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Improving Cognitive Web Accessibility: Can cognitive accessibility become a part of Universal Design?

by

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"For most people, technology makes things easier. But for people with disabilities, technology makes things possible. "

- Judy Heumann, Disability Rights Activist

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Abstract

The web has drastically changed the world in the last two decades. The internet has opened many doors for people with disabilities. United Nations have argued that equal access to the internet is a basic human right. However, the internet even when it is present remains inaccessible to many. Many people with cognitive disabilities lack the social skills, mental and physical ability to explore the world in 'regular' ways. With the help of the internet, they can interact and communicate with the world sitting behind a screen. Unfortunately, web accessibility has been lacking guidelines that specifically cater to cognitive needs. The applications of universal design are being adapted in various fields to make designs more inclusive, but can similar design principles help cognitive web accessibility too? The research paper discusses the shift in perspective for disabilities, the origins and importance of universal design and how its principles can be helpful for people with cognitive limitations.

This study attempts to answer the research question by a qualitative approach. It explores and analyzes existing research on cognitive disabilities, universal design and web accessibility. It suggests some improvements in the existing web accessibility principles and guidelines that can possibly make cognitive accessibility follow universal principles. It employs a case study to test with practical examples the proposed guidelines and new principles and comment on existing cognitive accessibility standards.

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Abbreviations

W3C	**W**orld **W**ide **W**eb **C**onsortium
UD	**U**niversal **D**esign
WHO	**W**orld **H**ealth **O**rganization
CD	**C**ognitive **D**isability
ASD	**A**utism **S**pectrum **D**isorder
ADHD	**A**ttention **D**eficit **H**yperactivity **D**isorder
WAI	**W**eb **A**cessibility **I**nitiative
WCAG	**W**eb **C**ontent **A**cessibility **G**uidelines
POUR	**P**erceivable **O**perable **U**nderstandable **R**obust
INIS	**I**rish **N**aturalisation and **I**mmigration **S**ervice
DSI	**D**own **S**yndrome **I**reland

Chapter 1

Introduction

1.1 Background and Context

"The power of the web is in its universality. Access by everyone regardless of disability is an essential aspect" [2], says Tim Berners-Lee, the director of World Wide Web Consortium (W3C) and the inventor of the world wide web. The web has been a radically helpful for people with disability by removing the roadblocks in terms of interaction and communication. Unfortunately its presence does not guarantee its accessibility. Most of the times, websites cater to the general population, which is not disabled. In order to make the user interface appealing, it is often made complex. Moreover, websites are not just text and image based. With the introduction of new features like animations, 3 dimensional visuals, retro typefaces and various multimedia experiences every now and then, it is essential to keep a check on the guidelines and revise them. The understanding of disability has come a long journey and with more research in the area guidelines are being revised by the W3C [3] frequently, the paper tries to understand current situation of cognitive accessibility.

1.2 Research Question and Methodology

This paper attempts to answer the research question:

"Can cognitive accessibility become a part of Universal Design?"

In order to reach the answer, understanding disability, problems faced by the target audience and what universal design might have to offer is foremost. It introduces some other questions like, how is the present situation in cognitive accessibility? Why might there be a need to merge cognitive accessibility with universal design? To answer these questions, this research paper uses a qualitative research methodology since the aim can be achieved using existing reviews and studies done by experts in the field of cognitive disabilities, web accessibility and universal design. The study aims to do a careful analysis of these topics, and find limitations in the existing system. The motivation of the research is to understand and apply the results found by the analysis to existing websites. This will help reach the ultimate goal of this paper by identifying if the results are practically implementable and usable.

1.3 Chapter Outline

This paper contains six chapters including an introduction, findings and reflection, practical examples via case studies and a conclusion. Chapter 1 gives an introduction of the whole paper and introduces the motivation behind the research and the goals it aims to achieve. Chapter 2 provides a viewpoint in disabilities, introduces cognitive disabilities and its different types. It then discusses the best way to categorize their problems. Chapter 3 presents the Universal Design concept, its origins, principles and importance. Further, chapter 4 discusses the existing web accessibility principles and examines these against the universal design principles. It analyses and reflects on the review done in previous chapters and introduces a new set of guidelines to improve existing principles. Chapter 5 implements these new guidelines and showcases practical examples of some good and bad practices. At last, chapter 6 presents a vision for future research and concludes the paper.

Chapter 2

Cognitive Disabilities and Problems faced

2.1 Introduction

This chapter presents the social stance on disability, discusses the types of disabilities and identifies the various problems faced by them. It investigates a proper way to categorize the problems to be able to address all types of cognitive disabilities. This chapter is organized into five sections. The first section introduces and outlines the chapter, the second discusses a shift in perspective of disabilities, clears the difference between an impairment and disability and observes disability from a social standpoint. The third section covers cognitive disability and it's two main categories. The fourth section explores and categorizes the various problems faced by people with cognitive disability. At last, the fifth section concludes the chapter by summarizing the analysis in short.

2.2 Disabilities - A shift in perspective

Humans vary extensively on their natural abilities [4]. Every person, at some point in their life, will experience a disability of some sort [5]. Many a time, disability is regarded as an individual failing or a personal tragedy. [6] According to The Disability Act (Government of Ireland, 2005), disability is defined as "A substantial restriction in

the capacity of the person to carry on a profession, business or occupation in the Irish State or to participate in social or cultural life in the Irish State by reason of an enduring physical, sensory, mental health or intellectual impairment [7]." To understand this definition correctly, we must understand the meanings of the words impairment and disability. The authors of the book, Handbook of Disability Studies, Braddock and Parish define disability as a social construct. They write that an impairment is a biological condition, for instance, the lack of mobility is an impairment, but an environment without ramps turn that impairment into a disability [8]. Similarly, the lack of accessibility on the web turns the intellectual impairment into a disability.

Many people suffer from invisible disabilities, like deaf people and blind people who don't wear any external aids. Most of the cognitive disabilities are invisible. Before the eighteenth century, impairments were quite prevalent but disability was not really in the picture [8]. In the 1960s, activists started campaigning for a shift in the spotlight from disability being perceived as an individuals incapability to the role of disabling barriers that exclude disabled people from participating in society [6]. The disabled community has been neglected and mistreated for far too long. The first time the morality behind the treatment of cognitively limited human beings became a topic of philosophical discussion was when philosophers challenged complacent beliefs about the morality of various harmful uses of animals, such as raising and killing them for food [9]. The introduction of this new terminology suggests a shift in perspective as we stop looking at the issue as a personal tragedy but a result of social inequalities.

2.3 Cognitive Disabilities

Cognitive disability is when a person has certain limitations in mental functioning and in skills such as communicating, taking care of themselves, and social skills [10]. It involves memory, perception, problem-solving, and conceptualizing challenges. Cognitive impairments are mostly associated to conditions such as Autism spectrum disorder (ASD), attention deficit hyperactivity disorder (ADHD), dyslexia, epilepsy, cerebral palsy or brain injury. They can also include developmental disabilities, pervasive developmental disorders, Rett syndrome, and Williams syndrome which are genetic disorders [11]. Cognitive impairment is neither a contagious condition that can be spread from one person to another, nor it is a form of mental illness like anxiety or depression. There

is no cure for such a condition. However, most people with this disability can learn to do many things. It just takes them more time and effort than others.

2.3.1 Learning and Intellectual Disabilities

Although it can imply a cognitive impairment, not all cognitive disorders imply poor intellectual performance [12]. However, V Cluley argues that intellectual disabilities are a part of learning disabilities[13]. According to Cornoldi, Cesare and Giofre et al. the two can be differentiated by a test [12]. This is generally measured by an intelligence quotient (IQ) test and divides cognitive disabilities into two sub-categories, learning and intellectual disabilities. A classical criterion for diagnosing intellectual disabilities is an IQ below 70 and severe adaptive problems, while people with learning disabilities have average intelligence and poor academic performance [12]. While the intellectually disabled face learning obstacles too, they also struggle with verbal and social skills. However, for people with learning disabilities, the way they process information is affected.

While it is true that very few individuals suffer from Intellectual disabilities, which constitutes 2-3 percentage of the overall world population, a large number of the 'regular' population becomes cognitively disabled at old age [14]. Individuals spend about 8 years of their lives living with disabilities, now that as a result of medical advancements, the average life expectancy in many countries is over 70 years. Alzheimer's and other types of dementia affect up to 20 per cent of people over the age of seventy-five [15]. This reinforces the aim of this paper to bring focus to cognitive disabilities and look for areas of improvement. When most of the people have or will have a cognitive condition, it is important to clear the stigma around it. Understanding the reasoning behind the classification and numbers about these disabilities is important as this will help us in identifying their specific user needs and effectively represent the cognitive disabled community.

2.4 Problems faced by the Cognitive Disabled

2.4.1 How should the problems be categorized?

People that suffer from cognitive disabilities can vary greatly in their type of abilities and disabilities. There are many overlaps even between the intellectual and learning disabilities. Moreover, it is difficult to classify some conditions like autism spectrum, in any of the two categories because of how differently it affects various individuals. What makes this blurred line between autism and intellectual disability murkier is that around 30 per cent of people who are on the spectrum also suffer from intellectual disabilities [16]. Hence, there is a great degree of variation, not just among various disabilities, but within one disability itself [17]. After looking at all these categories and the complexity of the disabilities, I found it is better to categorize cognitive disabilities by using functional characteristics rather than clinical diagnoses. The former perhaps would complicate matters and confuse the web designers and developers and stray them away from solutions.

