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ORIGINAL ARTICLE

The effects of skin colour distribution and topography cues on the perception of female facial age and health

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Abstract

According to evolutionary psychology, the preference for some facial characteristics reflects adaptations for mate choice because they signal aspects of mate quality. Although morphological features such as facial symmetry and sexually dimorphic traits have been studied extensively in recent years, little is known about skin condition in this context. The preferences for young and healthy looking skin could offer an explanation as to why women place such an importance on the condition of their skin and its refinement through e.g., cosmetic products. Recent research showed that facial skin colour distribution significantly influences the perception of age and attractiveness of female faces, independent of skin surface topography cues. However, the relative effect of skin colour distribution and topography cues on age and health perception remains to be investigated. We present data showing that both skin colour distribution and skin surface topography cues not only significantly influence the perception of female facial age and health but also convey differential information with regard to the strength of these effects. Our data indicate that skin surface topography cues account for a large proportion of variation in facial age perception, whereas skin colour distribution seems to be a stronger health cue.

Introduction

Evolutionary psychologists suggest that in humans, as in other animals, sexually selected physical characteristics all pertain to health, thereby suggesting that humans have evolved to view certain features as attractive and preferable. The perception of physical attractiveness is known to be sex specific because both sexes have different preferences for mates (e.g. Thornhill and Gangestad[1]). Numerous studies across a wide range of cultures have shown that in consideration of mates, men rank female beauty higher than women rank male appearance, whereas women rank male status and resources higher than men rank female status or resources.[2,3] Female beauty, therefore, is thought to signal youth, fertility and health, whereas male status and resources signal competitive ability and health.[4,5] With the aid of modern computer technology, numerous approaches to the study of facial appearance have considered characteristics such as facial symmetry, averageness and sexual dimorphism (see for review, Fink and Penton-Voak[6]). The influence of apparent skin condition has received little attention in this context, though, in recent years, evolutionary psychologists have made some progress with the empirical investigation of visible skin condition. Visible skin condition, particularly that of women, is supposed to influence human physical attraction and may therefore have some signalling value that is relevant for human mate choice. In this view, it is thought that males have evolved preferences for skin that signals youth and health as both are correlated with fertility.[7,8]

Fink *et al.*[9] showed that women's facial skin texture affects male judgement of facial attractiveness and found that homogeneous skin (i.e., an even distribution of features relating to both skin colour and skin surface topography) is most attractive. Jones *et al.*[10,11] showed that ratings of attractiveness of small skin patches extracted from the left and right cheeks of male facial images significantly correlated with ratings of facial attractiveness. It was also found that apparent health of skin influences male facial attractiveness, independent of shape information. More recent evidence for the association between perception of attractiveness and skin condition, although again in males, comes from Roberts *et al.*[12] These authors report that patches of skin from the cheeks of men being heterozygous at three loci in the major histocompatibility complex (MHC) were judged healthier than skin of homozygous men, and these ratings correlated with attractiveness judgements of the faces.

These studies were designed to control for possible age effects of different skin conditions rather than to study age-related variance of skin condition and its effects on facial attractiveness. Moreover, they did not differentiate between skin surface topography and skin colour distribution, although in view of evidence from medical studies, this seems to be of particular relevance, notably with investigations of age-related effects of skin condition on face perception. In this sense, recent research demonstrates that people are sensitive to variation in skin colour distribution, and that such variation affects visual perception of female facial attractiveness, healthiness and age, independent of surface topography cues.[13] However, this study removed skin surface topography cues such as fine lines and/or wrinkles, thereby isolating skin colour. Hence, on the basis of these data, no conclusion could be made on the relative effects of skin colour distribution and surface topography cues.

