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Measurement of eye size illusion caused by eyeliner, mascara, and eye shadow

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Synopsis
Do eyeliner, mascara, and eye shadow actually make the eyes appear larger than they really are? If so, by what percentage? To answer these questions, we employed psychophysical experiments. Experiment 1 manipulated the degree of eyeliner (4 levels) and mascara (5 levels), and measured perceived eye size using a psychophysical procedure called the staircase method. The results showed that both eyeliner and mascara make the eyes appear larger than they really are by up to 6% (13% in area), but their effects are not additive. Eyeliner increased perceived eye size only in the absence of mascara. In the presence of mascara, however, eyeliner has no additional effect. Experiment 2 measured perceived eye size with or without eye shadow and demonstrated that eye shadow increases perceived eye size by about 5% (10% in area). These findings indicate that one mechanism by which makeup and cosmetics alter facial appearances involves inducing visual illusions. In addition, it is suggested that the eye size illusion caused by eyeliner, mascara, and eye shadow employs the same mechanism as that of the Delboeuf illusion, a geometric illusion of assimilation.

INTRODUCTION

Cosmetics can enhance a woman's facial appearance in multiple ways. They can emphasize healthy, youthful looks (1,2); accentuate femininity and sexual attractiveness (3–6); improve bilateral symmetry of the face, which leads to increased attractiveness (7,8); make the complexion appear clean and tidy (9); increase perceived competence and self-confidence (2,10); and change the apparent shape and/or size of facial parts such as eyes, nose, and mouth (e.g., 11,12).

When our perception of the shape and/or size of an object differs from reality, it is called a visual illusion. The Delboeuf illusion, for example, consists of two concentric circles. When the diameter ratio between the two circles is appropriate, the size of the inner circle appears larger than it really is. The Delboeuf illusion is considered an assimilation of the inner circle with the outer circle (13, 14). If certain makeup causes the face to be perceived differently from real in terms of shape and/or size, then that can also be considered a visual illusion. A good example is eye makeup that causes the eyes to appear larger than they really are.

Although many previous psychological studies have investigated the impact of makeup on facial impressions (e.g., 2, 9, 10, 15–18) and on gaze direction (19), virtually nothing is known about

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the illusory aspect of makeup. However, for at least three reasons, the eye size illusion induced by eye makeup merits scientific investigation.

First, eyes are an important determinant of facial attractiveness. Previous facial identification experiments showed that information about the eye and eyebrow regions of facial stimuli was most clearly linked to observers' ability to discriminate those faces (20–22). Moreover, large eyes are viewed as more attractive than small eyes. For example, Baudouin and Tiberghien (7) showed that wider eyes make female faces more attractive (also 23, 24). Altering perception of eyes can cause a dramatic change in the overall facial impression, and most women emphasize their eyes above other features when applying makeup (25). Mulhern et al. (17) found that eye makeup is one of the most significant contributors to the enhancement of female facial attractiveness.

Second, although many makeup artists claim that eye makeup can make the eyes appear larger than they really are (e.g., 26–29), this claim has not yet been quantitatively demonstrated. One purpose of eye makeup is to make small eyes appear larger (e.g., 28–30). In fact, eye-enlarging makeup techniques are hugely popular among young Japanese women these days. However, so far, the effectiveness of these techniques has been supported only by makeup artists' experiences and subjective impressions. No scientific study has investigated such effects. The eye size illusion induced by eye makeup has yet to be quantitatively measured.

Third, if experiments demonstrate to what extent eye makeup increases the perceived eye size, there are a number of practical implications. For example, quantitative assessment of eye makeup may facilitate comparing/evaluating different items of cosmetics and proposing effective makeup techniques to consumers. Quantitative assessment can also help develop new cosmetic products that are more effective in making eyes appear larger. Furthermore, including numeric data in advertising renders more objectivity and credibility to an advertisement, thus increasing its appeal to consumers.

Psychophysics is a branch of perceptual psychology and vision science. It specializes in quantitatively measuring the perceived intensity or quantity of stimuli as a function of the physical intensity or quantity of the stimuli. Psychophysical methods are particularly useful for measuring the magnitude of visual illusions. If eyes appear larger than they really are as a result of eye makeup, it is a kind of illusion. Therefore, the effects of the makeup can be measured by psychophysical methods (31, 32).

