นิพจน์เชิงตัวเลขของการรับรู้สีเปรียบเทียบระหว่างกลุ่มคนที่มีวัฒนธรรมต่างกัน

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NUMERICAL EXPRESSION OF COLOR PERCEPTION FOR CROSS CULTURE COMPARISON

Mr. Yannawit Bangchokdee

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By	Mr. Yannawit Bangchokdee
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…… Dean of Faculty of Science
(Associate Professor Wanchai Phothiphichitr, Ph.D.)

THESIS COMMITTEE

…….. Chairman
(Professor Suda Kiatkamjornwong, Ph.D.)

…….……. Thesis Advisor
(Associate Professor Aran Hansuebsai, Ph.D.)

…….. Member
(Associate Professor Pontawee Pungrassamee, M.S.)

…….. Member
(Professor Chidchanok Lursinsap, Ph.D.)

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งานวิจัยนี้ได้ทำการศึกษานิพจน์เชิงตัวเลขของการรับรู้สีกับ 12 คำคู่ตรงข้ามที่แสดงความรู้สึกด้วยการใช้วิธีประเมินแบบ seven-point กับผู้สังเกตการณ์ชาวไทย เพื่อให้ได้สมการการรับรู้สีของคนไทยที่แสดงความสัมพันธ์ระหว่างค่าสีที่ได้จากการวัดและค่าที่ได้จากการประเมิน นำผลที่ได้ไปเปรียบเทียบกับวิธีการประเมินแบบ two-point และกับผลของสมการการรับรู้สีของคนญี่ปุ่นด้วยเทคนิคเชิงสถิติสหสัมพันธ์และ t-test ที่ระดับนัยสำคัญ 0.05 พบว่าผลการประเมินที่ได้จากทั้ง 2 วิธีมีความสัมพันธ์แบบเชิงเส้นด้วยค่าสัมประสิทธิ์สหสัมพันธ์สูงทั้ง 12 คำคู่ ซึ่งมีค่าอยู่ในช่วง 0.9718 ถึง 0.9888 ในขณะที่การวิเคราะห์ t-test แสดงให้เห็นว่ามีความแตกต่างของน้ำหนักสีเกิดขึ้นทุกน้ำหนักสี ในส่วนการเปรียบเทียบกับผลของชาวญี่ปุ่นพบว่ามีความสัมพันธ์อย่างมีนัยสำคัญยกเว้นในคู่ของ “Deep-Pale” และความแตกต่างของสีสันเกิดขึ้นใน “Warm-Cool”, “Deep-Pale” และ “Striking-Subdued” ส่วนความแตกต่างของน้ำหนักสีเกิดทั้ง 12 น้ำหนักสี นอกจากนี้ยังพบว่าผลของสมการการแปลงข้อมูลระหว่างชาวไทยและญี่ปุ่นที่ได้กับ color perception map จะถูกสร้างขึ้น จะมีประโยชน์สามารถทำนายผลของการรับรู้สีของชาวไทยและญี่ปุ่นได้

ภาควิชา วิทยาศาสตร์ทางภาพถ่ายและเทคโนโลยีทางการพิมพ์ ลายมือชื่อนิสิต.....
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4272264523 : MAJOR IMAGING TECHNOLOGY
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This research studies the numerical expression of the color perception corresponding to twelve opponent word pairs through two-point and seven-point assessments carried out by Thai observers. The twelve color perception equations were derived from the relationship between the colorimetric values and visual assessments. The obtained visual results between methods and countries (Thailand-Japan) were compared by determining correlation coefficients and paired t-test in terms of hue and tone at a significant level of 0.05. Relationships of twelve word pairs between methods were high with the range of correlation coefficient value 0.9718-0.9885 while hue differences were found in “Warm-Cool” and in “Gaudy-Plain” of achromatic color and tone comparisons were different at all twelve tones. There was a significant relationship between countries, with the exception of the “Deep-Pale.” Hue differences were found in “Warm-Cool,” “Deep-Pale,” and “Striking-Subdued.” Tone differences tended to occur in all twelve tones. Note that cross-cultural translation equation between Japanese-Thai data is possible, by which a color perception map was established. This map is useful to directly translate the magnitude of the color perceptions of Thai and Japanese.

Department……Imaging and Printing Technology……	Student’s signature……..….....
Field of study……Imaging Technology……..…	Advisor’s signature……..….....
Academic year……2000……...	Co-advisor’s signature……..…….

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Yannawit Bangchokdee

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CHAPTER 1

INTRODUCTION

Color is extremely important in the modern world, the variety of colors produced on textiles, paints, paper and plastics. Color is an important factor in the production of materials and is often vital to the commercial success of a product. Such as in the food case, the color used to judge the quality of the material, while in cases of packing, color is important in attracting customers. Color is a phenomenon of perception not an objective component or characteristic of a substance. Color perception involves three basic factors the source of light, objects under illumination, and the eyes and neural responses of observers. Stimuli received by the eye have no meaning until the brain interprets them. The eye records without understanding, the brain interprets the visual information fed to it by the eye and compares it with previous experiences but individual experiences vary, different conclusions will be drawn by different people. For the artist color means pigments. For the psychologist color means perception, which exists within the brain. For the physiologist color means a response of the nervous system. For the physicist color means an attribute of radiant energy and for the man in the street color is a combination of the property of objects and light sources (*1,2*).

Color physicists have been working with considerable success to create a reliable quantified visual scale for scientific applications. On the other hand, psychologists are investigating color perception from a psychological viewpoint. The interface between physical and sensational parameters is very important. In order to analyze the software mechanism of color perception in our brains, it is necessary to make some quantitative scales. Words are the output of color perception and the most useful key to communicate information. Ngampatipatpong's work has concentrated on words and languages, and also tried to fill the gap between color physics and psychology through the derivation of some scales based upon color emotions. A visual scale for assessing a color emotion in the CIELAB color space was obtained.

The twelve color emotion word pairs were selected as in the previous study. The technique for assessing those word pairs is based on the rating of the two-point method. The higher the rating employed, the more accurate the result becomes. Previous studies showed that it is possible to split the opponent color word pairs into three categories based on lightness, hue and chroma contribution (*3,4*).

This research investigates in detail color equations by using the observation technique and the seven-point method. A comparison between two-point and seven-point techniques; and between Thai and Japanese data will be made. A relationship model is obtained.

1.1 Objectives

One objective of this research is to assess quantitative color perception for Thai observers. Another objective is to apply the result for cross culture comparison between Thai and Japanese.

1.2 Scope of the Research

The dissertation covers the study on the effects of the visual assessment from the twelve opponent word pairs, the derivation of the visual assessments and colorimatric values to set the color perception equations, the colorimetric characteristics of the color perception on CIE L* C* and CIE a* b* diagrams, representing the relation between two opponent word pairs on color perception map. Compare visual results between two-point and seven-point techniques, between Japanese and Thai data, visual results from Japanese observers that were translated into Thai and visual results from Thai observers. In addition, the relationship models between Japanese and Thai are included.

1.3 Content of the Thesis

Chapter 2 contains the overview of the theoretical considerations and literature reviews that are related to this research. Chapter 3, the description on materials under study and the experimental procedures and apparatuses. Chapter 4, the results and discussion on the visual assessment, the color perception equations, the color perception values on CIELAB L* C* and CIELAB a* b* diagrams, the color perception maps, compare visual results between two-point and seven-point techniques and between Thai and Japanese data by paired t-test in terms of hue, tone and achromatic color and by correlation, compare Japanese data which were translated into Thai data and Thai data, translate visual results between Thai and Japanese by color perception equations and predicting color perception between Thai and Japanese on color perception maps. Finally the conclusion and suggestion come in Chapter 5.

CHAPTER 2

THEORETICAL CONSIDERATION AND LITERATURE REVIEW

2.1 Theoretical Considerations

2.1.1 The Perception of Color

Color perception involves three basic factors the source of light, objects under illumination, and the eyes and neural responses of observers. The visual process begins when radiant energy from the source strikes the object and some of this energy is reflected and passes through the lens to strike the retina in the eye. The retina is made up of a complex network of cells and neurons. The retina consists of a large number of cells which are sensitive to light; these the receptors cells are of two kinds, rods and cones. Rods are sensitive to brightness of light. Cones are cells of three different types which respond to red, blue and green wavelengths of light, respectively, and it is through these that all colors are seen. When the three types of cones are all stimulated equally, the eye and the brain see white, but if one type of cone is stimulated more than the other two, the image appears to be tinted with the corresponding primary hue.

The most central part of the retina is called the fovea and it has the largest concentration of cells. The fovea vision is used for distinguishing very fine detail, such as reading and seeing objects at distance. Outside the fovea, the number of cones is greatly reduced and they are situated quite apart from one another. The rods are completely absent from the fovea and fall out to the extreme periphery. The signals leave the retina via the optic nerve and eventually arrive at the back of the brain. The brain signals are interpreted through mental impressions that result in color (*5*,*6*).

2.1.2 The Munsell System

The Munsell system is the most frequently used of all the color order system. Artist Albert H. Munsell developed this system in 1905. The objective of Munsell was to have both a numerical system and a physical exemplification that have equal visual increments along each of the three perceptual dimensions, achieved via the Atlas of the Munsell Colors. The samples consist of painted paper and are available in both gloss and matte surfaces. Munsell uses the terms of hue, value (lightness) and chroma (saturation) to describe the attributes of color (*7*).

2.1.2.1 Munsell Hue

There are 10 hues arranged in the Munsell system is divided into five principal hues, Purple, Blue, Green, Yellow, and Red, and they are designated 5P, 5B, 5G, 5Y, and 5R, respectively, and five intermediate hues are also designated: 5PB, 5BG, 5GY, 5YR and 5RP, as shown in Finger 2-1 (*8*). For each of the ten hues, there are ten hues with notations as illustrated by the range between 5P and 5PB and consisting of 6P, 7P, 8P, 9P, 10P, 1PB, 2PB, 3PB, and 4PB. Therefore, there are 100 hue steps in the Munsell circle.

2.1.2.2 Munsell Value

There are ten main steps in the Munsell value scale with white given a notation of N10, black a N0, and intermediate grays given notations ranging between N0 and N10, as shown in Figure 2-2 (*9*). The design of the Munsell value scale is such that an intermediate gray with a Munsell value of 5 is perceptually halfway between white and black. Also, the perceived lightness difference between N3 and N4 samples is equivalent to the lightness difference between N6 and N7 samples or any other samples varying by one step in Munsell value.

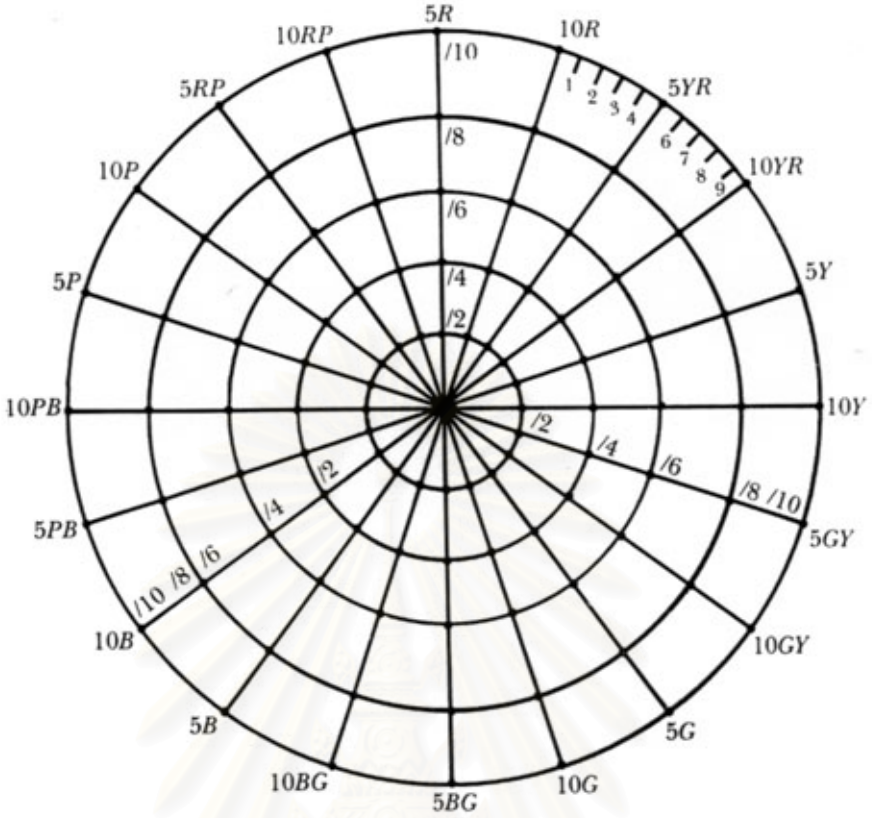

Figure 2-1 Arrangement of Hue circle in the Munsell system

2.1.2.3 Munsell Chroma

The distance of the sample from the value axis are intended to represent uniform differences in perceived chroma and are given numbers that are typically as small as 4 or less for weak colors, and 10 or more for strong colors. The scales of chroma extends from/0 for a neutral gray out to /10, /12, /14 or father (*10*).

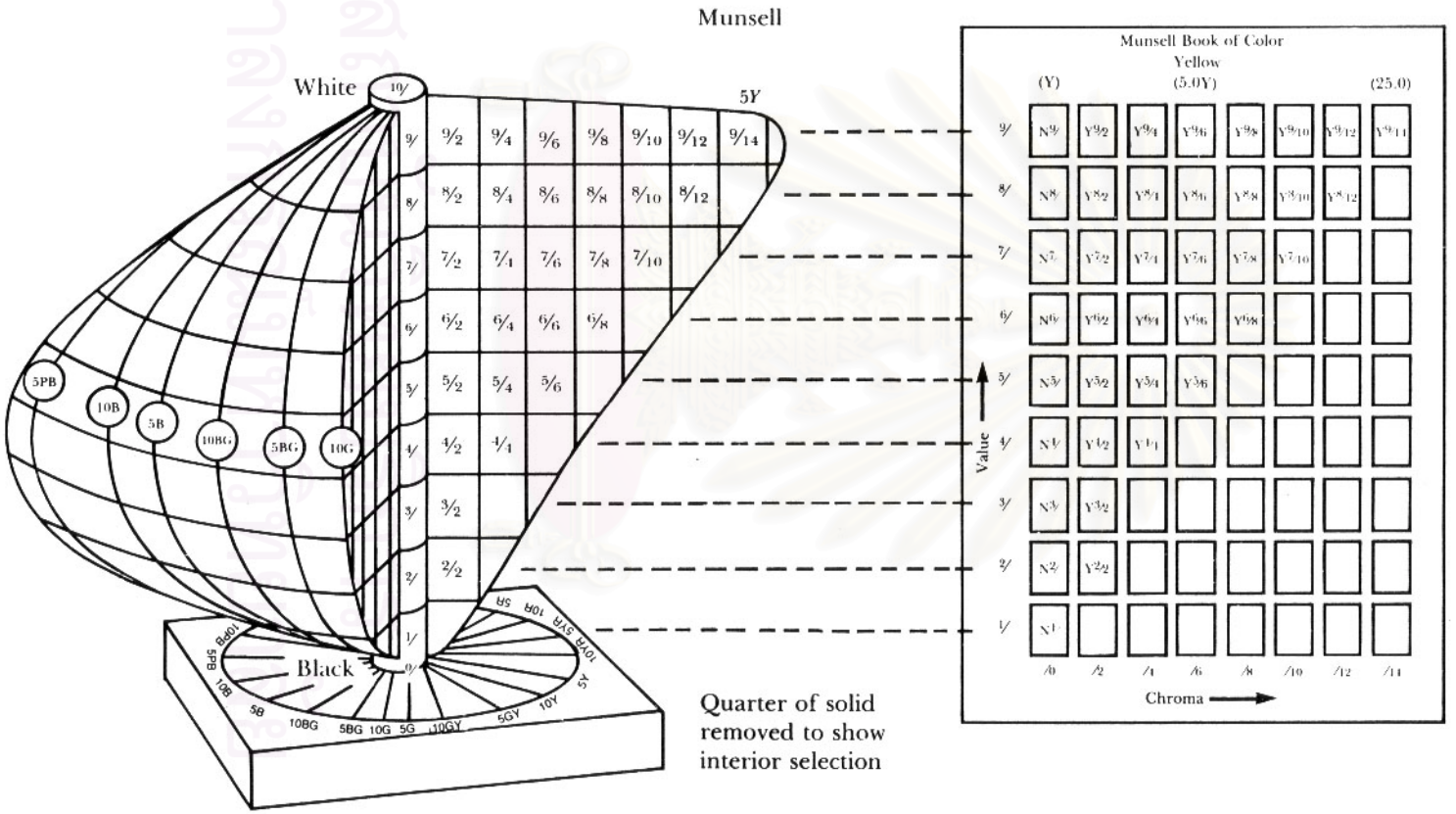

Figure 2-2 The Munsell color space

2.1.3 The CIE Color System

In 1931, the CIE (Commission International de l'Eclairage or International Commission on Illumination) developed the standards for description aspects of color specification called colorimetry. The standards of colorimetry to be concerned with the relative spectral distribution of radiant flux emitted by the source and incident on the object, the spectral reflectance factors of the object and the color matching function of the observer viewing the object (*11*). The CIE color system is a system to specify a color appearance quantitatively, is not directly based on psychological scaling of colors like the Munsell color system.

2.1.3.1 CIE Illuminants

The CIE has established a number of spectral power distributions as CIE illuminants for colorimetry. These distributions based on physical standards, such as blackbody radiators or Planckian radiator, or are based on statistical representations of measured light.

- CIE illuminant A represents a Planckian radiator with a color temperature of 2856 K, as shown in Figure 2-3 (*12*). It is used for colorimetric calculations when incandescent illumination is of interest.

- CIE illuminant C is the spectral power distribution of illuminant A as modified by particular liquid filters defined by the CIE. It represents a daylight simulator with a correlated color temperature of 6774 K, as shown in Figure 2-4 (*13*).

- CIE illuminants D65 and D50 are part of the CIE D series illuminants that have been statistically defined based upon a large number of measurements of natural daylight. Illuminant D65 represents an average daylight with a correlated color temperature of 6500 K, and D50 represents an average daylight with a correlated color temperature of 5003 K, as shown in Figure 2-4. D65 is commonly used in colorimetric applications, such as paints, plastics, and textiles. D50

is often used in graphic arts and computer industries. CIE D illuminants with other correlated color temperatures can be easily obtained.

- CIE F series illuminants represent typical spectral power distributions for various types of fluorescent sources including standard cool white, warm white, “full spectrum,” and tri-band, 12 in all. CIE illuminant F2 represents cool white fluorescent with a correlated color temperature of 4230 K. Illuminant F8 represents a fluorescent D50 simulator with a correlated color temperature of 5000 K, and illuminant F11 represents a tri-band fluorescent sources with a correlated color temperature of 4000 K, as shown in Figure 2-5 and in Figure 2-6 (*14*). Tri-band fluorescent sources are popular because of their efficiency, efficacy, and pleasing color-rendering properties.

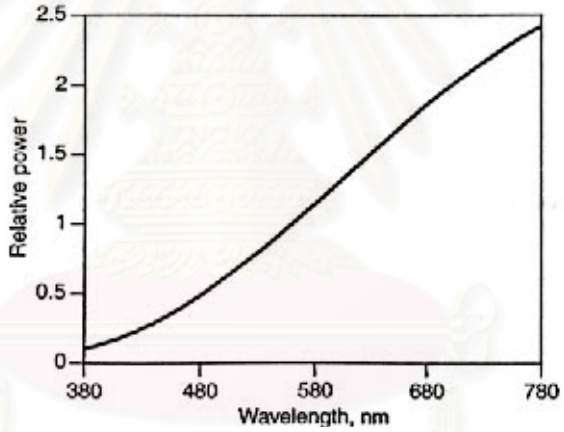

Figure 2-3 The spectral power distribution of CIE illuminant A

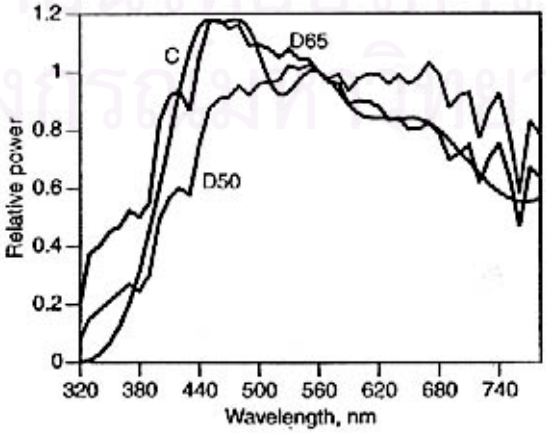

Figure 2-4 The spectral power distribution of CIE illuminants D50, D65 and C

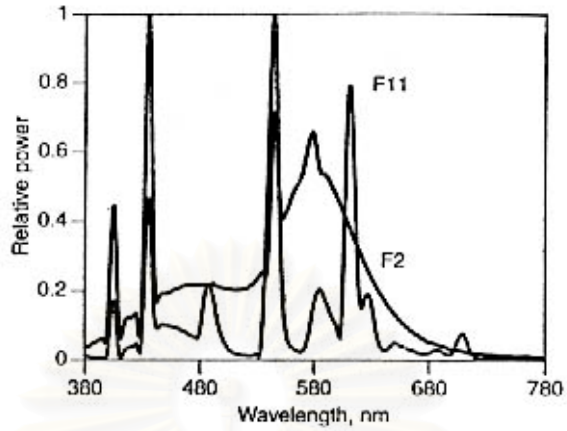

Figure 2-5 The spectral power distribution of CIE illuminant F2 and F11

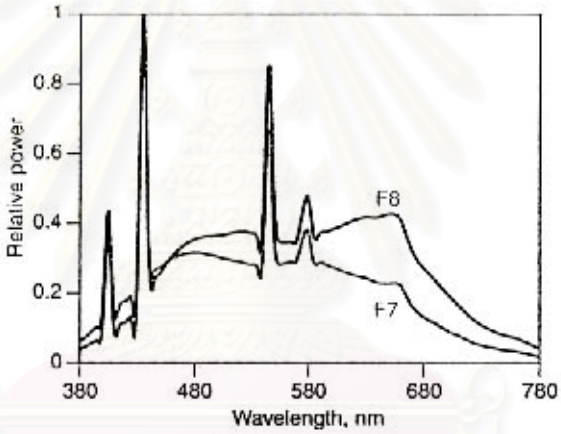

Figure 2-6 The spectral power distribution of CIE illuminants F7 and F8

2.1.3.2 Standard of Reflectance Factor

The CIE recommends that reflectance measurement should be made relative to the perfect reflecting diffuser. There is no object surface that has the properties of the perfect reflecting diffuser, but working standards of known spectral reflectance factors is normally used. The working standards for reflectance factor measurement are also called white standard. The effect of an object on light can be described by its spectral transmittance or reflectance curve. The spectral reflectance curve describes the object just as the spectral power distribution curve describes a source, as shown in Figure 2-7 (*15*).

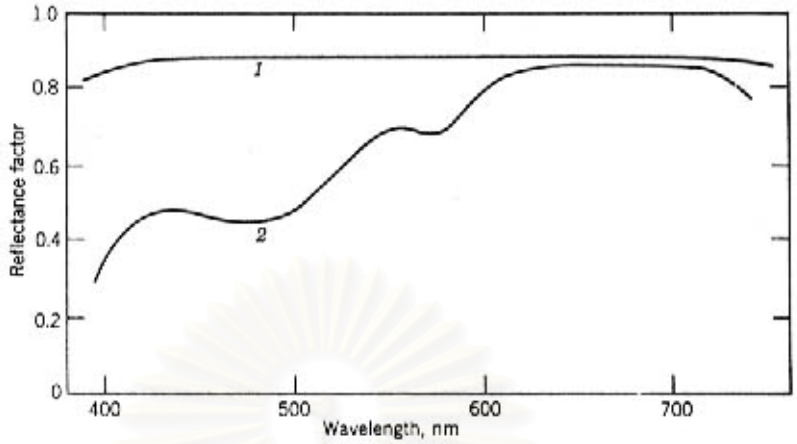

Figure 2-7 The spectral reflectance factor of hypothetical white (1) and tan (2) specimens

2.1.3.3 CIE Standard Observers

The colorimetric specifications of color based on the spectral tristimulus values of $\bar{x}_\lambda$, $\bar{y}_\lambda$ *and* $\bar{z}_\lambda$ which are also called the color matching functions. There are two sets of color-matching functions established by the CIE. The CIE 1931 standard colorimetric observer was determined from experiments by Guild and Wright, using a visual field that subtended 2 degrees that the matching stimuli were imaged onto the retina completely within the fovea. In 1964, the CIE recommended a set of color-matching functions are notated as $\bar{x}_{10\lambda}$, $\bar{y}_{10\lambda}$ and $\bar{z}_{10\lambda}$, for the experiments using a 10^o visual field that excluded the central fovea. The results for large fields were deemed significantly different from the 2^o standard, enough to warrant the establishment of the CIE 1964 supplementary standard colorimetric observer, sometimes called the 10^o observer, as shown in Figure 2-8 (*16*). Nowadays standards exist for two field sizes, 2^o and 10^o.

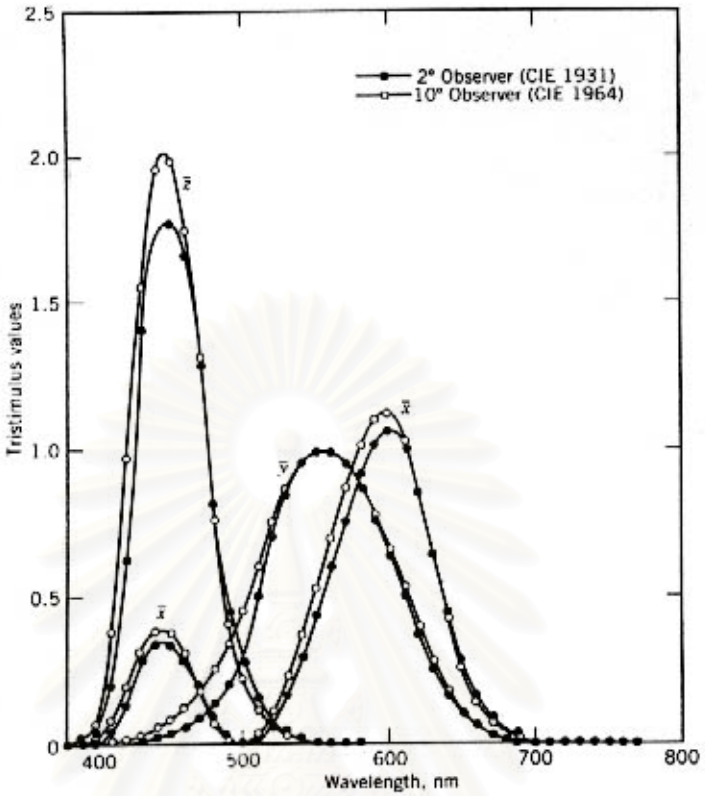

Figure 2-8 Comparison of color matching functions of the 1931 CIE Standard observers and the 1964 CIE Supplementary Observers

2.1.3.4 CIE XYZ Tristimulus Values

The CIE tristimulus values X, Y, and Z of color are obtained by multiplying together the relative power of a CIE standard illuminant, the reflectance factor or the transmittance of the object and the standard observer function, as shown in Figure 2-9 (*17*), by the equations as below:

$$X = k\sum S_\lambda R_\lambda \bar{x}_\lambda \Delta\lambda$$

$$Y = k\sum S_\lambda R_\lambda \bar{y}_\lambda \Delta\lambda$$

$$Z = k\sum S_\lambda R_\lambda \bar{z}_\lambda \Delta\lambda$$

$$k = 100 / \sum S_\lambda \bar{y}_\lambda \Delta\lambda \qquad (2.1)$$

Where, S_λ is the spectral power distribution of light illuminant or source

R_λ is the spectral reflectance factor of object

$\bar{x}_\lambda$, $\bar{y}_\lambda$ and $\bar{z}_\lambda$ are the color matching functions

k is a normalizing constant

$\Delta\lambda$ is the measurement wavelength interval

$\sum_\lambda$ is summation across wavelength

By convention, the value Y = 100, assigned to perfect white object reflecting 100% at all wavelengths, or to the perfect colorless sample transmitting 100% at all wavelengths, is the maximum value that Y can have for nonfluorescent sample.

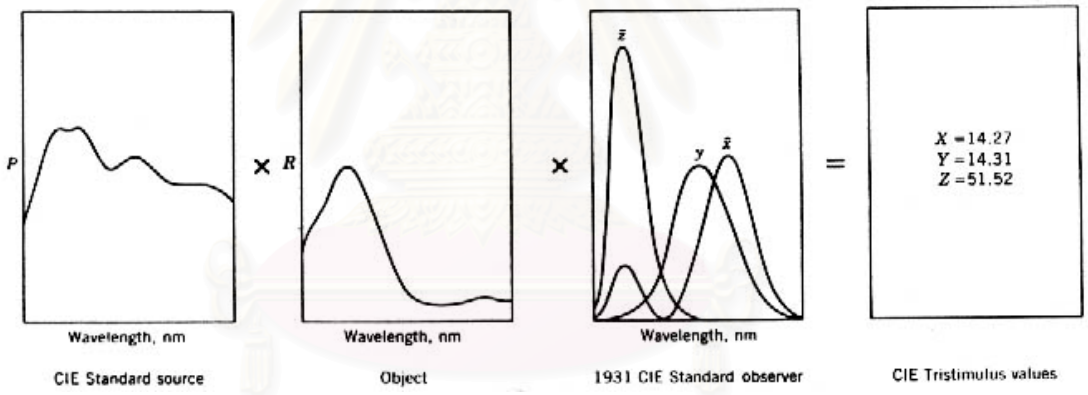

Figure 2-9 The CIE tristimulus values X, Y and Z of color

2.1.4 The CIELAB Color Space

The limitation of the CIE system is its non-uniformity. Equal changes in x, y or Y do not correspond to equal visual differences. Many attempts provided a more uniform system. The end result is CIELAB 1976 color space that for the measurement of color differences. This space extends tristimulus colorimetry to three-dimensional space with dimensions that approximately correlate with the perceived lightness, chroma and hue of a stimulus.

The variables used in the CIELAB system are L* as the correlate of lightness, a* as the correlate of redness or greenness, and b* as the correlate of yellowness or blueness, as shown in Figure 2-10 (*18*), are defined as follow.

$$L^* = 116(Y/Y_n)^{1/3}-16$$
$$a^* = 500[(X/X_n)^{1/3}-(Y/Y_n)^{1/3}]$$
$$b^* = 200[(Y/Y_n)^{1/3}-(Z/Z_n)^{1/3}]$$
$$C^* = (a^{*2}+ b^{*2})^{1/2}$$
$$h = \tan^{-1}(b^*/a^*) \qquad (2.2)$$

where, X/X_n, Y/Y_n, Z/Z_n, > 0.008856

X, Y and Z are the tristimulus values of the stimulus

X_n, Y_n and Z_0 are the tristimulus values of the reference white

C* is chroma

h is hue angle

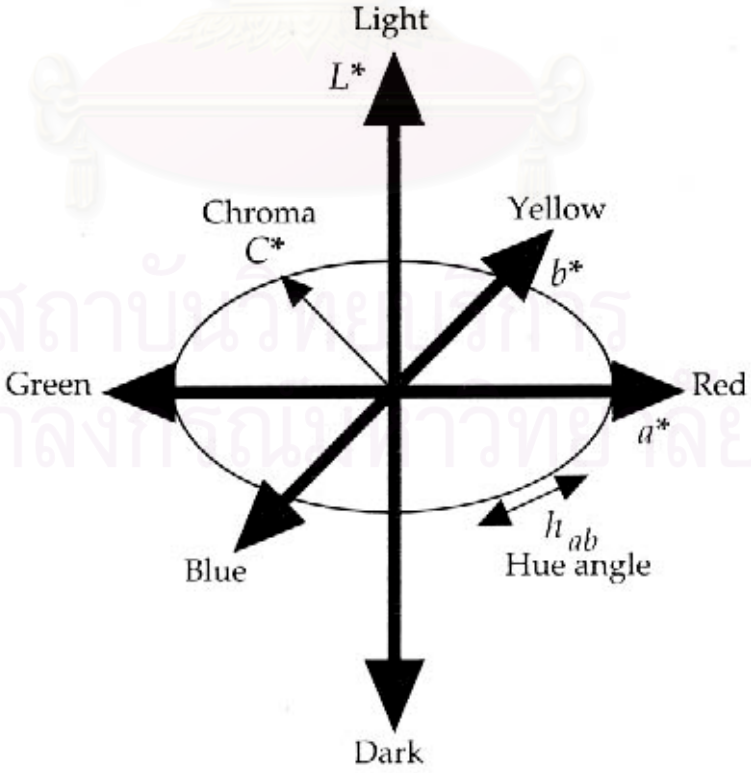

Figure 2-10 The cylindrical representation of the CIELAB color space

2.1.5 Regression and Correlation

2.1.5.1 The Simple Linear Regression

Regression analysis (*19*) is a statistical method that uses a relationship between two or more variables so that one variable can be predicted or explained by using information on the others. The relation between the variables using a mathematical formula is called the regression model. The simple linear regression model is the relationship is specified to have only one factor variable and the relationship is decried by a straight line, is of the from;

$$y = \beta_0 + \beta_1 x \tag{2.3}$$

where, *y* is the dependent variable

x is the independent variable

β_0 is the intercept

β_1 is the slope

2.1.5.2 The Correlation Coefficient

The Correlation Coefficient r (*20*), is a measure of the strength of the linear relationship between two variables x and y, which just as does the slope β_1. However, unlike the slope, the correlation coefficient is scaleless. It is computed as follow:

$$r = S_{xy} / (S_{xx}S_{xy})^{1/2} \tag{2.4}$$

where, $S_{xx} = \sum x^2 - (\sum x)^2 / n$

$S_{xx} = \sum xy - (\sum x)(\sum y) / n$

$S_{yy} = \sum y^2 - (\sum y)^2 / n$

The correlation coefficient has the following properties:

- Its value is between +1 and –1 inclusive.

- Values of +1 and –1 signify an exact positive and negative relationship, respectively, between the variables. That is the values of x and y exactly describes a straight line with a positive or negative slope depending on the sign of r.

- A correlation of zero indicates no linear relationship exist between the two variables. This condition does not, however, imply that there is no relationship since correlation does not measure the strength of curvilinear relationships.

- The correlation coefficient is symmetric with respect to x and y. It is thus a measure of the strength of a linear relationship regardless of whether x or y is the independent variable.

2.1.6 Inference for Two Populations

In many situation in statistics, the primary objective is to study how one parameter compares with another parameter which is larger mean (*21*).

2.1.6.1 Inference Concerning Two Population Means Based On Independent Sample

(1) Variables unknown and assumed equal

Hypothesis: $H_0 : \mu_1 = \mu_2$

$H_1 : \mu_1 \neq \mu_2$

Test statistic: $$t = \frac{(x_1 - x_2) - (\mu_1 - \mu_2)}{s_p \sqrt{(1/n_1) + (1/n_2)}} \qquad (2.5)$$

where $$s_p = \frac{\sqrt{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}}{n_1 + n_2 - 2}$$

Rejection region: reject H_0 : if $/t/ > t_{\alpha/2}$

where $df = n_1 + n_2 - 2$

This is called the “pooled sample standard deviation”.

(2) Variable unknown and not equal

Hypothesis: $H_0 : \mu_1 = \mu_2$

$H_1 : \mu_1 \neq \mu_2$

Test statistic: $$t = \frac{(x_1 - x_2) - (\mu_1 - \mu_2)}{\sqrt{(s_1^2/n_1) + (s_2^2/n_2)}} \quad (2.6)$$

Rejection region: reject H_0 : if $/t/ > t_{\alpha/2}$

where $$df = \frac{(n_1 - 1)(n_2 - 1)}{(n_2 - 1)c^2 + (1 - c)^2 (n_1 - 1)n_1 + n_2 - 2}$$

where $$c = \frac{s_1^2/n_1}{(s_1^2/n_1) + (s_2^2/n_2)}$$

This is called the "separate sample standard deviation".

The test statistic to be used depends on whether $\sigma_1 = \sigma_2$ or not. Sometimes a research will have a feel for whether this is true or not. The F-test is often employed to investigate this situation, use the test statistic;

$$F = s_1^2 / s_2^2 \quad (2.7)$$

Hypothesis: $H_0 : \sigma_1^2 = \sigma_2^2$

$H_1 : \sigma_1^2 \neq \sigma_2^2$

Rejection region: reject H_0 : if $F \geq F_{\alpha/2}$

where $df = (n_1 - 1, n_2 - 2)$

2.2 Literature Reviews

Nakamura et al. (*22*) derived the color image formulae and expressed the visual assessment against twelve color image word pairs of 'Vivid-Sombre', 'Deep-Pale', 'Warm-Cool', 'Light-Dark', 'Heavy-Light', 'Gaudy-Plain', 'Striking-Subdued', 'Dynamic-Passive', 'Distinct-Vague', 'Transparent-Turbid', 'Soft-Hard'

and ‘Strong-Weak’ in order to perform the numerical expression of human color image perception. The visual assessment which computed from colorimetric values was compared with the Munsell and CIELAB values. Each value from the empirical formulae was represent the color image to make the color image diagram and also projected the Munsell and CIELAB color order system on the diagrams.

Ho *(23*) researched about the relationship between colorimetric values and each opponent pair of the color images, ‘Warm-Cool’, ‘Dynamic-Passive’, ‘Light-Dark’ and ‘Soft-Hard’. The model formulae of each opponent pair of the color image was derived and the difference of the color images between the Japanese and British observers were also examined. ‘Warm-Cool’ color image was influenced by hue and chroma. ‘Dynamic- Passive’ color image was dominated by chroma. ‘Light-Dark’ color image was directly proportional to the lightness. ‘Soft-Hard’ color image was determined by lightness and chroma. The difference between the British observer in ‘Soft-Hard’ color image was found that Chroma C* more than 65 gave the British observers a Hard image while these color gave the Japanese observers a Soft image. The ‘Light-Dark’ color image for British observers had a higher correlation with the lightness than Japanese observers.

Parker-Jervis (*24*) studied the numerical interpretation of polar pairs of color image terms such as ‘Light-Dark’ and ‘Cool-Warm’. Observer data has been collected in Japan and UK using the same set of color panels viewed under similar conditions. Correlation analysis showed that dictionary equivalent pairs that are not necessarily the highest correlated, especially in the case of the Light-Dark pair. A stimulus-response model based on the CIE L* a* b* color co-ordinates of the panel and the logistic function was found to give reliable predictions of the judgement of the observer group. The model equation for the Light-Dark judgement showed a strong dependence on the L* value. A hue dependence was also modeled with blue hues predicted lighter than yellow, red and green hue sample of the same L* value.

Ngampatipatpong *(25)* attempts to link the gap between physical and perceptual colors parameter by deriving the quantitative visual scale of the word which express

human color perception which using the twelve opponent word pair and relevant to calorimetric values. The derivation of the visual assessment and calorimetric values establishes the color perception equation. It can analyze the calorimetric characteristic of the visual scale in CIE L*, C*, h color space and then obtain the color perception map. This diagram determines the relationship between the twelve opponent word pairs into three groups, which are dominated by chroma, lightness and hue, respectively.

Nakamura et al. *(26)* analyzed quantitatively the “Cool- Warm” feeling of color in terms of colorimetric value which is supposed correlate with the affective tone of color. The results of visual experiment confirmed that the “Cool-Warm” feeling was affected by hue and brightness more than by hue and chroma. Therefore, the visual evaluation of the “Cool-Warm” feeling was compare with hue and brightness and calculated from the colorimetric values. The empirical formula represent the “Cool-Warm” was shown as follow.

$$CW = aBr-80 \tag{2.8}$$

where, Br : Brightness value

a : Coefficient, $a = 20\{\cos(\pi \times \Delta H_{5YR}/50)+1\}$

ΔH_{5YR} : The munsell hue step from 5YR

Sato et al. *(27)* presented the affective tone of color that was quantitatively analyzed from psychological viewpoints. The fundamental factors were “Light-Dark”, “Deep-Pale” and “Heavy-Light” feeling. The feeling of various colors was verified with the above factors in term of correlated colorimetric values that related to the affective tone. The visual assessment was compared with lightness, color depth and the other parameters that computed from the colorimetric values in order to set of empirical formulae. The affective tone of color indicated that the feeling is mainly affected by lightness and color depth.

Sato et al. *(28)* performed a visual experiment to analyze quantitatively the feeling of color in terms of colorimetric values. The visual experiment confirmed that the feeling were mainly affected by Munsell chroma and Munsell value. Finally, the empirical formulae were established to represent the feeling as follow.

$$CI = [\{k_v(V - V_0)\}^2 + \{k_c(C - C_0)\}^2]^{1/2} - k_s \quad (2.9)$$

where, CI is color image value

V is Munsell value

C is Munsell chroma

V_0 is Munsell value when the color image percent is minimum

C_0 is Munsell chroma when the color image percent is minimum

k_v is constant of the contribution of Munsell value for the color image

k_c is constant of the contribution of Munsell chroma for the color image

k_s is constant for the scaling of the color image

Ngampatipatpong et al. *(29)* derived the quantitative visual scale of the word which express human emotion by using the opponent word pair and relevant to calorimetric values. The experiment establishes color emotion scale of Thai observers, which relates to its lightness and chroma.

Sato et al. *(30)* used the numerical expression of color emotion to find the instrumentally assessment. The twenty-four color emotion formulae based on the Munsell and CIELAB color systems were derived. The characteristic of color emotion simulated through the above formulae was indicated as color emotion lines in Munsell color system and the color emotion map was developed.

Xin et al. *(31)* investigated the twelve color emotions pairs and quantifying them with standard color specifications. The mathematical models were derived using the obtained visual assessment result from Hong Kong Chinese. Chroma of a color was found to be the dominant parameter affecting the ‘Warm-Cool’, ‘Vivid-Sombre’, ‘Gaudy-Plain’, ‘Striking-Subdued’ and ‘Dynamic-Passive’ color emotions. Lightness

of color was found to be the dominant parameter affecting the ‘Dee-Pale’, ‘Heavy-Light’, ‘Transparent-Turbid’, ‘Soft-Hard’ and ‘Strong-Weak’ color emotions. For the ‘Light-Dark’ and ‘Distinct-Vague’ color emotions were influenced by both the chroma and lightness of colors. The obtained visual assessment results from the Japanese, Thai and Hong Kong people were compared and very good correlation in the ‘Transparent-Turbid’ was found among these countries.

CHAPTER 3

EXPERIMENT

3.1 Materials

3.1.1 Neutral gray mask.

3.1.2 The polyester color samples are 20 hues, 12 tones and 6 achromatic colors, as follows;

20 hues	:	5R,10R, 5YR, 10YR, 5Y, 10Y , 5GY, 10GY, 5G, 10G, 5BG, 10BG, 5B, 10B, 5PB, 10PB, 5P, 10P, 5RP and 10RP.
12 tones	:	Pale Grayish, Pale, Light Grayish, Light Moderate, Light, Grayish, Moderate, Bright, Dark Grayish, Dark, Deep and Strong.
6 achromatic colors	:	N1, N2, N4, N6, N8 and N9.5.

In some tone regions textile dyeing colors were not available because of the non-existence of dyestuffs with acceptable fastness. Therefore, the totals of color samples were used in the experiment are 218. (see Appendix A) The size of the color sample is 1 cm. X 1.5 cm.

3.2 Apparatus

3.2.1 Gretag SPM 50 spectrophotometer.

3.2.2 Light cabinet with illuminant D65.

3.3 Observers

3.3.1 The observers were Thai native speakers ranging in age from 17-25.

3.3.2 The numbers of observers was 60.

3.4 Procedure

3.4.1 Preparation of color samples

In this study, 218 polyester color samples were selected systematically in color space using the SCOTDIC PLUS 2000 system, were manufactured by Kensaikan Co, Ltd. in Japan.

3.4.2 Measurement of the colorimetric values from 218 color samples

These colors were measured by the Gretag SPM 50 spectrophotometer under the illuminant D65 with 10 degree standard observer condition in terms of the colorimetric values, L*, a*, b*, C* and h. (see the data in Appendix B)

3.4.3 The visual assessment experiment

3.4.3.1 The twelve opponent word pairs in Thai are “Light-Dark,” “Warm-Cool”, ”Soft-Hard”, “Transparent-Turbid”, “Deep-Pale”, “Distinct-Vague”, “Heavy-Light”, “Vivid-Sombre”, “Strong-Weak”, “Dynamic-Passive”, “Gaudy-Plain” and “Striking-Subdued” as given in Table 3-1.

3.4.3.2 Each of the opponent word pairs was divided into seven levels (+3 to -3), representing the magnitude of color perception. The maximum value +3 was given to “Light”, “Soft”, “Warm”, “Transparent”, “Deep”, “Distinct”, “Heavy”, “Vivid”, “Strong”, “Dynamic”, “Gaudy” and “Striking”. Each step is 1 point so that opposite numerical response was –3 for “Dark”, “Hard”, “Cool”, “Turbid”, “Pale”,

Table 3-1 The opponent word pairs used for the visual assessments.

Symbol	The opponent word pairs in Thai	English Translation
LD	SAWANG (สว่าง) – MUED (มืด)	LIGHT – DARK
SH	NUM NUAL (นุ่มนวล) – KHAENG KRA DANG (แข็งกระด้าง)	SOFT – HARD
WC	RON (ร้อน) – YEN (เย็น)	WARM – COOL
TT	PRONG SAI (โปร่งใส) – TUEB (ทึบ)	TRANSPARENT – TURBID
DP	KHEM (เข้ม) – JANG (จาง)	DEEP – PALE
DV	CHAD JEN (ชัดเจน) – KA MUK KA MOORE (ขมุกขมัว)	DISTINCT – VAGUE
HL	NUCK (หนัก) – BOW (เบา)	HEAVY – LIGHT
VS	SOD SAI (สดใส) – MON (หม่น)	VIVID – SOMBRE
SW	KHEM KHAENG (เข้มแข็ง) – ON AIR (อ่อนแอ)	STRONG – WEAK
DYP	KLOEN WAI (เคลื่อนไหว) – SA NGOB NING (สงบนิ่ง)	DYNAMIC – PASSIVE
GP	CHOOD CHAD (ฉูดฉาด) – REAB (เรียบ)	GAUDY – PLAIN
SS	DOD DEN (โดดเด่น) – SEED (ซีด)	STRIKING – SUBDUED

“Vague”, “Light”, “Sombre”, “Weak”, “Passive”, “Plain” and “Subdued”, respectively. This process is called the seven-point method. (see Appendix C)

3.4.3.3 The observers were asked to choose the magnitude of color perception of the opponent word pairs when looking at the color samples under illuminant D65 in the light cabinet.

3.4.3.4 The visual scores were calculated from the answer of 60 observers as the percentage values ranging from +100% to -100% for each of the opponent word pairs. (see Appendix B) For example, the calculation of “Vivid-Sombre” percentage (VS%) is as following:

$$VS\% = \frac{a \times (-3) + b \times (-2) + c \times (-1) + d \times (0) + e \times (1) + f \times (2) + g \times (3)}{3 \times (a + b + c + d + e + f + g + h)} \times 100 \quad (3.1)$$

where; a, b, c, d, e, f, and g are the number of observers who choose –3, -2, -1, 0, 1, 2 and 3 respectively.

If all observers select “very Vivid” (+3), VS% becomes equal to +100%. If all observers select “very Sombre” (-3), VS% becomes equal to -100%. If one half of the observers select “very Vivid” and the other half select “very Sombre”, the percentage will be zero.

Similarly, the opponent word pairs of “Light-Dark”, “Warm-Cool”, ”Soft-Hard”, “Transparent-Turbid”, “Deep-Pale”, “Distinct-Vague”, “Heavy-Light”, “Strong-Weak”, “Dynamic-Passive”, “Gaudy-Plain” and “Striking-Subdued” can be calculated.

3.4.4 Establishment of empirical color perception equations

The relationship between the results obtained from the visual assessments and the colorimetric values were used to set empirical color perception equation. From the results of the color perception values (CP) were derived as a general equation base on CIE L*, C*, h as following

$$CP = [\{k_1(L^*-L^*_0)\}^2+\{k_2(C^*-C^*_0\}^2]^{1/2} + k_3 \quad (3.2)$$

where, CP : color perception value

L* : CIE L*, C*, h metric lightness

L^*_0 : CIE L*, C*, h metric lightness when visual assessment has the minimum value

C* : CIE L*, C*, h metric chroma

C^*_0 : CIE L*, C*, h metric chroma when visual assessment has the minimum value

K_1 : Contribution of CIE L*, C*, h L* for color perception

K_2 : Contribution of CIE L*, C*, h C* for color perception

K_3 : Color perception value when visual assessment has the minimum value

CP is large when L* and C* are far away from the L^*_0 and C^*_0 coordinates. L* and C* make a smaller contribution to the CP value when k_1 and k_2 are small and L* and C* make a greater contribution to the CP value when k_1 and k_2 are large.

3.4.5 Plot color perception lines of the color on CIE L*, C* and CIE a*, b* diagram

The color perception values were calculated from the color perception equation of each the opponent word pairs as indicated by the color perception lines in the CIE L*, C*, h color system.

3.4.6 Projection of CIE L*, C*, h color system on the color perception map

The colorimetric value of L*, C* and h were projected on a perceptual diagram. It represents relationships between two opponent word pairs.

3.4.7 Comparison visual results between two-point and seven-point techniques.

The visual assessment results obtained from two-point technique and seven-point technique were compared by paired t-test to indicate the similarity or difference and by correlation.

3.4.8 Comparing the data obtained from Japanese and Thai data

Thai and Japanese data comparison is made, by which the relationship model will be established.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Visual Assessment

The visual results of the twelve opponent word pairs were established. They are “Light-Dark”, “Warm-Cool”, ”Soft-Hard”, “Transparent-Turbid”, “Deep-Pale”, “Distinct-Vague”, “Heavy-Light”, “Vivid-Sombre”, “Strong-Weak”, “Dynamic-Passive”, “Gaudy-Plain” and “Striking-Subdued”. The figures represent the relationship between the derived results of the visual assessments and the colorimetric values in terms of L*, C* and h, respectively, as shown in Figure 4-1 to Figure 4-36. They are described as follows:

(a) The visual results of “Light-Dark” are shown in Figure 4-1 to Figure 4-3. The observers assess colors at high lightness and high chroma as “Light” and low lightness as “Dark”. The distribution and visual assessments of hue angles were randomly scattered. The visual scores obtained in ranged from –95% to 92%.

(b) The visual results of “Soft-Hard” are shown in Figure 4-4 to Figure 4-6. The observers assess colors at high lightness as “Soft” and low lightness as “Hard”. The distribution and visual assessments of chromas and hue angles were randomly scattered. The visual scores obtained in ranged from –72% to 72%.

(c) The visual results of “Warm-Cool” are shown in Figure 4-7 to Figure 4-9. The observers assess colors at high chroma as “Warm” and low chroma as “Cool”. The distributions of visual assessments on lightness were randomly scattered but on hue angle 0 to 120 were distributed much more than those in during from 120 to 310 hue angle. The observers assess colors as “Cool,” thus “Warm-Cool” has a strong influence on hue. The visual scores obtained in ranged from –61% to 84%.

(d) The visual results of “Transparent-Turbid” are shown in Figure 4-10 to Figure 4-12. The observers assess colors at high lightness and high chroma as “Transparent” and low lightness as “Turbid.” The distribution and visual assessments of hue angles were randomly scattered. The visual scores obtained in ranged from –92% to 76%.

(e) The visual results of “Deep-Pale” are shown in Figure 4-13 to Figure 4-15. The observers assess colors at high lightness as “Pale”, low lightness and high chroma as “Deep”. The distribution and visual assessments of hue angles were randomly scattered. The visual scores obtained in ranged from –86% to 97%.

(f) The visual results of “Distinct-Vague” are shown in Figure 4-16 to Figure 4-18. The observers assess colors at high chroma as “Distinct” and low chroma as “Vague”. The distribution and visual assessments of lightness and hue angles were randomly scattered. The visual scores obtained in ranged from –52% to 88%.

(g) The visual results of “Heavy-Light” are shown in Figure 4-19 to Figure 4-21. The observers assess colors at high lightness as “Light” and low lightness as “Heavy”. The distribution and visual assessments of lightness and hue angles were randomly scattered. The visual scores obtained in ranged from –88% to 96%.

(h) The visual results of “Vivid-Sombre” are shown in Figure 4-22 to Figure 4-24. The observers assess colors at high chroma as “Vivid” and low chroma as “Sombre”. The distribution and visual assessments of lightness and hue angles were randomly scattered. The visual scores obtained in ranged from –75% to 95%.

(i) The visual results of “Strong-Weak” are shown in Figure 4-25 to Figure 4-27. The observers assess high lightness and chroma as “Weak” and low lightness as “Strong”. The distribution and visual assessments of hue angles were randomly scattered. The visual scores obtained in ranged from –63% to 92%.

(j) The visual results of “Dynamic-Passive” are shown in Figure 4-28 to Figure 4-30. The observers assess colors at high chroma as “Dynamic” and low chroma as “Passive”. The distribution and visual assessments of lightness and hue angles were randomly scattered. The visual scores obtained in ranged from –82% to 77%.

(k) The visual results of “Gaudy-Plain” are shown in Figure 4-31 to Figure 4-33. The observers assess colors at high chroma as “Gaudy” and low chroma as “Plain”. The distribution and visual assessments of lightness and hue angles were randomly scattered. The visual scores obtained in ranged from –82% to 91%.

(l) The visual results of “Striking-Subdued” are shown in Figure 4-34 to Figure 4-36. The observers assess colors at low chroma as “Subdued”, low lightness and high chroma as “Striking”. The distribution and visual assessments of hue angles were randomly scattered. The visual scores obtained in ranged from –64% to 91%.