Bohman and Anderson, who researched extensively on web accessibility for cognitive disabilities [17], propose the use of a taxonomy of cognitive impairments based on functional descriptors like Problem solving, attention, memory, reading and verbal comprehension, visual and mathematical comprehension. Rowland, was in favour of developing only four categories, namely, problem solving, attention, memory, perception and processing [18]. Many of these descriptors are inter-related as explained below. Some of them, like mathematical comprehension seem unnecessary for web design but important to classify cognitive problems. Many of those problems could also be captured in problem solving skills. None of the above categories take into consideration the additional fatigue and physical problems caused by disabilities like down syndrome and cerebral palsy to name a few. Rimmer JH, Heller T el al. explore the cardiovascular fitness, muscle strength and endurance in people with down syndrome [19]. They access that physical activities or effort can cause potential health risks, body weight reduction and sedentary behaviour. Moreover, Emmons P and Anderson L investigate that in children with learning disabilities, ADHD, ASD, the child's delay in response or understanding relates to sensory dysfunction [20]. This sensory dysfunction can be caused by movement, touch, sight or sounds. To account for all such problems, this paper classifies them into six different

classes inspired by both Rowland, Bonham, Anderson and Rimmer et al. Moreover, this study aims to include sensory load in the visual comprehension class and hence, renamed it as visual comprehension and sensory load, which will include both the aspects, visual comprehension abilities and sensory load caused by both visual and auditory elements. Although there are many overlaps even among these categories, they provide a basis with the help of which cognitive requirements can be analyzed.

2.4.1.1 Problem solving

Problem solving is an important quality in almost all areas of life. It entails defining a problem, discovering the cause of the problem, identifying the sub-problems and then prioritizing solutions for the sub-problems and putting the solution into action [21]. Navigating the online world without these skills can be a major hindrance to the people with cognitive disabilities. Many websites are very difficult to navigate through. Problem solving is one of the most important skill when it comes to navigating a website and identifying the easiest and quickest way to reach the desired destination. Woolfolk links the problem with information processing theory [22]. Information Processing theory was developed by American psychologists in the 1950s. According to William Estes, our cognitive functions with the help of short term memory use available information to extract possible solutions and prioritize them based on the different characteristics of those possible solutions [23]. To define a problem, the user first tries to consult the sub-problems to dissect it and get more information. For instance, to get to the opening hours of an art gallery, the user will have to figure out under which section this information might be present. The next step is to identify alternative solutions. For instance, a user tries to go to the footer of the website where important details are summarized in most gallery websites and do not find it there, they must then think of alternative solutions. People who are skilled problem solvers will then evaluate and consider one of these alternatives. This also involves making sure that the alternative will not lead to some unanticipated issues. The last step after prioritizing their alternatives is to follow through and implement them.

Romain Delgrange, Jean-Marie Burkhardt and Valérie Gyselinck in 2020 studied the problem solving in adults with cognitive disabilities and by 'wayfinding' as a cognitive process. Their study was based on adults trying to get around the city for daily activities

and found that people with cognitive disabilities try to guess instead of using a bird's eye view as a spatial problem solving method [24]. The same problem is encountered while structuring a website as the process of reaching the destination on a website can be similar in terms of problem solving as finding a way on the map. Their study found that people with cognitive disabilities were more likely to ask for help to reach their destination. The problem lies with the inability of the cognitive disabled to look at the bigger picture and solve bigger problems by dissecting them because of which they end up relying on others when they were lost.

2.4.1.2 Attention

Attention not a single event, but a continuous complex process. The inability of the cognitive disabled to focus and block out any external stimuli like sound, visuals, flickering images in using the traditional web is a major, yet easily solvable problem. How does lack of attention affect the way they use the web? Interruptions can cause the users to lose sight of what they were doing, decrease their productivity and increase the number of mistakes made during the process [25]. Attention is also a helpful skill while multitasking. While multitasking, the brain does not work in parallel, but it tries to process the information in a serial manner by focusing its attention to different tasks for short periods of time [26]. So, the brain prioritizes, which comes with problem solving abilities, and then executes the solution. This means that our brain does not in reality work on multiple things at a time, but merely focuses its attention back and forth to different tasks. For example, while navigating a website to find the desired information, the brain constantly switches attention to process different types of information. This may end up causing sensory overload. The brain has a cognitive function called inhibitory control which allows a person to filter out irrelevant information and focus only on s specific execution [26]. ASD and ADHD are neurodevelopmental disorders that have 30 to 80 percent overlap between their symptoms [27]. They are mostly characterized by attention and sensory overload problems along with many other behavioural and social traits.

2.4.1.3 Memory

Working memory plays a crucial role in problem solving. Passolunghi and Siegel studied short-term, working memory and inhibitory control in children with learning disabilities and found that the students struggled with mathematical and verbal working memory tasks [28]. Since they have poor inhibitory control, the elimination of noise becomes difficult, making it harder to hold relevant information in their memory [29]. Long term and short term memory most importantly have two crucial differences, temporal decay and chunk capacity limits, whereas working memory is short-term memory applied to cognitive labour [30]. Long term memory is used to store primary and secondary knowledge which is significant for general cognition [31]. Chunk capacity limit is the most amount of information that a working memory can hold. While dealing with the web, people mostly make use of short-term and working memory as long-term memory is just the huge amounts of knowledge that is stored in our brains because of events that have happened in the past. Working memory also affects a person's ability to link images to words, which again is something to be taken in note of for web designers[30]. Another example is that a website with longer navigation paths to reach the destination will over-complicate a task as it will require more use of working memory. Many users over the age of seventy suffer from memory issues, these are people who were once 'normal' that now suffer from cognitive disabilities like Alzheimer's. The use of imagery for such audience can create a big difference. The fact that some experiences, if made more memorable with the use of imagery, will be easy to navigate is a subtle but important for web accessibility. A study on short-term memory in learning disabled children suggests that verbalization helped them read through textual information [32].

The information processing model, as discussed earlier, relies heavily on the way different types of memory process information in the brain. During each processing phase, some information is lost which is unattended or unrehearsed. When a person gets a sensory input, which can be visual like a flickering modal on a web page or audio, the responding sensory organ takes in that information as an involuntary response[23]. After giving it some attention, this goes to the short-term memory of the brain and this is where it tries to make it meaningful. After processing this information, the brain tries to connect the dots between this and existing knowledge to find a solution and act on it. This is the working memory doing the cognitive work. If web designers are aware of the information

processing model and how memory impact their users ability to complete tasks, better designs can be made while keeping these things in mind.

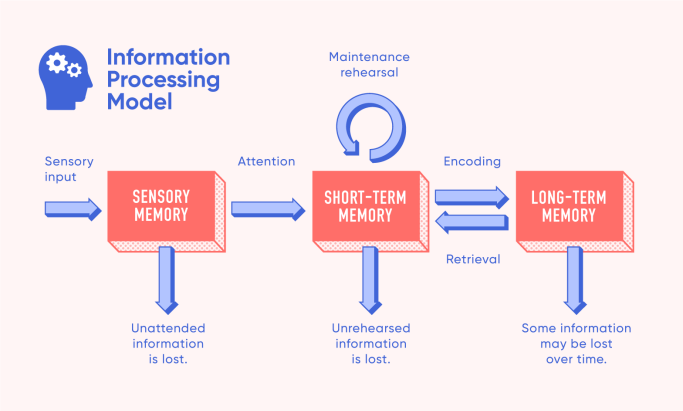

FIGURE 2.1: Information Processing Theory Model [1]

2.4.1.4 Reading, linguistic and verbal comprehension

Reading difficulties are most common in people with Dyslexia, ASD and ADHD. Reading has four major elements, phonetics, fluency, vocabulary and comprehension [33]. While phonetics are fluency has more to do with just reading, vocabulary and comprehension are the two components that are important to consider in web accessibility as they also impact user's ability of understand and hence complete a task with that understanding. Reading abilities in the past were mostly ignored by teachers, but with changes in the in education system as Kliewer studied in the 1990s, have brought in more focus on reading and not just functioning abilities of children, especially with cognitive limitations [33]. Using smaller sentences, and breaking down information in different paragraphs can make a page much easier to read and understand. Representing information with picture symbols or photographs can be a good way of providing alternatives to people who are mildly cognitively limited to the ones who are non-verbal. Browder, Wakeman and Spooner did a research on a thousand participants of varying cognitive limitations on their reading abilities and found that most of them were taught by sight words which was followed by picture identification [33]. This suggests that using more sight words in comprehensions on website, easy vocabulary may have a positive impact on their cognitive disabled audience. The use of active voice, instead of passive also seems to be a contributor for dyslexic users [34]. Although the data is limited and specific to one

country, and teaching techniques may greatly vary from place to place, there can be more user research done prior to a web design. Especially, if a website is targeted to one type of audience, it might be easier to analyze the type of vocabulary and symbols their audience is used to. Using such linguistic user research can help make the web content easy to understand and retain.

Another important factor in ease of reading text on a website is the typeface. Users with dyslexia find it extremely difficult to read through large amounts of texts written in typefaces that use serifs which make them look more crowded. For instance, the letters like 'c', 'a' and 'e' can be very confusing when used with typefaces that have less inter-lettering space [34]. Use of roman numerals is also difficult to comprehend by dyslexic users [35]. Smaller text with a poor heading structure and text alignment also makes reading complicated and time consuming. These are small and easy things that can make the life of a dyslexic person much easier. Metaphorical language can also be difficult to comprehend by users with cognitive limitations, such as idioms, simile that have become vernacular for most. Avoiding such comprehensions or providing a help for such references is another way of fixing this issue. A study on web accessibility for people with Down Syndrome suggested that use of italic font should be avoided and bold should be used instead [36]. The same study showed that when full words were used instead of abbreviations, the it provided the user with a temporal gain of 75.5 percent.

