Sensory Bioengineering Design: Colour, Textile and Human

Tetsuya Sato

Graduate School of Science and Technology, Kyoto Institute Technology
Matsugasaki, Sakyo-ku, Kyoto 606-8585, Japan

Abstract: The mechanism of human colour perception is very complex and difficult to analyse, especially the neural mechanisms which are not well understood. In order to analyse the mechanism, it is essential to derive some quantitative visual scales. Therefore, an attempt has been made to analyse the colorimetric characteristics of the scales in CIELAB colour space and then obtain a colour description map using perceptual axes. In addition, the relationship between the many colour word pairs has been determined using descriptive scales and statistical analysis.With the results, we derived empirical colour emotion equations to express our impression induced from colour. The instrumental colorimetric assessment of colour emotions can be made through the colour emotion equations that were derived. With sensory database and colour emotion equations, we envisaged the development of some useful tools for Information Technology. Colour emotion scales obtained can be transformed to CIELCh, CIELAB, XYZ, and RGB values, which can be output as colours by display devices. This colour output can be used by applications such as product design and development.

Keywords: Colour impression, numerical expression, colour measurement, sportswear.

1. Introduction

Colour sometimes gives us special effects. For example, in Japan, in December 1997, the animated TV program "Pocket Monsters" simultaneously induced seizures in photosensitive persons all over the country, and several hundred viewers were rushed to emergency hospitals. In addition, because 76% of affected viewers had latent photosensitivity, that is, they were unaware of their risk for light-induced seizures, and had never before experienced epileptic seizures [1]. Even in sports, we had an interesting paper about colour effects in Olympic games [2]. This paper informed that signals biologically attributed to red coloration in males may operate in the arena of combat sports.

Colour is perceived in the brain when light enters the eyes. The mechanism of human colour perception is very complex and difficult to analyse, especially the neural mechanisms which are not at all well understood. Colour physicists are concerned with investigating the perception of light and colour from a physical point of view, while psychologists are usually investigating colour from a perceptual and psychological slant. The relationship between physical and perceptual colour parameters is very important but little has been done to bridge the two areas up to the present time.

In order to analyse the neural mechanisms of colour vision in the human brain, quantitative scales of colour perception are needed. Words are the way by which we communicate colour perceptions and are the most useful key for developing quantitative scales. Some interesting psychological studies based on words have been carried out by Kobayashi [3,4] and Taft [5] who have investigated human colour emotions through statistical methods. But the results of the studies were not fully quantitative and so not enough to bridge the gap. Therefore, our research group is concentrating on words and languages and trying to fill the gap between colour perception and colour words through the derivation of visual scales based upon psychological sensations.

In a previous study [6], we have already collected more than a hundred colour description words in Japanese which express human feelings towards colour. In other papers [7-11], we chose some pairs of colour descriptive words from the previous study and attempted to colorimetrically derive emotional colour scales for them.

This paper is an example of sensory bio-engineering design researches, and a summary of my previous studies of our colour emotion research project funded by the Japan Society for the Promotion of Science (JSPS) and The Descente and Ishimoto Memorial Foundation for the Promotion of Sports Science, especially studies published as journal papers [12,13].

2. Colour emotion equation

Colour emotion equations were derived as emotional scales in previous studies, using many opponent Kansei word pairs [7-13]. The words

*Corresponding author's email: tsato@kit.ac.jp
JFBI Vol. 2 No. 2 2009 doi:10.3993/jfbi09200901

relating to sports in the studies were 'Beauty-Dirty', 'Braced-Relax', 'Clean-Not clean', 'Deep-Pale', 'Easy to move-Stiff to move', 'Fast-Slow', 'Gaudy-Plain', 'Hot-Cool', 'Heavy-Light', 'Light-Dark', 'Refreshing-Dull', 'Refined-Not Refined', 'Settling-Exciting', 'Striking-Subdued', 'Strong-Weak' and Youngish-Oldish'.

