the importance of web development. (CERN, Mundaneum and Science Museum 2022)

The growth of the online industry has prompted a fast-paced development of the technology behind it. The fast-paced development of such technology will lead to a multitude of confusion in the standard of practice in developing online interfaces (websites). The survey by El Sheikh and Tarawneh 2007 states the importance of a best practice due to the over price and time delays of web development. This raises the question of the current best course in using the latest technology, such as HTML, JavaScript, CSS, SQLite and others. These technologies are critical,

as it assures the streamlining of content for the ease of use for the users and their experience. (Connolly 2015)

Regardless of whatever understanding this comes through, it is only as new as the latest technology this study gathers. As the technologies evolve and develop, this study will remain stagnant. Hence, it is essential to look at the reasoning for developing current best practices, which could shed light on how they change. Although regardless of the pacing of technology development, there is still one part that remains somewhat steady and neutral. This is the human part of technology that is based on human desires, psychology, and physiology, which has remained mostly stagnant through the ages. However, some minorities are disregarded in these developments. Therefore, making most of the internet inaccessible for some users with disabilities or other bodily dysfunction such as visual impairment.

We are fortunate to live during the apex of the wave in which these inventions affect society. The greatest inventions of our time are the digital computers, the Net, and the World Wide Web. The web has a tremendous impact on contemporary companies. Still, developers work off of others who came before them and reflected on their history to understand better where they are going (Northwood 2018). Therefore, these developers have learned much from standards such as the WCAG 2.0 by W3C.

With the help of enormous data stores and an open web platform defined by W3C standards, developers can create rich interactive experiences accessible on any device. Leaders in the industry agree almost unanimously when they say HTML5 will be the foundation of this platform, even though the platform's limitations are still evolving. However, the platform's full potential depends on several other technologies that W3C and its partners are developing, such as CSS, SVG, WOFF, the Semantic Web stack, XML, and several APIs.(W3C 2021).

Numerous data and standards are in place to build digital material and apps usable by a diverse group of people, including those with vision, motor, hearing, speaking, or cognitive limitation. This is referred to as "digital accessibility." It should be one of the biggest priorities for modern developers, but this is not the case on many websites, thereby leading this study to learn how the WCAG standards and guidelines are being followed and utilised by developers.

## 1.1 The purpose of this dissertation

This dissertation aims to research the use of guidelines produced by the World Wide Web Consortium web accessibility initiative (W3C WAI).

- *To find out the usage of the guidelines such as "WCAG 1.0, 2.0" issued by W3C WAI in web development.*
- *To develop a Chrome extension that will counter any visual issues created by not following "WCAG 1.0, 2.0" and to find whether the extension improves the quality of life of people.*

This dissertation will pursue the development of an extension to enable users to browse any web pages that do not follow the WCAG standard. Users will then test the creation of this extension to evaluate if it has helped to remedy any disregard for the WCAG guidelines.

The findings made by this paper will not be conclusive as these technologies are amid constant improvements and innovation. Hence why any current solution for user experience becomes inconclusive for any future technology. Whereas, the reasoning behind the development of such technology will be invaluable as the reasoning is purely based on the design for people by people. Regardless of this fact, the study by El Sheikh and Tarawneh 2007, a web development firm shows how most developers do not have the required knowledge for web development and therefore demonstrates the importance of this dissertation to fill in that gap.

## 1.2 Background

This section defines the term "web accessibility" and covers the many WCAG versions, including its guiding principles, levels of conformity, and levels of compliance. Web accessibility seeks to increase the usability and accessibility of websites for as many users as possible, regardless of their technological capabilities, knowledge, or background. Through the Web Accessibility Initiative (WAI), W3C globally encourages the implementation of online accessibility standards. The initial iteration of the WAI's WCAG, which has since become a global standard, was released in 1999. The first public draft of WCAG 2.2 was released in February 2020, WCAG 2.1 in June 2018, and WCAG 2.0 in December 2008. The international standard ISO/IEC 40500:2012 is based on WCAG 2.0 (ISO/IEC 2019). All the success criteria from WCAG 2.0 are included in WCAG 2.1, along with an extra 17 success criteria. In September 2018, the European Union (Shadi Abou-Zahra 2018) approved WCAG 2.1 as a guideline for web pages and digital files.

The WCAG standards aid web designers and developers in better accommodating elderly and disabled users. These recommendations are meant for anyone who needs a reference standard for evaluating the accessibility of particular web material, as well as web developers and designers, authors of design software for web design and programming, and anybody else. Individuals regardless of their disabilities, benefit from web accessibility, which also makes websites easier to use.

### 1.2.1 Accessibility

According to the W3C, web accessibility is "essential for developers and organisations that want to create high quality websites and web tools, and not exclude people from using their products and services"(Shawn Lawton Henry and Liam McGee 2019). Accessibility is defined by the Information technology — Development of user interface accessibility — Part 1: Code of practice for creating accessible ICT products and services (ISO/IEC 2019) as "the degree to which people from a population with the broadest range of user demands, traits, and capacities can utilise certain products, systems, services, settings, and facilities to achieve certain goals in certain usage contexts".

## 1.2.2 WCAG

The WCAG 2.1 standard outlines ways to improve the accessibility of Web content for those with disabilities. Accessibility encompasses a wide spectrum of neurological, cognitive, linguistic, physical, verbal, and visual/auditory impairments. Although these recommendations cover many topics, not all types, levels, or combinations of disabilities may be accommodated. These principles also increase the usability of Web content for older people whose abilities change with age and frequently enhance usability for users as a whole. (W3C et al..2018)

This guideline has four main layers:

1. Principles - Perceivable, operable, intelligible, and robust are the four guiding principles for web accessibility.
2. Guidelines - Guidelines are listed after the principles. The 13 recommendations offer the fundamental objectives to cater for 340,000 different disabilities.
3. Success Criteria - Each recommendation comes with a WCAG 2.0-compliant tested success criterion. Testing design specifications, purchases, laws, and contracts call for doing this. Three levels of conformity are established to accommodate the requirements of various groups and circumstances: A (lowest), AA, and AAA (highest).
4. Sufficient and Advisory Techniques - The working group has also recorded numerous other techniques. The two types of techniques are those that are advising and those that are sufficient for satisfying the success criteria and are informative. (Spina 2019)(White 2019)

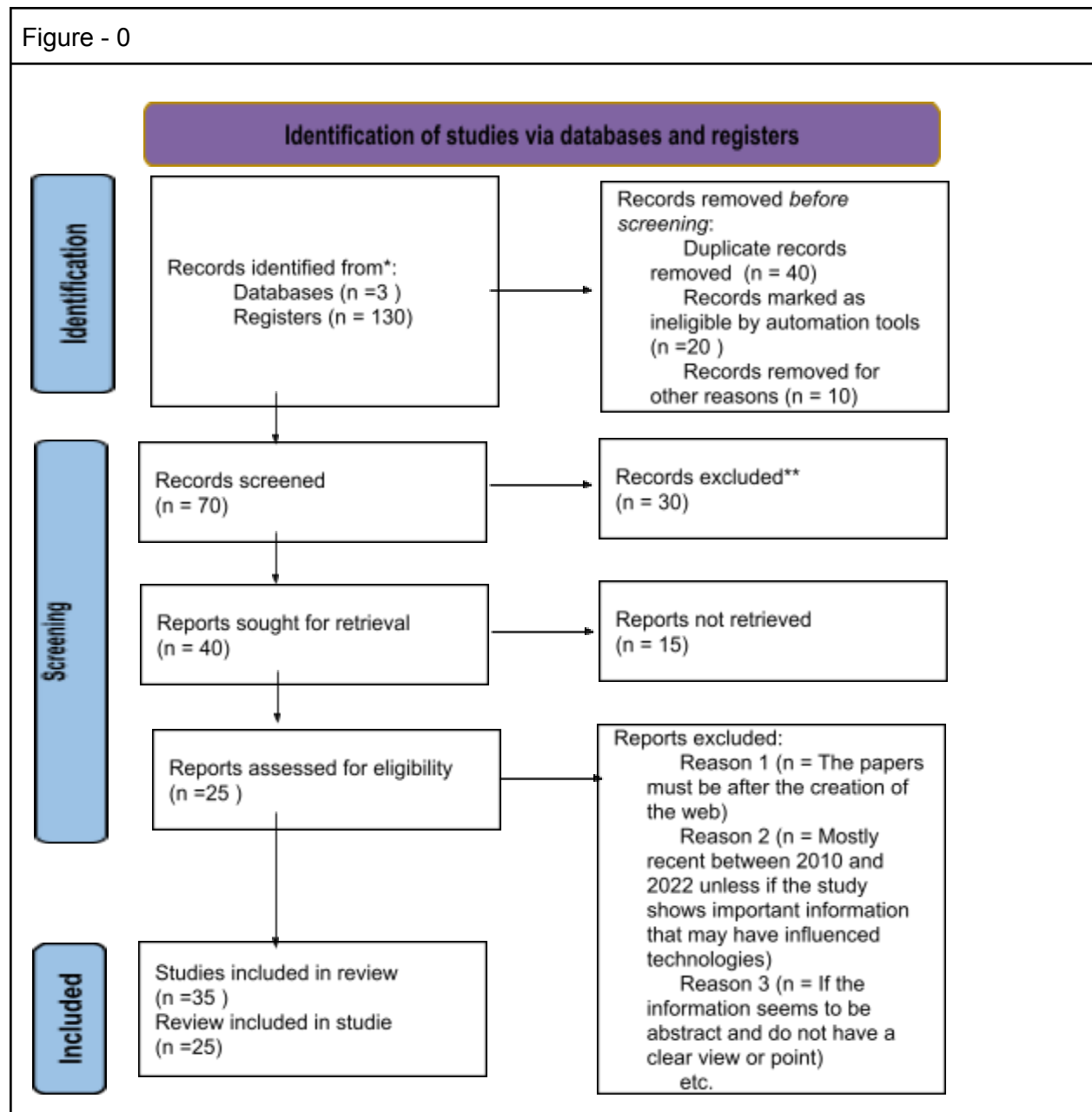
These layers collectively offer direction on how to make content more accessible. To best meet the needs of the broadest range of users, authors are advised to view and apply all layers they can, including advisory strategies. (W3C et al..2018)

## 2. Systematic Literature Review (SLR)

A SLR entails several distinct activities. The stages of a SLR are summarised in this section into two primary phases: Review Methodology, Conducting of Review and analysing the Review.

## 2.1 Review methodology

Google Scholar, Solent University Online Library Database, and Association for Computing Machinery are the three main databases used for online literature searches (ACM). The literature I read was focused on "web accessibility", and it was written over the previous ten years. The Prisma approach, which aids in the creation of systematic reviews and meta-analysis, serves as the primary method for information gathering. It also helps to evaluate the relevant documents critically. Each of the documents will be evaluated over the years from the newest to the oldest.





## 2.2 Disability and web access

People with cognitive disabilities have received attention since web accessibility targets a wide range of users, despite being ignored for years due to its complexity. Although the W3C has recognised the current forms of cognitive disorders for which the most recent version of WCAG caters, we have discovered in this research that there are many other sorts of cognitive disabilities to name. These include intellectual disability, memory impairments, perceptual disabilities, seizure disorders, attention deficit hyperactivity disorder (ADHD), autism spectrum disorder (ASD), and intellectual disability. People who have certain cognitive impairments have trouble utilising the internet, especially when there is too much information to absorb, unclear directions, typos, and poor grammar. (Hortizuela 2022)

One of the best methods to assist persons who are blind in understanding what an image on a website means is by providing alternative text. Web designers frequently disregard this crucial information, resulting in websites that are not similarly accessible to all visitors. A study by Leotta, Mori and Ribauda 2022 chose Azure Computer Vision Engine, Amazon Rekognition, Cloudsight, and Auto Alt-Text for Google Chrome as our four well-known products with heterogeneous qualities. They asked 76 survey participants to assess the descriptions of 60 photographs from Wikipedia without knowing the source. The total results demonstrate that despite realistic tool descriptions, individuals still favour human-authored writings on average as the automated descriptions still lack the level of detail found in human-written descriptions.

Moreover, a study on Ecomers website by Rajaselvi 2022 concluded that “those with visual impairments are unable to use an e-commerce website independently”. Numerous research is in progress to enable people with visual impairments to participate in online commerce. Regardless, a lot more effort needs to be done before visually impaired people can use e-commerce websites independently, not just to make purchases but also to handle their own bill payments.

Similarly, an accessibility study of a Bulgarian Regional museum website (Todorov, Bogdanova and Todorova–Ekmekci 2022) found that the majority of websites offer a subpar and unsatisfactory level of digital accessibility. Following is a list of the most prevalent accessibility issues discovered on museum websites:

1. The heading parts are not arranged in descending order; the h1–h6 tags are either absent or not used correctly.  
WCAG standards:  
Information and Relationships (Level A).  
2.4.6 Labels and Headings (Level AA).

2. The `html>` element lacks a `[lang]` tag, which causes screen readers to incorrectly pronounce the text on the website because they assume the website uses the default language.  
WCAG requirements: 3.1.1 Language of the Page (Level A).
3. Links lack recognisable names; yet, if they are present, they help screen reader users navigate the site more easily.  
WCAG requirements: Link Purpose Success Criteria 2.4.4 (Level A).
4. Informational elements should strive for brief, descriptive alternate text because image components do not have `[alt]` properties.  
Success Criteria 1.1.1 (Non-text Content) of the WCAG (Level A).
5. Insufficient contrast between foreground and background colours makes it difficult or impossible for many people to see low-contrast text. The homepage accessibility test for the Group of Seven advanced economies, which includes the United States, the United Kingdom, Germany, France, Italy, Japan, and Canada by Kesswani and Kumar 2022, also found it paramount to preserving the contrast between the background and foreground colours.  
Success Criteria 1.4.3: Contrasting (Minimum) (Level AA) under the WCAG.  
Contrast (Enhanced): Understanding Success Criteria 1.4.6 (Level AAA).

### 2.3 Accessibility testing and reasoning

It is anticipated that future studies on web accessibility analysis utilising automated testing methods will expand based on the rising rate of publication on web accessibility throughout time.(Abascal, Arrue and Valencia 2019)

The study's findings indicate a rising trend in the usage of automated testing software for web accessibility evaluations. AChecker used by Verkijika and De Wet 2020 in the study of Accessibility of South African university websites and WAVE are the two most often used automated testing technologies. These results can help practitioners understand which automated testing methods are most frequently utilised for web accessibility assessments.(MACAKOĞLU and Peker 2022)

By implementing accessibility features on websites in combination with accessibility evaluation software; businesses can reach a larger audience of consumers with their services or goods. To achieve this, programmers and website designers need to collaborate more closely with the WCAG to increase accessibility and usability (Campoverde-Molina, Lujan-Mora and Garcia 2020). This can be done by following the process model for regular screening of web accessibility, which outlines each action that must be taken to complete each phase. This order connects laws, resources, and knowledge. Additionally, this process model is capable of endless iterations, which can be used to maintain website accessibility through ongoing accessibility testing.(Campoverde-Molina, Luján-Mora and Valverde 2021)

### 2.4 What is web development?

Web development is a broad term covering many different types of work coinciding with one cohesive result. It requires the expertise of various skill bases such as graphic designers,

database administrators, system administrators etc. Although, this dissertation focuses mainly on the software engineering and the programming part of web development. As numerous different skills are entangled in the development of the web, it is important to realise how the layout and design of the website are directly related to the code and database it is derived from. Similarly, the server configuration and rendering capacity can drastically affect the website's graphic. (Connolly 2015)

The comparison between traditional development methodology and the multiple different web development methodologies in the Howcroft and Carroll 2000 paper proposes that Russon and Graham's web development methodologies are the most practical. This is derived from Isaias' and Issa's 2015 methodology as it aids in identifying problems through:

- Analysis
- Design
- Resource gathering
- Coding
- Testing
- Implementation
- Post-implement review, and maintenance

These methodologies, in combination with thoughts from the paper by Insfran and Fernandez 2008 state the importance of users required to learn present-day technology while retaining and refining old technology. This further enforces the importance of this paper as it tries to evaluate the best latest method for web development and how it could help the visually impaired.

Regardless, the greater picture shows how the infrastructure for building more accessible websites already exists. Books such as Ensuring Digital Accessibility Through Process and Policy (Lazar, Goldstein and Taylor 2015), fundamentals of web development (Connolly 2015) and Flask Web Development (Grinberg 2018) reinforce this fact with their deep understanding and guidance on how to create a better experience for all users.

## 2.5 General Terms

- Data - Information that can be handled by software such as SQLite, JavaScript, etc that knows the syntax used.
- Learning application - The primary purpose is for the education of the users. (In this case, learning to code)
- Application - Software that has a graphical interface, which can be used for tasks by the people
- Web application - Software that allows the rendering of HTML and CSS. Otherwise known as browsers of the internet eg Chrome, Firefox, Safari, etc.

## Acronyms

- Ajax - Asynchronous JavaScript And XML- For the function of loading data without reloading the whole page. The applications sometimes use XML to transport data, but commonly transport data such as JSON text. (Castillo 2017)

- CSS - A language used to style an HTML document. It chooses how the HTML should be displayed in the browser.
- JSON - JavaScript Object Notation - A format form used to transport data in a lightweight manner. It is used mainly to exchange data from the web page and server.
- SQLite - A language used to manipulate, store and retrieve data from a database.

(w3schools)

## 2.6 User Experience

The main definition of the idea of user experience for this dissertation comes from "Modern Web Development" (Esposito 2016) which explains how the experience is something that is felt by the user internally. This explains how interaction and usage are simple terms for a much broader interpretation of user experience. These interpretations include how the presentation may gain admiration, usability, emotional impact, etc. The goal is to create something pleasing for all types of users, regardless of age, sex, disability, etc, and to keep diversity at its core. Nevertheless, this is not the case if the website is aimed at a specific group, in which case the design should be aimed at those users. An example of this would be a website designed for the blind with features that will help them. In this dissertation, we will see some of these problems that a developer would face and how they would solve them at the software level.

Regarding user experience and accessibility, the conference paper "accessibility 2.0 by Kelly et al. 2007", concluded that the approaches to accessibility had to change. This was to adapt to the changes in the web content created, provided, and accessed. It suggests that the web culture or the use and content of websites are increasing, and therefore the users that the developers have to cater for have increased. The paper further talks about using the "WCAG 1.0", and potentially "WCAG 2.0" guidelines to enhance UX for the disabled.

Studies suggest that users usually just glance at a website to see if it piques their interest or need (Donaire 2009). Therefore the catering of a website for specific visitors is essential as the website's design will affect the type of visitors it attracts. This design is most usually connected to the website's utility, and the utility is the use of the website. Designs are powerful as they can bring in many different visitors (Hartson and Pyla 2012). Furthermore, ideas such as rewarding the user for their behaviour on the site can be used to entice and help make a better UX (Donaire 2009).

Disability is one of the key areas that should be focused on in this dissertation. The study by "Fodness, Kevin R 2016" on Disability and Cyberspace concluded the need for policy change for a better accessible environment online for the disabled. The study suggests how the lack of policy enables the creation of a website that only caters to the need of the most basic of targeted users. Furthermore, in a study by "Lazar et al. 2003", only one was found to have good access, and 49 others were non-accessible. The same is further seen in the paper by Lazar, Dudley-Sponaugle and Greenidge; "Improving web accessibility" (2004). This reiterates the importance of the study to create and review the best practice model which considers all types of users.

## 2.7 Analysis

A SLR has been conducted to examine papers concerning the accessibility of websites. This SLR discusses important themes relating to WCAG, online web accessibility, evaluation techniques for web accessibility, and disabilities. This review demonstrates the disparity between inaccessible websites for the disabled. Nevertheless, simultaneously, this paper shows the development, complexity, and inclusivity of the world wide web. It shows how web development with new technology can solve many issues using CSS and HTML designs. This was further encapsulated by books such as “Fundamentals of web development” (Connolly 2015).

This SLR has also found some of the most required accessibility issues in websites like contrast, label, alt text etc as seen in the study by Todorov, Bogdanova and Todorova–Ekmekci 2022. These key areas must be studied further to establish a fix as leaving it unaided will segregate more people and reduce web accessibility.

### 3. Pilot study

The extent of the usability of a product to a disabled person, can be measured according to the accessibility given to them, as per the iso 25010 standard states (Anon. 2011). Regardless of the recent development towards accessibility policies and considerations, all web contents are either difficult or impossible to use for the visually impaired.

The World Wide Web Consortium (W3C) is an organisation comprising the European Research Consortium for Informatics and Mathematics (ERCIM) in France and the MIT Computer Science and Artificial Intelligence laboratory in America, Beihang University of China and Keio University of Japan. To improve the accessibility of people with disabilities the W3C began the web accessibility initiative (WAI) (W3C 1997). This was brought forward to help people with disabilities to understand, perceive, navigate and interact with the web. The first version of the guideline by W3C was published in 1999 (WCGA 1.0). Later on, they published (WCAG 2.0) on the 11th of December 2008 and (WCAG 2.1) on the 5th of June 2018. Furthermore, a draft for (WCAG 2.2) is scheduled to be finalised by September 2022. WCAG 2.1 is the version that should be referenced for accessibility policies. The WCGA 2.1 has four main principles: robust, operable, understandable and perceivable. Further, conformance testing in three levels is defined as (lowest) A, AA and AAA (greatest). The study by Spina 2019 concluded that developers have to aspire to improve practice for accessibility and further involve disabled individuals in the user experience testing to achieve maximum accessibility goals.

The commitment toward web accessibility can be further seen from the ([Directive \(EU\) 2016/2102](#)) (European Union 2017) and this helps to promote the thought of better access for people with disabilities in websites and public service applications. The Directive lays down rules that help to build a more socially inclusive European 'Union of equality, where no one is secluded from the digital society and economy (European Union 2022). Similarly, it was seen as a matter of moral will and political will by the United Nations in the Convention on the Rights of Persons with Disabilities (CRPD) (United Nations 2022). The need for such action can be further illustrated by the Alajarmeh 2021 study which focused on the accessibility of health information from public health websites around the world. The study suggested the need for extensive efforts to decrease accessibility barriers. This is especially needed for the "100 million people in the European Union with some form of disability" (European Union 2022).

#### 3.2 Research Methodology

There are several research methods, and they are classified under different criteria. The data collected in this study is perceived and recorded in numbers. Such results are quantified using graphs; a Quantitative Research (Goddard and Melville 2004). Any other information from that data that cannot be grasped just by numbers will be used to form a theory-based summary in the form of Qualitative Research (Kothari 2004),(Goddard and Melville 2004). Furthermore, this paper uses WCGA 1,2.0 and 2.1 as the basis of the research to evaluate multiple websites for analytical research. (Patil and Mankar 2016) The main few research methods are stated above but, many other research methods could be applied, such as

- Descriptive Research - This is a fact clarified using surveys and case studies. Such facts can be explained or evidenced using many variables.
- Applied Research - Considers an immediate problem and tries to find a solution for it. This will be used to create a solution for any problems found by the data. (Kothari 2004)(Flick 2015)
- Fundamental Research - Leads to a new hypothesis, a new attribute of matter, or possibly the discovery of a new substance, that no one knows of, or has reported (Patil and Mankar 2016).
- Exploratory Research - Such research is based on theories and their justifications; they do not offer any conclusions about the subject of the study.
- Conclusive Research - This has a good design in the approach and attempts to answer the research question.
- Surveys - Aim to gather huge amounts of real-time data and aids the research process.
- Case Studies - Aid the foundation of the research and the formation of an idea for the study.

The NHS states that two million people in the UK are blind or partially sighted; 340,000 of them are officially blind or partially sighted (NHS 2021). Therefore, this study will focus on the presumption that sight is the most important sense in using the internet. This was also taken into consideration due to a study on 250 public participants in which 88% chose sight as the most important sense (Enoch et al. 2019).

User-based testing for an accessibility evaluation is a time-consuming and expensive endeavour as the users would need to have a recorded accessibility issue. Furthermore, there would be a multitude of different level accessibility issues which would need to be accounted for such as varying levels of visibility, colour blindness, etc. Therefore this preliminary pilot study will gather information about 11 websites, 4 of which are the most visited in the UK (Highlighted in green in figure 1 data) and give them an accessibility score. A chrome extension called “AXE coconut web-accessible” will be used to get an accurate reading on the accessibility score. The extension matches the score against pre-existing accessibility policies of WCAG2.1. Depending on the score, a solution will be identified and demonstrated for the most requested problem by making a new chrome extension. This will give a quantitative amount of problems that need to be solved and will further develop a quantitative type of solution. The solution will be a combination of online research and multiple sources such as books, websites and videos.