2.4.1.5 Visual comprehension and sensory overload

Visual comprehension affects an individual's executive processing. The use of colour can be a powerful tool in design if used correctly. Many people with cognitive disabilities suffer from sensory overload. In terms of colours and intricate design patterns, the concept of less is more, is fundamental for such an audience. Even a basic colour like white can appear blinding to some, but a subtle change in the shade brings together a harmonious design [34]. Alonso-Virgós and Lucía studied that users with down syndrome were able to surf the web better with a monochromatic background [36]. By changin the design of the page, there was a 40 percent chance that the user would make an error. The right layout, pictures, symbols, colours can be a game changer for people with dyslexia, down syndrome, ASD, ADHD and some intellectual disabilities. Individuals with severe cognitive limitation may also require a non-verbal method of communication of information.

This is where photographs and symbols come into play. Clever use of such resources can make it easier for the users to process information. Using images not only helps with the visual memory but also helps break the information into smaller chunks which in turn helps the working memory. Using enough white space, bigger font size and a way to even customize colour preferences can have great impact on user accessibility as we have looked before that cognitive disabilities affect each individual differently. Some users can change the background to their choice of colour, adjust the luminescence. For individuals with ASD that are attributed to having sensory overload, keeping the visual aesthetics of a website simple, especially, without any flickering sections to attract attention are key. These elements do more harm than good by increasing the noise and distracting the users. Cerebral Palsy, which is a severe learning disability, is caused by abnormalities caused in the brain in its early developmental stage [37]. It also affects hearing and visual comprehension. Such noisy websites can cause cognitive load. Cognitive load theory says that working memory and long term memory can have a great effect on learning and effectiveness [31]. It is the information that can be held in the working memory which is important for learning and understanding new things. By introducing more noise, the working memory is unable to hold more information which leads to an overload, causing more errors by cognitive disabled individuals. Mark and Diane suggest that a web page should not have more than 3-4 lines of text for cognitive web accessibility [35]. Use of more text may end up in cognitive load. Since people with down syndrome have slanted eyes, spatial representation and proper

In 2019, a study based on participants that had down syndrome suggested that when computers were used with gestural interaction instead of the traditional mouse and keyboard, the interaction times was considerably shorter. This represents that this type of human-computer interaction reduced a lot of errors that were caused otherwise [11].

2.4.1.6 Fatigue and other physical limitations

Many cognitive disabilities like Down Syndrome, cerebral palsy, Alzheimer's have physical affects alongside the cognitive limitations discussed earlier. Cerebral palsy appears in early childhood and its physical symptoms can include lack of muscle coordination, weakness in arms or legs, irregular involuntary movements like tremors and difficulty

in precise movements [38]. Some physical symptoms of down syndrome are poor muscle tone, shorter fingers and broad palms [39]. Alzheimer's on the other hand causes seizures, uncontrollable twitches, loss of balance and poor coordination along with weak muscles and general fatigue problems [40]. Prolonged use of poorly designed websites can cause fatigue and create a more error prone environment. Such physical limitations may lead them to look for an alternative means to access the web.

2.5 Summary

This chapter establishes the main problems faced by the people with cognitive disabilities. It reasons why the accessibility principles should not be discussed around the types of CD. It identifies many overlapping problems faced by various conditions that are associated with cognitive disability. This provides a base to structure new principles and guidelines that could address these problems.

Chapter 3

Universal Design

3.1 Introduction

This chapter introduces the history and principles of universal design, .It consists of six sections. The first is an introduction which provides a brief about the chapter and an outline. Next, section two provides a very short definition of universal design and leads to the section three where the history and origins of universal design are discussed. Further, section four elaborates the seven principles of universal design. Section five highlights the importance of adoption of universal design principles in web accessibility. Lastly, section six concludes the universal design concept.

3.2 What is Universal Design?

Imagine a world where everything is equally accessible to all. Universal Design (UD) is a principle that states that any environment should be designed for all and not just for the benefit of some people [41]. So, when and how did the idea of universal design start to emerge? This chapter presents a brief history and origin of the concept of Universal Design, its principles and importance.

3.3 History of Universal Design

Twentieth-century was the age of medical advancement. After World War 2, with developments in the field of technology and medicine, the quality of life drastically improved and the world saw a rise in life expectancy [42]. Now that people could live longer with their health conditions with modern medicine and equipment, especially in an ageing society with numerous disabilities, the world demanded an upgrade in existing designs to accommodate/adapt to everybody's needs. [43] The World Health Organization's (WHO) classification system has shifted from exclusively emphasizing the medical model, which views disability as a feature of the person, to the social model that sees disability resulting from an interaction of people with the environment [44]. The design methods have consequently seen a change from accommodating a special need for a person to making it inclusive for all.

The idea of universal design came into being from the world of Architecture. Began in Japan, the US, Europe in the 1950s when it was called 'barrier-free design' [43]. The term Universal Design was coined by Ronald Mace, a man that left a huge impact on the disability world as he himself suffered from Polio and spent his life in a wheelchair. He graduated as an architect from the North Carolina State University, where he later founded the Centre for Universal Design. As an architect, he focused on accessible buildings and brought in the concept of a design for all. Another important contributor in Universal Design was Selwyn Goldsmith, an architect, town-planner and disabilities advocate who also suffered from Polio and was a wheelchair user. He wrote several books on designs for the disabled community and urged that having special needs is not as uncommon as it is perceived, in fact, extremely normal and a basic requirement in all designs. The first laws to be passed in the late eighteenth century for disabilities were instrumental in where universal design has come today. The Architectural Barriers Act of 1968, Section 504 of the Rehabilitation Act of 1973 made it illegal for disabled people to be differentiated against [45]

3.4 Principles

In 1997, Ronald led a team of architects, engineers, product designers and environmental design researchers to define a set of rules a design needs to follow in order to be considered

universal [46]. Each principle has a number of criteria that must be fulfilled in order to meet the ideal standards. These are the 7 principles of design [47].

1. Equitable Use:

   The design is useful and marketable to people with diverse abilities [47].

   (a) All the users should have access to the same means of using the product. In cases when an identical design does not work for all, an equivalent must be available.

   (b) No users should feel segregated or stigmatized.

   (c) All users should have equal access to privacy, security, and safety features.

   (d) The design must be made appealing and engaging for all users.

   Many a times, while designing a platform for a diverse set of users, designers only tend create a design for 'normal' users and provide alternatives for anyone that has special needs. These alternative options not only take away from a normal web experience but also create a stigma around the disabled community.

2. Flexible in Use:

   The design accommodates a wide range of individual preferences and abilities [47].

   (a) The users should be provided with a choice while selecting which method they prefer to operate with.

   (b) The design should accommodate both left and right handed access.

   (c) If the user makes any mistakes, the design should be able to help them with their precision and accuracy.

   (d) The design should accommodate with user's pace.

   In other words, the design should be adaptable to user's needs. For example, cognitive disabled users have higher chances of making errors or doing a task slower than average users. In that case, a website should provide enough chances for users to make mistakes and not penalize them. Hints or other types of help can help in this accommodation of design.

3. Simple and Intuitive Use:

   Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level [47].

(a) Any unnecessary complication should be avoided to make the design simple and easy to use.

(b) The design should be in tune with the user's expectations and instinct.

(c) It should allow for a diverse range of literacy and language abilities of different users.

(d) The information should be arranged in a consistent and hierarchical order with respect to its importance and relevance.

(e) While performing a task, the users should be given proper help and feedback. The same should be done on completion of a task.

When a website works as the user expect it to, there is less chances of error. For example, a sensible hierarchy of information and consistency throughout the pages will ensure users are not expected to apply complex problem solving skills every time they look for something. Moreover, the design will not rely on user's ability to hold information in their working memory. Following a writing style that is inclusive for a diverse range of literacy and language abilities is another important point that will help with the reading, linguistic and verbal comprehension problems faced by the cognitive disabled community. It should be made easy to determine text links, not only should the colour of a link be contrasting from the background and nearby text, but also underlined so that its is consistent and instinctive.

4. Perceptible Information:
The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities [47].

(a) To present some important information, multiple methods like pictorial, verbal or tactile should also be used for effective understanding.

(b) The design should have enough contrast between important information and its surroundings to make it stand out.

(c) Clarity and readability of important information should be of high standard.

(d) Ensure that the design provides easy directions and instructions by distinguishing it's elements properly.

(e) The design should be compatible with various devices to accommodate the needs of people with sensory limitations.

This principle ensures that the design provides multiple methods of accessibility for a diverse set of users with varying sensory abilities. As discussed earlier, many people on the autism spectrum and down syndrome have difficulty processing information from some senses like vision, touch and/or auditory. Having a good contrast for important information will make sure even with visual problems or attention problems, these users are able to quickly navigate to the essentials. If user wants to make use of tools like a voice recognizing software, screen reader, text magnifier or a colour/contrast changer, they should have the ability to do so.

5. Tolerance for error:
   The design minimizes hazards and the adverse consequences of accidental or unintended actions [47].
   (a) Any elements that may cause errors should be eliminated or kept shielded.
   (b) Before any hazardous element is used, fair warnings should be given.
   (c) The design should have features that prevent it from absolute failure or malfunction.
   (d) In tasks that need vigilance, discourage unconscious action.

