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# Numerical expression of colour emotion and its application

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## ABSTRACT

Human emotions induced by colours are various but the emotions are expressed through words and languages. In order to analyse the emotions expressed through words and languages, visual assessment tests against colour emotions expressed by twelve kinds of word pairs were carried out in Japan, Thailand, Hong Kong and UK. The numerical expression of each colour emotion is being tried as a formula with an ellipsoid-shape resembling that of a colour difference formula. In this paper, the numerical expression of 'Soft-Hard' colour emotion was mainly discussed. The application of colour emotions via the empirical colour emotion formulae derived from *kansei* database (database of sensory assessments) was also briefly reported.

Keywords; Numerical expression, colour emotion, cross-culture comparison, colorimetric method, IT

## 1. INTRODUCTION

Colour physicists have been trying to derive a numerical visual scale with physical viewpoint while colour psychologists have been investigating colour perception and human behaviour with psychological viewpoint. The interface connecting physical and sensational parameters is very important. However, there is a big gap between the two areas. The main target of colour physicists is focused on colour itself, and that of colour psychologists is focused on human brain.

In order to analyse the mechanism of colour perception and cognition in brain, it is necessary to have quantitative scales. Word is the output of the colour perception, cognition and feeling and it is the most useful key for communication. Therefore, our research group is paying attention to words and languages. We investigated the use of the colour emotional words such as *deep*, *warm* and *soft*, which describe psychological sensations [1], and also we have been trying to derive visual scales of the psychological sensations [2-5]. These scales were numerically expressed as empirical formulae based on CIELAB and Munsell colour systems. With the scales, the magnitude of human colour emotions can be predicted through an instrumental method.

Unfortunately, real visual scales are not only corresponding to only the scales expressed by the colour systems and their parameters. The human emotions induced by colours might be different. One way of deriving visual scales to express colour emotions is to utilise the quantitative relationship between the colorimetric values and visual assessments.

On the other hand, there is a need for colour communication systems through multimedia are needed. Developments of colour communication systems have been achieved in the domains of communicating colour and image not the emotions or our feelings induced by colours. Generally, feelings are communicated through words and languages. In this paper, the application of the colour emotions via the empirical colour emotion formulae derived from *kansei* database is reported.

## 2. NUMERICAL EXPRESSION OF COLOUR EMOTION

The empirical colour emotion formulae have been derived in our current and previous researches [2-5]. These formulae predict the magnitude of human emotion induced from a colour. The initial work on the numerical expression of the colour emotions included 12 *kansei* word pairs is in shown Table 1.

Each colour emotion was numerically expressed as a formula with an ellipsoid-shape resembling that of a colour difference formula. A larger colour emotion value indicates a stronger colour emotions induced. The generic formula of the visual scale for colour emotion in the CIELAB colour space is given as the following;

$$CE = [\{k_L(L^*-L^*_O)\}^2+\{k_A(a^*-a^*_O)\}^2+\{k_B(b^*-b^*_O)\}^2]^{1/2}+k_M \quad (1)$$

where, CE is the predicted value of a colour emotion, L* is CIELAB metric lightness, C* is CIELAB metric chroma, $L^*_O$, $a^*_O$, $b^*_O$ are CIELAB L*, a* and b*, when the colour emotion is at its minimum, $k_L$, $k_A$, $k_B$ are the constants of the contribution of CIELAB L*, a* and b*, and $k_M$ is the constant for scaling

Table 1 *Kansei* word pairs used for visual assessments

| Symbol | Japanese | English | Thai | Chinese (Cantonese) |
|---|---|---|---|---|
| DP | Koi - Awai | Deep - Pale | Khem - Jang | Sem - Tsin |
| DYP | Doutekina - Seitekina | Dynamic - Passive | Kloenwai - Sangobning | Dung - Zing |
| DV | Hakkirishita - Bonyarishita | Distinct - Vague | Dodden - Seed | Tsing sik - Mou wu |
| GP | Hadena - Jimina | Gaudy - Plain | Choodchad - Reab | Zuk Jim - Pok sou |
| HL | Omoi - Karui | Heavy - Light | Nuck - Bow | Zung - Hing |
| LD | Akarui - Kurai | Light - Dark | Sawang - Mued | Gwong - Em |
| SH | Yawarakai - Katai | Soft - Hard | Numnual - Kangkradang | Jau jyn - Gin ngang |
| SS | Medatsu - Medatanai | Striking - Subdued | Chadjan - Kamukkamoe | Dyt muk - Jau wo |
| SW | Tsuyoi - Yowai | Strong - Weak | Khemkang - Oanaer | Koeng - Joek |
| TT | Sunda - Nigotta | Transparent - Turbid | Prongsai - Tueb | Tung tau - Wen zuk |
| VD | Azayakana - Kusunda | Vivid - Dull | Sodsai - Mon | Sin ming - Em tam |
| WC | Atatakai - Tsumetai | Warm - Cool | Ron - Yen | Nyn - Lang |
| Assessed in | Japan | UK | Thailand | Hong Kong |

