Effects of Skin Tone and Facial Characteristics on Perceived Attractiveness: A Cross-Cultural Study

Yinqiu Yuan, Li-Chen Ou, M. Ronnier Luo; Department of Colour Science, University of Leeds; Leeds, UK

Abstract

A psychophysical experiment was conducted to study how cultural background of the observer may influence the impression of face images, in terms of attractiveness. Eighteen British and 16 African observers participated in the experiment. Each observer viewed 128 face images generated from six original faces, including three races (Caucasian, Oriental and African) and both genders, each manipulated by skin tone and facial characteristics (eye size, horizontal locations of the eyes, and nose length). The experimental results show that although British and African observers both preferred high chroma faces, for British observers the most attractive faces had a hue angle close to 41°, whereas African observers preferred more reddish faces. The two observer groups were found to disagree most for skin colours near (a, b*) = (18, 16). The results also show that the observers tended to be more sensitive to changes in facial characteristics for the faces of their own race than for those of other races.*

Introduction

Human faces have a significant impact on the viewer's social impression and thus can influence the affective quality of images with human faces in them. For consumer images, such an impact may become even stronger if the viewer has a personal attachment to the face image, such as a picture of a family member [1]. A recent study [2] showed that images containing human faces had less variable observer responses than those without faces in them. This may suggest that human faces can help enhance image quality in a dominant, consistent manner.

Among the factors affecting visual impression of faces, skin tone and facial characteristics have both been considered the most important aspects, as they provide strong visual cues for the viewer's social perception of the faces, in terms of attractiveness, masculinity or health [3-4]. It has been shown that the viewer of a picture tend to prefer faces having skin tones more colourful than actual skin colours [5].

As suggested by recent papers, the cultural background of the viewer should be taken into consideration, especially for consumer images. In a study of preferred colour reproduction for Mongoloid, Caucasoid, and African people [6], Sanger et al. found that African skin colours were more colourful than the other races. Yano and Hashimoto [7] studied complexion preferences of Japanese people, and found that for Japanese women, the preferred skin tones were slightly higher in chroma and more reddish in hue than the actual complexion. They also found that the preferred skin colours of the Japanese were less colourful than those of Caucasian women.

These studies suggest that cultural background of the viewer may play an influential role in the assessment of skin tone preferences. Nevertheless, there were also studies that showed little cultural difference between ethnic groups, such as Kuang et al.'s recent work [8]. Fernandez and Fairchild [2] also pointed out that although the preference variability due to observers' cultural background was found to be statistically significant, it was not visually apparent. They found that the preference variability due to image content and the variability among observers were more significant than the variability due to cultural background. On the basis of these diverse findings, it is difficult to clarify whether skin colour preferences have a consistent, universal pattern/tendency shared by observers of various cultural backgrounds.

Regarding effects of facial characteristics on the affective quality of images, despite a large number of existing studies in this area [e.g. 3-5], most studies did not use proper methods to control factors that might affect observer responses, such as race, age, gender, facial feature or emotional expression. Moreover, almost all existing studies of skin colour preferences did not consider the influences of facial characteristics on the responses [e.g. 1-2, 6-8].

To address these issues, the present study used face images manipulated by both skin tone and facial features with better controlled variables, for assessment of facial attractiveness. Comparisons of the experimental results were made between two observer groups, British and African, to reveal any effects of cultural background.

Experimental methods

The psychophysical experiment consisted of two parts. The first part used face images as the stimuli, manipulated by skin tone; the second part manipulated the images by facial features (e.g. eye size). The image stimuli used in both parts were based on the same set of original faces, as shown in Figures 1 (a) to (f). The images were sampled to represent three races, Caucasian, Oriental and African, each including a female face and a male face. All images were presented using a calibrated cathode ray tube (CRT) display with a peak white (x, y, Y) = (0.309, 0.321, 64.9 cd/m2) which was close to D65.

For Part 1 of the experiment, the six original images were manipulated by altering the skin tone (i.e. mean a* and mean b* values of each face, without changing the image lightness). From each original image, 11 manipulated versions were generated using Matlab, with CIELAB values shown in Table 1 as the mean skin colours. This resulted in 6 x 11 = 66 image stimuli for Part 1 of the experiment. Figure 2 demonstrates examples of face images for each skin tone distributed in the CIELAB a*-b* space.

