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An interactive color picker that ensures WCAG2.0 compliant color contrast levels

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Abstract

Insufficient contrast between text and the background is a common problem on the web. WCAG2.0 addresses this problem, but the definition is hard to understand for most designers. Therefore, some web designers check their designs with contrast checking tools after the design is finished. If the design does not meet the WCAG2.0 guidelines the designer will have to go back and make adjustments. To overcome this problem a color picker tool is proposed that allows designers to select WCAG2.0 compliant colors during the design process thus eliminating the need for post-design color adjustments. First, the designer selects the first color freely from all available colors. Subsequently, only colors are presented that meets the chosen contrast level. In addition to being a design tool, it also serves as a pedagogical visualization aid that can help students and designers better understand the complex relationships between colors palettes and their contrasts.

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1. Introduction

Web is probably one of the most important sources of textual information. For text to be visually readable when rendered on computer displays the text has to be sufficiently large and the text has to have a sufficient contrast in relation with the background [1]. If the text color is too similar to the background color, it is not possible to read the text even if the text is rendered in large letters. The contrast is too small.

Current web browsers, especially those shipped with touch based devices, makes it easy for users to adjust the text size at any time using the shrink and expand gestures to fit the reading comfort of the user. Unfortunately, the

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user has not got the same level of control over colors and contrast. Although, color settings can be overridden in many web browsers, it is not easy not easy to do in practice.

Web designers are responsible for providing sufficient contrast on the web. Still, many web pages do not adhere to standards such as WCAG2.0. This suggests that many designers are unaware of the problems associated with contrast and reduced vision.

Web developers commonly work with hardware oriented RGB (red, green, blue) representations as used in HTML, while some web designers rely on the HSB (hue, saturation, brightness) representation. In the HSB model contrast can be achieved with different hues, different levels of saturation, and different levels of brightness or a combination of these.

It is recommended to rely on brightness contrast as hue and saturation contrasts are harder to perceive for users with color deficiencies [1]. A visual design based on brightness contrast is therefore also robust in terms of color blindness.

1.1. WCAG2.0 contrast

The World Wide Web Consortium (W3C) Web Contents Accessibility Guidelines (WCAG2.0) [2] refers to luminance contrast. The WCAG2.0 guidelines for level a criterion (criterion 1.4.3) recommends that body text should not rely on hue contrast at all. The level aa criterion states that the contrast should have a luminance contrast ratio of at least 4.5:1 for body text and 3:1 for headings. The level aaa criterion defines a contrast ratio between body text and its background of 7:1 and a contrast ratio for headings of 5:1.

WCAG2.0 defines luminance contrast according to the standards ISO-9241-3 [3] and ANSI-HFES-100-1988 as

$$contrast = \frac{L1 + 0.05}{L2 + 0.05} \quad (1)$$

where *L1* is the luminance of the brightest color and *L2* is the luminance of the darkest color. Luminance is defined as

$$L = 0.2126r + 0.7152g + 0.0722b \quad (2)$$

The factors r, g and b represent linear red, green and blue color components. The conversion between linear c and non-linear components k is based on IEC/4WD 61966-2-1 [4] and [5] as

$$c = \frac{k}{12.95} \quad (3)$$

If $k \leq 0.03928$, or

$$c = \left(\frac{k + 0.055}{1.055}\right)^{2.4} \quad (4)$$

If $k > 0.03928$. The value k is given by

$$k = \frac{C}{255} \quad (5)$$

Here C represents one of the three RGB-vector values defined by an 8-bit value in the interval 0 til 255. This mathematical contrast definition is non-trivial and it is understandably not easy for designers to build a mental model of how color choices affect contrast.