As we age, facial skin loses firmness, begins to wrinkle and develops discoloration and uneven pigmentation, particularly due to photoageing.[14,15] Thus, the judgement of facial skin age is influenced by the frequency of lines and wrinkles, but also by dyschromia and a decrease in bulk light reflection. Although the latter have been shown to alter female age perceptions by up to 20 years[13] and to affect heath judgements when skin topography cues are absent, it remains to be seen whether skin topography has a similar effect on perception and, indeed, how skin colour and topography relate to each other in this regard. We are aware of only one study, which has reported the effect of skin texture cues (lines and wrinkles) on age perception of facial composites. Perrett *et al*. used computer graphics technology to derive untextured composite faces (via digital image blending) when they studied the influence of parental age characteristics on facial attractiveness judgement. These composites were perceived to be an average of 5.8 years younger compared with the average biological age of the participants, suggesting that skin topography cues do indeed affect age perception. However, the relative strength of topography and skin colouration cues in influencing perception remains to be investigated.

Here, we report data of visual perception of facial images of females, aged 40 years and older, varying systematically in skin colour distribution and topography. The aim of the present study was to investigate (i) whether skin colour distribution and skin surface topography cues do significantly influence the perception of age and health of female faces and (ii) if they convey differential information with regard to the strength of theses effects. Our hypothesis was that, in the presence of both skin pigmentation and skin topography cues, the latter is a stronger age cue, whereas even skin colour distribution is perceived as more healthy.

Methods

Stimulus material

A total of 170 British women from the ages of 11 to 76 years (mean age, 37.39 years; SD, 17.35) was recruited and photographed from three views: frontal, left and right profile. This was achieved using a custom digital imaging rig comprising a 6.2-megapixel digital single-lens reflex camera fitted with a Nikon 45 mm 1 : 2.8P lens (Nikon Corporation, Tokyo, Japan), a fully cross-polarized multiple flash lighting system and a chin rest to ensure accurate, reproducible positioning of subjects and overall component stability. Images were captured and stored in uncompressed TIFF format at a resolution of 3277×2226 pixels and 72 dpi. Women did not use make-up, and any adornments were removed for the photography. No colour correction or spatial filtering was applied to these images. Of the original sample, we randomly selected 50 frontal images of women aged 40 and older so that our final set comprised women between the ages of 40 and 74 (mean age, 52.22 years; SD, 9.41). Images of women younger than 40 years of age were excluded because we wanted to ensure that our source images contained a sufficient dynamic range of both colour and topographical discontinuity to ensure sensitivity in probing the relative contribution of these two endpoints to perception. Previous large-base imaging studies have shown that both topographic and pigmented facial skin features accumulate progressively up to at least 60 years of age in a variety of ethnic populations, including Caucasians.[16]

From these images, four types of stimuli sets were created: *Set 1*, original (unmodified) faces; *Set 2*, faces with skin topography cues removed; *Set 3*, faces with skin

fig. 1 Sample stimulus image series of face Sets *1* to *4*. *Set 1*, original (unmodified) faces; *Set 2*, faces with skin topography cues removed; *Set 3*, faces with skin colour smoothed; *Set 4*, faces with skin topography cues removed and skin colour smoothed.

colour smoothed; *Set 4*, faces with skin topography cues removed and skin colour smoothed. Skin topography cues refer to surface characteristics such as facial furrows, folds, lines and wrinkles. In the faces of *Sets 2* and *4*, these features were removed digitally at the mouth, nose (naso-labial folds), forehead and also the peri-orbital region using the ‘healing’ tool in Adobe Photoshop 7.0 (Adobe Systems Inc., USA) i.e., samples of un-affected skin adjacent to the respective feature being cloned to replace them. Image processing was done on a duplicated layer. The digital brush was set to a size of 10 pixels, and images were enlarged by 400% before manipulation. ‘Skin colour’ refers to the evenness of pigmentation cues, which has been shown to affect perception of age and attractiveness of female faces.[13] Variation in skin colour evenness is driven by the homogeneity of the skin chromophores melanin and haemoglobin, which decreases with age because of the accumulation of local concentrations of these molecules, particularly in sun-exposed areas.[17] In the faces of stimuli *Sets 3* and *4*, the visible skin colour features associated with aged/photoaged skin (i.e. brown features such as lentigos/diffuse hyper-pigmentation and red features such as telangiectasia) were removed. All digital image manipulations were made by a naïve assistant who was blind to the hypotheses of the study, and resulting images were also cross-checked by another naïve assistant for consensus on the extent of manipulation.

