Color and luminance affect perceptual transparency of human skin

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ABSTRACT

Transparent skin has recently been one of the most important keyword in developing cosmetic products in Japan. Perceptual transparency must be related to colorimetric parameters, such as chromaticity and luminance. Therefore, we conducted psychophysical experiments to examine the effects of colorimetric parameters on the perceptual transparency.

In Experiment 1, we examined whether luminance information has an effect on the perceptual transparency. A small patch of the cheek was clipped from a face image of a Japanese woman. Based on that image, we generated four kinds of stimulus corresponding to four levels of average luminance. Participant's task was to choose the skin with higher perceived transparency using a 2AFC paradigm. The results showed that the skin with higher luminance values was perceived as more transparent.

In Experiment 2, we examined whether chromatic information affects the perceptual transparency of skin. We asked participants to choose the color so that they can maximize their perceived transparency by adjusting the a*b*- chromaticities of the skin patch. The results showed that each participant has an ideal chromaticity so as to perceive transparency of skin though there are quite large individual differences among the participants. In addition, we found that redder skin looks more transparent.

1. INTRODUCTION

Transparent skin has recently been one of the most important keywords in developing cosmetic products. If transparent perception of skin can be controlled by some parameters, it must be applied to makeup, designs and developments of cosmetics products. The term "transparent perception" is originally used in expressing skin perception in Japan. However, "transparency of skin" is an ambiguous expression because it is influenced by individual subjectivity and individual experience in practice. In addition, visual factors which determine the transparent perception of skin are still unknown.

Human skin has a complicated structure which consists of multilayers called an epidermis, dermis and subcutaneous tissue. The light which entered from the outer skin is repeatedly reflected, decreased and absorbed in each inner layer. As a result, the mixed light of a diffuse reflection ingredient and a specular reflection ingredient comes out from the skin [1]. The reflection characteristic of skin influences largely skin appearance. It was clearly shown by previous researches [2] that the higher rate of a specular reflection ingredient, in other words, the higher rate of the transmitted light to incident radiation makes the skin more transparency.

In addition, skin perception depends on colorimetrical parameters such as chromaticity, brightness, and luminosity. However, it is unclear what contributes to transparency of skin and how it is determined. Therefore, we conducted psychophysical experiments to examine the effects of colorimetric parameters on the perceptual transparency of the human skin.

2. EXPERIMENT 1

Previous research [3] indicated that the luminance distribution of human skin affects the skin age perception. However, it is unknown how luminance level of skin influences transparency of skin. First, we chose the image of the woman with uniform skin color out of 100 images of Japanese females. The woman did not have any makeup when the picture was taken. The small patch of the cheek was clipped from the face image of the female. The patch was a square and both length and width were 200 pixels. The RGB values of the image were converted to the XYZ values using the calibration data of the LC-display. The XYZ values of all the pixels were multiplied by four kinds of gain 0.5, 0.75, 1.0, and 1.25, while the xy-chromaticities were kept intact. Four stimuli had four levels of average luminance; 20.3, 30.4, 40.6 and 50.7[cd/m^2]. Stimulus conditions and the image stimuli are shown in Table 1 and Fig.1, respectively.

Table 1. Stimulus conditions

Luminance level	1	2	3	4
average luminance [cd/m^2]	20.3	30.4	40.6	50.7

(a) level 1 (b) level 2 (c) level 3 (d) level 4

Figure 1. Stimulus images

Five young Japanese university students (21-29 yrs) participated in the psychophysical experiment. In fact, the participants chose the skin with higher transparency along a 2AFC paradigm. The image stimuli were shown randomly for 3 trials. The experiment was conducted in a darkroom, and the participant face was fixed to the position away from the display 90 cm. The stimuli were displayed on the carefully calibrated LCD-monitor (ColorEdge CG245W: EIZO). The results shows that the higher luminance skin appears more transparent (Fig. 2).

