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Do women's preferences for symmetry change across the menstrual cycle?

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Abstract

In many species, symmetry enhances physical attractiveness of the face and body. In humans, facial attractiveness is also enhanced by symmetrical decoration in the form of facial paint [Cárdenas, R. A., & Harris, L. J. (2006)]. According to the good-genes hypothesis [e.g., Thornhill, R., & Gangestad, S. W. (1999)], symmetry is preferred because it is associated with mate quality. According to the receiver bias hypothesis [e.g., Enquist, M., & Johnstone, R. (1997)], it is a by-product of how the visual system is designed. Proponents of the good-genes hypothesis have suggested that a preference for symmetry may vary with fertility, namely, that it will be enhanced in women in the high-fertility phase of the menstrual cycle. Previous research does demonstrate that, during this phase, women prefer the scent of more symmetrical men [e.g., Gangestad, S. W., & Thornhill, R. (1998)]. However, research employing assessment of faces fails to find a similar effect [Koehler, N., Rhodes, G., & Simmons, L. W. (2002)]. Previous research asked subjects to judge faces one at a time during high fertility (around ovulation) and low fertility (menstruation). We used a different face-presentation method, tested women during the other low-fertility (midluteal) phase, and used decorated as well as undecorated faces. As in our prior study [Cárdenas, R. A., & Harris, L. J. (2006)], symmetry of facial features and symmetry of decoration enhanced attractiveness, but, contrary to the possible prediction of the good-genes hypothesis, the effects did not vary across the cycle. The results as they are, therefore, can be equally accommodated by both hypotheses.

Keywords: Symmetry; Facial attractiveness; Menstrual cycle

1. Introduction

Humans and other animals that reproduce sexually can enhance their reproductive success by choosing mates that will increase their offspring's fitness by giving them "good genes," high levels of parental care, or by some other means (e.g., Andersson, 1994; Darwin, 1882; Trivers, 1972). Identifying and attracting a mate that will increase reproductive success involves complex information-processing mechanisms, from perception to decision-making, where the quality of the mate as well as the costs and benefits of the choice must be correctly assessed (e.g., Miller & Todd, 1998). Given the importance of mate quality and the "computational" complexity of mate selection, evolutionary psychology proposes that humans and other animals that reproduce sexually have evolved perceptual-cognitive biases that facilitate the selection process (e.g., Symons, 1979; Miller & Todd, 1998; Thornhill & Gangestad, 1999).

Much research on humans has been devoted to the discovery and understanding of these perceptual-cognitive biases, with the focus mostly on biases for assessing mate quality based on the physical appearance of the face and body (for reviews, see Fink & Penton-Voak, 2002; Rhodes, 2006; Rhodes & Zebrowitz, 2002; Thornhill & Gangestad, 1999), and, in a few cases, on the quality of the voice (e.g., Feinberg et al., 2006; Puts, 2005). If physical appearance offers cues to mate quality, it raises the possibility that certain attributes will be seen as more attractive than others. One such attribute may be symmetry.

1.1. The role of symmetry

Darwin (1882) suggested that the preference for symmetry is a product of sexual selection. Research supports this possibility. Among the features found to contribute to attractiveness in several species, symmetry is among the most salient (e.g., Møller & Thornhill, 1998). In humans, it has been shown to enhance the attractiveness of the face as well as the body (Grammer, Fink, Juette, Ronzal, &

