

Influence of skin ageing features on Chinese women's perception of facial age and attractiveness

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Synopsis

OBJECTIVES: Ageing leads to characteristic changes in the appearance of facial skin. Among these changes, we can distinguish the skin topographic cues (skin sagging and wrinkles), the dark spots and the dark circles around the eyes. Although skin changes are similar in Caucasian and Chinese faces, the age of occurrence and the severity of age-related features differ between the two populations. Little is known about how the ageing of skin influences the perception of female faces in Chinese women. The aim of this study is to evaluate the contribution of the different age-related skin features to the perception of age and attractiveness in Chinese women.

METHODS: Facial images of Caucasian women and Chinese women in their 60s were manipulated separately to reduce the following skin features: (i) skin sagging and wrinkles, (ii) dark spots and (iii) dark circles. Finally, all signs were reduced simultaneously (iv). Female Chinese participants were asked to estimate the age difference between the modified and original images and evaluate the attractiveness of modified and original faces.

RESULTS: Chinese women perceived the Chinese faces as younger after the manipulation of dark spots than after the reduction in wrinkles/sagging, whereas they perceived the Caucasian faces as the youngest after the manipulation of wrinkles/sagging. Interestingly, Chinese women evaluated faces with reduced dark spots as being the most attractive whatever the origin of the face. The manipulation of dark circles contributed to making Caucasian and Chinese faces being perceived younger and more attractive than the original faces, although the effect was less pronounced than for the two other types of manipulation.

CONCLUSION: This is the first study to have examined the influence of various age-related skin features on the facial age and attractiveness perception of Chinese women. The results highlight different contributions of dark spots, sagging/wrinkles and dark circles to their perception of Chinese and Caucasian faces.

Résumé

OBJECTIFS: Le vieillissement entraîne des changements caractéristiques de l'apparence de la peau du visage. Parmi ces changements on distingue les éléments topographiques (relâchement de la peau

et rides), les taches brunes et les cernes sur le contour de l'œil. Bien que ces modifications cutanées avec l'âge soient similaires pour les visages caucasiens et chinois; leur âge d'apparition et leur degré de sévérité varient entre ces deux populations. Il y a très peu d'informations disponibles liées à l'influence du vieillissement cutané sur la perception des visages féminins par les femmes chinoises. L'objectif de cette étude est d'évaluer la contribution des différents signes de vieillissement à la perception de l'âge et d'attirance chez ces femmes.

METHODES: Des photos de visages de femmes caucasiennes et chinoises d'environ 60 ans ont été manipulées de façon à réduire séparément les signes suivants: (i) le relâchement de la peau et les rides, (ii) les taches brunes, et (iii) les cernes. Enfin, tous les signes ont été atténués ensemble (iv). Des participantes chinoises ont estimé, à partir de ces photos, l'écart d'âge entre la version originale et chaque version modifiée; elles ont également évalué l'attirance des visages originaux et modifiés.

RESULTATS: Les femmes chinoises ont jugé les visages chinois plus jeunes après correction des taches qu'après correction des rides/relâchement, alors que les visages caucasiens ont été perçus les plus jeunes après correction des rides/relâchement. Les femmes chinoises ont jugé que les visages avec correction des taches étaient les plus attirants quelle que soit l'origine du visage. La manipulation des cernes a entraîné un rajeunissement des 2 types de visages et les a rendus plus attirants, même si l'effet observé était moindre que pour les autres corrections.

CONCLUSION: Il s'agit de première étude qui examine l'influence de plusieurs signes de vieillissement cutanés sur la perception de l'âge et de l'attirance des visages par les femmes chinoises. Les résultats mettent en évidence que les taches, les rides/relâchement et les cernes contribuent différemment à leur perception des visages chinois et caucasiens.

Introduction

Age and attractiveness are among the first judgements we make when we meet a person and these judgements are strongly linked. Young faces are generally perceived to be more attractive than old faces, and estimated age is negatively correlated with perceived attractiveness [1–3].

Age perception is fundamental in East Asian cultures wherein an age hierarchy is critical for social interactions. For instance, the Japanese use different ways of speaking to individuals from different age groups; in Chinese culture, distinctive linguistic

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markers are used when people interact with older individuals [4]. In fact, Japanese and Chinese individuals living in their native country have been shown to be faster in their age judgement than individuals of Japanese and Chinese origin living in North America [4]. With these findings, the authors have provided the first evidence that cultural differences in social practices may shape the way we perceive facial age [4]. In addition, independently of their culture, individuals seem to be more accurate in estimating age from own-race faces than from other-race faces [5]. More generally, individuals are better at processing faces belonging to their own race than those belonging to another racial group. This 'other-race effect' (ORE) has been well established in person-recognition tasks [6, 7] and in sex-discrimination tasks [8], but needs to be confirmed in age judgement tasks. Like person-recognition tasks, the ORE in age estimation is likely to be reduced or even reversed after acculturation and after experiencing other-race faces [4, 5].

