Eye shape illusions induced by eyebrow positions

Soyogu Matsushita1, Kazunori Morikawa1, Saya Mitsuzane1, Haruna Yamanami2
1School of Human Sciences, Osaka University, Suita-shi 565-0871, Japan; 2Shiseido Research Center, Yokohama 224-8558, Japan; e-mail: soyogu@hus.osaka-u.ac.jp
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Abstract. We investigated whether the position of the eyebrows influences the perceived shape of the eyes by employing psychophysical measurements. Experiment 1 used arched and straight eyebrows at five different inclinations as stimuli and measured the perceived inclination of the eyes. The results demonstrated that the eyes are perceived to be somewhat inclined in the same direction as the eyebrows. Experiment 2 measured the perceived eye size by manipulating the distance between the eyes and the eyebrows and the curvature of the eyebrows across three levels. The results showed that the lower eyebrows (i.e., closer to eyes) made the eyes appear larger and the higher eyebrows made the eyes appear smaller, while eyebrow curvature had no effect on perceived eye size. Experiment 3 examined the role of the eye–eyebrow distance in the eye inclination illusion shown in experiment 1. The eye inclination illusion was unaffected by the eye–eyebrow distance, suggesting that the eye inclination illusion and the eye size illusion may involve different kinds of assimilation. These illusions are discussed in terms of face perception and possible practical applications.

Keywords: illusion, eye, eyebrow, face, assimilation, contrast

1 Introduction
Processing facial information is one of the most vital visual skills in everyday life. Typical humans can easily identify thousands of human faces. The mechanism of such a remarkable ability has been studied extensively. There is abundant research that found that perceiving human faces is based on two kinds of processing; featural processing of eyes, nose, and mouth as independent components and holistic (configural) processing of spatial relations between those features (e.g., McKone & Robbins, 2011; Tanaka & Farah, 1993). Although eyebrows are one of the most conspicuous features of the human face (Haig, 1985; Nagai et al., 2013), only a few studies have investigated the role of eyebrows in either featural processing or holistic processing. However, there are at least four reasons why the often-neglected eyebrows deserve further scientific investigation.

First, eyebrows have a large impact on face identification. For example, information in the eye and eyebrow region is most clearly linked to observers’ ability to discriminate faces (Nagai et al., 2013; Sekuler, Gaspar, Gold, & Bennett, 2004). Moreover, Sadr, Jarudi, and Sinha (2003) demonstrated that it is more difficult to identify faces without eyebrows than to identify faces without eyes. Altering eyebrows can cause a change in the overall facial impression (Morikawa, 2012, in press).

Second, it is still unknown whether holistic perception of one facial feature influences shape perception of other features. Such an effect is not impossible, given that holistic processing is known to either facilitate featural processing, as in the part–whole effect (Tanaka & Farah, 1993), or interfere with it, as in the composite-face effect (Rossion & Boremanse, 2008; Young, Hellawell, & Hay 1987). Moreover, alterations of some features can affect the processing of other features because facial features are interdependent in holistic processing (Tanaka & Sengco, 1997). In addition, Xiao et al. (2014) reported that the size of a whole face influences the perceived size of facial features. It is therefore worth investigating how eyebrows affect the perception of the other parts of the face such as eyes because such findings may further elucidate the relationship between holistic processing and featural processing.
Third, although makeup artists often claim that changing eyebrows can alter perceived eye shape, this claim has not been substantiated yet. If it is experimentally proven, the results could have practical implications because the eyes are one of the important determinants of facial attractiveness. For example, Baudouin and Tiberghien (2004) showed that wider eyes make female faces more attractive (cf. Geldart, Maurer, & Carney, 1999). Gründl et al. (2008) showed that young observers regarded the gently ascending eye angle (i.e., the lateral canthus being higher than normal) as more attractive than the normal eye angle. The need to study eyebrows is also justified by the fact that no other feature in the face can be as easily and dramatically altered as the eyebrows by means of cosmetics. If the position of eyebrows affects the perceived eye shape, there may be beneficial applications of the phenomenon.

