Improving Legibility of User Interfaces for Low Vision Conditions with a Crowdsource Platform

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Abstract

The growing importance of inclusive design solutions has prompted this study examining typography legibility and its impact on accessibility for users with low vision conditions. Focusing on factors such as typographic form, letter spacing, and font size, this research seeks to understand the unique demands of low vision individuals and how typography and user interface design can be adapted to improve legibility and accessibility. Previous research has provided insights into various aspects of typography legibility, but a comprehensive approach addressing the specific needs of low vision users has been lacking. This study contributes to the existing body of knowledge by deconstructing user interfaces (UI) and analyze the fundamental elements affecting legibility. By examining various UI elements and their relationship to text, this research offers personalized, integrated solutions for individuals to tailor websites to their unique needs.

The proposed platform differentiates itself from existing accessibility overlays (additional software that is intended to detect and address web accessibility issues on web sites) by emphasizing personalization based on individual preferences, leveraging crowdsourcing to create a variety of modification options. Although the proposal's primary focus is on low vision, it has the potential to assist a wide range of users with various needs. Despite some limitations and challenges faced during the project, this study provides insights into the factors contributing to the legibility of various typefaces, emphasizing the importance of customization to cater to specific needs. Future research should continue to explore these factors, further promoting a more inclusive approach to typography in diverse UI contexts.

Keywords: crowdsource, user interface, user experience, UX, UI, fonts, typeface, font, low vision, legibility, accessibility, overlay

Introduction

According to the World Health Organization(n.d.), 2.2 billion people have near or distance vision impairment. According to research conducted by Pew Research Center (2016), internet usage is prevalent among Americans roughly around 84% for those without disabilities and up to approximately 65% for disabled persons. Additionally, according to results of a survey by WebAIM in 2018 about specific participants having issues related to their eyesight, it was noted that over 71% used the internet on an everyday basis, signifying many people suffering from these conditions use online resources quite frequently. The increasing internet usage among individuals with low vision highlights the need for webpages and digital products to consider inclusive solutions that cater to their requirements.

With the ever-growing number of inclusive design solutions that take accessibility into account, it is crucial for that these solutions address their unique, individual needs. The social connectivity of the Internet and ease of access to numerous sources of information has helped us to nurture communities that include those who have been underprivileged. Mobile and Desktop interfaces are, for most of us, a part of our daily life and we gather our information through daily interlude readings[1] through social media platforms. However, the user interface of these platforms is mostly focused on people without disabilities, to which extra functions are added to facilitate use for people with disabilities. This secondary approach to a customer base with disabilities can be limiting and even frustrating to them while using these platforms which are often a crucial part of their daily lives. For example, reading is an important activity for individuals with glaucoma and other low vision patients, as it affects their quality of life (Kwon et al., 2019).

Boyarski et al. (1998) stressed the importance of considering various elements when discussing typography, whether in print or online. Although their study primarily focused on the formal qualities of typefaces, they argued that other factors such as type size, line length, and line spacing should also be taken into account. According to the authors, these factors should be considered together with the typeface when designing typography for any presentation format, and therefore should be tested concurrently. This statement is also supported by numerous studies that discuss the different factors that affect legibility.

[1] Interlude Reading is defined as the kind of reading that happens in a single brief sitting (i.e., a few paragraphs worth) or at short opportunistic interludes" (Wallace et al., 2022).

Since the paper is focused on the relation between legibility and digital user interfaces, examining UI elements within the context of the atomic design methodology. Atomic design[2] is a design methodology that involves breaking down a user interface into its smallest components and then constructing it back up through a hierarchical structure. This method allows for better organization and reusability of design elements. In this paper, we have used atomic design principles to analyze the impact of UI text on legibility. By breaking down the UI into its smallest building blocks, we were able to identify the specific visual elements that affect legibility, from the smallest to the largest elements. In this paper, atomic design system is comprised of three different stages. First stage, **Atoms**, are the smallest building blocks of the design system. They include individual UI elements like buttons, inputs, headings, and labels. Second Stage, **Organisms**, are the different parts of a user interface made up of groups of atoms, such as a header, a footer, or a content area. Finally, **Pages**, are organisms and atoms filled with images, and data. This analogy inspired the way we deconstruct and categorize the visual elements that are affecting the legibility, ranging from the smallest to the largest components.

[2] Frost (n.d.) outlines five distinct stages in Atomic design, but for legibility research, templates and molecules don't significantly differ from the other three stages, so they are not considered in this paper.

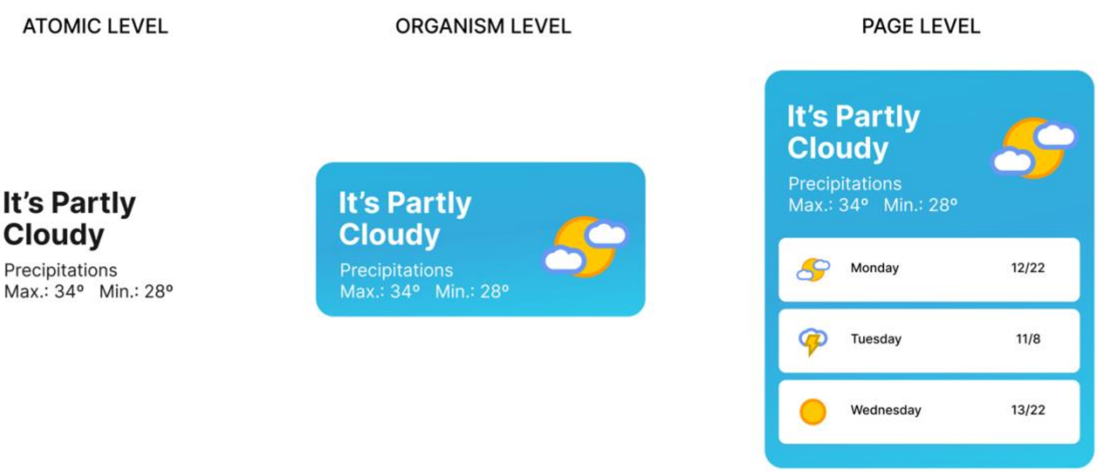

Figure A Looking at the factors that affect legibility in Atomic Levels

Legibility and readability

There are varying definitions of legibility and readability. In this work, I define the words in this way: legibility concerns how easy it is to identify each individual character or word in a typeface. Factors that impact this include the size of the font, the relative colour of the characters and their background, shape differences between characters as well as tracking and weight considerations. Readability requires legibility, but it also encompasses factors such as the number of characters per line, interline spacing (leading[3]) and using familiar fonts, careful adjust of justification or ragging

[3] Leading is the vertical space between lines of text. Too little leading can make text hard to read, while too much can make the visual harmony disappear.

parameters so readers can read freely without being hindered by any underlying distractions caused by poor typesetting.

Ultimately. readability depend on personal preference based on the complexity level involved within the texts they choose – familiarity with the subject matter may also contribute significantly to readability. Legibility is more concrete but can depend on the characteristics of the eyesight and visual processing of the reader. In general, larger-sized text accompanied by adequate spacing between characters and lines of type leads towards easier-to-read structures, making them good choices for engaging long-form writing experiences such as articles or books. There is prior research that has been done to show how typeface choice and how text is presented in a visual interface, could increase legibility.

As both a typeface and a user experience designer, I wanted to ask; ***How can typographic design decisions be utilized to enhance legibility on web context, particularly for individuals with low vision?***

To further investigate this question, a co-design plan was initially planned that would include the input of people with low vision conditions, with the aim of finding a way to design user interfaces that could accommodate their individual needs and improve legibility. Even though ethics board approval was received, this research could not be conducted due to several limitations, chiefly that of difficulty in recruiting participants. However, this obstacle led to a new approach, one that makes co-design an integral part of the ongoing implementation of the design: in this paper, prior research is being investigated and a design solution is being proposed that allows for user participation through use of the design. Future research may consider further incorporating co-design and user testing to evaluate the design and develop new iterations.

Literature Review

To understand the effects of a typeface we approached a cluster of text that is presented in a mobile interface, by investigating it in several different whereas we first investigated the characteristics of a letter, of a typeface and how we can measure the legibility of a typeface.

Later we investigated the surrounding visual area that the text is in. This includes the color of the text or the size of the text, number of characters per line, interline spacing (leading), tracking, how the contrast of the foreground and background is affecting the legibility, etc. Through investigating the text in this manner, we sought to find the essential elements affecting legibility of a text in a digital context.

What makes a typeface?

Fonts (or typefaces) are a set of letters, characters and glyphs that are harmonically uniformed by their common design features. Originally, a font referred to the size or boldness of a typeface used by typesetters in metal typesetting (ie., in the pre-digital environment, Times Roman Italic 12 point would be a ‘font’. The collective term for all sizes of Times Roman would be called a ‘typeface’, and all the varieties of Times Roman (roman, italic, bold and bold italic would be referred to as a ‘type family’. In current usage, the word ‘font’ is sometimes applied to the software that produces the forms, and the term ‘typeface’ applied to the visual manifestation of these forms. However, as in this paper, the terms ‘font’ and ‘typeface’ are used interchangeably, due to these two terms being used as if they were synonyms by most of the papers that are discussed.

Fonts are inherently a visual tool and are used in printed, or digital media to communicate semantic content and, particularly in large application, such as headings, have an aesthetic or connotational aspect. Fonts are a fundamental part of our daily life. With the growing usage of digital media, we cannot have a day without encountering fonts. That's why it is essential to begin by thoroughly examining the impact of fonts on legibility.

Difference Between Legibility and Readability?

The concept of what makes a text readable extends beyond legibility, considering reader comfort and ease, typeface familiarity, quality of typesetting, line length’s relationship to interline spacing (leading) and content complexity. Readability is subjective by nature, as every individual reader's experience differs from another’s. Readability is consequently further affected by unfamiliar vocabulary or subject matter the writer used in their writing. Moreover, readability is associated with an individual's reading habits, making certain texts harder for some to comprehend than others. In this regard, it is useful, when producing potentially difficult material, that readers have access points made readily available along with visually reducing density to improve general readability. (Hunt, 2020)

According to Hunt (2020), physiology is fundamental to legibility. Legibility is all about the vision of the individuals. The form of letters also can impact the ease with which text is read. Unconventional letter shapes may obstruct readability, as well as fonts that are excessively faint or bold, narrow, or with an unusually small x-height, or unevenly spaced. Optimally legible typefaces usually have similar qualities: a larger x-height, 'normal' proportions and evenly balanced strokes and counters. (Hunt, 2020).

According to Alsswey (2020), the font, type and size are vital components in designing the UI because it has a direct influence on elderly users' visions. Additionally, Alsswey (2020) also states that color is a vital aspect in UI. Colors can influence how users perceive and interpret the information presented in the UI, making it a powerful tool for communication. Therefore, choosing the right colors is crucial in creating an effective and user-friendly UI design.

Importance of Serif and Sans Serif Font Selection

One of the most important components of a text is the typeface being used and its characteristics, such as serifs, geometry, character width, and contrast. There have been studies that examine the relation between serifs and legibility over the decades. Serifs are letter strokes that are linked to the end of a larger letter stroke and they are one of the significant characteristics of a typeface.

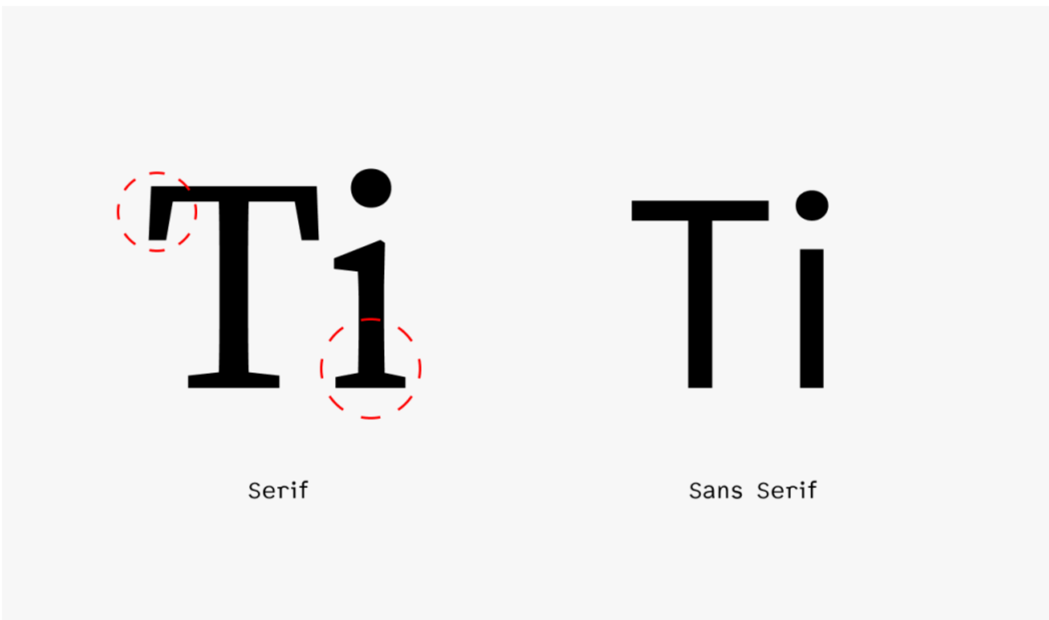

Figure B Serif (Left), Sans-Serif(Right), Serifs are shown with red dotted circles.

Research shows little difference in reading speed between sans-serif and serif typefaces (Arditi et al., 2005). Some studies suggest that if serifs do affect legibility, they could interfere with letter recognition and act as noise to a simple letter-form template, making it difficult for our brains to recognize the letter quickly and accurately (Arditi & Cho, 2005). Some readers with low vision prefer sans-serif typefaces (Russell-Minda et al., 2007).

However, it is challenging to determine whether one typeface is more legible than another, and the legibility of each typeface must be evaluated separately (Sheedy et al., 2005).

Figure C Atkinson Hyperlegible Font Sample

The Atkinson Hyperlegible sans-serif typeface was created to improve reading for those with impaired vision, but the decision to design a sans-serif were based on preferences of the organization rather than primary research (Letterform Archive, 2021). Finally, while sans-serif fonts are commonly used in various contexts to achieve maximum legibility, the choice between serif and sans-serif fonts for readability may ultimately depend on individual preference, with any improvement being typically very minimal (Arditi et al., 2005; De Lange et al., 1993).

Letter-spacing

Another factor that contributes to the legibility and readability of letters in words is letter spacing. If a letter is too far away from another, it may not be recognized as part of a single harmonic letter group, which might impact how words and sentences are interpreted. On the other hand, if letters are too close to each other, then it may be difficult to distinguish letters from each other.