This data in turn, will help to build a product (a visual aid extension), that helps to remedy any problems found in the pilot study. This idea is a combination of conclusive research from the pilot study and applied research leading from the results found. The applied research will focus on the building of the chrome extension, giving a reason for each attribute of the extension as it is built.

The built product will be analysed using surveys by random users. Survey analysis is crucial because it enables you to infer more general information about the impact of the extension on

the target audience. The information will then be analysed to create a sound conclusion for this dissertation.

### 3.3 AXE

Axe version 4.4.2, updated on May 12 2022, is an accessibility testing tool for websites and other HTML-based user interfaces. With it, accessibility testing can be automated in addition to conventional functional testing because it is quick, secure, lightweight, and built to interact seamlessly with any testing environment already in use.(Deque Systems 2022)

The extension helps identify common accessibility practices such as making sure every page has an h1 heading and to help avoid "gotchas" in Accessible Rich Internet Application (ARIA), where an ARIA attribute that is used is ignored (W3C et al.. 2017). Axe also offers a variety of rules for WCAG 2.0 and 2.1 on levels A and AA and, similarly, provides several best practices.

Axe-core can automatically identify 57% of WCAG violations on average. Additionally, axe-core will return elements as "incomplete" if the axe-core is not certain about a violation of WCAG and will suggest a review.

### 3.4 Hypothesis

The research and application of this dissertation will be split into two key parts. Firstly, there is a lack of usage of the guidelines such as "WCAG 1.0, 2.0", leading to a need for extensive redesigning and updating of most websites to accommodate the disabilities of people, especially the visually impaired.

Secondly, making a visual aid extension will help visually impaired users browse websites that are not accommodating.



### 3.5 Results

Websites	Critical	Serious	Moderate	Minor	Unknown	TOTAL ISSUES
<a href="https://students.solent.ac.uk/">https://students.solent.ac.uk/</a>	3	14	3	0	12	32
<a href="https://learn.solent.ac.uk/">https://learn.solent.ac.uk/</a>	1	7	7	1	9	25
<a href="https://www.bbc.co.uk/">https://www.bbc.co.uk/</a>	0	0	1	0	17	18
<a href="https://www.primark.com/">https://www.primark.com/</a>	0	1	6	0	2	9
<a href="https://www.asos.com/">https://www.asos.com/</a>	2	0	0	1	10	13
<a href="https://www.currys.co.uk/">https://www.currys.co.uk/</a>	1	35	5	444	10	495
<a href="https://www.facebook.com/">https://www.facebook.com/</a>	0	5	2	4	36	47
<a href="https://www.wikipedia.org/">https://www.wikipedia.org/</a>	1	0	9	5	39	54
<a href="https://dl.acm.org/">https://dl.acm.org/</a>	0	2	0	1	37	40
<a href="https://twitter.com/home">https://twitter.com/home</a>	3	0	2	0	7	12
<a href="https://www.dailymail.co.uk/home/index.html">https://www.dailymail.co.uk/home/index.html</a>	12	97	763	63	165	1100

Figure 1 :  
The data from tests with “AXE coconut web-accessible”.

<u>Solent</u>	Element does not have inner text that is visible to screen readers
	Ensures the contrast between foreground and background colours meets WCAG 2 AA contrast ratio thresholds

<p><u>Solent Learning</u></p>	<p>Ensures &lt;img&gt; elements have alternate text or a role of none or presentation</p> <p>Ensures the contrast between foreground and background colours meets WCAG 2 AA contrast ratio thresholds</p> <p>Ensures links have discernible text</p> <p>Ensures aria-hidden elements are not focusable nor contain focusable elements</p>
<p><u>BBC</u></p>	<p>A potential issue needs your review... Element's background colour could not be determined due to a background image</p>
<p><u><a href="https://www.primark.com/">https://www.primark.com/</a></u></p>	<p>Ensures the lang attribute of the &lt;html&gt; element has a valid value</p>
<p><u>ASOS</u></p>	<p>Ensures &lt;img&gt; elements have alternate text or a role of none or presentation</p> <p>A potential issue needs your review... Element's background colour could not be determined due to a background image</p>
<p><u>Currys</u></p>	<p>Ensures elements with an ARIA role that require child roles contain them</p> <p>Ensures aria-hidden elements are not focusable nor contain focusable elements</p> <p>Ensures the contrast between foreground and background colours meets WCAG 2 AA contrast ratio thresholds</p> <p>Ensures every id attribute value of active elements is unique</p>

<p><u>Currys</u></p>	<p>Ensures links have discernible text.</p> <p>Element has a tab index greater than 0.</p>
<p><u>Facebook</u></p>	<p>Ensures every ARIA progress bar node has an accessible name</p> <p>Ensure aria-hidden elements are not focusable nor contain focusable elements.</p> <p>A potential issue needs your review: An element's background colour could not be determined due to a background image</p>
<p><u>Wikipedia</u></p>	<p>Ensures every form element has a label</p> <p>A potential issue needs your review... Element's background colour could not be determined due to a background image</p>
<p><u>ACM</u></p>	<p>Ensures [role='img'] elements have alternate text</p> <p>Ensures the contrast between foreground and background colours meets WCAG 2 AA contrast ratio thresholds</p>

<p><u>Twitter</u></p>	<table border="1"> <tr> <td data-bbox="427 243 1474 344"> <p>Ensures all ARIA attributes have valid values</p> </td> </tr> <tr> <td data-bbox="427 344 1474 411"> <p>Ensures every form element has a label</p> </td> </tr> <tr> <td data-bbox="427 411 1474 478"> <p>Ensures &lt;meta name="viewport"&gt; does not disable text scaling and zooming</p> </td> </tr> <tr> <td data-bbox="427 478 1474 619"> <p>A potential issue needs your review... Element's background colour could not be determined due to a background and image</p> </td> </tr> </table>	<p>Ensures all ARIA attributes have valid values</p>	<p>Ensures every form element has a label</p>	<p>Ensures &lt;meta name="viewport"&gt; does not disable text scaling and zooming</p>	<p>A potential issue needs your review... Element's background colour could not be determined due to a background and image</p>
<p>Ensures all ARIA attributes have valid values</p>					
<p>Ensures every form element has a label</p>					
<p>Ensures &lt;meta name="viewport"&gt; does not disable text scaling and zooming</p>					
<p>A potential issue needs your review... Element's background colour could not be determined due to a background and image</p>					
<p><u>Daily Mail</u></p>	<table border="1"> <tr> <td data-bbox="427 726 1474 804"> <p>Ensures &lt;img&gt; elements have alternate text or a role of none or presentation</p> </td> </tr> <tr> <td data-bbox="427 804 1474 871"> <p>Ensures ARIA attributes are allowed for an element's role</p> </td> </tr> <tr> <td data-bbox="427 871 1474 968"> <p>Ensures the contrast between foreground and background colours meet WCAG 2 AA contrast ratio thresholds</p> </td> </tr> <tr> <td data-bbox="427 968 1474 1035"> <p>Ensures links have discernible text</p> </td> </tr> </table>	<p>Ensures &lt;img&gt; elements have alternate text or a role of none or presentation</p>	<p>Ensures ARIA attributes are allowed for an element's role</p>	<p>Ensures the contrast between foreground and background colours meet WCAG 2 AA contrast ratio thresholds</p>	<p>Ensures links have discernible text</p>
<p>Ensures &lt;img&gt; elements have alternate text or a role of none or presentation</p>					
<p>Ensures ARIA attributes are allowed for an element's role</p>					
<p>Ensures the contrast between foreground and background colours meet WCAG 2 AA contrast ratio thresholds</p>					
<p>Ensures links have discernible text</p>					
	<p>Figure 2: The main detailed problem and an advisory by AXE <a href="#">coconut</a> web-accessible test result. Red = Critical; needs immediate attention, Amber = Serious; needs attention, Yellow = Need more details but it is a possible problem.</p>				

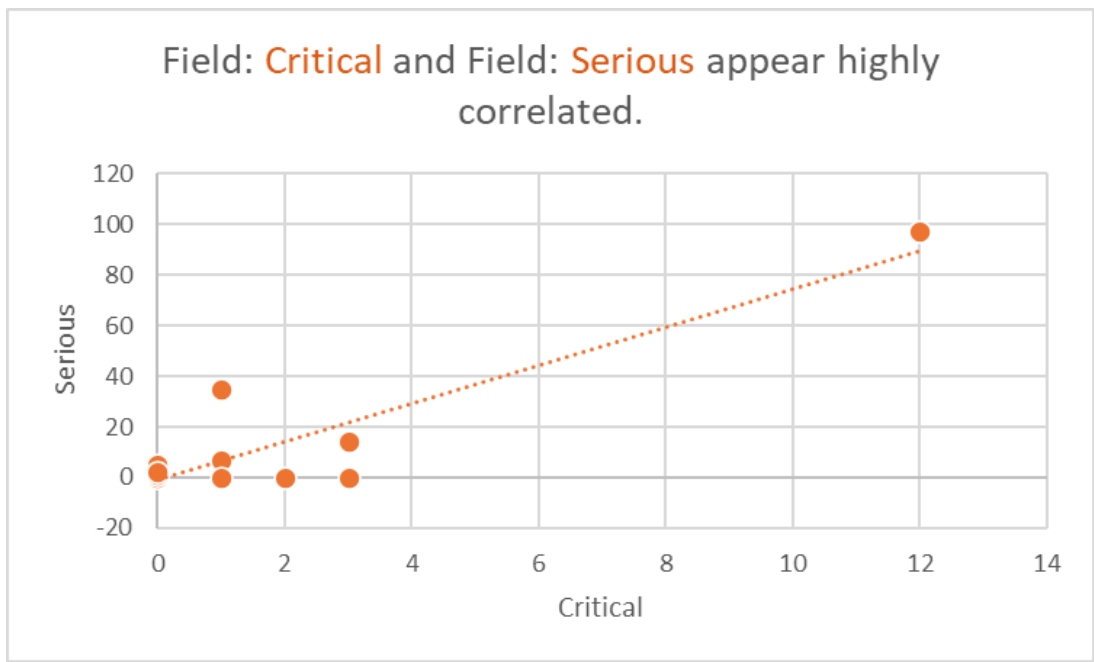


Figure 3:  
Trend of critical to serious issues with a website.

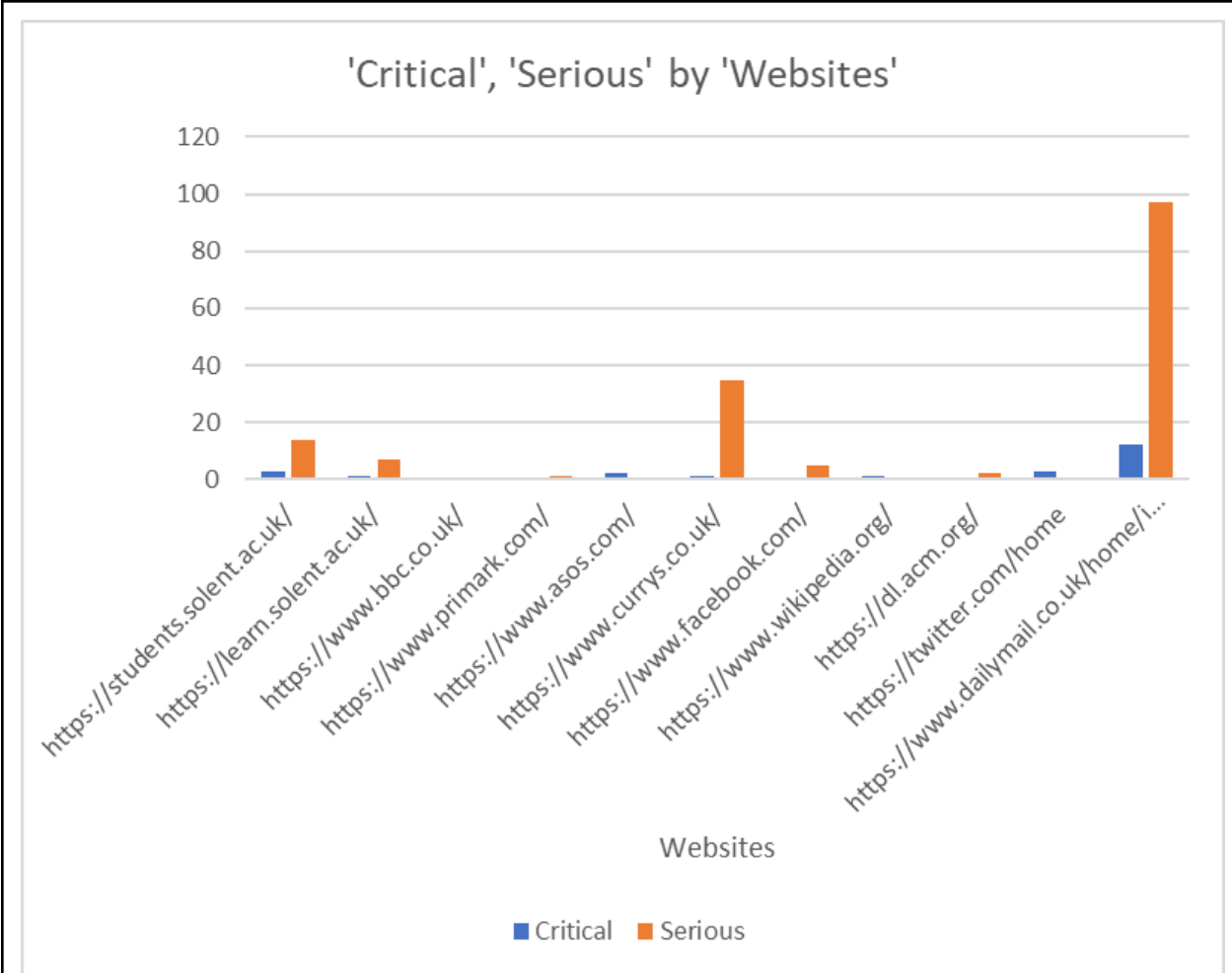


Figure 4:  
Shows the websites and how many critical and serious problems they have comparatively.

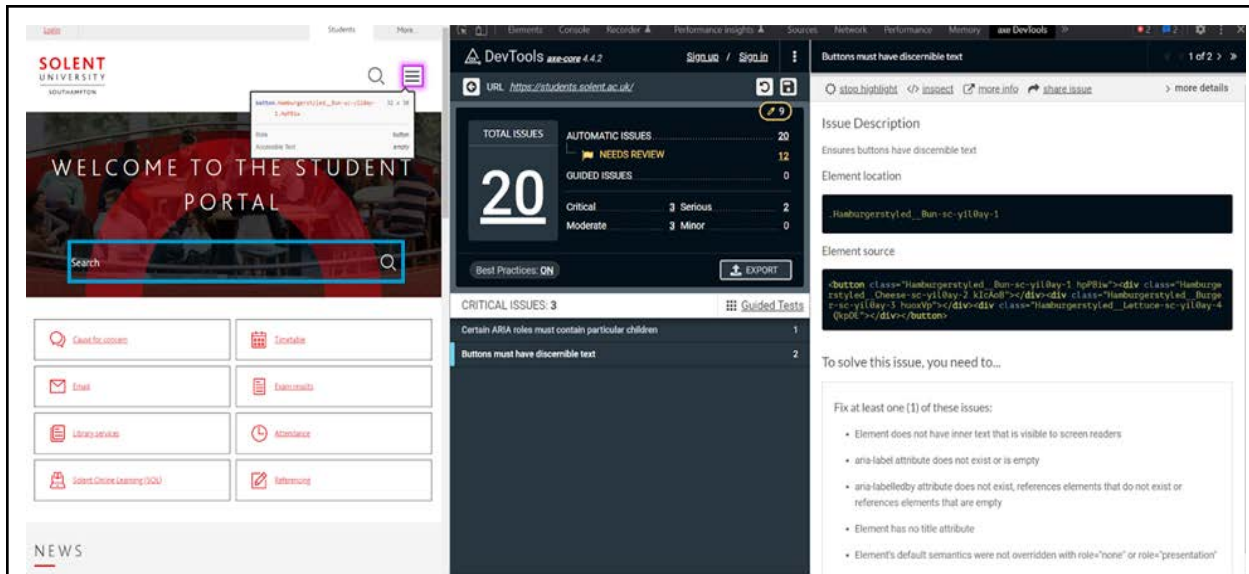


Figure 5:  
Non-discernible button

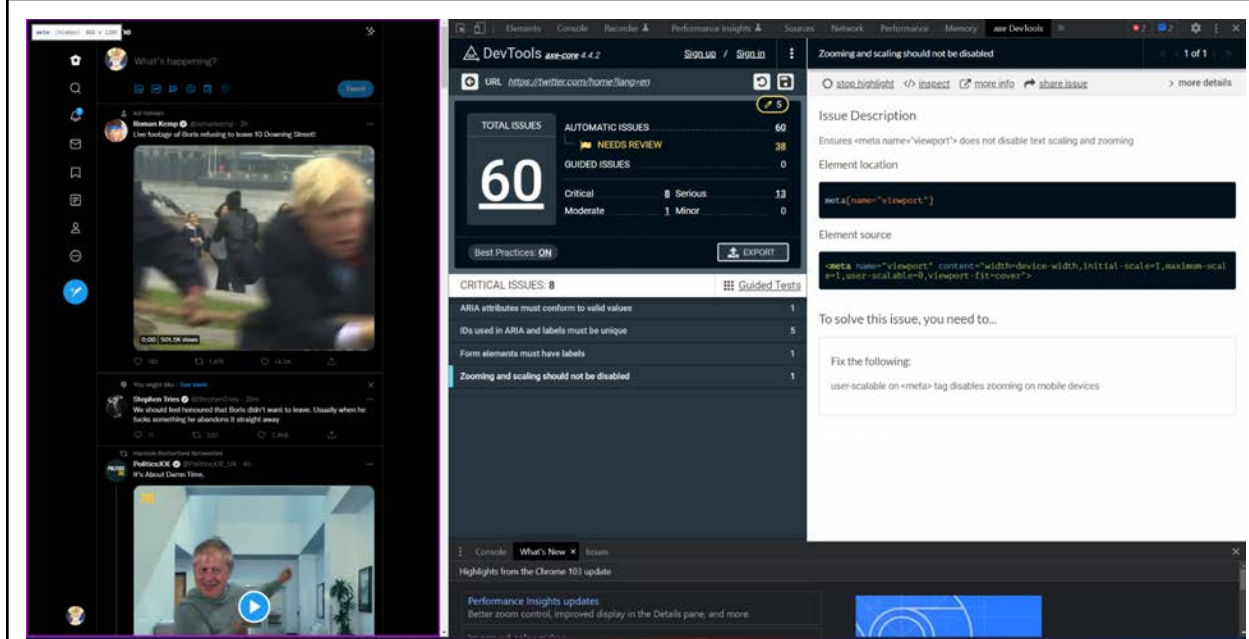


Figure 6:  
User-scalable on <meta> tag disables zooming on mobile devices

### 3.6 Pilot study Result Evaluation

Engaging closely with the results, it can be concluded that the hypothesis was right in predicting the need for extensive redesign or updates to accommodate the visually impaired. In total, there

were 1845 issues found of which 23 of them were critical (Figure 1). These critical issues could drastically affect users using third-party website readers to navigate the website. Sometimes the problems were as simple as not using the same size for heading or having discernible buttons, as seen in figure 5, similar to the findings in "Accessibility of Turkish university Websites" (Kurt 2017).

Further data analysis shows the failure to provide alternate text for images on the web pages, as seen in figure 2. Alternative (Alt) Text explains the "why" of an image concerning the information on a document or website. Screen reader software reads it aloud to users, and search engines have indexed it. As in this case of a missing image, it also appears on the website if the image cannot be loaded (Wu et al. 2017). Such features are key easy features that can be deployed with a single line of code; regardless, it is being forgotten and ignored. A similar problem can be seen on the university website in figure 5, where the search bar lacks contrast, making it difficult to see if it were not for the blue highlighting box. Furthermore, the placeholder text for the search bar is also not in compliance with W3C 2019, as it states that "Assistive technologies, such as screen readers, do not treat placeholder text as labels."

In terms of the top four websites, daily mail had the highest number of issues out of all the websites. It is also obvious from the website that it is not catering for users with disabilities as it has 12 critical problems, which could render the website non-navigable for someone blind or partially blind. Furthermore, it had 97 serious and 763 moderate problems that needed fixing.

Users have various levels of visual impairment, and allowing users to have varying text sizes is one of the best ways to help. But from figure 2, we can understand that Twitter does not allow this on mobile. This is also shown in figure 6, highlighted in a pink box above. Consequently, this violates "1.4.4: Resize text (Level AA)" by W3C 2022, which clearly states the importance of scalability being turned on and further shows examples of the code on their website.

Link description should be discernible, which is not the case for Currys, as seen in figure 2; Currys fourth amber box states, "Ensures links have the discernible text". Since the web URL of the destination is typically not sufficiently descriptive, the purpose of a link should be indicated by supplying descriptive text. In this manner, a user might tell this link apart from other links on the webpage and determine whether or not to click it.

Ensuring contrast between foreground is also another possible issue that occurred in many websites as a possible issue. This problem recurred five times making it one of the most recurring possible problems, as seen in figure 2 highlighted in yellow. The use of colours must be taken into strict consideration as there are multiple levels of colour blindness and visual ability that could affect the user's access or comprehension of a website. This is further established in W3C 2018. This Success Criteria's goal is to create enough contrast between the text and its background so that persons with average eyesight can read it (who do not use contrast-enhancing assistive technology). Hue and saturation have little to no impact on



readability, as measured by reading performance, in those without colour impairments (Sandnes and Zhao 2015).

### 3.6.1 Possible Solution

The best solution would be to take apart all these websites and redesign it from top to bottom following the latest W3C “WCAG 2.1” rules. This will take time, multiple policies and a substantial amount of money. Coincidentally, this is already happening as the government provides guidelines for services to follow to meet the WCAG 2.1 criteria (Gov.uk 2021).

Regardless, the best short-term solution will be building an extension that will provide a better experience for the visually impaired regardless of the website (Choi *et al.* 2019). Additionally, the extension will allow the user to customise each website to their liking, enabling consumers to consume the internet most comfortably (Miura *et al.* 2020).

Google chrome provides a great structure for this with its ability to integrate extensions and its guide to build one (chrome 2022). The extensions are composed of various, yet unified, parts. Scripts for the backdrop or the content, choice pages, UI elements, and different logic files are examples of components. HTML, CSS, and JavaScript are used in web development to generate extension components.

### 3.7 Pilot Study Analysis

A variety of recommendations and resources have been established by the W3C WAI, accessibility researchers, practitioners, and IT firms to assist organisations in ensuring that their websites are accessible. Despite this, the websites under analysis have poor accessibility due to poor coding practices. There are no laws regulating this, although numerous national recommendations indicate that all web pages should be accessible. As such, this should lead to the creation and finalisation of an extension for Google Chrome that can help reduce these accessibility issues in the next stage. This extension should enable the users to personalise each website to their disability and experience.

## 4. Chrome Extension Project

The Google Chrome browser which is commonly used nowadays on computers, provides several free and inexpensive apps and extensions to help create an all-inclusive environment. The assistive tools can be helpful learning support for people with and without disabilities using readily available applications and extensions for the Google Chrome browser. There are apps and extensions available to support organisational, mathematical, and literacy skills. With the aid of these technologies, numerous ways for representation, expression, and participation comply with the Universal Design. Creating such a Chrome extension to help better the experience of users with visual disabilities is the final goal of this study. The extension is created using HTML, JavaScript, and CSS7, the three most popular web languages.

Most Chrome extensions have minimal user interfaces because many operate in the back-end and do not require user involvement to function.

The most typical user interface for an extension can be seen on the toolbar or the address bar on the top right of the Chrome browser, and it is referred to as browser action. What an extension consists of is stated on the Chrome developer page (Google inc 2021), and the files include:

- “Manifest.json”: This file contains details about the extension, including its name, version, icons, and images, as well as its permissions, scripts, and functions. The manifest presents this information in a JSON format, as suggested by the file google
- “HTML”: The extension will typically consist of one or more HTML files unless it is a browser theme. The main file is listed under the background page in the manifest file. When the page action or browser action is pressed, it will remain invisibly in the background and carry out the process that it is allocated. The extension may contain additional HTML files that can open a pop-up window when activated by the browser action. This is how the settings page for the "visual aid" extension will work.
- JavaScript: Having a separate javascript is optional as it can be contained within the HTML files. If a separate javascript is being used, it should be listed in the manifest file under the content script. The manifest should further contain the URLs of the website to which the script needs to be injected, but this can be generalised to all URLs, a single URL, and a specific set of URLs.

Other files may include images and icons that are needed by the popup HTML or those needed by the javascript to execute an action (e.g. replacing all images in a URL with cat images).