Fourth, if the shape and/or orientation of eyebrows can influence the perceived shape and/or orientation of the eyes, the effect may be a case of visual geometric illusions. Studying the effects of eyebrows may uncover naturally occurring geometric illusions in the human face and shed light on the relationship between face perception and visual illusions. Interactions between contours usually manifest themselves as either illusions of assimilation or illusions of contrast. In illusions of assimilation the difference in size, orientation, etc. between neighbouring parts of the stimulus appears smaller than it really is. In the Bourdon illusion and the Lipps illusion, for example, the orientation of a line appears closer to that of an adjacent line than it really is. On the other hand, in illusions of contrast the difference in size, orientation, etc. between neighbouring parts of the stimulus appears exaggerated. In the Ebbinghaus illusion, which is an example of an illusion of size contrast, a circle surrounded by several larger circles is perceived as smaller than a circle of the same size surrounded by smaller circles. It is possible that such geometric illusions occur in human faces as well (Morikawa, 2012, in press; Schwanger, Ryf, & Hofer, 2003; Xiao et al., 2014). Historically, most visual illusions have been studied with very little relevance to everyday life. However, some illusions can be relevant (Morikawa, 2003). Eyebrows provide us with an excellent tool to study visual illusions in the most natural and socially important stimuli—that is, human faces.

This study aims to examine whether the configural processing of eyebrows affects the shape perception of eyes. Such effects would demonstrate that, when configural information of one part of the face is manipulated, neighbouring parts would also be perceptually distorted as if the face tried to keep balance as a whole. We employ psychophysical methods to precisely measure the perceived angle and size of eyes under the influence of eyebrows. Experiment 1 investigates whether the rotation of the eyebrows affects the perceived angle of the eyes. Experiment 2 examines whether the height of the eyebrows affects the perception of the eye size. Experiment 3 studies whether the height of the eyebrows modulates the influence of the eyebrow inclination on the perceived angle of the eyes.

2 Experiment 1
In this experiment we measure the perceived inclination of the eyes in facial photographs whose eyebrow angles are systematically manipulated. If the angles of eyes and eyebrows are assimilated, eyes should be perceived as inclined in the same direction as the eyebrow rotation, in a way similar to the Bourdon illusion. On the other hand, if the angles are contrasted, eyes should be perceived as inclined in the direction opposite to the eyebrow rotation, which is similar to an overestimation of acute angles in geometric illusions.

2.1 Method
2.1.1 Participants. Twenty-four undergraduate students (eight males and sixteen females) aged 18 to 27 years (M = 21.58 years, SD = 1.64 years) voluntarily participated. All self-reported normal or corrected-to-normal visual acuity.
2.1.2 Stimuli and apparatus. Experiments (including experiment 2) were run on a computer with a custom program. The stimuli were presented on a 24.1-inch LCD screen (NEC MultiSync LCD-PA241W). Although we did not secure the observing position with an apparatus, the viewing distance remained constant at approximately 70 cm.

All stimuli were generated from a single original facial image that was based on an average face of Japanese females but somewhat modified to represent typical attractiveness (figure 1b). The dimensions of the stimuli were 660 pixels wide (14.3 deg) and 900 pixels high (19.1 deg). The dimensions of the face itself were approximately 480 pixels wide (10.5 deg) at the cheekbone level and approximately 810 pixels high (17.3 deg) from the top of the head to the tip of the chin. The stimuli were colour images with a grey background (median RGB of 214, 219, and 213).

We used five levels of eyebrow inclination for the standard stimuli; the eyebrows were rotated from −8° to 8° in steps of 4° (negative rotation indicated drooping eyebrows; figure 1). All angles were defined relative to the original face. The range −8 to +8 was chosen because our preliminary experiment showed that faces within this range appeared normal. To examine the robustness of the effect of eyebrow inclination, we also varied the eyebrow shape; one shape was naturally arched, and the other was nearly straight. We created the straight eyebrow by lifting the position of the outer edge (ie ear side) of the eyebrow while keeping the positions of the inner edge (ie nose side) and the peak of the eyebrow arch unchanged. Hence, there were 10 standard stimuli (5 levels of inclination × 2 types of shape).

Figure 1. [In colour online, see http://dx.doi.org/10.1068/p7823] The standard stimuli in experiment 1. The top row [(a), (b), and (c)] shows the arched eyebrows, and the bottom row [(d), (e), and (f)] shows the straight eyebrows. The left column [(a) and (d)] shows the −8° rotated eyebrows, the centre column [(b) and (e)] shows the 0° rotated eyebrows, and the right column [(c) and (f)] shows the +8° rotated eyebrows. The eyes are identical in all the images.

