Color Appearance of the Neon Color Spreading Effect

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Abstract

As a part of this paper, the influence of various parameters within the target process of graphic reproduction on the color appearance of the neon color spreading effect was investigated. The shift in a color appearance qualitatively is determined through the calculation of changes in perceptual attributes of color, i.e. differences in lightness, chroma and hue.

The influence of different media (printed images, and LCD display) in the "cross-media" system was examined, as well as the role of the inserted segment color choice and background of the primary stimulus as an element of design solutions. These parameters were evaluated in a variety of ambient conditions and under the observation of three CIE standard light sources and illuminants.

It was found that it was mostly the changes of the chroma and lightness. The change in the color hue is the lowest.

Keywords: Color appearance, graphic reproduction, neon color spreading, perceptual attributes of color

1 Introduction

Presentation of color uses different media (printed images, LCD displays, TVs, cellphones, projectors etc.) to present to the viewer a "cross-media" reproduction system. Ensuring that the conditions for identical color perception, regardless of the medium of communication and regardless of all other parameters that influence the perception of color, is the basic function of such a system [1, 2]. Graphic color reproduction via a variety of media using different methods and procedures always leads to a change to the form of color data. The diversity of visual color perception creates the need for colorimetric research and the building of a psychophysical model of the human experience of color.

Color appearance under certain viewing conditions can be described via tristimulus color data. These include tristimulus functions represented by three parts of light spectrum. They define the color unambiguously: two colors with the same tristimulus functions, under the same observation conditions, can be seen as equal by a standard observer (and vice versa). This is information about the psychophysical properties of light leaving the surface of an object - color hue, color chroma and color lightness [3]. These characteristics are the perceptual attributes of color.

The perception of color can be described as the ability to recognize the difference between wavelengths of light. The perception of color at the end point is not the result of seeing the wavelength or the light but rather the experience of the illuminated object [4, 5].

Achieving uniformity of color (i.e. the correct color appearance) within a "cross-media" system is questionable under conditions which include occurrence of various psychophysical visual effects [6, 7, 8, 9].

There are a significant number of psychophysical visual effects the manifestation of which have yet to be fully explored. One of these is the neon color spreading effect. The effect of this is the shift in color appearance by creating an illusory extension of primary stimulus colors in the background of a given graphic reproductions in the grid area of the same size as the inserted segment of the primary stimulus, but also in the process of shaping templates as part of the development of a design solution [10]. Existing research into the the neon color spreading effect within the "cross-media" system of graphic reproduction has determined the intensity of the effect within certain parameters [10, 11, 12].

Determining the color appearance in a graphic reproduction process, in conditions with manifested psychophysical visual effects, is based on assessment of a psychophysical experience of an individual perceptual attributes of color (hue, lightness and chroma). This is possible by application of colorimetric and psychophysical research methods. Combined, they create a methodology for determining the physical values of visual perception of a color stimulus.

The aim of this study is to determine the impact of various parameters within a graphic reproduction system on the color appearance of the neon color spreading effect. Shift in a color appearance is an error in color perception. A qualitative analysis of the shift in a color appearance shows that the perceptual attribute of color is likely to change the most.

2 Experimental Part

2.1 Research Description

The colorimetric part of the research was conducted using a "Gretagmacbeth Eye-One" reflective spectrophotometer. Formed reference fields in a printed color chart were attributed by the corresponding CIE $L^*a^*b^*$ values. Based on this data, values between color differences ΔE^*_{94} in each field were calculated with respect to the colorimetric values of the printing substrate [13].

A psychophysical evaluation (a visual evaluation of test samples) was carried out using simultaneous binocular techniques to harmonize the relationship between the original and the reproduction (the reference and the test sample) in the "cross-media" system [14].

The research was conducted using a sample of 30 observers (16 male and 14 female observers with an average age of 21).

A stationary box for the observation of the test samples, "the Judge II-S" was used.

