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The Impact of Skin Colour on Facial Impressions

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ABSTRACT

This study investigates the most commonly used terms to describe facial impressions and to develop models to predict them from the colorimetric data. A comprehensive skin colour database was first accumulated. The relationship between different ethnicity groups was revealed and the colour scales to describe skin colours were identified. Subsequently, 22 terms for describing facial impression and appearance were collected. They were used to scale facial images on a display. The results were used to identify four facial percepts, Likeable, Sociable, Masculine and Youth. The results were used to develop models as a function of whiteness and hue angle.

KEYWORDS: skin colour, facial impressions, skin impression model

INTRODUCTION

Skin colours have been extensively studied due to its wide applications such as medical, cosmetic, colour reproduction. Many researchers accumulated skin colour database using different colour measuring instruments across different ethnicity groups [1-3]. However, each database included measuring results from different instruments and different subjects. There is a lack of consistency and results on instrument uncertainty. Our group has also accumulated about 200 subjects from 4 ethnicity groups and use 4 measuring methods at the same locations for each subject. For investigating facial impression, the previous results showed that facial colours have a big impact on visual appearance and hence overall facial impression [4, 5]. Yoshikawa, et al [6] shows that a reddish tinted lighter colour will increase facial whiteness, which is the essential attribute for Japanese female. This could be highly culture dependent.

This paper first describes the accumulation of the Leeds and Liverpool skin colour (LLSC) database. The result reveals the colour distribution between different ethnicity groups in CIELAB planes. This will then be followed by the investigation of the impact of colour on facial impression. Finally, equations were developed to predict facial impression from the skin colour information.

EXPERIMENTAL

The Leeds and Liverpool skin Database (LLSD)

It was mentioned earlier the importance of skin colour data. The CIE established a technical committee 1-92 *Skin Colour Database.* It was aimed to investigate the uncertainty in skin colour measurement and to recommend protocols for good measurement practice. The work was carried out between the university of Leeds and Liverpool. It includes 188 subjects including 4 ethnicity groups (Caucasian (79), Chinese (86), Sub Asian (13) and African (10)), 4 measuring method (spectrophotometer, tele-spectroradiometer (TSR), a calibrated digital camera and visual assessment). For each subject, 4-10 locations were measured by the four measuring methods. The results were reported in terms of instrument uncertainty and analyzed to reveal systematic patterns between different groups, different measuring methods, different locations and different genders [7,8]. Figure 1 shows the colour distribution between 4 skin groups and the results are plotted in CIELAB, a^*b^* and $L^*C_{ab}^*$ planes. Note that only TSR results are shown here and the distributions from all methods are all very similar.

The results clearly showed some trends that there is a distinct hue for the African group (~45º) (see red vector in Figure 1(b)) but the other three groups had larger spread from 14º to 73º. The most obvious trend

is the red line drawn in Figure 1(a) for both Caucasian and Oriental groups, i.e. a departure from the white, or a reduction of lightness and an increase of chroma. This trend line is following the direction of whiteness and depth as reported by Cho et al [10] and Berns [9] respectively. This implies that a skin colour could have high whiteness, or low depth, vice versa. It is also well known that oriental ladies prefer cosmetics to make them appear whiter. The black vector in Figure 1(a) represents the blackness of African group. This trend line is following the direction of blackness and vividness as reported by Cho et al [10] and Berns [9] respectively.
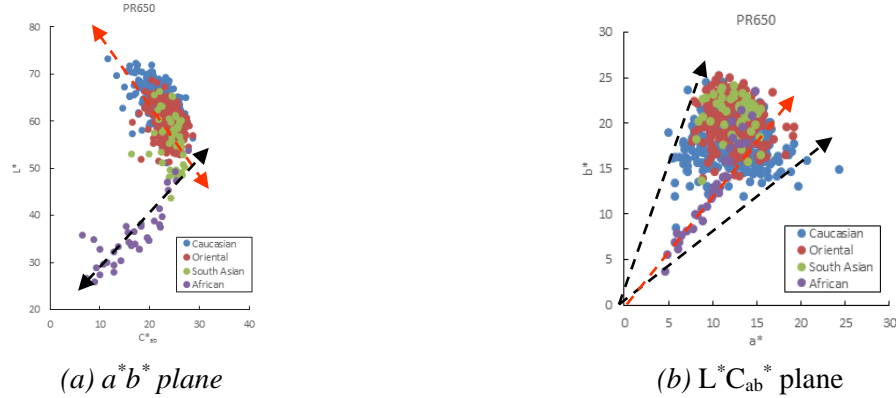

| (a) a^*b^* plane | (b) $L^*C_{ab}^*$ plane |

Figure 1: The colour distribution between different ethnicity groups plotted in a) a^*b^* and b) $L^*C_{ab}^*$ planes.

