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Sex, beauty, and the relative luminance of facial features

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Abstract. It has been suggested that the consistent luminance difference between the darker regions of the eyes and mouth and the lighter regions that surround them forms a pattern unique to faces. One of the more consistent uses of cosmetics to make the female face more attractive is to darken the eyes and mouth relative to the surrounding skin. The hypothesis that the size of the luminance difference between the eyes and mouth and the rest of the face affects the attractiveness of male and female faces differently was tested in four experiments in which attractiveness ratings were obtained for images of faces in which the luminance difference between the eyes and mouth and the rest of the face had been manipulated. Female faces were found to be more attractive when this luminance difference was increased than when it was decreased, and the opposite was found for male faces. An interpretation consistent with these results is that the luminance difference between the eyes and mouth and the rest of the face is naturally greater in women than men. In this case increasing or decreasing the luminance difference will make a face more feminine or masculine, respectively, and hence, more or less attractive depending on the sex of the face. Implications for the causes of cosmetics usage are discussed.

1 Introduction

Recent research has firmly replaced the belief that "beauty is in the eye of the beholder" with the notion that the perception of the attractiveness of a given face is largely consistent between observers, regardless of their age, sex, or cultural background (Etcoff 1999; Langlois et al 2000; Thornhill and Gangestad 1999; Zebrowitz 1997). A number of specific visual attributes that contribute to the attractiveness of a face have been proposed, including averageness (Langlois and Roggman 1990; Rhodes and Tremewan 1996), symmetry (Perrett et al 1999; Rhodes et al 1998), and sexual dimorphisms (Cunningham et al 1990; O'Toole et al 1998; Perrett et al 1998; Rhodes et al 2000).

Notably absent is explicit mention of photometric, or luminance attributes of facial attractiveness. The literature on facial attractiveness is almost entirely concerned with the location and shape of features. Much less attention has been paid to the relative luminance and coloration of those features. While in a number of studies, such as those based on photographic averages, attractiveness has been implicitly investigated in terms of the relative luminance of different features, none has identified specific determinants of attractiveness in these terms.

A body of literature has shown that relative luminance and coloration patterns play a role in other aspects of face processing, such as face detection (Thoresz and Sinha 2001; Watt 1994), identification (Yip and Sinha 2002), and age estimation (Burt and Perrett 1995). Coloration has been found to play a particularly important role in sex discrimination (Bruce et al 1993; Hill et al 1995; Tarr et al 2001). Because past studies have suggested that attractiveness is related to other facial attributes, such as identity (Rhodes and Tremewan 1996), age estimation (Deffenbacher et al 1998; Zebrowitz et al 1993), and especially sex discrimination, it stands to reason that luminance patterns also play an important role in attractiveness.

Recent findings with low-pass-filtered images of faces suggest that large-scale luminance patterns are important in determining attractiveness (Sadr et al 2002). In this study, attractiveness ratings of faces at varying levels of blur were obtained. The attractiveness ratings given to blurred faces were consistent with the attractiveness ratings given to the same faces without any blurring. This suggests that much of what determines the attractiveness of faces is not the high-frequency information in the fine features, but rather the low-frequency information that was preserved in the blurred images. The relevance of this work to the present study is that we are likely to find luminance effects on attractiveness not in the fine details of the face, but rather in the placement and relative luminance of large regions of dark and light.

It has been suggested that the consistent luminance difference between the darker regions of the eyes and mouth, and the lighter regions that surround them forms a pattern unique to faces. Roger Watt's work in image segmentation demonstrated that the horizontal regions centered over the eyes and over the mouth are darker than the horizontal areas above and below (Watt 1994). More recently Thoresz and Sinha have implemented a face-detection algorithm based on the notion that the eyes and mouth are darker than the surrounding face regions (Thoresz and Sinha 2001). The algorithm uses a coarse template to look for image regions with this pattern of light and dark relationships, considering only the spatial and relative luminance relations, but not the absolute luminances. The algorithm is successful at detecting novel faces, including examples of several races. This is additional evidence that the face has a distinctive luminance pattern, with the eyes and mouth darker than the surrounding regions of the face. This distinctive luminance pattern of faces can be thought of as the 'face pattern'. Because attributes that are important in one domain of face processing are typically important in other domains, the face pattern is likely to play a role not only in face detection, but also in aspects of face perception, such as attractiveness.

Though there are a number of uses of cosmetics, among the most common are darkening the eyes and mouth. Most cosmetics applied directly around the eyes or lips, to change their coloration, darken those features. This darkening of the eyes and mouth, without darkening other regions of the face, accentuates the face pattern by increasing its amplitude. It is likely not accidental that cosmetics are typically used in a way that accentuates the face pattern. Cosmetic use that changes the luminance or coloration of the face is far less common among men than women, historically as well as in the present (Corson 1972; Gunn 1973). It is a reasonable supposition that primarily women use cosmetics to accentuate the face pattern because only they are made more attractive by this transformation. This suggests that the relationship between attractiveness and the luminance difference between the eyes and mouth and the rest of the face (the amplitude of the face pattern) differs by sex, rather than being common to all faces.