The facial cues that individuals use in the judgement of age are likely to be similar regardless of the culture and regardless of the type of face (own race or other race) because the ways that faces change with age are similar among faces of different racial origins [9–11]. However, the relative contributions of different cues may differ between races and cultures.

When estimating age from looking at faces, the judgements are strongly based on the presence of age-related skin features, as skin undergoes dramatic visible changes with ageing [1, 2, 12–16]. There are three changes that particularly alter facial appearance and have been found to influence or at least predict perceived age: wrinkles and sagging, pigmented spots and darkness of the infraorbital area ('dark circles around the eyes'). These changes are all due to intrinsic ageing and photoageing [17]. Wrinkles and loss of elasticity of the skin ('sagging') are the most consistent change in intrinsic cutaneous ageing and are caused by flattening of the epidermal–dermal junction. This is aggravated by dermal elastosis due to chronic sun exposure and the deposition of abnormal amorphous elastic material in the papillary dermis [17]. Wrinkles and sagging have been shown to be important skin surface topographic cues in the perception of age [12–14, 16]. Dark spots (also known as solar lentigines) are due to unevenly distributed melanocytes in the basal layer, displaying areas of increased number of melanocytes and areas with reduced melanocytes, and are caused by cumulative photodamage [17]. Skin colour distribution (e.g. dark spots) has been shown to play an important role in perceived age [1, 2, 12, 14]. Facial skin appearance is also altered by darkness of the infraorbital area caused by multiple etiological factors ranging from excessive pigmentation to thin translucent lower eyelid skin [18]. Although this condition affects individuals from a wide range of age, it is aggravated by age [19]. Dark circles are correlated with the perceived age of female faces [14], but their influence on age perception has not yet been experimentally demonstrated.

Few studies have focused on the role of these age-related skin features on facial attractiveness, and they have been limited to Western participants evaluating Caucasian faces [1, 2, 15, 16]. Moreover, to the best of our knowledge, studies on the influence of different facial age-related features on perceived age have only been carried out in Western populations, with the notable exception of one study carried out on Chinese women [20]. Although the ways that Caucasian and Chinese faces change with age are quite similar, there are differences in the age of occurrence and the degree of severity of facial skin ageing features [9–11, 21]. A sign which is

strongly correlated with chronological age might be a stronger cue to age judgement than a sign which is slightly or not correlated with chronological age. In a correlational study, Mayes *et al.* asked Chinese participants to estimate the age of a large set of photographs of Chinese female faces. They investigated the relationship between perceived age and the severity of the ageing signs. The signs of ageing that most strongly predicted perceived age were fine lines, coarse wrinkles and overall photodamage; a slightly weaker relationship was observed for hyperpigmentation. Because all these ageing signs are related and are strongly associated with perceived age, the study did not directly address the question whether fine lines, for instance, have a greater effect on perceived age than hyperpigmentation.

Here, we aimed to extend this work through an experimental study by manipulating three types of skin ageing features (i.e. (i) wrinkles and skin sagging, (ii) dark spots and (iii) dark circles around the eyes) individually, to determine the strength of the different signs on the perception of age and attractiveness of Chinese women viewing Chinese and Caucasian female faces. Menopause is known to aggravate the appearance of skin ageing features [22], and women in their 50s are believed to be particularly concerned about their facial skin appearance. Because of this, we investigated the perception of women from this range of age.

Additionally, we tested how accurately Chinese women estimate the age of female faces from their own race (Chinese) and from another race (Caucasian), and we sought to determine whether there is estimation bias that differs according to the type of face.

Materials and methods

Ethics statement

The research conformed to the principles of the Helsinki Convention. The subjects reported in this manuscript gave their written informed consent. The individuals pictured in this manuscript did not give their written informed consent for their images to appear in a scientific publication, which is why their eyes are hidden. Their eyes were not hidden during the experiments.

Participants

Forty-one Chinese female participants (aged 50.9 ± 2.8 years, 24 menopausal), living in Guangzhou, were recruited.