Finally, the facial outlines (including the hair) of all stimuli were masked and the resulting images were then scaled to 570 × 650 pixels at 72 dpi in order to fit into the experiment presentation software. A sample image series of *Sets 1* to *4* are shown in fig. 1.

Rating study

A total of 200 participants (102 males and 98 females) from the local German population in Goettingen between the ages of 16 and 45 years (mean age, 24.49 years; SD, 4.33) rated the stimulus faces on colour-corrected TFT monitors (IBM Lenovo R60, IBM, White Plains, NY) set to a resolution of 1400 × 1050 pixels at 32-bit (‘true colour’) colour depth. There were 50 (different) raters for each of the four face sets. A one-way ANOVA indicated that the mean age of raters of the face sets did not significantly differ from each other ($F_{3,196} = 0.244$, $P > 0.05$).

All 50 faces per experiment were presented randomly in blocks on the screen using MediaLab software (Empirisoft Corp., New York, NY). Each participant was requested to estimate the biological age of the face using a single-year step scale ranging from 10 to 90 years and to rate each face for perceived health using a 7-point rating (1 = lowest rating of attribute, 7 = highest rating of attribute).

Results

A one-way repeated measures ANOVA was done to compare the means of estimated ages of faces of *Sets 1* to *4* and also the mean health ratings. The means and standard deviations are presented in Table 1. Mauchley’s test of sphericity indicated that the assumption of sphericity had been violated for both variables (age: $\chi^2 = 67.60$, health: $\chi^2 = 30.24$; all $\varepsilon < 1$, all $P < 0.05$); therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity. Only Bonferroni-corrected post hoc tests results are presented.

Age

The results indicate that there were significant differences of mean age estimates of the four face sets (Wilks’ Lambda = 0.16, $F_{1.69,82.60} = 186.94$, $P < 0.0001$); an overall effect size of 0.79 (partial η^2) showed that about 80% of the variation in perceived age can be accounted for by the

Table 1 Descriptive statistics for perceived age and health of female faces varying in skin colour and topography

Face set	*n*	Mean	SD
Age			
1	50	55.68	13.76
2	50	44.84	11.21
3	50	54.63	13.08
4	50	39.83	10.05
Health			
1	50	3.73	0.75
2	50	3.81	0.79
3	50	4.00	0.69
4	50	3.76	0.73

Note: *Set 1*, original (unmodified) faces; *Set 2*, faces with skin topography cues removed; *Set 3,* faces with skin colour smoothed; *Set 4*, faces with skin topography cues removed and skin colour smoothed.

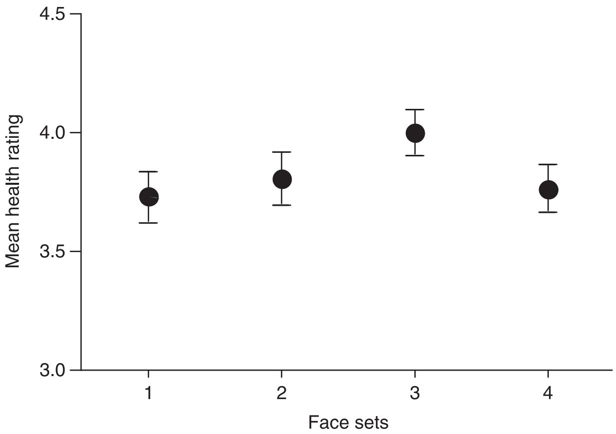

fig. 3 Means ± SE of perceived health of face Sets *1* to *4*. *Set 1*, original (unmodified) faces; *Set 2*, faces with skin topography cues removed; *Set 3,* faces with skin colour smoothed; *Set 4*, faces with skin topography cues removed and skin colour smoothed.