One such psychophysical method is called the staircase method, also known as the up-and-down method. To measure visual illusions induced by eye makeup, we employed a variant of the staircase method in which two faces are presented in each trial. An observer judges which face appears to have larger eyes. One face is a standard stimulus with eye makeup, whereas the other is a comparison stimulus without eye makeup. If the observer judges that the comparison stimulus has larger eyes, then on the next trial, the comparison stimulus is replaced with another comparison stimulus. This comparison stimulus has eyes one step smaller than the previous eyes, and the same process is then repeated. When the observer judges that the standard stimulus eyes are larger, the staircase direction reverses and on the next trial, the comparison stimulus is replaced with another comparison stimulus having eyes one step larger than the previous eyes, and the same process is then repeated. If the observer judges that the comparison stimulus eyes are larger, this triggers another reversal. When this procedure is repeated, the comparison stimulus eye size oscillates around the perceived eye size of the standard stimulus. The comparison stimulus eye size perceived as equal to the standard stimulus eye size is called the point of subjective equality

(PSE). The PSE can be calculated as the average of the eye size values where the staircase direction is reversed from upward to downward or vice versa. Using this method, we can measure the actual size of eyes without makeup that are perceived to be the same as those with makeup.

Eye makeup is mainly composed of eyeliner, mascara, and eye shadow, which work in concert to define and enhance the eyes. Eyeliner surrounds, reshapes, and accentuates the palpebral fissure. Mascara elongates, thickens, and darkens eyelashes; this is said to make the eyes appear larger and brighter. Applied to the eyelids or the skin around the eyes, eye shadow is a colored cosmetic that increases the eyes' prominence. Makeup artists' claim that eye makeup can cause the eyes to be perceived as larger has not been quantitatively substantiated. This study examines whether eyeliner, mascara, and eye shadow actually induce an assimilative illusion of larger eye size, and if so, to what degree eye size is overestimated.

EXPERIMENT 1

In this experiment, we measured the perceived eye size of facial images with various degrees of eyeliner and eyelash makeup (i.e., mascara and false eyelashes), using the experimental paradigm originally developed for studying visual illusions. If eyeliner and eyelash makeup assimilate the eye, the eye with makeup should appear larger than it really is.

We employed the staircase method to measure the PSE. This method uses two groups of stimuli: standard stimuli and comparison stimuli. Standard stimuli are the objects to be measured. In this experiment, the standard stimuli are images of faces with eye makeup, while comparison stimuli serve as a "ruler" or "scale." In this experiment, the comparison stimuli are images of faces without eye makeup, where eye size is systematically varied. The staircase method is an algorithm that seeks the quantity among the comparison stimuli that is perceived as equivalent to the quantity in a standard stimulus.

METHOD

PARTICIPANTS

Twenty-two undergraduate students (mean age 21.50 years, SD = 0.84; 8 males and 14 females) voluntarily participated. All reported normal or corrected-to-normal visual acuity and normal color vision. All participants were unaware of the purpose of the experiment.

STIMULI AND APPARATUS

The experiment was conducted using a computer with custom software. The stimuli were presented on a 24.1-inch LCD screen (NEC MultiSync LCDPA241W, NEC Corporation, Tokyo Japan). Although we did not secure the observing position with an apparatus, the viewing distance remained constant at approximately 70 cm.

The stimuli were facial images of a Japanese female with/without eyeliner and/or eyelash makeup (see below for details). Eye makeup was applied to the model's face by professional makeup artists. We edited the photographs so that all stimuli had exactly the same face except for the eye areas; each eye area with eye makeup was cut out as an elliptic area with blurred edges, and then pasted on the same facial image, using digital photo editing software. The dimensions of the

stimuli were 744 pixels wide (16.0° in visual angle) and 1052 pixels high (22.1°). The dimensions of the face itself were approximately 471 pixels wide (10.3°) at the cheekbone level and approximately 771 pixels high (16.5°) from the top of the head to the tip of the chin. The stimuli were colored images.

