

The Blue-Eyes Stereotype: Do Eye Color, Pupil Diameter, and Scleral Color Affect Attractiveness?

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Abstract

Background Blue eyes have been the embodiment of attractiveness not only for decades but even for centuries. The primary aim of this study was to determine whether iridal color, particularly color blue, can increase the attractiveness of a person's eye area. As a secondary aim, the study examined the impact of pupil diameter and scleral color on the attractiveness of the eye area.

Methods The stimulus material comprised images of the eye areas of 60 women ages 15–65 years. A total of 80 participants rated the attractiveness of each eye area on a 7-point Likert scale and estimated the age of the person. The color values of the iris and sclera were measured. As an additional subsample, 50% of the participants were asked what features of each eye area they found particularly appealing.

Results Most surprisingly, no correlation was found between iridal color and rated attractiveness. However, the participants mentioned the color blue more often as a positive aspect than other iridal colors. A high inverse correlation was observed between attractiveness of the eye area and age. The larger the pupil diameter and the whiter the scleral color, the lower was the real and perceived age and the higher was the attractiveness.

Conclusion The data showed that the “blue-eyes stereotype” does exist. People consider blue eyes attractive, but

in reality, blue is rated as attractive as other iridal colors. Bright scleral color and large pupils positively affect attractiveness because both features are significantly correlated with youthfulness.

Keywords Attractiveness · Eye color · Perceived age · Pupil diameter · Scleral color

As the central part of the human face [28], the area of the eyes plays an important role for a person's attractiveness. For centuries, blue eyes have been an attribute of beauty, particularly in women. When in earlier centuries artists painted idealized female beauties such as Eva, The Madonna, or The Venus, they mostly portrayed them with blond hair and blue eyes even in Mediterranean countries [3, 9].

Even currently, if people are asked in (scientifically rather worthless) opinion surveys what physical characteristics they prefer in a woman, blue eyes rank among the “top five” characteristics mentioned. This result was shown in a large-scale German single study in 2009 that included more than 4,500 male interviewees, almost 50% of whom preferred blue eyes in the woman of their dreams [12]. Of course, this conclusion cannot be entirely transferred to countries with a different prevalence of iridal colors.

Apart from the eye color, other important factors [6, 10, 14, 17, 21, 22, 28] are the shape and position of eyebrows; the length, shape, and color of lashes; skin quality; eye shape; eye axis; lid fissure height (parameters that can be easily changed by plastic aesthetic surgery [4, 5, 7, 13, 18–20]); pupil diameter; and scleral color. To date, hardly any scientific paper can explain the importance of eye color for individual attractiveness. Thus, such statements represent only individual subjective opinions but not the view of the general public.

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Methods

Stimulus Material

The stimulus material comprised images of the eye areas of 60 Caucasian women 15–65 years of age. Participation in this study was voluntary and unpaid. The photos were taken under highly standardized conditions, namely, straight head position, neutral facial expression, constant position of the camera, and lighting conditions of a professional photo studio. All images of the eye area including eyebrows were cropped from the photo of the entire face, showed the same picture details, and had a resolution of $1,024 \times 768$ pixels. Each photo was printed on regular 9×13 cm photographic paper, which resulted in an image approximating the size of a natural eye area.

Participants

In this study, 80 Caucasian participants (40 women and 40 men) were questioned about the attractiveness and the assessed age of each eye area. The study was conducted in a medium-sized city in Germany. The data were collected in public places such as pedestrian zones, stations, trains, and shopping centers to get a sample as representative of the German population as possible. The youngest participant was 30 years old, and the oldest was 50 years of age (mean, 38.4 ± 6.5 years). The study was limited to this age range because it represents the main clientele for plastic aesthetic surgeries. The restriction to both Caucasian participants and Caucasian stimuli reflected the percentage of Caucasian people among the German population (about 98%). Participation was voluntary and unpaid.

Procedure

For questioning, all eye area images were presented in a random array, which was rearranged after 50% of the

interviews to avoid position effects. No time limitation was imposed. First, all participants estimated the age of the person in the photo, then rated the attractiveness of the presented eye area on a 7-point-Likert-scale ranging from 1 (very unattractive) to 7 (very attractive). For each eye area, we calculated the mean attractiveness and age estimation given by all participants.

The empirical examination of attractiveness, as viewed by the general public, is an extremely important aspect. Attractiveness needs to be evaluated by the majority of a representative population, not only by the personal opinions of plastic surgeons with regard to their favorites and disfavorites. Only a large number of individuals (in this case 80) can show meaningful results for attractiveness.