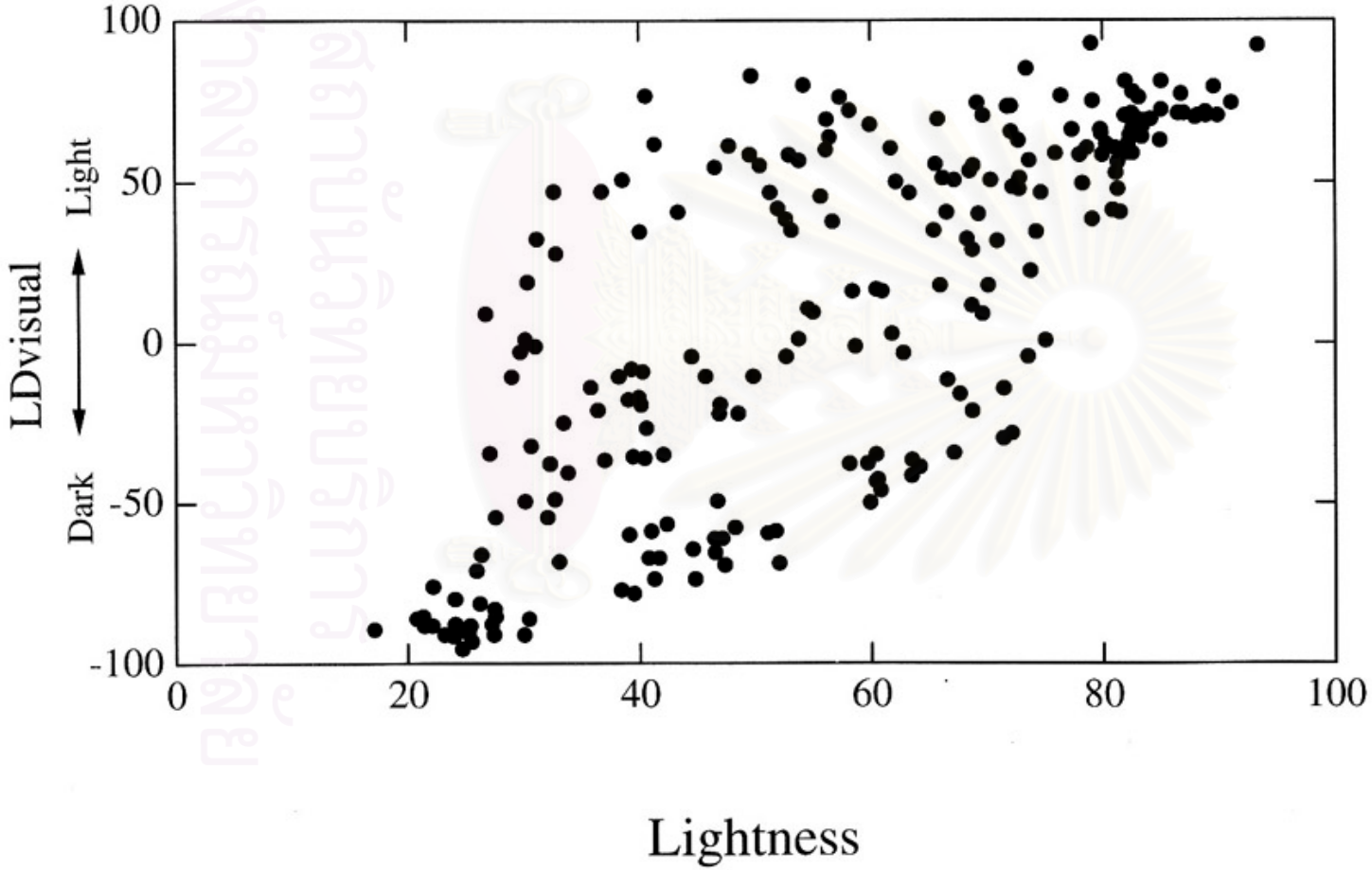

Figure 4-1 Visual results of "Light-Dark" on Lightness

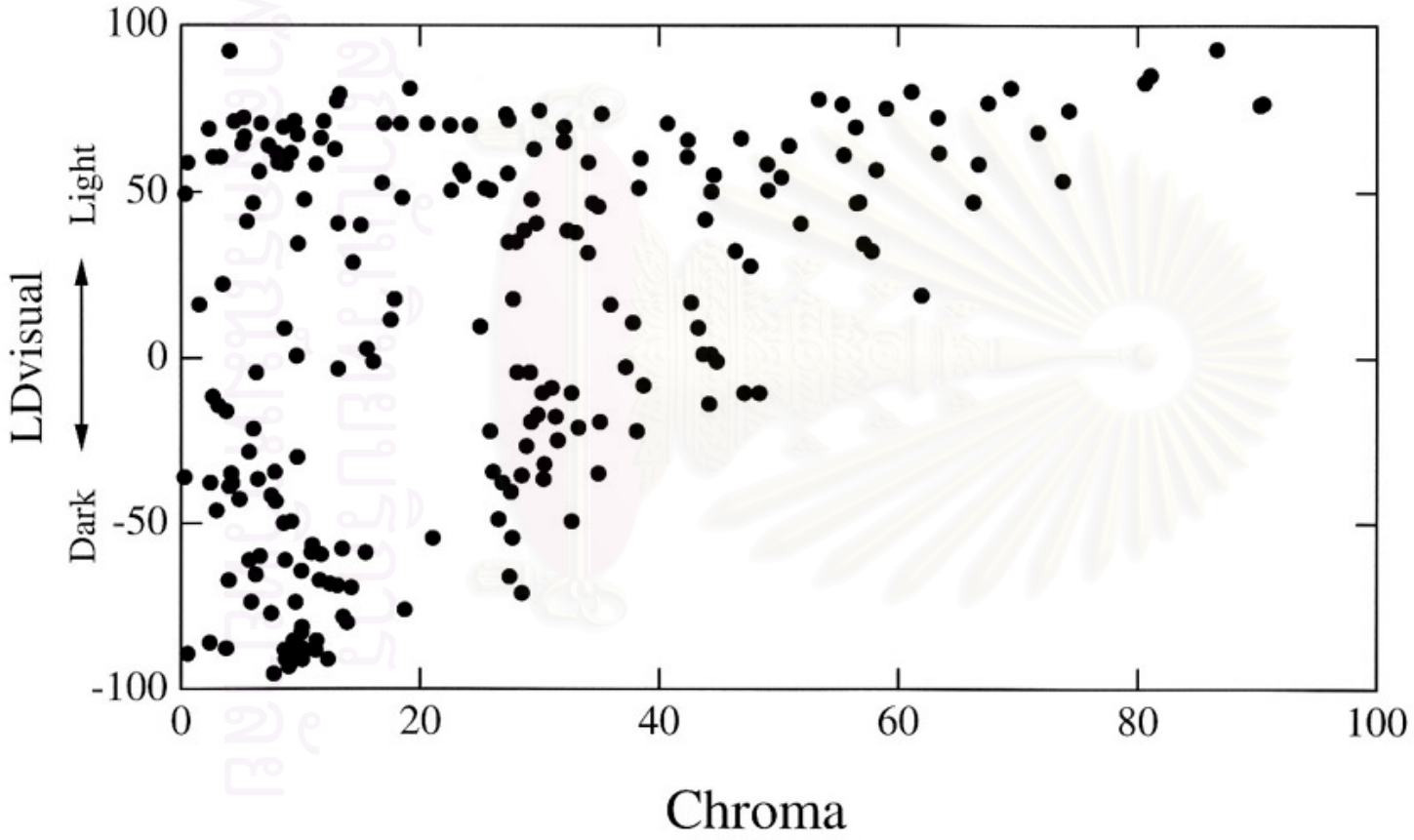

Figure 4-2 Visual results of "Light-Dark" on Chroma

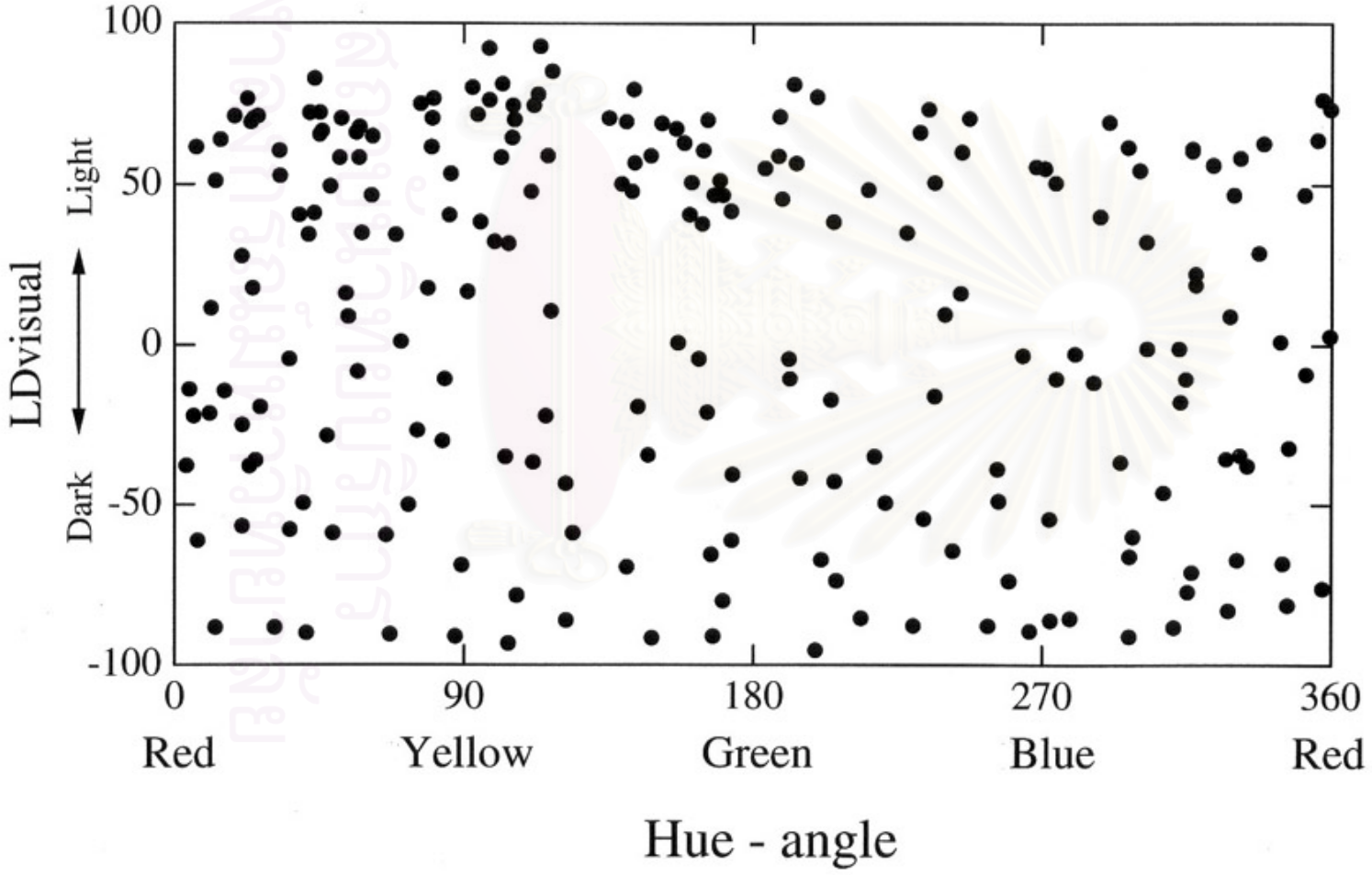

Figure 4-3 Visual results of "Light-Dark" on Hue-angle

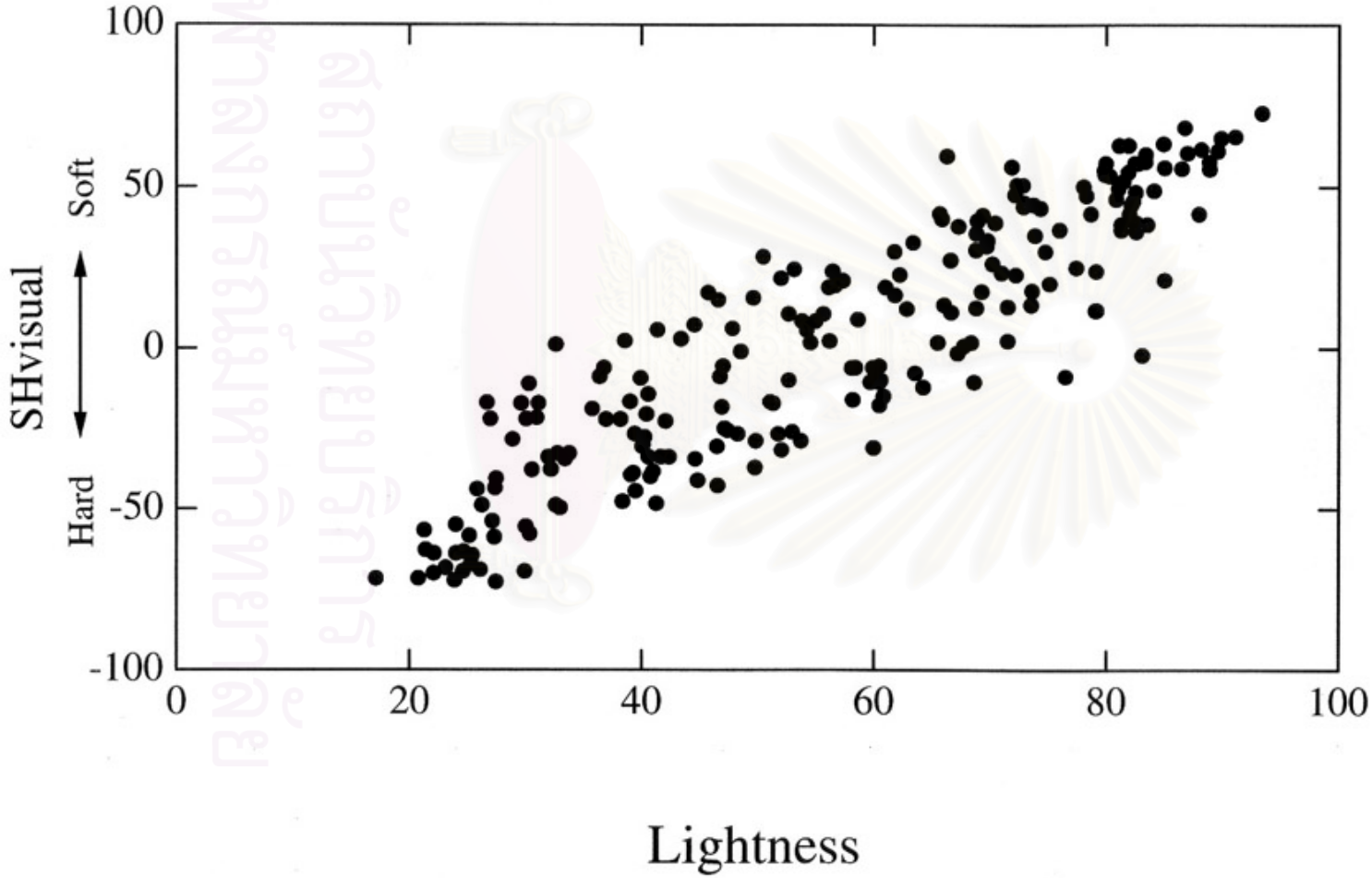

Figure 4-4 Visual results of "Soft-Hard" on Lightness

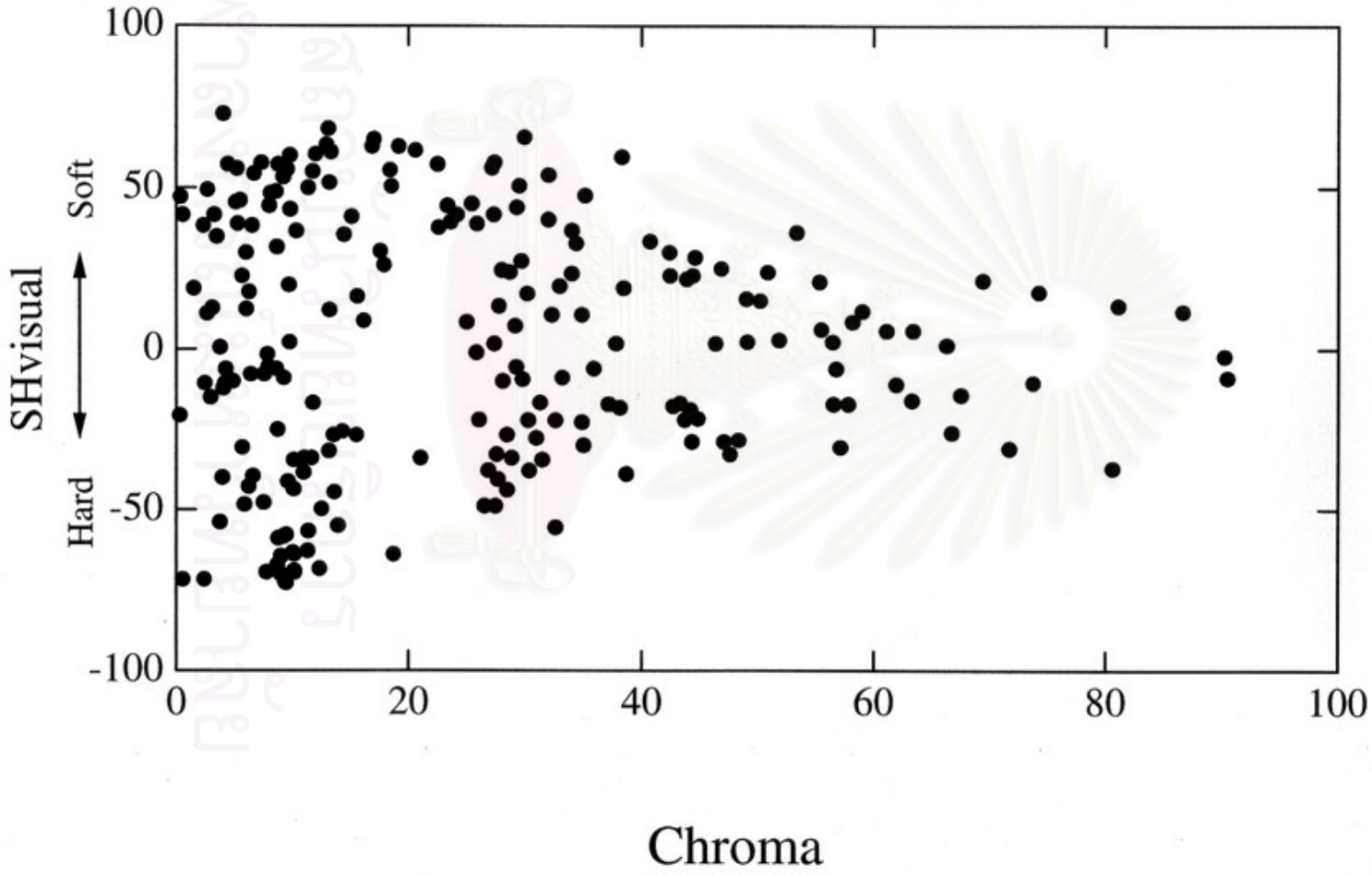

Figure 4-5 Visual results of "Soft-Hard" on Chroma

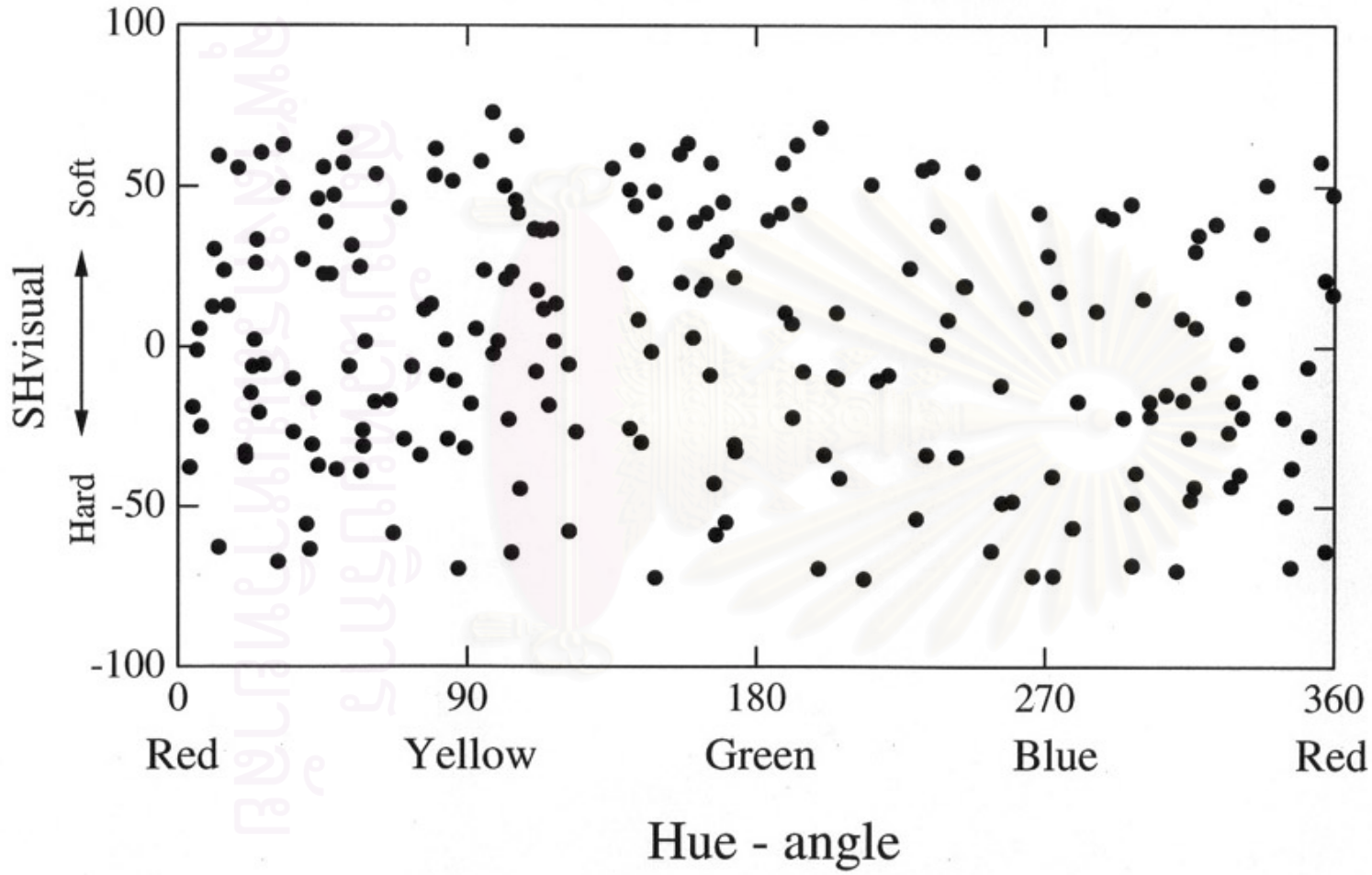

Figure 4-6 Visual results of "Soft-Hard" on Hue-angle

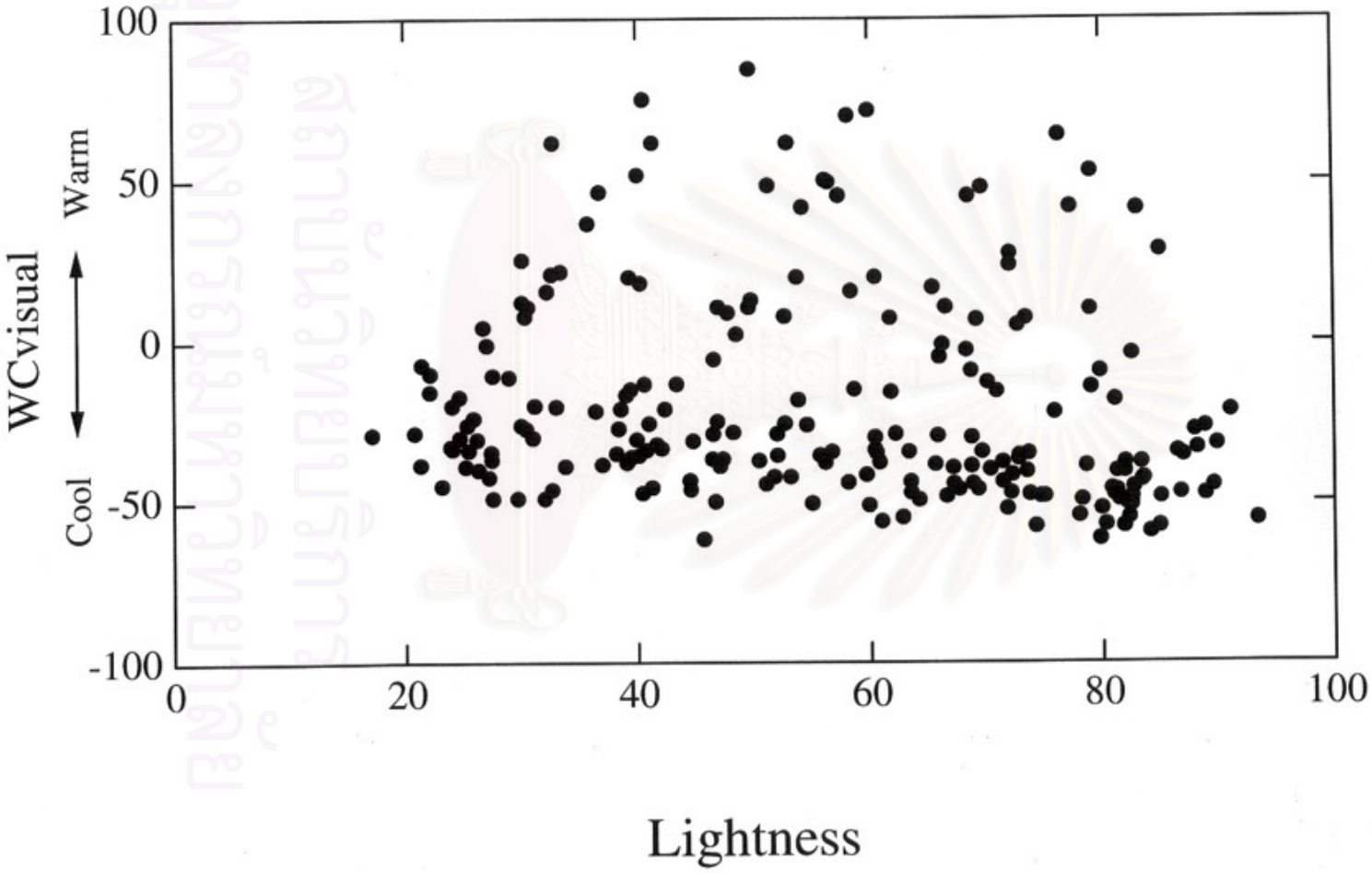

Figure 4-7 Visual results of "Warm-Cool" on Lightness

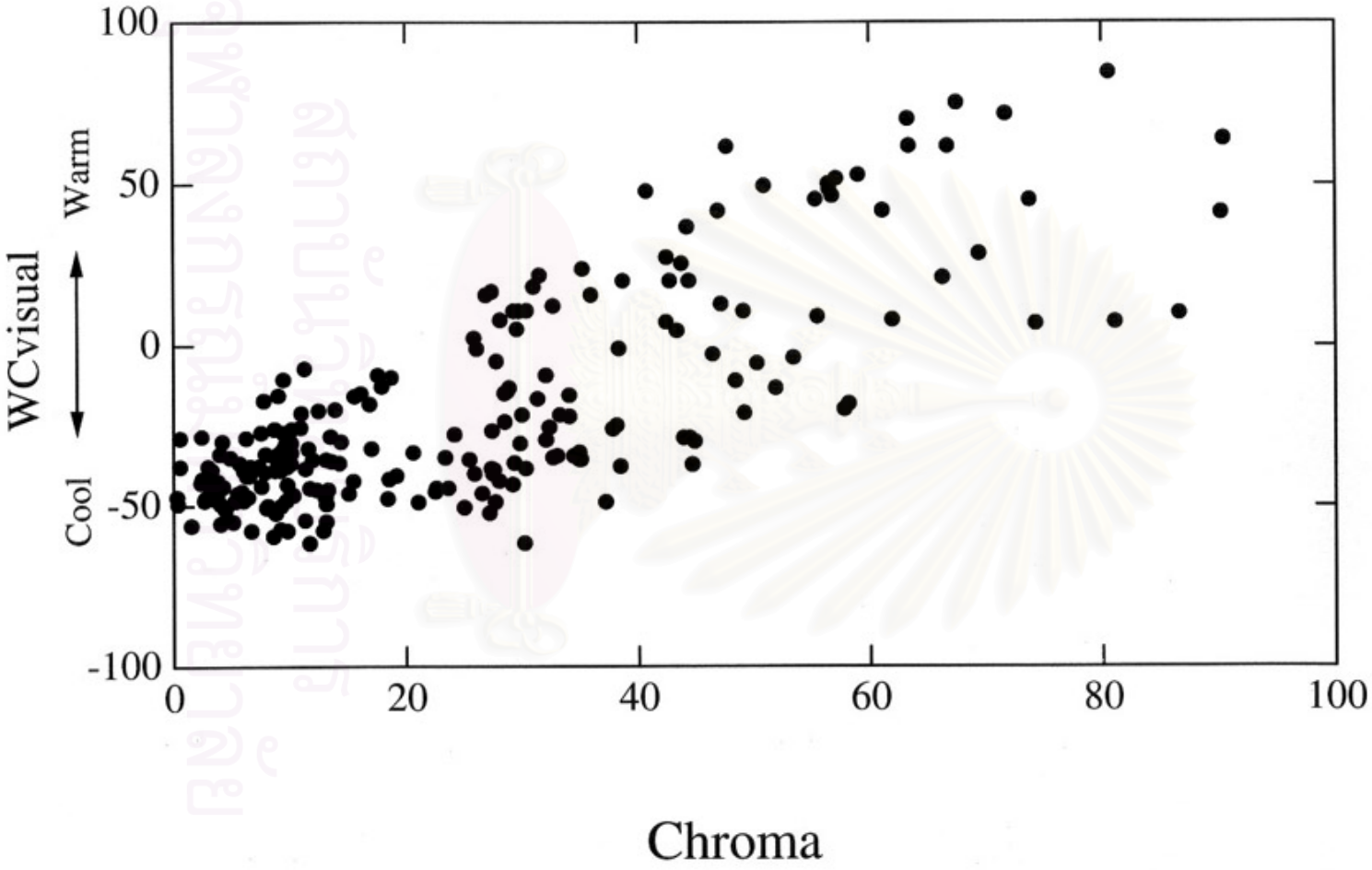

Figure 4-8 Visual results of "Warm-Cool" on Chroma

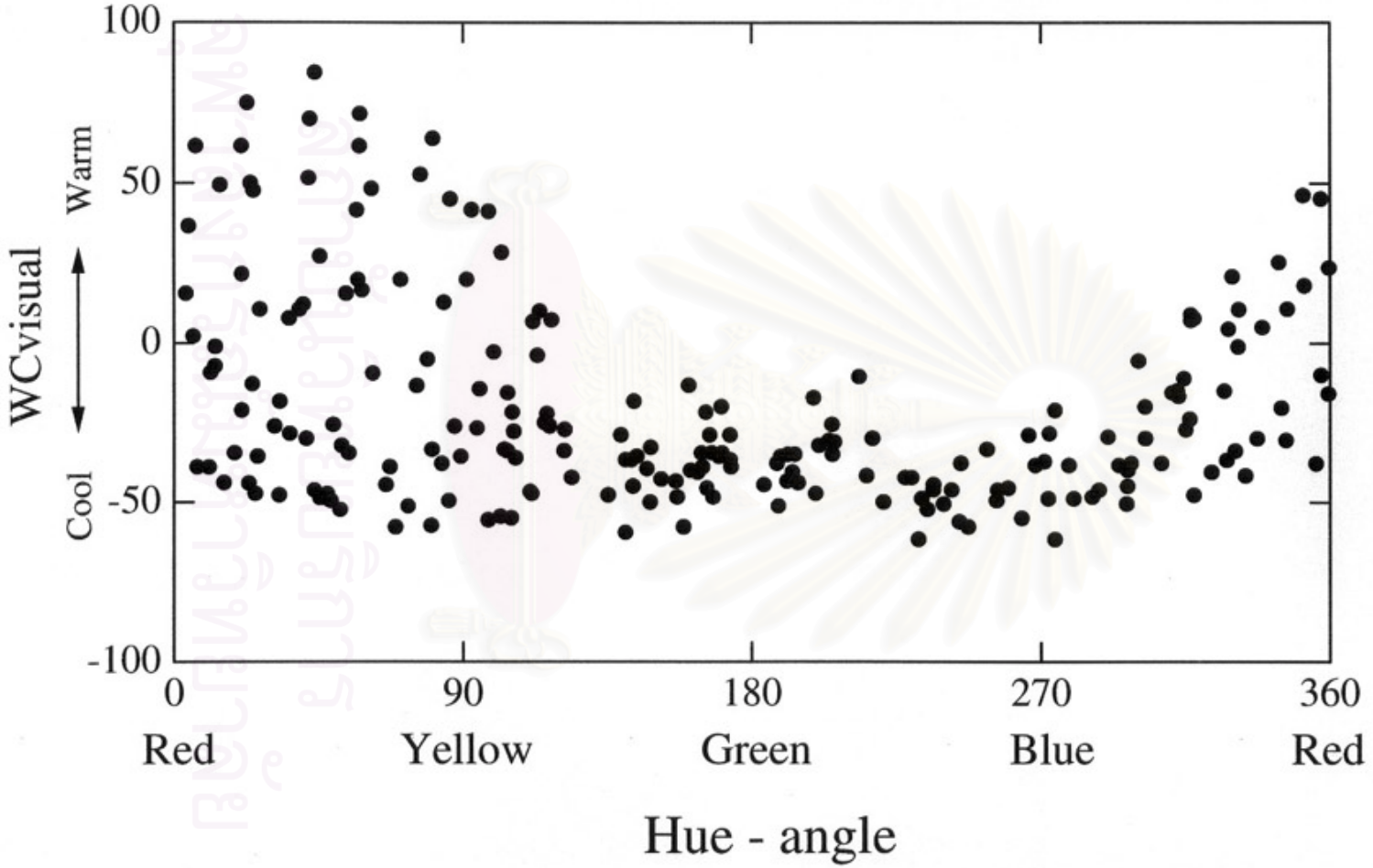

Figure 4-9 Visual results of "Warm-Cool" on Hue-angle

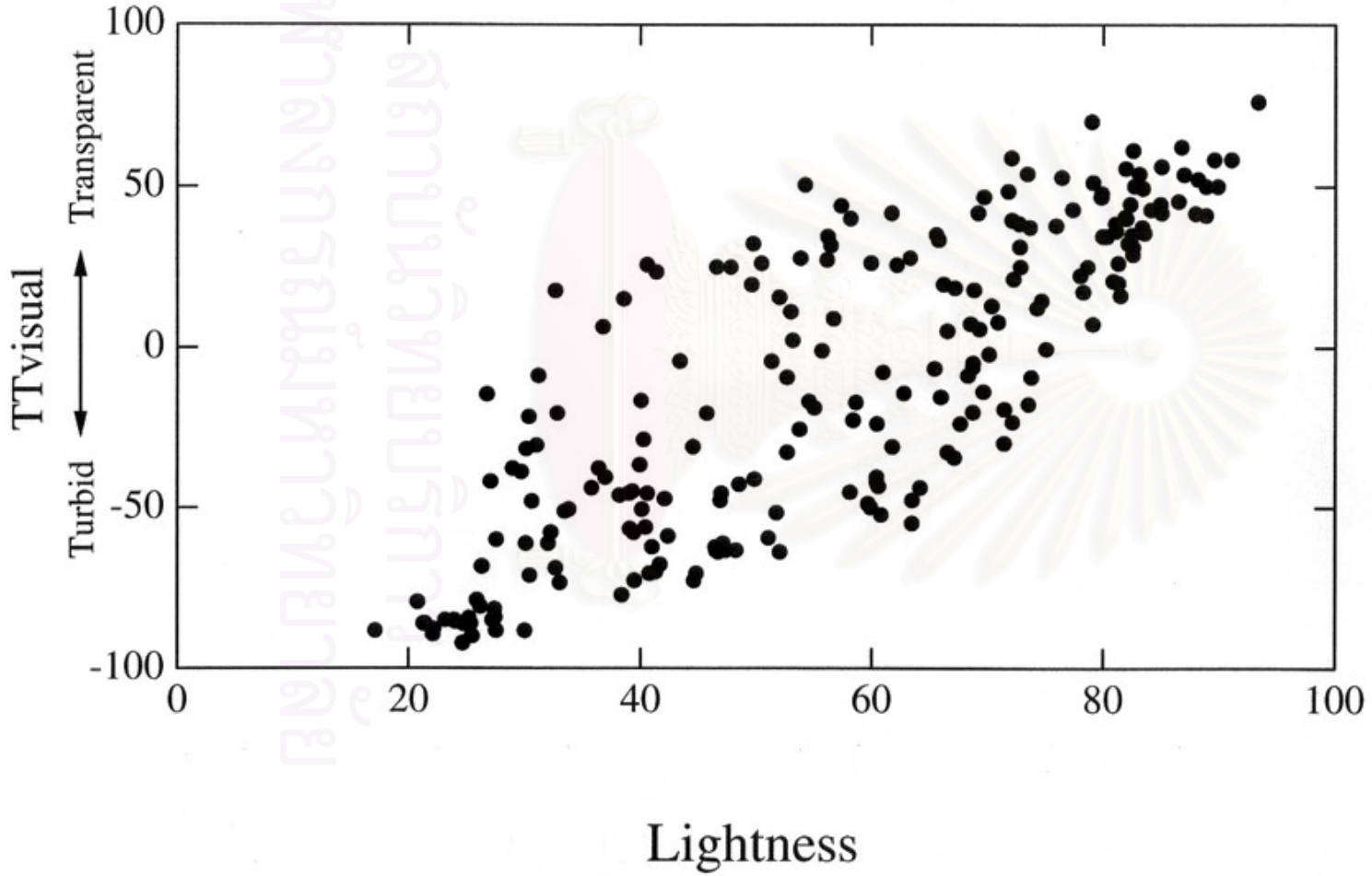

Figure 4-10 Visual results of "Transparent-Turbid" on Lightness

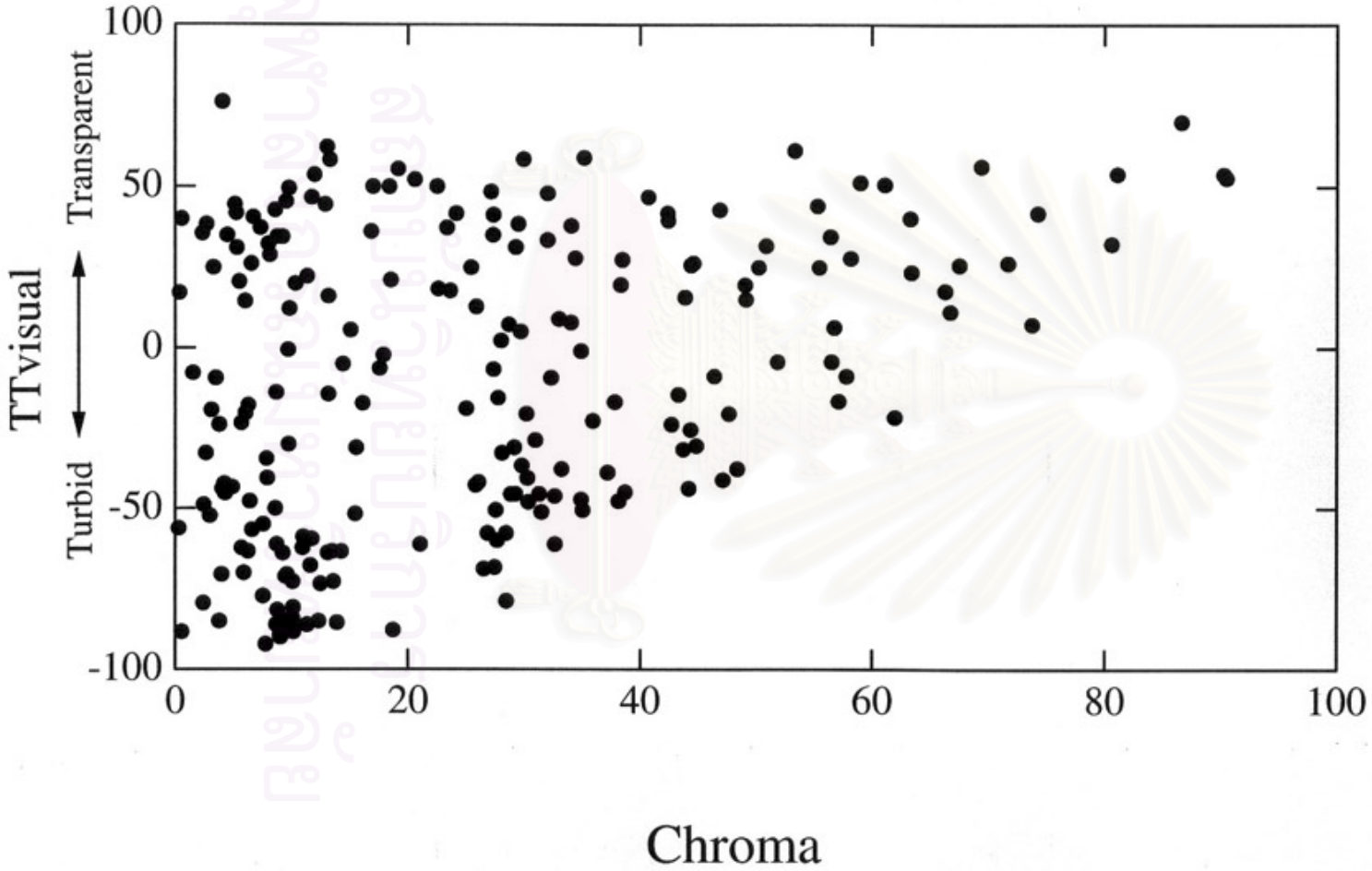

Figure 4-11 Visual results of "Transparent-Turbid" on Chroma

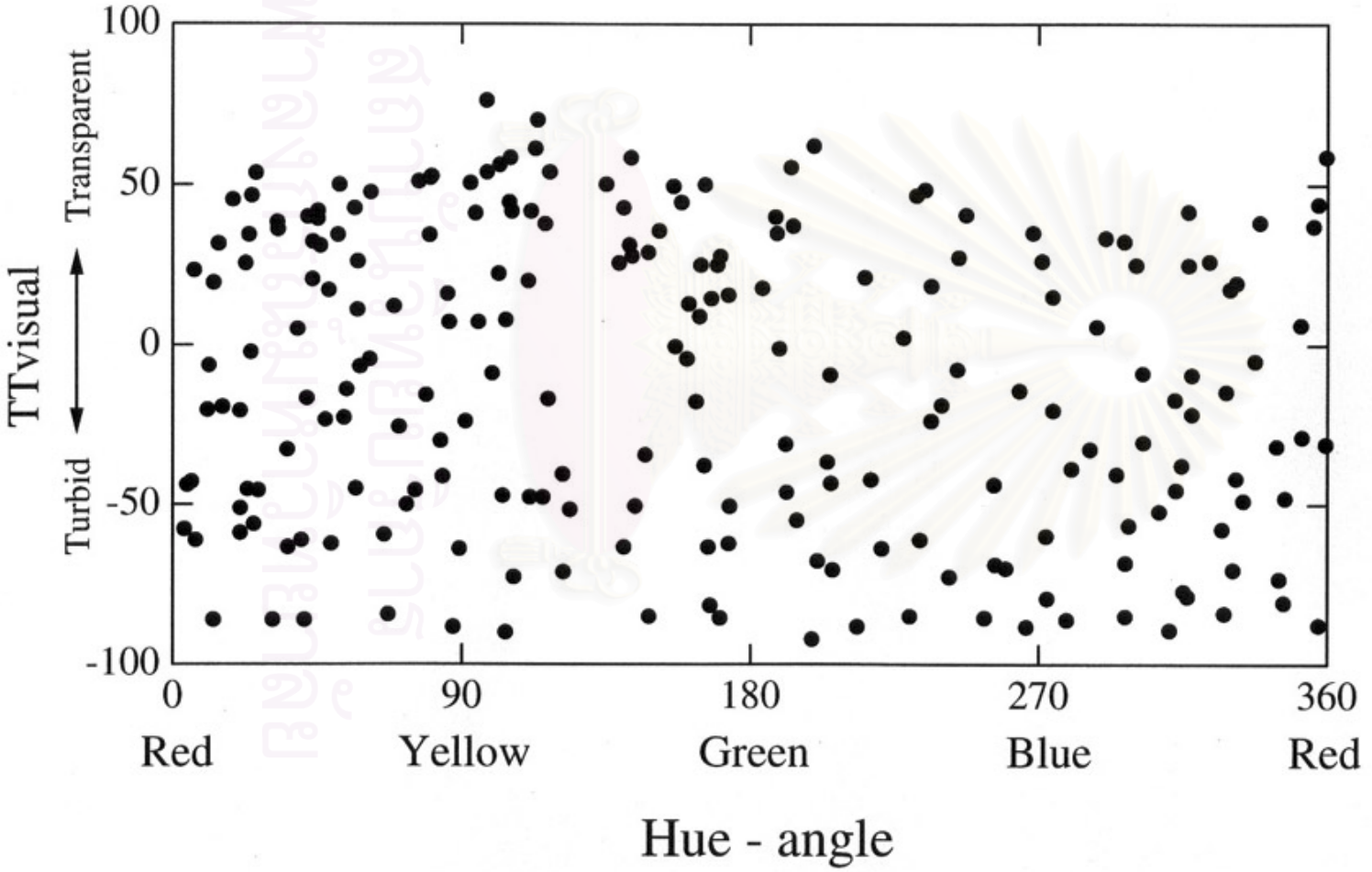

Figure 4-12 Visual results of "Transparent-Turbid" on Hue-angle

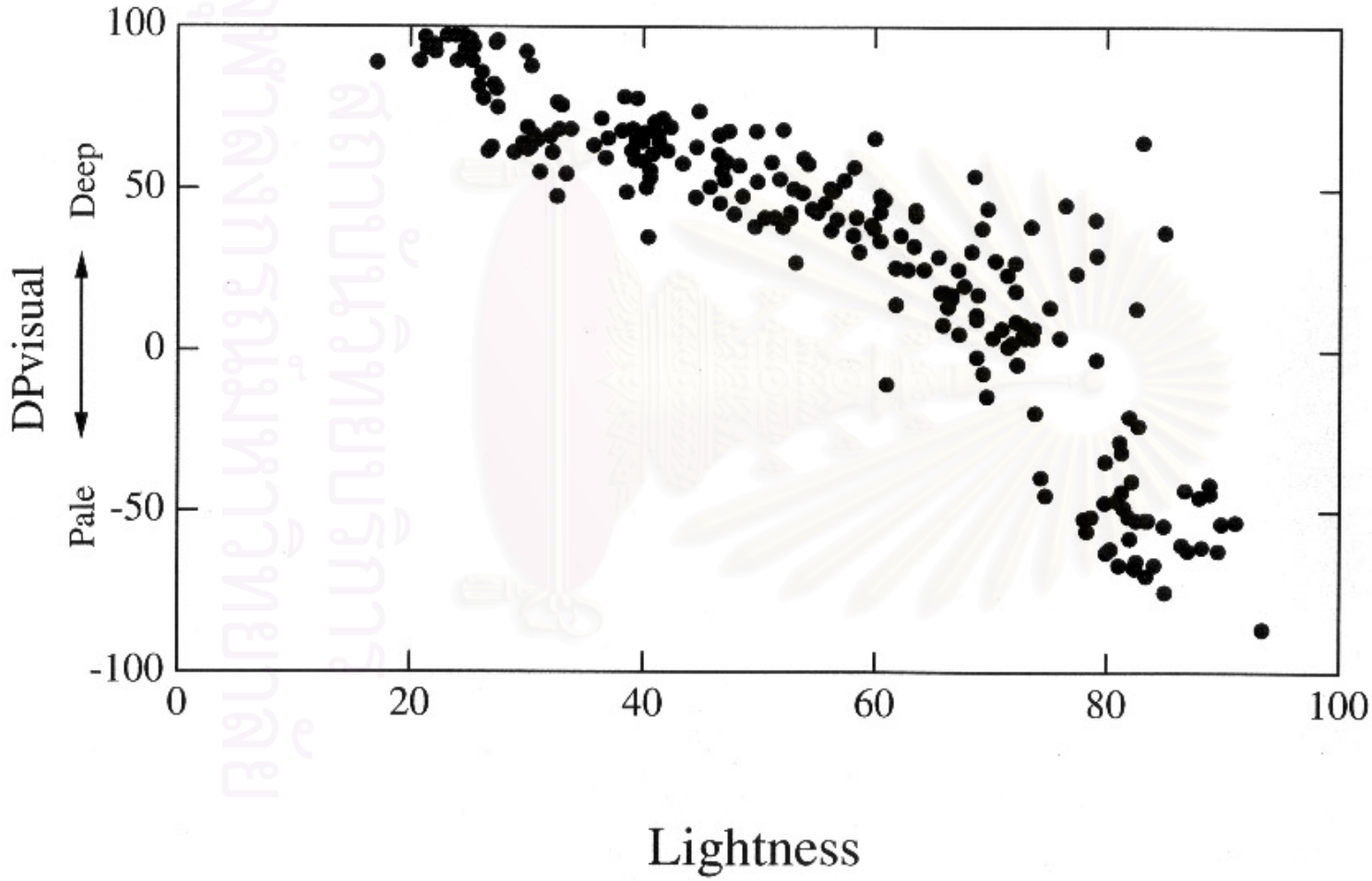

Figure 4-13 Visual results of "Deep-Pale" on Lightness

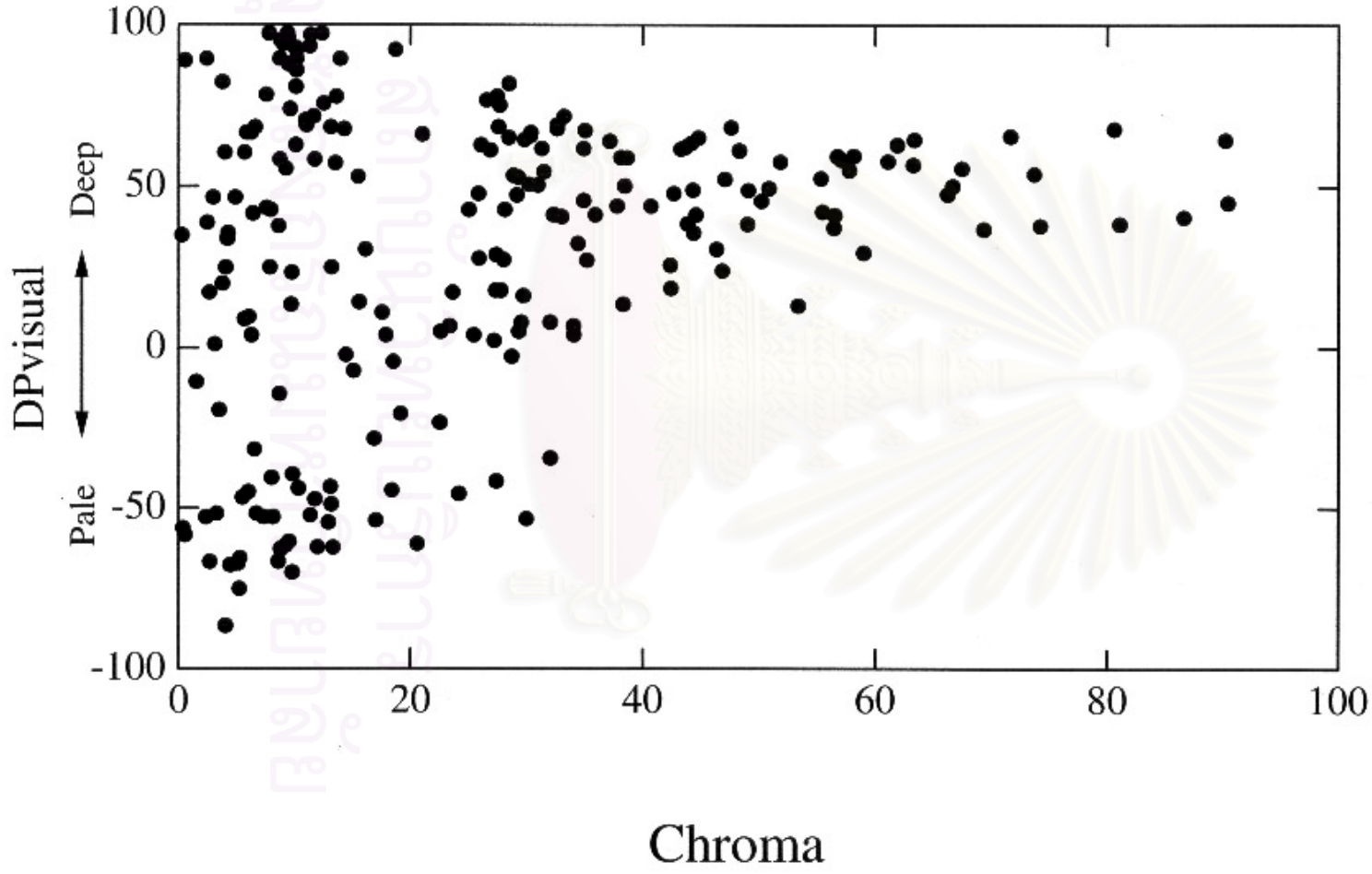

Figure 4-14 Visual results of "Deep-Pale" on Chroma

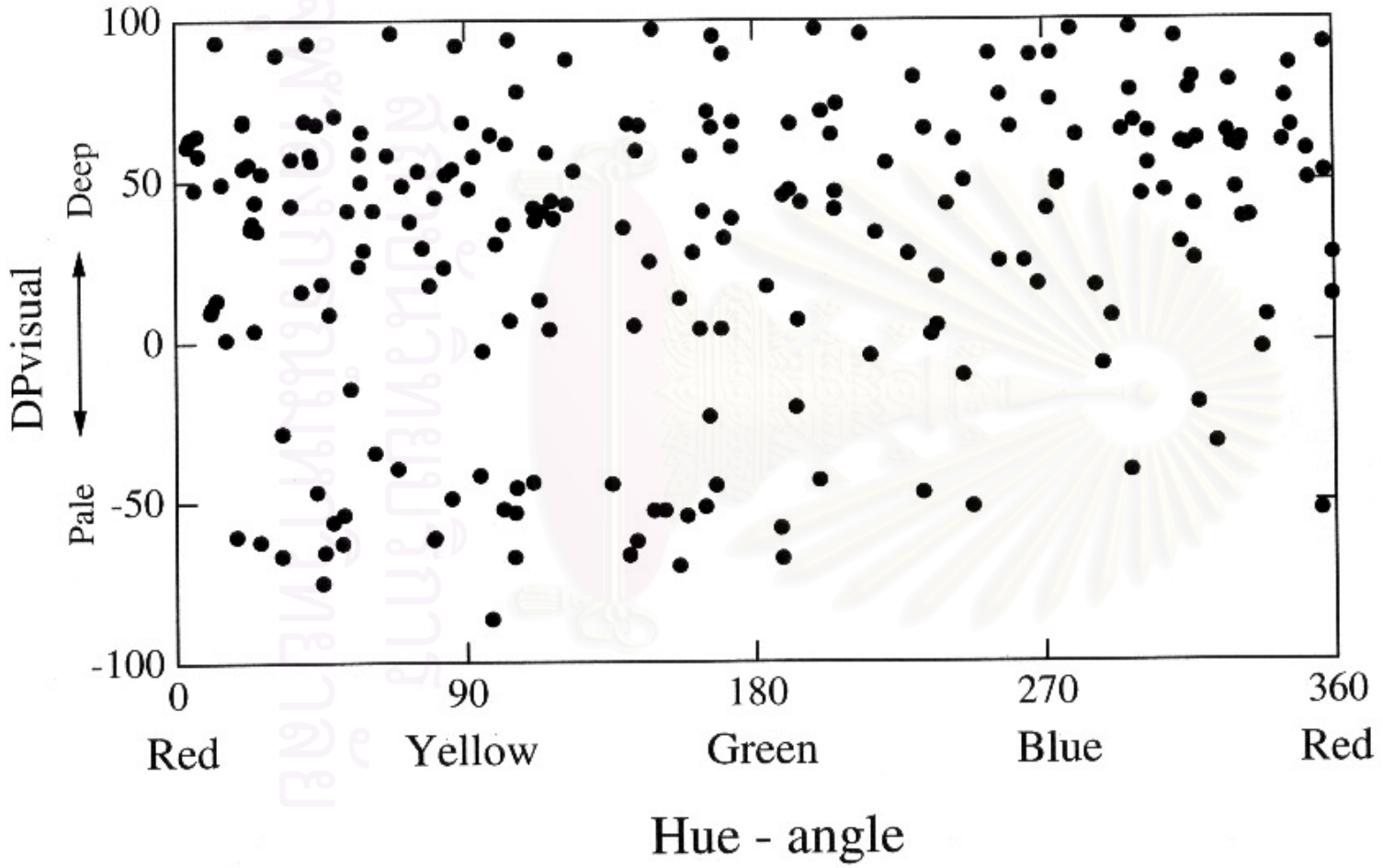

Figure 4-15 Visual results of "Deep-Pale" on Hue-angle

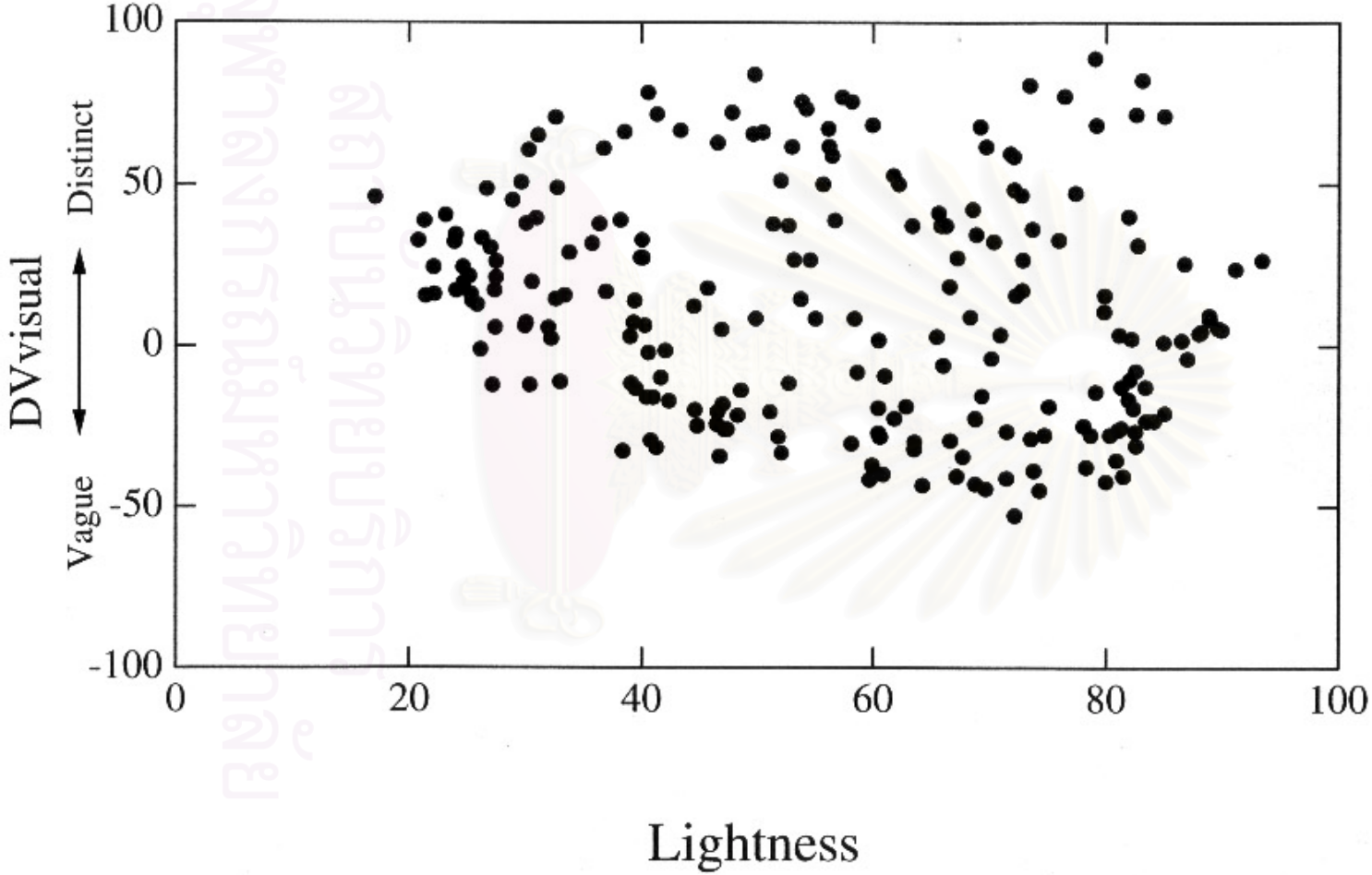

Figure 4-16 Visual results of "Distinct-Vague" on Lightness

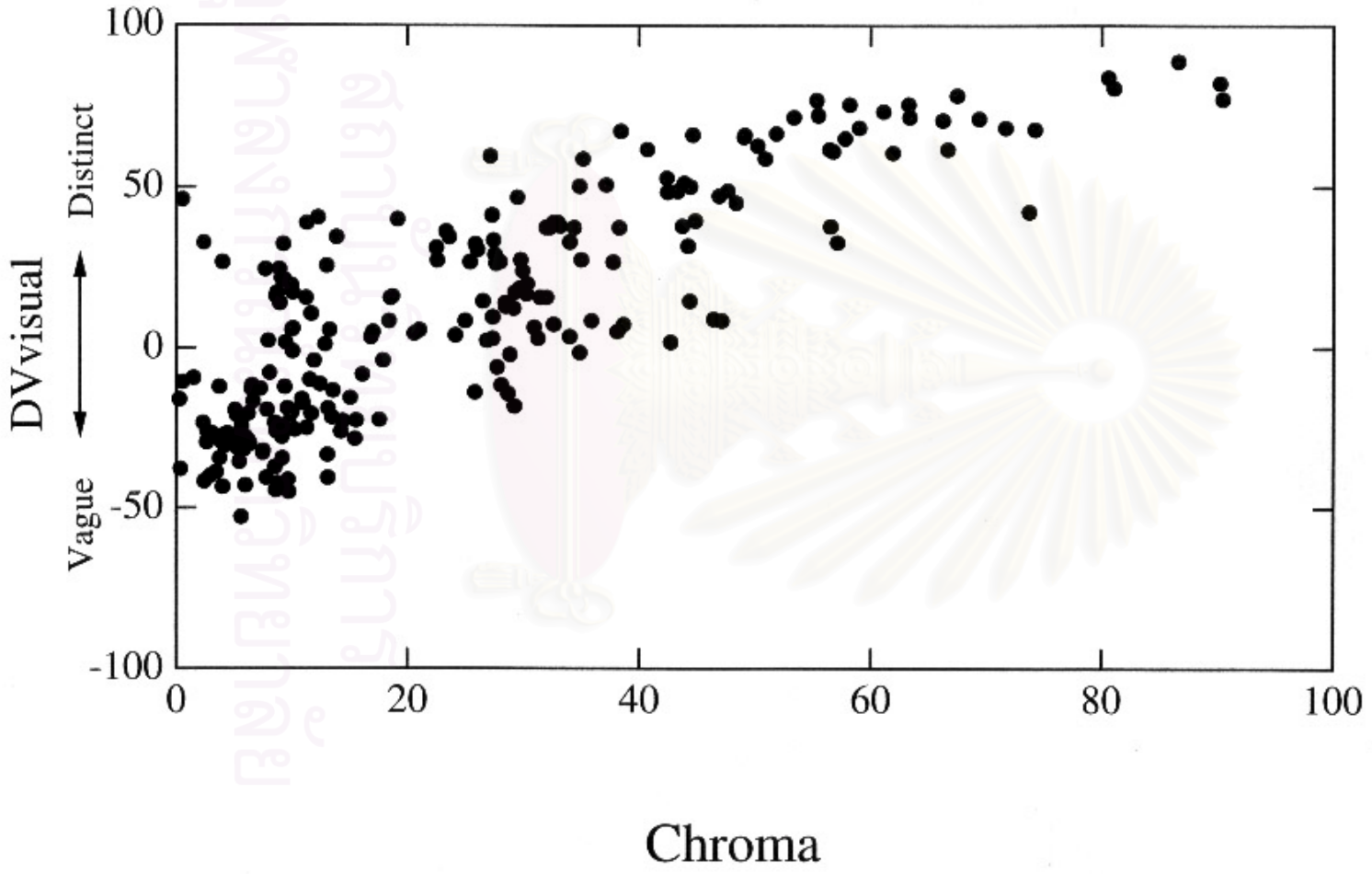

Figure 4-17 Visual results of "Distinct-Vague" on Chroma

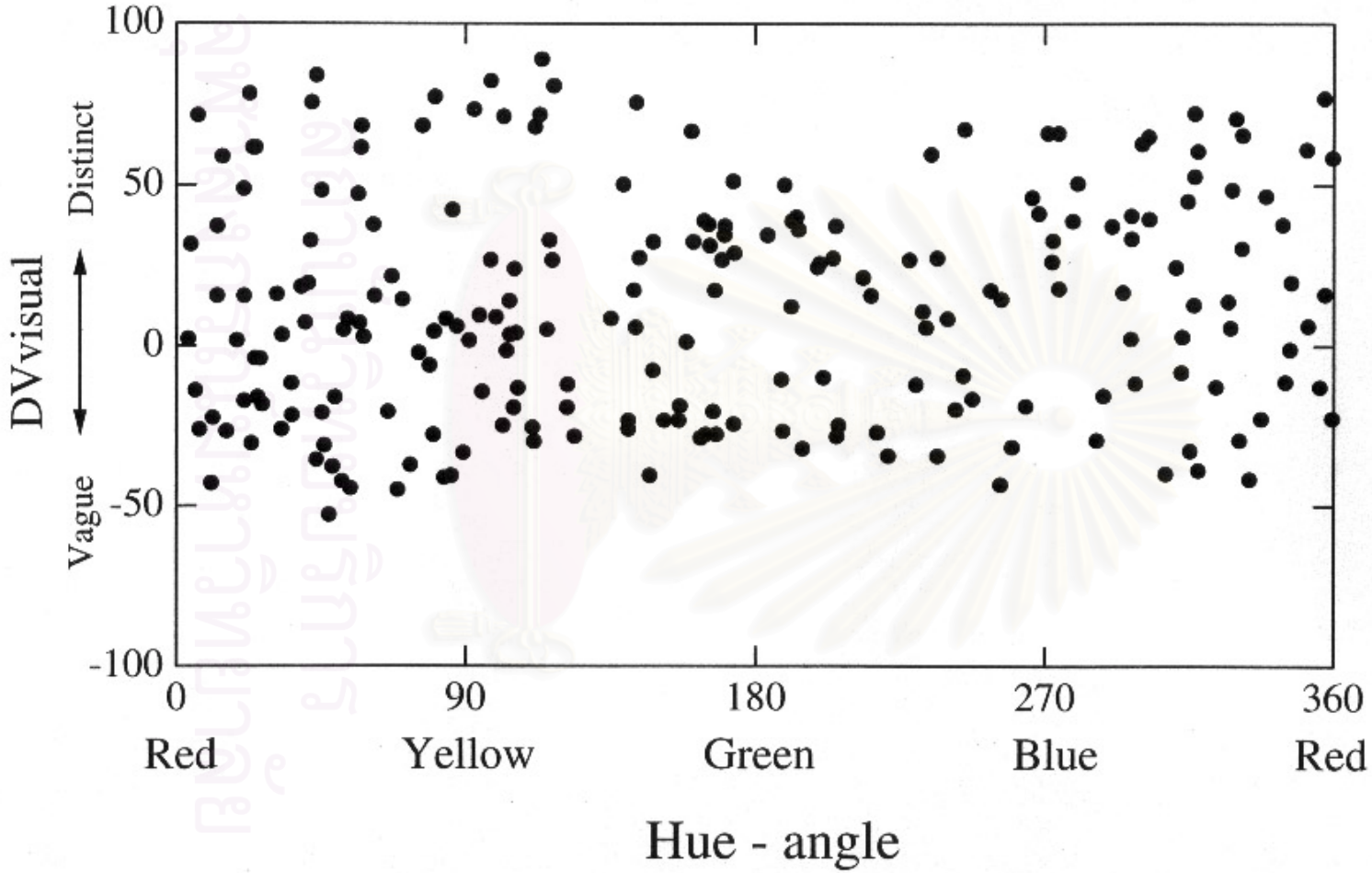

Figure 4-18 Visual results of "Distinct-Vague" on Hue-angle

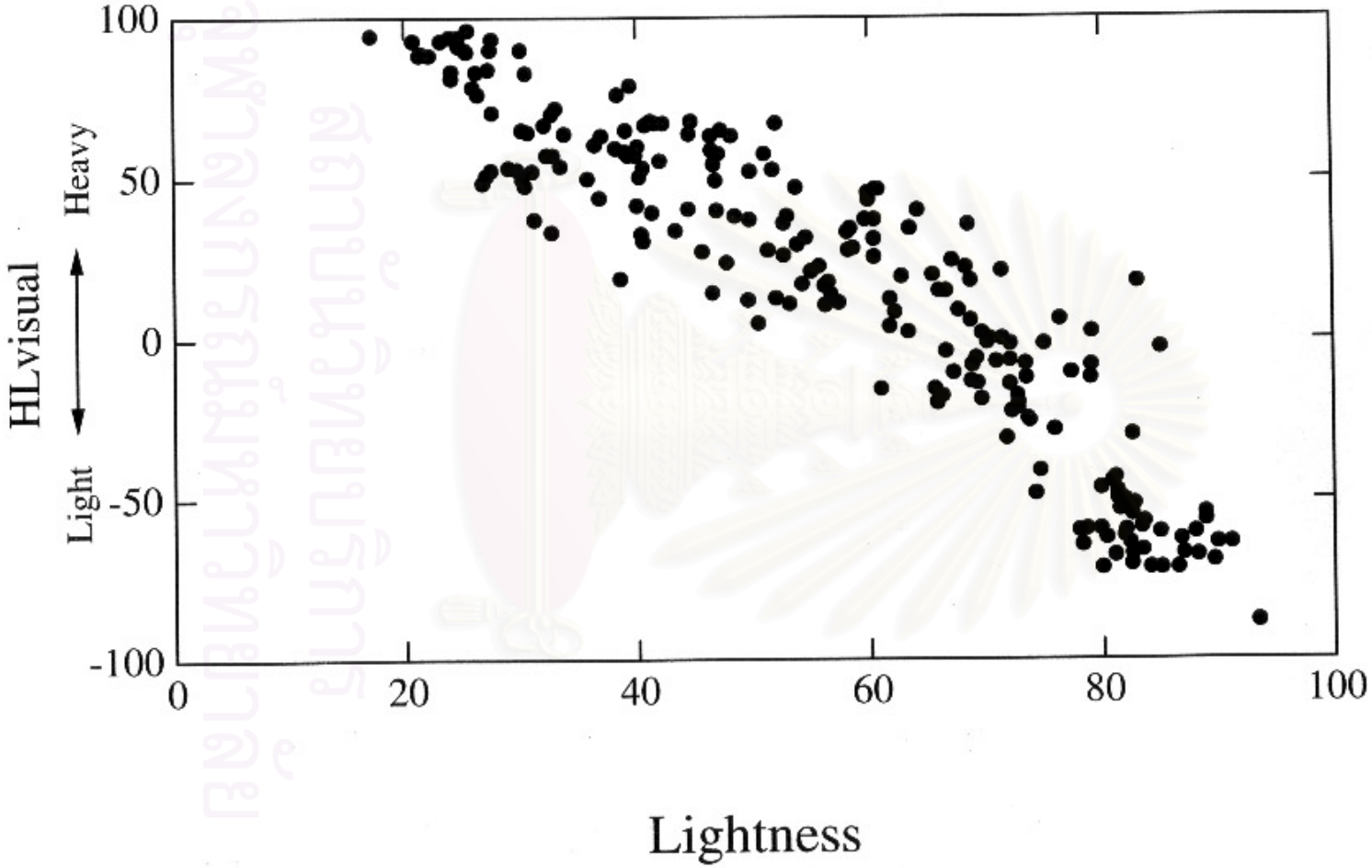

Figure 4-19 Visual results of "Heavy-Light" on Lightness

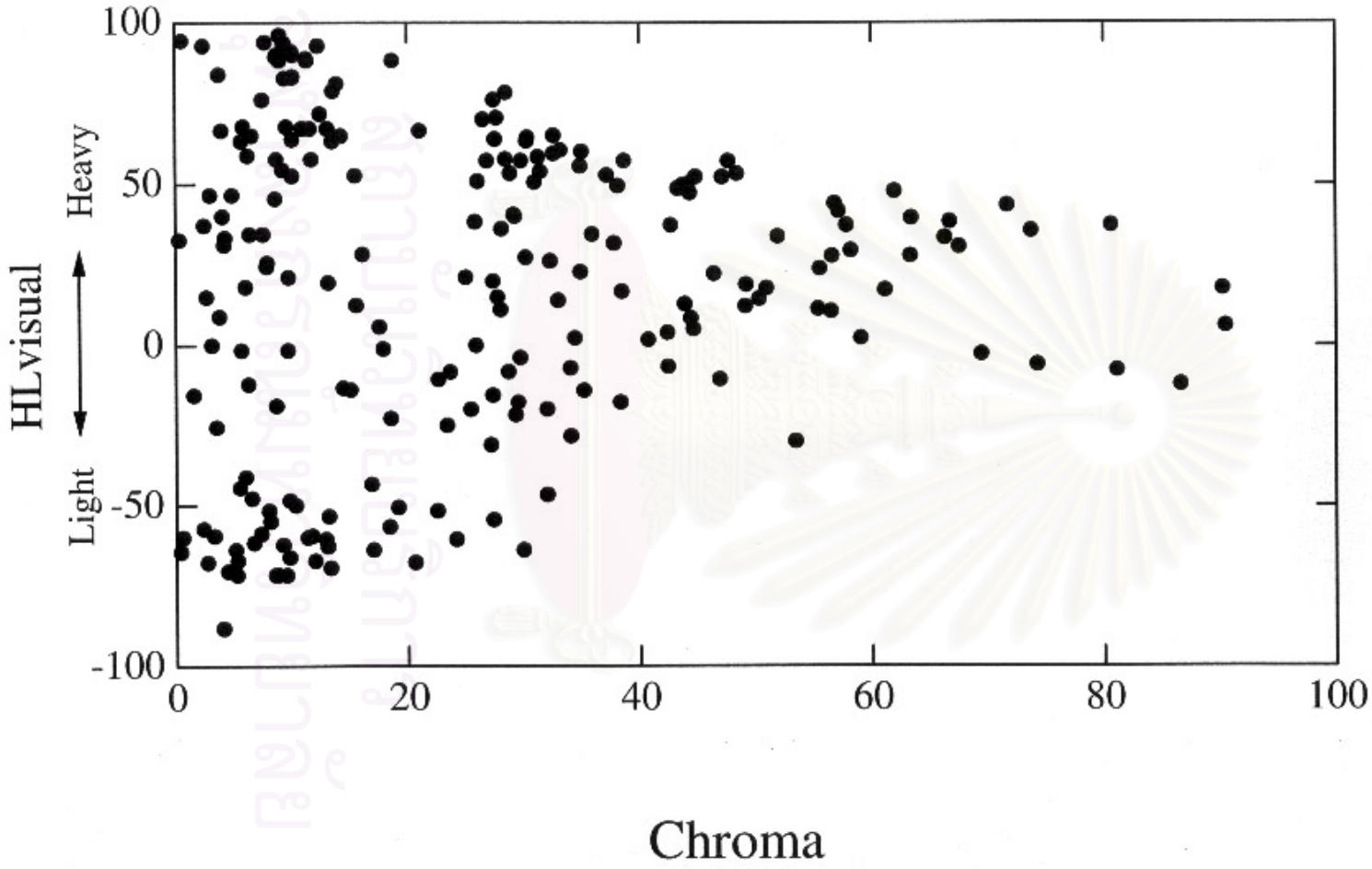

Figure 4-20 Visual results of "Heavy-Light" on Chroma

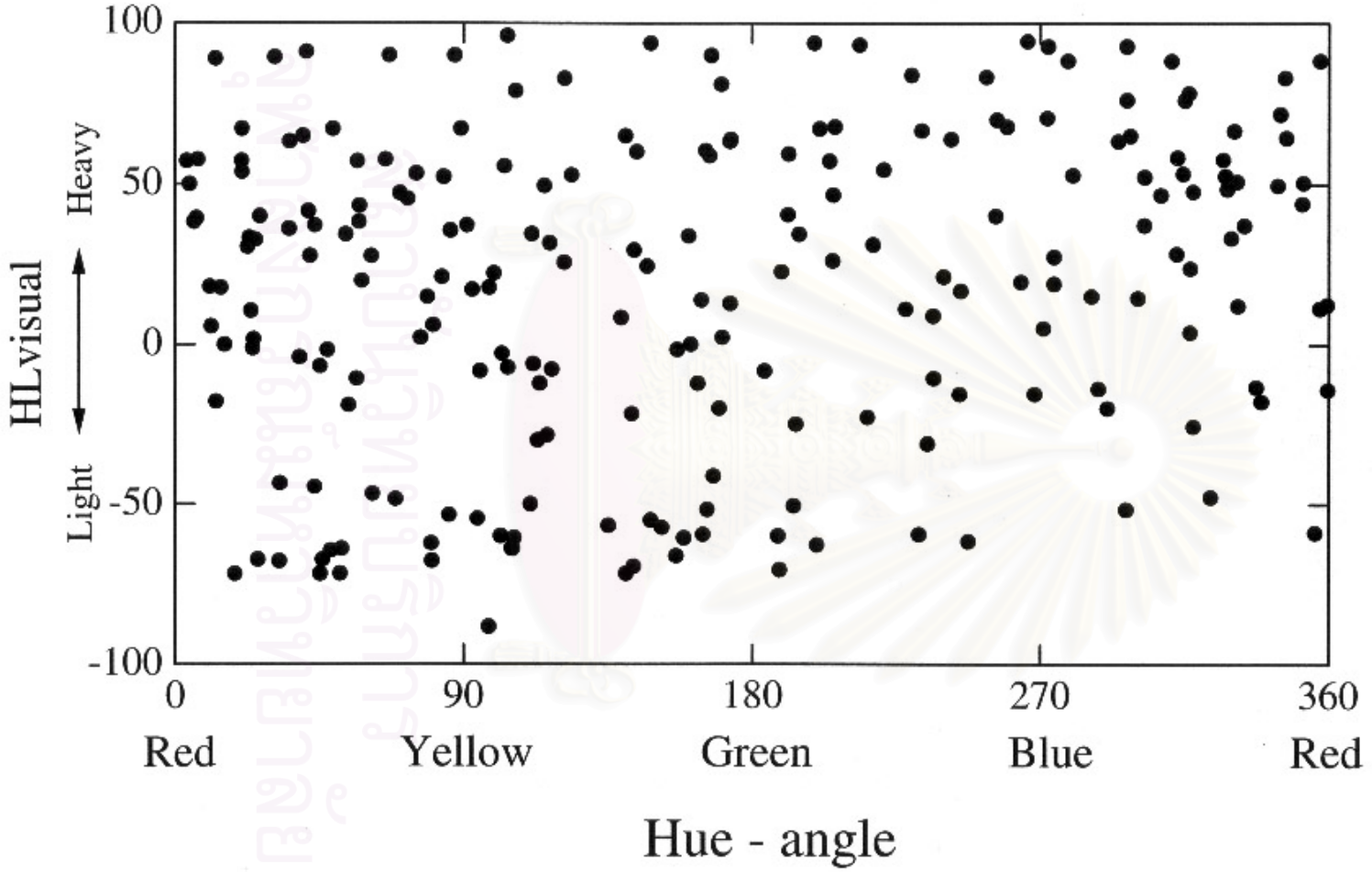

Figure 4-21 Visual results of "Heavy-Light" on Hue-angle

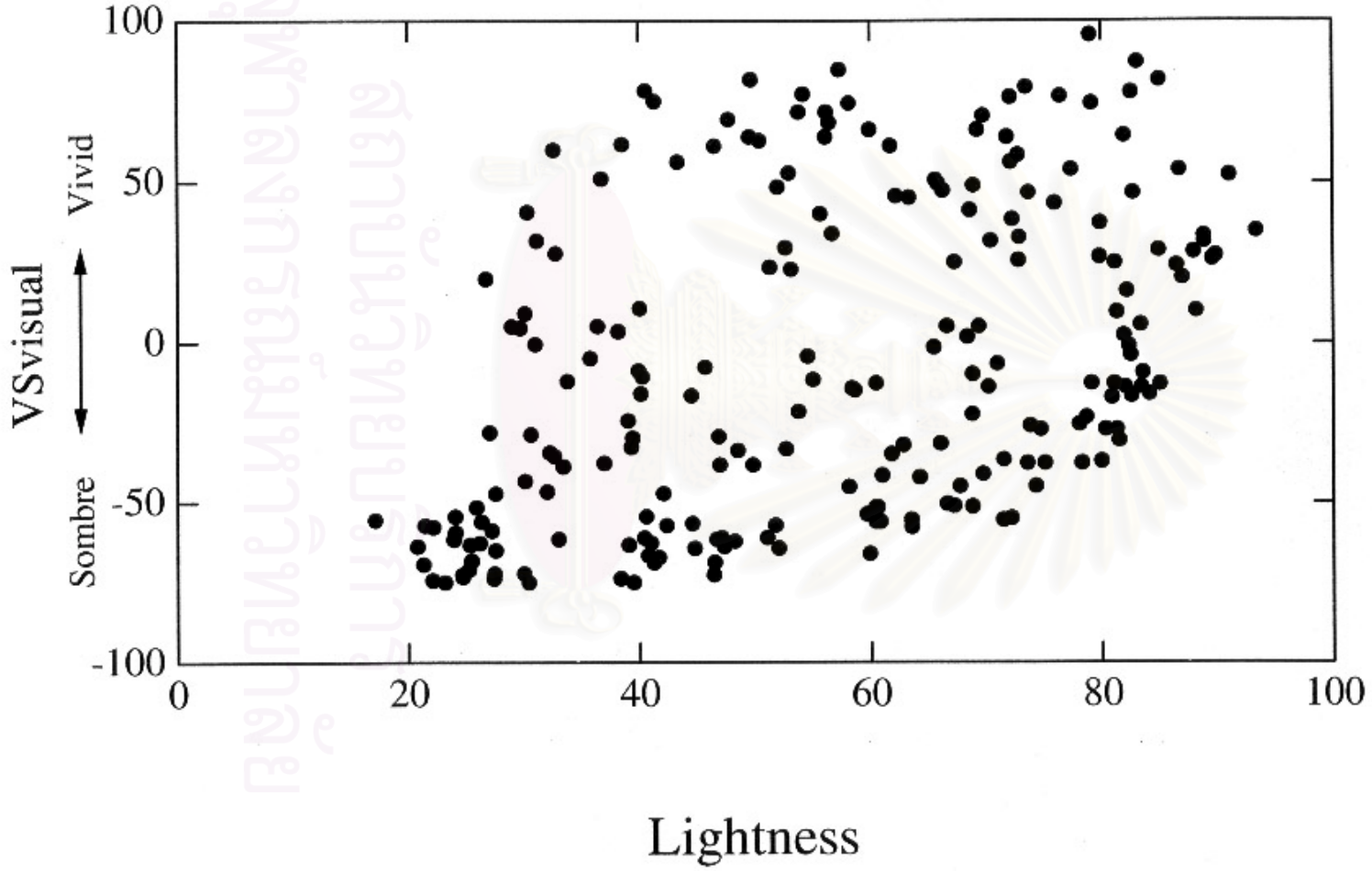

Figure 4-22 Visual results of "Vivid-Sombre" on Lightness

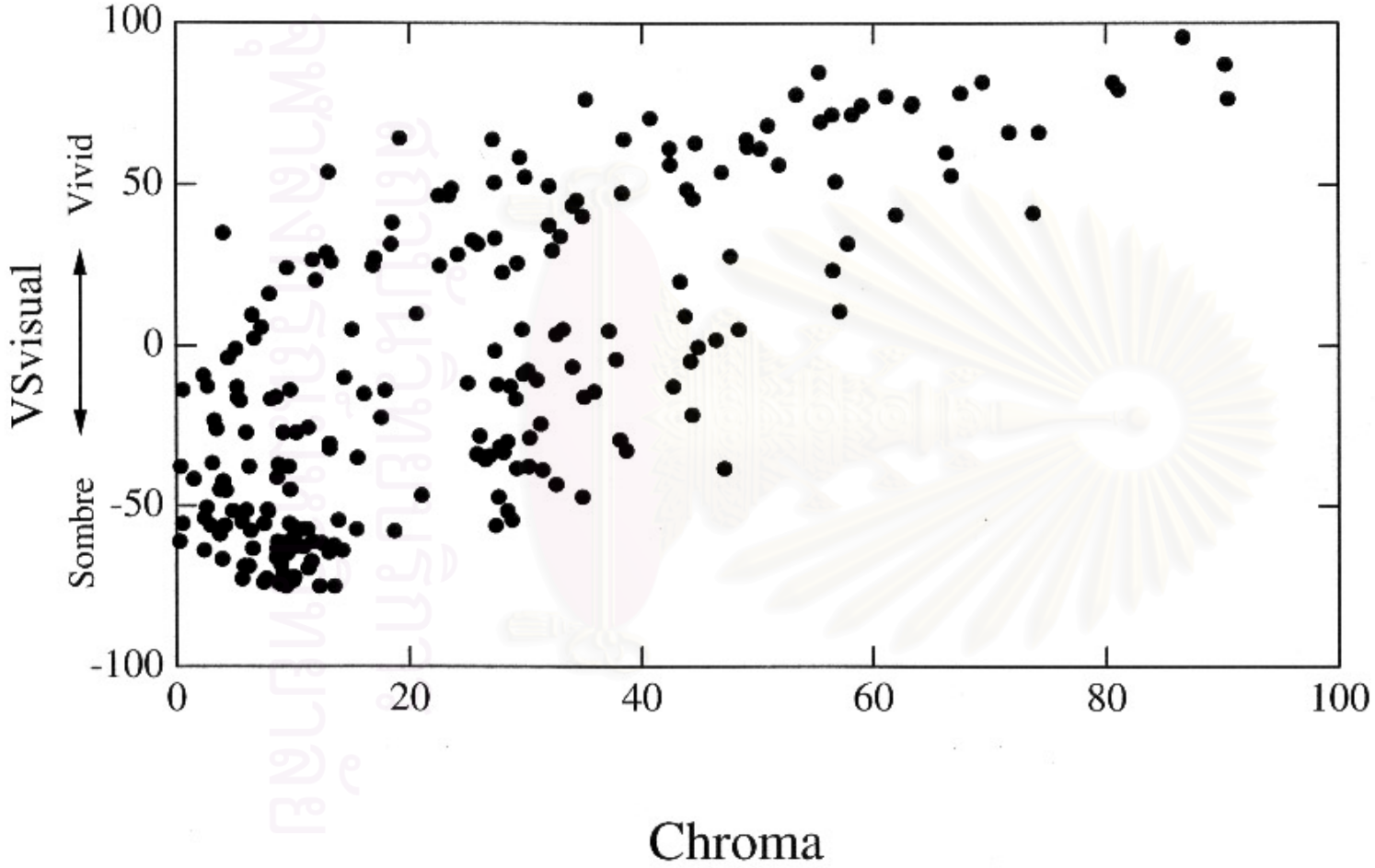

Figure 4-23 Visual results of "Vivid-Sombre" on Chroma

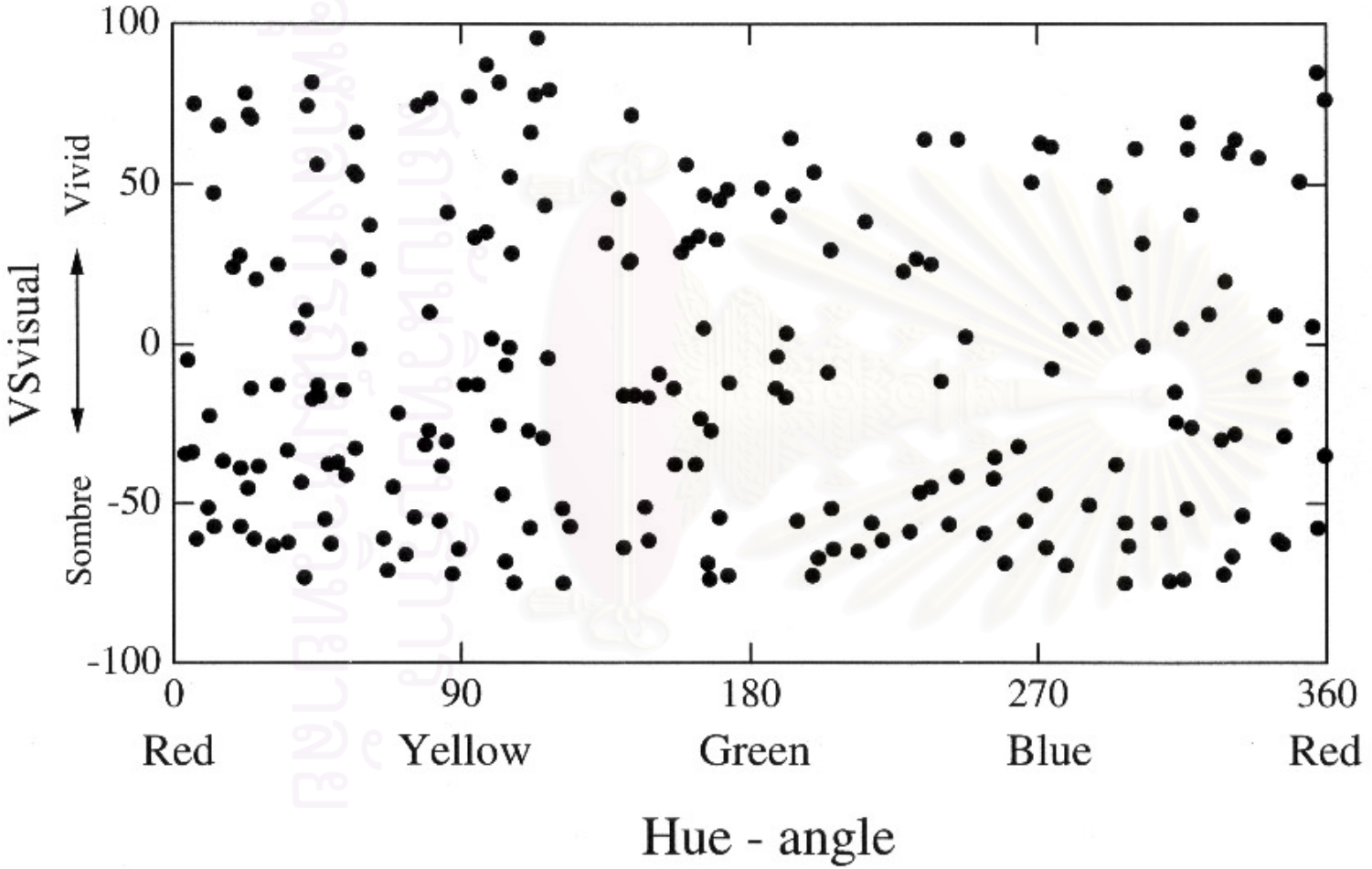

Figure 4-24 Visual results of "Vivid-Sombre" on Hue-angle

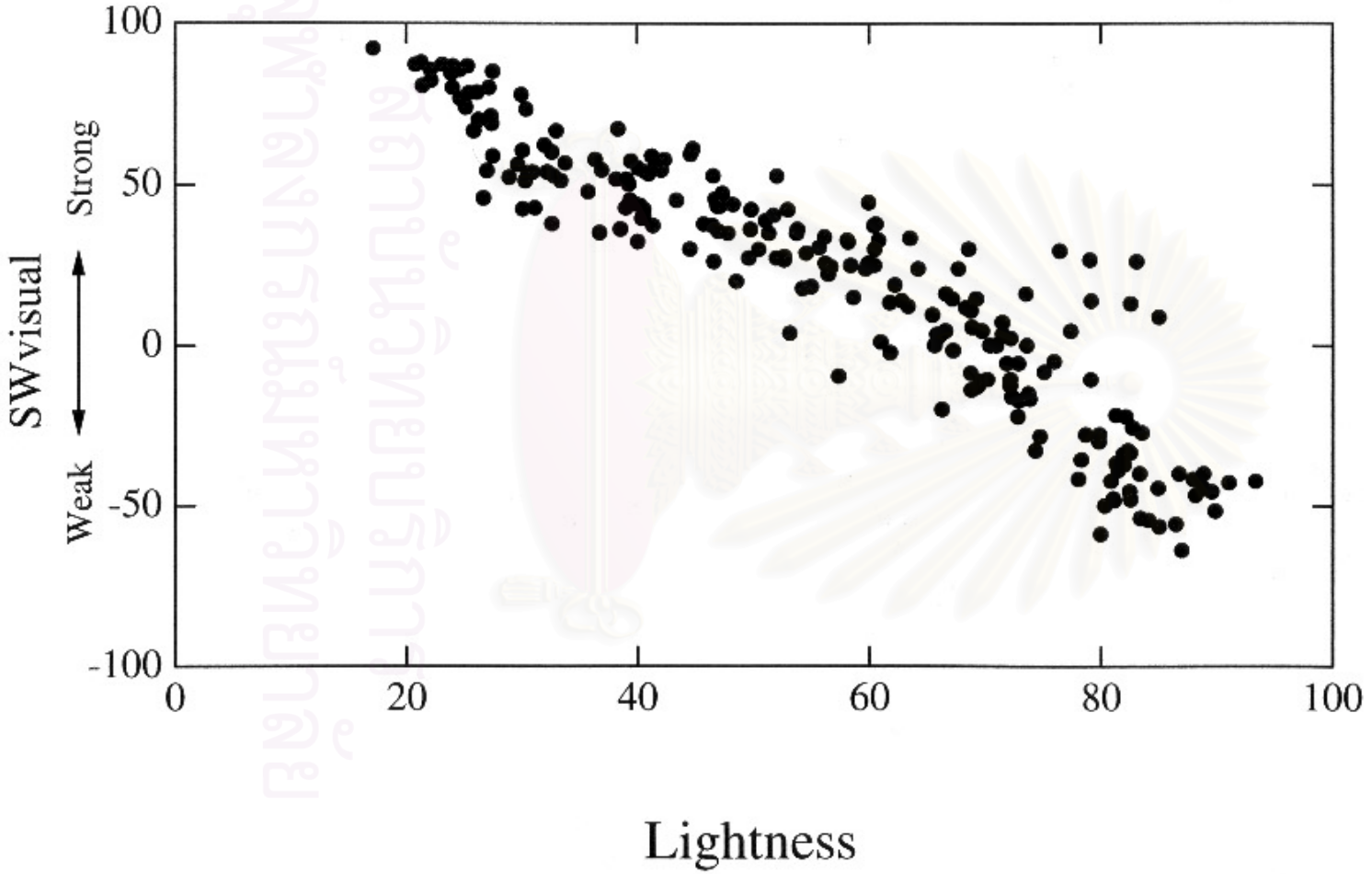

Figure 4-25 Visual results of "Strong-Weak" on Lightness

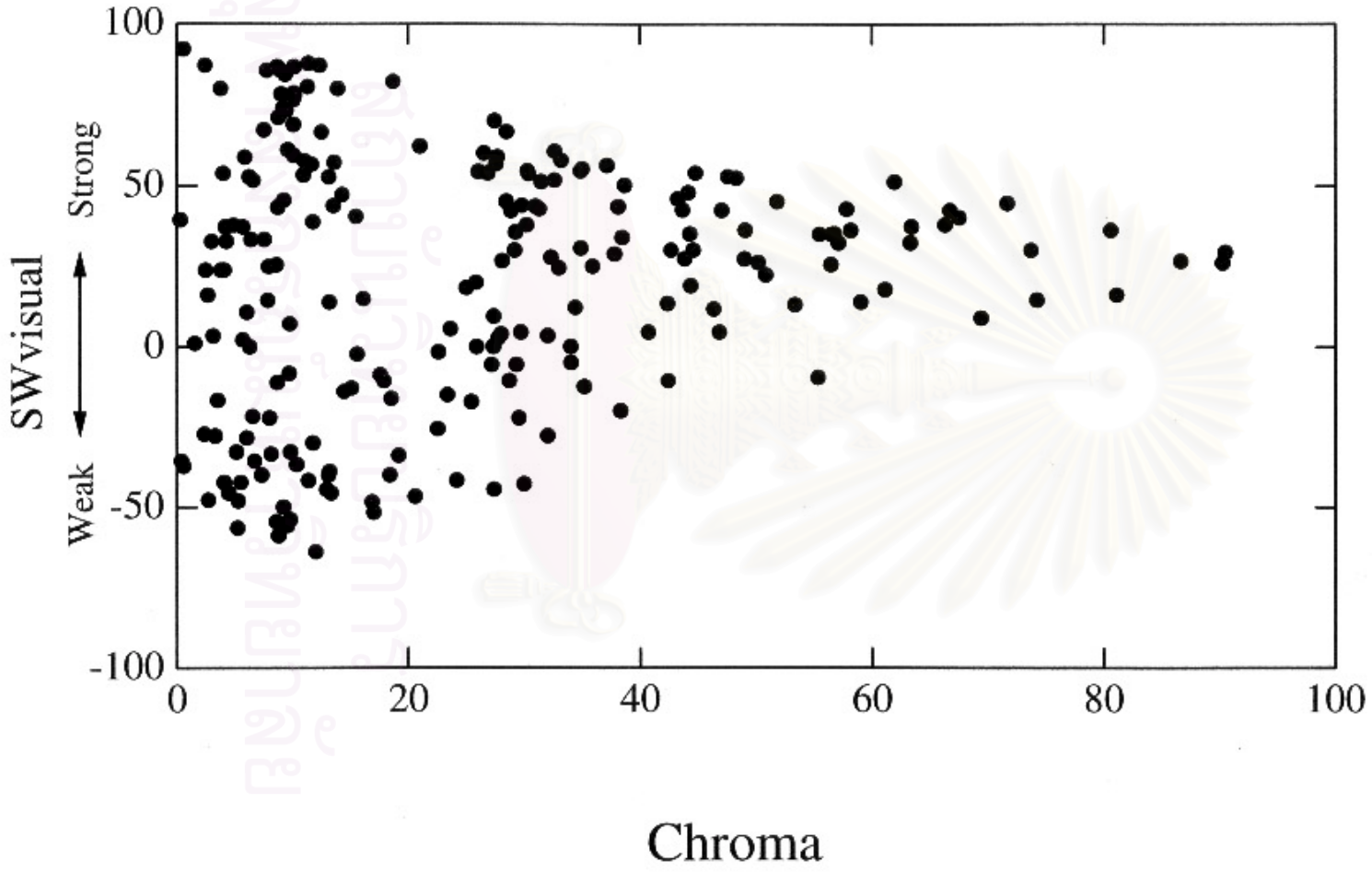

Figure 4-26 Visual results of "Strong-Weak" on Chroma

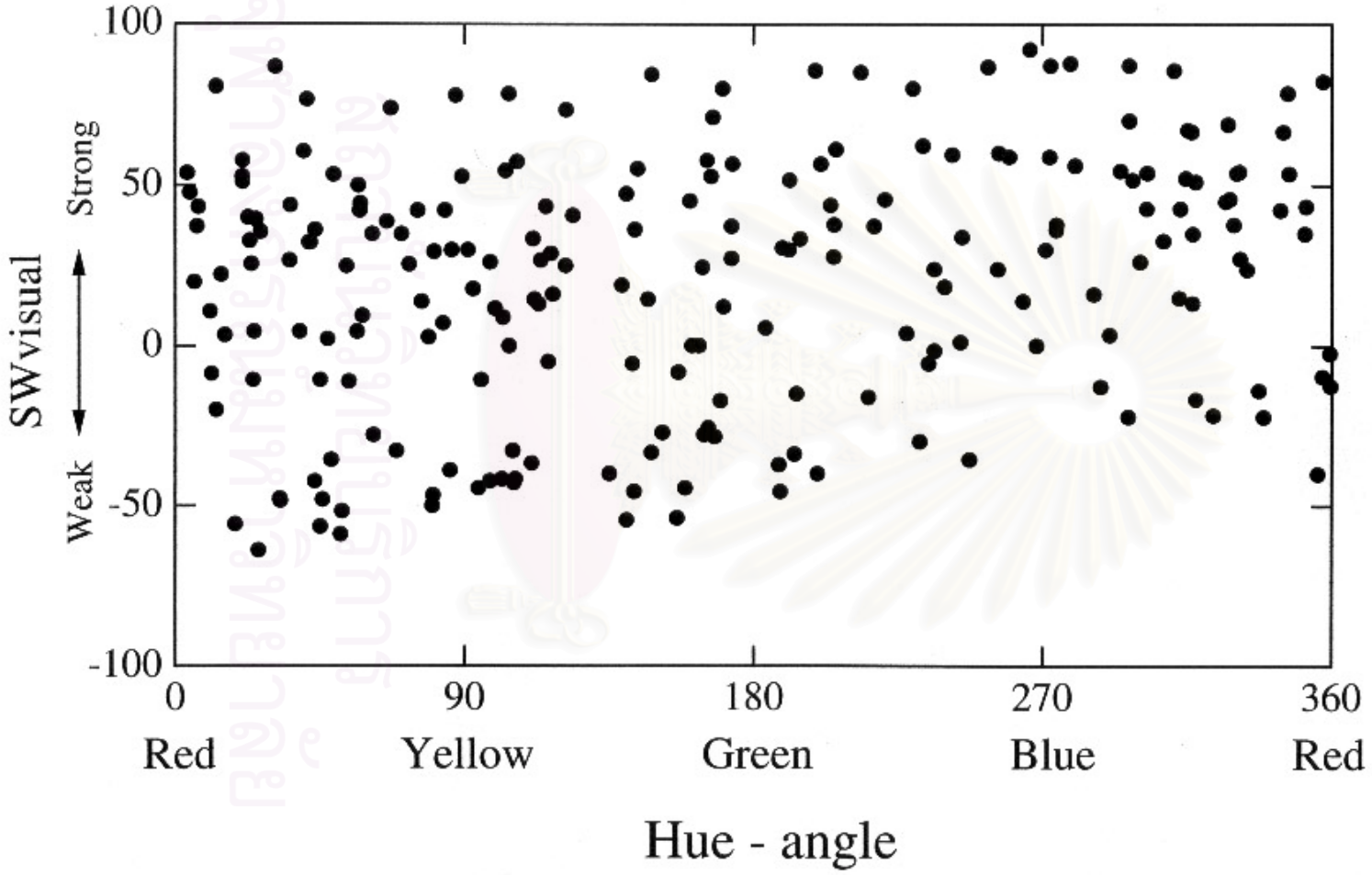

Figure 4-27 Visual results of "Strong-Weak" on Hue-angle

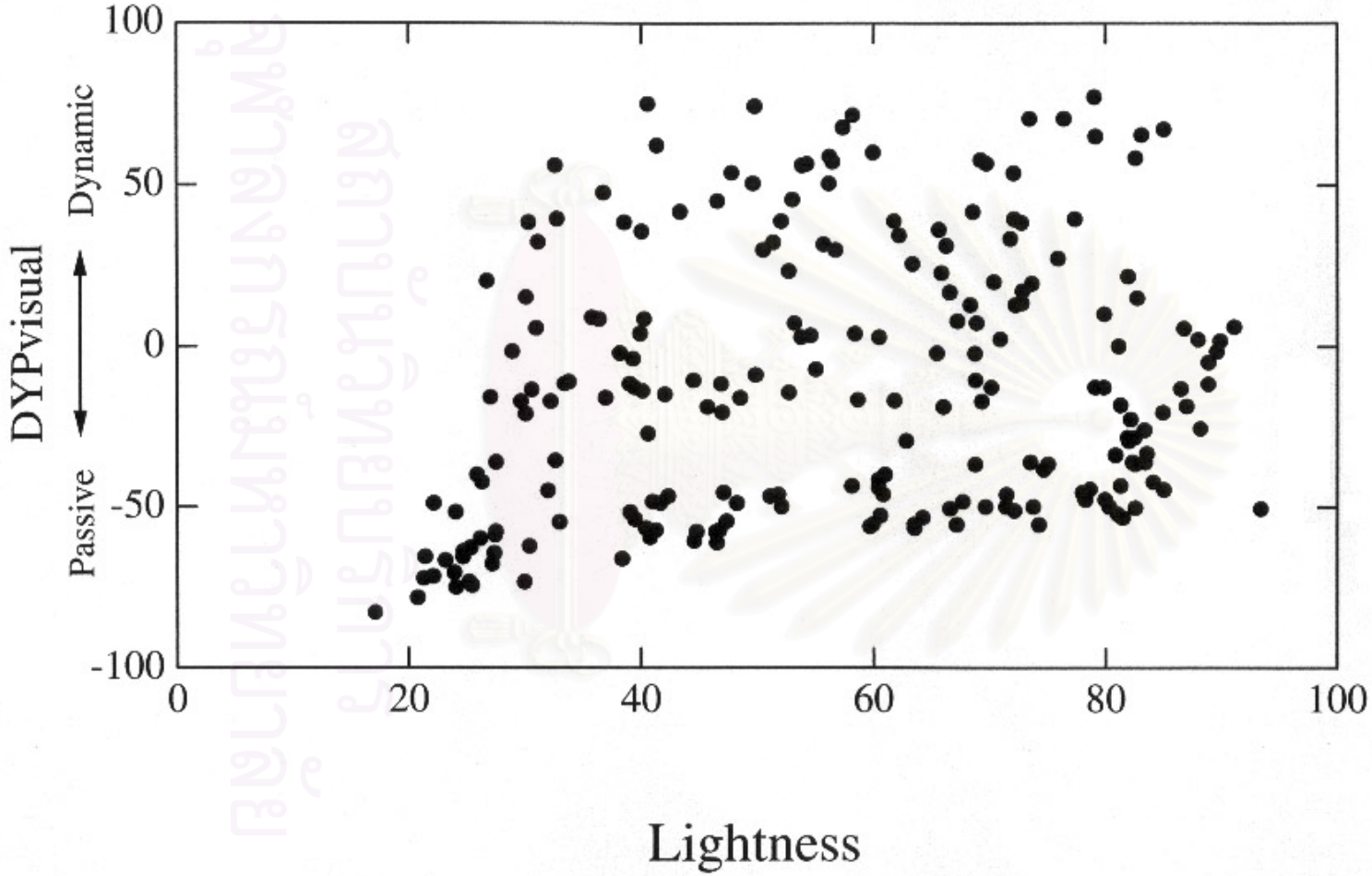

Figure 4-28 Visual results of "Dynamic-Passive" on Lightness

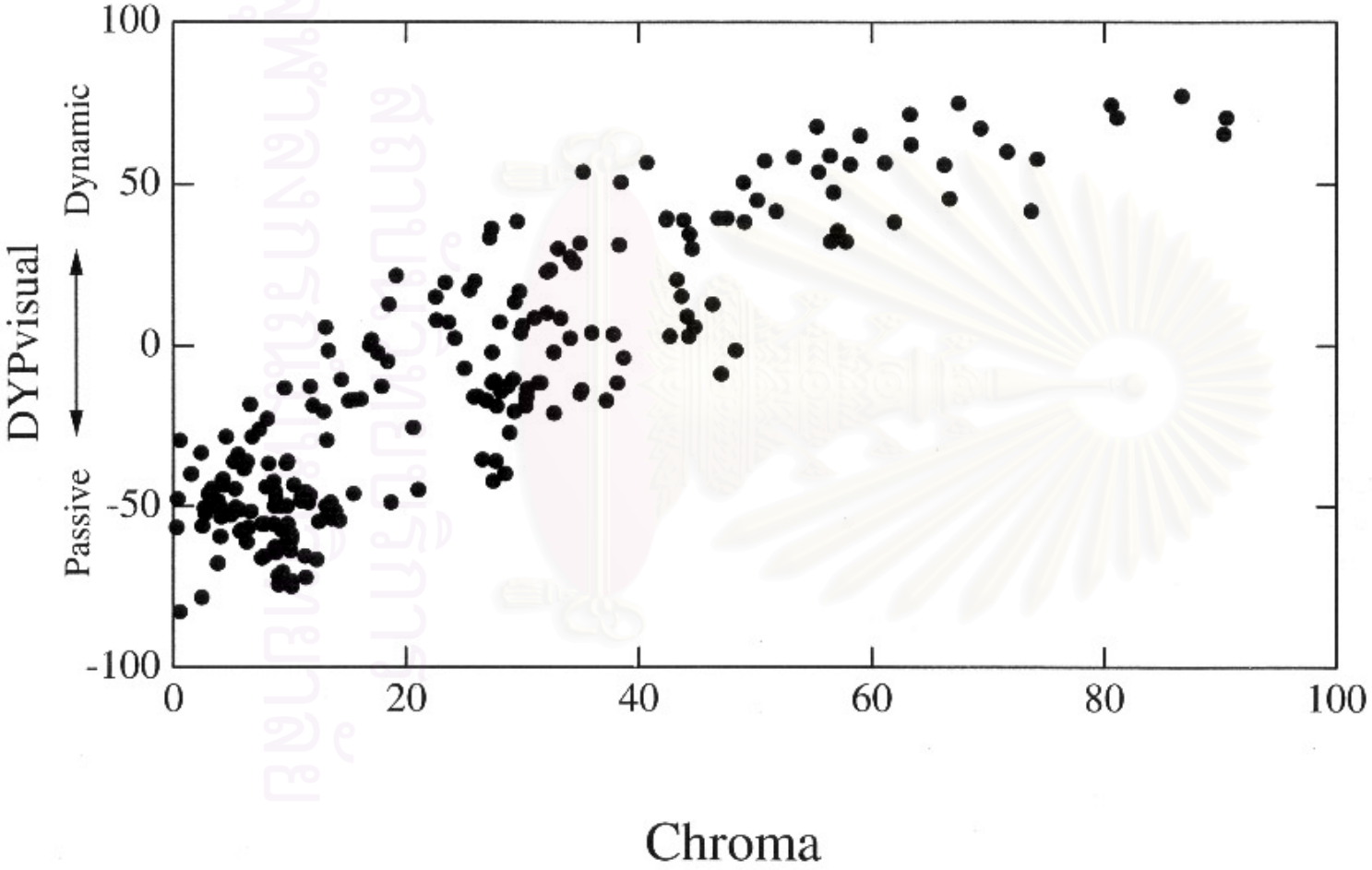

Figure 4-29 Visual results of "Dynamic-Passive" on Chroma

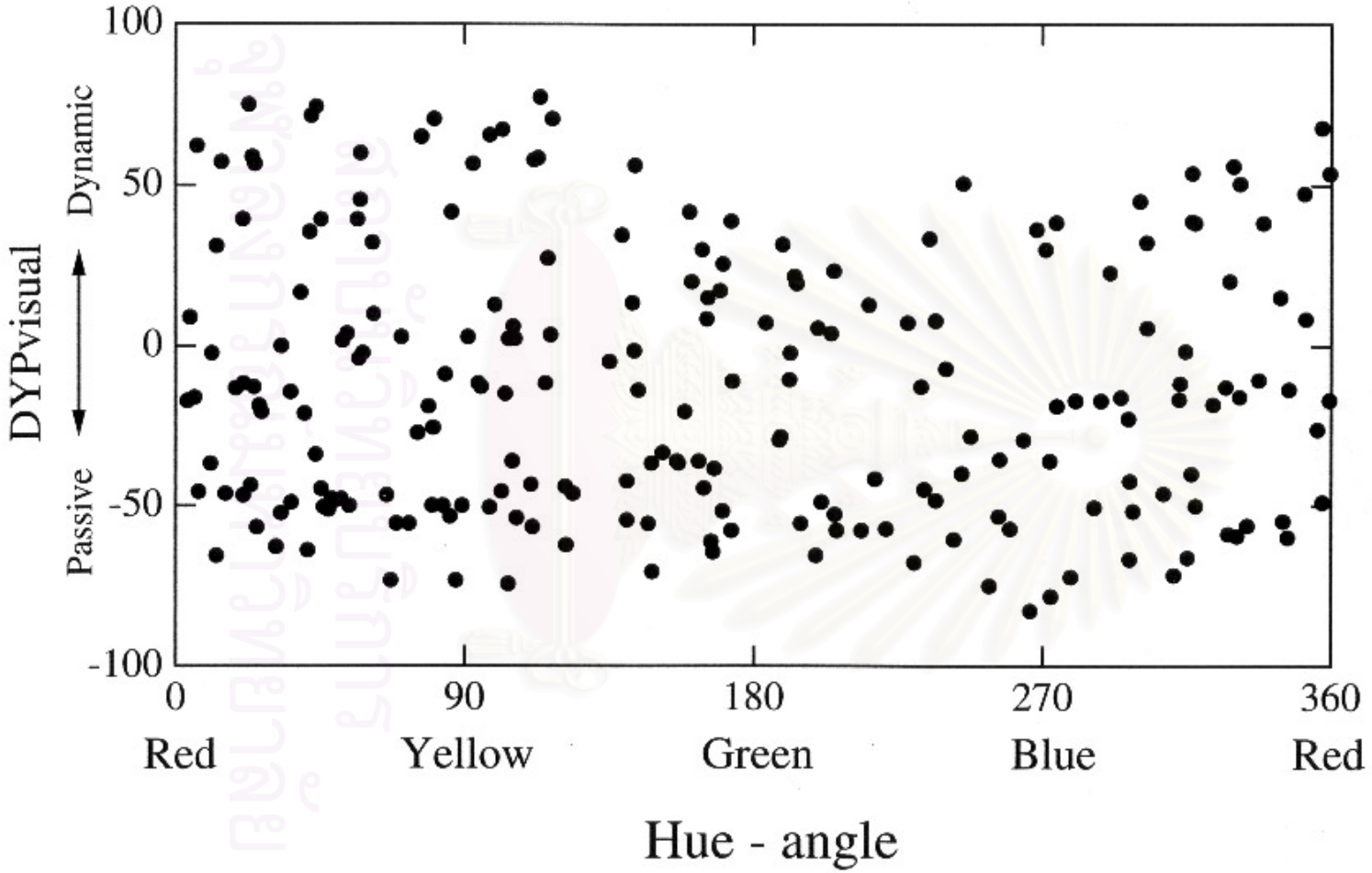

Figure 4-30 Visual results of "Dynamic-Passive" on Hue-angle

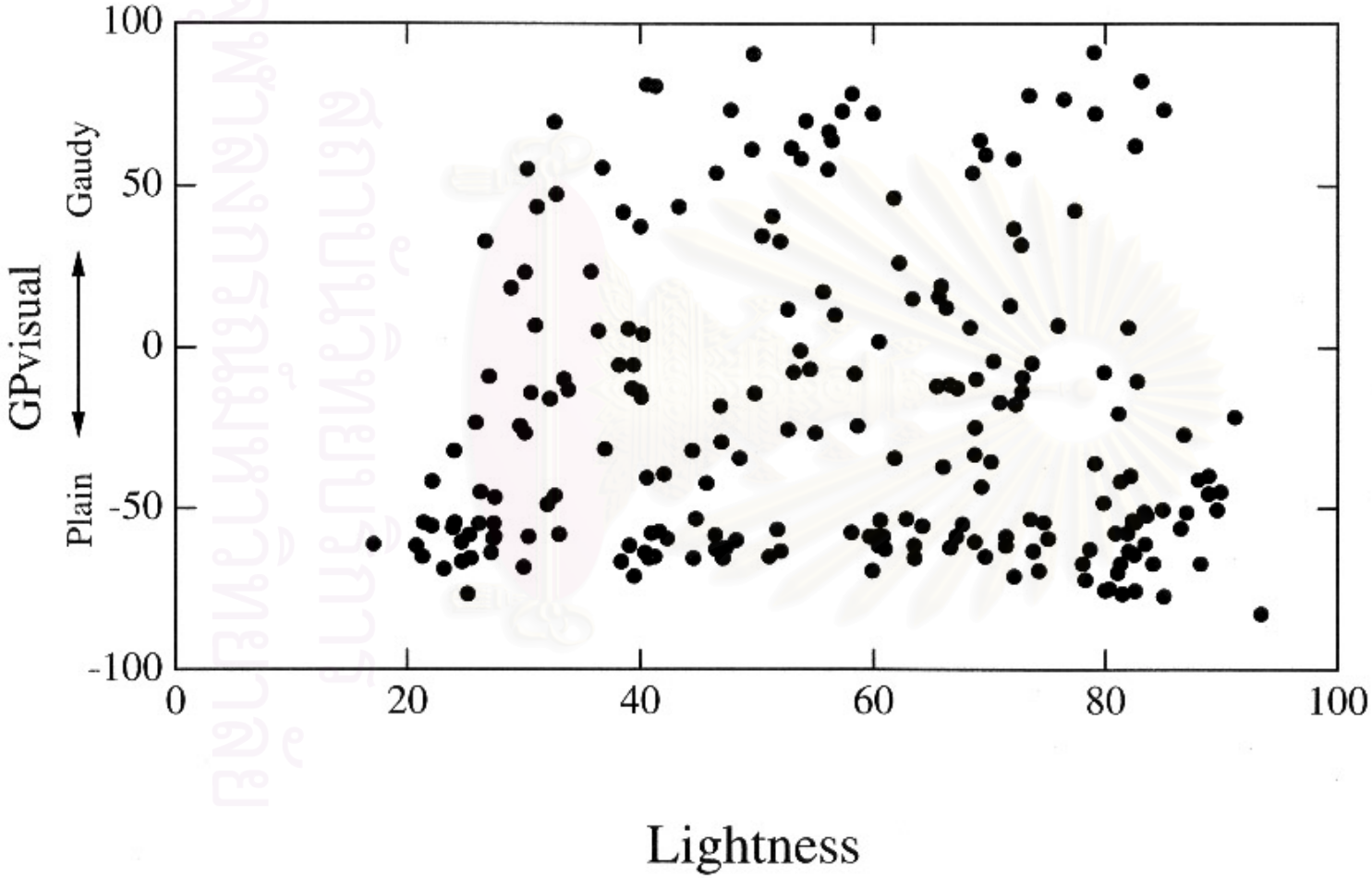

Figure 4-31 Visual results of "Gaudy-Plain" on Lightness

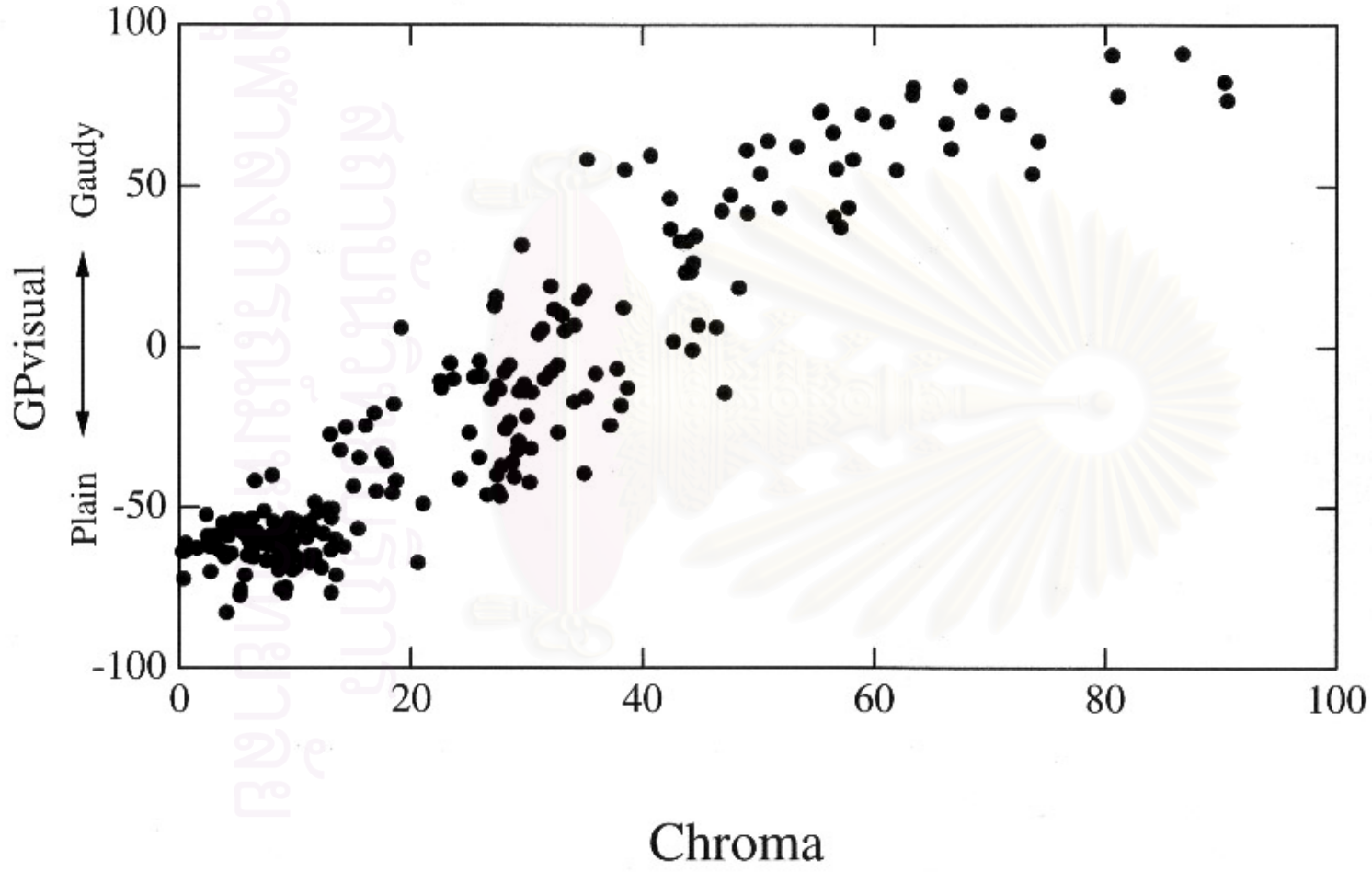

Figure 4-32 Visual results of "Gaudy-Plain" on Chroma

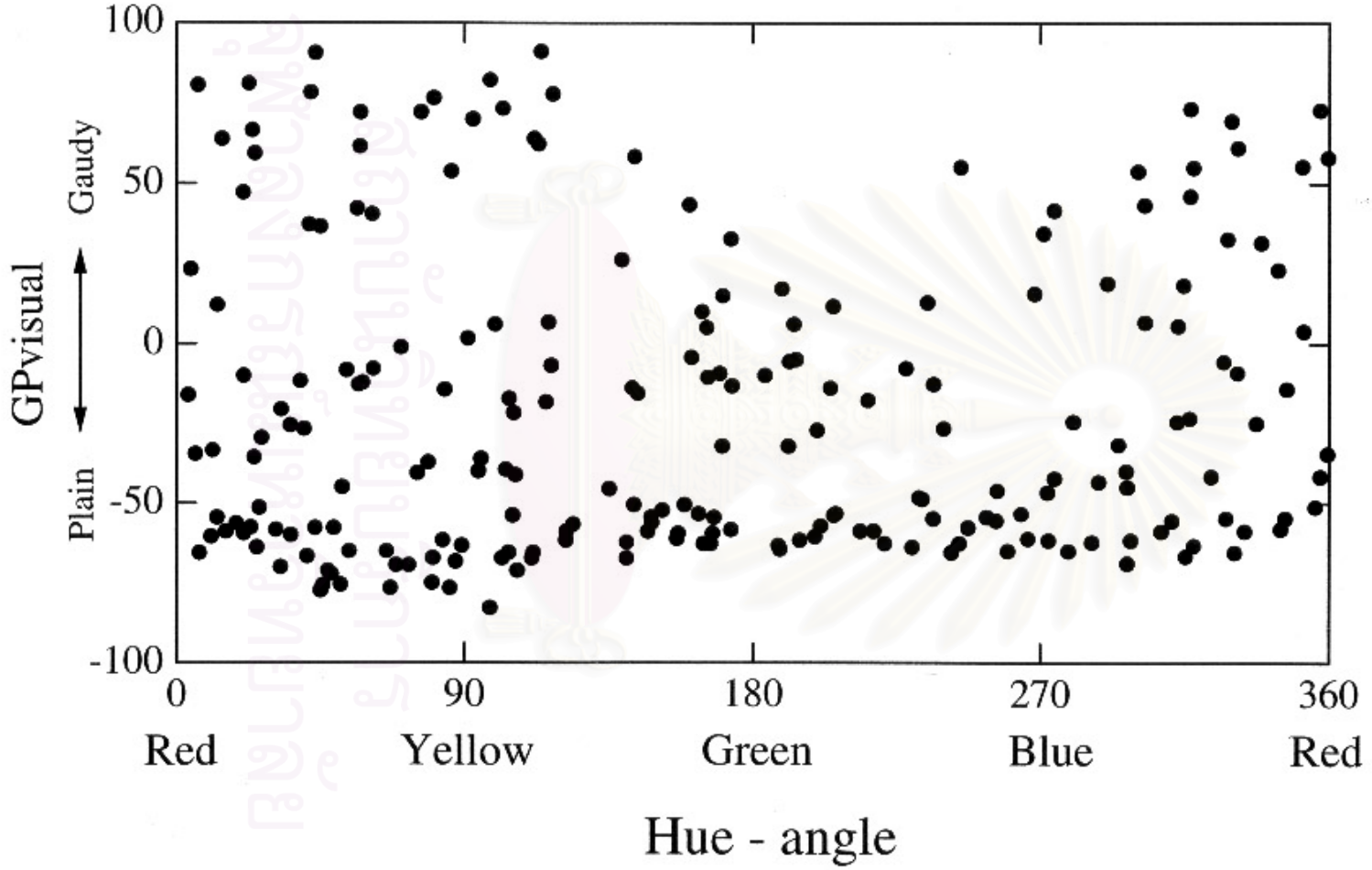

Figure 4-33 Visual results of "Gaudy-Plain" on Hue-angle

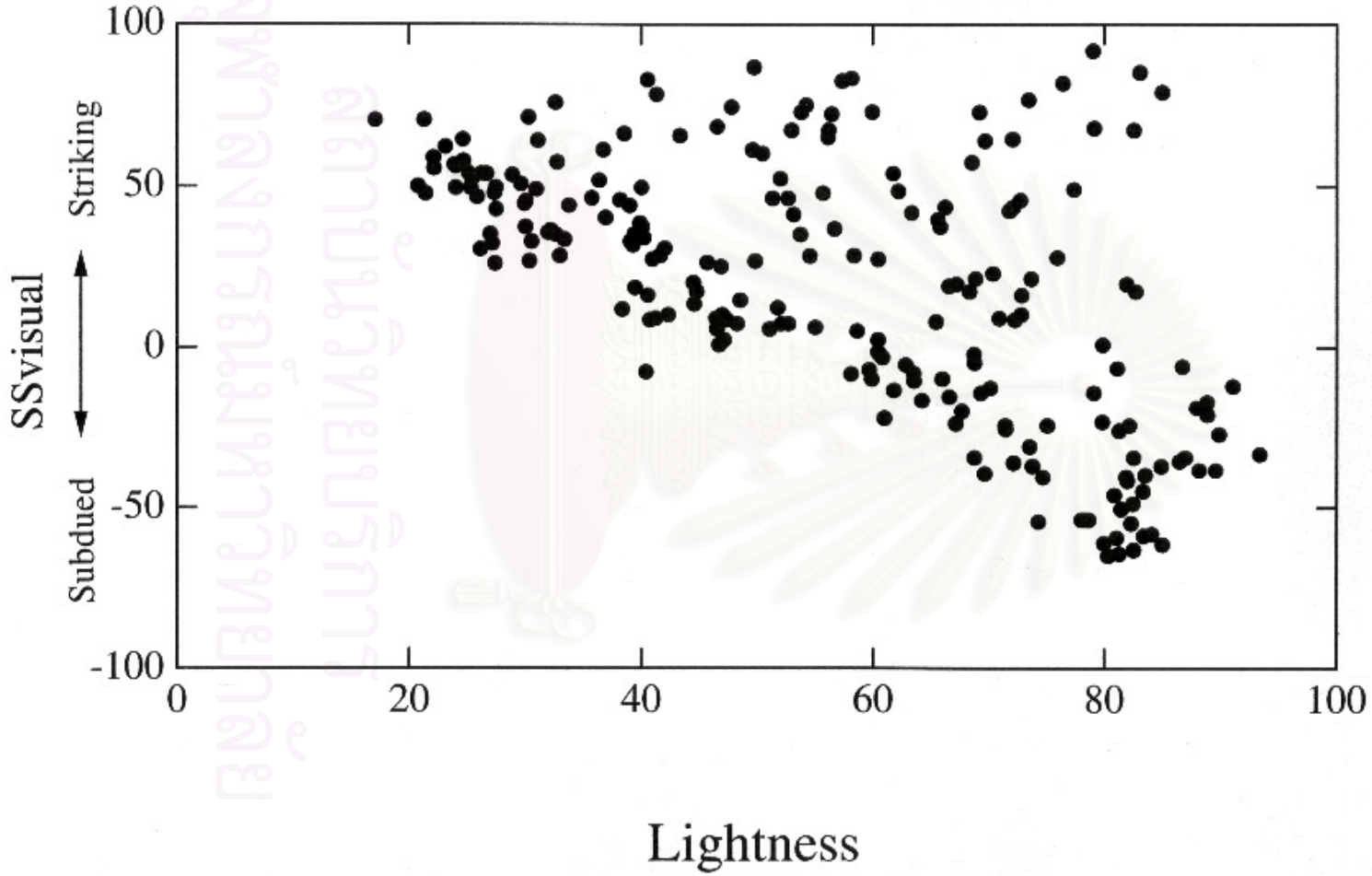

Figure 4-34 Visual results of "Striking-Subdued" on Lightness

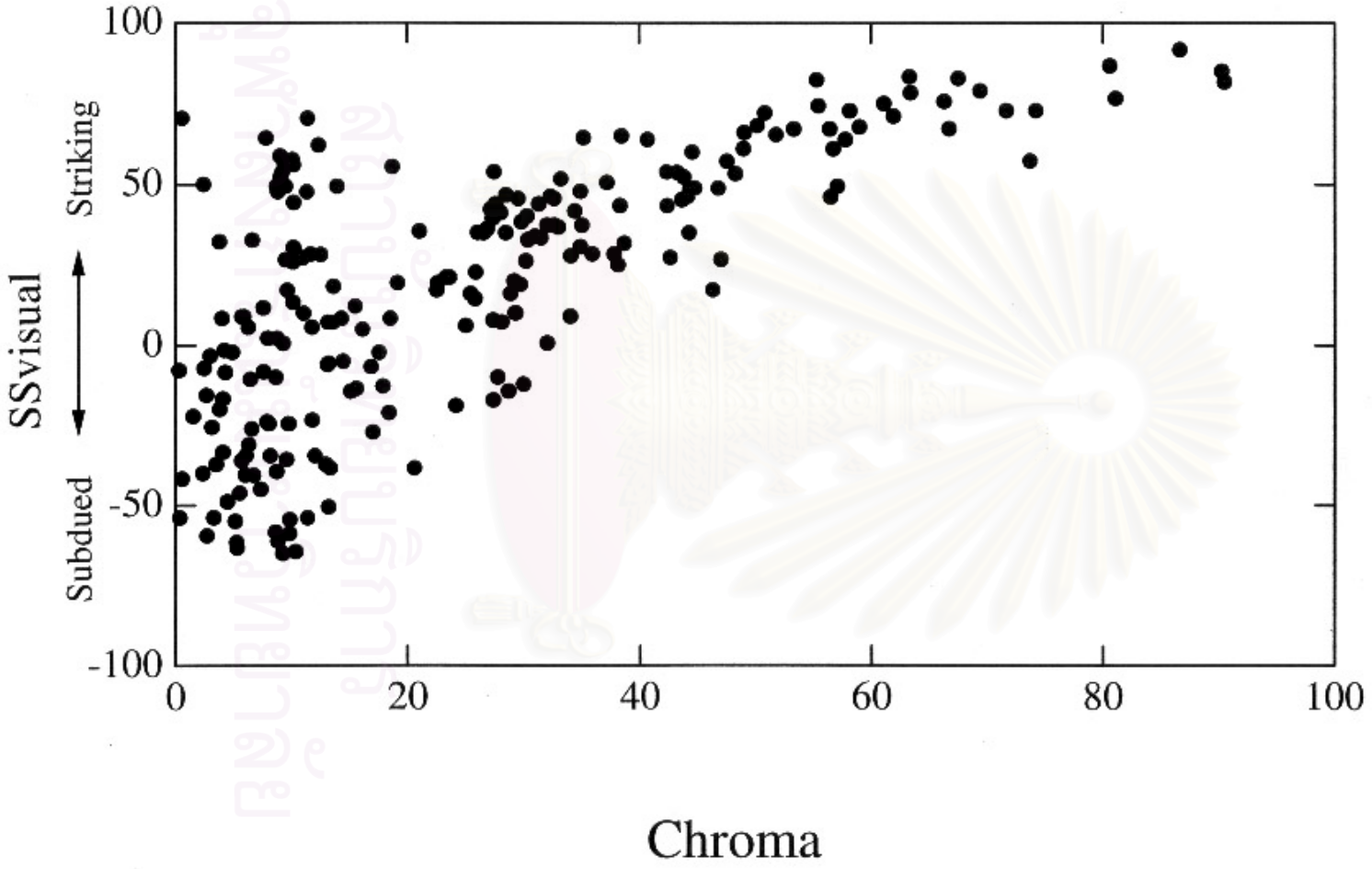

Figure 4-35 Visual results of "Striking-Subdued" on Chroma

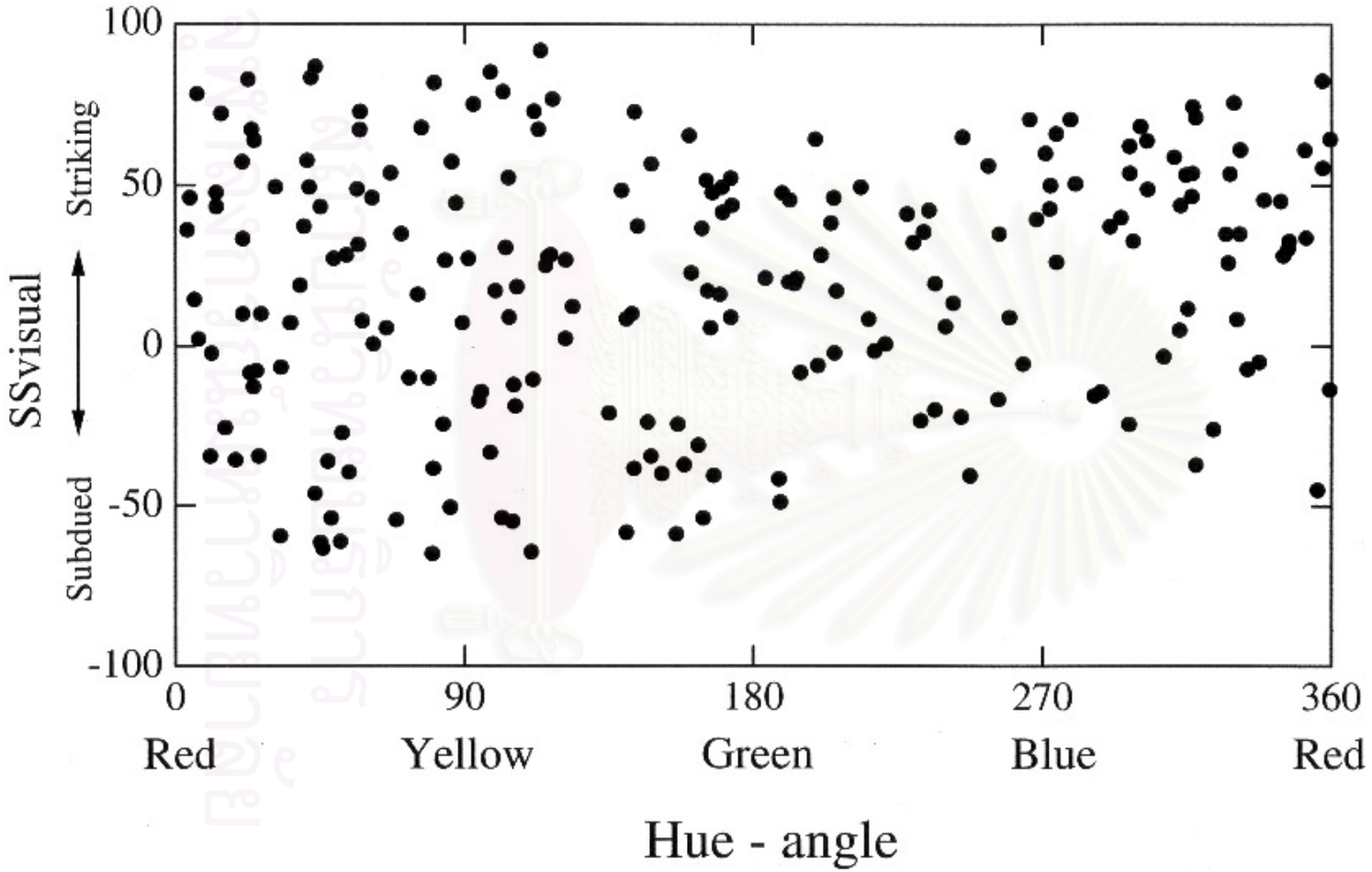

Figure 4-36 Visual results of "Striking-Subdued" on Hue-angle

4.2 Color Perception Equations

The empirical color perception equations were the tool for predicting color perception values of each of the opponent word pairs based on the CIELAB color system, as follows.

