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Objectively and Precisely Representing Subjective Beauty Desires: a novel method for quantification of consumer self-perceived ideal complexion from retouched selfies using image analysis

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1. Introduction

Beauty is in the eye of the beholder. With regards to ideal complexion, beauty is shown through the desired skin tone as a key component of the outer beauty, with its perception strongly influenced according to the varying cultural heritages in different regions of the world. While a tanned complexion has been pursued for many decades in Western countries, a fair and clear skin tone is coveted by people in most Asian countries [1-3]. Nowadays, in modern, technologically driven societies, beauty-conscious consumers project their appearance to the world via smartphone-selfies which are typically beautified with photo editing APPs [4-7]. To skin care researchers, this presents a unique alternative to conventional consumer perception studies. Classically, consumer perception of ideal complexion is ascertained through surveys requiring thoroughly-designed questionnaires and carefully selected facial images utilized for analysis [8-9]. The potential for inaccuracies may arise due to inconsistencies among panelists in understanding of the subject matter, level of engagement in survey completion, and the likely mental fatigue after repeating the requested tasks numerous times [10,11]. Conversely, allowing subjects to enhance their selfies in order to express their self-perceived ideal complexion optimizes each subject's innate motivation and enthusiasm to deliver a near-perfect target. To that end, we hereby report a novel consumer study to precisely quantify the self-perceived color targets of ideal complexion by image analysis of multiple skin color parameters from the before and after beautified selfies of a Chinese population.

There is abundant literature on both topics of ideal complexion measurement and selfie culture prevalence [12-14]. However, report on studies of combining the two for precisely capturing consumer perception targets is scarce. The effects of enhanced selfies have been studied in comparison to the originals, with measured parameters including skin color (hue, saturation, brightness) and facial features such as nose height and width, eyebrow height, and face width [15]. Digitally enhanced selfies have been perceived as more attractive by panelists [16]. In this study, we will quantitatively examine the extent of changes made by a group of Chinese women through enhancing their selfies in pursuit of an ideal complexion.

2. Materials and Methods

2.1. Subjects and facility: A group of 113 female Chinese volunteers aged 22-45 years old participated in a photographic survey after each of them having consented to an informed consent form. The survey was conducted at a skin testing laboratory in southern China. All subjects who participated in the survey washed their face in the morning of the day and, once arriving in the lab, acclimated under the controlled room temperature (21 ± 0.5°C) and humidity (50 ± 5%) conditions for at least 15 minutes before taking survey.

2.2. Image capture and selfie retouch: A frontal, full-face selfie of each survey participant was captured in the lab with a lab technician's assistance using the primary camera of an iPhone 15 Pro (Apple Inc., Cupertino, California, USA) under controlled studio lighting and a fixed focus distance. A plate of standard color chips with known color values was captured in the same frame of each selfie for post-capture image color correction. Each selfie was then transferred to its owner's smartphone for the participant to perform retouch using a beauty APP such as Meitu or Youcam to bring the picture to a condition of representing her desired "ideal complexion" based on her best understanding of the concept.

2.3. Image analysis: ImageJ, freeware developed by the National Institute of Health (Bethesda, Maryland, USA), was used to perform image analysis leveraging in-house developed algorithms for color correction, feature detection, and skin color parameter measurement. Each image before retouching was color corrected against the embedded color chips. A full-face region of interest (ROI) including the forehead, cheeks, as well as the periorbital, nasolabial, and perioral regions, was automatically (with manual confirmation of each key step) cropped out of each full-face image. Since skin features show a unique color or cast a shadow in an image, twenty color-related, visually perceivable parameters of skin including the color parameters in CIELAB color space, red and dark spots, greasy shininess, uneven skin tone and skin surface texture imperfection were measured from each ROI of the selfies. Table 1 lists the measured color parameters together with their definitions and descriptions.

Table 1. List of objectively measured, color-related and visually perceivable skin parameters

Parameters	Description
L*	Overall skin lightness in the L* channel of CIE-LAB color space
SD_{L*}	Standard deviation of L* pixel intensity distribution
a*	Overall skin redness in the a* channel of CIE-LAB color space
SD_{a*}	Standard deviation of a* pixel intensity distribution
b*	Overall skin yellowness in the b* channel of CIE-LAB color space
SD_{b*}	Standard deviation of b* pixel intensity distribution
ITA°	Individual typology angle; $ITA^{\circ} = atan\left\{\frac{L^*-50}{b^*}\right\} \times \frac{180}{\pi}$
h°	Hue angle in the CIELAB color wheel; $h^{\circ} = atan\left\{\frac{b^*}{a^*}\right\} \times \frac{180}{\pi}$
C*	Chroma; $C^* = \sqrt{(a^*)^2 + (b^*)^2}$
$dINT_{a*}$	Mean intensity difference in the a* between red spots and the full-face ROI
$pctA_{a*}$	Percent area of red spots in the ROI
$SI_{Redness}$	Index of red spot severity; $SI_{Redness} = dINT_{a^*} \times pctA_{a^*}/10$
$dINT_{b*}$	Mean intensity difference in the b* between dark spots and the full-face ROI
$pctA_{b*}$	Percent area of dark spots in the ROI
SI_{Dark}	Index of dark spot severity; $SI_{Dark} = dINT_{b^*} \times pctA_{b^*}/20$
$dINT_{L*}$	Intensity difference in L* between greasy-shine spots and the full-face ROI
$pctA_{L*}$	Percent area of greasy-shine spots in the ROI

