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Visible skin color distribution plays a role in the perception of age, attractiveness, and health in female faces☆

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Abstract

Evolutionary psychologists have proposed that preferences for facial characteristics, such as symmetry, averageness, and sexual dimorphism, may reflect adaptations for mate choice because they signal aspects of mate quality. Here, we show that facial skin color distribution significantly influences the perception of age and attractiveness of female faces, independent of facial form and skin surface topography. A set of three-dimensional shape-standardized stimulus faces—varying only in terms of skin color distribution due to variation in biological age and cumulative photodamage—was rated by a panel of naive judges for a variety of perceptual endpoints relating to age, health, and beauty. Shape- and topography-standardized stimulus faces with the homogeneous skin color distribution of young people were perceived as younger and received significantly higher ratings for attractiveness and health than analogous stimuli with the relatively inhomogeneous skin color distribution of more elderly people. Thus, skin color distribution, independent of facial form and skin surface topography, seems to have a major influence on the perception of female facial age and judgments of attractiveness and health as they may signal aspects of underlying physiological condition of an individual relevant for mate choice. We suggest that studies on human physical attractiveness and its perception need to

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consider the influence of visible skin condition driven by color distribution and differentiate between such effects and beauty-related traits due to facial shape and skin topography.

Keywords: Humans; Face; Skin condition; Age; Attractiveness; Sexual selection

1. Introduction

Coloration of feather and skin is known to influence sexual attractiveness in a wide variety of nonhuman animals (Andersson, 1994), and studies on pigmentation in birds have suggested that color signals may directly signal immunocompetence and health (Blount, Metcalfe, Birkhead, & Surai, 2003; McGraw & Ardia, 2003). A number of studies with birds have demonstrated that carotenoid-based coloration affects mate choice (e.g., McGraw & Hill, 2000). Although physical attractiveness in humans and its perception have been studied extensively in the past few years (see, for a review, Fink & Penton-Voak, 2002; Grammer, Fink, Møller, & Thornhill, 2003), there is only limited information available on the potential signaling value of visible skin color. It has been suggested that skin color has a significant effect on human mate selection since paler skin is a youthful and desired feature (Darwin, 1871; Frost, 1988; Van den Berghe & Frost, 1986), especially in women, but, to our knowledge, there have been only two empirical tests of this hypothesis in women.

Fink, Grammer, and Thornhill (2001) demonstrated that women's facial skin texture affects male judgment of facial attractiveness and found that homogeneous skin (i.e., an even distribution of features relating to both skin color and skin surface topography) is most attractive. Further, it was found that a slightly reddish skin (which may indicate more efficient blood circulation) is considered attractive and healthy. Analogous to the manner in which coloration plays a role in mate choice in birds, therefore, visible color and color distribution in human facial skin may provide an indication of the age, health, and attractiveness of the respective individual. More recently, Jones, Little, Burt, and Perrett (2004) demonstrated 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.

The findings of these two studies lend some support to the notion that skin color distribution influences facial attractiveness and suggest that attractive physical traits positively influence the perception of an individual's health. However, both studies used facial photographs of Caucasian men and women at college age (i.e., 18–25 years), which is not representative with regard to the variance in skin condition, which is probably small within that age range and may, thus, only provide information about a particular age group. Moreover, both 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. Some recent evidence for the association between perception of attractiveness and skin condition, though in males, comes from Roberts et al. (2005). 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 judgments of the faces.

All those studies that investigated apparent attractiveness and health of skin did not differentiate between skin surface topography and skin color distribution. However, in view of evidence from medical studies, this seems to be of particular relevance. In addition to changes in skin appearance due to chronological aging, there is consensus among the scientific and medical communities that exposure to ultraviolet radiation (UVR) in ordinary sunlight is a major factor in the etiology of the progressive, undesirable changes in the appearance of skin (chronic photodamage/photoaging) and in the risk of skin cancer (American Academy of Dermatology Consensus Conference, 1988; Bergfeld et al., 1997; Council of Scientific Affairs, 1989; Fisher et al., 1997; IARC, 1992; IARC, 2001; National Institutes of Health, 1989; Wlaschek et al., 2001). Caucasian skin is particularly prone to ultraviolet (UV) light injury (e.g., de Gruijl, 1999), and episodes of sunburn, even in childhood, have been shown to be associated with an increased risk factor for photocarcinogenesis, photoaging, and photoimmunosuppression (e.g., Naldi et al., 2005). It is likely that organisms with a higher resistance against such risk factors are also favored in contests for a mate and are, therefore, perceived as more attractive.