Face stimuli

Full-face images of 10 French Caucasian women aged 61 ± 4.2 years and 10 Chinese women aged 58.1 ± 4.5 years were selected from our photographic database. This database has facial images acquired using a photographic system that provides accurate and reproducible positioning of the subjects as well as reproducible lighting conditions. Subjects did not wear make-up or any adornments during image acquisition, their hair was not covered, their neck was visible, and their eyes were open. The selection of the 20 images ('target faces') relied on the presence of concomitant signs of dark spots, dark circles, wrinkles and sagging with moderate-to-severe grades, although the 20 target faces were representative of larger populations (French Caucasian and Chinese) in terms of the amount of age-related skin features. Their presence and severity had been evaluated previously by a trained dermatologist using photographic reference scales [23].

Stimuli modifications

Each facial image was manipulated by a professional graphic artist using Adobe Photoshop® 7.0 (Adobe Systems Inc., San Jose, CA, U.S.A.). Thus, for each target face, there were five images, the original versions and four modified versions: (i) reduced skin sagging and smoothed wrinkles, (ii) reduced dark spots, (iii) reduced dark circles (pigmented and vascular) and (iv) all the signs corrected together (Fig. 1a,b). All the signs together were manipulated and reduced to measure the effect of global manipulation on perceived age and attractiveness.

Most of the skin features were removed or smoothed using the *dodge* tool and the *burn* tool, whereas the *curves* were used to reduce the dark circles which cover a larger surface on the image. Finally, the *liquify* filter was applied to reduce some aspects of the skin sagging. For each face, the manipulation of the three types of skin feature was done on three separate layers. The three layers were then activated together to create the 'all signs corrected together' version.

The 'naturalness' of the manipulations was checked visually by the professional graphic artist and one investigator to avoid perturbing facial harmony. The level of manipulation applied was comparable between images within each type of manipulation.

Procedure

Forty-one participants viewed the images on a 43-cm screen. They were convened twice: the first time to evaluate age differences between the original and manipulated faces, and then to estimate the perceived age of the original faces; and the second time to evaluate the attractiveness of the original and the manipulated faces. The participants were not informed about the type of manipulation applied to the images. The two visits were separated by 1 week. For the sake of clarity in this article, we will present the different tasks independently of their chronological order during the study.

Age difference evaluation

For each manipulation, the evaluation of the perceived age difference between the original and the modified images was performed by the participants using a sequence of three images: original–modified–original. Each participant performed 80 evaluations (four sequences per target face, for a total of 20 target faces). To minimize the order of presentation bias, the sequences were randomized into four blocks, with one modified version of each target face in each block. The order of presentation of the 20 target faces was random within each block, and the four blocks were presented to the participants in random order. A short break was possible



Figure 1 (a) Example of an original Chinese face and the four types of manipulation (sagging/wrinkles, dark spots, dark circles and all signs). (b) Example of an original Caucasian face and the four types of manipulation (sagging/wrinkles, dark spots, dark circles and all signs). Subjects' eyes are masked in printed pictures to assure their anonymity, but were not masked during the evaluations. The boxes also mask manipulations in the region around the eye.

between the presentation of each block to avoid visual fatigue. Participants moved between images at their own speed.

For each original–modified–original sequence, the participants were asked whether they thought that the modified version appeared younger than the original picture, older than the original picture or the same age as the original picture and to provide an oral estimation of the perceived difference of age in years.

Attractiveness evaluation

We used the same procedure to present the images as for the age difference evaluation. However, this time the participants had to give an oral rating of the attractiveness of each modified face and the original face that preceded it on a 10-point Likert scale (1: not attractive, 10: very attractive). Then, we calculated the difference in attractiveness ratings between each manipulated face and the original face that preceded it.

Age estimation

The participants were shown the 20 original images individually in random order and asked to give an oral estimation of the perceived age of the target face. The duration of presentation was limited to 7s to force them to give a spontaneous estimation of age while leaving enough time for the investigator to record their answer.

Statistical analyses

All statistical analyses were carried out using SAS[®], version 9.1.3. (SAS Institute Inc., Cary, NC, U.S.A.).

Effect of the type of manipulation on age difference estimation

Analyses were conducted on the ‘age difference’ variable which was defined as the number of years of difference between each original image and the corresponding modified image. To study the effect of each manipulation (i.e. skin sagging and wrinkles, dark spots, dark circles or all signs) on the perceived age difference, a mixed linear model was used [24]. This model enables taking into account correlated data resulting from repeated measurements. In this model, the types of manipulation, the origin of the face, the real age of the face and the participant’s age were fixed effects. The participant’s identity and that of the target face were random effects. For the use of mixed models in similar research, see [25]. All the results are expressed as least square mean (LSMean) ± standard error (SE).