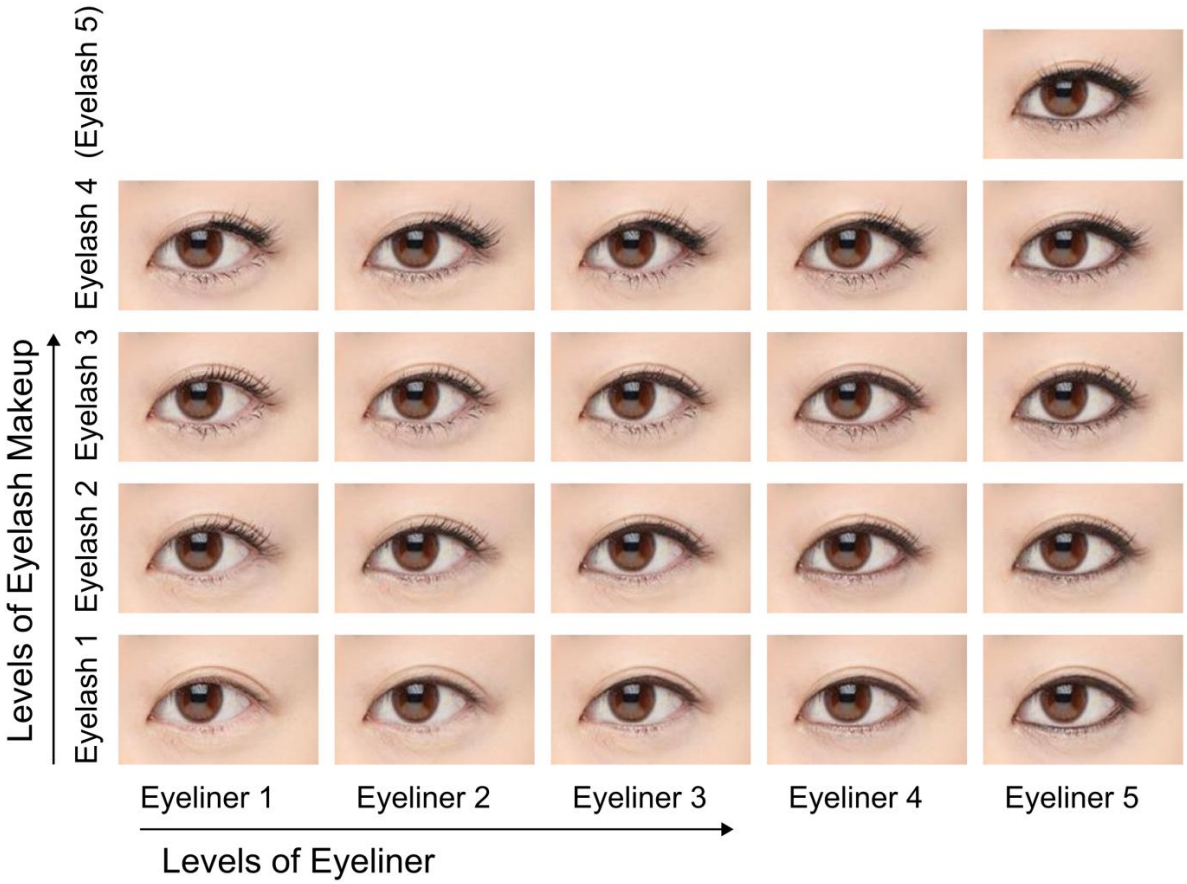

Figure 1. The eye areas of the standard stimuli used in Experiment 1. Eyeliner varies horizontally from light (left column) to moderate (right column). Eyelash makeup varies vertically from light (bottom row) to moderate (top row). See the text for the detailed descriptions of each condition. Note that these images show only the left eye but the actual standard stimuli showed the whole face.

The standard stimuli were facial images whose eye makeup was systematically manipulated from light to moderate. We used 4 levels of eyelash makeup: (a) no eyelash makeup (Figure 1, Eyelash 1); (b) mascara on only the upper eyelashes (Figure 1, Eyelash 2); (c) mascara on the upper and lower eyelashes (Figure 1, Eyelash 3); and (d) mascara on the upper and lower eyelashes with false eyelashes applied only on the outer half of the eye (Figure 1, Eyelash 4). In addition, we used 5 levels of eye-liner: (a) no eyeliner (Figure 1, Eyeliner 1); (b) brown eyeliner on the upper inner rim of the eye (Figure 1, Eyeliner 2); (c) brown eyeliner on the upper eyelid (Figure 1, Eyeliner 3); (d) brown eyeliner on the upper and lower eyelids (Figure 1, Eyeliner 4); and (e) black eyeliner on the upper and lower eyelids (Figure 1, Eyeliner 5). Thus, the combination of 4 levels of eyelash makeup and 5 levels of eyeliner yielded 20 standard stimuli. Another standard stimulus used was a combination of the thickest eyeliner (Eyeliner 5) and the thickest eyelash

makeup (Eyelash 5, with mascara on upper and lower eyelashes and with false eyelashes applied on *both* the inner and outer halves of the eye). Hence the total number of standard stimuli was 21. It was ensured that the levels of makeup were within the range of everyday makeup, not too heavy or unusually conspicuous. Thus, even the thickest level of eye makeup in this experiment was moderate.