In the second part of the experiment, the image stimuli included the six original faces, together with those manipulated by facial features. According to a recent study [9] facial attractiveness was closely related to eye size (small eyes vs. big eyes), horizontal locations of the eyes (eyes close vs. eyes apart) and nose length (short nose vs. long nose). Each original image was manipulated by the six facial feature modifications using Photoshop. Figures 3 (a) to (f) show examples of the six manipulations for the Caucasian female face. Thus, 6 x (1 + 6) = 42 images were used in Part 2.

Thirty-four observers, 18 British and 16 African, participated in the experiment. The British observers ranged in age from 18 to 21 years (mean=19.4; SD=0.8). The African observers all came from North Africa, ranged from 19 to 33 years (mean=25.4; SD=3.9). All observers were students at the University of Leeds, UK, and all passed Ishihara's test for colour deficiency. Each observer participated in both parts of the experiment, viewing 66 images for Part 1, 42 images for Part 2, and 20 replicated for testing the observer repeatability. This resulted in 66 + 42 + 20 = 128 face images for each observer.

Prior to the experiment, each observer spent at least three minutes in the darkened experimental room getting adapted to the dim environment. In the experiment, the image stimuli were presented individually in random order on the CRT display. The observer made judgements about the attractiveness of each face image on a six-point forced-choice scale: "very attractive", "attractive", "a little attractive", "a little unattractive", "unattractive" and "very unattractive". To avoid any effect of afterimage that might occur if the observer looked at a face image for too long, a full-screen medium grey was shown for one second between presentations of each image stimuli.

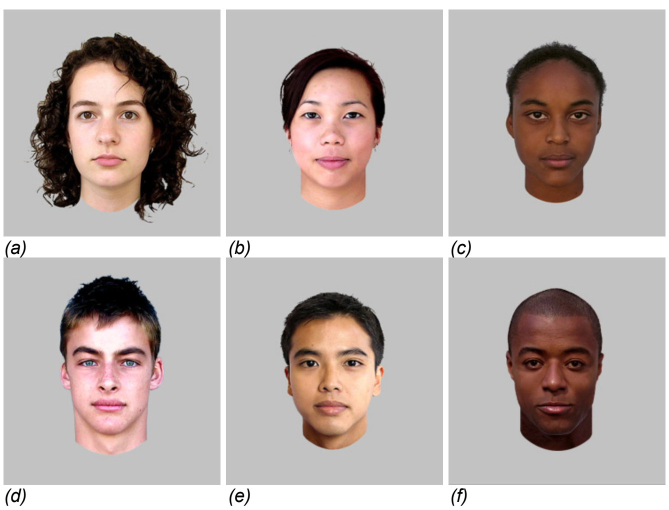

Figure 1 *Original images: (a) Caucasian female, (b) Oriental female, (c) African female, (d) Caucasian male, (e) Oriental male and (f) African male*

Table 1 The 11 skin tones used in this study

Skin tone	a^*	b^*	C^*_{ab}	h_{ab}
1	15.9	14.6	21.6	42.6
2	11.5	10.5	15.6	42.6
3	13.0	8.6	15.6	33.6
4	9.7	12.2	15.6	51.6
5	20.3	18.7	27.6	42.6
6	23.0	15.3	27.6	33.6
7	17.1	21.6	27.6	51.6
8	19.6	9.0	21.6	24.6
9	18.0	11.9	21.6	33.6
10	13.4	16.9	21.6	51.6
11	10.6	18.8	21.6	60.6