The present study is designed to determine whether the size of the luminance difference between the eyes and mouth and the rest of the face affects the attractiveness of male and female faces differently. Toward this end, four experiments were conducted in which subjects rated the attractiveness of images of faces that had been manipulated by changing the luminance difference between the eyes and mouth and the rest of the face. The criterion for evaluating the hypothesis was whether the results showed an interaction between the sex of the face and the manipulation.

The first two experiments were the most critical. In both experiments, versions of the stimuli faces were made such that the luminance difference was increased, decreased, or left unchanged, in order to investigate the effect of this manipulation on the rated attractiveness of those faces. In the first experiment, versions of each face were made in which the eyes and mouths of the faces were darkened, lightened, or left

unchanged, while the rest of the face was untouched. In the second experiment, versions of each face were made in which the eyes and mouths of the faces were left untouched, while the rest of the face was darkened, lightened, or left unchanged. Thus, in the first two experiments, there were versions of each face being rated in which the luminance difference between the eyes and mouth and the rest of the face was increased, decreased, or left unchanged, though the change was effected through different means. The reason for manipulating the luminance difference in two different ways was to make more certain that it was the relative luminance difference between the eyes and mouth and the rest of the face, and not the absolute luminance, that caused any changes to the rated attractiveness of the faces. The attractiveness ratings of the faces were compared by sex and by condition (whether the luminance difference was decreased, unchanged, or increased). The presence of an interaction between sex and condition was to be taken as grounds for accepting the hypothesis, while the lack of an interaction was to be taken as grounds for rejecting it.

The third and fourth experiments were performed as controls for the first two. The third experiment, unlike the other three, used images of the faces that included the entire head and neck. The images were the same as those used in experiment 1, except that more of the head was visible. This experiment was performed to assess whether the results of the first two experiments would be the same when the external features of the face were visible. Again, presence of a sex by condition interaction was to be taken as evidence in support of the hypothesis. In the fourth experiment, there were also three versions of each face, though the entire image was darkened or lightened, with no portion being left untouched. This experiment was performed to ensure that the results of the other experiments, in which the images in some conditions were darker than those in other conditions, were not due to a low-level effect of overall luminance. Because the manipulation did not change the relative luminance difference between the eyes and mouth and the rest of the face, presence of a sex by condition interaction was to be taken as evidence against the hypothesis in the fourth experiment.

2 General methods

2.1 *Stimuli*

Ninety images, 45 male and 45 female, were selected from the Aberdeen set in the University of Stirling PICS database (http://pics.psych.stir.ac.uk). The set consists of mostly Caucasian faces with a wide range of adult ages. Image manipulations were performed with the image processing software Adobe Photoshop. The images were converted to gray-scale to avoid confounding effects of hue and saturation. Except in experiment 3, the images were cropped such that only the inner features of the face were visible. The cropping was performed in order to reduce noise caused by extraneous variables such as hairstyle.

2.2 *Subjects*

In experiments 1 and 3, twenty paid subjects participated, ten male and ten female. In experiments 2 and 4, eighteen paid subjects participated, nine male and nine female.

2.3 *Procedure*

The procedure was the same for each of the four experiments. A within-subjects design was used, with presentation order of the faces pseudorandomized and counterbalanced across subjects for sex and condition. Each subject saw all of the stimuli images. Images were displayed on the CRT monitor until the subject made a rating by pressing a key, at which time the next image appeared. Faces were rated on a 7-point Likert scale of attractiveness, with a response of 1 indicating that the face was very unattractive

and a response of 7 indicating that the face was very attractive. For each experiment a three-way analysis of variance (ANOVA) was carried out on the attractiveness ratings, with sex of subject as a between-subjects factor, and condition and sex of face as repeated measures. A posteriori pairwise comparisons (Tukey's HSD) were conducted when the analysis of variance found significant differences between conditions.

3 Experiment 1

3.1 *Stimuli*

To manipulate the size of the luminance difference between the eyes and mouth and the rest of the face, the stimuli in experiment 1 had the eyes and mouth darkened, lightened, or left unchanged, while the rest of the face always remained unchanged. This resulted in an increased, decreased, or unchanged luminance difference between the eyes and mouth, and the rest of the face.

The burn tool in Adobe Photoshop was used to selectively darken the eyes and mouth, and the dodge tool was used to selectively lighten the eyes and mouth. The eye and mouth regions were hand-defined for each face. The eye regions included the iris, sclera, and a narrow band of skin around the lashes. The mouth region consisted of the lips. Custom brush sizes were used for each feature of each face. The same brush was used to darken and lighten a given feature of a particular face, to ensure that the same areas of the face were being affected in each version. The 'shadows' option was selected for both dodging and burning, causing only the darker pixels to be affected by the tool. This resulted in the sclera retaining its normal whiteness, and a more natural look for the manipulated features. Overall brightness manipulation would have caused the sclera to look dark—an unnatural and unhealthy feature. The luminance of the irises was increased or decreased by approximately 35 on a 256-level scale. When the features were darkened, the luminance difference with the rest of the face was increased, and when the features were lightened, the difference was decreased. Difference-increased and difference-decreased versions of each of the 90 original images were produced. Each stimulus face appeared in three conditions: difference increased, unchanged, and difference decreased. Examples of stimuli from experiment 1 are shown in figure 1.