In addition to attractiveness ratings and age estimations, 50% of the participants (20 men and 20 women; mean, 37.7 ± 7.4) were asked what features of each eye area they found particularly appealing. The answers to this open question were recorded by the investigator.

Measurement of Pupil Diameter and Eye Color

First, we quantified the pupil diameter of each eye area by measuring the image coordinates and by calculating the distances in pixels. Afterwards, the pupil diameter measurement was standardized by dividing it through the horizontal iris diameter measurement to avoid any errors due to irregular image cutouts. Therefore, the pupil diameter was expressed as a percentage of iris width.

Additionally, we measured the average hue of the iris. For this measurement, a defined square area within the iris was spanned with image-processing software (Adobe Photoshop). Based on the obtained picture information, we calculated the average color value (Fig. 1). The color coordinates were read according to the red, green, and blue (RGB) system and the hue, saturation, and brightness (HSB) system.

Fig. 1 The average iridal color measured by stretching a square area from the pupil's border to the border of the iris followed by calculation of mean color and measurement of hue, saturation, and brightness (HSB) and red, green, and blue (RGB) coordinates. The scleral color was measured analogically at the medial part of the sclera

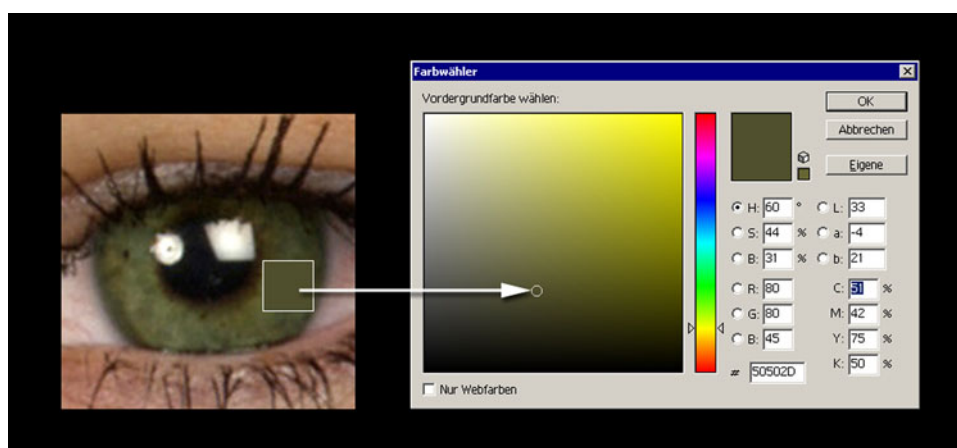
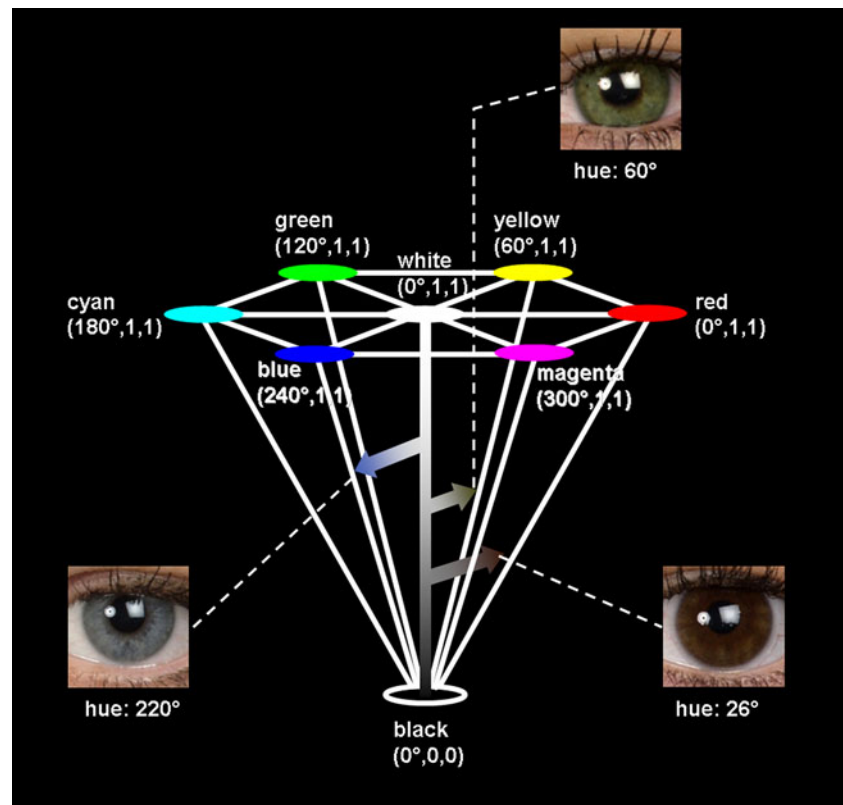