SI_{gShine}	Index of greasy shininess level; $SI_{gShine} = dINT_{L^*} \times pctA_{L^*}/20$
UST	Overall unevenness of skin tone; $UST = \frac{sd}{I} \times 100$ †
SVI	Index of skin visual imperfection (pores, fine-lines and wrinkles); $SVI = \frac{dINT \times S \times L}{I \times C} \times pctA$ ††

† where sd is the standard deviation and I stands for the mean pixel gray-scale intensity;
†† where $dINT$ stands for mean intensity difference between imperfect features and normal skin area; S for entropy in GLCM texture nomenclature; L the mean major length of the detected imperfect shapes which is >1% of the width of image frame; I the mean pixel gray-scale intensity of the imperfect shapes; C the circularity of the imperfect shapes and $pctA$ the mean percent area of imperfect shapes.

2.4. Statistical Analysis: Descriptive statistical analysis, along with constructing histogram charts and fitting data to Gaussian distribution curves was performed on all data measured from the facial ROIs using data analysis packages in ImageJ and Excel.

3. Results

All 113 participants completed the study. Visually, dramatic change in color properties of facial skin was evident when comparing an original selfie to its retouched version which reflects a participant's self-perceived ideal complexion. Measurement of multiple skin parameters across full-face ROIs using image analysis yielded results that quantify and document changes toward self-perceived ideal complexion. Example images of the selfies along with full-face ROI, and graphics illustrating the outcomes of feature detections are shown in Figure 1.

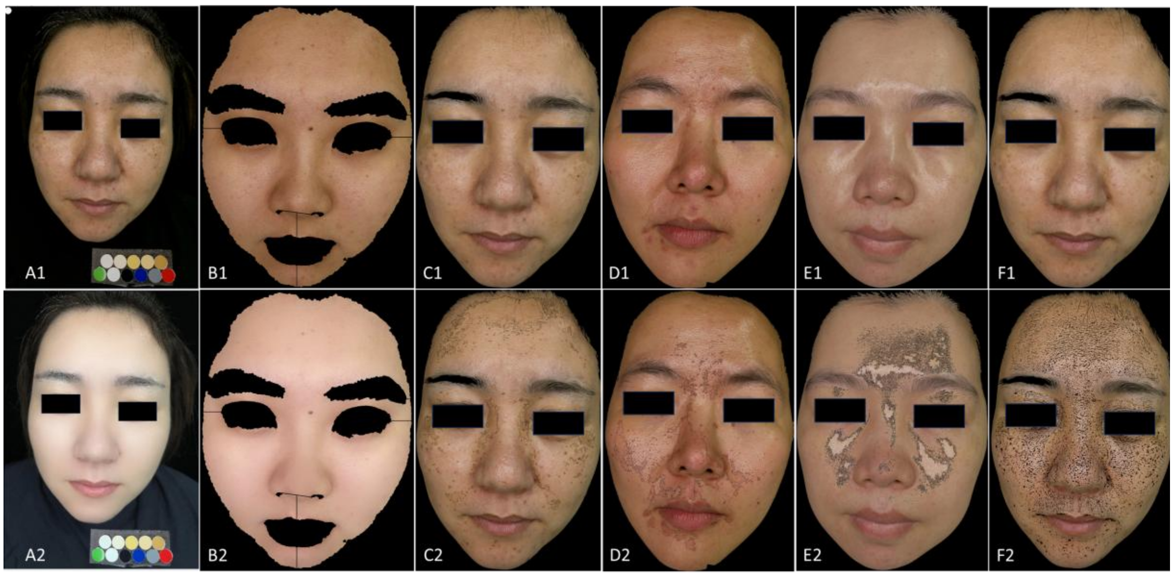

Figure 1. Example images of study participants illustrating the effects of selfie retouching and outcomes of facial feature detection. Column A: selfies before (A1) and after (A2) photo enhancing. Col. B: full-face ROI cropped out of images before (B1) and after (B2) photo enhancing. Col. C: dark spots shown in images before (C1) and after (C2) feature detection. Col. D: red spots shown in images before (D1) and after (D2) feature detection. Col. E: greasy shine spots shown in images before (E1) and after (E2) feature detection. Col. F: shapes of skin textural imperfection shown in images before (F1) and after (F2) feature detection.