3.2 *Results*

The results of experiment 1 are shown in figure 2. There was a significant interaction between condition and the sex of the face ($F_{2,36} = 22.49$, $p < 0.001$). Pairwise comparisons of the female faces found that the faces in the difference-increased and unchanged conditions elicited significantly more attractive ratings than the faces in the difference-decreased condition. The faces in the difference-increased condition were rated more attractive than those in the unchanged condition, but pairwise comparison showed the difference was not significant. The male faces showed the exact opposite configuration of results, with the faces in the difference-decreased and unchanged conditions being rated significantly more attractive than the faces in the difference-increased condition. Though the male faces were rated more attractive in the difference-decreased condition than the unchanged condition, the difference was not significant. There were no other significant effects.

The results show a clear interaction between the size of the luminance difference and the sex of the face being rated. These results support the claim that male and female faces are affected differently by changes to the luminance difference between the eyes and mouth and the rest of the face. Specifically, female faces were rated more attractive when the difference between the eyes and mouth was increased than when it was decreased, while for male faces the opposite was the case.

Figure 1. From left to right are examples of luminance-difference decreased, unchanged, and luminance-difference increased versions of female (top) and male (bottom) faces from experiment 1.

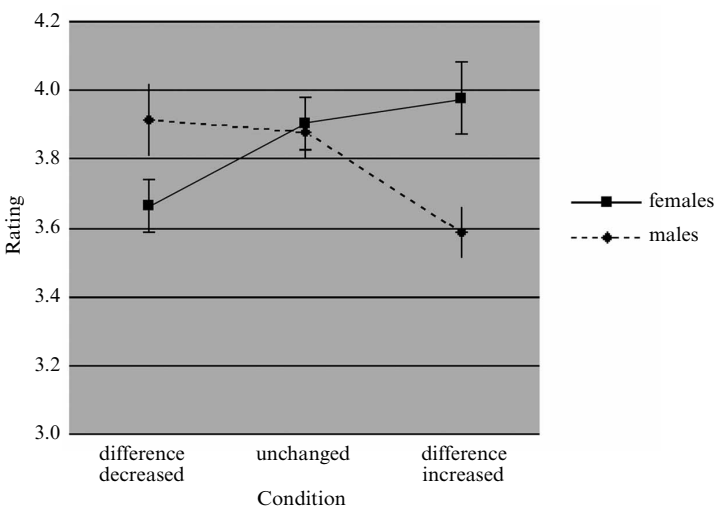

Figure 2. Results from experiment 1. Ratings for male and female faces are plotted for the three conditions. Higher numbers indicate higher ratings. Error bars are ± 1 SE.

4 Experiment 2

4.1 *Stimuli*

To manipulate the size of the luminance difference, the stimuli for experiment 2 had the eyes and mouth always remaining unchanged, while the rest of the face was darkened, lightened, or left unchanged. Darkening the rest of the face resulted in decreased luminance difference between the eyes and mouth and the rest of the face, while lightening the rest of the face resulted in increased difference.

To create the stimuli for experiment 2, a mask was drawn around the eyes and mouths of each of the original images. The eyes and mouth were defined with the same criteria as in experiment 1. The eye regions included the iris, sclera, and a narrow band of skin around the lashes. The mouth region consisted of the lips. The mask was then inverted and feathered by five pixels to create a graded boundary. The brightness of the remainder of the image was then increased or decreased by 20 points on a scale of 0 to 255, to produce two new images. Unlike in experiment 1, the method of manipulating the luminance difference between the eyes and mouth and the rest of the face did not affect the local contrast within the eyes and mouth. In one image the entire face, except the eyes and mouth, was lightened, and in the other image it was darkened. Because the eyes and mouth were held constant, luminance difference was increased when the rest of the face was lightened, and luminance difference was decreased when the rest of the face was darkened. As in experiment 1, each stimulus face appears in three conditions: difference increased, unchanged, and difference decreased. The stimuli were cropped to the same dimensions as in experiment 1. Examples of stimuli from experiment 2 are shown in figure 3.

