# Chronic sun damage and the perception of age, health and attractiveness

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Young and healthy-looking skin is a feature that is universally admired and considered attractive among humans. However, as we age, skin condition deteriorates due to a variety of intrinsic and extrinsic factors determined not only by genetics and physiological health but also by behaviour and lifestyle choice. As regards the latter, cumulative, repeated exposure to solar ultraviolet radiation (UVR) is linked intrinsically to the induction of specific types of skin cancer and the expression of cutaneous damage markers responsible for the majority of the visible signs of skin ageing. Here we review empirical evidence for skin-specific effects of chronic UVR exposure and relate it to perception of visible skin condition. In contrast to other dermatological accounts, we stress an evolutionary psychology context in understanding the significance of age-related changes in visible skin condition in human social cognition and interaction. We suggest that the "marriage" of the scientific fields of skin biology and evolutionary psychology provides a modern, powerful framework for investigating the causes, mechanisms and perception of chronic sun damage of skin, as it explains the human obsession with a youthful and healthy appearance. Hence, it may be that these insights bring true emotional impetus to the adoption of sun protection strategies, which could conceivably impact skin cancer rates in coming years.

## Introduction

Skin "ageing" is defined by the normal process of chronological ageing super-imposed by the process of so-called "extrinsic" ageing, mediated by a variety of exogenous factors. While the former is a universal human constant, the latter is determined largely by behaviour and lifestyle choice. In this context, there now exists overwhelming evidence that ultraviolet radiation (UVR; 290–400 nm) in terrestrial sunlight is associated with a multitude of deleterious dermatological events. Acute exposure of unprotected skin to solar UVR causes numerous physiological effects, the most obvious of which is sunburn.[1] Chronic effects from repeated exposure to solar UVR include specific types of skin cancer[2,3] and a myriad of degenerative events responsible for the majority of the visible signs of skin ageing ("photoageing");[4,5] this article is concerned with the latter.

Recent years have seen a very rapid increase in knowledge concerning the etiology, epidemiology and prevention of chronic solar UVR damage (for reviews see ref. 3, 6, and 7). According to a recent survey of over 1000 women each in Germany, UK and the USA (Fig. 1a; results on file at Procter & Gamble), self-perceived facial skin ageing increases progressively over time and, by the fifth decade, over half reported visible signs of photoageing in their own skin (wrinkling and hyper-pigmented spots). In the same survey, 80–90% of women also believed that both daily and past sun exposure or sunburn were contributing factors to older-looking skin (Fig. 1b). The message that exposure to solar UVR damages the appearance of skin is, therefore, clear and apparently understood. Thus, it is interesting that, whereas 80–90% of those women surveyed reported the use of sunscreens, only 20–50% reported use of a sunscreen while sun-bathing, while $<10\%$ reported always wearing a sunscreen when outside (Fig. 1c). In other words, whilst acknowledging the undesirable, visible skin effects of cumulative, chronic solar UVR exposure, the majority of women do not take steps to moderate this phenomenon.

## The "marriage" of skin biology and evolutionary psychology

These survey data sit uncomfortably alongside the results of recent and on-going research conducted in the rapidly growing field of evolutionary psychology,[8,9] which provides empirical evidence that human physical appearance (and "attractiveness" in particular) has significant influence on social interaction and mating behaviour (reviewed in ref. 10–12). Indeed, there is evidence that we unconsciously assign positive qualities to those we perceive as attractive[11,13,14] and that physical attractiveness is an important criterion for human mate selection.[15] In fact, the perception of facial attractiveness seems to be remarkably consistent, regardless of race, nationality, or age.[16] It should not be surprising, therefore, that we attach great importance to attractive, healthy and youthful-looking skin.[17,18] An improvement in facial skin appearance is accomplished relatively easily by the use of make-up,[19–21] although there is a modern trend toward the use of more invasive cosmetic "procedures", including chemical peels, the use of "fillers" and the injection of Botulinum toxin.[22] Of course, while these treatments are aimed at existing skin conditions, primary prevention would seem to be the better option, which makes the attitudes toward prophylaxis using sunscreens reported above all the more intriguing.