3.1. Changes in primary color parameters after selfie retouching

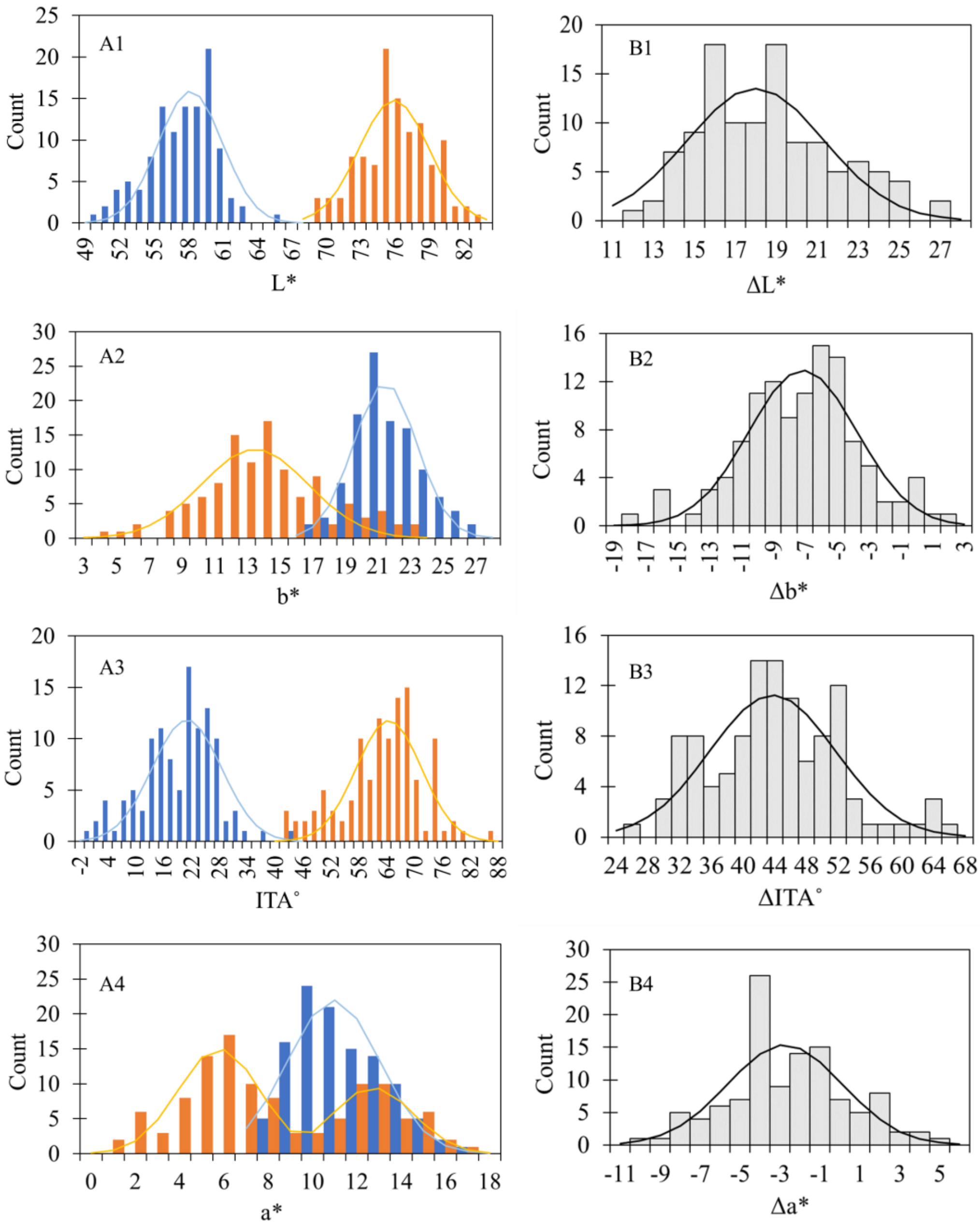

Figure 2. Changes in primary color values measured from selfies before and after participants' photo retouching. Charts in column A: histograms of the mean color values in the test population before (blue) and after (orange) selfie retouching. Colored bar charts: distributions; Curves: normal distribution regression curve. Gray bar charts in column B: histograms of participants' desired changes in color properties to achieve ideal complexion. Numbers 1, 2, 3 and 4 represent skin color properties of L*, b*, ITA˚ and a*, respectively.