### 4.1 XPath

XML path is how XPath is defined. It is a syntax or language which uses the XML path expression to find elements on a web page. The position of any element on a website utilising

the HTML DOM structure may be found using XPath(Gunawan et al. 2019). The location path is the XPath expression that is most helpful. A path location identifies a group of nodes in the document by using the one-step position. Selecting the document root node is the most straightforward location path. The slash symbol "/" represents the root. The Unix system file's root and the document's root node are both represented by the symbol.

## 4.2 CSS

Front-end Web developers utilise CSS, a standard language, to specify the appearance and feel of structured pages created using HTML and eXtensible Mark-up Language (XML). CSS comprises a series of style rules, each containing a selector that chooses the components in the HTML or XML page that need styling(Robbins 2012).

Pre-processors for CSS are one of the more recent modifications that have been suggested. The first version of CSS, CSS1, had only 50 attributes and was primarily used for presentations that took place on screens. All CSS1 properties are included in CSS2, along with 70 different attributes. For example, CSS2 can now describe aural presentations and page breaks, which was previously impossible. (Collison, Budd and Moll, 2017)

Such information about CSS is important as it creates a base to understand what the developed extension is doing inside the web browser. To put it simply, the CSS document of each URL is what the extension is editing (injecting new information into) to personalise the page.

## 4.3 Related work

There are between 176,608 and 188,620 extensions accessible in the Chrome Web Store, determined by the source. Google Chrome data show that not all have the same number of users, however. Particularly, 50% have fewer than 16 installations. Twenty-five thousand five hundred forty extensions only have one user, while another 19,379 extensions have no installations. Moreover, just 13 extensions have had more than 10 million installations.(debugbear 2020)(Catalin Cimpanu 2019)

This shows a scarcity of knowledge about the existence of many extensions and their uses. Furthermore, the unlikeliness of similar studies in the making and study of an extension for the help with visual disability.

## 4.4 System design

This part of the dissertation explains how the visual aid extension is designed around eyesight degeneration and other visual disabilities. To understand the reasoning behind the system; it is even more important to understand the problem the visual disabilities cause.

### 4.4.1 Eyesight

It is common to experience vision changes as a person ages. Among the typical alterations for elderly persons are:

- losing the capacity for close-up vision - Renders it impossible to use a web page without glasses when the fonts are small.
- having problems differentiating black from blue, for example,
- requiring more time to acclimatise to varying light levels.

The solutions to these issues are frequently simple. People might find it easier to retain their way of life and freedom with the aid of glasses, contact lenses, and better lighting.

People are more likely to get certain eye diseases and ailments as they age, and some eye changes are more severe. Get frequent eye exams to keep your eyes as healthy as possible and to catch any issues early.(NIH National Institute on Aging 2021)

Presbyopia:

Reduced accommodation amplitude, which impairs the eye's ability to shift its focus from far to near, is one of the symptoms of presbyopia, an age-related eye disorder. The age-related condition affects everyone around their mid-40s the most frequently. Presbyopic individuals frequently hold reading material at arm's length. While reading or performing other close tasks, some people have migraines or "weary eyes." If people have presbyopia, reading glasses or multifocal (bifocal) lenses can help them see better.(Gil-Cazorla, Shah and Naroo 2016)

Cataracts:

Cataracts are caused by foggy patches forming on the lens, a little transparent disc inside the eye. These patches typically enlarge with time, resulting in impaired, foggy vision and ultimately, blindness. Our lenses are typically as clear as glass when we are young, allowing us to see through them.(Liu *et al.* 2017)

These are a few aids for such visual degeneration by the Cleveland Clinic medical professional 2020.

A few low vision aids are

- Telescopic eyewear.
- light-filtering lenses.
- magnification devices.
- Electronic devices can be placed on a person reading material or held in their hand. E-books, iPads®, and other comparable electronic devices may frequently be set up to have large, dark letters, which benefits many patients with mild disabilities.

The last point of the Cleveland Clinic medical professional's 2020 article is what this dissertation is focused on. The use of technology to improve and help such users

#### 4.4.2 Font Sizing

The scalability of fonts can be one of the most useful tools for any with visual deterioration. It enables the user to enlarge all fonts evenly to help them read and navigate through the website. The font sizing is controlled through a range slider located at the top of the popup. The value of the slider is displayed on the left side of the slider. This value is taken. The range slide will be

paired with a button to send the value of the slide bar to the "content.js" file, which adjusts the size of the font according to the value of the slider. This is done by waiting for stylesheets, graphics, or subframes to load fully, the DOMContentLoaded event triggers once the basic HTML element has loaded and parsed into the browser. After the event, the listener will trigger the "DOMContentLoaded" event, the slider's value is recorded using the chrome storage API to save, retrieve, and track changes to user data, and this is then read and shown inside the popup in real-time. All these actions are done in the "popup.js" script connected to the popup HTML.

A second method can also be used; the streamlined runtime.sendMessage or tabs.sendMessage methods if users need to send a single message to another area of the user's extension (and, optionally, receive a response). This enables a user to transmit a single JSON-serializable message from an extension to a content script or the other way around. If the other side responds, it can be handled with an optional callback parameter.

It is also important to note that when the "content.js" file can only request information that the "popup.js" script has sent. Therefore it is also important to store the tab id. This will enable the "content.js" script to inject information into web pages that need to be personalised.

#### 4.4.3 Custom buttons

All items on the web page need to have a custom button added for the extension's functionality. These buttons will be stored inside the application and it will reload itself on each web page. This will allow the user to put each web page into a different colour blind mode, remove images, etc. Example:

If a user is going through a "Facebook" page and sees many pictures that irritate the user's eyes or trigger trypophobia, the user can go to the visual aid icon and the remove image button and remove all images on the page.

Due to the design of the java-script code and design of the software. The button values are key to enabling each different function. The javascript is reading the button value; then further sent to the "content.js". The content.js script requests the message, then reads the value, triggering the adjacent function by injecting a command to the CSS code of the web page.

#### 4.4.4 Colour blindness

In the world, 1 in 200 women and 1 in 12 males, suffer from colour blindness. However, they cannot clearly see red, green, or blue light. Most persons with colour blindness can see things as clearly as other people. Rarely do people lose their ability to perceive colour altogether.

In addition, there are other reasons for colour blindness. Most people with colour vision deficiencies are genetically predisposed to the disorder and have received it from their mothers. Additionally, various conditions, including diabetes and multiple sclerosis, the ageing process, certain medications, and other factors, can cause colour blindness over time. (Elrefaei 2018)

Reduced sensitivity to red light, reduced sensitivity to green light, and reduced sensitivity to blue light are all symptoms of protanomaly, deuteranomaly, and tritanomaly, respectively. There are two varieties of red-green colourblindness: protanopia and deuteranopia. Colour blindness to the blue-yellow spectrum is known as tritanopia. This is well explained in the paper “Smartphone-Based Image Colour Correction for Colour Blindness”. The paper further demonstrates the need for consideration for the colour blind as they are unrepresented in the design stage of many websites and products. The paper mainly focuses on algorithms and software that detect colour and auto-change. This would need a much deeper understanding of the colour theory and the technologies to allow all colour-blind users to achieve a personalised colour.

The effect of colour blindness can be seen ideally using the “<https://davidmathlogic.com/colorblind>” (David Nichols ) website, calculator. Modern computations were used to create the colourblindness simulations displayed on this website. However, although these calculations are frequently used and generally helpful, the confusion lines employed are flawed, and more research is necessary — particularly regarding the more uncommon types of colourblindness — to stotainty how precisely these simulations mirror each individual with colourblindness's colour vision. Green and red (David Nichols )

Red, green, and blue are the three primary colours detected by the three different types of cone cells in your eyes. It is a bad idea to utilise a red, green, and blue colour scheme since anomalies in these cells obstruct a person's ability to see these colours naturally. One should refrain from utilising red and green as complementary hues.

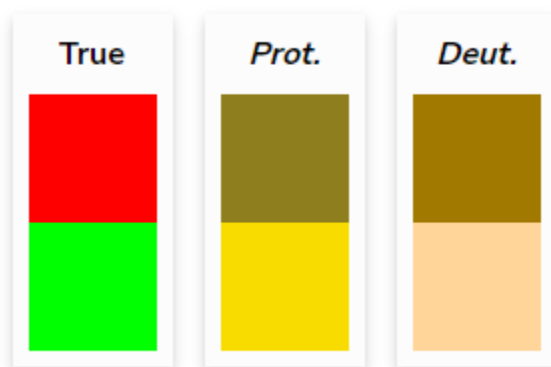


Figure 6

The reasoning can be seen in figure 8, which illustrates how shades of red and green have very low contrast for someone with red and green colour blindness, making it difficult or impossible for them to tell if a given colour is red or green. From the colourblind calculator, it can be inferred that utilising a comparable magenta and green colour scheme would be preferable to using red and green. This is illustrated below in figure 7.



Figure 7

There are colour blind palettes designed for colour blindness, as seen below in Figure 8.

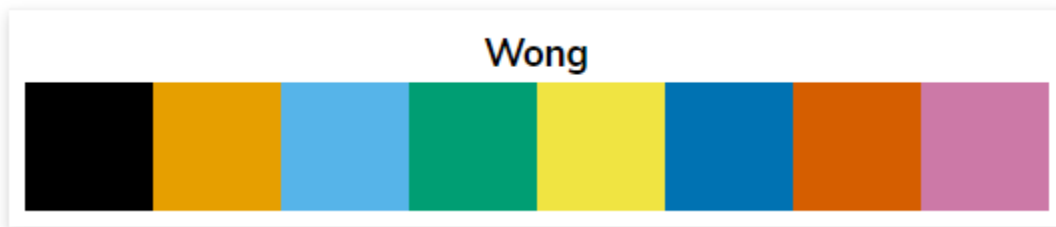


Figure 8 - Colour blind palette provided by Bang Wong (Wong 2011)

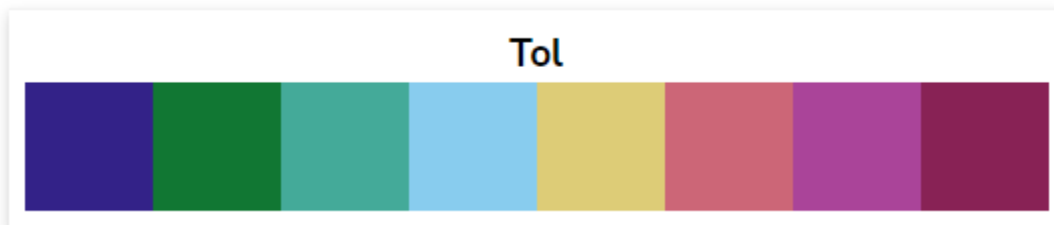


Figure 9 - Colour blind colour palette by Paul Tol 2021

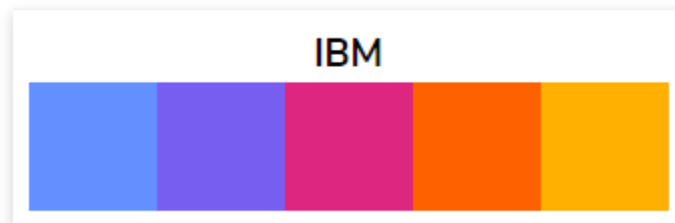


Figure 10 - Colour blind palette by IBM 2022

Furthermore, the WCAG 2.0 Use of colour understanding 1.4.1 (W3C® 2016) states why colour should be used with inclusivity:

- People who are partially sighted frequently have poor colour vision.
- Some senior users might not have good colour vision.
- When the information given by colour is also available in other visual forms, colour-blind users are helped.

- Access to content that requires colour may not be possible for users with text-only, limited-colour, or monochrome screens.
- Users who struggle with colour perception might look or listen for text hints.
- Text cues can be felt by users of Braille displays or other tactile interfaces.

#### 4.4.5 Colour blind modes

Name "Protanomaly separates the main three colour blind modes ", "Deuteranomaly " and "Tritanomaly "; the main three types of colour blindness. Additionally, there is a black and white mode which hopes to maximise contrast for all kinds of visual strength.

The extension designed for this project comes with four different modes to ensure maximum compatibility with any type of colour blindness. These modes reduce the number of colours to just two; this would align with many other studies that suggest the use of limited colours for colour-blind people, such as the book "Design Elements, Colour Fundamentals"( Sherin 2012). It is done using inspiration from the "Tol" colour pallet shown in figure 9 and the IBM colour pallet in figure 10. This was important as using this pallet enabled the greatest contrast for the named colour blindness. Furthermore, the more up-to-date research base allows the extension to cater to more types of colour blindness due to the more profound findings over the years from new studies. Regardless of the use of the pallet,essentialportant to understand that the pallet is not the most perfect for all colour blindness as there is a lack of research behind it (Paul Tol 2021). This is especially evident as a few different types of pallets have been designed and used, such as the colour pallet provided by the International Business Machines Corporation (IBM 2022), as seen in figure 10. An older colour blind pallet can be seen in figure 8 by Bang Wong, as shown in an article in 2011. The reason for showcasing these pallets is to illustrate the similarities and changes of these pallets.

This can be seen in figure 8 below. The process used to convert the colours is the same as the one explained above in the process of font sizing. However, the "contetn.js" script receiving the message converts the value of the colours when the corresponding message is received. Then proceed to apply it afterwards.

#### 4.4.6 Image Removing

We, humans, are visual beings. Visual information processing takes up a sizable portion of the human brain. Our cognitive abilities and capacity for attention are what underlie our enjoyment of visuals. We are often captivated by images, and they can capture our attention.

We perform alarmingly quick picture processing. When we see an image, we instantly analyse it and understand the meaning and scenario contained inside. Familiar objects can be recognised Within 100 milliseconds by the human brain. Within 380 milliseconds, people often recognise familiar faces, which is quite quick.(DiCarlo, Zoccolan and Rust 2012)(Sunday<i> et al.</i> 2022)



The most prevalent form of reflex epilepsy is photosensitive epilepsy. Photosensitive or pattern-sensitive people experience seizures in response to particular visual stimuli like strobe lights, flashing computer graphics, or, in some cases, fixed stripes and geometric patterns. Due to the dramatic increase in everyday exposure to electronic screens, the risk of these seizures has increased. (Covanis and Solodar 2021)

One in one hundred persons have epilepsy, and about three percentage have photosensitive epilepsy. This occurs when contrasts in light and dark patterns or specific flashing light rates cause spasms. The frequency of diagnosis after age 20 is less frequent in the case of photosensitive epilepsy and occurs more frequently in young adults and children. Photosensitive epilepsy can be triggered by pictures or lights that flash or flicker between 3 and 60 hertz (flashes per second). Similarly, geometric design with contrasting dark and light colours, including black and white, stripes, or checks, could all create a significant effect.(Covanis and Solodar 2021). One such visual hindrance may be “tryphobia”, referring to a severe dislike or anxiety of small, close-packed holes.

Most spontaneous seizures are all found in people with a range of well-known epileptic diseases (Arya 2019). This can be avoided by using a simplistic design with fewer bright colours and no patterns. A study on patients with photosensitive epilepsy found that material with flashing or repeated patterns is the most frequent trigger for photosensitive seizures (Prasad et al. 2012). Further, a study using electroencephalography cast doubt on the idea that photosensitivity and pattern sensitivity is always related, and they also raise concerns about the prevalence of pattern sensitivity in kids without epilepsy, especially those who also have migraine, headache, or academic issues (El Shakankiry and Kader 2012). This study illustrates how many people are not diagnosed correctly when looking for photosensitivity and suffer from migraines and scholastic difficulties when they are exposed to patterns. As there are many patterns, images, or colour combinations that could trigger an attack, it makes it difficult to accommodate all factors while still keeping aesthetics in mind. This is an area where the chrome extension excels, as the editing of the HTML done in the browser is personal to the user. This enables the user to utilise the whole aspect of any website without any discomfort.

Enabling the removal of images helps with conditions such as photosensitivity and tryphobia, by allowing users to remove images and replace them with the alt text description of the image. The alt text description of the image allows for seamless use of all websites. A more advanced form of such programs is out there that uses machine learning and scanning page such as “accessibe”. Accessibe is a web accessibility tool given to developers to include in their website to make it in compliance with “WCAG 2.1”. It is used by companies such as “PlayStation”, “BMW”, “Dolby” etc(accessibe 2022). The tool allows users of the website to personalise their disability. This is needed and very useful, but it is a paid service. This makes it hard for small-scale companies and webdevepors to utilise due to the cost. Therefore creating a small-scale free chrome extension to mimic such tools will help cater to a more extensive user base.

#### 4.4.7 Font type

Font types are essential to look at, as a study by Rello and Baeza-Yates in 2013 found that font styles affect how easily persons with dyslexia can read. Helvetica, Courier, Arial, Verdana, and CMU are suitable typefaces for people with dyslexia, considering reading ability and personal preferences. Additionally, italic fonts considerably reduced reading performance, whereas sans serif, monospaced, and roman font types significantly boosted reading performance. Arial in particular must be avoided because it makes text much harder to read. Studies by Bachmann and Mengheri in 2018 also suggest a need for separate fonts for dyslexia. In the case of this study, it was concluded that “EasyReading™” was better than the “Times New Roman version”.

The one thing that can be concluded from the study is that there is a correlation between the type of font and its readability. Therefore, instead of limiting the number of fonts to 1 or 2. It is much more practical to give the users the freedom to choose the fonts that correspond to their condition. Therefore, in this chrome extension, the users can access all the font families and fonts that are available with CSS. Then they will be able to apply it to the website changing all the fonts to the selected family and font. In the future, this can be updated by enabling the extension to access multiple fonts from google.

## 4.5 Extension Accessibility

With the help of extensions, users may design the perfect browsing environment that fits their tastes and capabilities. Extensions ought to provide accessibility features that promote a diverse user base by making the extension usable for those with vision impairments, hearing loss, low dexterity, and other limitations.

The usage of accessibility features can be advantageous for all users, not just those with special requirements. Keyboard shortcuts are useful for people with poor vision, poor hand dexterity, and power users alike. Both language learners and deaf users depend on captions and transcripts.

People can use an extension in many different ways. Some users rely on a screen magnifier and maybe a screen reader in addition to their regular keyboard, monitor, and mouse. Any developer may take measures to make an extension as accessible as possible, even if it is hard to forecast what tools users will use to access an extension.

### 4.5.1 Integrate accessible UI controls.

Users are unable to utilise an extension if they are unable to access the user interface controls. Utilising common HTML control is the quickest approach to designing an accessible user interface

### 4.5.2 Standard HTML controls include:

These are common HTML controls as seen from figures that scale easily, are keyboard accessible and are compliant with screen readers.

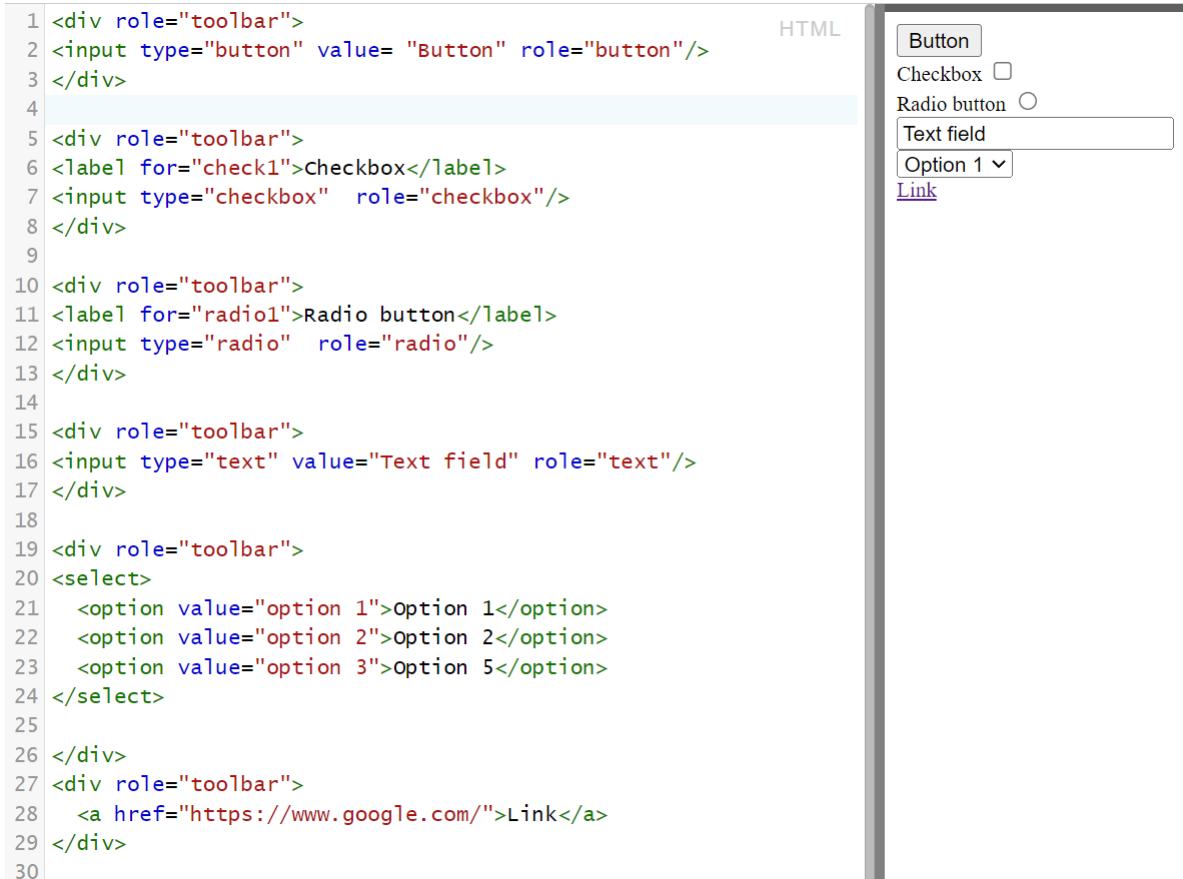


Figure: 9- HTML code and the right and the outcome on the left.

This standard is controlled under the WAI-ARIA, the Accessible Rich Internet Applications. It outlines how to increase the accessibility of Web apps and information for those with disabilities. It is notably useful for advanced user interface controls and dynamic content created with HTML, JavaScript, and related technologies.

In addition to having some appropriate styling applied by default to HTML "button", "check-box", "text" elements, etc, these elements also have built-in keyboard accessibility. This enables Users to navigate between the buttons by using the Tab, Return or Enter keys. CSS and Java can be used to make any

#### 4.5.3 Focus states

As you have browsed through websites, you may have noticed the blue outline surrounding links. These blue outline diagrams are called focus indicators. When an element is chosen, browsers by default display these outlines on it using a CSS pseudo-class. These built-in focus markers may not appeal to, and developers might be tempted to hide them. However, if you decide to remove this default style, make sure to add a new one in its stead.

When exploring a website, focus indications let users know which element is currently receiving the keyboard attention and assist them to locate themselves. People who are blind and need

screen readers, those with restricted mobility, those who have sustained ailments like carpal tunnel syndrome, and power users who favour this kind of navigation utilise these. Furthermore, some people only use a keyboard to navigate the internet. Links, form fields, widgets, buttons, and menu items should all be focusable. They must have a focus signal that distinguishes them from the surroundings.

The success of the focus state would be by enabling the user to clearly identify the component with which keyboard operations will interact at any given time; this feature benefits anyone who uses the keyboard to navigate the page. Furthermore, the focus location should also be beneficial for those who struggle with executive functions, short-term memory, or concentration issues. These are criteria set by WCAG 2.0 "Focus Visible: Understanding 2.4.7".

According to the WCAG 2.0, the focus indicators can be created by developers to match your brand's aesthetic and the design of your website. To make a state stand out from the rest of the information, make it highly apparent and contrasted. But for the simplistic design of the extension. It will be left with default settings, enabling it to tick all the criteria.

#### 4.5.4 Alternative text

The remove image mode stated above replaces the image with an alternate text description of the image, given by the web developer. This is frequently used by those with limited eyesight enabling the user to listen to the website. For the user to hear the words on a website, the screen reader converts text to speech. It is stated in the WCAG 2.0 H37: "Using alt attributes on img elements" that the words that are crucial to comprehending the content should be included in the alt text when they appear in a picture. As a result, the alt text will be able to serve the same purpose as the image on the website. That it must convey the same meaning as the image even though it does not need to describe the image's aesthetic features.

The alt> property of the image element and the context or surroundings of the image itself are the two places where a developer might present alternative text throughout the development stage.(W3C® 2016)

If the image only serves as decoration or if the surrounding context already adequately explains the subject. If the alt> attribute is left empty, screen readers will ignore it. Some screen readers will read the file name to the user if there is no alt text. This could lead to a bad experience for a user. For the extension, this means that it will leave it blank or replace the image with the file name.