"Light-Dark"

$$LD_{CIELAB} = [\{3.4(L^*-10)\}^2 + \{4.5(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 184 \quad (4.1)$$

"Soft-Hard"

$$SH_{CIELAB} = -[\{2.2(L^*-90)\}^2 + \{0.9(1-\Delta h_{290}/360)C^*\}^2]^{1/2} + 79 \quad (4.2)$$

"Warm-Cool"

$$WC_{CIELAB} = [\{0.27(L^*-100)\}^2 + \{1.48\{1+\cos(\Delta h_{40})\}(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 58 \quad (4.3)$$

"Transparent-Turbid"

$$TT_{CIELAB} = [\{3.1(L^*-30)\}^2 + \{2.7(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 122 \quad (4.4)$$

"Deep-Pale"

$$DP_{CIELAB} = [\{2.6(L^*-100)\}^2 + \{1.8(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 90 \quad (4.5)$$

"Distinct-Vague"

$$DV_{CIELAB} = [\{1.9(L^*-60)\}^2 + \{3.3(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 62 \quad (4.6)$$

"Heavy-Light"

$$HL_{CIELAB} = [\{2.6(L^*-100)\}^2 + \{0.6(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 96 \quad (4.7)$$

"Vivid-Sombre"

$$VS_{CIELAB} = [\{2.2(L^*-10)\}^2 + \{5(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 157 \quad (4.8)$$

"Strong-Weak"

$$SW_{CIELAB} = [\{2.1(L^*-90)\}^2 + \{0.6(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 52 \quad (4.9)$$

"Dynamic-Passive"

$$DYP_{CIELAB} = [\{1.1(L^*-20)\}^2 + \{3.8(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 100 \quad (4.10)$$

"Gaudy-Plain"

$$GP_{CIELAB} = [\{0.4(L^*-10)\}^2 + \{3.8(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 95 \quad (4.11)$$

"Striking-Subdued"

$$SS_{CIELAB} = [\{1.6(L^*-90)\}^2 + \{3.1(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 65 \quad (4.12)$$

where, L^* : CIELAB metric lightness

C^* : CIELAB metric chroma

h : CIELAB metric hue angle

Δh_x : CIELAB metric hue angle difference from h=x, $0 \leq \Delta h_x \leq 180$

The empirical color perception equations corresponding to the seven-point assessments were derived. To determine if the derived empirical color perception equations are suitable for the color perception, the results from visual assessment experiment through the seven-point method were plotted against those calculated from the equation based on linear regression. Figure 4-37 to Figure 4-48 illustrate relationship between the color perception values from direct visual assessments and those calculated from the equations. Then, the correlation coefficient was determined. The higher the correlation coefficient is the more relationship becomes an important determining factor. All of the equations had been confirmed to have higher correlation coefficient than 0.8845.

The ratios k_1 and k_2 in the color perception equation indicated that the word pairs of "Light-Dark", "Warm-Cool", "Distinct-Vague", "Vivid-Sombre", "Dynamic-Passive", "Gaudy-Plain" and "Striking-Subdued" contained contributions from both

lightness and chroma, although the contribution from chroma was more important that that of lightness in these word pairs. The word pairs of “Transparent-Turbid” is found to have about equal dependence on lightness and chroma. The word pairs of “Soft-Hard”, “Deep-Pale”, “Heavy-Light” and “Strong-Weak” contained greater contribution from lightness than from chroma.

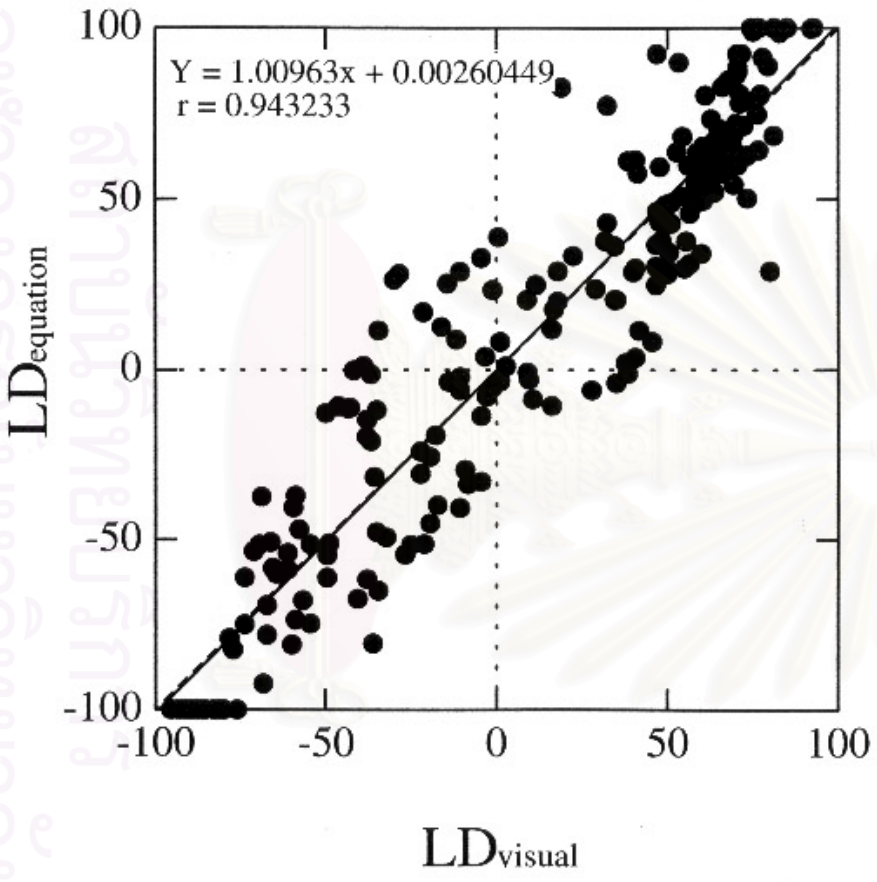

Figure 4-37 Relationship between visual results and equation of "Light-Dark"

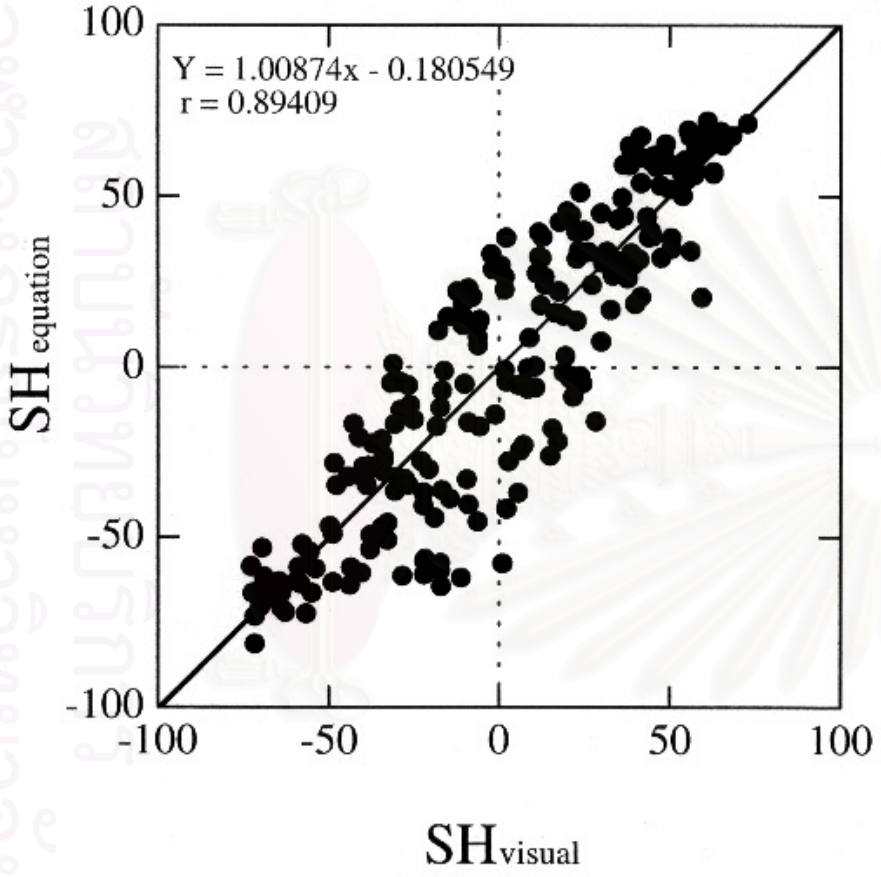

Figure 4-38 Relationship between visual results and equation of "Soft-Hard"

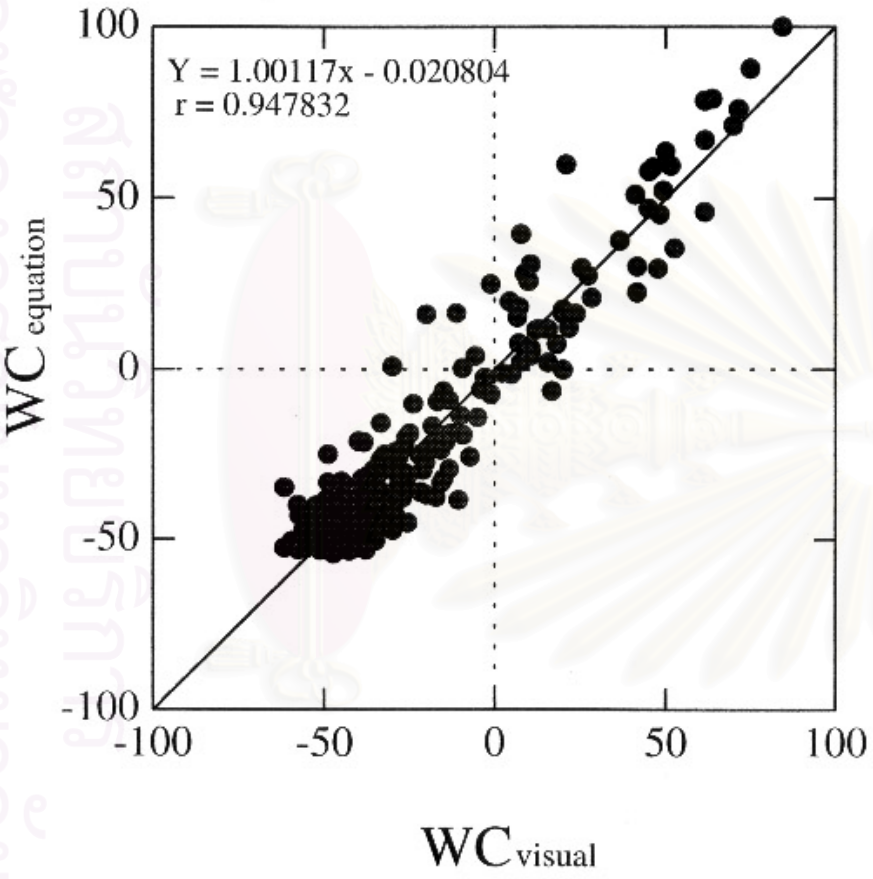

Figure 4-39 Relationship between visual results and equation of "Warm-Cool"

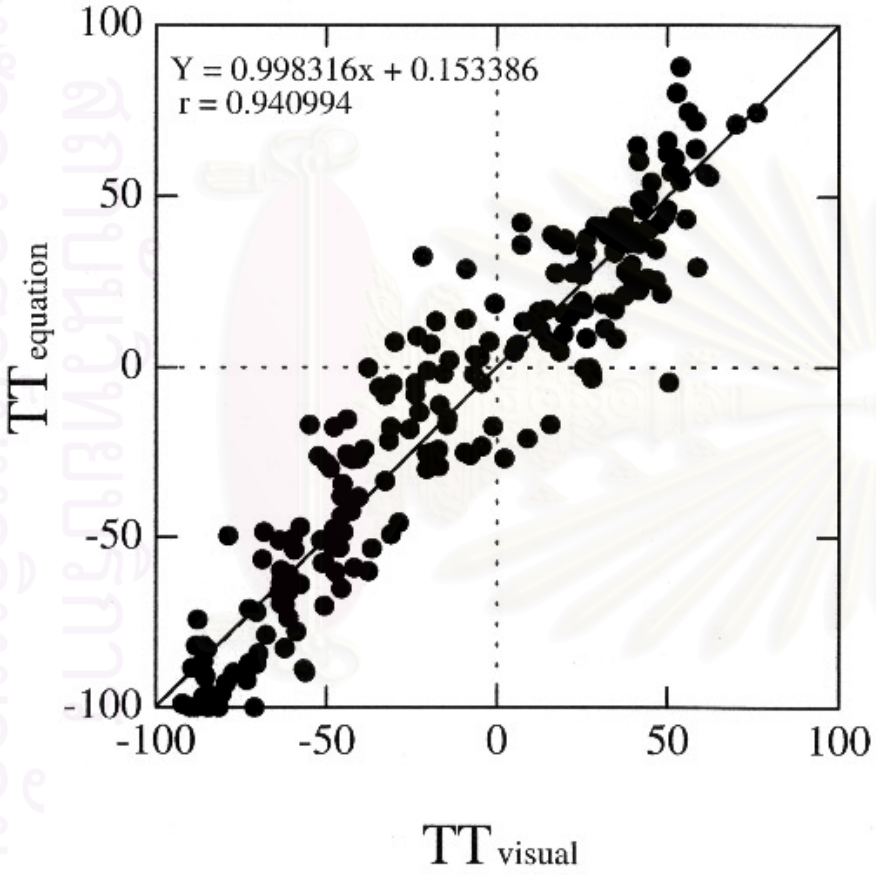

Figure 4-40 Relationship between visual results and equation of "Transparent-Turbid"

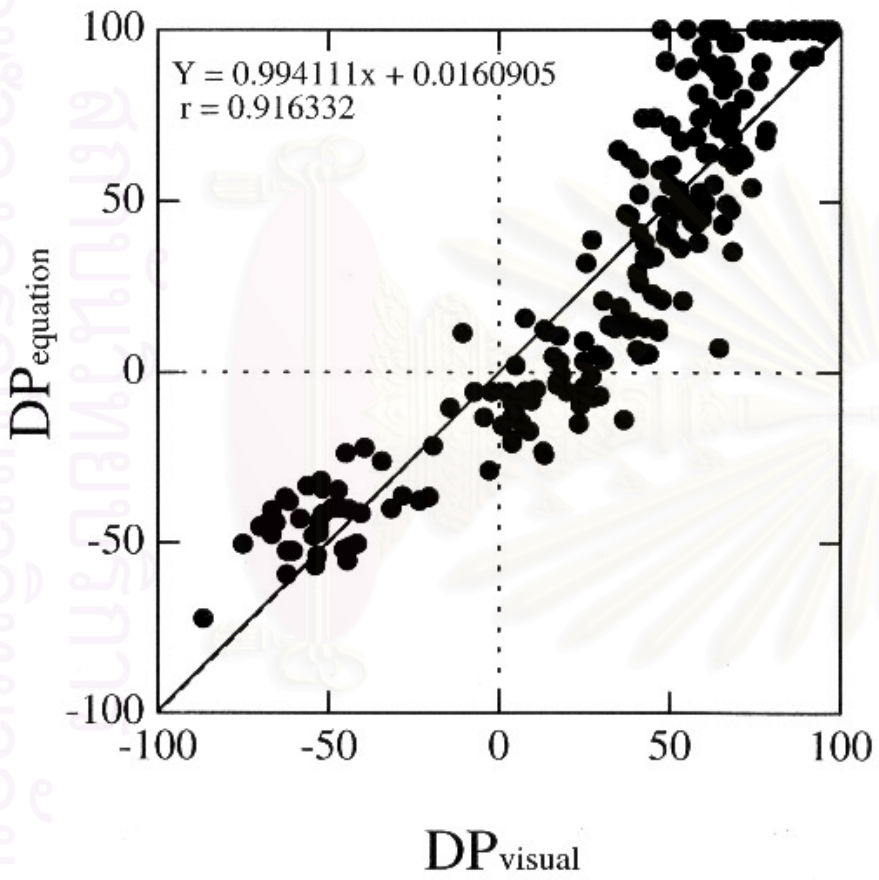

Figure 4-41 Relationship between visual results and equation of "Deep-Pale"

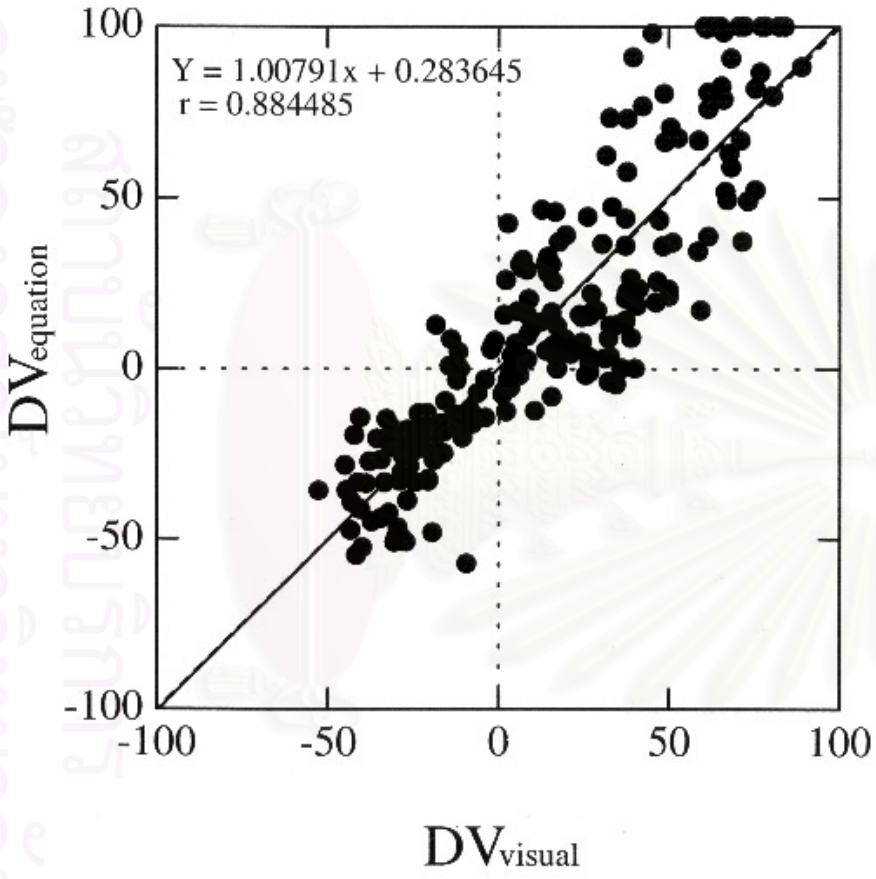

Figure 4-42 Relationship between visual results and equation of "Distinct-Vague"

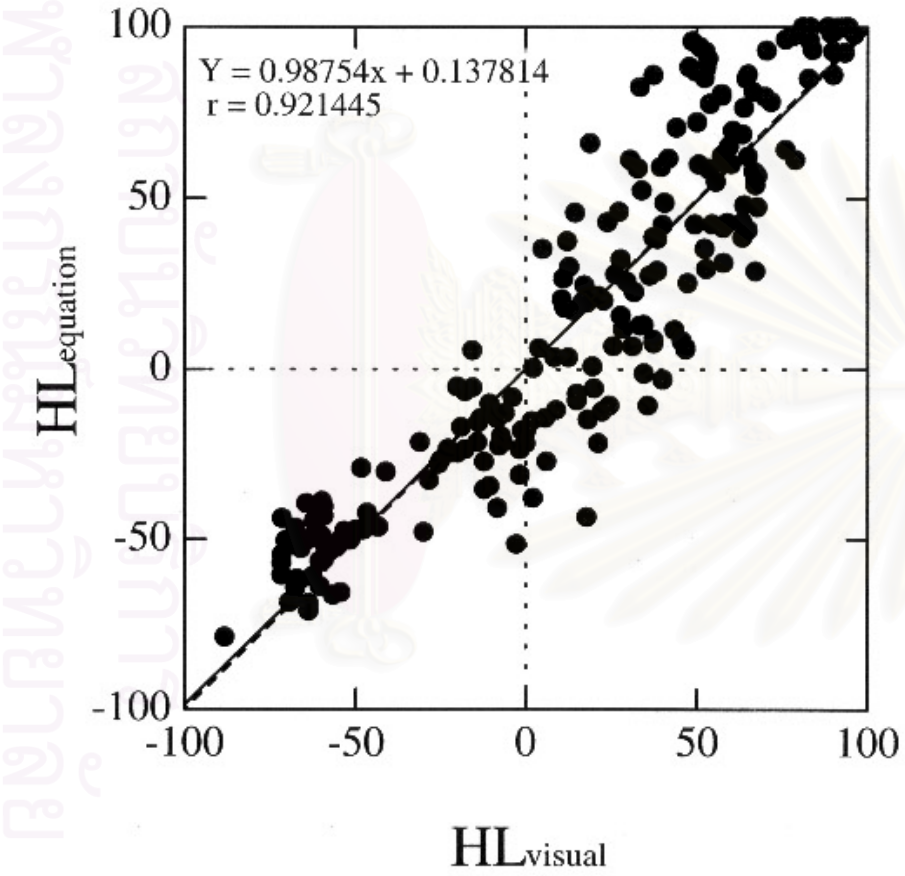

Figure 4-43 Relationship between visual results and equation of "Heavy-Light"

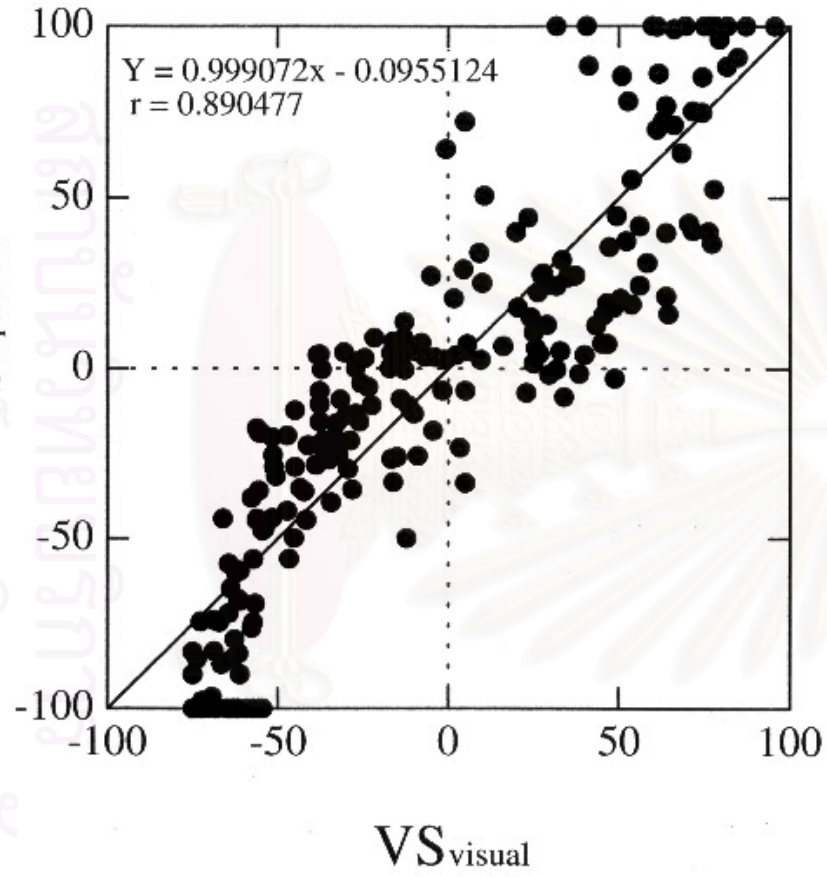

Figure 4-44 Relationship between visual results and equation of "Vivid-Sombre"

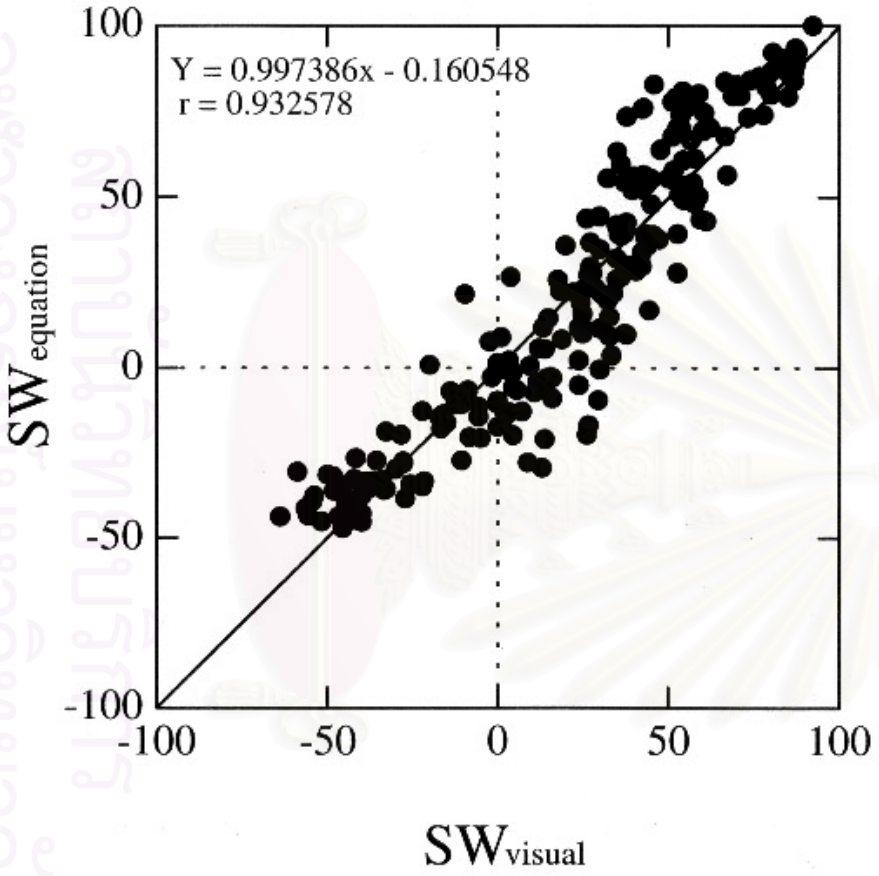

Figure 4-45 Relationship between visual results and equation of "Strong-Weak"

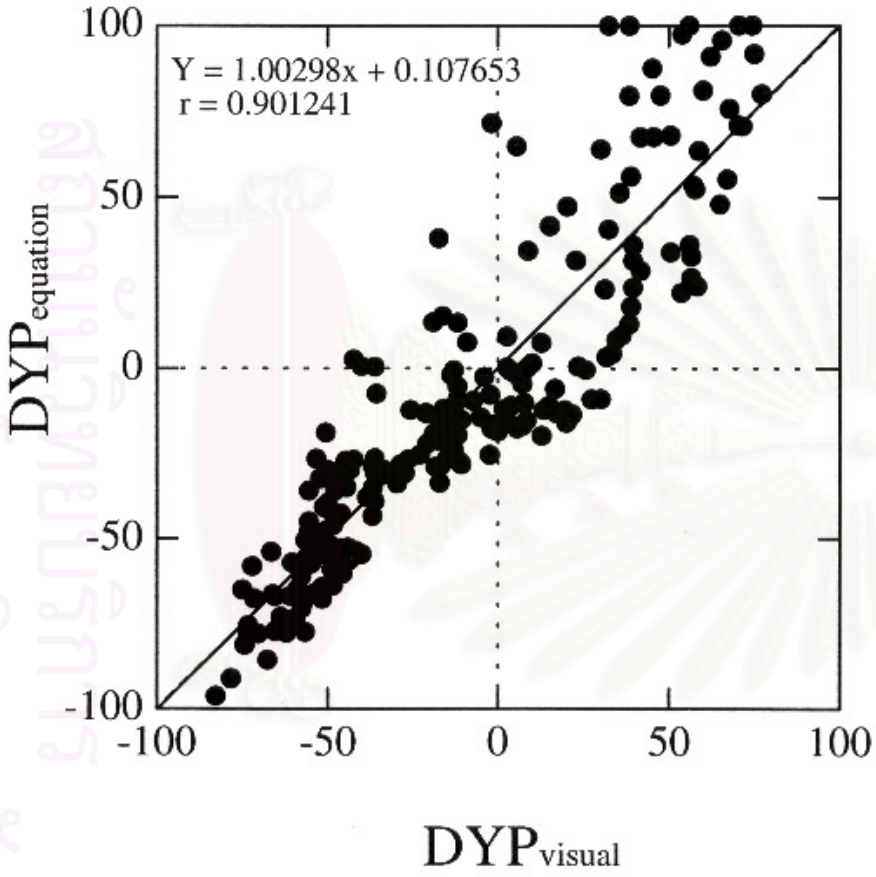

Figure 4-46 Relationship between visual results and equation of "Dynamic-Passive"

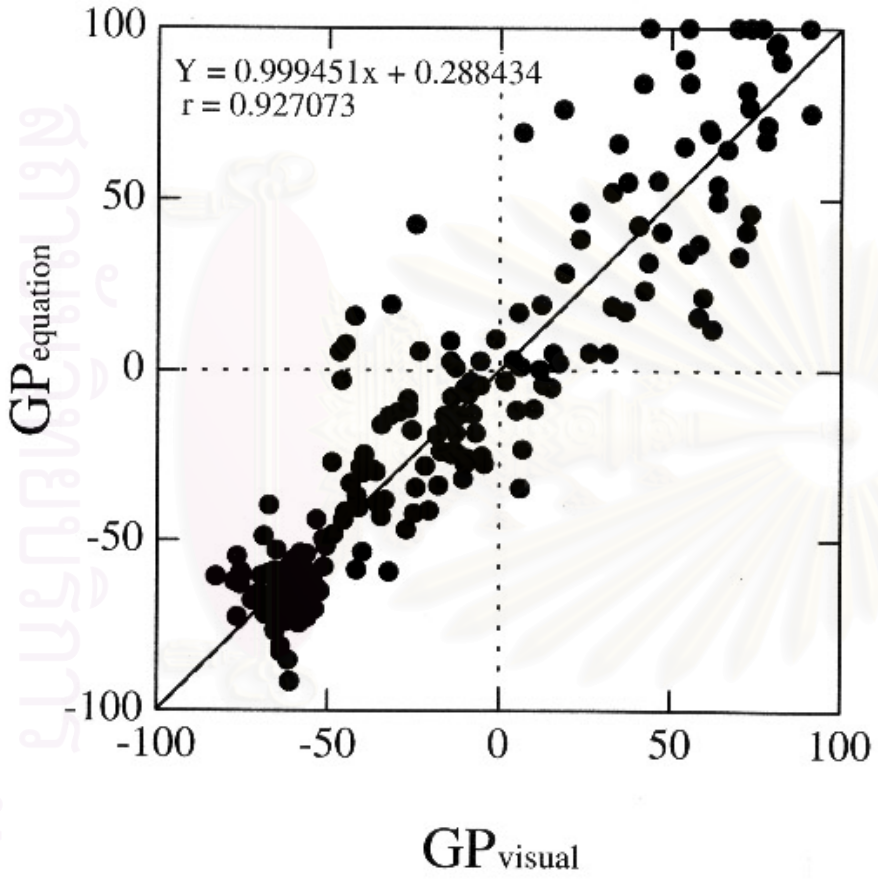

Figure 4-47 Relationship between visual results and equation of "Gaudy-Plain"

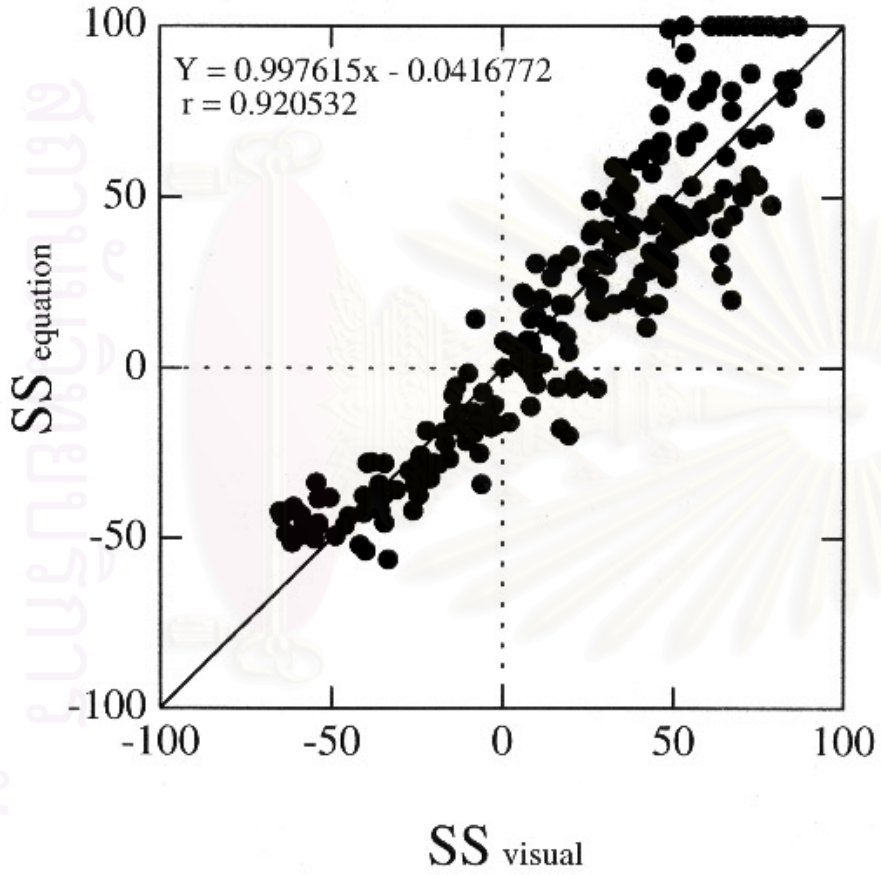

Figure 4-48 Relationship between visual results and equation of "Striking-Subdued"

4.3 Color Perception Values on CIE L*, C* and CIE a*, b* Diagrams

The characteristics of color perception values, which were calculated from each of the empirical color perception equations, were indicated by color perception lines on CIE L*, C* and CIE a*, b* diagrams. The color perception lines of the opponent word pairs are shown on Figure 4-49 to Figure 4-72. The summarize is as follows;

(a) The color perception lines of “Light-Dark” are shown in Figure 4-49. All observers assess color as “Light” at h=90 when lightness > 93 and at h=270 when Chroma > 67 and assess color as “Dark” in the region of low lightness and low chroma. In Figure 4-50 indicated results, which correspond to Figure 4-49, so that half of the observers assess color as “Light” and the other half assess as “Dark” the color near the center of color space. In addition, hue has a small contribution to “Light-Dark” color perception values on L* plane. The effect of hue is greatest in the yellow region and least in the blue region.

(b) The color perception lines of “Soft-Hard” are shown in Figure 4-51, and 75% of observers assess color as “Soft” and 25% of observers assess as “Hard” when lightness > 77 and all observers assess color as “Hard” when lightness < 9. In Figure 4-52 indicated results, which correspond to Figure 4-51, that 75% of observers assess color as “Hard” and 25% of observers assess as “Soft”.

(c) The color perception lines of “Warm-Cool” are shown in Figure 4-53, and 75% of observers assess color as “Warm” and 25 % of observers assess as “Cool” when chroma > 77 and 75 % of observers assess color as “Cool” and 25% of observers assess color as “Warm” at high gray. In Figure 4-54 indicated results, which correspond to Figure 4-53 shown that “Warm-Cool” color perception contribution to hue.

(d) The color perception lines of “Transparent-Turbid” are shown in Figure 4-55. All observers assess color as “Transparent” when high lightness and high Chroma and assess dark gray as “Turbid”. In Figure 4-56 indicated results that 75% of

observers assess color as “Turbid” and 25% of observers assess as “Transparent” at gray in the middle of color space. There was a small hue contribution to “Transparent-Turbid” color perception values on L* plane and this effect be greatest in the yellow region and least in the blue region.

(e) The color perception lines of “Deep-Pale” are shown in Figure 4-57. All observers assess color as “Pale” when lightness > 93 and assess color as “Deep” when lightness < 27. In Figure 4-58 indicated results that 75% of observers assess color as “Deep” and 25% of observers assess as “Pale” the color near the center of color space. There was a small hue contribution to “Deep-Pale” color perception values on L* plane and this effect be greatest in the yellow region and least in the blue region.

(f) The color perception lines of “Distinct-Vague” are shown in Figure 4-59. All observers assess color as “Distinct” at h=90 when chroma > 93 and at h=270 when Chroma > 67. The observers 75% assess color as “Vague” and 25% assess color as “Distinct” in the middle gray. In Figure 4-60 indicated results that half of observers assess color as “Distinct” and the other half assess as “Vague” the color near the center of color space. There was a small hue contribution to “Distinct-Vague” color perception values on L* plane and this effect be greatest in the yellow region and least in the blue region.

(g) The color perception lines of “Heavy-Light” are shown in Figure 4-61, that all observers assess color as “Heavy” when lightness > 98 and assess color as “Light” when lightness < 25. In Figure 4-62 indicated that 75% of observers assess color as “Heavy” and 25% of observers assess as “Light”.

(h) The color perception lines of “Vivid-Sombre” are shown in Figure 4-63. All observers assess color as “Vivid” at h=90 when Chroma > 93 and at h=270 when Chroma > 55 and assess color as “Sombre” in the region of low lightness and low chroma. In Figure 4-64 indicated results that 75% of observers assess as “Sombre” and 25% of observers assess as “Vivid” at gray near the center of color space. There

was a small hue contribution to “Vivid-Sombre” color perception values on L* plane and this effect be greatest in the yellow region and least in the blue region.

(i) The color perception lines of “Strong-Weak” are shown in Figure 4-65. All observers assess color as “Strong” when lightness < 18 and 75% of observers assess color as “Weak” and 25% assess as “Strong” at gray when lightness are 89 and 90. In Figure 4-66 indicated results that 75% of observers assess as “Strong” and 25% of observers assess as “Weak”.

(j) The color perception lines of “Dynamic-Passive” are shown in Figure 4-67. All observers assess color as “Dynamic” at h=90 when chroma > 95 and at h=270 when Chroma > 56 and assess color as “Passive” at the gray when lightness is 20. In Figure 4-68 indicated results that 25% of observers assess color as “Passive” and 75% of observers assess as “Passive” at gray near the center of color space. There was a small hue contribution to “Dynamic-Passive” color perception values on L* plane and this effect be greatest in the yellow region and least in the blue region.

(k) The color perception lines of “Gaudy-Plain” are shown in Figure 4-69. All observers assess color as “Gaudy” at h=90 when chroma > 93 and at h=270 when Chroma > 55 and assess dark gray as “Plain”. In Figure 4-70 indicated results that 25% of observers assess color as “Gaudy” and 75% of observers assess as “Plain” at gray near the center of color space. There was a small hue contribution to “Gaudy-Plain” color perception values on L* plane and this effect be greatest in the yellow region and least in the blue region.

(l) The color perception lines of “Striking-Subdued” are shown in Figure 4-71. All observers assess color as “Striking” at h=90 when chroma > 96 and at h=270 when Chroma > 57. The 25% of observers assess color as “Striking” and 75% of observers assess “Subdued” at high gray. In Figure 4-72 indicated results that half of observers assess as “Striking” and the other half assess as “Subdued” at center of the color space. There was a small hue contribution to “Striking-Subdued” color

perception values on L* plane. The effect of hue is greatest in the yellow region and least in the blue region.

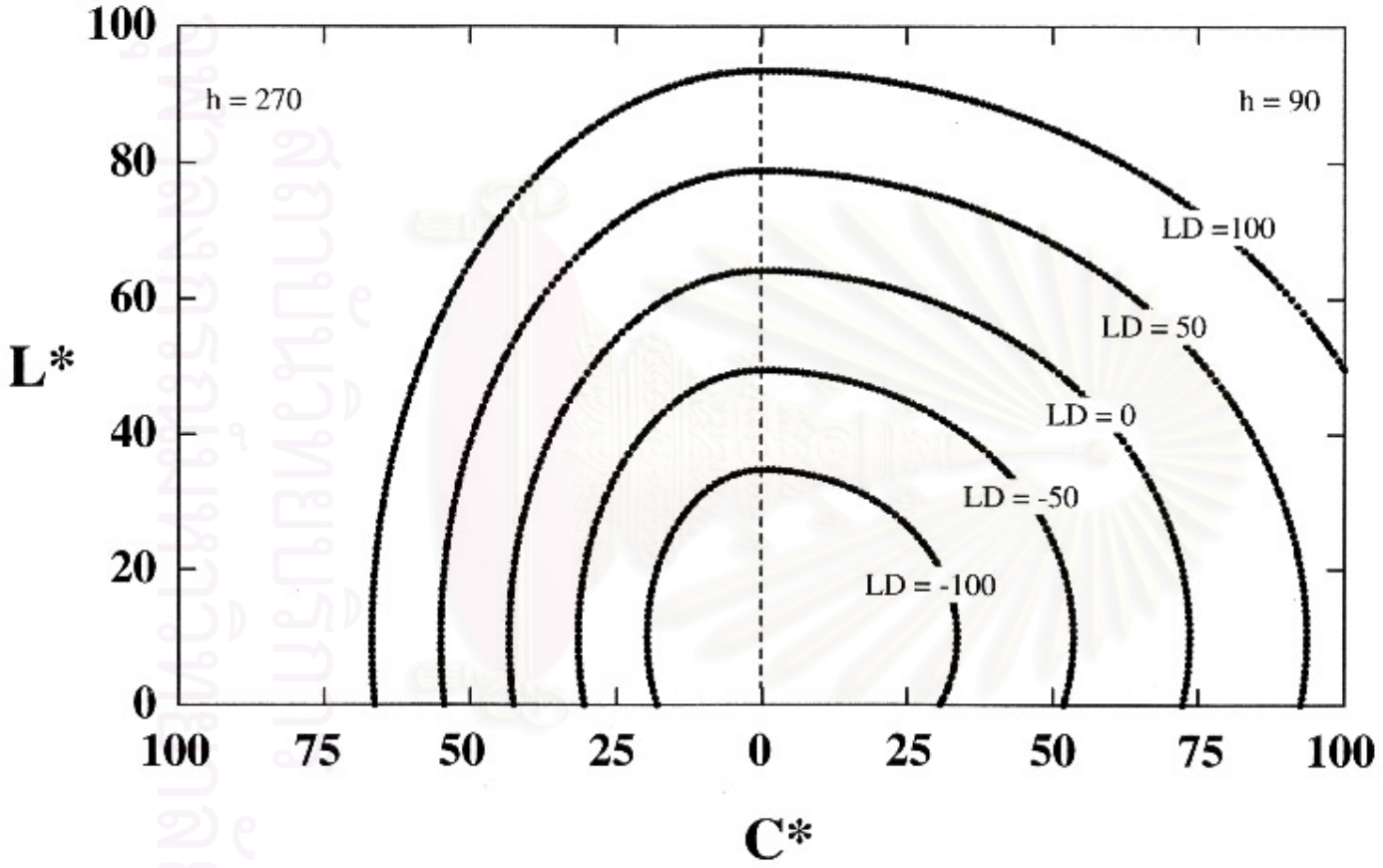

Figure 4-49 Color perception lines of "Light-Dark" on CIE L* C* (h=270 and h=90) plane

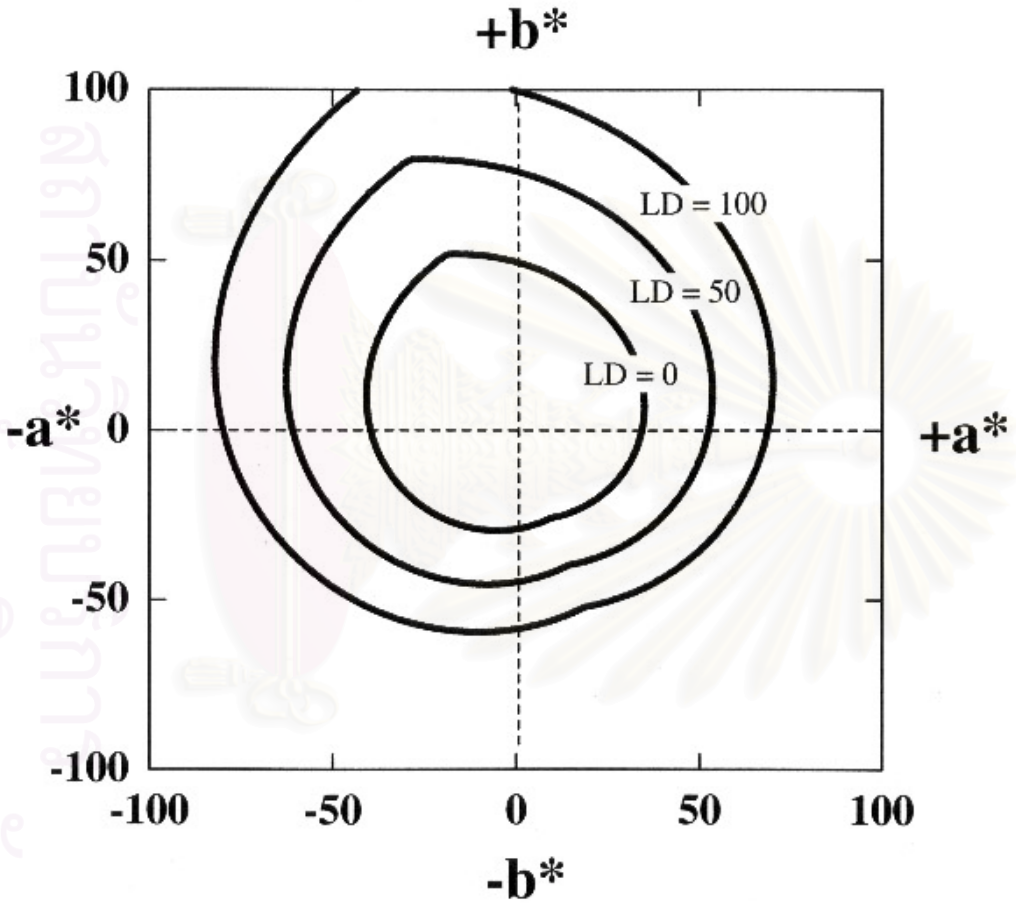

Figure 4-50 Color perception lines of "Light-Dark" on CIE a* b* (L*=50) plane

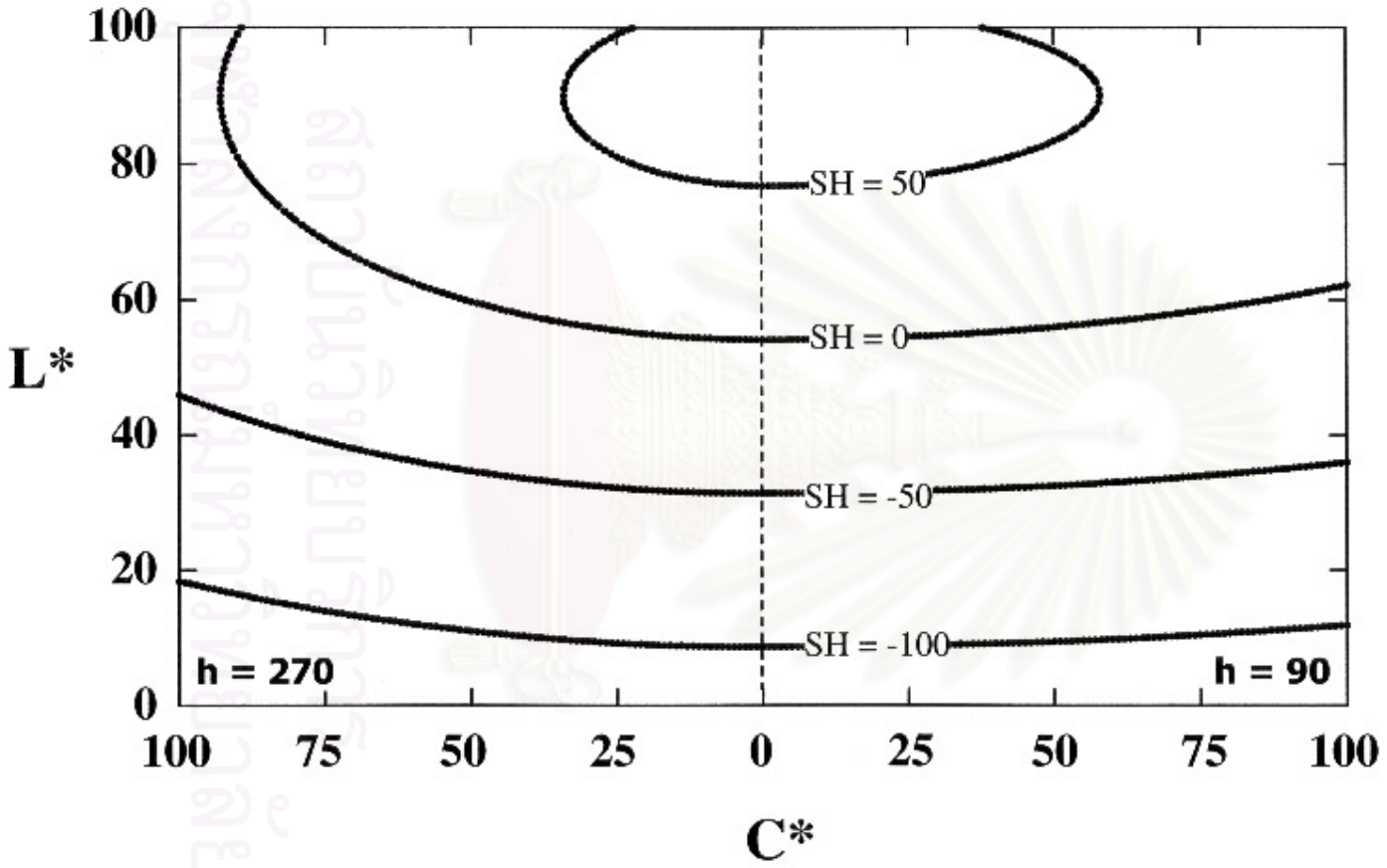

Figure 4-51 Color perception lines of "Soft-Hard" on CIE L* C* (h=270 and h=90) plane

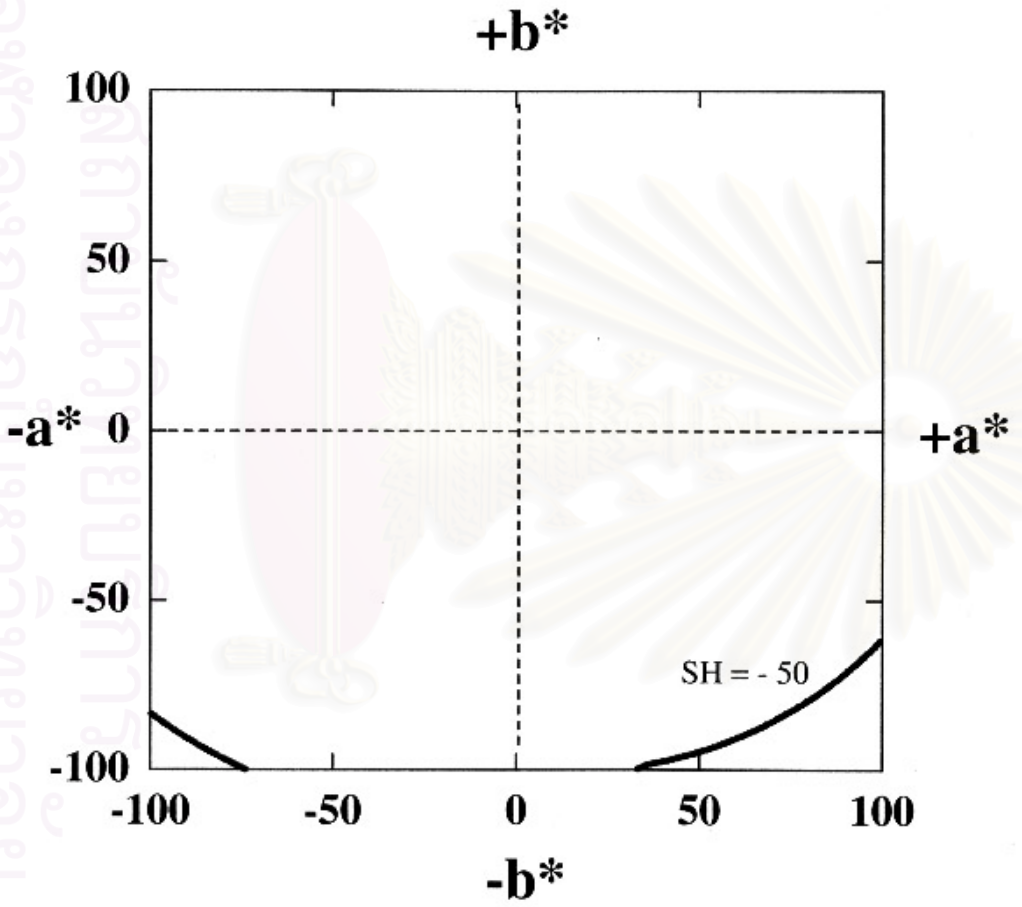

Figure 4-52 Color perception lines of "Soft-Hard" on CIE a* b* (L*=50) plane

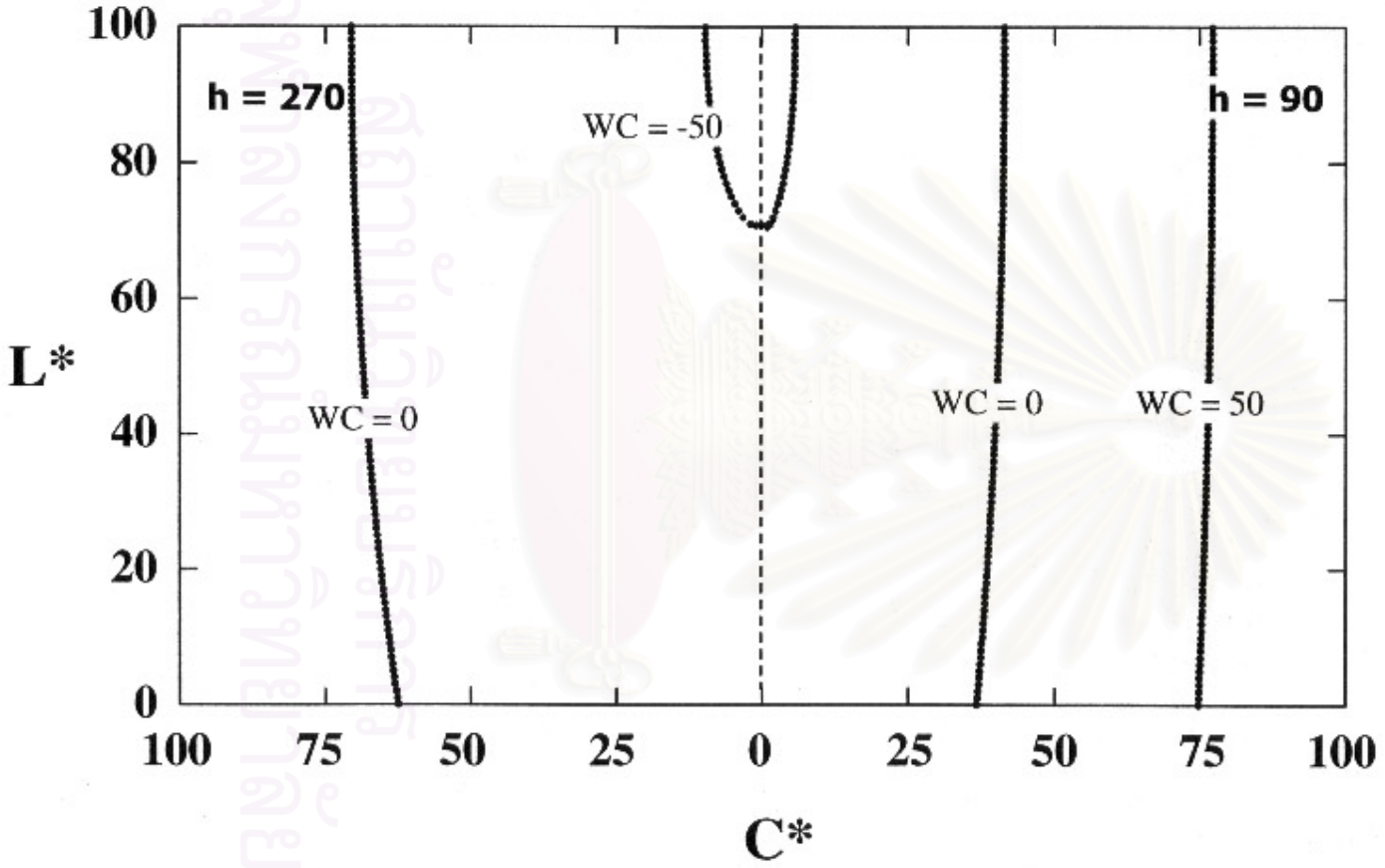

Figure 4-53 Color perception lines of "Warm-Cool" on CIE L* C* (h=270 and h=90) plane

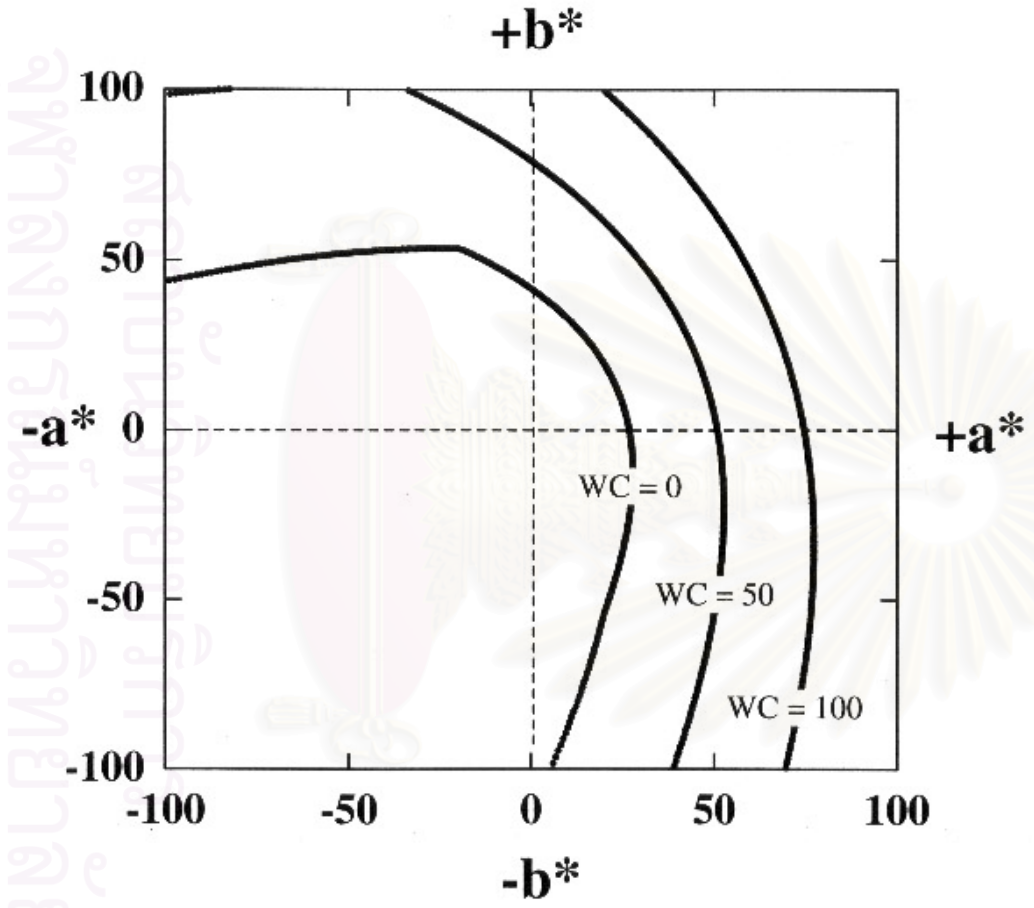

Figure 4-54 Color perception lines of "Warm-Cool" on CIE a* b* (L*=50) plane

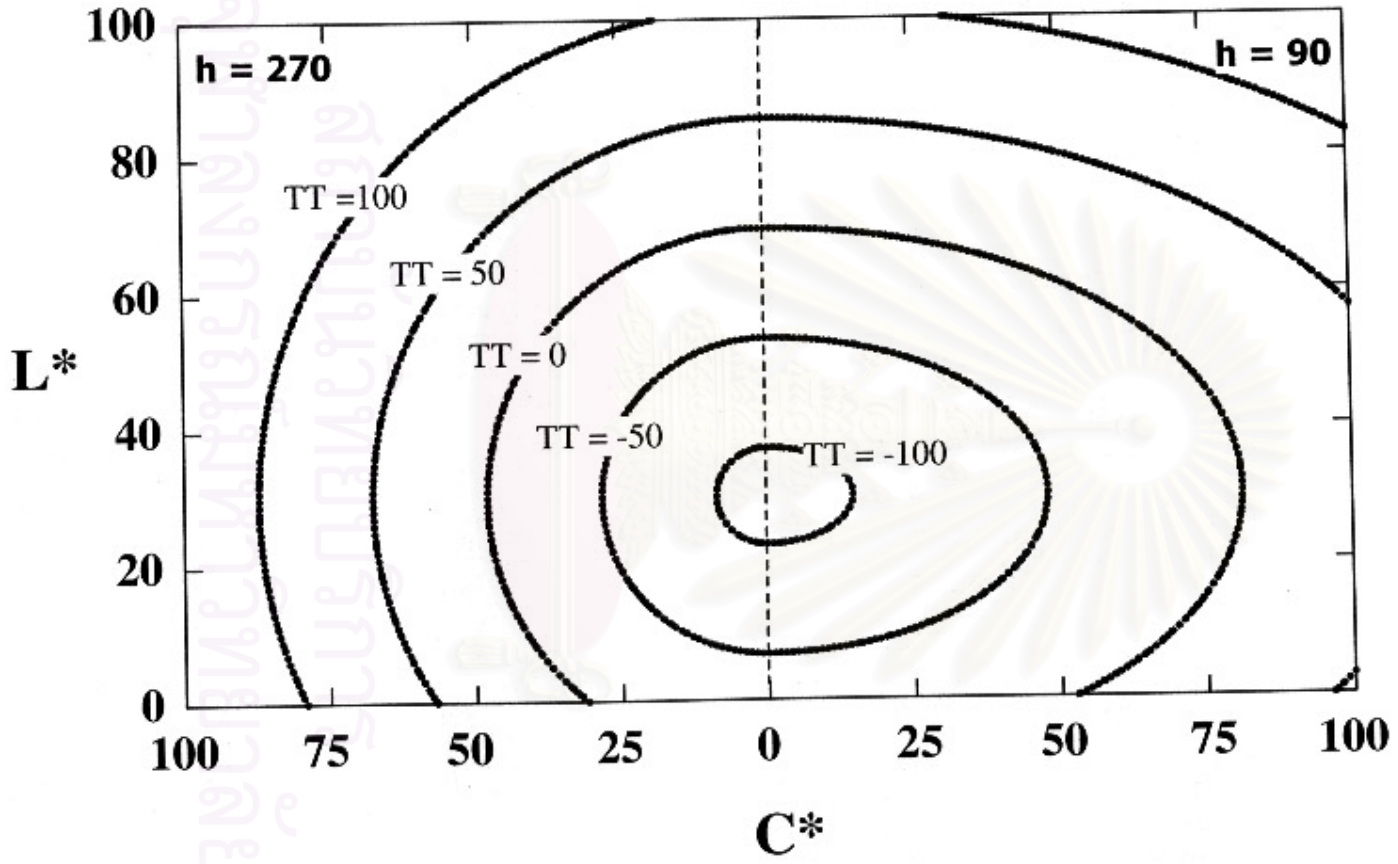

Figure 4-55 Color perception lines of "Transparent-Turbid" on CIE L* C* (h=270 and h=90) plane

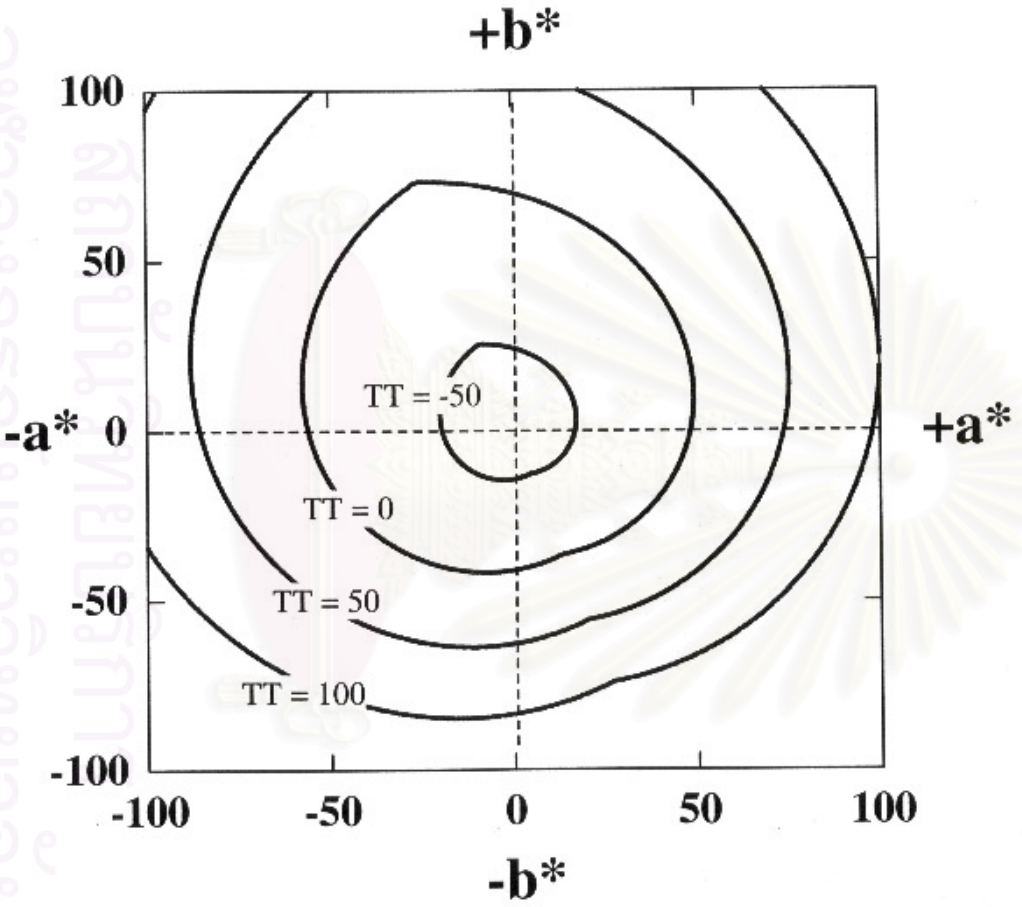

Figure 4-56 Color perception lines of "Transparent-Turbid" on CIE a* b* (L*=50) plane

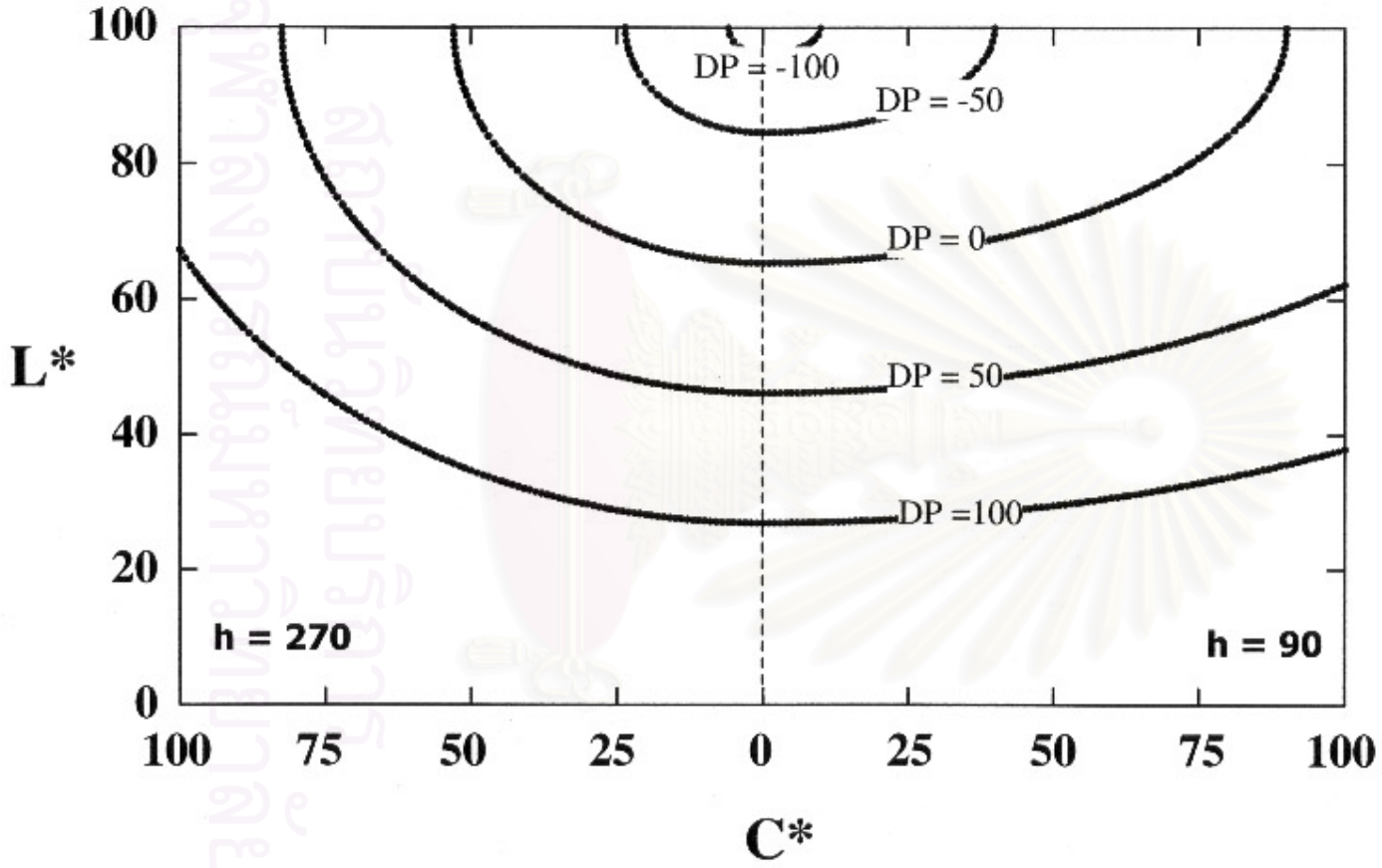

Figure 4-57 Color perception lines of "Deep-Pale" on CIE L* C* (h=270 and h=90) plane

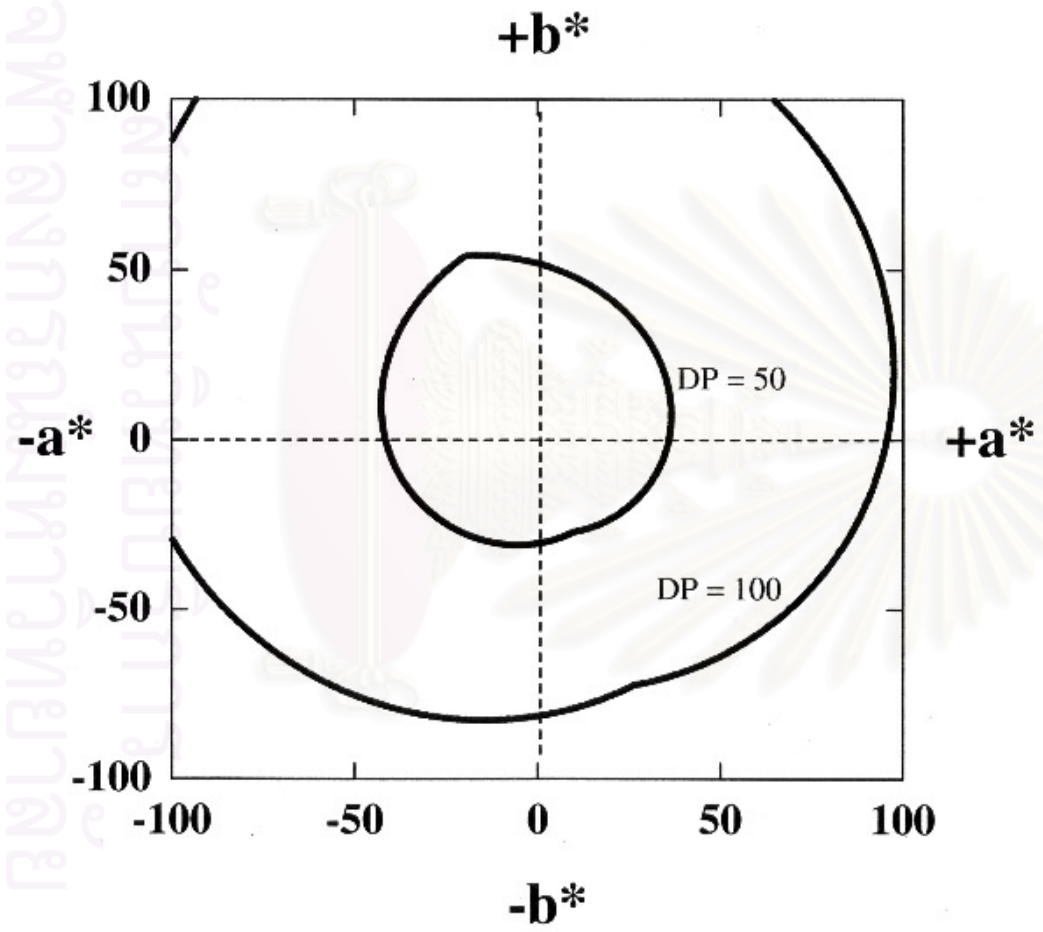

Figure 4-58 Color perception lines of "Deep-Pale" on CIE a* b* (L*=50) plane

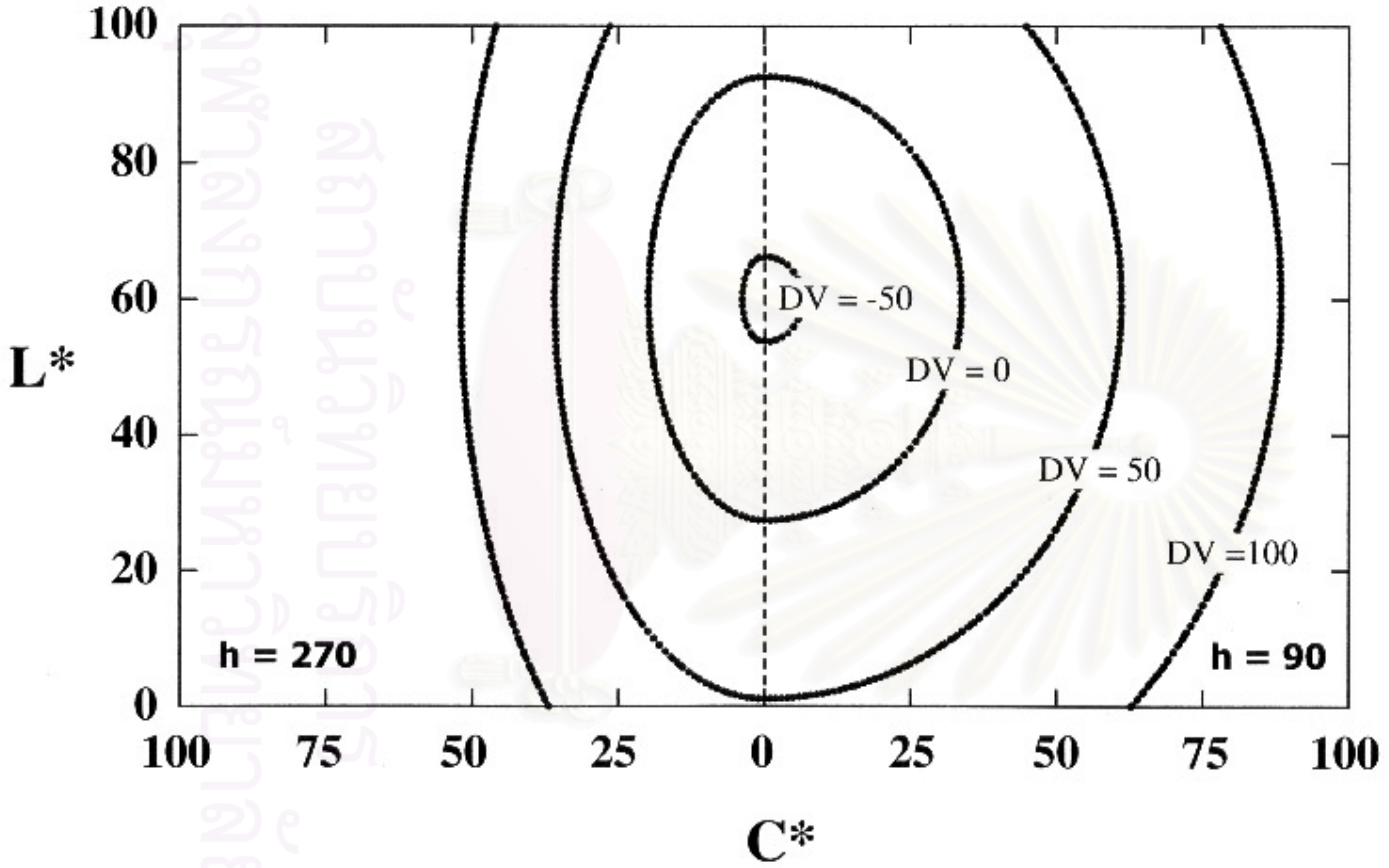

Figure 4-59 Color perception lines of "Distinct-Vague" on CIE L* C* (h=270 and h=90) plane

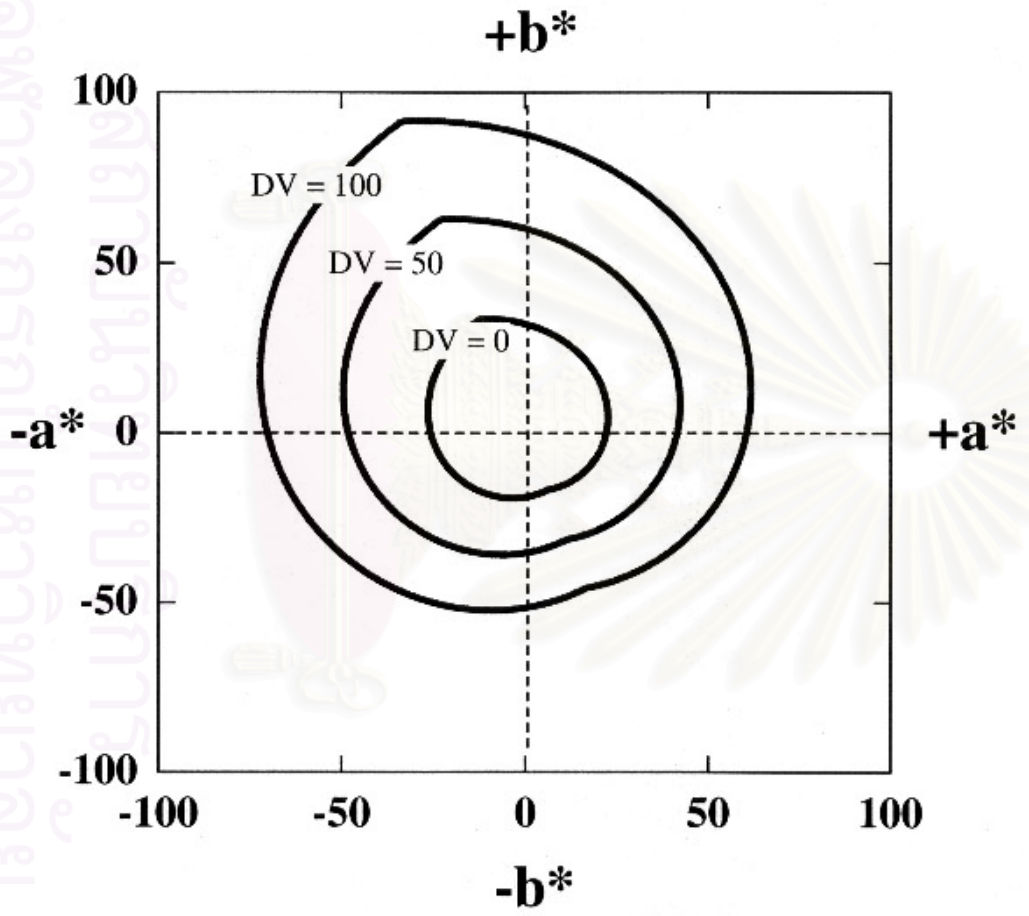

Figure 4-60 Color perception lines of "Distinct-Vague" on CIE a* b* (L*=50) plane

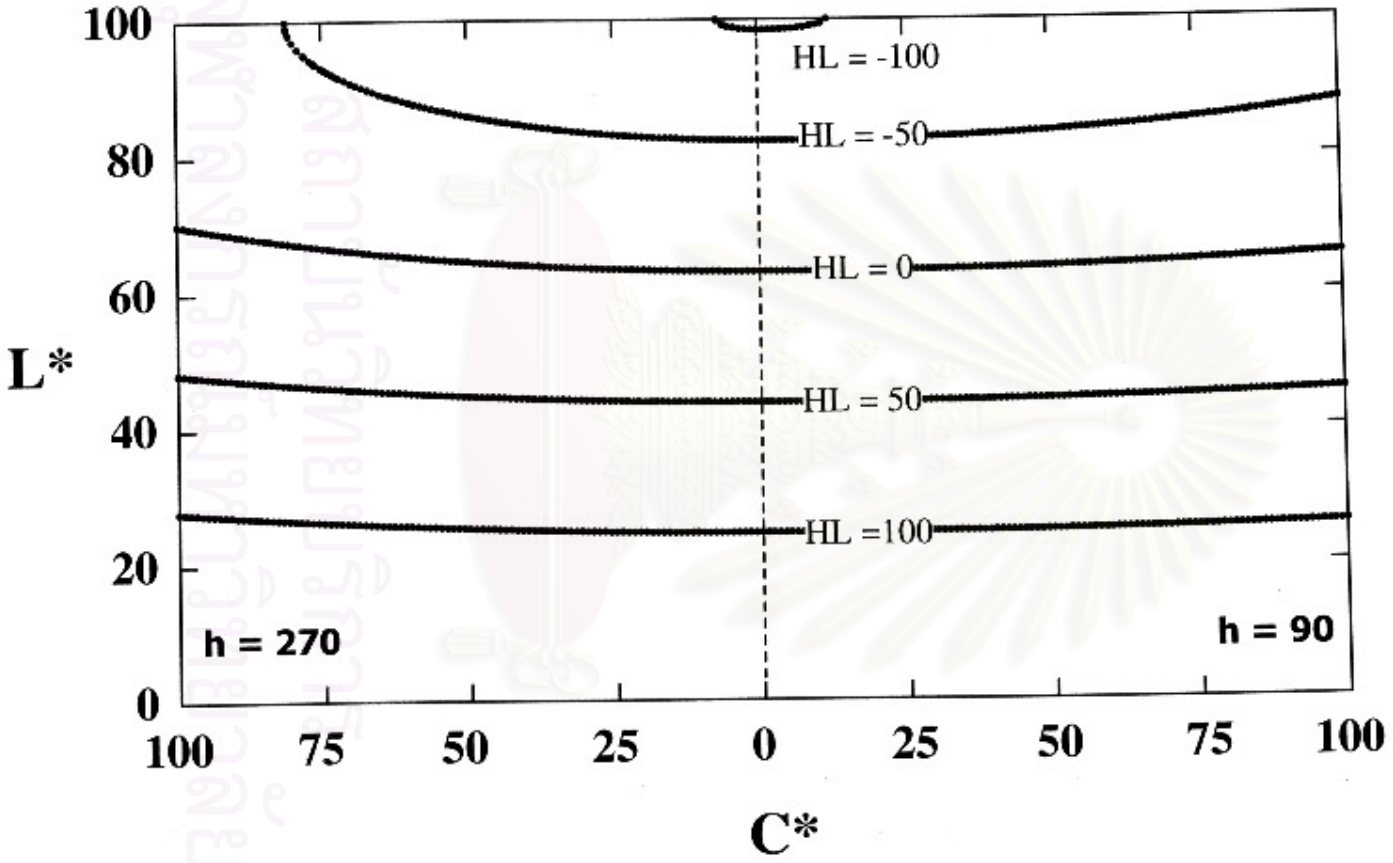

Figure 4-61 Color perception lines of "Heavy-Light" on CIE L* C* (h=270 and h=90) plane

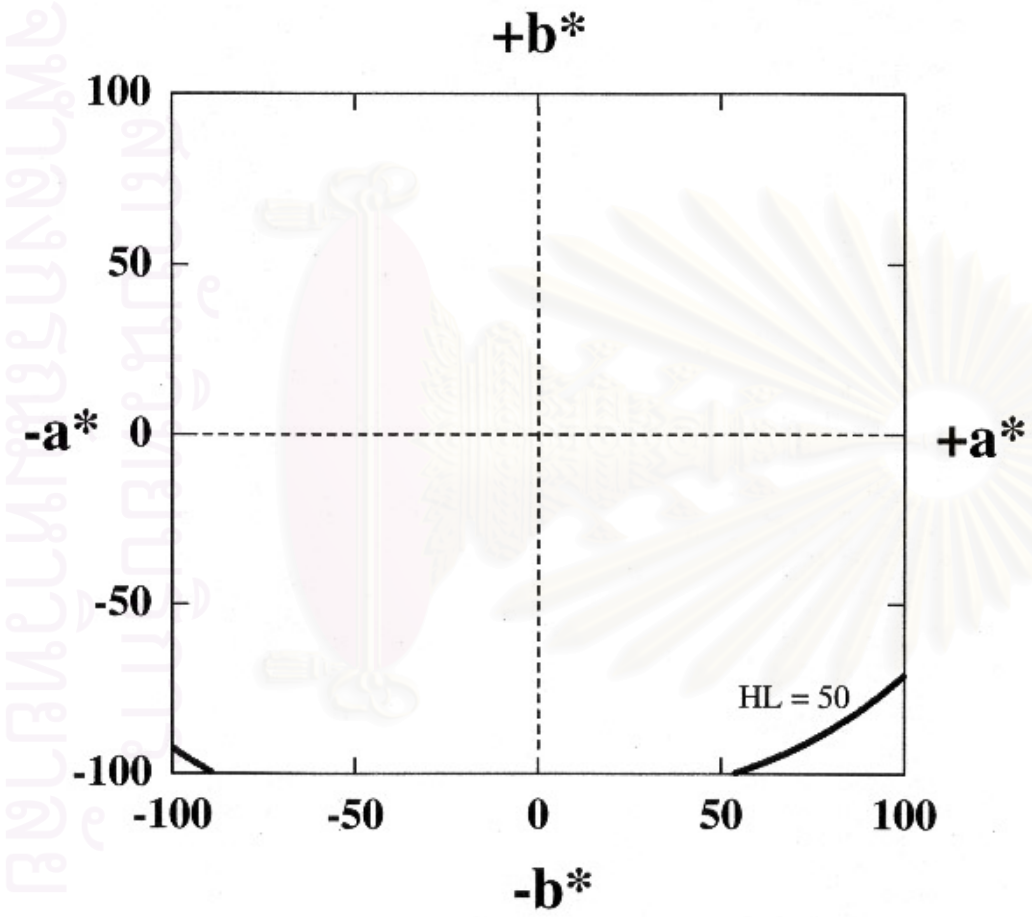

Figure 4-62 Color perception lines of "Heavy-Light" on CIE a* b* (L*=50) plane

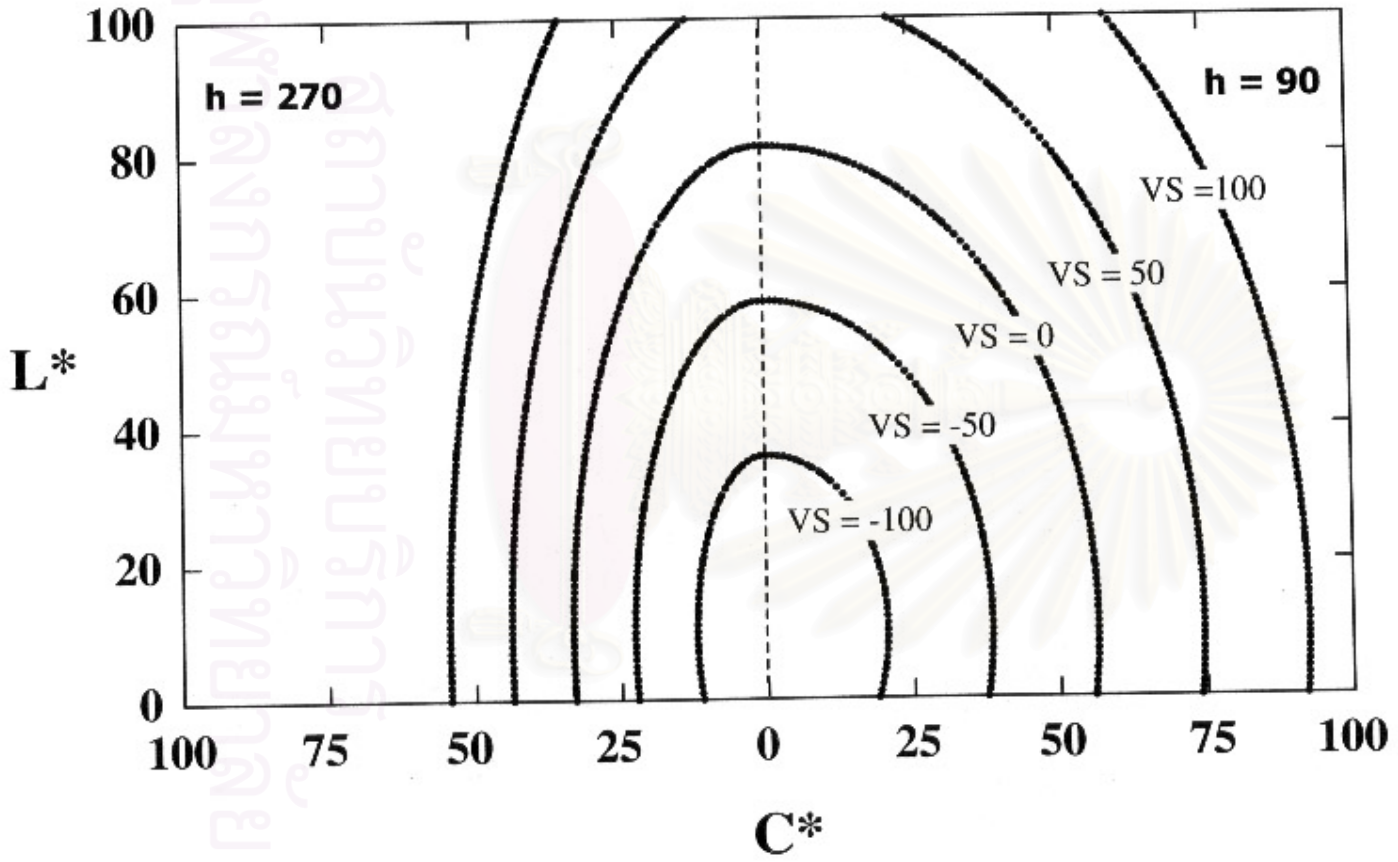

Figure 4-63 Color perception lines of "Vivid-Sombre" on CIE L* C* (h=270 and h=90) plane