Fig. 2 The color cone is a three-dimensional model illustrating the relationships between hue, saturation, and brightness. Hues were arranged around the circle, beginning with red (0°), followed by saturation from the center (minimum) to the circle's border (maximum) and brightness from the apex (minimum) to the base (maximum). In this system, each iridal color can be expressed by three numbers and thus can be statistically analyzed



The same procedure was used for measuring the scleral color. In the HSB system, a value between 0° and 360° was assigned for each hue, defined by the wavelength of the light. The values were 0° for pure red, 120° for pure green, and 240° for pure blue. The color impression also depended on saturation (level of gray content and purity of color) and brightness. The color brown resulted from red to orange hues (of low brightness), whereas green-colored irises mainly resulted from shades of yellow with reduced saturation and brightness. The color cone in Fig. 2 illustrates this relation.

Statistical Analysis

For analysis of the data, we calculated correlations (according to Pearson) between the following variables: real age of an eye, its perceived age, and its rated attractiveness. For the last two variables, the mean ratings for each eye area over all raters were used. These variables were correlated with the measured parameters of an eye area (pupil diameter and color parameters of iris and sclera) (Table 1).

In addition, all eye areas were classified into three categories based on their iridal color: brown, blue, and a category termed “combined.” A one-way analysis of variance (ANOVA) was calculated to test whether the mean

attractiveness ratings depended on the category of eye color (Table 2).

To examine whether a prejudice that blue eyes could be more attractive (“blue-eyes stereotype”) existed among the participants, we counted how often (in response to the open questions) the iridal color was reported to be a positive feature of a certain eye area. If it was reported by a participant, it was coded with “1,” and if not, it was coded with “0.” For each eye, we totaled the number of times that iridal color was mentioned. Then the mean for all eyes of each color category was calculated and analyzed with a one-way-ANOVA if the means of the three eye color categories differed significantly (Table 3).

Results

All statistical evaluations were made with regard to three variables:

1. The actual age of the person whose eye area was photographed
2. The mean perceived age of the eye area estimated by the participants
3. The mean assessed attractiveness of the eye area rated by the participants.

Table 1 Pupil diameter and measured parameters of iridal and scleral color correlated with rated attractiveness, real age, and perceived age of the eye area

Variable	Description	Unit	Correlation with attractiveness	Correlation with real age	Correlation with perceived age
Attractiveness	1–7	Points		–0.87 ^a	–0.91 ^a
Stimulus person's real age	Years	Years	–0.87 ^a		0.98 ^a
Stimulus person's perceived age	Years	Years	–0.91 ^a	0.98 ^a	
Pupil diameter	% of iris width	% of iris width	0.61 ^a	–0.68 ^a	–0.67 ^a
Hue of iris	0–360°	Angle in °	–0.05 (NS)	0.04 (NS)	0.02 (NS)
Saturation of iris	%	%	–0.06 (NS)	0.05 (NS)	0.06 (NS)
Brightness of iris	%	%	–0.07 (NS)	0.05 (NS)	0.06 (NS)
Blue of iris (RGB system)	0–255	–	0.02 (NS)	–0.02 (NS)	–0.03 (NS)
Hue of sclera	0–360°	Angle in °	–0.17 (NS)	0.23 (NS)	0.24 (NS)
Saturation of sclera	%	%	–0.39 ^a	0.45 ^a	0.44 ^a
Brightness of sclera	%	%	0.21 (NS)	–0.29 ^b	–0.28 ^b

NS nonsignificant difference

^a $P < 0.01$ ^b $P < 0.05$ **Table 2** Mean attractiveness values for eye areas: results of analysis of variance (ANOVA) depending on eye color^a

Eye color	<i>n</i>	Mean	<i>F</i> value	<i>P</i> value
Brown	23	3.30 ± 1.13	0.39	0.682
Combined	21	3.06 ± 1.40		
Blue	16	3.38 ± 0.99		
Total	60	3.24 ± 1.19		