Google is working on an automation image captioning program. By explaining images using text-to-speech technologies, automatic image captioning, the process of automatically creating a natural-language description for an image, has the potential to help those with visual impairments. Nevertheless, accurate image captioning is a difficult undertaking that necessitates coordination. Therefore, it will still take time for such technology to fully emerge for the consumer market. If such technology can be free, it can be utilised in the future development of this extension.(Google 2022)

#### 4.5.5 Semantic Markup content

Semantic meanings are attached to several HTML tags. Thus, the element itself provides some context for the kind of material that appears in the space between the opening and closing tags. For instance, when a browser detects an h1 heading, it understands it to suggest that the h1 object's elements are the section's most significant heading. An h1 element is used to designate the most significant heading of a certain website page or part, according to its semantic usage.

A reader can better understand the sequence of the content by using titles with large text sizes. Similarly, heading tags (H1) are used by screen readers to read information. By scanning each heading in a hierarchical sequence, individuals who have difficulty seeing can acquire a summary of the webpage in this manner.

The majority of sites have a visual layout with a header, main content area, footer, and occasionally sidebars. The header usually contains the site's logo, navigation bar, search, and other important information. Computationally, regions like "header," "nav," "main," "aside," and "footer" establish a page's fundamental semantic structure in a website. These significant website portions are easily navigable for screen reader users. ARIA milestone roles that are equal can accomplish the same. "Region" and "landmark" are frequently used interchangeably. (webaim 2020)

This leads to the thought process of how the extension should go through a similar thought process. To enable the user to use a screen reader to go through the popup. The extension will have h2 tags to describe the modes and follow the semantic structure.

#### 4.5.6 Keyboard Accessibility

Another crucial aspect of web development is keyboard accessibility. A keyboard is required to navigate material for those with motor disabilities, the blind who use screen readers, those who lack fine motor skills, and sometimes power users also utilise it.

The placement of interactive components on a website is crucial, and the navigation must be clear and easy to use. The visual flow of the page must be taken into consideration, in the development of the tab order. Header, primary navigation, content buttons and inputs, and lastly the footer are to be listed from left to right and top to bottom. (W3C® 2016)

Testing the website just using a keyboard is a recommended technique. To navigate across links and forms, press the Tab key. Try selecting an element by pressing the Enter key. Make sure that each of the interactive features remains logically sequential and predictable. To be able to access the entire website without a mouse would be the preferred outcome. W3C® 2016 "Keyboard: Understanding SC 2.1.1" gives a deep walkthrough on the criteria to achieve all this a more and it will be simple to use such test to ensure that the extensions popup is well designed and keyboard accessible.

## 4.6 Storage

The three main techniques of data storage as a chrome extension will be covered in this section, along with the benefits and drawbacks of employing each one in the making of the extension. In this section, the reasoning behind the storage will be discussed.

### 4.6.1 Chrome extension localStorage:

There are two storage options for this; the first one being storage on the user's Chrome account. This permits 512 items at most and 100 kb of data. Older versions of Chrome only allow for One update every 2 seconds, making them unusable for applications that require frequent, quick updates. The limitation has been raised to two write operations per second since Chrome release 40, and going beyond it will result in a runtime error. This can be seen if you look at this example: The truck chrome.storage is not a big one. It is a collection of tubes. And if you do not regulate the number of items transferred, those tubes can be filled. If they are filled when you send your message, it will be delayed if someone adds a lot of material in that tube. The second portion of localStorage, which saves data on the user's local drive. This has a storage limit of 5 MB by default. However it is possible to grant the extension the limitless storage permission, through "manifest.json" file. (developer.chrome 2022)

### 4.6.2 HTML5 localStorage:

When using the Chrome browser, the extension is allocated a default set to a 5 megabytes limit per website, just like the localStorage for chrome extension as stated above. These storage access points are synchronous, making them simpler to use. Considering that 5 MB of memory would enable for at least 5 200 000 characters to be kept, and that a typical URL size of 70 digits would suggest that the localStorage can hold more than 74 000 items, saving URL values in this manner would be advantageous. If the programme were to keep additional data in each entry, the number would be lower, regardless it is still sufficient for the typical user. For the JSON format to be used, the items are stored as a key-value in the localStorage and they would represent as a type of string. The online and local storage have functions for storing items and they are asynchronous chrome storage. (developer.chrome 2022)

### 4.6.3 User's hard drive:

Utilising the hard disc located locally by the user is the final storage option. In addition to being challenging to construct, it limits the user to using a single computer because it cannot synchronise between computers. However, there shouldn't be a problem with storage space. Chrome only permits extensions to store files to the user's selected download location, so that also looks to be a problem. Theoretically, it is possible to add a subdirectory to the downloads folder to organise the files any further. The chrome extension requires permission for the downloads from the "manifest.js" file in order to use this. This enables an application to access the user's chosen download folder. (developer.chrome 2022)

#### 4.6.4 Storage Evaluation

Although the HTML5 localStorage is quick and simple to use, the storage size limit prevents it from storing anything other than text data. When it comes to the extension's ability to store photographs, this will pose a problem. (developer.chrome 2022)

The localStorage for Chrome extension has a limited 5mb of storage to the user's hard drive and the user is limited to accessing it only through the extension. In contrast to HTML5 localStorage, it supports storage of any kind of data format, not only text. It is stated by chrome in chrome.storage documentation 2022 that "User data can be stored as objects (the localStorage API stores data in strings)". The disadvantage being Online storage is that it is asynchronous and has a throughput cap. (developer.mozilla-MDN contributors 2022)

Chrome retains the information locally even when it is not connected. Chrome syncs the info for the next time the browser is connected. Storage.sync will continue to function even if a user turns off syncing. It will act just like storage.local in this situation. (developer.chrome 2022)

On the other hand when the developer utilises storage.sync, which can be done if the user has sync enabled. Then the records will sync to the Chrome browser logged in by the user.

The benefit of saving on the hard drive of the user is that the item can be saved in any type of format, and storage space is practically limitless. Nevertheless, it is limited to a directory that the user allocated which can be altered by the System design user, unintentionally or purposefully. This can cause unpredictable reactions when the extension tries to read the file. (developer.chrome 2022)

#### 4.7 Hardware Consideration

The strategic choices that went into designing the extension to adapt to various device hardware will be covered in this section.

Various screen resolutions:

Different computers have different screen resolutions (w3schools 2022). Because of this, the sidebar's size will be specified as a small pixel size of 300px by 400px, leaving enough room for readers on all types of screens. If the size were declared in the percentage of the browser window; it will potentially not accommodate the extension popup if the window is too small. The user will be able to modify the popup's dimensions for a later version.

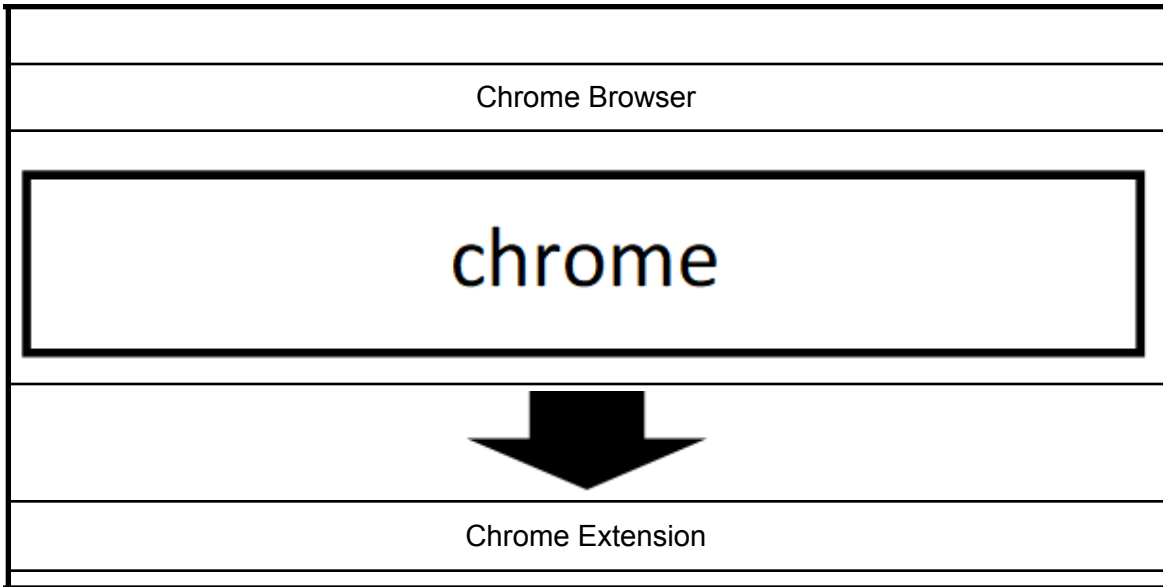
Extension for android devices:

Extensions and apps are not supported by Chrome on an android platform currently. Furthermore, the developers for chrome android have come forth and stated their disinterest in supporting extensions in their chrome android app in the near future.

#### 4.8 Implementation



#### 4.8.1 System architecture



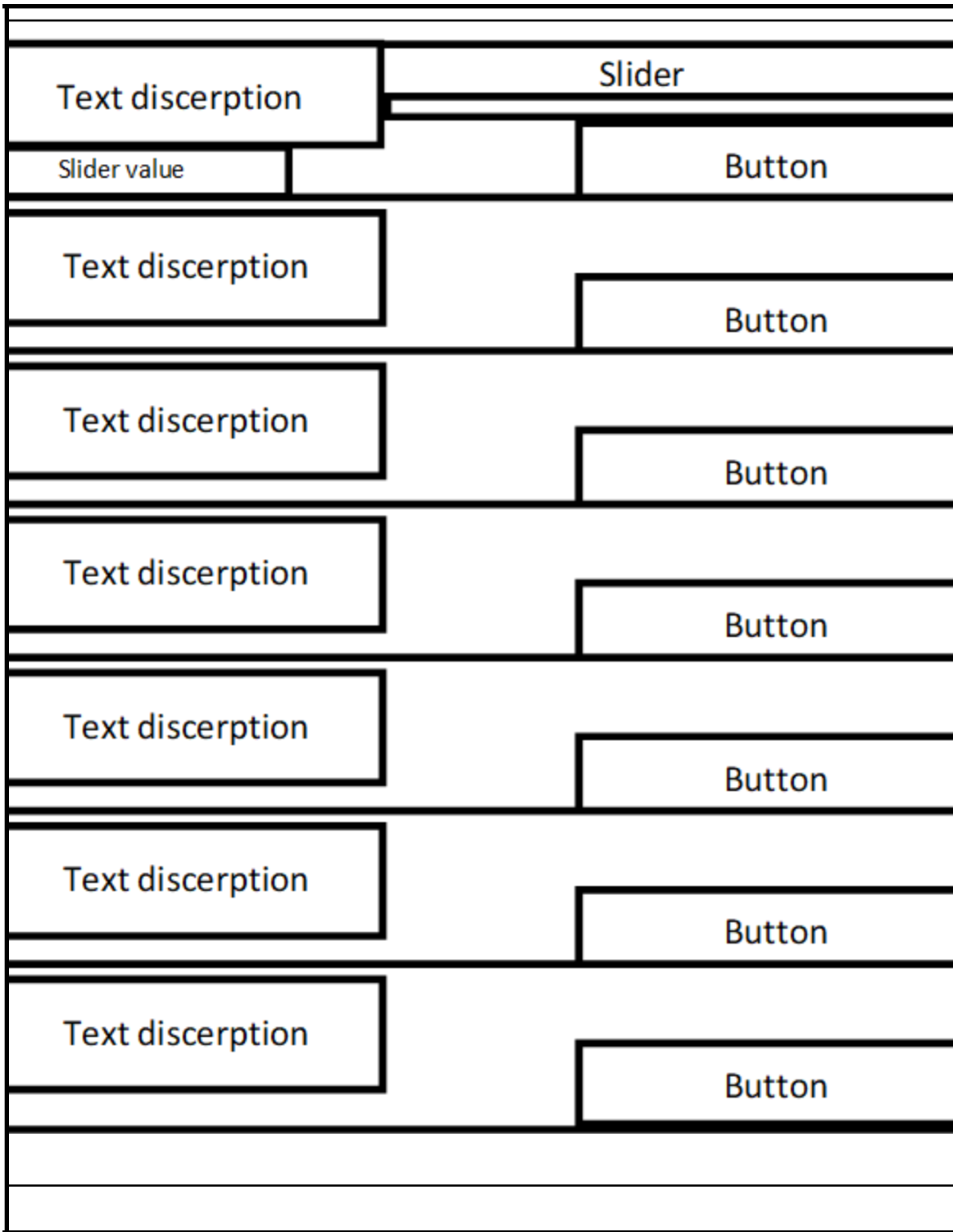
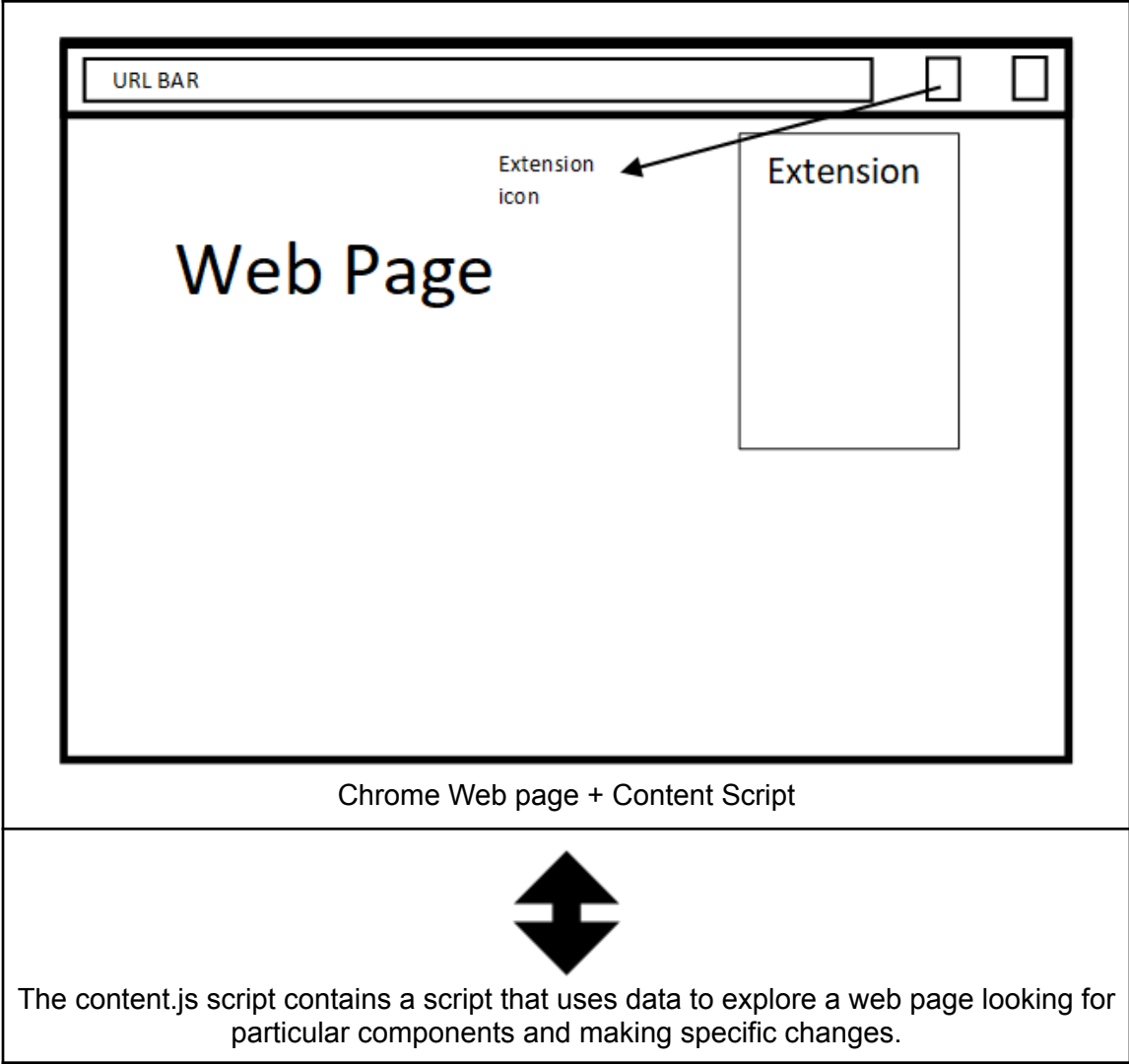
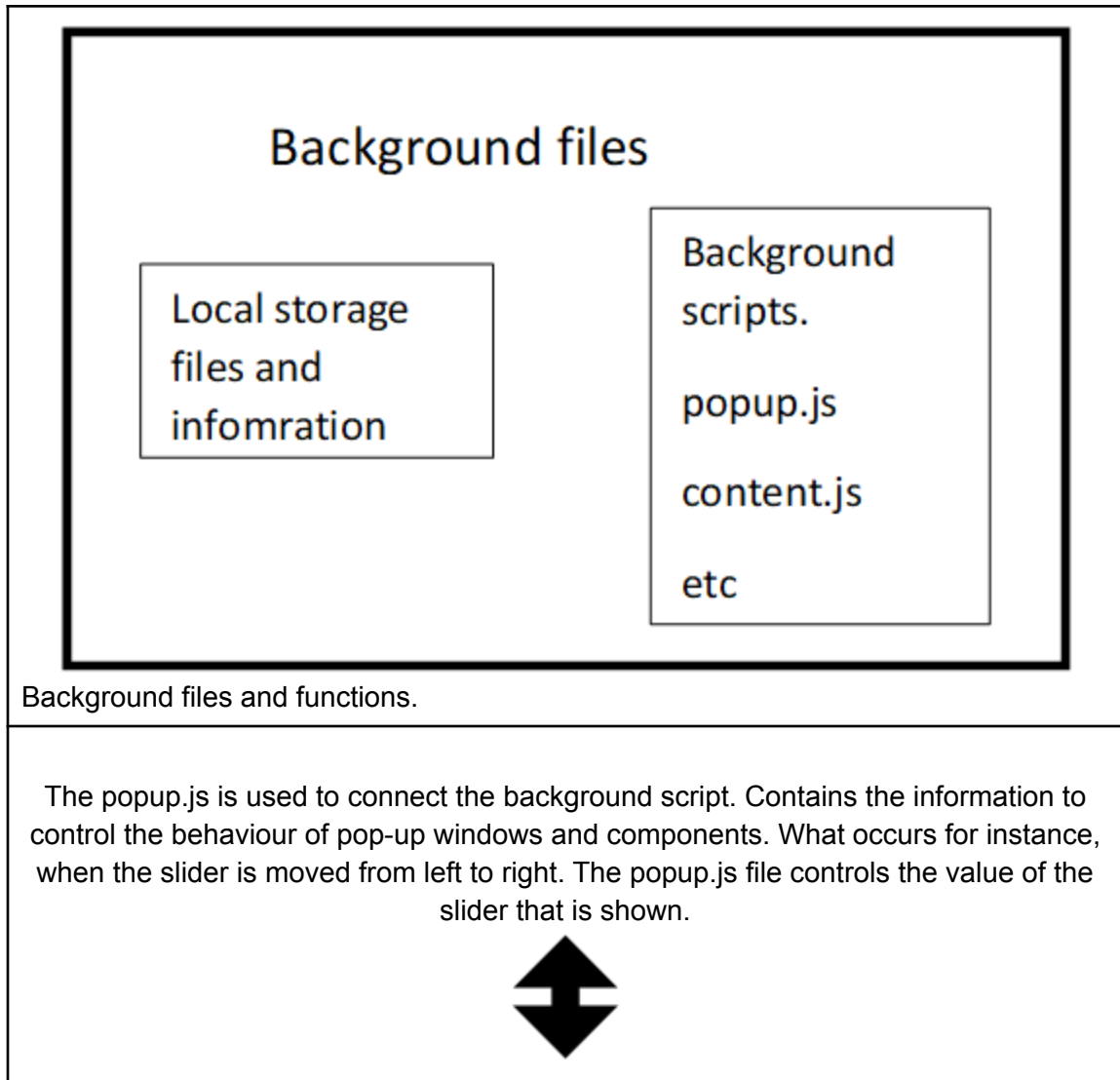


Figure 11: Illustrates the extension being part of the chrome browser.





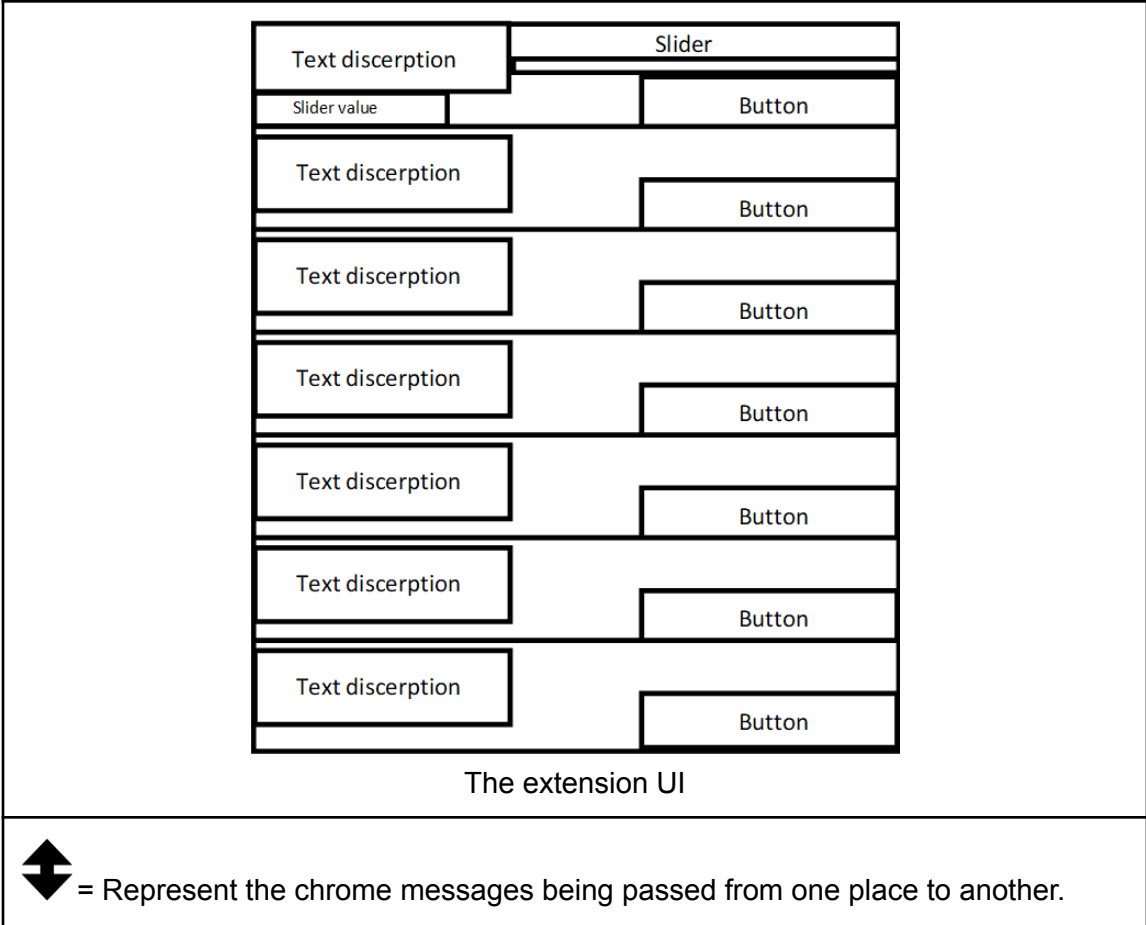


Figure 12: From the perspective of the developer: the architecture

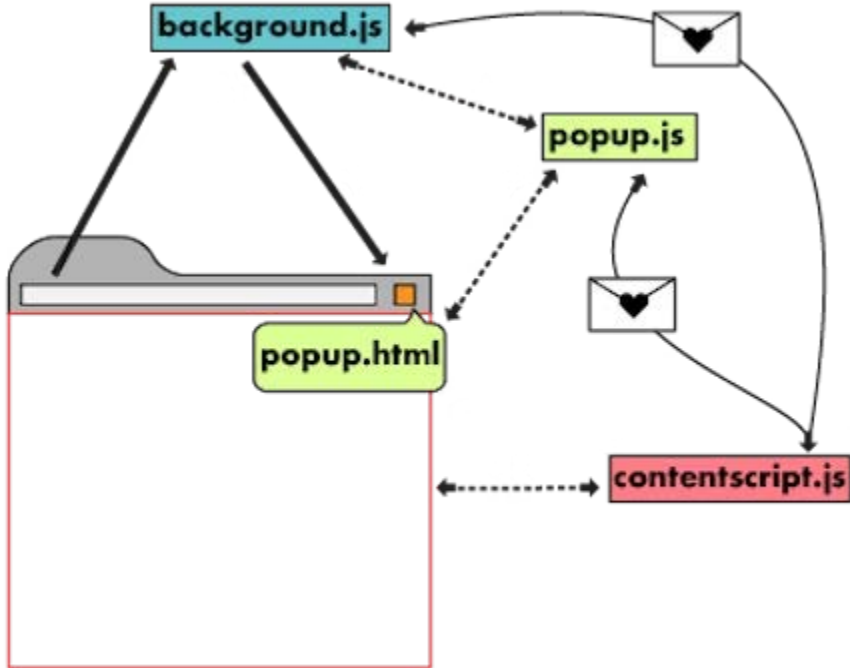


Figure 13: Architecture illustration provided by Chrome.(developer.chrome 2022 (Architecture overview))

All the messages are handled by the service handler; it works as an event handler for the extension. It is a very important part of the extension as it listens for any browser events. It is only launched when it is required and freed when it is idling. It is inert until an event occurs, at which point it executes the logic given to it. As long as it provides the necessary rights in the manifest.json file, a service worker gets accessibility to all of the Chrome APIs.(developer.chrome 2022 (Architecture overview)). This interaction between all the different scripts, content script, browsers etc can be seen below in figure13.5.

