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Analysis of Cross-Cultural Color Emotion

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Abstract: This study investigates the relationship between color perceptual attributes and color emotions, as well as the influence of different cultural backgrounds. Totally 214 color samples were evaluated on 12 emotion variables by subjects from seven different region groups in the psychophysical experiment. By factor analysis, it was found that three factors were sufficient to represent 80 ''region-emotion'' variables. For each variable, there is no distinct difference among different region groups. The 12 emotion variables could be divided into four categories, namely, activity index, potency index, definition index, and temperature index. Factor scores were further calculated to study the determinants on each factor. The analysis showed that the three factors were mainly related to chroma, lightness, and hue, respectively. It was concluded that chroma and lightness were the most important factors on color emotion, whereas the influences of hue and cultural background were very limited. © 2007 Wiley Periodicals, Inc. Col Res Appl, 32, 223–229, 2007; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/col.20321

Key words: psychology; color perception; color emotion; cross-culture

INTRODUCTION

It is known that color may influence human emotions or feelings, in the sense that some colors may make one happy, while some colors may make one depressive. Simultaneously, color itself has some characteristics, which can be described by semantic words, such as ''warm–cool,'' ''light–dark,'' ''soft–hard,'' etc. The semantic words describing the characteristics of colors and human's emotional responses on colors are generally termed as color emotion.[1–4] It would be interesting and worthwhile to investigate the relationship between color emotions and color stimulus. The findings of color emotion can be applied in applications such as fashion and environment design. They would be the basis on which suitable colors reflecting particular emotions can be easily and reasonably selected.

However, the relationship between color and emotion is very complex. Color emotion may be influenced by age and sex of subjects, as well as their national and cultural backgrounds. Previous studies were conducted to the categorization of human emotions induced by color and to find their relationship with color perception. For example,

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TABLE I. The subject numbers of different regions involved in visual assessments.

Region	Number of subjects
Hong Kong (HK)	70
Japan (JP)	80
Thailand (TH)	60
Taiwan (TW)	56
Italy (IT)	56
Spain (SP)	56
Sweden (SW)	62

Osgood[5] studied the agreement of color meaning between Anglo and Navajo groups using a very limited number of colors. Sivik[6] presented the possible differences on color connotations between Greek and Swedish people. He extracted four factors—excitement, evaluation, forcefulness, and temperature—to represent color emotion. He also found that the total correlation over emotion variables and colors is high between the Greeks and the Swedes. Sato *et al.*[3] split color emotion into three categories (activity, potency, and warm–cool) in Japan. Ou *et al.*[7] also found the same three categories in British and Chinese observers. Most recently, the emotional responses of people from three Asia regions were compared quantitatively and qualitatively by Xin *et al.*[8,9] They found that lightness and chroma were more important than hue on color emotions, and good correlations of color emotions were found among the three regions. We[10] also investigated the color emotions in HK lately. However, as the subjects involved in those studies were from very limited regions (at most three), we consider their findings may be not universal.

This study analyzes and compares the color emotions of people from seven regions, including four Asia regions (Kyoto in Japan, Bangkok in Thailand, HongKong, and Taiwan) and three western regions (Italy, Sweden, and Spain). It is attempted to clarify the influences of culture and color perception attributes on color emotions and lead to a more general relationship between color emotions and each influence factor.

EXPERIMENTAL PROCEDURE AND METHODOLOGY

The numbers of subjects in the visual experiments used in the seven regions are listed in Table I. They are all university students aging from 17 to 24, with half males and half females. Each subject was asked to take the Isihara Color Blindness Test[11] before the experiment to ensure he/she has normal color vision.