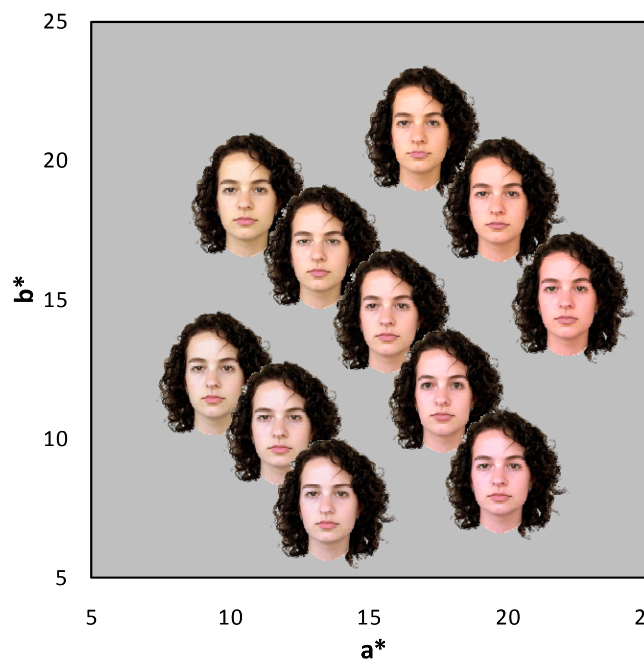

Figure 2 *Examples of the 11 skin tones distributed in CIELAB a*-b* space*

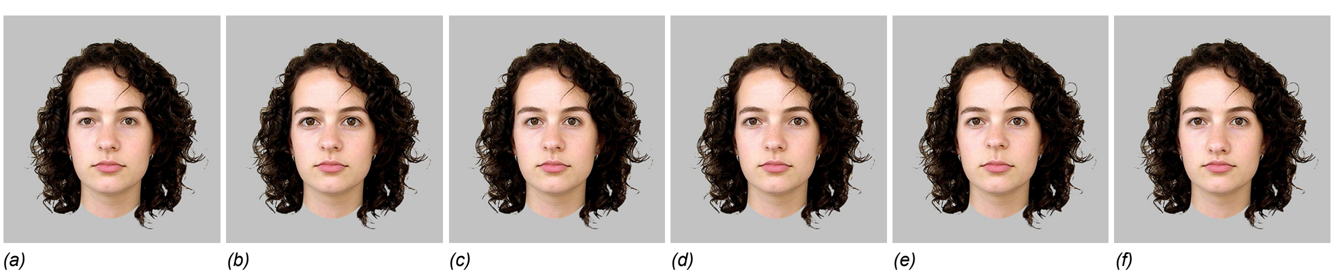

Figure 3 *Examples of image manipulation by facial features: (a) small eye size, (b) big eye size, (c) eyes close, (d) eyes apart, (e) short nose and (f) long nose*

Consistency of observer data

The observer responses were tested in terms of inter- and intra-observer variability; the former shows how well individual observer responses agreed with the mean responses, and the latter represents the repeatability of each observer's responses for the 20 replicated images. Both inter- and intra-observer variability values were calculated using the Root Mean Square (RMS) measure.

As a result, the inter-observer variability value was 1.53 for British observers and 1.38 for African observers. The intra-observer variability value was 1.33 for British observers and 1.14 for African observers. The results suggest that the observer responses were more consistent for African observers than for British responses.

Effects of culture on attractiveness based on skin tone

The first part of the experiment was aimed to establish whether there was any impact of culture on facial attractiveness for different skin tones. Figure 4 shows a scatter graph where British responses are plotted against African responses to the six sets of face images – Caucasian female, Oriental female, African female, Caucasian male, Oriental male and African male – each manipulated by skin tone. For African observers, all female faces were more attractive than male faces, regardless of skin tone difference. This tendency is not shown for British results. The graph also shows lower correlation coefficients between the two observer groups for Caucasian faces than for other faces, with R=0.02 for Caucasian female and R=0.36 for Caucasian male, suggesting the responses by the two groups disagreed most on Caucasian faces.

To investigate the data in more detail, bubble charts were made on the basis of CIELAB a*-b* space. Figures 5 (a) to (c) show the bubble charts for British responses to face images of the three races, Caucasian, Oriental and African, respectively. Figure 5 (d) shows the result including images of all three races. The bubble size represents mean response for a specific skin tone, in terms of the z-score. The higher the z-score is, the more attractive the faces. For all three sets of images, the high z-score bubbles tend to be located at the high chroma area. The locations of the high z-score bubbles appear to be related to hue angle, too. The overall trend of British observer response to all face images (Figure 5d) was modelled by Equation (1), standing for 70% of the total variance (R2=0.70). The equation suggests that British observers preferred skin colours having high chroma, with a hue angle of around 41°.

$$A_{UK} = -29 + 0.15\left[C^*_{ab} + 175\cos\left(h_{ab} - 41°\right)\right] \quad (1)$$

where C^*_{ab} and h_{ab} are CIELAB chroma and hue angle, respectively.