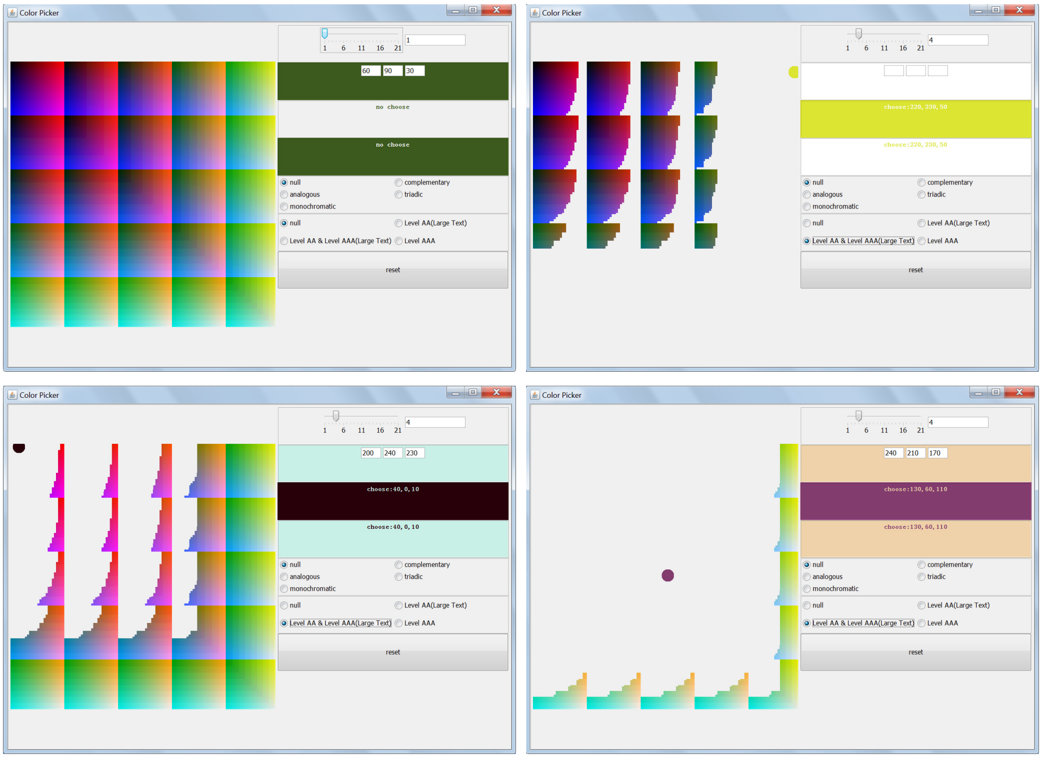

Fig. 1. Effect of color selections using the tool. a) The entire color space represented using red-green plane slices for different levels of blue, b) Valid colors after selecting a yellow color, c). Valid colors after selecting a dark grey color and d) Valid colors after selecting a purple color in the middle of the color space.

Web designers that are aware of the problems associated with low contrast levels may use tools to check whether their design provides sufficient contrast. One of many such online color contrast checker tools is Snook (http://snook.ca/technical/color_contrast/color.html). With such tools the contrast checks are performed after a design is finished. If a design fails to meet contrast checks the designer will have to go back and adjust the design. Moreover, such approaches are also vulnerable to the diligence of the designers, and it is easy to forget to check for sufficient contrast.

2. Background

The legibility of text has long been an active area of research from the pioneering studies of printed text by Tinker [6, 7] up until the present day with research into readability of displays. These include studies of visual performance with cathode ray tubes [8], effects of prior experiences with printed text on reading computer displays [9], effects of display quality on visual search [10], effects of polarity [11], effects of text-background color combinations [12, 13] and effects of chromatics and luminance contrast on reading [14, 15, 16]. None of these studies have addressed visual impairments. More recently electronic paper has received attention [17, 18, 19].

Not only size and color combinations affect readability. Also, stroke width can make low contrast text easier to read. Ricco’s law predicts this [20], namely that the product of the threshold intensity and the area is constant. The detection of luminance intensity differences is predicted by Weber’s law in that larger differences are needed to detect higher luminance. This relationship exploited in several image-contrast enhancement algorithms [21].

Check for accessibility of web sites, such as sufficient contrast levels, are frequently performed after the main design phase [22] or real-time proxy-based contrast corrections during browsing [23]. Some research also has addressed making general images robust to color blindness via various color palette transforms [24, 25].