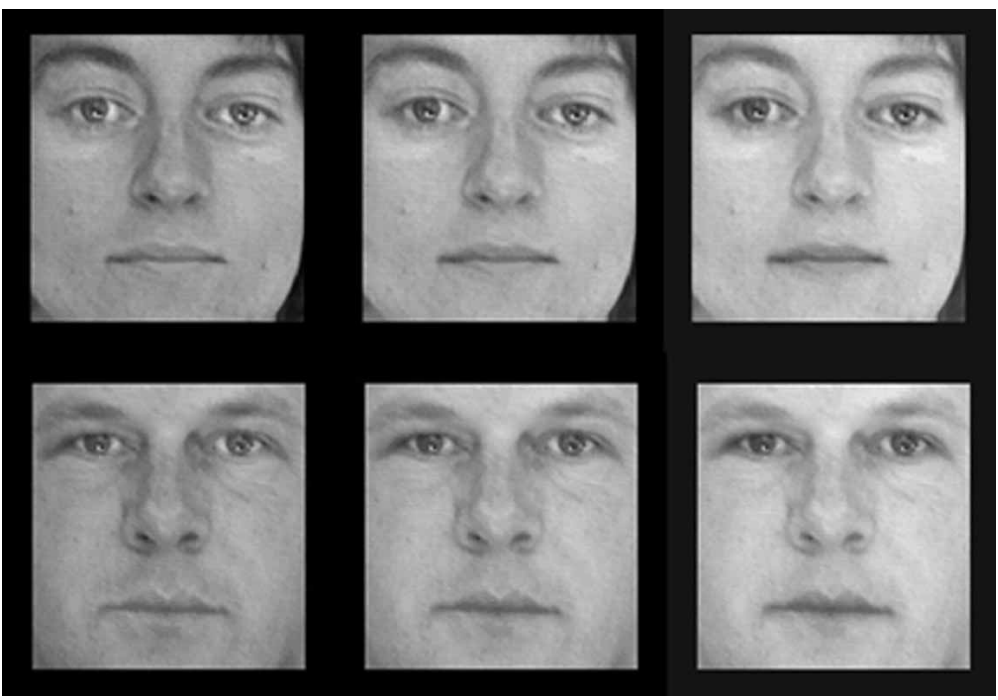

Figure 3. From left to right are examples of luminance-difference decreased, unchanged, and luminance-difference increased versions of female (top) and male (bottom) faces from experiment 2.

4.2 *Results*

The results of experiment 2 are shown in figure 4. There was a significant interaction between condition and the sex of the face ($F_{2,32} = 8.55$, $p < 0.001$). Pairwise comparisons of the female faces found no significant differences between any of the conditions. However, for the male faces, significant differences were found between all three of the conditions, with the difference-decreased faces more attractive than the unchanged faces, which were in turn more attractive than the difference-increased faces. There was also a significant main effect of condition ($F_{2,32} = 9.82$, $p < 0.001$) that was driven by the effect of the manipulations on the male faces. Pairwise comparisons of the conditions, for the male and female faces combined, showed the faces

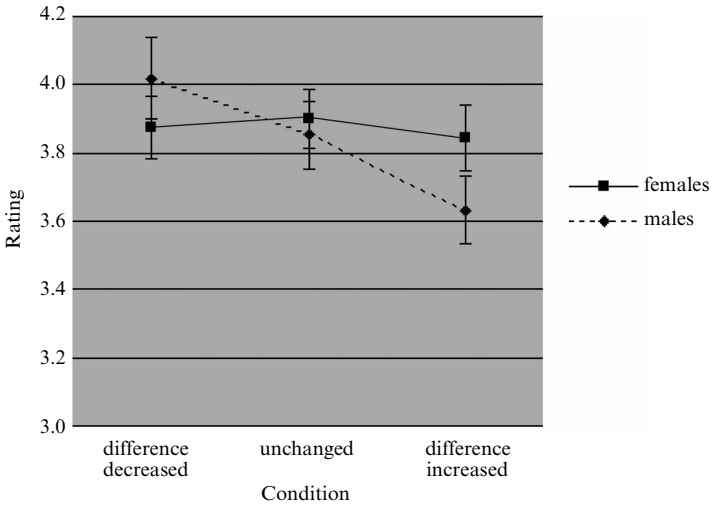

Figure 4. Results from experiment 2. Ratings for male and female faces are plotted for the three conditions. Higher numbers indicate higher ratings. Error bars are ±1 SE.

in the difference-decreased and unchanged conditions to be significantly more attractive than the faces in the difference-increased condition. Though the faces were rated more attractive in the difference-decreased condition than in the unchanged condition, the difference was not significant.

The results of experiment 2 show a clear interaction between the luminance difference and the sex of the face being rated, again supporting the claim that male and female faces are affected differently by the size of the luminance difference between the eyes and mouth and the rest of the face. The results for male faces in experiment 2 were consistent with the notion that male faces are more attractive when the luminance difference between the eyes and mouth and the rest of the face is decreased, and less attractive when it is increased. However, the same manipulations had no effect at all on the female faces, casting some uncertainty on the assertion that this luminance difference plays a role in female attractiveness. Both the male and female faces in the difference-decreased condition looked tanned, and in the difference-increased condition they looked pasty. It is possible that this interacted with the effect of manipulating the luminance difference of the face pattern, resulting in the overall main effect of condition and the lack of difference between conditions for the female faces.

5 Experiment 3

5.1 *Stimuli*

The same faces, with the same manipulations, were used in experiment 3 as in experiment 1, except that they were left uncropped, so that the hair and bounding contours of the face were visible. This experiment was performed to ensure that the results of the first two experiments were not due to artifacts of the cropping procedure. Examples of stimuli from experiment 3 are shown in figure 5.

5.2 *Results*

The results of experiment 3 are shown in figure 6. There was a significant interaction between condition and sex of face ($F_{2,36} = 40.06$, $p < 0.001$). Pairwise comparisons of the female faces found the unchanged faces to be significantly more attractive than the difference-decreased faces. Though the unchanged faces were rated more attractive than the difference-increased faces, which were in turn rated more attractive than the difference-decreased faces, neither difference was significant. Pairwise comparisons of

Figure 5. From left to right are examples of luminance-difference decreased, unchanged, and luminance-difference increased versions of female (top) and male (bottom) faces from experiment 3.