The present study investigated the perception of facial age and attractiveness in relation to apparent skin color distribution. Since age and attractiveness are known to be influenced by facial form (Perrett, May, & Yoshikawa, 1994) and facial furrows (Leveque & Goubanova, 2004), a set of three-dimensional (3D) shape-standardized stimulus faces was generated, which varied only in terms of visible skin color distribution and chronological age, respectively. We hypothesized that visible facial skin color distribution significantly influences the perception of biological age and attractiveness of females. Clearly, shape-standardized faces with the applied skin color distribution of young people should be perceived younger, healthier, and more attractive than shape-standardized faces that receive the skin color distribution of older people. If this hypothesis were true, it would argue for an influence of visible skin color distribution on the perception of female facial attractiveness.

2. Methods

2.1. Stimulus material

A total of 170 British women from the ages of 11 to 76 years (mean age=37.39, S.D.=17.35) were recruited and photographed from three views: frontal, left, and right profiles. This was achieved using a custom digital imaging rig comprising a 6.2-megapixel digital single-lens reflex camera fitted with a Nikkor 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. No color correction or spatial filtering was applied to these images. One image was finally removed from the sample because of problems with image quality, resulting in a final set of n=169 faces (with three views of each).

Full cross-polarization of the light source was used to effectively eliminate visible high-frequency/low-amplitude skin surface topography ("microtexture"). In order to avoid the potential influence of high-amplitude skin surface topography (i.e., facial furrows, folds, lines, wrinkles) on age perception and attractiveness ratings, we carefully removed these features at the mouth, nose, and at the orbital region using the soft cloning stamp in Adobe Photoshop 7.0 (Adobe Systems Inc., USA), with samples of unaffected skin adjacent to the respective feature being cloned to replace them. For the creation of two-dimensional (2D) skin color maps, each face was fitted onto a 2D template by matching the position of pupils and mouth gap with the template. These 2D skin color maps used frontal and side views of images, thus preserving the 3D information (spatial color distribution) of the faces. The individual 2D skin color maps were then matched with a template grid in order to fit on a shape-standardized 3D wire-frame mesh on the basis of definition of digital somatometric landmarks for the eyes and the mouth and the use of thin-plate spline algorithm (for details about the methodology, see Bookstein, 1997). Before the final rendering of 3D faces, test renders were made in order to detect possible artifacts until the results were satisfactory.

Final rendering of 3D faces was achieved using Poser 6 (e-frontier, Scotts Valley, CA, USA). The virtual camera position of the render engine was set to the middle of the face with a focus of 160 mm in order to avoid optical distortion. Camera plane and face plane were parallel. Render size was set at 650×816 pixels, resulting in faces of 19 cm length at a screen resolution of 1600×1200 pixels. The result was a set of n=169 3D facial images, standardized

Fig. 1. 3D facial images, standardized in shape but preserving individual skin color distribution of the original 2D facial photographs. "Real age" refers to the age of the participant from which the digital photograph was taken, and "Estimated age" denotes the mean (with decimals removed) of estimated age from all participants for the final 3D stimulus face.

in shape while preserving the individual skin color variation of the original 2D facial photographs (Fig. 1). In order to increase photo-realism, a skin-shading system was used, which added subsurface scatter (i.e., light passing through and diffusing within a thin translucent material) to the skin color maps. Hairstyle and eye color were also kept constant within all images. Lighting was fixed within each image by applying two virtual light sources. Shadow mapping was performed using one virtual light source, and the second virtual light source used ambient occlusion in order to further enforce the same shape on the skin color map for the observer. To guarantee a consistent color work environment, we carried out all photo manipulations, the stimulus generation, and the final ratings of stimuli on color-corrected monitors (LaCie electron 19blue IV, LaCie, Hillsboro, OR, USA).