Figures 6 (a) to (d) show bubble charts for African responses. Compared with British results as demonstrated in Figures 5 (a) to (d), the African observers seem to prefer more reddish faces. The overall trend of African responses (Figure 6d) was modelled by Equation (2), representing 82% of the total variance (R^2=0.82).

$$A_{AF} = -5 + 0.15\left[C^*_{ab} + 17\cos\left(h_{ab} - 0°\right)\right] \quad (2)$$

Equations (1) and (2) show that the differences between responses given by the two observer groups include both hue angle (i.e. African observers preferred more reddish skin colours) and chroma (i.e. contribution of chroma to the predicted value is higher for African than for British observers).

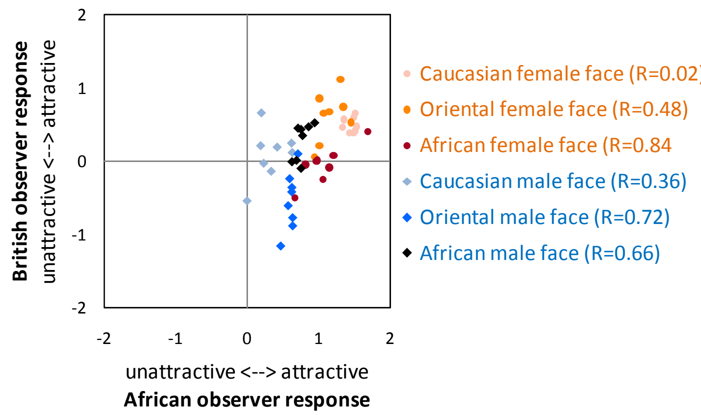

Figure 4 *British responses plotted against African responses to the six sets of face images*

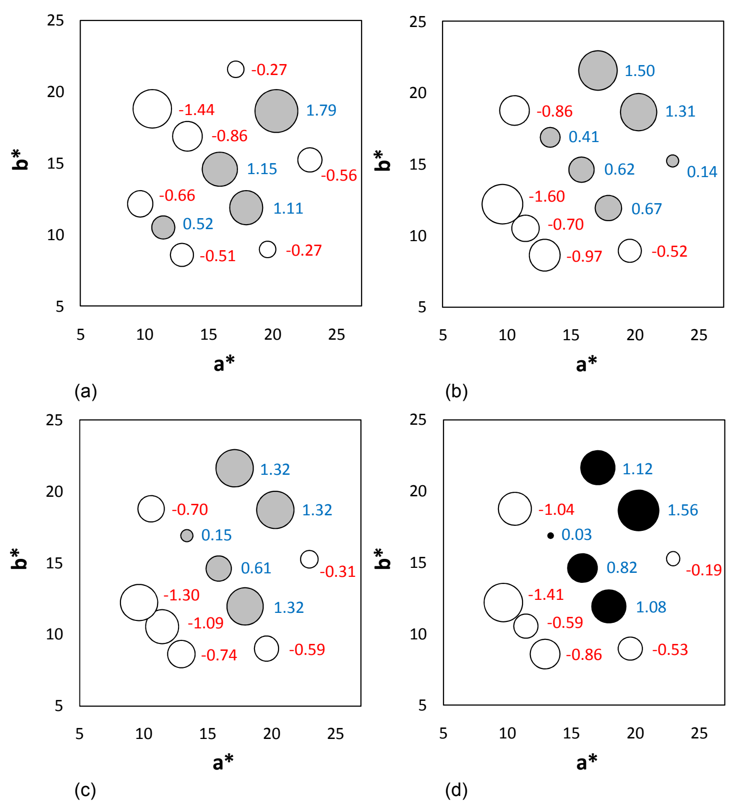

Figure 5 *Bubble size represents British observers' mean response to (a) Caucasian, (b) Oriental, (c) African and (d) all images for each skin tone, in terms of z-score (higher value means more attractive)*