## 3. APPLICATION OF THE NUMERICAL EXPRESSION OF COLOUR EMOTION

Currently, the keyword of the application of colour technology is *colour communication*. The colour communication is to reproduce colours and to manage colours. Especially, it is the most important to communicate colour images accurately. While the current application of colour communications are in the domain of colour reproduction accuracy and colour management, it is suggested in this study the communication of colour emotions induced by colours, in addition to the communication of colours. With *kansei* database and colour emotion formulae, we envisage the development of some useful tools for *Information Technology*. Colour emotion scales obtained can be transformed to CIELCh, CIELAB, XYZ, and RGB values through a reverse operation, which can be output as colours by display devices [5,6]. This colour output can be used by applications such as product design and development, which can then be further extended to applications on Internet. The process of the application is shown in Figure 1.

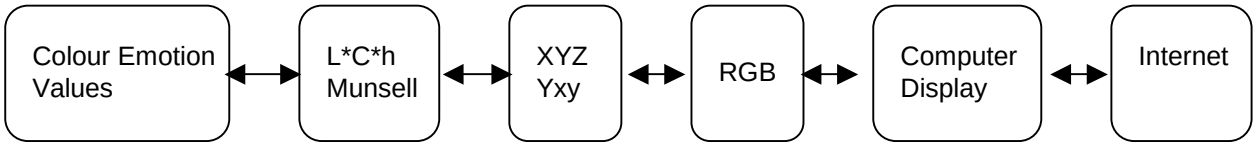


Figure 1 Process for the expression of colour emotions on a computer display and Internet

## 4. APPLICATION OF THE CROSS-CULTURE COMPARISON

It is not so easy to communicate feelings between two languages, especially the magnitudes of the feelings, and in general, a word of one language has no unique counterpart in other languages. How can we communicate the magnitude of colour emotion on a cross-culture platform?

As an example, the formulae of 'Soft-Hard' colour emotions in Japan, Thailand, Hong Kong and United Kingdom, which were derived from the relationship between visual assessments and CIELAB values of colour samples, are shown as followings;

$$SH_{JP} = [(3.2L^*)^2+\{2.4(1-\Delta h_{290}/360)C^*\}^2]^{1/2}-180 \quad (2)$$

$$SH_{TH} = -[\{3.5(L^*-100)\}^2+\{2.0(1-\Delta h_{290}/360)C^*\}^2]^{1/2}+155 \quad (3)$$

$$SH_{HK} = [(3.2L^*)^2+\{1.0(1-\Delta h_{290}/360)C^*\}^2]^{1/2}-180 \quad (4)$$

$$SH_{UK} = -[\{2.9(L^*-100)\}^2+\{2.5(1-\Delta h_{290}/360)C^*\}^2]^{1/2}+155 \quad (5)$$

where, JP, TH, HK and UK are Japan, Thailand, Hong Kong and United Kingdom, respectively.

L* : CIELAB metric lightness

C* : CIELAB metric chroma

$\Delta h_{290}$ : CIELAB metric hue-angle difference from h=290, $0 \leqq \Delta h_{290} \leqq 180$

Table 2 shows the correlation coefficients between the visual assessments of the four countries and the instrumental predictions by the formulae. The correlation coefficients between visual and instrumental assessments were around 0.9. Therefore, the formulae will be able to be applied to the objective assessment of 'Soft-Hard' colour emotion through colorimetric method.

Table 2 The correlation coefficient between visual and instrumental 'Soft-Hard' colour emotion assessments

| | JP | TH | HK | UK |
|---|---|---|---|---|
| Correlation coefficients | 0.913 | 0.855 | 0.927 | 0.882 |