   Tolerance for error ensures that committing errors is made difficult. Websites that are not resilient to human errors can be extremely dangerous. The user can be a customer or an admin of the website, hence, such tolerance mechanisms should be applied consistently throughout the website. For example, the details of a product needs an update on an e-commerce website. The admin, who has cognitive disabilities, finds it difficult to pay attention, changes the price of the item from 2 Euros to 200 Euros and is not alerted by the website before the change is committed. Errors like such can cost an employee their job. Such tasks that need vigilance, must be given fair warnings beforehand.

6. Low Physical Effort:
   The design can be used efficiently and comfortably and with a minimum of fatigue [47].
   (a) The design should allow the user to be in a safe body position.
   (b) The design should make use of manageable operational forces.
   (c) Any repetitive actions should be reduced.

(d) Continuous physical effort should be minimized.

This means any strain or exertion causing element in a design should be eliminated. As discussed in the problems faced in the last section, many people with cognitive disabilities also suffer from physical limitations that lead can lead to fatigue. Hence, for these users with reduced muscle tone, curved and short fingers, poor muscle coordination, alternative designs should ensure that they are comfortable and safe to use. Such conditions can cause fatigue if a design does not minimize physical effort.

7. Size and Space for Approach and Use:
   Appropriate size and space is provided for approach, reach, manipulation, and use, regardless of user's body size, posture, or mobility [47].

   (a) The design should allow a seated or standing user a clear line of sight to critical features.

   (b) Make it easy for any seated or standing user to reach all components.

   (c) The design should be able to be used by users of different hand and grip sizes

   (d) Make sure there's enough room for aiding devices or personal assistance.

   Many people with cerebral palsy are wheelchair users [48], the size and space for use is an important principle that relates to this group. Websites, if designed in such a way that only work on horizontal or vertical view might be difficult to use on a wheelchair as it limits their approach of use. Also, the third point of this principle can be useful for people with down syndrome for their different hand and grip sizes as they might have wide palms and curved fingers. A design that is too closely packed might be difficult for people accessing it with aiding devices as it gives them less room to operate it.

3.5 Importance

Although, the Centre for Universal Design itself says that these principles only consider the usability of the product at its core, which is a significant but not the only aspect considered in the design. An inclusive and smart design must also include economic, cultural, gender and environmental concerns. People without disabilities might not even

realise that they have been using products with universal design in their everyday life and that is a telling sign of an inclusive design that doesn't differentiate a group of people as peculiar or different. While labels help to identify problems for different groups of people, the solution must be elegant enough to serve all, regardless of their age, size and abilities. There is a need to recognise that existing designs are not acceptable just because they are assumed to be accessible by 'most' people. There are currently more than 2 billion disabled people in the world, which is 37.5 per cent of the world's population [49]. According to the WHO, a disabled person is anyone who has "a problem in body function or structure, an activity limitation, has a difficulty in executing a task or action; with a participation restriction"[49]. Reinforcing Selwyn Goldsmith's vision of people with disabilities being treated as normal people, a design that fails more than one-third of the world's population is simply not a good design. We have set the standard too low for designs to pass that serves as a reminder to people that they are different and need extra help in order to use the same things as others.

While these principles are 'universal', for web content accessibility, most lawsuits follow the Web Content Accessibility Guidelines(WCAG) which are organized around four of these principles: Perceivable, Operable, Understandable, and Robust (or POUR) [50].

3.6 Summary

This chapter explored the concept of Universal Design, its origin and importance. It introduced its seven principles. The chapter extended the importance of these principles for disability and points out that these concepts are not followed in the web accessibility world.

Chapter 4

Web Accessibility Principles: Finding scope for improvement

4.1 Introduction

This chapter presents the existing web accessibility principles and compares them with universal design principles to identify and examine shortcomings in the system. After an analysis of the principles with problems discussed in chapter 2, a new set of recommended guidelines is produced. It includes five sections. The first section explains the web accessibility principles and guidelines. It sheds light on some national laws and discusses the outdated guidelines that they follow. In the next section, the web accessibility principles are compared with the universal design principles based on the problems they address. Observations from this analysis are highlighted in a subsection. Further, in section four a new set of guidelines is produced which bridges the gap between the two principles. These guidelines are not an exhaustive list, instead, an additional list that is recommended to follow with existing web accessibility principles. The last section summarizes the analysis and concludes the chapter.

4.2 Existing Principles

In an international effort to make the web accessible, standards are put in place like the Web Accessibility Initiative (WAI) [51] and some governmental laws like The Disability

Act, 2005 [52], Web and Mobile Accessibility Directive, 2016, Section 508 of the US Rehabilitation Act of 1973, as amended [53]. The WAI has three areas of focus, which is, User Agent Accessibility Guidelines, Authoring Tool Accessibility Guidelines and the WCAG [51]. The most widely acceptable web accessibility guidelines that are also followed by a number of countries for the web accessibility laws are released by the World Wide Web Consortium (W3C) [52]. The W3C released their first ever set of principles and guidelines called the WCAG 1.0 in the year 1999 [54]. The latest version of these guidelines WCAG 2.2 is still a working draft which was published on 21st May 2021 [55]. The WCAG 2.1 guidelines were first published in July 2008 but have since been regularly updated [56]. The last update was on 5th June 2018, although most countries like Australia, Canada, China, Denmark, Finland, France, Germany, Hong Kong, India, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, Republic of Korea, Sweden, Switzerland, Taiwan, United Kingdom and the United States only follow the WCAG 2.0 version for their national laws and policies [52].

The WCAG has four principles that are the foundations of web accessibility. Each principle consists of specific guidelines that are regularly updated in each release. The principles have remained the same throughout the last twenty two years, but have become more detailed and inclusive with more research and additions. The purpose of discussing these principles is to understand the existing system in place and relate it to the problems discussed in previous the chapter. Although the guidelines in WCAG 2.2 are not formally approved, this paper will use them to keep the analysis relevant with latest recommendations. The WCAG follows four set of principles as follows [57]:

1. Perceivable:

   Perceivable means that the users are able to understand the content of the web using their senses. Taking care of these could help the cognitive disabled users with reading, linguistic and verbal comprehension (4) and visual comprehension and sensory overload (5) and fatigue and physical limitations (6) since this deals with making sure the information is presented in a proper hierarchy and alternative methods are provided for access. This includes four checkpoints:

   (a) Provide alternative text for any non-textual content

   Every image, icon or a graphic should have a descriptive alternative text. The main purpose of the alternative text is for people with visual disabilities

to be able to understand the meaning or purpose of the image. For instance, for the hamburger icon, the appropriate alternative text would be 'menu' and not 'hamburger icon'. These texts also help with keyboard navigation as they act as labels on icons and images.

(b) Provide captions or other means to understand multimedia

For audience that cannot see or hear videos and audios on a web page, alternatives should be provided. This includes text transcripts for audio content like lyrics of a song, captions of a podcast to name a few and audio descriptions or transcripts of movements or actions that are not included in dialogues.

(c) Provide various ways to present the content

Content should be able to be presented in different ways, for this to be possible, the content needs to follow a proper hierarchy for an easy conversion. This also helps tolls that are used to create a summary of the page.

(d) Ensure content is clear and understandable to see and hear

Using the right right colours and contrast plays an important role in clarity of readability. An important aspect is also that colour alone should not be given the sole responsibility of conveying a message as this can be confusing for people with colour blindness. Also, if a user suffers from sensory overload and uses a tool that converts the web page to just black and white colour, any element which only used colour to distinguish information will be rendered useless. Any audio or video elements should not auto play as they might interfere with text to speech devices or act as a distraction.

2. Operable:

This principle ensures that all functionalities are easily usable like controls, buttons and other interactive elements. Operable web environment could take care of problem-solving (1), memory (3) and visual comprehension and sensory overload(5) and fatigue and physical problems (6) as it ensures enough time is given to the user, the design does not have a negative impact on visual or auditory triggers and does not cause physical unease.

(a) Ensure that keyboard access is available

Keyboard access means all the content should not just be usable by a mouse

but also a keyboard and the focus should be such that the user does not get trapped.

(b) Sufficient time should be given to user to read and access

There are several ways to ensure that enough time is given for access, like there should not be auto scrolling, an option to pause or extend time limits. For instance, short session timeouts can make a process tiresome and user could lose their focus and may just give up instead of re authenticating every time.

(c) The design should not cause any seizures or physical discomfort

Flashing elements should be avoided at all costs. If completely necessary, prior warning should at least be given before use. These include bright colours or patterns that flicker at a rate or even animations or any moving image can cause photosensitive reactions or seizures.

(d) Design should be easy to navigate and locate

When pages are titled properly and correct information is present under relevant headings and structure it makes the experience easier. The same piece of information, if available under different sections or pages will lead to confusion and make user take longer to reach their destination. Most users go to menus and navigation bars to locate the information they need, this should be meaningful.

(e) Inputs other than keyboards should also be functional

For users with physical disabilities, it is important to have other input options like gesture, touch and voice recognition. Interactive elements like buttons should be large in size for easy touch access.

3. Understandable:

Consistency is key, be it in design, presentation or usage patterns. It could save time and ensure that user does not spend additional effort on learning how to use a new website. This could help with problem solving (1) and reading, linguistic and verbal comprehensive problems (4) as design will be predictable and easy to understand.

(a) Ensure the text is easy to understand

The website should be able to detect the language used like English, Hindi

or Arabic. Language detection helps screen readers [58]. Another way of making it understandable could be defining unusual words, avoiding the use of idioms and keeping sentences short.

(b) Design should be able to predictable to operate

Ensuring that all the pages of a website follow a similar navigation pattern could make the design predictable and easy to use. Elements that are repeated should have the same labels on every time they appear on the web pages. If a change is required on a page, user's consent should be asked prior to it.

