An Empirical Comparison of User Color Preferences in Electronic Interface Design

Robert W. Kerbs
California State Polytechnic University, California, Pomona, USA
rwkerbs@csupomona.edu

Abstract
Electronic interface design is a subjective process that can entail difficult choices. The complex interaction of design elements such as font type, screen size, and color preferences make effectiveness comparisons difficult. Experts often disagree about which elements and to what extent they contribute to better interface designs. Complicating the design process is the pervasive availability of the Internet, and various mobile devices, which introduces additional design challenges. However, experts do agree that in order to maximize content understanding, information should be presented clearly, usefully and unambiguously. By performing isolated experiments in the form of online surveys, it may be possible to provide the interface designer with general design guidelines. In practice, the results of such empirical surveys could serve as a baseline for creating new designs. As an example, this paper describes the motivations, design, implementation and results of an online survey that evaluated the color preferences of text superimposed over different colored backgrounds. Results of this survey indicate user preference for primary colored backgrounds in concert with white, black or light-blue foreground colors.

Key words: Human computer interaction, color analysis, website design, online surveys.

1. Motivations
The motivations for conducting an online survey to analyze user color preferences are many-fold: the widespread introduction and availability of mobile devices, aging populations and the emergence of information-based society.

1.1 Availability of Mobile Communications Devices
Advancements in the manufacturability of electronic interfaces, such as LCDs and LEDs, have led to the introduction of mobile devices that incorporate color display interfaces. These devices include PDAs, cell phones, mobile computers, among others – most possessing limited viewing areas. One desirable trait among these devices is that they display information in a manner that supports the clear dissemination of information (Grundel & Schneider-Hufschmidt, 1999).

1.2 Aging Populations
Many regions of the world are experiencing an upward shift in the age of their populations. A representation of this trend is displayed in Figure 1. This figure shows three projections of the residential population in the United States, by age, for the next fifty years. The population pyramids clearly indicate a trend towards larger proportions of the elderly.

As people age certain cognitive and physical changes take place. Active areas of research that measure these changes are frequently broken down into specific categories, including: verbal

meaning, spatial ability, reasoning, number skill and word fluency (AFAR, 2001). An area the interface designer must be especially sensitive to is the degradation of eyesight that most people commonly experience around age 45[1]. Consequently, interface design for devices that will be used by a wide age-range of people should include a representative sample.

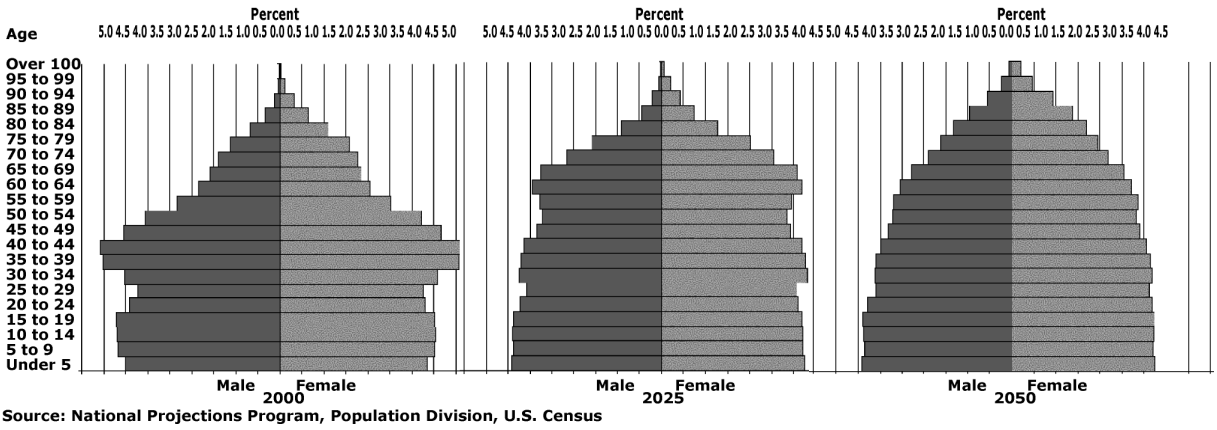

Figure 1. Projected Resident Population of the United States for the years 2000, 2025 and 2050. The scale on the left represents age in five year increments, the top represents percentage of population in 0.5% increments and the bottom shows the breakdown for the three time-periods by sex.

1.3 Information-Based Societies

The global emergence of information-based societies requires interface designs that facilitate the acquisition, manipulation and communication of information electronically. The Internet now possesses more 380 million people worldwide with another 170,000 people added every day (Staudt, 2001) — this is in addition to the one billion users who subscribe to mobile communication services (ETSI, 2002). There is a clear need to understand how this transmission of information can be performed efficiently and in an easily interpretable fashion.