In the visual experiments, 214 color samples with size of 1.0 cm × 1.5 cm were used. They were selected from the SCOTDIC PLUS 2000 system, which is a color specifier containing 2450 shades dyed with disperse dyes on polyester. It is a textile version of the Munsell color order system. The selected samples are reasonably and uniformly distributed in the hue, lightness, and chroma dimensions. The spectral reflectance of each color sample was measured using a GretagMacbeth ColorEye 2180 spectrophotometer and then converted into CIE L^*, a^*, and b^* colorimetric values. The distribution of the color samples in CIELAB space is shown in Fig. 1.

Twelve pairs of color emotional words for description of human color emotion were used in visual assessment. Native language was used in the experiment. Table II shows seven original languages for 12 emotion word pairs. These 12 fundamental words were chosen from more than one hundred color description words, considering that they were the most frequently used semantic words and also represent the low level of color emotion.[1]

The experiment was conducted in a dark room and the ambient lighting can be neglected. The color samples were put in a Verivide light cabinet illuminated by an artificial daylight D65 with medium illumination level. In the experiment, a neutral gray mask with medium lightness level was used to cover the surrounding area of the color sample to avoid the influence of the surrounding colors. The color samples were illuminated along their normal and the observers were asked to view the samples at ∼45° to the normal, with a distance around 30 cm. A

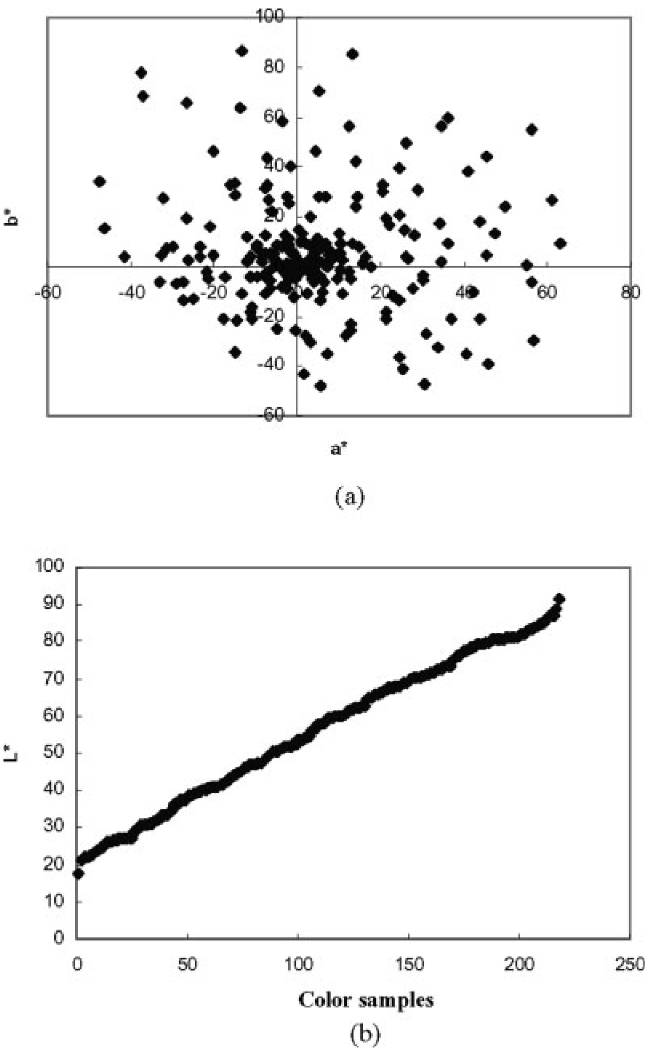

FIG. 1. The distribution of color samples in CIE LAB color space.

TABLE II. Seven original languages for 12 emotion word pairs.