(c) Proper error tolerance should be provided

Users should be given enough chances to make mistakes before being penalised for it. For instance, providing error messages and help labels could give the user an opportunity to review and correct their mistakes before any submission.

4. Robust:

A design is robust if it functions well on any of the user's desired technology.

(a) Design should function with future tools as well as current tools

The technologies used should be easily up-gradable to ensure compatibility in the future. For instance, the markup language should be valid making it easy to interpret.

4.3 Merging Universal Design Principles with Web Accessibility Principles

While UD and WCAG principles seem to have many overlaps, there are some important aspects in the UD principles that are not covered in the WCAG [51]. Although UD was aimed at physical environments at first, these design principles are proved helpful in many diverse fields like educational environments, product design and other assisting technologies [59], [60], [61]. The idea of going deeply into each of these principles was to understand each guideline and compare and finally combine these existing principles to identify where the WCAG principles fall short. The comparison can be seen in table 4.1

UD principles	**WCAG principles**	**CD problems addressed**
Equitable use:1(a),(b) ,(c), (d) Providing same or equivalent experience. Privacy. No stigmatization. Appealing for all	A general objective that is explained by all WCAG principles as a whole	-
Flexible in Use: 2(a) Choice in method of operation; Perceptible Information 4(a) multiple ways of representation	Perceivable 1(a) text alternative (b) captions for multimedia (c) ways to present the content	(4) reading, linguistic and verbal comprehension (6)Fatigue and physical problems
Flexible in Use: 2(b) left and right hand access	-	(6)Fatigue and physical problems
Flexible in Use: 2(d) accommodate with user's pace	Operable: 2(b) sufficient time to access	(1)problem solving, (3)memory, (5) visual comprehension and sensory overload (6)fatigue
Simple and Intuitive Use: 3(b) in tune with user expectations (c),(d) information is consistent and hierarchical	Understandable: 3(b) predictable	(1)problem solving
Simple and Intuitive use: 3(c) language abilities	Understandable: 3(a) readable	(4) reading, linguistic and verbal comprehension
Simple and Intuitive Use: 3(e) proper help and feedback	Understandable: 3(c) error tolerance	(2) attention (4) reading, linguistic and verbal comprehension (5) visual comprehension and sensory overload (6) fatigue
Perceptible Information: 4(e) compatible with devices for sensory limitations	Operable: 2(c) seizures and physical reactions	(2) attention (4) reading, linguistic and verbal comprehension
Perceptible Information: 4(b) contrast between information and background 4(c) clarity and readability 4(d) easy directions by distinguishing elements	Perceivable: 1(d)easy to see and hear; Operable 2(d) easy to navigate and locate; Understandable: 3(a) text is easy to understand 3(b) predictable to operate	(1)problem solving (2)attention (4) reading, linguistic and verbal comprehension (5)visual comprehension and sensory overload
Tolerance for error: 5(a)error causing elements be shielded (b) warning before hazardous element (c)prevent absolute failure (d)discourage unconscious action	Understandable: 3(c) error tolerance	(1)problem solving (2)attention (3)memory
Low Physical Effort: 6(a), (b), (c) safe body position, manageable operational forces and avoid repetitive actions	-	(6)fatigue and physical problems
Size and Space for Approach and Use: 7(a),(b),(c),(d) line of sight for essential information, standing or seated position, hand grip sizes, room for aiding devices.	-	(6)fatigue and physical problems

Table 4.1: Comparison of UD with WCAG principles

Here is some reasoning behind the mapping of the principles with some WCAG 2.2 guidelines [55]:

- Flexible in use 2 (a) and Perceptible information 4(a) is mapped with Perceivable 1(c) since choice in method of operation is provided to an extent if the design has multiple ways to present the content. For instance, 1.1.1 Non-textual Alternatives, 1.2.2 Prerecorded captions, 1.2.3 Audio Description or Media Alternative, 1.2.4 Live captions, 1.2.6 Prerecorded sign language, 1.2.8 Media Alternative, 1.3.1 Meaningful Sequences. By providing a meaningful sequence, the content can be easily converted to different presentations and operated the preferred way.

- Flexible in Use 2(d) is mapped with Operable 2(b) since accommodation to user's pace is provided by enabling user with sufficient time to access. For example: 2.2.1 Timing adjustable, 2.2.2 pause, stop, hide, 2.2.5 re-authenticating and 2.2.6 timeouts.

- Simple and Intuitive use 3(b),(d) is mapped with Understandable 3(b) since user expectations fall in line with consistency and hierarchy of information. These are synonymous to the WCAG principles of predictability and consistency. For example: 3.2.3 Consistent Navigation, 3.2.4 Consistent Identification and 3.2.6 Consistent Help.

- Simple and Intuitive use 3(c) is mapped with Understandable 3(a) since different literacy and language abilities are taken care of in readable guidelines. For example, 3.1.5 Reading level and 3.1.6 Pronunciation. The reading level guideline ensures that the text should only be of a lower secondary education level.

- Simple and Intuitive use 3(e) is mapped with Understandable 3(c) as proper help and feedback is provided when the principle of error tolerance is fulfilled. For example: 3.3.2 Labels or Instructions, 3.3.3 Error suggestions, 3.3.5 Help.

- Perceptible Information 4(e) is mapped with Operable 2(c). Although compatibility with devices for sensory limitations is not exactly fulfilled by using design that does not cause seizures, since it only creates a safe environment where such an event will not occur, still the principle addresses the problem in an indirect way. For example: 2.3.1 Three Flashes or below threshold, 2.3.2 three flashes and 2.3.3 animations from interaction. This criteria suggests that there should not be more

than three flashes in one second on a page, and any motion animations that are activated by interaction should have a way to be disabled.

- Perceptible Information 4(b),(c) and (d) are mapped with Perceivable 1(d), Operable 2(d) and Understandable 3(a) and (b) since contrast, clarity and distinguishable elements can be laid out with principles that enable for elements that are easy to see and hear and is predictable. For example: 1.4.1 Use of Colour, 1.4.3 Contrast, 1.4.8 Visual Presentation, 1.4.11 Non-text Contrast, 1.4.12 Text Spacing 1.4.13 Content on hover or focus 3.1.1 Language of Page, 3.1.2 Language of Parts, 3.2.1 On Focus, 3.2.7 Visible Controls and 2.4.6 Headings and Labels, 2.4.7 Focus Visible, 2.4.10 Section Headings and 2.4.11 Focus Appearance.

- Tolerance for error 5(a), (b), (c), (d) are mapped with Understandable 3(c) since it deals with various types of error tolerance guidelines. For example: 3.3.1 Error Identification, 3.3.3 Error Suggestion, 3.3.4 Error Prevention for legal, financial and data. The Error prevention guideline ensures that any pages that includes a legal bond or a financial transaction is reversible, checked and confirmed. Before finalising any such important information it is first reviewed and only then confirmed.

4.3.1 Observations

After comparing the two types of principles, here are some observations:

- There is no straightforward one to one or one to many mutually exclusive mapping between the two principles.

- Each principle in UD corresponds to one or more principles in WCAG and vice-versa. For instance, Flexible in use (2) with Perceivable (1) and Operable(2); Simple and Intuitive Use (3) with Understandable(3); Perceptible Information (4) with Perceivable (1), Operable (2) and Understandable(3); Tolerance for Error (5) with Understandable (3).

- There are no WCAG principles for Low Physical Effort (6) and Size and Space for Approach and Use (7).

- There are no UD principles for Robust (4).

- Equitable Use (1) is a set of general principles that are overall covered by all the WCAG principles as a whole.
- Sensory overload problems are not sufficiently covered in WCAG principles. For instance, only seizure preventing guidelines are provided.
- Sensory overload for visual and auditory problems is not covered.
- Problems with language abilities are only partially covered.
- Error tolerance is covered by introducing hints and errors but no strict guideline to ensure the text is displayed throughout the process
- No guidelines for recommended typefaces for dyslexic users.
- No threshold is recommended for text on web pages to prevent cognitive load.

The comparison between these principles and their mapping with which CD problems they address is significant in understanding which principles can be, if at all, neglected or not. Moreover, this comparison is essential in building a new set of guidelines that addresses all the problems with the existing system.

4.4 Recommended Guidelines

The criteria of the new recommendations for cognitive web accessibility that encompass universal design was that they:

1. addressed at least one cognitive problem.
2. provided a specific guideline that may or may not fall under the existing WCAG principles.

As it is clear from the comparison, problems related to fatigue or physical issues are not covered as of today. Guidelines that account for such issues need to be placed in a new principle as the existing POUR principles do not account for any physical or external aid difficulties. Some problems like sensory overload were only covered on surface level like the three frame flickering rule which protects seizures and but visual

Recommendations	**Principle**
1. Provide option to mute all sounds	Operable
2. Provide a big, clearly visible search box	Operable
3. Do not allow elements to expand, move or change without user action	Operable
4. Provide user help with chat	Operable
5. Do not use figurative speech in text	Understandable
6. Do not use roman numerals	Understandable
7. Use active voice instead of passive voice in text and audio	Understandable
8. Do not use serif typefaces	Understandable
9. Use 3-4 lines of text on a web page	Understandable
10. Use bold instead of italics to highlight important information	Understandable
11. Do not use abbreviations	Understandable
12. Help text should not disappear	Understandable
13. Use monochromatic background	Perceivable
14. Group similar content or actions together for fewer clicks	Low Effort
15. Make interactive elements large for poor motor skills	Low Effort

Table 4.2: Recommended Guidelines to fit WCAG into UD principles

overload can be caused by too many moving elements on the page as well. For example, navigation menu opens up on mouse hover. When such big chunks of elements appear and disappear just by hovering, it can cause visual overload and distractions. There were no explicit guidelines for auditory load. Another guideline that is not entirely covered is for language abilities. Although, by that sense, this does include the use of idioms. Noens, Ilse and van Berckelaer-Onnes researched on communication with people with ASD and learning disabilities and found that they struggle with the understanding of any non-literal text or figurative speech [62]. Moreover, the challenges with problem solving abilities could be minimized with the introduction of user help by chat bots or chat agents [3]. With the help of chat, the user would not have to struggle to navigate through the pages to find something, instead they can simply ask someone. When it comes to memory problems and chunk capacity limit, as discussed in the CD problems section, presenting less information on a page could be greatly helpful. Again, there is no explicit guideline for such an issue.