Effect of the type of manipulation on facial attractiveness

First, the attractiveness rating difference was calculated as the difference between the rating given to the modified face and the original face. The variable ‘difference in attractiveness’ is a discrete variable that was not normally distributed. Therefore, the variable was dichotomized according to the median ‘slight-to-moderate increase’ in attractiveness (difference in attractiveness ≤ 2) versus ‘strong increase’ in attractiveness (difference in attractiveness > 2) to focus on the study of the strongest differences in attractiveness. An analysis of variance with mixed effects was conducted to study the influence of the manipulations on facial attractiveness. In this model, the participant’s age, the real age of their face, its origin and the type of manipulation were fixed effects. The participant’s identity and that of the target face were random effects. Associations were expressed as adjusted odds ratios (AOR) together with estimates of their 95% confidence interval (95% CI).

Relationship between perceived age and real age

First, the mean perceived age by the participants was calculated for each face. Then, the relationship between the mean perceived age and the real age of the face was studied using a graphical display, and the Spearman’s correlation coefficient was calculated. This analysis was conducted for each racial group separately. The Mann–Whitney test was finally used to compare the estimation bias (difference between perceived age and real age) for the two racial groups (Caucasian vs. Chinese). The link between the real age of the face and mean perceived age within each racial group was tested using a Spearman’s correlation.

Results

Effect of age-related skin features on age difference estimation

The four types of manipulation each showed a significant impact on age perception ($P < 0.0001$) whatever the race of the face, but the strength of the effect differed between the two races (Fig. 2). The largest age difference was observed after manipulation of all the signs whatever the origin of the face. The effect of this type of manipulation on the age difference was significantly higher for Caucasian faces than for Chinese ones (-6.6 ± 0.3 years vs. -5.7 ± 0.3 years for Caucasian and Chinese faces, respectively; $P < 0.001$). For Chinese faces, the reduction in dark spots resulted

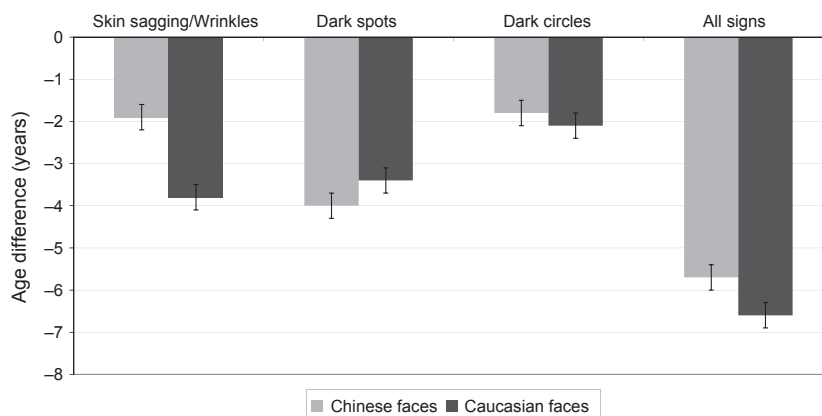


Figure 2 Effect of each manipulation on perceived age difference (LSMean + SE in years) of Chinese faces and Caucasian faces.

in a greater age reduction (-4.0 ± 0.3 years) than the manipulation of skin sagging and wrinkles (-1.9 ± 0.3 years). The opposite pattern was observed for Caucasian faces although the difference was not statistically different (-3.4 ± 0.3 years and -3.7 ± 0.3 years, respectively). The effect of the manipulation of dark spots was greater for Chinese faces than for Caucasian faces ($P = 0.01$), whereas the manipulation of sagging and wrinkles led to a greater age difference for Caucasian faces ($P < 0.001$). The manipulation of dark circles resulted in the lowest effect on age difference for Caucasian faces (-2.1 ± 0.3 years) but in an effect similar to that of the manipulation of sagging and wrinkles for Chinese faces (-1.8 ± 0.3 years).

Effect of the type of manipulation on facial attractiveness

All the types of manipulation resulted in an improvement in the attractiveness of the faces. The distribution of increase in attractiveness ('slight-to-moderate increase' vs. 'strong increase') according to the type of manipulation and the origin of the face is shown in Fig. 3. The greatest effect on the increase in facial attractiveness was observed for the manipulation of all the signs. This manipulation resulted in a 'strong increase' in attractiveness in 65% and 76% of the trials for Chinese and Caucasian faces, respectively. Regarding individual manipulations, the manipulation of dark spots improved facial attractiveness most, regardless of the origin of the face. This manipulation resulted in a 'strong increase' in attractiveness in 50% and 40% of the trials for Chinese and Caucasian faces, respectively.