No.	English	Cantonese	Taiwanese	Japanese	Thai	Swedish	Spanish	Italian
		Original language						
I	Light-dark (LD)	光 - 暗	明一暗	明るい - 暗い	สว่าง - มืด	Ljus-Mörk	*claro-oscuro*	chiaro-scuro
2	Soft-hard (SH)	柔軟 - 堅硬	軟一硬	やわらかい - かたい	นุ่มนวล - แข็งกระด้าง	Mjuk-Hård	*suave-duro*	debole-forte
3	Warm-cool (WC)	暖 - 冷	暖一冷	あたたかい - 冷たい	ร้อน - เย็น	Varm-Kall	*caliente-frío*	caldo-freddo
4	Turbid-transparent (TT)	濁 - 通透	混濁一澄澈	濁った - 澄んだ	ทึบ - โปร่งใส	Grumlig-Klar	–	torbido-trasparente
5	Deep-pale (DP)	深 - 淺	濃一淡	濃い - 淡い	เข้ม - จาง	Mättad-Omättad	*intenso-pálido*	cupo-pallido
6	Vague-distinct (VD)	模糊 - 清晰	模糊一清晰	ぼんやりした - はっきりした	ซีด - โดดเด่น	Diffus-Tydlig	–	vago-distinto
7	Heavy-light (HL)	重 - 輕	重一輕	重い - 軽い	หนัก - เบา	Tung-Lätt	–	oppressivo-piacevole
8	Vivid-sombre (VS)	鮮明 - 暗淡	鮮艷一平淡	鮮やかな - くすんだ	สดใส - หม่น	Livlig-Lugn	*vivo-apagado*	vivido-triste
9	Strong-weak (SW)	強 - 弱	強一弱	強い - 弱い	เข้มแข็ - อ่อนแอ	Stark-Svag	–	forte-debole
10	Passive-dynamic (PaDy)	靜 - 動	靜一動	静的な - 動的な	สงบนิ่ง - เคลื่อนไหว	Passiv-Aktiv	*pasivo-dinámico*	passive-dinamico
11	Gaudy-plain (GP)	俗艷 - 樸素	俗麗一樸實	派手な - 地味な	ฉูดฉาด - เรียบ	Flärdfull-Alldaglig	*chillón-serio*	sgargiante-scialbo
12	Striking-subdued (SS)	奪目 - 柔和	醒目一柔和	目立つ - 目立たない	ชัดเจน - ขมุกขมัว	Iögonfallande-Dämpad	–	impressionante-sommesso

TABLE III. The loadings on each factor (Fact.) and corresponding communality (Comm.) of each "region-emotion" variable.