^a Scale from 1 (very unattractive) to 7 (very attractive)**Table 3** Mean number of positive references to eye color given as an answer to the open question “What features of this eye area do you find particularly attractive?” Results of analysis of variance (ANOVA) depending on eye color

Eye color	<i>n</i>	Mean	<i>F</i> value	<i>P</i> value
Brown	23	9.48 ± 5.56	16.56	<0.001
Combined	21	7.67 ± 3.09		
Blue	16	16.44 ± 5.34		
Total	60	10.70 ± 5.90		

Every measured variable of the eye area was calculated to determine its correlation with the three variables. Our results showed a very strong correlation between the attractiveness of the eye area and age ($r = -0.87$). The younger a person's eye area, the more beautiful it was perceived to be. Furthermore, the participants were able to estimate a person's age. The correlation between mean assessed age and real age was nearly perfect ($r = 0.98$). The pupil diameter correlated highly not only with

attractiveness ($r = 0.61$) but also with the real age ($r = -0.68$) and the assessed age ($r = -0.67$) of the eye area. This correlation means that the larger a pupil (given equal light conditions), the more attractive and younger was the perception of the eye area.

Surprisingly, no correlation existed between attractiveness ($r = 0.02$) or age ($r = 0.05$) and the measured iridal color of the eye area. The scleral color correlated differently. Increased brightness indicated eyes of a younger age ($r = -0.29$), and low saturation (i.e., gray or white without a tint) correlated with an attractive ($r = -0.39$) and young ($r = 0.45$) eye area.

In addition, all eye areas were classified into three categories based on their iridal color: brown, blue, and a category termed “combined.” The remaining category included 21 (of 60) eyes with blue, gray, and brown components. At first sight, these eyes would be considered “green,” although they do not appear green at a closer look.

An ANOVA was calculated to analyze whether blue eyes ($n = 16$) received higher mean attractiveness assessments than brown eyes ($n = 23$) or eyes of combined colors. However, the result showed no significant differences ($F [59,2] = 0.39$; $P = 0.68$).

In addition to attractiveness ratings and age estimations, a subsample of 40 participants were asked what features of each eye area they found particularly attractive. The answers to this open question were recorded by the investigator.

For the analysis, we counted how often the eye color was reported to be a positive feature of a certain eye area.

An ANOVA was calculated to analyze whether such a reference depended on the eye color. The data showed that the eye color was much more often mentioned as positive if the iridal color was blue (mean, 16.44 ± 5.34) in contrast to brown (mean, 9.48 ± 5.56) or combined colors (mean, 7.67 ± 3.09). The difference was highly significant ($F [59,2] = 16.56$; $P < 0.001$). For blue eyes, the number of positive references was 73% higher than for brown eyes and more than twice as high as for combined colors.

Discussion

Iridal Color

At first, the reported findings on iridal color seem to be contradictory. In the interviews, the iridal color was mentioned as a positive feature much more often when the iridal color was blue. On the other hand, blue eyes were not rated more attractive than eyes of other colors. Our objective measurements of iridal colors (hue, saturation, brightness) also did not show any relationship with attractiveness. Our implemented method for color measurement was valid. Its validity was confirmed by the fact that the same method worked well for measuring scleral color, in which high brightness and low saturation showed a low or medium correlation with attractiveness or age.

On closer inspection, these findings are not surprising. These results attest to a phenomenon we like to term the “blue-eyes stereotype.” People believe that blue eyes make eye areas attractive, but when they judge the attractiveness of eye areas, the iridal color is not a criterion for their decision making. The myth of blue eyes seems to be not more than a simple prejudice. For the attractiveness of an eye area, the iridal color is not relevant.

When the very high correlations between attractiveness and age of an eye area ($r = -0.87$), or more precisely the perceived age of an eye area ($r = -0.91$), are investigated, it becomes clear that an eye area’s attractiveness depends primarily on features signaling youthfulness. However, the iridal color (in contrast to the scleral color) is a feature that remains constant from youth to old age.

Explaining the reason for this stereotype is difficult and speculative. Perhaps the frequency of eye colors plays a role. In most countries, blue eyes are less prevalent than other eye colors and may have the image of something special and more valuable. If this assumption is true, brown eyes should be preferred in countries where the majority of the population has blue eyes. This frequency-dependent effect on sexual selection has already been shown with regard to hair color [26].