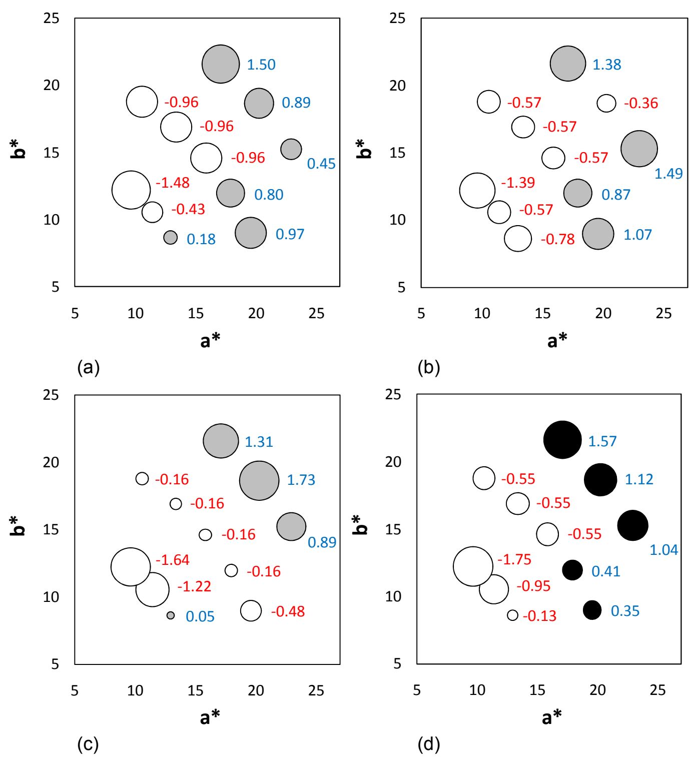

Figure 6 *Bubble size represents African observers' mean response to (a) Caucasian, (b) Oriental, (c) African and (d) all images for each skin tone, in terms of z-score (higher value means more attractive)*

To see more clearly as to how well British and African observers agreed with each other for each skin colour, correlation coefficients were calculated for each skin colour between the two observer groups, in terms of their responses to all face images. The results are shown in Figure 7, where the bubble size represents correlation coefficient for each skin colour; the higher the correlation coefficient is, the better agreement between the two observer groups. The bubble in the middle of the graph shows the lowest correlation coefficient, -0.20. It appears that the further away from this colour, the higher the correlation coefficient. This tendency was modelled by Equation (3), standing for 81% of the total variance (R^2=0.81).

The equation suggests that British and African observers disagreed most for skin colours around (a*, b*) = (18, 16).

$$G_{UK.AF} = -0.5 + 1.5\log\left[\left(\frac{a^*-18}{2}\right)^2 + (b^*-16)^2\right]^{\frac{1}{2}} \qquad (3)$$

where a* and b* are CIELAB coordinates.

Effects of culture on attractiveness based on facial characteristics

The aim of Part 2 was to establish whether there was any impact of culture on perceived attractiveness for different facial characteristics (e.g. eye size). To achieve this, the attractiveness responses were first compared between the two observer groups by scatter graphs, where British responses are plotted against African responses. Figures 8 (a) to (c) show the results for Caucasian, Oriental and African faces, respectively. The responses to Oriental faces show the highest correlation coefficient, 0.87, whereas the results for Caucasian faces and those for African faces both show lower correlation coefficients, 0.26 and 0.63, respectively. This suggests that the two observer groups are more likely to disagree on the attractiveness for face images of their own race than for those of other races.

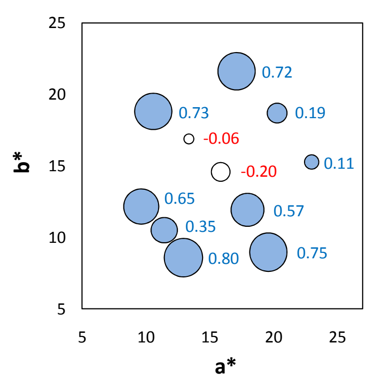

Figure 7 *Bubble size represents the correlation coefficient between British and African observer responses to all face images for each skin tone (higher value means better agreement between the two observer groups for the specific skin tone)*