A significant interaction between type of manipulation and origin of face ($P < 0.0001$) was found, that is, the effect of the type of manipulation differed according to the origin of the face (see Tables I and II). Caucasian faces after manipulation of dark circles, sagging/wrinkles and all signs had more chance of obtaining a strong increase in attractiveness than Chinese faces. In contrast, Chinese faces had more chance of obtaining a strong increase in attractiveness after the manipulation of dark spots than Caucasian faces (Table I). The results in Table II allow comparing the contribution of the different age-related features on perceived facial attractive-

Table I The effects of the type of manipulation on facial attractiveness differed according to the origin of face ('origin of face' as a fixed effect). For example, Caucasian faces after manipulation of sagging/wrinkles had 2.82 more chance of obtaining a 'strong increase' in attractiveness than Chinese faces with similar manipulation ($P < 0.0001$), whereas Chinese faces after manipulation of dark spots had 1.5 more chance of obtaining a 'strong increase' in attractiveness than Caucasian faces with similar manipulation ($P = 0.0063$)

'Origin of face' effect	Odds ratio (OR)	Standard error	CI of 95%	$P > \chi^2$
Caucasian vs. Chinese/ sagging and wrinkles	2.82	0.51	[1.97; 4.02]	<0.0001
Chinese vs. Caucasian/ dark spots	1.50	0.22	[1.12; 2.00]	0.0063
Caucasian vs. Chinese/ dark circles	1.63	0.34	[1.08; 2.45]	0.0199
Caucasian vs. Chinese/ all signs	1.78	0.29	[1.30; 2.44]	0.0004

A large confidence interval (CI) indicates low OR precision. If the CI of the OR does not overlap value 1, a difference is statistically significant. P is Wald test probability.

ness within each race of face. For instance, Chinese faces and Caucasian faces after the manipulation of dark spots had, respectively, 6.07 and 1.44 chance of obtaining a 'strong' increase in attractiveness than after manipulation of sagging/wrinkles ($P < 0.0001$).

Relationship between perceived age and real age on original faces

Perceived age was significantly correlated with real age for Chinese faces ($r = 0.72$, $P = 0.02$) but not for Caucasian faces ($r = 0.13$, $P = 0.72$; Fig. 4). This result reflects a low accuracy for Chinese women to perceive the age of the Caucasian (other race) faces. The

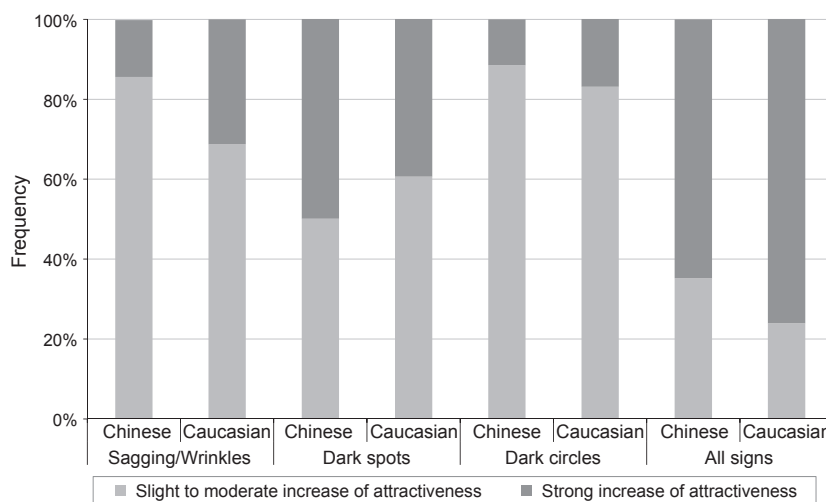


Figure 3 Distribution of increase in attractiveness after manipulation ('strong increase' vs. 'slight-to-moderate increase') according to racial group and type of manipulation.

Table II The effects of the type of manipulation on facial attractiveness differed according to the origin of face ('type of manipulation' as a fixed effect). For example, Caucasian faces after manipulation of sagging/wrinkles had 2.2 more chance of obtaining a 'strong increase' in attractiveness than after manipulation of dark circles ($P < 0.0001$). Chinese faces after manipulation of dark spots had 6.07 more chance of obtaining a 'strong increase' in attractiveness than after manipulation of sagging/wrinkles ($P < 0.0001$)

'Type of manipulation' effect	Odds ratio (OR)	Standard error	CI of 95%	$P > \chi^2$
Sagging and wrinkles vs. dark circles/ Caucasian	2.20	0.32	[1.66; 2.92]	<0.0001
Sagging and wrinkles vs. dark circles/ Chinese	1.27	0.20	[0.94; 1.73]	0.1233
All signs vs. sagging and wrinkles/ Caucasian	7.02	0.92	[5.42; 9.08]	<0.0001
All signs vs. sagging and wrinkles/ Chinese	11.10	1.68	[8.25; 14.92]	<0.0001
Dark spots vs. sagging and wrinkles/ Caucasian	1.44	0.17	[1.13; 1.83]	0.0027
Dark spots vs. sagging and wrinkles/ Chinese	6.07	0.92	[4.51; 8.18]	<0.0001
All signs vs. dark circles/ Caucasian	15.47	2.43	[11.37; 21.06]	<0.0001
All signs vs. dark circles/ Chinese	14.12	2.31	[10.25; 19.46]	<0.0001
Dark spots vs. dark circles/ Caucasian	3.17	0.42	[2.44; 4.12]	<0.0001
Dark spots vs. dark circles/ Chinese	7.73	1.21	[5.68; 10.51]	<0.0001
All signs vs. dark spots/ Caucasian	4.88	0.62	[3.80; 6.25]	<0.0001
All signs vs. dark spots/ Chinese	1.83	0.19	[1.49; 2.24]	<0.0001

A large confidence interval (CI) indicates low OR precision. If the CI of the OR does not overlap value 1, a difference is statistically significant. P is Wald test probability.

estimation bias between the perceived age of the original faces and the real age was on average -1.1 ± 2.4 years younger for the Chinese faces (mean real age 58.1 ± 4.5 years; mean perceived age 57.0 ± 3.7 years) and 4.1 ± 4.9 years older for the Caucasian faces (mean real age 61.0 ± 4.2 years; mean perceived age 65.1 ± 2.6 years). These results demonstrate that Chinese women slightly underestimated the age of Chinese faces, whereas they largely overestimated the age of Caucasian faces.

Discussion

This study is the first to investigate the influence of the modification of age-related features of different types of face (Chinese and Caucasian, mean real age 58.1 ± 4.5 and 61.0 ± 4.2 years, respectively) on perceived age and attractiveness judgements made by Chinese women using an experimental approach.

The effects of different skin features on the perception of age

We found that Chinese women perceived Chinese faces as significantly younger after the reduction in dark spots than after the reduction in sagging/wrinkles, whereas their perception was influenced much more by the manipulation of sagging/wrinkles in Caucasian faces. Although ageing leads to characteristic changes in facial skin features that are common to Caucasian and Chinese women, there are differences in their age of occurrence and degree of severity between the two populations. The age of occurrence of skin surface topographic features (sagging and wrinkles) is younger for Caucasian women than for Chinese women [21], whereas it is the contrary for dark spots, which appear earlier in Chinese women. Whereas dark spots are the main skin ageing concerns for Chinese women, skin topographic features were found to be a stronger cue to age perception when they evaluate Caucasian faces. These findings suggest that the overall appearance of Caucasian female faces is likely to be more strongly altered by the presence of wrinkles and sagging on the different areas of the face, specifically on the eye region, than Chinese faces. Another potential reason for these findings is that Chinese women may know about the main skin ageing concerns of Caucasian female faces, and it could have influenced their judgement. In a previous study, Fink *et al.* [12] manipulated skin topography cues (facial furrows, folds, lines and wrinkles) separately from the skin colour irregularities of Caucasian faces (40 years and older); then, they analysed the effect of the manipulations on estimated age. They found that faces with reduced skin topography cues were judged to be younger by Western participants (German, male and female) than faces with smoothed skin colour. These previous findings added to our present results on Caucasian faces suggest that Western and non-Western women use age-related skin features similarly when trying to estimate the age of Caucasian faces.

Our results on the contribution of skin features to age perception in Chinese faces are mostly consistent with the study by Mayes *et al.* [20], in which a relationship was found between perceived age and wrinkles and pigmented irregularities. However, there are some small differences between the two studies in terms of the weight of the different types of facial skin features in the perception of age. When they analysed the relationships between perceived age and the visual assessment scores of facial skin ageing in a larger set of faces, the strongest relationships were for the coarse wrinkles and overall photodamage (fine lines, wrinkles, hyperpigmentation and sallowness). The relationship was weaker, although significant, for hyperpigmentation alone. These differences with our study are likely to be due to the different methods used. Firstly, Mayes *et al.* did not use the same photographic scales as ours, so they classified skin features differently. For instance, they defined hyperpigmentation by light, patchy, mottled hyperpigmentation and solar freckling, including melasma (lentiginos, or 'dark spots', were not included), whereas we manipulated lentiginos only ('dark spots'). Women from our study did not have facial melasma, nor did they have 'solar freckling' because they were photographed during winter. Secondly, the range of real face ages was different between the two studies. Mayes *et al.* used faces from 25 to 70 years of age, whereas we manipulated the faces of Chinese women in their 60s. Finally, they used a correlational study to analyse the link between the visual scores of skin ageing features and perceived age, whereas we used an experimental approach to estimate the strength of each skin feature to age perception.

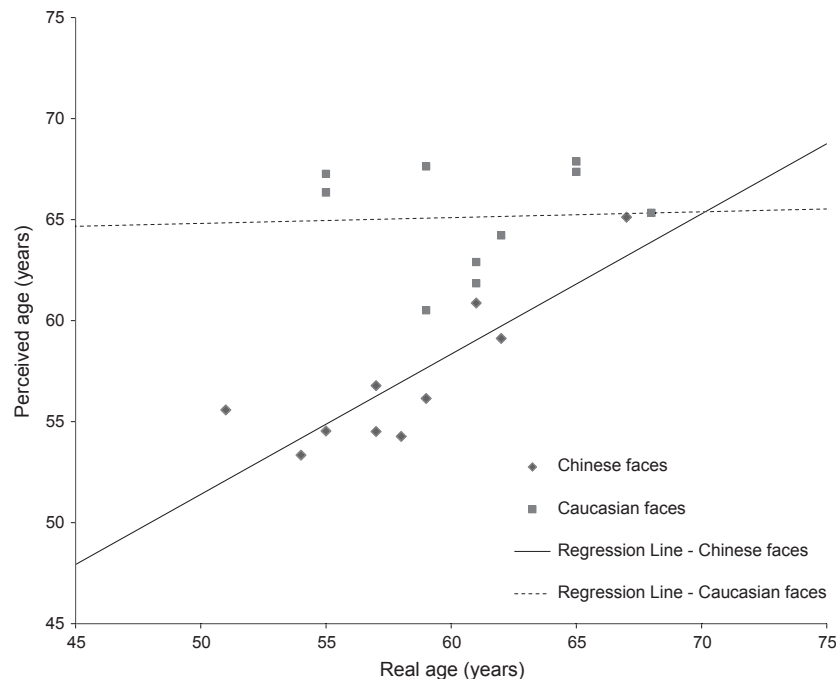


Figure 4 Correlation between the real age and the mean perceived age from all the participants. Spearman's $R = 0.72$ ($P = 0.02$) for Chinese faces; Spearman's $R = 0.13$ ($P = 0.72$) for Caucasian faces.

Interestingly, in the second part of their study, Mayes and colleagues averaged faces of Chinese women (in their 60s) judged to look older than their real age (older composite) and faces judged to look younger than their real age (younger composite). In addition to highlighting differences in the severity of wrinkles and overall photodamage, the composite faces also highlighted differences in overall facial sagging (i.e. eye sagging [eye shape and eyelid folds] and nasolabial fold). In our present study, we manipulated sagging and wrinkles features together; consequently, we were not able to determine the contribution of skin sagging features alone on age estimation. It might be interesting to manipulate them separately and analyse the effect on the evaluation of age difference.

Regarding the manipulation of dark circles, it contributed to making Caucasian and Chinese faces younger and more attractive, although the effect was globally lower than for the two other manipulations. Dark circles affected individuals of all ages, giving the person a tired and sad look [18]. This sign being less correlated with chronological age, it was expected to influence age perception to a lower extent than dark spots or skin topographic cues.

The effects of different skin features on the perception of facial attractiveness

Our results on facial attractiveness are consistent with previous findings showing that youthful appearance is attractive [26]. Faces after manipulation of age-related skin features lead to a younger appearance and were perceived as more attractive than the original faces, regardless of the type of manipulation (skin sagging and wrinkles, dark spots, dark circles and all signs together). Beyond this general and expected finding, it is noteworthy that when

Chinese women evaluated Chinese faces, they judged the faces with the youngest appearance (manipulation of dark spots) as the most attractive, whereas when the same women evaluated Caucasian faces, their responses followed a different pattern. Indeed, they judged the faces with reduced dark spots as more attractive but older than the faces with reduced sagging and wrinkles. These results suggest that Chinese women consider skin colour heterogeneity (i.e. dark spots) as a sign of beauty rather than a sign of ageing. That may explain in part why the use of whitening products and aesthetic procedures is widespread among Chinese women, to mask their dark spots (including freckles), even at an early age [27, 28]. Skin evenness has long been a beauty concern for Chinese women, as can be observed in older paintings in which young women are represented with a perfect light and even facial skin tone.

From these results, it also appears that the correction of the major age-related skin features individually did not lead to a dramatic reduction in age, whereas facial attractiveness was consistently improved (e.g. up to 4 years younger and up to 50% of strong increase in attractiveness after correction for dark spots in Chinese faces). And in a recent study, the researchers revealed that the mean overall age reduction following ageing face surgery was about 3 years, whereas attractiveness was not consistently improved [29]. One potential explanation to these observations is that facial surgery does not only modify the skin appearance, it also leads to changes in the global shape of the face and can reduce facial harmony. By reducing the visibility of facial skin ageing features while maintaining the facial natural harmony, cosmetics can make a face look younger as well as more attractive.

Effect of the origin of face on age estimation

When Chinese women were asked to estimate the age of original Chinese and Caucasian female faces (without manipulation), they slightly underestimated the age of Chinese faces (−1.1 years), whereas they largely overestimated the age of Caucasian faces (+4.1 years). The different directions of the age estimation bias according to the origin of face suggest that Caucasian faces looked older than their age, whereas the Chinese faces looked slightly younger than their real age. These results are likely explained by the differences in facial aging between Caucasian and Asian faces. Indeed, Asian female faces, even older faces, have many 'baby-faced' attributes, including wideness and roundness, higher eyebrows, fuller upper lids and fuller lips [30]. Therefore, with age, the Asian female face maintains a younger appearance despite the presence of age-related skin features. The Caucasian female face undergoes more dramatic changes in facial shape with ageing (i.e. lips become thinner and longer). Another potential reason for the overestimation of the age of Caucasian women by Chinese women may be due to the images of Western models or actresses diffused in China, which tend to portray youthful heavily touched-up or made-up faces. Compared with these advertising facial stimuli to which urban Chinese are frequently exposed, the facial stimuli from our study could have been slightly overestimated in age because they depicted women without make-up or photograph retouching.

Chinese women were found to be less accurate when they estimated the age of Caucasian faces than of Chinese faces, supporting the 'other-race effect' hypothesis on age estimation that was previously suggested by Dehon and Brédart [5]. Chinese women are better 'trained' to estimate the age of Chinese women than Caucasian women because they interact with them more frequently. In addition, their culture, which places emphasis on respect for older individuals, cultivates more sophisticated processing of facial age information for older adults than for younger adults [4]. They might have been less accurate with younger adult Chinese faces.

Conclusion

This research has explored different aspects of age perception in Chinese women.

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This is the first study to have examined the influence of various age-related skin features on the facial age and attractiveness perception of Chinese women. Our findings highlight different contributions of dark spots, sagging/wrinkles and dark circles to Chinese women's perception of Chinese and Caucasian faces. They support the hypothesis that people do not use the same cues to age perception equally for all races and further that they accurately give greater weight to cues that are more diagnostic of age for the particular race. Moreover, we provide further evidences for an other-race effect on age estimation with Chinese women being less accurate when they estimate the age of Caucasian faces than Chinese faces.

This work was limited to a narrow age range of Chinese women living in one of the main cities of China, and it could be interesting to extend it to a larger age group (faces and participants) and to the perception of women by Chinese men. The influence of exposure to Caucasian females' faces through mass media and advertisements could be tested by comparing our results with the perception of Chinese women living in the countryside who are less exposed to mass media and the Internet. Our findings demonstrate that modifying facial appearance by reducing age-related features dramatically increases facial attractiveness even in a culture where ageing is viewed positively [31]. Future studies could address the question of the influence of skin ageing features on other social perceptions of women in China (for example, warmth and trustworthiness). Furthermore, this work could be extended to other facial features that have recently been identified as cues for perceiving age in Caucasian that have not yet been studied in Chinese women, such as facial contrast and sclera coloration [32, 33].

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