# A Color Model in the Usability of Computer Interface Applied to Users with Low Vision

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**Abstract.** This paper presents the results of a research on the usability of computer interfaces through colors for Low Vision users. It describes the methodology used, the 3 web interfaces tested for usability with the users in question, showing the results for the development of a prototype interface with colors as the main aspect. The prototype developed is presented with the usability test carried out with it. As a result of the work, a proposed color model is presented that includes Low Vision users in the construction and upgrading of computer interfaces, aimed at the usability of web interfaces.

**Keywords:** Color, Usability, Low Vision.

## 1 Introduction

The current guidelines for the design and redesign of computer interfaces, which consider Universal Design requirements and are applied to users in general, does not ensure that all users are equally benefited in the same manner by those requirements. It occurs due to the great diversity of the requirements demanded by the disabled and non-disabled population [3].

Among those with disabilities in Brazil [5], a number of 35 million of people with Low Vision are users of web facilities in some way to obtain information, knowledge and interact with friends. Those users need specific tools that stimulate their skills and permit social inclusion without reducing or limiting their actions. Such tools are used in order to increase their functional view, enable them to increase visual efficiency and are applied to a range of countless possibilities.

From this perspective, this paper introduces a study aiming to propose a color model to assist web designers in developing interfaces for users with low vision. This study demonstrates the difficulties faced by users with low vision to navigate virtual environments. A usability test was carried out on three web interfaces with 10 low vision users with the use of color as a facilitator in the process of understanding, reading, identifying and memorizing information.

In order to identify the three most accessed websites by users, two open questions were applied in unstructured interviews. Participants who had adequate functional vision were chosen to navigate the web without the aid of voice programs. This enabled the researcher to identify eventual difficulties, problems and characteristics common to participants in the survey.

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After selecting the websites to be used in the study, a usability test was carried out using a questionnaire with 10 questions to identify the efficiency of the websites in carrying out some tasks; the efficiency of colors to assist in carrying out some tasks; the use of colors to reduce mistakes; and the contribution of the colors to: identify participant perception of the website function, learn some website functions, and memorize information in the website though color layout. The survey was carried out in an information technology laboratory where it was possible observe and film participant behavior.

As a result, prototype website was designed in order to validate and identify the contrasts of colors which would improve the usability of web interfaces. The results of the survey shows the categorization of the color contrast considering efficiency as the first characteristic most voted by respondents, followed by facility of reading, memorization, feeling of safety, and assistance in reading for users with light sensitivity and other characteristics.

It was necessary to analyze the color combinations separating them in the following components: main menu, submenu, heading, body of text and footnotes. This approach was used to design a contrasting color model which improved interface usability for the user and the website. In addition, this approach also improved the accessibility of users with low vision, enabling them to navigate in virtual environments with functional view comfortably and satisfactorily without the aid of any assistive technology.

Below we present the Low Vision disability in order to provide a better understanding of the development of this research.

## 2 Low Vision Disability

According to Faye [4], the term Low Vision (LV) is usually applied to define a situation in which the eye has had one of its visual impulse carrying paths irreversibly altered, where the loss of sight represents an obstacle for the development of a person's normal life and requires special correction. Carvalho [1] and Vanderheiden & Vanderheiden [12] state that this disability includes problems such as darkening of vision, blurred vision, mist or film over the eyes, vision only of objects that are extremely close objects or loss of distant vision, color distortion or color blindness, visual field defects, tunnel vision, lack or peripheral vision, abnormal sensitivity to light or brightness and night blindness..

LV uses or is potentially capable of making use of vision to plan or execute certain tasks [2]. The main characteristic for a person to be diagnosed as having LV is related to the visual capacity a person has between 20/40 and 20/200 after correction. This means that a person with 20/200 vision can see an object from a distance of 20 feet, while a person whose vision is considered normal can see the same object from a distance of 200 feet. It is also described as the degree of visual weakening that results in incapability and visual performance reduction.

Due to those issues, Paschoal [8] states that LV is in an intermediate position between the reality of people who can see normally and total visually disabled people.

They is not treated as people with normal vision, as they feature limitations that do not allow to perform certain functions, and are not treated as blind, as they have residual vision that allows to execute some tasks perfectly. This borderline condition leads to difficulty in adjusting to society and the consequent exclusion at a higher level than the exclusion of people who are blind or have normal vision.

Despite the difficulties faced with LV, the factor that best determines vision quality lies in the brain's ability to capture, codify, select and organize the images perceived by the eyes. This way, Sá [11] points out that visual efficiency takes place through the quality and efficient use of the visual potential according to the conditions of stimulation and activation of the visual functions, which means that emotional factors, environmental conditions and life contingencies of the person interfere directly in the potential use of vision.