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The eyebrow shape of all comparative stimuli was naturally arched. There were 11 levels of eye inclination for the comparative stimuli; the eyes were rotated from −5° to 5° in steps of 1° (figure 2). To implement these manipulations, each eyebrow or eye was cut out as an elliptic area with blurred edges, rotated and then pasted back on the base face image, using digital photo editing software. The centre of the rotation of the eyebrow was the medial end (the nose side edge) of the eyebrow. The eye was rotated around the centre of its pupil.

2.1.3 Procedure. The experiments had been approved by the ethical board of School of Human Sciences of Osaka University. After each participant signed the informed consent form and was given the instructions, the experimental task started. On each trial a standard stimulus and a comparative stimulus were displayed side by side on the computer screen. The background of the images was grey. After the presentation of the stimuli for 1500 ms, the screen changed to a grey blank. The task was to choose the stimulus whose eyes appeared to be more turned up (ie positively rotated) compared with the other face. We instructed participants not to focus on a few specific points of the stimulus, but to pay attention to the whole area of the face. The blank screen was presented for at least 1500 ms or until the participants responded. Following the response, the next stimulus pair was presented. To measure the eye angle of the comparative stimulus that was perceived to be the same as the eye angle of the standard stimulus, we used the staircase method, also known as the up-and-down method. For each standard stimulus there were one initially ascending staircase and one initially descending staircase; hence, the experiment consisted of 20 concurrent staircases of trials, which were randomly interleaved. Whether the standard stimulus was presented on the left or right hand side of the screen was determined at random. The eyes of the comparative stimulus for the first trial of each staircase were rotated by either −5° (ascending series) or 5° (descending series). Each staircase was terminated when the step direction of the staircase reversed eight times.

2.2 Results and discussion
First, we computed the point of subjective equality (PSE) for each standard stimulus; the PSE was the mean of the eye angles of the comparative stimuli where the step direction reversed from upward to downward or from downward to upward (figure 3). A two-way ANOVA with eyebrow inclination and eyebrow shape as the independent factors indicated that both main effects were significant for eyebrow inclination ($F_{4,92} = 30.67, p < 0.0001$) and for eyebrow...
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shape ($F_{1,23} = 16.67, \ p < 0.0001$). In addition, the interaction between the two factors was also significant ($F_{4,92} = 2.63, \ p = 0.04$). The simple main effects revealed that the straight eyebrows made the eyes appear more positively inclined than did the arched eyebrows when the eyebrow rotation was $-4^\circ$ to $8^\circ$ ($p < 0.05$), probably because the straight eyebrows in this range appeared more positively inclined than the corresponding arched eyebrows. It did not necessarily mean that the assimilative power of the straight eyebrows was greater than that of the corresponding arched eyebrows. We next calculated the slope of the regression line for the perceived inclination of the eyes as a function of the inclination of the eyebrows in each eyebrow shape condition separately. The analysis revealed that $1^\circ$ of objective eyebrow rotation induced an apparent eye inclination of $0.18^\circ$ in the straight eyebrow condition ($t_{23} = 6.57, \ p < 0.0001$), and an apparent eye inclination of $0.16^\circ$ in the arched eyebrow condition ($t_{23} = 5.90, \ p < 0.0001$). The difference between these slopes was not significant ($t_{23} = 1.32, \ p = 0.20$). This indicates that the straight eyebrows and the arched eyebrows were equally effective in assimilating the perceived eye inclination.

These results indicate that the apparent inclination of the eyes was assimilated with the inclination of the eyebrows. It should be noted that in reality facial expressions can change eyebrow inclination far more than eye inclination. Therefore, observers may interpret eyebrow inclination as transient whereas eye inclination is permanent. Nevertheless, the results exhibited the same trend regardless of eyebrow shape. This suggests that the phenomenon of assimilation of eyes and eyebrows is relatively robust against variations of eyebrow shape.

3 Experiment 2
To investigate whether eyebrows can also affect the perception of eye size, in experiment 2 we measured perceived eye size as a function of shape and position of the eyebrows. Experiment 1 showed that the eye is assimilated to the eyebrow to some extent. If the assimilative power remains constant regardless of the distance between the eye and eyebrow, the perceived eye size may appear unchanged as the eyebrow position is shifted higher. However, if the power of assimilation is stronger when the eyebrow is closer to the eye, then the eye should appear larger as the eyebrow is shifted closer to the eye.