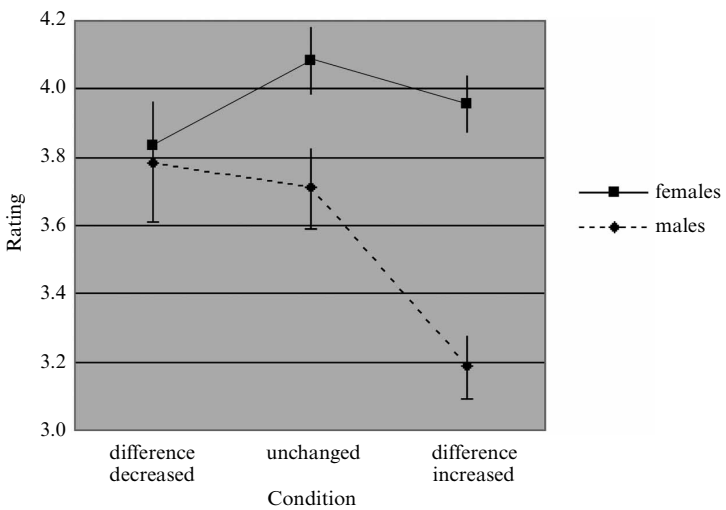

Figure 6. Results from experiment 3. Ratings for male and female faces are plotted for the three conditions. Higher numbers indicate higher ratings. Error bars are ± 1 SE.

the male faces showed the faces in the difference-decreased and unchanged conditions to be rated significantly more attractive than the faces in the difference-increased condition. Though the male faces were rated more attractive in the difference-decreased condition than the unchanged condition, this difference was not significant. There were also significant main effects of condition ($F_{2,36} = 13.13$, $p < 0.001$), and sex of the face ($F_{1,18} = 15.24$, $p < 0.001$), with female faces rated more attractive than male faces. Pairwise comparisons between the conditions, for the male and female faces combined, revealed that the faces in the difference-decreased and unchanged conditions were rated significantly more attractive than the faces in the difference-increased condition. Though the faces were rated more attractive in the unchanged condition than in the difference-decreased condition, the difference was not significant.

In experiment 3, as in the first two experiments with cropped faces, there was a significant interaction between the luminance difference and the sex of the face being rated, again supporting the claim that male and female faces are affected differently by the size of the luminance difference between the eyes and mouth and the rest of the face. However, the results of experiment 3 also differed from those of the two experiments with cropped faces in ways that reduce the comparability of the experiments. There were main effects both of sex and of condition, with the females being rated more attractive than the males, and the difference-increased faces being rated less attractive than the other conditions. The set of faces was well matched between the sexes for attractiveness without hair and facial outlines, but inclusion of those features made the male faces less attractive, and the female faces more attractive. This difference unfortunately makes the results of experiment 3 less suitable for comparison with the results of the experiments in which only part of the face is visible. The main effect of condition, with the difference-increased faces less attractive than the other faces, was likely to have been caused by an artifact of the manipulation rather than of the cropping. Normally the eyes and mouth of a face are not significantly darker than the hair. However, for most of the faces in the difference-increased condition of experiment 3, the eyes and mouth were the darkest regions of the entire head. This unusual darkness of the features relative to the hair likely caused the lowered ratings for the faces of both sexes in the difference-increased condition. Though the intensity of the manipulations was appropriate for the faces with internal features only, they were probably too large for entire heads. Yet despite these critical differences between the whole-head stimuli set and the cropped stimuli set, both yielded significant interactions between sex and condition.

6 Experiment 4

6.1 *Stimuli*

Experiment 4 was designed to test the possibility that the main effect of condition in experiment 2, and to a lesser extent experiment 1, was actually caused by an effect of overall luminance on attractiveness. The stimuli in experiment 4 were created by increasing or decreasing the luminance of the entire image by 20 points on a scale of 0 to 255. This was the same manipulation that was performed in experiment 2, except that it was performed over the entire image, including the mouth and eyes as well as the rest of the face. The relative difference between the eyes and mouth and the rest of the face was unaffected by this manipulation. Each stimulus face appeared in three conditions: darkened, unchanged, and lightened. The stimuli were cropped to the same dimensions as in experiments 1 and 2. Examples of stimuli from experiment 4 are shown in figure 7.