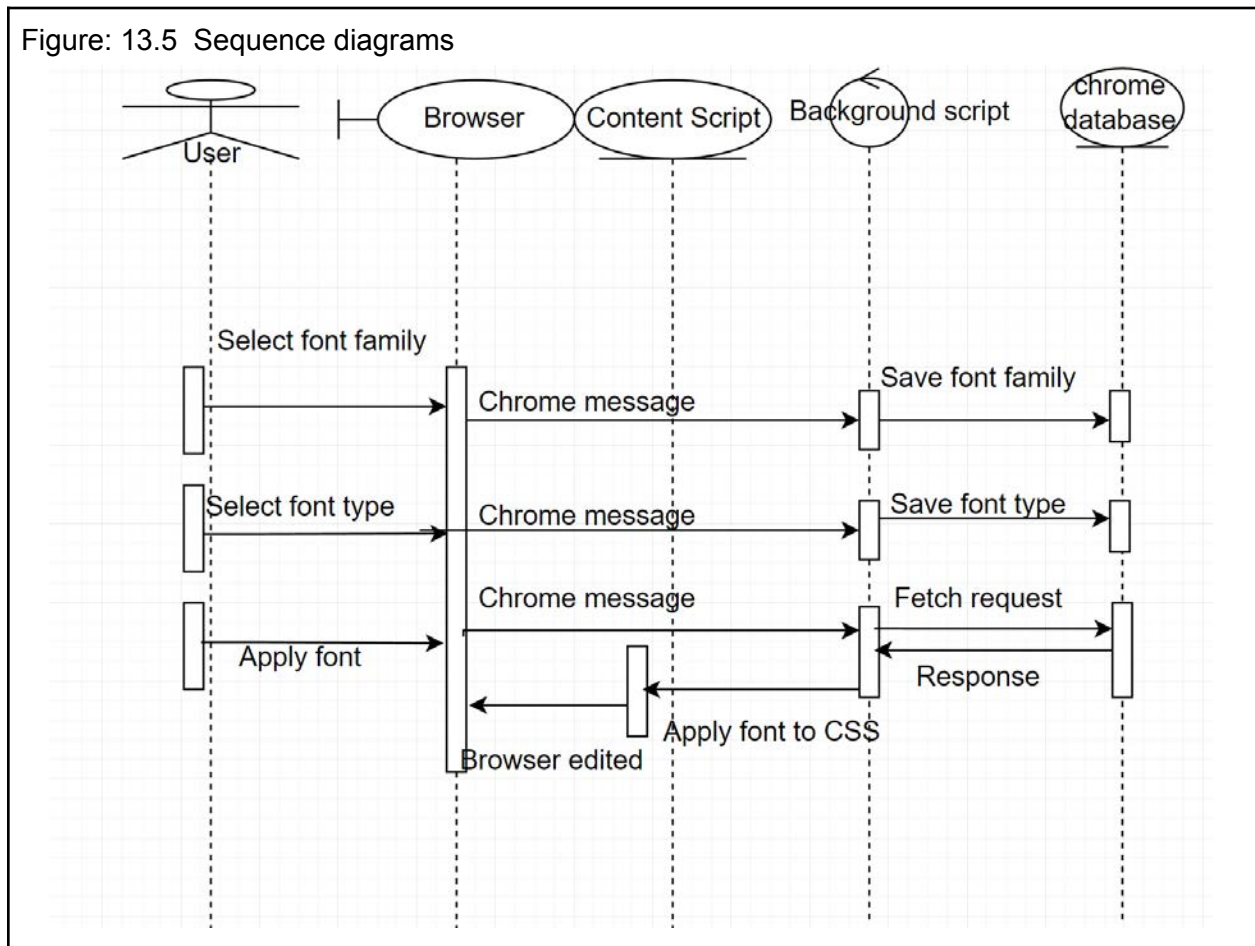


Figure 12 depicts the extension's structure as seen by a developer's view. The illustration above visualises the locations of the various extension components as well as which components interact with one another via Chrome messages. This is further better illustrated by chrome in figure 13 above.

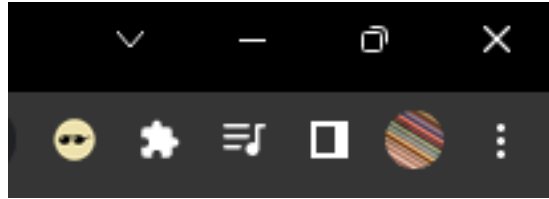


Figure 14

Toolbar icon: Each extension needs a toolbar icon to appear in the browser as seen above in figure 14. Toolbar icons make it simple to retrieve information and let users know what extensions are available, further enabling them to differentiate between them. This icon is the interactive element of all the extensions, and it brings out the popup menu. For the Visual aid extension, the icon shown below in figure 15 was designed.

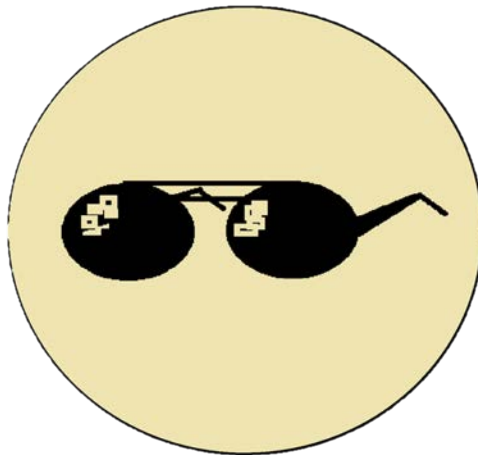


Figure 15: Visual aid icon

#### 4.8.2 Incognito mode

Except when specifically permitted by the user within the extension's settings screen, extensions cannot run in incognito windows. Regular and incognito windows by default operate as a common cohesive process. Extensions, however, have the option of running incognito windows in a different process or not at all. This behaviour can be specified in the manifest's "incognito" key.

### 4.8.3 Extension permissions

```
1  {
2    "manifest_version": 3,
3    "name": "visuall aid",
4    "version": "1",
5    "web_accessible_resources": [
6      {
7        "matches": ["*://*/*"]
8      }
9    ],
10   "content_scripts": [
11     {
12       "matches": ["<all_urls>"],
13       "js": ["content.js"]
14     }
15   ],
16   "background": {
17     "service_worker": "background.js"
18   },
19   "action": {
20     "default_icon": "ct.png",
21     "default_popup": "popup.html",
22     "default_title": "Visuall Aid"
23   },
24   "permissions": ["scripting", "tabs", "storage", "unlimitedStorage", "tts"],
25   "host_permissions": ["*://*/*"]
26 }
27
```

Figure 16: manifest.json file including the “Manifest declaration”.

#### Manifest - Web Accessible Resources:

Web accessible resources are packages of files that can be used and accessed by the extension and web page at all times. Any item contained in an extension's package can be made web accessible. Extensions generally use this functionality to upload assets and images need to be loaded for the web pages.

The resources are restricted to the scripts and pages loaded in by the extension, and they are not available to the web by default. The web accessible resources manifest property allows extension authors to specify what assets are available and to what sources.

All resources contained in an extension could previously be accessed from any web page before the release of Manifest V2. This made it possible for a malicious website to identify the extensions that a user has installed or to take advantage of security flaws (like XSS issues) in installed extensions. (chrome 2022 under Manifest - Web Accessible Resources)



To safeguard users' privacy, access to such resources was restricted starting with Manifest V2. Only resources that were expressly marked as being web accessible were exposed by Manifest V2 extensions.

With Manifest V3, you have more precise control over how specific pages, domains, or extensions are exposed to specific resources. Therefore manifest 3 was the obvious choice, as it has the security features and customisable. But it is important to note that, for the practicality of the extension and due to the lack of storing user's personal data. The resources are set to be able to be used by all websites.

Matches: specifies which pages may access the assets with the list of URL match criteria. URLs are only matched using the source. Subdomain screening is included in origins and paths taken are ignored.

Declare permissions:

The extension should specify the purpose in the manifest's permissions section in order to use the majority of "chrome.\*API". Three types of permissions can be requested by extensions, and they can be provided using the corresponding manifest keys:

Permissions: have a number of strings (such as "bookmarks") already enlisted.

Optional\_permissions: Functions similarly to standard permissions, but it is granted at runtime instead of beforehand by the user of the extension.

host\_permissions: Contains match pattern, one or more that allows access to a one or multiple hosts.

This extension only uses the "permissions" key and the permissions include (can be seen in figure 16):

"scripting": The chrome.scripting API can be used to inject CSS and JavaScript into websites. Similar to what you can accomplish with content scripts, extensions can also make decisions at runtime by utilising the chrome.scripting API.

"tabs": Provides your extension with access to special Tab object fields used by a number of APIs, particularly chrome.tabs and chrome.windows. In many cases, in order to access these APIs, your extension does not need to disclose the "tabs" permission.

"storage": Utilised to keep user information for the extension.

"unlimitedStorage": Grants a limitless amount of space for local storage files and databases that are client-side data. The extension is only permitted to use 5 MB of local storage without this permission.

"tts": the text-to-speech generated by the chrome.tts API (TTS). The associated ttsEngine API, which enables an extension to construct a speech engine, is also worth mentioning.

(developer Chrome 2022 Declare permissions)

#### 4.8.4 Software design

Because extensions are designed to be quick software packages that can improve browser functionality, the application is a chrome extension. This is in line with the objective of the dissertation. The sidebar that makes up the main user interface can be turned on or off. The

user will accomplish this by clicking a button in the right-hand address bar. Along the right side of the browser is where the sidebar is situated. Users will be able to modify the sidebar's position in future versions of the extension by visiting the options page. The placement for the icon for the extension can be seen below in the figure 17 highlighted in red. When the sidebar is toggled on, it will sit on top of the webpage because moving or resizing it could break the layout and interfere with some of the functions. Pushing other items off a page and replacing them with new ones could give the page the impression that it has more room to work with than it actually does. This is especially true for websites that modify their layout based on the window width. This is illustrated in figure 18 highlighted in red.

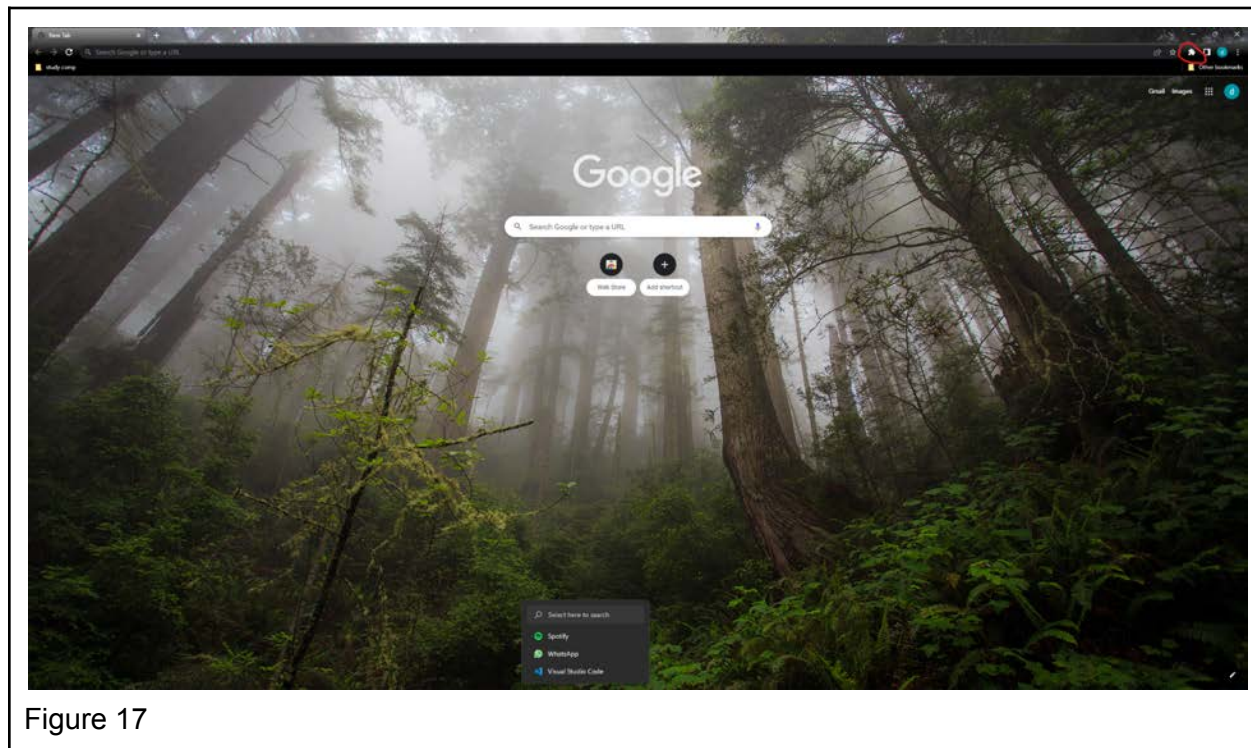


Figure 17

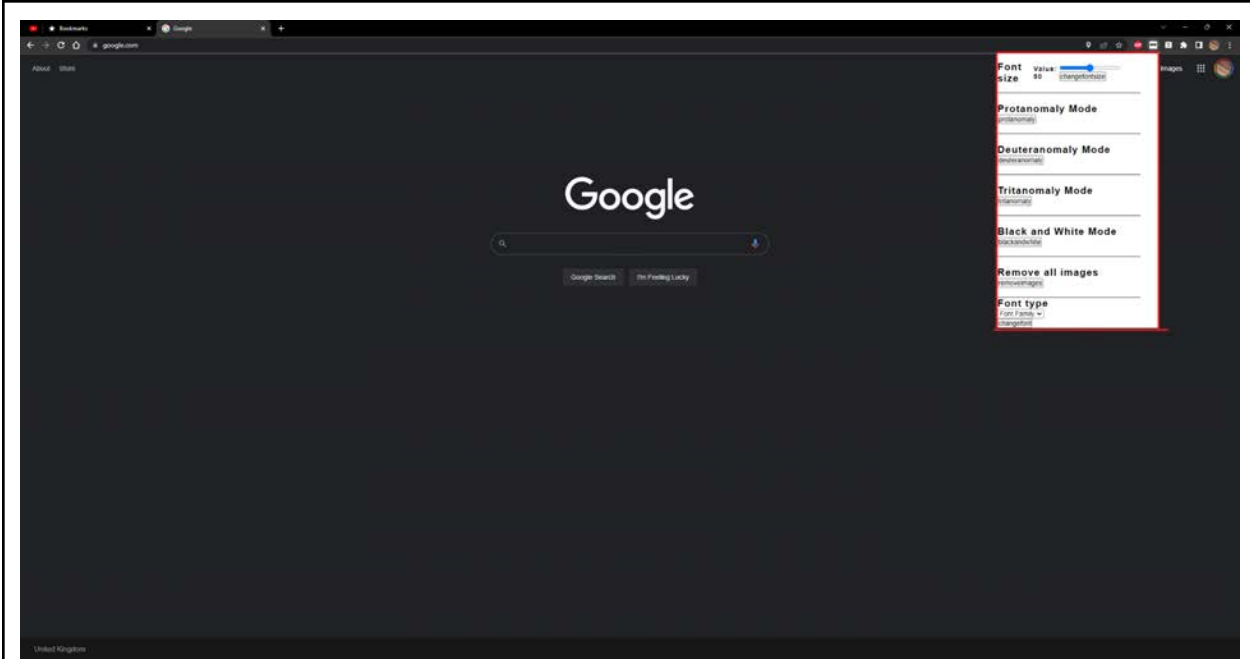
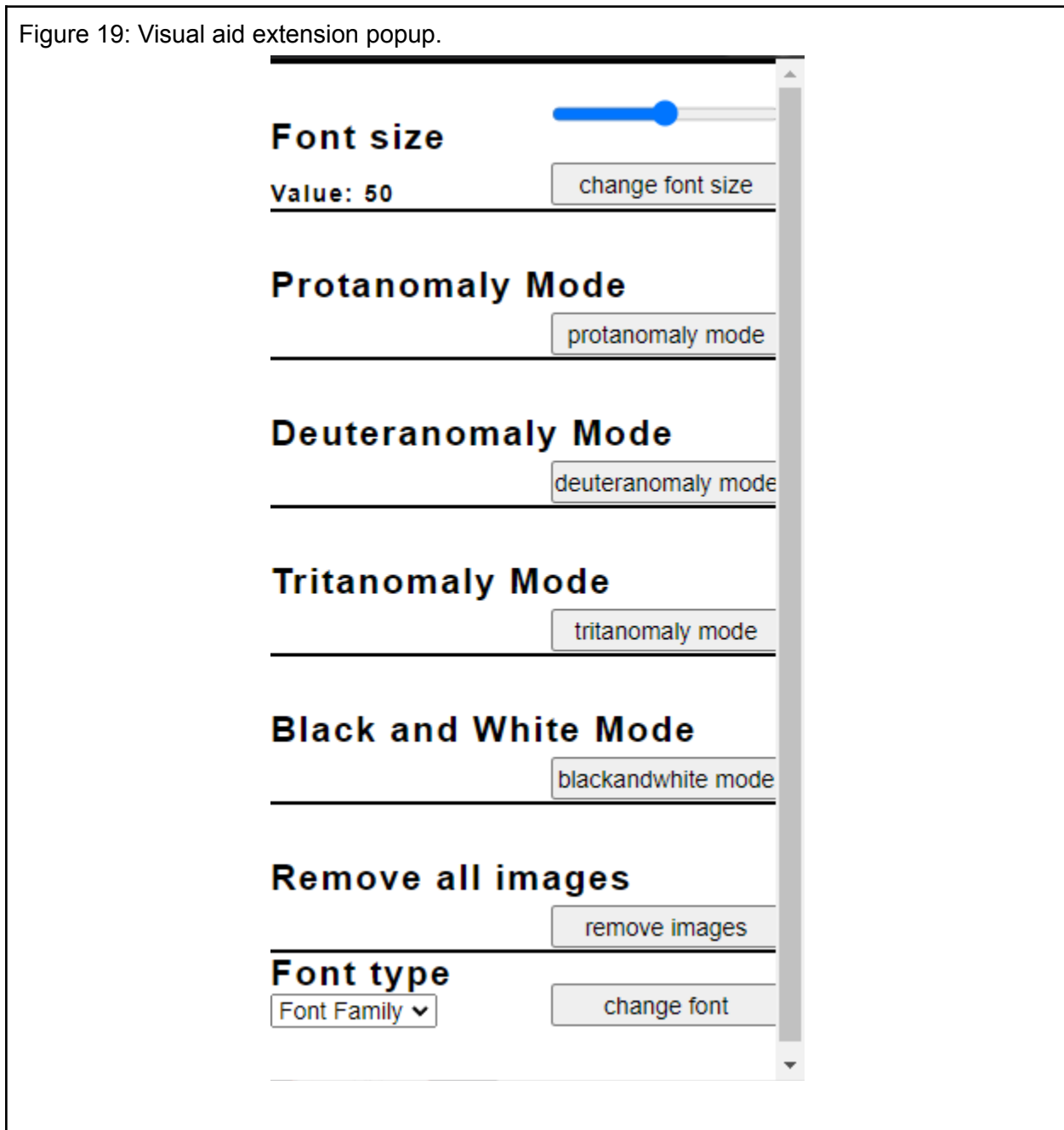


Figure 18

Figure 19: Visual aid extension popup.



The graphical interface for the visual aid popup can be seen above in figure 19. Figure 19 is a screenshot taken from, version 1 of the visual aid extension. It shows a structured layout in a 300px by 600px layout. Each form /section divided into sections of 85px, and some given a bit extra to accommodate the extra features.

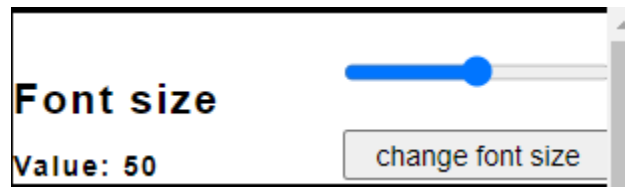
The font is in h2 tags as discussed above for their size, as it is the most appropriate for a visual aid extension. It enables all users to visually identify each setting. The fonts are set to san serif as it was one of the most readable fonts according to Rello and Baeza-Yates in 2013.

The size of the buttons is also set with width of 135px and height of 25px, making it bigger than the default size and further even out all the buttons. The larger surface area of the buttons allows for easier accessibility for users with less dexterity or poor vision. The button's values are also set to the usage (telling the user what it does) of the button; this can be read by screen readers, allowing for a better compatibility, and following guidelines of "WCAG 2".

The colour of the extension may look bland. But it was important to make sure to give as much contrast as possible and be inline on being all inclusive. There might be conditions that may not allow even for this design; regardless it is the best design in context to this extension. Nevertheless, the extension can be updated to accommodate the user base and their needs, maximising the future potential of the extension.

#### 4.8.5 Font Sizing option

4.8.6 Figure 20: Font sizing



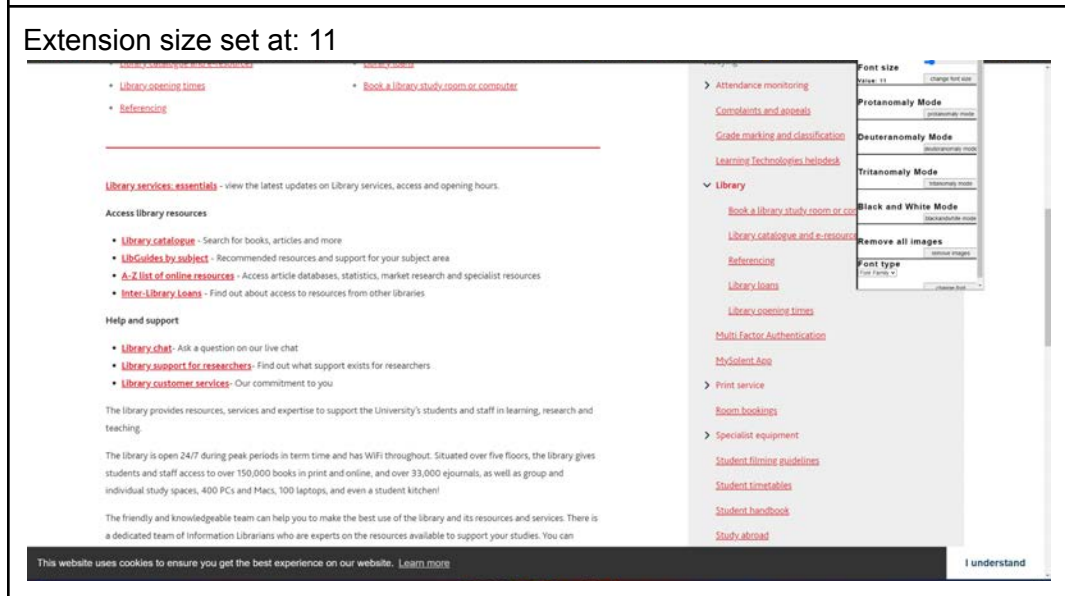
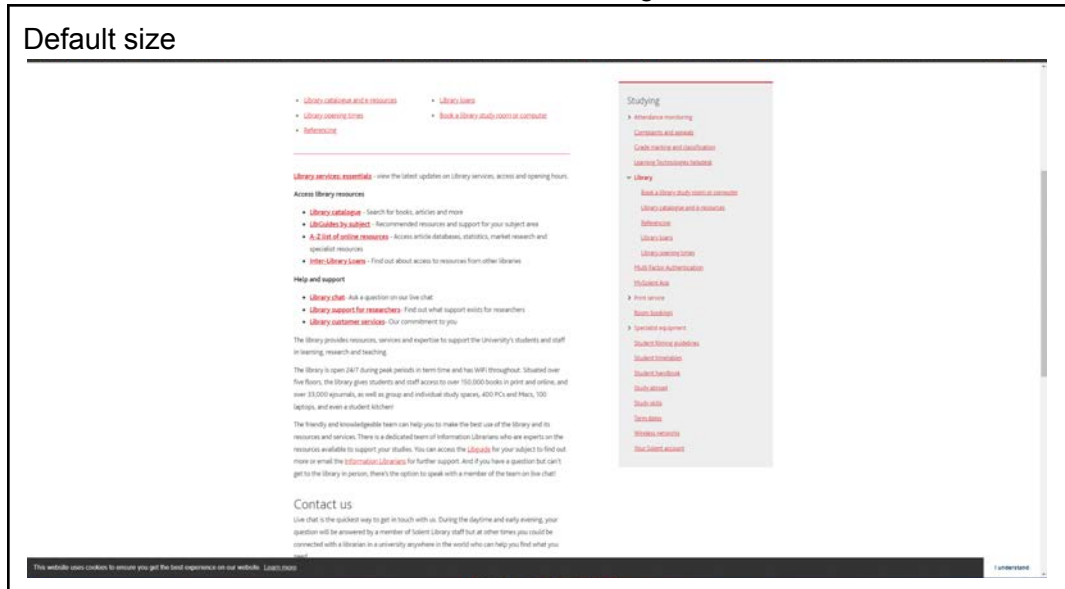
The font sizing function of the extension can be seen in figure 20 above. The size is controlled by the slider and the value of the slider is shown on the bottom left of the section box. The slider is used to adjust the to the value the user would like. Then when the user has found the value they prefer, they press the button "change font size" positioned on the bottom right. This will send the value to the popup script which sends the value to the content script. Which in turn changes the CSS script on the website executing the font size change.