Because the vertical distance between the eye and the eyebrow can be defined as either the distance between the eye and the lowest part of the eyebrow or the distance between the eye and the highest part (i.e., the peak) of the eyebrow, there are two methods to manipulate the distance between the eye and the eyebrow. First, the whole eyebrow can be shifted up or down without changing its shape. Second, the height of the peak of the eyebrow curve can be moved up or down relative to both ends of the eyebrow, which changes the eyebrow curvature. Shifting the eyebrow peaks high (e.g., the rightmost column of figure 4) conveys the impression that the eyebrows are ‘raised’ as in the facial expression of surprise.
Normally, raising the eyebrows causes the eyes to open wide. Thus, shifting the eyebrow peaks high may make the eyes appear larger than they really are. Therefore, we employed both methods.

3.1 Method
The same general methods and procedures were used as those of experiment 1 except for the following differences.

3.1.1 Participants. Twenty-four undergraduate students (thirteen males and eleven females) aged 19 to 35 years ($M = 21.34$ years, $SD = 3.21$ years) voluntarily participated.

Figure 4. [In colour online.] The standard stimuli used in experiment 2. The top row [(a), (b), and (c)] shows whole high, the centre row [(d), (e), and (f)] shows whole middle, and the bottom row [(g), (h), and (i)] shows whole low conditions. The left column [(a), (d), and (g)] shows peak low, the centre column [(b), (e), and (h)] shows peak middle, and the right column [(c), (f), and (i)] shows peak high conditions. The eyes are identical among all images.
3.1.2 Stimuli. The standard stimuli were facial images whose eyebrow shape and position were manipulated (figure 4). We used three levels of the position of the whole eyebrows: −8 (whole low), 0 (whole middle), and 8 (whole high) pixels shifted from the original eyebrow position. In addition, for each level of the whole eyebrow position we used three levels of peak height of the eyebrow arch: −8 (peak low), 0 (peak middle), and 8 (peak high) pixels shifted from the peak height of the original eyebrow shape. We created these shapes by shifting the eyebrow peak up or down while keeping the positions of both ends of the eyebrow unchanged. Hence, the total number of the standard stimuli was nine. In the original face the vertical length of the eye (i.e., the distance between the top and bottom of the palpebral fissure) was 36 pixels, and the distance between the top of the eye and the lower edge of the eyebrow was 45 pixels on the vertical line that passes through the centre of the pupil. Therefore, the step of 8 pixels was equivalent to 22% of the vertical length of the eye. Comparative stimuli were the face images whose eye size was reduced or enlarged from 90% to 110% in steps of 2% both horizontally and vertically (figure 5).

![Figure 5](image)

**Figure 5.** [In colour online.] Samples of the comparative stimuli used in experiment 2. (a) The 90% eye size and (b) the 110% eye size.

3.1.3 Procedure. On each trial a standard stimulus and a comparative stimulus were presented side by side. The task was to judge which face appeared to have larger eyes. For each standard stimulus there were one initially ascending staircase and one initially descending staircase; thus, the experiment consisted of 18 concurrent staircases of trials. The comparative stimulus for the first presentation for each series was either 90% (ascending series) or 110% (descending series). Each staircase was terminated when the step direction of the staircase reversed eight times.

3.2 Results and discussion
The PSE was the mean of the eye size of the comparative stimuli where the step direction of the staircase reversed (figure 6). A two-way ANOVA with whole height and peak height as the two independent factors indicated that only the main effect of whole height was significant ($F_{2,46} = 16.22, p < 0.0001$). The perceived relative eye size was 99%, 100%, and 101% for the whole high, whole middle, and whole low conditions, respectively. The multiple comparisons revealed that the eyes in the whole low condition were perceived as significantly larger than in the whole high condition (Tukey’s HSD = 1.18, $p < 0.05$).
The results did not show an ‘eyelid lifting effect’ by the eyebrow but, instead, showed the opposite influence of the whole eyebrow height. The perceived eye size became smaller as the whole eyebrow moved higher. At a first glance, the results of experiment 2 might seem to contradict the assimilative effect shown by experiment 1. However, at least two accounts can explain our counterassimilation results. First, the area of the upper eyelid (between the upper edge of the eye and the lower edge of the eyebrow) may have contrasted to the area of the eye (ie palpebral fissure). It is common, at least in geometric illusions, that two adjacent areas make a contrast in size as in the Ebbinghaus illusion. Second, the eye and eyebrow may always be assimilated to some extent, but increasing the distance between the eye and eyebrow may weaken such preexisting assimilation. The relationship between the eye–eyebrow distance and the strength of assimilation may be analogous to that of the inner circle and outer circle of the Delboeuf illusion (see section 5).