Another explanation for the positive image of the color blue may be the possibility of a genetic relationship

between blue eyes and blond hair and fair skin. Perhaps the stereotype is based on a preference for blond hair that extends to blue eyes because eye color correlates with hair color [8, 15, 16, 25].

Similar to hair and skin color, iridal pigmentation is mainly determined by the quantity and type of melanin in the melanocytes of the pigment epithelium and the uvea [29]. This pigmentation differs between the eumelanin in dark-colored irides and the pheomelanin found in melanocytes of eyes with light-colored irides (Fig. 3).

Newborns [15, 24] usually have blue eyes due to the small amount of melanin in the irides. Pigmentation can change and shift to its final color in the first few months or

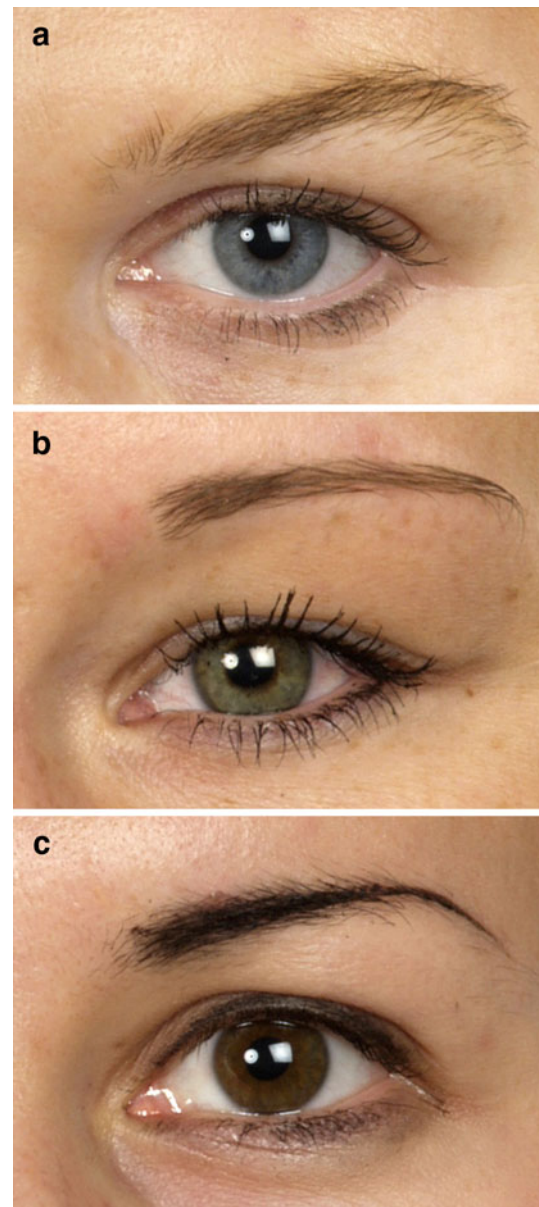


Fig. 3 Three different eye colors. **a** Blue. **b** Green. **c** Brown

years of a person's life. Pathologic changes in iridal colors must be differentiated because they could lead to limited attractiveness. These changes mostly occur, for instance, in uveitis, heterochromic cyclitis, pigment dispersion, Oculocutaneous albinism, glaucoma, cataract, and iridal melanoma due to up- or downregulation of the melanin content in the cells.

Pupil Diameter

Our results also showed a preference for eye areas with a wide pupil diameter (given equal light conditions) and for bright and shiny scleral color. Both features are found in the eye areas of younger people. Interindividual differences in pupil size have the following different pathophysiologic reasons:

1. Cataract [2]. Due to the aggregation of the optical media (cornea, lens), sensibility to light and reflex ions increases, resulting in reactionary miosis.
2. Senile miosis [14, 17]. The cause of senile miosis is heavily discussed in the scientific community (e.g., atrophy in the Westphal–Edinger nucleus, decreased sympathetic pupillary tone, and sleep disorders).

The finding that eyes with large pupils are assessed as more attractive than eyes with small pupils is not new [1, 3, 11, 23, 27]. This effect was found even when images of the complete face were presented and only the pupil size was manipulated. But the effect usually is explained in another way. Because pupils also enlarge as a consequence of positive emotions and sexual arousal, wide pupils are interpreted as a signal of the counterpart's (sexual) interest and sympathy [11]. This interpretation also may be correct, but our data indicate, through the high correlation of pupil diameter with age ($r = -0.68$) and rated attractiveness ($r = 0.61$), a very simple alternative explanation for this phenomenon: Wide pupils signal youthfulness (Fig. 4).