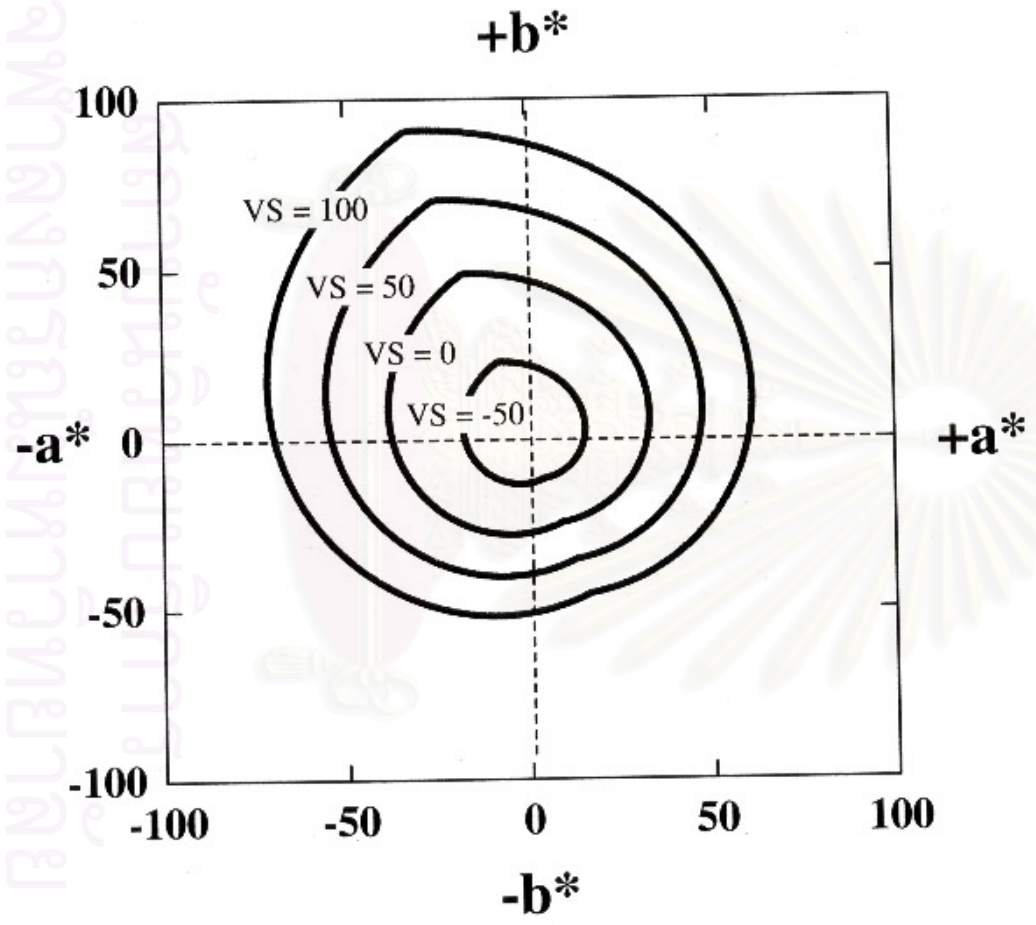

Figure 4-64 Color perception lines of "Vivid-Sombre" on CIE a* b* (L*=50) plane

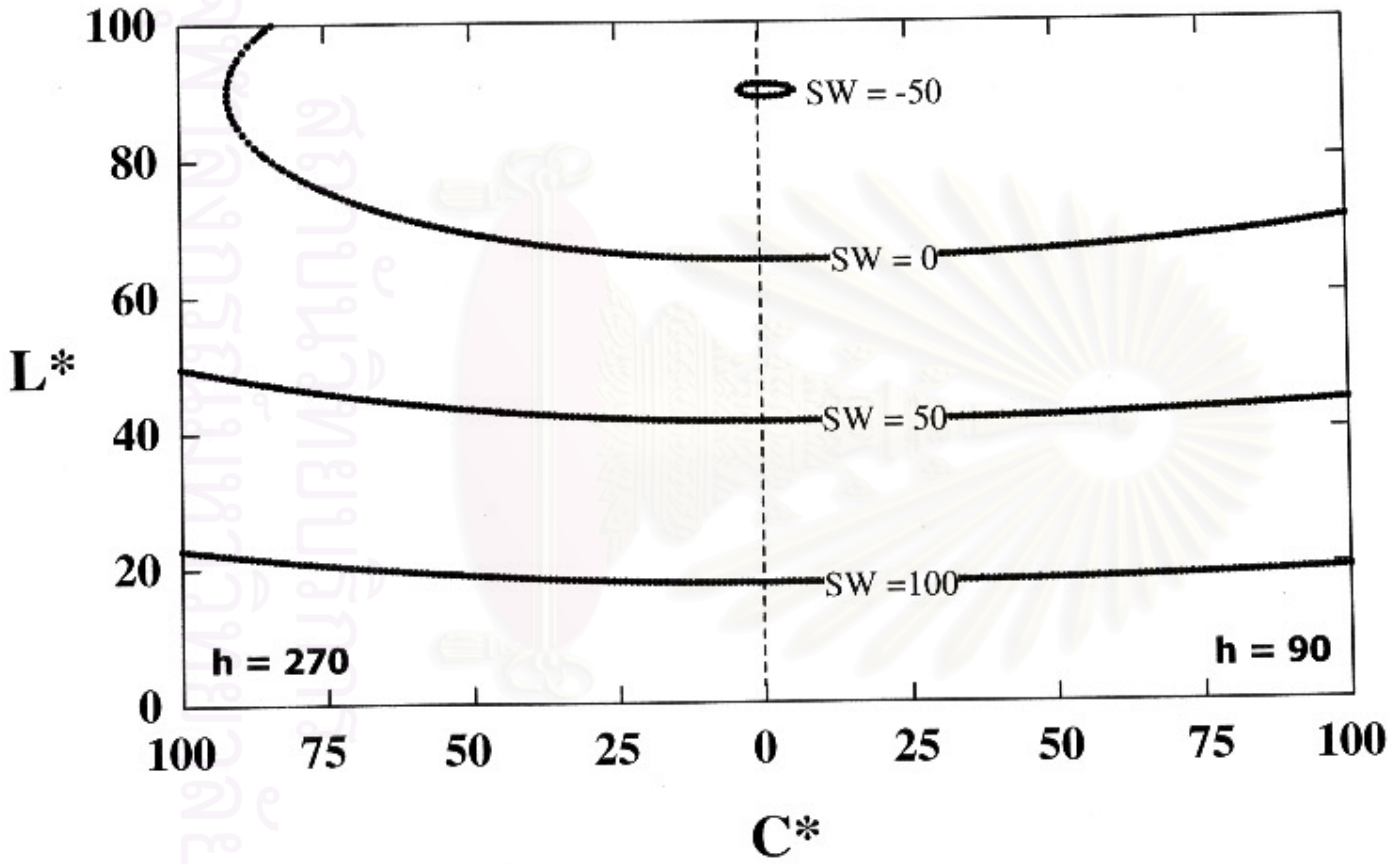

Figure 4-65 Color perception lines of "Strong-Weak" on CIE L* C* (h=270 and h=90) plane

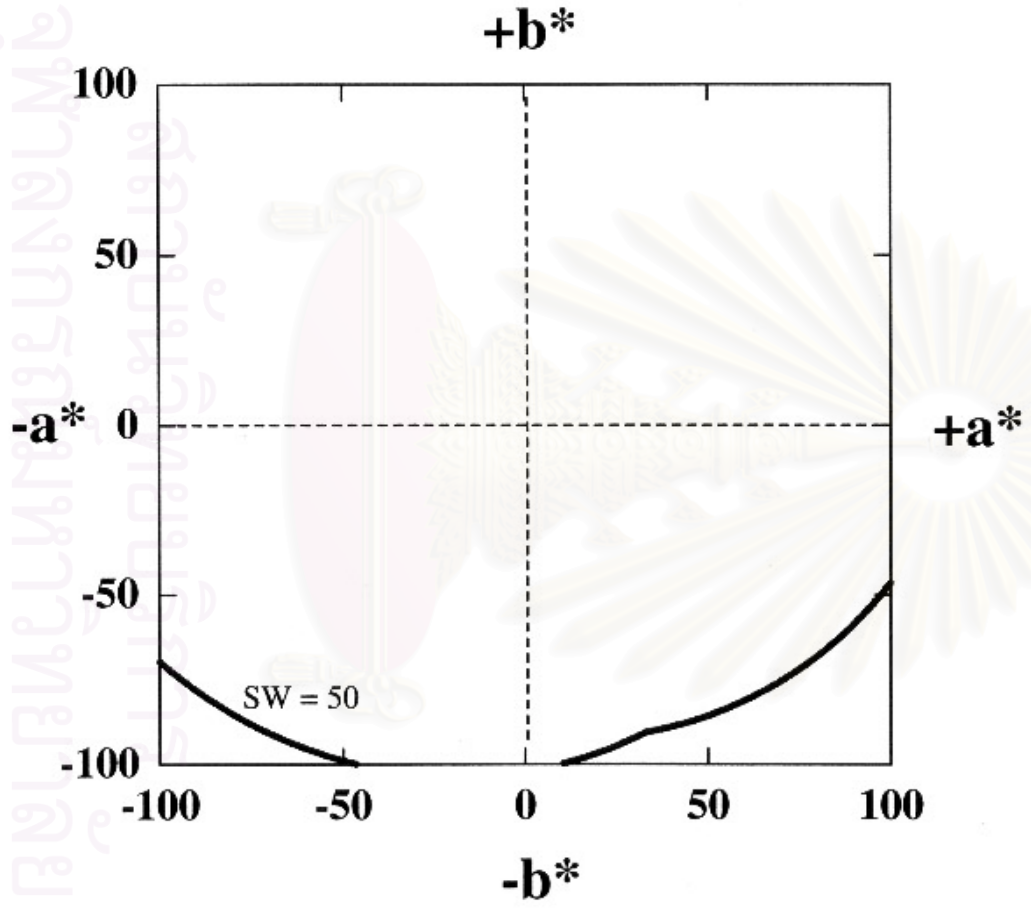

Figure 4-66 Color perception lines of "Strong-Weak" on CIE a* b* (L*=50) plane

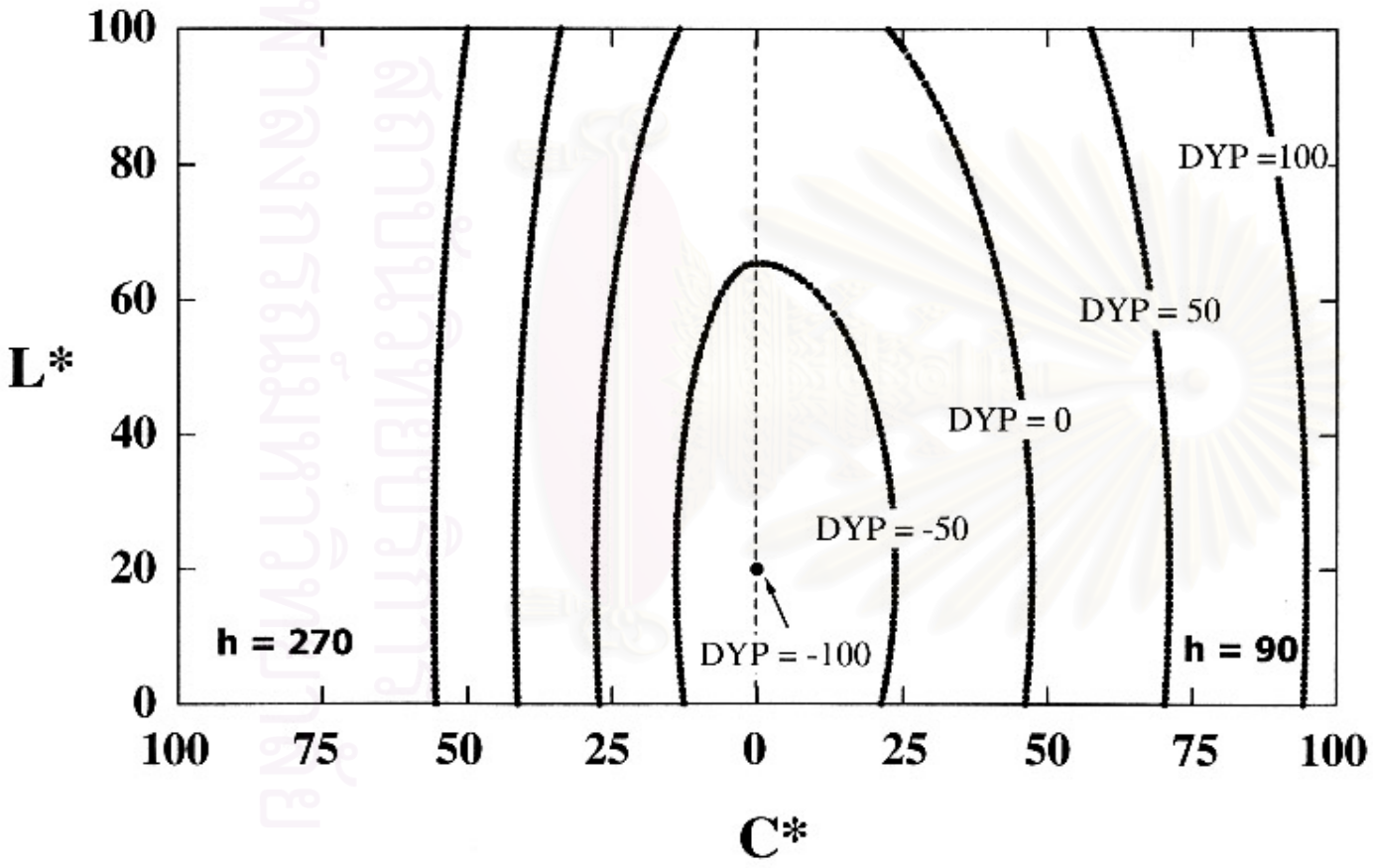

Figure 4-67 Color perception lines of "Dynamic-Passive" on CIE L* C* (h=270 and h=90) plane

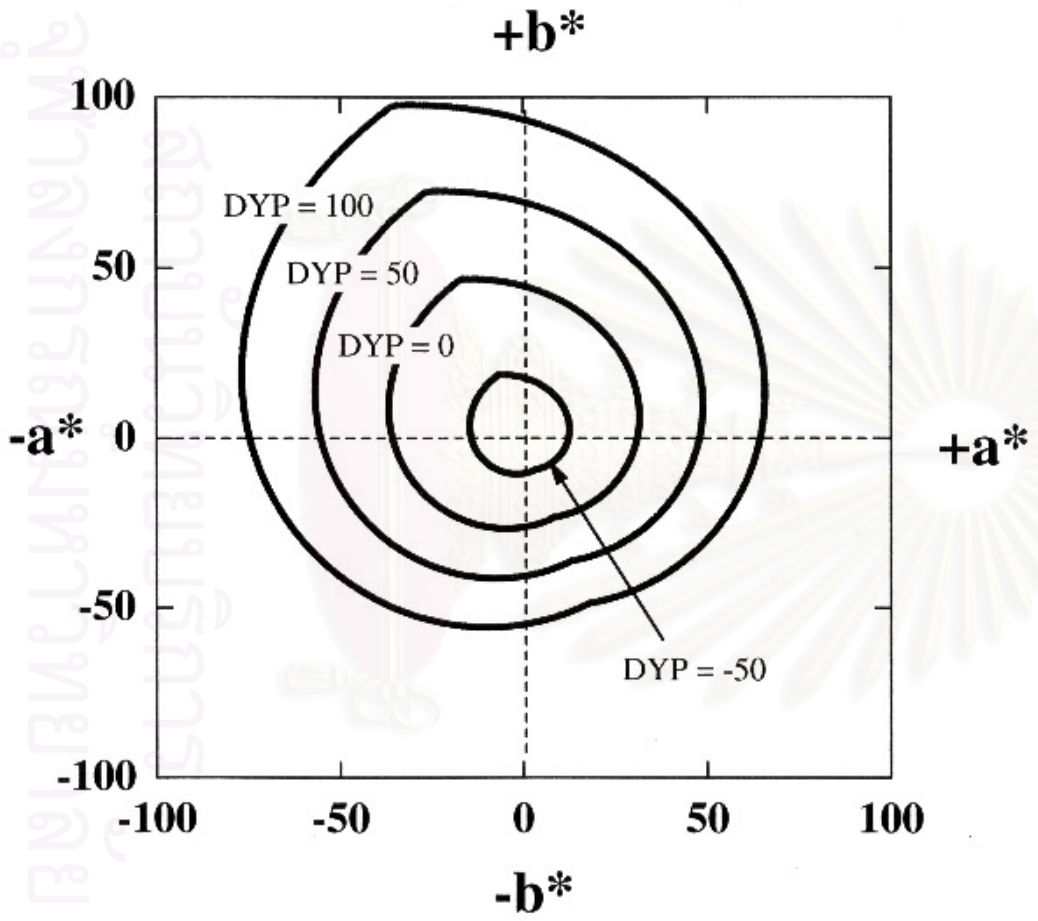

Figure 4-68 Color perception lines of "Dynamic-Passive" on CIE a* b* (L*=50) plane

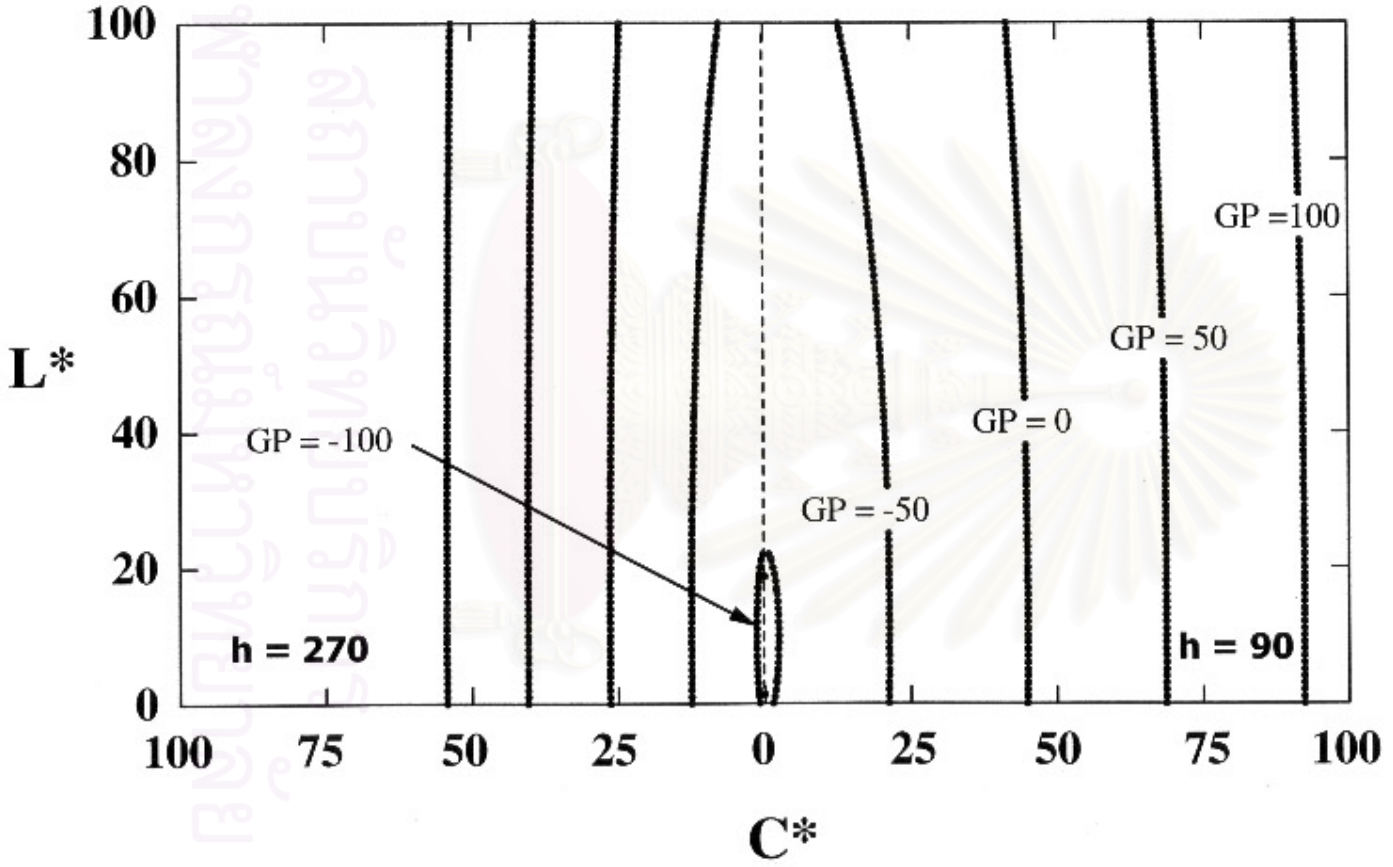

Figure 4-69 Color perception lines of "Gaudy-Plain" on CIE L* C* (h=270 and h=90) plane

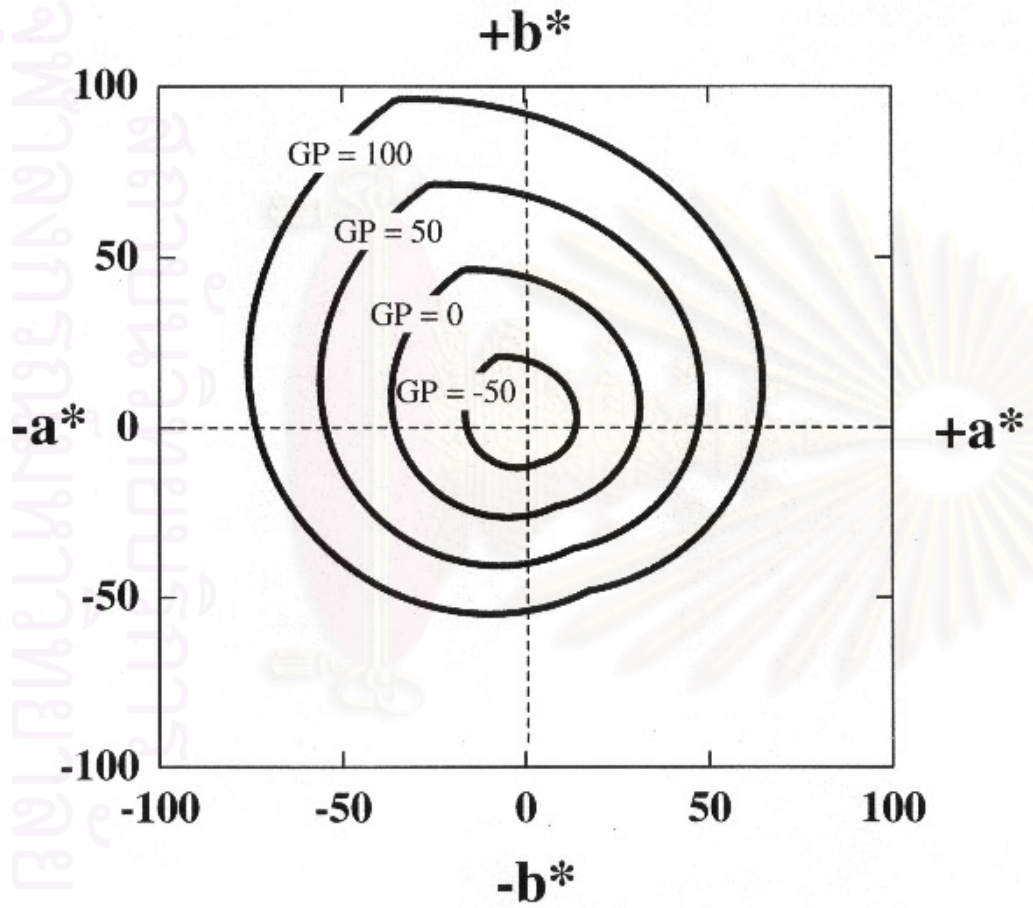

Figure 4-70 Color perception lines of "Gaudy-Plain" on CIE a* b* (L*=50) plane

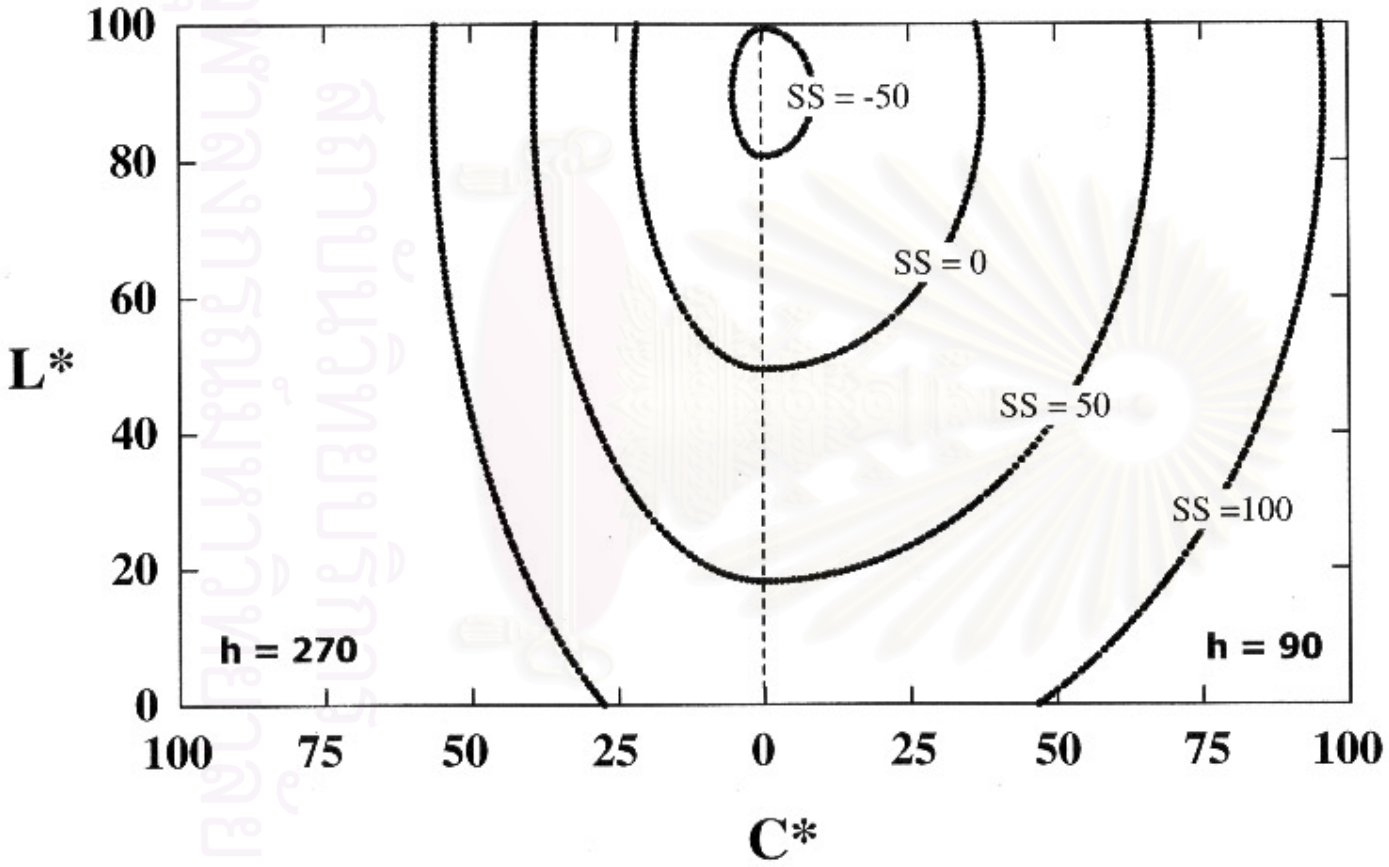

Figure 4-71 Color perception lines of "Striking-Subdued" on CIE L* C* (h=270 and h=90) plane

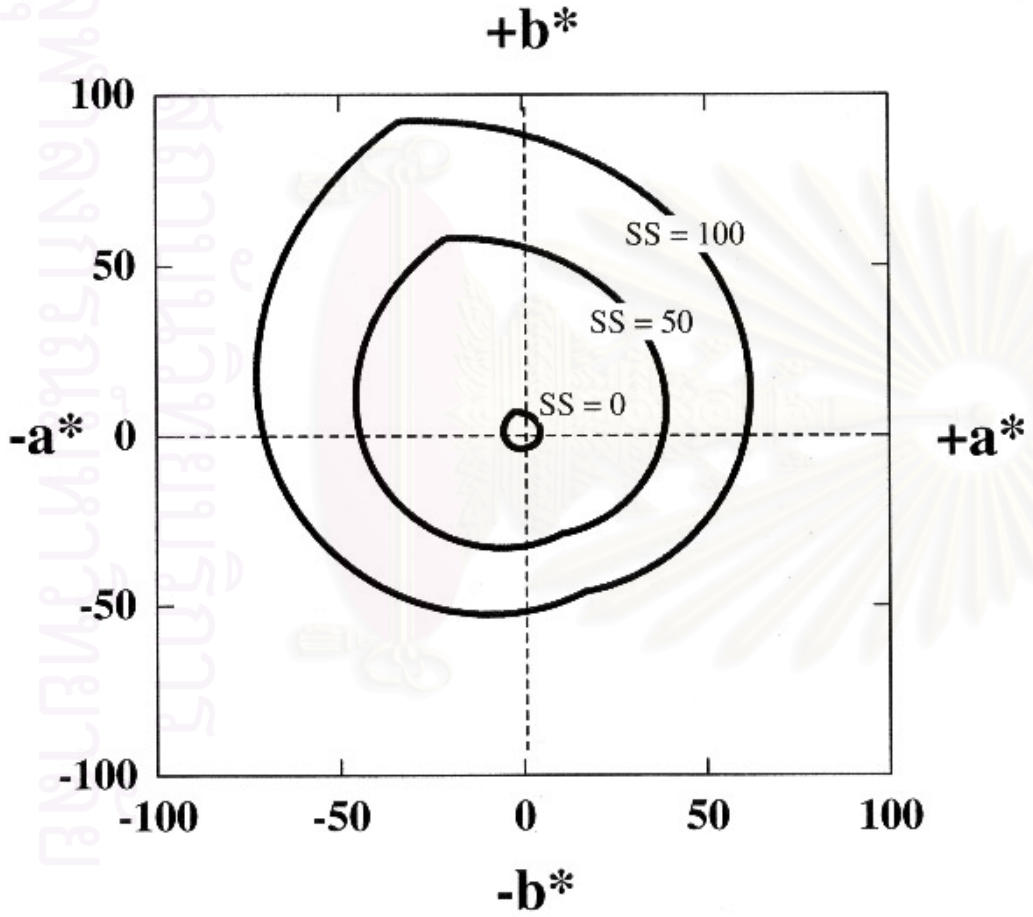

Figure 4-72 Color perception lines of "Striking-Subdued" on CIE a* b* (L*=50) plane

4.4 Color Perception Maps

The relationships between two opponent word pairs in terms of L* and C* were projected on the color perception maps through color perception equations are shown in Figure 4-73 to Figure 4-138. For example, Figure 4-76 means the lightness of “Light-Dark” and “Deep-Pale” gives a positive response but the chroma negative response in Figure 4-130 means both lightness and chroma of “Vivid-Sombre” and ”Dynamic-Passive” a yields positive response. These figures show the degree of the color perception in blue (h=270) and yellowish red (h=90) areas. The color perception maps can be a useful tool for color communication. In addition, the relationships between two opponent word pairs can describe through the correlation coefficient of visual assessment results are shown in Table 4-1.

When the correlation coefficient between two opponent word pairs was high, were describing similar colorimetric properties. From Table 4-1, the correlation coefficients greater than 0.900 were found at:

- “Light-Dark” and “Transparent-Turbid”
- “Deep-Pale” and “Heavy-Light”
- “Deep-Pale” and “Strong-Weak”
- “Heavy-Light” and “Strong-Weak”
- “Vivid-Sombre” and “Dynamic-Passive”
- “Dynamic-Passive” and “Gaudy-Plain”

Table 4-1 Correlation coefficients between the visual assessments against twelve color perceptions

Symbol	LD	SH	WC	TT	DP	DV	HL	VS	SW	DYP	GP	SS
LD	**1**											
SH	0.83994	**1**										
WC	0.24780	- 0.2046	**1**									
TT	**0.97768**	0.87663	0.16517	**1**								
DP	- 0.6928	- 0.8952	0.34277	- 0.7387	**1**							
DV	0.37215	- 0.0551	0.61112	0.32211	0.32429	**1**						
HL	- 0.8256	- 0.9538	0.21785	- 0.8685	**0.96610**	0.12233	**1**					
VS	0.86021	0.55934	0.48547	0.82951	- 0.2780	0.74699	-0.4808	**1**				
SW	- 0.7773	- 0.9492	0.22309	- 0.8187	**0.96412**	0.22456	**0.97322**	-0.4065	**1**			
DYP	0.71931	0.34610	0.66974	0.65500	- 0.0281	0.79009	-0.2382	**0.92824**	- 0.1868	**1**		
GP	0.53286	0.09162	0.77281	0.45728	0.21613	0.86397	0.00609	0.83646	0.06880	**0.94908**	**1**	
SS	- 0.1281	- 0.5227	0.62982	- 0.1833	0.77049	0.83168	0.61313	0.35555	0.67568	0.53275	0.71909	**1**

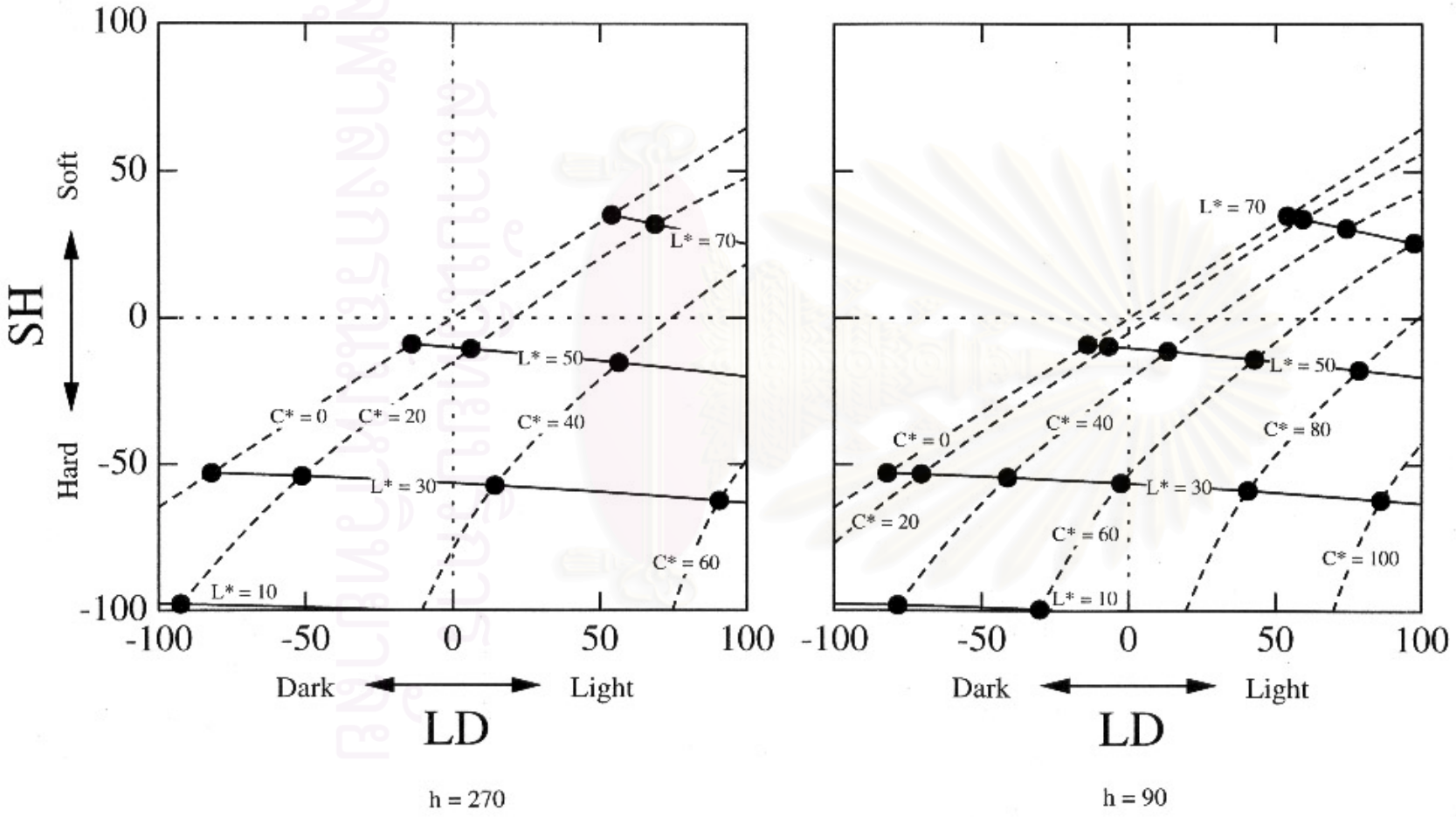

Figure 4-73 The projection of L* C* on LD-SH color perception map : h = 270, h = 90

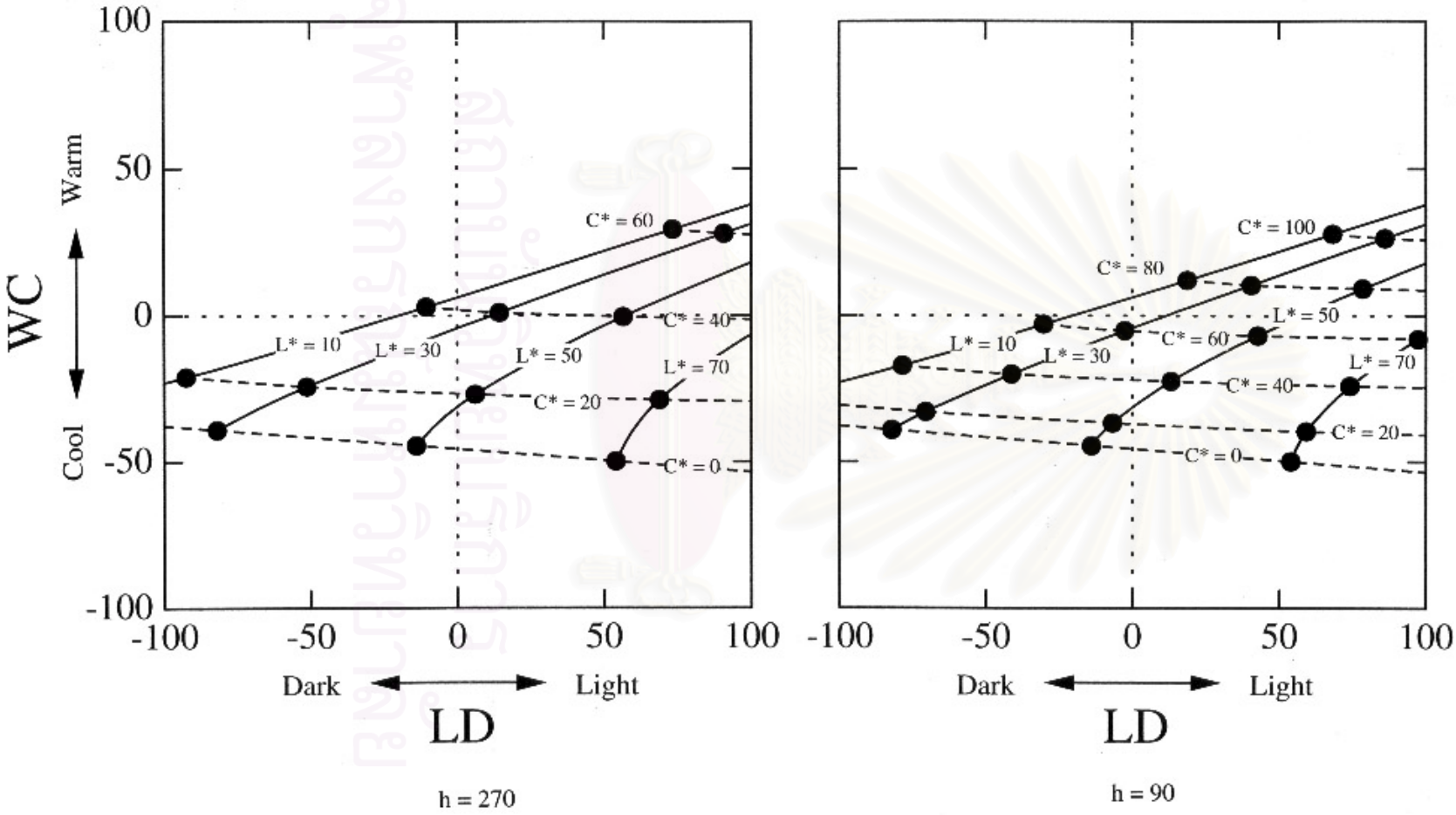

Figure 4-74 The projection of L* C* on LD-WC color perception map : h = 270, h = 90

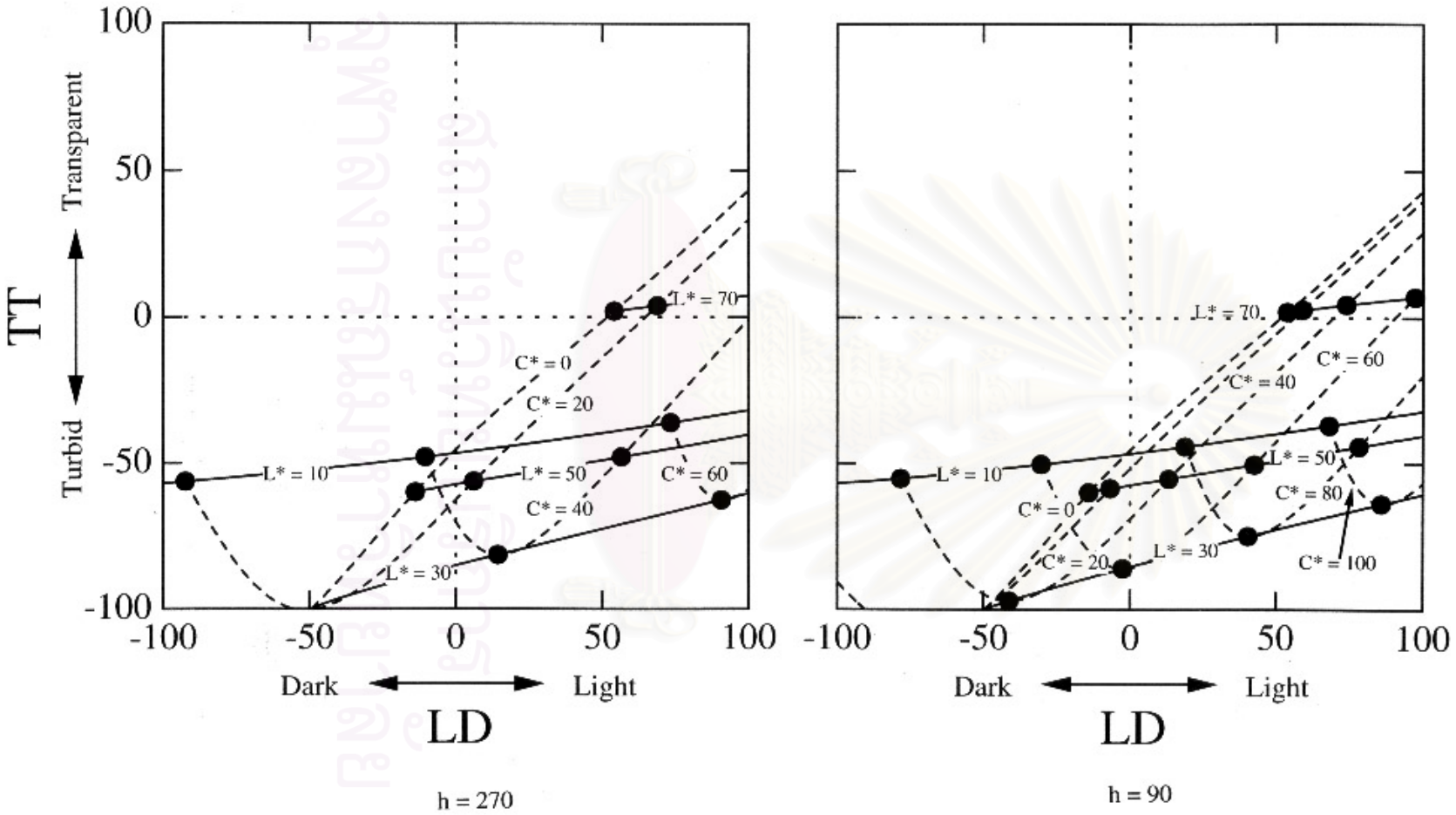

Figure 4-75 The projection of L* C* on LD-TT color perception map : h = 270, h = 90

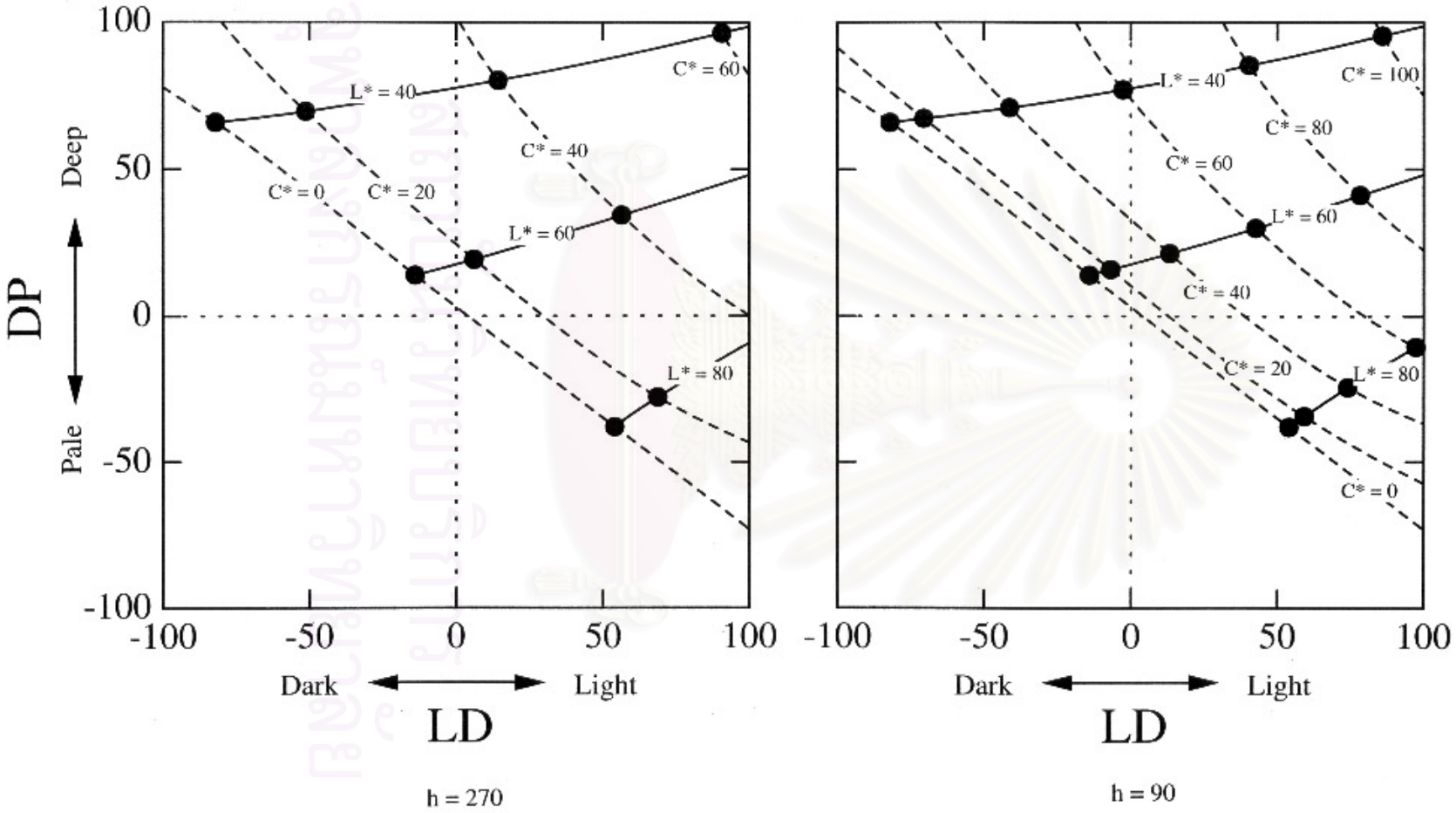

Figure 4-76 The projection of L* C* on LD-DP color perception map : h = 270, h = 90

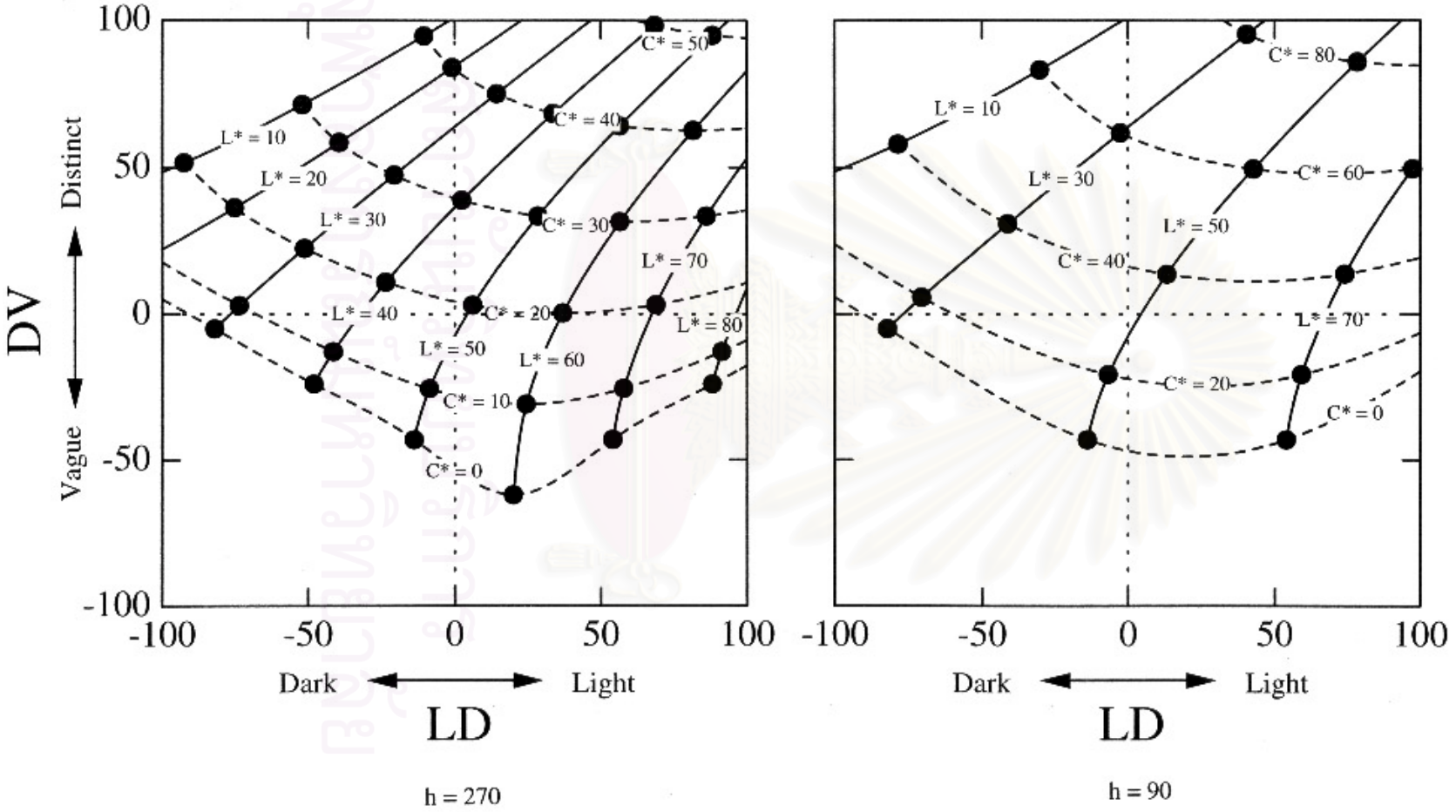

Figure 4-77 The projection of L* C* on LD-DV color perception map : h = 270, h = 90

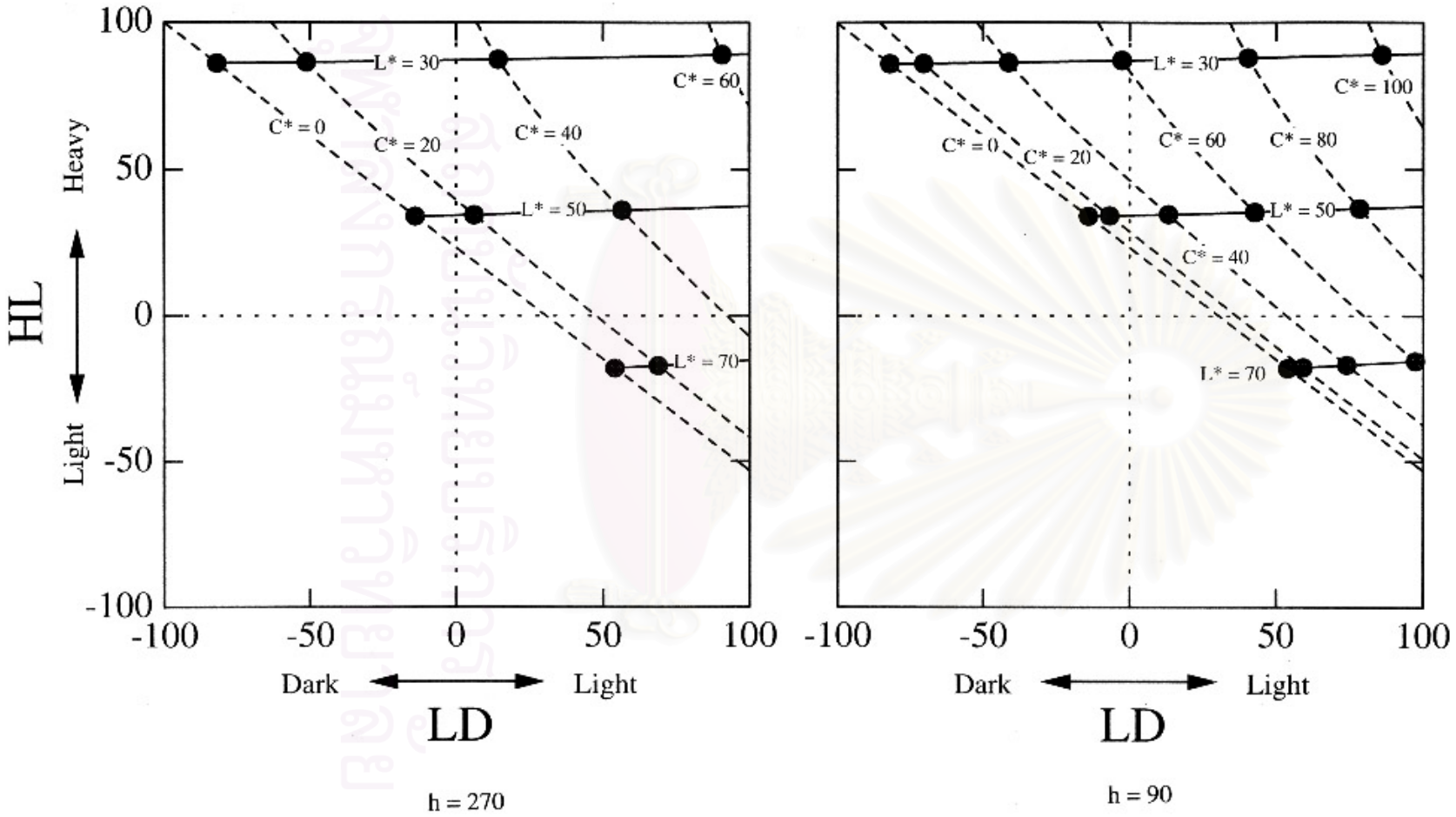

Figure 4-78 The projection of L* C* on LD-HL color perception map : h = 270, h = 90

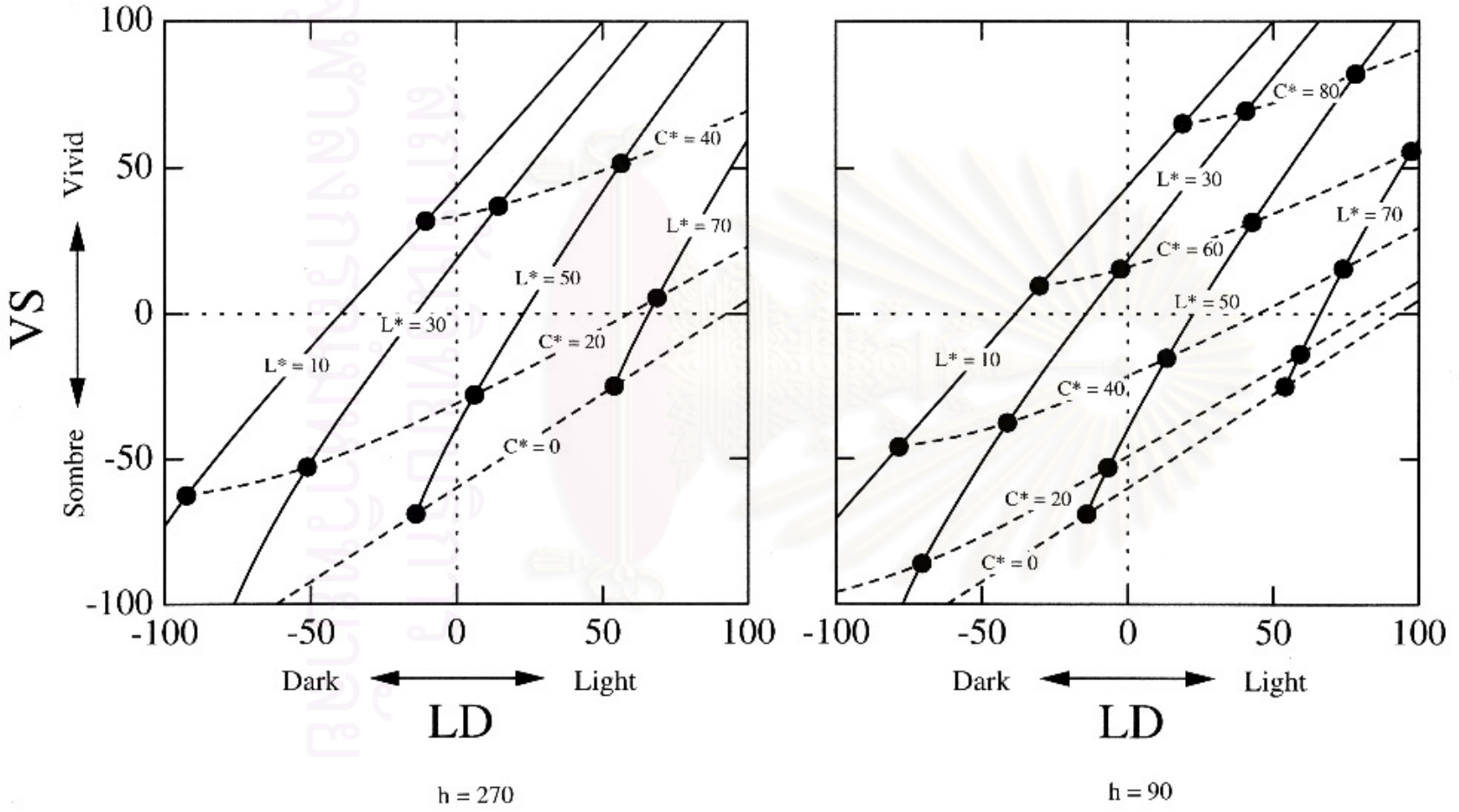

Figure 4-79 The projection of L* C* on LD-VS color perception map : h = 270, h = 90

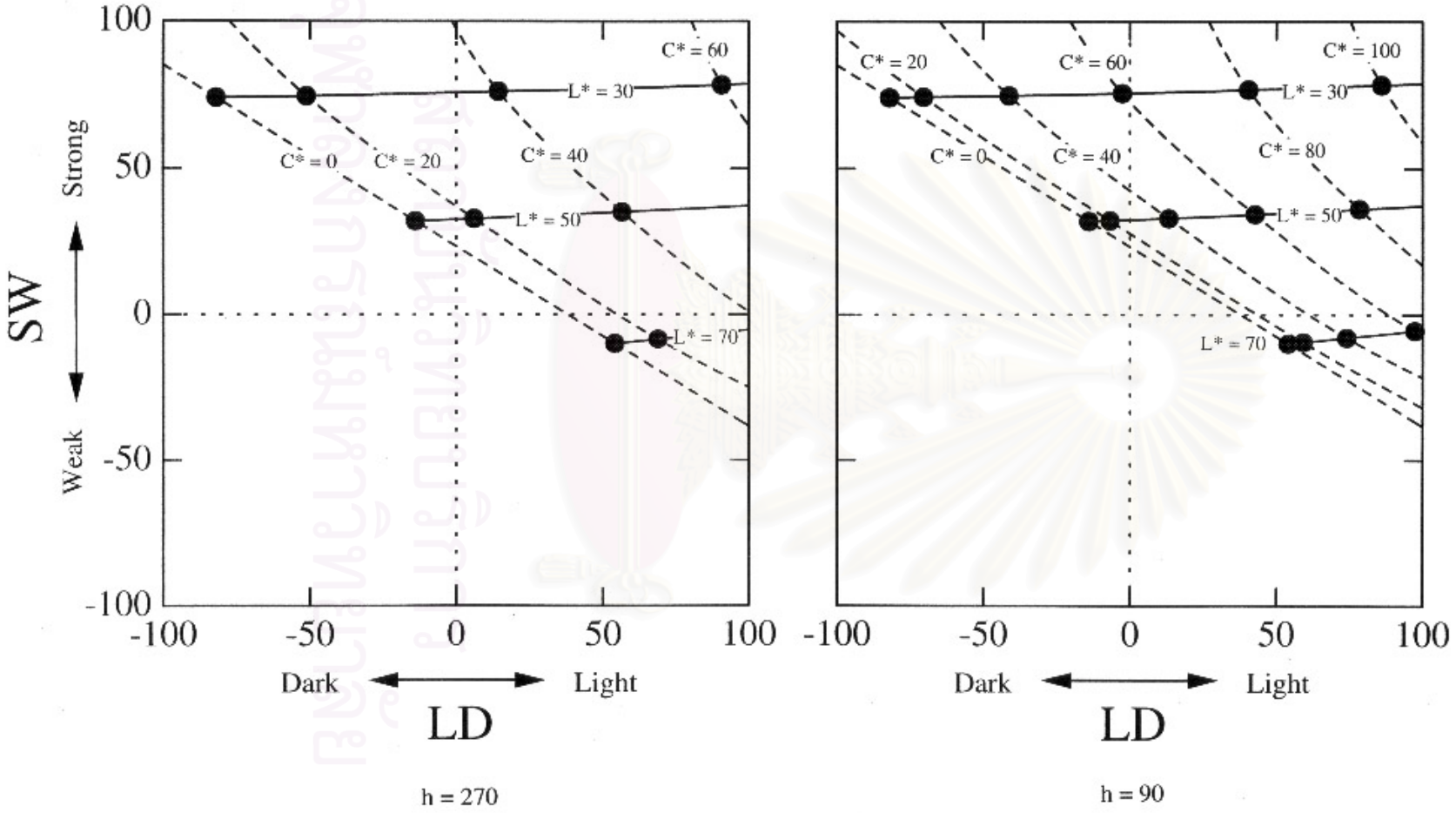

Figure 4-80 The projection of L* C* on LD-SW color perception map : h = 270, h = 90

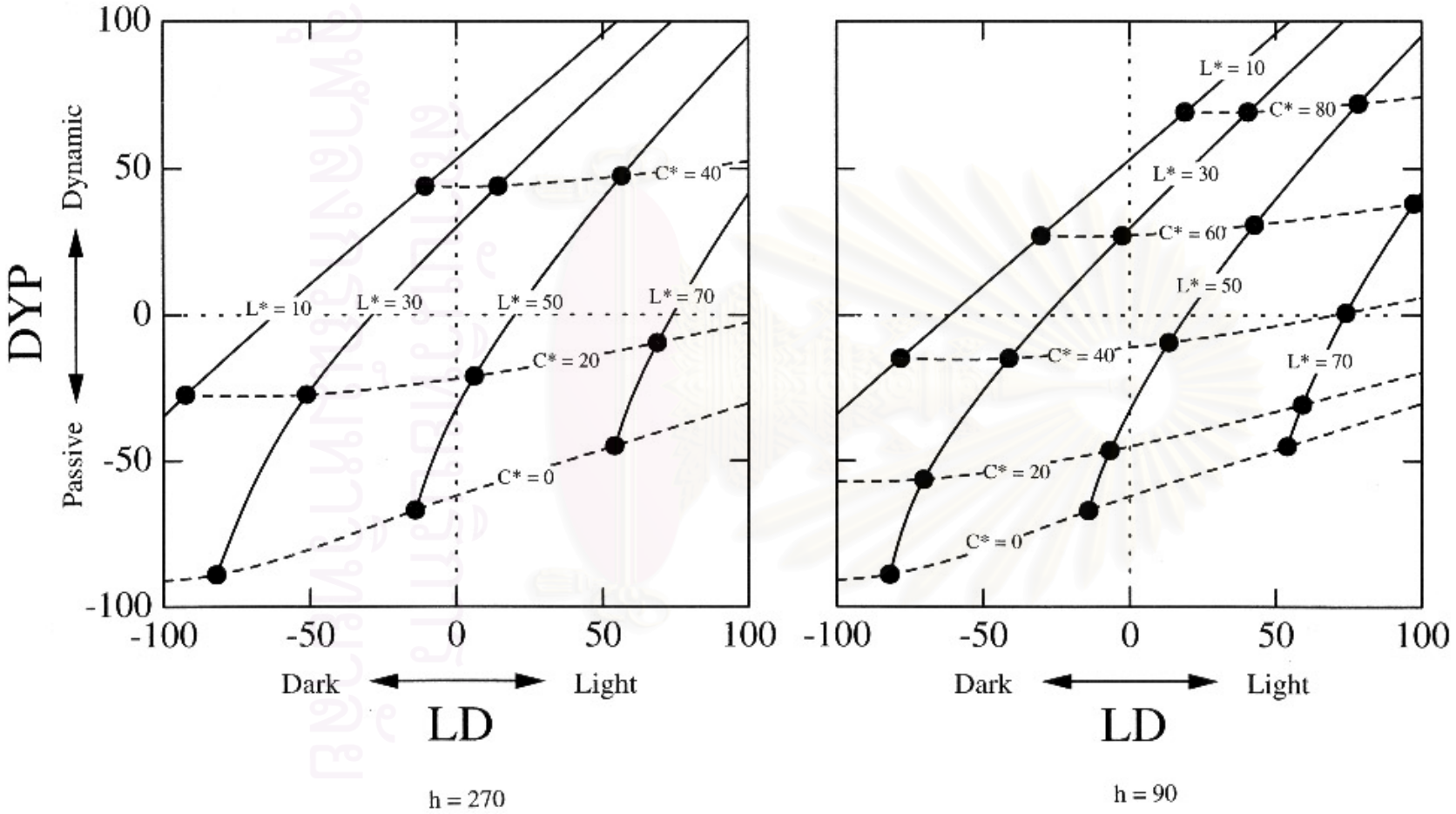

Figure 4-81 The projection of L* C* on LD-DYP color perception map

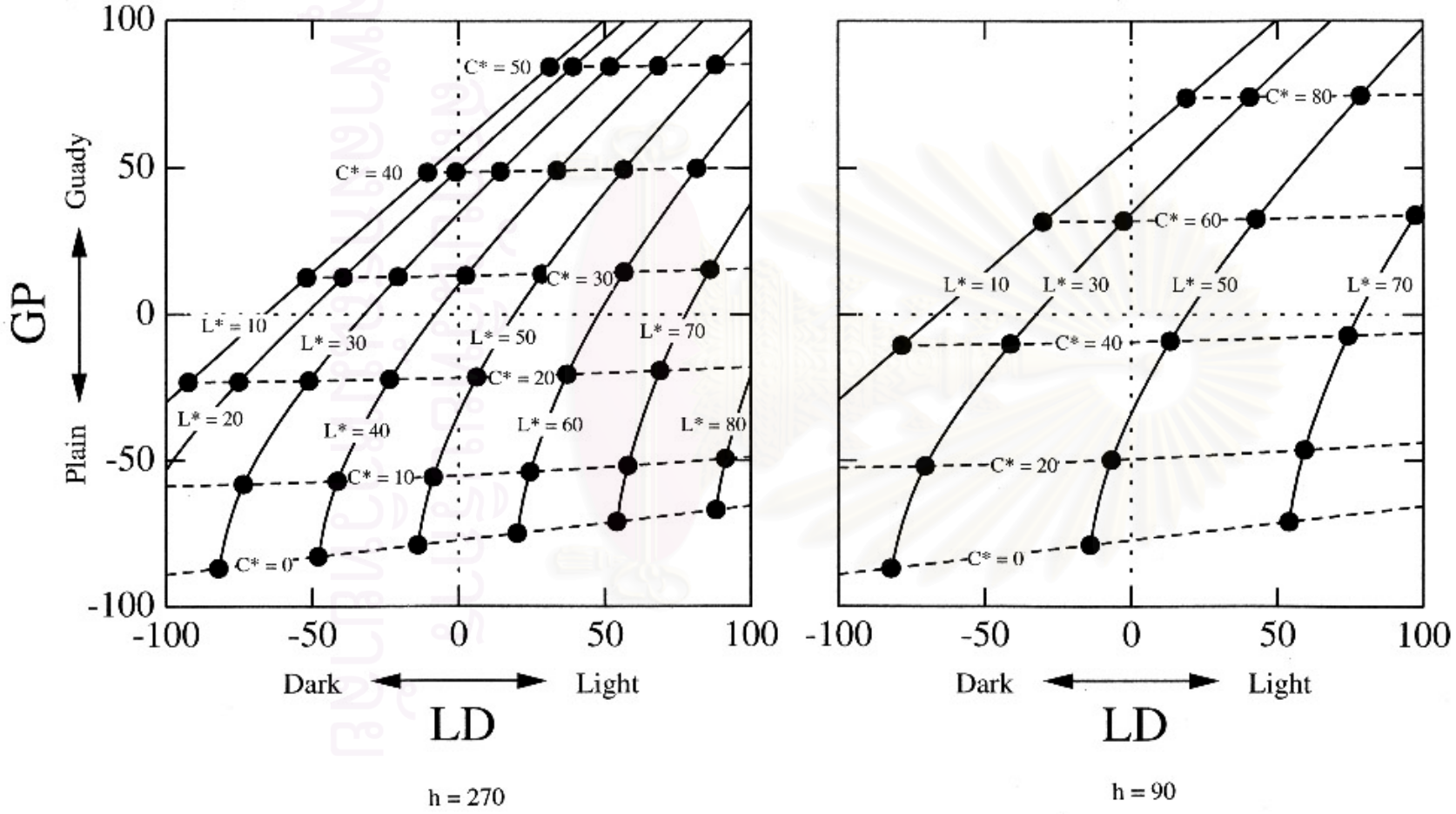

Figure 4-82 The projection of L* C* on LD-GP color perception map : h = 270, h = 90

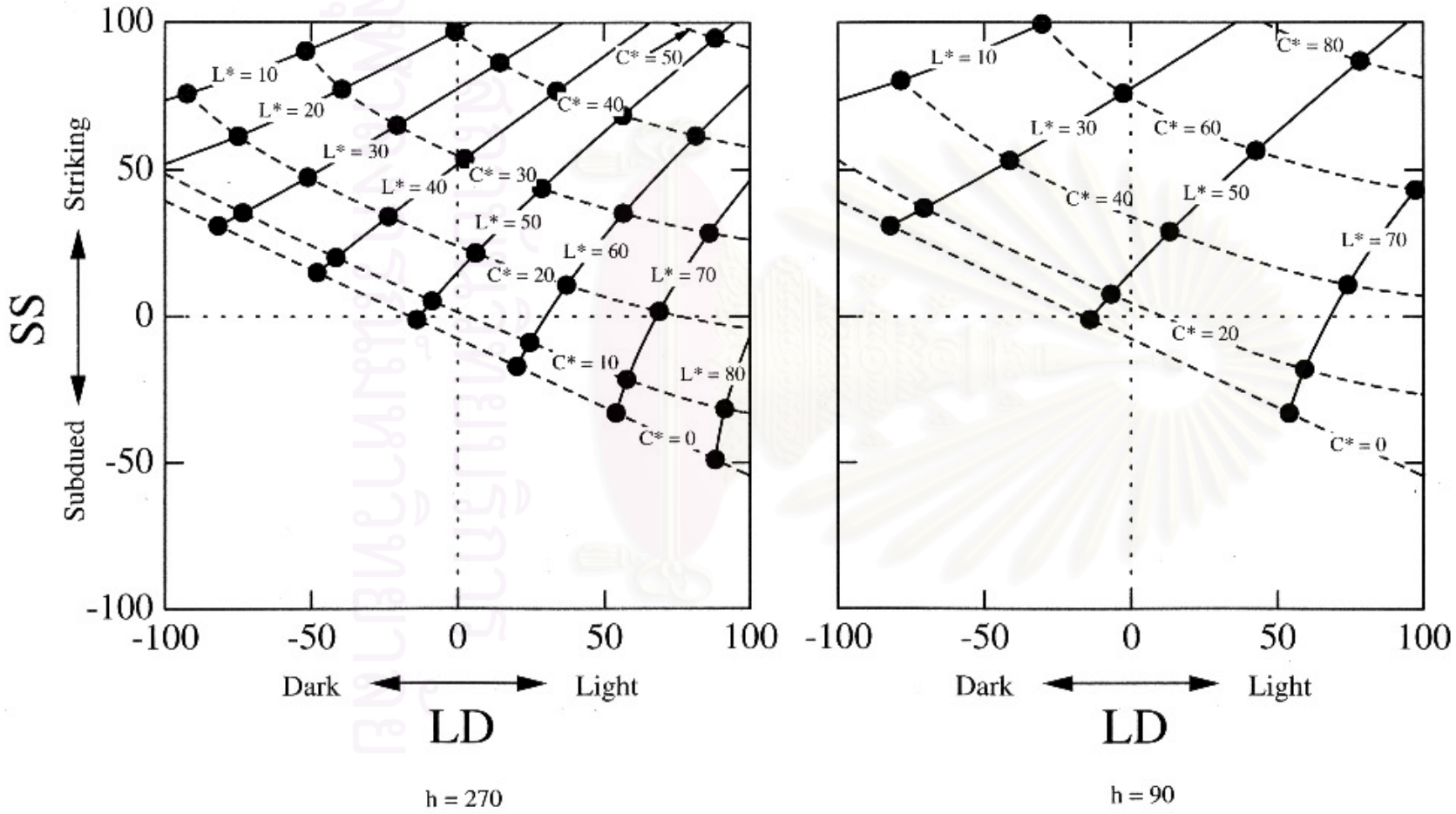

Figure 4-83 The projection of L* C* on LD-SS color perception map : h = 270, h = 90

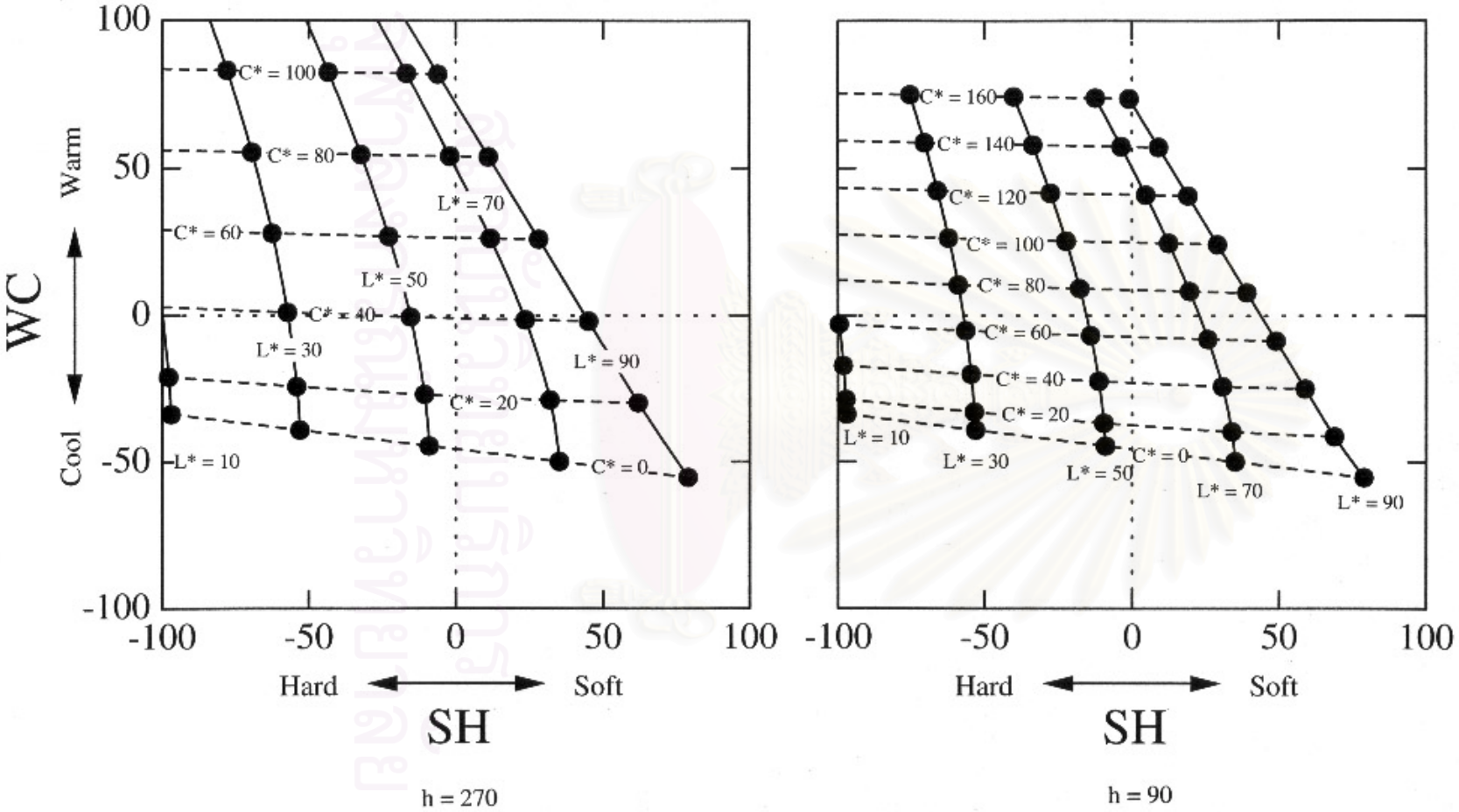

Figure 4-84 The projection of L* C* on SH-WC color perception map : h = 270, h = 90

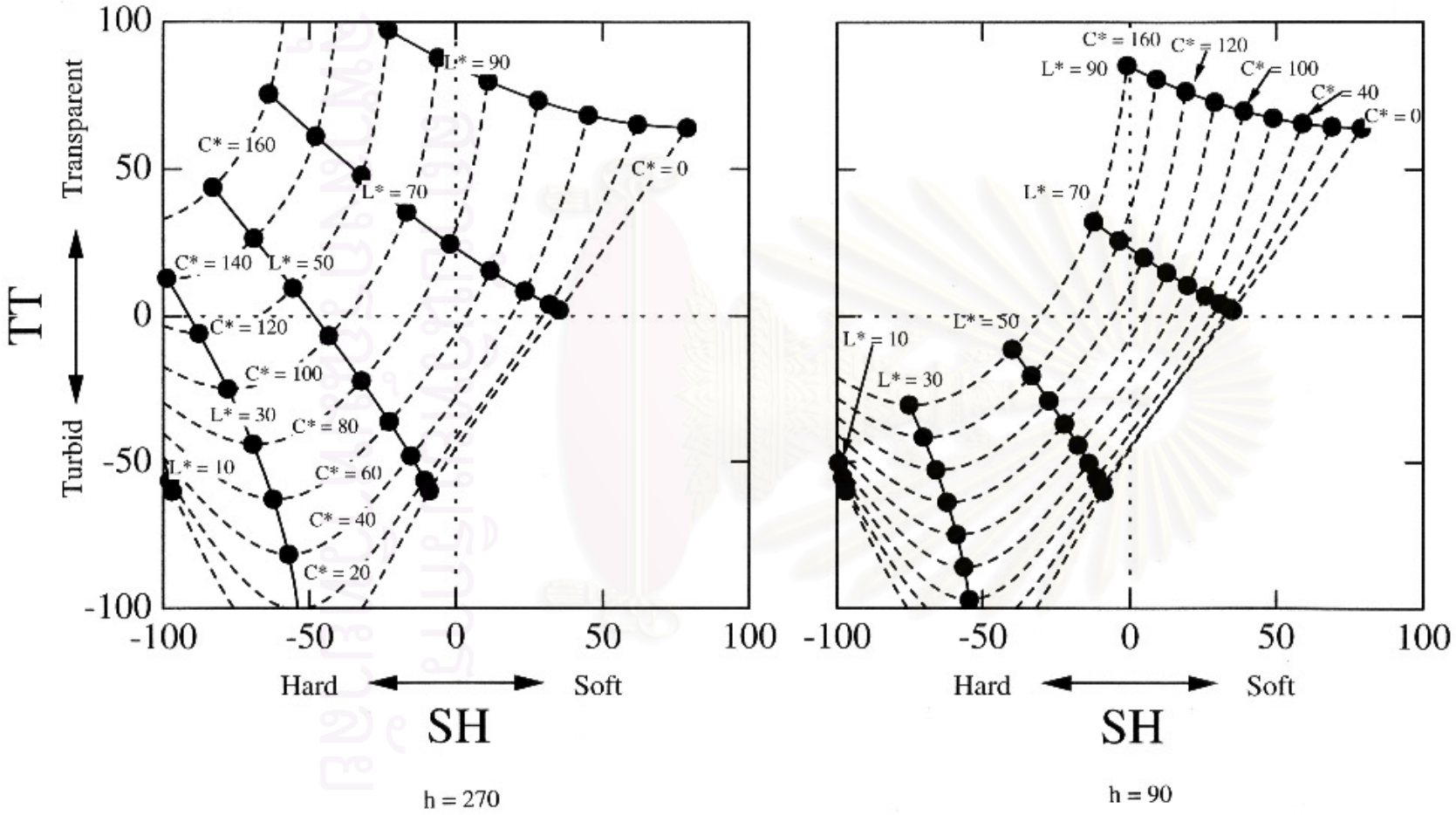

Figure 4-85 The projection of L* C* on SH-TT color perception map : h = 270, h = 90

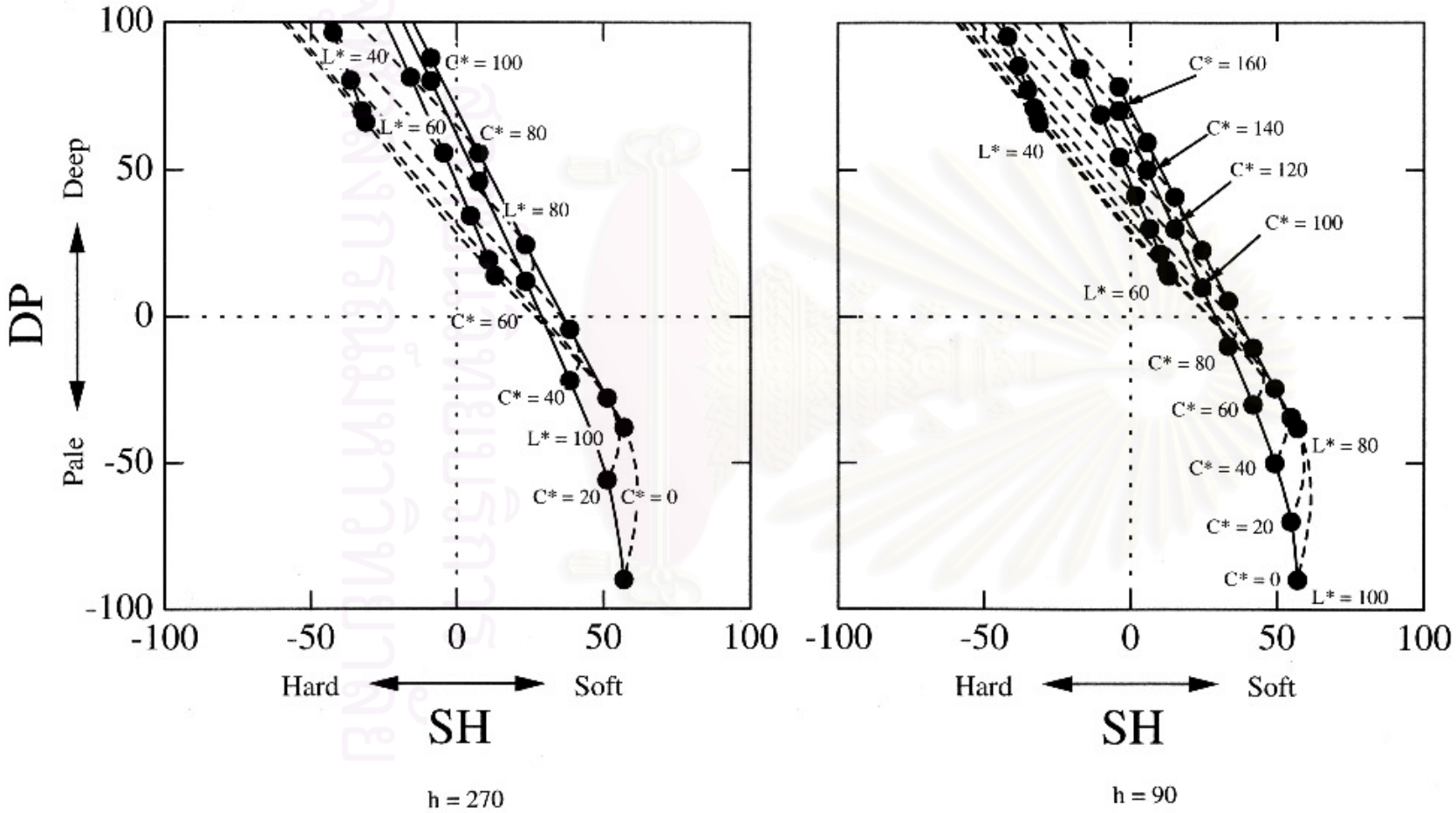

Figure 4-86 The projection of L* C* on SH-DP color perception map : h = 270, h = 90

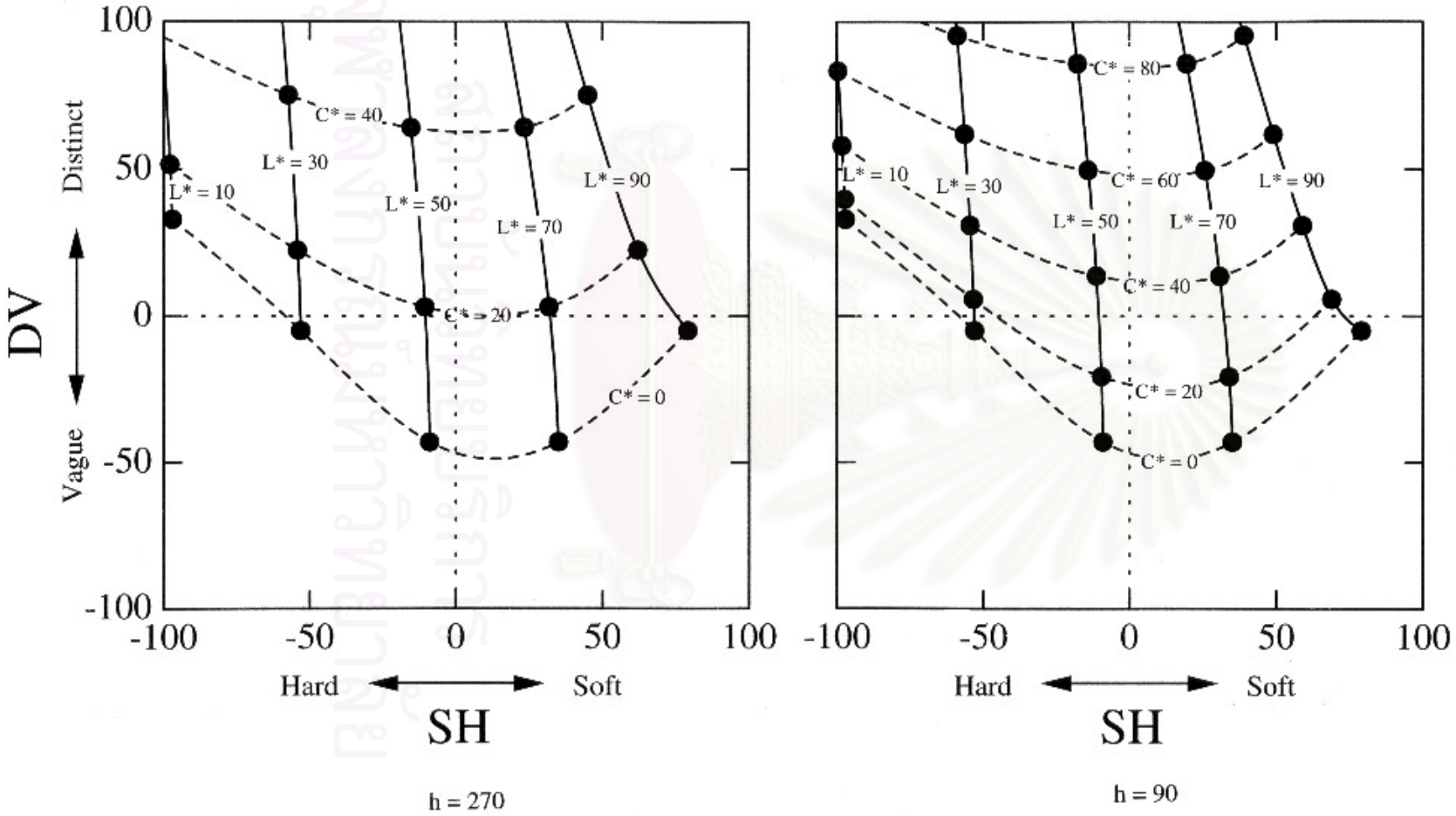

Figure 4-87 The projection of L* C* on SH-DV color perception map : h = 270, h = 90

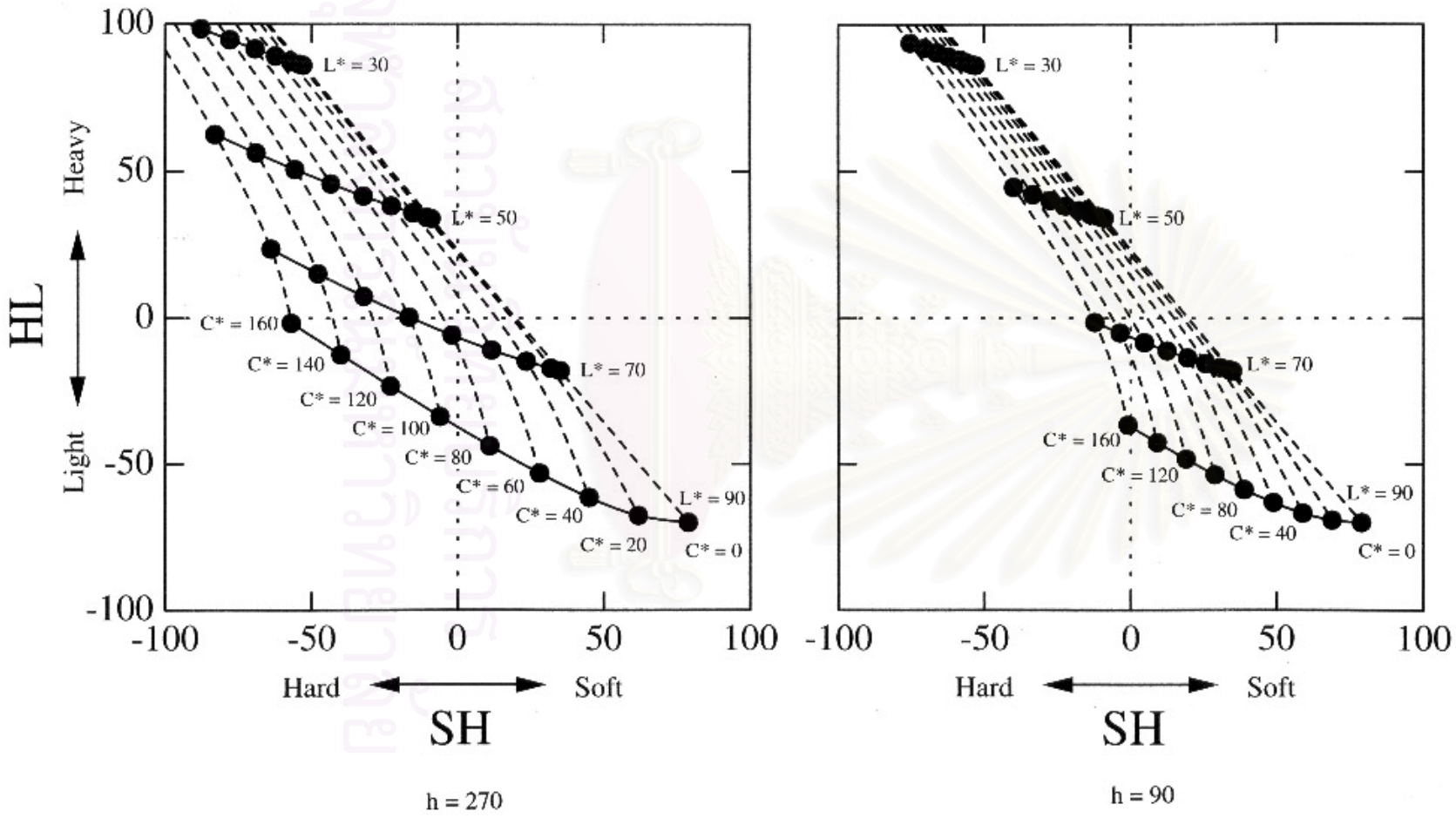

Figure 4-88 The projection of L* C* on SH-HL color perception map : h = 270, h = 90