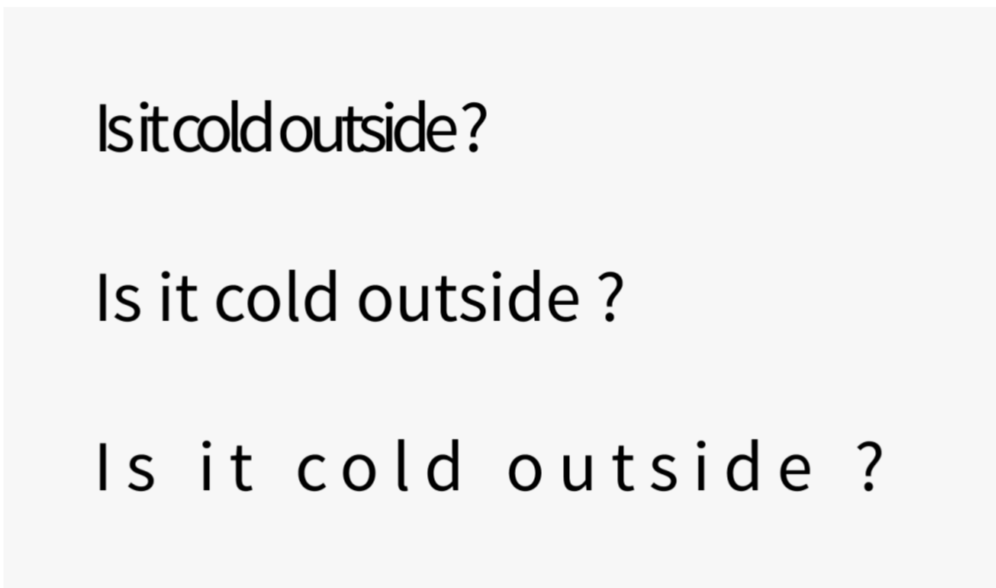

Figure D Letter spacing Differences.

Although studies on whether sans-serif or serif typefaces are better for legibility are lacking, a report by Hillier (2008) suggests that serif fonts are somewhat more legible than sans serif fonts due to their inter-letter spacing. These results might imply that inter-letter spacing has a major impact on readability rather than the letterforms.

A study by Perea, M., & Gomez, P. (2012) mentions that small increases (relative to the default settings) in inter-letter spacing influence eye movement control in adult readers. This shows that inter-letter spacing is an important feature to consider when processing text, and that digital app implementations should include the ability to change inter-letter spacing.

However, G. E. Legge, (2016), suggests that increasing letter spacing is ineffective to enhance legibility with low vision, but extra-wide spacing between lines (line spacing is the vertical gap between text lines.) or words may be beneficial for some low-vision users. In his overall summary, Legge (2016) states that the effects of text variables on low vision reading can be condensed into the following points: print size and display size are crucial, with magnification often being necessary. High contrast is typically essential, and bright displays and contrast reversal can be advantageous. Inter-line and inter-word spacing may offer some assistance. While the impact of font is generally minimal, fixed width fonts may prove useful for reading close to the acuity limit.

Studies on dyslexia have found that increased letter spacing can benefit dyslexic readers in accuracy, speed, or word identification (Spinelli et al., 2002; Zorzi et al., 2012; Perea et al., 2012). However, Schneps et al. (2013) observed mixed benefits from increased letter spacing for struggling readers, while shorter text lines with fewer characters showed clear advantages, including a significant increase in reading speed. Chung (2012) studied the effects of different letter spacings on reading speed in central and peripheral vision using Courier font with five spacings. Bigelow (2019, p. 168) reports Chung's results revealed a "critical letter spacing," beyond which reading speed plateaued, and then slightly decreased with much larger spacings.

X-Height

The x-height is the height of the lowercase letter x in a typeface. Typefaces have different x-heights, which can greatly impact the overall look of the text.

Figure E X Height differences between letters are shown.

Legge and Bigelow (2011) states that x-height is valuable in vision research due to its consistent appearance in legibility studies, linear scaling in computer fonts, and specific design features in small-scale fonts that enhance visibility.

Bigelow et al. (2019) refer to a study by Mansfield, Legge, and Bane (1996), which suggests that legibility can be influenced by differences in type features such as size, width, and boldness, and this effect can vary depending on reader vision and type design. For instance, readers with normal vision read Times Roman 5% faster than Courier Bold[4] at moderate print sizes but read Courier Bold up to twice as fast as Times at tiny sizes. Similarly, readers with low vision read Courier faster than Times at both moderate and tiny sizes. Therefore, legibility is not solely a graphical characteristic and may be difficult to determine which features are more influential. Tarita-Nistor et al. (2013) also found that while Courier was superior to Times Roman in reading acuity, it was not superior in maximum reading speed for readers with macular degeneration.

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[4] Mansfield et al.(1996) states that the difference in reading speed between Times and Courier may be caused by the differences in letter spacing between the two fonts. A tighter packing of characters horizontally allows for more characters to fit into the higher resolution area of the retina, resulting in more letters being processed in each fixation.

Italic

Italic is a slanted font style that emphasizes text and creates a visual contrast to the upright Roman typeface, making important words stand out.

Figure F Roman and Italic Style Differences

Italic letters are less accurately recognized and reading lowercase italic type is slower than reading roman type, according to studies from Roethlein (1912) and Tinker (1963). However, Sheedy et al. (2005) found that italics only affected legibility for words and not individual letters. The causes of this difference are unclear and may be due to less legible characteristics, unfamiliarity with extended italic text, or font choice. Rello and Baeza-Yates (2013) found that italic fonts are harder to read for people with dyslexia compared to roman fonts, but they suggest that fonts designed for people with dyslexia can improve accessibility without negatively impacting others.

Typeface Weight

Typeface weight is typically described using impressionistic adjectives, which can vary between typefaces and languages. Typeface weight refers to how thick or thin the letters in a font appear. Weight is usually described as light, regular, medium, bold, or extra bold.

Figure G Different Typeface Weights illustrated. From Top to Bottom: Regular, Semi-Bold, Bold, Black

The World Wide Web Consortium (W3C) has defined a numerical scale for font-weight ranging from 100 to 900, with higher numbers representing bolder weights. Bold weights are often used to signify emphasis or structural distinction and are designed to be distinctly different from normal text weight. In text type families, bold weights typically range between 1.4 and 2.0 times the weight of normal text, providing an adequate distinction for common usage. (Bigelow, 2019)

Sheedy et al. (2005) suggest that increasing the stroke width of characters can improve legibility, and bold letters are more legible than non-bold ones. However, there is a limit to the amount of stroke width that can enhance legibility, beyond which further increase does not improve it. This balance between stroke and counter is crucial for visual acuity, as demonstrated by the similarity in weight of highway signs worldwide.[5]

According to the Russell-Minda et al. (2007), a sans serif typeface no smaller than a 12-point type font[6] in bold weight (font style) provides the most readable conditions for both medication bottles and flat-surface labels and health literature; and also, is based on individual preferences.

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[5] For example; Highway Gothic, FHWA, DIN 1451 Eng- & Mittelschrift, Drogowka are used in many countries for highway signage

[6] Different typefaces can have different visual sizes, even when they are set to the same point size. Because typefaces have different proportions, x-heights, and stroke widths they can look different on the page. For example, a 12-point Century Gothic typeface may appear visually larger than a 12-point Futura typeface, even though they are both the same point size.

However, Bernard et al. (2013) states that, bold print does not improve reading speed for people with *central vision loss* who rely on their peripheral vision. The thicker letter-strokes of bold print decrease reading speed more in the periphery than at the center. This may be due to letter crowding in the periphery, which is more severe than at the center.

Fixed and Variable Width

Fixed-width fonts have letters and characters that have unified character width, while variable-width fonts have characters that vary in width.

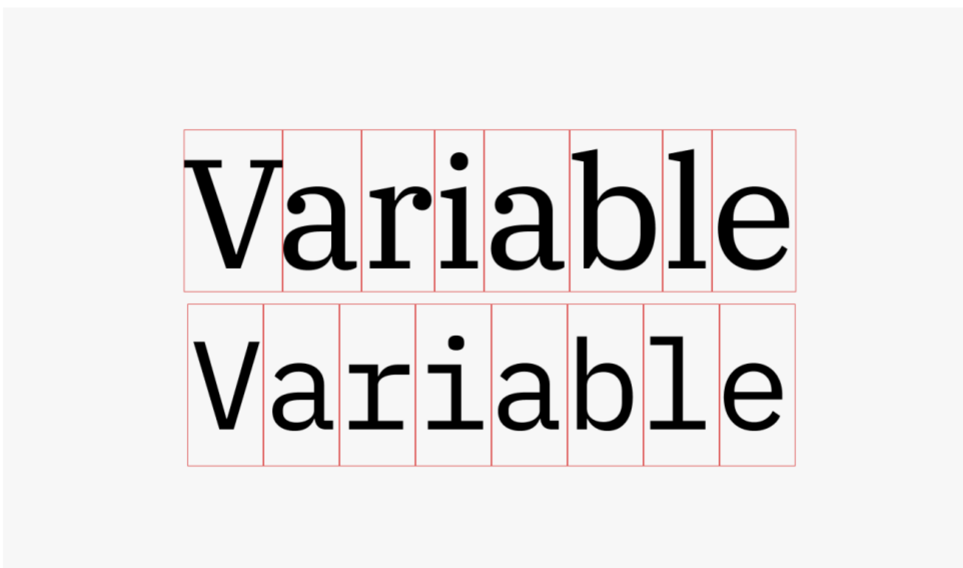

Figure H Variable Width; IBM Plex Serif (Top), Fixed Width; IBM Plex Mono (Bottom)

Bigelow (2019) states that most fonts in everyday use have different widths for each letter. For example, Times Roman and Helvetica have slightly smaller width-to-height ratios in contrast to fonts like Courier have the same width for every letter, with a higher ratio to fit both wide and narrow letters.

Arditi, Knoblauch, and Grunwald (1990) found that while variable-width fonts were read faster than fixed-width at large sizes (*Character size was adjusted using different monitors and font points, ranging from 9-point to 18-point*), fixed-width fonts were read faster than variable-width at small sizes, after making a fixed-width variation of Times Roman by adjusting inter-letter spacing to ensure equal letter widths, unlike a true fixed-width font like Courier where the letter forms are designed to have equal widths.

Impact of Capital Letters

Bigelow (2019) reviews two studies on capital and lowercase legibility. Tinker (1963) discovered that capitals were read slower than lowercase, with 90% of readers favoring lowercase. Conversely, Arditi & Cho (2007) found that small font size capitals were read faster by both normal and low vision readers. The advantage disappeared for larger fonts and normal sighted readers. The findings suggest that letter size influences legibility for low vision readers and small text, with upper-case text being more legible than lower-case when point size is fixed, as capitals have approximately 184% more area in Arial font.

Typeface aesthetics, their emotional affect, and individual perceptions

Each Latin alphabet letterform skeleton, according to Zender M. (2019), activates a distinct fundamental visual feature or combination of basic visual components of perception plus non-basic characteristics of reflection and duplication, with high-frequency vowel letters activating a distinctive set of visual properties. Zender's findings also suggest that research might be conducted to create legibility metrics based on the relationship between letterforms (a letter’s shape) and perceptual features.

Perceptual features, according to Cohen (Cohen, 2011; Zender M., 2019), allow the detection and recognition of specific characteristics of objects. The basic idea is that items have distinct visual characteristics that distinguish them from other objects in the visual environment and allow them to stand out. This hypothetical scale may be used to locate typefaces that function better for long texts than short ones.

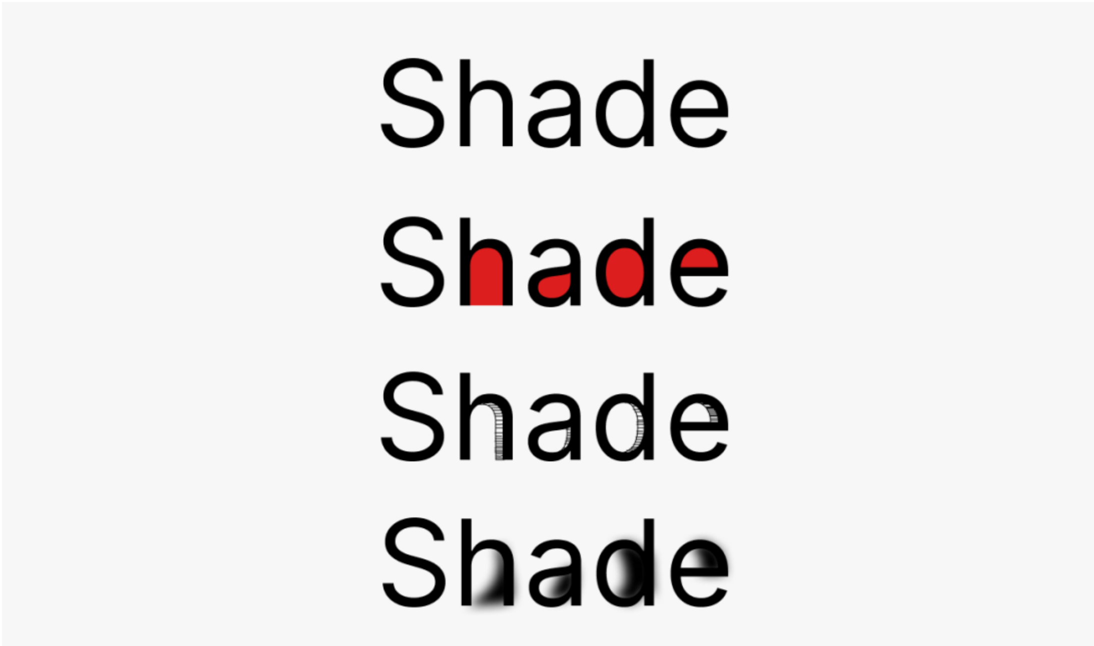

Figure 9 Illustration to show what Noordzij suggests, shading the counter forms of the letter. One example is with shading with strokes, the other one is using shadow Red shows the counters of the letters

The Design Week magazine's article (Design Week, 2003) mentions that Gerrit Noordzij, a typeface designer, feels that the simplest way to understand what a word means is to write it and shade the counter forms of the letters. People with dyslexia, Noordzij believes, might ultimately learn to read through **'perception training.**' This statement, *in our opinion*, backs up the previous study stated by Zender M. (2019) on how letter perception is primarily dependent on basic visual features that we have been conditioned to see regularly.

The overall look and style of a typeface could impact its legibility and the message it conveys. Our conditioning to certain visual elements can shape our perception, leading to some typefaces being seen as functional or non-functional, and visually appealing or unappealing. This visual conditioning may also evoke emotional reactions and result in varying individual interpretations.