	Varimax-rotated loadings				
Variable	Fact. 1	Fact. 2	Fact. 3	Fact. 4	Comm.
HK_LD	0.67	−0.69	0.12	−0.07	0.95
HK_SH	−0.12	−0.96	0.00	0.09	0.94
HK_WC	0.77	−0.06	0.57	−0.07	0.91
HK_TT	−0.39	0.85	0.04	0.13	0.90
HK_DP	0.12	0.97	0.01	−0.08	0.96
HK_VD	−0.65	0.71	0.00	0.13	0.95
HK_HL	0.13	0.97	0.02	−0.09	0.97
HK_VS	0.93	−0.25	0.16	−0.04	0.95
HK_SW	0.38	0.89	0.03	−0.15	0.95
HK_PaDy	−0.93	−0.10	−0.27	0.04	0.96
HK_GP	0.94	0.12	0.22	0.03	0.95
HK_SS	0.92	0.27	0.16	−0.05	0.95
JP_LD	0.61	−0.75	0.14	0.00	0.95
JP_SH	0.09	−0.92	0.28	0.09	0.94
JP_WC	0.47	−0.23	0.81	−0.01	0.92
JP_TT	−0.63	0.71	0.14	0.16	0.94
JP_DP	0.29	0.91	0.04	−0.13	0.93
JP_VD	−0.82	−0.39	0.02	0.25	0.89
JP_HL	0.01	0.97	0.00	−0.04	0.95
JP_VS	0.95	−0.13	0.00	−0.12	0.93
JP_SW	0.59	0.73	0.03	−0.19	0.92
JP_PaDy	−0.92	−0.17	−0.21	0.05	0.92
JP_GP	0.95	−0.09	0.12	−0.02	0.93
JP_SS	0.96	0.03	0.11	−0.10	0.94
TH_LD	0.48	−0.82	0.16	−0.02	0.93
TH_SH	0.10	−0.96	−0.06	0.02	0.93
TH_WC	0.60	0.14	0.70	−0.04	0.86
TH_TT	−0.42	0.87	−0.08	0.16	0.96
TH_DP	0.28	0.88	0.08	0.12	0.88
TH_VD	−0.92	−0.06	−0.09	0.20	0.90
TH_HL	0.06	0.96	0.05	0.13	0.94
TH_VS	0.82	−0.50	0.12	−0.12	0.95
TH_SW	0.19	0.94	−0.02	0.05	0.92
TH_PaDy	−0.88	0.29	−0.28	−0.06	0.94
TH_GP	0.92	−0.04	0.28	0.02	0.93
TH_SS	0.74	0.58	0.12	−0.08	0.91
SP_LD	−0.04	−0.94	0.05	0.11	0.90
SP_SH	−0.21	−0.93	0.01	0.12	0.92
SP_WC	0.41	0.19	0.80	0.04	0.85
SP_TT	−0.67	0.62	0.08	0.06	0.85
SP_DP	0.53	0.78	0.06	−0.06	0.90
SP_VS	0.91	−0.06	0.15	0.13	0.86
SP_PaDy	−0.90	0.09	−0.17	−0.12	0.87
SP_GP	0.89	−0.12	0.21	0.15	0.88
TW_LD	0.45	−0.85	0.10	−0.07	0.94
TW_SH	0.34	−0.79	0.42	0.02	0.92
TW_WC	0.36	−0.16	0.85	0.02	0.88
TW_TT	−0.68	0.64	0.00	0.23	0.92
TW_DP	0.24	0.95	0.05	0.01	0.96
TW_VD	−0.86	0.23	0.01	0.33	0.89
TW_HL	0.01	0.98	−0.02	0.02	0.96
TW_VS	0.91	0.30	0.11	−0.04	0.94
TW_SW	0.62	0.74	0.02	−0.16	0.96
TW_PaDy	−0.93	0.00	−0.22	0.00	0.91
TW_GP	0.94	0.07	0.18	0.04	0.93
TW_SS	0.82	0.49	0.05	−0.14	0.94
IT_LD	0.24	−0.92	0.09	−0.08	0.93
IT_SH	−0.64	−0.58	−0.10	0.24	0.82
IT_WC	0.75	−0.16	0.45	−0.23	0.84
IT_TT	−0.30	0.83	0.08	0.30	0.87
IT_DP	−0.09	0.93	−0.05	0.13	0.89
IT_VD	−0.76	−0.23	0.04	0.34	0.75
IT_HL	−0.38	0.71	0.08	0.36	0.79
IT_VS	0.77	−0.48	−0.02	−0.29	0.91
IT_SW	0.63	0.58	−0.05	−0.30	0.83
IT_PaDy	−0.86	0.12	0.02	0.23	0.81

TABLE III. (*Continued*)

	Varimax-rotated loadings				
Variable	Fact. 1	Fact. 2	Fact. 3	Fact. 4	Comm.
IT_GP	0.85	0.11	0.06	−0.27	0.81
IT_SS	0.83	0.22	0.07	−0.29	0.83
SW_LD	0.08	−0.95	0.08	0.10	0.92
SW_SH	−0.15	−0.39	0.76	0.05	0.75
SW_WC	0.23	0.32	0.82	−0.03	0.83
SW_TT	−0.92	0.15	0.04	−0.05	0.87
SW_DP	0.29	0.93	0.05	−0.06	0.95
SW_VD	−0.93	−0.22	−0.05	−0.06	0.91
SW_HL	−0.03	0.97	−0.02	−0.07	0.94
SW_VS	0.92	−0.17	0.16	0.15	0.93
SW_SW	0.73	0.64	0.03	0.00	0.94
SW_PaDy	−0.95	0.02	−0.12	−0.16	0.94
SW_GP	0.91	−0.05	0.05	0.17	0.87
SW_SS	0.95	−0.05	0.11	0.15	0.95
%VAR	*0.44*	*0.38*	*0.07*	*0.02*	*0.91*

