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Whiteness (W) and lightness (L*) relationship

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ABSTRACT

In developing photographs of scenes to give the same impression of lightness constancy for the real scenes a function to relate the lightness L* to the amount of whiteness W that can be obtained by the elementary color naming method became necessary. Fifteen Thai young subjects and two Japanese participated in the experiment and the function was derived, which differed from previous result obtained for 4 Thai subjects and from the data given by NCS, but slightly.

Keywords: Elementary color naming, Whiteness, Lightness, Lightness constancy, Photograph

1. INTRODUCTION

It is useful if we can perceive the color constancy and the lightness constancy in a photographic scene but we cannot normally. The concept of recognized visual space of illumination RVSI says that we can get the constancy if we can perceive a 3D scene in a photograph. Phuangsuwan et al developed a D-up viewer and a stereoscope with which a 2D photograph was perceived as a 3D scene and showed the color constancy in the photograph[1, 2]. However, the D-up viewer or the stereoscope are not available at any time and at any place and it was desired to give the same color appearance in an ordinary photograph as for the real space. The modification was done for the lightness constancy in a photograph and the result

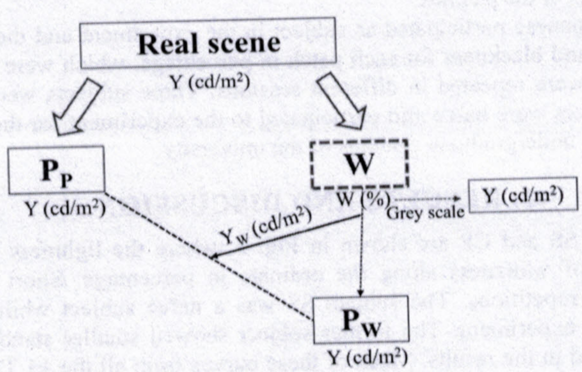

Figure 1. Flow chart of picture modification.

was satisfactory to some extent[3, 4]. Figure 1 shows the flow chart of the modification. The right-hand flow shows the determination of the amount of whiteness and blackness for a real space by the 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. 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 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 4 subjects[4]. In this report the relation was obtained by 15 Thai subjects.

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2. METHOD

Sixteen achromatic patches covering the metric lightness L* of 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 cm^2 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 and open circle for the CIE light source A. The solid curve shows the black body locus.

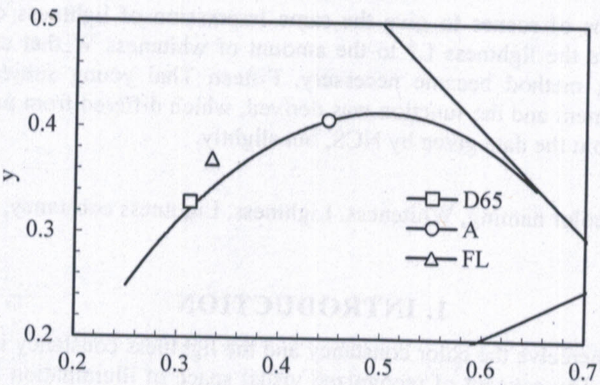

Figure 2. Illumination in the subject room shown by an open triangle.

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

Fifteen Thai and two Japanese participated as subject in the experiment 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 the experiment for the first time. Except the three subjects they were all undergraduate students of the university.

3. RESULTS AND DISCUSSION

Results of two subjects SS and CP are shown in Fig. 3, where the lightness L* 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 was not reflected in the results. Mean of these curves from all the 15 Thai subjects was taken and is shown in Fig. 4 with standard deviation among subjects. The individual variance is not large.