Governmental agencies around the world have acknowledged the convergence of information-based technologies and telecommunication by initiating programs to understand future requirements (Valtonen, 2001). Electronic commerce is experiencing an enormous increase in the number of business transactions being conducted online; buyers are being provided with direct access to product information and services; and retail customer are now requiring interfaces that maximize their ease-of-use (Pedlow, 1999).

Some people believe the transition from an industrial-based society to an information-based society is not unlike the 1860's when there was a transition from an agrarian-based society to an industrial-based society. It was during that time that people began learning different skills to help them be productive, and successful, in the newly developing environment with which they found themselves (Wright, 1996). Consequently, it may not be unrealistic to think that there will be a similar reallocation in the skill-base of the populace as information-based society becomes pervasive.

[1] This degradation is referred to as presbyopia – which is characterized by the stiffening of the crystalline lens resulting in blurred vision. Someone who experiences presbyopia will find that reading materials, such as newspapers, menus and books, will need to be held at arm's length in order to focus properly.

2. Experimental Foundations

2.1 Online Surveys

Due to the growth in the number of mobile and Internet users, the implementation of focused online surveys is a natural and convenient way of obtaining user feedback. Online usability surveys can take many forms. On one extreme, the temporal elements of a website are tested; how much time a user spent on each page, how long it took for a user to find and select a specific link, etc. On the other extreme, users are asked a series questions with the corresponding answers being automatically recorded without a temporal variable playing a part. This was the type of online survey that was designed and implemented in this paper — the idea was to allow the user to be in charge of how fast she or he would take on each question thus accommodating a wide spectrum of users.

There are a number of areas where online surveys differ from traditional usability surveys. One difference is that various users from all over the world can take the survey at any time during the day or night. Along with this convenience comes the difficulty of not always being able to verify the identity of a user, or stopping a user from taking a survey multiple times — resulting in skewed test results. Another difference is that the non-expert user self-administers the survey without interaction with a usability expert (a non-expert user being one that may not be formally trained in usability but may be expert in some other field (Aijo & Mantere, 2001)). As a result, the usability expert is not provided with a visual recording of the user traversing the website. However, in many cases this may not be a major concern; interfaces are designed so that the non-expert user can experiment with them – consequently helping with understanding the interfaces and learning the interface's capabilities (Riedl & Amant, 2002).

2.2 Representing Text on Web Pages

Computer screens are generally more difficult to read than paper. The reasons for the reduction in readability are complex (Mills & Weldon, 1987). This experiment utilized the sans serif font Verdana because of its readability and familiarity by most computer users. Each textual image was displayed in a 15 point sized font to ensure each test image was legible.

To minimize the possibility of user distraction, due to the wording of a textual image, test images consisted of foreground text possessing the same sequence of characters. The displayed text message was the concatenation of the words *The*, *Of* and *And – TheOfAnd*. This word combination was selected because these words appear more frequently in the English written form than any others (Carroll, Davies, & Richman, 1971; Johansson & Ho, 1989). In addition, it was believed that most users wouldn't be confused by them.

2.3 Color Selection

The colors selected for analyses were decided upon by surveying 20 websites in each of five commonly visited website categories, including: financial services, academic institutions, retailers, museums and search engines. Each website was analyzed by recording the predominant foreground text color and background colors found on each home page. Based upon the frequency of occurrence for all websites, a general color usage heuristic was generated. The colors that were ultimately selected were the three primary colors red, green, and blue; three secondary colors, cyan, magenta and yellow; the tertiary color light-blue; and the achromatic colors black and white.

In order to maximize the number of survey participants no specific color model was used to render the color swatches (i.e. CIE LUV, CIE LAB, or Munsell). Instead, it was thought more useful to select colors that everyone, theoretically, should be able to view in different web browsers, on different platforms and using different monitor resolutions. Consequently, web-safe colors that best matched the website color analysis mentioned above were selected for use in this survey[2].

2.3 Experiment Description

The experiment consisted of twenty-four questions. Each question contained three color swatches each with a different combination of solid background color and foreground text color[3]. Subjects were requested to select which swatch in each question was the most legible. At the bottom of the survey was a comments box so participants could provide feedback if desired (this was an optional box so not everyone filled it in). Figure 2 displays a portion of the online *Color Combination Survey*.