questionnaire, with 12 pairs of emotion variables written in subject's native language, was asked to fill out. After viewing a color sample, the subject was asked to describe the color by selecting a more appropriate word for each word pair listed in Table II.

RESULTS AND DISCUSSION

Quantifying Color Emotions

After obtaining the results of the visual assessments, the two-point method[8,9] is used to quantify the emotion of each color. The value +1 is given to the selection of left-hand word in each pairs such as ''warm,'' ''light,'' and ''deep,'' and the value −1 is given to the right-hand word such as ''cool,'' ''dark,'' and ''pale.'' The magnitude of each scale for every color is calculated according to Eq. (1) and a 8 × 214 matrix for Spain and a 12 × 214 matrix for each of other six regions can be obtained.

$$s = \frac{x(+1) + y(-1)}{x + y} \times 100 \tag{1}$$

In Eq. (1), x and y are the numbers of subjects selecting left- and right-hand of each emotion pair, respectively.

Factor Analysis

Factor analysis is carried out to reduce the emotion variables to a smaller number of basic dimensions, and therefore more compact information can be achieved in the following analysis and comparison. For this purpose, principle component analysis with Varimax rotation is employed. Each emotion of each region is regarded as one variable. In this sense, there are totally 80 variables (8 in Spain and 12 in each of other six regions). Each variable is marked in ''region-emotion'' style in this study. For example, the judgment of Hong Kong subjects on ''warm–cool'' is marked as ''HK-WC.'' Using screen test criterion, four factors were retained to represent the entire set of variables. The rotated factor loadings and communality for each variable are shown in Table III.

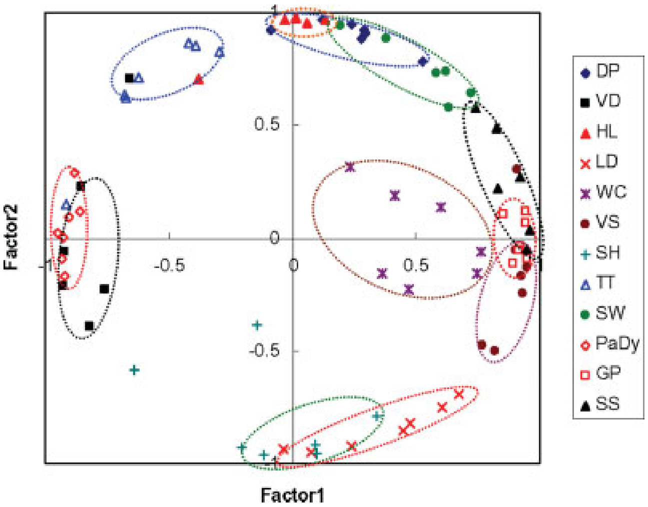

FIG. 2. The distribution of the factor loadings of emotion variables on the first two factors.