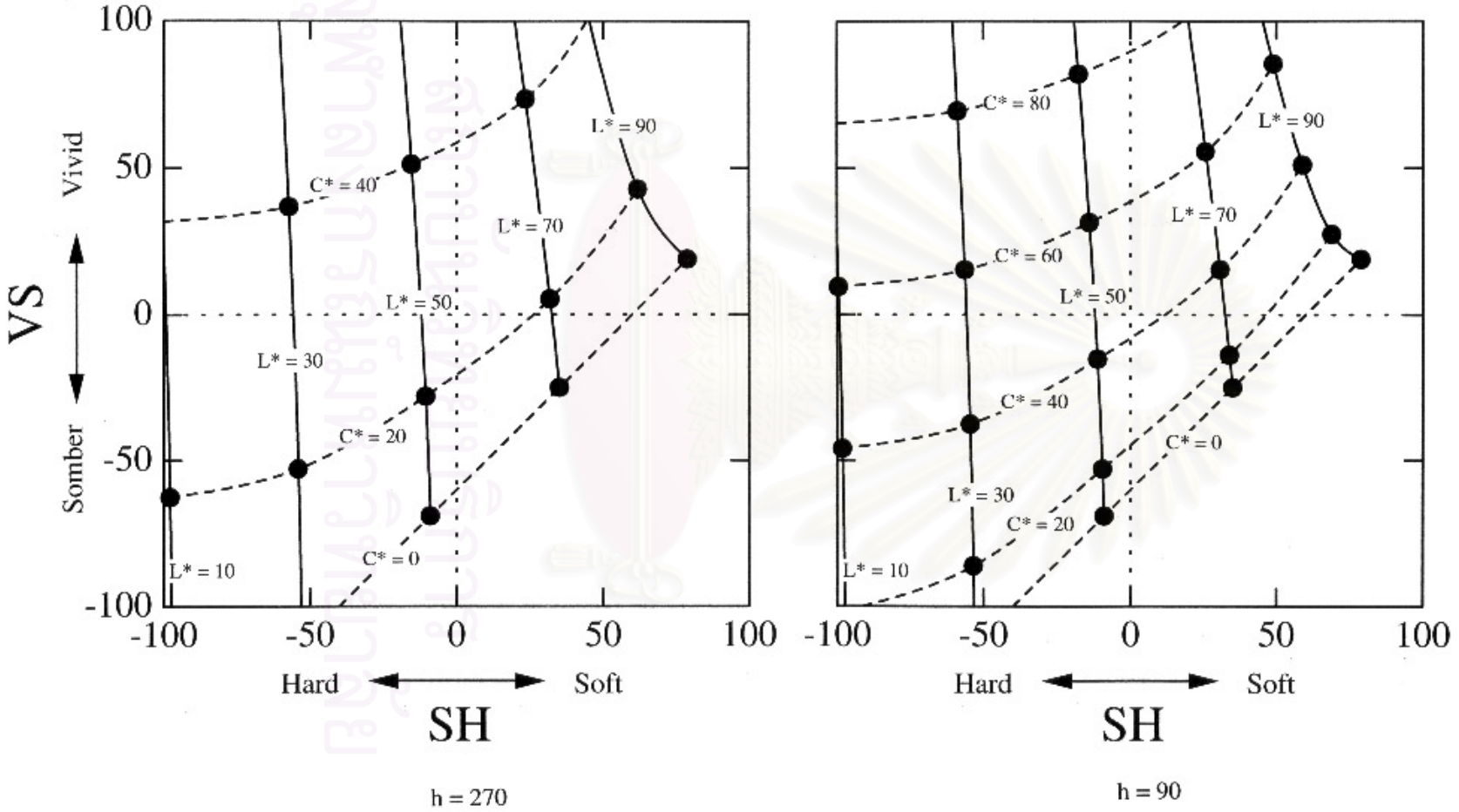

Figure 4-89 The projection of L* C* on SH-VS color perception map : h = 270, h = 90

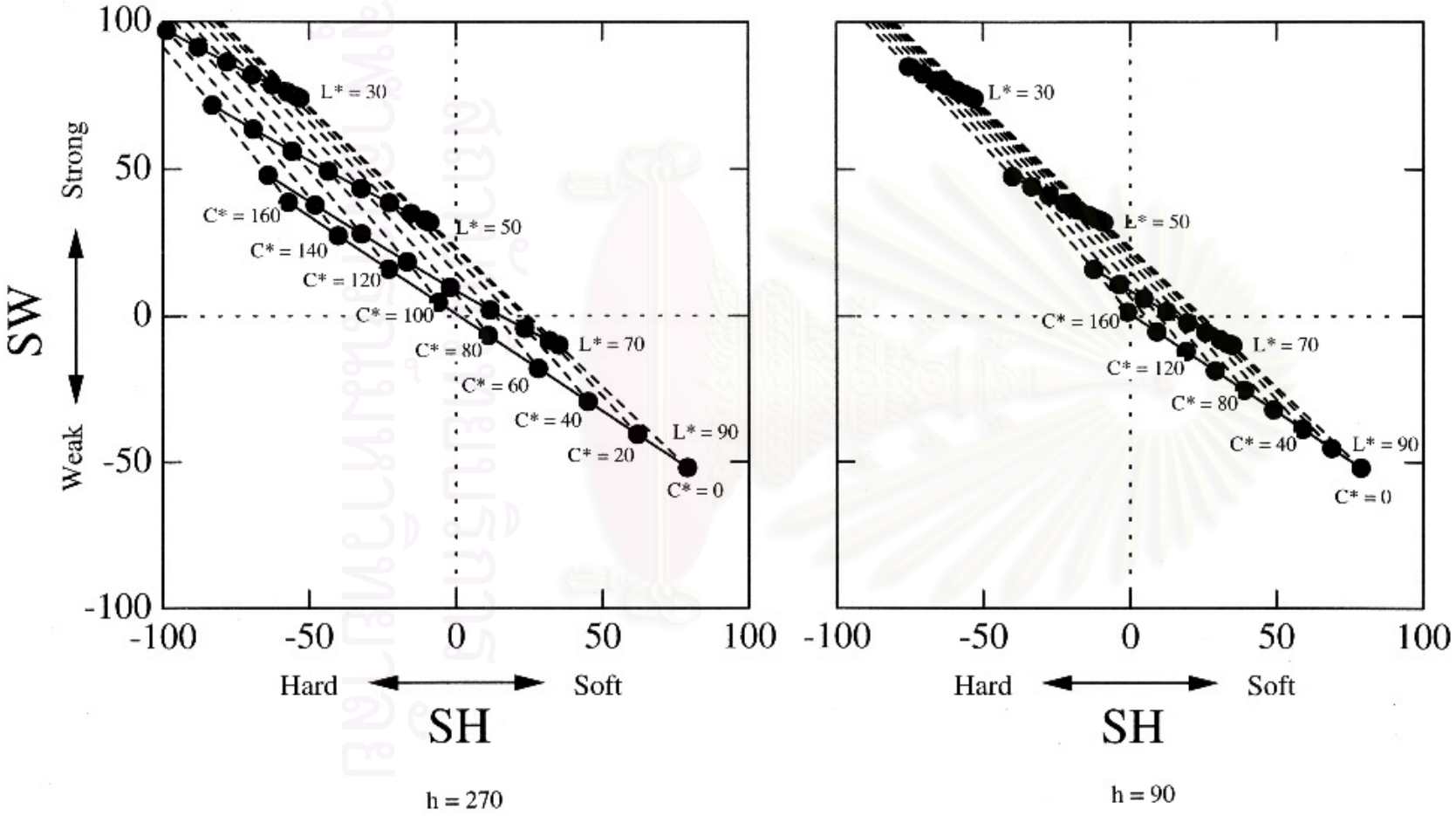

Figure 4-90 The projection of L* C* on SH-SW color perception map : h = 270, h = 90

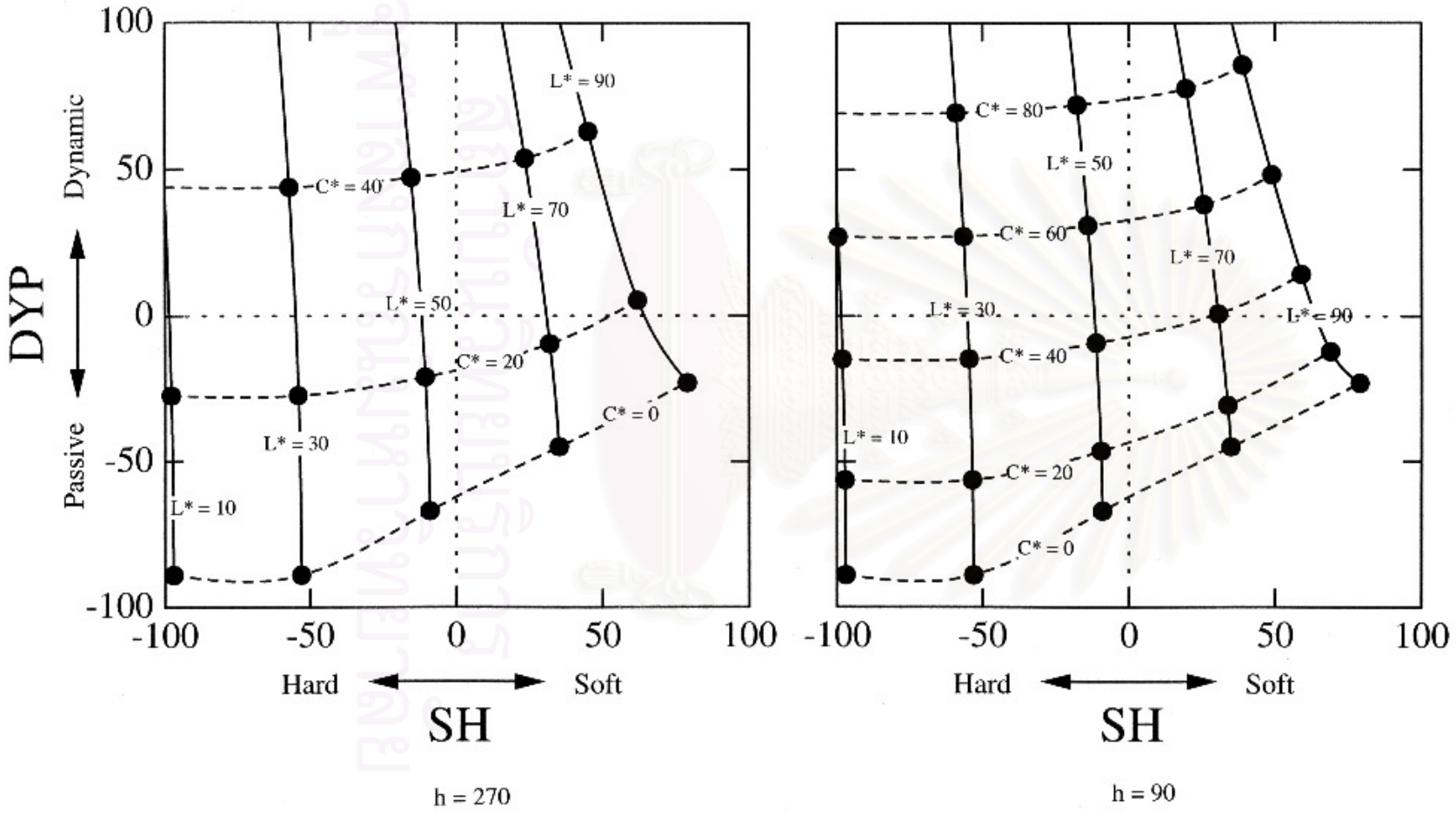

Figure 4-91 The projection of L* C* on SH-DYP color perception map : h = 270, h = 90

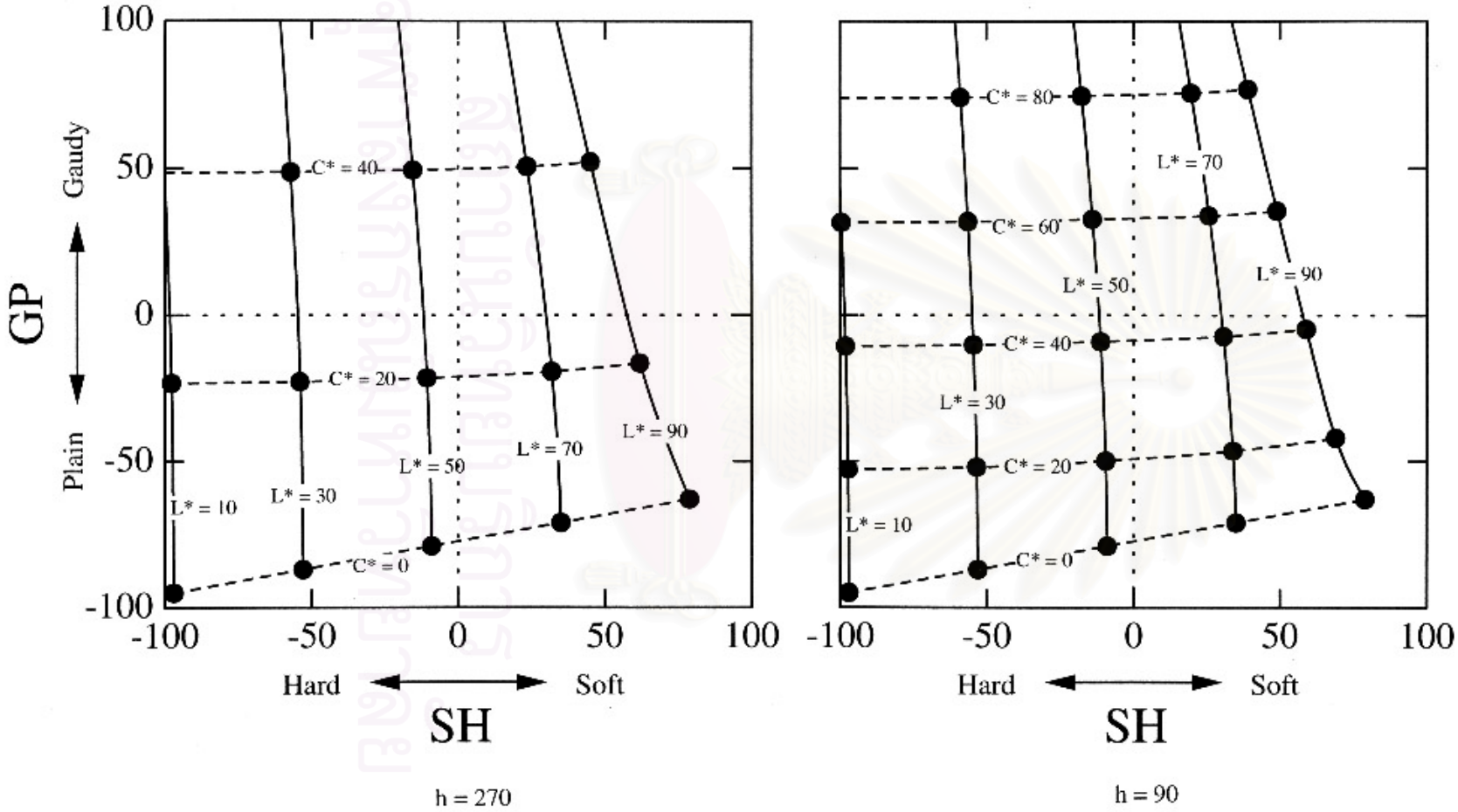

Figure 4-92 The projection of L* C* on SH-GP color perception map : h = 270, h = 90

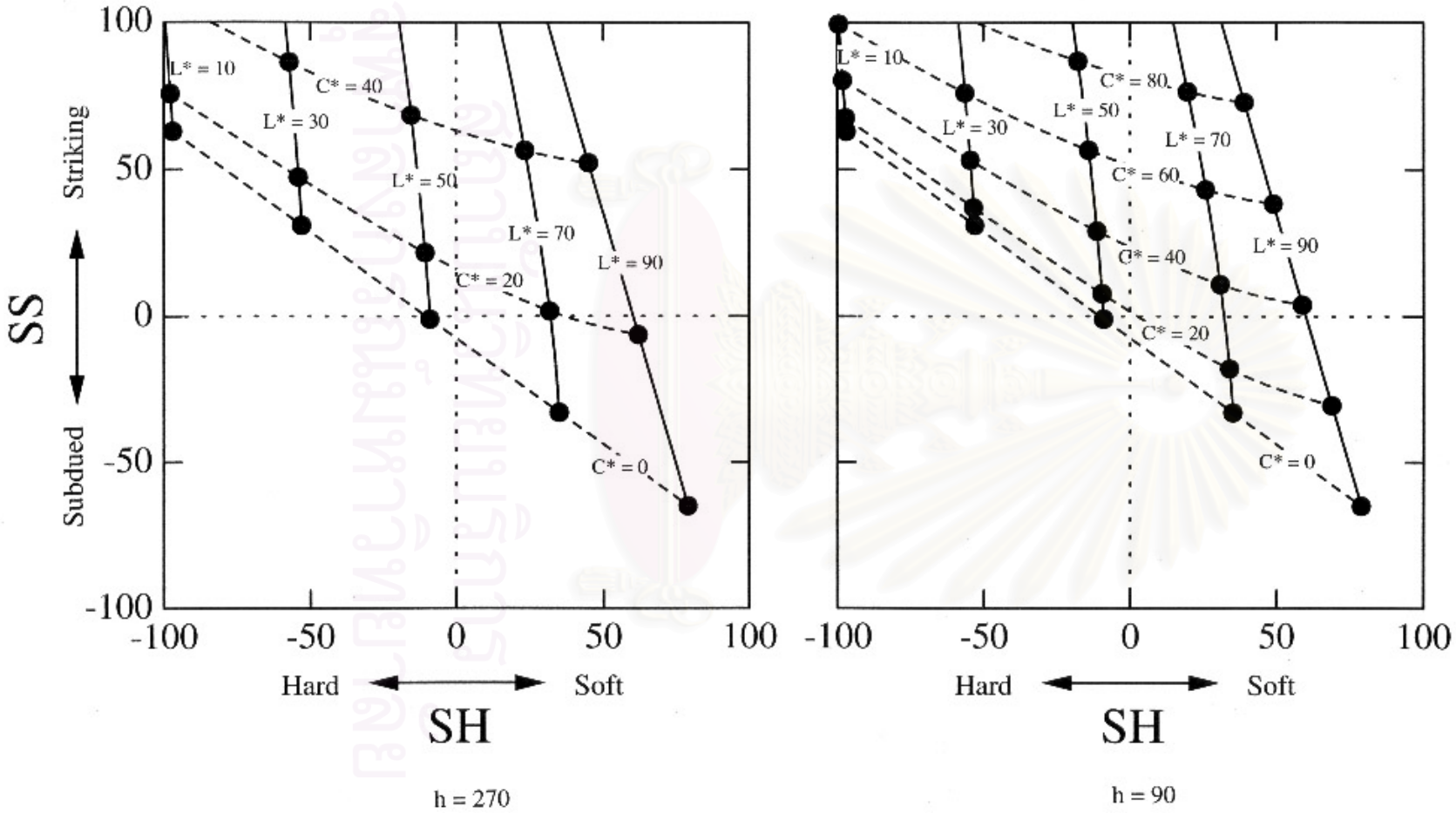

Figure 4-93 The projection of L* C* on SH-SS color perception map : h = 270, h = 90

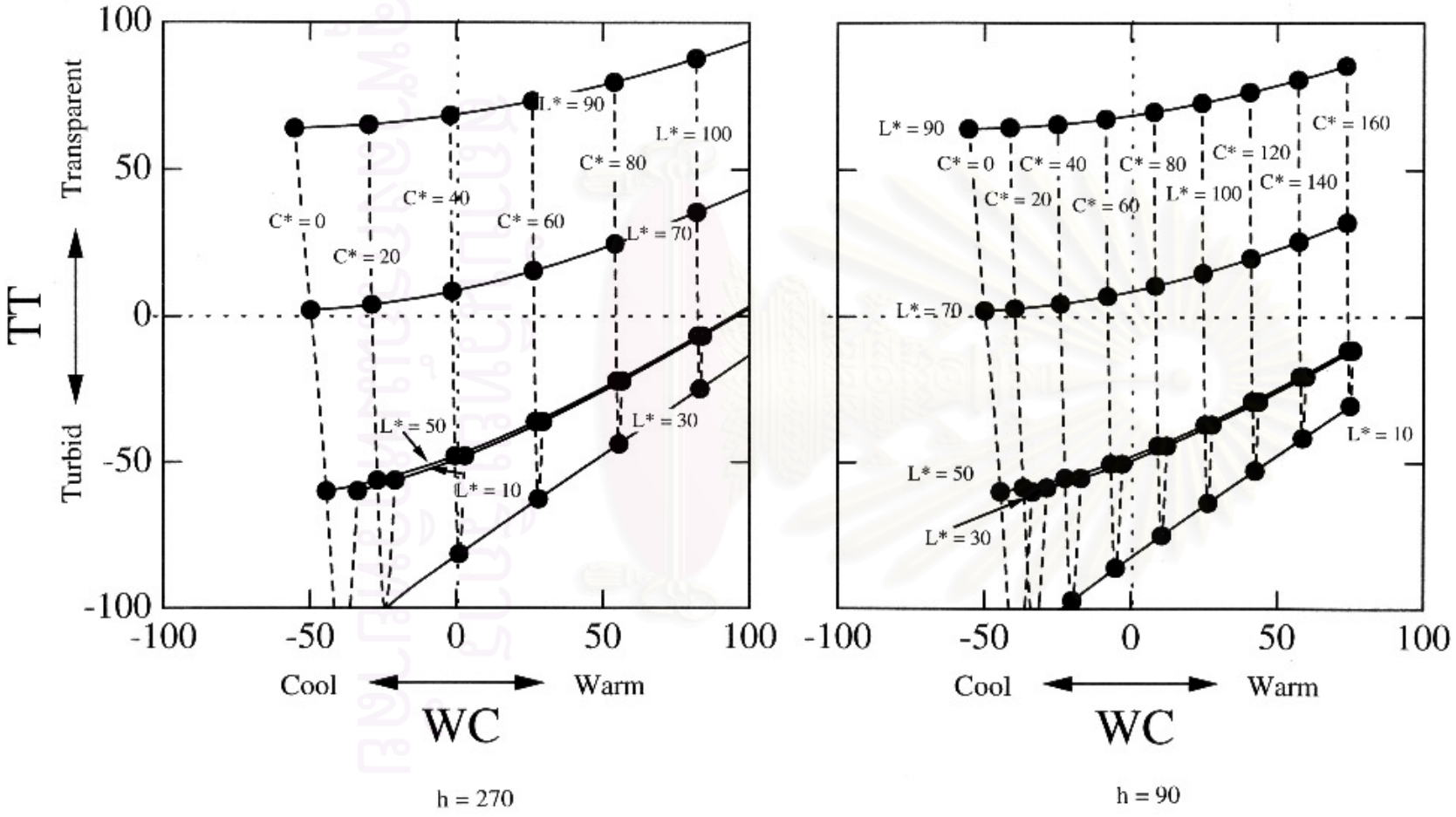

Figure 4-94 The projection of L* C* on WC-TT color perception map : h = 270, h = 90

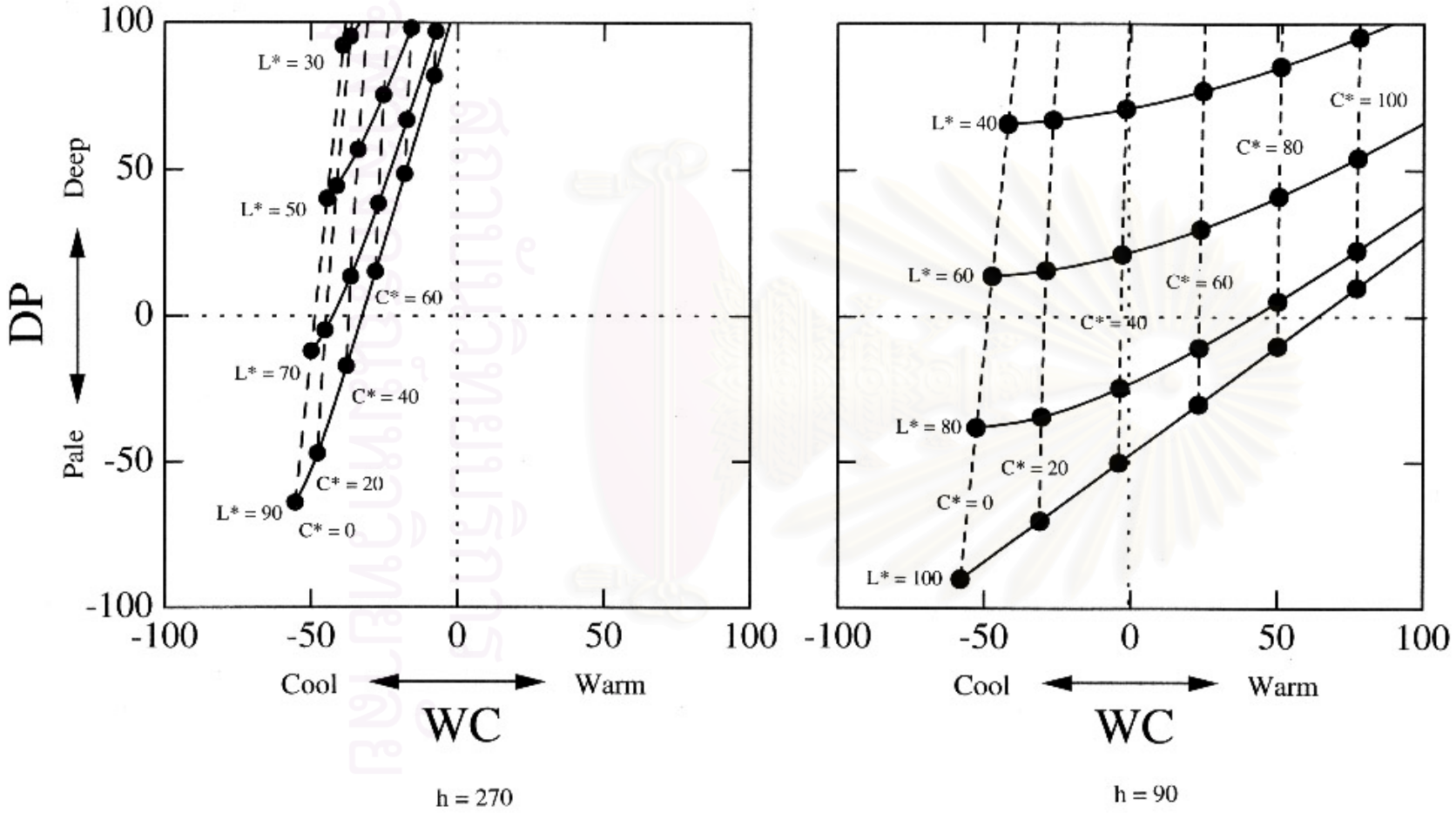

Figure 4-95 The projection of L* C* on WC-DP color perception map : h = 270, h = 90

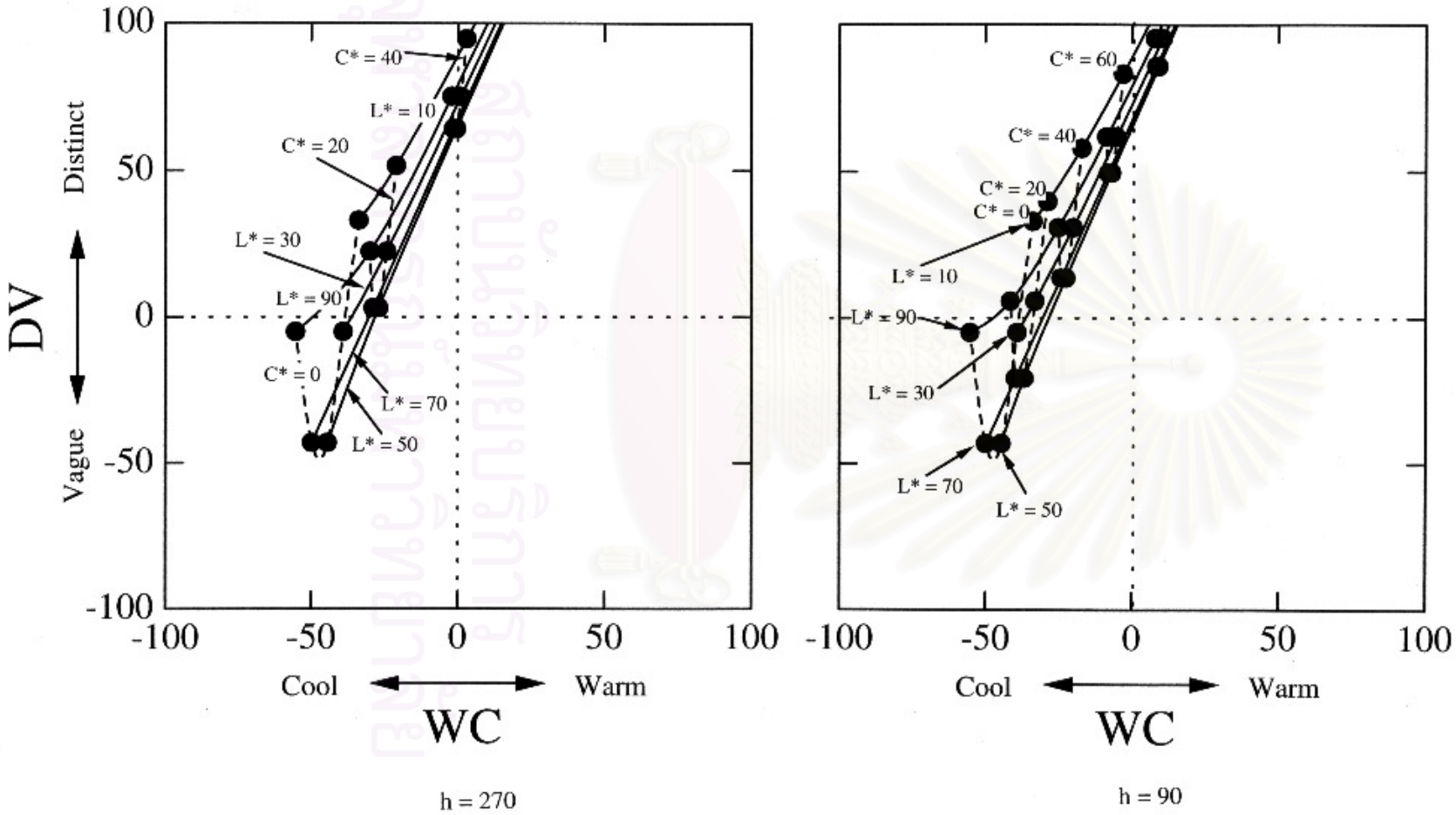

Figure 4-96 The projection of L* C* on WC-DV color perception map : h = 270, h = 90

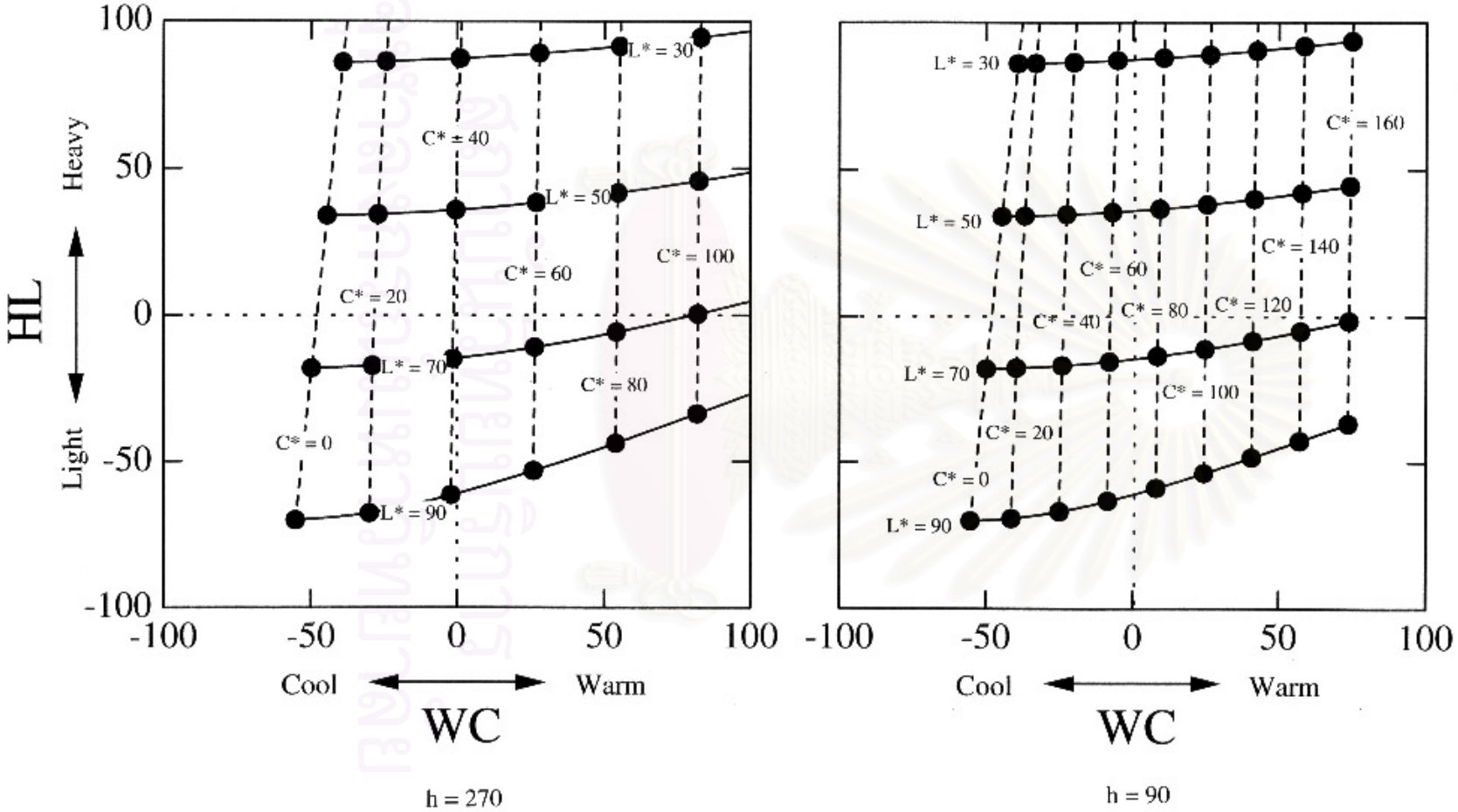

Figure 4-97 The projection of L* C* on WC-HL color perception map : h = 270, h = 90

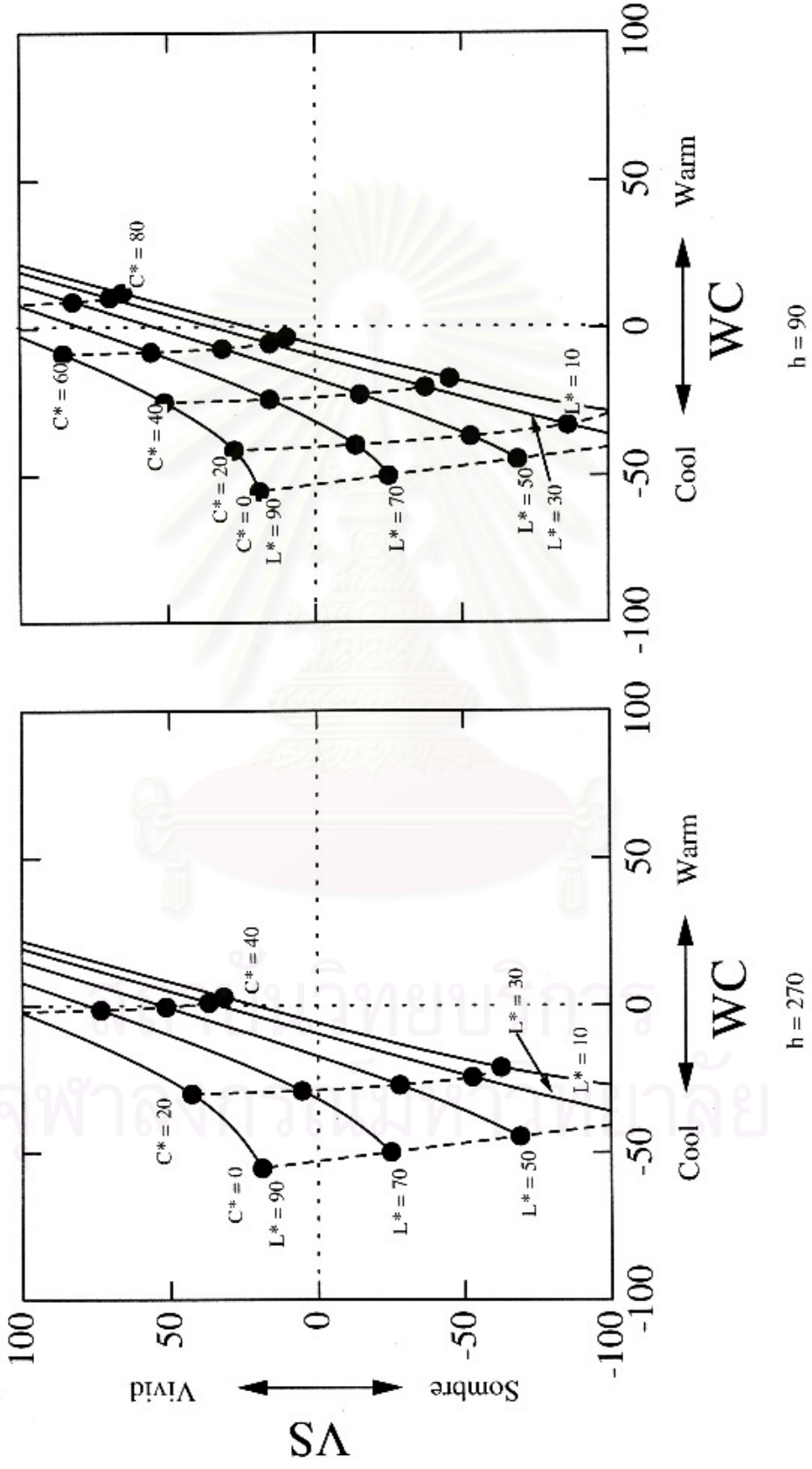

Figure 4-98 The projection of L* C* on WC-VS color perception map : h = 270, h = 90

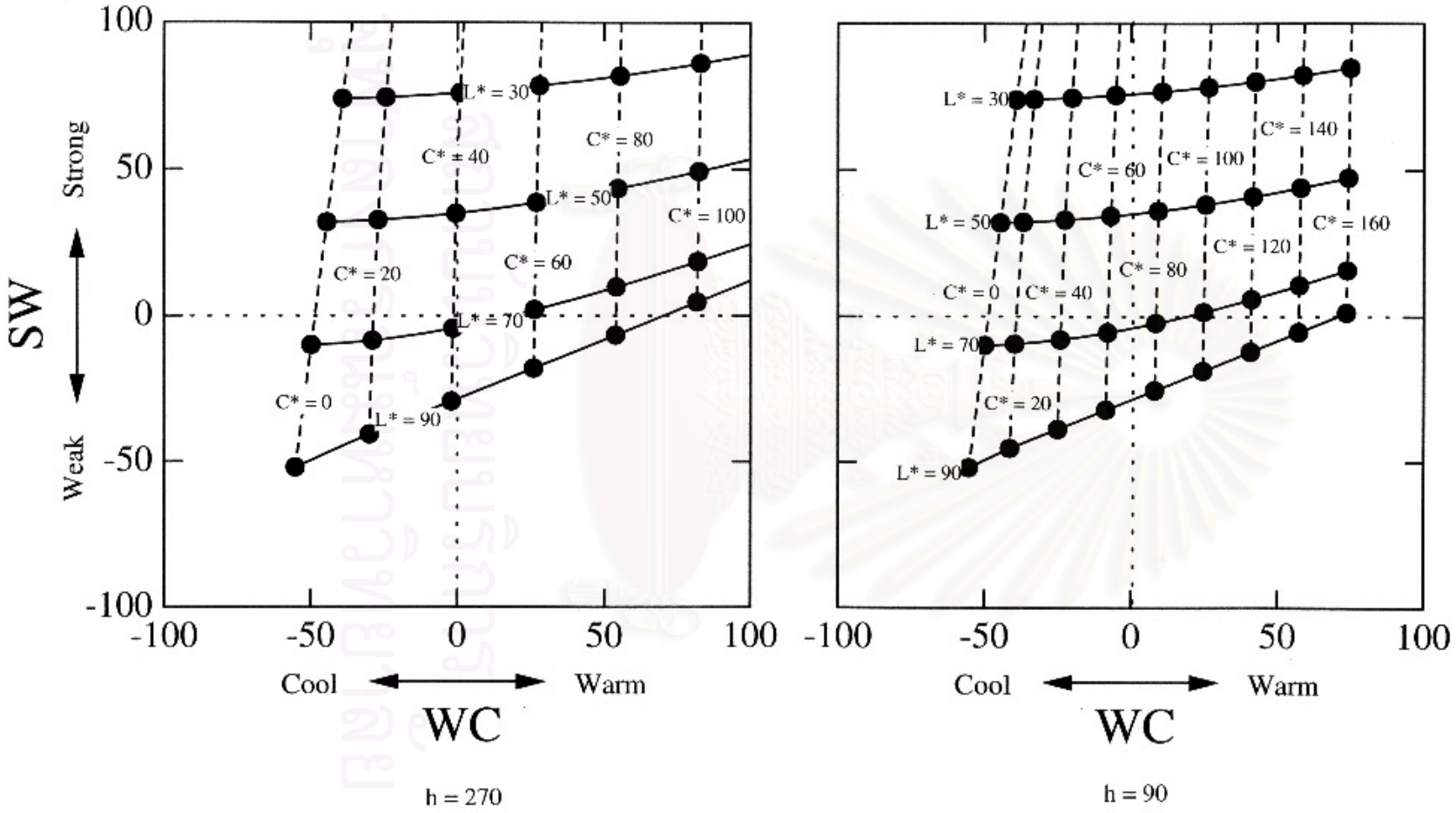

Figure 4-99 The projection of L* C* on WC-SW color perception map : h = 270, h = 90

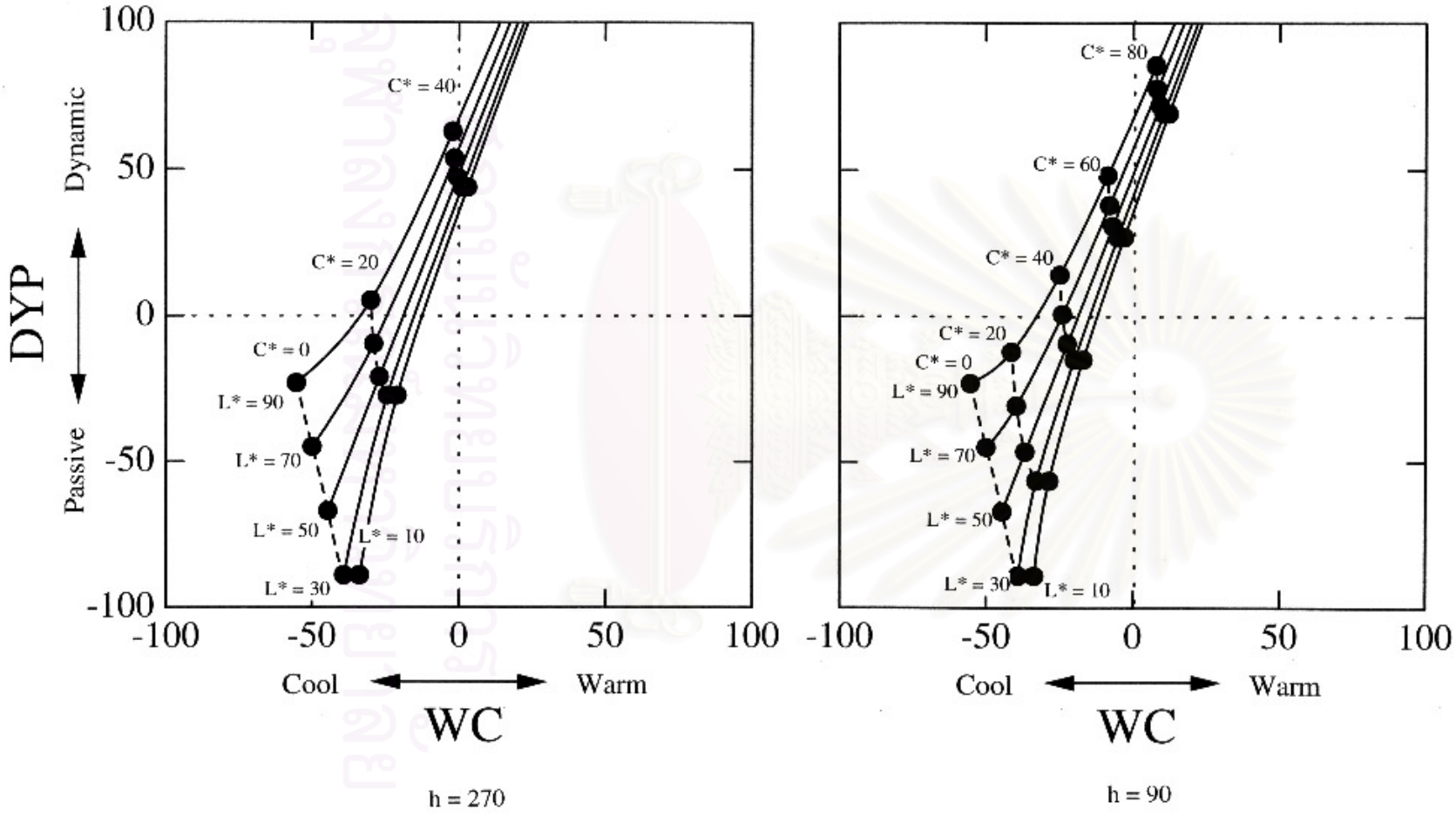

Figure 4-100 The projection of L* C* on WC-DYP color perception map : h = 270, h = 90

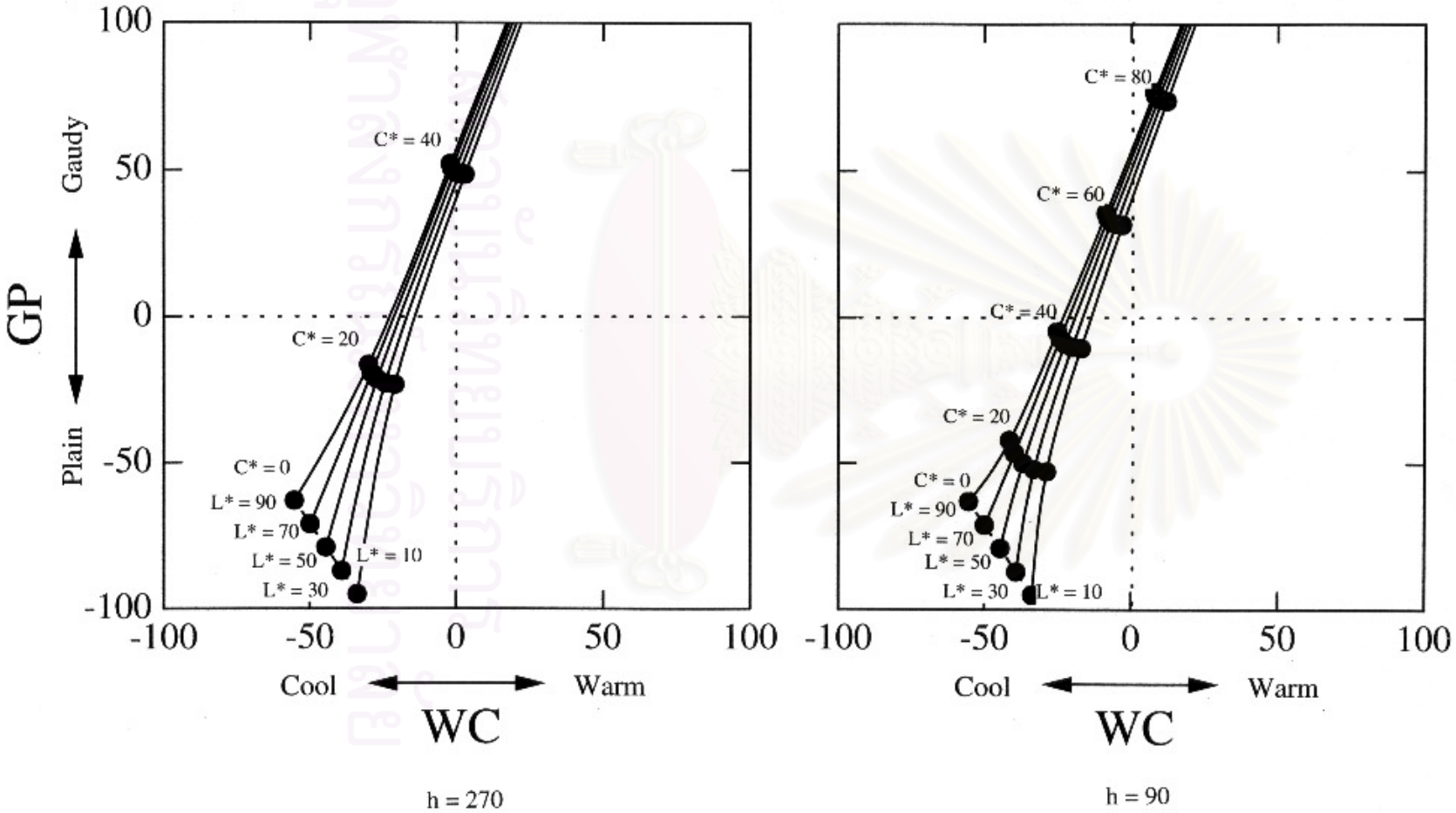

Figure 4-101 The projection of L* C* on WC-GP color perception map : h = 270, h = 90

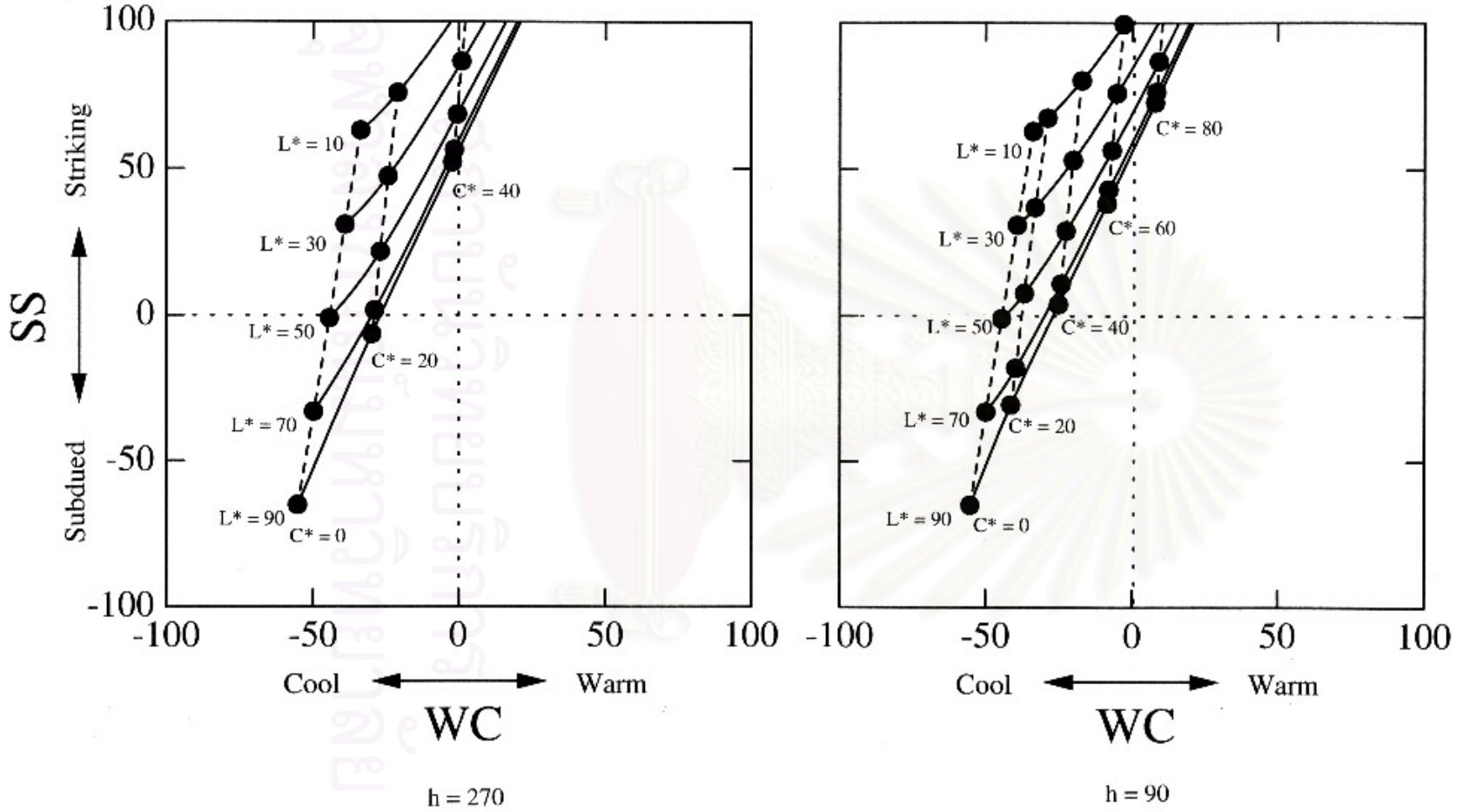

Figure 4-102 The projection of L* C* on WC-SS color perception map : h = 270, h = 90

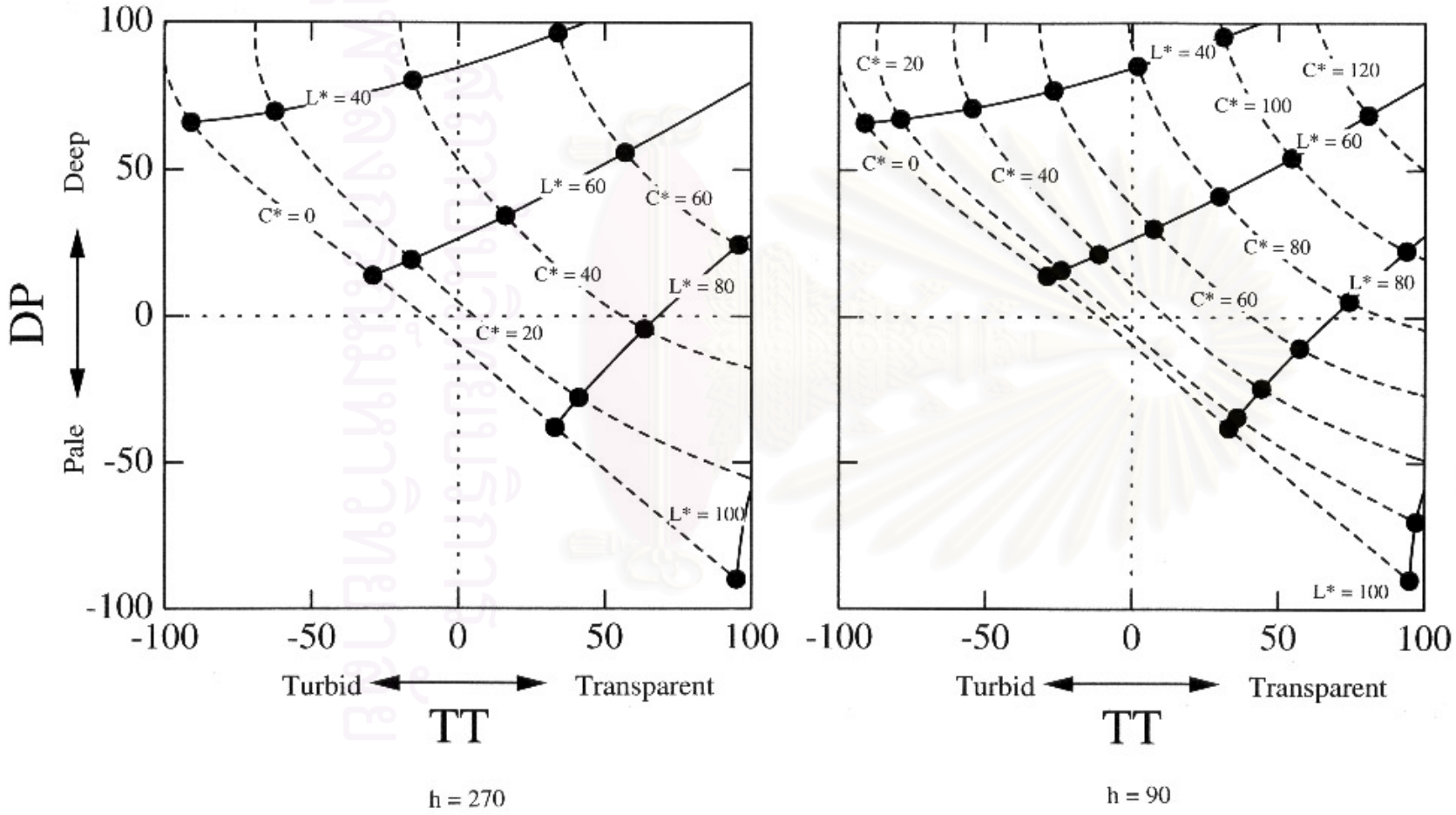

Figure 4-103 The projection of L* C* on TT-DP color perception map : h = 270, h = 90

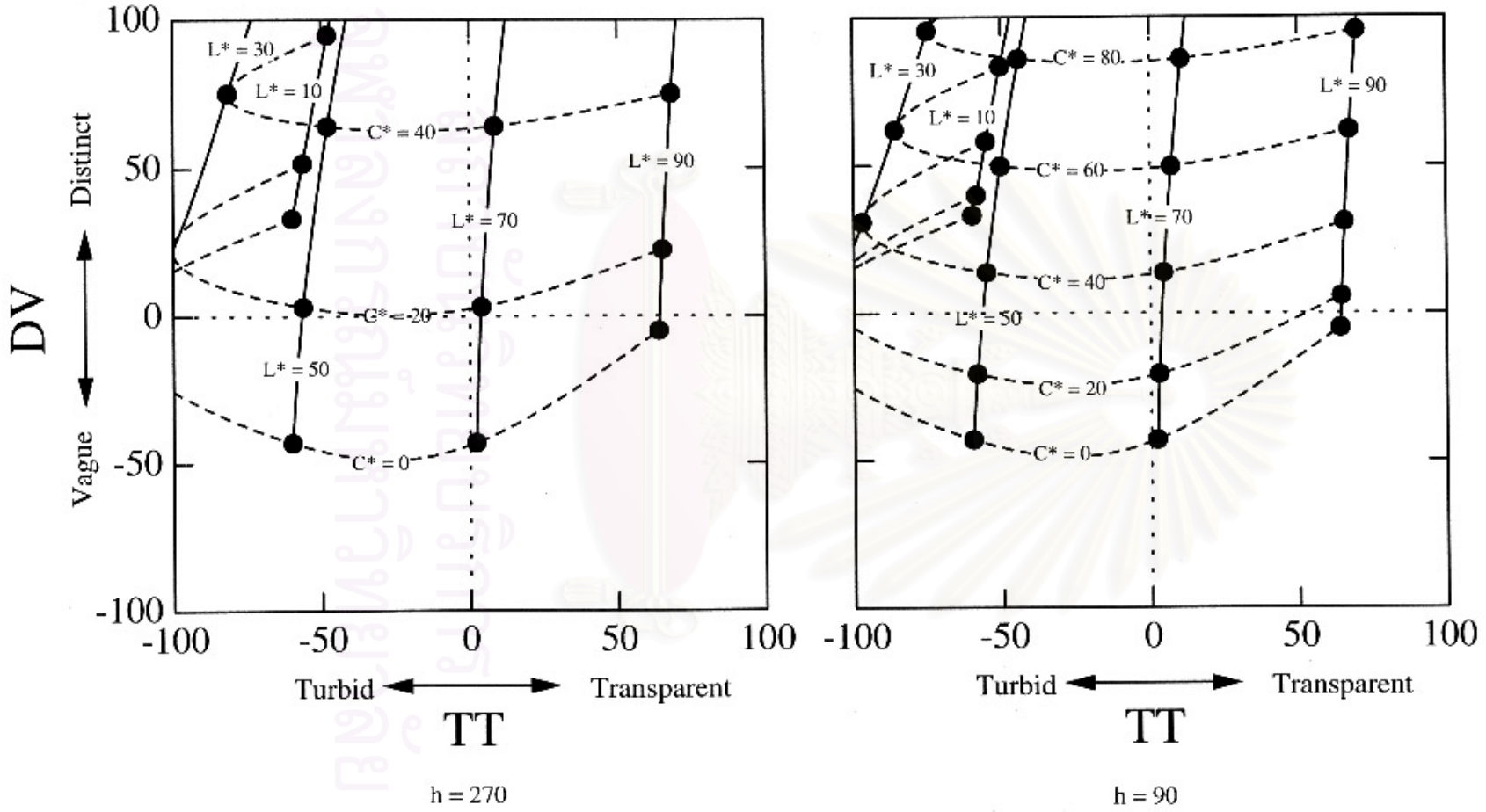

Figure 4-104 The projection of L* C* on TT-DV color perception map : h = 270, h = 90

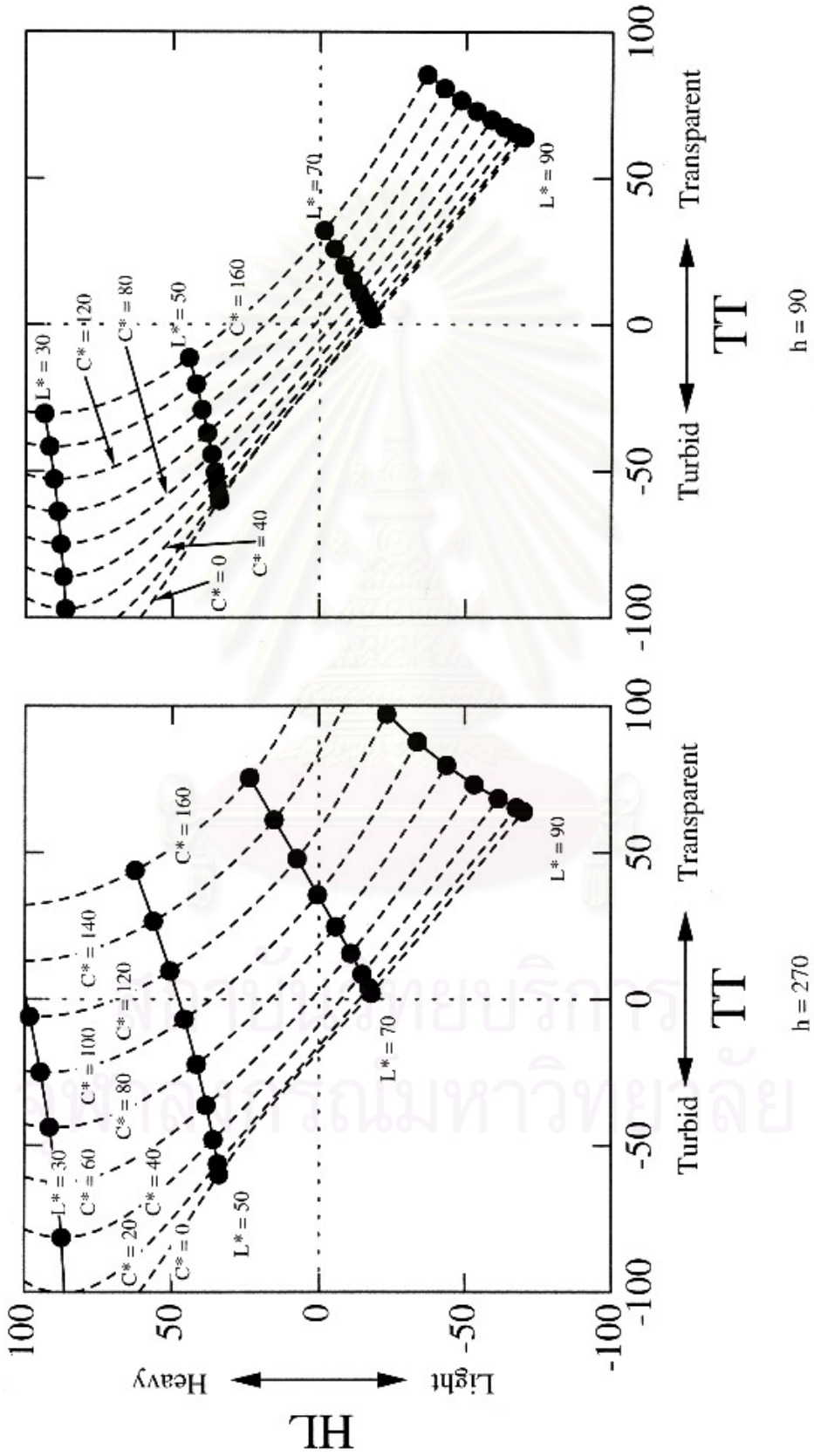

Figure 4-105 The projection of L* C* on TT-HL color perception map : h = 270, h = 90

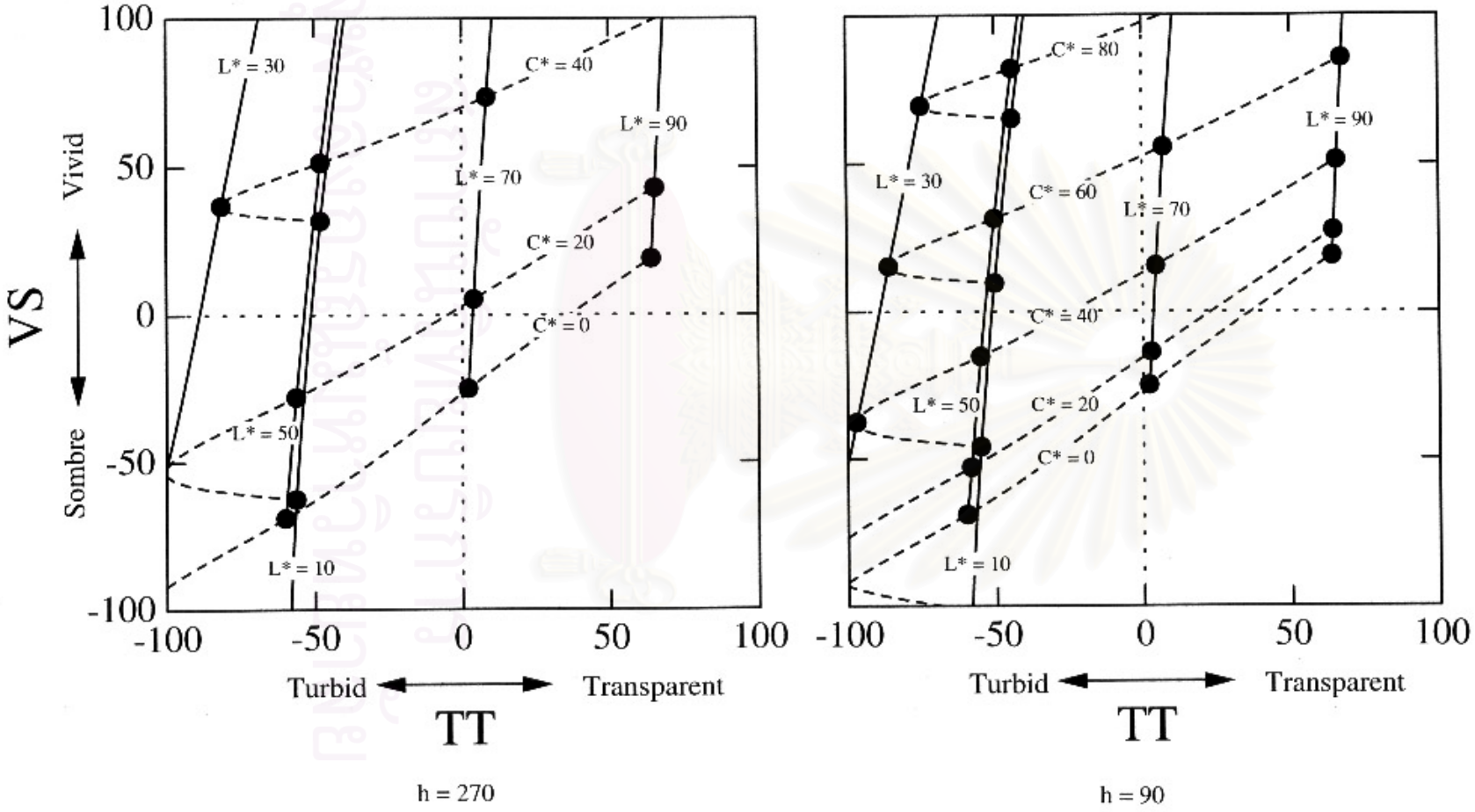

Figure 4-106 The projection of L* C* on TT-VS color perception map : h = 270, h = 90

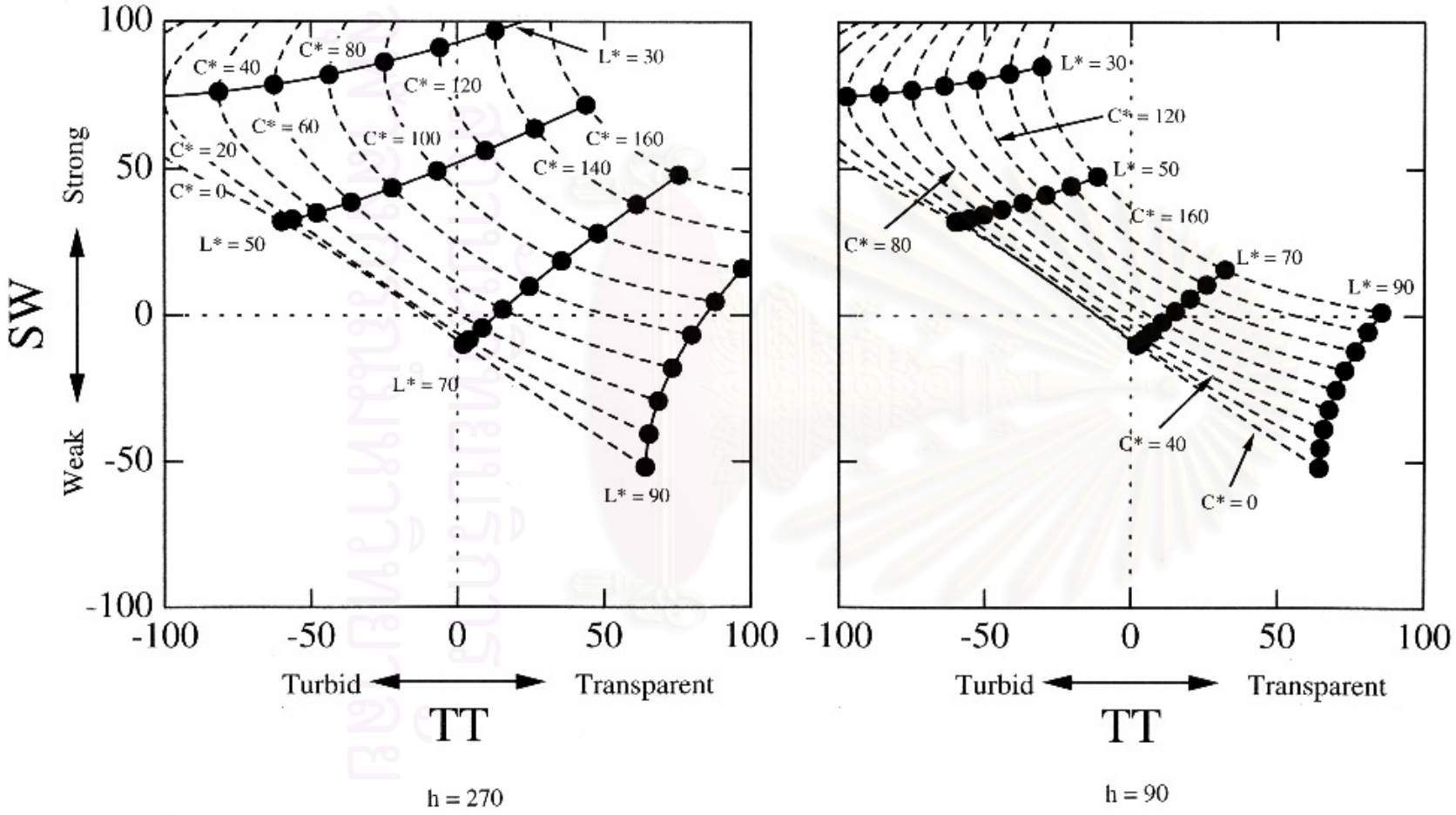

Figure 4-107 The projection of L* C* on TT-SW color perception map : h = 270, h = 90

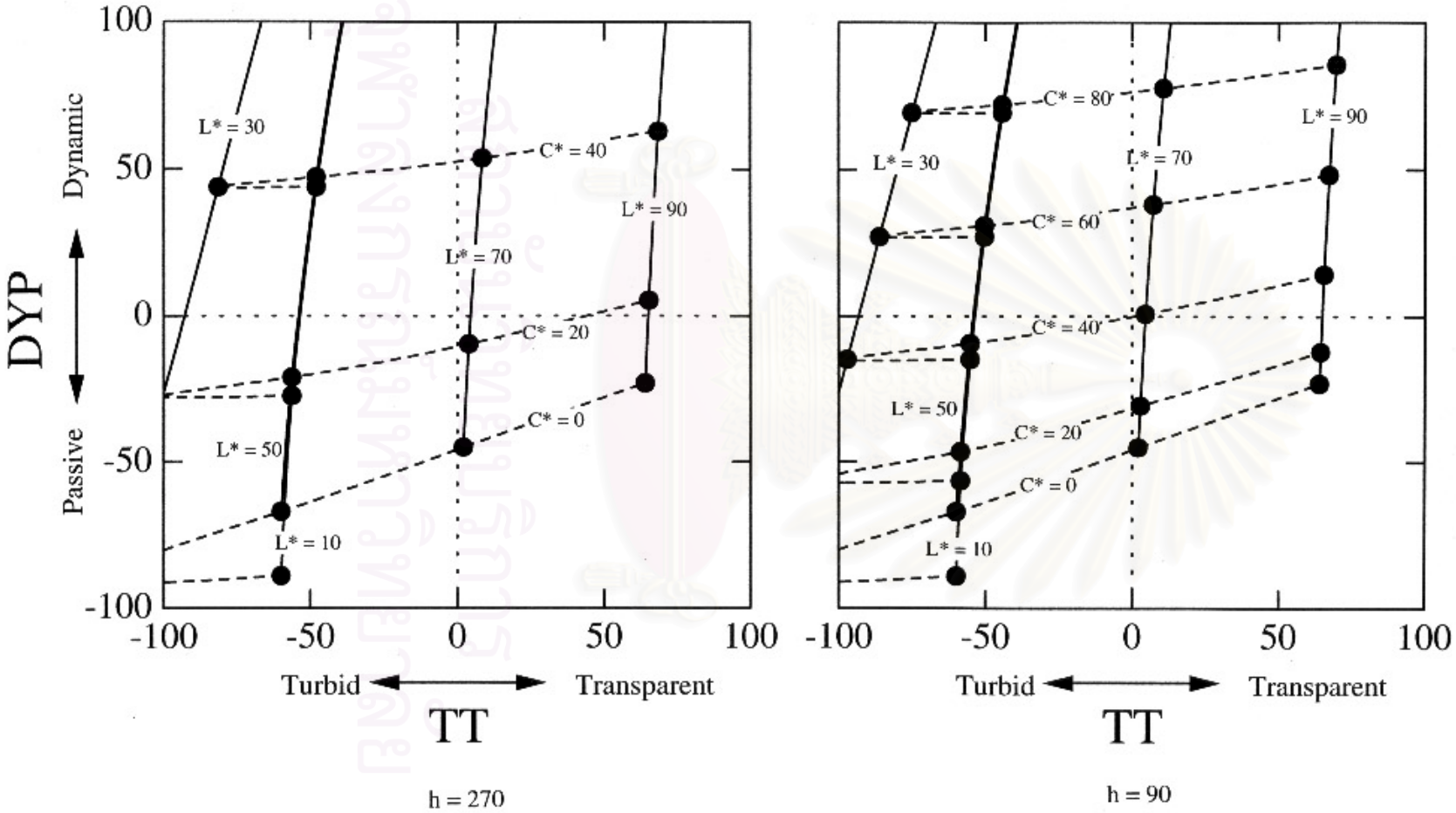

Figure 4-108 The projection of L* C* on TT-DYP color perception map : h = 270, h = 90

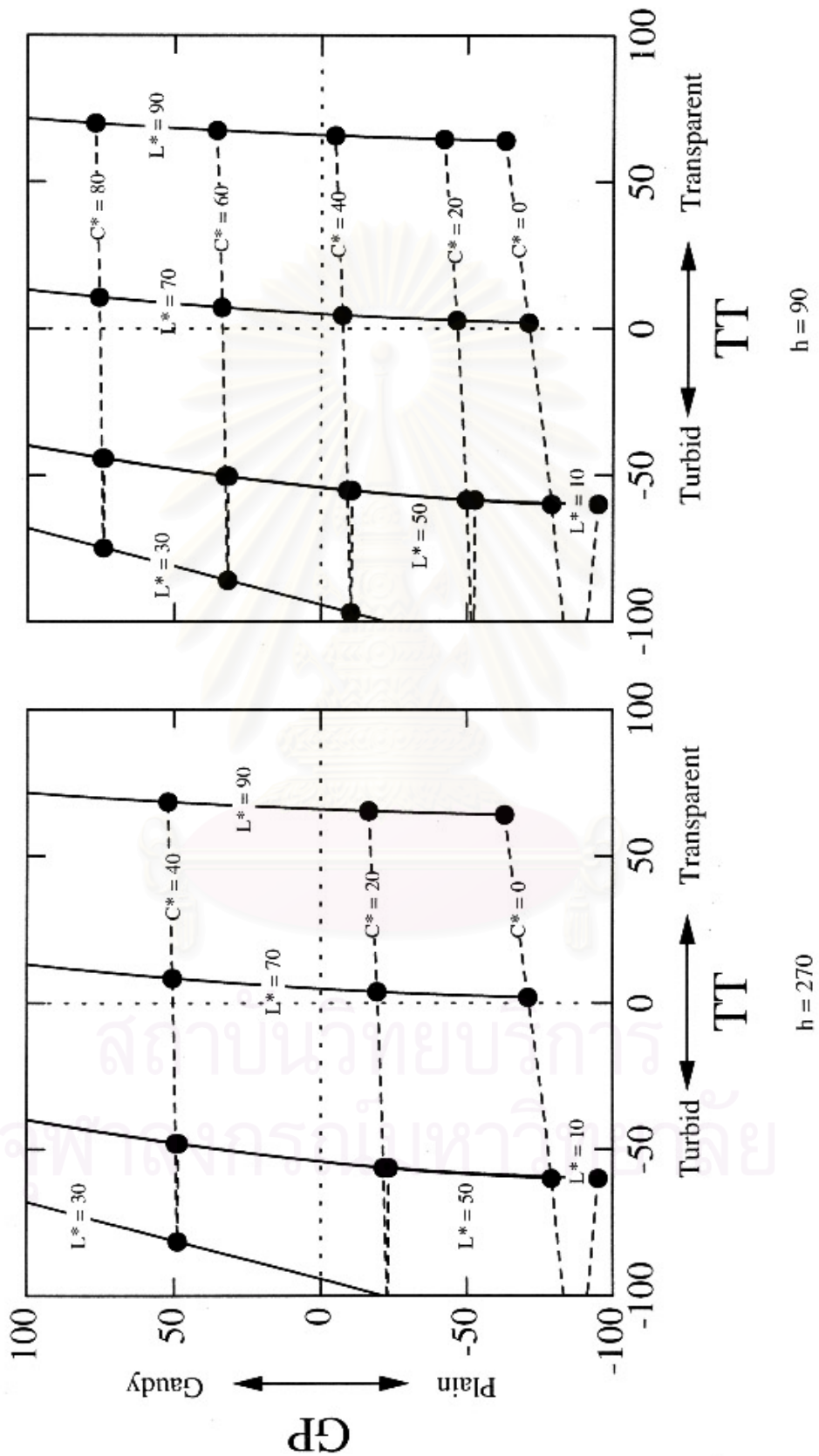

Figure 4-109 The projection of L* C* on TT-GP color perception map : h = 270, h = 90

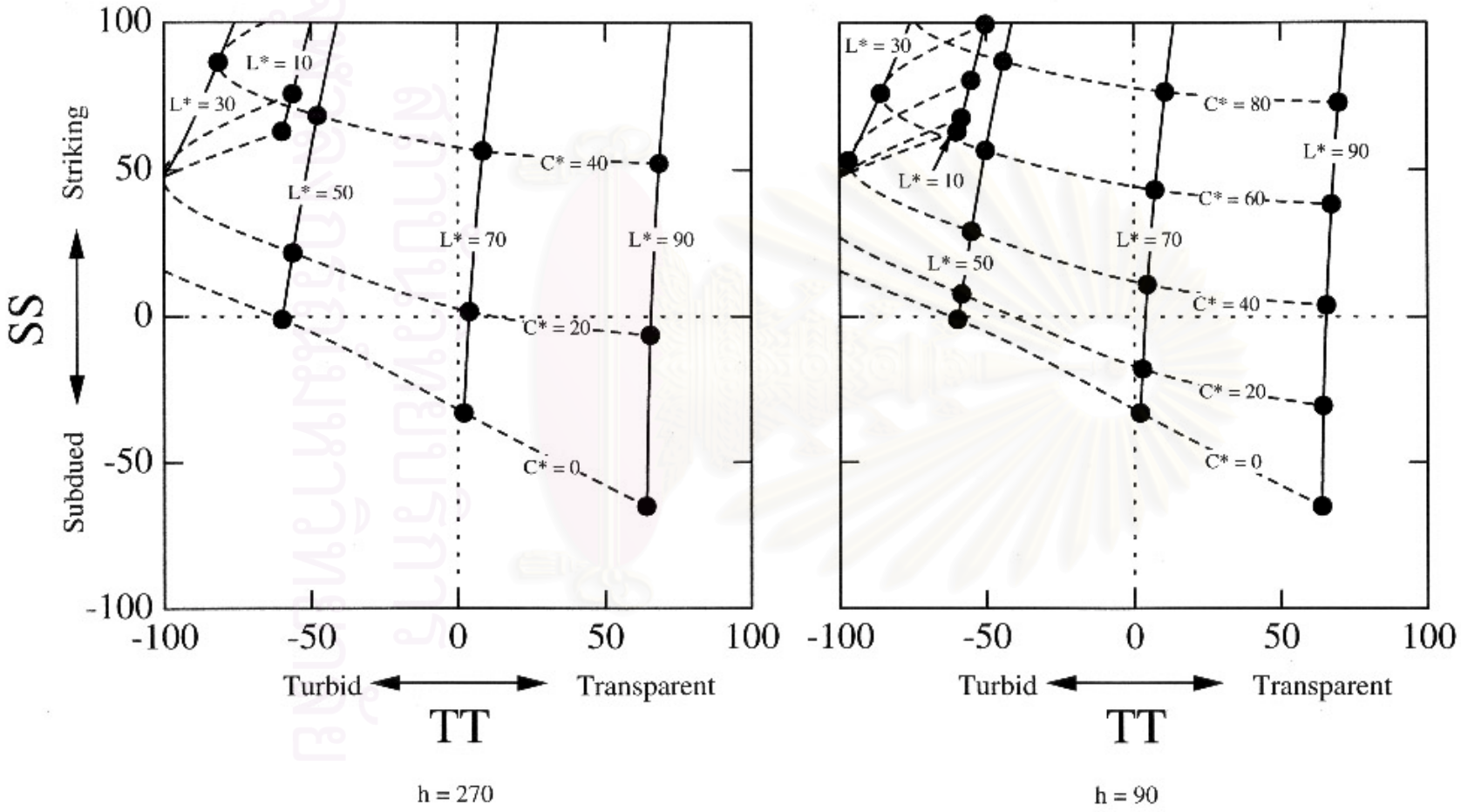

Figure 4-110 The projection of L* C* on TT-SS color perception map : h = 270, h = 90

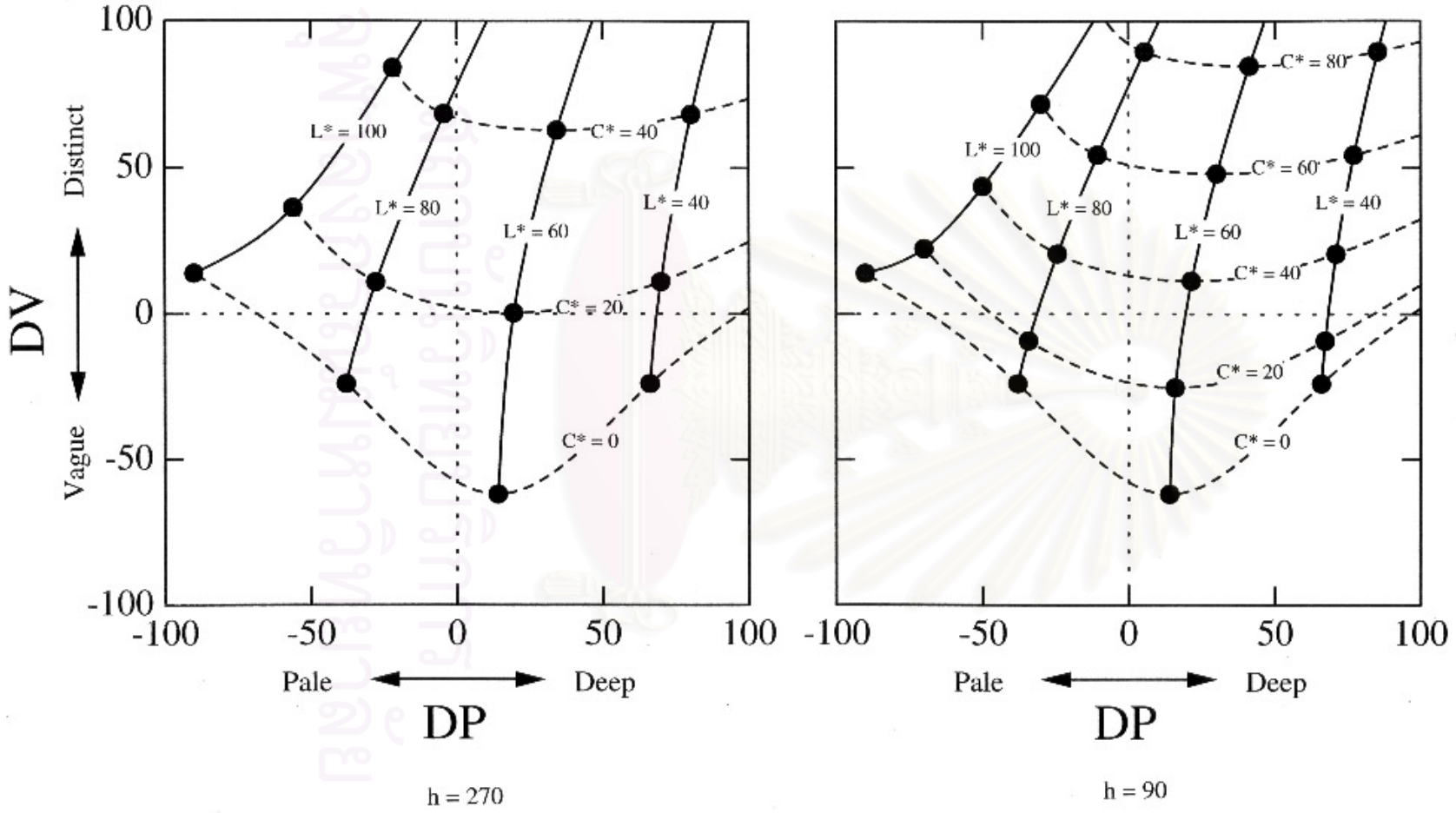

Figure 4-111 The projection of L* C* on DP-DV color perception map : h = 270, h = 90

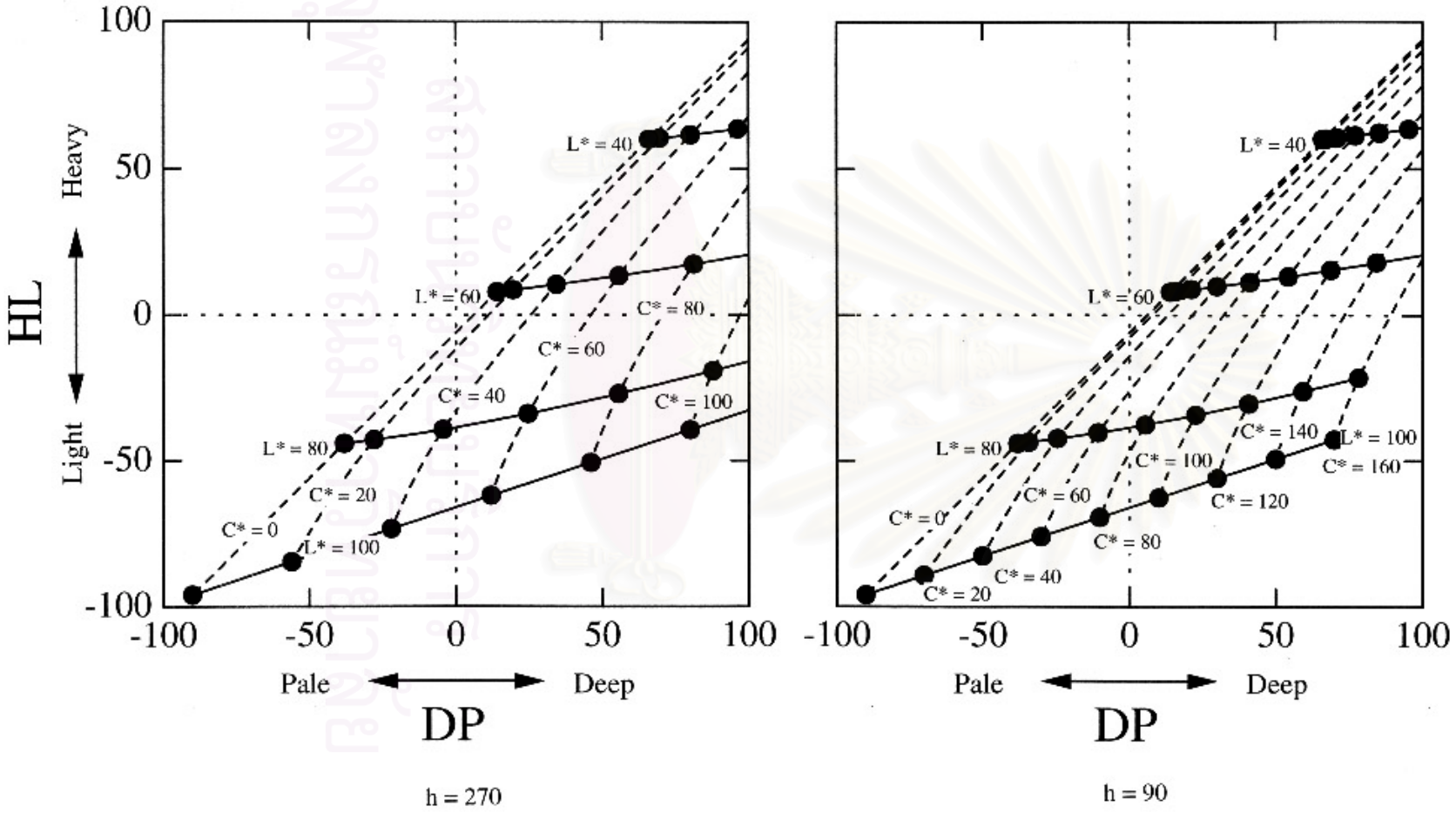

Figure 4-112 The projection of L* C* on DP-HL color perception map : h = 270, h = 90