The comparison stimuli were facial images, without any eye makeup, whose eye size was sequentially changed from 88% to 112% of the original eye size (i.e., 100%) in steps of 2% both horizontally and vertically (Figure 2). Note that a horizontal and vertical change of 2% is approximately equal to a change of 4% in area. To implement these manipulations, each eye was cut out as an elliptic area with blurred edges, enlarged or reduced, and then pasted back on the base facial image, using digital photo editing software. Hence, the standard stimulus with Eyeliner 1 and Eyelash 1 was identical to the comparison stimulus of 100% eye size.

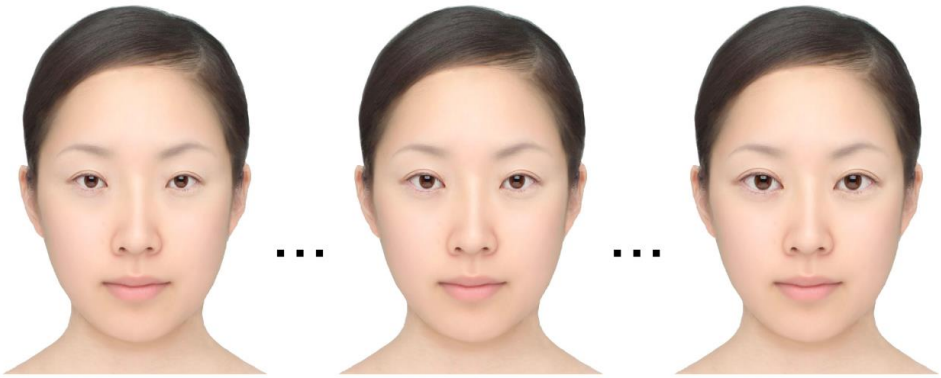

Figure 2. Samples of the comparison stimuli used in Experiment 1. Left: 88% eye size. Center: 100% eye size. Right: 112% eye size. Although the eyes shown here are those of the actual model used in the experiment, the rest of the face is replaced with another face to hide her identity because the model consented to have only her unaltered face published, not the manipulated ones.

PROCEDURE

The two experiments were approved by the ethical board of the School of Human Sciences of Osaka University. After each participant signed the informed consent form and was given instructions, the experimental task started. Each trial began with the presentation of a blank gray screen for 1000 ms. Then, a standard stimulus and a comparison stimulus were displayed side by side (Figure 3). The background of the images was gray. After the presentation of the stimuli for 1500 ms, the screen changed to a blank gray. The task was to choose the stimulus whose eyes appeared larger compared to the other stimulus. We instructed participants not to focus on only 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 trial began. To measure the comparison stimulus eye size perceived to be the same as the standard stimulus eye size, we used the previously explained staircase method. For each standard stimulus, there was one initially ascending staircase and one initially descending staircase; hence, the experiment consisted of 42 concurrent staircases of trials randomly interleaved. The comparison stimulus eye size for each staircase's first trial was selected from

either 88% (ascending staircase) or 112% (descending staircase). Each staircase was terminated when the staircase direction reversed eight times. Whether the standard stimulus was presented on the left or right side of the screen was determined randomly for each trial.

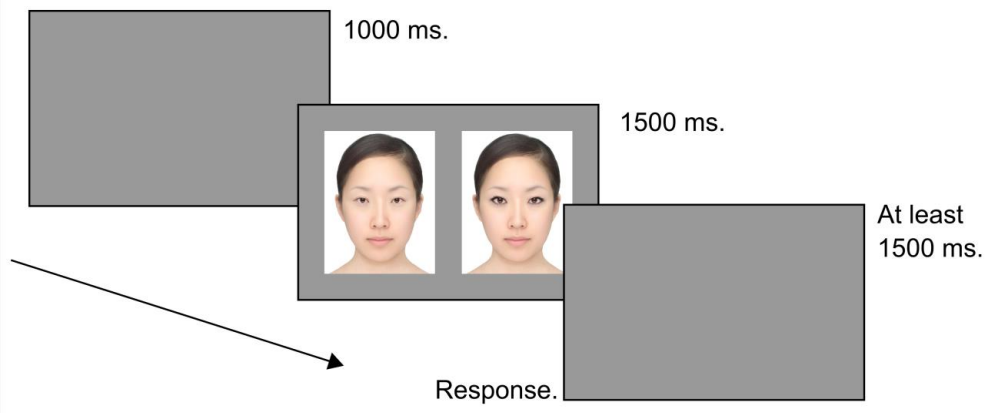

Figure 3. Schematic drawing of a trial. A standard stimulus and a comparison stimulus were presented side by side on the screen. The blank screen was presented before and after the presentation of the stimuli.