From this table, the fourth factor can be removed since it only represents 2% of total variance. The first three factors, which represent 89% of the total variance, are considered to be sufficient in representing the 80 emotion variables with little information loss. The first two factors are the most important ones, as they account for 44 and 38% of total variance, respectively. Factor 3 only accounts for 7%. The distribution of the factor loadings of emotion variables on the first two factors is illustrated in Fig. 2. In this figure, the loadings of each variable from different regions were shown in the same symbol. Thus, there are 12 groups of data in the figure and the distribution of each group was circled by ellipse. According to this figure, all emotion variables can be approximately divided into four categories. The first category, which comprises variables of ''passive–dynamic,'' ''vague–distinct,'' ''gaudy–plain,'' ''vivid–sombre,'' and ''subdued–striking,'' has a high loading on Factor 1. The second category, which comprises variables ''deep–pale,'' ''heavy–light,'' ''strong–weak,'' ''soft–hard,'' and ''light–dark,'' has a high loading on Factor 2. The emotion variable ''transparent–turbid'' becomes the third category, which has similar loadings on the two factors. The fourth category also contains only one variable ''warm–cool.'' We note that the sample variance of the fourth category cannot be completely represented by the first two factors. From Fig. 2, it is easy to find that all variables, except ''warm–cool,'' are distributed approximately on the boundary of the unit circle decided by Factor 1 and Factor 2. This point is also confirmed in Table III by the observation that the ''warm–cool'' variable has high loadings on not only Factor 1 but Factor 3 as well. The meaning of each category is determined by the involved emotion variables. Therefore, the first category can be defined as an activity index, and the second category as potency index. Similarly, the ''transparent–turbid'' variable in the third category can be interpreted as a definition index, while the fourth category as temperature index. These four indexes can be used to specify the emotion of single colors systematically and consistently.

TABLE IV. Correlation coefficients *r* of extracted factors and color perception attributes.

r	*L**	*C**	*h*
Factor 1	−0.11	*0.86*	−0.01
Factor 2	*−0.95*	0.04	0.10
Factor 3	0.10	0.35	−0.13

Factor Scores and Their Determinants

The estimated values of the common factors, called factor scores, are very important and convenient for further regression analysis. To study the determinants on each factor, the factor scores were calculated and their relationships with color perception attributes, i.e., hue, lightness, and chroma, were analyzed.

These three extracted factors are actually the linear transformations of the original variables (emotion variables). The calculation of factor scores is as follows[12]:

$$\underset{(80\times3)}{\mathbf{B}} = \underset{(80\times80)}{\mathbf{R}^{-1}}\ \underset{(80\times3)}{\mathbf{A}} \tag{2}$$

$$\underset{(214\times3)}{\mathbf{F}} = \underset{(214\times80)}{\mathbf{T}}\ \underset{(80\times3)}{\mathbf{A}} \tag{3}$$

In these two equations, **R** is the correlation matrix of 80 emotion variables, **A** is the rotated factor loading matrix, **B** is the factor score coefficient matrix, **T** is the standardized observation matrix, and **F** is the factor score matrix. Through these calculations, a 214 × 3 factor score matrix **F** can be obtained.

To study the determinants on each factor, the correlation coefficients between each factor and CIE L^*, C^*, h are given in Table IV. Very high correlations were observed between Factor 1 and chroma, and Factor 2 and lightness. The graphical representations of the factors and color perception attributes are shown in Fig. 3. From Figs. 3(a) and 3(b), a linear relationship between Factor 1 and chroma, and Factor 2 and lightness can be observed, respectively. As the first category (activity index) has a high loading on Factor 1, it can be concluded that human's responses on the emotion variables of this category are mainly determined by chroma. The second category (potency index) has a high loading on Factor 2 and therefore it is mainly decided by lightness. The variable ''transparent–turbid,'' which is defined as definition index, has the same loadings on the first two factors and is mainly influenced by lightness and chroma. From Fig. 3(c), it is obvious that hue has a significant influence on Factor 3. It can be further found that the colors containing R, Y, and P have positive values on Factor 3, whereas those containing G, B, and N have negative values. Since we have known that ''warm–cool'' has high loadings on not only Factor 1 but also Factor 3, it can be concluded that human's response on color temperature is mainly influenced by hue and chroma.