Facial Impression

To study the relationship between skin colour and facial impression, two experiments were carried out on an EIZO CG243W display. Experiment 1 first accumulated 23 word pairs, as given in Table 1, which were most widely used to describe facial impression. The other half were obtained from our earlier study [11].

Table 1. The 23 word-pairs used to scale each image

English	Chinese (simplified)	English	Chinese (simplified)
Attractive-Unattractive	吸引人的-不吸引人的	Pale-Pink	苍白的-红润的
Tensed-Relaxed	焦虑的-从容的	Tan-Fair	黝黑的-白皙的
Dislikeable−Likable	**不讨人喜欢的-讨人喜欢的**	Opaque−Translucent	不通透的-通透的
Unnatural−Natural	不自然的-自然的	Dry−Moist	干燥的-水嫩的
Unhealthy-Healthy	不健康的-健康的	Matt−Glossy	无光泽-有光泽
Ordinary−Imaginative	平庸的-想象力丰富的	Rough−Smooth	粗糙-光滑
Fussy-Easygoing	挑剔的-温和的	Blemished−Clear	有瑕疵的-无瑕疵的
Babylike−Mature	不成熟的-成熟的	**Agedness−Youth**	**年老的-年轻的**
Serious−Funny	严肃的-幽默的	Stupid−Intelligent	笨的-聪明的
Dull-Lively	沉闷的-活泼的	**Feminine-Masculine**	**女性化的-男性化的**
Autistic−Sociable	**孤僻的-合群的**		
Loner-Cooperative	独来独往的-乐于合作的		
Passive-Active	被动的-主动的		

Two original facial images were chosen from the LLSC database and each was rendered in 26 directions according to the two scales identified in Experiment 1, whiteness and hue, as shown in Figure 2. Ten observers were asked to judge which word in each word pair is more suitable for the image displayed. In total, 11960 assessments (52 images×23attributes×10observers) were made. The principle component analysis was used to analyses the experimental results.

Experiment 2 studied 4 images using 5 impressions found in Experiment 1. Twenty-four observers participated to assess each image. Again, each original image was rendered into 26 images. In total, 1560,000 assessments (325image pair×4 images×5attributes×24observers) were made. Later, models were developed to predict each impression in terms of whiteness and hue angle.
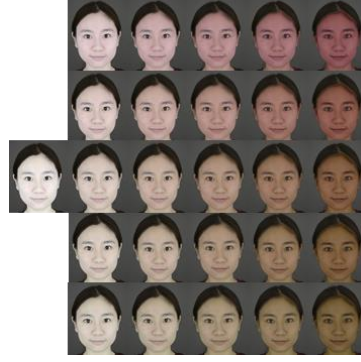
Figure 2: the 26 images rendered surrounding the original

RESULTS AND DISCUSSION

The results had good intra-observer and inter-observer agreements with a mean wrong decision equal to 18% and 26% (for Experiment 1), respectively; 12% and 21% (for Experiment 2), respectively.

The results of Experiment 1 showed that 4 word-pairs were extracted from all 23 pairs (those within the same PCA component are marked in the same colour in Table 1). They are *Likeable, Sociable, Masculine* and *Youth*. Note those terms were chosen to represent all word-pairs in each component except the 'youth'，which is used here to express all the appearance word-pairs, i.e. a more youth skin colour would appear fairer, smoother, clearer, and more pinkish, translucent, moist, gloss.