The L* (skin lightness) values measured from the facial ROIs of retouched selfies were much higher than that of original selfies. As we could see in chart A1 of Figure 2, the distribution of the L* values in the original selfies of the study population (blue bars) shifted entirely to a higher-value region in retouched selfies (orange bars). The change in lightness, ΔL*, was calculated for each participant and its distribution for the population is shown in B1. Literally, all participants had chosen to lighten their selfie, with a mean increase of 18.11 in L* units and a maximum of 26.58. A statistically significant reduction in the b* (skin yellowness) is seen in A2 of Figure 2. The mean reduction in b* for the study population is -7.9 units, and it is seen in B2 of Figure 2 that almost all participants have chosen to reduce the yellowness. Reflecting the increased L* and decreased b*, the ITA˚ values are found to be dramatically higher in retouched selfies as shown in A3. Similar to the L*, all participants show a positive ΔITA˚ in B3, with a mean change of 43.3 in ITA˚ units and a maximum of 64.68 units.

An interesting phenomenon was observed with the change in skin redness (a*). While the majority of participants chose to reduce their facial redness, there were about one-third of people who had chosen to enhance their overall redness level, as shown by the bi-modal distribution of a* values for the retouched selfies in A4. The bar chart in B4 shows some Δa* values on the positive side, which confirms the observation.

