# Investigation of facial attractiveness using a facial image database

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## ABSTRACT

Colour appearances of 60 Chinese and 60 Caucasians facial images were reproduced on display using colour reproduction technology. Their image characteristics including facial colour, contrast between feature and surrounding skin, and skin heterogeneity were achieved for each facial image. Using categorical judgment technique, perceived attractiveness were assessed in psychophysical experiment by 20 Chinese subjects. Effect of image characteristics to attractiveness was investigated. Results showed that facial attractiveness is highly corrected to image characteristics including facial skin colour, facial contrast and skin heterogeneity.

**KEYWORDS:** facial attractiveness, skin colour, skin heterogeneity

## INTRODUCTION

Face is an identity. A healthy and attractive facial appearance is always highly desired. Interest in the relationship between perceived psychological scale of attractiveness and the optical properties of human facial colour has been greatly stimulated by the increased prevalence of cosmetic surgery and also by applications in graphic art and computer vision[1].

Previous studies have found that for Caucasian women, facial colour contrast is a cue for age perception [2]. Facial healthiness can be affected by skin colour which varies with the amount of oxygen hemoglobin [3]. It is also well acknowledged that perceived facial attractiveness can also be highly affected by factors of culture and environment. A typical example is that Chinese females prefer to look white whereas Caucasian females generally dislike this look.

The aim of this study is to investigate how facial colour affects perceived facial attractiveness from Chinese and Caucasian subjects. Liverpool-Leeds facial image database, consists of 60 Chinese facial images and 60 Caucasians facial images were used and their facial colour appearance were reproduced truly on a BenQ colour professional display. A psychophysical experiment was conducted in Anshan, China to assess perceived facial attractiveness and facial healthiness for those facial images using a categorical judgement method by 20 Chinese subjects. The relationship between perceived attractiveness from those subjects was investigated. Subsequently, colour characteristics, including skin colour, facial colour contrast and skin colour variation, and how they could affect facial healthiness and facial attractiveness were analyzed.

## METHODLOGY

### Liverpool-Leeds facial image database

A facial image database was collected in University of Liverpool in collaboration with University of Leeds [4]. Facial images of subjects were captured under controlled viewing conditions using a SLR camera with colour characterisation processing. To achieve uniform lighting, a VeriVide DigiEye® light booth was used, the inside of which was painted with a mid-grey matte colour and illuminated by a D65 fluorescent

simulator offering evenly diffused illumination. During the data collection, the participant sat on an adjustable chair in the viewing cabinet and adjusted their position until their target facial area was within the camera lens. The camera, a Nikon D7000 digital SLR camera controlled by the DigiEye system software, was used to capture images with fixed exposure, white balance and ISO settings. The image capture distance between camera lens and training colour charts (or the subject's face) was fixed to 57.5cm and the capture angle was 0 degrees. Subsequently, skin colour of each subject was measured using a Konica Minolta CM 700d spectrophotometer. Overall, facial images of 188 subjects, including 86 Orientals (41 female and 45 male), 79 Caucasians (65 female and 14 male), 13 South Asians (6 female and 7 male) and 10 Africans (5 female and 5 male) were collected.

**Image Processing**

From the database, each image's RGB data was transformed to CIELAB uniform colour space [5] via a camera characterisation process. To truly reproduce colour appearance of those facial images, a BenQ colour professional display was used and the white point was set to D65 (which is the same as the illumination for facial image capturing). Colour characterisation was conducted for the display using the method of piecewise linear interpolation assuming constant chromaticity coordinate (PLCC) [6] and the CIELAB values for each image pixel were transformed to display RGB for each facial image. Subsequently, each facial image was edited to remove hair, ears and clothes and scaled to fit the center part of the screen. Finally, the image background was set to middle grey (L*=50, a*=0 and b*=0 in CIELAB colour space) as shown in Figure 1.

*Figure 1: Example of processed facial image*

In this study, 120 facial images, including 60 Chinese facial images and 60 Caucasians facial images were selected to represent Chinese faces and Caucasians face with neutral facial impression.

*Figure 2. Facial images for Chinese and Caucasians*

**Colour characteristics**

For each facial image, skin colour in terms of lightness, redness and yellowness were represented by the grand mean of L*, a* and b* for each pixel of facial area in CIELAB uniform colour space.

To represent facial contrast, lightness (L*), chroma (C*) and hue ($h_{ab}$) of each feature (mouth, eye and eyebrow) and surrounding skin were calculated. For each colour attribute, contrast for each feature was obtained using Equation 1. Overall contrast was calculated by averaging contrast for three features [2]. Thus

$$C_{feature} = \frac{A_{Skin} - A_{feature}}{A_{skin} + A_{feature}} \qquad (1)$$

where C represents contrast and A represents one of the colour attributes in CIELAB uniform colour space.