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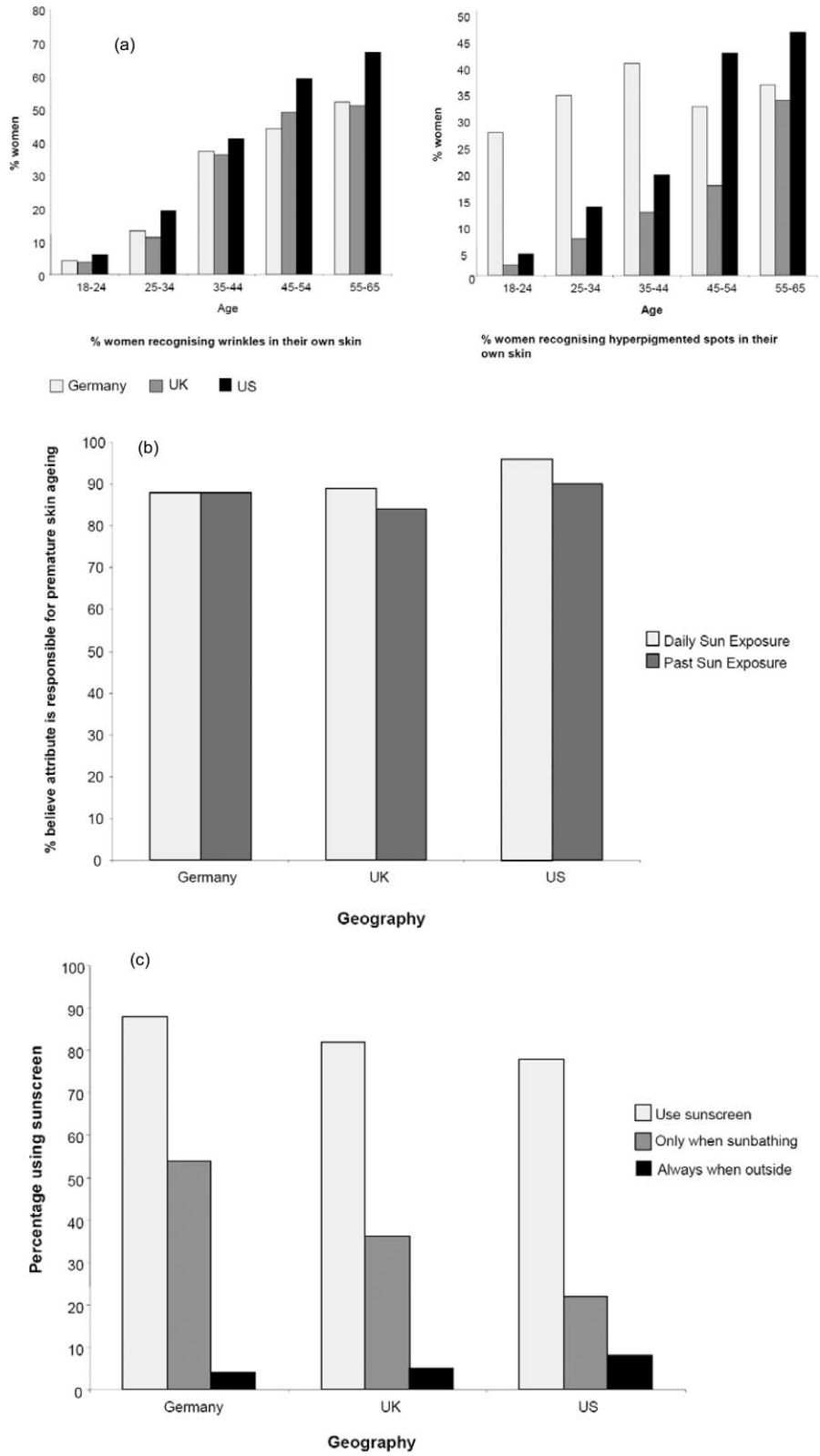


**Fig. 1** Results of a large-base survey conducted on women aged 18–65 years, 1000 each in the UK, Germany and the USA. (a) Percentage of women in different age groups recognising the appearance of wrinkles and hyper-pigmented spots in their own facial skin. (b) Percentage of women believing that daily and past sun exposure were contributing factors to older-looking skin. (c) Percentage of women using sunscreen in different scenarios.

 

Until recently, research into facial attractiveness focused predominantly upon the influence of symmetry, averageness and sexually dimorphic traits on appearance (for reviews, see ref. 23–29). All concluded that these physical characteristics probably reflect an individual's underlying genetic quality.[30] Facial symmetry, averageness and sexually dimorphic features are, however, relatively stable "macro" endpoints characterised by shape. Remarkably, it is only recently that researchers in the field of evolutionary psychology have started to consider facial skin itself as a visible marker of an individual's mate quality (in terms of health and reproductive potential). In studies that presented isolated fields of skin images to participants, it has been shown that people are very sensitive to variation in apparent skin condition. For example, when presenting small areas of skin cropped from the cheeks of male facial images to female judges, Jones *et al.*[31] found a positive correlation between health and attractiveness judgements, completely independent of information relating to face shape. Moreover, in an attempt to link the perceived attractiveness of visible skin condition to the genetic quality of the viewer, Roberts *et al.*[32] demonstrated that small areas of skin cropped from facial images of men heterozygous at all three loci of the major histocompatibility complex were judged by women to be both healthier and more attractive than cropped skin images of men who were homozygous at one or more of these loci.

Considered as a whole, it seems that there needs to be a far greater understanding of the relationship between the known skin-specific effects of chronic UVR exposure and the perception of such effects, given the evidence which is now starting to accumulate for the significance of skin in human social cognition and interaction. To this end, in recent years we have been engaged in a unique collaboration between the fields of skin biology, its measurement and evolutionary psychology. Here we review relevant findings and latest insights from this "marriage" of science disciplines, as they relate to chronic sun damage and the perception of age, health and attractiveness.

## Photoageing and changes in visible skin condition

There is consensus among the scientific and medical communities that chronic exposure to UVR in ordinary sunlight is a major factor in the etiology of the progressive undesirable changes in the appearance of skin.[2,3,33–38] Indeed, as simple within-subject evidence of the phenomenon of photoageing, one need only compare and contrast those areas of the body that receive a relatively low lifetime dose of solar UVR (*e.g.*, skin on the buttock or volar forearm) to those receiving a corresponding higher dose (*e.g.*, skin on the face, neck or dorsal forearm). Fig. 2 provides an example of this universal human observation.