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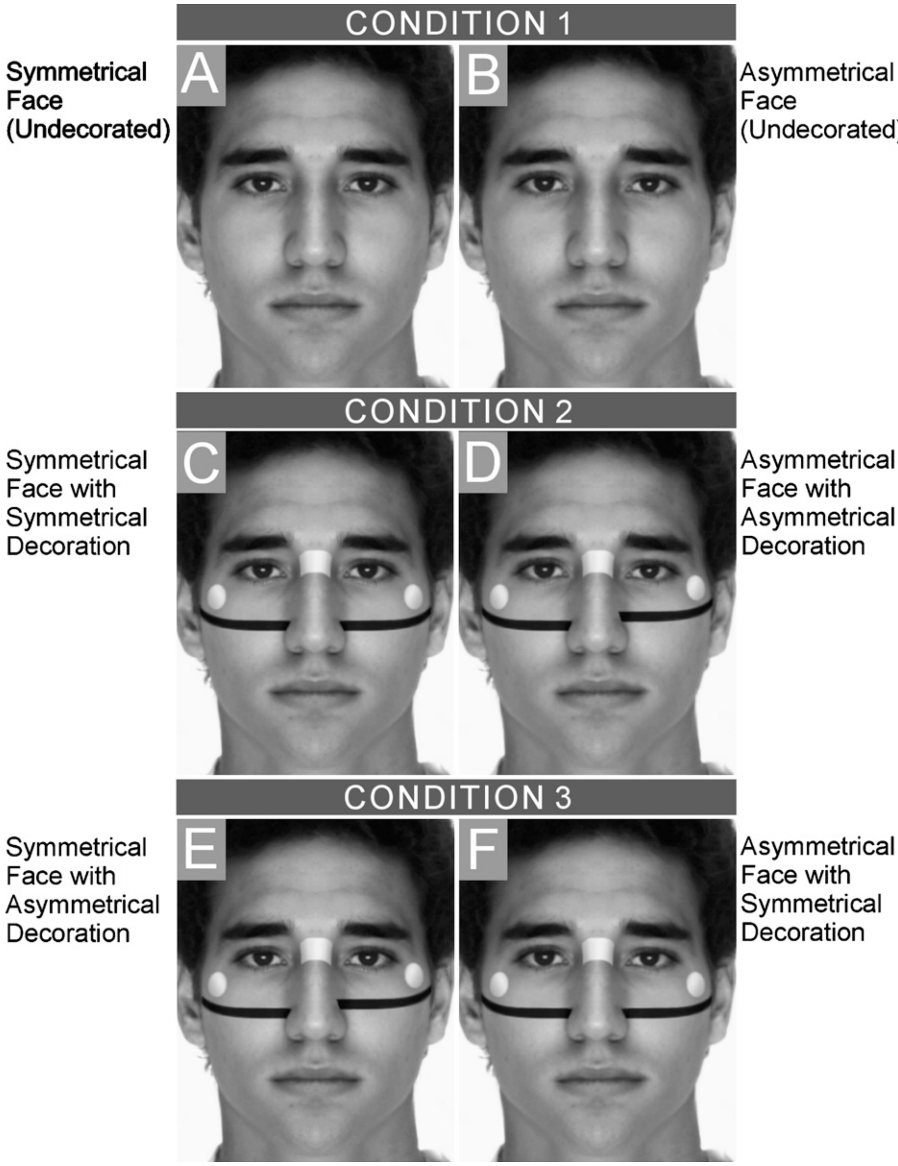

Fig. 1. Design of symmetrical and asymmetrical faces by manipulation of symmetry of face and symmetry of paint.

Thornhill, 2002; Grammer & Thornhill, 1994; Perrett et al., 1999; Rhodes, Proffitt, Grady, & Sumich, 1998). Facial attractiveness is also enhanced by symmetrical decoration in the form of facial paint (Cárdenas & Harris, 2006), a finding consistent with the widespread use of symmetrical designs in face painting (e.g., Boas, 1955; for examples, see Fig. 1 in Cárdenas & Harris, 2006). Symmetry is also perceptually salient as indicated by its rapid and accurate detection in adults (e.g., Evans, Wenderoth, & Cheng, 2000; Tyler, 2002; Wagemans, 1999) and its high signal value even for infants (Bornstein, Ferdinasen, & Gross, 1981). Preference for symmetry also appears to be unaffected by learning (Rentschler, Jüttner, Unzicker, & Landis, 1999; Washburn & Humphrey, 2001).

Together, the evidence for the perceptual salience of symmetry and for the universality of the preference suggests that the preference has an evolutionary basis. Two hypotheses have been proposed to account for its evolution: the receiver bias hypothesis (Enquist & Arak, 1994; Enquist & Johnstone, 1997; Johnstone, 1994) and the good-genes hypothesis (e.g., Thornhill & Gangestad, 1999).