RESULTS AND DISCUSSION

First, we computed the PSE for each standard stimulus (Figure 4); the PSE was the mean of the comparison stimuli eye sizes where the staircase direction reversed from upward to downward or from downward to upward. Because the Eyelash 5 condition was not combined with all levels of eyeliner, and its PSE did not differ from the PSEs of the Eyelash 2–4 conditions, Eyelash 5 was excluded from further analysis. A two-way repeated-measures ANOVA with eyelash makeup and eyeliner as the independent factors indicated that both main effects were statistically significant, $F_{3, 63} = 91.33$, $P < .001$ and $F_{4, 84} = 5.05$, $P = .001$, respectively. In addition, the interaction between the two factors was also statistically significant, $F_{12, 252} = 9.79$, $P < .001$. The multiple comparisons between the eyelash makeup conditions revealed that the perceived eye size without eyelash makeup (Eyelash 1) was smaller than those with eyelash makeup (Eyelash 2–4), $P < .05$. However, there was no statistically significant difference between the conditions in which eyelash makeup was present (i.e., Eyelash 2–4), indicating that thin eyelash makeup was just as effective as thick eyelash makeup. The mean of perceived eye size with eyelash makeup (excluding the condition without eyelash makeup) was approximately 106.1% (113% in area).

The simple main effects revealed that eyeliner affected the perceived eye size especially when eyelash makeup was not applied, $F_{4, 336} = 25.04$, $P < .001$. Multiple comparisons between stimuli with eyeliner but without eyelash makeup revealed that the perceived eye size tended to increase as the eyeliner became thicker, although there was no statistically significant difference between the stimuli of brown eyeliner on both eyelids (Eyeliner 3) and black eyeliner on both eyelids (Eyeliner 4). The perceived eye size of the stimulus Eyeliner 5, Eyelash 1 (i.e., the thickest eyeliner without eyelash makeup) was approximately 104.8% (110% in area).

Eyeliner and/or eyelash makeup induced the size illusion; eyes with makeup appeared larger than they really were. The increase in perceived eye size with eyelash makeup was equivalent to approximately 6% of the original eye size. Interestingly, within the range of eyelash makeup in this experiment, any degree of eyelash makeup had the same effect on eye size perception. On the

other hand, the influence of eyeliner was clear only when eyelash makeup was absent. Eyeliner did not make the eyes appear any larger in the presence of eyelash makeup. These indicate that, as far as eye size illusion is concerned, eyeliner and eyelash makeup do not function additively.

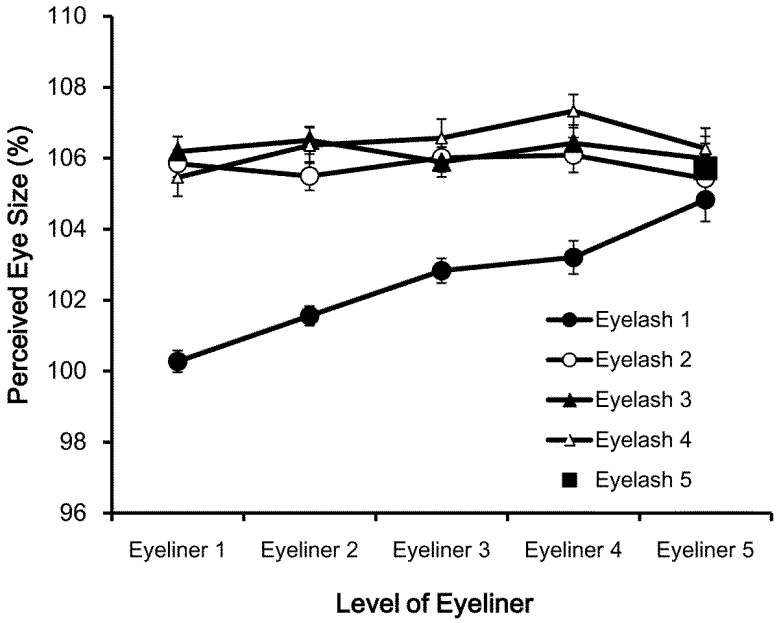

Figure 4. Perceived eye size as a function of thickness of eyelash makeup and eyeliner. The labels (e.g., "Eyeliner 1") correspond to those in Figure 1.