As a result of the user survey, Choi et al. (2016) revealed that a variety of visual characteristics of typefaces had weak/strong emotional effects on viewers, and they validated that certain emotions and sensations may be transferred through text messages.) A study by Li and Suen (2010) investigates the link between fonts and personality characteristics. The fonts used in this research were categorized based on the personalities of the fonts. The typographic and visual aspects of the fonts in these categories are thoroughly analysed. This might imply that typefaces contain qualities that can elicit emotions in the reader, and that while building an accessible and universal font, the font's visual appearance should be considered.

Font Size

In addition to the research on the letterform, inter-spacing and usage of serifs, another aspect that must be considered is that the font size. Font size is the height of characters in a typeface, measured in points (one point equal to 1/72 of an inch). Choosing the appropriate font size is important for creating legibility and visually appealing text.

Other research about font sizes and legibility by K. Sagawa et al. (2013) proposes a complete evaluation approach for minimum viewable font size. The researchers devised and put to the test a universal font size estimate equation. However, where their research falls short is that it is not appropriate for people with extremely low visual acuity, such as those who have poor eyesight, for whom additional research is required. In research by J.E. Sheedy and their colleagues, a threshold size technique was used to assess the effects of font design and electronic display characteristics on text legibility. (Sheedy et al, 2005) Participants' visual acuity was tested using a variety of fonts, 3 font-smoothing modes, 4 font sizes, 10-pixel heights, and 4 stroke widths in a variety of combinations.

Threshold, or a contrast threshold, is the lowest level of contrast that the patient can resolve according to Wikipedia. MyHealthAlberta describes visual acuity as “a measure of how well a person can focus on an object.” (Myhealth.Alberta.ca, 2019) The research that Sheedy and their colleagues had carried out (Sheedy et al, 2005) found that individual lowercase letters were 10% to 20% more legible than lowercase words the researchers believe that this letter superiority effect shows that individual letters play a major role in word recognition at the threshold of visual acuity, while word shape plays a minor, if any, part. Sheedy et al. (2005) also found that Franklin Gothic Book is less legible than Franklin Gothic Medium, Demi, and Heavy. The reason for the improved legibility of the latter fonts is unclear, but it may be due to their wider stroke width, wider overall width, or a combination of both factors. According to their findings, of the typefaces they tested, Verdana and Arial were the most legible, while Times New Roman and Franklin were the least legible.

Russell-Minda et al. (2007) and Rello et al. (2013) found that font type and size are crucial for legibility, especially for those with low vision or dyslexia. They found that sans-serif fonts like Helvetica and Arial are better for low-vision users than Times New Roman. For best legibility, they recommend a 16–18-point font size. Rello et al. suggest using 18pt font size and default line spacing of 1.0 for web text to maximize legibility, comprehension, and user perception. Line-spacing recommendations for dyslexic readers vary, but Rello et al. found that linespacing has little impact on legibility and comprehension, except when too much space hinders reading performance. For example; a 16pt text with 10 point leading would be hard to read.

When evaluating font size effects, it's important to consider x-height, as it can impact legibility. Fonts like Arial, Times New Roman, and Helvetica have different x-heights, which can directly influence the legibility.

Fonts designed to increase peripheral letter recognition and low vision

Bigelow (2019) notes that digital type technology has significantly aided in the study of the psychophysics of reading and legibility, as well as in the development and testing of fonts for low vision, macular degeneration, developmental dyslexia, and other reading difficulties that have been traditionally overlooked by commercial typography.

A typeface created by Bernard, J. B et al. (2016), called the Eido, was created to decrease inter-letter similarity and to improve letter performance. According to their research, when respondents were asked to read single phrases, they noticed that the reading speeds of the Eido and Courier fonts were nearly identical. Other results, on the other hand, show that Eido reduced perceptual errors in peripheral crowded letter identification and peripheral word recognition. Letter confusion was decreased by the Eido typeface, but not letter mislocation, which accounts for a significant portion of regular letter crowding problems. Letter crowding occurs when a letter is encircled by other letters, making it difficult for the reader to read the letter. When compared to the Courier font, the difference between letter confusion and letter mislocation mistakes during crowding is interesting. (Bernard, J. B et al., 2016) It has been concluded by their study that too much differentiation between letters within a typeface has a negative impact on letter and word recognition.

In their study, K. Ompteda (2022) integrated scientific and design knowledge to identify optimal typeface weights for low vision readers, finding that bolder typefaces with stroke width values of 22-33% (percent of x-height) and letter widths above 83% improve reading performance for this group. This contributes to evidence-based print guidelines for low vision readers. However, not all bold typefaces are effective, and the regular weight typefaces commonly used in design practice have lower stroke width values and are not optimal for low vision legibility. To improve legibility, the author proposes recommending weights above "regular" and increasing letter width, and that sans serif typefaces that have been shown to improve legibility and are commonly available include Gill Sans Bold, Helvetica Bold, Arial Bold, Verdana Bold, Franklin Gothic Medium, and Franklin Gothic Demi.

While research suggests that increased letter spacing does not necessarily improve legibility, some studies have found a benefit for increased letter spacing and leading of proportionally spaced sans serif typefaces. Xiong et al.'s (2018) study on spacing found that typefaces with larger spacing permit smaller reading acuity, raising the question of whether proportionally spaced typefaces with increased letter widths and letter spacing could achieve equivalent legibility. For example, Maxular Rx Bold, a proportionally spaced typeface with larger letter widths and letter spacing, performs similarly to Courier but permits smaller reading acuity than Helvetica and Times. Investigating proportionally spaced typefaces with larger letter width and letter spacing could provide valuable insights. They also found that enhanced spacing within a font contributes to the ability to read tinier letters, but fonts with greater spacing were read more slowly, especially for Eido and Maxular

Rx. The study suggested that macular degeneration patients with low-contrast sensitivity might benefit more from a bolder font like Maxular Rx, and that digital displays make it much easier to manipulate text properties, emphasizing the importance of making spacing an adjustable property for digitized texts.

Discussion

The literature review shows that many factors affect the legibility of typefaces, and recommendations for legible typefaces sometimes contradict other findings. This suggests that improving legibility may not solely depend on the choice of fonts, and other factors may play a role. With the conflicting findings, it is possible that a typeface that works well for one person may not work for another person and could even decrease legibility. Therefore, it is important to consider other factors that could be influencing legibility, such as font size, spacing, contrast, and lighting conditions. Using serif or sans serif typefaces does not have a significant impact on legibility. Most suggestions provided by professionals, researchers, and organizations tend to highlight Helvetica, Arial, Verdana, and Times New Roman[7] as the most commonly used typefaces and considered to be the most legible among the other commonly used typefaces, but of course this is due to their common usage more than anything else. However, it is crucial to consider elements

[7] As discussed in Ompteda (2022), Sheedy et al. (2005), Russell-Minda et al. (2007), Mansfield et al. (1996)

such as character width and x-height when assessing typeface legibility. Given that each font possesses unique characteristics, comparing them directly can be challenging, and it would be akin to comparing apples to oranges if these varying parameters are not considered and readers are equally unique.

The Sheedy et al. (2005) study tested different weights of the Franklin Gothic typeface to investigate stroke width and legibility. They found that lighter weight typefaces (Regular and Light fonts) were less legible than heavier ones (Medium, Semibold, Bold fonts), but it was unclear what caused this. Ompteda (2022) later found that legibility improved with increased stroke width for lowercase letters and words but not for uppercase letters. The study recommended using typefaces like Gill Sans Bold and Franklin Gothic Medium.

For a default legible typeface, we would recommend a font with minimum character width where the width of the uppercase letter "O" is 85 percent and maximum 110 percent.[8] For the x-height a font should be 70 percent minimum and 80 percent maximum of the font's body height. For default typefaces, I would suggest for a monospaced font, such as Source Code Pro, serif fonts including Georgia, as well as a sans-serif option like Verdana. Increasing the minimum font size to 14pt for paragraphs can offer more

[8] ADA Standards for Accessible Design (2010) was taken as a reference.

legibility. It is important to acknowledge that these recommendations are merely suggestions for further investigation.

Technology Literacy

Researchers conducted a contextual inquiry method (where researchers observe and discuss the user's daily activities one-on-one) to see how people with low vision use computers to gain information. The article states that even tech-savvy participants felt uneasy and out of control because due to the interfaces of the accessibility tools they used in the experiments. The findings of this study demonstrate how low vision people's demands differ from those of blind people. This may suggest that interface of a product could affect the effectiveness of a product that aims to be helpful. A study by Harrison (2004) is looking into a new low vision reading assist. According to the findings, people with low vision have similar levels of technology-related anxiety to blind people, but they are more likely to interact with technology that improves their quality of life, which means that if a technology adds value to their life, such as assisting them with their vision, they are more likely to interact with it.

Web Content Accessibility Guidelines (WCAG), ACA and ADA

Accessibility and inclusivity are critical and cannot be ignored. Laws and guidelines have been established globally and nationally to ensure that products and content are accessible to all individuals. This paper focuses on

WCAG, ACA, and ADA. WCAG provides web accessibility guidelines, while the ADA and ACA are laws that enforce accessibility. The ADA applies to the United States, while the ACA applies to Canada. However, the legal requirements could still contribute to ensuring that products and websites are accessible globally. Both ADA and ACA[9] advise complying with the Web Content Accessibility Guidelines (WCAG) to ensure accessibility.

WCAG, developed by the Accessibility Guidelines Working Group as part of the W3C Web Accessibility Initiative, is a stable standard that helps make web content more accessible to people with disabilities. It is widely recognized and used by web developers, designers, and organizations worldwide. It provides guidance in several layers, including principles, guidelines, testable success criteria, and sufficient and advisory techniques.

The principles provide the foundation, and the guidelines provide basic goals for authors to work towards. Testable success criteria are provided for each guideline, and three levels of conformance (A, AA, and AAA) are defined. WCAG is designed to be stable and referenceable, with supporting documents available for other important purposes. WCAG's "Perceivable" criteria ensures that web content is perceivable and covers color use, audio

[9] Guidance on the accessible Canada regulations - publications.gc.ca. (n.d.). Retrieved April 29, 2023, from https://publications.gc.ca/collections/collection_2022/nac-asc/AS4-30-1-2021-eng.pdf

control, contrast, text resizing, images of text, content presentation, and dismissing additional content. Legibility is key, with specific guidelines such as using text instead of images, high contrast ratios, and user control over audio and colors. Consider using advisory techniques to ensure maximum accessibility to all users.

Additionally, according to W3C RDWG symposium paper[10], legibility and readability are often treated as an additional thing, rather than being addressed early in the design and implementation phase. This exclusion negatively impacts people with cognitive disabilities, who have a permanent need for accessible content. It is important to involve people and ensure accessible content is thought of and implemented from the beginning of the web design process. A possible approach to comprehensive accessibility includes design and requirement analysis, accessible web design and user testing, accessible content generation, and website launch and operation. User involvement and testing are important throughout the process to ensure the site is accessible and easy to use.

The Accessible Canada Act is a Canadian law aimed at removing and preventing barriers to accessibility, particularly for people with disabilities. It

[10] Including easy to read, legibility and readability into web engineering. Submission for the RDWG Symposium on Easy-to-Read on the Web. (n.d.). Retrieved April 29, 2023, from https://www.w3.org/WAI/RD/2012/easy-to-read/paper10/

covers various areas, such as employment, transportation, and information and communication technologies.

Relation Between Colors and UI Elements

Tserdanelis et al. (2015) emphasize the importance of small variations in elements such as semantics, font, and colors, which can significantly impact the user interface (UI) and how users react. They recommend that UI designers consider the functional and aesthetic requirements of the target user base, tailoring scripting and audio/visual presentation accordingly. Furthermore, they highlight how colors and fonts can affect users' moods and trigger different expectations. They cite studies demonstrating the universal autonomic responses of the brain stem and limbic system to certain colors, which can influence customers' perception of products or services. Even small decisions, such as font and color choices, can make a big impact on the success of customer interactions. Ultimately, when thoughtfully utilized, these components can design improved customer interface and ensure successful interactions.

According to Bragg et al. (2017), color can improve legibility for low-vision readers, especially for vision partial to certain light wavelengths. White text on a black background is commonly preferred by readers with a clouded lens, which scatters light and creates glare. Black background reduces light and subsequent glare, which often improves reading. The authors also mention that named colors are more easily recognized.

Bragg et al. (2017) found that using color can help low-vision readers, especially those with partial vision in certain light wavelengths. Colored lenses can also speed up reading. Low-vision readers with clouded lenses prefer white text on a black background because it reduces glare. Bragg et al. used a black background in their designs and experiments for this reason, and they also used named colors, which are easier to recognize. They suggest that animated scripts could also improve legibility for low-vision readers, and they test two design options. Even though these designs are not perfect, they showed that learning to read animated scripts can enhance legibility.

According to Alsswey (2020), elderly individuals experience declining visual abilities that make it challenging for them to perform tasks involving small font sizes, visually complex interfaces, and low contrast colors. Additionally, they may also experience a decline in contrast sensitivity and reduced color sensitivity, particularly in the blue and green range, due to the aging process that affects the elasticity of the lens (Thorslund & Strand, 2016; Alsswey (2020)). Elderly individuals may also have difficulty with depth perception and light sensitivity, which can impact their ability to locate objects correctly in the distance. UI components such as font type, size, style, background and foreground colors, patterns, and images may cause eye strain and fatigue for elderly users (Yang et al. 2016; Alsswey (2020)).

Moreover, older adults have less sensitivity to color contrast compared to younger people, especially in the blue-green range (Phiriyapokanon, 2011). To improve the clarity and legibility of UI design for elderly users, it is crucial to use suitable contrast colors between text and background, foreground and background, and avoid using colors of similar lightness adjacent to one another regarding the wavelength. This will help enhance vision and make it easier for elderly users to use text and other components like buttons and menus.

One way to address the challenge of accommodating a growing number of application features while optimizing screen space is to enable users or applications **to customize the user interface,** according to Stuerzlinger et al. (2006). In their study, they found that users could improve their performance through the use of adaptive and adaptable menus if they were aware of the possibility of adapting and had access to a simple interface.

According to Ogata et al. (2019) using a layout with columns when reading text can make it easier to read and help prevent losing your place while reading. This is because seeing several complete lines of text at once can help you follow along and stay on track. When reading text that is presented in a single column, it's more likely that you may lose your place and struggle to follow along, which can make reading more difficult and time-consuming. By using a layout with columns, you can improve your reading experience and read more efficiently. This may be especially important for individuals with glaucoma, as research has shown that low contrast between text and background can reduce reading speed in such individuals (Burton et al., 2012). In fact, the effect of low contrast letters on reading speed in patients with glaucomatous visual field defects in both eyes was found to be more pronounced than that observed in visually healthy people of similar age (Burton et al., 2012).