Thus, it is understood that LV needs specific tools that stimulate its possibilities and bring social inclusion, without reducing or limiting the person's actions, with the functional vision of that person resulting in an increase of their visual efficiency and leading to a variety of possibilities.

Even with the constant creation of technologies that allow for better accessibility to the web environments by the disabled in general, there are no guidelines for the development of interfaces aimed specifically at LV. This makes evident the search for research and development of products and resources that stimulate those persons' visual stimulation, with colors carrying great importance in this relation due to the possibility they offer in calling attention, indicate aspects of the interface, make memorization easier, create back planes, direct reading and making it possible for it to designate meaning and value to those interfaces according to their interpretation [6].

## 3 Methodology

To make use of colors as facilitators in the process of understanding, reading, identifying and memorizing of a web interface with LV, we have established the usability test as an assessment method that is user-centered.

According to Cybis et al. [3], the usability test focuses on the assessment of the quality of interaction between users and system. The objective of this test is to ascertain problems found, measure their impact on the interaction and identify causes on the interface. It involves actual users of the system carrying out certain tasks in a real context in order to reflect the general behavior of the target population.

To take part in the usability test, we selected 10 LV users [3], regardless of each one's diagnostic and etiology, considering only the functional vision required to navigate the web without voice programs to make it possible to identify problems and positive points common to all participants.

To identify the three sites mostly accessed by the participants, an initial interview was made, with two open questions (Table 1), to collect primary data.

**Table 1.** Questions about the sites mostly accessed

| | |
|---|---|
| 1. | What are the sites you want to navigate without the use of voice programmes, but can not? Give three examples: |
| 2. | What problems do you find with the sites listed when you use them? Please describe the problems in detail if possible: |

The analysis of the answers provided resulted in search sites: Google (Fig. 1), information sites: Zero Hora Newspaper (Fig.2) and bank sites: Banco do Brasil (Fig. 3), since the majority of LV use these sites to make payments, check account statements, among others.

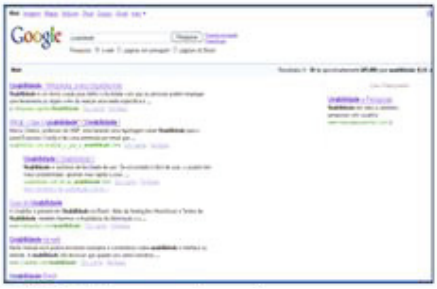


**Fig. 1.** http://www.google.com.br

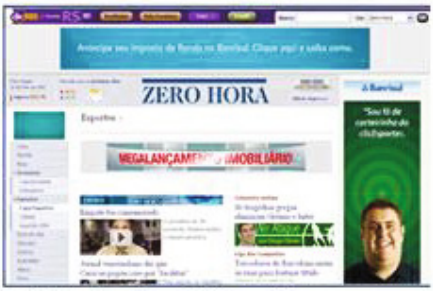


**Fig. 2.** http://zerohora.clicrbs.com.br

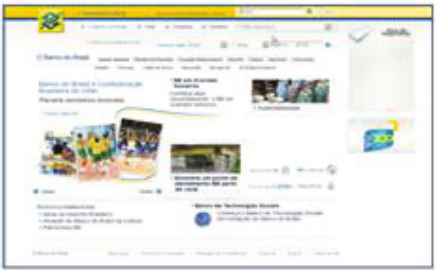

**Fig. 3.** http://www.bb.com.br

### *3.1* Usability Testing of the Three Sites

The usability test was done in an information technology laboratory (APADEV); carried out in a questionnaire form with questions based on the usability aims and resulting from user experience [9]. A term of consent was produced through which the participants agree to take part in the test and authorize the disclosure of the results in the scientific medium, which allowed the data to be filmed individually.

The questionnaire was based on usability aims with 10 questions such as: the effectiveness of the sites to do what was expected of them; how efficient were the colors in aiding the accomplishment of tasks; the safety provided by the colors reducing errors and mistakes; the site function perceived through colors; how the colors contributed in their quick learning of how to use the sites; and memorization of the information laid out on the sites through colors.

The simplicity of the Google site helped in searches and the user of larger fonts, in bold or highlighted with more space "between letters" and *sans serif* contributed directly in the efficiency of colors for identification, learning, memorization and the easiness to read the site contents. The lack of the option for inverted contrast of the site's interface (dark background with light colored letters) made it impossible for participants who are highly sensitive to light to navigate it.

On the Zero Hora Newspaper site, the importance was perceived of the high contrast between the background colors and the letter colors adequately. However, the use of high contrast by the site did nor assure the expected usability, because the use of many colors on the interface resulted in difficult memorization and slowed down the visual adaptation by a LV user to the change from one color to another.