The receiver bias hypothesis posits that the preference is a by-product of an object-recognition system, whereby symmetry becomes perceptually salient when the mean of a population of stimuli with random asymmetries corresponds to a symmetrical stimulus. Random asymmetries occur in two forms: as "fluctuating asymmetries" (FA), that is, random deviations from perfect bilateral symmetry due to developmental stress (e.g., parasites, mutations), and as variations in an object's orientation and position (e.g., rotations and mirror images). In either case, when symmetry corresponds to the mean of such asymmetries, the hypothesis posits that the preference for symmetry emerges from a generalization process (Enquist & Johnstone, 1997; Jansson, Forknam, & Enquist, 2002). By this account, although the object-recognition system, the presumed mechanism behind the preference for symmetry, is adaptive (e.g., for recognizing other organisms, including predators), the preference itself did not evolve to enhance reproductive success; it evolved instead as a by-product of how the recognition system works. The implication is that preference for symmetry should generalize to all symmetrical stimuli and, therefore, to all faces, whether or not they are "mate-appropriate" for sexual reproduction. Symmetrical faces should therefore be preferred whether they are the same sex as, or the opposite sex of, the individual judging them.

In contrast, the good-genes hypothesis posits that symmetry is an indicator of fitness and, therefore, of mate quality, and as such is associated with mating success. The rationale is based on the idea that "fluctuating asymmetries" are inverse indicators of fitness, that is, of an individual's capacity to cope with environmental stressors during development (e.g., Van Valen, 1962; Zakharov, 1981). Thus, females who choose mates with lower levels of asymmetry, for example, with high symmetry, will enhance their offspring's viability on the premise that they will carry the good genes necessary for survival. A further possible implication is that the preference for symmetrical faces could be enhanced for mate-appropriate faces.

Proponents of the good-genes hypothesis, while acknowledging that FA might be associated with mate quality (low developmental instability) (e.g., Van Valen, 1962; Zakharov, 1981), do not claim that mate choice is *necessarily* the product of a perceptual bias toward symmetry *per se*, but rather that it ultimately could be based on other characteristics that signal mate quality (e.g., femininity) (Fink & Penton-Voak, 2002; Gangestad & Thornhill, 2003). This distinction is most evident in studies that find an association between attractiveness and FA of traits whose symmetry cannot be directly ascertained by the subject (e.g., Gangestad & Thornhill, 1998; Rikowski & Grammer, 1999). Thus, although the good-genes hypothesis does not reject the potential existence of a perceptual bias toward symmetry arising from sexual selection, it does not claim that the bias is necessary.

If, by the good-genes hypothesis, a preference for mates who are more symmetrical can enhance reproductive success, then such a preference might exhibit adaptive, facultative shifts that track the probability of reproduction taking place. This applies particularly to females, whose preference for symmetry could vary across the menstrual cycle such that it will be lower during the low-fertility (menstrual and luteal) phases, when luteinizing hormone is low, and higher during the high-fertility (ovulatory) late-follicular phase, when luteinizing hormone is high (e.g., Roseff et al., 1989). Normally, fertility (the probability of conception) is high between Days 10 and 17 of the cycle, and highest 2 days prior to ovulation, but drops substantially 1 day after ovulation (Dunson, Baird, Wilcox, & Weinberg, 1999). Thus, low fertility is typically defined as including Days 1–7 and 20–28.

1.2. Preference shifts across the menstrual cycle for mate characteristics other than symmetry

Before considering the evidence as it pertains to symmetry, is there any evidence that women's attractiveness judgments vary across the menstrual cycle for other mate-appropriate characteristics? Two such characteristics are facial "masculinity" and voice pitch. More masculine faces are darker and show longer, broader lower jaws, more pronounced supraorbital ridges and cheekbones, smaller eyes, and thinner lips (e.g., Farkas, 1994; Frost, 1994); more masculine voices are lower-pitched, as indicated by fundamental frequency (Dabbs & Mallinger, 1999). Several studies do show a shift in preference such that, during the high-fertility phase, women prefer more masculine faces (e.g., Johnston, Hagel, Franklin, Fink, & Grammer, 2001; Penton-Voak et al., 1999) as well as lower-pitched voices (Feinberg et al., 2006; Puts, 2005).