The results of Experiment 2 showed that there are systematic patterns as illustrated in Figure 3 for the Figure 2 oriental female (OF) image. The range between the dash lines were the range of the skin whiteness and hue angle of LLSC. The red dash line was the original skin colour of the subject in the image.
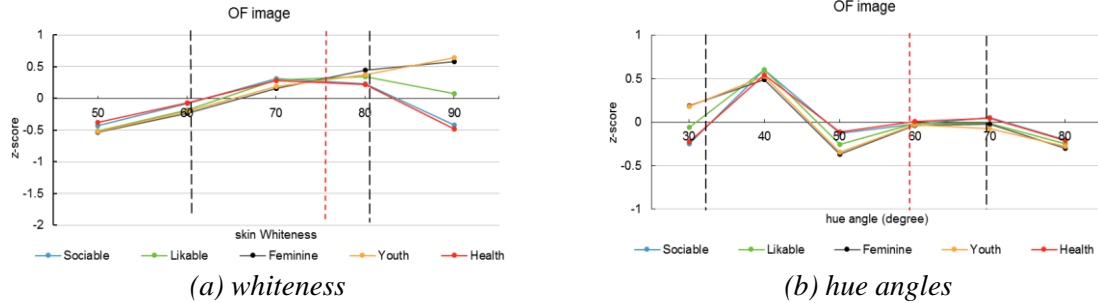

(a) whiteness   *(b) hue angles*

Figure 3: Plot of z-scores for the impressions of the OF image against a) whiteness and b) hue angles

It can be seen that a high whiteness face feels more youthful and feminine, but appears less likeable, sociable and healthy. A moderate whiteness face would give the latter three more positive feelings. As for hue angles, a hue angle around 40 degree will give positive impressions for all 5 impressions. Similar analysis was conducted for the other three faces, male/female, Caucasian/Chinese combinations. In general, for preference (likeable), some conclusions can be drawn from female images: 1) the high whiteness of 90 and 80 are preferred for Oriental and Caucasian respectively; and 2) for hue angles, Caucasian prefers 40°-50° and oriental prefers 40° (see Figure 3(b)). This seems to confirm the study by Yoshikawa, et al [6]. A reddish white skin colour is most preferred by Japanese, for which a slightly reddish tint can further enhance the whiteness perception.

Efforts were also made to develop different forms of model to fit the visual impression data. It was found a model like equation (1) can produce simple and accurate predictions to the visual results.

Model=$p_0+p_{10}\,h+p_{01}\,w+p_{20}\,h^2+p_{11}\,h\,w+p_{02}\,w^2+p_{30}\,h^3+p_{21}\,h^2w+P_{21}\,hw^2+p_{03}\,w^3$

where *w = 100-sqrt[(g-L*)^2+C_{ab}*^{2}]*

and L^*, C^*_{ab}, h are CIELAB lightness, chroma and hue angle of the facial skin colour considered. The g is the maximum whiteness of the ethnicity. In this study, the g values of the Oriental and Caucasian are 76 and 80.7, respectively. The 10 p coefficients were optimised until the visual data and predicted results giving the highest correlation coefficients. Figure 4 shows the visual likeable results plotted against the model prediction for a) Oriental and b) Caucasian female images.
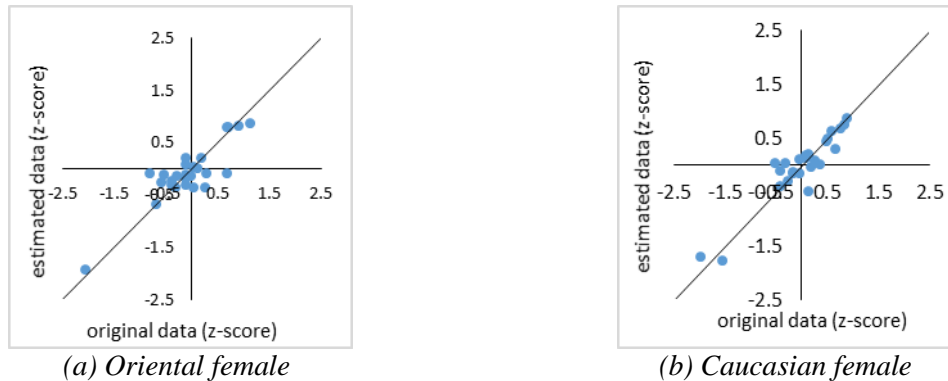

| (a) Oriental female | (b) Caucasian female |

Figure 4: The plot of visual likeable results against the model predictions for a) Oriental female ($R^2=0.65$) and (b) Caucasian female($R^2=0.85$).

CONCLUSION

A comprehensive skin colour database was accumulated. The colour distribution between different ethnicity groups were revealed and whiteness and hue angles can describe skin colours well. 23 word-pairs were accumulated and used to scale facial images on a display. PCA was conducted to extract 4 components, Likeable, Sociable, Feminine, Youth. The results were used to scale more images. Finally, models were developed to fit the experimental results to predict facial impression from skin colour.

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