A study by Huang (2007), aimed to see how reduced icon size and different figure/background contrasts affected legibility. The results showed that only luminance contrast[11] influenced legibility with smaller icons. When icons were larger, luminance contrast didn't matter. The study found that increasing luminance contrast improved legibility with smaller icons.

Ramirez (2021) explains that the use of color can significantly improve the usability of an information display in various areas if used effectively, but if not used properly, it can decrease an application's performance and

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[11] Luminance contrast is the difference in brightness between an object's foreground and background. It is the difference in brightness between brightness of an item and that of its surroundings.

decrease user satisfaction. Additionally, the effective use of boldness in a UI's typography is crucial to successful product design since the periphery is inclined to look for boldness, making it an effective way for elements to "pop" in peripheral vision.

According to Erdogan (2008), for color combinations, black or blue text on a white background was found to be the best for instructional web design, as it has high legibility. Foreground and background color combinations on the extreme ends of the color spectrum, such as blue and red, do not provide sufficient contrast for screen displays and have low legibility. High contrast between text and the background is crucial for legibility in web design. Some color combinations, such as red with green or blue, should be avoided as they make pages unreadable for visually disabled users. It is not feasible to test every variable combination for legibility, but high contrast and suitable color combinations are essential for instructional web pages.

Importance of Individual Choice

Ompteda (2022) discusses Arditi’s (2004) study, which used prototype software (Font Tailor) and found that low vision participants choose different parameter values to customise typefaces based on their visual needs. Beveratou (2016; Ompteda 2022) notes that individuals with different types of visual impairment have different legibility needs when customising typefaces. Shaw's (1969; Ompteda 2022) study provides empirical evidence that typographic variables influence legibility differently, depending on the underlying reason for visual impairment. Shaw found that readers with cataract were helped more by an increase in weight than size, while readers with glaucoma were more affected by typographic changes, and size and weight were both important for them.

Readers with macular degeneration benefited from increases in print size and a change to a sans serif type, but not from an increase in weight, contrary to expectations. Although experiments testing normally sighted participants at threshold sizes can be applied to people with low vision who often read at their acuity limit, Shaw's research is a reminder that different visual abilities can influence the results of legibility studies.

According to Wallace et al. (2022), their findings suggest that individuation has the potential to increase reading speed for readers, indicating that it could enhance legibility for all. Moreover, their study highlights the potential for machines to assist readers in achieving their full reading potential, which could have significant impacts on individual reading efficacy in the future.

As its mentioned earlier Stuerzlinger et al. (2006) recommends applications to enable users to customize the user interface. This is supported by the findings of Wallace et al. (2022) which they state that a future of individualization might boost legibility.

There is already research that has been done to achieve more effective individualised text modification. One example is FontMART by Cai et al. (2022), a personalized font recommendation tool powered by machine learning. Starting with a selection of readable fonts, FontMART can detect nuanced associations between reading speed and reader and font characteristics and serve as a bridge to improve font design for readability. Arial has shown good performance across age groups, and personalized font recommendations can increase reading speed for participants.

Helping Communities through Crowdsourcing

Song et al (2018) discusses the importance of web accessibility and how web accessibility standards and conformance evaluations can help achieve this goal. They propose a crowdsourcing-based accessibility evaluation system to aggregate answers from non-experts with varying abilities. The evaluation showed that the system significantly outperforms other approaches in detecting barriers in inaccessible web page. Their surveys showed that there is a correlation with the evaluation system and the perception of users with disabilities.

Takagi et al. (2013) emphasize the significance of accessible information in the modern workplace. They propose leveraging intraorganizational crowdsourcing to improve workplace accessibility by providing captions for meeting videos, describing key diagrams, and converting scanned materials into text files. However, the authors recognize the challenges of maintaining the confidentiality and reaching employees with niche spare time for tasks. To address these issues, they designed Crowd Card, a new crowdsourcing platform optimized for workplace environments, which suggests tasks to employees in a manner similar to web advertising, considering work contexts, employee interests and expertise, and material security (Takagi et al., 2013).

Furthermore, employee expertise can be a strong advantage, as understanding business materials often requires the latest business context and knowledge. Crowd Card is designed to improve workplace accessibility by embedding tasks in a uniform card format that resembles web banners, which can be placed in various user interfaces that employees use daily. The system automatically displays suitable cards for each employee by considering the confidentiality, work context, interests, and expertise. This approach leverages employee expertise, captures niche time, and ensures confidentiality, thereby addressing the challenges associated with intraorganizational crowdsourcing (Takagi et al., 2013).

Kotaro et al. (2015) highlighted the importance of public transportation for blind and low-vision individuals and the challenges they face. To address this issue, they introduced a method for collecting bus stop location and landmark descriptions using online crowdsourcing and Google Street View (GSV) through a custom tool called Bus Stop CSI. This approach is more scalable compared to previous work, such as GoBraille and StopInfo.

Landmarks are crucial for visually impaired people to navigate to public transit, but their location and spatial context are not typically captured in traditional navigation tools. To investigate the potential of using minimally trained crowd workers to find and label bus stop landmarks, the authors posted their tool to MTurk. They found that workers could locate and label bus stops with an accuracy of 82.5%, which increased to 87.3% with a simple majority vote scheme. Benches and shelters were found to be the most helpful landmarks.

However, the approach has limitations, such as inaccurate bus stop locations from the Google Maps API, image age issues, and scene difficulty in GSV. To address these challenges, future work could integrate other streetscape imagery sources, investigate the use of 3D point cloud data, and explore the inclusion of additional landmark types.

These studies highlight how crowdsourcing can effectively improve accessibility in different areas. Future research should continue exploring new ways to use crowdsourcing for accessibility, considering each unique situation and its challenges.

Crowdsourced and Personalized UI Modification Platform to Enhance Legibility

Research has revealed a correlation between specific visual selections and enhanced legibility. Tailored user interface may enhance legibility since not all individuals possess identical optical needs. People with limited eyesight or particular impairments might struggle to decipher certain font dimensions, hues, or contrast ratios. **Personalized text customization could substantially impact legibility and accessibility in such situations**. To improve the default settings for the text, the platform would also crowdsource user feedback on how readable different visual options are. This would start a cycle of constructive criticism and text improvement that could benefit all readers.

We believe that community-supported solutions can be faster and more effective against the slowness of a single organization. An example of this is open-source applications and the recently released Steam-deck. Steam Deck is a device developed for playing PC desktop games in a mobile form. But one of the handicaps of a mobile gamepad form is that it doesn't fully translate to games developed for the PC. For this reason, some game companies are adapting their games specifically for Steam Deck controls, but since there are thousands of games in the Steam Deck game library, it is almost impossible for every single game to be optimized for Steam Deck's control layout. Therefore, it Steam Deck allows users to download, test and use the controller layouts designed by the users under the name of "community layout" on the Steam Deck to make most of the games playable. With this feature users can design their own controller layouts and share it with millions of people, making games that were previously impossible to play in a mobile form playable.

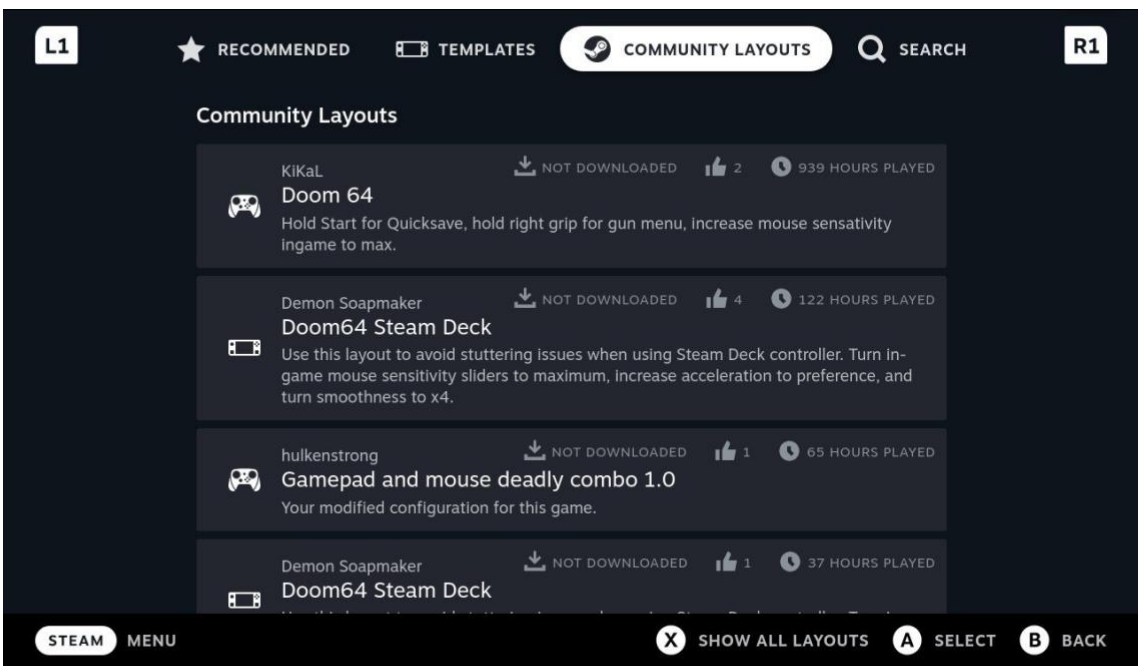

Figure 10 Steam Deck - Community Layouts for Doom 64 (1997)

The community layout feature of the Steam Deck was one of the main inspirations behind the project that is being proposed in this paper. Previous studies have demonstrated how community-driven applications can support the creation of pertinent material for those who require accessibility. The project intends to promote the sharing of accessible material that benefits many people, regardless of their technical skills or platform limitations, by creating a cooperative and inclusive platform.

Accessibility Overlays

Accessibility overlays are tools that modify websites and applications to make them more accessible for people with disabilities. They can add features like text-to-speech and magnification to help people with disabilities use these websites and applications.

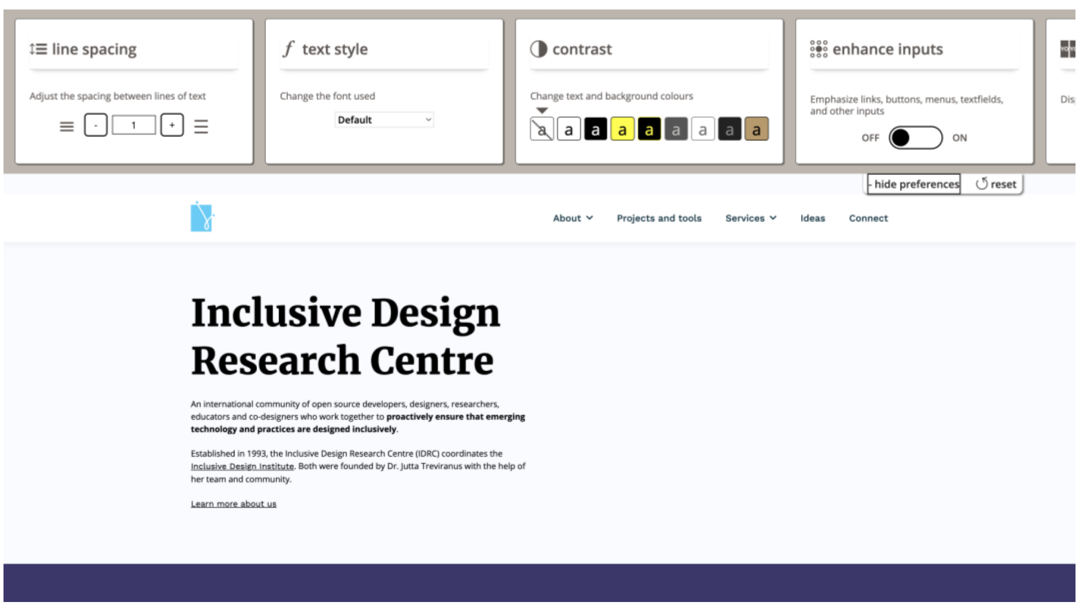

Figure K An Example for Accessibility Overlays, IDRC Website (http://idrc.ocadu.ca)

Accessibility overlays can be tricky to work with. In one hand a website with an embedded overlay could make us think that the website owners are not so keen on fixing the accessibility issues and instead they are using the overlays as an excuse. On the other hand, as inclusive design recognizes that everyone has unique needs thus, they may need unique solutions. Overlays could help people with unique needs to be met.

According to Propeller Media Works (2021), overlays often override users' existing assistive technology tools, do not work well on mobile devices, and open security holes. "Accessible" websites that offer reduced navigation, features, and content are also to be avoided. To deliver a truly ADA and WCAG compliant website, it is best to follow accepted best practices, including an automated audit of the entire website, manual testing of select unique pages, and assistive technology testing of the same select unique pages and use-cases. The website can then be properly remediated, addressing all WCAG 2.1 A, AA violations. One tool cannot fix all the accessibility needs, and website owners shouldn't abandon their legal and moral obligations just because they implemented an accessibility overlay tool.

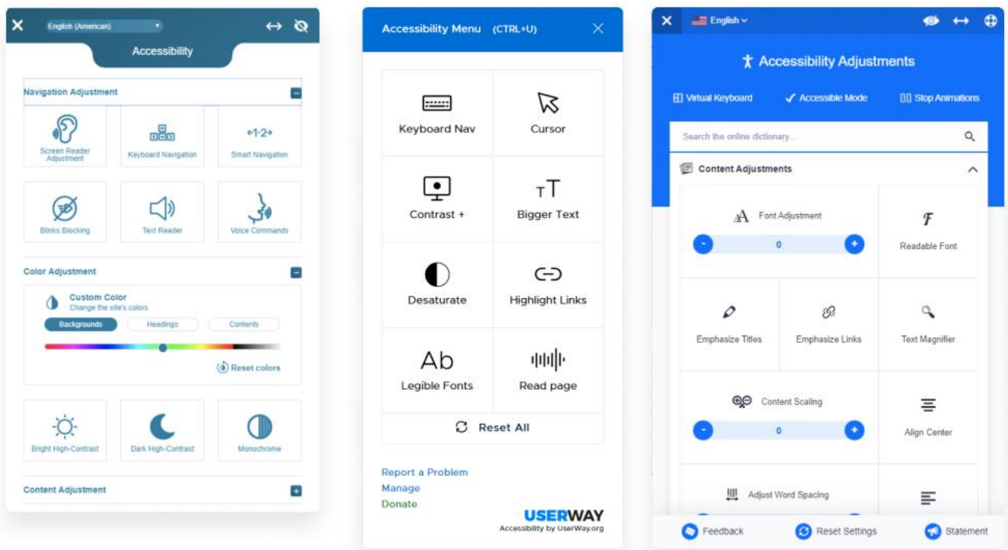

Figure 12 Popular Accessibility Overlays; UserWay and accessiBe etc.