The undesirable skin changes associated with chronic photodamage include: dryness, roughness, actinic keratoses, irregular pigmentation (freckling/lentigines), wrinkling, elastosis, loss of elasticity, dilated/tortuous blood vessels (telangiectasia), blackheads (solar comedones) and sebaceous hyperplasia.[4,37,39] Various dosimetry and modelling studies have demonstrated wide variation in personal exposure to solar UVR, accounted for not only by the obvious effects of geography and season, but also by the very significant effect of behaviour and lifestyle (*e.g.*, indoor *vs.* outdoor occupation, involvement in outdoor sports/recreation, choice of holiday location, *etc.*).[40–43] That the skin changes mentioned above

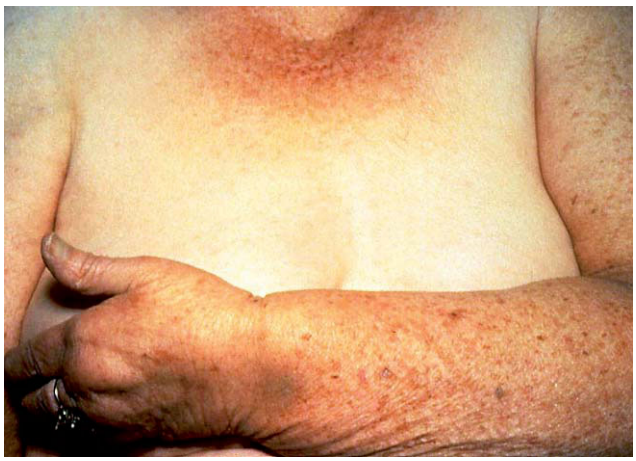

**Fig. 2** Juxtaposition of prominent chronic UVR damage on sun-exposed skin (arms, upper chest/neck) and remarkably smooth, unblemished skin within non-sun exposed areas within the same subject (image courtesy of Professor Ronald Marks).

are the result of such cumulative solar UVR dose is supported by human survey and experimental data:

- Caucasian women with a high sun exposure history have a higher incidence of chronic photodamage than women with a low exposure history.[44,45]
- Fair-skinned persons in areas of high insolation appear older than age-matched cohorts in areas of lower insolation.[46]
- Fair-skinned individuals with high sun exposure appear more aged than those with lower sun exposure within the same geographical area.[47]
- Areas of skin (face and neck) chronically exposed to low levels of sunlight exhibit significant signs of photodamage in dermal tissues compared to unexposed skin (inside upper arm or abdomen) in the same individuals.[38,48]

### Mechanisms of UVR-induced skin changes

Much insight into UVR-induced skin change has come from the use of animal models, specifically the SKH1 albino hairless mouse, used for over 30 years as a model for human photoageing (see the reviews in ref. 49–54). In this model, Bissett *et al.*[55] found that two waveband regions were responsible for all histological, physical and visible skin changes studied: 285–305 nm (predominantly UVB) and 315–360 nm (predominantly UVA). With the exception of skin sagging, shorter wavelengths of UVR were by far the most efficient at inducing changes in the skin of hairless mice, *i.e.* epidermal thickening, collagen damage, elastosis, and increases in glycosaminoglycan levels. UVA can produce elastosis in the hairless mouse, but only at high doses.[56] Although the role of UVA radiation in chronic photodamage in man is not fully understood, the potential of these wavelengths to cause skin change cannot be ignored. The UVR in ordinary daylight is predominantly UVA, which is forward-scattered into deeper skin layers compared to shorter wavelengths.[57]

Research in recent years has provided clearer insight into mechanisms for these effects at the molecular level. For example, Fisher and co-workers,[36,58–60] conducted a series of experiments on the buttock skin of human volunteers (not normally exposed to UVR). In these studies, UVR up-regulated AP1-1 and NF-κB binding to

DNA, known stimulators of matrix metalloproteinase (MMP) expression. Since metalloproteinases are known to degrade collagen and elastin in the skin, it was hypothesised that induction of MMPs may be a primary mechanism mediating cutaneous photoageing. These observations were supported further by Berneburg *et al.*[61] While it appears that free radical damage is part of the normal ageing process of the skin,[6] further free radical damage by UVR-generated reactive oxygen species (ROS) probably plays an important additional role in photoageing. Garmyn *et al.*[62,63] proposed a damage model whereby UVR produces sufficient ROS (and consequent free radicals) to overwhelm antioxidant defences, leading to oxidative damage of all skin components (proteins, lipids and DNA), leading eventually to chronic visible change in skin appearance. This hypothesis is supported by the work of Scharffetter-Kochanek and colleagues, demonstrating apparent ROS-involvement in the UVA-dependent induction of MMP-1, MMP-2 and MMP-3[64–67] and the involvement of hydroxyl radical and lipid peroxidation intermediates in the UVB-induction of MMP-1 and MMP-3.[68,69]