We carried out visual assessments of colour impression by semantic differential method, and compared the visual assessment results with CIELAB values of used colour samples. With the results, equations were derived for expressing the colour impressions. A foundational colour emotion equation CE is given below:

$$CE=[\{K_L(L^*-L^*_0)\}^2+\{K_A(a^*-a^*_0)\}^2+\{K_B(b^*-b^*_0)\}^2]^{1/2}+K_M \quad (1)$$

where, CE: Prediction value of the colour emotion
L*: CIELAB metric lightness
L^*_0, a^*_0, b^*_0: CIELAB L*, a*, and b* when the colour emotion is minimum
K_L, K_A, K_B: Constants of the contribution of CIELAB L*, a*, and b*
K_M: Constant for scaling

Each colour emotion equation for sportswear colour is given below:

Beautiful-Dirty (BD),
BD=[{6.5・(L*-40)}2+{5.5・(a*-10)}2+{4.5・(b*-20)}2]1/2-220 (2)

Braced-Relax (BR),
BR=[{2.9・(L*-70)}2+{2.9・(a*-10)}2+{3.3・(b*-20)}2]1/2-100 (3)

Clean-Not clean (CN),
CN=[{7.0・(L*-40)}2+{5.4・(a*-10)}2+{4.8・(b*-20)}2]1/2-210 (4)

Deep-Pale (DP),
$DP=[\{6.0\cdot(L^*-100)\}^2+(3.5\cdot a^*)^2+(4.0\cdot b^*)^2]^{1/2}-260$ (5)

Easy to move-Stiff to move (ES),
$ES=[\{4.6\cdot(L^*-30)\}^2+\{1.6\cdot(a^*-20)\}^2+\{1.2\cdot(b^*-60)\}^2]^{1/2}-140$ (6)

Fast –Slow (FS),
$FS=[\{6.2\cdot(L^*-40)\}^2+\{4.4\cdot(a^*-10)\}^2+\{4.2\cdot(b^*-20)\}^2]^{1/2}-200$ (7)

Gaudy-Plain (GP),
$GP=[\{4.6\cdot(L^*-50)\}^2+(8.2\cdot a^*)^2+\{5.4\cdot(b^*-10)\}^2]^{1/2}-210$ (8)

Hot-Cool (HC),
$HC=[\{4.0\cdot(L^*-100)\}^2+\{5.0\cdot(a^*+10)\}^2+\{2.0\cdot(b^*+20)\}^2]^{1/2}-220$ (9)

Heavy-Light (HL),
$HL=[\{5.0\cdot(L^*-100)\}^2+(1.5\cdot b^*)^2]^{1/2}-210$ (10)

Light-Dark (LD),
$LD=\{(5.8\cdot L^*)^2+(7.8\cdot a^*)^2+(5.4\cdot b^*)^2\}^{1/2}-400$ (11)

Refreshing-Dull (RD),
$RD=[\{9.0\cdot(L^*-40)\}^2+\{4.5\cdot(a^*-10)\}^2+\{6.0\cdot(b^*-10)\}^2]^{1/2}-270$ (12)

Refined-Not refined (RN),
$RN=[\{4.6\cdot(L^*-50)\}^2+\{2.6\cdot(a^*-20)\}^2+\{2.8\cdot(b^*-40)\}^2]^{1/2}-160$ (13)

Settling-Exciting (SE),
$SE=\{(5.0\cdot a^*)^2+(2.0\cdot b^*)^2\}^{1/2}-110$ (14)

Striking-Subdued (SS),
$SS=[\{2.5\cdot(L^*-50)\}^2+(6.0\cdot a^*)^2+(4.5\cdot b^*)^2]^{1/2}-140$ (15)

Strong-Weak (SW),
$SW=[\{4.2\cdot(L^*-80)\}^2+(0.6\cdot a^*)^2+(1.0\cdot b^*)^2]^{1/2}-90$ (16)

Youngish-Oldish (YO),
$YO=[\{8.0\cdot(L^*-40)\}^2+\{8.0\cdot(a^*-10)\}^2+\{6.0\cdot(b^*-20)\}^2]^{1/2}-300$ (17)

3. Application of numerical expression

Traditional colour systems are based on three attributes such as hue, lightness and chroma. But our sensations are various. Therefore, we can develop another colour system based on the sensations as shown in Figure 1. Figure 1 shows a colour emotion description system by 'Light-Dark' and 'Gaudy-Plain', which are projected yellow and blue hue planes [12].

Currently, the keyword of the application of colour technology is *colour communication*. The colour communication is including colour reproduction colours and colour management. Especially, it is most important to communicate colour images accurately. While the current application of colour communications are in the domain of colour reproduction accuracy and colour