The execution of this can be seen in the figure 21 below. It illustrates one "Solent university web page" in the default size, extension sizing set at 11, and 51. The difference can be seen from the default size to the extension size set to 11. There is an even drastic difference from default and extension size 50. This will enable most users to read even without their glasses if they have bad vision.

The extension changed every single font including the cooky popup message sent by the website seen in the bottom of the website. This is because the content.js file systematically goes through each tag in the html file of the website and increases the size corresponding to the

user's choice. This may be too much for the user as it increases the size of the title and footer notes. But this can be updated to enable the user to select what they want to zoom in to.

It is also important to note that this is a simpler and faster option compared to the one provided by the chrome browser. Which can be seen in the settings bar.



Extension size set at: 51

[Library services: essentials](#) - view the latest updates on Library services, access and opening hours.

Access library resources

- [Library catalogue](#) - Search for books, articles and more
- [LibGuides by subject](#) - Recommended resources

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**Library**

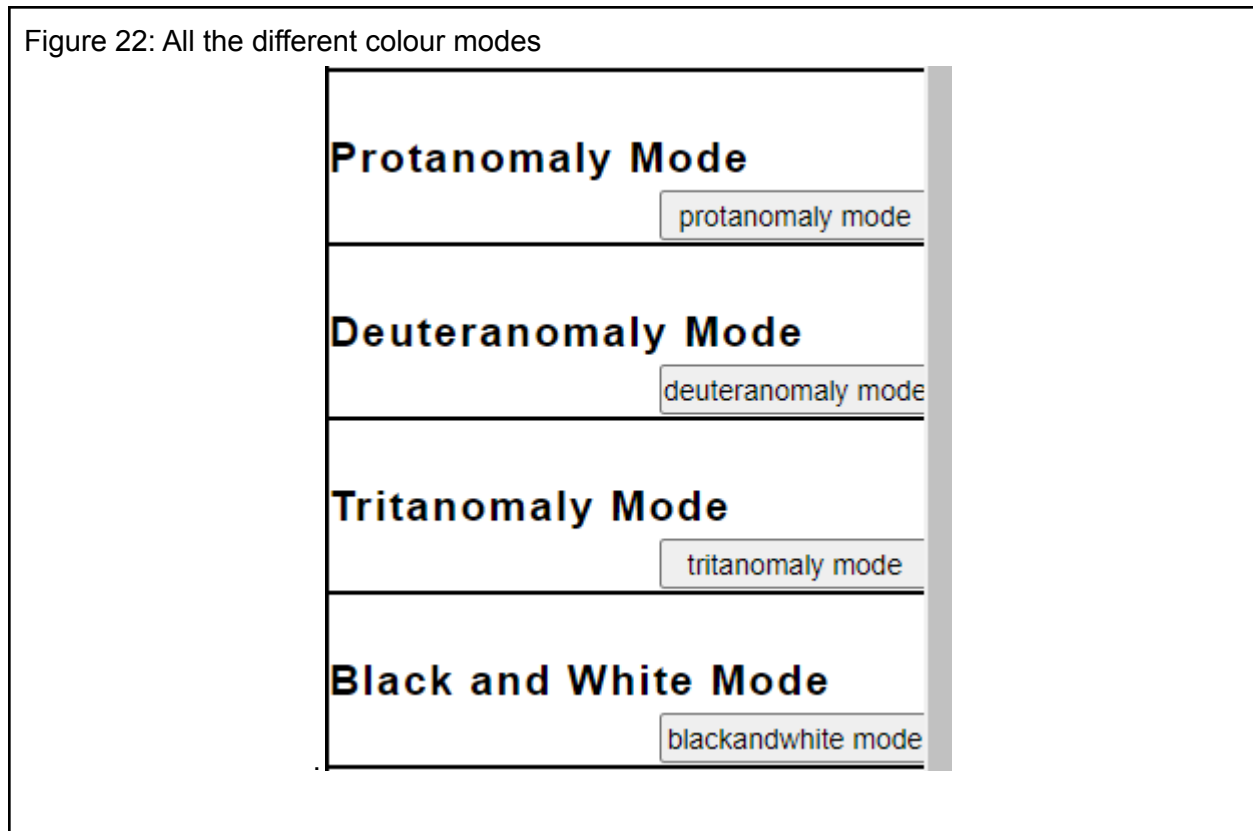
[Book a library study room or](#)

**I understand**

Figure: 21 -Shows “<https://students.solent.ac.uk/studying/library>” website in 3 different sizes.

#### 4.8.7 Colour modes Option

Figure 22: All the different colour modes



There are four different colour modes implemented and they are built to be simple in nature. It can be activated with a single press of a button. The colour modes only affect the background and font colour. It does not remove or replace the colour of any images or icons in the web page. These modes are implemented to maximise contrast for the visually colour-blind users. The design is again made simple with each section being boxed out and the mode names being in h2 tags, for ease of navigation. The button values also correlate with the action of the button. This in turn, makes it easier for users with screen readers.

Each mode uniformed every page by using 2 contrasting colours as suggested by many studies and researched colour pallets such as the one by Paul Tol 2021 (as researched discussed in colour blind modes above).

The active mode of each of these modes can be seen below in figure 23 to 27. For the most common web users with no visual problems, this may look very unnecessary. On the other hand, these colours are specifically picked to create the greatest contrast for the colour-blind users.



Colours chosen:

The following figures from 23 to 27, will illustrate the Solent website under the different modes and the colours will be defined in bullet points. Furthermore, the colour used will be contrasted with what colour-blind people will see. An example of this can be seen in figure 24, the colour pink ("#D35FB7") is seen as blue for someone with Protanomaly (Prot.). This also enforces the difference in visual strength from normal vision to colour blind.

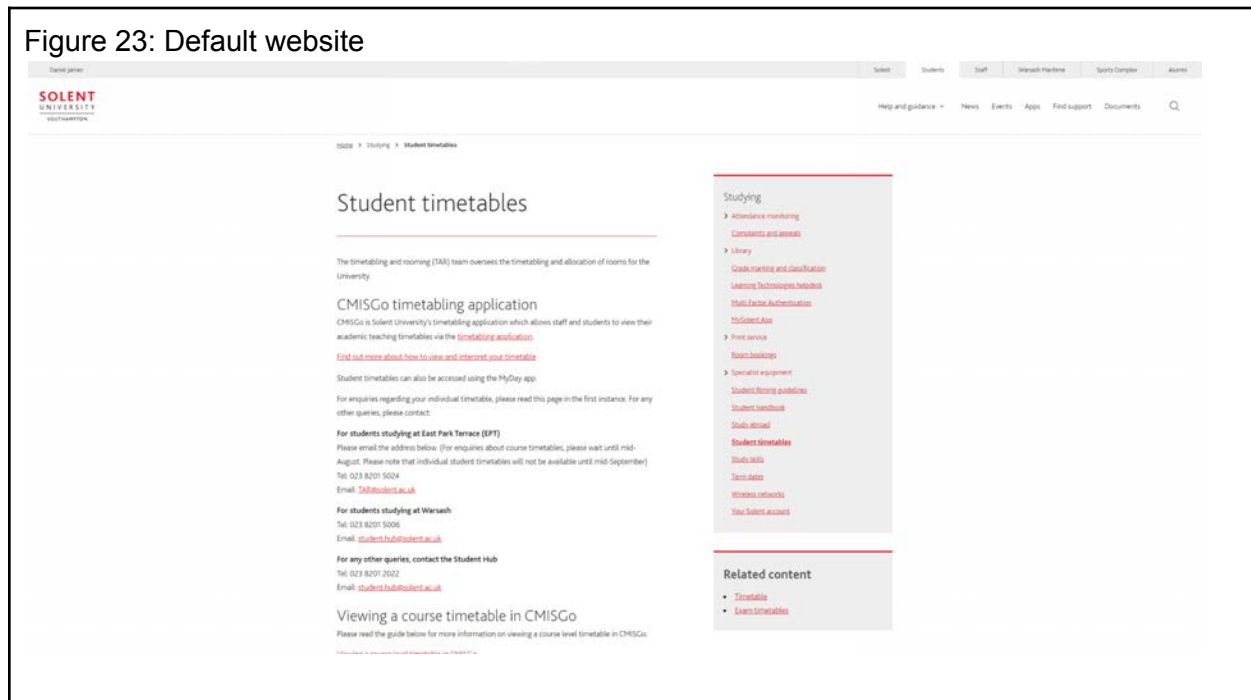
Keys:

1. Protanomaly (Prot.)
2. Deuteranomaly (Deut.)
3. Tritanomaly (Trit.)

Disclaimer: (Please understand the colours may vary from format to format or monitor to monitor. This is because everyone perceives colours differently and each computer monitor has a unique ability to represent colours.)

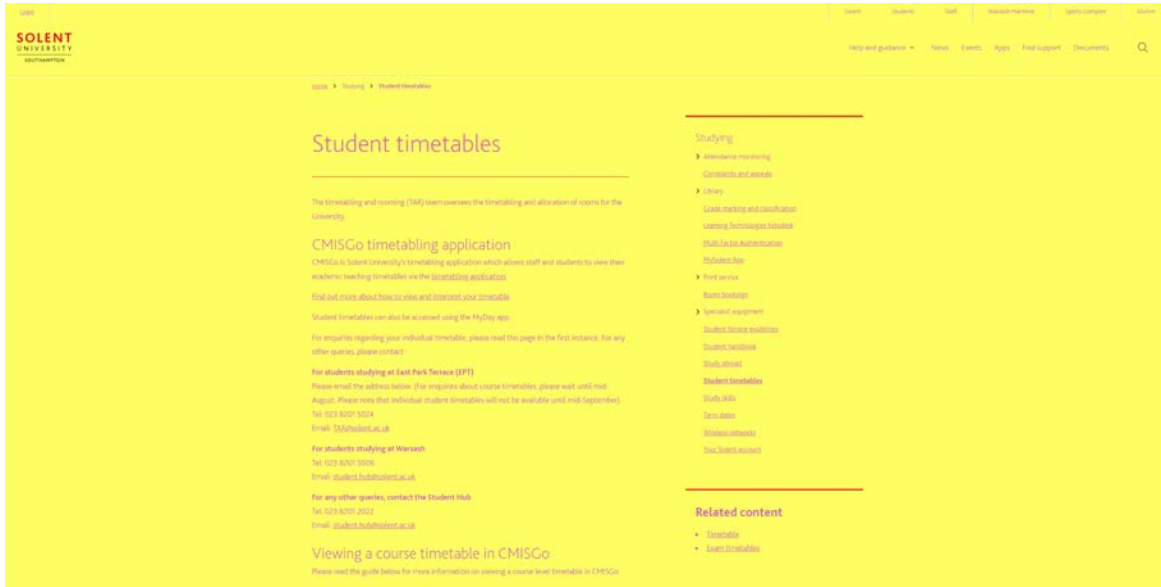
- Default Website
  - Font: "default "
  - Background: "default "

Figure 23: Default website

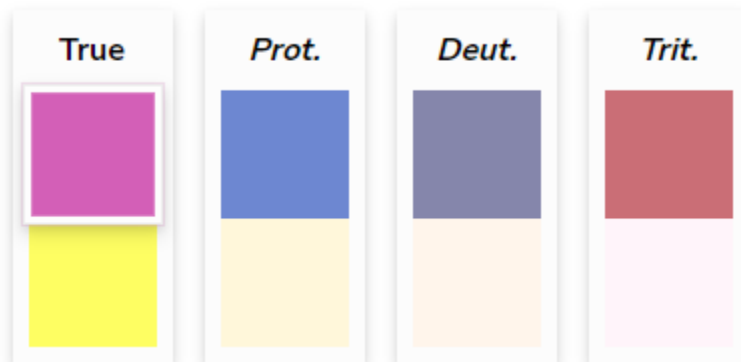


- Protanomaly mode
  - Font: "#D35FB7"
  - Background: "#FEFE62"

Figure 24: Protanomaly Mode



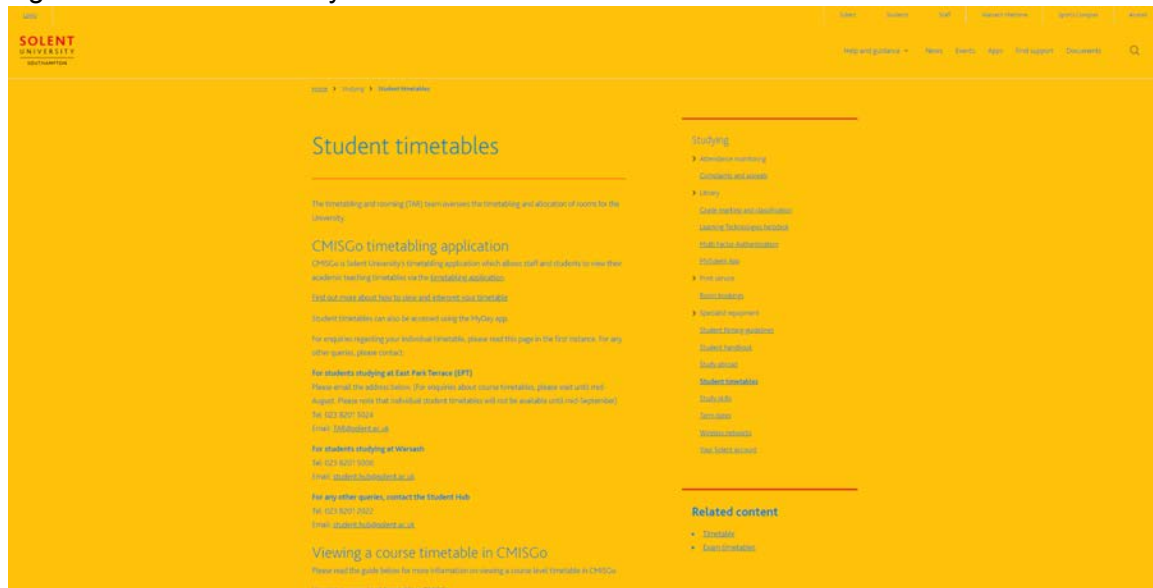
What normal visual people see vs colour blind.





- Deuteranomaly mode
  - Font: "#0C7BDC"
  - Background: "#FFC20A"

Figure 25: Deuteranomaly Mode

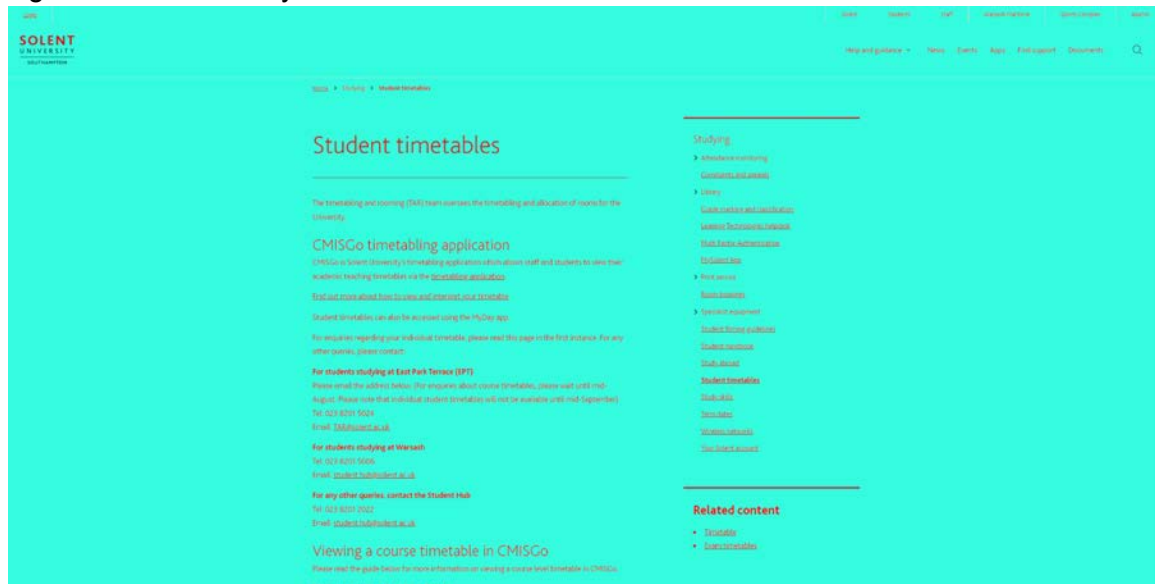


What normal visual people see vs colour blind.

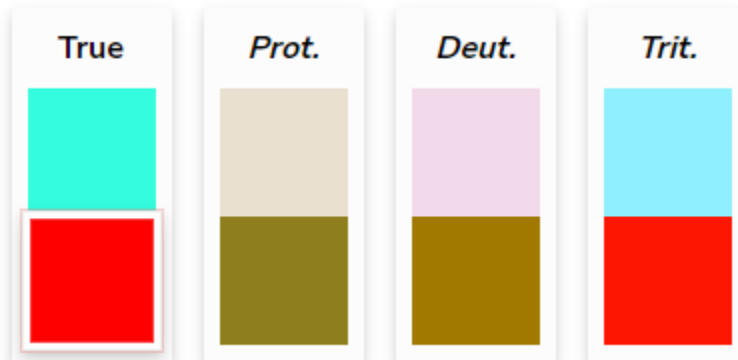


- Protanomaly mode
  - Font: "#FF0000"
  - Background: "#34FCDF"

Figure 26: Tritanomaly Mode



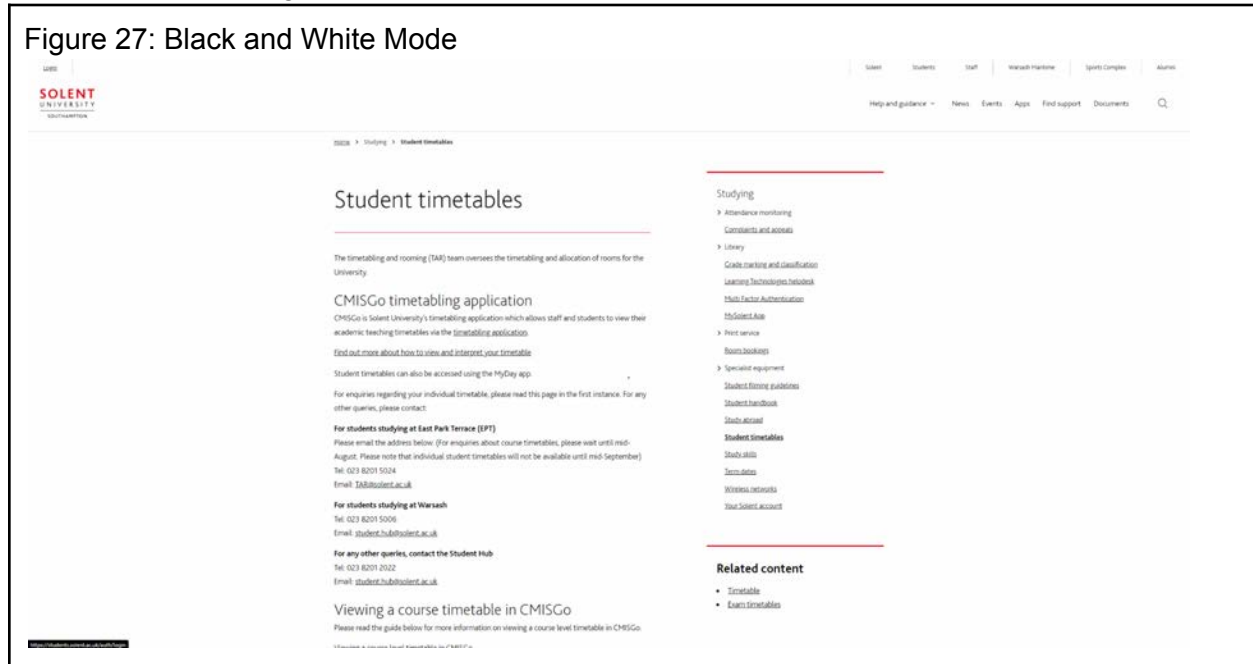
What normal visual people see vs colour blind.