### Relation of UVR-induced skin changes to appearance

How is this damage expressed in the skin components governing appearance? First of all, it is well established that UVR can cause changes in the relative composition and deposition pattern of the dermal matrix proteins, collagen and elastin.[70] It is now known that chronic exposure to sub-erythemal doses of UVR can cause significant damage to collagen and elastin in hairless mice.[49,50,71,72] These *in vivo* data are supported by the molecular mechanistic studies of Fisher *et al.*[36,58] Wlaschek *et al.*[38] provide a compelling case for a major role for ROS in the induction of changes in gene expression pathways related to collagen degradation and elastin accumulation. The most obvious and striking visible features of this photodamage are skin wrinkling, roughness and sagging (see Fig. 3), because the consequent loss of collagen density reduces tensile strength while abnormal expression of elastin leads to a significant reduction in the spring-like, elastic properties of skin. The delicate surface structure of youth ("microrelief", an intricate isotropic arrangement of discrete primary and secondary lines of 20–200μm in depth, intersecting at regular intervals to form polygonal plateaus[73]), therefore, changes progressively such that much of the finer secondary structure is lost and anisotropy increases as the primary lines become the dominant feature.[74–76] Superimposed upon these changes is the progressive development of deeper invaginations of the skin surface, forming the structures commonly known as "lines and wrinkles". These features are in the order of multiples of 100 μm in depth and develop particularly in areas of both chronic sun exposure and repeated flexure (the peri-orbital and naso-labial areas of the ageing face being classically associated with these features). There is varying opinion over the classification of wrinkles, although the four classes proposed and reviewed by Pierard *et al.*[76] (type 1, atrophic; type 2, elastotic; type 3, expressional; type 4, gravitational) all have their ultimate root in the compromised mechanics of atrophied dermal tissue, driven primarily by chronic photodamage.

While this effect on skin mechanical properties is relatively well characterised, it is not widely appreciated, however, that there is also an impact on skin optics. As collagen is the primary optical sub-surface scattering component within human skin, this progressive reduction in collagen density drives an accompanying reduction in intra-cutaneous bulk light transport and, therefore, perceived youthful "glow" or "brightness". Furthermore, chronic UVR exposure also leads to abnormal distribution of the two chromophores responsible for human skin colouration, melanin(s) and haemoglobin. In young, healthy skin, both constitutive and facultative melanin expression is uniform and synchronous, resulting in a homogeneous distribution of the melanin chromophore in both basal and sun-exposed sites.[77–79] Distribution is so homogeneous that skin colouration is essentially featureless, lacking visible contrast. Despite the apparent age-related loss of melanogenic activity in non-sun-exposed skin,[80] it is now well established that cumulative life-time exposure to solar UVR results in a progressive accumulation of "mottled hyperpigmentation", including "diffuse hyperpigmentation" (the "whispy" dyspigmentation commonly present on sun-exposed skin, not related to systemic disease), and solar lentigines (Fig. 4).[81–84] The molecular mechanisms for these phenomena are still not completely understood, although

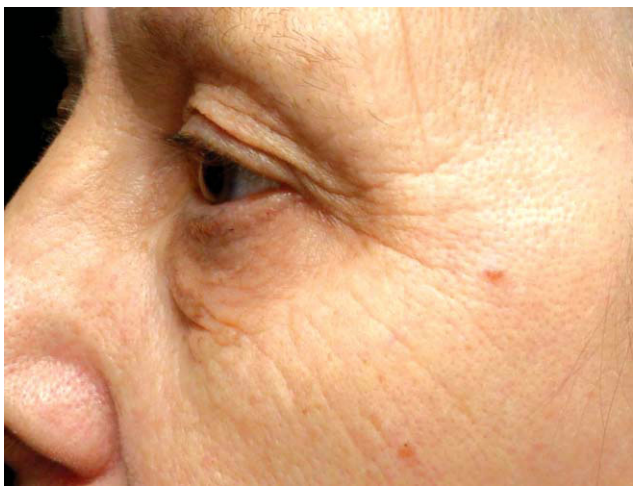

**Fig. 3** Peri-orbital wrinkling.

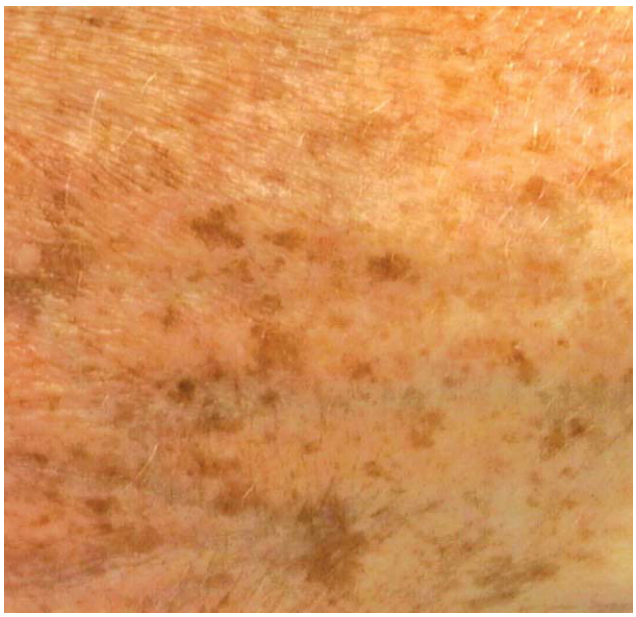

**Fig. 4** Lentigos and diffuse hyper-pigmentation.

 

it is thought that ROS mediate heterogeneity in melanocyte proliferation and activity.[85] Due to variation in epidermal melanin content and melanosome distribution, pigmentary alterations vary in their severity and manifestation among different ethnic groups (reviewed in ref. 86 and 87). The net result is that the process of photoageing produces localised concentration and an increasingly heterogeneous distribution of melanin in human skin, with increased visible contrast.