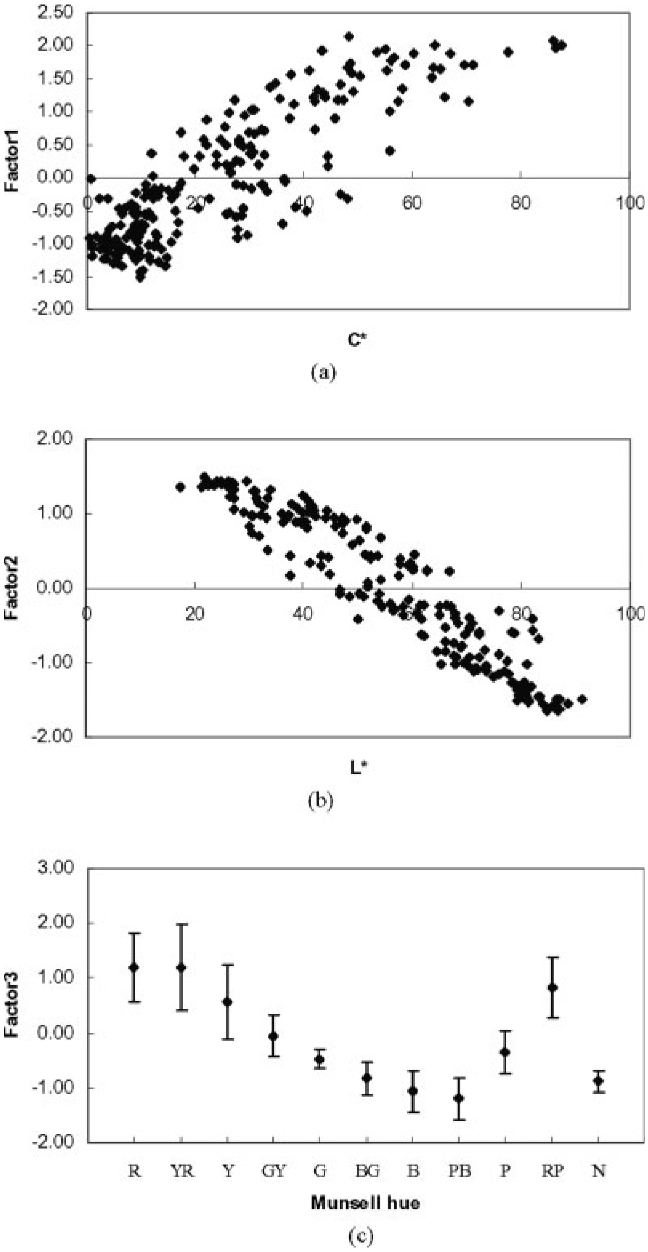

FIG. 3. The relationship between color perception attributes and extracted factors. (a) Relationship between chroma C^* and Factor 1; (b) relationship between lightness L^* and Factor 2; (c) relationship between Munsell hues and the mean scores (with ±1 standard deviation) of Factor 3.

Comparison Between Groups of Subjects

It is interesting and very useful to investigate the differences and similarities between different groups on color emotion. For example, the study may enable designers to easily select appropriate colors for customers with different cultural backgrounds. In addition, it may also contribute to the exploration of color psychology.