A list of recommended guidelines that can be added to the existing principles to make the web accessibility for cognitive disabled more functional and fall into universal design is proposed in Table 4.2:

4.5 Summary

By comparing the UD and WCAG principles against problems faced by the people with cognitive disability, this chapter finds that most of the UD principles are covered by POUR. Two out of seven principles were not covered at all. Although, some characteristics from the other five were present in POUR, many problems discussed in chapter 3 were not answered by either of them. Since principles are not precise, they were mapped according to the specific guidelines from WCAG 2.2 that follow the POUR. Some problems were still not recognized by these latest guidelines. Especially, problems related to fatigue, motor skills and other physical kind could not be addressed by the existing four principles. To address them, a new principle is proposed, called 'Low Effort'. Interestingly, the 2 UD principles that could not be mapped with any WCAG principles addressed this problem. This new principle will help solve both these issues. This new proposal widens the scope of web accessibility principles and tries to answer the research question if the cognitive web accessibility can follow a universal design approach.

Although, the proposed guidelines and principle make cognitive accessibility trace a universal design approach, there are some gaps. Some guidelines like 2 and 15 are not specific and use words like 'large', 'big', 'visible' which are subjective. In way one, they are flexible, but could make an analysis complicated. Most of these are objective. Further research is required to decide the precision of these guidelines. Without a usability test with users having cognitive disabilities, a fixed number cannot be assigned to how 'big' the search box should be and what size is acceptable for any interactive element to be usable by wheelchair users and users with poor motor skills.

Chapter 5

Case Studies

5.1 Introduction

This chapter demonstrates practical examples of the proposed web accessibility guidelines. Two websites, one from the public domain and another from private will be tested for their adaption of cognitive accessibility in terms of universal design. The chapter consists of five sections. Section one provides an introduction and outline of the chapter. Section two presents the methodology used for the case studies and the questions it attempts to answer. Next, section three and four . At last, section five discusses the observations and results from the case studies.

5.2 Methodology

Heuristic evaluation is commonly used method in usability inspection of web designs [63] when specific guidelines are not available. Since a set of fifteen guidelines which are proposed in the last chapter are specific instead of a general rule of thumb or vague principles [64], this paper uses evaluates the accessibility based on these guidelines instead of heuristics to test the two websites for case studies. Two websites from public and private sector were selected, both catering to different types of audience. One, a public immigration service whose target audience is the general public, another a health care related website. This was done to aim websites whose primary audience would consist of different types of people to get a rounder view of the current web accessibility situation.

The first website is the Irish Naturalisation and Immigration Service (INIS), a public website for people seeking permission to visit, work or study in Ireland, for citizenship or international protection [65]. The second website is Down Syndrome Ireland which is a non profit organization that provides support for people with Down Syndrome and their families [66]. The evaluations are only done on the homepage and one sub-page of both the websites.

The aim of these case studies is not only to see good and bad practices followed, but also to reveal whether publishing web accessibility guidelines and creating laws around them affects the quality of websites that fall under these laws. Are websites that are aimed for users with cognitive disabilities designed to be more accessible?

5.3 Case Study 01: A website of public sector

5.3.1 Introduction

Website url: http://www.inis.gov.ie/ An accessibility evaluation on the INIS website, which belongs to the public domain will be evaluated against the 15 guidelines proposed by this paper.

5.3.2 Evaluation

1. Guideline 1: Provide option to mute all sounds
   The website follows this requirement as it does not have any audio elements.

2. Guideline 2: Provide a big, clearly visible search box
   The website does not follow this requirement. After scouring the website, a very small 'search' text can be found on the top right corner of the website. Since is very difficult to locate, its presence might not be of much use. See figure 5.1 for reference.

3. Guideline 3: Do not allow elements to expand, move or change without user action
   The website follows this guideline. All elements like navigation bar, search bar, labels, links, text remain static. There are no animations or moving elements on the website that might cause sensory overload.

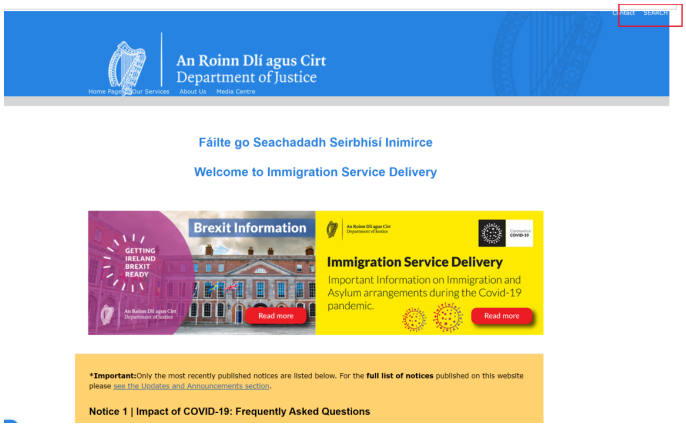

FIGURE 5.1: INIS homepage with very small search text

4. Guideline 4: Provide user help with chat

   The website does not follow this guideline. The only user help provided is a search box, but no chat bot or live chat options are available to users.

5. Guideline 5: Do not use figurative speech

   The website follows this guideline. Clear and straightforward message is given with literal speech everywhere on the website.

6. Guideline 6: Do not use roman numerals

   The website follows this guideline. The commonly used Hindu-Arabic numerals are used instead of Roman numerals throughout the website. See figure 5.2 for reference.

FIGURE 5.2: INIS sub-page using Hindu-Arabic numerals

7. Guideline 7: Use active voice instead of passive voice in text and audio

   The website follows this guideline. A clear and simple writing style is used with only active voice throughout the website.

8. Guideline 8: Do not use serif typefaces

   The website follows this guideline. A sans-serif typeface is used for easy readability.

9. Guideline 9: Use 3-4 lines of text on a web page

   The website does not follow this guideline. Multiples paragraphs with very long sentences are used on any web page. See figure 5.3 for reference.

FIGURE 5.3: INIS homepage with long lines of text

10. Guideline 10: Use bold instead of italics to highlight important information

    The website follows this guideline. Although italicised text is used at times, important information has been highlighted with the use of bold text. See figure 5.2 for reference.

11. Guideline 11: Do not use abbreviations

    The website does not follow this guideline. Full forms of organisations and terminologies are used multiple times throughout the website. See figure 5.4 and 5.5 for reference.

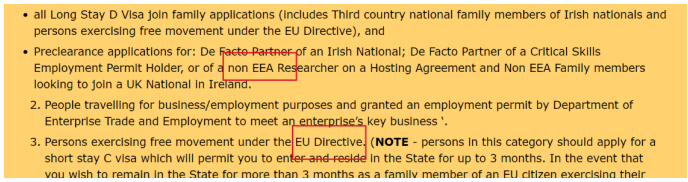

FIGURE 5.4: INIS homepage with use of abbreviations

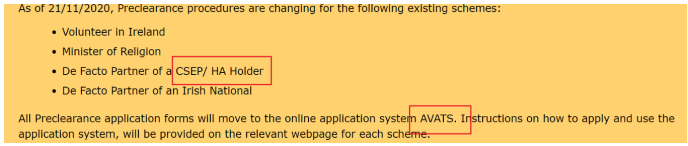

FIGURE 5.5: INIS homepage with use of abbreviations

12. Guideline 12: Help text should not disappear

    The website does not follow this guideline. The forms do not have help or hint

text with alongside the input elements. Only the colour of the element changes to red, but no text appears. Even if the colour is considered as help, it disappears when the user clicks outside the element. See figure 5.6 for reference.

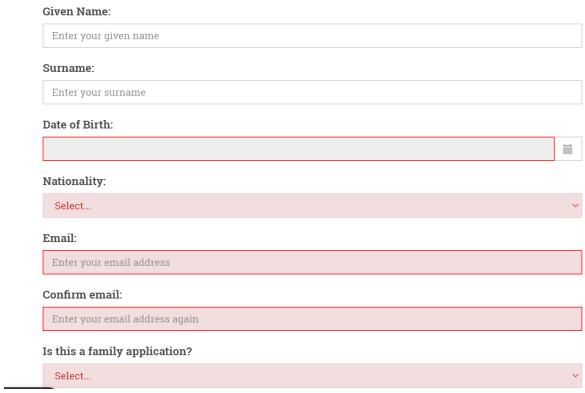

FIGURE 5.6: INIS sub-page having an input element without help text

13. Guideline 13: Use monochromatic background

    The website follows this guideline. The website uses a plain white background for all its pages.

14. Guideline 14: Group similar content or actions together for fewer clicks

    The website does not this guideline. While the website does categorize content, as it provides a navigation at the top, but it only contains three categories, one of which is just 'about' the website. There is no category or direct link for users who want to reach the registration page, which can be considered one of the most important pages for an immigration website. First user clicks on 'All Services', then 6 clicks later, the user is redirected to another website for registration form.