Byrne-Haber (2020) explains that accessibility overlays are tools that aim to detect and repair HTML accessibility issues on non-mobile websites, but they have limitations. They cannot detect or fix all accessibility issues, and relying on them may lead to a lack of investment in accessibility. Furthermore, overlay vendor guarantees may not cover the full costs of accessibility lawsuits. Overlays address only the symptoms of accessibility issues and do not solve the root cause, which is a lack of education and process changes for stakeholders. They force users to learn a new tool, and they may impact security and performance. Overlays are not effective for mobile websites. Therefore, overlays should only be used as a temporary measure while working on a more sustainable solution.

Barnhart’s (2022) critique of overlays emphasizes that they are not a reliable solution for web accessibility, despite marketing claims of being a “total web accessibility solution” or “fully automated.” According to the author, overlays tend to conceal underlying accessibility issues rather than addressing them, creating legal liabilities and privacy concerns, and possibly hindering the user experience for people with disabilities. The author suggests investing in real accessibility through professional audits and remediation or DIY approaches, prioritizing the creation of user-centric digital experiences for all users, including those with disabilities.

Feingold (2022) states that true digital accessibility requires proper design and inclusion from the start, and these widgets only offer limited tools that may not remediate all barriers. Relying on them may lead to inaccessible websites being deployed, and building an accessibility program requires significant effort and commitment. To ensure an inclusive user experience, accessibility must be considered from the beginning of the design process and incorporated into all aspects of the design.

Taylor (2019) pointed out that the major weakness of overlays is their override of the assistive technology already used by people with disabilities to navigate websites. These users have learned to use their devices with features like text-to-speech, zoom, and color contrast, but overlays force them to turn off their preferred assistive technology and rely on the limited features of the overlay. This can limit access to useful features such as form controls and links, causing frustration for users. As a result, overlays may not serve the customers they are designed to help, and their value may be lost for the average screen-reader user.

Legal Issues with Accessibility Overlays

Accessibility advocates have been highly critical of overlays, and there have been instances where lawsuits have been filed against businesses that employed accessibility overlays but maintained the inaccessible features on their websites. Additionally, legal action has been taken against accessibility overlay providers who have been accused of using excessively confident advertising slogans.

Overlay Fact Sheet(n.d.), a website endorsed by many accessibility advocates, states that overlay products offer widgets with controls that can modify page presentation, such as contrast and text size, to enhance accessibility for users with disabilities. However, these features are often redundant as users usually have similar options available through built-in or additional software. Overlay Fact Sheet (n.d.) states that website accessibility is essential for creating an inclusive digital space that accommodates all users, including those with disabilities. However, some overlay products that claim to fix accessibility issues on websites have limited reliability and effectiveness. It’s important to note that overlays cannot fix some types of content, such as Flash, Java, Silverlight, PDF, HTML5 Canvas, SVG, and media files. In addition to excluding some potential users, this could put websites at risk of legal action.

Some overlays may track users without their consent or the option to opt-out. To ensure accessibility, it is recommended to address accessibility issues directly rather than relying on overlays.

Overall, while overlay products claim to enhance website accessibility for users with disabilities, they often have limitations, are not reliable, and may even create legal and privacy concerns. Overlays are not a substitute for proper accessibility design and should only be used as a temporary measure while working on a more sustainable solution. Accessibility should be considered from the beginning of the design process, and a website should be inherently inclusive and not depend on overlay tools or separate websites for different users. To ensure full compliance with accessibility standards and provide an inclusive user experience, it is recommended to follow accepted best practices and invest in professional audits.

According to Byrne-Haber’s study (2018), a website must be inherently inclusive and not depend on overlay tools or separate websites for different users. The project proposed in this paper is not precisely an overlay tool, but a UI modification tool that utilizes the potential of sharing and infinite iterations to discover a legible and comfortable reading setting for individuals with variety of low vision conditions.

The primary objective of this project is to expand the accessibility for user testing for websites and gather data to determine which settings work effectively for particular websites and conditions.

How Does It Work?

This proposed project sets itself apart from embedded accessibility overlays by emphasizing not only UI modifications, but also the ability to share, adapt, and iterate. Moreover, it is not integrated into a specific website, enabling its use on any webpage users might visit. Examining the project through the lens of inclusive design, allowing variety of settings could potentially help individuals to tailor websites to their unique needs. Inclusive design embraces the diverse qualities of individuals, offering adaptable solutions rather than a one-size-fits-all approach. It promotes personalized, integrated solutions while respecting people’s autonomy in making choices and recognizing their own requirements.

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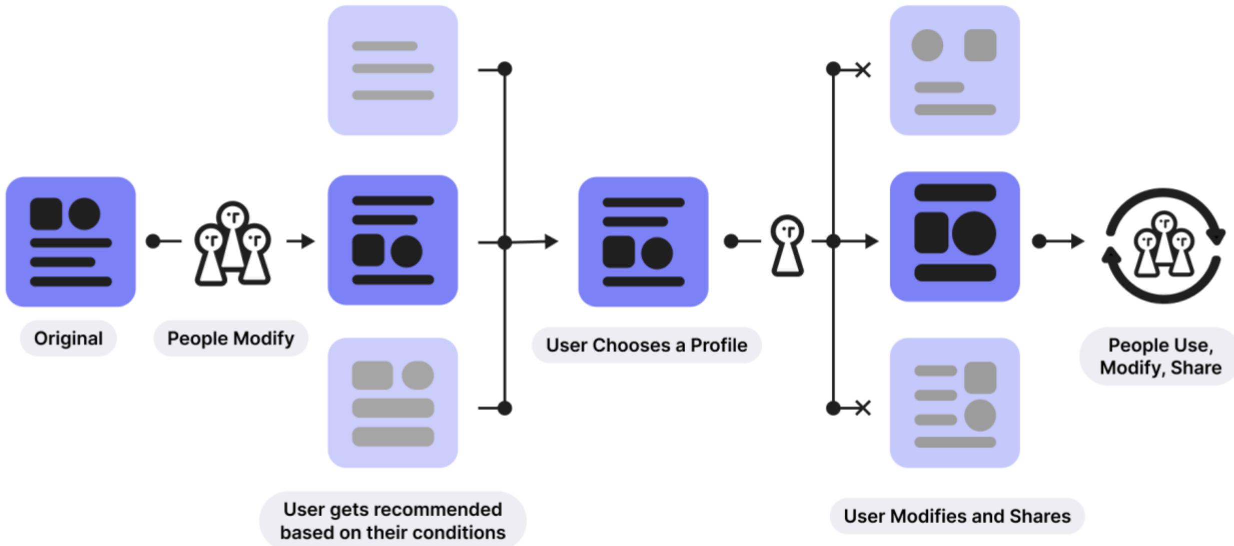

Figure M The Flowchart to illustrate the logic behind the crowdsourced UI modifications

With this in mind, the proposed crowdsourced modification cycle starts by users modifying the website and creating variety of profiles[12]. The system recommends profiles to the user based on their condition and selected tags and sorts them by relevance and popularity. The user chooses one of these profiles and applies it to the webpage they are currently viewing. Additionally, the user has the option to make minor modifications to the recommended profile and share the newly created version with others. Once

[12] Profiles are sets of settings that can change the appearance of web pages.

created and shared, others can discover the new profile and further modify and share their own versions with the community.

The platform is essentially a web-browser extension that allows users to modify any website and sharing them under the name “profiles”. These profiles can be copied and edited by other users to further modify the profile for the specific needs of any user. To make modifying webpages easier for people with little technological familiarity there are three proposed levels of modification.

Level One: four recommended and/or saved profiles by the user.

Level Two: Allowing user to customize the text(font) size, recommended fonts for their low vision needs, and foreground/background colors by allowing them to choose from five recommended color pairs.

Level Three: for the users who would like to further customize the website to create the most optimal reading setting. This level allows users to customize everything from, x-height, leading, letter spacing, changing multiple fonts, line height, individual web elements and more.

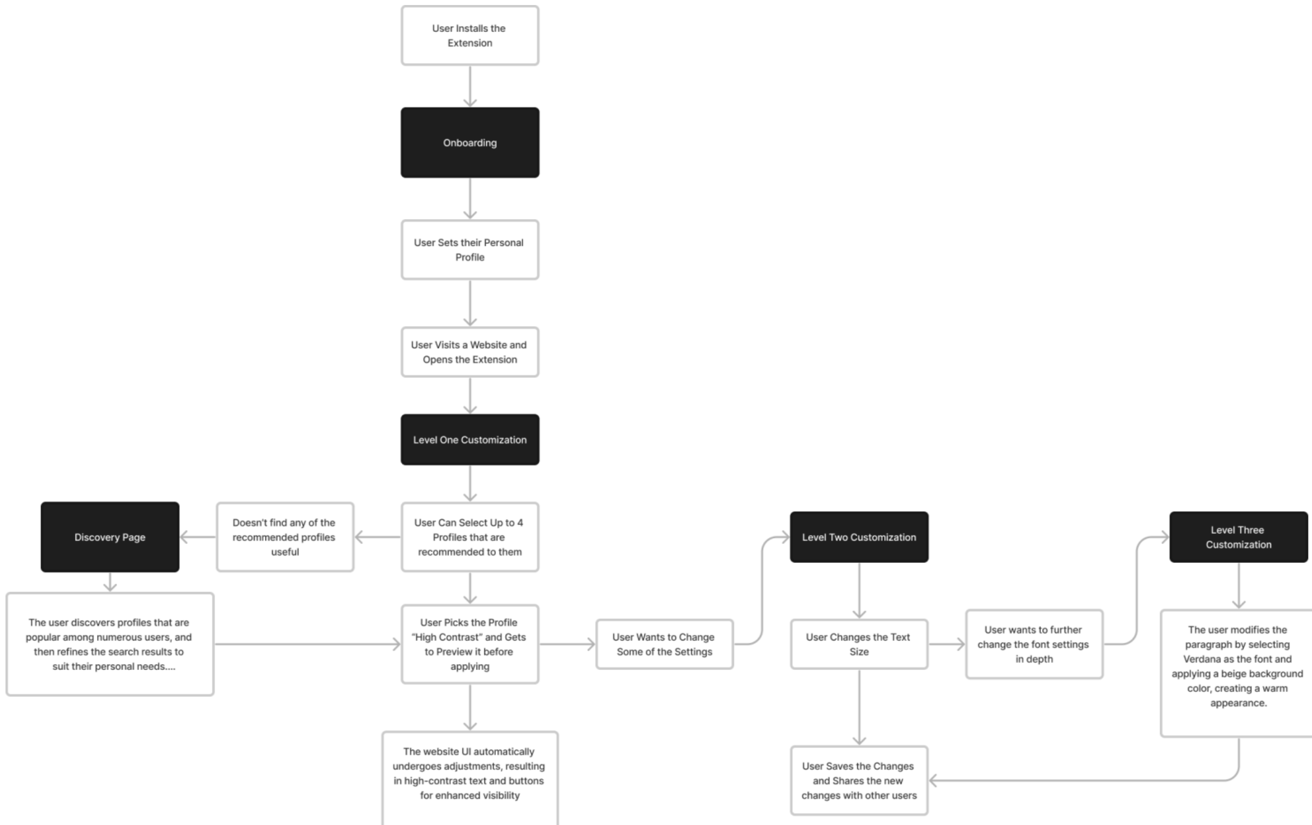

Figure 14 The detailed user flow

Onboarding

Initially, users are greeted with a screen where they enter their low-vision condition into their personal profile. Through a series of questions, such as whether they frequently require larger text or zoom-in capabilities, the platform assesses their needs to determine whether if there is a custom profile[13] that the platform could recommend to them. After setting up their

[13] Custom profiles are sets of settings that can change the look of web pages. A personal profile, on the other hand, refers to a user's account that displays their information, or vision conditions.

personal profile they are presented with a short tutorial to teach them how to use the platform.

Customization

To accommodate users with varying levels of technological familiarity, the platform proposes three distinct levels of modification for altering webpages. This tiered approach ensures that individuals with limited technological understanding can effectively use the platform.

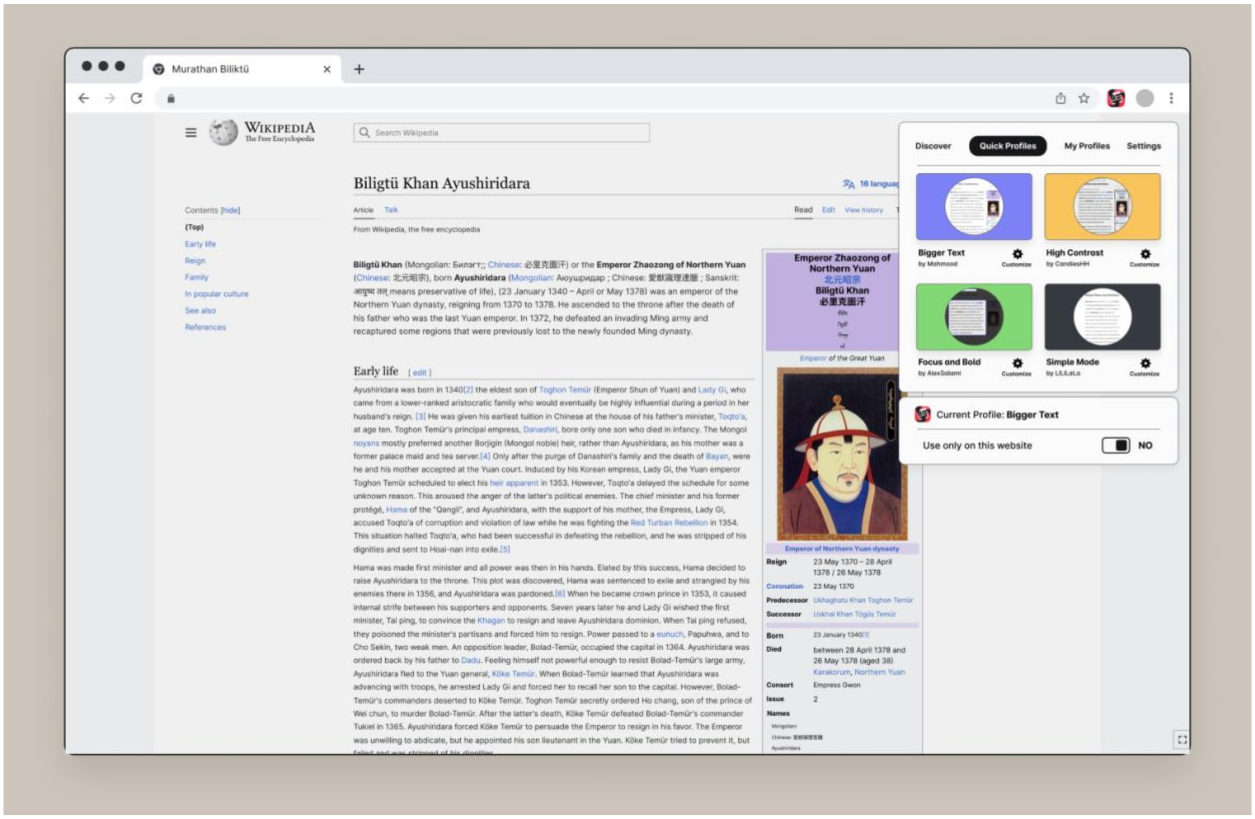

Figure O Extension overview

Level One: This level is designed for users with limited technological expertise. It offers four basic profiles (named quick profiles) which are recommendations based on the needs that have been specified by the user in the onboarding screen/personal profile.