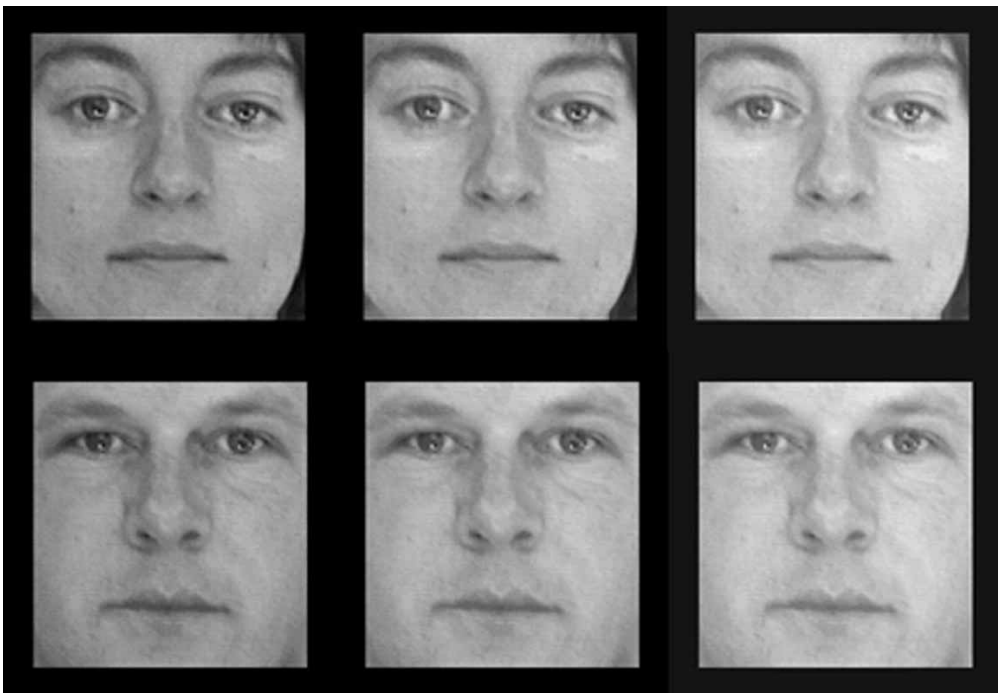

Figure 7. From left to right are examples of darkened, unchanged, and brightened versions of female (top) and male (bottom) faces from experiment 4.

6.2 *Results*

Figure 8 shows the attractiveness ratings of male and female faces under the three experimental conditions: lightened, unchanged, and darkened. There was no interaction between condition and sex of face ($F_{2,32} = 0.56$, $p = 0.6$). Though the female faces were rated more attractive than the male faces in all three conditions, the effect was not significant ($F_{1,16} = 1.79$, $p = 0.2$). The only significant effect in experiment 4 was a three-way interaction between sex of the face, sex of the rater, and condition ($F_{2,32} = 8.15$, $p < 0.005$). Figure 9 shows the attractiveness ratings of male and female faces, as rated by male and female subjects, under the three experimental conditions. This interaction is likely caused by the different ratings given by male and female subjects to the unchanged male faces. A posteriori testing revealed no significant pair-wise effects between conditions, as modified by sex of face and sex of rater.

The results of experiment 4 discount the possibility that there is a low-level effect of luminance on the judgments of attractiveness made in experiment 2. Though there was a significant three-way interaction between sex of the face, sex of the rater, and condition, it is not clear that there is any meaningful interpretation of this effect. More importantly, given the lack of main effects or two-way interactions, it is not clear what such a result might mean or that it is relevant to the study. Critically, unlike the other three experiments in which the luminance difference between the eyes and mouth and the rest of the face was manipulated, there was no interaction between condition and sex of face in experiment 4.

7 Discussion

The effect on attractiveness, of manipulating the luminance difference between the eyes and mouth and the rest of the face, was investigated in four experiments. In all three experiments in which faces were manipulated, such that the luminance difference between the eyes and mouth and the rest of the face could be larger or smaller, there

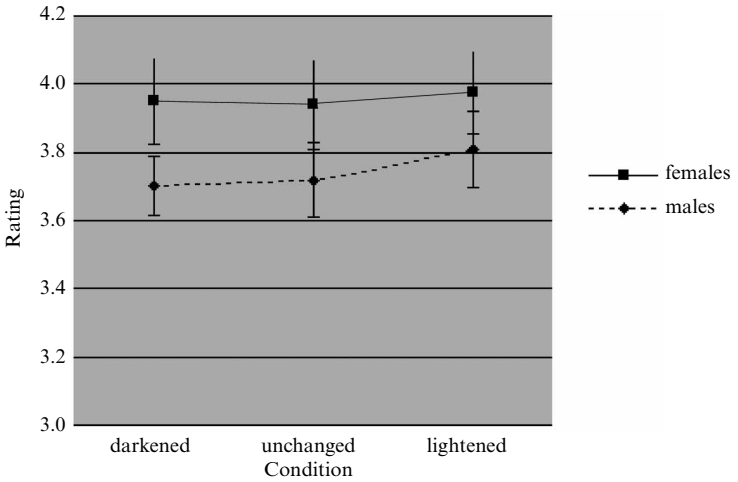

Figure 8. Results from experiment 4. Ratings for male and female faces plotted for the three overall luminance conditions. Higher numbers indicate higher ratings. Error bars are ±1 SE.

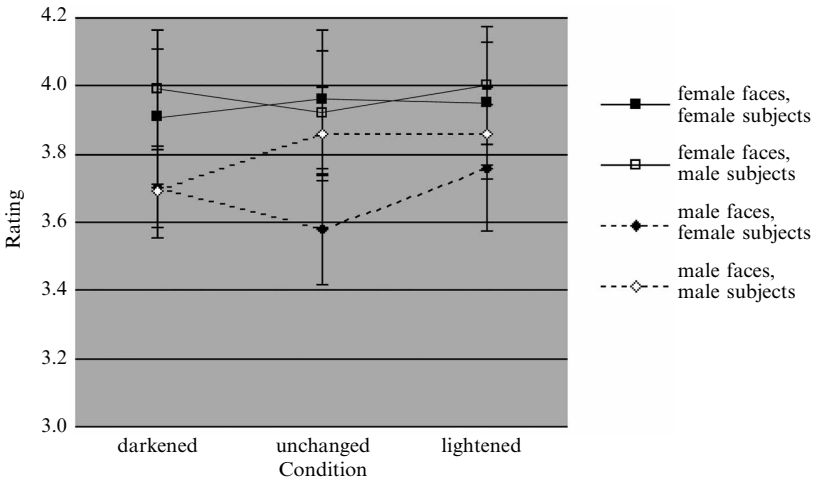

Figure 9. Results from experiment 4 showing the three-way interaction between the sex of the face, the sex of the rater, and condition. Ratings for male and female faces and male and female raters are plotted for the three overall luminance conditions. Higher numbers indicate higher ratings. Error bars are ±1 SE.