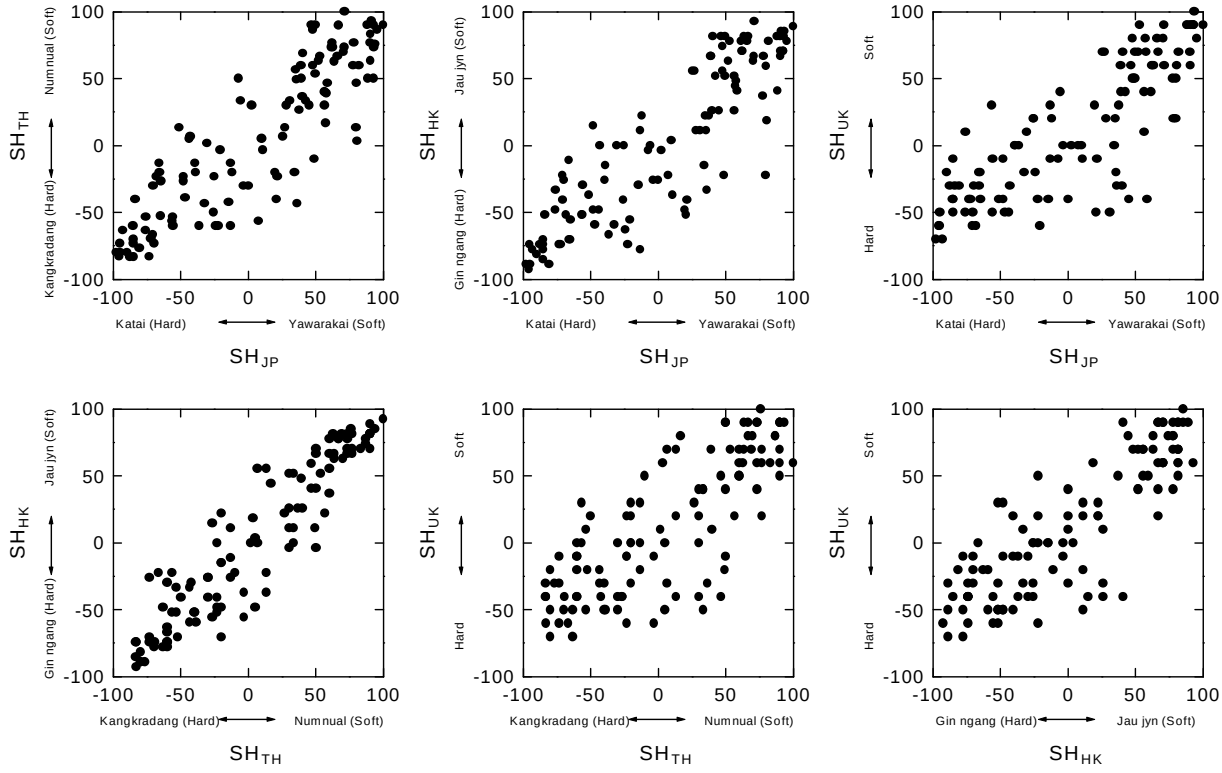


Figure 2 The comparison between 'Soft-Hard' assessments obtained in four countries

Figure 2 shows the relationships between visual assessments carried out with the same colour samples in the four countries. The size of colour samples was 114, and the numbers of observers were 60, 60, 60 and 30 in Japan, Thailand, Hong Kong and UK, respectively. The most 'Soft' colour areas in the four data sets were the same as high lightness colours near white, and the most 'Hard' areas were low lightness colours near black in all of the four countries. But, on the whole, the magnitudes of the emotions were a little different. The highest similarity was found in the relationship between Thai and Hong Kong 'Soft-Hard' emotions. The lowest one was found in the relationship between Thai and UK.

The correlation coefficients between visual assessments obtained in two countries were given in Table 3. Additionally, the correlation coefficients between instrumental assessments predicted through the colour emotion formulae were also given in Table 3. The high correlation between instrumental assessments means that the colour emotion formulae can be applied to the quantitative translation of colour emotions based on colorimetric values.

Table 3 The correlation coefficient between 'Soft-Hard' colour emotion assessments obtained in four countries

| | JP-TH | JP-HK | JP-UK | TH-HK | TH-UK | HK-UK |
|---|---|---|---|---|---|---|
| Visual assessment | 0.879 | 0.876 | 0.817 | 0.933 | 0.784 | 0.850 |
| Instrumental assessment | 0.949 | 0.986 | 0.907 | 0.987 | 0.990 | 0.960 |

## 5. SUMMARY AND FURTHER STUDY

Comparing the *kansei* databases collected in the four countries, we should find the similarity and discrepancy among the results. This study on 'Soft-Hard' colour emotion and our recent studies showed that some colour emotions were not identical. However, the comparison and conversion can be obtained through the use of colour emotion formulae. The understanding of differences in colour emotions and the use of this knowledge in the development of new products are very important.

As further studies, the discrepancy and similarity among the databases should be analysed in details. The analysis will be useful to make way for estimates of the cultural influence of each country. But the *kansei* database used in this study is not enough to discuss about the details of the influence from culture. Because just only one database in a country was used in this study, and the observers' age was around twenty years old. Many *kansei* databases should carefully be collected, and the databases should be analysed more quantitatively with objective viewpoints.

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