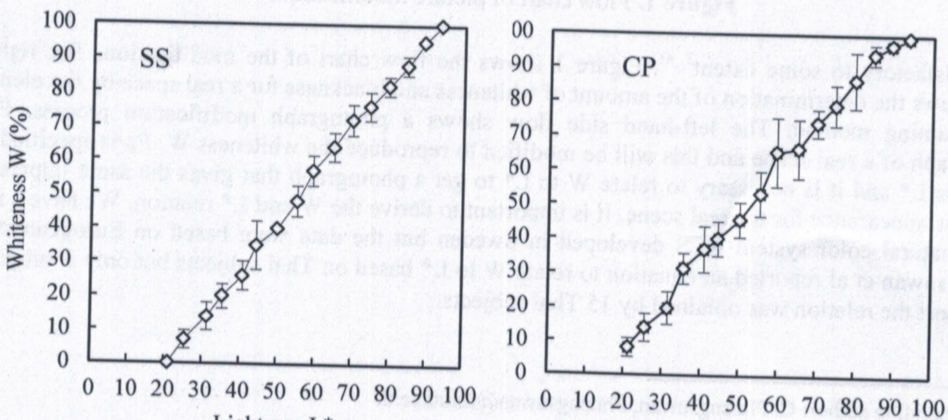

Figure 3. Results from subject SS and CP.

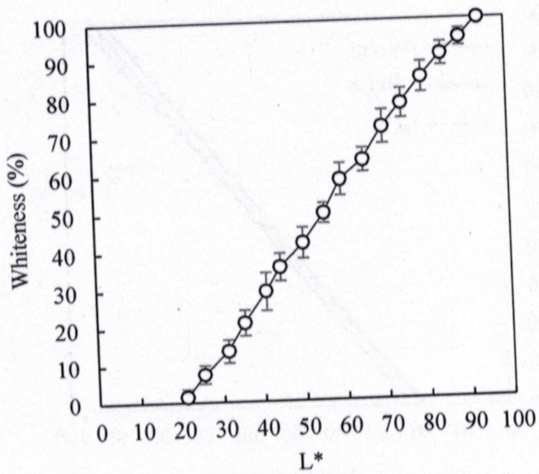

Figure 4. Average of 15 subjects with standard deviation.

In Fig. 5 other previous two results are plotted together with the present result, the present result by open circles, the previous result by Phuangsuwan et al.[3] by open squares, and NCS by open triangles[5]. It

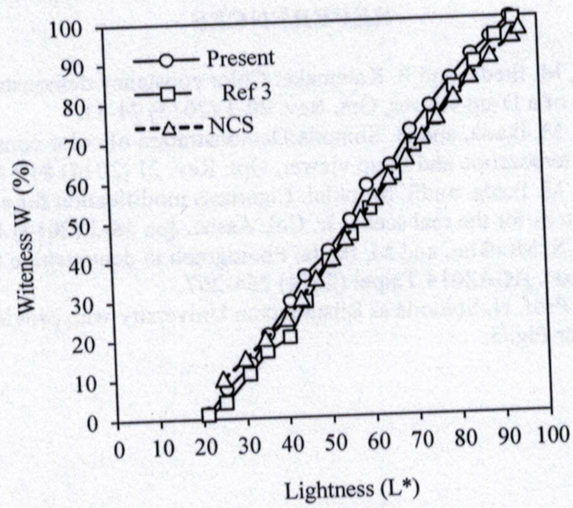

Figure 5. Comparison of the results from present with Ref 3 and NCS.

is seen that the present result locates upper than other two results indicating more white judgment for each patch. The previous results[3] were obtained in a room illuminated by fluorescent lamps of daylight type but the illuminance was not controlled, while the present data were obtained at a constant illuminance. The NSC data were obtained under the CIE D65. These differences of experimental condition might have caused the difference in the results. In spite of the difference in detail among three results they are all approximated by lines to show a simple 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. 6.

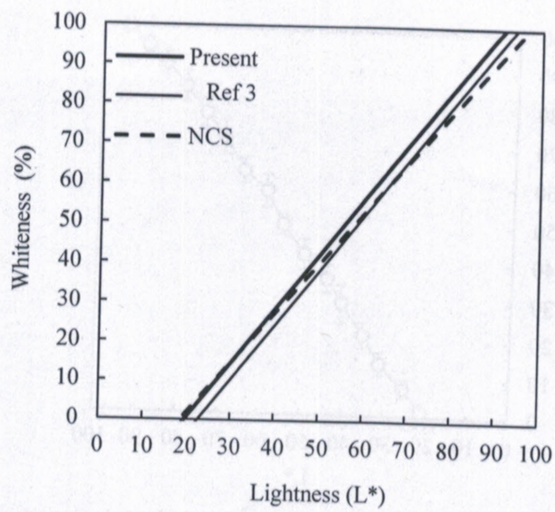

Figure 6. The regression lines of the present result, Ref 3 and NCS.

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