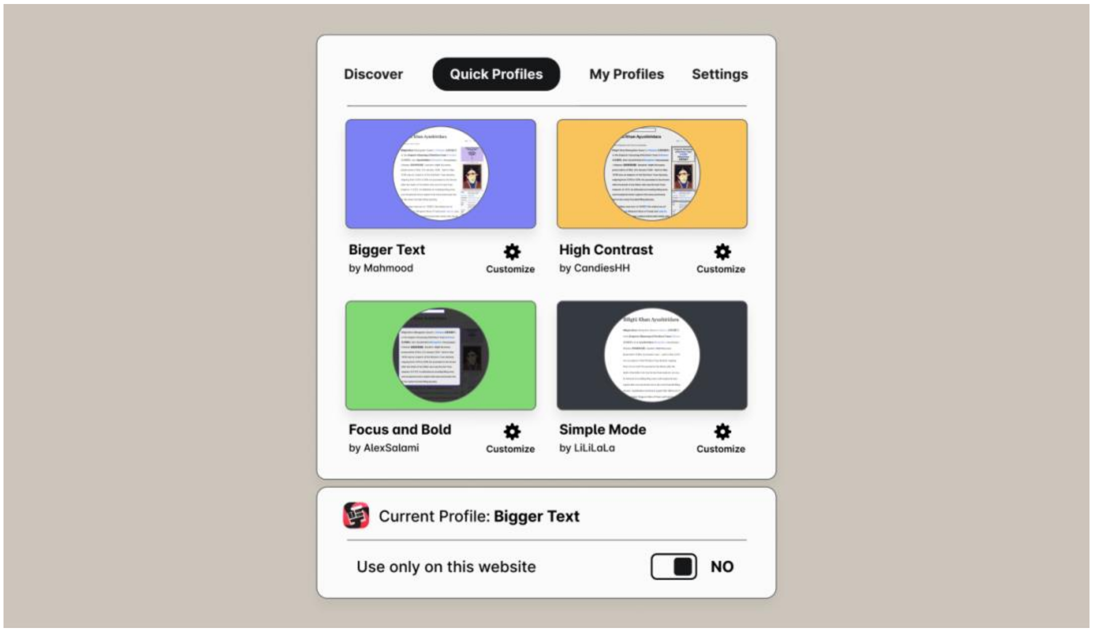

Figure P Level One Customization

These four profiles are colour coded to make them easier to differentiate, and they all have a small preview of the changes that they do to the website in a circular image. Each of these profiles can be customized by clicking on the "Customize" button located next to each option. This leads the users to the second level of customization which is more advanced. These modifications can be applied to the current website that the users are viewing or all the websites that they are visiting.

Level Two: This level offers straightforward tools for making essential modifications, such as adjusting text size, altering font styles, and changing colour contrast. A simplified set of options helps users to make basic changes to web content without feeling overwhelmed by complex settings. Users can change the text size by using a five-level slider which goes from smaller to bigger size. The non-usage of numbers to indicate text size is deliberate because technical terms like pixels might not be understood by everyday users.

The platform offers about five legible fonts that work well for most people. However, users with specific conditions may receive font recommendations tailored to their needs. For example, someone with macular degeneration might be suggested to use the Macular Rx font, which is more legible for their condition. Color pairs that the users can pick are only five and are basically change the color contrast of the websites. By offering a limited set of color pairs, the platform simplifies the decision-making process.

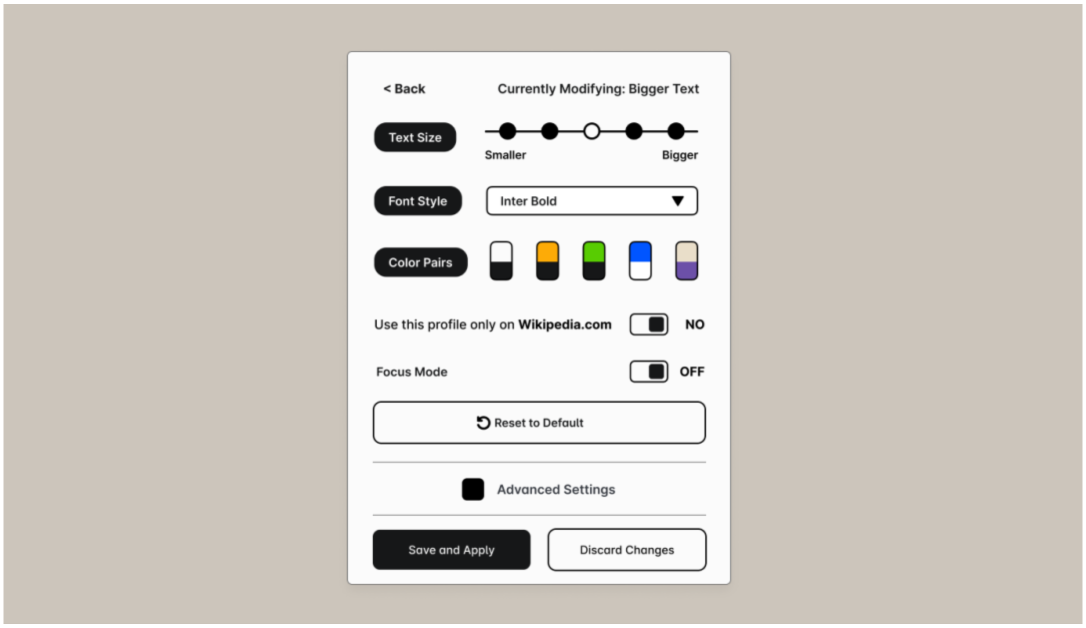

Figure Q Level Two Customization

The users can decide to use these changes only on the website that they are currently viewing or use it globally around all the websites they are visiting. With the "***focus mode***" users will be able to view a small rectangular frame that highlights only a small portion of the website. This could help some users to be not distracted by the other elements of the website.

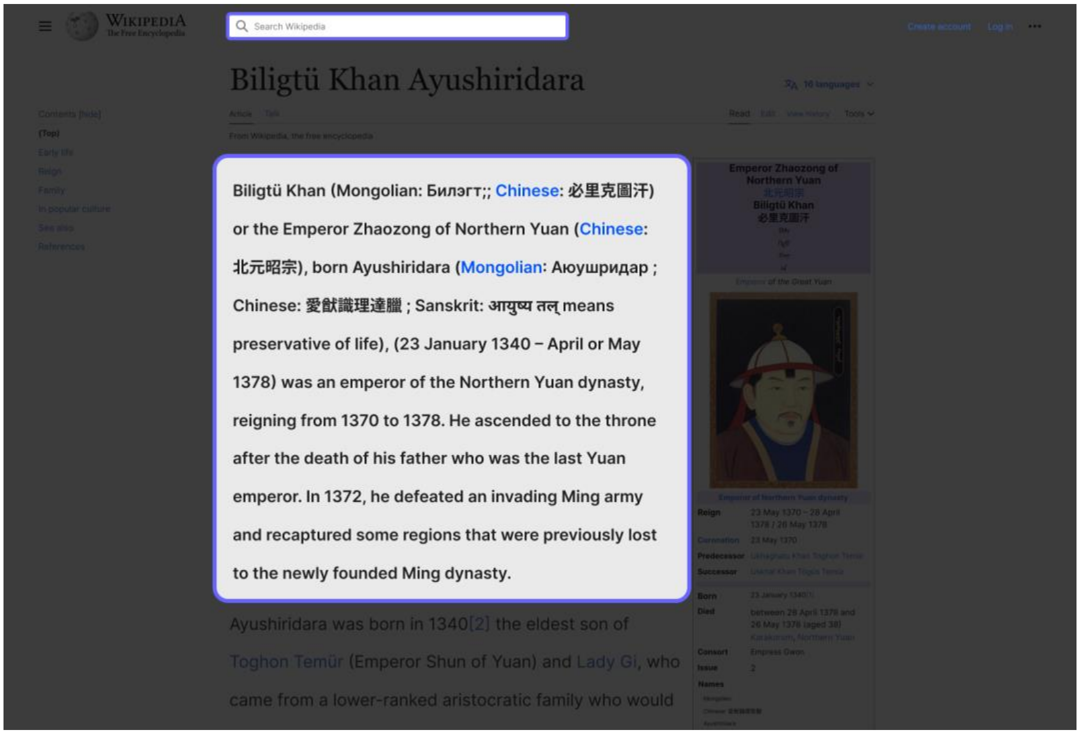

Figure R A Webpage viewed with Focus Mode on.

Level Three: At this level, users can modify the webpages with more precise settings, allowing them to customize x-height, leading, letter spacing, line height, individual web elements, being able to change individual fonts on a website, margin and padding of a web element etc. This level of customization is intended to allow personalization of the reading context for a wide range of low vision conditions.

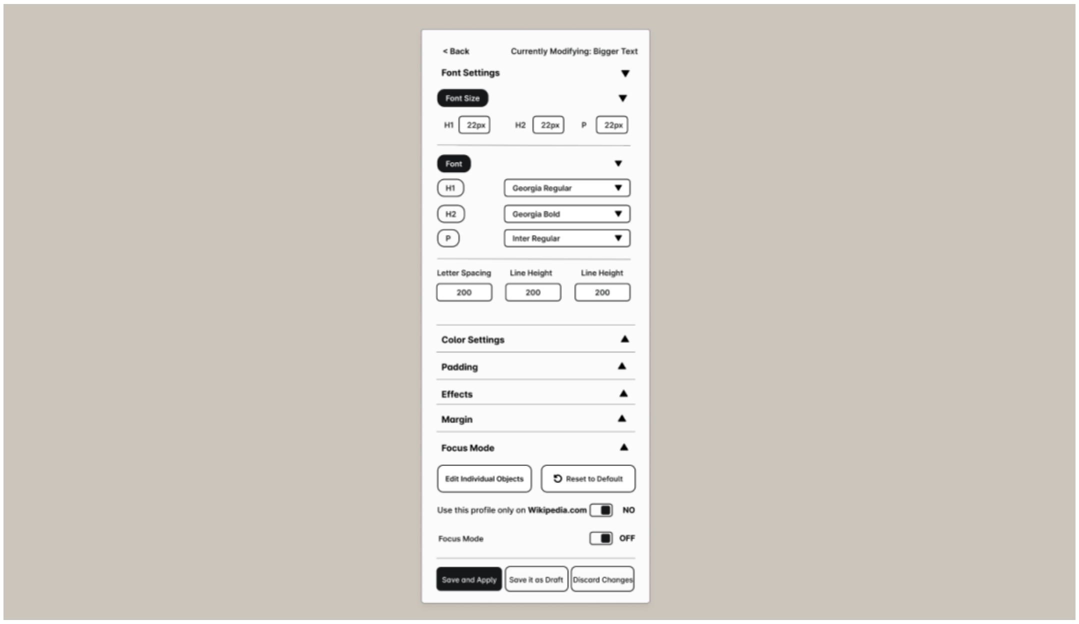

Figure S Level Three Customization, Font Settings

Allowing users to customize advanced CSS and HTML and being able to share these changes with numerous people online could help many people with low vision conditions.

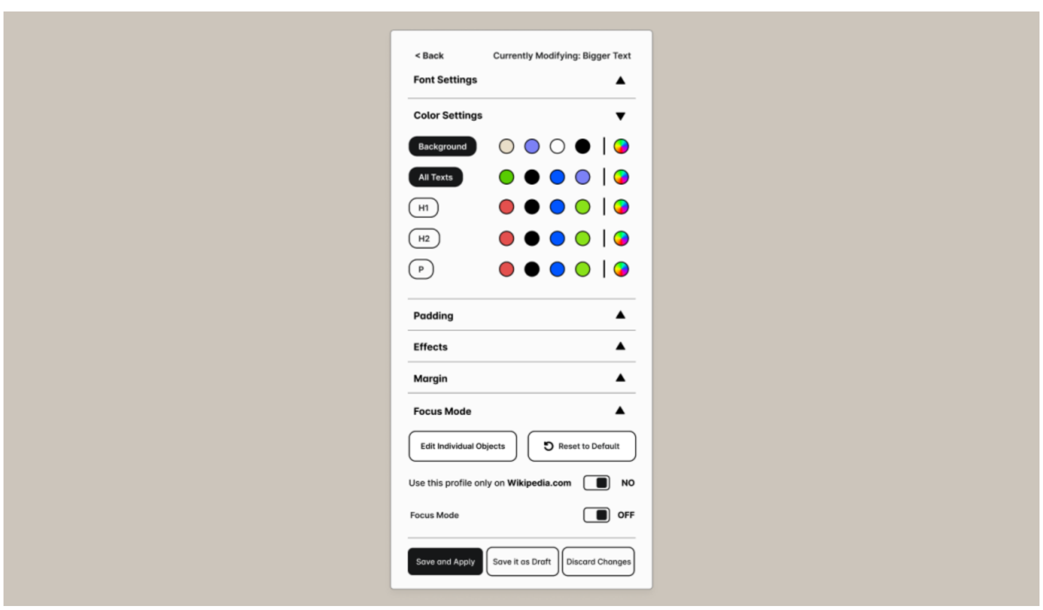

Figure T Level Three Customization, Color Settings

Users could save and apply the changes directly or to save the changes as a draft and test the settings another time before applying them to the webpages that they are viewing.

Drafts

A user might not want to completely change a profile that they are customizing. Drafts require no commitment and can inspire users to experiment with various configurations to enhance legibility on a webpage. This approach alleviates concerns about losing progress or a previously preferred profile setting.