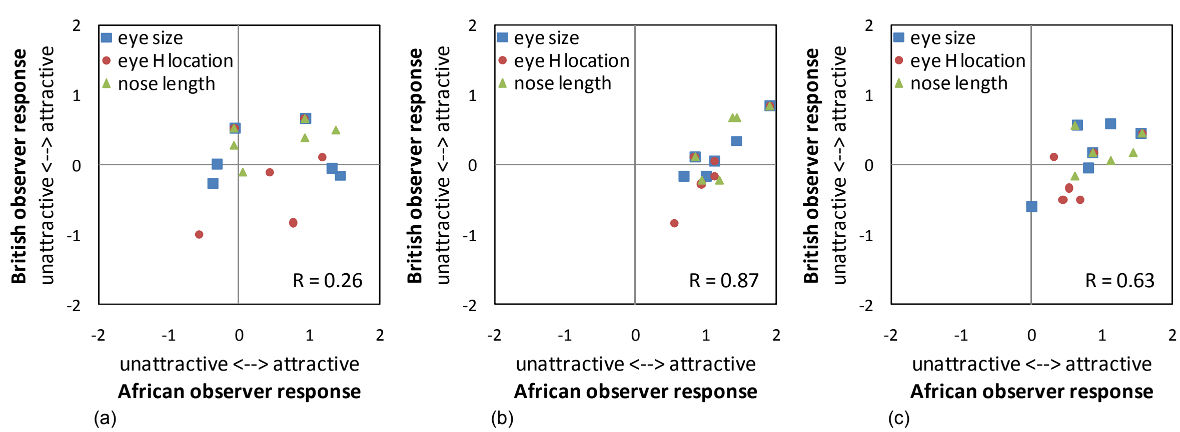

Figure 8 *Comparisons between British and African observer responses for (a) Caucasian, (b) Oriental and (c) African face images*

To investigate further as to how facial characteristics might contribute to the disagreement between the two observer groups, bar charts were made to show the observer responses to face images manipulated by eye size, horizontal locations of eyes, and nose length, as shown in Figures 9 to 11, respectively. In each bar chart, the observer responses (i.e. mean attractiveness values) are represented by the bars for face images in one of the three race groups: Caucasian, Oriental and African.

It is clear that most of the mean attractiveness values given by African observers tend to be higher than those given by British observers, suggesting that the face images appeared more attractive to African than to British observers.

The facial characteristics seem to have different impacts on observer responses for images of different races. For instance, Figure 9 (a) shows that the difference in British responses between small eye size and medium size, and the difference between medium eye size and big size for Caucasian faces, both appear to be larger than those for Oriental and for African faces. Figure 9 (b), on the other hand, shows that the response differences as described above for African observers are more significant for African faces than for other faces. Similar "trends" can also be found in Figures 10 and 11 – the impacts of facial characteristics on British response tend to be more significant for Caucasian faces than for other faces, and for African observers such impacts are more significant on judgements for African faces than for other faces.

To see whether the above "trends" were statistically meaningful, t-test was performed for mean values of different facial characteristics. Table 1 shows the p-values resulted from the t-test, representing the probability for the difference being insignificant between the mean values in question. This means that the lower the p-value is, the more significant the difference between the mean values in question.

As shown in the table, for British observer results, the p-values tend to be smaller for Caucasian faces than for the other faces, with a mean p-value of 0.05 for Caucasian face images manipulated by eye size, 0.01 for those manipulated by horizontal locations of the eyes, and 0.39 for those manipulated by nose length. For African observer results, on the other hand, the p-values are smaller for African face images than for the other faces, with a mean p-value of 0.09 for Caucasian face images manipulated by eye size, 0.05 for those manipulated by horizontal locations of the eyes, and 0.34 for those manipulated by nose length. The results agree well with the "trends" previously described on the basis of Figures 9 to 11.

Note that for the British results, the p-values are the highest for Caucasian faces, and the least for African faces; for African observer results, on the other hand, the p-values are the highest for African faces, and the least for Caucasian faces. This suggests that observers were more sensitive to changes in facial characteristics for faces of their own race than to those for other races.

Moreover, for both observer groups, the mean p-values are highest for images manipulated by horizontal locations of the eyes, and least for those manipulated by nose length. This suggests that facial attractiveness is influenced most strongly by the horizontal locations of the eyes, and least by nose length.

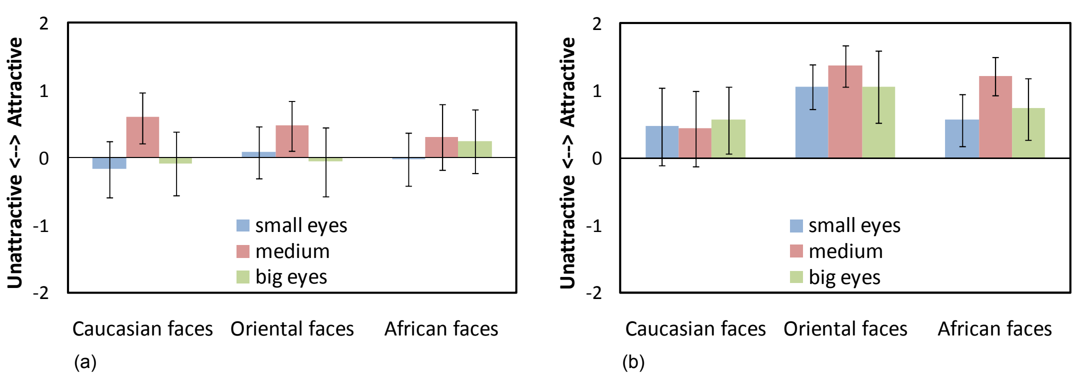

Figure 9 *Responses by (a) British and (b) African observers to face images manipulated by eye size. Error bars show 90% confidence intervals.*