Haemoglobin is confined to red blood cells within the rich network of vessels of the dermal plexus. Whereas it is generally accepted that intrinsic ageing produces a reduction in the superficial horizontal capillary plexus,[83,88–90] once again the vasculature of sun-exposed skin is markedly different. Photo-ageing results in capillaries that are tortuous and dilated, producing a spectrum of severity of telangiectasia (Fig. 5).[70,91] Within areas of chronic sun exposure, the vessel wall appears to thicken as a result of the peripheral addition of a layer of basement membrane-like material.[92–94] A combination of this increased vascular rigidity and a reduction in density of the supportive, perivascular connective tissue produces fragile vessel walls that are less able to support the internal turgor of blood volume and external mechanical stress. As a result of this mechanical failure, chronic dilation, the formation of sinuses and galleries and, to a limited extent, low-grade purpura, drive the progressive and classic appearance of telangiectasia and "blotchiness" associated with ageing skin. Importantly, once again, photo-ageing produces a steady accumulation of local concentrations of this chromophore in human skin and an associated increase in visible contrast of haemoglobin-based features.

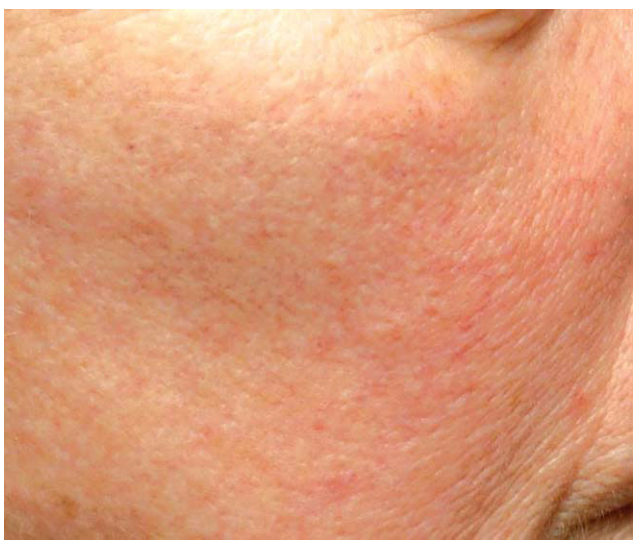

**Fig. 5** Telangiectasia.

### Contrast sensitivity and perception of skin

How do these biological changes of skin relate to its perception? Quite simply, we view the world through sensitive visible-light meters (*i.e.*, the human eye) and, therefore, the phenomenon of "contrast sensitivity" is of critical importance when considering the perception of topography and chromophore changes in human skin. "Contrast" can be defined simply as a ratio of adjacent luminance values and "contrast sensitivity" is a measure of how faded or washed-out an image can become before it is no longer distinguishable from a uniform field. It has been determined experimentally that the minimum discernible difference in grey-scale level that the human eye can detect is about 2% of full brightness.[95,96] This outstanding contrast sensitivity allows us to perceive the world around us in great detail; indeed, without contrast, we would effectively be rendered blind. The human eye, therefore, is drawn automatically to areas with high ratios of adjacent luminance—in simple terms, we view the world through edges created by contrast. Contrast sensitivity is a function of the size and spatial frequency of the features in the image. However, this is not a direct relationship as larger objects are not always easier to see than smaller objects, due to reduced contrast. Visible contrast is greatest, therefore, when both the ratio of adjacent luminance values is high and when features that contain these values are large.

In young skin, reflection from the skin surface is largely diffuse, due to the large number of reflecting polygonal plateaus that make up "microrelief", and this has been found to be predictive for perception of soft, firm skin.[97] As microrelief is lost with increasing age and cumulative photodamage, so too is this natural "soft-focus" effect, driving low-contrast optics. In ageing human skin, contrast is certainly increased by high ratios of adjacent luminance values due to shadowing formed by high amplitude/low frequency surface topography—and especially so in the case of linear features such as "lines", "furrows" and "wrinkles".

Colour, however, also plays an important role in the perception of age, health and attractiveness. It has already been established that the process of intrinsic and extrinsic ageing drives a steady accumulation of enlarging, localised concentrations of the two coloured chromophores, melanin and haemoglobin. In other words, independent of contrast formed by shape and/or topography, localised concentration of chromophores in ageing skin causes a significant increase in visible contrast, particularly in sun-exposed areas such as the face.