4 Experiment 3
In this experiment we examined whether the height of eyebrows modulates the influence of eyebrow inclination on the perceived angle of eyes. We measured the eye inclination illusion while manipulating the eyebrow inclination and the eye–eyebrow distance simultaneously. Experiment 2 showed that the eye size overestimation decreases as the eye–eyebrow distance increases, probably because the assimilation between the eye and the eyebrow weakens. If the assimilation of inclination shown in experiment 1 involves the same mechanism as the assimilation of size shown in experiment 2, then the eye inclination illusion should decrease as the eye–eyebrow distance increases.

4.1 Method
The same general methods and procedures were used as those of experiment 1 except for the following differences.

4.1.1 Participants. Twenty undergraduate and graduate students (seven males and thirteen females) aged 19 to 29 years ($M = 21$ years, SD = 2.1 years) voluntarily participated.

4.1.2 Stimuli. The standard stimuli were facial images whose eyebrow position and inclination were manipulated (figure 7). There were four levels of the position of the whole eyebrows: $-8$, $0$, $+8$, and $+16$ pixels shifted from the original eyebrow position. In addition, for each level of the whole eyebrow position there were two levels of inclination of the eyebrow—namely, $-8^\circ$ and $8^\circ$ rotated from the original eyebrow inclination. Hence, there were eight standard stimuli. The comparison stimuli were the same as those in experiment 1, whose eyebrow inclination was always $0^\circ$. 

![Figure 6. Perceived eye size as a function of whole eyebrow height and peak height.](image)
4.1.3 Procedure. For each standard stimulus there were one initially ascending staircase and one initially descending staircase; thus, the experiment consisted of 16 concurrent staircases of trials.

4.2 Results and discussion

The PSE was the mean of the eye inclination of the comparative stimuli where the step direction of the staircase reversed (figure 8). A two-way ANOVA with eyebrow height and inclination as the two independent factors indicated that only the main effect of inclination was significant ($F_{1, 19} = 213.47, p < 0.0001$). The mean perceived relative eye inclination was $-1.20^\circ$ and $1.11^\circ$ for the $-8^\circ$ inclined and $+8^\circ$ inclined eyebrow conditions, respectively.

Figure 7. [In colour online.] The standard stimuli in experiment 3. The upper row [(a), (b), (c), and (d)] shows the $-8^\circ$ rotated eyebrows, and the lower row [(e), (f), (g), and (h)] shows the $+8^\circ$ rotated eyebrows. The leftmost column [(a) and (e)] shows the $-8$ pixels lower eyebrows, the second from the left column [(b) and (f)] shows the eyebrows at the original height, the third column [(c) and (g)] shows the $+8$ pixels higher eyebrows, and the rightmost column [(d) and (h)] shows the $+16$ pixels higher eyebrows. The eyes are identical in all the images.

Figure 8. Perceived eye inclination as a function of eyebrow height and rotation.
The lack of a significant interaction between the two factors indicated that there was no significant influence of the eye–eyebrow distance on the eye inclination illusion. A possible interpretation of this result is that eyebrow inclination was so salient a feature that it overpowered the modulating effect of the eye–eyebrow distance. If we had used a wider range of eye–eyebrow distances, we might have obtained a significant interaction. However, it is evident that the eye inclination illusion is much less susceptible to eye–eyebrow distance than the eye size illusion. The result suggests that the mechanism of assimilation of inclination is different from the mechanism of assimilation of size.

5 General discussion
In the present study we used psychophysical methods to investigate whether the position of the eyebrows influences the perceived inclination and size of the eyes. Experiment 1 demonstrated that drooping eyebrows make the eyes appear to be drooping as well, and that eyebrows which are rotated upward laterally (ie like a V-shape) make the eyes also look inclined upward. Experiment 2 established that eyes appear larger when the position of eyebrows is lower (ie closer to the eyes). Experiment 3 revealed that the eye inclination illusion demonstrated in experiment 1 was not affected by eye–eyebrow distance, suggesting that the eye inclination illusion and the eye size illusion may involve different kinds of assimilation. Taken together, these results suggest that the shape of one part of a face affects the perception of other facial parts. This is probably because face perception relies heavily on holistic or configural processing.

Our findings strongly suggest that one needs to exercise caution when using isolated facial features (eg eyes, nose, and mouth) as experimental stimuli in face perception research. This is because isolated facial features may be perceived differently when they are embedded in a whole face due to visual illusions caused by neighbouring features. Thus, physically identical facial features may appear different depending on whether they are shown in isolation or as part of the whole face.