was an interaction between the manipulation and the sex of the face being rated. In the one experiment in which overall luminance, but not relative luminance, was changed, there was no interaction between the manipulation and the sex of the face being rated. More specifically, changing the luminance of only the eyes and mouth (experiments 1 and 3) or only the rest of the face (experiment 2) affected the attractiveness of male and female faces differently. However, changing the luminance value of the entire image (experiment 4) did not affect the attractiveness of male and female faces differently. The results obtained support the hypothesis that the luminance difference between the eyes and mouth and the rest of the face does affect the attractiveness of male and female faces differently.

For the most part, female faces were more attractive with the luminance difference increased than with it decreased, while male faces were more attractive with the luminance difference decreased than with it increased. The female faces in experiment 2

were an exception to this. With these faces there was no effect of the manipulation, which consisted of changing the luminance of the rest of the face, while holding the eyes and mouth constant. In experiment 2, both the male and the female faces that were darkened in this way appeared to be somewhat tanned. Hence, it is possible that the appearance of tanning was a separate influence, balancing the possible reduction in attractiveness caused by reducing the luminance difference between the eyes and mouth and the rest of the face.

The results of experiment 3 did not neatly match those of experiment 1, even though the stimuli differed only by how much of the face was visible. However, much of the difference was due to the main effect between male and female faces when the hair and face boundary were visible. Though well matched across sex for facial attractiveness, the set was not well matched for the attractiveness of the entire heads. Aside from this main effect of the sex of the face, the other major difference between the results of experiments 1 and 3 was that the difference-increased faces (eyes and mouth darkened) were rated less attractive both for male and for female faces when the context of the external features was visible. This effect of condition was likely caused by the eyes and mouths being darker than the external features in the difference-increased condition. It is likely the case that the luminance manipulations that were appropriate for the internal features-only faces of experiment 1 were simply too great for the entire heads, in which there was more context in which to read the relative luminance variations of the features. But despite these two differences between the results of experiments 1 and 3, a critical similarity remained. In both experiments there was an interaction between the sex of the face and the manipulation.

Regardless, further work will need to be performed in order to understand the effects on attractiveness of sex and the luminance difference between the eyes and mouth and the rest of the face, that were found in this study. Also, images of non-Caucasian faces will need to be tested to determine whether the results obtained in this study are common to attractiveness ratings of the faces of all races, and color images will need to be tested to make certain that the results are not an artifact of having used gray-scale images.

The similarity between the appearance of the experimental manipulations on the eyes and mouth, and those caused by the use of common cosmetics raises the issue of the causal relationship between cosmetics and the results of these experiments. One possibility is that, because people are used to seeing the eyes and mouths of women, but not men, darkened by cosmetics, they find that darkened eyes and mouths are attractive on a woman, but strange on a man. In this case, the use of cosmetics is a cause rather than a result of the attractiveness effects suggested by the present findings. However, the results are also consistent with another explanation, that both the use of cosmetics and the present results are caused by the effects on attractiveness of emphasizing a sexually dimorphic facial attribute. The sex dimorphism that could cause both the use of cosmetics and the present results is a greater luminance difference between the eyes and mouth and the rest of the face in females than in males. The evidence for the existence of this dimorphism, and how its existence could cause the present results and the use of cosmetics are described below.

Within all ethnic groups measured, male skin is darker than female skin (for an extensive review of the literature see Frost 1988). Recent evidence has suggested that skin pigmentation is a compromise between healthy and unhealthy effects of exposure to ultraviolet (UV) radiation (Jablonski and Chaplin 2000). Exposure to UV light breaks down folic acid, a vitamin necessary for cell division and producing new DNA. However, exposure to UV light also leads to the synthesis of previtamin D_3, which is necessary for preventing a variety of diseases such as rickets, osteomalacia, and osteoporosis, and also helps enhance calcium absorption. Pregnancy entails greater need for calcium, the absorption of which can be increased through higher blood concentrations

of previtamin D_3. The result of this requirement of pregnancy is that men and women have slightly different needs for exposure to UV light, with women needing more. The primary method for shielding the body from UV light is darker pigmentation from melanin, hemoglobin, and carotene. In this account, the lighter skin of females is ultimately a result of their greater need for UV light to synthesize previtamin D_3 to support the greater calcium needs of pregnancy.

Systematic studies of the pigmentation of the eyes and lips in particular have not been performed. The eyes are particularly sensitive to light, and under separate genetic control for pigmentation. Both the eyes and the lips are particularly important for social communication. Thus, there is reason to suspect that the pigmentation of the eyes and lips is subject to different demands than is the skin on the rest of the face. Because the facial features form a very small portion of the body area exposed to UV light, yet are sensitive and particularly important, it is likely that the need for photoprotection in these areas outweighs the small potential benefit of slightly more surface area for the synthesis of previtamin D_3. This could partially explain why the eyes and the mouth are darker than the rest of the face. Critically for the present study, it is likely that the compromise in the eyes and mouth between photoprotection and synthesis of previtamin D_3, unlike in the skin of the rest of the face, does not differ significantly between the sexes.