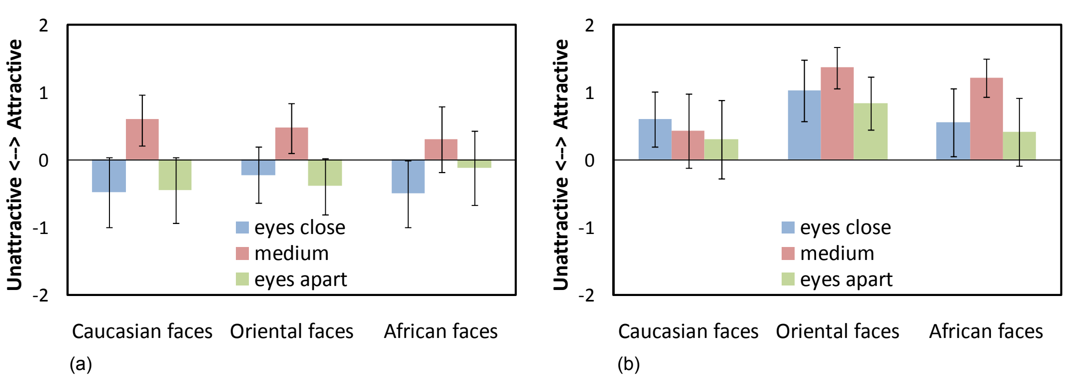

Figure 10 *Responses by (a) British and (b) African observers to face images manipulated by horizontal locations of the eyes*

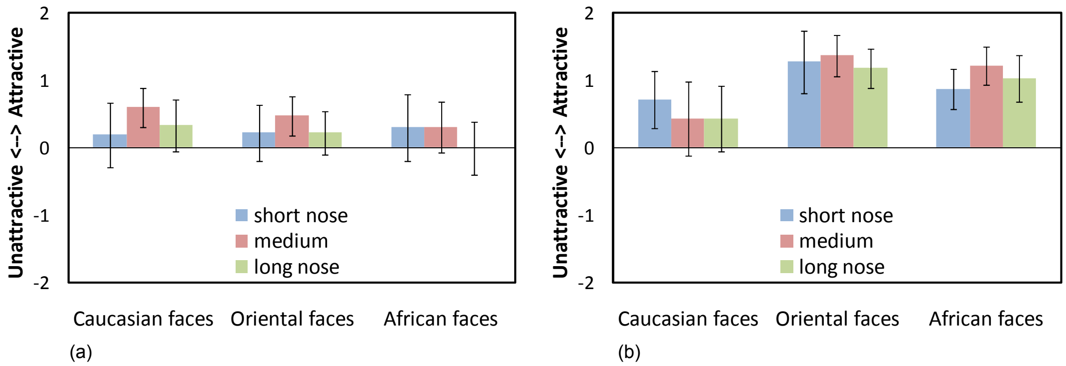

Figure 11 *Responses by (a) British and (b) African observers to face images manipulated by nose length. Error bars show 90% confidence intervals.*

Table 2 P-values associated with t-test for observer responses to images manipulated by facial features

	British observer results			African observer results		
Eye size	Caucasian faces	Oriental faces	African faces	Caucasian faces	Oriental faces	African faces
Small vs. medium	0.03	0.24	0.41	0.95	0.26	0.03
Medium vs. big	0.07	0.18	0.89	0.78	0.42	0.15
Mean	**0.05**	0.21	0.65	0.87	0.34	**0.09**
Eye H-location						
Close vs. medium	0.01	0.05	0.06	0.68	0.32	0.07
Medium vs. apart	0.01	0.02	0.35	0.80	0.09	0.03
Mean	**0.01**	0.03	0.21	0.74	0.20	**0.05**
Nose length						
Short vs. medium	0.29	0.46	1.00	0.51	0.78	0.18
Medium vs. long	0.49	0.49	0.47	1.00	0.47	0.50
Mean	**0.39**	0.48	0.73	0.75	0.63	**0.34**

Conclusion

The experimental results show that there were strong impacts of cultural background of the observer on facial attractiveness. According to the results (Table 2), such impacts may be due to the tendency that the observers were more sensitive to changes in facial characteristics for the faces of their own race than for other races, i.e. British observers were more sensitive to Caucasian faces than to other faces, whereas African observers were more sensitive to African faces than to other faces.