3.2. Changes in other color-related skin attributes

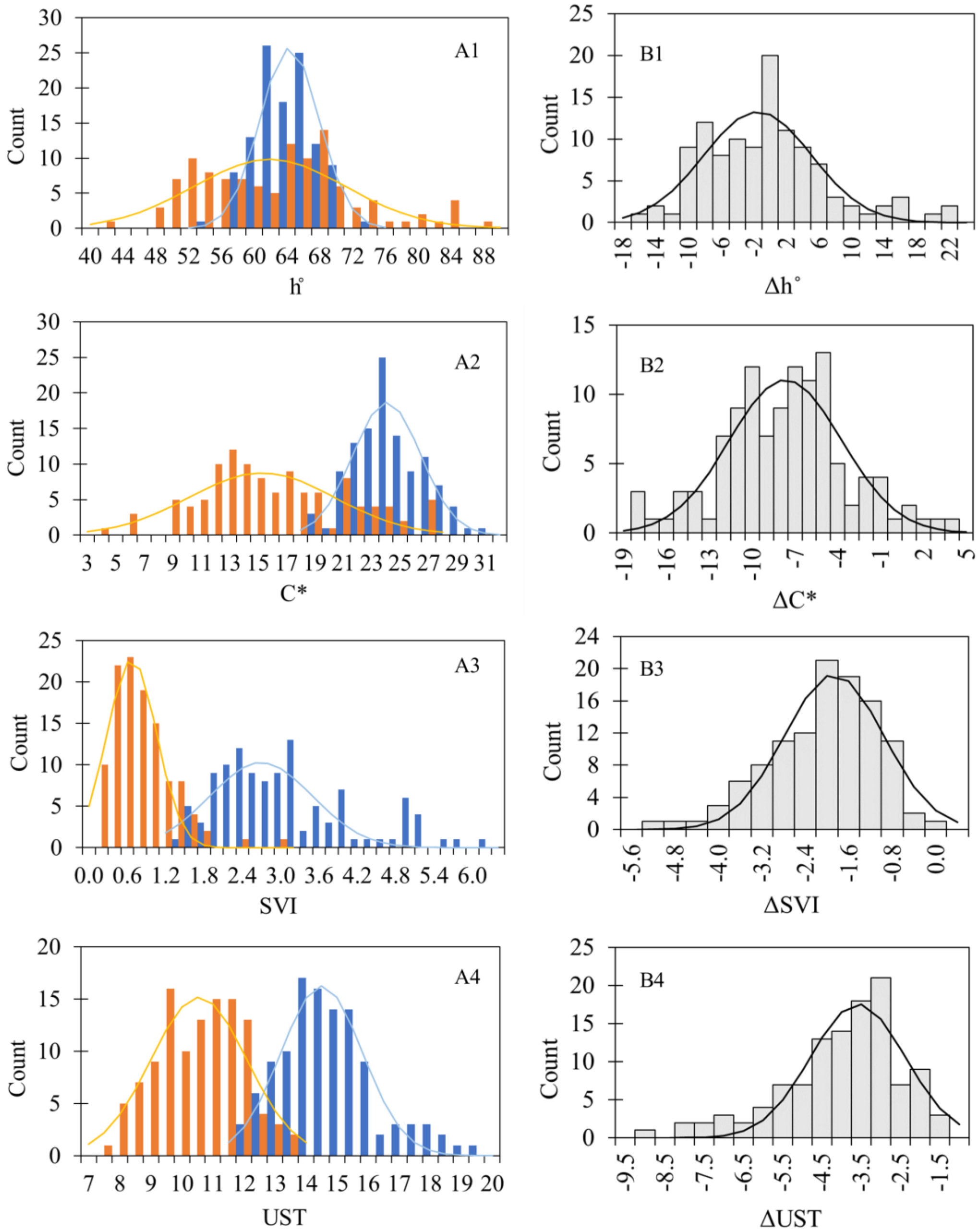

Figure 3. Changes in other color-related skin attributes. Charts in column A: histograms of the mean color values in the test population before (blue) and after (orange) selfie retouching. Colored bar charts: distributions; Curves: normal distribution regression curve. Gray bar charts in column B: histograms of desired changes in color properties to achieve ideal complexion. Numbers 1, 2, 3 and 4 represent skin color attributes of h˚, C*, SVI and UST, respectively.

Decreased hue angle (h˚) was detected in selfies after retouching although the change was barely significant, which indicates the participants preferred a red tone to a yellow one for the balance between a* and b* as shown in A1 and B1 of Figure 3. Compared to h˚, the chroma (C*) values of retouched selfies were significantly lower, which could have been caused by the dramatically increased ITA˚ values that threw off the balance between the L* and the a*b* values, as shown in A2 and B2. The index of skin visual imperfection (SVI) was significantly reduced after retouching indicating the participants desired a more visually-smooth texture, as shown in A3. All participants had chosen to reduce the skin visual imperfection in their re-touched selfies (B3), with a mean change of -2.27 in SVI units and a maximum reduction of -5.41 units. Significant reduction in overall skin tone unevenness (UST) was seen in retouched selfies as shown in A4 in which the distribution of mean UST values of the test population shifted lower. All participants showed negative ΔUST values as seen in B4, with a mean change of -4.26 and a maximum reduction of -9.09 units.