15. Guideline 15: Make interactive elements large for poor motor skills

    The website does not follow this guideline. All interactive elements are very small in size, which makes it difficult to locate and operate them. It could be extremely difficult not only for a user with poor motor but also visual abilities. See figure 5.7 for reference.

5.3.3 Results

The INIS website follows 8 out of the 15 recommended guidelines. Although, it is a website from public sector, that means it has to follow stricter laws than private websites

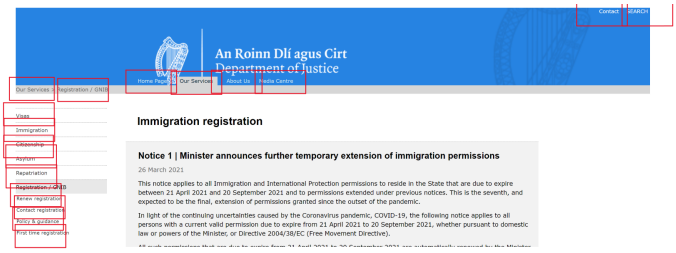

FIGURE 5.7: INIS homepage with small interactive elements

[52], the score is still not satisfactory

5.4 Case Study 02: A website of private sector

5.4.1 Introduction

Website url: https://downsyndrome.ie/ The Down Syndrome Ireland (DSI) is a non profit organisation whose main audience is people with down syndrome, their families and professionals in the field. The evaluation will

5.4.2 Evaluation

1. Guideline 1: Provide option to mute all sounds
   The website follows this requirement as it does not have any audio elements.

2. Guideline 2: Provide a big, clearly visible search box
   The website does not follow this requirement. While a search box is present, it is difficult to locate since it does not stand out and is crowded by other information.

3. Guideline 3: Do not allow elements to expand, move or change without user action
   The website does not follow this guideline. Several elements on the homepage expand and animate. For instance, the background image changes every few seconds, the navigation bar and the social media labels expands on hover which can be very distracting, the 'See and Learn Program', 'Family Support' and 'Local services and support' tiles change background on hover. See figure 5.9 and 5.10 for reference.

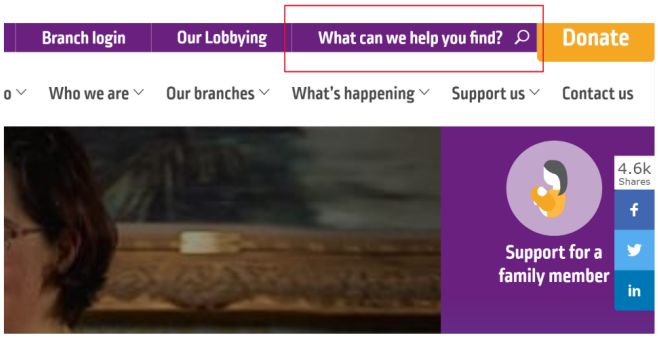

FIGURE 5.8: DSI homepage with search box

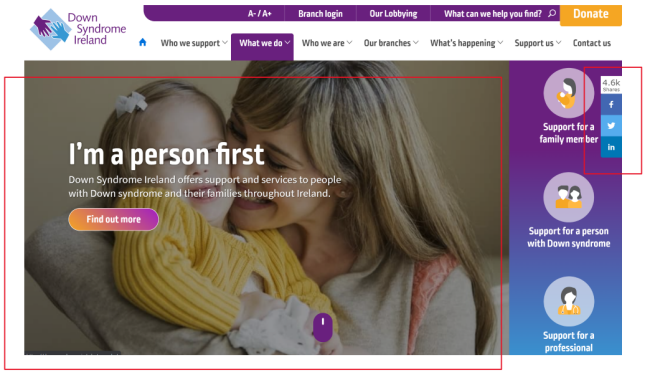

FIGURE 5.9: DSI homepage with moving and changing elements

4. Guideline 4: Provide user help with chat

   The website does not follow this guideline. The website does not provide any user help features like live chat with an agent or a chat bot.

5. Guideline 5: Do not use figurative speech in text

   The website does not follow this guideline. Phrases like 'goldmine of information', 'flavour of our services' are used, which are not factual and straightforward. This figurative speech is discouraged for users with cognitive disabilities. See figure 5.11 for reference.

6. Guideline 6: Do not use roman numerals

   The website follows this guideline. Hindu-Arabic numerals are used which are easy to read and understand. See figure 5.12 for reference.

7. Guideline 7: Use active voice instead of passive voice in text and audio

   The website follows this guideline. It uses active instead of passive voice.

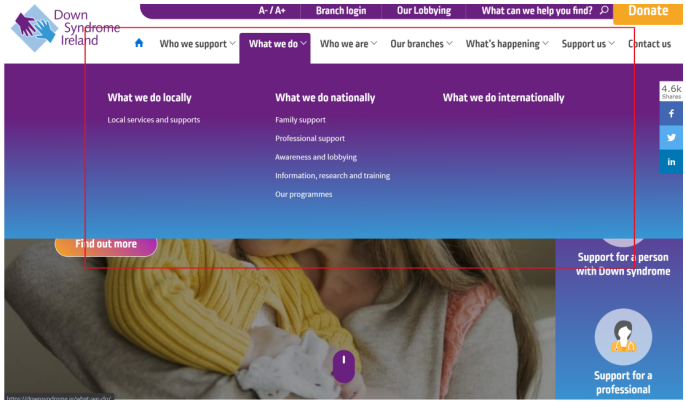

FIGURE 5.10: DSI homepage with moving and changing elements

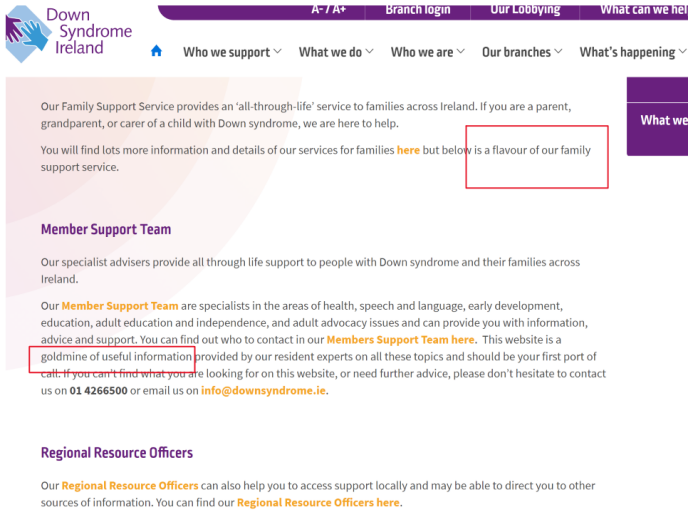

FIGURE 5.11: DSI sub-page with usage of figurative speech

8. Guideline 8: Do not use serif typefaces

   The website follows this guideline. A sans serif typeface is used throughout the website.

9. Guideline 9: Use 3-4 lines of text on a web page

   The website does not follow this guideline. Multiple extremely long sentences are used throughout the website. See figure 5.13 for reference.

10. Guideline 10: Use bold instead of italics to highlight important information

    The website does not follow this guideline. Italicized text is used to highlight some information. See figure 5.14 for reference.

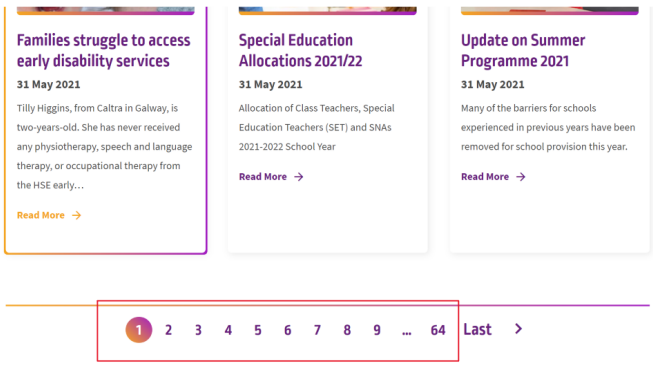

FIGURE 5.12: DSI sub-page with Hindu-Arabic numerals

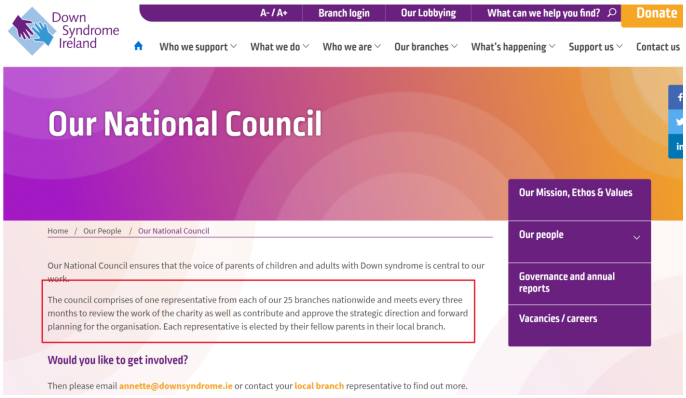

FIGURE 5.13: DSI sub-page with very long sentences

11. Guideline 11: Do not use abbreviations

    The website does not follow this guideline. It repeatedly uses abbreviations without explicitly stating what their full forms are. See figure 5.15 for reference.

12. Guideline 12: Help text should not disappear

    The website follows this guideline. The help text for forms appears when a field is not filled. It does not disappear even when the user clicks anywhere else on the form and loses focus of the element. See figure 5.16 for reference.

13. Guideline 13: Use monochromatic background

    The website does not follow this guideline. A multi-colour gradient image is used as a background for the website which makes it distracting and hard to understand the text. See figure 5.17 for reference.