- Black and White mode
  - Font: "#000000"
  - Background: "#FFFFFF"

Figure 27: Black and White Mode



#### 4.8.8 Remove image option

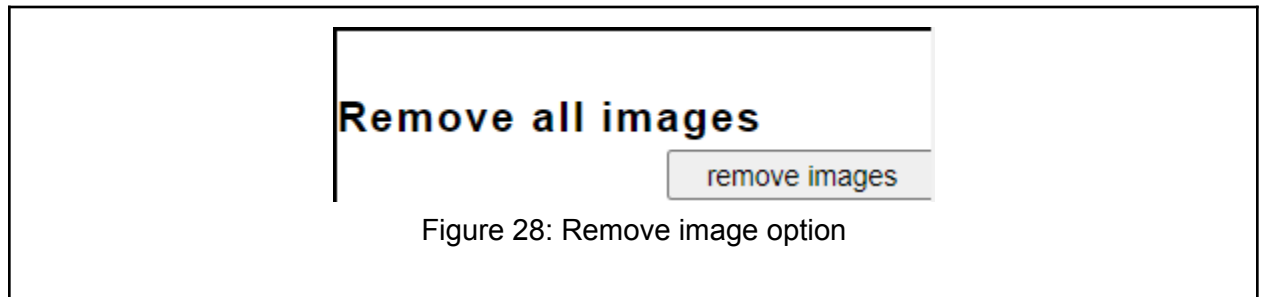
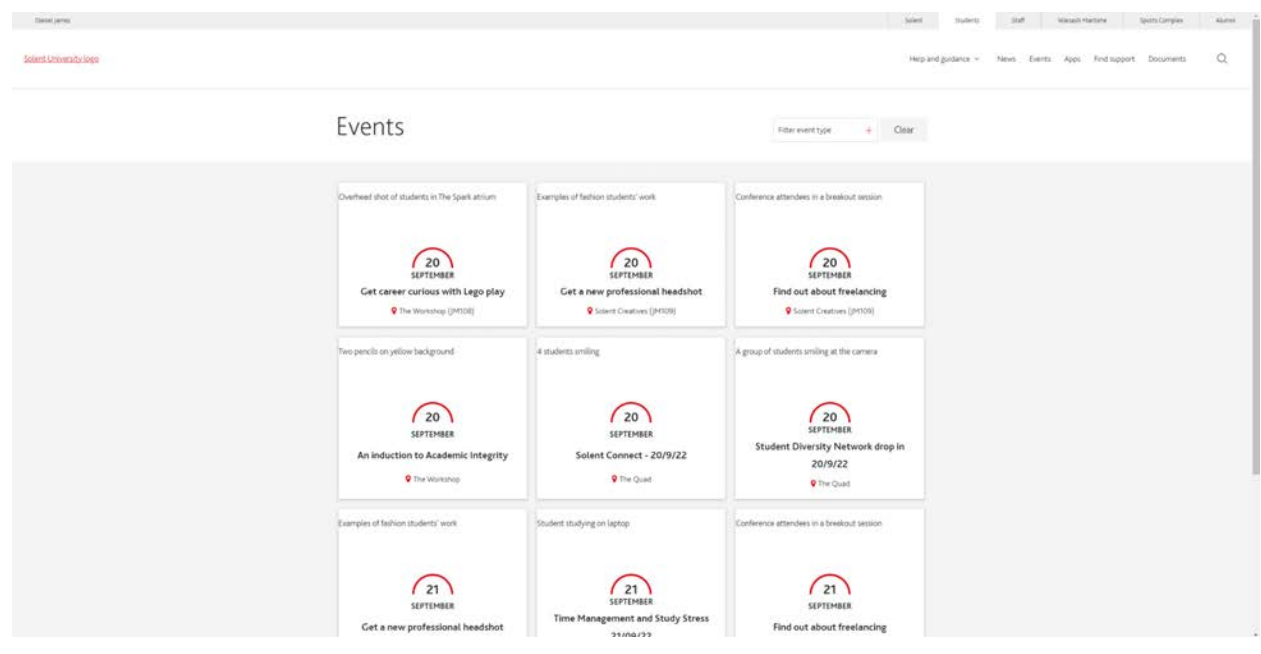
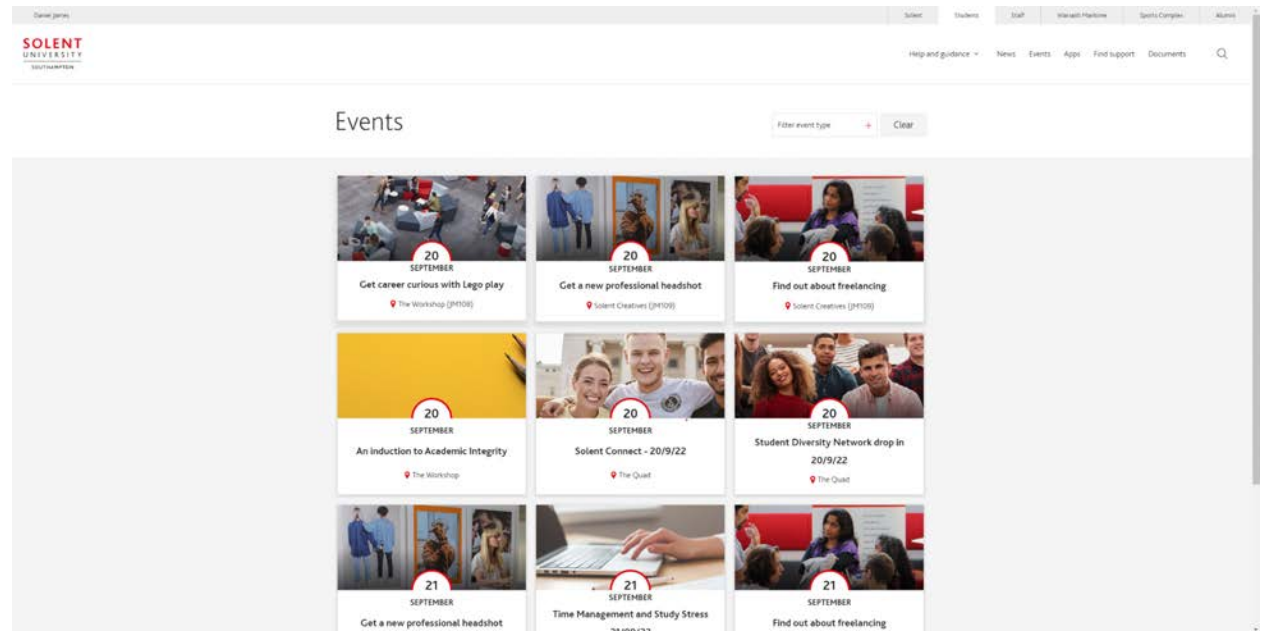


Figure 28: Remove image option

The remove image mode is designed as simple as all the other options, and it removes all images and relapses them with the alt text for the images. This can be seen below in the figure 29, Which shows the preview of the website with the images and post, after the “remove images” button is pressed. It is important to consider how the alt text will not be placed, if there was none given by the developer. But this can be prevented in the future with the googles auto description ai, as discussed above in the “Alternative text” sub section.



Figure 29:



#### 4.8.9 Change Font Option

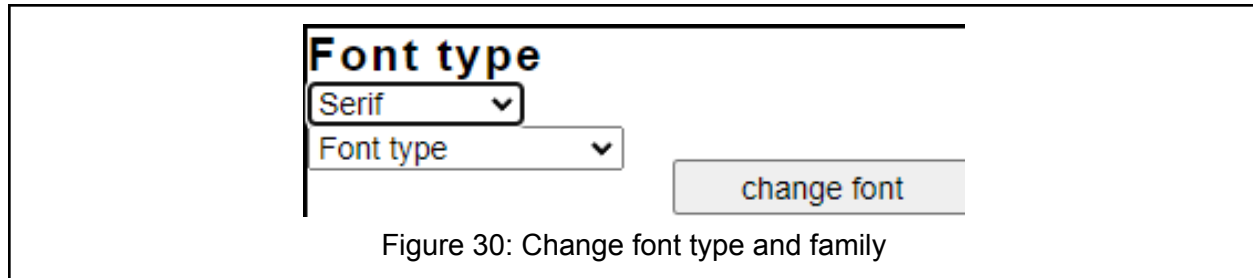
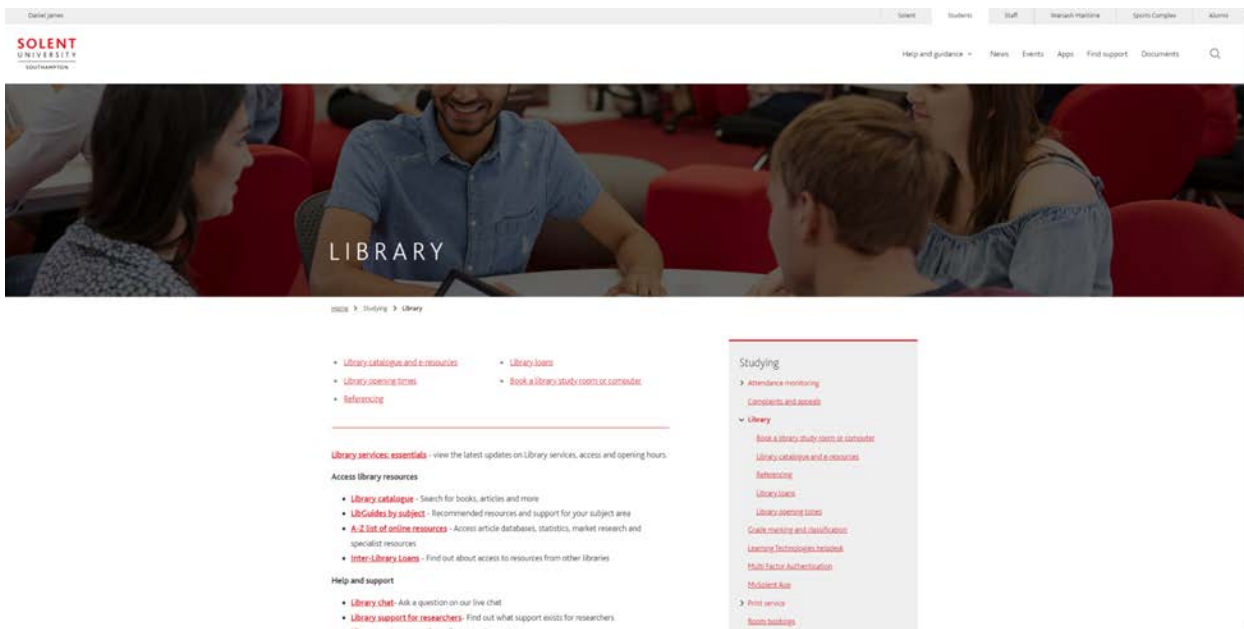


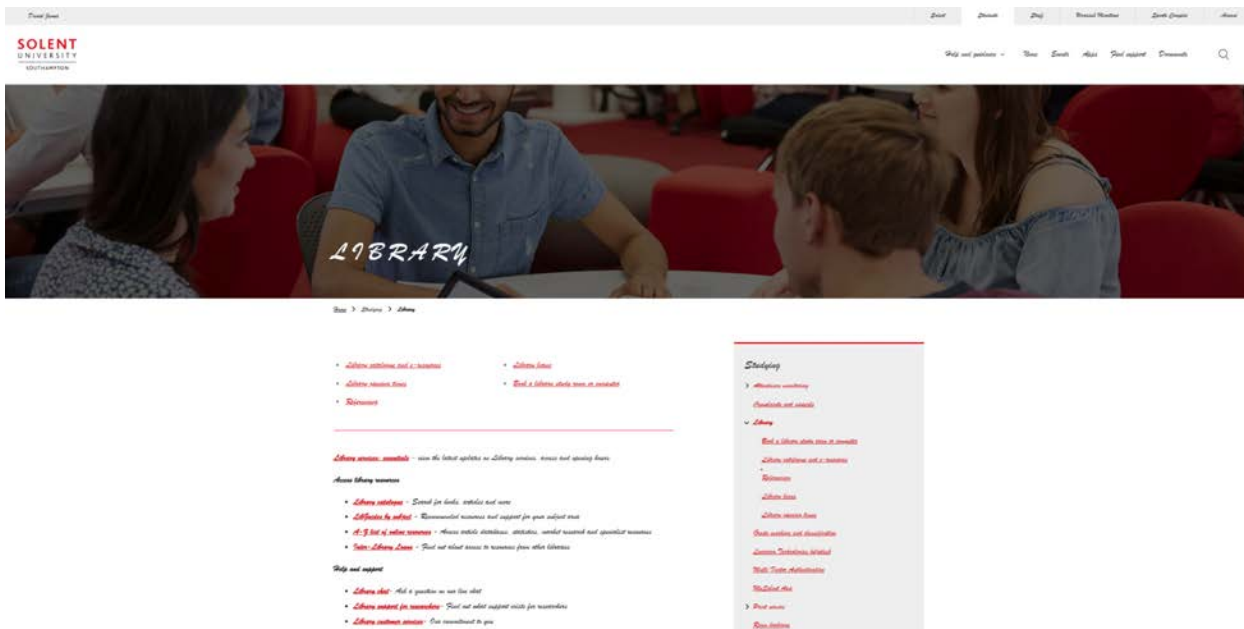
Figure 30: Change font type and family

Changing fonts is made easy using this option as it enables the users to use all the fonts that are available with the content script of the html. First the user must choose the font family, then the user will be presented with a second option to choose the “font type”. Followed with pressing the button will result with the font being changed for the whole website. The example of this can be seen below in figure 31. Future updates could add more font family and types to the system to be useful for a diverse user base.

Figure 31: change font option



Default website font.



Website font set to Cursive cursive brush script font.

## 4.9 Evaluation of results

### 4.9.1 Assessment Information

A team of 41 anonymous users has conducted a review on this extension created in this dissertation. It would have been favourable to have a particular set of participants with known visual conditions such as colour blindness or cataracts. But due to the cost and timeframe of this study; the participants will be chosen at random. Information regarding this evaluation will be provided in the following section. To get the test users started with the extension's testing, a user manual had been prepared and sent to them. The user guide is provided below. Appendix A contains the evaluation form that was given to the test users to complete after they had a chance to try out the extension.

### 4.9.2 User manual

The user guide provided to test subjects is this one:

- Sidebar:  
A little icon will appear to the right of the address bar after the installation of the extension. It opens the extension popup (graphical interface) when clicked. You will hear a prompt saying, “visual aid extension open”, when it is opened. If you switch to a new page, the sidebar will not remain open.
- The popup:  
When you have opened the popup. You will see multiple options named accordingly.
  - Option 1 Change Font size: There is a range slider positioned on the top right of the popup. This can be used to insert the value you want. The value of the range slider can be seen in the bottom left of the font size block. After the value has been decided, simply click the button “change font size” to apply the changes. This can be done as many times as possible to reach your preferred font size.
  - Option 2 Different colour modes: There are 4 different colour modes. These will change the background and font colour of any websites. Simply pressing the button for the preferred colour mode will change the website. The different modes range from:
    - Protanomaly Mode
    - Deuteranomaly Mode
    - Tritanomaly Mode
    - Black and White Mode
  - Option 3 Remove images: This option removes all loaded images from a website, if the “remover image” button is pressed.
  - Option 4 Change font: To change the font of any website; simply go to the last option of the popup. Click the drop-down menu for the “font family” and choose the one that is preferred. This will enable you to choose a second drop down

menu to specify the “font type” that is needed. After the font family and type is chosen. Follow it up by clicking the “change font” button, which will change the font.

#### 4.9.3 Predictions

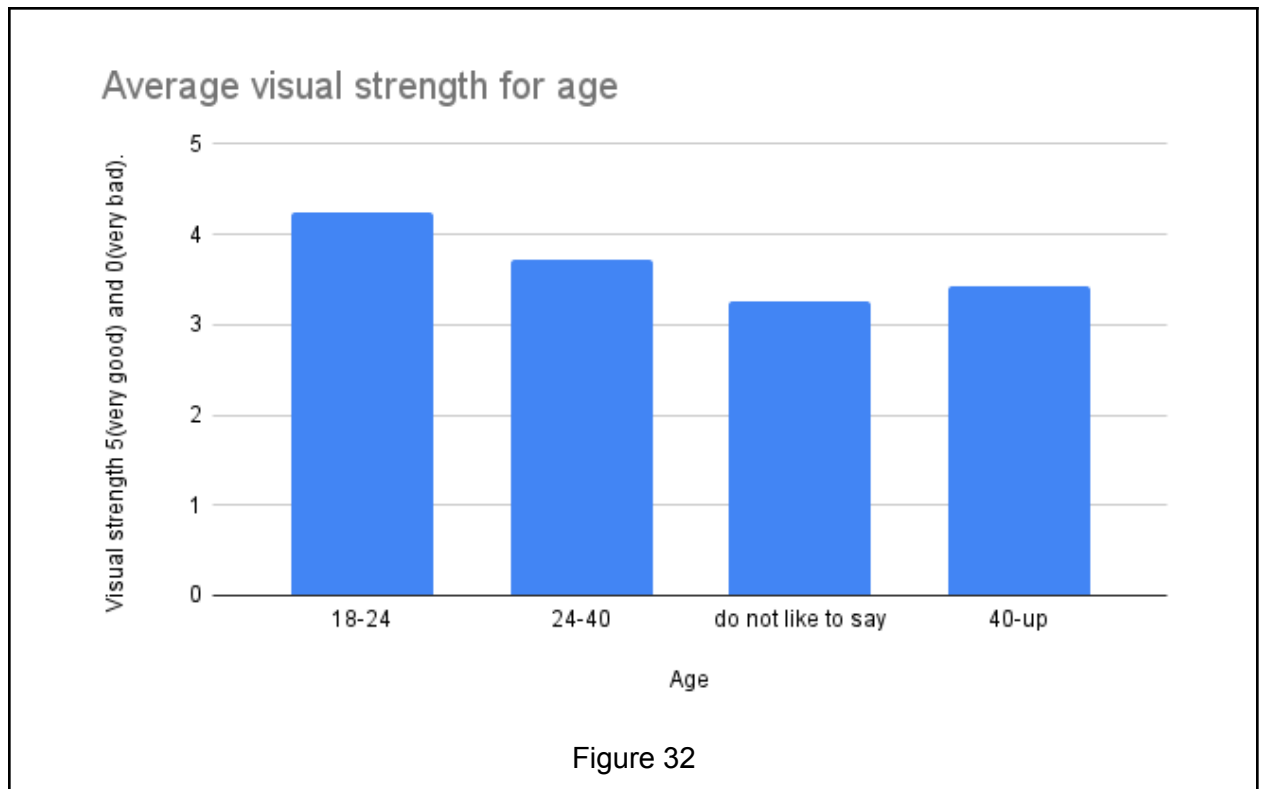
- Overall, the extension will be useful, as it has a number of useful functions in one place.
- Most of the participants with perfect vision will not find the extension as useful as visually impaired.
- Users with perfect vision will find the extension to be simplistic and boring aesthetically.
- Visual strength will positively affect the effectiveness of the extension.

#### 4.9.4 General information

The users participating in this test will remain anonymous for privacy reasons. The only personal data that would be collected is their age range, visual strength and conditions related to vision. The following syntax is used to indicate direct quotes from test users: "quote from test user." With the exception of some spelling corrections, the test users' quotes are almost identical to the response they provided on the evaluation form. Answers that are not written in English, would be translated in an effort to preserve their meaning.

#### 4.9.5 Visual strength and Extension

This study found that there was a correlation in the age and the visual strength of the users. This can be seen in the figure 32 bar chart. It illustrates how anyone that had an age range above 40 had a visual strength below 3.5 out 5. Which should consequently show the usefulness of the extension for older users. This is due to the extension being aimed at visually impaired users and figure 32 shows how there is a higher chance visual strength decreases as you age. This is further seen in the study by Burton *et al.* 2021 and Steinmetz *et al.* 2021.



The correlation for the visual strength and the need for such extension can be seen further in the figure 33 chart which establishes the idea that the extension was indeed useful for the more visually impaired. This can be seen in the increase in usefulness scale in contrast to the visual strength in the said chart. This can also tie in to the hypothesis, which states that the visual aid extension will help visually impaired users. The reasoning for this could be related back to the preliminary pilot study (Pilot study Result Evaluation page), which showed a lack of usage of the WCAG 2.0 in websites; hence leading users to turn to other options like extensions to fill in the gap. This is important to look at as this data indicates how 16 people, which is 39% percent of the participants have visual strength below 4. These users potentially, may not be able to navigate through each website without some kind of aid just due to their visual condition. Concreting the need for better contrast, larger fonts and maybe even different fonts, which the visual aid extension provides.

Moreover there were 26 users that found the extension useful, 1 very useful and 11 users found average in the useful scale. This shows a clear need for such extension or better implementation of the WCAG 2.0. On the contrary 3 users found it “not useful” to use the extension and looking at the data shows how they have a really good visual strength ranging from 4 to 5 (figure 33).

### Extension usefulness compared to visual strength.

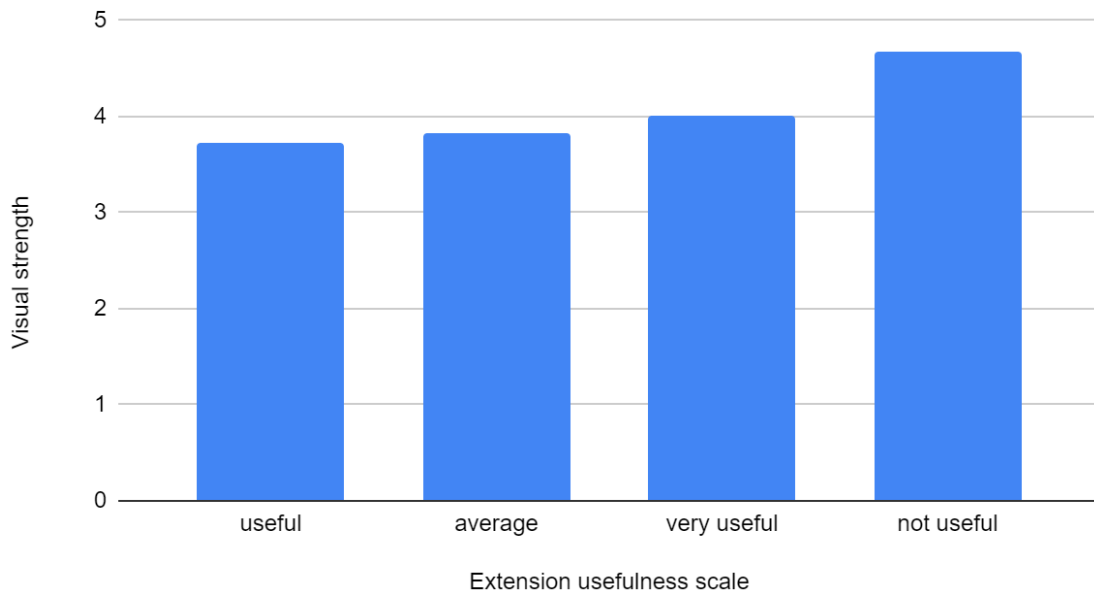


Figure 33

#### 4.9.6 Specific Visual Conditions

The form also asked the participants to write down any visual conditions they have. This is important, as it enables better understanding of the use of the extension. For example in table in Figure 34, there is mention of 2 participants with colour blindness and 3 others with specific colour blindness. Namely protanomaly, tritanomaly and deuteranomaly which are all types of colour blindness which affect colour recognition in different colours. By looking at the appendix B (highlighted in blue); it can be seen that these users found using this extension useful. Furthermore, look at their answer for “whether they found the colour blind mode useful”; show how 3 of the colour blind participants found the mode very useful and 2 found it useful. This is not conclusive evidence of the extension working for all colour blindness, but it does give merit to the idea of the creation of the extension. This is further enforced by the comment by one of the colour blind users which stated that “the font change was pretty neat, and the contrast change really helped with the reading.”

On the other hand nearly 27 people have stated to have no visually deteriorating conditions, which is 65.85% percent of the participants. But this may be simply due to the fracking of the question, not taking into consideration the visual strength of the user. As some of the users that said they had no visual condition stated that they had visual strength of 3 or 2 which is weak. Exhibiting that users do not see lower visual strength as a visual condition.

Figure 34:

3.Any visual related condition if any (e.g colour blindness, Trypophobia etc).	Count of Timestamp
None	27
Trypophobia	4
Presbyopia	2
Colour blindness	2
Protanomaly	1
Tritanomaly	1
bad eyesight from young	1
Cataracts	1
bad eyesight	1
Deuteranomaly	1
<b>Grand Total</b>	<b>41</b>



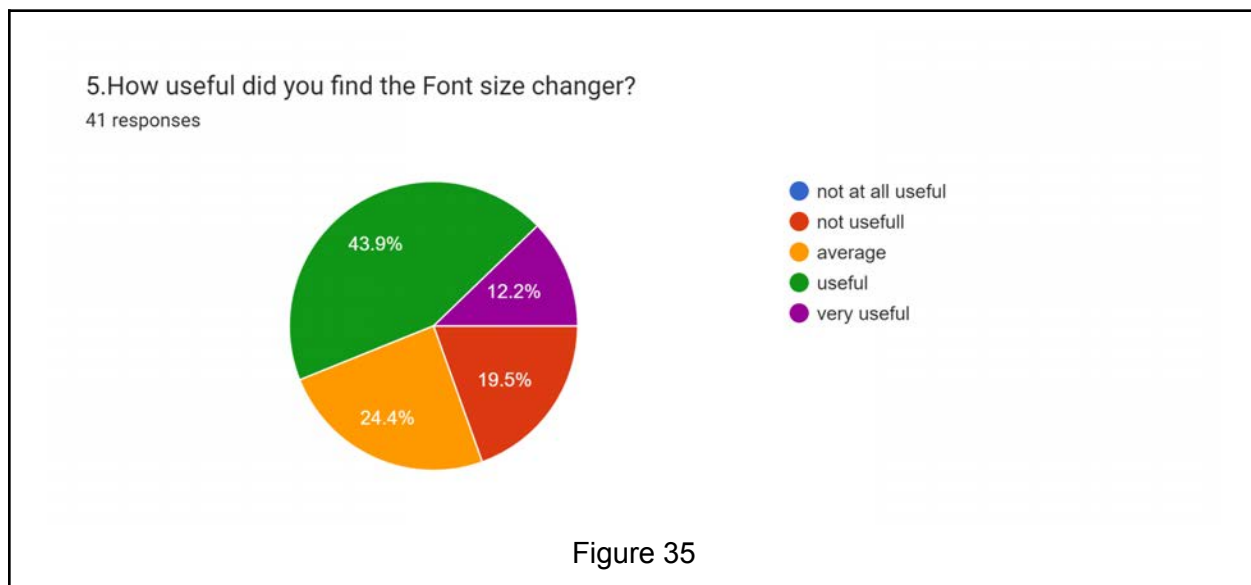


#### 4.9.7 Extension evaluation results

##### 1. How useful did you find the visual aid extension?

- The font size changing attribute was found useful by 43.9% percent of the participants and 12.2 % percent participants found it very useful (figure 34 below). This can be combined with the analysis above (Visual strength and Extension), which showed there were 16 users that had visual strength below 4. Which would have found this font charger useful. This is further backed up by 9 comments by the users, which indicated the font size changer as an helpful attribute of the extension.