3.3. Changes in spot severity

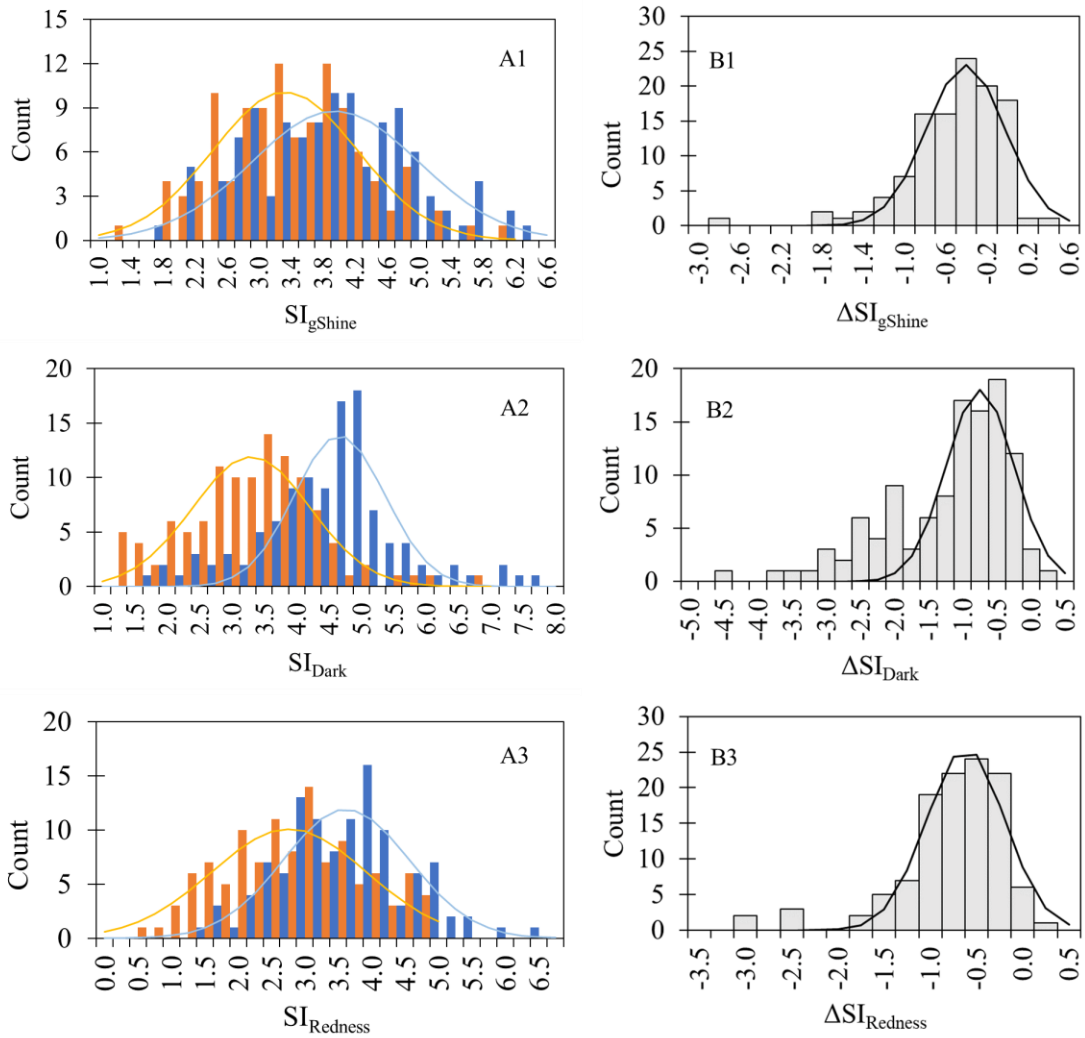

Figure 4. Changes in indexes of spot severity after selfie retouching. Charts in column A: histograms of mean attribute values in the test population before (blue) and after (orange) selfie retouching. Colored bar charts: distributions; Curves: normal distribution regression curve. Gray bar charts in column B: histograms of desired changes in color properties to achieve ideal complexion. Numbers 1, 2 and 3 represent greasy shine, dark and red spots, respectively.

Visually perceivable spots in three different dimensions (greasy shine, dark and red spots) were measured in selfies before and after retouch. Significant reduction in greasy shininess was detected as shown in A1 of Figure 4, in which the distribution of mean spot index (SI_{gShine}) of the test population shifted toward the lower end of the scale. More than 98% of participants showed negative ΔSI_{gShine} values in B1, with a mean change of -0.243 in greasy shine severity units and a maximum reduction of -1.07 units. A statistically significant reduction in SI_{Dark} was also detected as shown by the shift in distributions in A2. The mean change, ΔSI_{Dark}, was -0.69 in dark spot severity unit and there were more than 99% of participants chose to lighten the dark spots as shown in B2. Similar to dark spots, statistically significant reduction in skin redness ($SI_{Redness}$) was also detected as shown by the shift in distributions in A3. The mean change, $\Delta SI_{Redness}$, was -0.87 in redness severity unit and there were more than 99% of participants chose to lighten skin redness, as indicated in B3.

3.4. The prioritized ranking of skin attributes that affect self-perceived ideal complexion

To show a relative contributing effects among the test parameters we compared the percent improvement, $\%IMP_X = \Delta X / \bar{X}_{Original} \times 100\%$, for each of the 20 attributes after selfie retouch. The mean $\%IMP$ in $ITA°$ for the test population was found to be 369%, way high off the chart when compared to that of the other measured parameters. The $\%IMPs$ of the remaining parameters are shown by a radar chart in Figure 5. The top 9 attributes, ranging from ITA^o to UST on the right-hand side of the radar chart, were identified with the $\%IMP$ values being >29% in contribution to achieving a self-perceived ideal complexion.

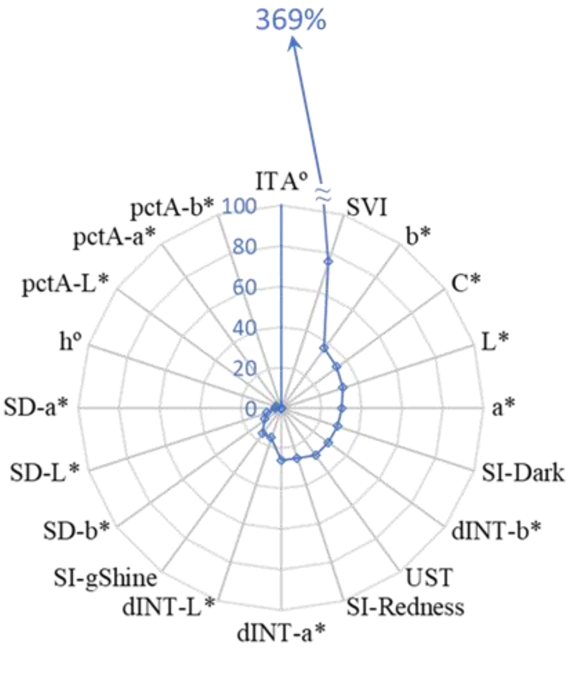

Figure 5. Radar chart displaying the rank order of skin attributes that contribute significantly to the consumer self-perceived ideal complexion.

3.4. Summary of changes in all 20 color-related parameters

The results of all 20 parameters measured from the original and the retouched selfies are listed in Table 2 where the rank order is based on the %IMP values, and the target color values for the test participants' self-perceived ideal complexion are shown in the column of retouched selfies.