## Chronic solar UVR skin damage and perception of age, health and attractiveness

It is a widespread notion that flawless skin is one of the most universally desired human features.[98,99] Males in particular are attracted to female skin which is free of blemishes, lesions, eruptions, warts, cysts, tumors, acne, and hirsutism,[99] as such skin signals youth and health and is, therefore, perceived as attractive. However, even a cursory inspection of the literature reveals that most of the evidence available is anecdotal (see ref. 17, 98–100) and, although human beauty "standards" have often been proclaimed, the scientific evidence supporting the significance of human skin in an evolutionary psychology context is actually scarce. Most studies of facial attractiveness have investigated characteristics such as symmetry, phenotypic averageness and sexually dimorphic traits (for reviews, see ref. 10, 24 and 28). It is thought that these characteristics all pertain to health, leading to the conclusion that humans have evolved to view certain bodily features as attractive because they are displayed by healthy individuals. Evolutionary psychologists argue that preferences for these traits are adaptive because mating with individuals who display them

are advantageous in terms of reproductive success. But what about skin? Can it be added to this list of features that signal aspects of significance in human mate selection?

Comparative studies in the animal kingdom provide evidence that body surface and colour signals are important in sexual selection. For example, feather and skin colouration is known to influence sexual attractiveness in a wide variety of non-human animals[101] and studies on pigmentation in birds have shown that colour signals are linked to immuno-competence and health.[102,103] Carotenoid-based colouration in birds affects mate choice[104] and there is similar evidence for an association between colour display and mate choice in other organisms, including butterflies,[105] fish[106] and lizards.[107] The general finding is that males prefer more brightly coloured females, suggesting that visual displays are intersexual signals resulting in male preferences for certain females. The evidence for the role of colouration from studies using non-human primates is, perhaps, a little more intuitive. Waitt *et al.*[108] report that female rhesus macaques preferred males with red facial colouration and suggest that male colouration is a quality cue. More recently, Setchell *et al.*[109] report an increase in facial colouration of female mandrills, proportional with age, and argue that colour, therefore, signals reproductive quality. If we follow the phylogenetic tree, it seems plausible to argue that there may be a link between visible skin condition and perception of quality derived from skin in humans also.

In this light, it is worth considering the fact that dermatoses in humans often reflect systemic physiological imbalance and may thus be associated with reduced reproductive ability. For example, in sufferers with the endocrine disorder polycystic ovary syndrome, an increase in androgens is responsible for symptoms expressed through both fertility-related problems and characteristic dark skin patches (acanthosis nigricans; for example, see ref. 110).

### Skin condition and face perception

Fink, Grammer and Thornhill[111] showed that, in a sample of young Caucasian women, facial skin affected male judgement of facial attractiveness. By using an objective image segmentation method that quantified contrast in facial skin images, they found that homogeneous skin was perceived as most attractive. However, in contrast to previous reports,[112] this study did not find a male preference for women with paler skin. This may be explicable in terms of a preference for sun-tanned skin and seems reasonable also when considering the general skin colouration of the American population the sample faces were selected from.[18]

More recently, evolutionary psychologists have made some progress with the empirical investigation of visible skin condition by emphasizing the signalling value of its colouration in particular. Fink, Grammer and Matts[113] found that variation in the homogeneity of female skin colour distribution can alter perception of facial age by up to 20 years. This study used digital images of faces that were standardized with respect to their form and in which information relating to skin surface topography was removed. Thus, they differed only with respect to the skin colour distribution of the original images (Fig. 6). As significant variance was observed with visual perception of facial age and judgements of attractiveness, health and youth, this signal can only have been due to changes in the homogeneity of visible skin colour distribution—driven predominantly by chronic UVR exposure. The remarkably high correlations between estimated age and facial attributes observed suggest that human skin condition has a signalling value independent of facial form and topography, which affects mate preference. In addition, by using the same stimuli in an eye-tracking study, Fink *et al.*[114] found not only that judgement of visible skin colour distribution varies in correspondence to local homogeneity of pigmentation, but that this variation also selectively attracts the viewer's attention. In accord with Fink, Grammer and Matts,[113] shape- and topography-standardized stimulus faces with even skin colouration were judged to be younger, received higher attractiveness ratings, and received a higher number of gaze fixations and longer dwell-time.

From these recent studies, it may be concluded that facial skin ageing, with the dyschromia and decrease in bulk light reflection characteristic of chronic UVR damage,[79] can be readily perceived by men and women and, in consequence, affects our perception of others. However, as in many studies of human attractiveness,