EXPERIMENT 2

In this experiment, we psychophysically examined whether another major component of eye makeup, namely eye shadow, also causes eye size illusion. In addition, we tried to overcome some of the limitations of Experiment 1, which used a facial image of only one individual as the basis for all the standard stimuli. This might limit the generalizability of the conclusions in Experiment 1 because the results might depend on particular facial features of the model. To overcome this problem in Experiment 2, we used several models whose faces were fairly distinct from one another. We also increased the number of observers to more than 100 so that the results would better reflect the general public's perception. In Experiment 2, only female observers were involved because most cosmetics are purchased and used by females. Therefore, from a marketing perspective, investigating how females perceive faces with makeup is more useful and cost-effective than investigating male perceptions.

METHOD

PARTICIPANTS

One-hundred-four females (mean age 35.1 years, SD = 8.5) voluntarily participated in this experiment. They received a reward for their participation. All reported normal or corrected-to-normal visual acuity and normal color vision. All participants were unaware of the purpose of the experiment and were tested individually.

STIMULI AND APPARATUS

The experiment was conducted using a computer with custom software. The stimuli were presented on a 24.1-inch LCD screen (NANAO FlexScan SX2461W-BK, EIZO Corporation, Ishikawa, Japan). Although we did not secure the observing position with an apparatus, the viewing distance remained constant at approximately 75 cm.

The stimuli were photographs of 6 Japanese females with/without eye shadow. The applied eye shadow was *Maquillage True Eye Shadow* ® manufactured by Shiseido Co., Ltd. (Tokyo, Japan) This product is a multicolor palette eye shadow composed of 5 carefully balanced shades including "line color" for the edge of eyelids and "main color" for broader area around the eyes, and so on. The general method of creating the stimuli was the same as that in Experiment 1. The dimensions of the stimuli were 744 pixels wide (16.3° in visual angle) and 1052 pixels high (22.9°). The mean dimensions (across the 6 models) of the face itself were approximately 479 (SD = 19.6) pixels wide (10.6°) at the cheekbone level and approximately 807 (SD = 26.7) pixels high (17.7°) from the top of the head to the tip of the chin. The stimuli were color images with a gray background.

The standard stimuli were facial images with/without eye shadow (Figure 5). Because the levels of eye shadow were binary (with or without) for the 6 models, the total number of standard stimuli was 12.

Figure 5. Samples of the standard stimuli used in Experiment 2. Left: Without eye shadow. Right: With eye shadow. These images are Model E in Figure 7.

The comparison stimuli were images of individual faces, without any eye makeup, whose eye size was sequentially changed from 90% to 110% of the original eye size (i.e., 100%) in steps of 2% both horizontally and vertically (Figure 6). These comparison stimuli were made for each model. Note that the original eye size of one model might differ from that of another model; thus the percentage indicates the relative size within models.

Figure 6. Samples of the comparison stimuli used in Experiment 2. Left: 90% eye size. Center: 100% eye size. Right: 110% eye size.

PROCEDURE

The same procedure as that of Experiment 1 was used, except for the following. For counter balancing, half of the participants were instructed to choose the stimulus whose eyes appeared smaller, and the other half were instructed to choose the stimulus whose eyes appeared larger. For each standard stimulus, there were two initially ascending staircases and two initially descending staircases; hence, the experiment consisted of 48 concurrent staircases of trials, randomly interleaved. In all the trials, the model in the presented comparison stimulus was always the same person as in the standard stimulus. The eye size of the comparison stimulus for the first trial of each staircase was selected from either 90% (ascending series) or 110% (descending series).

RESULTS AND DISCUSSION

The PSE for each standard stimulus was calculated in the same way as that in Experiment 1 (Figure 7). The mean of the perceived eye size with eye shadow was 104.8 % (SD = 0.83; 110% in area), whereas that without eye shadow was 100.1% (SD = 0.20).

A two-way repeated-measures ANOVA with eye shadow and model as factors showed that the main effects of both factors were statistically significant, $F_{1, 103} = 471.98$, $P < .001$ and $F_{5, 515} = 13.27$, $P < .001$. In addition, the interaction between the two factors was statistically significant, $F_{5, 515} = 10.46$. The analysis of simple main effects confirmed the statistically significant effect of eye shadow for all 6 models, $P < .001$. The PSE with eye shadow was not equal among the models, $P < .001$, indicating that the strength of the eye shadow effect varies with the individual to some extent.