Our current findings support the hypothesis that the effect of eyebrow rotation on the perceived inclination of the eyes is an illusion of assimilation (experiment 1). From the viewpoint of assimilation versus contrast, however, the results of experiment 2 are ambiguous. The effect of eye–eyebrow distance on the perceived size of the eyes could be interpreted as an illusion of contrast in size between the eye area and the area above the eye. Xiao et al. (2014) reported that the eyes embedded in a smaller face frame are perceived as larger than eyes of the same size embedded in a larger face, which they interpreted as a size-contrast illusion similar to the Ebbinghaus illusion. Therefore, it is possible that a larger area above the eye would make the eye below appear smaller in comparison.

However, this illusion could also be construed as an illusion of assimilation whereby the eye becomes assimilated toward the eyebrow. We assume that the mere presence of eyebrows, regardless of their position, makes eyes appear larger than they really are. The amount of eye size overestimation is greater when the eyebrow position is low than when it is high. This speculation is consistent with what is known about the Delboeuf illusion, which is an illusion of assimilation where the inner circle appears larger in the presence of an outer circle. The magnitude of the Delboeuf illusion reaches a maximum when the radius ratio is $2:3$ (Oyama, 1960). If the eyebrow and the upper contour of the eye correspond partially to the outer and inner circles of the Delboeuf illusion figure, respectively, then the radius ratio is closer to the optimum $2:3$ in the whole low condition than in the whole middle or whole high conditions. Therefore, the results of experiment 2 accord with the prediction based on the Delboeuf illusion.
Morikawa (2012, in press) suggested that illusions in the human face and body tend to follow the direction of assimilation rather than the direction of contrast. One reason for the predominance of assimilation may be the fact that spaces between the lines or elements that constitute classical geometric illusions are empty, whereas spaces between facial parts or between body parts are filled and connected with tissue such as skin, muscles, and bones. Moreover, the development of different parts of an individual’s body is often governed and controlled by the same genetic and hormonal mechanisms. Therefore, if an individual’s eyebrows are drooping, his or her eyes are likely to droop as well. If one part of the body is plump, other parts are likely to be plump as well. It is interesting to hypothesize that eyebrows induce eye illusions because the visual system takes these biological co-occurrences and correlations into account (Morikawa, in press).

Another curious aspect of the present results is the fact that, even though the magnitude of the illusions was rather small compared with well-known geometric illusions, observers’ judgments were consistent and stable as shown by the very short error bars in figures 3 and 6, which made the statistical significance level extremely high. This low variability in judgment is probably because the human visual system is particularly tuned to discriminating fine differences in the human face. Identifying and recognizing faces is an extremely important skill in society. We are so sensitive to the configuration of facial features that shifting eyebrow position by only a few millimetres can cause a pronounced change in impression (Morikawa, in press).

Our results imply that eyebrows can affect facial attractiveness directly but also indirectly through their influence on the perceived shape and size of eyes. It is known that the shape and size of the eyes affect facial attractiveness. People tend to find larger eyes more attractive (Baudouin & Tiberghien, 2004; Geldart et al., 1999). Feser, Gründl, Eisenmann-Klein, & Prantl (2007) found that young observers (up to 30 years of age) prefer faces whose eyebrows are in a lower position (i.e. nearer to the eyes). Our findings may be one of the reasons for their result; the lower eyebrows induced an illusory overestimation of eye size, which led to higher attractiveness. In addition, Gründl et al. (2008) showed that young observers regarded the laterally ascending eye axis (i.e. higher lateral canthus), or ‘Jaguar’s eye’, as more attractive than the horizontal eye axis. These types of eyes can be realized by means of altering eyebrows.

As a means of improving facial appearance, manipulating the eyebrows with makeup is much easier, less costly, and far more reversible than cosmetic surgery. Although further studies are necessary to measure the attractiveness of eyebrows per se, we believe that our findings have considerable practical value.

There are certain issues that the present study did not sufficiently investigate. One example is the problem regarding individual differences in faces. The stimuli in this study were constructed from only one person’s face. To verify the generality of this study’s findings, it would be of interest to study these illusions using a variety of faces from different races. Moreover, we have yet to test the effect of eyebrows on facial parts other than eyes, the effect of the size of eyebrows on the perceived size of eyes, and the transfer from adaptation to eyebrows to perceived properties of eyes. In addition, testing the same facial images inverted would be a valuable way to determine the extent to which the illusions are related to face processing per se. Future research should further address these various issues.

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References