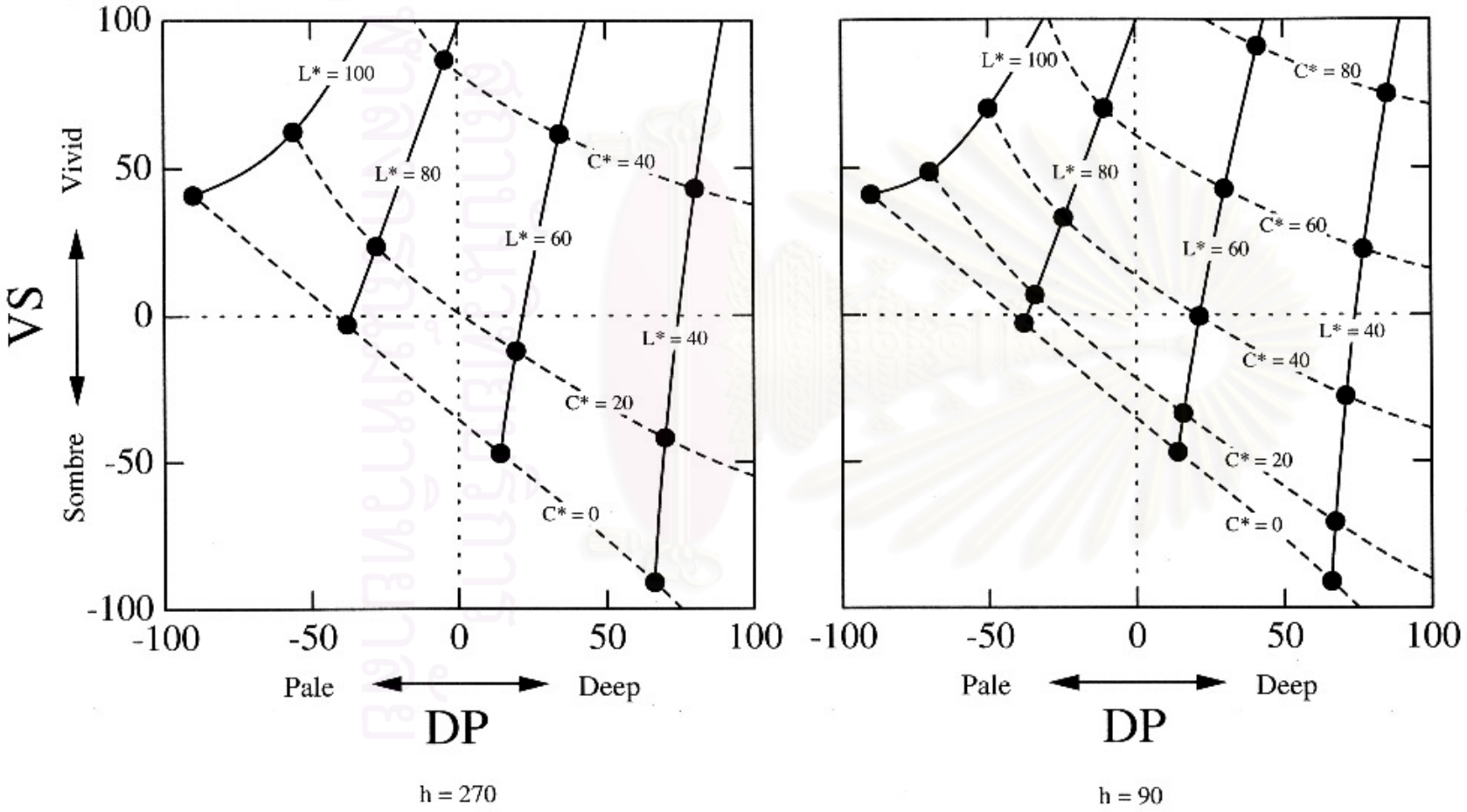

Figure 4-113 The projection of L* C* on DP-VS color perception map : h = 270, h = 90

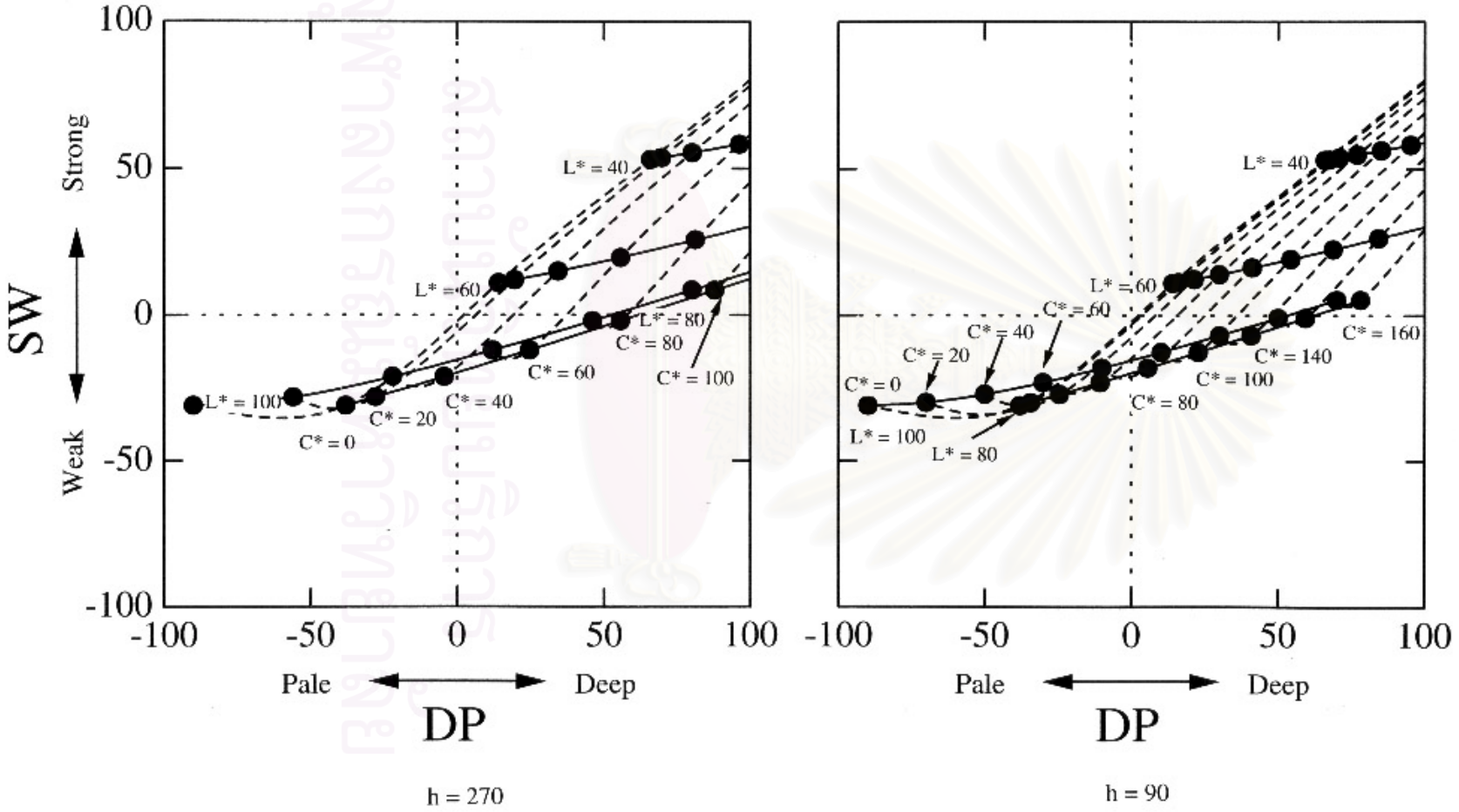

Figure 4-114 The projection of L* C* on DP-SW color perception map : h = 270, h = 90

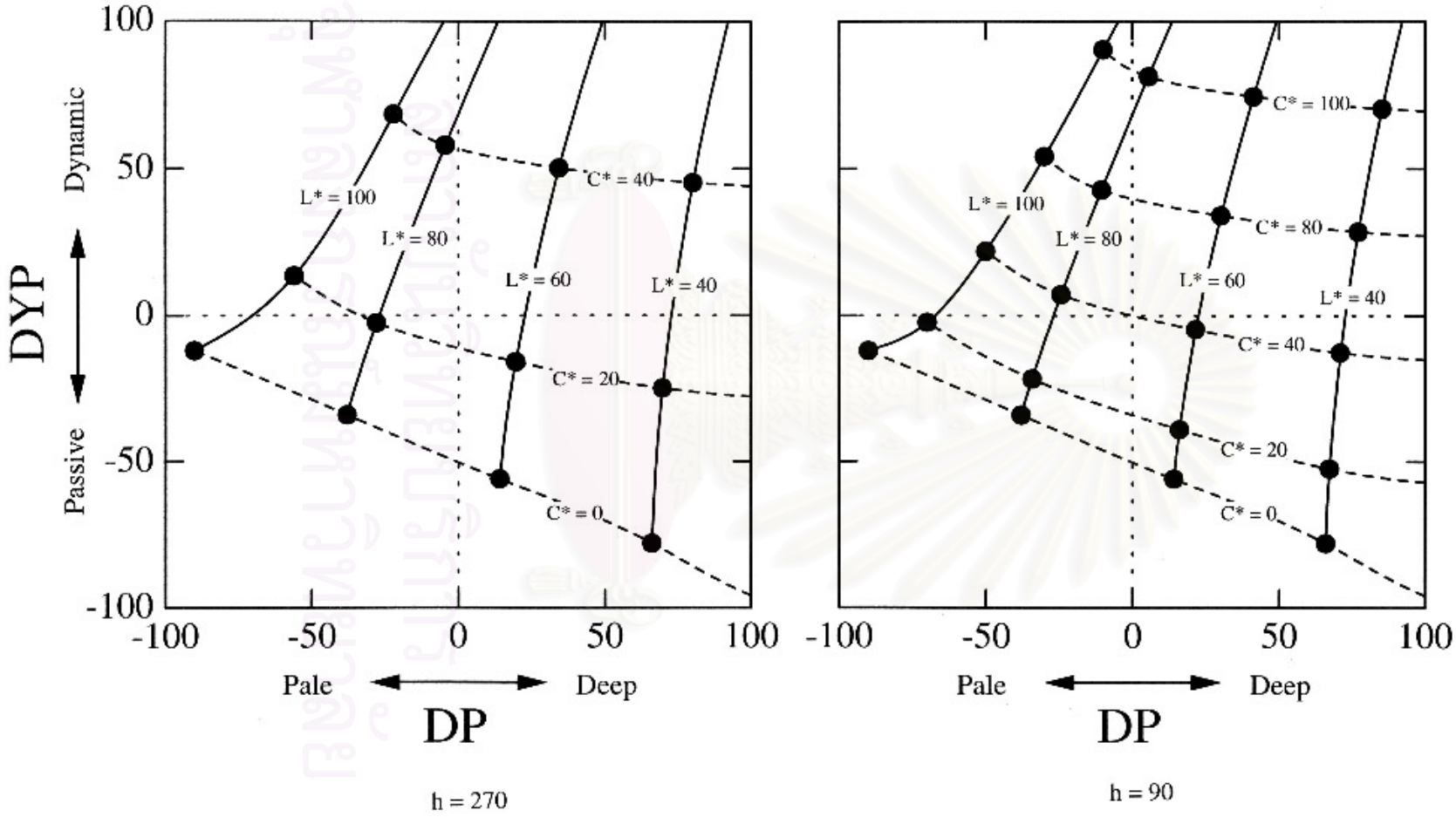

Figure 4-115 The projection of L* C* on DP-DYP color perception map : h = 270, h = 90

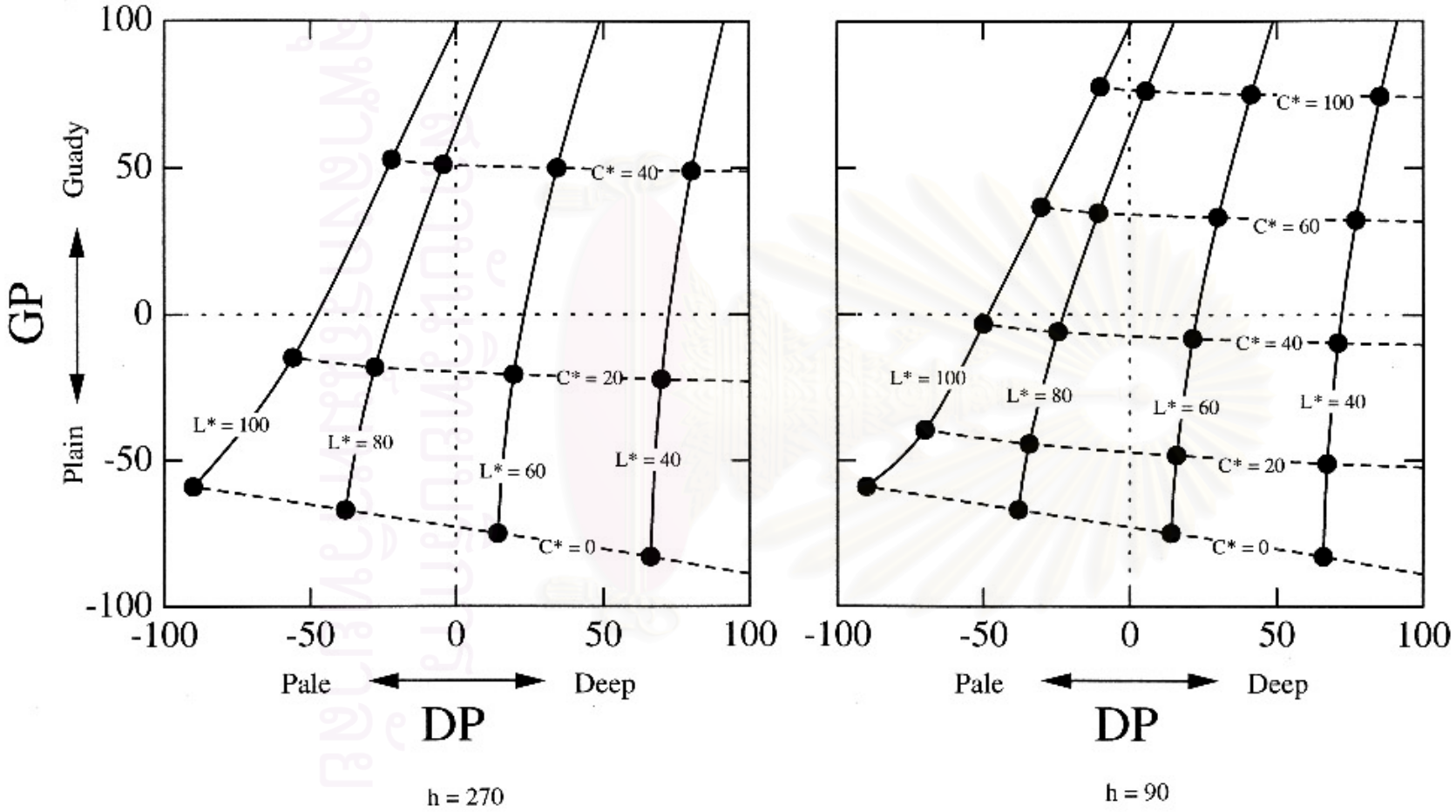

Figure 4-116 The projection of L* C* on DP-GP color perception map : h = 270, h = 90

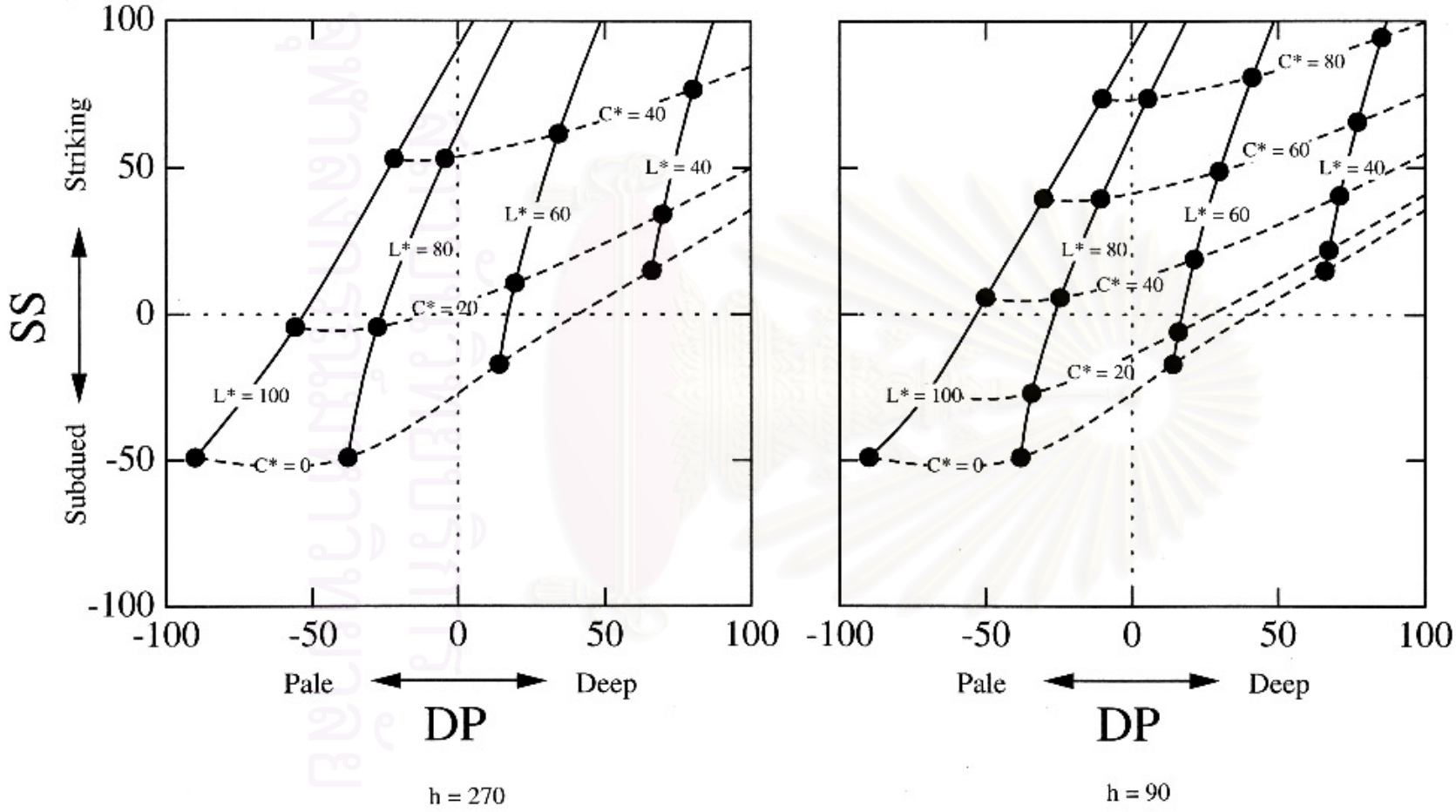

Figure 4-117 The projection of L* C* on DP-SS color perception map : h = 270, h = 90

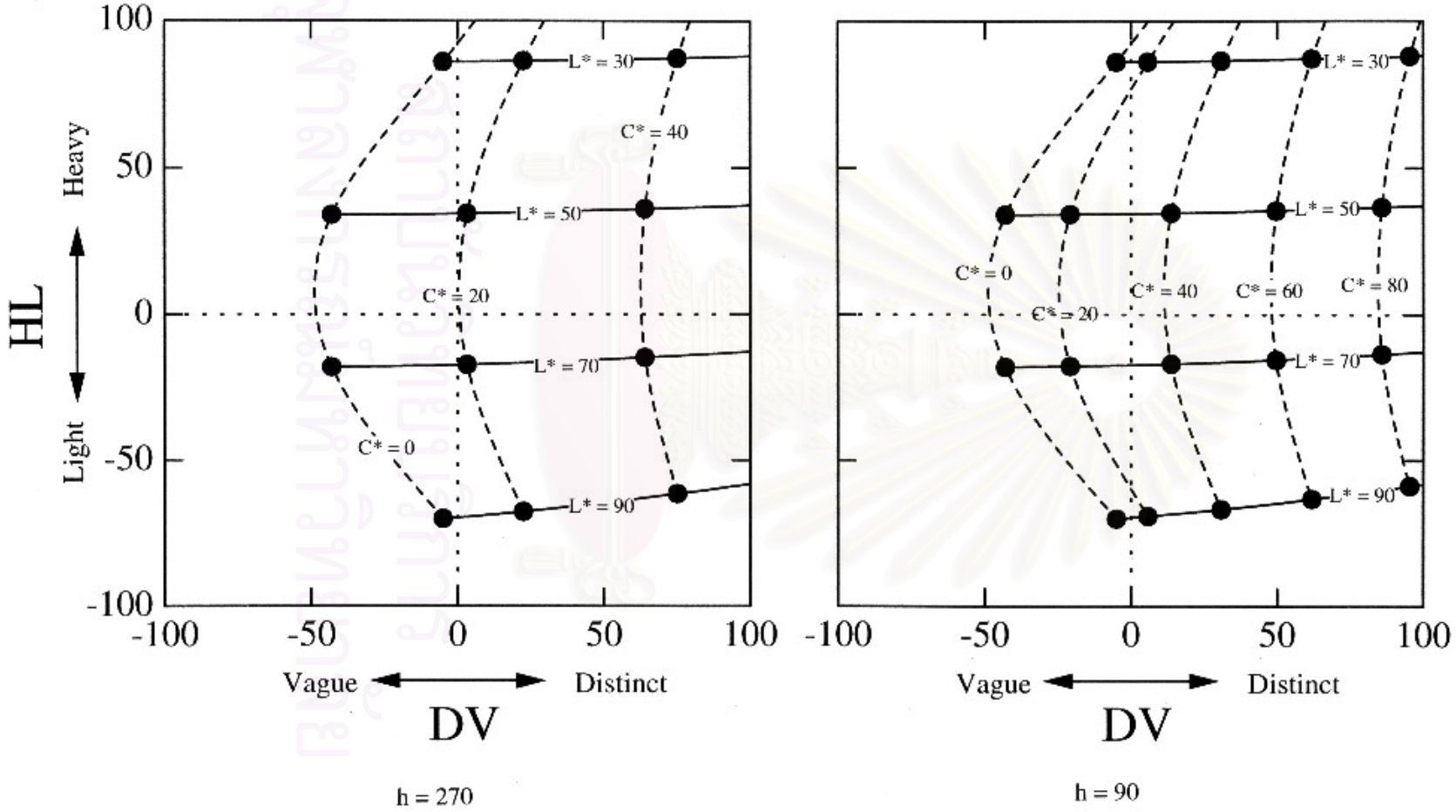

Figure 4-118 The projection of L* C* on DV-HL color perception map : h = 270, h = 90

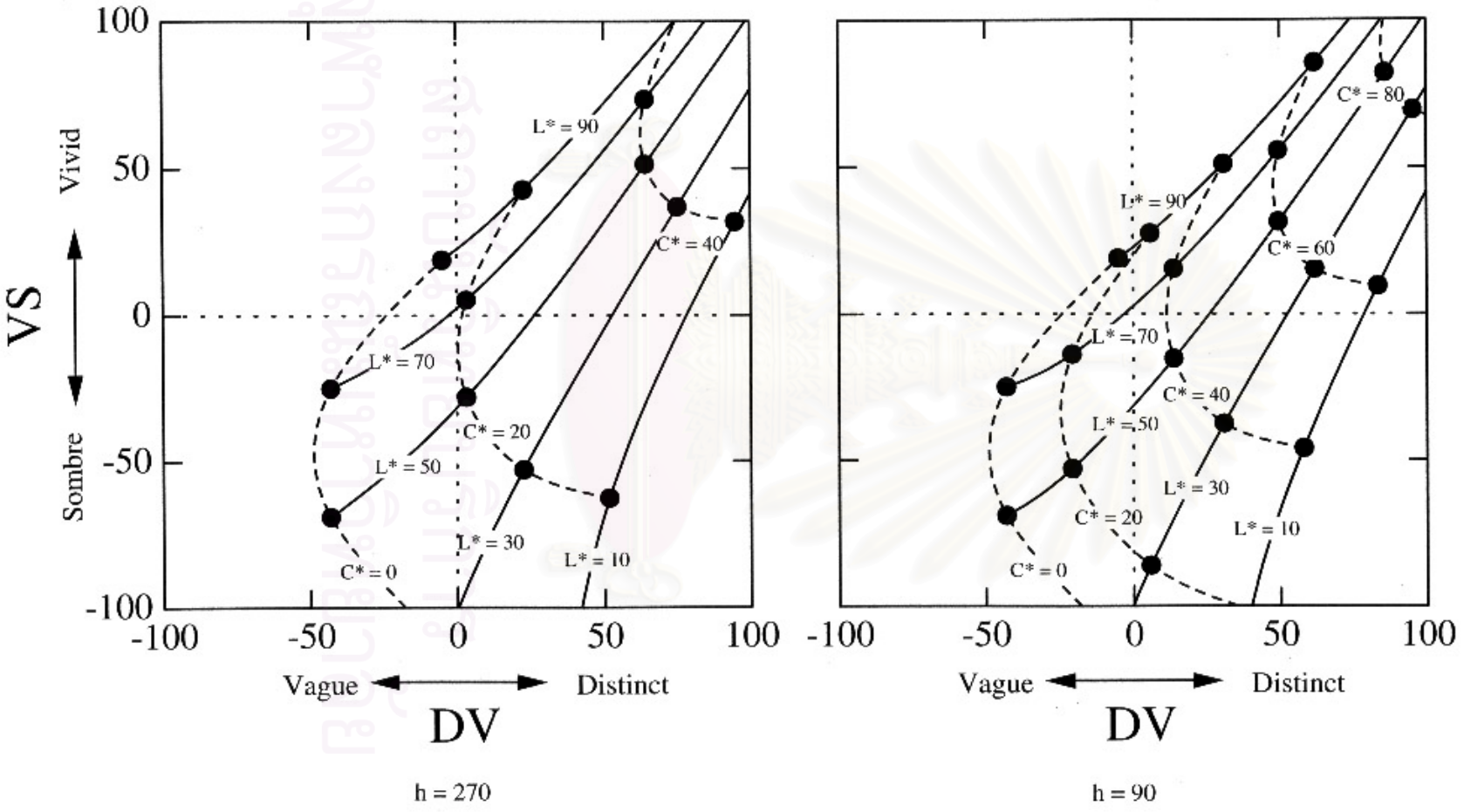

Figure 4-119 The projection of L* C* on DV-VS color perception map : h = 270, h = 90

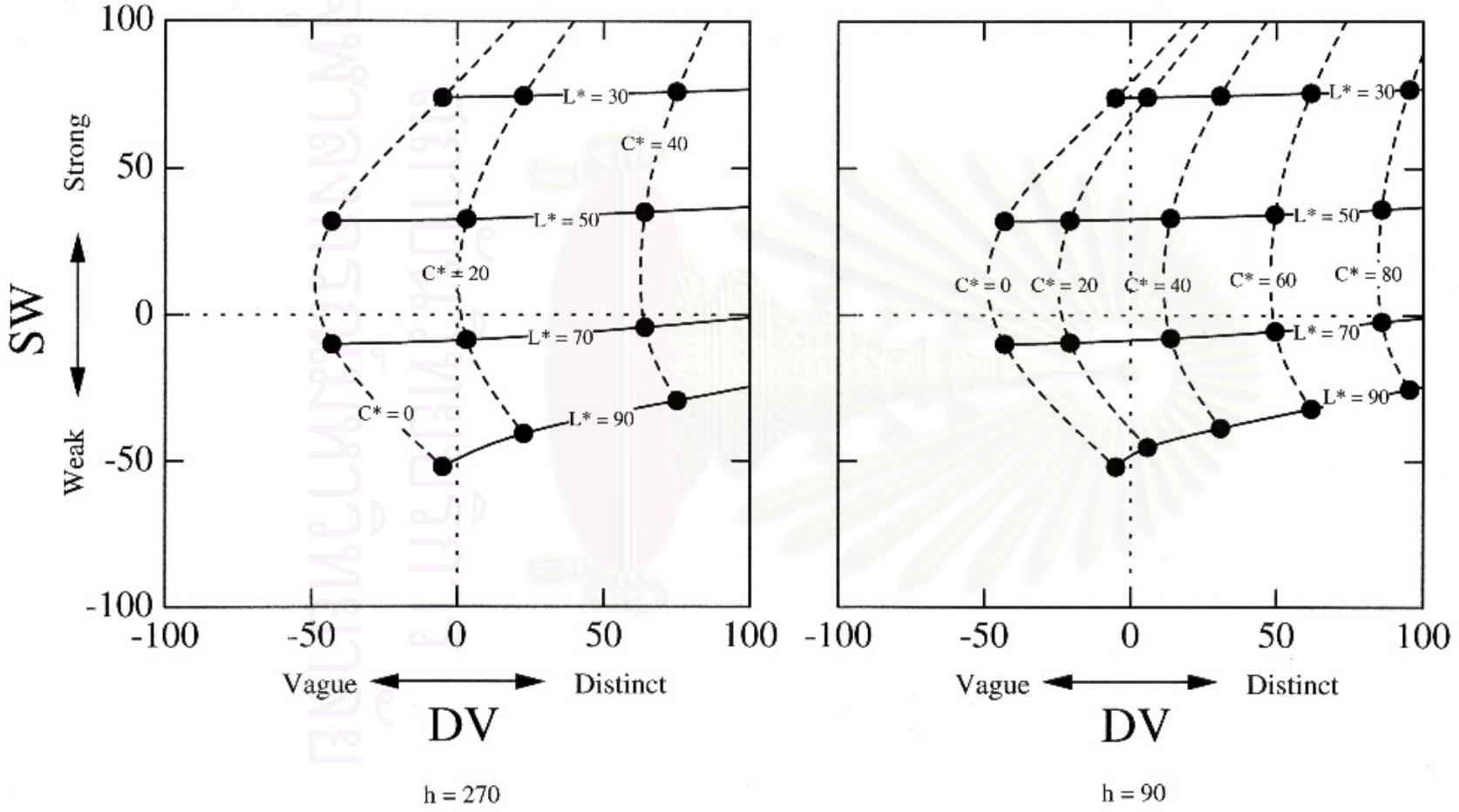

Figure 4-120 The projection of L* C* on DV-SW color perception map : h = 270, h = 90

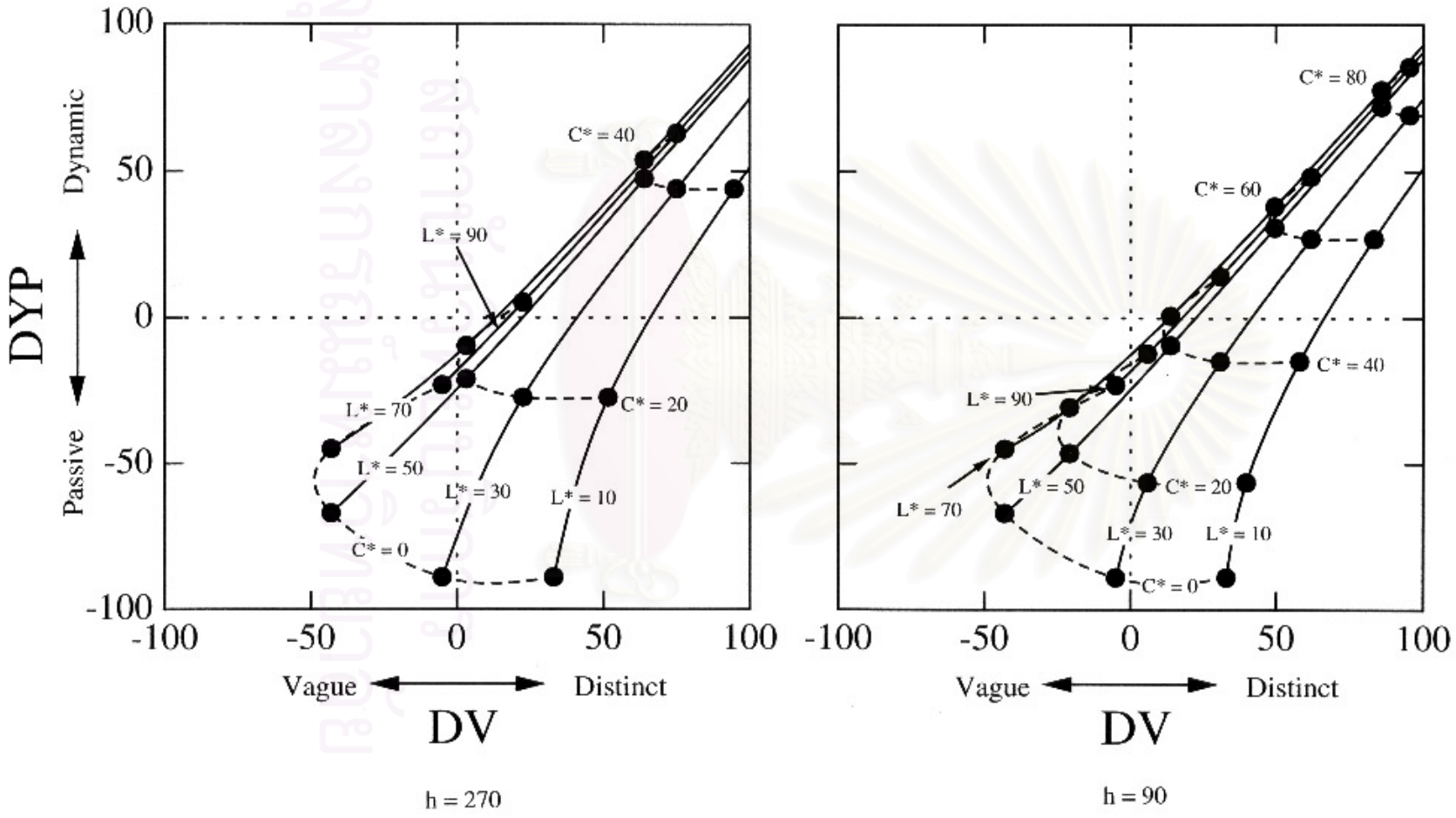

Figure 4-121 The projection of L* C* on DV-DYP color perception map : h = 270, h = 90

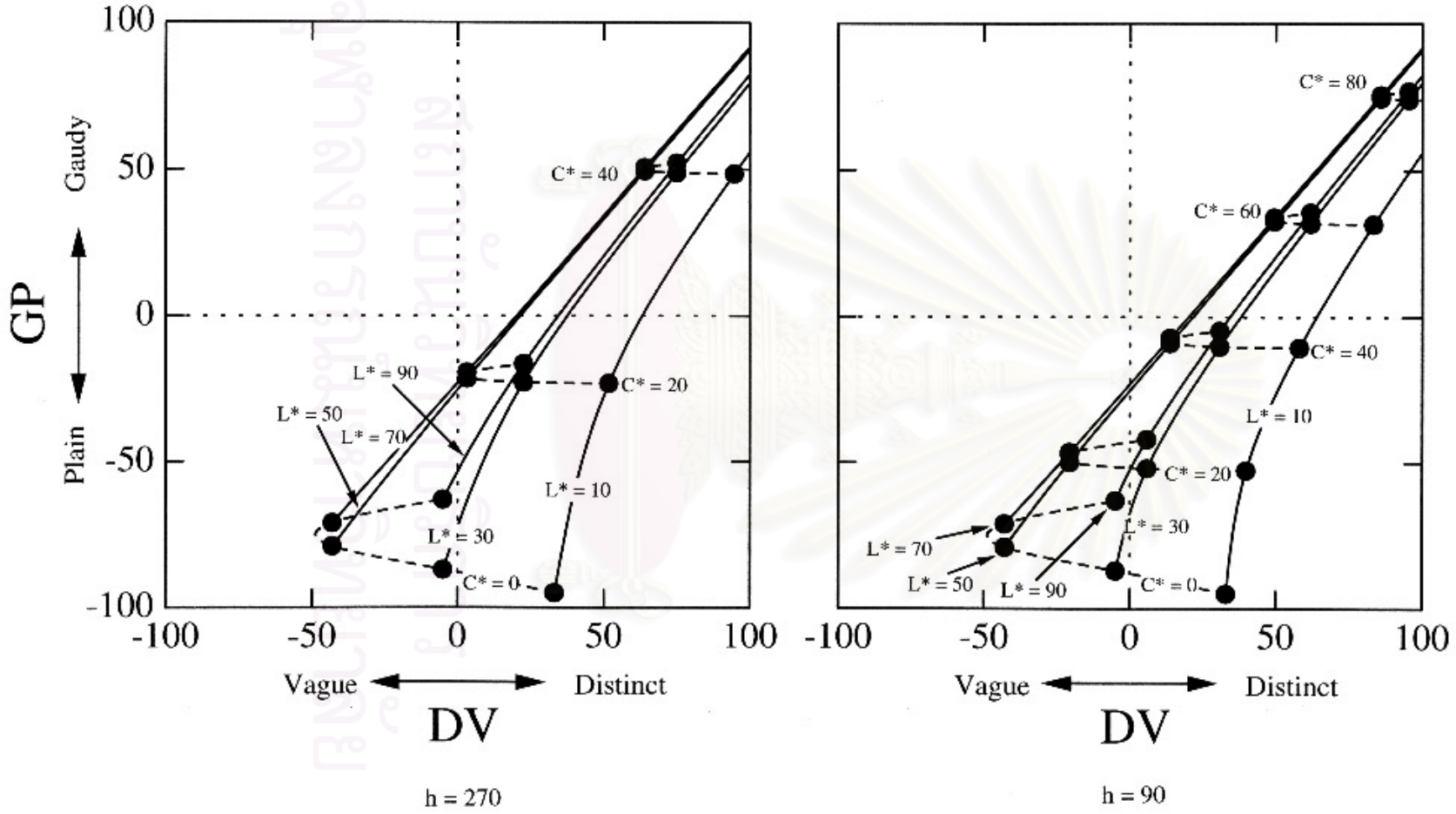

Figure 4-122 The projection of L* C* on DV-GP color perception map : h = 270, h = 90

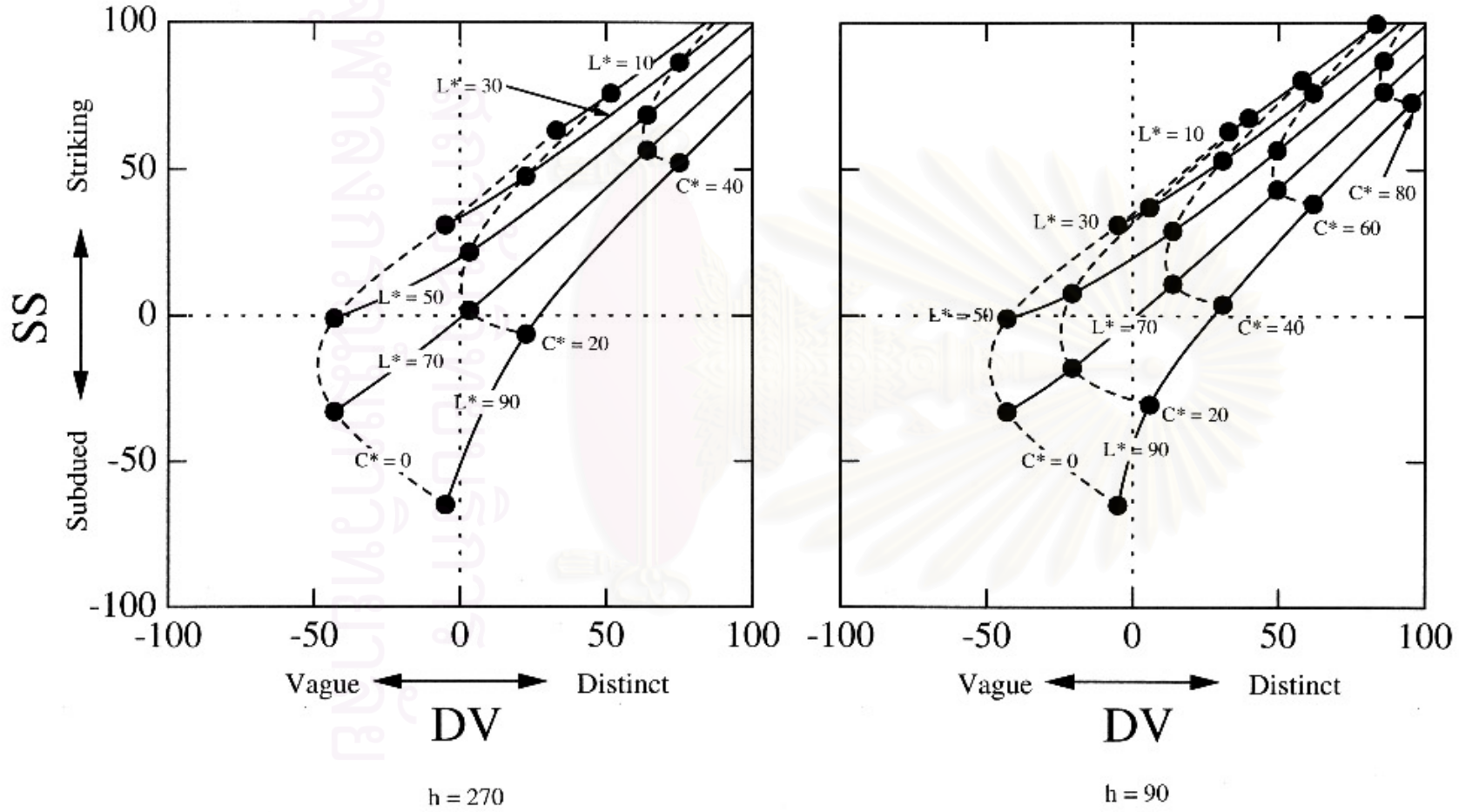

Figure 4-123 The projection of L* C* on DV-SS color perception map : h = 270, h = 90

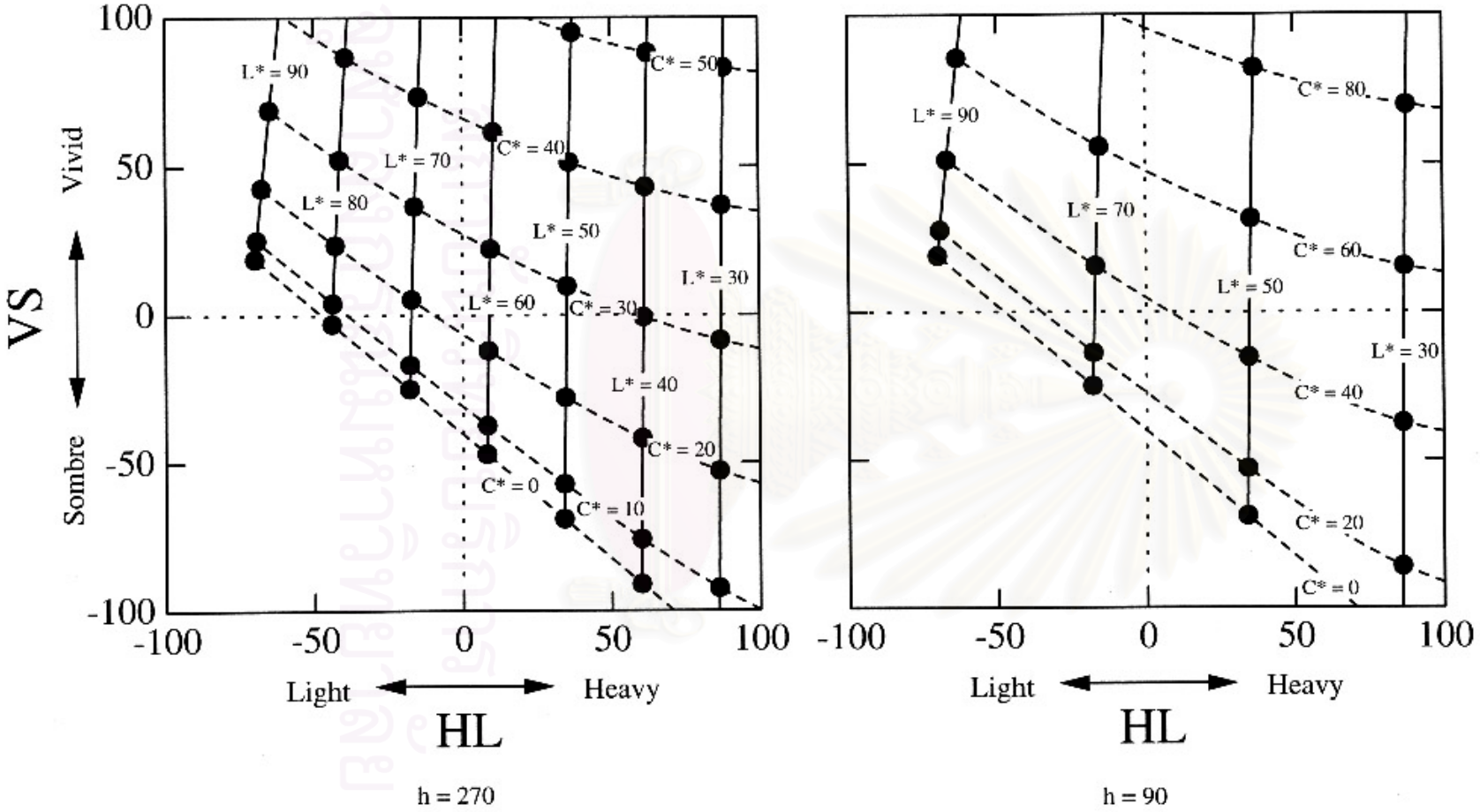

Figure 4-124 The projection of L* C* on HL-VS color perception map : h = 270, h = 90

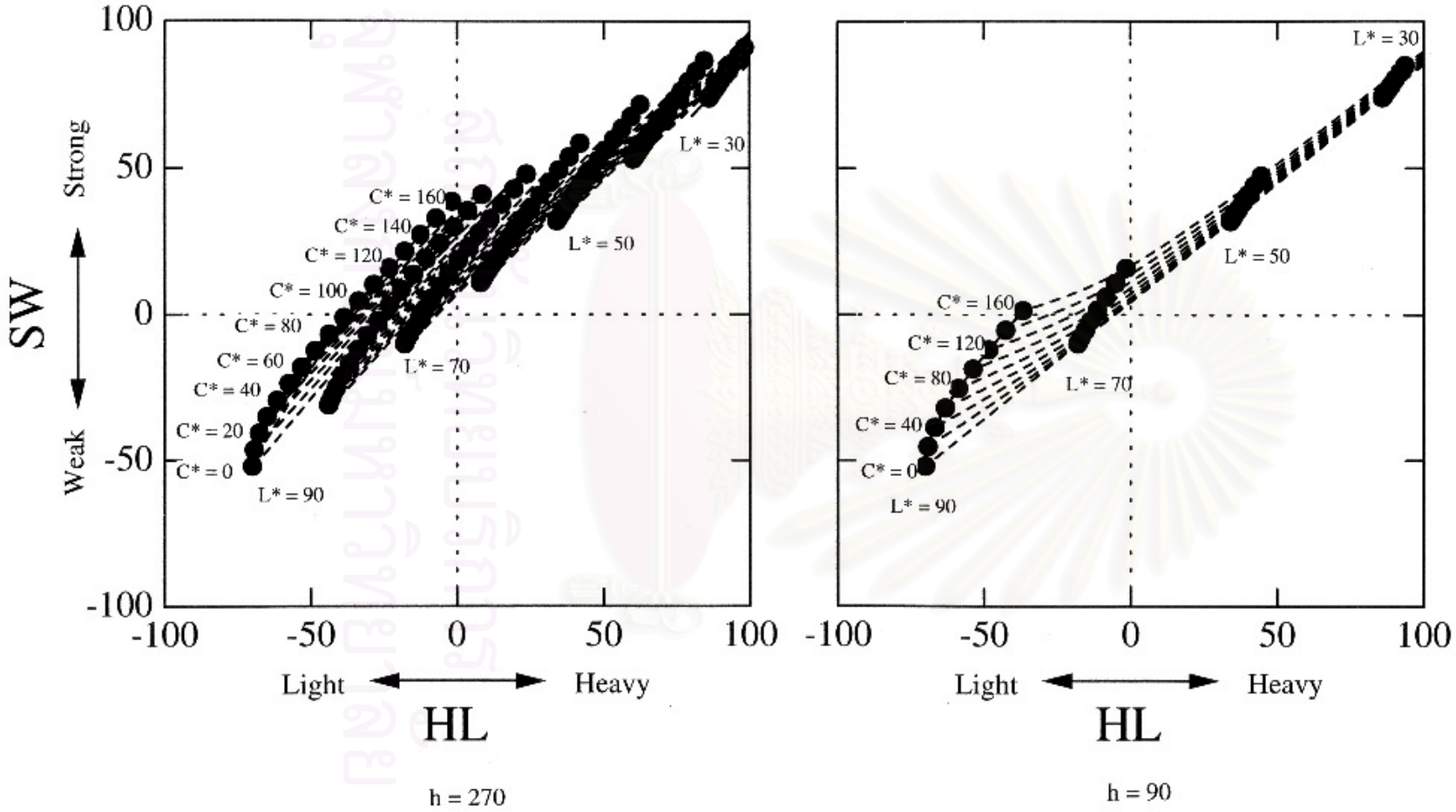

Figure 4-125 The projection of L* C* on HL-SW color perception map : h = 270, h = 90

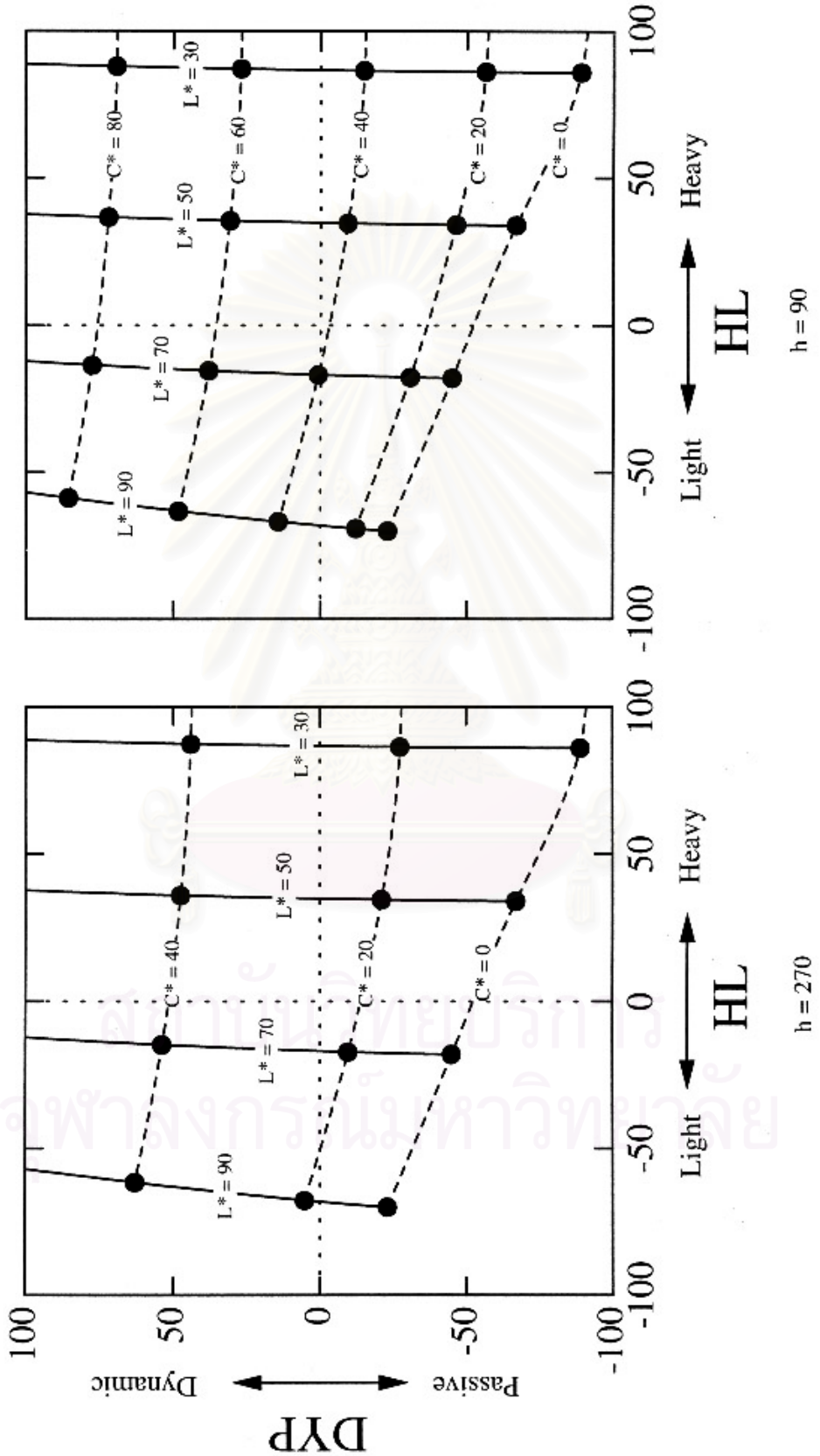

Figure 4-126 The projection of L* C* on HL-DYP color perception map : h = 270, h = 90

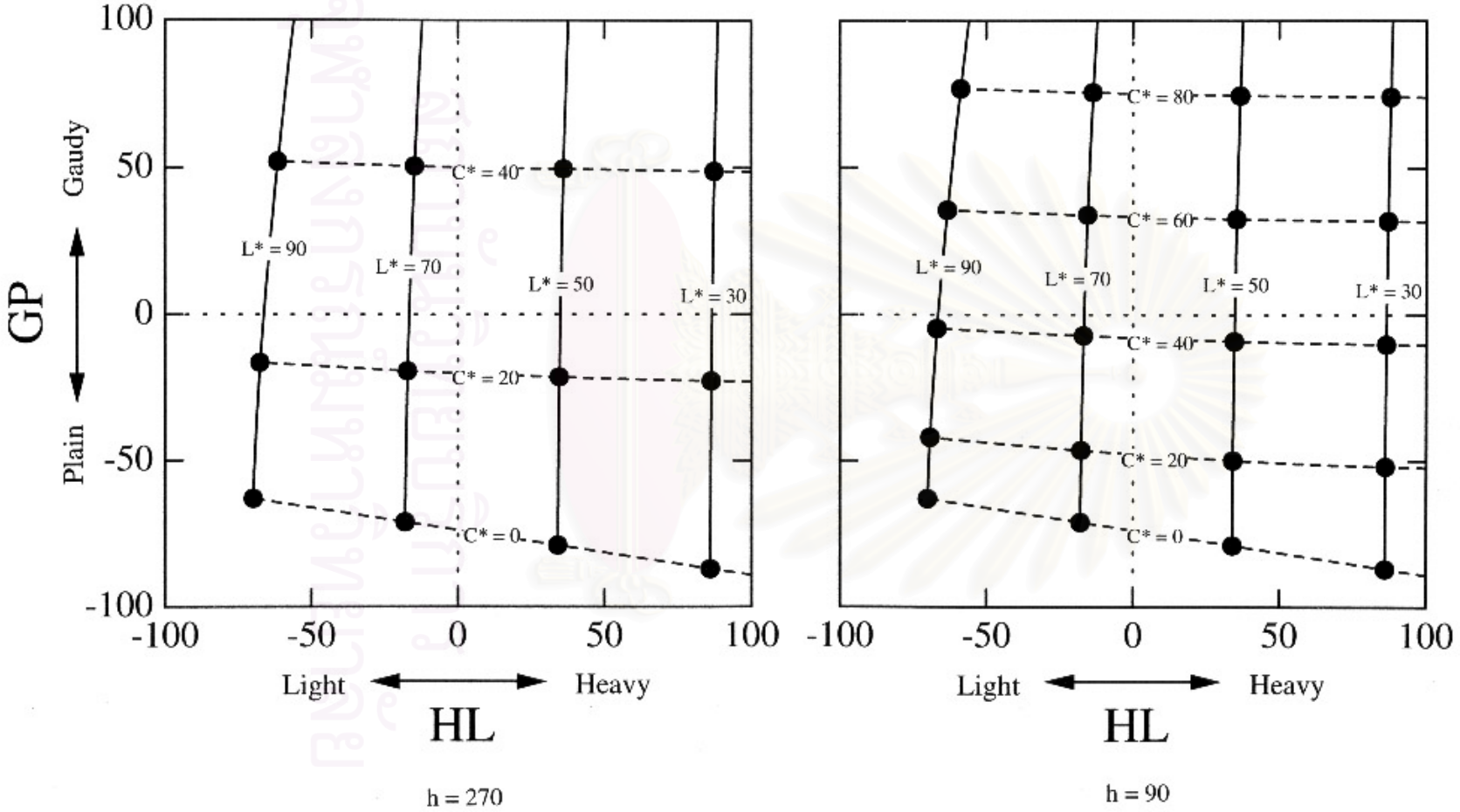

Figure 4-127 The projection of L* C* on HL-GP color perception map : h = 270, h = 90

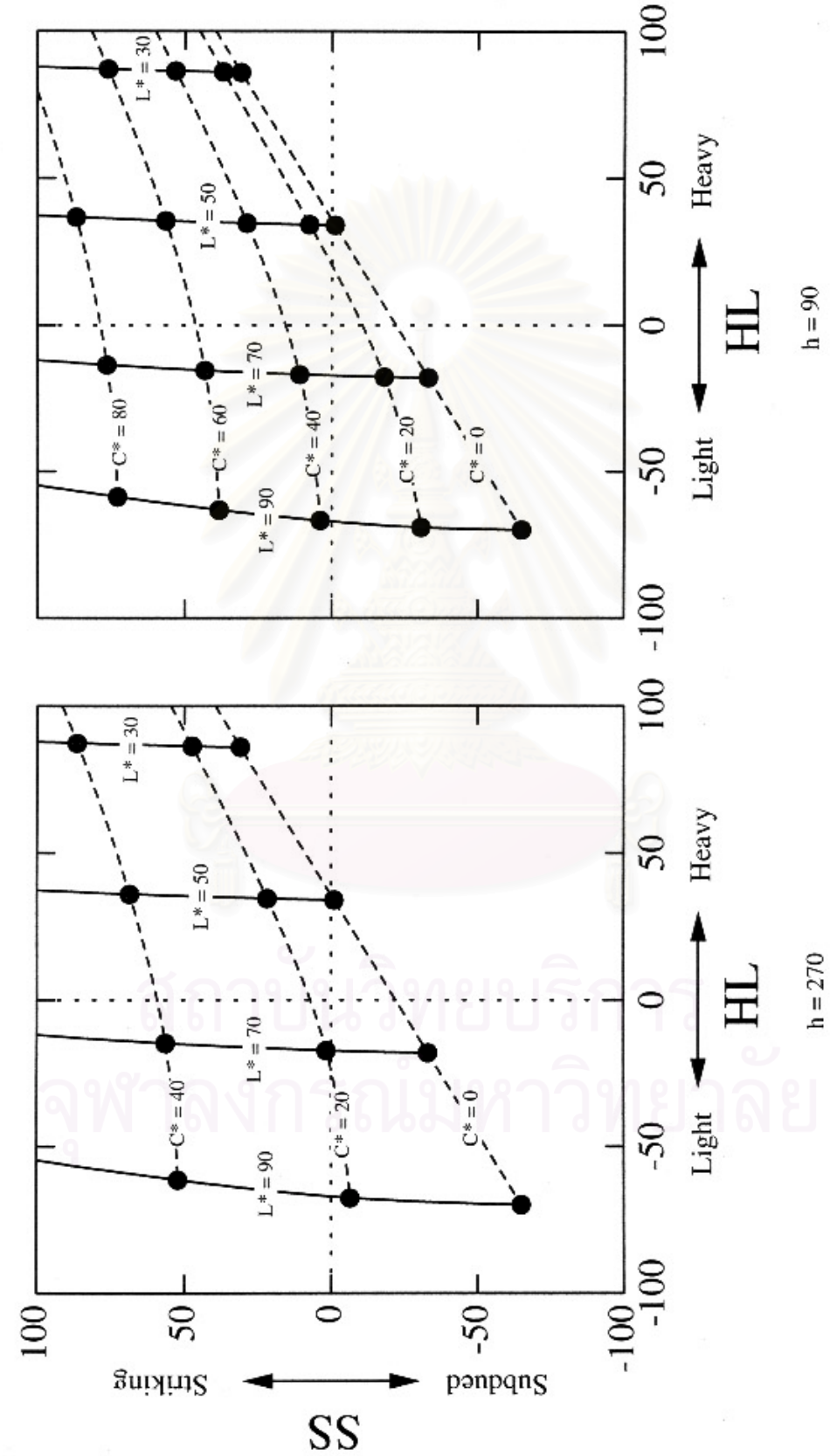

Figure 4-128 The projection of L* C* on HL-SS color perception map : h = 270, h = 90

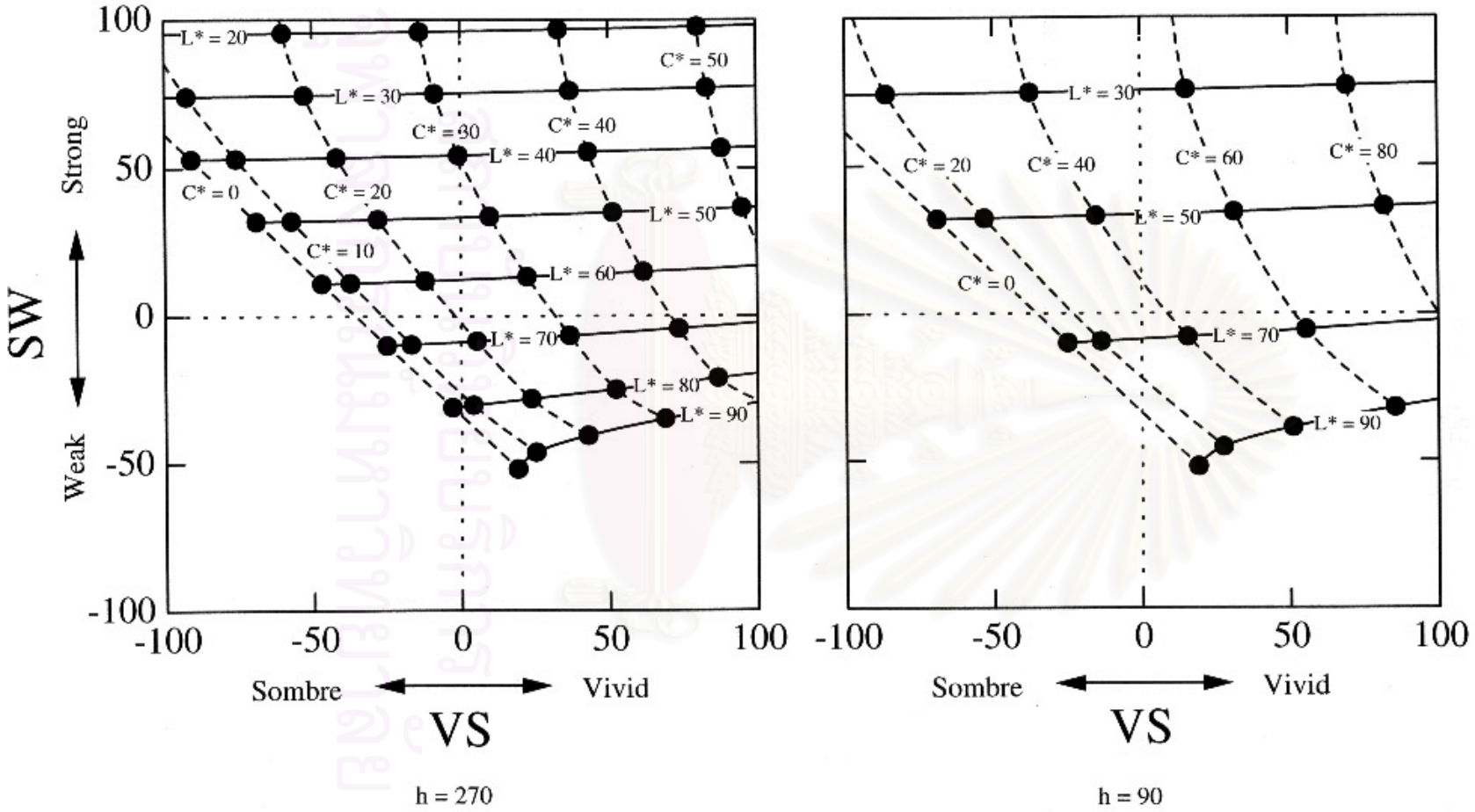

Figure 4-129 The projection of L* C* on VS-SW color perception map : h = 270, h = 90

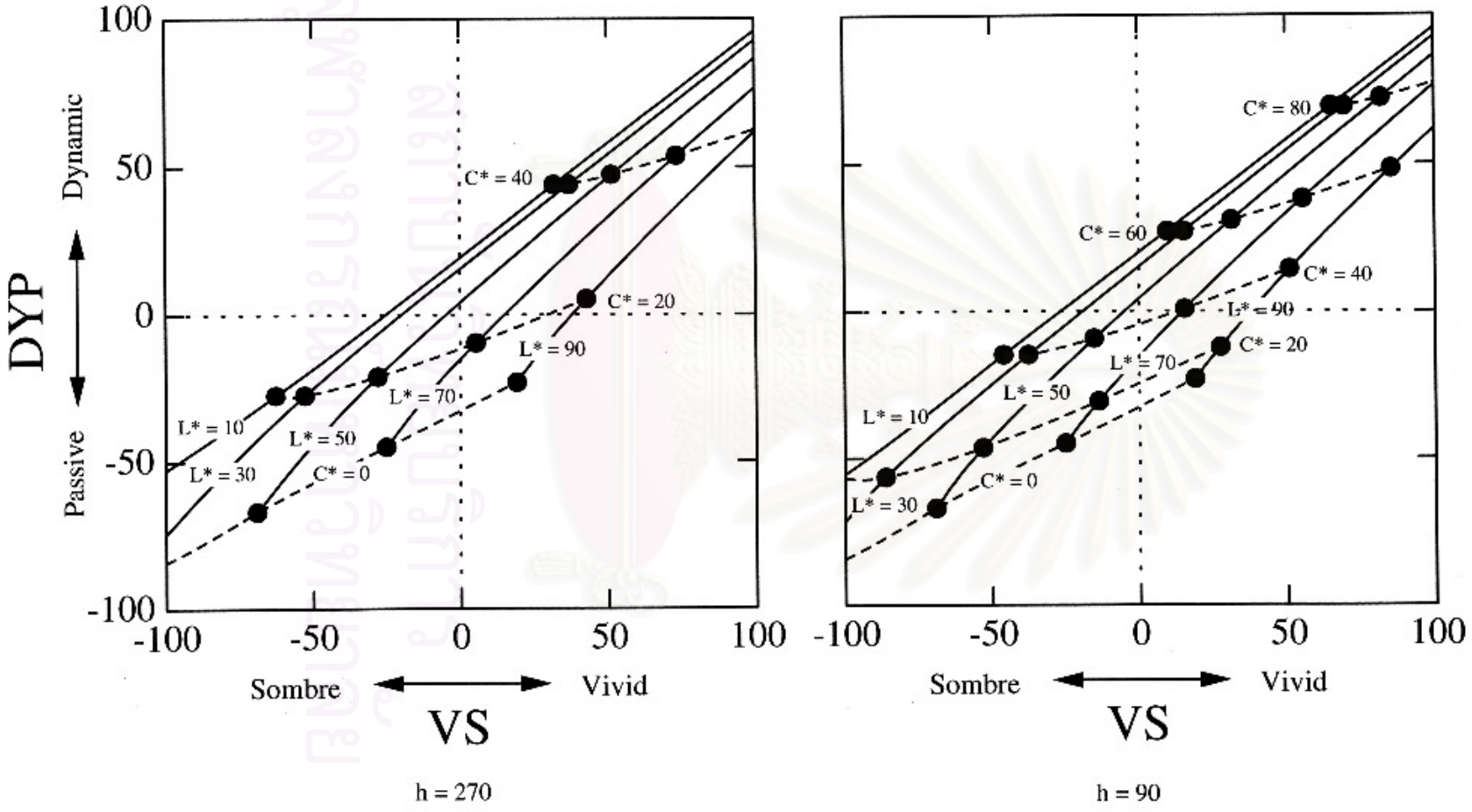

Figure 4-130 The projection of L* C* on VS-DYP color perception map : h = 270, h = 90

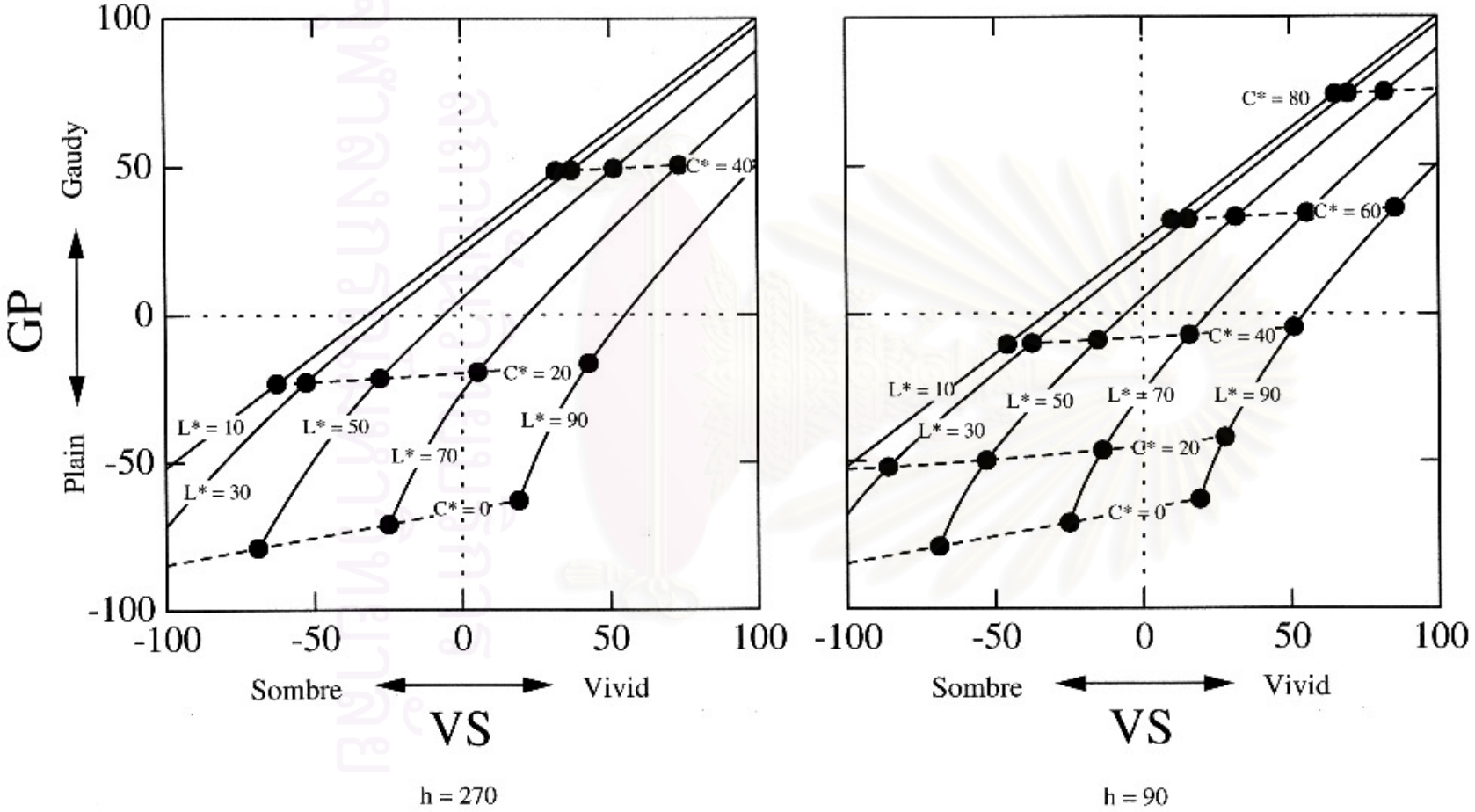

Figure 4-131 The projection of L* C* on VS-GP color perception map : h = 270, h = 90

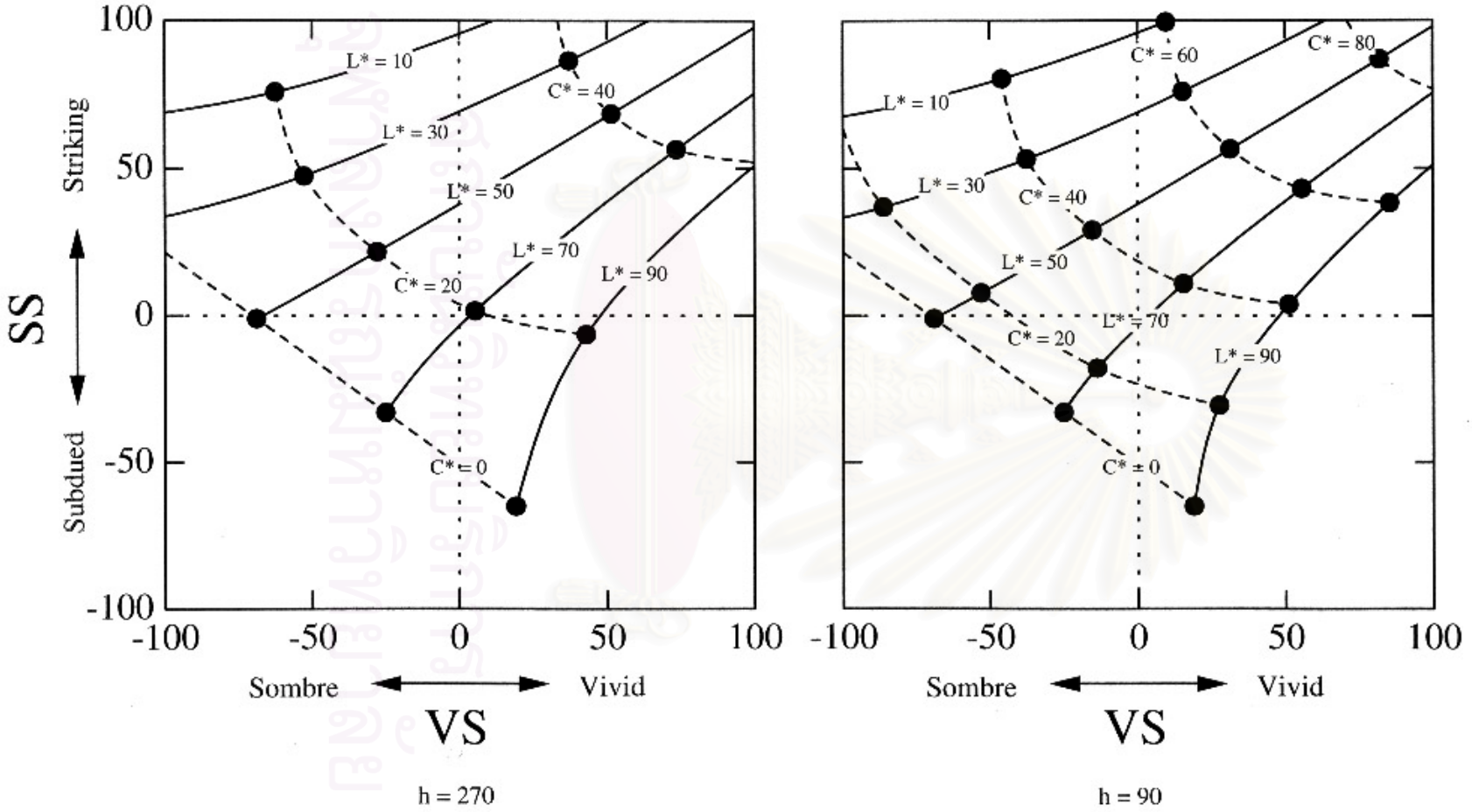

Figure 4-132 The projection of L* C* on VS-SS color perception map : h = 270, h = 90

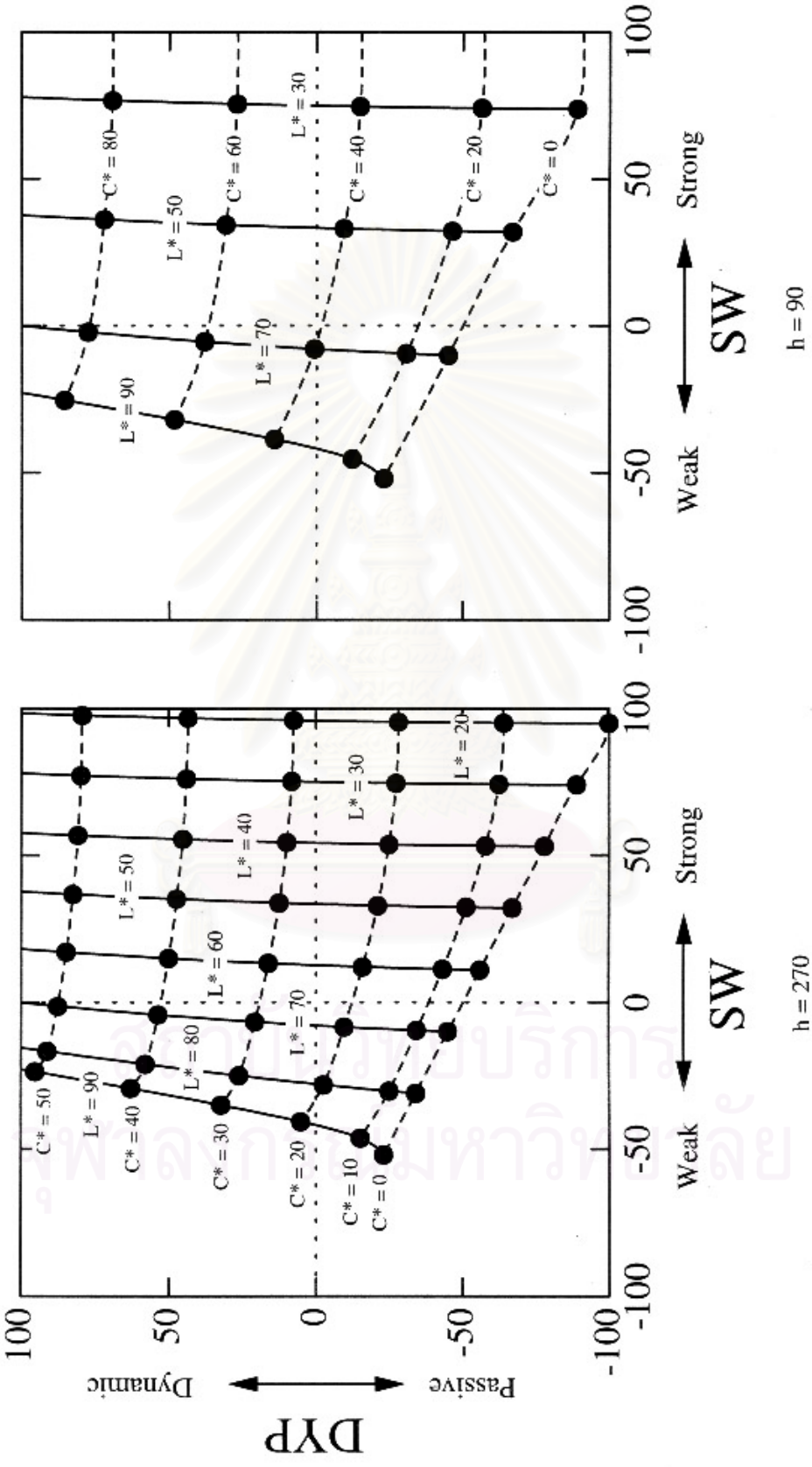

Figure 4-133 The projection of L* C* on SW-DYP color perception ma p: h = 270, h = 90

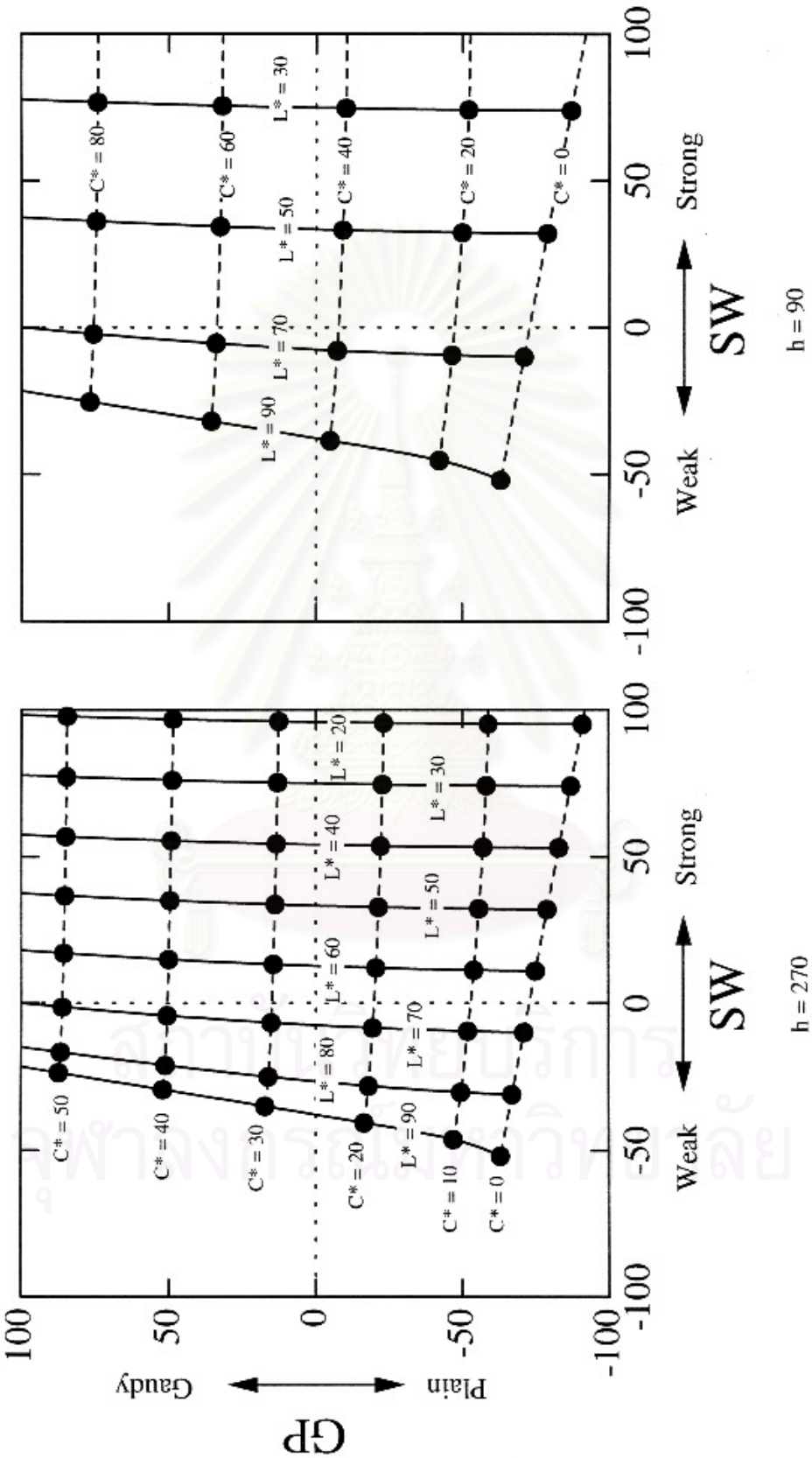

Figure 4-134 The projection of L* C* on SW-GP color perception map : h = 270, h = 90

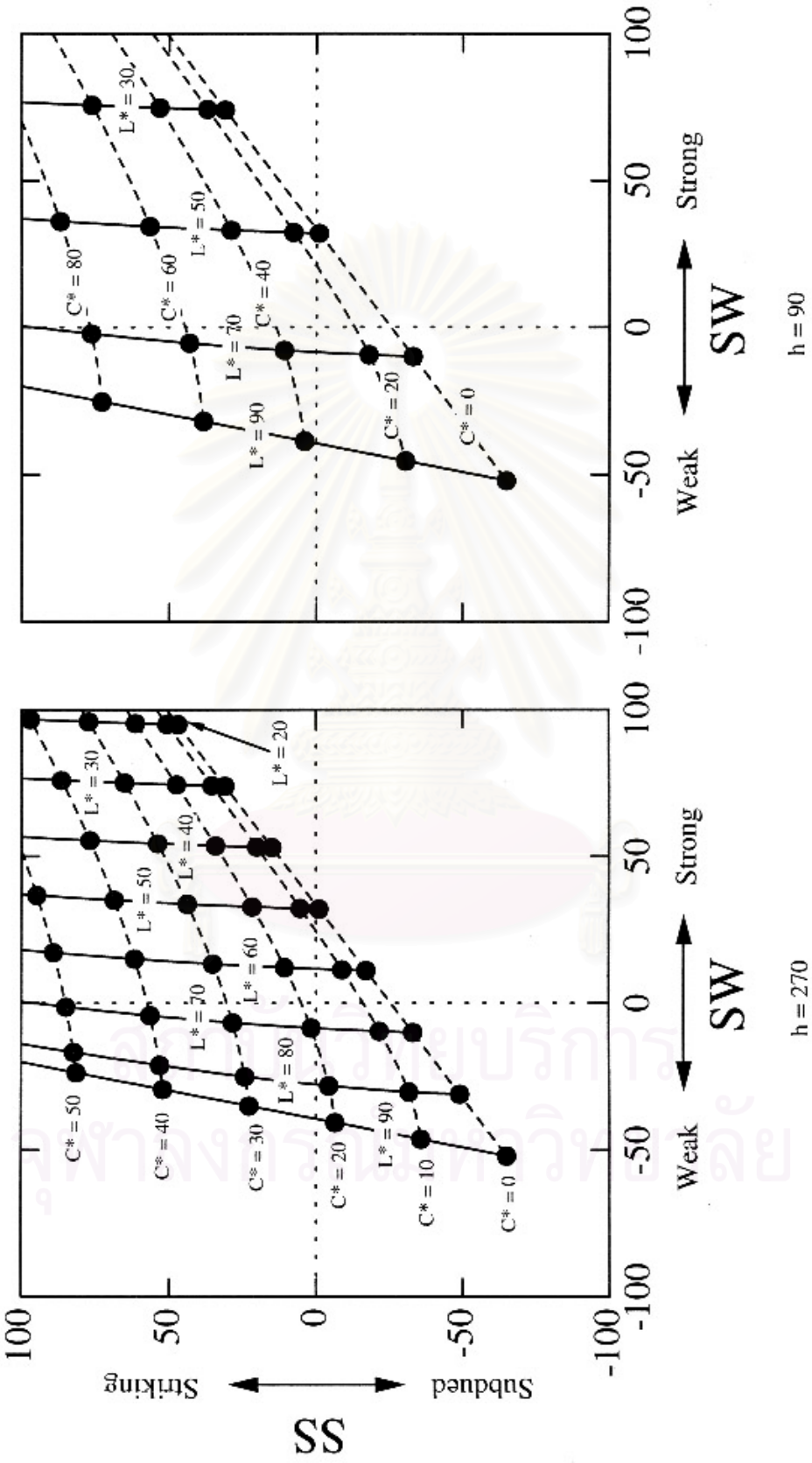

Figure 4-135 The projection of L* C* on SW-SS color perception map : h = 270, h = 90

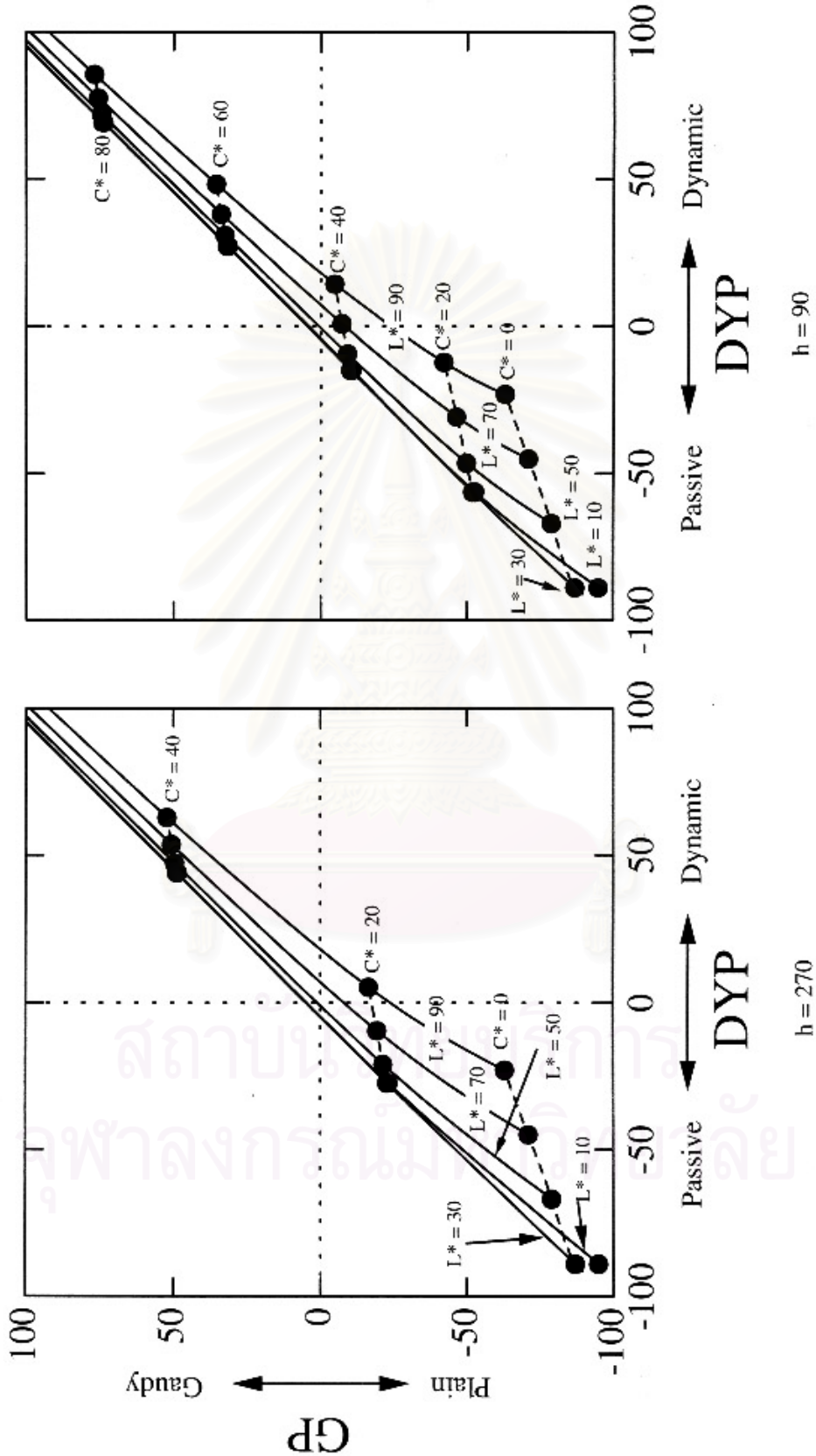

Figure 4-136 The projection of L* C* on DYP-GP color perception map : h = 270, h = 90

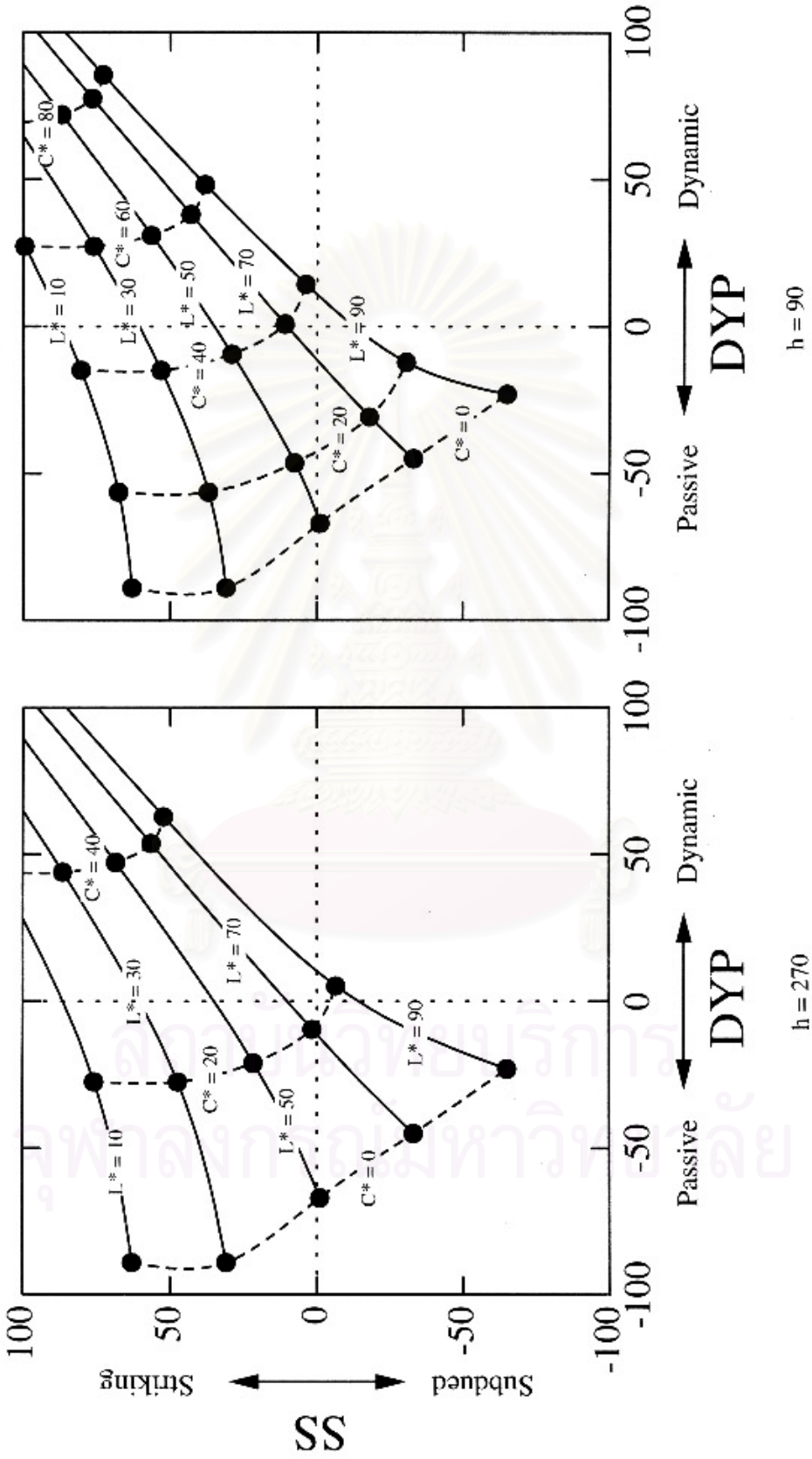

Figure 4-137 The projection of L* C* on DYP-SS color perception map : h = 270, h = 90

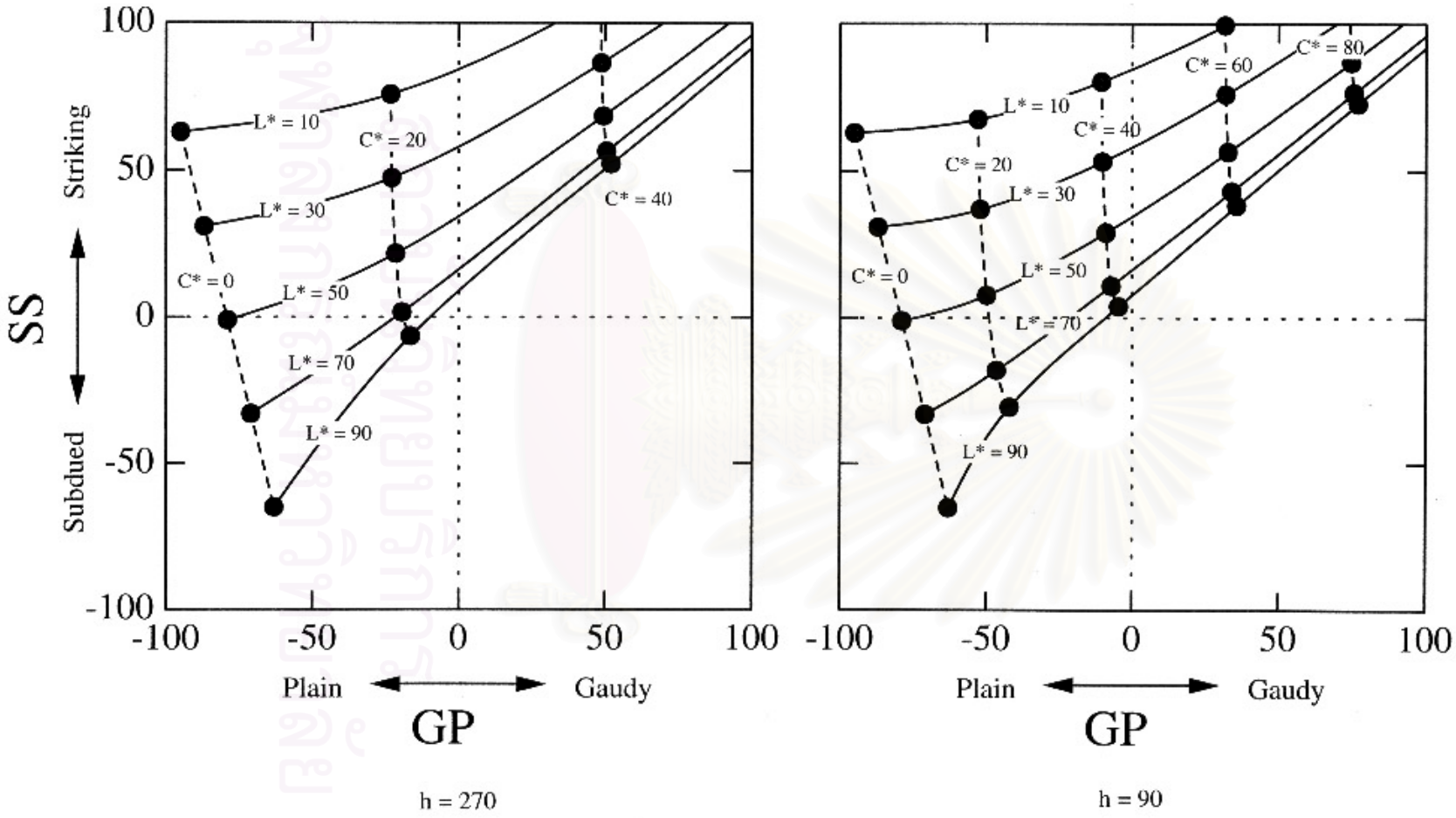

Figure 4-138 The projection of L* C* on GP-SS color perception map : h = 270, h = 90

4.5 Comparison of Visual Results between Two-Point and Seven-Point Techniques

4.5.1 Correlation Coefficients

The relationships between visual results assessed through the two-point (see Appendix D) and seven-point methods for each of the opponent word pairs are shown in Table 4-2. The table shows all high correlation coefficients for the twelve opponent word pairs.