2.2. Rating study

A total of 430 participants (198 males and 232 females), mainly nonstudents, between the ages of 13 and 76 years (mean age=29.45, S.D.=12.24) rated the stimulus faces on color-corrected CRT monitors (LaCie electron 19blue IV, LaCie) set to a resolution of 1600×1200 pixels. Faces were presented randomly on the screen, and each participant rated 10 randomly selected stimuli. Participants were requested to estimate the biological age of each face using a single-step scale ranging from 10 to 60 years. In addition, participants were asked to rate each face for three global descriptors of facial perception (attractive, healthy, and youthful) and 12 aspects of skin condition in particular (luminous, even tone, clear/translucent, pure, mottled, beautiful, firm, elastic, aged, wrinkled, soft, and smooth) using a 10-point rating. A final question probed the ease with which participants were able to perform the rating task, using a 10-point scale (1=*difficult* to 10=*easy*). Here, we report only the statistical results of the ratings for perceived attractiveness, healthiness, and youthfulness, which (a) are most relevant to the perception of overall facial appearance and (b) enable a more ready comparison with previous studies.

3. Results

The estimated biological age (aggregated estimates from all judges for each face) of facial images ranged from 17.8 to 36.7 years (mean age=24.47, S.D.=7.14), a span of some 20 years. A one-sample Kolmogorov–Smirnov goodness-of-fit test indicated that actual and estimated age and all three attributes were normally distributed (actual age: Z=1.043, p=.227; estimated age: Z=.989, p=.282; attractive: Z=.410, p=.996; healthy: Z=.600, p=.864; youthful: Z=.883, p=.416). There was a significant positive correlation (Pearson's r) between the actual biological age of the subjects who provided facial images and the corresponding estimated age of their 3D shape-standardized faces varying only in visible skin color distribution (r=.708, p<.01, two tailed). Significant negative correlations emerged between estimated facial age and the global face attributes (attractive: r=−.557, p<.01; healthy: r=−.543, p<.01; youthful: r=−.871, p<.01). Reliability of male and female perception of age and rated attributes was high with Cronbach α values between .60 and .83, the exception being the question relating to the ease with which participants were able to perform the rating task (Cronbach α=.064). On average, males considered the evaluation of female attractiveness and age-related changes of skin color distribution to be a significantly easier task than females (t=2.056, df=168, p<.05).

On the basis of our results, visible skin color distribution appears to have major influence on the perception of female facial age and judgments of attractiveness, health, and youth.

4. Discussion

The results presented suggest that visible skin color distribution plays an important role in subjective evaluation of female facial beauty. Our investigation further indicates that people judge female faces on other attributes in addition to facial shape and form. It was also found that males performed better with this task than females. To clarify this, we standardized the stimuli used in the present study with respect to their facial form and we removed information relating to skin surface topography. Thus, they differed only with respect to the skin color distribution from the original images. As significant variance was observed with visual perception of facial age and judgments of attractiveness, health, and youth, this signal, therefore, can only be due to changes in visible skin color distribution. The remarkably high correlations between estimated age and facial attributes suggest that human skin condition has a signaling value independent of facial form and topography, probably indicating aspects of an individual's physiological condition, which are relevant for mate choice. Finally, it is also worthy of note that, as regards the high correlation between actual biological age and that perceived in derived stimuli, the dynamic range of the estimated ages indicates that visible facial color distribution can account for up to 20 years of apparent age, independent of facial form and skin surface topography.