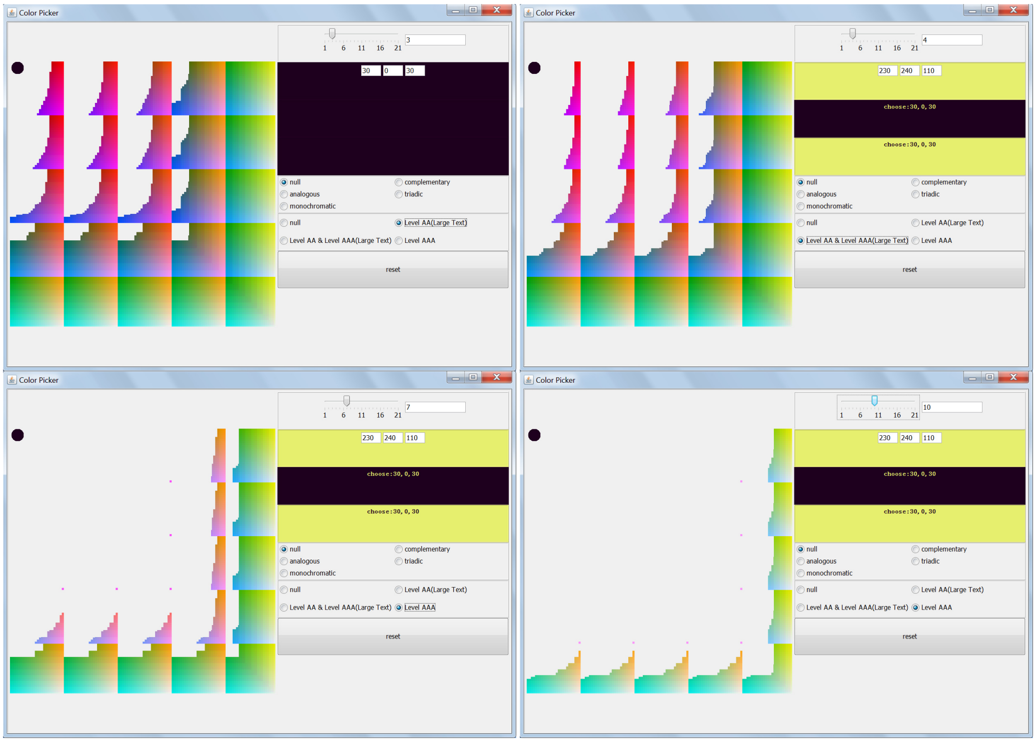

Fig. 2. Varying contrast level: a) Valid colors after selecting a dark gray with contrast level 3 (aa headings), b) Valid colors after selecting a dark gray with contrast level 4.5 (aa body text), c) Valid colors after selecting a dark gray with contrast level 7 (aaa body text) and d) Valid colors after selecting a dark gray with contrast level 10.

Little research has been conducted into the general computer color selection process. Van den Broek el al. [26] found that several common color picking interfaces are complex to use. Various textbooks and internet discussions reveal that there are different opinions about which color model a color picking tool should have. However, Douglas and Kirkpatrick found that that visual feedback is more important than the actual color model used [28]. Other color selection studies include that of Gonzales [27].

In terms of contrast, attempts have been made at generating palettes that help designers cater for color blindness [29]. Light emitting displays also pose different problems to printed text. In particular, it may be difficult to read text suffering from color bleeding which may occur with self-luminous white text on black backgrounds [30].

It has been argued that the WCAG2.0 contrast requirements should be incorporated into the design tools such that low contrast color combinations are avoided [31]. This study attempts to realize this principle by exploring a concrete color picking prototype that only allow WCAG2.0 compliant color combinations to be selected.

3. Color Picker Tool

An interactive prototype color picker tool was developed. First, the tool displays a representation of the entire color space. The prototype employs the hardware oriented RGB color space for simplicity. The color cube is displayed as red-green color plane slices at various levels of blue. These slices are laid out in a grid (see Fig. 1a).