For both kinds of preferences—faces and voices—there is also evidence that the menstrual cycle effect is more reliably found when women make their judgments as though choosing partners for short-term as distinct from long-term relationships (Penton-Voak et al., 1999; Puts, 2005). Such selectivity could be accounted for by women's shifts in reproductive strategies across the menstrual cycle. Compared to men, women pay a far greater physiological cost in offspring production and have far greater physiological constraints on the number of offspring they can have. This cost-disadvantage suggests that a woman will enhance her reproductive success not by choosing short-term mates, but by choosing a mate willing to provide continuous high parental investment in her offspring for the long term (Trivers, 1972). In fact, there is evidence that for long-term relationships, women prefer mates with high status, resources, ambition, and maturity (Buss, 1989). At ovulation, however, women also can help their offspring genetically by choosing mates with high genetic quality. This conjecture is supported by the above-mentioned studies showing that, at ovulation, women are more attracted to cues that signal genetic quality, such as masculinity (for a recent review, see Gangestad, Thornhill, & Garver-Apgar, 2005). Thus, preference shifts in mate characteristics may reflect women's mating strategies designed to optimize the balance between the transfer of good genes to offspring (short-term relationship) and parental investment (long-term relationship) (Cashdan, 1996).

1.3. Preference shifts for symmetry across the menstrual cycle

In sum, the evidence does show variations across the menstrual cycle in women's judgments about the attractiveness of mate-appropriate characteristics other than symmetry. The evidence for judgments of symmetry is less clear.

On the positive side are studies showing that women rate the *scent* of more symmetrical men as more attractive when fertility is high (e.g., Gangestad & Thornhill, 1998; Rikowski & Grammer, 1999). In these studies, however, only the men's scents, but not their faces, were rated, so the evidence for a visual bias toward symmetry is at best only indirect. On the negative side, Koehler, Rhodes, and Simmons (2002) studied women's ratings of men's attractiveness based directly on their facial symmetry and found no evidence that the preference was enhanced when fertility was high. Instead, symmetrical faces were preferred by the same margin across the cycle. In this study, the subjects were asked to judge the attractiveness of the faces in the context of short- *and* long-term relationships. This too did not affect their preference for symmetry. They were also asked to judge the attractiveness of female faces but now, understandably, without any mention of a relationship. Again, symmetrical faces were preferred by the same margin across the cycle. Although female faces were rated as more attractive than male faces in general, there was no evidence that symmetry affected the attractiveness of male faces more than female faces. Finally, the study included a control group of women taking hormonal contraceptives, so that fertility was constantly low. Curiously, these women showed an enhanced preference for symmetrical female faces when conception was "high," meaning that time when, in the abscence of conception they would have been at risk.

The indirect tests of a perceptual bias toward symmetry thus find a cyclic shift in preference, whereas the study of Koehler et al. (2002), the one direct test, does not. It is possible, however, that its failure was due in part to the decision by Koehler et al. to use only the menstruation phase of the cycle as the "low-fertility" phase. Although the probability of conception during menstruation is very low, hormone fluctuations are not the same during the other low-fertility phase, the midluteal phase. If it is hormonal changes across the cycle that are responsible for changes in symmetry preference through their presumed effects on brain mechanisms underlying symmetry detection and preference, it may be that the midluteal phase will show preference changes that were not observed in the menstruation phase. The reason would be that some hormones, particularly progesterone, show their greatest fluctuations during the time near ovulation and the midluteal phase, but not during menstruation and ovulation. Indeed, women's responses to male faces do change during the midluteal phase: their preference for darker skin diminishes (Frost, 1994) as does their preference for masculinized faces (Jones et al., 2005).