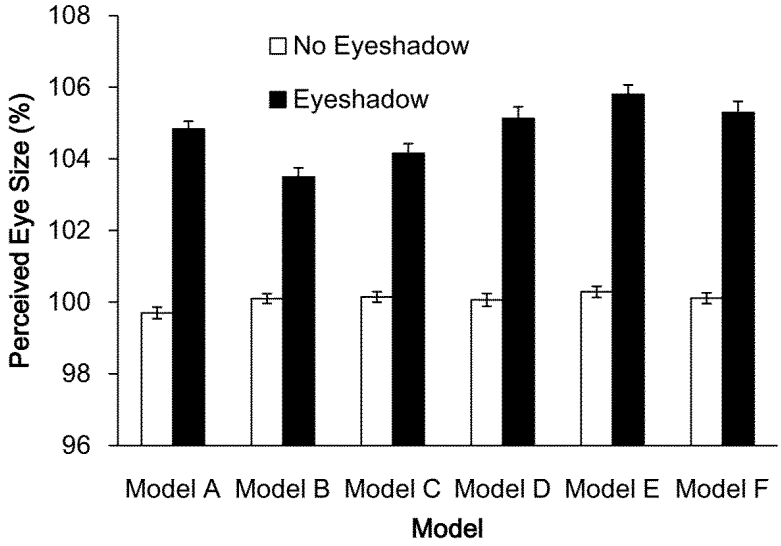

Figure 7. Perceived eye size with/without eye shadow for each model.

This experiment demonstrated the eye-enlarging effect of eye shadow. Although the faces of the 6 models in Experiment 2 were fairly distinct from one another, the magnitudes of the eye shadow illusion were relatively stable and distributed around 5% across the 6 faces. This suggests that the illusory effect of eye shadow is a robust phenomenon, not dependent on the particular facial features of an individual.

The mean magnitude of the eye size overestimation caused by eye shadow was similar to that of Experiment 1. The eye shadow palette used in this experiment included a rather dark color that may have worked like eyeliner. However, it seems unlikely that the eye size illusion is induced by such eyeliner-like effect alone, because the eye size overestimation in this experiment was larger than that of eyeliner alone in Experiment 1. Therefore, we can reasonably assume that the eye-enlarging effect of eye shadow is induced by the synergy between the various colors of eye shadow, not only by the darkest color.

GENERAL DISCUSSION

In the present study, we used psychophysical methods to measure the magnitude of eye size illusions caused by eye makeup. Using a single face with 20 levels of eyeliner and eyelash makeup, Experiment 1 demonstrated that mascara and false eyelashes make the eyes appear larger than they really are by about 6% on an average. When eyeliner is used alone without mascara or false eyelashes, making eyeliner thicker and darker increases the perceived eye size gradually up to 5%. However, the effects of mascara and eyeliner are not additive. In the presence of mascara, eyeliner has no additional effect on perceived eye size. Using 6 different individual faces, Experiment 2 measured perceived eye size with or without eye shadow. The results demonstrated that eye shadow increases the perceived eye size by about 5% on an average.

Why does eyeliner have no effect on the perceived eye size when mascara is also applied? One possible reason is that eyeliner and mascara share the same space. The eyeliner used in Experiment 1 was thin to moderate. Therefore, when the eyelashes were thickened with mascara,

the roots of the eyelashes may have become dark enough to overshadow the eyeliner. Had the eyeliner been thicker, it might have strengthened the eye size illusion caused by mascara.

The eye size illusion caused by eyeliner and mascara is likely an illusion of assimilation in which the eye becomes assimilated with eyeliner and mascara. This mechanism seems similar to that of the Delboeuf illusion where the size of the inner circle appears larger than it really is when placed within a somewhat larger outer circle, due to the assimilation of the inner circle with the outer circle. The Delboeuf illusion arises even when the outer circle is incomplete (33). In the present experiment, the contour of the palpebral fissure corresponds to the inner circle, and eyeliner and mascara correspond to the outer circle. There have been reports that face perception is subject to various geometric illusions (31,32,34,35).

Many makeup artists believe that one purpose of eye shadow is to add depth to the eyes. The experiment by Abe et al. (36) showed that eye shadow enhances perceived depth and size of the eyes, although they did not measure the illusion's absolute magnitude. These researchers argued that an increase in subjective distance between the observer and the eyes leads to an overestimation of eye size because of constancy scaling. Constancy scaling implies that the perceived size of an object increases as its perceived distance from the observer increases, even when the actual distance and size of the retinal image generated by the object remain the same. However, the magnitudes of the eye size illusion induced by eye shadow in Experiment 2 are far too large to be explained by constancy scaling. To induce a 4.8% overestimation of eye size at a viewing distance of 75 cm by constancy scaling alone, the eyes would have to be perceived as being 3.6 cm deep in the head; this is anatomically impossible. Therefore, we conclude that eye shadow induces effects beyond merely enhancing the eyes' depth, such as an illusion of assimilation.