Discover and Share Profiles

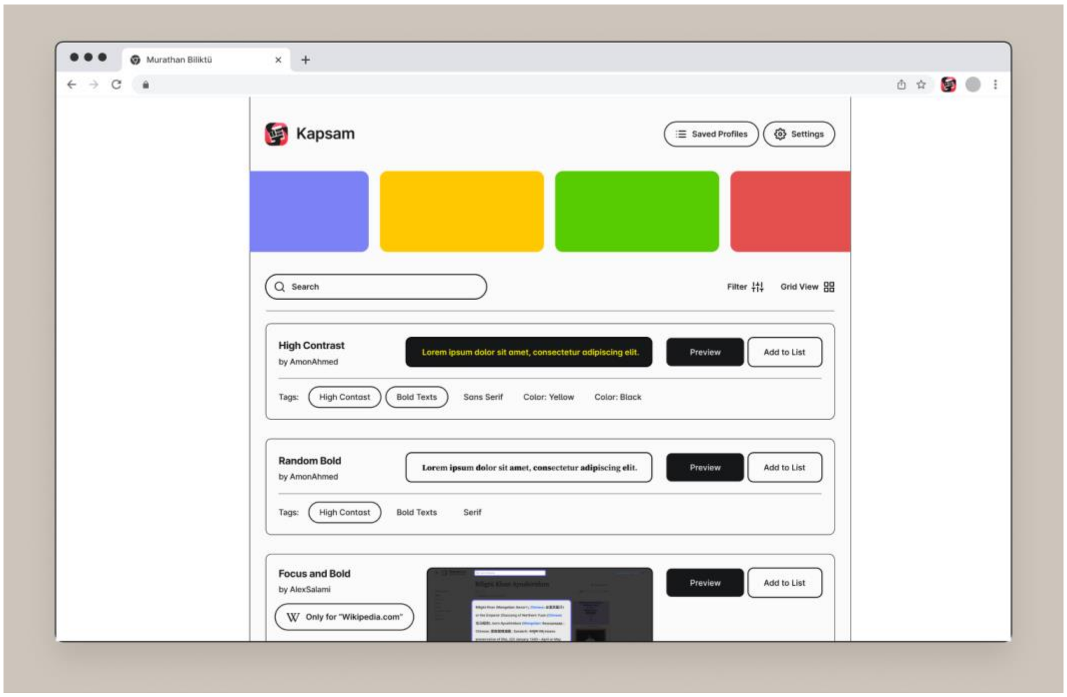

Figure U Discovery Page

The profiles created by users could be shared online with the other users. To access the shared profiles, users can go to the Discovery page of the platform. Here they can filter the search results by their own needs.

Remixing Profiles

Sometimes shared profiles may need to be adjusted for individuals. It makes sense to clone these profiles and make edits to suit the user's needs. This is why there is a feature which is named "***remix***" that allows further customization on shared profiles without affecting the profile that was originally shared by its creator.

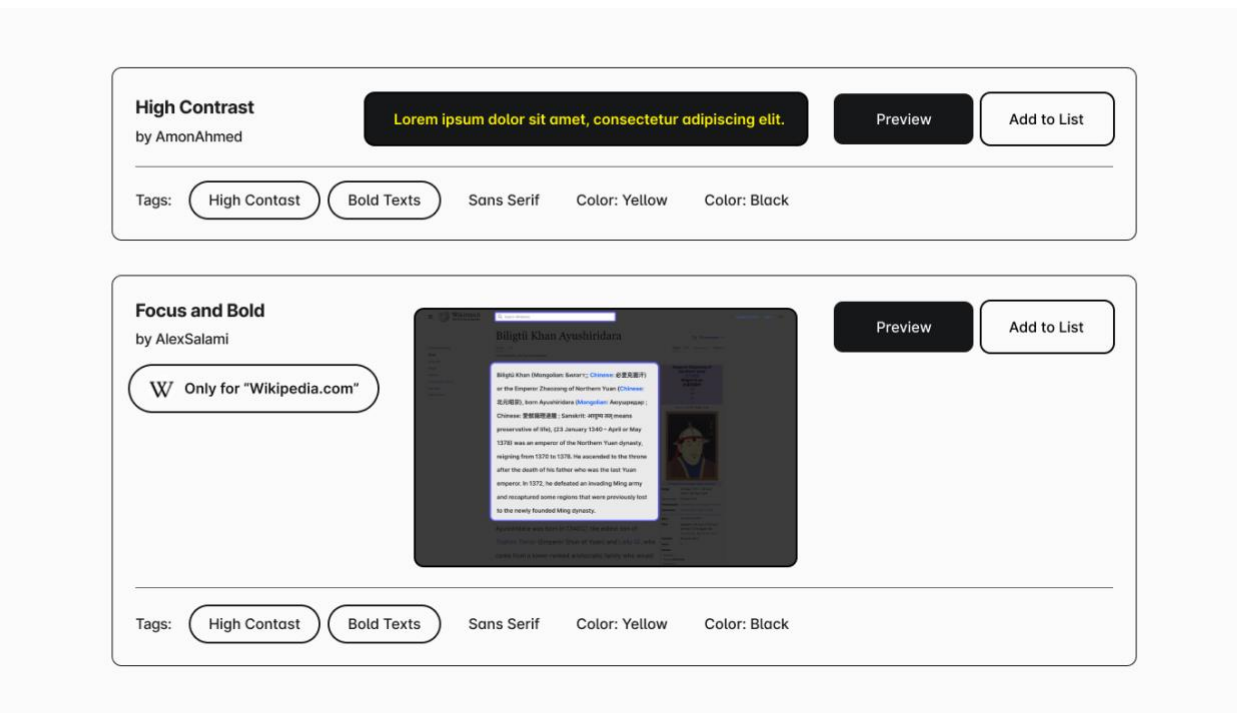

Figure V Search Results

Previewing Profiles When Searching

Search results are shown in a list format with the profile name, the creator's name, a preview frame, and buttons for adding the profile to a list or previewing it. Tags associated with each profile are showcased below these elements. Similar tags related to users' individual requirements are highlighted. For universal profiles not exclusive to a single website, a small preview window displays text and colour settings.

Recommendation Pop-up

When a user visits a website that is popular among the users, a pop-up appears in the lower right corner of the screen. Users can view a quick preview of the changes or fully preview by clicking "Preview."