If it is the case that female eyes and mouths are as dark as those of males, the luminance difference between the eyes and the mouth and the rest of the face is greater in women than men, because the rest of the face is lighter in women than in men. This provides reason to believe that the luminance difference between the eyes and mouth and the rest of the face could be sexually dimorphic, with a larger luminance difference in female than male faces. But how could such a sexual dimorphism explain the present results or use of cosmetics?

The effects of masculinity and femininity (the emphasis of sexual dimorphism) on the attractiveness of faces have been measured primarily in two ways. First, with facial morphing software to emphasize or de-emphasize the differences between faces, typically averaged male and female faces. The assumption is that the difference between these two (averaged) faces captures the features that make a face more masculine or feminine. The faces produced by morphing between and beyond these two faces are then rated for attractiveness to determine the degree of masculinity or femininity considered to be most attractive. The other common methodology is to look for correlations between the ratings of masculinity and femininity and the ratings of attractiveness of particular faces. Increasing the femininity of a female face through morphing has consistently been shown to make it more attractive (Perrett et al 1998; Rhodes et al 2000). Also, ratings of femininity correlate strongly with attractiveness for female faces (Bruce et al 1994; O'Toole et al 1998). Evidence for the role of masculinity in determining male attractiveness is more mixed. Increasing the masculinity of a male face through morphing has been found both to make the face less attractive (Perrett et al 1998; Rhodes et al 2000) and to make it more attractive (Johnston et al 2001). The Johnston study used a slightly different methodology, in that the two faces used to create the morph were not an averaged male face and an averaged female face, but an averaged male face and a male face judged as highly masculine. However, ratings of masculinity consistently correlate strongly with attractiveness for male faces (Cunningham et al 1990; O'Toole et al 1998; Scheib et al 1999). The studies in which morphing has been used to investigate the relationship between masculinity and attractiveness are consistent in their methodology, with only the stimuli faces produced by morphing between two faces. The correlational studies investigated several (40 or more) images of actual (not morphed) faces. Thus, for the sort of stimuli used in the experiments reported here (actual faces rather than morphs), more masculine faces have been consistently found to be more attractive than less masculine (feminine) faces.

Masculinity and femininity are determined by sexually dimorphic qualities. Previous research, described above, has suggested that making a face more masculine or feminine will have opposite effects on the attractiveness of male and female faces. For example, the distance between the eye and eyebrow is greater in female than male faces. If this distance is increased, it will make a female face look more feminine, and hence *more* attractive. However, the same manipulation would also make a male face look more feminine, and hence *less* attractive. Accentuating a sexually dimorphic quality in a face will usually cause an increase in attractiveness if the face is of one sex, but a decrease in attractiveness if the face is of the other sex. That is to say that the same manipulation, to a sexually dimorphic feature, can cause opposite changes to the attractiveness of male and female faces.

In this study, the same manipulations, increasing or decreasing the luminance difference between the eyes and mouth and the rest of the face, led to roughly opposite changes in the attractiveness ratings of male and female faces. Thus, the results of this study are consistent with the notion that the manipulations affected a sexually dimorphic attribute, which caused opposite changes to the attractiveness of male and female faces. This putative sexual dimorphism is the luminance difference between the eyes and mouth and the rest of the face. The presence of this same dimorphism may also explain the use of cosmetics by women to darken the eyes and mouth—that it accentuates a preexisting sexual dimorphism, thereby making the face more feminine, and hence more attractive.

An obvious problem with this account is that it suggested that men could also use cosmetics to accentuate their masculinity, by lightening their eyes and lips or darkening the rest of their face. But it is far less common for males to use cosmetics than for females. Previous work has shown a stronger connection between femininity and attractiveness in women than for masculinity and attractiveness in men (Bronstad et al 2002; Bruce et al 1994; O'Toole et al 1998). Thus, it may be that men do not use cosmetics because they stand to gain less by accentuating their masculinity than do women by accentuating their femininity. Also, it could be said that males innately possess a kind of cosmetics for decreasing the luminance difference—their beards. As hair is almost always darker than skin, beards reduce the luminance difference between the mouth and the rest of the face.

Though the present results seem to support the assertion that the luminance difference between the eyes and mouth and the rest of the face is larger in females than males, we cannot yet conclude this. To conclude that males and females differ in the luminance difference between the eyes and mouth and the rest of the face, we will need to investigate the luminance patterns of male and female faces that are not wearing cosmetics, and are photographed under consistent lighting conditions from one sitter to the next. Unfortunately, the present stimuli set is not appropriate for addressing this question. The lighting and exposure of each of the images was not kept rigidly consistent, so comparing luminance relationships across images would likely tell us more about differences between the lighting and exposure conditions of the photographs than about differences between the faces. Also, some of the female faces are wearing cosmetics, but there is no documentation of exactly which faces or what cosmetics were applied to those faces. It would not be surprising to find that male and female faces differ in relative luminance when the females are wearing cosmetics and the males are not. Conclusions about the sexual dismorphism of relative luminance will require systematic examination of a set of faces photographed without cosmetics under rigidly consistent lighting. The assertion that the present study does support is that the size of the luminance difference between the eyes and mouth and the rest of the face affects the attractiveness of male and female faces differently.

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