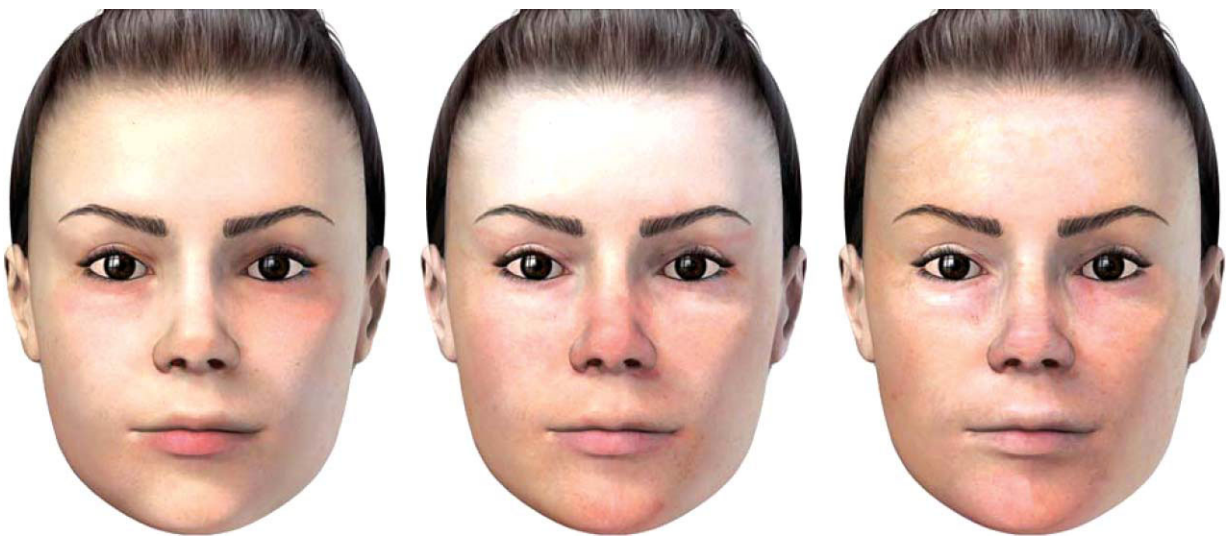

**Fig. 6** Examples of shape and topography-standardised stimuli with skin colour distribution as the only variable (from the study of Fink *et al.*).[113]

 

these findings were based on perception of apparent differences in visible skin condition in the context of whole faces. Thus, in order to investigate the hypothesis that variation in judgement of facial skin is indeed a matter of contrast sensitivity (which can be quantified objectively), Matts *et al.*[77] studied the relationship between perception of skin condition and homogeneity of chromophore distribution. As the authors note, one shortcoming of available psychobiological studies on the effect of skin condition on facial perception and judgement is that, "to date, it appears that a foundational approach to cutaneous optics has not yet been considered". We now have a variety of sophisticated mathematical models to explain the interaction of light with skin. A review of these models reveals that normal human skin colouration is driven overwhelmingly by only three components, namely absorption (and associated spectral modification) by the melanin and haemoglobin chromophores and sub-surface scattering by collagen.[115] It follows, therefore, that the kaleidoscope of both inter- and intra-individual skin colouration is derived solely from unique blends of these three optical components. Understanding how the expression and presentation of these molecules change with age, therefore, is critical in understanding the changing appearance of skin across a human lifetime.

Matts *et al.*,[77] therefore, investigated visual perception of isolated fields of skin, cropped from images of female faces, and related the perception of these images to (a) an objective analysis of homogeneity of skin colouration and (b) to grey-scale concentration maps of (eu)melanin and (oxy)haemoglobin in the same image, obtained using non-contact SIAscope technology (Fig. 7; see also ref. 77 and 116 for details). It was found that homogeneity of unprocessed images correlated positively with perceived age, health and attractiveness. Homogeneity of melanin and haemoglobin chromophore maps was positively and significantly correlated with that of unprocessed images and negatively correlated with estimated age. Thus, skin colour homogeneity, driven directly by melanin and haemoglobin distribution, influences perception of age, health and attractiveness.

However, facial skin age is influenced not only by dyschromia and a decrease in bulk light reflection, but also the severity and frequency of lines and wrinkles due particularly to photo-ageing[117,118] and a loss of hygroscopicity and hydration (for example, see ref. [119]). In an early attempt to study the effect of skin surface topography cues on perception, Perrett *et al.*[120] used computer graphics technology to derive untextured composite faces (*via* digital image blending) when they studied the influence of parental age characteristics on perception of facial attractiveness. These composites were perceived to be some six years younger compared with the average biological age of the participants, suggesting that skin topography cues do indeed affect age perception. While such digitally-synthesised facial stimuli can be useful in testing one's response to certain facial characteristics, in reality visible skin condition is comprised by a complex interaction of skin colouration and skin surface topography. In order to investigate the relative strength of topography and skin colouration cues in influencing perception, Fink and Matts[121] systematically removed skin colouration and topography cues in female facial images and then investigated the perceived age and health of these stimuli. It was found that skin colour and topography affect perception of both age and health, but convey differential information with regard to the strength of these effects. When skin colour information was preserved but skin surface topography cues (such as fine lines and wrinkles) were removed, the investigators noted a decrease in the estimated age of female faces of about 10 years compared to unmodified faces. In contrast, digital smoothing of facial discolouration resulted in a decrease of perceived age of one to five years. Female faces were judged youngest when these image manipulations were combined, *i.e.* when both surface topography cues were removed and skin colour was smoothed, resulting in 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.*[120] Interestingly, the highest ratings