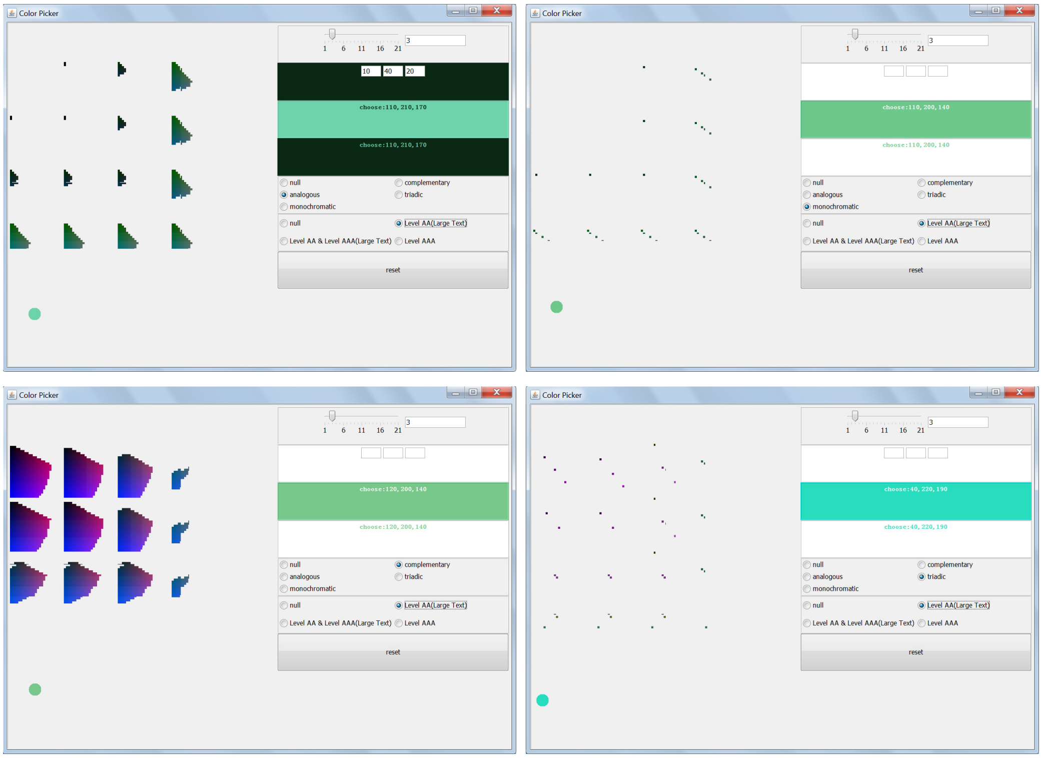

Fig. 3. Color harmonies: a) Valid colors with a analogue color harmony after selecting a cyan with contrast level 3, b) Valid colors with a monochrome color harmony after selecting a cyan with contrast level 3, c) Valid colors with a complimentary color harmony after selecting cyan with contrast level 3 and d) Valid colors with a triadic color harmony after selecting a cyan with contrast level 3.

The user first choose a color and the chosen color is highlighted. All the colors that do not adhere to the set contrast level are disabled leaving only valid colors. Figs.1b, 1c and 1d show the result after selecting different colors in the color space.

The contrast level can be set in two ways. Either by using the contrast slider or choosing the specific WCAG2.0 levels, that is level aa for body text, level aa for heading, level aaa for body text or level aaa for headings. The effect of selecting different contrast levels are illustrated in Figs. 2a, 2b, 2c and 2d.

The contrast level is related to the visual acuity of the user. Colors with low contrast levels are perceivable by users with high visual acuity, while the required contrast level increases as a function of reduced visual acuity. For WCAG2.0 the level aa criteria (4.5:1 for body text and 3:1 for headings) are based on empirical findings for users with a visual acuity of 20/40 and the level aaa criteria (7:1 for body text and 5:1 for headings) are based on empirical findings for users with a visual acuity of 20/80 (W3C, 2008).

The higher the contrast level is the larger portion of the population is included. According to Laitinen [32] approximately 95.9% of the Finish population have a visual acuity of 20/40, 1.6% of the population has a visual acuity of 20/80, and 0.5% are technically blind. Visual acuity is also connected to age as vision is often reduced with aging [33]. At the same time, high contrast levels reduce the design space. It may be tempting for designers to sacrifice the last 5% or even the last 10% of the population by relying on low contrast levels. However, the WCAG2.0 level aaa criterion covers most of the population.

Most designers employ color harmonies in their designs such as monochromatic colors, neighboring colors, contrast colors, triads, split complementary, etc. We therefore also provided a color harmony filter that allows designers to immediately see all the contrast compliant colors for a given color contrast. This further limited the color space and gives the designer a smaller color palette to choose from and hopefully leads to more rapid design decisions. The color harmony filters are demonstrated in Figs. 3a, 3b, 3c and 3d.