Finally, it is possible that the absence of a shift in preference in the study of Koehler et al had something to do with their method of face presentation. The faces in that study represented four different degrees of symmetry (low, normal, high, and perfect symmetry) and were presented on a computer screen one at a time and rated on a seven-point scale. Although the one-at-a-time method is sensitive enough to detect overall preferences for symmetrical faces (e.g., Rhodes et al., 1998), it may not be sensitive enough to detect preference shifts across the menstrual cycle. If so, the use of this method may have allowed other aspects of the task (such as memory retrieval) to confound the effect of menstrual cycle on the preference for symmetry.

In sum, although cyclic preference shifts are found for facial masculinity, voice pitch, and male scent, it is not clear that facial symmetry will show the same trend.

1.4. The current study

The primary goal of the current study was to test the symmetry cyclic-shift hypothesis using a different and potentially more sensitive method of face presentation and by testing subjects during the other (20- to 28-day) low-fertility phase of their menstrual cycle. The method used was forced choice, in which subjects are shown pairs of faces (a symmetrical version and an asymmetrical version of the same face) and are asked to choose the more attractive face of the pair. The method thus allows the faces' levels of symmetry to be compared directly and has been used successfully in studies of facial attractiveness (e.g., Perrett et al., 1999), including our prior study (Cárdenas & Harris, 2006).

In as much as our prior study also found that symmetrical facial decoration enhanced facial attractiveness, whether applied to asymmetrical faces or symmetrical faces, and that asymmetrical decoration decreased attractiveness, a second goal was to see whether decoration would affect judgments of facial attractiveness differently across the menstrual cycle. As mentioned earlier, preference for symmetrical mates might be either the direct result of sexual selection or a by-product of an object-recognition system. Both hypotheses imply, although this is not mandatory for the first hypothesis, the existence of perceptual mechanisms tuned to detect symmetry fast and accurately. In principle, decoration could be used to exploit such a sensory bias by manipulating it so as, in the case of symmetrical decoration, to enhance attractiveness in a way comparable to the effects of "supernormal stimuli" reported in the classic ethological literature (e.g., Tinbergen, 1951; see also Ryan, 1998). By applying decoration to faces, we therefore could compare the relative effectiveness of intrinsic physical features with features that can be added through decoration. In the same way that the good-genes and the receiver bias hypotheses can account equally for the basic preference for facial symmetry, they likewise would account equally for the effect of symmetrical decoration. Any further effects of the sex of the face and any findings of preference shifts across the menstrual cycle, however, would be better accommodated by the good-genes hypothesis.

Finally, because our prior study suggested that, compared to men, women were more affected by symmetrical decoration when judging mate-appropriate faces than when judging mate-inappropriate faces, a third goal was to compare the effects of menstrual cycle on judgments of faces of both sexes on the possibility that if the preference for symmetry is enhanced in the high-fertility phase, it will be only or predominantly for mate-appropriate, that is, male faces. If so, it would be further evidence that the preference is functional for mate selection, as proposed by the good-genes hypothesis.

In sum, the study was designed to address the following questions, one set for undecorated faces, another for decorated faces. For undecorated faces, the questions are: (1) Will symmetrical faces be preferred over asymmetrical faces? (2) Will the effects of symmetry on attractiveness be the same for male and female faces? (3) Will the effect of symmetry change across the menstrual cycle? For decorated faces, the questions are: (1) Will decoration affect facial attractiveness over the level obtained without decoration? (2) Will symmetrically decorated faces be preferred over asymmetrically decorated faces? (3) If so, will the effect change depending of the sex of the face and (4) on the subject's fertility status?

2. Method

2.1. Subjects

The subjects were 60 undergraduate women ranging in age from 17 to 36 years (mean±S.D.=19.8±2.86). Thirty-eight were students at Michigan State University (East Lansing, MI) and 22 at the Universidad de Magallanes, Chile. There were three qualifications for participation: subjects could not be taking hormonal contraceptives, had to have regular menstrual cycles, and had to identify themselves as heterosexual. We imposed this last qualification to test the good-genes hypothesis in a context relevant for sexual reproduction. For their participation, the Americans received class credit, and the Chileans received 1000 Chilean pesos (equivalent to about US$2).