Regarding facial attractiveness based on skin tone, the results demonstrate that British observers preferred skin colours of higher chroma values, with a hue angle of about 41° (Equation 1). African observers, on the other hand, had preferences for more reddish, higher chroma faces (Equation 2). According to Equation (3), the two observer groups disagreed most for skin colours in the region around (a^*, b^*) = (18, 16), a colour located at the borderline of the preference tolerance for the two observer groups.

As previously mentioned, all observers were ranged from 19 to 33 years, and all images were of young adult faces. Thus, the experimental results may only suggest tendency of visual responses by young adults to faces of young adults, and the results may not apply to other age groups. Fink et al. [10] have shown that skin colour distribution had significant impacts on both perceived youth and attractiveness.

The outcomes of the present study may be applied in the area of in-camera processing of facial colour based on facial features and cultural background of the user (or of the person in the photo). To the best of the author's knowledge, there has been no research using a systematic, psychophysical method to look into the relationship of preferred facial skin tone and the facial features. Only a few studies have investigated the facial attractiveness and the face shape. For instance, both Jones et al. [11] and Fink et al. [10] have found that the effect of skin colour conditions on facial attractiveness was independent of face shape. It will be interesting to explore further in this area.

References

[1] Jun, J., Ou, L., Oicherman, B., Wei, S., Luo, M. R., Nachilieli, H. and Staelin, C. (2010) Psychophysical and psychophysiological measurement of image emotion, Proceedings of the IS&T/SID 18th Color Imaging Conference, 121-127.

[2] Fernandez, S.R. and Fairchild, M.D. (2001) Preferred colour reproduction of images with unknown colorimetry, Proceedings of IS&T/SID 9th Colour Imaging Conference, 274-279.

[3] Hassin, R. and Trope, Y. (2000) Facing faces: studies on the cognitive aspects of physiognomy, Journal of Personality and Social Psychology, 78, 837-852.

[4] Swami, V., Furnham, A. and Joshi, K. (2008) The influence of skin tone, hair length, and hair colour on ratings of women's physical

attractiveness, health and fertility, Scandinavian Journal of Psychology, 49, 429-437.
[5] Zeng, H. and Luo, M.R. (2010) Colour and Tolerance of Preferred Skin Colours, Proceedings of IS&T/SID 18th Color Imaging Conference, 190-195.
[6] Sanger, D., Asada, T., Haneishi, H. and Miyake, Y. (1994) Facial pattern detection and its preferred color reproduction, Proceedings of IS&T/SID 2nd Color Imaging Conference, 149-153.
[7] Yano, T. and Hashimoto, K. (1997) Preference for Japanese complexion color under illumination, Color Research and Application, 22, 269-274.
[8] Kuang, J., Jiang, X., Quan, S. and Chiu, A. (2005) A psychophysical study on the influence factors of color preference in photographic color reproduction, Proceedings of SPIE/IS&T Electronic Imaging: Image Quality and System Performance II, 5668, 12-19.
[9] Yuan, Y., Ou, L. and Luo, M. R. (2011) Gender differences in social perception for skin tones, Proceedings of AIC Midterm Meeting 2011.
[10] Fink, B., Grammer, K. and Matts, P. (2006) Visible skin colour distribution plays a role in the perception of age, attractiveness, and health in female faces, Evolution and Human Behavior, 27, 433-442.
[11] Jones, B. C., Little, A. and Feinberg, D., Penton-Voak, I., Tiddeman, B. and Perrett, D. (2004) The relationship between shape symmetry and perceived skin condition in male facial attractiveness, Evolution and Human Behaviour, 25, 24-30.

Author Biography

Yinqiu Yuan received her BEng from Anhui University of Science and Technology, China in 1995, an MEng from China University of Mining and Technology, China in 1998 and a PhD from Nanjing University of Aeronautics and Astronautics, China in 2001, all in the area of mechanical engineering. She has been an MSc by Research student in colour and imaging science at the University of Leeds, UK since 2010.