There is evidence for an association between color display and mate choice in insects such as butterflies (Ellers & Boggs, 2003) and in fish (Amundsen & Forsgren, 2001) and lizards (LeBas & Marshall, 2000). These studies demonstrated that males preferred less-melanised or brightly colored females, suggesting that visual displays are intersexual signals resulting in male mate choice of particular females. Evidence for the role of coloration can also be found in studies using nonhuman primates. Waitt et al. (2003) report that female rhesus macaques preferred males with red facial coloration by suggesting that male coloration may thus provide a cue to male quality. Setchell, Wickings, and Knapp (2006) report an increase in facial coloration of female mandrills, proportional with age, and suggest that color may, therefore, signal reproductive quality. Knowledge about the potential signaling value of human skin has been based mainly on speculation, although studies report some correlation between facial attractiveness and/or apparent health in males (Jones, Little, Feinberg, et al., 2004; Jones et al., 2005) and females (Fink et al., 2001; Jones, Little, Burt, et al., 2004). These studies, however, did not differentiate between skin surface topography and skin color distribution. Our data indicate that the latter affects, to a significant degree, perception of age, attractiveness, and health in females. Two possible explanations for this phenomenon are considered below.

Firstly, female body features are linked to age and reproductive condition, both of which are presumed to correlate with a woman's ratio of the hormones estrogen (E) to testosterone (T; Grammer et al., 2003; Symons, 1995). Attractive signals usually correspond to high E/T ratios. Recent evidence for this assertion is provided by Law Smith et al. (2006) who report that facial femininity, attractiveness, and apparent health are a cue to E levels in women and, by deduction, probably to reproductive health. Studies in dermatology have found a relationship between dermatoses (i.e., physiological and pathological changes of the skin) and an increase of the level of androgens in women (e.g., Held, Nader, & Rodriguez-Rigau, 1984). Overproduction of androgens, with associated clinical manifestation of dermatoses, is often due to a malfunction of the ovaries (Schiavone, Rietschel, & Sgoutas, 1983). Consequently, some dermatoses may denote a disturbance in the balance of T and E and reduced female reproductive ability and condition. Thus, information from the visible skin may be crucial for male mate choice since phenotypic modifications seem to be closely associated with genetic constitution. Organisms with a higher resistance against parasites are thought to be favored in contests for a partner (Grammer & Thornhill, 1994). A reduced immune defense may also be responsible for higher susceptibility to parasites and pathogens, and this may be traced back via skin condition. The finding by Roberts et al. (2005) about MHC heterozygosity and the associated increase in ratings of healthiness of skin patches provides some support for this assertion since MHC genes code for proteins involved in immune response.

Secondly, besides such effects, which are clearly linked to hormonal status, visible skin condition is also subject to huge variation due to chronic photodamage as a result of cumulative lifetime exposure to UVR in ordinary daylight, which results in undesirable skin changes such as dryness, roughness, actinic keratoses, irregular pigmentation (freckling/lentigines), wrinkling, elastosis, loss of elasticity, dilated/tortuous surface blood vessels, blackheads (solar comedones), and sebaceous hyperplasia (Boyd et al., 1995; Gilchrest, 1996; Taylor, Stern, Leyden, & Gilchrest, 1990). The incidence and severity of these skin changes are a function of cumulative solar UVR exposure as supported by human survey and experimental data (e.g., Berg, 1989; Contet-Audonneau, Jeanmaire, & Pauly, 1999; Wlaschek et al., 2001). In this present study, we have taken considerable care to specifically remove photoaging endpoints related to cutaneous form and topography from the final stimuli used for rating. It is possible, therefore, to predict with some confidence the origin of the considerable differences noted in the single, resulting variable—visible skin color distribution. Importantly, all of the processes discussed above result in a significant increase in visible skin color unevenness and contrast that are probably responsible for the perceived changes in age, health, and beauty, independent of facial form and skin surface topography, reported in this study. It is clear, though, that future studies will be needed to identify and quantify the skin chromophores responsible for these visible effects.

In summary, therefore, we suggest that studies on the perception of human physical attractiveness need to consider the influence of facial skin color distribution and differentiate between such effects and other shape-related traits including skin surface topography. The finding that men reported a greater ease in the judgment of female faces was interesting, but it requires further investigation before we can say whether they have developed some adaptive preferences for the evaluation of female attractiveness, health, and youth, which also relate to skin condition, or if this result merely indicates a male tendency to overestimate their perceptual abilities.

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