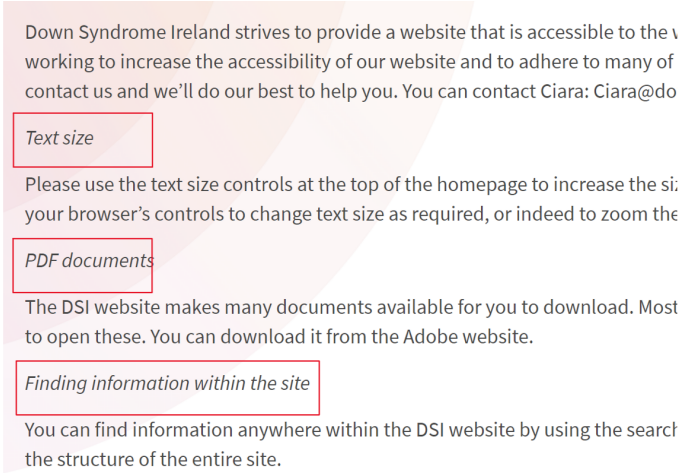

FIGURE 5.14: DSI sub-page with italicized text for important information

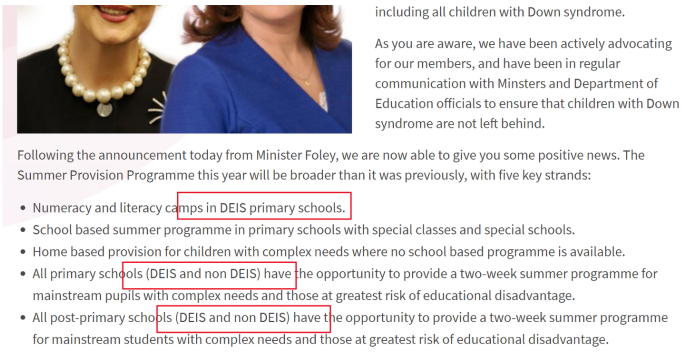

FIGURE 5.15: DSI sub-page with use of abbreviations

14. Guideline 14: Group similar content or actions together for fewer clicks

    The website follows the guideline. Content is organised into relevant sections for fewer clicks.

15. Guideline 15: Make interactive elements large for poor motor skills

    The website does not follow the guidelines. Although the guideline does not provide a specific size for an element, figure 5.18 is referenced to see the crowding among elements fighting for space. This could be extremely problematic for users with poor motor skills as it will increase effort for users to mark their precision while interacting with the element.

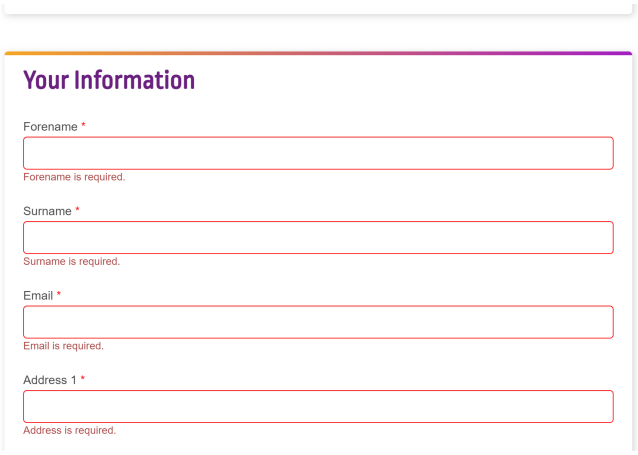

FIGURE 5.16: DSI sub-page with help text

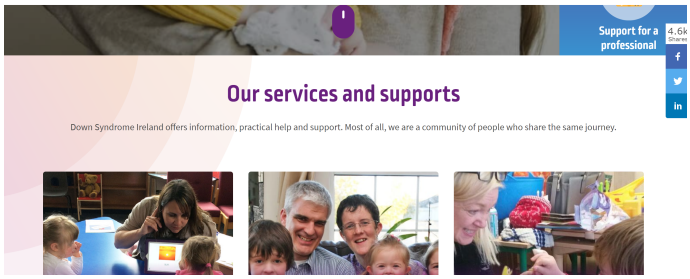

FIGURE 5.17: DSI homepage with multi-colour background

5.4.3 Results

The website only follows 7 out of 15 guidelines that are recommended by this paper. For a website that is mainly focused towards cognitive disabled users, the web accessibility score is not passable. The website contains an Accessibility Statement (figure 5.14) which only covers three aspects, namely, text size, availability of PDF documents to download and a search bar. This shows the present state of web accessibility and the importance of such studies that identify problems and list how they can be addressed.

5.5 Results and Discussion

Two case studies were done to demonstrate practical examples of web accessibility practices that are followed today in public and private spaces. Interestingly, both the websites got a similar score, with INIS 8/15 and DSI 7/15. To reveal whether they had similar patterns of compliance with the guidelines, a checklist is prepared which can be seen in

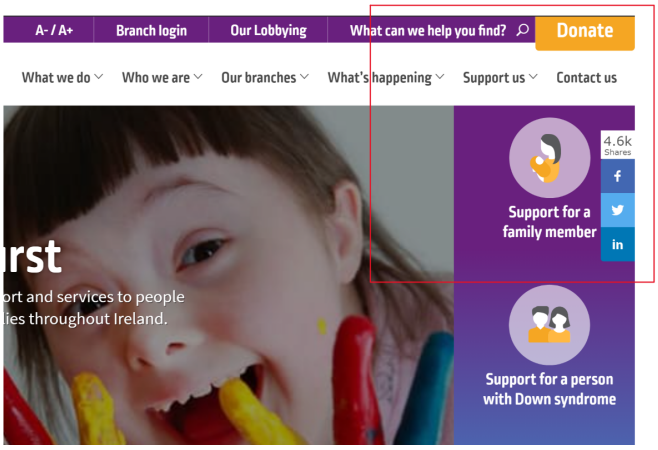

FIGURE 5.18: DSI homepage with small sized labels and interactive elements

table 5.1. Out of 15, only 4 distinct guidelines are met by both the websites which fall under the principles Operable and Perceivable. The newly recommended principle of Low Effort was not satisfied. These examples give an insight on the existing poor web accessibility practices for users with cognitive disabilities as multiple problems faced by them are not accounted for.

To meet many of the guidelines, it does not require much effort, only awareness. For instance, providing a big and easily visible search bar only requires a small design change. Using italics for important information, a monochromatic background, making interactive elements large, not using abbreviations are easy fixes that do not require the organizations to spend extra money. One recommendation which was not followed by either of the websites was providing user help with chat. This could be the only guideline that is comparatively difficult to fulfil as it needs the organization to invest in a chat bot or hire people to work as agents to chat with users.

It was difficult to test some guidelines due to lack of precision. For instance, both the websites had search boxes, but the guideline required it to be big and easy to use. This can be interpreted in many ways, for some the search box in DSI website could have been passable but for some it could be difficult to see due to its placement near multiple other elements, lack of the word 'search' which is generally used by websites was another reason that made it difficult to find. Moreover, the last guideline requires large interactive elements to ensure users with poor motor skills are able to use them. 'Large'

Guideline	**Website 1 (INIS)**	**Website 2 (DSI)**
1. Provide option to mute all sounds	Followed	Followed
2. Provide a big, clearly visible search box	Not Followed	Not Followed
3. Do not allow elements to expand, move or change without user action	Followed	Not Followed
4. Provide user help with chat	Not Followed	Not Followed
5. Do not use figurative speech in text	Followed	Not Followed
6. Do not use roman numerals	Followed	Followed
7. Use active voice instead of passive voice in text and audio	Followed	Followed
8. Do not use serif typefaces	Followed	Followed
9. Use 3-4 lines of text on a web page	Not Followed	Not Followed
10. Use bold instead of italics to highlight important information	Followed	Not Followed
11. Do not use abbreviations	Not Followed	Not Followed
12. Help text should not disappear	Not Followed	Followed
13. Use monochromatic background	Followed	Not Followed
14. Group similar content or actions together for fewer clicks	Not Followed	Followed
15. Make interactive elements large for poor motor skills	Not Followed	Not Followed

TABLE 5.1: Checklist of fulfilment of proposed guidelines by INIS and DSI websites

is again subjective and varies for users with different requirements and conditions. Such guidelines need further research.

Chapter 6

Conclusion

6.1 Research Contribution

There is plenty literature on web accessibility but very little on cognitive web accessibility. The aim of this paper was to explore and identify some challenges with existing cognitive accessibility practices and analyze it with universal design principles. The study is able to classify problems and propose new guidelines and principles that aim to make cognitive accessibility more in line with universal design principles. The paper has taken the research further ahead and with practical examples found that the guidelines are easy to test. The study also extends to show that the problems addressed by proposed guidelines could be easily fixed without much effort. Poor web designs are being made not due to lack to infrastructure but lack of awareness.

6.2 Limitations and Further Research

Although, the research question " Can cognitive web accessibility be a part of Universal Design?" has been answered, that yes, it is possible, the proposed guidelines are subjective, and not exhaustive. Due to time constraints and limitations because of the pandemic, the research was done by qualitative analysis of existing material. Proposing precise guidelines for size and degree of clarity would be unfair with just literature reviews. In order to improve this study, the future work for this research will require a usability inspections by professional web designers and tests by users with cognitive

disabilities. Usability inspections, as Quiñones et al. highlight [63], are revisions made by experts in the area with their own judgement and usability test are examinations of the product usability by real users. Only after the guidelines are tested with the users directly impacted by them, a well informed opinion can be made. Improvements can be made with the help of the feedback and suggestions.

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