The color appearance shift caused by the manifestation of neon color spreading effect is obtained by calculating the perceptual attributes of color: lightness difference (ΔL^*), chroma difference (ΔC^*_{ab}) and hue difference (ΔH^*_{ab}). The reference values used are the CIE $L^*a^*b^*$ of the same size as the background. Dominant or pronounced changes in specific perceived perceptual attributes of color describes the color appearance shift of the manifested effect.

Changes of the perceptual attributes of color are calculated using the following equations [13]:

$$\Delta L^* = L^* - L^*_{ref} \tag{1}$$

$$\Delta C^*_{ab} = C^*_{ab} - C^*_{abref} \tag{2}$$

$$\Delta H^*_{ab} = \sqrt{\left[\left(\Delta a^*\right)^2 + \left(\Delta b^*\right)^2 - \left(\Delta C^*_{ab}\right)^2\right]} \tag{3}$$

For the purposes of this research twelve test samples were created (Table 1.) using the Adobe Illustrator application. The test samples were based on the Ehrenstein Model - a specific geometric structure consisting of an octagonal system involving gridlines formed by overlapping different color combinations of the primary stimulus.

The color lines on each test sample were combinations of primary colors of additive (red, green and blue) and a subtractive synthesis (cyan, magenta and yellow) as an insert segment of the primary stimulus.

Table .1 Color Combinations of Test Samples

Tests Samples	Inserted Segment Color	Surround Color
1	red	"black"
2	green	"black"
3	blue	"black"
4	cyan	"black"
5	magenta	"black"
6	yellow	"black"
7	red	cyan
8	green	magenta
9	blue	yellow
10	cyan	red
11	magenta	green
12	yellow	blue

"Black" is used as the surround color for the primary stimulus in one instance (Figure 1.) together with colors that are complementary to the color of the inserted segment of the primary stimulus, which are used in a second instance (Figure 2.). The background of the entire primary stimulus is a "white" media color.

When creating test samples a CMYK color scheme was used. A bitmap (*.psd) file format was used. The test samples were printed on a machine calibrated for digital printing - "Epson StylusPro 7900 HDR" - using a liquid toner principle (Epson UltraChrome HDR ink). Rasterization and printing were completed using a "GMG ColorProof" application with an absolute ICC colorimetric rendering method.

The impact of different media was analyzed: the printing surface (GMG ProofMedia - Proof paper Gloss) and the LCD display (HP DreamColor LP2480zx). The measurements were taken under three different CIE standard light sources ("Daylight" D65, "Cool White Fluorescent Light Source" CWF F2 and "Artificial Light" A).

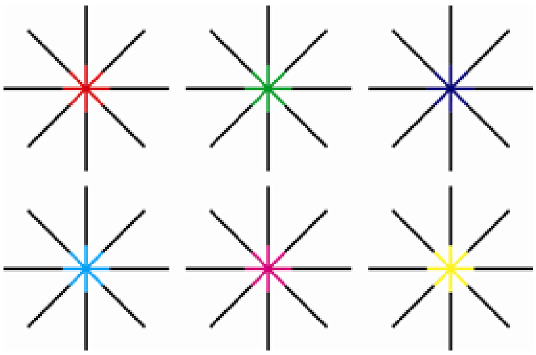

Figure 1 Test Samples with a "Black" Surround

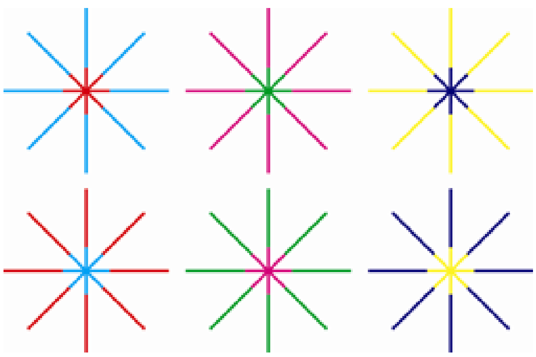

Figure 2 Test Samples with Complementary Color Surrounds

2.2 Results and Discussion

These graphical representation of the calculation method applied to changes of perceptual color attributes is, in accordance with set research target parameters, given in line diagrams in Figures 3 – 14. Some of these diagrams give a comparative overview of the change of a specific perceptual color attributes due to the standard light sources (D65, CWF and A) for the six colors of the insert segments (red, green, blue, cyan, magenta and yellow), the default media (printed images and LCD display) and the specific background color ("black" or its complementary color).