Scleral Color

The participants' preference for a bright and low-saturated sclera also can be explained by a preference for features signaling youthfulness. This explanation is supported by the fact that the measured parameters correlate with the age of an eye area. The color of the sclera can appear different to different observers. Scleral redness results from the blood vessels in the conjunctiva and corpus ciliare. If these parts of the eyes are irritated (e.g., by allergy, infection, or trauma), the blood vessels react by dilating, and the sclera shows a reddish color.

With age, the most common change in scleral color is yellowing, caused by a color change of the elastic fibers in the conjunctiva due to ultraviolet sunlight exposure. The

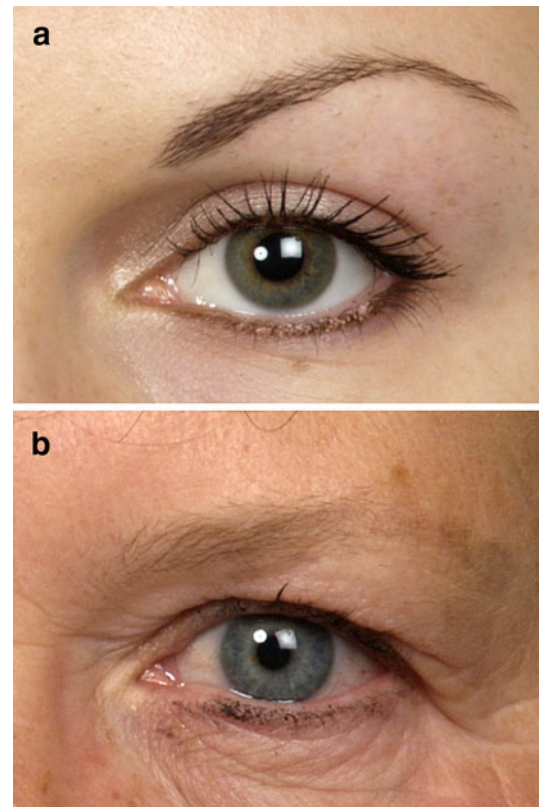


Fig. 4 Pupil diameter and scleral color. **a** Age 20 years. **b** Age 55 years

blue appearance of the sclera results from the thinning of the sclera, which allows the choroid to shine through. This process also is associated with osteogenesis imperfecta (through degeneration of the mesenchyme and scleral atrophie), Marfan's syndrome, Ehlers-Danlos syndrome, pseudoxanthoma elasticum, and long-term use of steroids. Most newborns also have, physiologically, a blue-colored sclera.

Conclusion

Our study showed the myth about blue eyes to be incorrect. Independent of the age or gender of the person questioned, the iridal color does not make any difference in the perceived attractiveness of an eye area whether brown, blue, gray, or green.

First, eye color attractiveness depends on the individual preference of the beholder. Second, even the persons in this study who mentioned blue color as a positive feature of the presented eye areas did not essentially rate blue eyes higher than eyes of other iridal colors. A "blue-eyes stereotype" seems to exist. People think blue eyes are more attractive but they in fact do not assess them as more attractive. A large pupil diameter and a bright, shiny sclera, both of

which signal youth and attractiveness (Fig. 4a) [1, 3, 11, 23, 27], are preferred by most individuals, whereas a small pupil and dull sclera are disliked by most people (Fig. 4b).

Nevertheless, none of the examined parameters can be changed or influenced by the advances in plastic aesthetic surgery. Yet, pupil diameter and scleral color remain immutable parameters that are attributes of age and correlate with attractiveness. Only the iridal color can be noninvasively modified with colored contact lenses according to individual preferences. The customers of colored contact lenses hope to enhance their attractiveness. However, our study shows that iridal color is irrelevant for attractiveness. Iridal color does not affect the beauty of an eye area no more than the beauty of an entire face or an entire person.

In our study, we examined eye areas of German women and had German participants (all Caucasians) who judged the attractiveness. Many people in Germany have blue or mixed eye color. In other countries with more brown-eyed people, the preferences of the study participants could be different because the evaluation of blue eyes also may be influenced by culture. However, this should rather affect the “blue-eyes stereotype” and less the real attractiveness ratings because it was shown that an eye’s attractiveness is highly correlated with features signaling youth and that youthfulness is a criterion for attractiveness shared by all cultures.

It would be interesting for future studies to repeat this experiment in other countries to highlight how the evaluation of eye color depends on the raters’ own eye color or their culture.

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