2.2. Menstrual cycle

On recruitment, subjects were asked three questions: (1) to indicate whether or not they were currently taking oral hormonal contraceptives; (2) to indicate the day of onset (Day 1) of their last two menstrual cycles; and (3) to estimate the average length of their cycle. Based on this information, subjects were scheduled for two test sessions, one when their risk of conception was likely to be high (closest to Day 12, therefore closest to ovulation) and one when it was likely to be low (closest to Day 22, therefore closest to the midluteal phase). Testing order was counterbalanced so that for half the subjects, testing began during the high-risk phase, for the other half during the low-risk phase.

The three questions were repeated at each session and once again, by e-mail, a few weeks after the second session. Given that self-report information is not always accurate, the information was collected at multiple times to determine whether or not the subjects were tested during the appropriate phases of their cycle. The mean cycle length for the 60 subjects was 29.14 days (range, 15–37) with S.D.=3.8. These figures are similar to those typically found in studies with large samples (e.g., Colombo & Masarotto, 2000).

2.3. Faces

The faces were produced from digital images of 32 faces of young adults (16 male and 16 female), all with naturally asymmetrical facial features, selected from the AR Database (Martinez & Benavente, 1998). All were frontal-view faces with "neutral" expression, photographed under standard illumination and with a resolution of 768 by 576 pixels and 24 bits of depth. Faces were resized, translated, and rotated to a standard center position. Each face's features and skin texture were manipulated using methods similar to those described in detail elsewhere (Perrett et al., 1999; Rhodes et al., 2001). First, the position of facial features of each original face was recorded by placing 304 reference points on each image. Then, for each face, we created a synthetic skin texture with symmetric color information. Left–left and right–right composites for each original face were made by dividing the original face in the midsagittal axis and then combining each half with its mirror image (e.g., left-half combined with left-half mirror image). Using a computer script, 304 points were placed on each composite face. A morphing software, Winmorph 3.01, used this information to produce 32 synthetic-symmetric skin textures by averaging (morphing) each pair of composite faces. We used a synthetic-symmetric skin texture instead of the original asymmetrical texture because it has been reported to show a more marked effect of symmetry on preferences (Perrett et al., 1999). The software then produced 32 asymmetrical faces by remapping (warping) each synthetic skin texture to fit the asymmetrical features of each original face (as indicated by the 304 reference points). A symmetrical version of each face was created with an additional computer script that calculated the average position (x, y) of feature points of each original face and then used this information to remap the synthetic skin to fit the symmetric (averaged) facial features. All symmetrical and asymmetrical faces were manually retouched to have the same hairstyle and visible clothing. This process yielded 64 faces—32 with asymmetrical features and 32 with symmetrical features.

To these 64 faces, two designs of facial paint, one symmetrical, the other asymmetrical, were applied with Corel PhotoPaint by using a reference mask containing the pixel coordinates of the areas to be painted in each face. The symmetrical design was modeled after a design used by the Selk'nam of Tierra del Fuego, South America (Gusinde, 1982). It consisted of a central white square on the bridge of the nose and a black horizontal stripe on each cheek with a white circle to the outside. To make the design asymmetrical, the stripe and circle on one side were displaced by 3 mm (10 pixels). We chose this relatively slight level of asymmetry in order to mimic the degree of naturally occurring asymmetries in most faces. By this method, 128 faces with facial paint were produced, 64 asymmetrical and 64 symmetrical. Examples are shown in Fig. 1.

2.4. Experimental conditions

In Condition 1 (Fig. 1, Faces A and B), an undecorated symmetrical face was paired with an undecorated asymmetrical face. This condition also provided a baseline against which to compare the effect of symmetry of paint on subjects' judgments. In Condition 2 (Fig. 1, Faces C and D), a symmetrical face decorated with symmetrical paint was paired with an asymmetrical face decorated with asymmetrical paint. This condition was designed to enhance the perceived difference in symmetry between the symmetrical and asymmetrical face. In Condition 3 (Fig. 1, Faces E and F), an asymmetrical face with symmetrical paint was paired with a symmetrical face with asymmetrical paint. This condition was designed to diminish the perceived difference in symmetry between the symmetrical and asymmetrical face. In our prior study (Cárdenas & Harris, 2006), the conditions correponding to current conditions 2 and 3 elicited the strongest effect of decoration on facial attractiveness (decorated faces whose facial symmetry was held constant showed an effect roughly midway between these two conditions). In the current study, we therefore included only these conditions in order to maximize the likelihood of detecting a preference shift across the cycle (as well as to reduce the number of total trials).