Lightness Differences *ΔL**

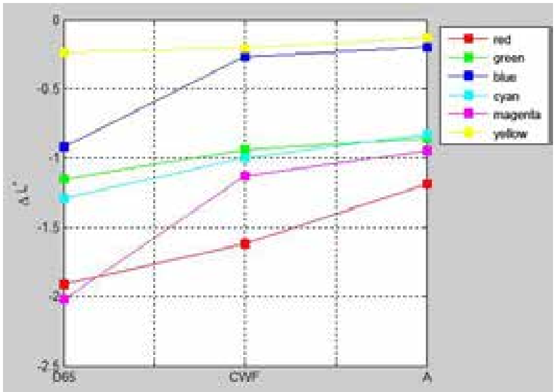

Figure 3. Lightness Differences on a Printed Images by "Black" Surround Color

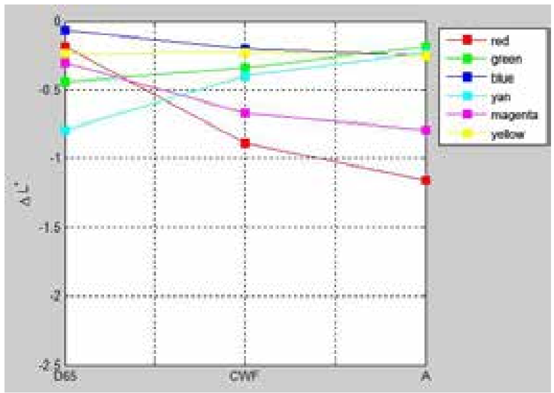

Figure 4. Lightness Differences on a Printed Images by Complementary Surround Color

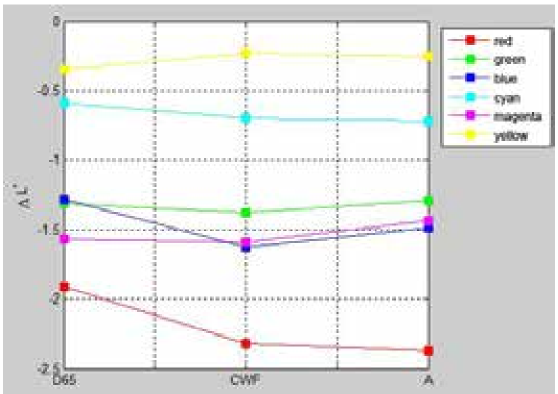

Figure 5. Lightness Differences of the LCD Display by "Black" Surround Color

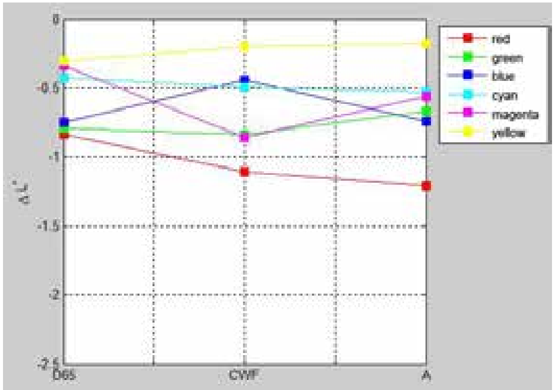

Figure 6. Lightness Differences of the LCD Display by Complementary Surround Color

Figures 2 - 6 show that in all test samples and for all the research parameters the results showed negative value of lightness differences ΔL^*. This implies that the measured stimulus (the color spreading into effect) is darker than the reference stimulus (background color, medium) [13].

Lightness differences values ΔL^* in most incidents are more pronounced for the "black" surround color (value changes in the lightness range for most cases are $\Delta L^* = -2 - 0$) in relation to the complementary surround color (value changes in the lightness range for most cases is $\Delta L^* = -1 - 0$).

The biggest lightness differences were in most cases observed for the Ehrenstein sample red insert segment, regardless of light source, surround color or media. The least lightness differences were in most cases observed for yellow, regardless of light source, surrround color or media. This corresponds with the fact that the yellow color is characterized by high lightness and the lightness differences of yellow color compared to the lightness of the "white" color surround, is the smallest.

The LCD display, as a medium, shows the most uniformed change in lightness if light source variable is taken into consideration. This result corresponds with the established fact that this is an alternative medium in which, mixing of light stimulus occurs without any modulation of individual color components prior to entering the human eye.

Chroma Differences ΔC^*_{ab}

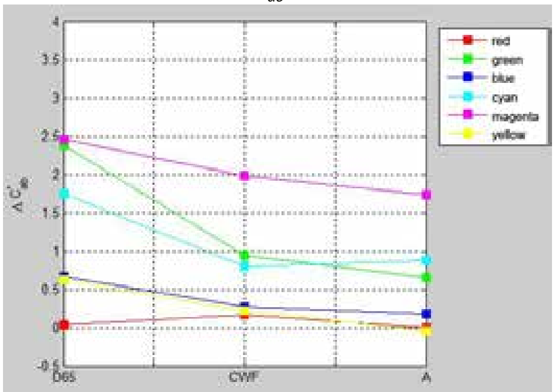

Figure 7. Chroma Differences on a Printed Images by "Black" Surround Color

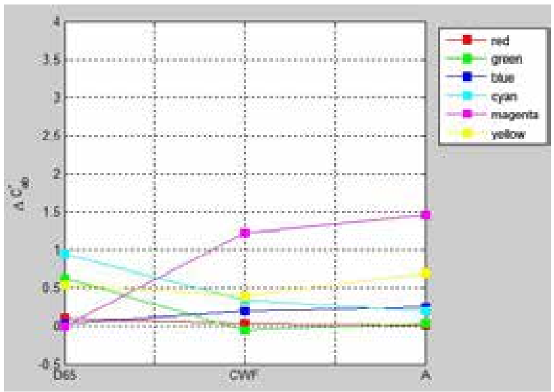

Figure 8. Chroma Differences on a Printed Images by Complementary Surround Color

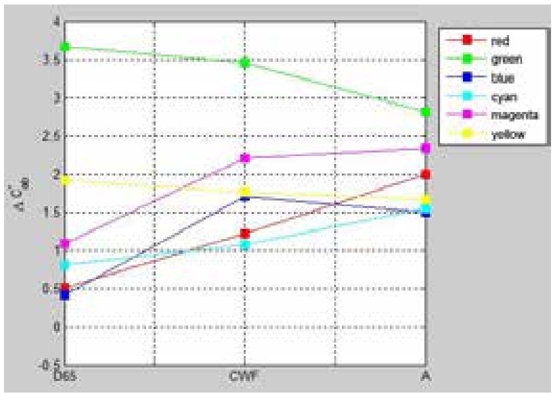

Figure 9. Chroma Differences of the LCD Display by "Black" Surround Color

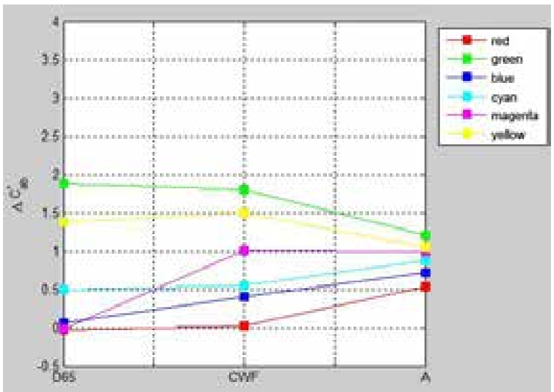

Figure 10. Chroma Differences of the LCD Display by Complementary Surround Color

A graphic display of chroma differences ΔC^*_{ab} in a manifested neon color spreading effect is given in Figures 7 – 10. These Figures show that the values of chroma differences are expected to be positive, and in a few cases there are minor deviations which are not statistically significant (values from -0.02 to -0.06). A positive value of a chroma differences indicates higher induced color chroma in the manifested neon color spreading effect in relation to the surface (medium) chroma.

Chroma differences values range from ΔC^*_{ab} = 0 – 3.66. Larger chroma differences can be seen in LCD displays used as media compared to a printed images used as a medium.

Chroma differences is generally more pronounced in "black" color surround in relation to complementary surround color for attributed colors of inserted segments. This ratio is higher in subtractive media (printed images) than the additive medium (LCD display). In case of a yellow color of inserted segments a uniform chroma changes in both the surround colors may be observed.

The minimum chromatic differences of values were observed in the red insert segment. The red insert segment showed a slightly higher chroma differences with an A light source and an LCD display.

The highest values of chroma differences were observed in the magenta and, in particular, green insert segments for which, with the D65 light source the change was almost twice of other insert segment colors (for "black" surround color on the LCD display).

Hue Differences ΔH^*_{ab}

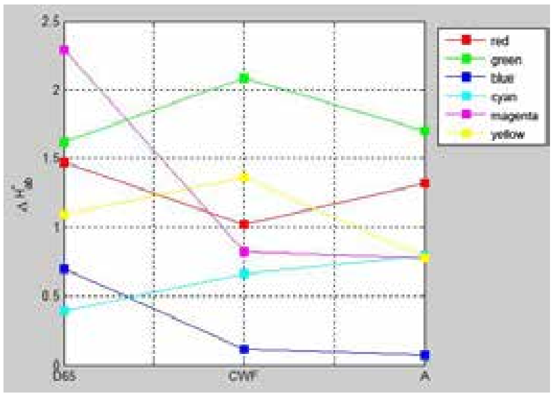

Figure 11. Hue Differences on a Printed Images by "Black" Surround Color

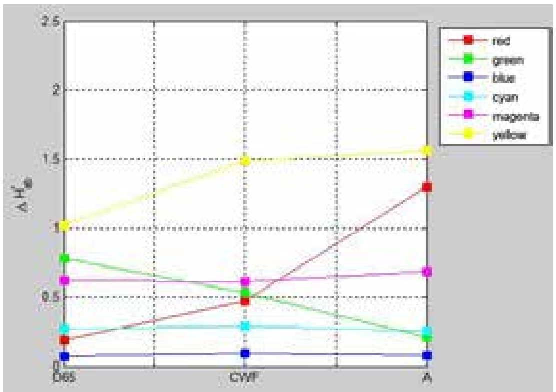

Figure 12. Hue Differences on a Printed Images by Complementary Surround Color

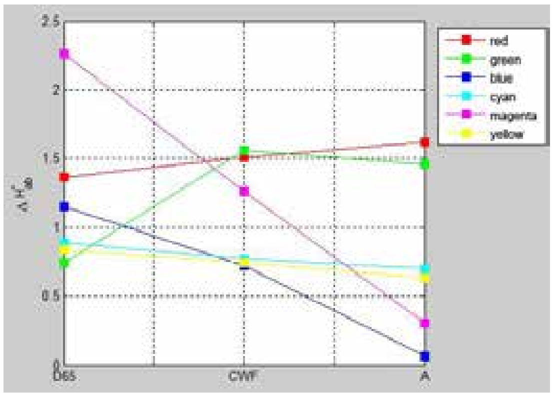

Figure 13. Hue Differences of the LCD Display by "Black" Surround Color

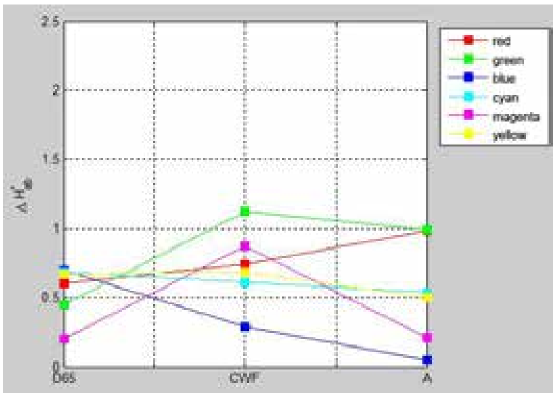

Figure 14. Hue Differences of the LCD Display by Complementary Surround Color

The results show that the incidence of color shift is least in terms of changes of a hue differences. Figures 9 - 12 show the changes of tone values for induced, extended color due to the manifested neon color spreading effect.

The calculated values of tone changes ΔH^*_{ab} range from ΔH^*_{ab} = 0 – 2.29. The lowest recorded values are in blue insert segments, which was earlier previously attributed to the eye's slowness to process the color blue. On the LCD display these values for the color blue are slightly higher when compared to other colors of the inserted segment.

The highest changes in color hue values can in most cases be seen in green, magenta and red colored insert segments.

A more significant change in the color hue of the "black" surround was identified in relation to the complementary surround color. The difference was almost double on printed images than on the LCD display where the difference is negligible.

Certain regularity in the change of color hue ΔH^*_{ab} was not observed in relation to individual light sources.

3 Conclusion

Through a qualitative analysis of illusory color appearance shifts in manifested neon color spreading effect observed through a change of the perceptual attributes of color it was determined that the error in color perception mostly related to the error in the perception of chroma differences ΔC^*_{ab} and an error in lightness differences ΔL^* perception. An error in hue differences ΔH^*_{ab} perception was generally lower than in the previous stated attributes.

The resulting values of changes for each perceptual attributes of color are consistent with the positional averages of the color differences ΔE^*_{94} which is an indicator of the researched effect intensity presented in published papers [10, 11 and 12].

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Conclusion

The Bauhaus movement influence on the visual communication designers in Greece had given birth to a stream that resulted in the creation of a series of works based on the principles of this modern style. The Minimalism and functionality of this design trend - using the vertical text formatting, the implementation of the diagonal direction both on linear elements as well as in the text -got through the times and are widely used till today. This is confirmed both by the font designers, and the poster designers, as in the case with the contemporary Frutiger font which at the end is a remake of the Frutiger font from the Bauhaus period. New technologies, through digitization, are used in graphic design without ignoring the Bauhaus principles. Their applications are not limited to fonts, but also in the whole spectrum of visual communication, in color, form and image.

The sociopolitical context of the Bauhaus period defined the new design flow that ought to shake off, whatever was connected with the past and build a more fair society. This trend occupied and influenced all the Greek post-date, applied art schools, graphic design and visual communication in Greece. Putting aside decoration and ornaments many artists created great works based on simplicity and functionality. Consequently, a design arises that favors functionality and clear forms, and this is exactly what John Kouroudis, graphic designer and creator of the packaging of the Korres products, did. He left all unnecessary features aside and kept what was useful focusing on simplicity and functionality. He applied the Bauhaus principles and achieved design optimization.

This movement's influence in graphic design was taken after by a large number of designers who implemented the clear graphic design in word and picture, reflecting the dialogue between Bauhaus and modern graphic design.

Influences of Bauhaus architecture can be also detected in Greece. The US Embassy -created by Gropius-, the War Museum and the National Gallery of Athens, the Porto Carras Grand Resort -designed by Gropius-, the building of the National Bank in Republic Square, in Thessaloniki, and other buildings were designed by Greek architects who were influenced by modernism and Bauhaus. A Typical example is the refugee apartments in Alexandra's Avenue in Athens.

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