For skin heterogeneity, four parts (forehead, cheek, nose and chin) of each image were selected. Their MCDM (the mean colour difference to the mean value) was calculated in CIELAB uniform colour space. To achieve MCDM, firstly, the mean of the selected part was calculated in CIELAB colour space. Then, the mean of the colour differences between each pixel in the selected part and the mean of the selected part was calculated for each part. Finally, grand mean was calculated to represent MCDM for four parts. Note that the unit of MCDM is CIELAB colour difference and smaller MCDM represents a better performance in terms of skin heterogeneity.

**Psychophysical experiment**

A psychophysical experiment was conducted to assess perceived attractiveness by 20 Chinese subjects using the categorical judgment technique. Subjects were asked to view a facial image and then scale (1-7) overall attractiveness for the face in the image where 1 represents least attractiveness and 7 represents best attractiveness. Numbers between one and seven to represent equal intervals of attractiveness so that the difference between any neighbouring categories be the same. After the experiment, all observer data were averaged and transformed to Z scores using Torgerson's law of categorical judgment [7].

## RESULTS AND ANALYSIS

To investigate how colour characteristics (colour, colour contrast and colour heterogeneity) affect perceived facial attractiveness, colour characteristics for each facial image were calculated. Figure 2 represents colour specification of overall mean of each facial image in CIELAB uniform colour space (blue dot represents Chinese faces; yellow dot represents Caucasians faces). It can be seen that colour in each facial images are lighter and covers a larger range of yellowness than redness.

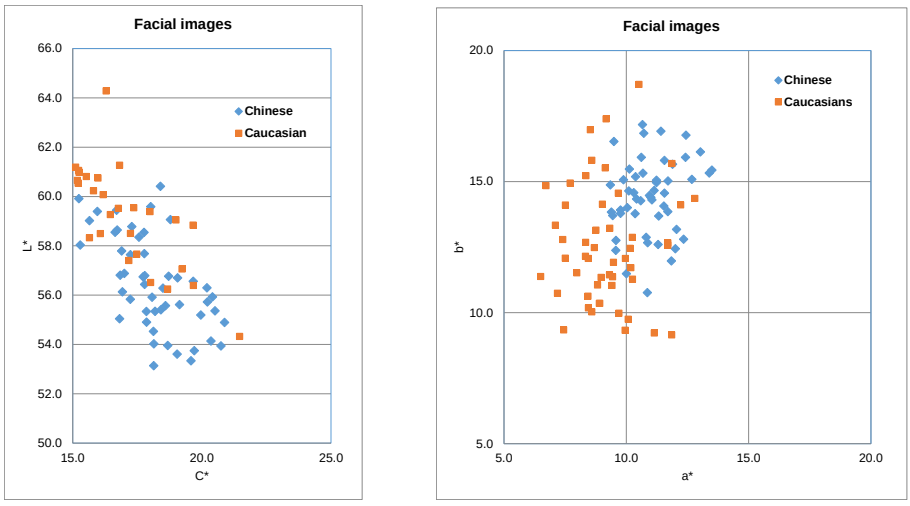


*Figure 2: Colour specifications of mean facial colours of testing images in CIELAB*

To further investigate their relationship, correlation coefficients between each of facial colour characteristics and subjective scale of attractiveness were calculated and results are listed in Table 1.

Table 1. Correlation coefficient (r) between facial image characteristics (Colour, Contrast and Heterogeneity) and subjective scale of attractiveness

| Correlation coefficient | Colour | | | Contrast | | | Heterogeneity |
|---|---|---|---|---|---|---|---|
| | L* | a* | b* | C_L | C_C | C_h | MCDM |
| Chinese faces | 0.61 | -0.45 | -0.01 | 0.26 | -0.16 | 0.58 | -0.50 |
| Caucasians faces | 0.52 | -0.71 | -0.03 | 0.60 | -0.16 | 0.47 | -0.66 |

As shown in Table 1, correlation coefficient (r) between MCDM and healthiness scale is approximately -0.5 and -0.7 for Chinese and Caucasians images, indicating facial healthiness is highly correlated with their skin heterogeneity. Minus means that the smaller the MCDM is, the higher score for attractiveness. Effect of skin colours to attractiveness seems significant as well. Compared with colour attributes, lightness and redness has the largest effect and yellowness has the least effect. When Chinese subject assess a Caucasian faces, correlation of attractiveness and redness seems very large (r=-0.71). It indicates that Chinese subject prefer to see a Caucasian face with skin of a lower redness. In term of contrast, it is also found that a large lightness and hue difference in facial contrast indicates a facial attractiveness. Comparing with Chinese faces, when Chinese subject viewed a Caucasians face, they prefer to see a higher contract in lightness.

## CONCLUSION

Using a large set of facial images, attractiveness of Chinese face and Caucasians faces were assessed by 20 Chinese subjects in a psychophysical experiment. Results shown that colour characteristics, including skin colours, facial contrast and colour variation can all affect attractiveness. Although the overall tendency of those effects to either Chinese or Caucasians faces is similar, their magnitude was significantly different.

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