The Banco do Brasil site presented a lot of disorderly content, directly interfering in participant navigating, resulting in delays, tiredness and even giving up trying to access the page. The text contrast in bold, dark blue text (larger letter) with the strong yellow background and the white background on the site were perceived by all participant users as being the "best contrast. The contrast of the text in bold, dark blue with the white background made it possible for them to identify and read information with any letter size.

Throughout the test, both the interest and the motivation from the participants to contribute in the identification of the positive and negative characteristics of each one of the three sites were determining to obtain the results presented.

### 3.2 Prototype Site

From the results obtained in the above described test, it was possible to develop a prototype site and carry out the same usability test to confirm the contribution of colors in the usability of web interfaces.

Five interface variations were established with combinations of distinct colors placed as links on the heading. The combinations below were based on factors such as: allowing to read from a distance, call attention, direct the vision, make searching easier, memorize the layout of contents, prevent errors and surprise the user.

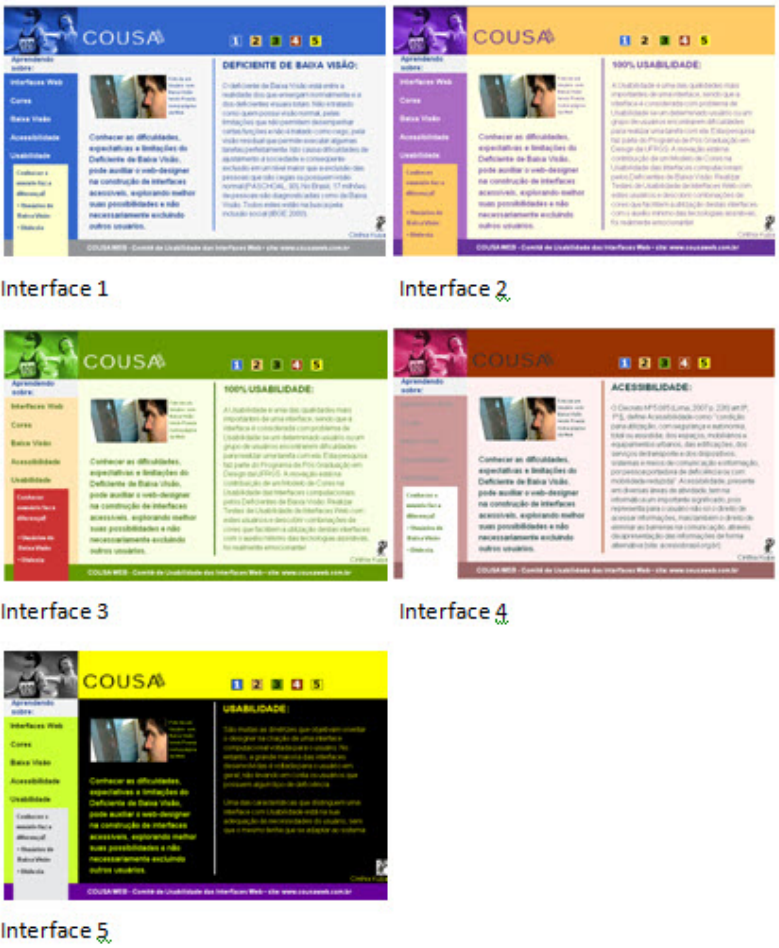


**Fig. 4.** Interface Prototypes with different color contrasts

This usability test was carried out using the same criteria, participants, information technology laboratory (APADEV) and questionnaire that were created to test the three existing sites. By analyzing the results, we observed that interface 1 contrast was the most efficient, being the one that best transmitted safety for navigating was the most perceived, did not generate difficulty in understanding or reading the texts with any font size. Compared with the other contrasts, it was possible for participants to read at a greater distance and for longer, in addition to these users qualifying this contrast as pleasant and rewarding.

Interface 5 contrast, in turn, was the most adequate to indicate the active window and helping to locate the links to the other interfaces, acting as an indicator. Thus, we reached the conclusion that this contrast option may be used for the main menu and submenu and inform about links that lead to more extensive texts. However, according to observations by the participants, the text font seemed to reduce visually in size,

which in fact did not occur. This way, it can be stated that this contrast should not be used when the text fonts are small and thin, as it visually reduces their size, hampering text comprehension.

The contrast with red background and bold, white text on interface 3 submenu shoed to be efficient for reading and was well accepted by all.

The use of few colors on the same interface helped with user appreciation, generated interest to explore the page and showed how important colors are for the general context. These combinations brought to evidence the difficulty of LV to identify different color hues. They perceived the difference between the primary color and other variations, and managed to read the content when it was adequate, but could not identify what the variations of the primary color were precisely. In interface 2 main menu, some named the medium violet color as “pink”, “lilac” and even “light blue”, as with the orange color heading as “yellow”.