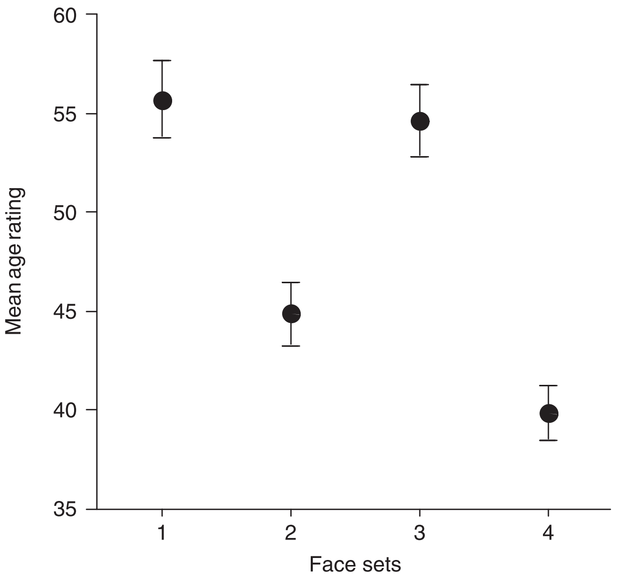

fig. 2 Means ± SE of estimated age of face Sets *1* to *4*. *Set 1*, original (unmodified) faces; *Set 2*, faces with skin topography cues removed; *Set 3*, faces with skin colour smoothed; *Set 4*, faces with skin topography cues removed and skin colour smoothed.

different levels of apparent skin condition. Faces with topography cues removed and colour smoothed (*Set 4*) were judged youngest (see Table 1 and fig. 2). Pair-wise comparisons revealed significant differences between all combinations of face sets with the largest difference (–15.85 years, $P < 0.001$) between faces of *Sets 1* (unmodified) and *4* (topography cues removed and colour smoothed), and the smallest difference (–1.05 years, $P < 0.05$) between faces of *Sets 1* and *3* (colour smoothed). The mean difference of estimated age between faces of *Sets 2* (topography cues removed) and *4* (topography cues removed and colour smoothed) was –5.02 years ($P < 0.001$). We concluded, therefore, that skin surface topography cues had a significantly stronger influence on facial age perception than skin colour distribution.

Health

A significant effect of skin condition on perceived health of faces was found (Wilks' Lambda = 0.52, $F_{2.26,102.87} = 6.53$, $P < 0.001$), which accounted for 12% of variation in health perception (partial $\eta^2 = 0.12$). Faces with smoothed skin colour (*Set 3*) were rated highest (see Table 1 and fig. 3). Pair-wise comparisons revealed that the main effect was caused by the significant difference between faces of *Set 3* (colour smoothed) against all other face sets with the largest difference of mean ratings to faces of *Set 1* (unmodified; 0.27, $P < 0.001$), followed by the faces of *Sets 4* (topography cues removed and colour smoothed; 0.24, $P < 0.001$) and *2* (topography cues removed; 0.20, $P < 0.01$). We concluded, therefore, that the absence of facial discoloration is a key indicator of health.

Discussion

The results of the present study suggest that people are sensitive to cues of both visible skin colour distribution and skin surface topography when making judgements of facial age and health, two attributes that are probably most influential in the evaluation of human facial attractiveness.[18,19] However, our data also indicate that skin colour and topography cues convey differential information with regard to the strength of effect on age and health judgements. The removal of skin surface topography cues (such as fine lines and wrinkles), but preservation of skin colour information, resulted in a decrease of estimated age of female faces of about 10 years compared with the age judgements of unmodified faces. In contrast, digital smoothing of facial discoloration resulted in a decrease of perceived age of 1 to 5 years. Female faces were judged youngest when combining these image manipulations (i.e., when both surface topography cues were removed and skin colour was smoothed, there was a decrease in perceived age of approximately 15 years). This indicates that, although the manipulation of both variables affected perceived age, skin topography cues accounted for the larger proportion of variation in age estimation, which supports previous reports by Perrett *et al*. These authors used image composite techniques to create face sets with and without texture cues and found that texture information contributes significantly to perception of facial age and attractiveness. The techniques used in this present study were different, the Photoshop 'healing' tool being used for our colour and topography manipulations in original high-resolution digital images of participants. We acknowledge that concerns could be raised as to the subjectivity of these manipulations (and intend to address these in future studies). We do believe, however, that in view of the aims of this study (i.e. the synthesis of face sets differing in skin topography and colouration cues), the use of original, individual facial images has some advantage as it retains the full skin colour and topography information of each face (which is partly lost or smoothed with digital blending). This applies to both skin topography and colour cues, the inevitable result of such image manipulation being that skin colour evenness increases. In the present study, we wanted to preserve precisely the original, unmodified colour distribution signal, given that two recent studies have shown that this plays a significant role in the judgement of facial age, attractiveness and health.[13,17]