On the contrary 19.5 percent of the users did not find the font enlarger helpful. The data illustrates how out of 7, 6 of the users that did not find it useful had a visual strength above 4, leading them to not need the font size changer. There was a single outlier that had visual strength of 3, This could be due to a number of reasons such as having prescription glasses to cobalt the visual strength at all times, use of other font enlargers etc.

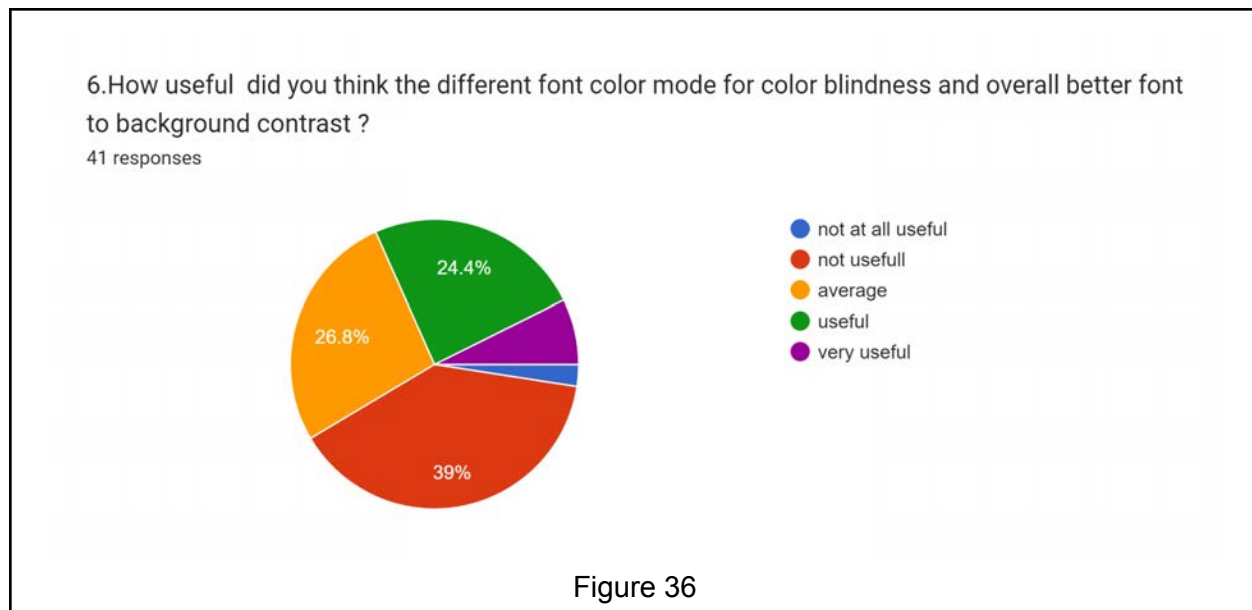


2. How useful did you think the different font colour mode for colour blindness and overall better font to background contrast ?

- Looking at figure 34 above we can conclude that there were 5 users in need of the colour blind mode. But the data in Figure 35 indicates a majority liking the different colour modes. This is due to the contrast that the colour modes give between the font and background of each website. With 13 users commenting on how they favour the “black and white” mode as one of the best attributes of the extension. The reasons given were linked to how it increased the “contrast”. This is a positive outlook for the extension due to it achieving the goal it set out to do.

On the contrary there was 39 percent of the users that did not find the colour modes useful. This can be in correlation with how the majority of users do not have any colour blindness. Hence do not wish to make their website plain and boring graphically.

Lastly two of the users that stated that they did not find the colour mode useful commented on how they liked the black and white mode. With one of the stating “the size changer and the black and white colour changer as it helped me to get better contrast. Enabling me to read even if I forget my glasses.” This is an outlier and might be due to the users not correlating colour modes with black and white. But this comment is important to look at as it indicates usage cases and scenarios that might prompt the need for such extension. This is in contrast with a majority of websites in the pilot study that was found to have a lack of contrast (appendix A) according to the WCAG 2.0; reinforcing the necessity for the extension.



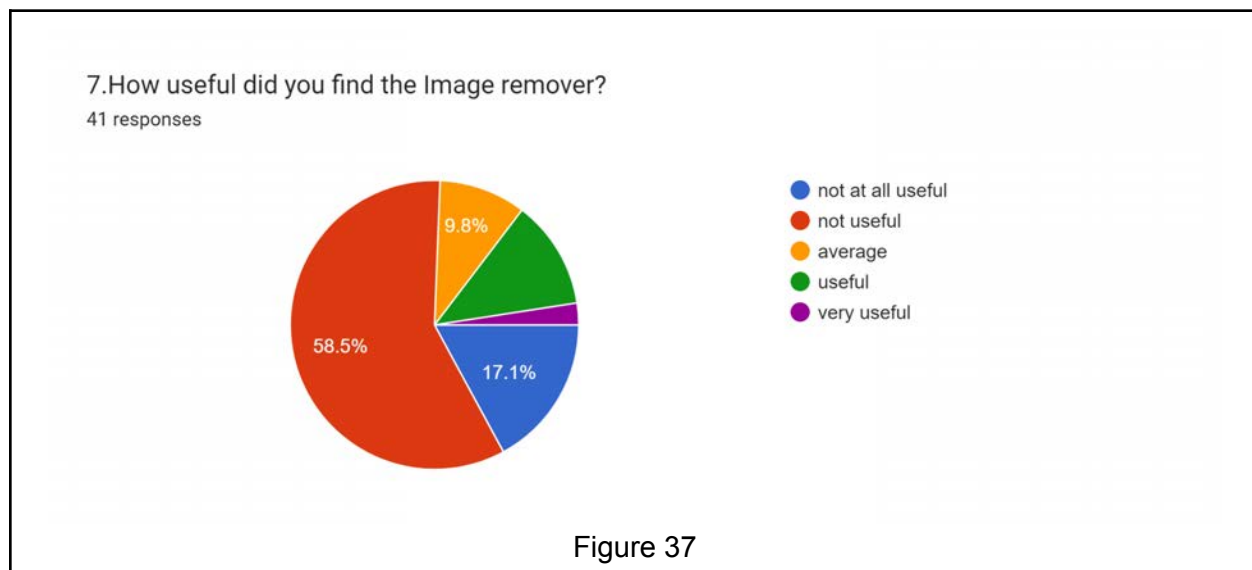
### 3. How useful did you find the Image remover?

- There were 6 people in total that found removing all images from the website useful, which is a total of 14.6% of the users. Furthermore in those 6, one user found the image remover particularly useful.

There were 4 users with “tryphobia” enlisted above in figure 34 above. As such the result for usefulness for the image remover is consistent with the narrative that the extension is helping to enhance the visual experience of those who have visually related conditions.

In the pilot study there were multiple websites where the “element's background colour could not be determined due to a background and image”. This will help combat this problem as the removed images will be replaced with the alt text given by the developer and it will not interfere with the colour recognition of a screen reader.

The comment by one of the participants said that, “The black and white mode made it easier to read. Removing the images seems like a nice feature as you can just concentrate on the text.”. This indicates a second usage case scenario for removing images. A scenario where the user does not want to be distracted by images, e.g. studying, working etc..

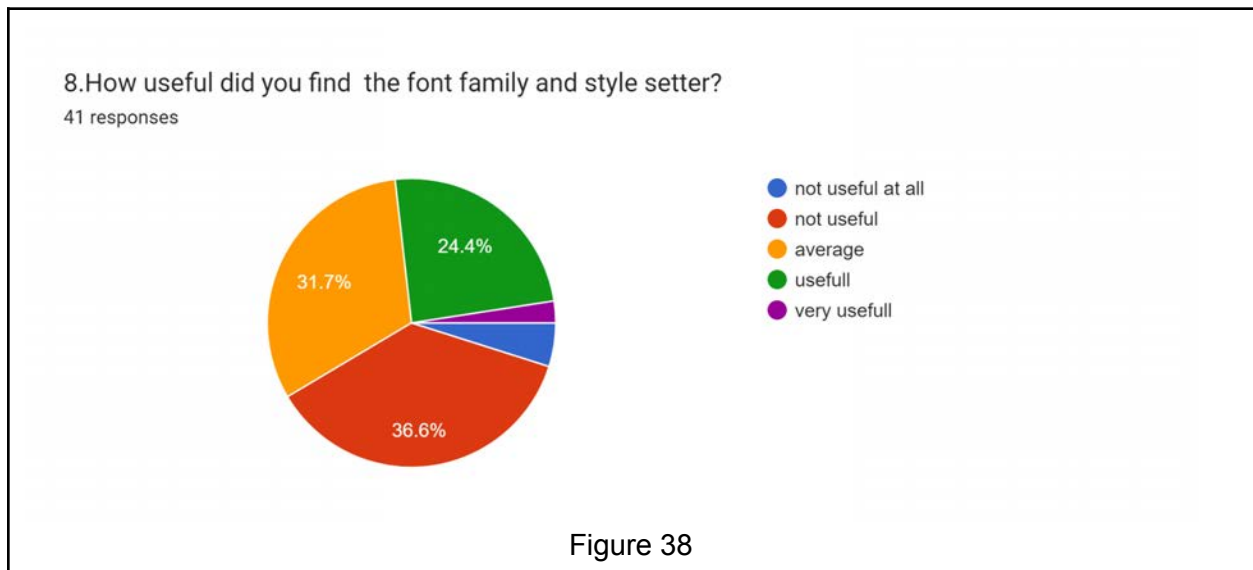


4. How useful did you find the font family and style setter?

- The font changer can be seen to be useful for a total of 26.8% of the users, equating to 11 users. The font changer was aimed at users with dyslexia, but figure 34 has no users with dyslexia stated shows that the extension has not reached the intended target in this study. Making most of this result redundant. Regardless, 11 users still found this feature to be useful and out of the 11, 9 of the users had visual strength above 4. This could be due to the users using the font changer to stylise the website to their preferred font. This is still a helpful feature, as it helps to create a better experience.

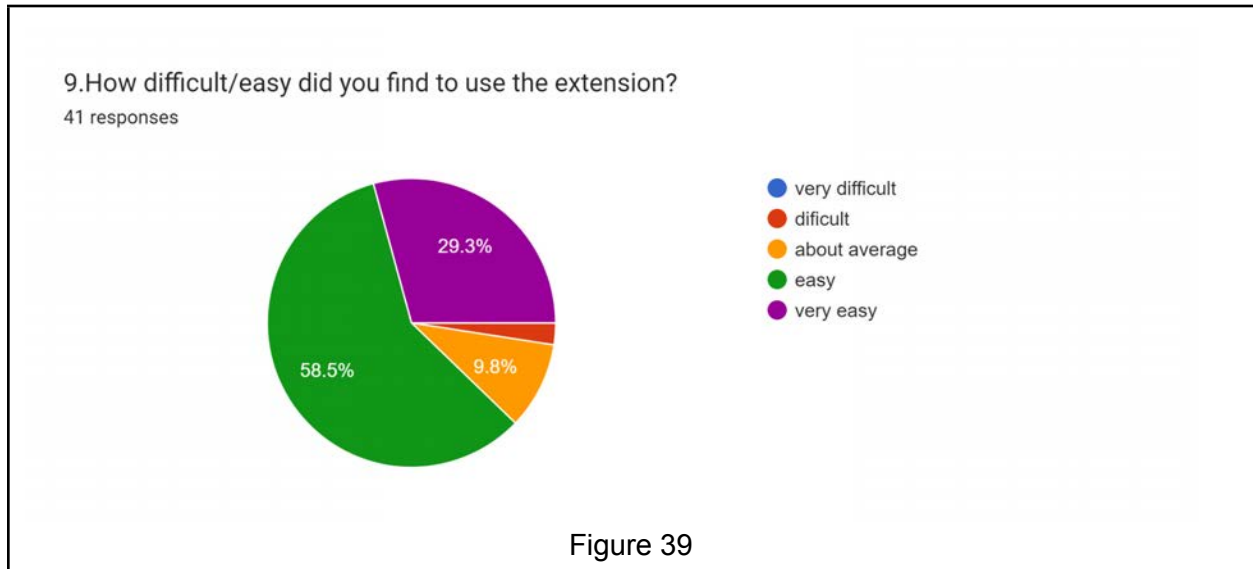
On the other hand, a large number of users found it to be average on the useful scale. The reasoning for this was not commented on by any of the participants. But logical reasoning, such as there is a lack of variety in the font family, could be one of them or most websites already have a good font selection. Still, 13 users that scored it “average” shows that it has useful attributes.

This font changer also has the lowest amount of “not useful”. attributing to the fact that the font changer was useful for the majority in terms of aesthetics but not in terms of visual aid.



5. How difficult/easy did you find to use the extension?

- The extension was found to be easy to use for the majority of the users. With 24 users saying it was “easy” to use and another 12 stating that it was “very easy”. Giving an overwhelming majority found it easy to use. Only one user above 40 found it hard to use. This may be due to the fact that the user is not familiar with the technology. The user also stated how they found it “It was hard to understand the modes.” Further illustrating the fact that the user may not know how it works. Regardless, the easy use of this extension goes to the simplicity of the design.



6. Recommended additions or changes to the extension from users included:

- a. “If it could auto detect some colours and change it”
  - This suggestion indicates a need for an auto-detect function that changes the colour of the website depending on how colour blind friendly it is. Indicating the further need for such extensions and reinforcing the purpose of this dissertation.
- b. “Having other contrasts would have been great.”
  - The lack of choice in the type of contrast can be resolved by enabling the user to pick a colour of their choice for the background and font. With the use of a range bar.
- c. “It would have been better if it was more aesthetically pleasing.”
  - This extension is not there to be pleasing for the eyes. On the contrary, it is to help accommodate more users with various visual irregularities. As such, it is important to keep it simple.
- d. “The app font could have been bigger”
  - The extension icon being small is a problem that is hard-wired into the chrome extension. This can only be solved from chrome, the browser side.

- e. "It was difficult to see the images before activating the app, so it would be better if I could change the setting before entering the website."
  - This comment is also in line with other comments suggesting the extension to scan the web page beforehand and stop any specific type of images or all images. This needs more time and expertise to develop, but it is possible with image recognition technology like google lens.

#### 4.9.8 Similar products

There are other products that are similar to this visual aid extension. For example, there is an extension called "Font changer plus"(Ana Watkins 2020). This extension focuses just on the font and gives deep customisation of fonts in every website. However, it does not have various features such as font changer, colour modes, remove image etc.

Another example would "accessibe 2022". This is a subscription service for web developers, and it helps to meet all the WCAG 2.0 standards. This includes image remover, dyslexia mode, focus mode, different colour modes etc. But the expense of such a subscription is always out of the reach of common web developers and companies. Therefore, the visual aid extensions are a free substitute for such services for the aid of the common users.

#### 4.9.9 Result Summary

The results conclude that the extension was useful in multiple ways for different visually impaired users. It showed how age correlated with visual strength (Figure 32) and how the lower visual strength users found it more useful than those with good visual strength. These two results are enough to cover the dissertation's purpose. The purpose is to determine if the extension helps discriminant users with visual impairment. This is further backed up by four users that had colour blind and found the extension to be very useful.

It can also be noted that the font size changer was the most useful out of all the extension features. This was due to the number of users suffering from basic visual loss. This extension enabled these users to browse the web without their perception glasses.

On the contrary, specific features like the different colour modes and image removers were found to be not so useful for the majority. This is since these features were made for specific visual conditions and will only help such conditions to the best. Normal users can still use it, but they will not find it as useful.

The results also indicated that the extension might not be perfect in all aspects of its future. As one of the users commented on how the extension should save the user's setting of the extension for all the websites. These are aspects that could have made it an even better experience for the users.

#### 4.10 Extension analysis

There are multiple visual impairments, and the standards, such as the “WCAG 2.0” tries to control all websites to accommodate the majority of them. However, it is not practical for the “W3C” to control and filter every single website. Therefore, in this chapter, the visual aid extension was designed and made. This chapter went through each thought process such as the hardware, visual design, accessibility, system design etc, and made sure to include all aspects of the reasoning behind the extension.

Leading from the reasoning behind the extension, this chapter went on to analyse the extension with user evaluation. This evaluation lent itself to fulfilling the purpose of the dissertation to create an extension that helps to combat the lack of usage of “WCAG 1.0,2.0” established in the pilot study of this dissertation and improve the quality of life for the visually impaired.

#### 4.11 Dissertation Purposes.

This dissertation was intended to analyse modern-day web development and how it accommodated disabled users. This intent was split into two parts. The first is by looking at the usage of “WCAG 1.0, 2.0” issued by W3C. The exploration of this question led to the literature review that concluded that there is a lack of accessibility for many with disabilities and visual impairments. The studies by Hortizuela 2022 and the study by Rajaselvi 2022 are examples showcasing the lack of utility of the internet for the disabled.

Further exploration of this led to using a combination research methodology to explore this concept. The pilot study, which tested multiple websites, was the conclusive research that was used to answer the first part of this dissertation. This concludes that multiple websites lack usage of the WCAG guideline.

The second part of the purpose of the dissertation lies in creating a remedy for such a problem by using the Chrome extension and further analysing if it enables better usage of web pages by users with disability. This was done through surveys. In the end, the creation of the extension was found to be helpful. Nevertheless, there were still improvements that could have been made. Regardless, as an initial product of the short time of research, the visual aid extension proved to be an effective remedy for the lack of usage of the WCAG guidelines.



## 5. Conclusion

One of the most important problems facing the online community is web accessibility. This online platform is protected by multiple policies and guidelines, but not all developers fully design it to the standard. Due to this, disabled users suffer several accessibility-related issues that limit their usage of the website, which may have an impact on both their ability to enjoy equal rights and the organisation's financial success. This dissertation examined the detrimental effects of web accessibility issues and critically considered the core issues connected to it, mainly focusing on visual disabilities and further creating the visual aid extension as the solution. The free online add-on to the Chrome browsers has been shown to help users with different types of visual disabilities. The extension provided an easy-fix solution for a limited amount of problems. The extension relies on pre-existing platforms and technology to control and personalise any website for the personalisation of all users. The reliability of this fix can be seen from the feedback on the extension from the survey. This dissertation also concluded how developing visual aid extensions through user feedback could help even more people.

### 5.1 Ethical clearance

No personal data has been collected in this research. Any data will only be used for the benefit of the making of the extension.

# Ethical clearance for research and innovation projects

Project status

Status

● ● ● Approved

Actions

Date	Who	Action	Comments
14:30:00 22 September 2022	Kalin Penev	Supervisor approved	
14:18:00 22 September 2022	Daniel James	Principal investigator submitted	

## Ethics release checklist (ERC)

Project details

Project name:

Principal investigator:

Faculty:

Level:

Course:

Unit code:

Supervisor name:

Figure 40 - Ethical Clearance for research (Approved).

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## Appendix A

1.Age

- 18-24
- 24-40
- 40-up
- do not like to say

2.Visual strength

- 1   2   3   4   5
- very bad(need high power glass to see)                  very good(can see very well)

3.Any visual related condition if any (e.g color blindness, Trypophobia etc).

Your answer \_\_\_\_\_

4.How useful did you find the visual aid extension?

- not at all useful
- not useful
- average
- useful
- very useful

5.How useful did you find the Font size changer?

- not at all useful
- not usefull
- average
- useful
- very useful

6.How useful did you think the different font color mode for color blindness and overall better font to background contrast ?

- not at all useful
- not usefull
- average
- useful
- very useful

7.How useful did you find the Image remover?

- not at all useful
- not useful
- average
- useful
- very useful

8.How useful did you find the font family and style setter?

- not useful at all
- not useful
- average
- usefull
- very usefull

9.How difficult/easy did you find to use the extension?

- very difficult
- difficult
- about average
- easy
- very easy

10.If you found it difficult; what would you improve?

Your answer \_\_\_\_\_

11.Is their any attributes that you would like to add to the extension?

Your answer \_\_\_\_\_

12.Is their any attributes that you liked about the extension?

Your answer \_\_\_\_\_

Appendix B :

Visual aid extension evaluation form Results.

Timestamp	1.Age	2.Visual strength	3.Any visual related condition if any (e.g colour blindness, Trypophobia etc).	4.How useful did you find the visual aid extension?	5.How useful did you find the Font size changer?	6.How useful did you think the different font colour mode for colour blindness and overall better font to background contrast?	7.How useful did you find the Image remover?	8.How useful did you find the font family and style setter?	9.How difficult/easy did you find to use the extension?
9/6/2022 0:13:20	18-24	5	Protanomaly	useful	average	useful	not useful	not useful	very easy
9/6/2022 0:15:05	24-40	4	None	useful	useful	not at all useful	not at all useful	useful	very easy
9/6/2022 0:19:58	do not like to say	1	Cataracts	average	useful	not useful	not at all useful	average	about average
9/6/2022 0:38:01	24-40	4	Deuteranomaly	useful	useful	very useful	not useful	average	easy
9/6/2022 0:39:44	18-24	5	No	average	average	average	average	average	about average
9/6/2022 0:44:41	24-40	4	Colour blindness	very useful	useful	very useful	not useful	not useful at all	very easy
9/6/2022 0:51:49	24-40	2	Presbyopia	useful	useful	not useful	not useful	not useful	easy

9/6/2022 0:55:30	40-up	4	Trypophobia	useful	not useful	not useful	useful	not useful	easy
9/6/2022 1:06:13	18-24	4	Tritanomaly	useful	average	very useful	not useful	not useful	easy
9/6/2022 1:13:02	18-24	3	None	useful	very useful	not useful	not useful	useful	about average
9/6/2022 1:27:51	40-up	3	No	useful	useful	average	average	useful	difficult
9/6/2022 1:31:23	24-40	5	no	average	average	not useful	not useful	average	easy
9/6/2022 1:36:52	40-up	4	N/A	not useful	not useful	not useful	not useful	not useful	easy
9/6/2022 1:41:19	18-24	5	Nothing	not useful	useful	not useful	not useful	not useful	very easy
9/6/2022 1:48:24	18-24	4	Trypophobia	useful	not useful	not useful	very useful	not useful	easy
9/6/2022 1:48:55	24-40	2	bad eyesight from young	useful	very useful	not useful	not useful	not useful	very easy
9/6/2022 1:50:43	40-up	2	n/a	average	useful	useful	not at all useful	very useful	easy
9/6/2022 1:56:34	40-up	5	None	useful	useful	not useful	not useful	useful	very easy
9/6/2022 1:57:56	do not like to say	5		not useful	not useful	not useful	not useful	not useful	very easy
9/6/2022 2:05:03	18-24	2	Presbyopia	useful	very useful	average	not at all useful	average	easy
9/8/2022	18-24	4	No	useful	useful	useful	useful	useful	easy



15:20:3 7									
9/8/202 2 15:38:2 2	24-40	4	None at the moment	useful	useful	useful	not useful	not useful	very easy
9/8/202 2 15:39:3 7	40-up	3	No	average	not useful	averag e	not useful	not useful	easy
9/8/202 2 15:44:4 2	18-24	5	Trypoph obia	useful	average	averag e	useful	average	very easy
9/8/202 2 15:48:5 6	do not like to say	2	No	useful	very useful	averag e	not useful	average	very easy
9/8/202 2 15:51:3 6	40-up	3	No	useful	very useful	useful	not at all useful	not useful	easy
9/8/202 2 15:53:1 5	24-40	4	No	useful	useful	not useful	not useful	useful	easy
9/8/202 2 15:55:3 9	24-40	3	No	useful	useful	averag e	not at all useful	not useful at all	easy
9/8/202 2 15:56:4 2	18-24	5	NO	average	average	not useful	not useful	average	easy
9/8/202 2 16:00:0 7	24-40	5	NO	useful	useful	not useful	not useful	not useful	easy
9/8/202 2 16:04:4 5	24-40	5	None	useful	useful	useful	not useful	useful	easy
9/8/202 2	18-24	4	NO	average	not useful	useful	average	useful	about average

16:07:08									
9/8/2022 16:13:45	24-40	4	Trypophobia	useful	average	average	useful	average	easy
9/8/2022 16:14:43	18-24	5	None	useful	not useful	average	not useful	average	easy
9/8/2022 16:26:23	18-24	5	No	average	average	useful	not useful	average	easy
9/8/2022 16:43:07	24-40	4	None	useful	useful	not useful	useful	useful	very easy
9/8/2022 18:03:54	24-40	2	bad eyesight	useful	useful	not useful	not useful	average	very easy
9/8/2022 18:05:47	do not like to say	5	Colour blindness	useful	average	useful	not at all useful	not useful	easy
9/8/2022 18:09:05	18-24	4	No	average	not useful	average	not useful	useful	easy
9/8/2022 18:10:49	18-24	3		average	useful	average	average	average	easy
9/8/2022 18:13:09	18-24	5	n/a	average	average	useful	not useful	not useful	easy