It should be noted that the effect of decoration on attractiveness will be analyzed between conditions (e.g., between Conditions 2 and 3) so that if decoration proves to have no effect on attractiveness, then there would be no reason to expect the preference for symmetrical faces to change across conditions. This analysis thus ensures that the effect of decoration will not be confounded with face symmetry (as it would be if the effect were analyzed separately for each condition).

Condition 1 consisted of 32 trials (16 male faces and 16 female faces); Conditions 2 and 3 consisted of 12 trials each (six male faces and six female faces). Each subject therefore judged a total of 54 face pairs. Across conditions, the faces comprising each pair were left–right counterbalanced for positions of the faces with symmetrical and asymmetrical features and for positions of the faces with symmetrical and asymmetrical paint.

2.5. Procedure

In the current study we focused on short-term relationships for judgments of facial attractiveness. A short-term relationship was defined as "one involving a minimal amount of commitment and where the chances of the relationship continuing long-term are low."[1] We focused on short-term relationships because symmetry is postulated to be an indicator of the mate's physical quality, and because the evidence cited earlier, that women have different mate preferences for short- and long-term relationships, suggests that physical attractiveness is more important when choosing a short-term mate than a long-term mate for whom other characteristics (e.g., parental skills and financial means) are known to be more influential. In addition, as already noted, some prior studies found menstrual cycle effects on women's mate preferences only or predominantly for judgments pertaining to short-term relationships.

As in the study of Koehler et al. (2002), the subjects were questioned about female as well as male faces except that we modified the instructions to make both kinds of questions suitable for mate-appropriate selection. For male faces, subjects were instructed to "choose the face that you would prefer for a short-term sexual relationship." For female faces, subjects were instructed to "choose the face that you think men will prefer for a short-term sexual relationship." For each pair, subjects were asked to first choose one face and then to indicate their strength of choice by checking one of three options underneath the face chosen (options were "weak," "moderate," and "strong").

Faces were presented on a LCD screen (215×285 mm) of a laptop computer. A computer interface was designed for stimulus presentation and data recording. Subjects triggered the image presentation with a mouse-click and were allowed to advance the images at their own pace, without time limits. Decision times, however, were recorded automatically by the laptop computer in order to detect subjects who finished the task much faster than most others, on the possibility that very fast times might indicate a lack of engagement in the task. For purposes of this screening, "much faster" was defined as more than 1 S.D. faster than the entire group of subjects (the entire group's average decision time was 8.8 s per trial for undecorated faces, S.D.=3.6). By this measure, 10 subjects were identified as possibly unengaged. Their responses on the face-judgment task then were checked for patterns consistent with this possibility (e.g., making more than 16 consecutive choices of the face displayed at the left of the screen). Six subjects met these criteria (very fast response times and absence of or low response variability) and were excluded from further analyses. One subject was also excluded who identified herself as homosexual. Post hoc data analysis showed, however, that including these seven subjects did not change the results. Subjects were tested individually in a quiet room and completed the task in about 15 min.

For data analysis, a computer script automatically coded subjects' choices (these numerical values were not visible to subjects). The values assigned to the asymmetrical face, when chosen, ranged from 0=strong, to 1=moderate, to 2=weak. The values assigned to the symmetrical face, when chosen, ranged from 3=weak, to 4=moderate, to 5=strong. In this way the overall score for each face pair could range from 0 ("*strong*" *preference for the asymmetrical face*) to 5 ("*strong*" *preference for the symmetrical face*), where a

[1] This was the same definition used by Koehler et al. (2002) except that we replaced their word "slim" with the word "low."