From Fig. 2, it can be seen that the differences between different groups are relatively small. The emotional responses of the groups in the seven regions are very similar for most of emotion variables. The emotion variables ''passive–dynamic'' and ''gaudy–plain'' have almost equal loadings for different groups in Asia and West regions on the first two factors. It means that people from different culture have almost the same ''passive'' or ''dynamic,'' ''gaudy'' or ''plain'' experiences on colors. The distributions of the variables including ''vivid–somber,'' ''subdued–striking,'' ''deep–pale,'' ''strong–weak,'' ''soft–hard,'' and ''light–dark'' are also close for different regions. It means that, despite of the different cultural backgrounds, human's responses on these variables are quite similar. In addition, there are some variables with high-concentrated distribution for most of observer groups except one or two groups. For example, most of ''turbid–transparent'' have high loadings on Factor 2, but ''SW-TT'' loads heavily on Factor 1. This indicated that lightness was the main influence on most of people's response on ''turbid–transparent,'' whereas chroma seems more important for Swedes. It seems that lightness is the main factor on the judgment of ''heavy–light'' for most of observers, whereas chroma also has quite important influence on Italian's response. Most of observer groups judge the colors with high lightness to be ''soft,'' whereas Italians feel that the colors with high lightness or low chroma are ''soft.'' For Swedes, it seems that hue is more important, and they judge colors containing Y or R as ''soft'' and those containing B as ''hard.'' For the variable ''vague–distinct,'' chroma is the determinant for most of observer groups, whereas lightness is also very important for Hong Kong subjects. Many researchers[3,6,13,14] found variable ''warm–cool'' was mainly decided by hue. In this study, however, we found chroma is also very important. In addition, the influences of chroma and hue on ''warm–cool'' are inconsistent for these seven regions. Chroma is more important for observers from Hong Kong and Italy, whereas hue is a decisive factor for those from Japan, Taiwan, Sweden, and Spain. For Thai people, chroma and hue are almost of the same importance.

Comparison with Previous Studies

The variations in choice of emotion variables, color samples, and characteristics and culture background of subjects may have some influence on the direct comparison of the results of present work with other studies. Nevertheless, considerable similarities were still found.

As in this study, Sivik[6] also found excitement (here called ''activity''), forcefulness (here called ''potency''), and temperature factors in his color emotion study on Greeks and the Swedes. In addition, evaluation factor was extracted in his study but not in our study since evaluative variables such as ''good–bad'' and ''beautiful–ugly'' were not included in the present work. Kunishima and Yanase[13] studied the visual effects of wall colors and also found three factors: activity, evaluation, and warmness (here called ''temperature''). More recently, Sato *et al.*[3] found the same three color emotion factors as in our study except definition index.

For the determinants on each factor, this holds particularly for the relation of activity (also called ''excitement'' or ''dynamism'') and chroma,[3,14,15] and potency (also called ''forcefulness'') and lightness.[3,14,16] For temperature factor (also called ''warmness''), hue is seen as the main determinant in most of previous studies.[3,6,13,16] However, in this study, chroma is more important on temperature factor than hue for some region groups.

On the whole, the agreement between seven region groups in this study and with previous studies is impressive since these studies were conducted in different times on peoples with different culture and education background, and sometimes different experiment condition. This result suggests that it may be possible using a limited number of factors to compose a color emotion space, which can systemically specify human's emotional response on colors. Furthermore, some inherent or biological relationship may exist between color and human's emotional response, regardless of characteristic of observers.

CONCLUSION

In this study, a psychophysical experiment was conducted to study the color emotions of seven different region groups. The analysis found that 89% of total variance of the 80 ''region-emotion'' variables can be explained by three factors. Among these, 82% of total variance can be represented by the first two factors. It was found that Factor 1 and Factor 2 were mainly related to chroma and lightness, respectively, and Factor 3 was mainly related to hue and accounts for 7% of total variance. This indicates that the meaning of a color is influenced mainly by its lightness and chroma and little by its hue. According to the loadings on the factors, for most of emotional variables, there was no distinct difference among the seven region groups. The main inconsistence comes from the emotion ''warm–cool.'' Although all groups evaluated the ''warm–cool'' based on the colors' chroma and hue, they did not have a consistent opinion on which one is more important. Finally, based on the loadings of each variable, we classified the 12 color emotion word pairs into four categories. The first category was defined as activity index and the second category as potency index. These two categories are heavily dependant on chroma and lightness, respectively. The third category included only the single variable ''turbid–transparent'' and was termed as definition index. This index is mainly related to both chroma and lightness. The fourth category, which contains the only variable ''warm–cool,'' has a large dependency on both hue and chroma. These four indexes can be used to systematically and consistently specify the emotions of single colors.

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