Table 2. Summary of changes in all 20 color-related parameters after selfie retouch

Rank	Parameter	Original	Retouched	Change	s.d.	P value	%Improve
1	ITA°	18.78	61.73	42.94	8.22	0.000	369.2
2	SVI	2.92	0.65	-2.27	1.00	0.000	76.0
3	b*	21.26	13.52	-7.74	3.69	0.000	36.3
4	C*	23.92	15.82	-8.10	4.38	0.000	34.2
5	L*	57.16	75.31	18.15	3.29	0.000	32.0
6	a*	10.86	7.87	-3.00	2.90	0.000	30.1
7	SI_{Dark}	4.45	3.14	-1.31	0.84	0.000	29.3
8	$dINT_{b*}$	5.58	3.93	-1.64	1.00	0.000	29.2
9	UST	14.52	10.26	-4.26	1.50	0.000	29.0
10	$SI_{Redness}$	3.51	2.64	-0.87	0.59	0.000	26.3
11	$dINT_{a*}$	6.01	4.46	-1.53	1.03	0.000	25.9
12	$dINT_{L*}$	14.69	12.37	-2.32	1.63	0.000	15.5
13	SI_{gShine}	3.88	3.27	-0.61	0.47	0.000	15.5
14	SD_{b*}	2.79	2.50	-0.29	0.46	0.000	9.6
15	SD_{L*}	7.09	6.57	-0.52	0.60	0.000	7.2
16	SD_{a*}	2.25	2.31	0.06	0.35	0.088	3.1
17	h°	63.04	61.60	-1.44	7.56	0.046	2.5
18	$pctA_{L*}$	5.29	5.29	0.00	0.00	1.000	0.0
19	$pctA_{a*}$	5.82	5.82	0.00	0.00	1.000	0.0
20	$pctA_{b*}$	15.87	15.87	0.00	0.00	1.000	0.0

4. Discussion

The popular practice of consumers' retouching selfies has a lot to offer the cosmetic industry. Over the past two decades, research into applying and expanding Goffman's dramaturgical theory to online virtual environments has revealed that the phenomenon of taking, enhancing, and sharing selfies aligns with Goffman's theory of self-presentation in everyday life [17,18]. Application of such a selfie enhancing technique to obtaining consumer self-perceived beauty standards in this study has demonstrated that the approach is practical and credible, as per the psychological principle of the dramaturgical framework that beauty-conscious consumers are unlikely to be indifferent when preparing their image for presenting themselves to the world. Thus, it minimizes the drawbacks of the conventional panel evaluation process by eliminating potential risks of panelist disengagement resulted from mental fatigue.

With regard to image analysis, one unique advantage of utilizing retouched selfies is that the facial images before and after retouching are identical except changes in color properties. For spots severity measurement, it has been convenient and accurate to use the same spot area detected in the original image and to measure only the pixel intensity for comparing spot severity before and after selfie enhancing. This approach minimized the potential variability resulted from detecting spot areas in selfies before and after retouching.

Comparing the target color values of ideal complexion obtained in this study to that of other studies in literature, we noticed some interesting differences. Yano and Hashimoto in 1997 estimated “preferred complexion of Japanese woman” by evaluating complexion of 3 female models under various color of illumination. Shifts to a redder and more saturated skin tone were observed when comparing preferred to actual complexion in Japanese woman [19]. This present study on the contrary shows reduced saturation and red skin tone in ideal complexion suggesting differences in culture and traditions between two different ethnicities. He et. al. in 2017 conducted a similar study on Chinese models with a focus on method development of a preferred skin color index for complexion of Chinese people [20]. The recent studies on ideal complexion of various ethnic groups in 2022 [8,9] utilized facial images with a spectrum of complexion levels, and employed panels to evaluate ideal complexion in a paired-comparison manner. Compared to this study, the results of those two studies might have been limited to the range of complexion samples as the ideal complexion determined was not as dramatic as that in this study. One article which had a concept similar to this present study described a method of taking photos from participants of East Asian origin and manipulating the photo by research personnels to result in various levels of “whiter” photos. The actual and edited photos were then presented for 288 panelists to select their most preferred image. It was reported, similar to our present study, that the participants idealized a phenotypically “whiter” face than they objectively had [21]. Summarizing the above comparison, it is our believe that this current study is more pertinent in capturing consumer self-perceived ideal complexion which was expressed directly and explicitly via the participants' selfie editing.

5. Conclusion

From this study we concluded that this virtual selfie-enhancing technique, coupled with image analysis of various facial skin attributes, offers a clear and effective way to studying the desired complexion of modern metropolitan consumers in China. Comparing with existing ideal complexion studies in the literature, we believe it is the first time for one to obtain such direct and explicit target values of skin attributes for self-perceived ideal complexion. The difference between actual and ideal complexion was dramatic, and the trends of having fair skin, less yellow, moderate red, reduced surface imperfection, increased color uniformity and reduced greasy shininess were clearly evident. This study would serve as a valuable tool for understanding the ideal complexion across different ethnicities, regions, and genders in future studies. Additionally, it provides actionable consumer insights and enables the development of targeted cosmetic solutions for personalized skin tone management.