Table 1
Mean preference in percentages (and S.D. in parentheses) for symmetrical faces according to experimental condition, sex of the face, and subjects' fertility status

	n	High fertility		Low fertility	
		Male faces	Female faces	Male Faces	Female faces
Condition 1	53	52.69 (5.06)	53.21 (6.07)	52.67 (5.90)	52.59 (6.83)
Condition 2	53	59.94 (12.29)	61.13 (14.46)	59.43 (11.60)	60.19 (12.20)
Condition 3	53	43.14 (11.81)	42.58 (14.14)	44.34 (12.15)	44.21 (14.52)

score of 3 or higher indicates a relatively stronger preference for the symmetrical face.

3. Results

3.1. Condition 1: undecorated faces

The results for undecorated faces (Condition 1) are summarized in Table 1. Taking the questions listed earlier in order, the results showed that symmetrical faces were judged as more attractive than asymmetrical faces across the 32 trials of both sessions. Although the mean preference was only modest (mean±S.D.=52.8±4.03%) and in the lower end of the range of preferences found in prior studies using blend methods for manipulating faces, it was greater than expected by chance, where chance was set at 50% [one-sample, one-tailed t test: $t(52)=5.04$, $p<.001$]. The effect size ($r=.33$) was also close to that typically found in prior studies using the blend method (for 16 studies, $r=.43$, S.D.=.32; Rhodes, 2006).

The data also show that symmetrical faces were preferred above chance for male and female faces alike and in both phases of the menstrual cycle [high fertility—male faces: $t(52)=3.87$, $p=.0001$, female faces: $t(52)=3.85$, $p=.0001$; low fertility—male faces: $t(52)=3.29$, $p=.0009$, female faces: $t(52)=2.76$, $p=.003$].

A 2 (Sex of face)×2 (Symmetry of face)×2 (Risk of conception) repeated-measures analysis of variance (ANOVA) showed that the strength of preference for symmetrical faces was not related to the subjects' fertility status [$F(1,52)=0.197$, $p=.659$], the sex of the face [$F(1,52)=0.093$, $p=.761$] or to the two variables in combination [for interaction, $F(1,52)=0.201$, $p=.656$].

3.2. Conditions 2 and 3: decorated faces

The results for decorated faces (Conditions 2 and 3) are also summarized in Table 1. Again, taking the questions listed earlier in order, the results showed that decoration (Condition 2) did affect the attractiveness of the faces over the level obtained with undecorated faces (Condition 1) and did so to a substantial degree [Condition 1=52.8 vs. Condition 2=60.2, $t(52)=5.87$, $p<.0001$]. A 2 (symmetry of paint)×2 (Sex of face)×2 (Symmetry of the face)×2 (Risk of conception) repeated-measures ANOVA also showed that the preference was substantially affected by symmetrical decoration [$F(1,52)=36.231$, $p<.001$, partial $\eta^2=.411$] such that symmetrical paint enhanced facial attractiveness (Condition 2), while asymmetrical paint decreased attractiveness to the point where symmetrical faces were no longer preferred (Condition 3); in fact, for Condition 3, *asymmetrical* faces were preferred [preference for asymmetrical faces=56.4, $t(52)=4.1682$, $p=.0001$]. The effect size for the preference of symmetrical faces in Condition 2 ($r=.37$) was comparable to that in our prior study ($r=.48$).

Preference scores in the decoration conditions (Conditions 2 and 3), however, were not affected by the subjects' fertility status [$F(1,52)=0.233$, $p=.631$], by the sex of the face [$F(1,52)=0.182$, $p=.672$], or by the interaction between these factors and symmetry of the decoration (all p's >.05).

3.3. Further analyses

To corroborate the results reported above, three additional steps were taken. First, the menstrual cycle data for the 53 subjects who met the requirements for participation were screened for the possibility that for some subjects the testing sessions did not take place during the times of interest, that is, during the low and high phases of fertility. The reasons would either be inconsistencies in subjects' answers about the characteristics of their menstrual cycle or, based on their answers, a failure to predict the onset of their next menstruation within 4 days. Seven Americans and 3 Chileans were identified as suspect by these criteria. Reanalysis of the data with these subjects excluded, however, did not significantly change the pattern of results.

Second, women with longer cycles tend to ovulate later than women with shorter cycles (e.g., Wilcox, