The Distribution of Color Tones in CIELAB Space

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ABSTRACT

This study aimed to see how these 17 PCCS tones distribute in the CIELAB L^*-C^* diagram. Thirty-two observers were invited to take part in a psychophysical experiment. Three hundred and sixty-five color samples were provided in the experiment. Each observer was required to do visual identification to classify 365 color samples into 17 PCCS tones. The results showed that the achromatic color tone remained consistent with those purposed by PCCS. However, 12 chromatic color tones were found to be overlapped. Five chromatic tones were found to be sufficient, including STRONG, MILD, LIGHT, GRAYISH, DARK.

KEYWORDS: ***Tone, Design, CIELAB space, PCCS, Modifier***

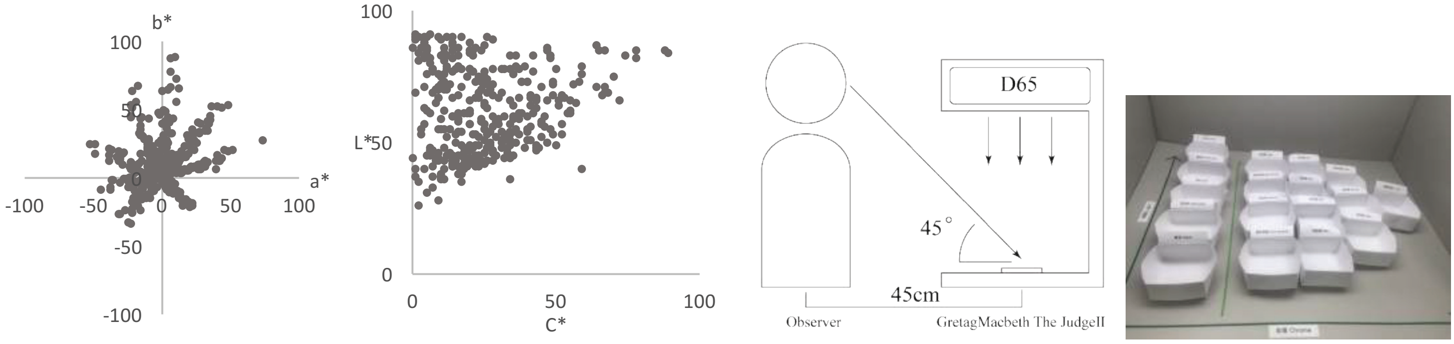
INTRODUCTION

Color tone has long been used in the design practice[1-3]. It gives industrial designers efficient to select color. Many studies[4-11] carried out the experiment to explore the distribution of color tone in color space. However, these studies used the material-based color order system, leading the results impractical for number-based color system, i.e., CIELAB. This study aimed to explore how these 17 PCCS tones distribute in the CIELAB L*-C* diagram.

EXPERIMENTAL PLAN••

To explore how these 17 tones distribute in the CIELAB L*-C* diagram. Thirty-two observers were invited to take part, including 8 males and 24 females with an average age of 20.2 years old. Each observer was required to do visual identification to classify 365 color samples into 17 PCCS tones, including vivid (v), bright (b), strong (s), deep (dp), light (lt), soft (sf), dull (d), dark (dk), pale (p), light grayish (ltg), grayish (g), dark grayish (dg), white (w), light gray (lgr), gray (gr), dark gray (dgr) and black (bk), together with “other” category.

In terms of color selection, color samples were selected from 8 hue in Natural Color System (NCS), including Y, Y50R, R, R50B, B, B50G, G and G50Y. In each hue page in the NCS book, all the colors were used. In total, 365 colors were used. Each color was applied onto 2*2 cm paper and measured by a GretagMacbethR Eye-One. The CIELAB values for each color sample were calculated under CIE D65 and 1931 standard colorimetric. The distribution of color samples on CIELAB space are illustrated in Figure 1 (a) and (b).



(a) CIELAB *a**-*b** diagram (b) CIELAB *L**-*C** diagram (c) Viewing geometry (d) Categories of tone

Figure 1: (a) and (b)The distribution of color samples in CIELAB space. (c)Viewing geometry (d)Categories of tone

The experiment was carried out in a dark room. Each observer was asked to do the Ishihara Color Vision test. The color samples were displayed in a viewing cabinet and illuminated by a D65 simulator. The viewing distance was about 45 cm with a 0/45 illuminating/viewing geometry, as shown in Figure 1 (c). Each observer was required to identify each color sample into one case, representing each tone category. In each case, the Chinese and English tone name were displayed on the case, as shown in Figure 1 (d).

RESULTS

In order to see how these 17 tones distribute in the CIELAB *L**-*C** diagram. The frequency of color sample in each tone category was calculated. It was found that 67 colors are identified into several tone categories, reflecting these 67 colors are unclear in these tone categories. Furthermore, these 67 colors were excluded. The results obtained from 298 colors are illustrated in Figure 3.

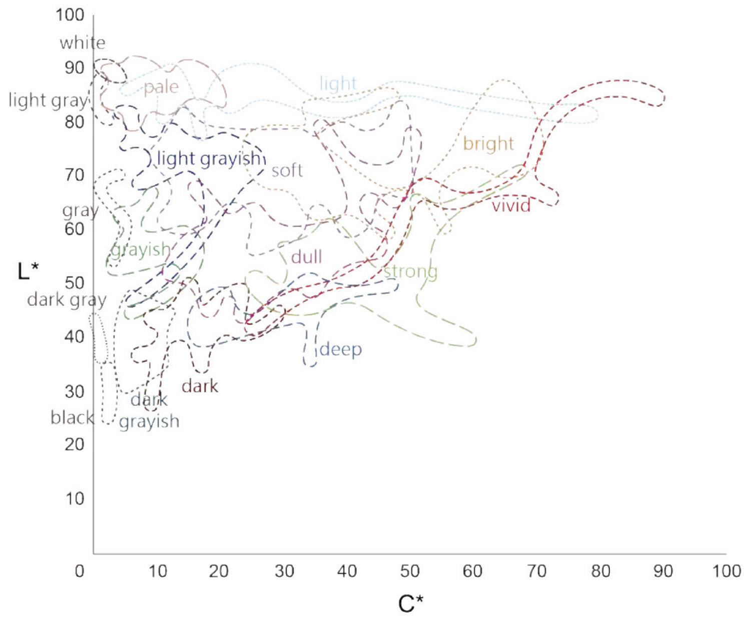


Figure 3: The distribution of 17 PCCS tones

In Figure 3, it was found:

(1) The achromatic tones of *w*, *lgr*, *gr*, *dgr* and *bk* were consistent with those proposed by PCCS.

(2) The PCCS tones of *v*, *s* and *dp* were appeared to be overlapped and distributed in the bottom of the boundary of *L*-C** color gamut.

(3) The PCCS tone of *b* was found to be divided into two areas at *C** of 50.

(4) The PCCS tones of *sf* and *d* were overlapped with the *b* tone having lower chroma. These colors were distributed in the middle of the *L*-C** color gamut.

(5) The colors with higher lightness, exceed 80, were identified into *lt* and *p* tones.

(6) The colors having chroma less than 30 were identified into *ltg*, *g*, *dg* and *dk* tones. On the lightness axis, the *ltg* tone was higher than *g* tone, followed by *dk* and *dg*. On the chroma axis, the *dk* tone was higher than *dg* tone.

SUMMARY AND CONCLUSION

The purpose of current paper is to see how these 17 tones distribute in the CIELAB L*-C* diagram. The result showed that five tone categories were sufficient for describing chromatic colors, including STRONG, MILD, LIGHT, GRAYISH and DARK, as summarized in Figure 4 (a) to (f). In these diagram, one square represents five units in the L* and C* axis. The findings are summarized below.

(1) In Figure 4 (a), the tone of STRONG consists of the v, dp and the b having chroma more than 50. The boundary of STRONG ranges between 15 and 90 on chroma axis, 35 and 90 on lightness axis.

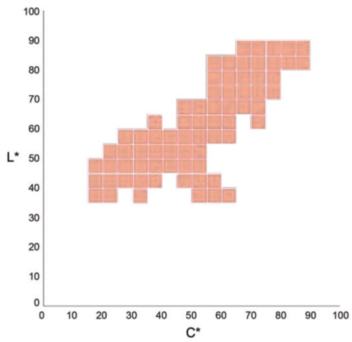
(2) In Figure 4 (b), the tone of MILD consists of the *sf*, *d* and the *b* having chroma less than 50. The boundary of MILD ranges between 5 and 55 on chroma axis, 40 and 90 on lightness axis.

(3) In Figure 4 (c), the tone of LIGHT consists of *lt* and *p*. The boundary of LIGHT ranges between 80 and 100 on lightness axis.

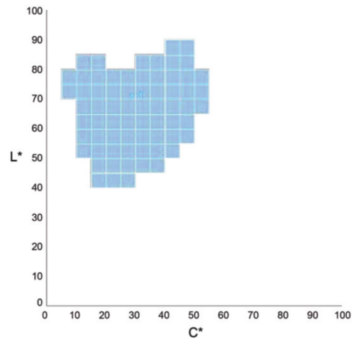
(4) In Figure 4 (d), the tone of GRAYISH consists of *ltg* and *g*. The boundary of GRAYISH ranges between 0 and 30 on chroma axis, 40 and 85 on lightness axis.

(5) In Figure 4 (e), the tone of DARK consists of *dk* and *dkg*. The boundary of DARK ranges between 0 and 30 on chroma axis, 25 and 55 on lightness axis.

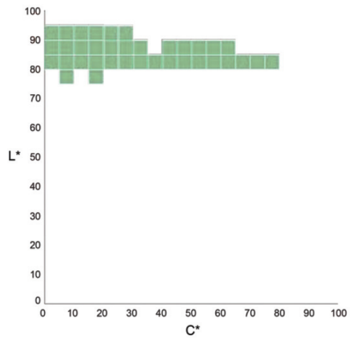
In Figure 4 (f), five tone categories are clearer than the existing PCCS tone in CIELAB. However, these five chromatic tones were overlapped partially. Future studies are expected to clarify the boundary and to see how designers use these tones.



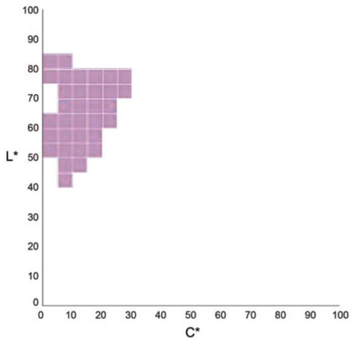
(a) The tone of STRONG



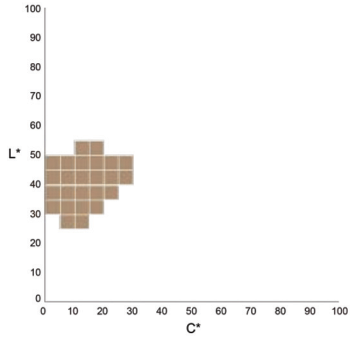
(b) The tone of MILD



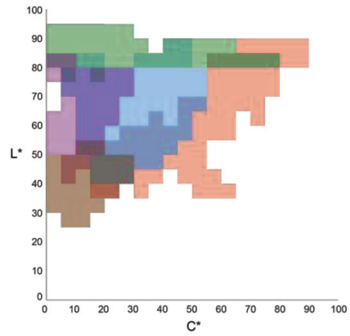
(c) The tone of LIGHT



(d) The tone of GRAYISH



(e) The tone of DARK



(f) The distribution of TONE

Figure 4: The distribution of color tones purposed by current study

ACKNOWLEDGEMENTS

This study was supported in part by a grant from Ministry of Science and Technology in Taiwan. The project number is MOST 105-2221-E-036-011.

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