References

[1] Xie, Q. and Zhang, M., White or tan? A cross-cultural analysis of skin beauty advertisements between China and the United States, Asian Journal of Communication, **23** (2013) DOI.org/10.1080/01292986.2012.756046

[2] Cafri, G., Thompson, J.K., Roehrig, M., et al., An investigation of appearance motives for tanning: The development and evaluation of the Physical Appearance Reasons for Tanning Scale (PARTS) and its relation to sunbathing and indoor tanning intentions, Body Image, **3** (2006) 199–209.

[3] Lua, B.L. and Robic, J., Yellowness in skin complexion: Analysis of self-perception of women in China evaluated against clinical parameters of yellowness, Skin Res. Technol., **30** (2024). DOI.org/10.1111/srt.13831.

[4] Bullingham, L. and Vasconcelos, A.C., The presentation of self in the online world: Goffman and the study of online identities. Journal of Information Science, **39** (2013) 101 - 112. http://dx.doi.org/10.1177/0165551512470051.

[5] Murray, D.C., Notes to self: the visual culture of selfies in the age of social media, Consumption Markets & Culture, **18** (2015) 490–516. DOI:10.1080/10253866.2015.1052967.
[6] Orekh, E. and Bogomiagkova, E., 'Being on Trend': Selfie as a Social Phenomenon, International Journal of Digital Society, **8** (2017) 1238–1243.
[7] Chae, J., Virtual makeover: Selfie-taking and social media use increase selfie-editing frequency through social comparison, Computers in Human Behavior, **66** (2017) 370–376.
[8] Qu, D., Liu, J.W., Wu, Z.Q., et al., Characterizing and Modeling Complexion by Panel Perception and Objective Measurement of Skin Attributes from a Chinese Population, J. Cosmet. Sci., **73** (2022) 297–313.
[9] Wu, Z.Q., Qu, D., Whitehead, S., et al., Quantification of perception towards facial skin ideal complexion in multiple ethnic populations from clinical imaging cues, Int. J. Cosmet. Sci., **44** (2022) 636-649.
[10] Savage, S.J. and Waldman, D.M., Learning and fatigue during choice experiments: a comparison of online and mail survey modes, J. Appl. Econ., **23** (2008) 351–371.
[11] Hassan, E.K., Jones, A.M. and Buckingham, G., A novel protocol to induce mental fatigue, Behavior Research Methods, **56** (2024) 3995–4008.
[12] Ang, L., Lee, B.J., Kim, H., et al., STOP: a Spectroscopic Tip Optical Probe for skin complexion characterization, Biomedical Optics Conference 2016, OSA Technical Digest, (2016). doi.org/10.1364/CANCER.2016.JM3A.28.
[13] Wang, S., Xu, M., Meng, H., et al., Analysis of Influential Factors of Complexion based on ITA Value, Asian J. Beauty Cosmetol., **16** (2018) 591–598
[14] Veldhuis, J., Alleva, J.M., Bij de Vaate, A.J.D., et al., Me, my selfie, and I: The relations between selfie behaviors, body image, self-objectification, and self-esteem in young women, Psychology of Popular Media, **9** (2020) 3–13.
[15] Parsa, KM., Talati, IA., Wang, H., et al., Quantitative Analysis of Enhanced Selfies in a Young Adult Population, Facial Plast. Surg., **37** (2021) 651–656.
[16] Parsa, KM., Charipova, K., Chu, E., et al., Social Perception of Self-Enhanced Photographs, Facial Plast. Surg., **38** (2022) 279–284. DOI: 10.1055/s-0041-1741110.
[17] Faimau, G., Towards a theoretical understanding of the selfie: A descriptive review, Sociology Compass. (2020) e12840. https://doi.org/10.1111/soc4.12840.
[18] Bullingham, L. and Vasconcelos, A.C., The presentation of self in the online world: Goffman and the study of online identities. J. of Information Science, **39** (2013) 101 - 112.
[19] Yano, T. and Hashimoto, K., Preference for Japanese complexion color under illumination, Color Research and Application, **22** (1997) 269–274.
[20] He, J., Lin, Y., Yano, T., Noguchi, H., Yamaguchi, S. and Matsubayashi, Y., Preference for appearance of Chinese complexion under different lighting, Lighting Research & Technology, **49** (2015). https://doi.org/10.1177/1477153515615171.
[21] Thai, M., Lee, A.J., Axt, J.R., et al., Discrepancies in East Asians' perceived actual and ideal phenotypic facial features. Asian American Journal of Psychology, **11** (2020) 117–125. https://doi.org/10.1037/aap0000181.