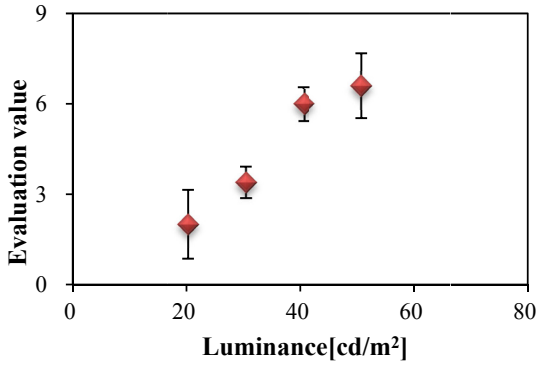

Figure 2. Results of Experiment 1

Moreover, in order to analyze the influence of the luminance level in the transparent estimation of human skin, an analysis of variance was conducted within one factor (participants). As a result, there was a significant difference among luminance level conditions, suggesting that luminance information strongly affects perceptual transparency of skin.

3. EXPERIMENT 2

We conducted Experiment 2 to examine whether chromatic information affects to the translucent perception of skin. We measured chromaticity values of the bare face of a Japanese female by using a 2D luminance colorimeter (UA1000:Topcon), and clipped the part of cheek from the measurement data. The skin patch was a square and both length and width were 160 pixels, respectively. We converted XYZ values of the image into L*a*b* values. We increased or decreased the a* and b* values by one each, and made 2601 (51x51) image stimuli in total.

Five subjects participated in the experiment. The participants chose the skin with the highest perceptual transparency from all stimuli in five trials [4]. Participants chose the stimulus of the cheek that appeared the highest transparency in real time with the interface we developed. The experiment environment was the same as Experiment 1.

We plotted all the optimal chromaticities of the skin patch on the a*-b* plane (Fig.3). In addition, we calculated the average values of five trials for every subject, and plotted the average optimal chromaticities in the a*-b* plane shown in Fig. 4.

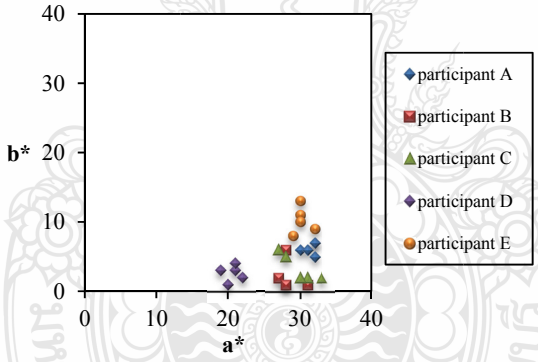

Figure 3. The optimal chromaticities of transparent skin for each participant

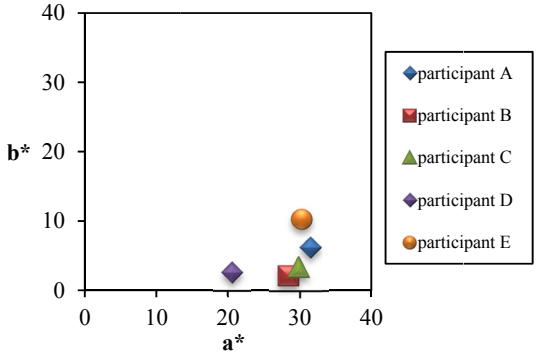

Figure 4. Average optimal chromaticities of transparent skin for each participant

Figures 3 and 4 show that both optimal a*and b* values exist in the first quadrant in all subjects. Although there are large individual differences among subjects, few differences in each participant. These facts suggest that each subject has an individual ideal color for transparent skin. In addition, the results indicate that the redder skin appears more transparent.

4. CONCLUSION

Higher luminance induces more perceptual transparency of human skin. In addition, an individual ideal color exists for transparent skin in each participant. Finally, it was found that redder skin looks more transparent. These results suggest that we can control transparency of skin by adjusting luminance level and color of skin though there are large individual differences between observers.

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