It was noted that the apparent contribution of skin colour evenness to age perception was larger in stimulus faces in which topography cues had been removed first, relative to faces in which topography cues were preserved and colour smoothing performed around these features (approximate age differences of 5 and 1 years vs. original, respectively). This may reflect the relative technical difficulty of achieving complete colour smoothing when topography and colour cues were co-located (common in photoaged faces). Nevertheless, it is clear that, for both values (1 and 5 years), colour provides a smaller age signal than topography.

The pattern was different, however, with regards to health judgements from images of female faces. The highest ratings for perceived healthiness were obtained for stimulus faces with only a smoothing of skin colour. Removing surface topography resulted in a marginal increase in health rating, whereas faces with smoothed skin colour were rated significantly more positively compared to both unmodified faces and to faces with skin topography cues removed. Interestingly, faces with skin topography cues removed and skin colour smoothed did not receive the highest health judgements.

The few studies on human physical appearance that have considered apparent skin condition provide accumulating evidence on the importance of visible skin condition on perception of facial attractiveness. In view of the evolutionary psychological assumption that male mate preference reflects the adaptive mechanism of evaluation of female appearance with respect to their eligibility as potential partner, age and health are probably the most important attributes in this context. However, most of the studies have been performed using premenopausal women at college age[9] or using male subjects.[10–12] Little, thus, is known about these phenomena in a broad female population. Fink, Grammer, and Matts[13] reported that people judge female faces on attributes other than facial shape and form. These authors created virtual three-dimensional stimuli from high-resolution digital facial images that were standardized with respect to face shape, feature and skin surface topography. Practically, new computer techniques allowed the mapping of the skin colour distribution from 170 images of women aged 11 to 76 years onto the three-dimensional standardized head of a young woman, meaning that the perceptual impact of skin colour evenness could be studied single-variably. It was observed that skin colour distribution alone was able to strongly influence visual perception of facial age and judgements of attractiveness, health and youth. Although the dynamic range of the estimated ages from this study indicated that visible facial colour distribution can account for up to 20 years of apparent age, independent of face shape and skin surface topography, the ecological validity may be questionable.

In normal ageing skin, intrinsic and extrinsic factors affect are responsible for changes of pigmentation and skin surface topography, although the latter are usually more pronounced in older individuals.[14] It seems, therefore, plausible to argue that in premenopausal women and particularly those at college age who comprise the most common samples in attractiveness research, skin coloration is more important with regard to facial appearance than skin surface topography. In the sample used in the present study, comprising women aged 40 and older, removal of topography cues had a much stronger effect on facial age perception than skin colour smoothing, although the diminution of both variables resulted in the greatest decrease in perceived age.

It is perhaps puzzling why faces with both topography and discoloration cues removed did not receive the highest health ratings. We consider this likely due to these faces reflecting an 'artificial' signal, which, in this combination, is naturally not present. Our data indicate, however, that even in the presence of topography cues (which are associated strongly with age), we are sensitive to skin coloration cues and relate them to healthiness. Put another way, these present data reveal that, in mature women, a diminution of facial discoloration can result in a significant increase of perceived health and, in turn, a concomitant increase in perceived attractiveness. Perhaps we have uncovered the importance of even skin coloration in the hitherto unqualified notion of 'growing old gracefully'.

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