Table 4-2 Relationship between visual results from two-point and seven-point methods

Word pairs	Correlation coefficient (r)
Light-Dark	0.9855
Soft-Hard	0.9846
Warm-Cool	0.9801
Transparent-Turbid	0.9797
Deep-Pale	0.9758
Distinct-Vague	0.9861
Heavy-Light	0.9792
Vivid-Sombre	0.9861
Strong-Weak	0.9718
Dynamic-Passive	0.9883
Gaudy-Plain	0.9885
Striking-Subdued	0.9766

4.5.2 T-tested

To investigate more in detail in terms of hue and tone of color, paired t-test was used. The results are shown in Table 4-3 and Table 4-4, respectively.

Based on the paired t-test, significant differences in hue were found in “Warm-Cool” of 10G, 5BG, 10BG, 5B, 10B, 5PB and 10PB and in “Gaudy-Plain” of

achromatic color. While in the case of tone, no significant differences were found in some cases, as follow:

- “Light-Dark” at moderate and deep tones.

- ”Soft-Hard” at light grayish, moderate, bright, deep and strong tones.

- “Warm-Cool” at pale, light moderate, light, moderate, dark, deep and strong tones.

- “Transparent-Turbid” at light moderate, moderate, deep and strong tones.

- “Deep-Pale” at light tone.

- “Distinct-Vague” at pale, light moderate, moderate, dark grayish and dark tones.

- “Heavy-Light” at light moderate, light and bright tones.

- “Vivid-Sombre” at light moderate, moderate, dark and deep tones.

- “Strong-Weak” at light moderate and light tones.

- “Dynamic-Passive” at pale, light moderate, moderate, dark and deep tones.

- “Gaudy-Plain” at pale, light moderate, moderate, dark and deep tones.

- “Striking-Subdued” at pale, light grayish and light moderate tones.

Table 4-3 Comparison of color perceptions between visual results from two-point and seven-point methods in term of hue

Color Perception	Significant Difference between two-point and seven-point methods in term of hue at 0.05 level of significance																				
	5R	10R	5YR	10 YR	5Y	10Y	5GY	10 GY	5G	10G	5BG	10 BG	5B	10B	5PB	10 PB	5P	10P	5RP	10 RP	N
Light-Dark	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Soft-Hard	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Warm-Cool	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
Transparent-Turbid	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Deep-Pale	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Distinct-Vague	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Heavy-Light	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Vivid-Sombre	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Strong-Weak	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Dynamic-Passive	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Gaudy-Plain	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes
Striking-Subdued	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No

Table 4-4 Comparison of color perceptions between visual results from two-point and seven-point methods in term of tone

Color Perception	Significant Difference between two-point and seven-point methods in term of tone at 0.05 level of significance											
	Pale Grayish	Pale	Light Grayish	Light Moderate	Light	Grayish	Moderate	Bright	Dark Grayish	Dark	Deep	Strong
Light-Dark	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes
Soft-Hard	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	Yes	No	No
Warm-Cool	Yes	No	Yes	No	No	Yes	No	Yes	Yes	No	No	No
Transparent-Turbid	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No	No
Deep-Pale	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distinct-Vague	Yes	No	Yes	No	Yes	Yes	No	Yes	No	No	Yes	Yes
Heavy-Light	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Vivid-Sombre	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	No	Yes
Strong-Weak	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dynamic-Passive	Yes	No	Yes	No	Yes	Yes	No	Yes	Yes	No	No	Yes
Gaudy-Plain	Yes	No	Yes	No	Yes	Yes	No	Yes	Yes	No	No	Yes
Striking-Subdued	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

4.6 Comparison between Thai and Japanese Data

4.6.1 Observer Comparison

Firstly, The comparison between visual results of Thai and Japanese observers (see Appendix E) corresponding to the seven-point assessments was made and are shown in Table 4-5.

Table 4-5 Relationship between visual results from Thai and Japanese observers

Word pairs	Correlation coefficient (r)
Light-Dark	0.94695
Soft-Hard	0.9361
Warm-Cool	0.9090
Transparent-Turbid	0.8732
Deep-Pale	- 0.8937
Distinct-Vague	0.9004
Heavy-Light	0.9482
Vivid-Sombre	0.9525
Strong-Weak	0.9210
Dynamic-Passive	0.8470
Gaudy-Plain	0.8839
Striking-Subdued	0.6551

The high correlations [0.9210-0.9525] were found at “Strong-Weak,” “Soft-Hard,” “Light-Dark,” “Heavy-Light,” and “Vivid-Sombre.” The lower correlations [0.8470-0.9090] are at “Dynamic-Passive,” “Transparent-Turbid,” “Gaudy-Plain,” “Distinct-Vague,” and “Warm-Cool” and the lowest correlation in “Striking-Subdued” was 0.6551 while the high negative correlation is in “Deep-Pale” – 0.8937.

Secondly, The visual results between Thai and Japanese observers were compared by a paired *t*-test. If the calculated *t*-value is lower than the critical *t*-value at the 0.05 level of significance, the color perception of the two regions is considered

as “no significant difference”; whereas if the calculated one is larger than the critical one, the difference significant.

Table 4-6 shows the comparison of visual results in term of hue, by which significant differences were found in “Warm-Cool” of 5GY, 5G, 5BG and 5B; in “Deep-Pale” of 5PB, 5P, and 5RP and in “Striking-Subdued” of 5YR. While no significant differences were found in some cases of the comparison of visual results in term of tone as follows (Table 4-7)

- “Light-Dark” at moderate, bright, dark, deep and strong tones.

- ”Soft-Hard” at pale, light grayish, light moderate, light, grayish, moderate, bright, dark grayish, dark, deep and strong tones.

- “Warm-Cool” at light moderate, light, grayish, moderate, bright, dark grayish, dark, deep and strong tones.

- “Transparent-Turbid” at light grayish, light moderate, moderate, bright, deep and strong tones.

- “Deep-Pale” at light grayish and light tones.

- “Distinct-Vague” at pale grayish, light grayish, light moderate, grayish, moderate, bright, dark grayish, dark, deep and strong tones.

- “Heavy-Light” at pale grayish, pale, bright, deep and strong tones.

- “Vivid-Sombre” at pale grayish, pale, light moderate, moderate, bright, deep and strong tones.

- “Strong-Weak” at dark, deep and strong tones.

- “Dynamic-Passive” at pale grayish, light grayish, moderate, bright, deep and strong tones.

- “Gaudy-Plain” at light moderate, light, moderate, bright, dark, deep and strong tones.

- “Striking-Subdued” at light moderate, bright, deep and strong tones.

Table 4-6 Comparison of color perceptions between visual results from Thai and Japanese in term of hue

Color Perception	Significant Difference between Thai and Japanese in term of hue at 0.05 level of significance										
	5R	5YR	5Y	5GY	5G	5BG	5B	5PB	5P	5RP	N
Light-Dark	No	No	No	No	No	No	No	No	No	No	No
Soft-Hard	No	No	No	No	No	No	No	No	No	No	No
Warm-Cool	No	No	No	Yes	Yes	Yes	Yes	No	No	No	No
Transparent-Turbid	No	No	No	No	No	No	No	No	No	No	No
Deep-Pale	No	No	No	No	No	No	No	Yes	Yes	Yes	No
Distinct-Vague	No	No	No	No	No	No	No	No	No	No	No
Heavy-Light	No	No	No	No	No	No	No	No	No	No	No
Vivid-Sombre	No	No	No	No	No	No	No	No	No	No	No
Strong-Weak	No	No	No	No	No	No	No	No	No	No	No
Dynamic-Passive	No	No	No	No	No	No	No	No	No	No	No
Gaudy-Plain	No	No	No	No	No	No	No	No	No	No	No
Striking-Subdued	No	Yes	No	No	No	No	No	No	No	No	No

Table 4-7 Comparison of color perceptions between visual results from Thai and Japanese in term of tone

Color Perception	Significant Difference between Thai and Japanese in term of tone at 0.05 level of significance											
	Pale Grayish	Pale	Light Grayish	Light Moderate	Light	Grayish	Moderate	Bright	Dark Grayish	Dark	Deep	Strong
Light-Dark	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	No	No
Soft-Hard	Yes	No	No	No	No	No	No	No	No	No	No	No
Warm-Cool	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No
Transparent-Turbid	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No
Deep-Pale	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distinct-Vague	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
Heavy-Light	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No
Vivid-Sombre	No	No	Yes	No	Yes	Yes	No	No	Yes	Yes	No	No
Strong-Weak	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Dynamic-Passive	No	Yes	No	Yes	Yes	Yes	No	No	Yes	Yes	No	No
Gaudy-Plain	Yes	Yes	Yes	No	No	Yes	No	No	Yes	Yes	No	No
Striking-Subdued	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No	No

4.7 Cross-cultural translation equations

The twelve color perception equations that allowed us to study the relationship between Thai and Japanese perceptions were derived for the purpose of enabling us to translate Japanese to Thai or vice versa. (see Appendix F) The equations follows:

"Light-Dark"

$$LD_{TH} = [\{3.4(L^*-10)\}^2+(\{4.5/4.1\}[(LD_{JP}+155)^2-\{2.2(L^*+0)\}^2]^{1/2})^2]^{1/2}-184 \quad (4.13)$$

"Soft-Hard"

$$SH_{TH} = -[\{2.2(L^*-90)\}^2+(\{0.9/1.5\}[(SH_{JP}+115)^2-\{1.9L^*\}^2]^{1/2})^2]^{1/2}+79 \quad (4.14)$$

"Warm-Cool"

$$WC_{TH} = [\{0.27(L^*-100)\}^2+ \ldots$$
$$\ldots\{1.48\{1+\cos(\Delta h_{40})\}\{(WC_{JP}+35) / (1.2+1.8\{\cos(\Delta h_{55})/360\})\}\}^2]^{1/2}- 58 \quad (4.15)$$

"Transparent-Turbid"

$$TT_{TH} = [\{3.1(L^*-30)\}^2+\ldots$$
$$\ldots\{(\{TT_{JP}+85)^2- \{2.18(L^*-35)\}^2) / ((1+0.3\cos(\Delta h_{220}))^2\}]^{1/2}- 122 \quad (4.16)$$

"Deep-Pale"

$$DP_{TH} = [\{2.6(L^*-100)\}^2- \ldots$$
$$\ldots(1.8/1.3)^2\{(\{DP_{JP}-105)^2+ \{2.4(L^*-100)\}^2)/((1+0.8\cos(\Delta h_{90}))^2\}]^{1/2}- 90 \quad (4.17)$$

"Distinct-Vague"

$$DV_{TH} = [\{1.9(L^*-60)\}^2+(\{3.3/2.8\}[(DV_{JP}+60)^2-\{1.6(L^*-65)\}^2]^{1/2})^2]^{1/2}-62 \quad (4.18)$$

"Heavy-Light"

$$HL_{TH} = [\{2.6(L^*-100)\}^2+(\{0.6/0.1\}[-\{(HL_{JP}-135)^2+\{2.3(L^*-0)\}^2\}]^{1/2})^2]^{1/2}-184 \quad (4.19)$$

"Vivid-Sombre"

$$VS_{TH} = [\{2.2(L^*-10)\}^2+(\{5/3.6\}[(VS_{JP}+95)^2-\{2.2(L^*-40)\}^2]^{1/2})^2]^{1/2}-157 \quad (4.20)$$

"Strong-Weak"

$$SW_{TH} = [\{2.1(L^*-90)\}^2+(\{0.6/2.0\}[(SW_{JP}+75)^2-\{2.2(L^*-85)\}^2]^{1/2})^2]^{1/2}-52 \quad (4.21)$$

"Dynamic-Passive"

$$DYP_{TH} = [\{1.1(L^*-20)\}^2+(\{3.8/2.5\}[(DYP_{JP}+55)^2-\{0.2(L^*-50)\}^2]^{1/2})^2]^{1/2}-100 \quad (4.22)$$

"Gaudy-Plain"

$$GP_{TH} = [\{0.4(L^*-10)\}^2+(\{3.8/3.6\}[(GP_{JP}+85)^2-\{1.4(L^*-50)\}^2]^{1/2})^2]^{1/2}-95 \quad (4.23)$$

"Striking-Subdued"

$$SS_{TH} = [\{1.6(L^*-90)\}^2+(\{3.1/3.4\}[(SS_{JP}+75)^2-\{1.0(L^*-40)\}^2]^{1/2})^2]^{1/2}-65 \quad (4.24)$$

where; L^* : CIELAB metric lightness

Δh_x : CIELAB metric hue angle difference from h=x, $0 \leq \Delta h_x \leq 180$

The relationship between Japanese visual results, which were translated into Thai (see Appendix G) and Thai visual results are shown in Table 4-8. The range of the highest correlations [0.9400-0.9601] were found in the "Strong-Weak," "Vivid-Sombre," "Heavy-Light," and "light-Dark" areas. High correlations [0.8805-0.9261] were found in the "Transparent-Turbid," "Striking-Subdued," "Gaudy-Plain," "Distinct-Vague," "Dynamic-Passive," "Deep-Pale," and "Warm-Cool" areas. Thus, the cross-cultural translation equations used to derive the data in these groups are considered to be close to reality. Note that the correlation coefficient in the "Soft-Hard" area was 0.7908. This implies that color perception equation used for translating the "Soft-Hard" data needs to be improved.

Table 4-8 Relationship between Japanese visual results which were translated into Thai and Thai visual results

Word pairs	Correlation coefficient (r)
Light-Dark	0.9601
Soft-Hard	0.7908
Warm-Cool	0.9261
Transparent-Turbid	0.8805
Deep-Pale	0.9077
Distinct-Vague	0.9010
Heavy-Light	0.9492
Vivid-Sombre	0.9492
Strong-Weak	0.9400
Dynamic-Passive	0.9046
Gaudy-Plain	0.8953
Striking-Subdued	0.8930

In addition, the translation between the color perceptions of Japanese and Thai observers may be indicated by plotting data derived from color perception equations on the color perception map are shown in Figure 4-139 to Figure 4-150. From these diagram it is easy to see the degree of color perceptions. For example, in Figure 4-139 at L*, C* and h are 70, 0 and 270, respectively. The color perception of “Light-Dark” in Japanese and Thai can be predicted to be about -1 and 54. Thus, this diagram is useful for quantitative communication of the difference between the color perceptions of Japanese and Thai observers.

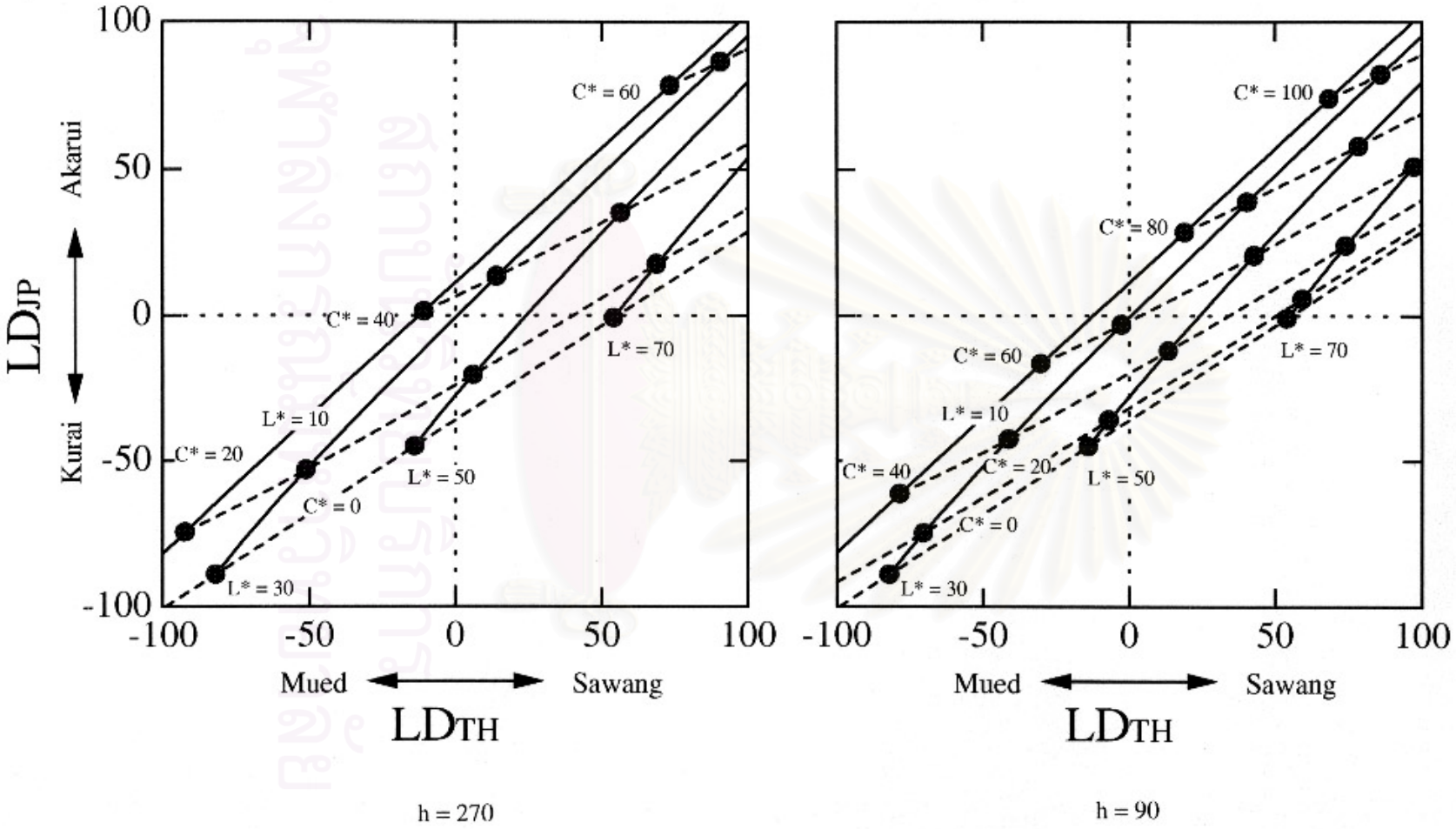

Figure 4-139 The projection of L* C* on LD_{JP}-LD_{TH} color perception map : h = 270, h = 90

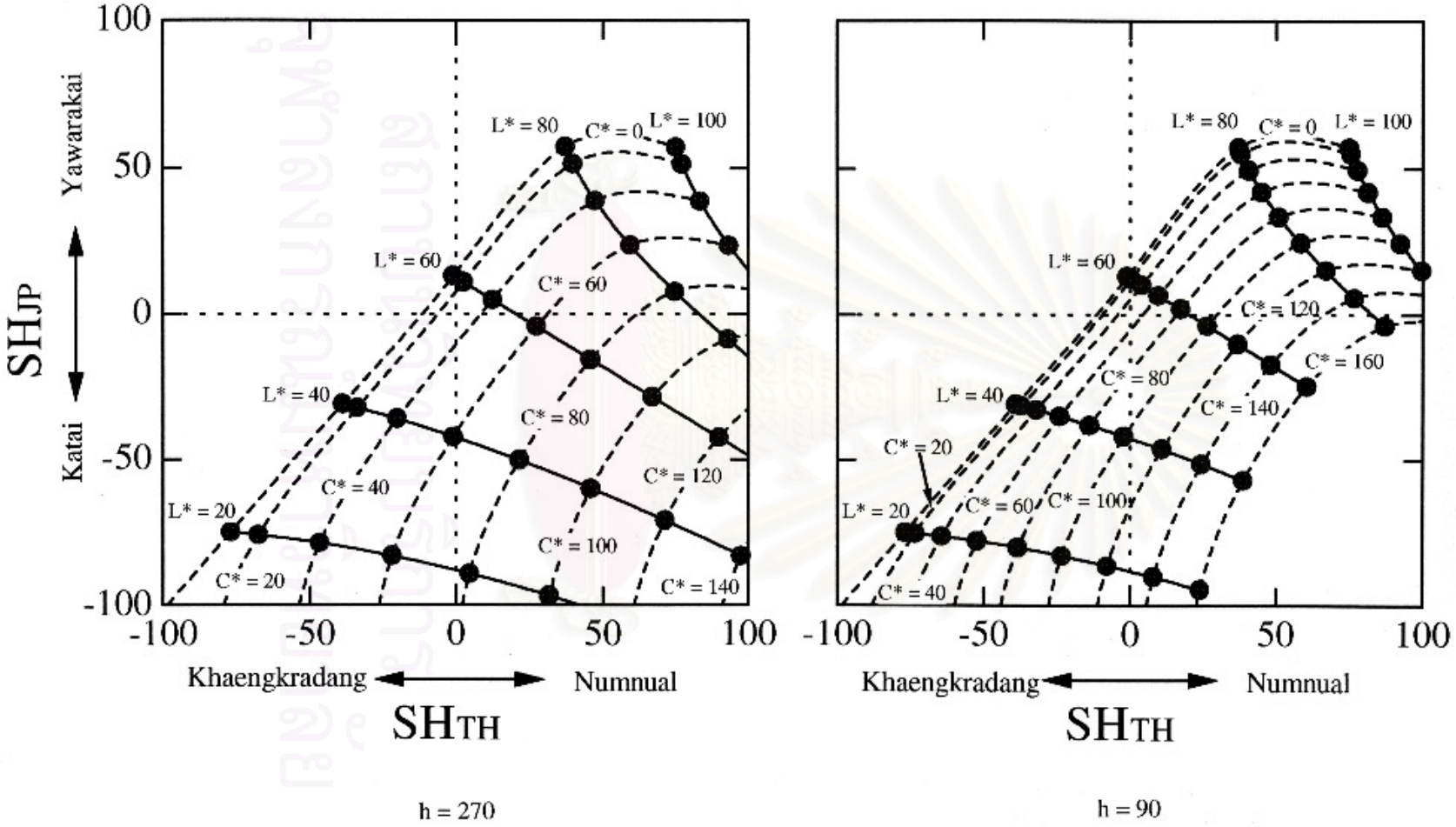

Figure 4-140 The projection of L* C* on SH_{JP}-SH_{TH} color perception map : h = 270, h = 90

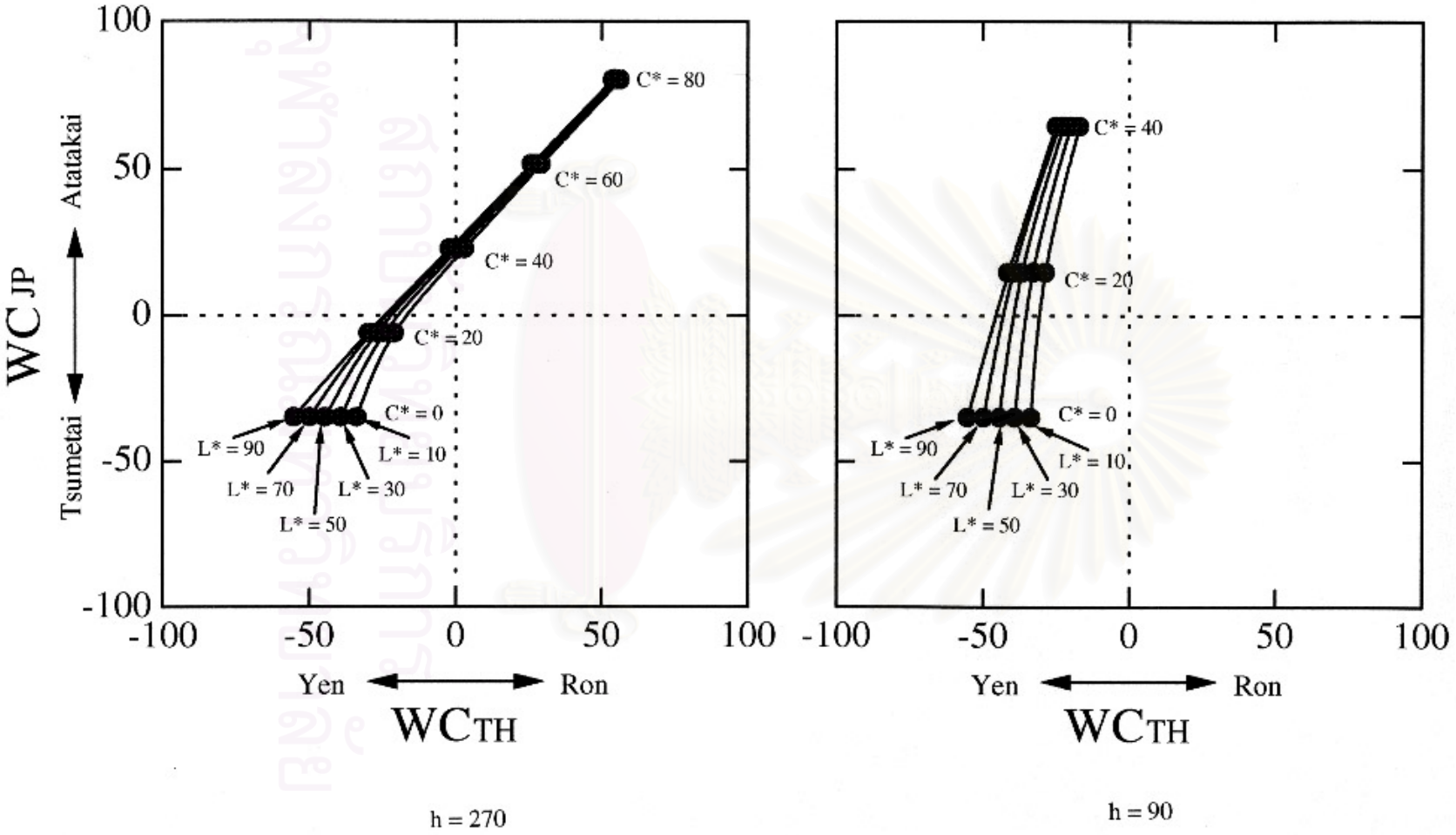

Figure 4-141 The projection of L* C* on WC_{JP}-WC_{TH} color perception map : h = 270, h = 90

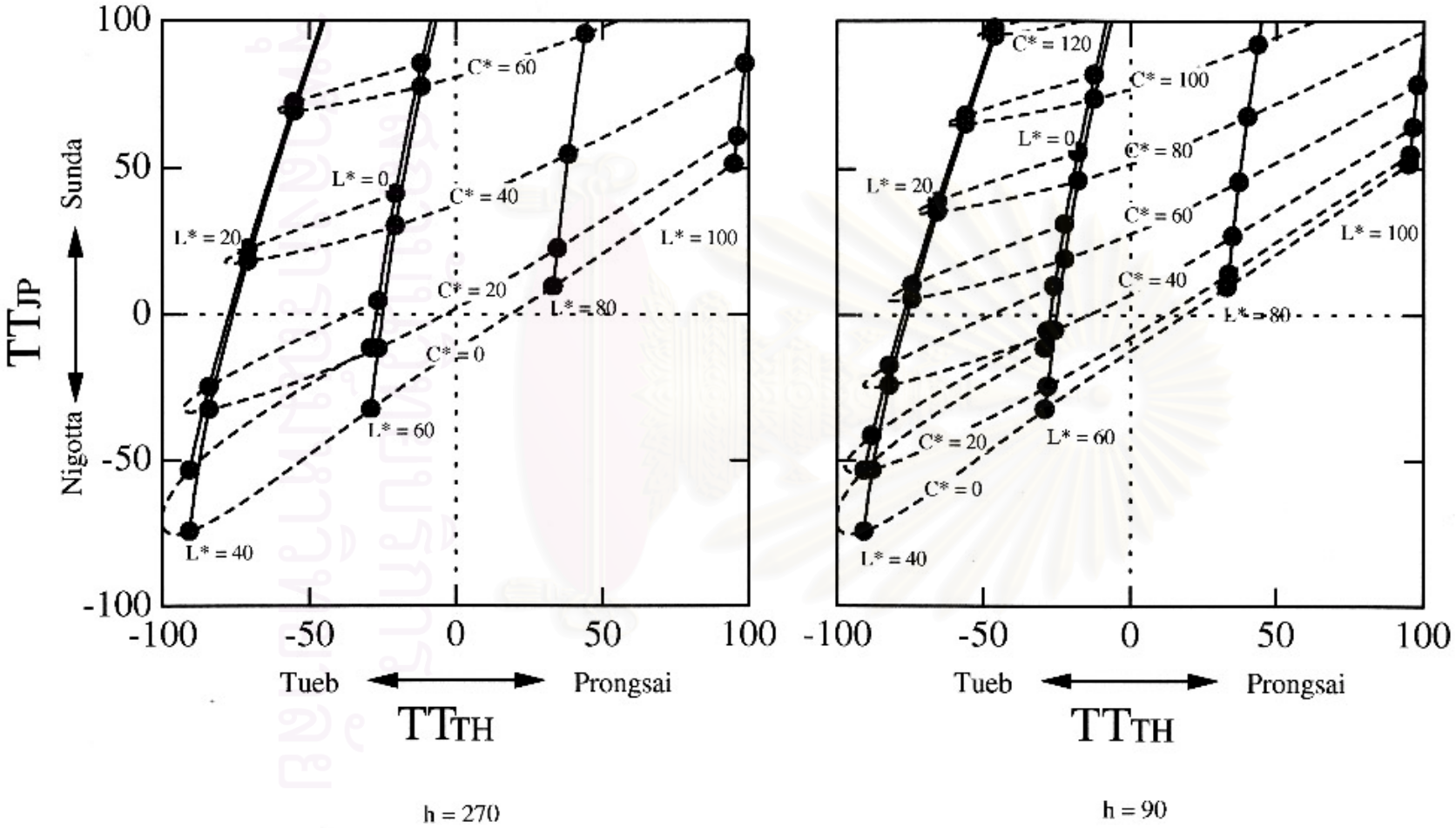

Figure 4-142 The projection of L* C* on TT_{JP}-TT_{TH} color perception map : h = 270, h = 90

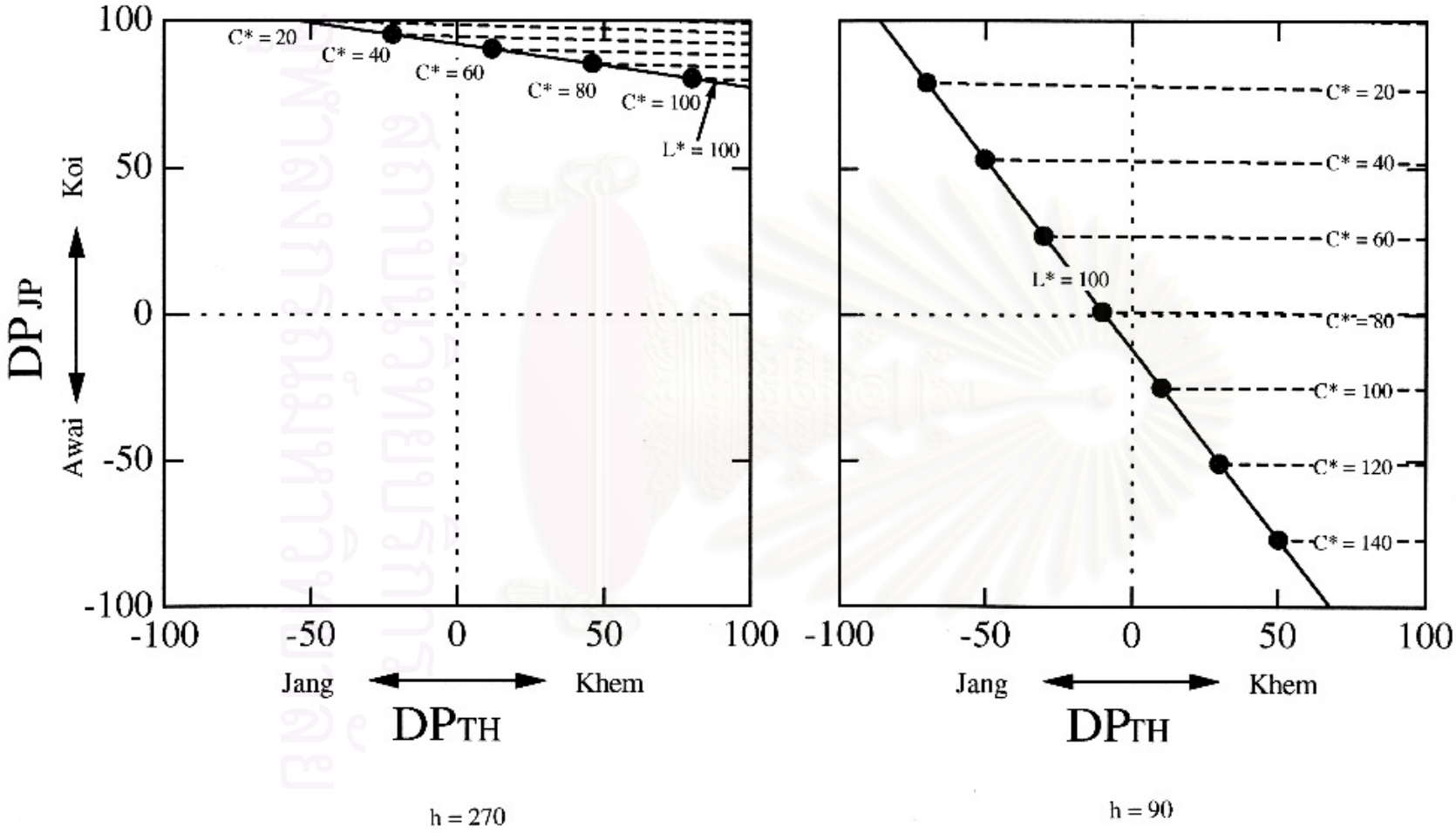

Figure 4-143 The projection of L* C* on DP_{JP}-DP_{TH} color perception map : h = 270, h = 90

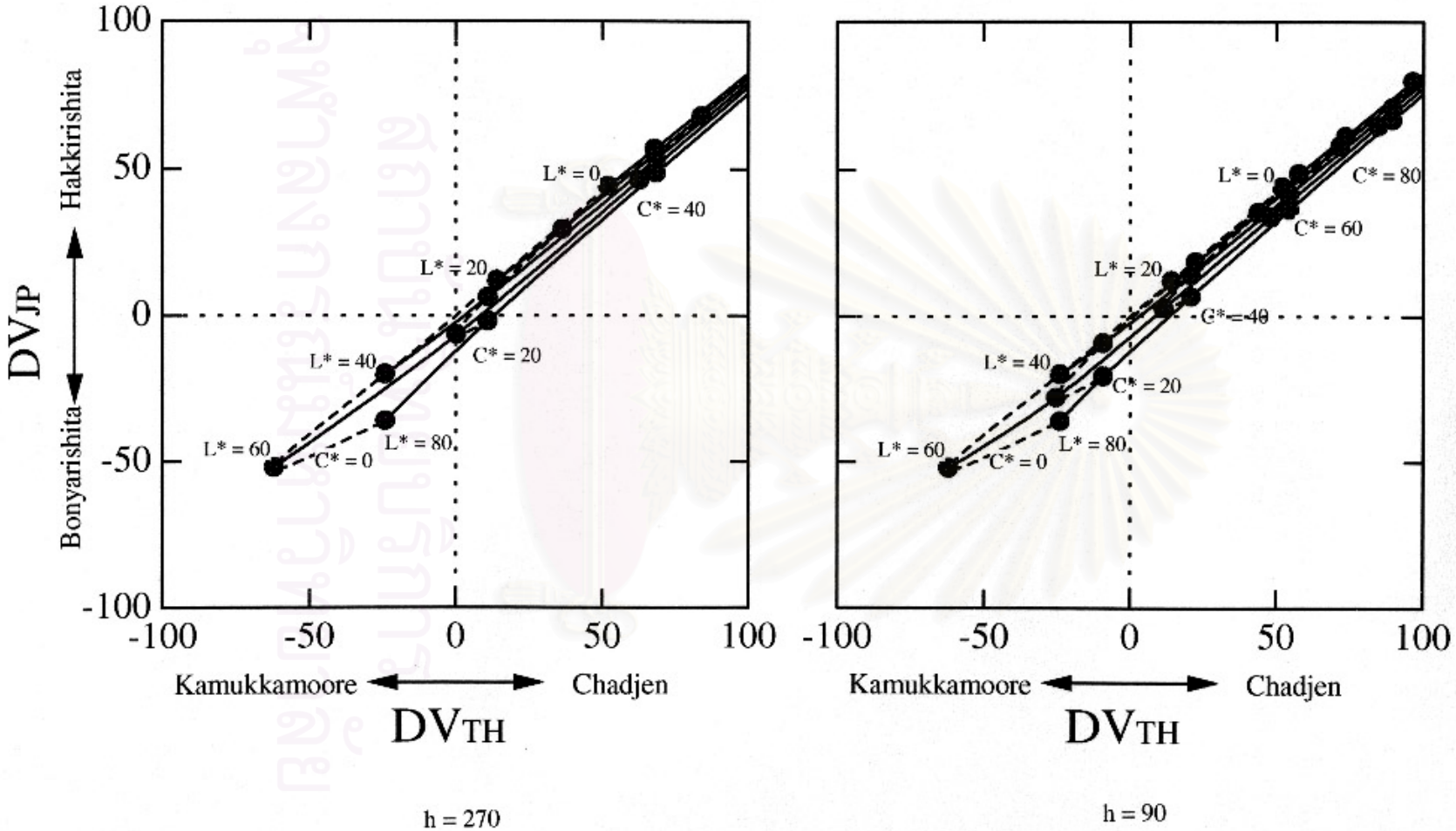

Figure 4-144 The projection of L* C* on DV_{JP}-DV_{TH} color perception map : h = 270, h = 90

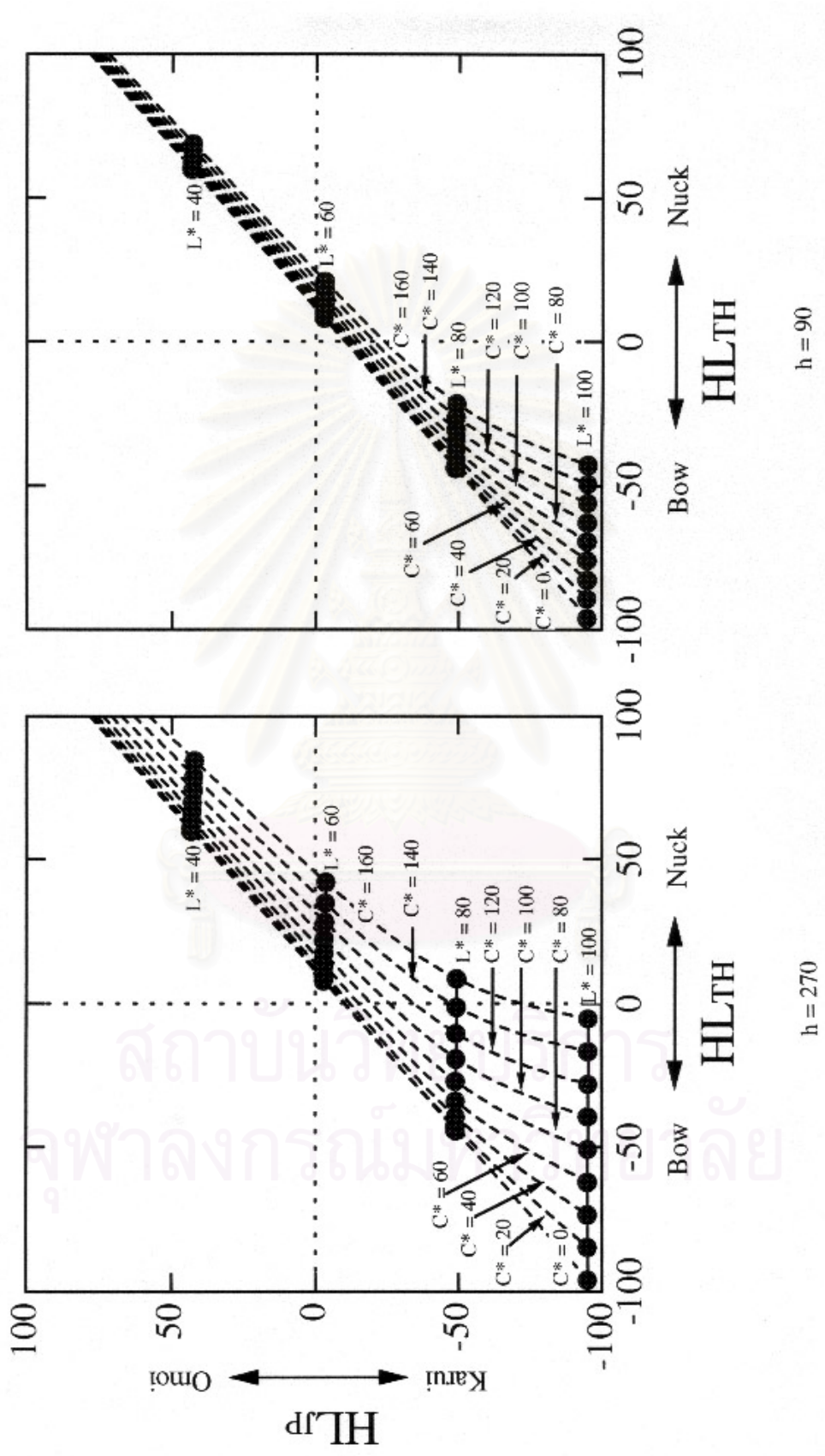

Figure 4-145 The projection of L* C* on HL_{JP}-HL_{TH} color perception map : h = 270, h = 90

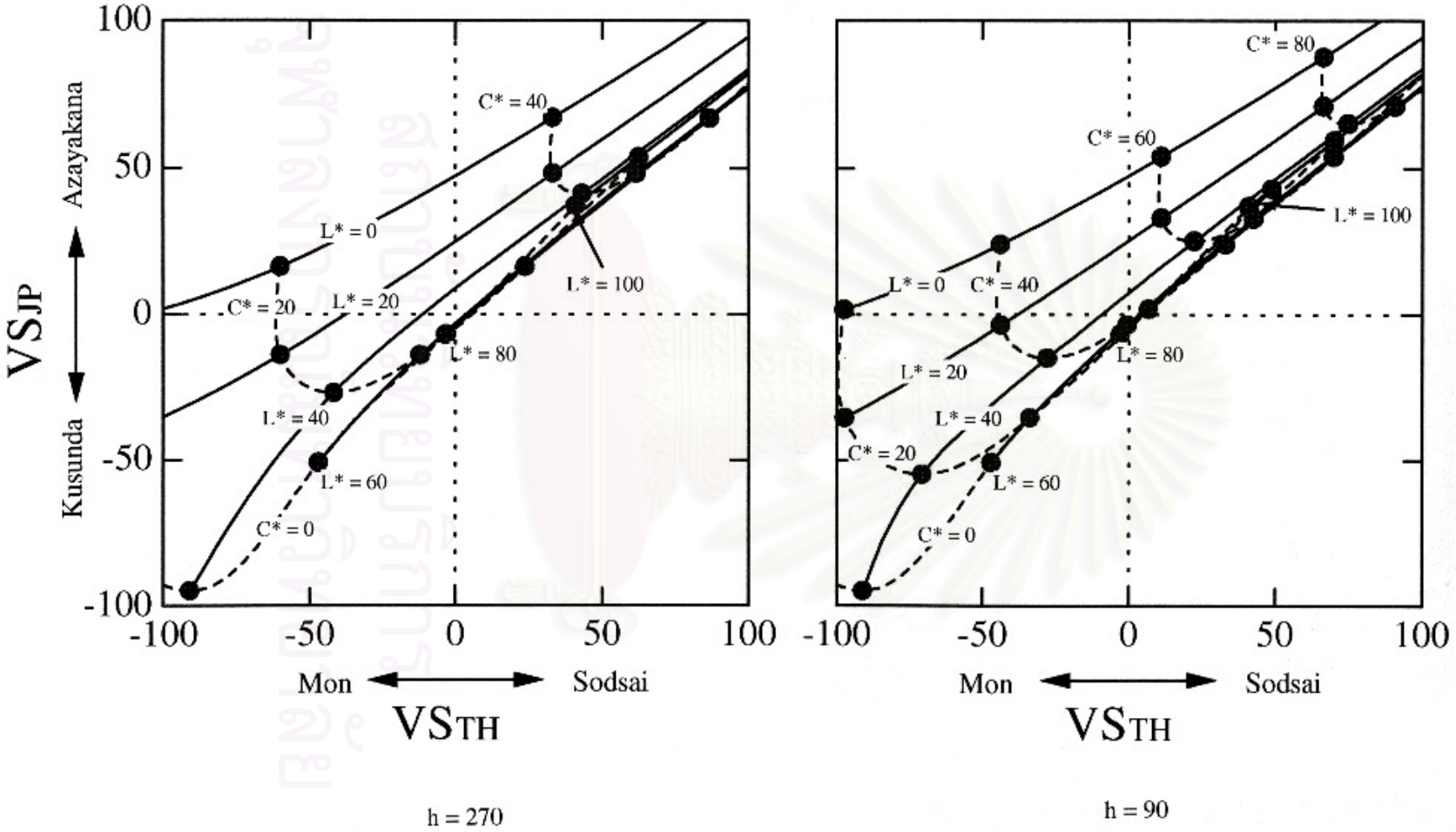

Figure 4-146 The projection of L* C* on VS_{JP}-VS_{TH} color perception map : h = 270, h = 90

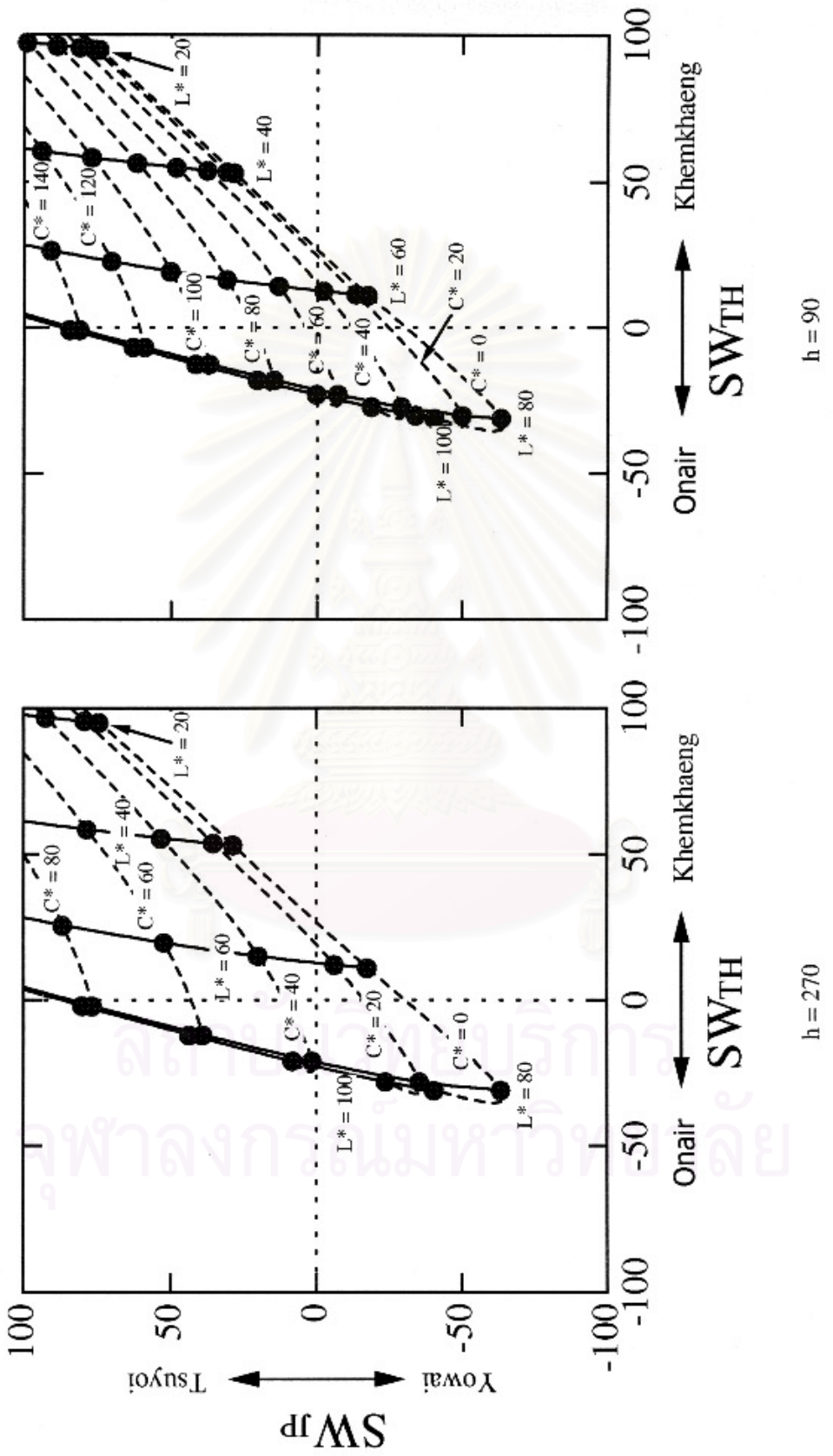

Figure 4-147 The projection of L* C* on SW_{JP}-SW_{TH} color perception map : h = 270, h = 90

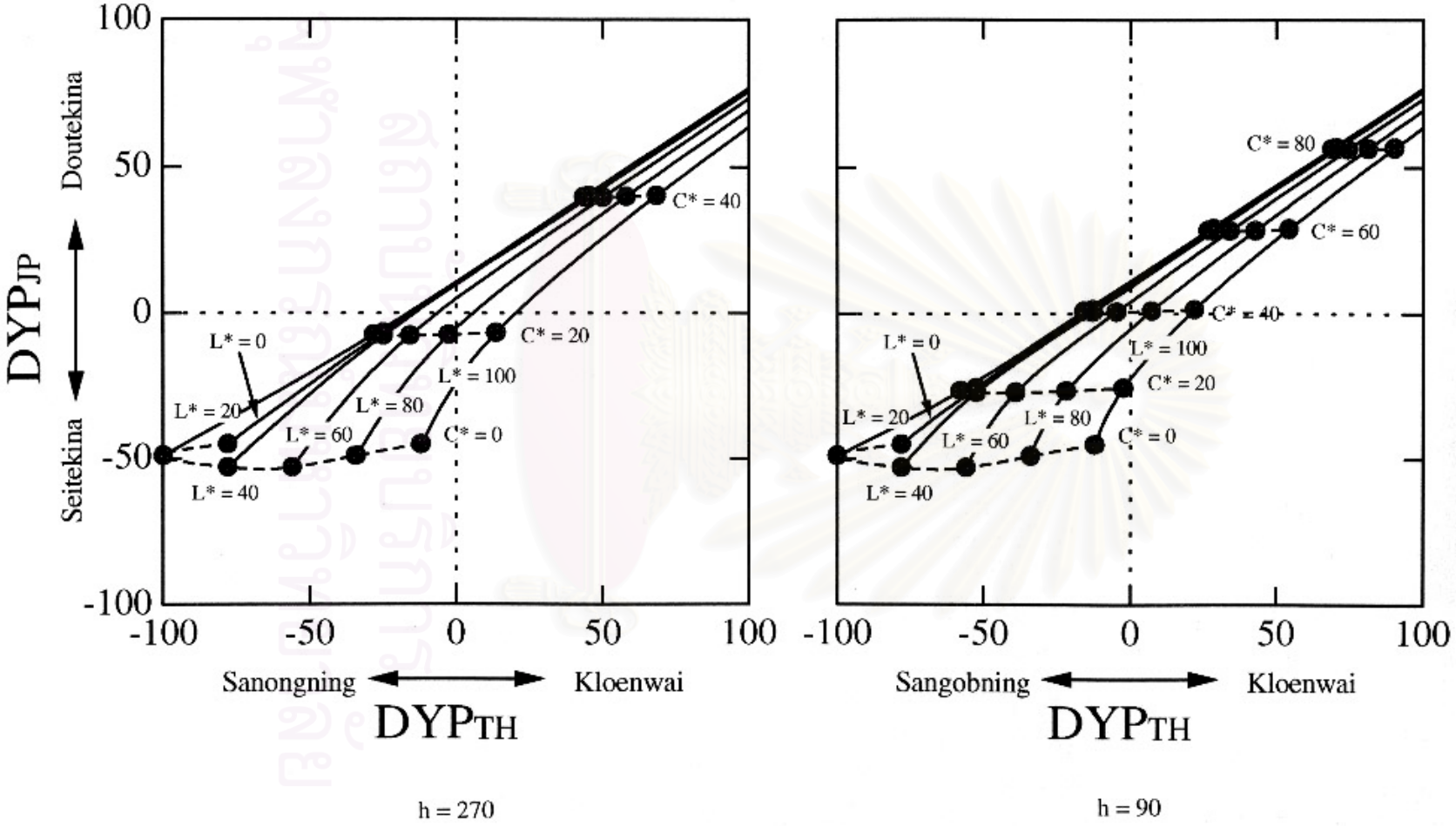

Figure 4-148 The projection of L* C* on DYP_{JP}-DYP_{TH} color perception map : h = 270, h = 90

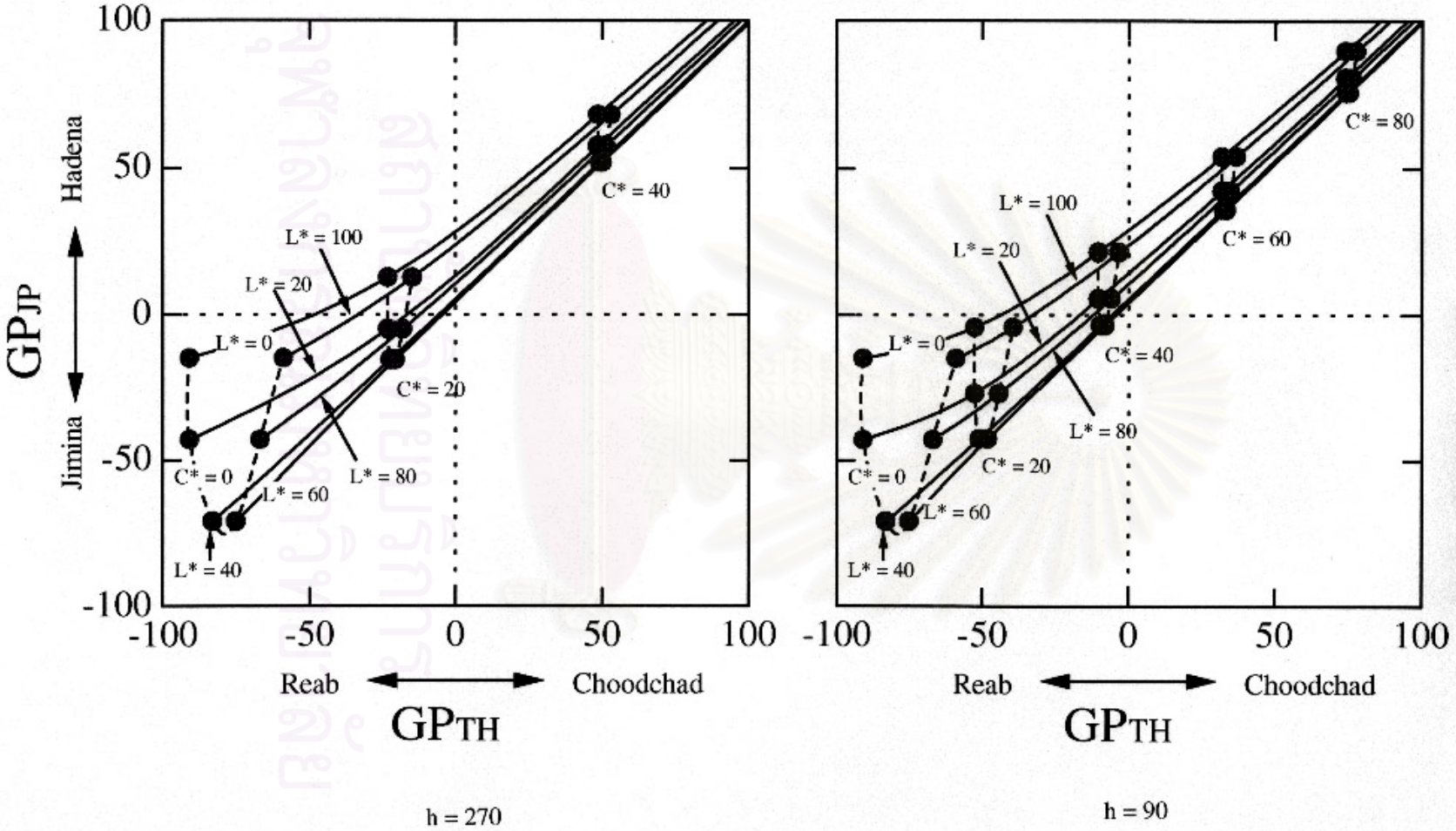

Figure 4-149 The projection of L* C* on GP_{JP}-GP_{TH} color perception map : h = 270, h = 90

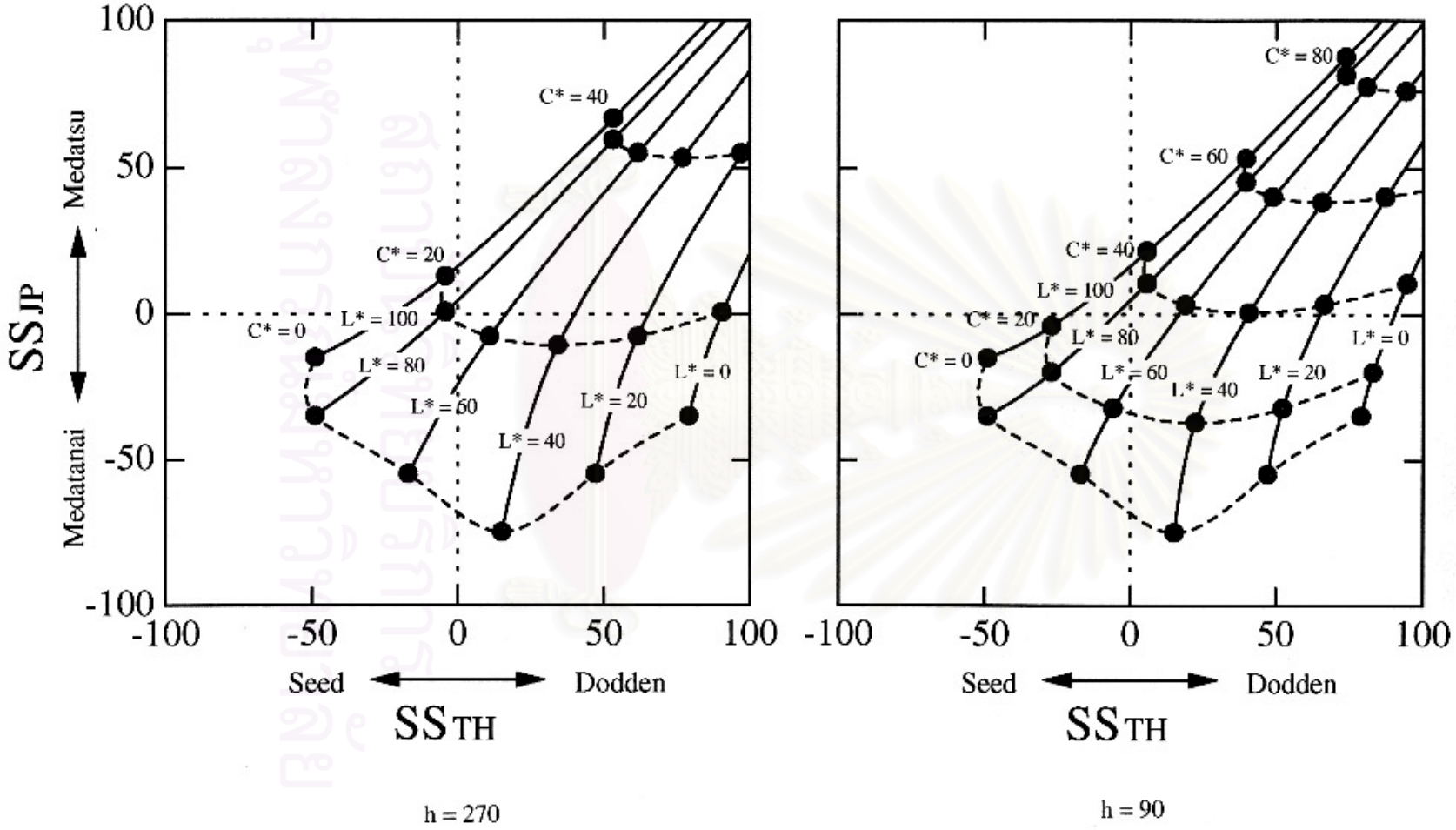

Figure 4-150 The projection of L* C* on SS_{JP}-SS_{TH} color perception map : h = 270, h = 90

CHAPTER 5

CONCLUSION

This research studies the numerical expression of the color perception that corresponds to the seven-point assessments carried out by Thai observers. From the visual assessment results, lightness and chroma seem to affect the color perceptions of all twelve opponent word pairs while hue has strong influence for the color perceptions of “Warm-Cool” as well. The twelve color perception equations were derived from the relationship between the colorimetric values and visual assessments of each of the opponent word pairs. The magnitude of color perception can be predicted by these empirical equations. The colorimetric properties of the color perception can be shown on a color perception map. This color perception map will be helpful for communicating of the color perceptions.

Strong relationships of visual results between the two-point and seven-point methods were obtained at all twelve opponent word pairs. When compared through paired *t*-test in term of hue, significant difference were found in “Warm-Cool” and in “Gaudy-Plain” of achromatic color; and in term of tone, significant differences were found all twelve tones.

When comparing visual results between Thai and Japanese data, high range of correlation coefficients were found at “Light-Dark”, “Soft-Hard”, “Warm-Cool”, “Distinct-Vague”, “Heavy-Light”, “Vivid-Sombre” and “Strong-Weak”. Lower correlation coefficients in “Transparent-Turbid”, “Dynamic-Passive” and “Gaudy-Plain” and lowest the correlation coefficient in “Striking-Subdued”; while the negative correlation coefficient was in “Deep-Pale”. When compared through paired *t*-test in term of hue, significant differences were found in “Warm-Cool”, “Deep-Pale” and in “Striking-Subdued”. In term of tone significant differences were found all twelve tones.

The twelve color perception equations for translation of visual results are considered to be sufficiently accurate except in “Soft-Hard”. The colorimetric properties of the color perception between Japanese and Thai on the color perception map will be a helpful tool for quantitative communication of color perceptions between Japanese and Thais.

Concluding Suggestions

The body of research data that is the basis of this report while intensive is still limited. It is strongly recommended that the next research project in this area use a broader selection of color samples including a variety of carefully selected pigment and organic dye based colors. A single light sources was used. Any future effort would benefit from a larger number of light sources to cover a much broader range of perceptual experiences. The Munsell System used for this report is one of a number of outstanding methods of organizing color space. The organization of a future report should embrace as many systems as possible with the specific intention of comparing the subjective and objective results among the various systems. Finally computer software will need to be written that organizes this entire body of research for convenient and useful computer access. Finally, it is suggested that the computer program will become the most important feature of such a research project and in itself powerful from of color communication.

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APPENDICES

APPENDIX A

LISTS OF COLOR SAMPLES

Table A-1 Color samples using in the experiment

Hue	Tones											
	Pale Grayish	Pale	Light Grayish	Light Moderate	Light	Grayish	Moderate	Bright	Dark Grayish	Dark	Deep	Strong
5R	5R1	5R2	5R3	5R4	5R5	5R6	5R7	5R8	5R9	5R10	5R11	5R12
10R	10R1	10R2	10R3	10R4	10R5	10R6	10R7	10R8	10R9	10R10	10R11	10R12
5YR	5YR1	5YR2	5YR3	5YR4	5YR5	5YR6	5YR7	5YR8	5YR9	5YR10	5YR11	5YR12
10YR	10YR1	10YR2	10YR3	10YR4	10YR5	10YR6	10YR7	10YR8	10YR9	10YR10		
5Y	5Y1	5Y2	5Y3	5Y4	5Y5	5Y6	5Y7	5Y8	5Y9	5Y10		
10Y	10Y1	10Y2	10Y3	10Y4	10Y5	10Y6	10Y7	10Y8	10Y9	10Y10		
5GY	5GY1	5GY2	5GY3	5GY4	5GY5	5GY6	5GY7	5GY8	5GY9	5GY10	5GY11	5GY12
10GY	10GY1	10GY2	10GY3	10GY4		10GY6	10GY7		10GY9	10GY10	10GY11	
5G	5G1	5G2	5G3	5G4		5G6	5G7		5G9	5G10	5G11	
10G	10G1	10G2	10G3	10G4		10G6	10G7		10G9	10G10	10G11	
5BG	5BG1	5BG2	5BG3	5BG4		5BG6	5BG7		5BG9	5BG10	5BG11	
10BG	10BG1	10BG2	10BG3	10BG4		10BG6	10BG7		10BG9	10BG10		
5B	5B1	5B2	5B3	5B4		5B6	5B7		5B9	5B10		
10B	10B1	10B2	10B3	10B4	10B5	10B6	10B7	10B8	10B9	10B10		

Table A-1 Color samples using in the experiment (cont.)

Hue	Tones											
	Pale Grayish	Pale	Light Grayish	Light Moderate	Light	Grayish	Moderate	Bright	Dark Grayish	Dark	Deep	Strong
5BP	5BP1	5BP2	5BP3	5BP4	5BP5	5BP6	5BP7	5BP8	5BP9	5BP10	5BP11	5BP12
10BP	10BP1	10BP2	10BP3	10BP4	1BPP5	10BP6	10BP7	10BP8	10BP9	10BP10	10BP11	10BP12
5P	51	5P2	5P3	5P4	5P5	5P6	5P7	5P8	5P9	5P10	5P11	5P12
10P	10P1	10P2	10P3	10P4	10P5	10P6	10P7	10P8	10P9	10P10	10P11	10P12
5RP	5RP1	5RP2	5RP3	5RP4	5RP5	5RP6	5RP7	5RP8	5RP9	5RP10	5RP11	5RP12
10RP	10RP1	10RP2	10RP3	10RP4	10RP5	10RP6	10RP7	10RP8	10RP9	10RP10	10RP11	10RP12
N	N1	N2		N4		N6		N8	N9.5			

APPENDIX B

COLORIMETRIC VALUES AND VISUAL ASSESSMENT VALUES FROM THAI OBSERVERS

Table B-1 Colorimetric values of color samples and visual assessment values through 7-point method from Thai observers

Color	Colorimetric Values					Visual Assessment Values											
Sample	a*	b*	L*	C*	h	WC	LD	DP	VS	HL	SW	SH	TT	DV	DYP	GP	SS
5R1	3.98	3.78	80.86	5.49	43.56	-46.11	41.11	-46.67	-17.22	-44.44	-42.22	46.11	20.56	-35.56	-33.89	-57.78	-46.11
5R2	14.15	9.17	81.11	16.86	32.94	-18.33	52.78	-28.33	25.00	-43.33	-48.33	62.78	36.11	3.33	0.00	-20.56	-6.67
5R3	3	0.84	71.47	3.12	15.57	-43.89	-14.44	1.11	-36.67	0.00	3.33	12.78	-19.44	-26.67	-46.11	-58.89	-25.56
5R4	16.31	7.37	70.15	17.9	24.32	-12.78	17.78	3.89	-13.89	-1.11	-10.56	26.11	-2.22	-3.89	-12.78	-35.56	-12.78
5R5	37	17.01	69.74	40.72	24.69	47.78	70.56	43.89	70.56	1.67	4.44	33.33	46.67	61.67	56.67	59.44	63.89
5R6	10.27	3.95	42.35	11	21.04	-21.11	-56.67	68.89	-57.22	67.22	57.78	-33.89	-58.89	-17.22	-46.67	-59.44	10.00
5R7	26.15	13.16	46.99	29.28	26.71	10.56	-19.44	52.78	-38.33	40.00	35.56	-5.56	-45.56	-18.33	-20.56	-29.44	10.00
5R8	51.66	22.82	56.21	56.48	23.83	50.00	69.44	37.22	71.67	10.56	25.56	2.22	34.44	61.67	58.89	66.67	67.22
5R9	10.99	2.49	21.43	11.27	12.77	-7.22	-88.33	93.33	-57.22	88.89	80.56	-62.78	-86.11	15.56	-65.56	-54.44	47.78
5R10	29.41	11.31	33.42	31.51	21.04	21.67	-25.00	54.44	-38.89	53.89	51.11	-34.44	-51.11	15.56	-11.67	-10.00	33.33
5R11	44.49	17.04	32.77	47.64	20.96	61.67	27.78	68.33	27.78	57.22	52.78	-32.78	-20.56	48.89	39.44	47.22	57.22
5R12	62.27	26.06	40.59	67.5	22.71	75.00	76.67	55.56	78.33	30.56	40.00	-14.44	25.56	78.33	75.00	81.11	82.78
10R1	5.48	6.89	79.96	8.8	51.49	-52.22	58.33	-62.78	-37.22	-71.67	-58.89	57.22	34.44	-42.22	-47.78	-75.56	-61.11
10R2	10.47	13.42	89.9	17.02	52.03	-32.22	70.56	-53.89	27.22	-63.89	-51.67	65.00	50.00	5.00	1.67	-45.00	-27.22
10R3	3.81	4.16	72.15	5.65	47.51	-47.22	-28.33	8.89	-55.00	-1.67	2.22	22.78	-23.33	-52.78	-51.11	-71.11	-36.11
10R4	23.12	18.69	66.58	29.73	38.95	10.56	40.56	16.11	5.00	-3.89	4.44	27.22	5.00	18.33	16.67	-11.67	18.89
10R5	29.87	30.14	72.12	42.44	45.26	27.22	65.56	18.33	56.11	-6.67	-10.56	22.78	39.44	48.33	39.44	36.67	43.33
10R6	10.94	7.93	48.26	13.52	35.93	-28.33	-57.78	57.22	-62.22	63.33	43.89	-26.67	-63.33	-21.67	-48.89	-60.00	7.22
10R7	22.81	16.47	52.68	28.13	35.82	7.78	-4.44	42.78	-33.33	36.11	26.67	-10.00	-32.78	-11.67	-14.44	-25.56	7.22
10R8	46.86	42.58	58.18	63.31	42.26	70.00	72.22	56.67	74.44	27.78	32.22	-16.11	40.00	75.56	71.67	78.33	83.33
10R9	7.43	4.52	25.32	8.7	31.33	-26.11	-88.33	89.44	-63.33	89.44	86.67	-67.22	-86.11	16.11	-62.78	-58.33	49.44
10R10	27.97	21.05	30.08	32.66	40.13	12.22	-49.44	68.89	-43.33	65.00	60.56	-55.56	-61.11	7.22	-21.11	-26.67	37.22
10R11	42.59	38.08	40.04	57.13	41.8	51.67	34.44	58.33	10.56	41.67	32.22	-30.56	-16.67	32.78	35.56	37.22	49.44
10R12	58.23	55.72	49.76	80.59	43.74	84.44	82.78	67.78	81.67	37.22	36.11	-37.22	32.22	83.89	74.44	90.56	86.67
5YR1	3.53	9.15	74.3	9.81	68.89	-57.78	34.44	-39.44	-45.00	-48.33	-32.78	43.33	12.22	-45.00	-55.56	-69.44	-54.44
5YR2	15.22	28.21	79.88	32.06	61.65	-9.44	65.00	-34.44	37.22	-46.67	-27.78	53.89	47.78	15.56	10.00	-7.78	0.56
5YR3	5.08	7.02	69.66	8.67	54.15	-34.44	8.89	-14.44	-41.11	-18.89	-11.11	31.67	-13.89	-44.44	-50.00	-65.00	-39.44
5YR4	14.37	23.29	65.48	27.36	58.33	16.67	35.00	28.89	-1.67	20.00	9.44	1.67	-6.67	2.78	-2.22	-12.22	7.78
5YR5	25.72	39.21	77.38	46.89	56.74	41.67	66.11	23.89	53.89	-10.56	4.44	25.00	42.78	47.22	39.44	42.22	48.89
5YR6	7.12	8.31	40.98	10.94	49.41	-25.56	-58.89	70.56	-62.78	67.22	53.33	-38.33	-62.22	-16.11	-48.33	-57.78	27.22
5YR7	21.42	28.84	58.4	35.92	53.4	15.56	16.11	41.11	-14.44	34.44	25.00	-6.11	-22.78	8.33	3.89	-8.33	28.33
5YR8	38.26	60.63	59.98	71.69	57.74	71.67	67.78	65.56	66.11	43.33	44.44	-31.11	26.11	68.33	60.00	72.22	72.78

Table B-1 Colorimetric values of color samples and visual assessment values through 7-point method from Thai observers (cont.)

Color	Colorimetric Values					Visual Assessment Values											
Sample	a*	b*	L*	C*	h	WC	LD	DP	VS	HL	SW	SH	TT	DV	DYP	GP	SS
5YR9	7.57	6.61	24.7	10.04	41.12	-30.00	-90.00	92.78	-73.33	91.11	76.67	-63.33	-86.11	19.44	-63.89	-66.67	57.78
5YR10	21.06	32.45	39.3	38.68	57.02	20.00	-8.33	58.89	-32.78	57.22	50.00	-38.89	-45.00	7.22	-3.89	-12.78	31.67
5YR11	27.1	49.62	51.35	56.54	61.36	48.33	46.67	41.11	23.33	27.78	35.00	-17.22	-4.44	37.78	32.22	40.56	46.11
5YR12	35.78	56.27	52.99	66.69	57.55	61.67	58.33	50.00	52.78	38.33	42.22	-26.11	11.11	61.67	45.56	61.67	67.22
10YR1	1.6	9.07	80.32	9.21	80	-57.22	61.67	-61.67	-27.22	-62.22	-50.00	53.33	34.44	-27.78	-50.00	-75.00	-65.00
10YR2	3.5	20.29	88.16	20.59	80.23	-33.33	70.56	-61.11	10.00	-67.78	-46.67	61.67	52.22	4.44	-25.56	-67.22	-38.33
10YR3	2.54	8.21	59.89	8.59	72.78	-51.11	-50.00	37.78	-66.11	45.56	25.56	-6.11	-50.00	-37.22	-55.56	-69.44	-10.00
10YR4	5.4	27.23	66.02	27.76	78.78	-5.00	17.78	17.78	-31.67	15.00	2.78	13.33	-15.56	-6.11	-18.89	-37.22	-10.00
10YR5	13.58	57.46	79.15	59.04	76.7	52.78	75.00	29.44	74.44	2.22	13.89	11.67	51.11	68.33	65.00	72.22	67.78
10YR6	4.81	10.71	51.05	11.74	65.83	-44.44	-59.44	58.33	-61.11	57.78	38.89	-16.67	-59.44	-20.56	-46.67	-65.00	5.56
10YR7	14.86	41.79	53.74	44.35	70.43	20.00	1.11	48.89	-21.67	47.22	35.00	-28.89	-25.56	14.44	2.78	-1.11	35.00
10YR8	14.76	89.28	76.44	90.49	80.61	63.89	76.67	45.00	76.67	6.11	29.44	-8.89	52.78	77.22	70.56	76.67	81.67
10YR9	3.56	8.44	25.18	9.16	67.13	-38.89	-90.56	96.11	-71.11	90.00	73.89	-58.33	-84.44	21.67	-73.33	-76.67	53.89
10YR10	7.22	27.95	40.58	28.87	75.51	-13.33	-26.67	53.33	-54.44	53.33	42.22	-33.89	-45.56	-2.22	-27.22	-40.56	16.11
5Y1	1.04	13.13	81.48	13.17	85.45	-49.44	40.56	-48.89	-30.56	-53.33	-38.89	51.67	16.11	-40.56	-53.33	-76.67	-50.56
5Y2	-2.04	27.32	88.85	27.4	94.27	-26.67	71.67	-41.67	33.33	-54.44	-44.44	57.78	41.11	9.44	-11.67	-40.00	-17.22
5Y3	1.14	9.66	71.45	9.72	83.26	-37.78	-30.00	23.33	-55.56	21.11	7.22	2.22	-30.00	-41.11	-50.00	-61.67	-24.44
5Y4	-2.59	28.59	79.1	28.71	95.17	-14.44	38.33	-2.78	-12.78	-8.33	-10.56	23.89	7.22	-14.44	-12.78	-36.11	-14.44
5Y5	-2.88	61.05	54.22	61.12	92.7	41.67	80.00	57.78	77.22	17.22	17.78	5.56	50.56	73.33	56.67	70.00	75.00
5Y6	0.18	13.13	52.04	13.13	89.2	-35.56	-68.89	68.33	-64.44	67.22	52.78	-31.67	-63.89	-33.33	-50.00	-63.33	7.22
5Y7	-0.76	42.69	60.46	42.7	91.03	20.00	16.67	47.78	-12.78	37.22	30.00	-17.78	-23.89	1.67	2.78	1.67	27.22
5Y8	5.15	73.55	68.59	73.73	85.99	45.00	53.33	53.89	41.11	35.56	30.00	-10.56	7.22	42.22	41.67	53.89	57.22
5Y9	0.49	10.14	29.97	10.15	87.23	-26.11	-91.11	92.22	-72.22	90.00	77.78	-69.44	-88.33	6.11	-73.33	-68.33	44.44
5Y10	5	47.46	49.84	47.13	83.99	12.78	-10.56	52.22	-38.33	52.22	42.22	-28.89	-41.11	8.33	-8.89	-14.44	26.67
10Y1	-2.27	11.09	78.04	11.32	101.57	-54.44	58.33	-52.22	-25.56	-60.00	-41.67	50.00	22.22	-25.00	-45.56	-67.22	-53.89
10Y2	-7.86	28.92	91.1	29.97	105.2	-21.67	74.44	-53.33	52.22	-63.89	-42.78	65.56	58.33	23.89	6.11	-21.67	-12.22
10Y3	-2.34	5.98	63.55	6.42	111.32	-47.22	-36.67	41.67	-57.78	34.44	33.33	-7.78	-47.78	-30.00	-56.67	-65.56	-10.56
10Y4	-8.09	33.08	70.92	34.06	103.75	-15.56	31.67	6.67	-6.67	-7.22	0.00	23.33	7.78	3.33	2.22	-17.22	8.89
10Y5	-14.31	67.91	85.03	69.4	101.9	28.33	81.11	36.67	81.67	-2.78	8.89	21.11	56.11	71.11	67.22	73.33	78.89
10Y6	-3.82	13.03	39.49	13.58	106.34	-36.11	-78.33	77.78	-75.00	78.89	57.22	-44.44	-72.78	-13.33	-53.89	-71.11	18.33
10Y7	-7.6	45.76	68.35	46.39	99.43	-2.78	32.22	30.56	1.67	22.22	11.67	1.67	-8.89	8.89	12.78	6.11	17.22
10Y8	-12.44	89.39	83.1	90.25	97.92	41.11	76.11	64.44	87.22	17.78	26.11	-2.22	53.89	82.22	65.56	82.22	85.00

Table B-1 Colorimetric values of color samples and visual assessment values through 7-point method from Thai observers (cont.)

Color	Colorimetric Values					Visual Assessment Values											
Sample	a*	b*	L*	C*	h	WC	LD	DP	VS	HL	SW	SH	TT	DV	DYP	GP	SS
10Y9	-2.14	8.76	25.44	9.02	103.74	-33.89	-93.33	93.89	-68.33	96.11	78.33	-64.44	-90.00	13.89	-74.44	-65.56	52.22
10Y10	-7.69	33.85	42.07	34.92	102.79	-33.33	-35.00	61.67	-47.22	55.56	54.44	-22.78	-47.22	-1.67	-15.00	-39.44	30.56
5GY1	-3.67	9.66	81.27	10.33	110.79	-46.67	47.78	-43.89	-27.22	-50.00	-36.67	36.67	20.00	-25.56	-43.33	-67.22	-64.44
5GY2	-6.56	23.27	87.95	24.17	105.75	-27.78	70.00	-45.56	28.33	-60.56	-41.67	41.67	41.67	3.89	2.22	-41.11	-18.89
5GY3	-4.14	6.75	60.45	7.92	121.49	-33.89	-43.33	42.78	-51.67	25.56	25.00	-5.56	-40.56	-19.44	-44.07	-61.67	2.22
5GY4	-14.94	30.62	75.95	34.07	116.01	-22.22	58.89	3.89	43.33	-28.33	-5.00	36.67	37.78	32.77	27.22	6.67	27.78
5GY5	-20.94	49.11	82.57	53.39	113.09	-3.89	77.78	12.99	77.78	-30.00	12.99	36.11	61.11	71.67	58.33	62.22	67.22
5GY6	-8.59	12.85	51.77	15.46	123.78	-42.22	-58.89	53.11	-57.22	52.78	40.56	-26.67	-51.67	-28.33	-46.11	-56.67	12.22
5GY7	-17.09	33.73	54.56	37.81	116.87	-26.11	10.56	43.89	-4.44	31.67	28.81	1.69	-16.95	26.55	3.39	-6.90	28.25
5GY8	-34.92	79.26	79.01	86.61	113.78	10.00	92.78	40.56	95.56	-12.22	26.67	11.67	70.00	88.89	77.22	91.11	91.67
5GY9	-4.96	8.03	30.4	9.44	121.66	-27.22	-86.11	87.78	-75.00	82.78	73.33	-57.78	-71.11	-12.22	-62.22	-58.89	26.67
5GY10	-16.28	34.5	46.89	38.15	115.26	-25.00	-22.22	58.89	-29.44	49.44	43.33	-18.33	-47.78	5.00	-11.67	-18.33	25.00
5GY11	-27.56	68.95	69.24	74.25	111.78	6.67	74.44	37.78	66.10	-6.11	14.44	17.51	41.67	67.78	57.78	63.89	72.78
5GY12	-37.51	71.9	73.47	81.1	117.5	7.22	85.00	38.33	79.44	-7.78	16.11	13.33	53.89	80.56	70.56	77.78	76.67
10GY1	-6.91	4.28	82.52	8.12	148.22	-50.00	58.89	-52.78	-16.67	-55.00	-33.33	48.33	28.89	-7.78	-36.67	-54.44	-34.44
10GY2	-13.06	12.96	88.89	18.4	135.21	-47.78	70.56	-44.44	31.67	-56.67	-40.00	55.56	50.00	8.33	-5.00	-45.56	-21.11
10GY3	-6.59	4.25	67.17	7.84	147.2	-39.44	-34.44	25.00	-51.11	24.44	14.44	-1.67	-34.44	-40.56	-55.56	-58.89	-23.89
10GY4	-23.21	17.93	72.81	29.33	142.3	-36.67	47.78	5.00	25.56	-21.67	-5.56	43.89	31.11	17.22	13.33	-13.89	10.00
10GY6	-11	9.07	47.37	14.26	140.49	-36.67	-69.44	67.78	-63.89	65.00	47.22	-25.56	-63.33	-26.11	-54.44	-62.22	8.33
10GY7	-33.57	29.1	62.2	44.43	139.08	-28.89	50.00	35.56	45.56	8.33	18.89	22.78	25.56	50.00	34.44	26.11	48.33
10GY9	-7.97	4.91	23.92	9.36	148.37	-32.78	-91.67	97.22	-61.67	93.89	84.44	-72.22	-85.00	32.22	-70.56	-56.11	56.67
10GY10	-28.41	20.55	40.11	35.06	144.12	-35.56	-19.44	67.22	-16.11	60.00	55.00	-30.00	-50.56	27.22	-13.89	-15.56	37.22
10GY11	-46.54	34.92	53.84	58.19	143.12	-18.33	56.67	59.44	71.67	29.44	36.11	8.33	27.78	75.56	56.11	58.33	72.78
5G1	-6.61	5.45	84.11	8.57	140.49	-59.44	69.44	-66.67	-16.11	-71.67	-54.44	48.89	42.78	-23.33	-42.22	-67.22	-58.33
5G2	-10.61	8.02	89.58	13.3	142.92	-45.00	79.44	-62.22	26.11	-69.44	-45.56	61.11	58.33	5.56	-1.67	-50.56	-38.33
5G3	-9.9	3.84	75.08	9.69	156.63	-48.33	0.56	13.33	-37.78	-1.67	-8.33	20.00	-0.56	-18.89	-36.67	-59.44	-24.44
5G4	-24.45	8.48	70.39	25.88	160.87	-40.00	50.56	27.78	31.67	0.00	0.00	38.89	12.78	32.22	20.00	-4.44	22.78
5G6	-6.08	1.42	46.54	6.25	166.86	-28.89	-65.56	66.67	-68.89	58.89	52.78	-42.78	-63.33	-20.56	-61.11	-62.78	5.56
5G7	-31.76	9.03	56.71	33.02	164.13	-34.44	37.78	40.56	33.89	13.89	24.44	19.44	8.89	38.89	30.00	10.00	36.67
5G9	-8.59	1.91	27.38	8.8	167.46	-34.44	-91.11	95.00	-73.89	90.00	71.11	-58.89	-81.67	17.22	-64.44	-59.44	47.78
5G10	-32.17	8.28	36.41	33.22	165.56	-21.67	-21.11	71.67	5.00	60.56	57.78	-8.89	-37.78	37.78	8.33	5.00	51.67
5G11	-48.82	17.48	43.39	51.85	160.3	-13.33	40.56	57.78	56.11	33.89	45.00	2.78	-4.44	66.67	41.67	43.33	65.56

Table B-1 Colorimetric values of color samples and visual assessment values through 7-point method from Thai observers (cont.)

Color	Colorimetric Values					Visual Assessment Values											
Sample	a*	b*	L*	C*	h	WC	LD	DP	VS	HL	SW	SH	TT	DV	DYP	GP	SS
10G1	-8.95	3.94	83.39	9.78	156.23	-43.33	67.22	-70.00	-13.89	-66.11	-53.89	60.00	49.44	-23.33	-36.11	-61.11	-58.89
10G2	-21.84	5.49	82.72	22.52	165.89	-45.56	70.00	-23.33	46.67	-51.67	-25.56	57.22	50.00	31.11	15.00	-10.56	17.22
10G3	-5.99	1.82	73.54	6.26	163.05	-40.56	-4.44	3.89	-37.78	-12.22	0.00	17.78	-17.78	-28.89	-36.11	-53.33	-31.11
10G4	-25.05	4.54	72.85	25.45	169.73	-35.56	51.11	3.89	32.78	-20.00	-17.22	45.00	25.00	26.67	17.22	-9.44	16.11
10G6	-5.64	0.67	46.48	5.68	173.26	-36.67	-61.11	60.56	-72.78	63.33	37.22	-30.56	-62.22	-24.44	-57.78	-58.33	8.89
10G7	-39.96	5.59	63.35	34.42	170.66	-34.44	46.67	32.22	45.00	2.22	12.22	32.78	27.78	37.22	25.56	15.00	41.67
10G9	-13.73	2.29	24.03	13.92	170.53	-20.00	-80.00	89.44	-54.44	81.11	80.00	-55.00	-85.56	34.44	-51.67	-32.22	49.44
10G10	-27.42	3.09	33.79	27.59	173.57	-38.89	-40.56	68.33	-12.22	63.89	56.67	-32.78	-50.56	28.89	-11.11	-13.33	43.89
10G11	-43.61	5.17	52.02	43.91	173.24	-28.89	41.67	38.33	48.33	12.78	27.22	21.67	15.56	51.11	38.89	32.78	52.22
5BG1	-5.89	1.26	74.69	6.02	167.92	-48.33	46.67	-45.00	-27.22	-41.11	-28.33	30.00	14.44	-27.78	-38.33	-54.44	-40.56
5BG2	-12.03	4.7	84.93	12.91	158.67	-57.78	62.78	-54.44	28.89	-60.56	-44.44	63.33	44.44	1.11	-20.56	-50.56	-37.22
5BG3	-7.32	-1.9	63.53	7.57	194.53	-43.89	-41.67	43.33	-55.56	34.44	33.33	-7.78	-55.00	-32.22	-55.56	-61.67	-8.33
5BG4	-23.56	-1.58	68.89	23.62	183.83	-44.44	55.00	17.22	48.89	-8.33	5.56	39.44	17.78	34.44	7.22	-10.00	21.11
5BG6	-10.84	-4.18	41.67	11.61	201.08	-32.22	-67.22	71.67	-67.22	67.22	56.67	-33.89	-67.78	-10.00	-48.89	-57.22	28.33
5BG7	-34.5	-5.47	55.69	34.93	189.01	-35.56	45.56	45.56	40.00	22.78	30.56	10.56	-1.11	50.00	31.67	17.22	47.78
5BG9	-7.36	-2.57	24.64	7.79	199.27	-17.22	-95.56	97.22	-72.78	93.89	85.56	-69.44	-92.22	24.44	-65.56	-60.56	64.44
5BG10	-31.99	-6.4	38.19	32.63	191.32	-35.00	-10.56	67.78	3.33	59.44	51.67	-22.22	-46.11	38.89	-2.22	-5.56	45.56
5BG11	-28.65	-5.61	44.52	29.19	191.08	-43.33	-4.44	47.22	-16.67	40.56	30.00	7.22	-31.11	12.22	-10.56	-32.22	20.00
10BG1	-3.17	0.88	78.64	3.29	164.57	-38.89	60.56	-51.67	-23.33	-59.44	-27.78	41.67	25.00	-27.78	-44.44	-62.78	-53.89
10BG2	-18.67	-4.23	81.94	19.15	192.77	-40.56	81.11	-20.56	64.44	-50.56	-33.89	62.78	55.56	40.00	21.67	6.11	19.44
10BG3	-4.43	-2.08	60.59	4.89	205.21	-35.00	-42.78	46.67	-51.67	46.67	37.78	-10.00	-43.33	-28.33	-52.78	-53.89	-2.22
10BG4	-22.74	-5.44	73.67	23.38	193.45	-35.00	56.67	6.67	46.67	-25.00	-15.00	44.44	37.22	36.11	19.44	-5.00	21.11
10BG6	-8.62	-4.18	44.81	9.58	205.85	-31.11	-73.89	73.89	-64.44	67.78	61.11	-41.11	-70.56	-25.00	-57.78	-53.33	17.22
10BG7	-29.29	-13.7	52.69	32.34	205.07	-25.56	38.33	41.11	29.44	26.11	27.78	10.56	-9.44	37.22	23.33	11.67	46.11
10BG9	-7.88	-5.21	27.51	9.45	213.51	-10.56	-85.56	95.56	-65.00	93.33	85.00	-72.78	-88.33	21.11	-57.78	-58.89	49.44
10BG10	-27.21	-12.17	39.94	29.81	204.09	-30.56	-17.22	64.44	-8.89	57.22	43.89	-9.44	-36.67	27.22	3.89	-13.89	38.33
5B1	-4.43	-0.65	82.49	4.47	188.33	-51.11	71.11	-67.78	-3.89	-70.56	-45.56	57.22	35.00	-26.67	-28.33	-64.44	-48.89
5B2	-12.3	-4.46	86.73	13.08	199.94	-47.22	77.22	-43.33	53.89	-62.78	-40.00	68.33	62.22	25.56	5.56	-27.22	-6.11
5B3	-3.32	-2.58	60.44	4.2	217.78	-30.00	-35.00	33.89	-56.11	31.11	37.22	-10.56	-42.22	-27.22	-41.67	-58.89	-1.67
5B4	-15.01	-10.86	72.27	18.52	215.88	-41.67	48.33	-4.44	38.33	-22.78	-16.11	50.56	21.11	15.56	12.78	-17.78	8.33
5B6	-6.95	-6.07	46.74	9.23	221.17	-50.00	-49.44	55.56	-61.67	54.44	45.56	-8.89	-63.89	-34.44	-57.22	-62.78	0.56
5B7	-18.78	-20.82	53.14	28.04	227.94	-42.22	35.00	27.22	22.78	11.11	3.89	24.44	2.22	26.67	7.22	-7.78	41.11

Table B-1 Colorimetric values of color samples and visual assessment values through 7-point method from Thai observers (cont.)