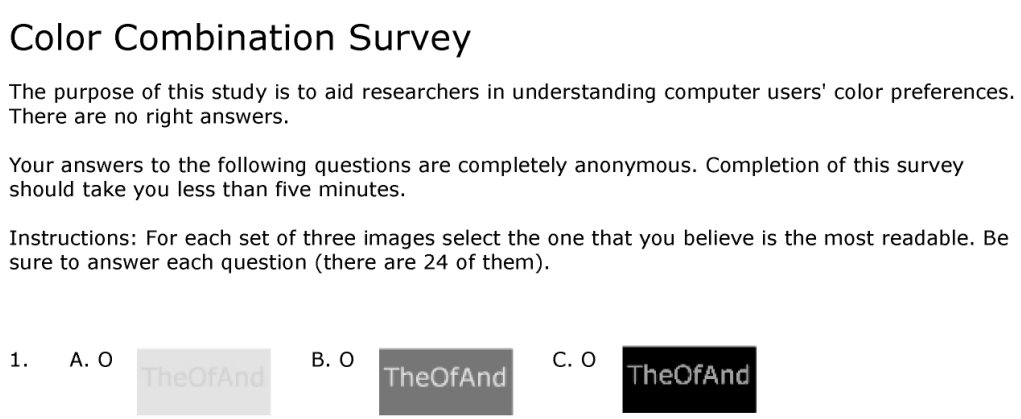

Figure 2. The Color Combination Survey. One question (of 24) is shown.

2.5 The Website

The design and implementation of this survey required the use of a website to administer the experiment online. This website utilized an online form in conjunction with a Common Gateway Interface (CGI) script that automatically populated a Structured Query Language (SQL) database. The intention was to allow users of all web-based browsers, display devices and platforms to be able to take the survey without requiring any special hardware or software. The survey was made continuously available online to users for approximately one year (June 2002-2003).

3. Analysis

3.1 Survey Participants

Survey participants were mostly from the computer science classes I taught during the one-year duration of the survey. This is thought to be the case because during the beginning of each term I would announce to each class the availability and purpose of the survey; consequently resulting in a surge in number of surveys taken. However, it is thought that other participants took the survey as I provided a link at the bottom of my emails encouraging anyone I communicated with to also participate.

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[2] Web-safe colors are 216 colors that were agreed upon by computer manufacturers to assure that there is consistency between users of different computer systems viewing the same web page.

[3] The reason 24 questions were selected was because there are 84 possible combinations of 9 colors in groupings of 3.

Some online surveys are designed in such a way that user must create a username and password before being allowed to participate (sometimes other information is also required). In general terms, the purpose of survey registration is to ensure that each user only takes the survey once and to properly profile survey results. In order to maximize the number of people who would take the survey described in this paper, it was decided to not require such a registration. As a result, it is possible that someone could have taken the survey more than once.

3.2 Results

153 surveys were attempted. Incomplete surveys, even if all questions were answered but one, were removed from the dataset. Consequently, the overall number of surveys that were accepted for analysis was 138.

40% of survey participants preferred the achromatic colors black or white or the tertiary color light-blue for the background color. This compared with a 32% preference for primary colored backgrounds and 28% for secondary colored backgrounds. For foreground text color, survey participants preferred both the primary colors and the grouping of white, black and light-blue equally with 36% each – secondary colors were preferred for the remaining 28%.

4. Conclusions and Future Work

Analysis of the experimental data determined that users do have preferences for achromatic/light-blue backgrounds in conjunction with primary colored or achromatic/light-blue foreground text. It was not found that secondary colors were preferred for either background color or foreground text color. Consequently, based upon the survey results obtained in this study it is recommended that the interface designer not use secondary colors for either background color or foreground text color.

By empirically determining these preferences, it is hoped that the interface designer could use these findings to help efficiently maximize the readability of designs. Manufacturers could benefit by utilizing these color combinations in test-marketing of interface design possibilities, thereby, possibly reducing development time. Finally, end users would ultimately benefit from designs that satisfy their requirements and needs.

With this said, this study is not intended to be definitive in nature. Other combinations of colors are also available and may result in different results. As previously stated, only web-safe colors were selected based upon a survey of certain website segments. In addition, there were probably more survey participants younger than 45 years old possibly skewing the overall results. Even with these limitations this study demonstrates one of many such online surveys that the human factors researcher could create to better guide the interface designer.

A further experiment is being performed that uses the same color combinations as this survey but a temporal element to the survey has been added. As the user moves the cursor over the text, the background and foreground change colors, then the user makes a decision as to which image, of a selection of three, is the most readable. The dynamic nature of this experiment will be compared with the results found in this paper.

References