It should be stressed that such observation did not prevent them from reading the contents, nor did those colors assist in the interface usability. Simplification of tone variations in color composition favoring LV navigating is not an essential and indispensable requirement if the interface is adequate in other ways.

## 4 Color Model

The result from the test analysis led to a categorization of color contrasts where efficiency was placed first, followed by easiness to read, to memorize, conveying security, assistance in reading for light sensitive users and other characteristics. It was necessary to analyze the color combination separating them into the following elements: main menu, submenu, heading, text body and footnote.

The objective of this color model is to indicate to web designers good practices for creating or adjusting interfaces with the use of colors that make possible for LV to navigate through the virtual environment with just their functional vision in a comfortable and satisfactory fashion without the aid of assistive technologies.

- Contrasts that are more efficient for reading (Figure 5)
- Contrasts that reach several types of LV diagnostics (Figure 6)
- Contrasts more esthetically appreciated (Figure 7)
- Contrasts that allow for the use of other combinations in the same interface (Figure 8)
- Contrasts that better indicate and assist in the identification of icons, topics and titles (Figure 9)
- Contrasts that assist reading by light sensitive users (Figure 10 and Figure 11
- Contrasts deemed to be discreet (Figure 12)
- Contrasts that make reading easier of long texts with small lettered fonts, but make reading more difficult for light sensitive users ( Figure 13)

All these proposed color combinations were tested by LV users who collaborated with the research. Next to each color contrast there is a brief comment suggesting which situation it may be used.

With this, we intend to assist web designers in the choice of contrasts that seek to include specific qualities on each site in pursuit of defined objectives. The character of this color model is innovative and concerns the limitations those users have, but does not prevent other people from being included.


**Fig. 5.** Contrastes mais eficientes paraler


**Fig. 6.** Contrastes p/ diversos tipos BV


**Fig. 7.** Contrastes mais percebidos


**Fig. 8.** Contrastes Neutros

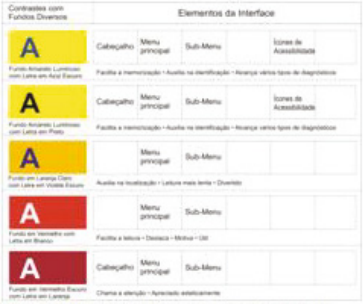


**Fig. 9.** Contrastes que melhor sinalizam

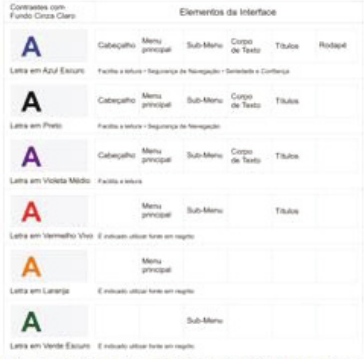


**Fig. 10.** Contrastes para a sensibilidade à luz


**Fig. 11.** Contrastes para a sensibilidade à luz


**Fig. 12.** Contrastes considerados discretos

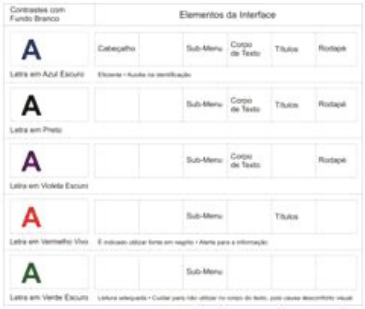


**Fig. 13.** Contrastes que facilitam a leitura de textos longos

## 5 Final Considerations

Despite the advances in computing, there is still a significant portion of people who are still outside of this reality. Understanding and making use of guidelines that include users with different characteristics in the development of a site, as simple as it may be, helps in a considerable increase in building awareness to ensure adequate accessibility and usability without distinction.

Comprehension of the interaction between user and computer system through the interface leads us to knowledge of usability as a quality attribute related to easy use of an interface and determine it as the basis to carry out experiments for researching. In that relation, we perceived that color definition has a direct influence in the quality of presenting the information conveyed by any means of communication. Thus, it is necessary to know about the Low Vision disability in order to attain a comprehension of its actual difficulties.

The result obtained from this research show that colors are the visual element with the strongest influence in interface usability, establishing that when colors are used in the construction of a user interface following certain criteria and taking into consideration the limitations of Low Vision users can positively assist in the usability of that interface. We suggest that the color model created and presented in this article be used and commented on by web designers, allowing Low Vision users to enjoy those facilities and validate the research carried out and assisting in the disclosure of this knowledge among professionals in the design & technology area.

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