What is the mechanism of the eye shadow illusion? Does eye shadow make the eyes appear larger because the eyes are directly assimilated into eye shadow, or because eye shadow enhances the assimilation of the eyes into the eyebrows? Typical eye shadow is darkest along the sharp boundary of the upper eyelid, and gradates to the skin tone toward the eyebrow. Possibly then, the eye is assimilated with eye shadow in much the same way as with eyeliner and mascara, which may induce an overestimation of eye size. Another possibility is that eye shadow enhances the perceptual grouping of the eye and the eyebrow by reducing the difference in luminance between the eyebrow and the skin below. The eyebrow alone causes an overestimation of eye size due to a mechanism like the Delboeuf illusion (37,38). Eye shadow possibly bridges the space between the eye and the eyebrow, thereby increasing the assimilation of the eye into the eyebrow. It might be that the eye shadow effect involves both the assimilation of the eye into eye shadow and enhancement of the assimilation of the eye into the eyebrow. Further research is necessary to elucidate the exact mechanism by which eye shadow causes the eye to appear larger.

Another unresolved issue is whether the illusion caused by eyeliner and mascara and that caused by eye shadow is additive. One limitation of the present study is that we did not combine eye shadow with eyeliner or mascara. Eye shadow does not share the same space as eyeliner and mascara. Thus, a possibility remains that application of eye shadow further enhances the eye size illusion caused by eyeliner and mascara. Future research should examine this aspect.

Morikawa (31, 32) suggested that illusions in the human face and body tend towards assimilation, rather than contrast. One reason for the predominance of assimilative illusions might be that spaces between facial parts or between body parts are filled with and connected to tissues such as

skin, muscles, and bones, unlike the empty spaces between the lines that constitute classical geometric illusions (32). 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 thin, other parts are also likely to be thin (31, 32). We hypothesize that visual perception is affected by these biological co-occurrences and natural correlations.

Morikawa (31, 32) also observed that, when geometric illusions in the human face and body are psychophysically measured, the maximum illusion magnitudes tend to be around 5%, a sort of a "magic number." That is exactly what the present experiments replicated. An illusion magnitude of 5% is small, as compared to well-known geometric illusions. Perhaps there exists a natural upper limit to visual illusions in the human face so that the illusions occur only to the extent that the resulting distortions do not appear unnatural. Notably, although a difference of 5% may be numerically small, the difference is perceptually conspicuous, perhaps because the human visual system is especially tuned to detecting 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 we can reliably perceive even a physically small difference (31, 32).

Historically, most researchers have studied visual illusions with very little relevance to ordinary life. Most visual illusion stimuli have been highly contrived and unnatural figures created artificially in laboratories. The human visual system seldom encounters such stimuli in the natural environment or in daily life. However, illusions in natural objects, albeit much less dramatic than artificial ones, are far more prevalent in our daily lives than we may think. In fact, some illusions can be very relevant and useful in everyday life (31, 32, 39).

The present study investigated visual illusions in the human face, the most natural and socially important stimulus. The results indicated that one mechanism by which cosmetics and makeup alter facial appearances is by inducing visual illusions. Our results demonstrated that cosmetic illusions can be quantitatively measured using psychophysical methods. Russell (40) stated, "Though cosmetics are applied to the face of the wearer, they are designed to operate on the visual system of the perceiver." Because the human visual system judges what is beautiful or attractive, we have to investigate cosmetics and makeup in terms of the perceiver's visual system. Therefore, research on visual perception can be an important part of cosmetic science. We believe that measurement and analysis of cosmetic illusions will become a new and fruitful field of cosmetic research in the future.

CONCLUSIONS

Our experiments examined whether eyes with makeup—eyeliner, mascara, and eye shadow—are perceived to be larger than they really are. To this end, we applied an experimental paradigm used in visual illusion studies. Measurements revealed that perceived eye size was overestimated by about 6% (13% in area) with eyeliner and/or mascara, and about 5% with eye shadow. We concluded that eye makeup causes eye size illusions because of perceptual assimilation and that our experimental paradigm can quantitatively measure these perceptual illusions.

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