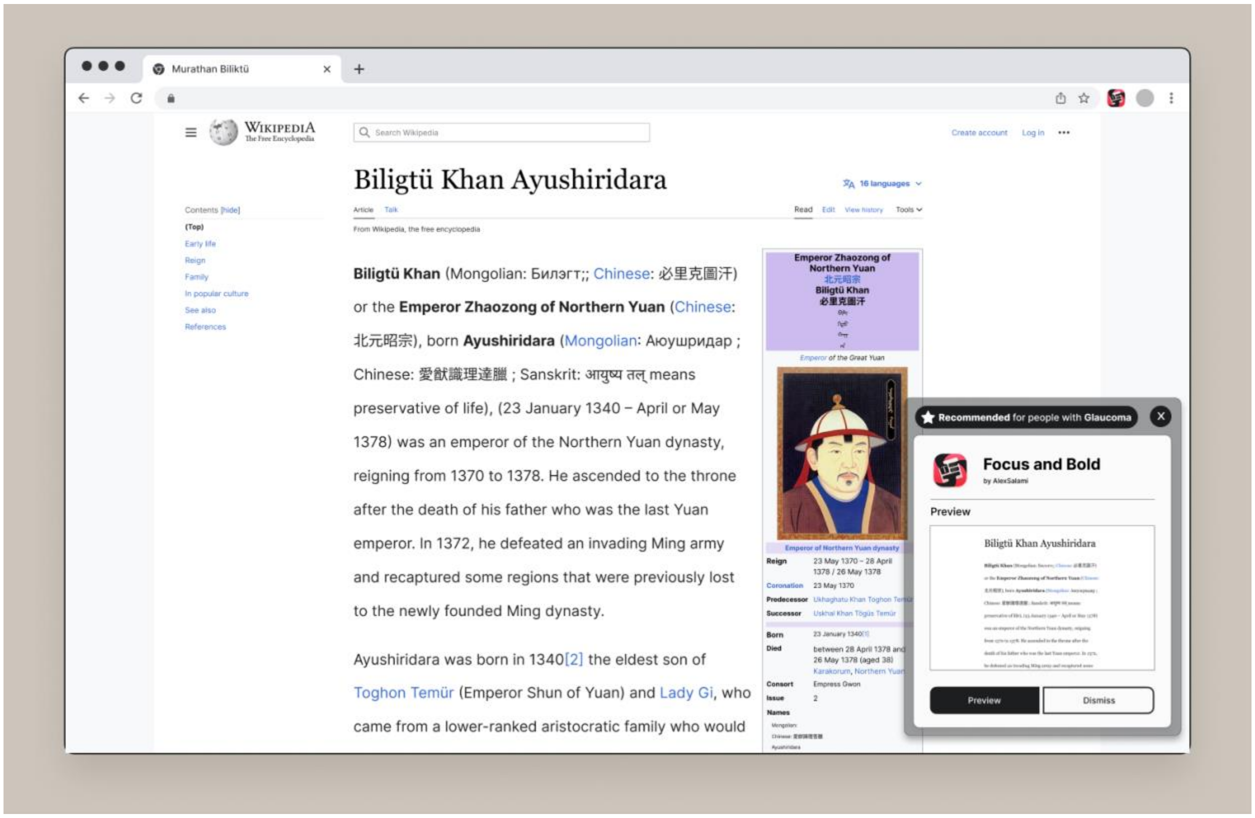

Figure W Profile Recommendation Pop-up

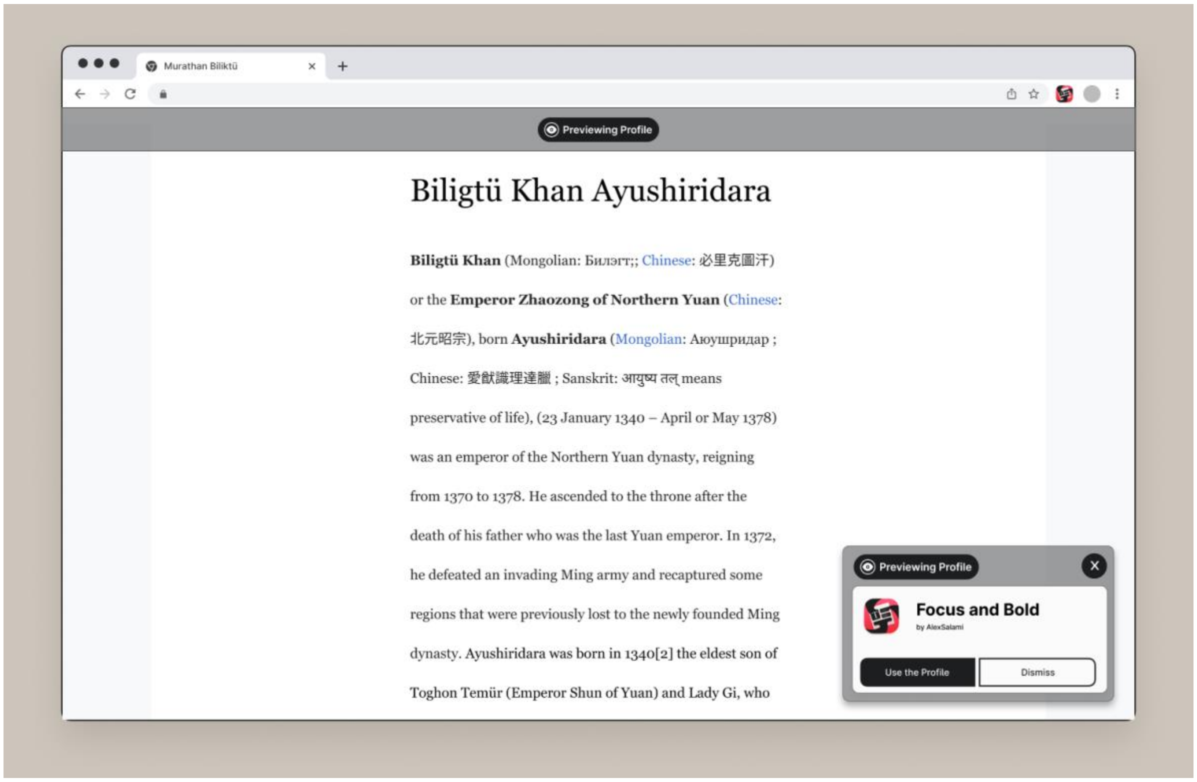

Figure X Recommendation Pop-Up, Previewing Profile

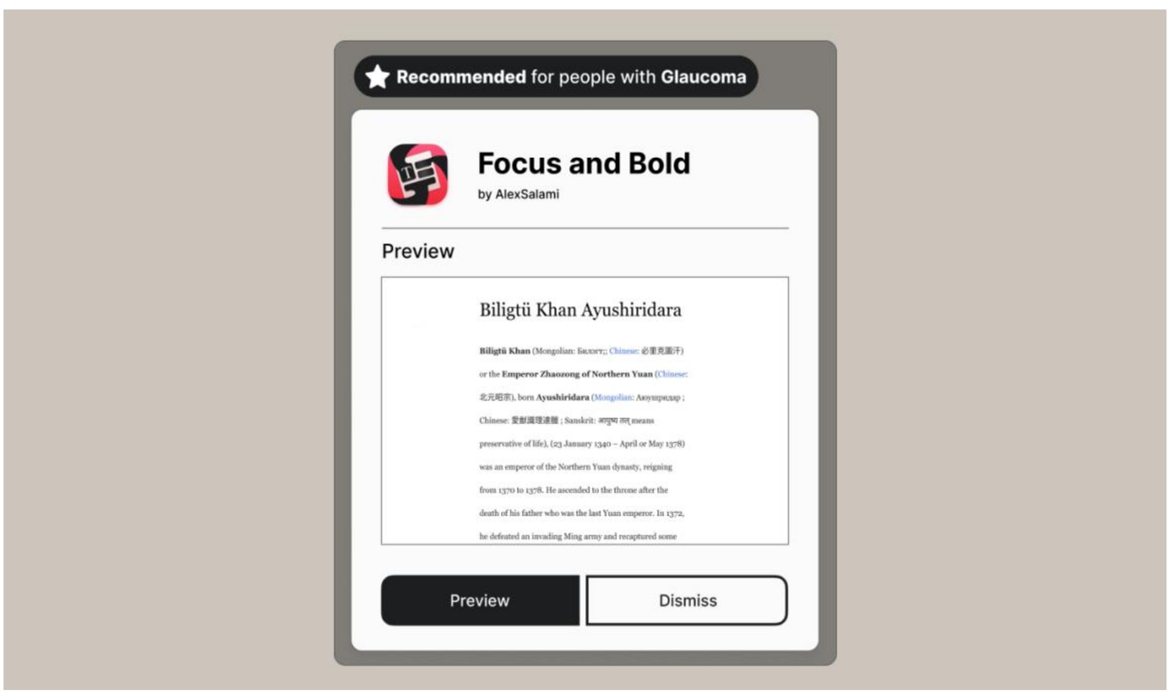

Figure Y Recommendation Pop-up

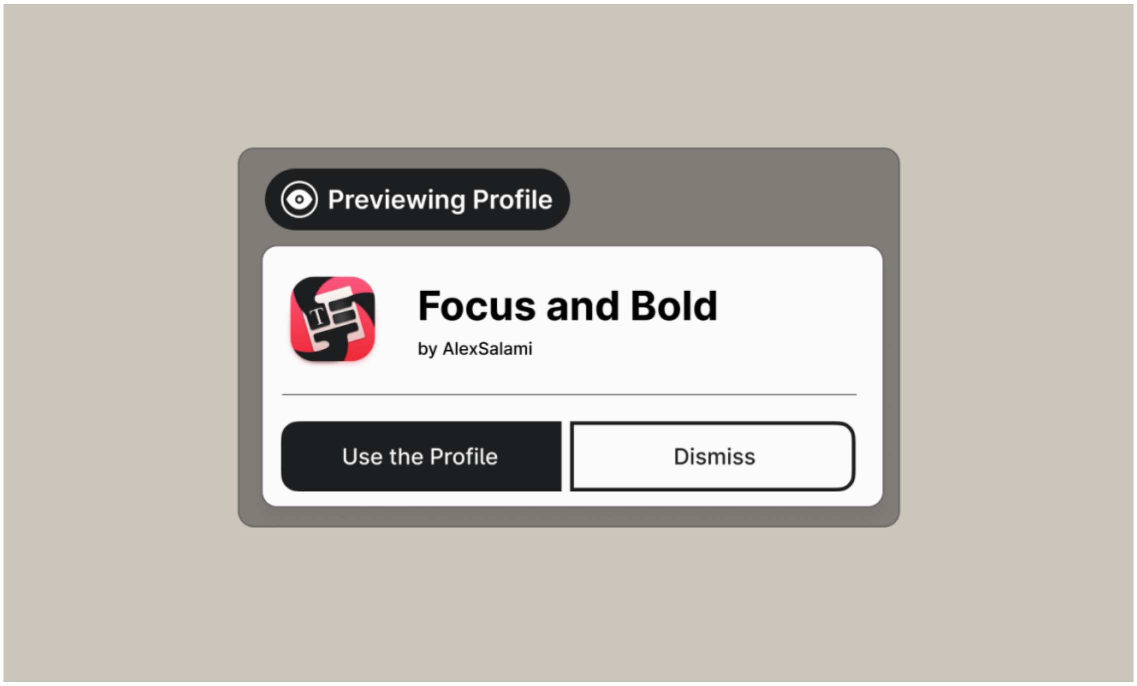

Figure Z Recommendation Pop-up, Previewing Profile, Just the Pop-Up

Discussion

This proposed platform sets itself apart from existing accessibility overlays by emphasizing personalization based on individual preferences, rather than merely offering generic solutions. Leveraging crowdsourcing, the platform creates a variety of modification options to cater to distinct needs, enhancing comfort and legibility. This approach does have advantages, as it makes the user the primary designer of their own experience. It's worth noting that while the platform's primary focus may be on low vision, it has the potential to assist a wide range of users with various needs or unique ways of interacting with websites. As an inclusive design project, the goal is to enable as many people as possible to experiment with different settings, ultimately identifying the optimal configurations for specific low vision conditions or other disabilities.

It's possible to integrate this platform into apps, not just webpages. In addition to the possible future applications, some concerns have been raised regarding the depth of website modifications and the method of saving and loading modifications. The platform may use embedded JavaScript code from a third-party provider, and this might raise security concerns that could jeopardize user data. The user experience design is also an important consideration, as is the protection and anonymization of user data.

Finally, the platform could potentially serve as a valuable research resource for other designers focused on creating accessible websites. By showcasing the design preferences of individuals with specific conditions, the platform enables designers to gain insights into the needs and preferences of diverse users.

Limitations

Throughout this project, we encountered certain constraints that were beyond our control. A primary challenge we faced was the unexpected and rapid shift in the project's scope, largely due to unforeseen circumstances. Initially, the project aimed to serve participants with peripheral vision loss, and we intended to conduct co-design sessions to better understand their needs and enhance the user interface for optimal legibility. However, we couldn’t recruit participants within our tight deadline. This abrupt change in direction compelled us to reassess our project timeline and left us with a limited time. As a result, we were unable to delve deeper into the details of UI and UX design or explore accessibility overlays. Additionally, we could not recruit participants for user testing the proposed project. However, these findings and proposals may be contested or could pave the way for new discoveries in future work.

Conclusion

In conclusion, the legibility of typography is influenced by a range of factors, including font type, letter spacing, and font size. Although sans-serif fonts are widely recognized for their legibility, the choice between serif and sans-serif fonts is often subjective, with marginal measurable improvements. It is crucial to understand the unique needs of individuals with low vision and many other conditions and acknowledge the importance of customizing typefaces to cater to their specific needs.

Our philosophical approach is Inclusive Design, which recognizes and respects the diversity of individuals and aims to create solutions that meet the needs of everyone. Inclusive design involves an iterative process that includes co-designers from diverse backgrounds and experiences, with the goal of creating an inclusive process and tools that support diverse participation and have a broader beneficial impact on society.[14]

This paper proposes a UI modification tool that allows users with low vision conditions to tailor their reading settings, setting it apart from embedded accessibility overlays. By focusing on adaptability and the ability to share, iterate, and apply to any webpage, this project aims to expand accessibility

[14] *Philosophy*. Inclusive Design Research Centre. (n.d.). Retrieved April 30, 2023, from https://idrc.ocadu.ca/about/philosophy/

for user testing and gather data on effective settings for specific websites and conditions.

Following the Inclusive Design philosophy, by allowing users to modify the websites for their unique needs and share these modifications through the platform, researchers can gather feedback from a broad range of individuals, leading to more inclusive tools that accommodate diverse participation. This participatory approach could foster a sense of community and encourage users to share and design interfaces that focuses on legibility as a community. Once the platform is implemented, researchers can study how people use the platform, opening up new possibilities for community-informed design solutions. This approach can lead to the development of products that are more collaborative, diverse, and accessible in the future.

Future research should continue to explore the factors that contribute to the legibility of various typefaces, further promoting a more inclusive approach to typography in diverse UI contexts. As with any research, the findings and proposals in this paper may be subject to debate or inspire new insights in future studies.

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Appendices

Appendix A: Footnotes

1. Interlude Reading is defined as the kind of reading that happens in a single brief sitting (i.e., a few paragraphs worth) or at short opportunistic interludes" (Wallace et al., 2022).
2. Frost (n.d.) outlines five distinct stages in Atomic design, but for legibility research, templates and molecules don't significantly differ from the other three stages, so they are not considered in this paper.
3. Leading is the vertical space between lines of text. Too little leading can make text hard to read, while too much can make the visual harmony disappear.
4. Different typefaces can have different visual sizes, even when they are set to the same point size. Because typefaces have different proportions, x-heights, and stroke widths they can look different on the page. For example, a 12-point Century Gothic typeface may appear visually larger than a 12-point Futura typeface, even though they are both the same point size.
5. Mansfield et al.(1996) states that the difference in reading speed between Times and Courier may be caused by the differences in letter spacing between the two fonts. A tighter packing of characters horizontally allows for more characters to fit into the higher resolution

area of the retina, resulting in more letters being processed in each fixation.

6. For example; Highway Gothic, FHWA, DIN 1451 Eng- & Mittelschrift, Drogowka are used in many countries for highway signage
7. The letter skeleton is the basic shape and structure of a letter without any decorative features. It defines the placement and proportions of the different parts of a letterform.
8. As discussed in Ompteda (2022), Sheedy et al. (2005), Russell-Minda et al. (2007), Mansfield et al. (1996)
9. ADA Standards for Accessible Design (2010) was taken as a reference.
10. Luminance contrast is the difference in brightness between an object's foreground and background. It is the difference in brightness between brightness of an item and that of its surroundings.
11. Guidance on the accessible Canada regulations - publications.gc.ca. (n.d.). Retrieved April 29, 2023, from https://publications.gc.ca/collections/collection_2022/nac-asc/AS4-30-1-2021-eng.pdf
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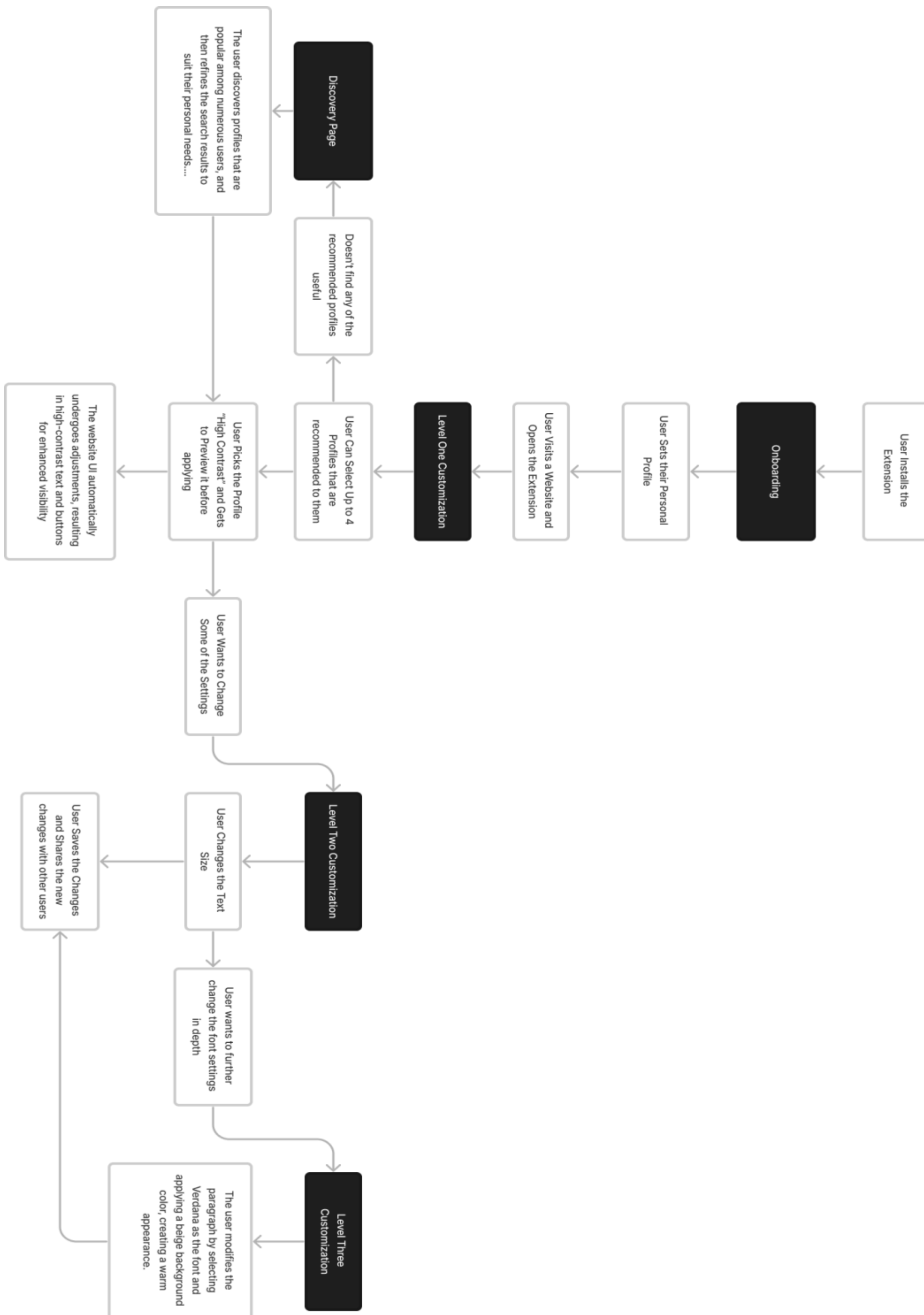
13. Blurred visuals are not used to simulate low vision, but rather to increase the level of noise in the text.
14. Profiles are sets of settings that can change the look of web pages.
15. Custom profiles are sets of settings that can change the look of web pages. A personal profile, on the other hand, refers to a user's account that displays their information, or vision conditions.

Appendix B: The User Flow



1.3 The User Flow

Appendix C: Earlier Attempts, Kapsam Font

Overall, the literature points out the people, especially with low vision conditions, could benefit from the personalisation of the interface that presents the reading context. With the advancing web and app development technologies it has become easier to modify visual elements and other properties of text. The crowdsourcing is also a beneficial and plausible method of sharing content to help one other. I believe that an app or a browser extension that has UI templates for various low-vision conditions (not limited to) that are supported by crowdsourcing and its users.

Earlier attempts that I made to improve legibility was with a custom typeface that I designed, named Kapsam. I wanted to design a font that is easily readable for blurry vision that is caused by some low vision conditions. The unique properties of this font are the diverse range of weights, varying letter heights, and irregular serifs that differ between individual letters. The design choices were made to increase the spacing between letters for the purpose of enhancing letter distinction with the space between letters and the unique characteristics of each letter. (While increasing spacing between letters in text can be done with many kinds of software, only sophisticated users are likely to have the interest or knowledge to implement this feature.)

Figure AA Kapsam Font

When comparing blurred texts between Kapsam font and four other fonts, it was found that Kapsam was more legible for four participants with low vision. However, this finding was the result of a casual research and not a scientifically conducted study. As a result, I later changed the scope of the project and abandoned the development of the font. Nevertheless, there is potential to revise the font for further research on its impact on legibility.

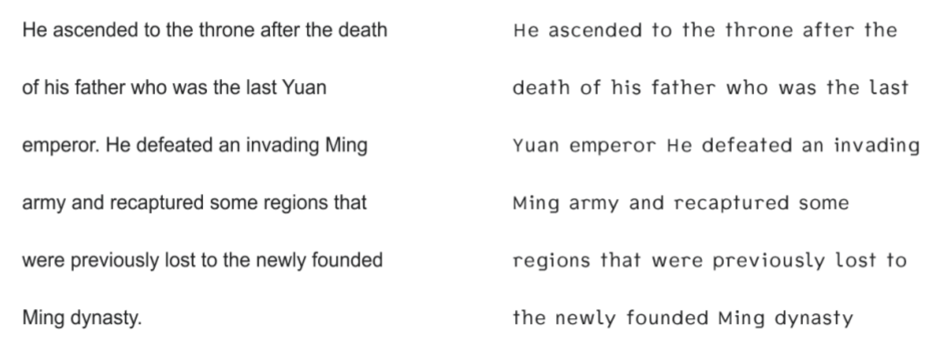


Figure BB Arial (Left) Kapsam (Right)

Figure CC Arial (Left) Kapsam (Right), Blurred[15]

[15] Blurred visuals are not used to simulate low vision, but rather to increase the level of noise in the text.