日本色彩学会第47回全国大会 [名古屋] '16　発表論文集
Proceedings of the 47th Annual Meeting

会期：2016年6月4日〜5日
会場：名城大学（天白キャンパス）
*
口頭発表：35件
ポスター発表：35件
（カラーデザイン作品発表を含む）

発 行

WHITENESS (W) AND LIGHTNESS (L*) RELATIONSHIP

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1. Introduction

It is useful if we can print photographs that show the same color appearance as for the real scene under the normal observing situation. The modification for a photograph was carried out for the lightness constancy and the result was satisfactory to some extent[1, 2]. Figure 1 shows the flow chart for the modification. The right-hand flow shows the determination of the amount of whiteness and blackness for a real space by the
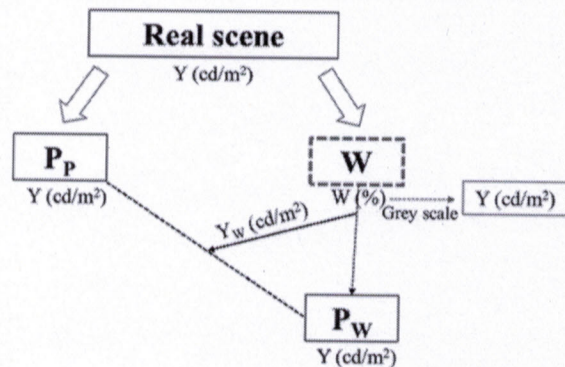

Fig. 1 Flow chart for lightness modification in photograph.

elementary color naming method. The left-hand side flow shows a photograph modification process. Pp is a photograph of a real scene and this will be modified to reproduce the whiteness W in a photograph Pw. Pp is specified by the lightness L* and it is necessary to relate W to L* to get a photograph that gives the same impression of lightness appearance for the real scene. It is important to derive the W and L* relation. We have

a quantified relation in the natural color system NCS developed in Sweden but the data were based on European subjects. Phuangsuwan et al reported an equation to relate W to L* based on Thai subjects but only 5 subjects[3]. In this report the relation was again obtained by 15 Thai subjects and under a controlled lighting.

2. Method

Sixteen achromatic patches covering the metric lightness L* from 21 to 93 with steps of about 5 were prepared. A subject was presented with one of them at a time through a square mask of 3 x 3 cm² at distance of about 65 cm giving 2.6° x 2.6° arc of visual angle under fluorescent lamps of the daylight type of which chromaticity point on the CIE xy diagram is shown by an open triangle in Fig. 2. The open square is for D65 which was used by Swedish group in developing NCS. An open circle shows the CIE A light source. The solid curve shows the
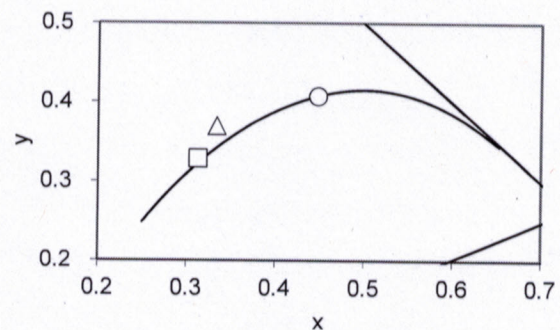

Fig. 2 Color illumination in the subject room.

black body locus. The mask for the test patch was made of a gray paper of L*=55 and the measurement was carried out in a room illuminated at 900 lx at the patches. Fifteen Thai

and two Japanese participated as subject and they were asked to judge the amounts of whiteness and blackness for each patch in percentage, which were presented in a random order. Five such sessions were repeated in different sessions. Three subjects were well trained for this kind of experiment but others were naïve and participated to this kind of experiment for the first time. Except the three subjects they were all undergraduate students of the university. Figure 3 shows the atmosphere of experimenting. Left person is a subject and the right person an experimenter just changing the test patch.
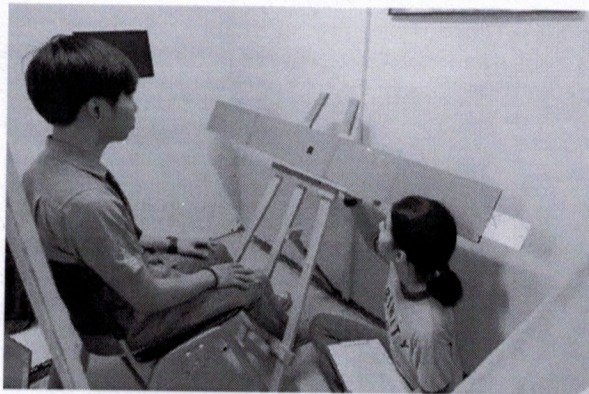

Fig. 3 The atmosphere of experimenting.

3. Results and Discussion

Results of two subjects SS and CP are shown in Fig. 4, where the lightness L* of test patches is taken along the abscissa and the amount of whiteness along the ordinate in percentage. Short vertical bars indicate standard deviation of five repetitions. The subject SS was a naïve subject while the subject CP well trained for psychophysical experiment. The former subject showed smaller standard deviation and the experience did not reflect to the variance of judgment. Figure 5 is the mean of 15 Thai subjects with standard deviation among subjects. The individual variance is not large.