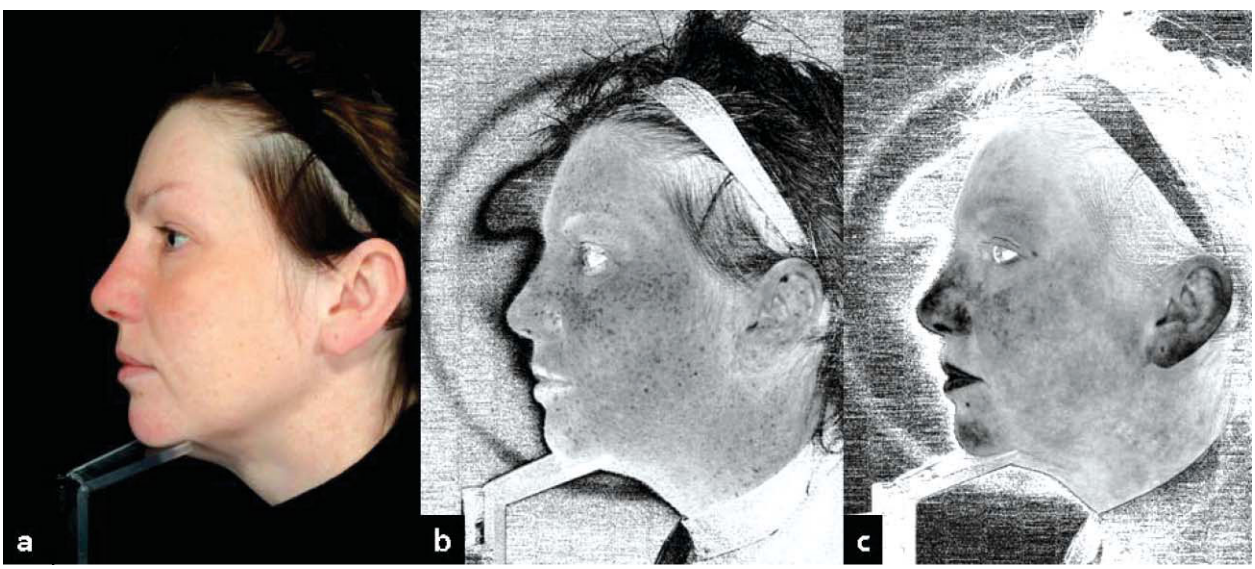


**Fig. 7** Example of non-contact SIAscopy. (a) Original cross-polarised image; (b) grey-scale eumelanin concentration map; (c) grey-scale oxyhaemoglobin concentration map.

of perceived health were obtained for stimulus faces with only a smoothing of skin colour. An important conclusion of the study by Fink and Matts[121] was that, although the dynamic range of the estimated ages from this study indicated that visible facial colour distribution can account for up to twenty years of apparent age, independent of face shape and skin surface topography,[113] the ecological validity of this observation may be questionable. In normal ageing skin, intrinsic and extrinsic factors are responsible for changes of pigmentation and skin surface topography, though the latter are usually more pronounced in older individuals.[117] Thus, in pre-menopausal women, and particularly those at college age who comprise the majority of subjects in attractiveness research, skin colouration may be more important with regard to facial appearance than skin surface topography. In the older sample used in the Fink and Matts study,[121] comprising women aged 40+, removal of topography cues had a stronger effect on facial age perception than skin colour smoothing (although the visibility of both variables resulted in the greatest decrease in perceived age). Even in the presence of topography cues, we appear to be sensitive to skin colouration cues and relate them to healthiness. In other words, in mature women, a diminution of facial discolouration can result in a significant increase of perceived health and, in turn, a concomitant increase in perceived attractiveness. It may be that we are now starting to bring true meaning to the previously unqualified notion of "growing old gracefully".

## Conclusion

Until recently, scientific attention has been focused, and rightly so, on the more sinister effects of chronic exposure to erythemally-effective solar UVR, *i.e.* the induction of skin cancers. The World Health Organization has estimated that, in the year 2000, up to 71 000 deaths worldwide were attributable to UVR exposure.[122] In developed Western countries, skin cancer rates continue to rise dramatically. In the UK, for example, skin cancer is the most common form of cancer, with at least 70 000 new cases and 2300 deaths annually.[123] Despite wide and varied public information campaigns mediated by word of mouth, mass media and the internet, however, various data suggest that public perception of the risk and severity of skin cancer remains low.[124,125]

As reviewed in this article, essentially the same erythemally-effective wavelengths of solar UVR responsible for these cancers also propagate a range of visible cutaneous damage endpoints, the phenomenon of photoageing. In an attempt to translate these events relating to photobiology into a concept understandable to the non-expert layman, the term "premature ageing" has entered the vernacular. Indeed, markets worldwide are already noting the introduction of commercial sunscreens claiming additional benefits beyond standard protection metrics (*i.e.*, SPF and UVA/broad spectrum protection), relating to the prevention of "premature ageing". The inference is clear: if current campaigns and claims are not enough to encourage the use of appropriate photoprotective measures, perhaps alerting the consumer to the chronic effects of solar UVR on her/his appearance may provide an incremental call to action.

The emerging collaboration between the disciplines of biology and evolutionary psychology is now starting to make sense of the rather unsatisfactory term "premature ageing", revealing the often profound signalling value of these skin changes as regards perceived age, health and attractiveness. It may be that the new insights we are uncovering, which for the first time relate chronic UVR skin damage markers to perception in a broader context, bring true emotional impetus to protect and maintain one's appearance. If this is the case, it may not be unreasonable to hypothesise that a resulting increased and more diligent use of sun protective strategies, including sunscreens, would have an impact on skin cancer rates in coming years.

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