4. Experimental results

4.1. Experimental setup

The prototype WCAG color picker tool was evaluated by six designers in individual talk aloud design sessions and compared to an ordinary non-WCAG color picker tool with the same color layout. The participants were asked to adhere to the WCAG2.0 guidelines in their designs. The ordinary color picker tool did not constrain the choice of colors and the participants were therefore asked to use a contrast calculator together with the non-WCAG tool. In this way we attempted to simulate the current practice in a controlled environment.

The six designers varied in experience and background. Each designer was given two wireframe designs and asked to select colors for the text with the inspiration of a clothes store in summer and a games website with Japanese cartoon characters, respectively.

4.2. WCAG2.0 contrast

The main feedback from the design sessions were as follows: The color picker tool appeared to lack some colors in color layout. In particular, this designer claimed that the shades of yellow were too greenish. Consequently, this designer did not find the desired colors. It is likely that there could be a problem with our implementation in that it does not display the colors correctly. Another explanation could be that the presentation biases the perception of the colors in an unfavorable manner.

The game design comprised a partial design with some colors given. Most of the designers wanted to use these given colors as a basis for their design. However, they found it difficult to locate the exact color on the color picker. This illustrates the need for a color analyzer as new designs often are based on existing elements. This could for instance be company logo colors, product brand colors, etc. Commonly used tools such as Photoshop have such color analysis functionality built in. A future version of our color picker tool should also incorporate such functionality.

An interesting observation was that the designs for the clothes company fell into two distinct categories. One group preferred warm colors such as yellow and pink, which they associated with sunshine and heat. The other group chose cool color such as blue and green as these colors were associated with beaches and the ocean. This observation does not directly relate to the color picker tool, but rather a consequence of the experimental design..

The participants provided positive feedback on the WCAG color picker tool compared to the non-WCAG color picker tool. Even though the WCAG tool provided less choice they found it useful that it helped them adhere to the WCAG2.0 color guidelines and hence saved time and effort by not having to use the contrast calculator.

The sessions revealed that when either the foreground color or the background color is black or white it is easier to select colors that adhere to the WCAG2.0 guidelines. One interpretation of this is that web sites based around black and white may achieve sufficient contract by chance.

Four of the six participants failed to satisfy the contrast constraints for clothes website headings at the first attempt using the non-WCAG tool, while only two of the participants failed at the first attempt at selecting body text colors. Thus more participants found it harder to set the heading colors than body text colors, although the contrast limits for headings (3:1) is lower than that for body text (4.5:1).

Participants who are familiar with setting RGB values directly via text fields are able to locate the desired colors more quickly. A tool such therefore provide both direct manipulation and text based modes of input in parallel.

One participant failed to achieve a sufficiently high contrast for the body text on the game website using the WCAG tool. The reason was that this participant accidentally set the incorrect threshold to headings instead of body text by clicking on the wrong radio button. Clearly, the design satisfied the contrast constraints for heading, but not for body text. This result suggests that the user interface of the color picker tool needs a redesign with the goal of preventing the setting of incorrect thresholds.

Finally, the sessions did not reveal any signs that that gender influenced the designers' color choices, despite the fact that gender related color preferences are claimed by some researchers [34]. One explanation for their absence in our study could be that the designers we included have a more professional approach to colors than non-designers.

5. Conclusions

A color picking tool for assisting designers selecting color combinations that exhibit sufficient contrasts has been presented. The interactive tool only allows the selection of color combinations that adhere to given contrast thresholds, including the contrast levels defined by WCAG2.0. By working with valid colors during the entire design process it is likely that a better result is achieved in shorter since unnecessary and time-consuming post-design adjustments are avoided. The interactivity of the tool allows it to be used as a pedagogical learning aid as the effects of various color selections are visualized in an understandable manner.

Future work includes a redesign of the tool for improved usability. A more intuitive representation of contrast limits needs to be devised. Improved usability could perhaps also be achieved if the hardware-centric RGB presentation is replaced with an HSB presentation where colors are represented in terms of hue, saturation and brightness. The HSB-model is closer to how designers work with colors.

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