In Fig. 6 other two previous results are plotted together with the present result; the present result by open circles, the previous results by Phuangsuwan et al.[3] by open squares, and NCS by open triangles[4]. It is seen that the present result locates upper than other two results indicating more white judgment for each patch.
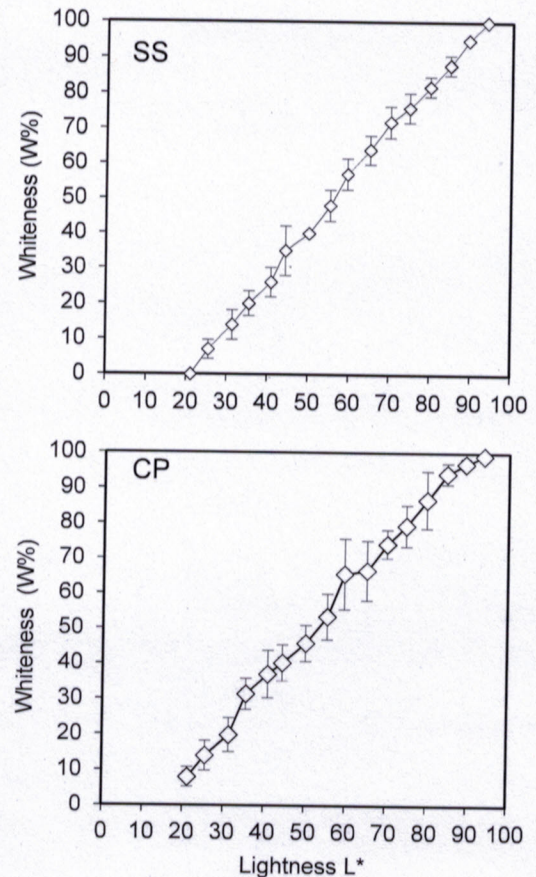

Fig. 4 Result of subject SS and CP.

The previous results were obtained in a room illuminated by fluorescent lamps of the daylight type but the illuminance was not well controlled. The NSC data were obtained under the CIE D65. The present data were obtained at a constant illuminance.
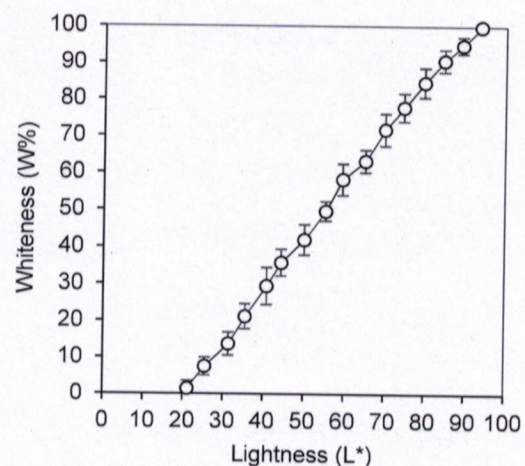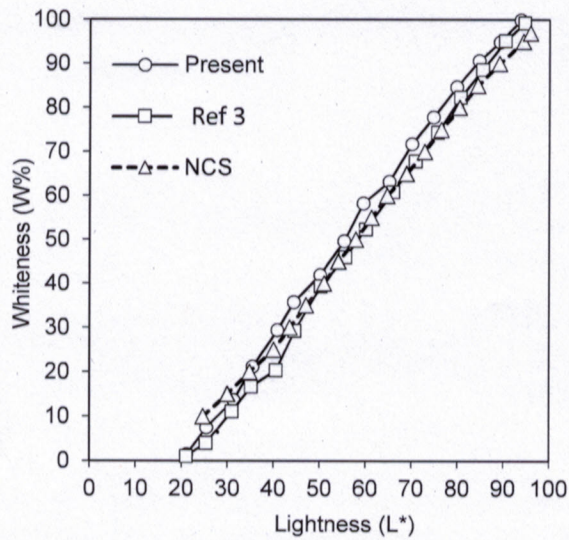

Fig. 5 Mean of fifteen subjects.

Fig. 6 Present result, Ref 3, and NCS result plotted together.

These difference of experimental condition might have caused the difference in the results. In spite of the difference in detail among three results they can be all approximated by lines to show a simple
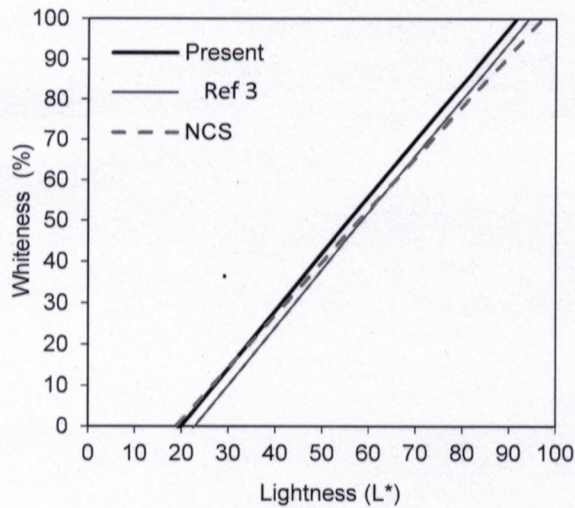

Fig. 7 The regression line of three results.

relationship between L* and W. The regression lines are

Present results　　W = 1.394L* - 27.6,

Ref 3　　　　　　W = 1.401L* - 31.9,

NCS　　　　　　W = 1.278L* - 26.5,

and they are shown in Fig. 7 by a black solid line for the present result, a red thin line for the previous work[3], and a green dotted line for NCS. The NCS showed a shallower slope than other two.

References
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3) C. Phuangsuwan, M. Ikeda, and: S. Mooklai: Photograph to demonstrate the lightness constancy of a real scene, Proc. ACA2014 Taipei (2014) 264-267.
4) We acknowledge Prof. H. Shinoda at Ritsumeikan University to provide us with the NCS table to be used for Fig. 6.