Color	Colorimetric Values					Visual Assessment Values											
Sample	a*	b*	L*	C*	h	WC	LD	DP	VS	HL	SW	SH	TT	DV	DYP	GP	SS
5B9	-8.89	-10.53	27.17	3.78	229.84	-42.22	-87.78	82.22	-58.89	83.89	80.00	-53.89	-85.00	-12.22	-67.78	-63.89	32.22
5B10	-12.63	-16.83	32	21.04	233.11	-48.89	-54.44	66.11	-46.67	66.67	62.22	-33.89	-61.11	5.56	-45.00	-48.89	35.56
10B1	-2.06	1.11	83.55	2.34	151.7	-42.78	68.89	-52.78	-9.44	-57.22	-27.22	38.33	35.56	-23.33	-33.33	-52.22	-40.00
10B2	-7.21	-9.25	79.82	11.73	232.05	-61.67	66.11	-47.22	26.67	-59.44	-30.00	55.00	46.67	10.56	-12.78	-48.33	-23.33
10B3	-2.07	-3.14	67.68	3.77	236.58	-46.11	-16.11	20.00	-45.00	8.89	23.89	0.56	-23.89	-34.44	-48.33	-55.00	-20.00
10B4	-12.41	-18.88	67.25	22.59	236.68	-44.44	50.56	5.00	25.00	-10.56	-1.67	37.78	18.33	27.22	7.78	-12.78	19.44
10B5	-15.67	-22.2	71.83	27.17	234.79	-52.22	73.33	2.22	63.89	-31.11	-5.56	56.11	48.33	59.44	33.33	12.78	42.22
10B6	-4.69	-8.91	44.58	10.07	242.26	-46.11	-64.44	62.78	-56.67	63.89	59.44	-34.44	-72.78	-20.00	-60.56	-65.56	13.33
10B7	-12.61	-21.61	55.01	25.02	239.74	-50.56	9.44	42.78	-11.67	21.11	18.33	8.33	-18.89	8.33	-7.22	-26.67	6.11
10B8	-16.13	-34.79	56.13	38.48	245.21	-37.78	60.00	50.00	63.89	16.67	33.89	18.89	27.22	67.22	50.56	55.00	65.00
10B9	-2.92	-9.7	24.06	10.13	253.24	-33.33	-87.78	89.44	-59.44	83.33	86.67	-63.89	-85.56	17.22	-75.00	-54.44	56.11
10B10	-6.19	-25.81	32.63	26.55	256.52	-46.11	-48.89	76.67	-35.56	70.00	60.00	-48.89	-68.89	14.44	-35.56	-46.11	35.00
5PB1	-0.54	-0.08	81.98	0.55	187.98	-37.78	58.89	-58.33	-13.89	-60.00	-37.22	41.67	40.00	-10.56	-29.44	-63.33	-41.67
*5PB2	-2.56	-6.18	81.9	6.69	247.51	-57.78	70.56	-51.67	2.22	-61.67	-35.56	54.44	40.56	-16.67	-28.33	-57.78	-40.56
5PB3	-0.97	-3.96	64.23	4.07	256.21	-49.44	-38.89	25.00	-42.22	40.00	23.89	-12.22	-43.89	-43.33	-53.33	-55.56	-16.67
5PB4	-1.39	-13.09	62.83	13.17	263.95	-55.00	-3.33	25.00	-32.22	19.44	13.89	12.22	-14.44	-18.89	-29.44	-53.33	-5.56
5PB5	-0.83	-27.34	65.63	27.35	268.25	-38.33	55.56	17.78	50.56	-15.56	0.00	41.67	35.00	41.11	36.11	15.56	39.44
5PB6	-1.04	-5.77	41.27	5.87	259.75	-45.56	-73.89	66.67	-68.89	67.78	58.89	-48.33	-70.00	-31.67	-57.22	-65.00	8.89
5PB7	2.33	-30.13	45.72	30.22	274.43	-61.67	-10.56	50.56	-7.78	27.22	37.78	17.22	-20.56	17.78	-18.89	-42.22	26.11
5PB8	0.76	-44.63	50.46	44.64	270.98	-37.22	55.00	41.11	62.78	5.00	30.00	28.33	26.11	66.11	30.00	34.44	60.00
5PB9	1.73	-11.23	21.3	11.36	278.76	-38.33	-85.56	96.67	-69.44	88.33	87.78	-56.67	-86.11	38.89	-72.22	-65.00	70.56
5PB10	1.11	-27.62	27.5	27.7	272.3	-48.89	-54.44	75.00	-47.22	70.56	58.89	-40.56	-60.00	26.11	-36.11	-46.67	42.78
5PB11	6.61	-36.62	29.68	37.21	280.23	-48.89	-2.78	63.89	4.44	52.78	56.11	-17.22	-38.89	50.56	-17.22	-24.44	50.56
5PB12	3.67	-48.98	38.57	49.12	274.29	-21.11	50.56	48.89	61.67	18.89	36.11	2.22	15.00	66.11	38.33	41.67	66.11
10PB1	0.24	0.27	78.27	0.36	48.68	-49.44	49.44	-56.11	-37.78	-64.44	-35.56	47.22	17.22	-37.78	-47.78	-72.22	-53.89
10PB2	3.61	-7.16	82.16	8.02	296.78	-50.56	61.67	-40.56	16.11	-51.67	-22.22	44.44	32.22	2.22	-22.78	-40.00	-24.44
10PB3	0.73	-2.54	66.61	2.65	286.02	-48.33	-11.67	17.22	-50.56	15.00	16.11	11.11	-32.78	-29.44	-50.56	-62.22	-15.56
10PB4	4.69	-14.31	69.32	15.06	288.14	-46.11	40.00	-7.22	5.00	-13.89	-12.78	41.11	5.56	-15.56	-17.22	-43.33	-14.44
10PB5	11.43	-29.95	65.86	32.06	290.88	-29.44	69.44	7.78	49.44	-20.00	3.33	40.00	33.33	37.22	22.78	18.89	37.22
10PB6	3.11	-5.83	39.09	6.6	298.08	-37.78	-60.00	68.33	-63.33	65.00	51.67	-39.44	-56.67	-11.67	-51.67	-61.67	32.78
10PB7	12.46	-27.62	36.98	30.31	294.28	-38.33	-36.67	65.56	-37.78	63.33	54.44	-22.22	-40.56	16.67	-16.11	-31.67	40.00
10PB8	25.41	-43.31	46.58	50.22	300.4	-5.56	54.44	45.56	61.11	14.44	26.11	15.00	25.00	62.78	45.00	53.89	68.33

Table B-1 Colorimetric values of color samples and visual assessment values through 7-point method from Thai observers (cont.)

Color	Colorimetric Values					Visual Assessment Values											
Sample	a*	b*	L*	C*	h	WC	LD	DP	VS	HL	SW	SH	TT	DV	DYP	GP	SS
10PB9	5.59	-10.98	23.13	12.32	296.99	-45.00	-91.11	97.22	-75.00	92.78	87.22	-68.33	-85.00	40.56	-66.67	-68.89	62.22
10PB10	12.52	-24.44	26.29	27.46	297.13	-40.00	-66.11	77.78	-56.11	76.11	70.00	-48.89	-68.33	33.33	-42.22	-45.00	53.89
10PB11	24.16	-37.79	31	44.85	302.59	-30.00	-1.11	65.00	-0.56	52.22	53.89	-21.67	-30.56	39.44	5.56	6.67	48.89
10PB12	30.97	-48.81	31.16	57.81	302.4	-20.00	32.22	55.00	31.67	37.22	42.78	-17.22	-8.89	65.00	32.22	43.33	63.89
5P1	5.59	-2.36	73.8	3.5	317.63	-47.78	22.22	-19.44	-26.11	-25.56	-16.67	35.00	-9.44	-38.89	-50.00	-63.33	-37.22
5P2	5.22	-3.91	81.28	6.52	323.19	-40.56	56.11	-31.67	9.44	-47.78	-21.67	38.33	26.11	-12.78	-18.33	-41.67	-26.11
5P3	1.82	-2.36	60.81	2.98	307.63	-37.78	-46.11	46.67	-56.11	46.67	32.78	-15.00	-52.22	-40.00	-46.11	-58.89	-3.33
5P4	10.87	-11.87	58.62	16.1	312.49	-15.00	-1.11	30.56	-15.00	28.33	15.00	8.89	-17.22	-8.33	-16.67	-24.44	5.00
5P5	30.81	-29.12	61.75	42.39	316.61	7.22	60.56	25.56	61.11	3.89	13.33	30.00	41.67	52.78	38.89	46.11	53.89
5P6	5.35	-5.33	38.39	7.55	315.12	-27.22	-77.22	78.33	-73.89	76.11	67.22	-47.78	-77.22	-32.78	-66.11	-66.67	11.67
5P7	21.31	-22.95	39.02	31.32	312.88	-16.67	-17.78	61.67	-24.44	58.33	42.78	-16.67	-45.56	2.78	-11.67	5.56	43.89
5P8	40.42	-37.98	47.8	55.47	316.78	8.89	61.11	42.22	69.44	23.89	35.00	6.11	25.00	72.22	53.89	73.33	74.44
5P9	5.82	-6.88	22.11	9.01	310.94	-15.56	-88.33	94.44	-74.44	88.33	85.56	-70.00	-89.44	24.44	-71.67	-55.56	58.89
5P10	20.66	-19.65	25.87	28.51	316.43	-23.89	-71.11	81.67	-51.67	78.33	66.67	-43.89	-78.89	12.78	-40.00	-23.33	46.67
5P11	33.91	-34.95	28.91	48.37	314.5	-11.11	-10.56	61.11	5.00	53.33	52.22	-28.33	-37.78	45.00	-1.67	18.33	53.33
5P12	45.78	-41.74	30.34	61.95	317.64	7.78	18.89	62.78	40.56	47.78	51.11	-11.11	-21.67	60.56	38.33	55.00	71.11
10P1	2.26	1.46	81.04	2.69	32.75	-47.78	60.56	-66.67	-12.78	-67.78	-47.78	49.44	38.33	-26.11	-52.22	-70.00	-59.44
10P2	7.32	-0.56	83.36	7.34	355.65	-37.78	63.89	-52.78	5.56	-58.89	-40.00	57.78	37.22	-12.78	-26.11	-51.11	-45.00
10P3	2.21	-1.09	59.69	2.46	333.8	-41.67	-37.78	38.89	-53.89	37.22	23.89	-10.56	-48.89	-41.67	-56.11	-58.89	-7.22
10P4	13.3	-5.53	68.79	14.4	337.43	-30.00	28.89	-2.22	-10.00	-13.33	-13.89	35.56	-5.00	-22.78	-10.56	-25.00	-5.00
10P5	27.56	-10.62	72.76	29.53	338.93	5.00	62.78	7.78	58.33	-17.78	-22.22	50.56	38.33	46.67	38.33	31.67	45.56
10P6	3.48	-1.96	40.79	3.99	330.56	-33.89	-67.22	60.56	-66.67	66.67	53.89	-40.00	-70.56	-29.44	-59.44	-65.56	8.33
10P7	23.87	-15.49	39.42	28.48	327.05	-15.00	-35.56	65.00	-30.00	57.78	45.00	-26.67	-57.78	13.89	-12.78	-5.56	35.00
10P8	43.16	-23.31	49.62	49.05	331.63	10.56	58.33	38.33	63.89	12.22	27.22	15.56	19.44	65.56	50.56	61.11	61.11
10P9	8.54	-5.37	27.41	10.09	327.84	-36.72	-83.05	80.79	-72.32	52.54	68.93	-43.50	-84.18	5.65	-58.76	-54.80	25.99
10P10	22.89	-12.5	27.03	26.08	331.37	-1.13	-34.46	62.71	-28.25	50.85	54.24	-22.03	-41.81	30.51	-15.82	-9.04	35.03
10P11	36.86	-22.76	26.71	43.32	328.31	4.52	9.04	61.58	19.77	48.59	45.76	-16.95	-14.69	48.59	20.34	32.77	53.67
10P12	57.19	-33.5	32.65	66.28	329.64	20.90	46.89	47.46	59.89	33.33	37.85	1.13	17.51	70.62	55.93	69.49	75.71
5RP1	3.66	3.79	82.55	5.27	46.01	-48.59	66.67	-65.54	-16.38	-67.23	-48.02	38.98	31.03	-31.07	-50.28	-75.71	-63.28
5RP2	9.01	3.07	86.48	9.52	18.78	-34.46	71.19	-60.45	24.14	-71.75	-55.75	55.75	45.40	1.72	-13.22	-56.32	-35.63
5RP3	3.92	1.7	58.12	4.27	23.38	-44.07	-37.85	35.59	-45.20	33.33	32.77	-6.21	-45.20	-30.51	-43.50	-57.63	-8.47
5RP4	15.56	-0.12	61.81	15.56	359.54	-15.82	2.82	14.12	-35.03	12.43	-2.30	16.38	-31.07	-22.60	-16.95	-34.46	-13.56

Table B-1 Colorimetric values of color samples and visual assessment values through 7-point method from Thai observers (cont.)

Color	Colorimetric Values					Visual Assessment Values											
Sample	a*	b*	L*	C*	h	WC	LD	DP	VS	HL	SW	SH	TT	DV	DYP	GP	SS
5RP5	35.21	-0.2	72.11	35.21	359.68	23.73	73.45	27.12	76.27	-14.12	-12.43	47.46	58.76	58.62	53.67	58.19	64.41
5RP6	12.05	-3.23	33.02	12.47	344.98	-20.34	-68.36	75.71	-61.58	71.75	66.67	-49.72	-73.45	-11.30	-54.80	-58.19	28.25
5RP7	30.7	-4.29	40.25	31	352.04	18.08	-9.04	50.28	-10.73	50.57	43.50	-27.68	-28.81	6.21	8.47	3.95	33.90
5RP8	55.26	-2.68	57.36	55.33	357.21	45.20	76.27	52.54	84.75	11.30	-9.60	20.90	44.07	76.84	67.80	72.88	82.49
5RP9	9.86	-2.38	26.14	10.14	346.41	-30.51	-81.36	85.88	-62.71	83.05	78.53	-68.93	-80.79	-1.13	-59.89	-54.80	30.51
5RP10	29.51	-7.24	30.59	30.38	346.81	10.73	-32.20	66.67	-28.81	64.41	53.67	-37.85	-48.02	19.77	-13.56	-14.12	32.77
5RP11	42.03	-12	30.09	43.71	344.06	25.42	1.13	62.15	9.04	49.72	42.37	-22.03	-31.64	37.85	15.25	23.16	45.20
5RP12	56.38	-8.21	36.79	56.78	351.71	46.33	46.89	59.32	50.85	44.07	35.03	-6.21	6.21	61.02	47.46	55.37	61.02
10RP1	3.67	3.72	85.01	5.23	45.37	-48.59	72.32	-75.14	-12.99	-71.75	-56.50	55.93	41.81	-20.90	-44.63	-77.40	-61.58
10RP2	10.75	5.25	86.98	11.96	26.05	-35.59	71.19	-62.15	20.34	-67.23	-63.84	60.45	53.67	-3.95	-18.64	-51.41	-34.46
10RP3	5.93	1.14	68.77	6.04	10.92	-38.98	-21.47	9.60	-51.41	18.08	10.73	12.43	-20.34	-42.94	-36.72	-60.45	-34.46
10RP4	17.22	3.44	68.74	17.56	11.3	-9.20	11.49	10.92	-22.41	5.75	-8.62	30.46	-6.32	-22.41	-2.30	-33.33	-2.30
10RP5	32.37	8.53	66.28	38.34	12.86	-1.11	51.11	13.33	47.22	-17.78	-20.00	59.44	19.44	37.22	31.11	12.22	43.33
10RP6	8.64	1.08	47.13	8.71	7.14	-38.89	-61.11	58.33	-61.11	57.78	43.33	-25.00	-61.11	-26.11	-45.56	-65.56	2.22
10RP7	25.71	2.64	48.55	25.84	5.87	2.22	-22.22	47.78	-33.89	38.33	20.00	-1.11	-42.78	-13.89	-16.11	-34.44	14.44
10RP8	49.3	12.65	56.47	50.9	14.39	49.44	63.89	49.44	68.33	17.78	22.22	23.89	31.67	58.89	57.22	63.89	72.22
10RP9	18.69	-0.87	22.15	18.71	357.34	-10.00	-76.11	92.22	-57.78	88.33	82.22	-63.89	-87.78	16.11	-48.89	-41.67	55.56
10RP10	26.82	1.74	32.25	26.88	3.71	15.56	-37.78	61.11	-34.44	57.22	53.89	-37.78	-57.78	2.22	-17.22	-16.11	36.11
10RP11	44.07	3.51	35.76	44.21	4.56	36.67	-13.89	63.33	-5.00	50.00	47.78	-18.89	-43.89	31.67	8.89	23.33	46.11
10RP12	62.97	7.46	41.36	63.41	6.76	61.67	61.67	64.44	75.00	39.44	37.22	5.56	23.33	71.67	62.22	80.56	78.33
N1	-0.04	-0.54	17.11	0.55	266.07	-28.89	-89.44	88.89	-55.56	94.44	92.22	-71.67	-88.33	46.11	-82.78	-61.11	70.56
N-2	0.11	-2.41	20.79	2.41	272.51	-28.33	-86.11	89.44	-63.89	92.78	87.22	-71.67	-79.44	32.78	-78.33	-61.67	50.00
N-4	0.27	0.13	40.42	0.3	25.3	-47.22	-36.11	35.00	-61.11	32.78	39.44	-20.56	-56.11	-16.11	-56.67	-63.89	-7.78
N-6	-0.65	-1.38	60.98	1.52	244.72	-56.11	16.11	-10.56	-41.67	-15.56	1.11	18.89	-7.78	-9.44	-40.00	-62.78	-22.22
N-8	-1.32	4.94	82.31	5.11	104.95	-55.00	64.44	-67.22	-1.11	-63.89	-32.78	45.56	44.44	-19.44	-36.11	-53.89	-55.00
N95	-0.56	4.02	93.39	4.06	97.88	-55.56	92.22	-86.67	35.00	-88.33	-42.22	72.78	76.11	26.67	-50.56	-82.78	-33.33

APPENDIX C

QUESTIONNAIRE THE VISUAL EXPERIMENT

แบบทดสอบ
เรื่อง การวิเคราะห์การรับรู้สีเชิงปริมาณของคนไทย

วันที่.....เดือน..... พ.ศ. .....

รายละเอียดผู้ทดลอง

1. ชื่อ..... 2. เพศ..... 3. อายุ.....

วิธีการทดลองการรับรู้สี

1. ดูตัวอย่างสีในตู้ควบคุมแสงที่ระดับความส่องสว่าง D65
2. กรอกหมายเลขตัวอย่างสี เช่น 10R5
3. นำหน้ากากสีเทาปิดบนตัวอย่างสี
4. แต่ละคู่คำพูดแสดงความรู้สึกตรงข้ามแบ่งเป็น 7 ระดับ และเลือกคำพูดเพียง 1 ระดับที่พิจารณาแล้วว่ามีความเหมาะสมกับตัวอย่างสีมากที่สุด ได้แก่

มืดมาก	มืดปานกลาง	มืดน้อย	ปานกลาง	สว่างน้อย	สว่างปานกลาง	สว่างมาก
แข็งกระด้างมาก	แข็งกระด้างปานกลาง	แข็งกระด้างน้อย	ปานกลาง	นุ่มนวลน้อย	นุ่มนวลปานกลาง	นุ่มนวลมาก
เย็นมาก	เย็นปานกลาง	เย็นน้อย	ปานกลาง	ร้อนน้อย	ร้อนปานกลาง	ร้อนมาก
ทึบมาก	ทึบปานกลาง	ทึบใสน้อย	ปานกลาง	โปร่งใสน้อย	โปร่งใสปานกลาง	โปร่งใสมาก
จางมาก	จางปานกลาง	จางน้อย	ปานกลาง	เข้มน้อย	เข้มปานกลาง	เข้มมาก
ขมุกขมัวมาก	ขมุกขมัวปานกลาง	ขมุกขมัวน้อย	ปานกลาง	ชัดเจนน้อย	ชัดเจนปานกลาง	ชัดเจนมาก
เบามาก	เบาปานกลาง	เบาน้อย	ปานกลาง	หนักน้อย	หนักปานกลาง	หนักมาก
หม่นมาก	หม่นปานกลาง	หม่นน้อย	ปานกลาง	สดใสน้อย	สดใสปานกลาง	สดใสมาก
อ่อนแอมาก	อ่อนแอปานกลาง	อ่อนแอน้อย	ปานกลาง	เข้มแข็งน้อย	เข้มแข็งปานกลาง	เข้มแข็งมาก
สงบนิ่งมาก	สงบนิ่งไหวปานกลาง	สงบนิ่งไหวน้อย	ปานกลาง	เคลื่อนไหวน้อย	เคลื่อนไหวปานกลาง	เคลื่อนไหวมาก
เรียบมาก	เรียบปานกลาง	เรียบน้อย	ปานกลาง	ขุดฉาดน้อย	ขุดฉาดปานกลาง	ขุดฉาดมาก
ฉีดมาก	ฉีดปานกลาง	ฉีดน้อย	ปานกลาง	โดดเด่นน้อย	โดดเด่นปานกลาง	โดดเด่นมาก
-3	-2	-1	0	1	2	3

5. นำตัวเลขที่แสดงระดับต่าง ๆ ที่อยู่ด้านล่างมาใช้แทน
6. ทำจนครบ 218 ตัวอย่างสี

Color No	มืด-สว่าง	แข็งกระด้าง นุ่มนวล	เย็น-ร้อน	ทึบ-โปร่งใส	จาง-เข้ม	ขุ่นขมัว-ชัดเจน	เบา-หนัก	หม่น-สดใส	อ่อนแอ-เข้มแข็ง	สงบนิ่ง-เคลื่อนไหว	เรียบ-ฉูดฉาด	ชืด-โดดเด่น

APPENDIX D

VISUAL ASSESSMENT VALUES THROUGH 2-POINT METHOD FROM THAI OBSERVERS

Table D-1 Visual assessment values through 2-point method

Color Sample	Visual Assessment Values											
	LD	SH	WC	TT	DP	DV	HL	VS	SW	DYP	GP	SS
5R1	63.33	66.67	-66.10	33.33	-70.00	-62.71	-69.49	-33.33	-66.67	-45.76	-83.33	-72.88
5R2	80.00	90.00	-11.86	65.00	-46.67	6.67	-69.49	50.00	-86.67	10.00	-26.67	0.00
5R3	-36.67	13.33	-76.67	-40.00	0.00	-43.33	8.47	-56.67	13.33	-66.67	-86.67	-46.67
5R4	33.33	50.00	-15.25	5.08	20.00	-10.00	5.08	-20.00	-18.64	-16.67	-40.00	-20.34
5R5	93.33	63.33	63.33	79.66	66.67	90.00	-3.33	90.00	20.00	86.67	86.67	80.00
5R6	-83.33	-43.33	-37.93	-86.67	96.67	-26.67	96.67	-80.00	93.33	-72.88	-86.67	13.79
5R7	-36.67	-20.00	20.00	-80.00	90.00	-36.67	86.67	-63.33	73.33	-30.00	-40.00	33.33
5R8	100.00	13.33	70.00	70.00	66.67	93.33	13.33	100.00	43.33	86.67	96.67	96.67
5R9	-96.67	-83.33	-20.00	-100.00	100.00	23.33	96.67	-83.33	100.00	-80.00	-73.33	63.33
5R10	-43.33	-60.00	43.33	-80.00	90.00	23.33	83.33	-60.00	90.00	-10.00	-6.67	73.33
5R11	56.67	-60.00	86.67	-33.33	100.00	70.00	90.00	56.67	86.67	70.00	80.00	93.33
5R12	100.00	-3.33	86.67	43.33	86.67	93.33	50.00	93.33	66.67	96.67	96.67	96.67
10R1	83.33	83.33	-60.00	56.67	-80.00	-73.33	-93.33	-53.33	-80.00	-63.33	-93.33	-83.33
10R2	86.67	86.67	-30.00	76.67	-80.00	23.33	-86.67	36.67	-66.67	10.00	-63.33	-43.33
10R3	-53.33	52.54	-70.00	-45.76	13.33	-83.33	-3.33	-83.33	10.00	-89.83	-100.00	-70.00
10R4	76.67	56.67	13.33	10.00	30.00	30.00	-11.86	3.33	10.00	30.00	-8.47	43.33
10R5	96.67	46.67	53.33	80.00	40.00	83.33	-13.33	86.67	-10.00	70.00	70.00	73.33
10R6	-90.00	-46.67	-53.33	-100.00	93.33	-33.33	100.00	-96.67	73.33	-80.00	-90.00	10.00
10R7	0.00	-20.00	20.00	-70.00	90.00	-20.00	73.33	-63.33	60.00	-20.00	-36.67	23.33
10R8	93.33	-16.67	86.67	63.33	86.67	86.67	51.67	86.67	60.00	90.00	83.33	96.67
10R9	-96.67	-86.67	-50.00	-93.33	96.67	10.00	96.67	-73.33	100.00	-76.67	-66.67	66.67
10R10	-73.33	-93.33	26.67	-83.33	96.67	3.33	93.33	-60.00	90.00	-30.00	-26.67	63.33
10R11	60.00	-63.33	83.33	-43.33	96.67	53.33	73.33	23.33	73.33	70.00	66.67	96.67
10R12	100.00	-53.33	96.67	50.00	90.00	96.67	63.33	93.33	70.00	93.33	100.00	100.00
5YR1	60.00	70.00	-83.33	20.00	-50.00	-70.00	-60.00	-70.00	-56.67	-73.33	-90.00	-80.00
5YR2	96.67	90.00	-6.67	90.00	-46.67	23.33	-66.67	60.00	-53.33	23.33	-10.00	3.33
5YR3	23.33	53.33	-60.00	-30.00	-20.00	-70.00	-33.33	-70.00	-10.00	-80.00	-96.67	-66.67
5YR4	73.33	3.33	43.33	-20.00	60.00	10.00	50.00	3.33	20.00	6.67	-3.33	26.67
5YR5	90.00	50.00	66.67	76.67	30.00	73.33	-26.67	73.33	3.33	63.33	63.33	70.00
5YR6	-83.33	-56.67	-49.15	-83.33	93.33	-23.33	93.33	-86.67	80.00	-70.00	-80.00	40.00
5YR7	30.00	-10.00	33.33	-40.00	80.00	23.33	70.00	-23.33	46.67	13.33	-3.33	56.67

Table D-1 Visual assessment values through 2-point method (cont.)

Color Sample	Visual Assessment Values											
	LD	SH	WC	TT	DP	DV	HL	VS	SW	DYP	GP	SS
5YR8	86.67	-43.33	93.33	43.33	90.00	93.33	70.00	90.00	73.33	86.67	100.00	100.00
5YR9	-96.67	-76.67	-38.98	-96.67	100.00	30.00	96.67	-83.33	80.00	-76.67	-76.67	76.67
5YR10	-3.33	-60.00	33.33	-70.00	93.33	10.00	86.67	-50.00	86.67	-6.67	-13.33	56.67
5YR11	86.67	-23.33	80.00	0.00	66.67	66.67	46.67	46.67	66.67	70.00	73.33	86.67
5YR12	86.67	-40.00	86.67	23.33	73.33	93.33	60.00	90.00	70.00	73.33	96.67	100.00
10YR1	83.33	70.00	-73.33	46.67	-73.33	-50.00	-76.67	-40.00	-76.67	-60.00	-96.67	-83.33
10YR2	90.00	83.33	-33.33	83.33	-83.33	13.33	-93.33	20.00	-70.00	-33.33	-86.67	-56.67
10YR3	-80.00	-10.00	-86.67	-83.33	60.00	-56.67	73.33	-100.00	50.00	-83.33	-96.67	-6.67
10YR4	50.00	23.33	-10.00	-43.33	40.00	-10.00	40.00	-53.33	13.33	-13.33	-53.33	-16.67
10YR5	100.00	26.67	80.00	83.33	36.67	93.33	-6.67	96.67	33.33	90.00	93.33	86.67
10YR6	-90.00	-20.00	-76.67	-93.33	86.67	-33.33	93.33	-93.33	60.00	-73.33	-93.33	13.33
10YR7	16.67	-50.00	50.00	-46.67	93.33	23.33	90.00	-40.00	66.67	20.00	16.67	66.67
10YR8	90.00	-13.33	83.33	76.67	63.33	93.33	3.33	86.67	46.67	90.00	86.67	90.00
10YR9	-96.67	-66.67	-50.00	-93.33	100.00	26.67	96.67	-83.33	83.33	-90.00	-90.00	63.33
10YR10	-46.67	-56.67	-28.33	-73.33	83.33	0.00	83.33	-83.33	70.00	-43.33	-63.33	26.67
5Y1	63.33	73.33	-70.00	16.67	-70.00	-70.00	-80.00	-53.33	-60.00	-80.00	-96.67	-80.00
5Y2	96.67	86.67	-33.33	63.33	-60.00	13.33	-83.33	53.33	-76.67	-16.67	-53.33	-26.67
5Y3	-53.33	6.67	-76.67	-60.00	56.67	-66.67	46.67	-93.33	20.00	-83.33	-96.67	-40.00
5Y4	66.67	46.67	-13.33	26.67	3.33	-26.67	-6.67	-30.00	-30.00	-13.33	-63.33	-16.67
5Y5	100.00	16.67	60.00	86.67	76.67	96.67	23.33	100.00	23.33	83.33	90.00	93.33
5Y6	-96.67	-50.00	-63.33	-90.00	93.33	-46.67	96.67	-90.00	83.33	-73.33	-90.00	10.00
5Y7	43.33	-30.00	50.00	-43.33	93.33	10.00	83.33	-20.00	66.67	13.33	13.33	56.67
5Y8	80.00	-20.00	70.00	16.67	90.00	66.67	56.67	63.33	70.00	66.67	90.00	90.00
5Y9	-96.67	-83.33	-26.67	-96.67	100.00	6.67	100.00	-83.33	93.33	-83.33	-83.33	66.67
5Y10	-16.67	-60.00	26.67	-70.00	93.33	16.67	86.67	-66.67	86.67	-13.33	-26.67	56.67
10Y1	80.00	70.00	-80.00	33.33	-66.67	-33.33	-80.00	-40.00	-56.67	-60.00	-90.00	-76.67
10Y2	93.33	93.33	-16.67	86.67	-73.33	43.33	-83.33	80.00	-63.33	6.67	-23.33	-20.00
10Y3	-63.33	-16.67	-83.33	-80.00	76.67	-56.67	66.67	-93.33	60.00	-90.00	-96.67	-23.33
10Y4	66.67	43.33	-30.00	16.67	16.67	6.67	-6.67	-6.67	-6.67	0.00	-26.67	23.33
10Y5	96.67	33.33	43.33	83.33	53.33	93.33	-13.33	96.67	6.67	90.00	93.33	100.00
10Y6	-100.00	-63.33	-53.33	-90.00	96.67	-20.00	93.33	-100.00	83.33	-76.67	-96.67	23.33

Table D-1 Visual assessment values through 2-point method (cont.)

Color Sample	Visual Assessment Values											
	LD	SH	WC	TT	DP	DV	HL	VS	SW	DYP	GP	SS
10Y7	63.33	13.33	0.00	-10.00	66.67	16.67	36.67	6.67	23.33	36.67	10.00	30.00
10Y8	86.67	-3.33	56.67	76.67	60.00	96.67	23.33	100.00	33.33	83.33	90.00	96.67
10Y9	-96.67	-73.33	-46.67	-96.67	96.67	10.00	100.00	-80.00	90.00	-86.67	-76.67	66.67
10Y10	-60.00	-36.67	-53.33	-73.33	96.67	-6.67	86.67	-73.33	93.33	-10.00	-53.33	56.67
5GY1	73.33	63.33	-73.33	23.33	-70.00	-53.33	-70.00	-50.00	-46.67	-66.67	-93.33	-96.67
5GY2	90.00	73.33	-30.00	76.67	-66.67	20.00	-86.67	46.67	-73.33	23.33	-56.67	-16.67
5GY3	-76.67	-20.00	-56.67	-73.33	73.33	-36.67	53.33	-90.00	53.33	-70.00	-93.33	10.00
5GY4	86.67	76.67	-30.00	66.67	13.33	53.33	-43.33	70.00	-10.00	63.33	30.00	63.33
5GY5	93.33	76.67	-3.33	93.33	6.67	96.67	-43.33	93.33	43.33	83.33	83.33	86.67
5GY6	-93.33	-56.67	-70.00	-80.00	80.00	-46.67	83.33	-86.67	76.67	-80.00	-83.33	36.67
5GY7	13.33	5.08	-50.00	-28.81	80.00	38.98	66.67	-3.33	66.10	1.69	-10.34	55.93
5GY8	100.00	30.00	20.00	93.33	60.00	100.00	-16.67	100.00	46.67	96.67	100.00	100.00
5GY9	-96.67	-73.33	-36.67	-76.67	96.67	-16.67	93.33	-86.67	83.33	-76.67	-66.67	46.67
5GY10	-33.33	-30.00	-43.33	-83.33	96.67	6.67	90.00	-53.33	83.33	-13.33	-33.33	50.00
5GY11	100.00	46.67	6.67	70.00	66.67	93.33	-3.33	93.33	50.00	86.67	93.33	100.00
5GY12	100.00	36.67	13.33	80.00	53.33	93.33	-10.00	96.67	33.33	93.33	100.00	96.67
10GY1	76.67	86.67	-73.33	46.67	-76.67	-10.00	-73.33	-36.67	-46.67	-46.67	-76.67	-50.00
10GY2	93.33	83.33	-66.67	86.67	-63.33	23.33	-76.67	63.33	-70.00	3.33	-70.00	-26.67
10GY3	-80.00	-6.67	-73.33	-66.67	56.67	-66.67	56.67	-93.33	40.00	-83.05	-93.33	-53.33
10GY4	80.00	80.00	-56.67	63.33	13.33	33.33	-36.67	56.67	6.67	33.33	-33.33	16.67
10GY6	-100.00	-50.00	-60.00	-96.67	96.67	-46.67	96.67	-93.33	86.67	-86.44	-86.67	30.00
10GY7	90.00	66.67	-40.00	66.67	66.67	86.67	30.00	73.33	53.33	62.71	60.00	90.00
10GY9	-93.33	-86.67	-30.00	-93.33	100.00	43.33	100.00	-66.67	93.33	-86.44	-63.33	70.00
10GY10	-26.67	-60.00	-53.33	-80.00	96.67	40.00	96.67	-20.00	90.00	-18.64	-20.00	70.00
10GY11	80.00	16.67	-13.33	40.00	90.00	100.00	46.67	90.00	73.33	83.33	73.33	96.67
5G1	90.00	73.33	-73.33	60.00	-90.00	-43.33	-90.00	-33.33	-80.00	-60.00	-90.00	-80.00
5G2	96.67	93.33	-56.67	83.33	-83.33	16.67	-90.00	40.00	-63.33	10.00	-73.33	-50.00
5G3	-3.33	30.00	-80.00	-3.33	30.00	-43.33	10.00	-76.67	-20.00	-63.33	-96.67	-50.00
5G4	86.67	60.00	-60.00	23.33	50.00	53.33	6.67	60.00	0.00	46.67	3.33	43.33
5G6	-96.67	-60.00	-53.33	-86.67	93.33	-30.00	90.00	-96.67	80.00	-90.00	-96.67	6.67
5G7	60.00	40.00	-46.67	23.33	70.00	60.00	33.33	50.00	40.00	53.33	23.33	56.67

Table D-1 Visual assessment values through 2-point method (cont.)

Color Sample	Visual Assessment Values											
	LD	SH	WC	TT	DP	DV	HL	VS	SW	DYP	GP	SS
5G9	-96.67	-70.00	-40.00	-90.00	100.00	20.00	100.00	-90.00	90.00	-80.00	-73.33	63.33
5G10	-23.33	-23.33	-26.67	-53.33	100.00	53.33	90.00	16.67	93.33	13.33	13.33	86.67
5G11	63.33	-3.33	-10.00	-3.33	90.00	96.67	53.33	86.67	76.67	60.00	60.00	93.33
10G1	90.00	83.33	-60.00	73.33	-93.33	-40.00	-90.00	-23.33	-83.33	-46.67	-83.33	-76.67
10G2	93.33	86.67	-59.32	86.67	-30.00	53.33	-70.00	76.67	-40.00	30.00	-3.33	26.67
10G3	-13.33	30.00	-76.67	-36.67	6.67	-63.33	-16.67	-76.67	6.67	-56.67	-93.33	-60.00
10G4	86.67	70.00	-56.67	46.67	10.00	40.00	-26.67	60.00	-23.33	40.00	-10.00	30.00
10G6	-93.33	-36.67	-63.33	-93.33	86.67	-33.33	93.33	-96.67	63.33	-90.00	-86.67	16.67
10G7	73.33	46.67	-46.67	43.33	60.00	50.00	0.00	66.67	16.67	43.33	36.67	73.33
10G9	-86.67	-66.67	-23.33	-93.33	93.33	40.00	90.00	-60.00	90.00	-56.67	-43.33	66.67
10G10	-53.33	-50.00	-50.00	-76.67	96.67	43.33	90.00	-16.67	90.00	-6.67	-6.67	76.67
10G11	66.67	46.67	-30.00	30.00	66.67	83.33	23.33	73.33	50.00	66.67	60.00	86.67
5BG1	80.00	50.00	-76.67	20.00	-73.33	-53.33	-70.00	-46.67	-60.00	-63.33	-86.67	-66.67
5BG2	90.00	90.00	-86.67	76.67	-83.33	-3.33	-90.00	43.33	-76.67	-30.00	-73.33	-63.33
5BG3	-76.67	-13.33	-80.00	-86.67	83.33	-50.00	66.67	-93.33	70.00	-80.00	-100.00	6.67
5BG4	90.00	73.33	-53.33	36.67	36.67	50.00	-20.00	80.00	10.00	26.67	-10.00	46.67
5BG6	-93.33	-53.33	-53.33	-96.67	93.33	-20.00	93.33	-96.67	90.00	-73.33	-83.33	53.33
5BG7	76.67	30.00	-43.33	-3.33	86.67	80.00	40.00	60.00	66.67	56.67	33.33	76.67
5BG9	-100.00	-80.00	-26.67	-96.67	100.00	23.33	100.00	-86.67	96.67	-80.00	-83.33	80.00
5BG10	-6.67	-30.00	-53.33	-70.00	90.00	50.00	83.33	13.33	86.67	0.00	3.33	93.33
5BG11	0.00	6.67	-70.00	-53.33	80.00	16.67	73.33	-30.00	50.00	-10.00	-50.00	43.33
10BG1	83.33	73.33	-56.67	36.67	-66.67	-60.00	-83.33	-46.67	-46.67	-60.00	-83.33	-80.00
10BG2	100.00	96.67	-53.33	86.67	-26.67	73.33	-76.67	93.33	-50.00	40.00	16.67	30.00
10BG3	-70.00	-20.00	-56.67	-76.67	76.67	-46.67	76.67	-86.67	80.00	-80.00	-80.00	3.33
10BG4	86.67	76.67	-46.67	66.67	6.67	63.33	-43.33	83.33	-26.67	36.67	-10.00	40.00
10BG6	-100.00	-66.67	-53.33	-100.00	100.00	-46.67	93.33	-96.67	100.00	-83.33	-80.00	40.00
10BG7	70.00	26.67	-36.67	-26.67	70.00	66.67	46.67	50.00	63.33	46.67	13.33	83.33
10BG9	-90.00	-90.00	-16.67	-100.00	100.00	23.33	96.67	-80.00	100.00	-70.00	-80.00	76.67
10BG10	-13.33	-3.33	-40.00	-56.67	93.33	40.00	90.00	-6.67	76.67	23.33	-13.33	73.33
5B1	90.00	90.00	-70.00	56.67	-93.33	-43.33	-90.00	-13.33	-66.67	-33.33	-90.00	-76.67
5B2	96.67	100.00	-63.33	96.67	-63.33	46.67	-83.33	73.33	-53.33	13.33	-40.00	-13.33

Table D-1 Visual assessment values through 2-point method (cont.)

Color Sample	Visual Assessment Values											
	LD	SH	WC	TT	DP	DV	HL	VS	SW	DYP	GP	SS
5B3	-63.33	-20.00	-63.33	-73.33	60.00	-43.33	56.67	-90.00	73.33	-70.00	-93.33	3.33
5B4	83.33	86.67	-63.33	30.00	-13.33	36.67	-40.00	53.33	-26.67	26.67	-26.67	20.00
5B6	-76.67	-13.33	-80.00	-93.33	93.33	-53.33	86.67	-80.00	76.67	-86.67	-90.00	3.33
5B7	60.00	50.00	-66.67	10.00	53.33	46.67	26.67	36.67	13.33	20.00	-3.33	70.00
5B9	-100.00	-73.33	-66.67	-96.67	93.33	-13.33	100.00	-70.00	93.33	-80.00	-80.00	56.67
5B10	-80.00	-40.00	-76.67	-90.00	93.33	13.33	100.00	-70.00	93.33	-56.67	-63.33	70.00
10B1	90.00	63.33	-63.33	63.33	-73.33	-46.67	-73.33	-23.33	-36.67	-50.00	-73.33	-53.33
10B2	90.00	86.67	-80.00	86.67	-66.67	13.33	-83.33	40.00	-53.33	-16.67	-76.67	-36.67
10B3	-23.33	-6.67	-86.67	-46.67	43.33	-63.33	13.33	-83.33	46.67	-76.67	-90.00	-46.67
10B4	80.00	76.67	-66.67	40.00	13.33	43.33	-16.67	30.00	0.00	20.00	-23.33	30.00
10B5	100.00	86.67	-76.67	83.33	3.33	90.00	-46.67	90.00	-10.00	53.33	26.67	70.00
10B6	-86.67	-43.33	-76.67	-96.67	90.00	-26.67	86.67	-76.67	86.67	-83.33	-90.00	23.33
10B7	16.67	20.00	-73.33	-36.67	86.67	6.67	43.33	-20.00	36.67	-8.47	-43.33	18.64
10B8	83.33	43.33	-46.67	50.00	80.00	90.00	26.67	86.67	63.33	80.00	83.33	90.00
10B9	-90.00	-70.00	-50.00	-90.00	93.33	16.67	86.67	-70.00	90.00	-80.00	-66.67	70.00
10B10	-73.33	-63.33	-70.00	-86.67	96.67	13.33	93.33	-46.67	90.00	-40.00	-66.67	63.33
5PB1	80.00	68.97	-60.00	63.33	-73.33	-26.67	-80.00	-23.33	-56.67	-33.33	-90.00	-56.67
*5PB2	96.67	89.83	-86.67	76.67	-66.67	-30.00	-83.33	6.67	-56.67	-36.67	-83.33	-53.33
5PB3	-70.00	-13.33	-86.67	-76.67	53.33	-60.00	73.33	-66.67	43.33	-83.33	-79.66	-25.42
5PB4	-6.67	26.67	-83.33	-53.33	56.67	-36.67	56.67	-50.00	35.59	-38.98	-93.33	-10.00
5PB5	83.33	76.67	-46.67	70.00	23.33	70.00	-28.81	80.00	6.67	66.10	36.67	70.00
5PB6	-93.33	-73.33	-63.33	-90.00	83.33	-43.33	86.67	-90.00	83.33	-80.00	-90.00	20.00
5PB7	-16.67	30.00	-93.33	-46.67	86.67	16.67	50.00	-13.33	66.67	-26.67	-56.67	46.67
5PB8	83.33	56.67	-53.33	43.33	66.67	93.33	6.67	90.00	63.33	52.54	53.33	86.67
5PB9	-86.67	-63.33	-53.33	-90.00	100.00	43.33	96.67	-76.67	100.00	-83.33	-76.67	76.67
5PB10	-80.00	-60.00	-73.33	-83.33	100.00	33.33	96.67	-70.00	83.33	-53.33	-60.00	76.67
5PB11	3.33	-20.00	-70.00	-56.67	96.67	73.33	76.67	10.00	96.67	-20.00	-23.33	96.67
5PB12	66.67	13.33	-30.00	26.67	83.33	86.67	30.00	86.67	60.00	60.00	70.00	93.33
10PB1	73.33	70.00	-66.67	20.00	-76.67	-66.67	-86.67	-66.67	-66.67	-60.00	-93.33	-76.67
10PB2	83.33	60.00	-60.00	40.00	-56.67	-13.33	-73.33	16.67	-33.33	-26.67	-60.00	-36.67
10PB3	-26.67	20.00	-90.00	-60.00	36.67	-50.00	36.67	-83.33	23.33	-76.67	-93.33	-26.67

Table D-1 Visual assessment values through 2-point method (cont.)

Color Sample	Visual Assessment Values											
	LD	SH	WC	TT	DP	DV	HL	VS	SW	DYP	GP	SS
10PB4	70.00	73.33	-60.00	10.00	-13.33	-26.67	-26.67	-3.33	-30.00	-30.00	-73.33	-30.00
10PB5	90.00	73.33	-43.33	66.67	20.00	50.00	-36.67	73.33	13.33	43.33	43.33	50.00
10PB6	-80.00	-60.00	-63.33	-76.67	93.33	-16.67	93.33	-80.00	73.33	-70.00	-80.00	46.67
10PB7	-60.00	-30.00	-60.00	-63.33	96.67	26.67	96.67	-60.00	90.00	-10.00	-40.00	76.67
10PB8	86.67	30.00	-3.33	43.33	76.67	86.67	33.33	86.67	56.67	66.67	76.67	93.33
10PB9	-93.33	-73.33	-70.00	-90.00	100.00	50.00	96.67	-80.00	100.00	-80.00	-83.33	73.33
10PB10	-81.67	-65.00	-68.33	-85.00	95.00	51.67	91.67	-71.67	95.00	-58.33	-58.33	91.67
10PB11	3.33	-30.00	-50.00	-36.67	96.67	70.00	86.67	3.33	90.00	23.33	26.67	93.33
10PB12	46.67	-20.00	-26.67	-6.67	90.00	86.67	70.00	50.00	66.67	60.00	66.67	95.00
5P1	50.00	60.00	-66.67	-20.00	-16.67	-80.00	-40.00	-63.33	-23.33	-76.67	-93.33	-80.00
5P2	90.00	66.67	-50.00	53.33	-50.00	-30.00	-70.00	16.67	-23.33	-18.33	-63.33	-46.67
5P3	-76.67	-23.33	-60.00	-93.33	80.00	-63.33	83.33	-90.00	73.33	-86.67	-93.33	13.33
5P4	13.33	33.33	-30.00	-26.67	63.33	-6.67	53.33	-26.67	30.00	-11.86	-26.67	20.00
5P5	86.67	60.00	16.67	78.33	40.00	73.33	13.33	76.67	31.67	66.67	66.67	76.67
5P6	-100.00	-66.67	-43.33	-100.00	100.00	-43.33	96.67	-96.67	90.00	-90.00	-93.33	26.67
5P7	-23.33	-26.67	-13.33	-73.33	90.00	6.67	93.33	-30.00	73.33	-16.67	23.33	83.33
5P8	93.33	33.33	13.33	50.00	70.00	96.67	46.67	93.33	73.33	86.67	96.67	100.00
5P9	-86.67	-80.00	-6.67	-93.33	100.00	26.67	90.00	-80.00	96.67	-80.00	-70.00	76.67
5P10	-90.00	-63.33	-36.67	-96.67	100.00	23.33	96.67	-66.67	96.67	-56.67	-20.00	83.33
5P11	-6.67	-53.33	0.00	-63.33	96.67	70.00	90.00	26.67	86.67	0.00	46.67	93.33
5P12	40.00	-26.67	16.67	-13.33	90.00	86.67	80.00	63.33	93.33	66.67	83.33	100.00
10P1	86.67	83.33	-72.88	66.67	-90.00	-56.67	-96.67	-20.00	-63.33	-73.33	-93.33	-86.67
10P2	93.33	90.00	-50.00	70.00	-80.00	-30.00	-80.00	13.33	-60.00	-40.00	-80.00	-66.67
10P3	-70.00	-26.67	-73.33	-83.33	73.33	-63.33	76.67	-86.67	60.00	-93.33	-93.33	0.00
10P4	66.67	66.67	-40.00	-3.33	13.33	-36.67	-10.00	-13.33	-10.00	-6.67	-36.67	3.33
10P5	93.33	83.33	30.00	80.00	23.33	73.33	-23.33	86.67	-33.33	73.33	60.00	73.33
10P6	-83.33	-63.33	-53.33	-86.67	86.67	-36.67	96.67	-93.33	80.00	-76.67	-93.33	33.33
10P7	-50.00	-50.00	-10.00	-93.33	96.67	16.67	93.33	-46.67	86.67	-6.67	0.00	80.00
10P8	90.00	46.67	20.00	43.33	60.00	93.33	23.33	86.67	56.67	83.33	83.33	86.67
10P9	-100.00	-52.54	-49.15	-96.61	96.61	5.08	62.71	-86.44	96.61	-72.88	-76.27	42.37
10P10	-42.37	-28.81	11.86	-52.54	93.22	45.76	76.27	-25.42	89.83	-15.25	5.08	66.10

Table D-1 Visual assessment values through 2-point method (cont.)

Color Sample	Visual Assessment Values											
	LD	SH	WC	TT	DP	DV	HL	VS	SW	DYP	GP	SS
10P11	32.20	-32.20	15.25	-18.64	93.22	86.44	86.44	55.93	86.44	52.54	66.10	96.61
10P12	66.10	25.42	28.81	42.37	66.10	93.22	62.71	89.83	72.88	89.83	93.22	100.00
5RP1	93.22	62.71	-76.27	49.15	-86.44	-59.32	-89.83	-32.20	-72.88	-69.49	-96.61	-86.44
5RP2	93.22	75.86	-45.76	86.21	-89.83	17.24	-96.61	44.83	-86.21	-6.90	-82.76	-55.17
5RP3	-72.88	1.69	-76.27	-89.83	69.49	-55.93	69.49	-69.49	66.10	-76.27	-89.83	1.69
5RP4	18.64	38.98	-15.25	-59.32	38.98	-35.59	35.59	-62.71	11.86	-22.03	-59.32	-8.47
5RP5	96.61	83.05	55.93	100.00	45.76	86.21	-25.42	93.22	-1.69	93.22	86.44	89.83
5RP6	-86.44	-69.49	-18.64	-100.00	100.00	-11.86	96.61	-93.22	100.00	-83.05	-83.05	52.54
5RP7	-1.69	-42.37	42.37	-49.15	89.83	11.86	93.22	-1.69	83.05	32.20	25.42	72.88
5RP8	96.61	49.15	62.71	72.88	76.27	96.61	18.64	96.61	-18.64	93.22	86.44	100.00
5RP9	-89.83	-83.05	-42.37	-96.61	93.22	-5.08	96.61	-69.49	100.00	-79.66	-69.49	49.15
5RP10	-38.98	-52.54	42.37	-79.66	93.22	28.81	96.61	-28.81	89.83	-8.47	-11.86	72.88
5RP11	11.86	-38.98	52.54	-52.54	96.61	59.32	79.66	28.81	83.05	49.15	55.93	93.22
5RP12	79.66	5.08	62.71	18.64	86.44	89.83	76.27	76.27	72.88	79.66	79.66	86.44
10RP1	93.22	86.44	-59.32	59.32	-100.00	-28.81	-93.22	-11.86	-74.58	-52.54	-96.61	-79.66
10RP2	100.00	83.05	-45.76	79.66	-96.61	-1.69	-93.22	38.98	-86.44	-18.64	-72.88	-42.37
10RP3	-38.98	22.03	-83.05	-52.54	25.42	-76.27	55.93	-79.66	35.59	-55.93	-93.22	-59.32
10RP4	34.48	62.07	0.00	-13.79	27.59	-44.83	10.34	-37.93	-6.90	13.79	-58.62	3.45
10RP5	90.00	90.00	6.67	25.42	30.00	53.33	-30.00	66.67	-26.67	50.00	26.67	66.67
10RP6	-93.33	-36.67	-72.88	-93.33	86.67	-43.33	93.33	-93.33	73.33	-70.00	-96.67	3.33
10RP7	-30.00	-3.33	10.00	-72.88	96.67	-23.33	83.33	-60.00	46.67	-23.33	-53.33	36.67
10RP8	83.33	53.33	66.67	53.33	80.00	76.67	30.00	86.67	33.33	86.67	83.33	86.67
10RP9	-86.67	-86.67	-11.86	-100.00	100.00	20.00	100.00	-66.67	100.00	-66.10	-52.54	70.00
10RP10	-66.67	-66.67	43.33	-93.33	93.33	13.33	93.33	-56.67	100.00	-20.00	-10.00	76.67
10RP11	-13.33	-30.00	63.33	-76.67	96.67	53.33	86.67	6.67	90.00	20.00	53.33	83.33
10RP12	86.67	26.67	80.00	40.00	90.00	86.67	56.67	93.33	70.00	93.33	96.67	90.00
N1	-89.83	-83.05	-35.59	-93.33	90.00	43.33	96.67	-56.67	100.00	-93.22	-72.88	81.36
N-2	-93.33	-80.00	-45.76	-86.67	96.67	33.33	100.00	-66.67	100.00	-86.67	-72.88	53.33
N-4	-60.00	-23.33	-73.33	-86.44	53.33	-20.00	46.67	-93.33	62.71	-76.67	-93.33	-11.86
N-6	13.33	33.33	-83.05	-20.00	-10.00	-13.33	-20.00	-66.67	13.33	-53.33	-86.67	-36.67
N-8	76.67	60.00	-66.10	66.67	-76.67	-30.00	-70.00	3.33	-46.67	-50.00	-68.33	-70.00

Table D-1 Visual assessment values through 2-point method (cont.)

Color Sample	Visual Assessment Values											
	LD	SH	WC	TT	DP	DV	HL	VS	SW	DYP	GP	SS
N95	96.67	90.00	-59.32	86.67	-93.22	30.00	-93.33	49.15	-55.93	-56.67	-93.33	-26.67

APPENDIX E

VISUAL ASSESSMENT VALUES FROM JAPANESE OBSERVERS

Table E-1 Visual assessment values from Japanese observers through 7-point method

Color Sample	Visual Assessment Values												
	WC	LD	DP	VS	HL	SW	LD	SH	TT	DV	DYP	GP	SS
5R1	-22.63	8.33	56.54	-29.63	-51.05	-58.33	1.31	25.49	-2.61	-32.03	-46.41	-39.22	-45.10
5R2	23.29	45.12	58.54	7.32	-51.22	-52.03	34.01	53.90	17.31	-25.64	-22.22	-8.50	-9.15
5R3	-34.58	-9.88	37.97	-32.50	-35.42	-42.08	-29.41	1.92	-21.79	-40.00	-46.41	-43.14	-46.41
5R4	20.09	11.54	37.72	-20.09	-27.78	-32.48	17.65	38.46	-5.23	-22.88	-25.69	-22.00	-19.23
5R5	44.18	61.11	36.51	34.14	-30.92	-20.63	48.67	34.00	26.67	33.33	27.45	28.00	34.00
5R6	-2.41	-50.42	-36.25	-55.42	47.26	25.42	-41.83	-38.00	-45.10	-9.80	-32.03	-49.67	-39.22
5R7	40.87	-12.30	-22.22	-30.16	32.94	19.05	5.77	0.65	-23.72	-1.31	-1.33	-13.73	-9.80
5R8	53.91	58.02	-12.76	45.83	7.92	33.74	43.14	16.34	6.54	35.29	39.87	39.22	39.22
5R9	14.47	-73.08	-81.20	-45.57	79.22	75.76	-60.13	-57.52	-46.41	1.96	-28.10	-49.67	-39.87
5R10	41.03	-23.21	-55.98	-31.60	54.67	46.58	-3.27	-10.67	-26.80	3.92	-7.19	-23.53	-18.87
5R11	72.92	26.25	-64.17	12.76	56.25	61.25	33.99	-30.72	-11.76	44.23	44.22	44.44	53.59
5R12	77.92	82.92	-57.08	75.00	35.42	72.50	79.17	2.08	22.22	78.47	71.53	81.94	85.42
5YR1	-15.61	-2.95	45.27	-37.13	-37.61	-47.68	-4.40	28.16	-8.97	-36.54	-34.64	-37.18	-42.31
5YR2	37.45	47.50	43.75	30.45	-40.42	-32.08	33.33	44.67	15.69	-6.80	-16.00	-12.93	-6.00
5YR3	-21.37	-12.82	36.32	-39.32	-30.30	-33.76	-28.67	-6.12	-31.33	-30.67	-38.67	-44.00	-39.33
5YR4	31.69	11.52	25.61	-18.70	-17.27	-22.63	12.00	20.26	-13.07	-15.38	-19.23	-26.14	-26.80
5YR5	49.35	58.33	27.78	45.61	-31.62	-9.40	49.28	37.68	21.01	20.29	25.36	21.74	26.81
5YR6	6.02	-47.79	-41.15	-44.03	46.15	29.44	-34.64	-25.00	-48.00	-22.88	-28.00	-51.33	-39.10
5YR7	32.08	4.58	-4.58	-19.17	5.00	1.25	6.00	3.47	-12.93	-12.93	-15.33	-25.85	-19.73
5YR8	67.52	60.61	-32.48	44.44	20.94	41.88	63.33	6.00	20.92	58.82	55.13	56.21	65.38
5YR9	8.86	-72.89	-84.81	-44.44	79.27	73.33	-60.13	-54.00	-45.33	18.00	-19.61	-51.70	-34.01
5YR10	32.49	-18.99	-53.59	-14.77	46.41	37.55	-9.80	-22.88	-35.95	6.00	-7.19	-24.18	-16.99
5YR11	47.92	6.83	-35.90	-11.25	36.25	32.92	17.65	-15.69	-17.65	21.57	15.03	2.00	19.61
5YR12	63.01	43.90	-38.27	20.44	31.33	35.86	17.65	-14.10	-12.67	24.36	26.00	24.84	26.92
5Y1	-34.15	13.25	52.67	-16.26	-51.22	-61.73	0.00	22.46	-5.44	-36.17	-47.83	-52.17	-44.20
5Y2	4.64	46.67	52.14	13.92	-58.97	-55.56	30.72	45.10	13.73	-24.84	-27.45	-19.61	-17.65
5Y3	-28.97	-9.09	35.83	-35.34	-29.17	-41.06	-24.18	4.40	-30.13	-45.51	-47.33	-57.52	-52.29
5Y4	-4.58	20.00	41.15	-17.95	-35.86	-41.25	10.00	26.92	-7.84	-23.53	-32.68	-39.22	-27.45
5Y5	36.84	64.10	16.03	54.43	-32.47	-6.58	57.52	22.44	22.42	57.05	49.33	60.13	62.75
5Y6	-19.34	-39.51	-2.03	-38.33	13.33	1.63	-27.45	-6.67	-37.33	-29.41	-34.67	-39.33	-42.48
5Y7	10.00	-4.17	-14.17	-20.42	7.08	7.92	6.12	-1.36	-22.45	1.36	-18.75	-19.05	-7.48

Table E-1 Visual assessment values from Japanese observers through 7-point method (cont.)

Color Sample	Visual Assessment Values												
	WC	LD	DP	VS	HL	SW	LD	SH	TT	DV	DYP	GP	SS
5Y8	27.57	45.42	-27.98	17.70	4.58	26.42	35.80	4.58	-6.54	31.37	31.37	29.41	35.29
5Y9	-6.49	-72.73	-73.87	-46.34	65.82	55.56	-61.44	-54.00	-51.02	2.00	-32.00	-57.33	-44.67
5Y10	18.75	-19.17	-31.67	-24.17	34.58	31.67	-1.36	-20.92	-32.68	4.49	-4.08	-13.61	1.96
5GY1	-39.83	7.02	56.00	-23.38	-51.71	-59.31	-1.96	20.26	-8.18	-29.56	-47.06	-40.88	-42.18
5GY2	-5.28	47.15	58.54	17.92	-57.32	-56.10	24.67	42.48	12.18	-15.69	-30.07	-13.07	-15.03
5GY3	-34.47	-37.75	10.98	-41.77	-1.98	-9.02	-42.00	-10.67	-46.00	-43.14	-52.00	-59.33	-57.33
5GY4	-0.83	35.83	43.75	10.83	-41.25	-34.17	25.85	32.00	4.00	2.00	-6.00	0.68	-1.36
5GY5	19.23	65.81	35.86	61.90	-41.67	-6.25	54.32	50.91	32.72	24.69	18.67	33.95	31.48
5GY6	-16.67	-38.27	-15.85	-42.50	23.29	4.53	-13.73	-0.64	-36.60	-37.25	-33.33	-49.02	-36.54
5GY7	8.97	-13.50	-26.67	-22.36	25.83	14.77	8.16	5.23	-16.67	-0.64	-2.61	-15.38	-1.21
5GY8	21.25	82.70	1.25	81.43	-24.05	30.83	84.67	30.07	42.77	82.67	62.00	80.77	84.31
5GY9	-21.79	-67.51	-66.24	-54.01	64.14	48.52	-55.56	-50.33	-48.00	5.88	-20.26	-52.67	-35.95
5GY10	8.64	-6.17	-28.27	-3.46	30.86	32.07	4.08	2.04	-19.05	4.08	-6.80	-6.12	1.36
5GY11	20.48	59.44	-12.05	47.39	-8.94	25.70	70.21	16.67	29.86	68.09	53.90	60.67	70.21
5GY12	26.42	78.90	-6.25	77.37	-24.89	25.51	48.08	19.23	0.63	-7.27	-12.82	-8.18	-8.33
5G1	-42.74	26.16	65.83	-11.54	-60.76	-60.76	11.76	39.46	11.11	-35.22	-44.67	-26.80	-19.61
5G2	-21.10	45.68	66.67	21.37	-65.43	-60.42	51.33	49.67	55.10	-0.67	-12.00	-1.92	3.33
5G3	-37.72	9.21	44.74	-23.25	-40.35	-42.98	-4.08	21.33	-13.46	-26.00	-33.33	-27.33	-36.67
5G4	-5.42	49.38	49.37	24.17	-38.68	-37.08	31.37	31.37	16.99	8.50	-3.27	5.88	8.50
5G6	-30.83	-46.67	-18.33	-50.21	32.08	13.33	-48.00	-25.33	-50.33	-37.33	-56.86	-62.67	-60.00
5G7	8.75	22.08	-2.92	11.97	2.92	6.67	24.18	17.65	1.96	6.41	2.61	7.19	14.38
5G9	-17.83	-66.67	-76.71	-43.37	74.21	64.68	-67.97	-62.09	-63.40	5.33	-24.53	-56.86	-37.33
5G10	9.28	-2.85	-54.67	12.05	42.19	51.03	20.67	-12.67	-4.08	34.69	18.30	22.00	29.33
5G11	17.54	42.98	-36.00	48.65	26.94	42.22	59.48	-9.80	24.18	62.82	46.00	58.17	60.13
5BG1	-36.59	-2.95	40.17	-21.93	-39.66	-38.75	-0.65	14.38	-9.80	-35.33	-37.25	-42.26	-42.48
5BG2	-36.25	45.00	62.08	31.25	-67.08	-60.00	51.33	60.78	54.90	-7.05	-25.60	4.58	5.23
5BG3	-35.80	-26.75	7.82	-37.45	4.12	-8.64	-8.84	2.72	-14.97	-31.94	-44.22	-46.94	-40.82
5BG4	-22.36	29.54	32.91	21.94	-27.85	-18.99	35.29	28.21	25.49	12.67	-6.80	13.73	15.03
5BG6	-27.92	-51.25	-30.83	-47.08	38.75	24.17	-47.71	-39.87	-49.02	-32.03	-34.64	-49.67	-44.67
5BG7	-7.92	42.08	-9.58	41.67	-4.94	13.33	38.00	16.34	11.33	27.21	14.00	28.67	34.67
5BG9	-24.00	-79.56	-83.56	-44.14	77.06	75.56	-59.33	-62.09	-57.33	-7.55	-37.33	-58.50	-45.33

Table E-1 Visual assessment values from Japanese observers through 7-point method (cont.)

Color Sample	Visual Assessment Values												
	WC	LD	DP	VS	HL	SW	LD	SH	TT	DV	DYP	GP	SS
5BG10	-3.75	-10.00	-50.21	-2.50	43.33	47.50	2.56	-33.33	-12.82	33.33	10.90	6.54	15.69
5BG11	-7.00	8.86	-20.16	-3.75	17.48	19.41	22.22	-15.69	-2.08	26.80	18.59	21.57	23.53
10B1	-43.04	15.38	51.05	-13.50	-55.70	-60.76	19.87	38.56	18.95	-23.53	-44.03	-29.41	-33.99
5B2	-43.46	52.74	61.60	29.91	-67.93	-57.38	52.29	54.25	50.33	5.23	-15.33	3.27	8.50
5B3	-33.33	-32.52	-1.73	-36.21	10.29	-8.94	-24.18	-12.18	-35.95	-39.22	-45.10	-54.90	-57.69
5B4	-37.97	27.27	35.02	10.00	-34.19	-29.22	34.64	33.96	27.45	16.00	0.65	14.38	16.99
5B6	-36.21	-48.56	-21.40	-43.50	22.22	13.58	-36.00	-20.00	-38.00	-33.99	-45.33	-48.67	-49.33
5B7	-34.17	19.92	-23.05	16.46	5.76	16.25	14.74	-10.67	-1.92	23.27	7.33	16.99	24.18
5B9	-36.29	-62.50	-70.00	-34.57	63.33	56.67	-47.33	-52.67	-42.00	13.33	-26.00	-38.67	-20.00
5B10	-34.58	-44.17	-66.25	-24.89	50.62	52.50	-14.67	-34.00	-29.33	21.33	-6.00	-10.67	-15.33
5PB1	-45.93	14.23	45.27	-16.67	-53.97	-58.33	9.80	32.68	1.28	-26.67	-47.71	-39.33	-31.41
*5PB2	-44.73	24.90	55.98	-6.41	-55.27	-59.07	27.45	45.75	26.14	-16.67	-41.18	-22.88	-20.67
5PB3	-40.16	-36.18	3.88	-41.67	-1.20	-7.63	-24.18	-14.38	-29.41	-38.46	-45.10	-50.98	-54.25
5PB4	-36.36	-12.55	19.91	-25.97	-7.79	-23.81	1.96	19.23	-0.65	-23.72	-30.67	-28.21	-22.88
5PB5	-42.86	33.33	38.10	27.84	-37.70	-23.02	44.44	41.18	36.60	15.03	-3.40	6.29	16.34
5PB6	-45.42	-57.81	-39.58	-51.67	48.97	23.33	-52.83	-37.91	-51.92	-28.57	-47.71	-62.75	-52.29
5PB7	-38.33	-1.67	-8.33	-4.94	0.84	10.42	20.92	19.61	13.73	2.56	-9.62	-0.65	3.92
5PB8	-41.06	45.53	-20.33	51.98	1.19	29.67	56.21	4.58	39.46	58.17	45.75	56.86	60.78
5PB9	-27.71	-77.51	-82.52	-36.55	80.56	74.30	-70.21	-71.53	-42.75	21.99	-29.79	-51.06	-28.26
5PB10	-42.50	-37.08	-63.82	-7.26	49.58	54.17	-24.18	-31.37	-24.84	17.61	-9.80	-15.03	-5.23
5PB11	-32.90	5.13	-57.46	28.14	41.67	51.85	58.67	-22.00	32.72	57.69	34.67	49.33	57.33
5PB12	-31.73	45.38	-44.98	62.25	18.29	48.59	71.15	-4.67	44.00	76.47	50.98	72.55	75.16
5P1	-39.17	2.06	45.68	-23.05	-41.98	-50.42	-2.67	23.40	-11.56	-46.26	-64.63	-58.33	-54.42
5P2	-30.42	25.83	57.81	-0.42	-56.25	-59.26	18.00	42.00	21.15	-22.22	-32.68	-15.00	-17.65
5P3	-38.03	-31.60	9.83	-40.69	0.43	-16.24	-30.56	-10.90	-36.05	-46.00	-50.69	-50.67	-52.08
5P4	-19.83	-0.83	20.68	-17.75	-11.93	-14.17	-6.41	7.69	-12.82	-20.13	-23.72	-21.38	-13.46
5P5	5.42	41.67	17.08	38.33	-5.42	7.50	53.85	22.88	37.91	38.67	21.79	36.60	36.54
5P6	-27.43	-52.14	-32.49	-47.26	36.71	27.35	-52.94	-46.79	-46.41	-18.67	-43.33	-51.70	-47.71
5P7	-8.86	-19.41	-31.65	-21.10	35.42	29.54	19.61	-21.33	-3.27	22.22	11.76	17.65	29.41
5P8	5.91	42.19	-18.61	48.72	12.50	30.38	60.26	-3.92	28.10	57.86	37.82	58.82	57.52
5P9	-26.16	-89.58	-91.25	-44.44	89.87	83.75	-80.39	-84.97	-48.00	25.69	-41.18	-54.90	-28.85

Table E-1 Visual assessment values from Japanese observers through 7-point method (cont.)

Color Sample	Visual Assessment Values												
	WC	LD	DP	VS	HL	SW	LD	SH	TT	DV	DYP	GP	SS
5P10	-15.26	-55.42	-71.49	-23.69	61.85	62.25	-18.00	-54.67	-20.00	31.41	-5.77	6.54	21.57
5P11	-1.67	17.92	-61.67	41.35	43.62	57.92	30.72	-29.41	1.31	56.46	37.91	51.63	52.94
5P12	-0.88	32.90	-61.40	53.51	43.86	63.16	49.02	-22.44	22.45	65.38	45.10	64.67	70.59
5RP1	-24.05	13.08	59.74	-17.28	-63.29	-67.09	11.54	35.29	10.26	-39.51	-45.10	-43.14	-41.67
5RP2	11.81	48.10	67.51	12.39	-62.87	-59.92	32.03	55.56	35.29	-26.80	-30.07	-15.03	-13.07
5RP3	-28.95	-34.65	14.04	-42.22	5.26	-9.21	-30.07	-16.99	-37.91	-42.48	-43.79	-55.56	-53.59
5RP4	11.52	-1.23	16.87	-30.04	-5.83	-11.93	-2.67	10.46	-25.49	-23.53	-26.14	-28.10	-25.49
5RP5	43.62	59.67	30.00	47.74	-30.12	-8.64	60.13	32.68	32.03	45.75	31.37	40.52	45.10
5RP6	-9.28	-52.32	-45.99	-41.03	51.90	37.97	-44.67	-37.18	-49.67	-20.26	-29.41	-47.06	-35.29
5RP7	25.42	-14.10	-28.69	-22.50	37.55	35.90	7.69	-12.00	-26.14	1.96	1.96	5.13	16.34
5RP8	56.12	78.06	-31.65	68.35	10.55	38.82	72.00	12.00	28.00	62.09	62.75	70.00	77.12
5RP9	0.83	-70.00	-75.00	-46.84	75.11	68.33	-69.93	-56.86	-54.90	-0.65	-33.33	-54.25	-45.10
5RP10	16.46	-27.08	-60.83	-12.50	51.05	50.42	-27.21	-29.41	-28.76	11.76	-6.54	-8.50	-8.50
5RP11	20.25	2.11	-56.96	10.97	54.85	56.96	28.47	-25.69	-12.50	38.19	23.13	34.04	40.28
5RP12	56.12	63.29	-64.14	59.07	44.30	59.92	70.51	-7.69	15.38	71.33	60.13	73.86	71.90
N1	-35.42	-91.25	-94.51	-28.14	95.42	90.42	-81.33	-76.28	-36.05	27.33	-35.37	-54.90	-25.17
N-2	-35.90	-90.30	-90.30	-51.48	91.14	84.39	-79.74	-76.67	-38.00	26.28	-32.08	-56.21	-26.92
N-4	-35.83	-67.50	-47.08	-57.92	52.92	35.83	-53.33	-33.99	-44.67	-19.33	-50.00	-61.33	-58.00
N-6	-37.08	-33.33	0.42	-36.25	3.33	-9.17	-25.33	-17.33	-31.33	-42.67	-53.59	-56.67	-52.00
N-8	-46.67	18.33	52.08	-16.25	-55.83	-57.50	12.93	33.33	10.88	-27.21	-46.26	-33.33	-25.17
N95	-46.41	51.90	59.49	25.32	-76.79	-65.40	35.90	51.63	41.83	7.19	-37.41	-7.84	-5.23

APPENDIX F

JAPANESE COLOR PERCEPTION EQUATIONS

The Japanese color Preceptions corresponding to the 7-point method.

"Akarui-Kurai"

$$LD = [\{2.2(L^*+0)\}^2 + \{4.1(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 155 \quad \text{(F-1)}$$

"Yawarakai-Katai"

$$SH = [\{1.9L^*\}^2 + \{1.5(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 1159 \quad \text{(F-2)}$$

"Atatakai-Tsumetai"

$$WC = [1.2+1.8\{\cos(\Delta h_{55})/360\}](1-\Delta h_{290}/360)C^* - 35 \quad \text{(F-3)}$$

"Sunda-Nigotta"

$$TTCIELAB = [\{2.1(L^*-35)\}^2 + \{2.7(1+0.3\cos(\Delta h_{220}))(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 85 \quad \text{(F-4)}$$

"Koi-Awai"

$$DP = -[\{2.4(L^*-100)\}^2 + \{1.3(1+0.8\cos(\Delta h90))(1-\Delta h_{290}/360)C^*\}^2]^{1/2} + 105 \quad \text{(F-5)}$$

"Hakkirishita-Bonyarishita"

$$DVCIELAB = [\{1.6(L^*-65)\}^2 + \{2.8(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 60 \quad \text{(F-6)}$$

"Omoi-Karui"

$$HL = -[\{2.3(L^*-0)\}^2 + \{0.1(1-\Delta h_{290}/360)C^*\}^2]^{1/2} + 135 \quad \text{(F-7)}$$

"Azayakana-Kusunda"

$$VS = [\{2.2(L^*-40)\}^2 + \{3.6(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 95 \quad \text{(F-8)}$$

"Tsuyoi-Yowai"

$$SW = [\{2.3(L^*-85)\}^2 + \{2.0(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 75 \quad \text{(F-9)}$$

"Doutekina-Seitekina"

$$DYP = [\{0.2(L^*-50)\}^2 + \{2.5(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 55 \quad \text{(F-10)}$$

"Hadena-Jimina"

$$GPCIELAB = [\{1.4(L^*-50)\}^2 + \{3.6(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 85 \quad \text{(F-11)}$$

"Medatsu-Medatanai"

$$SSCIELAB = [\{1.0(L^*-40)\}^2 + \{3.4(1-\Delta h_{290}/360)C^*\}^2]^{1/2} - 75 \quad \text{(F-12)}$$

where, L^* : CIELAB metric lightness

C^* : CIELAB metric chroma

h : CIELAB metric hue angle

Δh_x : CIELAB metric hue angle difference from $h=x$, $0 \leq \Delta hx \leq 180$

APPENDIX G

JAPANESE VISUAL RESULTS
THAT WERE TRANSLATED INTO THAI

Table G-1 Japanese visual results that were translated into Thai

Color Sample	Visual Results											
	LD	SH	WC	TT	DP	DV	HL	VS	SW	DYP	GP	SS
5R1	47.47	-	-44.75	62.80	-41.05	-17.98	-46.27	-22.18	-32.53	-32.37	-59.32	-
5R2	79.97	30.00	-0.21	69.80	-42.23	-12.18	-45.98	16.11	-32.41	-16.82	-21.47	-15.02
5R3	13.79	-	-50.29	28.27	-16.38	-32.45	-28.63	-28.66	-12.83	-42.27	-55.84	-38.06
5R4	31.53	15.99	-2.99	28.60	-14.60	-15.23	-19.60	-16.33	-9.51	-29.36	-30.93	-11.77
5R5	78.00	19.48	20.66	39.56	-12.72	49.08	-21.36	45.06	-7.47	36.61	22.86	35.80
5R6	-60.83	-25.27	-22.22	-71.48	60.53	-10.21	64.89	-67.21	48.50	-57.37	-57.52	17.91
5R7	-20.46	-24.62	18.29	-47.67	49.52	4.36	49.19	-38.30	39.47	-13.19	-18.37	25.62
5R8	63.35	-8.67	30.67	-8.61	30.52	49.20	23.01	58.07	23.69	49.59	37.13	51.44
5R9	-100.00	-73.55	-4.61	-77.10	100.00	4.09	100.00	-100.00	93.24	-59.93	-	48.21
5R10	-40.34	-54.93	19.27	-75.35	84.14	6.88	73.78	-56.81	67.59	-26.01	-34.02	38.84
5R11	13.63	-51.22	50.22	-64.19	89.96	57.25	76.31	-0.46	70.29	51.38	39.73	83.65
5R12	79.06	-41.69	54.77	-31.63	76.03	99.08	54.46	88.50	57.00	93.63	81.14	100.00
5YR1	21.29	45.77	-37.65	41.51	-22.33	-29.01	-31.02	-36.56	-18.57	-33.19	-53.10	-43.69
5YR2	79.12	40.12	13.67	65.64	-30.93	6.09	-33.10	42.03	-27.44	-11.83	-26.44	-10.78
5YR3	7.31	-	-42.25	20.08	-12.37	-24.21	-22.78	-36.25	-8.59	-40.32	-55.84	-28.28
5YR4	23.20	18.26	8.44	11.81	-0.34	-8.51	-7.50	-17.72	0.49	-26.29	-33.91	-11.41
5YR5	85.47	41.18	25.43	59.83	-17.83	35.58	-22.07	60.34	-19.40	37.25	13.69	23.76
5YR6	-61.75	-31.99	-14.51	-76.25	66.48	-26.77	63.63	-58.83	51.69	-52.99	-59.57	19.98
5YR7	9.66	5.71	9.12	-10.62	24.28	-7.62	17.93	-18.86	16.05	-26.43	-30.98	4.27
5YR8	67.17	9.89	43.70	9.19	39.88	77.85	37.97	56.14	18.40	73.04	54.49	70.35
5YR9	-99.53	-66.61	-10.18	-83.02	100.00	22.27	100.00	-96.02	86.52	-46.52	-	45.05
5YR10	-33.63	-36.57	10.56	-73.39	76.60	12.00	64.56	-28.28	55.78	-24.34	-31.25	31.84
5YR11	2.76	-5.37	24.84	-32.67	52.30	32.91	53.93	-14.85	32.81	11.89	-1.80	40.46
5YR12	43.53	-1.31	39.51	-25.92	51.43	36.30	49.12	23.88	30.09	28.35	22.03	44.41
5Y1	51.56	-	-52.93	64.28	-38.74	-21.84	-46.31	-10.51	-33.92	-32.12	-93.74	-
5Y2	90.56	-	-18.71	93.90	-44.95	-9.20	-54.31	19.57	-46.08	-14.25	-44.48	-36.78
5Y3	18.35	57.12	-48.26	24.64	-17.76	-35.82	-21.50	-27.04	-13.02	-42.53	-70.60	-41.02
5Y4	51.85	-	-27.41	56.47	-27.76	-12.41	-28.50	-14.51	-27.28	-27.20	-59.61	-34.77
5Y5	14.42	17.01	14.06	15.31	44.05	71.71	-22.51	28.81	25.89	62.67	50.84	67.09
5Y6	-43.16	-7.52	-37.83	-38.77	32.25	-29.52	26.54	-42.73	28.31	-53.14	-44.20	1.46
5Y7	1.95	16.47	-12.26	-7.33	28.31	10.07	20.26	-20.54	13.06	-29.26	-24.64	10.02

Table G-1 Japanese visual results that were translated into Thai (cont.)

Color Sample	Visual Results											
	LD	SH	WC	TT	DP	DV	HL	VS	SW	DYP	GP	SS
5Y8	61.94	44.10	4.37	22.96	27.52	46.69	19.33	25.70	1.22	41.63	24.85	37.94
5Y9	-97.07	-53.74	-24.08	-94.42	97.96	2.89	85.83	-82.55	74.90	-63.87	-89.24	34.52
5Y10	-24.19	-8.42	-3.23	-44.02	50.73	11.69	51.38	-29.42	35.33	-15.93	-17.98	29.64
5GY1	42.42	-	-51.04	63.91	-38.31	-18.31	-46.96	-22.40	-33.19	-32.22	-67.36	-
5GY2	89.25	-	-28.41	90.63	-48.28	-0.99	-52.82	24.10	-45.10	-16.98	-34.67	-31.65
5GY3	-24.92	19.54	-47.31	-15.23	11.13	-44.96	9.18	-37.77	10.93	-55.37	-64.31	-18.34
5GY4	60.90	45.57	-23.50	49.90	-24.75	14.04	-34.33	16.72	-20.54	-3.72	-9.35	-2.53
5GY5	98.86	42.29	-4.07	79.84	-28.11	41.55	-33.55	80.02	-26.19	31.07	24.63	24.84
5GY6	-40.20	-11.76	-35.63	-39.97	38.81	-42.42	37.82	-45.80	28.91	-51.99	-53.64	4.62
5GY7	-12.18	-6.85	-12.72	-23.93	41.44	6.09	41.10	-23.87	24.61	-11.78	-19.73	21.94
5GY8	100.00	75.97	-1.98	72.82	-1.25	100.00	-11.52	100.00	-12.94	89.11	76.81	76.89
5GY9	-92.84	-53.00	-35.09	-92.81	94.46	9.83	83.92	-89.53	73.63	-46.27	-73.33	36.48
5GY10	-11.37	-26.43	-12.45	-46.61	50.81	9.48	46.77	-7.49	40.64	-21.00	-10.60	32.83
5GY11	77.63	32.16	-2.43	38.17	15.67	89.82	3.85	63.02	-0.06	74.07	58.10	68.97
5GY12	100.00	49.73	3.30	40.34	8.12	3.43	-12.80	100.00	-6.69	-13.28	-17.21	-6.00
5G1	64.79	-	-49.17	77.77	-48.27	-21.15	-57.18	-8.84	-38.93	-28.49	-48.85	-32.90
5G2	93.07	-	-43.85	100.00	-56.85	16.73	-62.24	31.24	-47.94	-0.01	-20.29	-8.42
5G3	37.68	55.15	-50.74	41.20	-25.83	-16.06	-34.11	-17.85	-19.98	-31.44	-39.51	-36.61
5G4	67.91	23.28	-27.30	36.60	-20.76	20.44	-31.56	33.60	-10.35	-4.00	-0.85	12.49
5G6	-56.78	-16.14	-42.97	-60.54	48.10	-43.83	47.68	-58.28	39.83	-70.68	-67.43	5.50
5G7	27.26	-8.20	-12.58	-10.17	24.03	14.72	15.44	16.79	19.58	-3.58	3.67	31.24
5G9	-90.74	-59.03	-31.89	-99.25	100.00	5.73	95.31	-86.42	80.57	-53.51	-	40.23
5G10	-13.93	-47.90	-10.36	-56.60	77.04	43.85	59.64	1.81	61.99	12.77	16.17	62.98
5G11	37.59	-30.75	-3.20	-27.23	60.11	80.47	43.28	55.34	48.33	55.65	56.40	78.99
5BG1	26.26	74.04	-50.98	40.92	-22.67	-25.53	-33.40	-16.65	-18.83	-34.48	-57.10	-42.36
5BG2	80.02	39.27	-53.74	95.88	-45.44	5.31	-64.06	37.78	-40.47	-16.47	-11.53	-4.69
5BG3	-11.51	22.32	-48.12	3.55	9.73	-28.46	16.09	-33.34	5.24	-49.55	-53.77	-16.80
5BG4	46.80	21.26	-42.71	35.48	-10.24	24.95	-19.43	30.77	-5.77	-9.31	8.04	19.71
5BG6	-64.39	-26.13	-40.68	-75.09	59.72	-41.78	55.29	-60.83	49.87	-61.01	-57.46	17.11
5BG7	46.29	-10.00	-28.07	-8.33	29.47	39.51	6.92	52.58	22.24	11.97	26.10	48.20
5BG9	-100.00	-65.66	-34.80	-89.81	100.00	-12.96	98.53	-96.30	86.81	-73.82	-	42.05

Table G-1 Japanese visual results that were translated into Thai (cont.)

Color Sample	Visual Results											
	LD	SH	WC	TT	DP	DV	HL	VS	SW	DYP	GP	SS
5BG10	-19.15	-38.29	-22.19	-60.93	70.91	41.53	61.02	-15.01	58.09	2.05	-0.12	52.01
5BG11	2.83	-26.18	-25.90	-42.62	48.97	36.69	31.78	-9.72	43.85	15.05	17.97	50.56
10B1	56.27	61.82	-48.64	73.82	-39.69	-9.13	-51.53	-6.11	-35.91	-29.88	-47.85	-52.17
5B2	95.12	47.84	-48.65	97.76	-50.67	22.05	-64.84	42.19	-43.33	-5.61	-11.66	-0.67
5B3	-23.81	22.69	-47.18	-11.92	20.52	-38.57	23.04	-35.37	11.24	-53.16	-61.18	-19.03
5B4	49.74	26.32	-49.91	46.00	-16.33	29.61	-26.69	17.59	-13.26	2.07	7.80	18.60
5B6	-55.74	-18.23	-43.57	-55.92	47.84	-41.90	36.59	-51.12	39.24	-67.13	-54.19	7.80
5B7	21.73	-4.17	-45.32	-21.87	40.01	34.14	18.75	20.54	27.25	1.51	13.97	42.36
5B9	-88.11	-60.63	-38.29	-85.88	100.00	18.32	83.00	-72.78	80.46	-55.73	-58.02	46.79
5B10	-63.64	-52.63	-39.63	-78.42	91.17	28.04	68.95	-51.17	70.75	-24.56	-20.75	42.31
5PB1	51.32	-	-45.37	68.04	-33.16	-14.22	-49.62	-13.49	-34.56	-31.61	-64.28	-47.93
*5PB2	59.67	49.94	-46.68	75.53	-39.33	-4.63	-50.95	-3.53	-34.43	-29.42	-41.46	-31.18
5PB3	-17.47	38.11	-46.92	1.15	10.70	-35.60	10.05	-35.73	3.94	-49.23	-57.84	-24.86
5PB4	0.74	8.10	-47.86	6.51	3.45	-19.22	2.85	-22.51	5.14	-40.22	-34.06	-3.86
5PB5	46.99	1.21	-45.53	31.06	-9.06	27.07	-29.41	37.77	-0.04	-7.01	1.15	23.93
5PB6	-70.69	-27.95	-38.69	-77.66	64.54	-37.40	66.78	-65.66	50.48	-74.26	-71.87	15.67
5PB7	-7.82	-36.46	-42.92	-30.12	41.29	7.36	13.73	-10.21	40.85	-25.45	-5.08	35.86
5PB8	45.68	-18.25	-43.16	-4.51	42.00	75.59	15.66	63.57	33.73	56.77	55.62	73.73
5PB9	-100.00	-72.30	-35.37	-74.83	100.00	28.47	100.00	-92.18	93.24	-62.60	-	51.75
5PB10	-56.33	-64.30	-36.87	-72.89	93.64	20.55	68.20	-36.41	79.22	-31.19	-29.72	52.85
5PB11	-10.66	-60.78	-38.88	-30.97	89.97	73.11	60.01	16.86	75.22	36.58	43.97	89.25
5PB12	39.98	-45.43	-41.05	-19.13	67.84	94.77	35.13	69.97	57.55	62.33	70.44	94.70
5P1	27.55	46.90	-49.57	38.22	-23.51	-36.40	-36.03	-19.77	-17.94	-39.48	-81.76	-57.44
5P2	61.33	50.98	-50.87	71.56	-40.84	-9.61	-52.05	5.51	-33.31	-25.11	-30.05	-25.57
5P3	-21.32	22.58	-46.91	-10.96	12.87	-47.21	11.89	-38.46	9.79	-54.76	-56.78	-17.57
5P4	4.72	3.83	-38.01	-10.22	9.81	-16.28	-1.66	-17.15	14.20	-36.30	-26.39	8.26
5P5	52.13	2.53	-12.43	21.13	6.30	54.11	7.97	50.56	10.32	25.39	33.97	44.61
5P6	-69.88	-33.03	-39.41	-81.82	65.62	-20.47	52.95	-65.93	56.55	-73.29	-61.56	21.24
5P7	-32.58	-38.22	-25.03	-52.67	63.20	30.79	52.47	-36.15	55.38	3.56	12.79	60.36
5P8	38.36	-20.79	-10.94	-16.29	46.23	75.50	29.37	57.54	39.02	44.36	57.56	73.17
5P9	-100.00	-69.31	-34.85	-79.00	100.00	32.05	100.00	-100.00	92.47	-80.63	-	50.34

Table G-1 Japanese visual results that were translated into Thai (cont.)

Color Sample	Visual Results											
	LD	SH	WC	TT	DP	DV	HL	VS	SW	DYP	GP	SS
5P10	79.84	-63.56	-28.49	-68.29	100.00	40.29	82.01	-60.81	83.38	-25.24	-4.77	69.62
5P11	2.66	-60.70	-16.75	-54.84	94.32	72.23	63.02	34.56	77.38	41.43	46.42	86.93
5P12	19.94	-58.97	-16.08	-38.83	92.03	82.85	64.68	52.39	75.12	52.47	60.76	98.31
5RP1	50.84	-	-46.21	73.12	-42.75	-25.61	-60.09	-14.78	-36.26	-30.27	-73.05	-
5RP2	89.72	46.06	-11.55	93.06	-53.57	-10.98	-59.42	20.29	-43.33	-18.33	-34.38	-26.05
5RP3	-39.07	22.40	-44.77	-17.05	20.17	-41.36	17.36	-49.29	16.28	-54.91	-63.98	-14.61
5RP4	8.17	12.08	-10.71	-4.12	7.94	-19.20	5.08	-28.49	8.31	-36.56	-34.10	-4.49
5RP5	78.56	29.47	20.35	49.32	-11.69	63.81	-20.71	61.48	-10.21	43.08	35.41	44.08
5RP6	-74.74	-48.90	-23.85	-93.09	80.37	-23.45	70.18	-68.18	67.79	-58.83	-61.01	32.96
5RP7	-26.80	-37.70	12.41	-65.61	60.65	6.45	54.63	-36.34	53.72	-10.64	-0.03	50.20
5RP8	82.74	-1.36	46.57	5.92	44.68	81.52	26.33	85.91	22.61	83.61	69.18	82.21
5RP9	-98.05	-62.39	-12.96	-92.94	100.00	0.94	96.36	-92.07	83.57	-67.10	-	40.11
5RP10	-46.43	-56.84	2.90	-78.02	90.93	16.87	69.82	-36.74	73.39	-25.64	-18.71	47.46
5RP11	-15.15	-58.59	6.97	-65.67	90.74	50.69	74.86	-5.39	75.13	19.15	28.00	77.05
5RP12	54.85	-47.18	46.79	-41.27	87.39	91.00	63.98	64.91	62.82	75.94	72.16	93.70
N1	-100.00	-82.52	-35.62	-54.92	100.00	21.50	100.00	-100.00	100.00	-72.41	-	57.39
N-2	-100.00	-72.94	-36.59	-71.31	100.00	34.49	100.00	-100.00	95.24	-66.20	-	52.96
N-4	-82.78	-31.02	-41.89	-76.13	70.35	-22.16	71.21	-72.58	53.32	-76.45	-70.82	15.83
N-6	-24.81	29.13	-47.25	-8.62	19.26	-42.19	15.16	-35.97	10.26	-55.02	-63.58	-18.23
N-8	54.47	-	-45.50	72.28	-37.66	-15.20	-51.70	-14.40	-35.09	-30.89	-56.38	-38.40
N95	95.69	-	-46.52	100.00	-51.67	20.94	-75.38	22.74	-49.49	-16.12	-39.10	-26.66

VITA

Mr. Yannawit Bangchokdee was born on January 5, 1975 in Bangkok, Thailand. He received his B.Sc. degree in Science from the Faculty of Agro-Industry, Kasetsart University in 1998, and he has been a graduate student in the Imaging Technology Program, Graduate school, Chulalongkorn University since 1998.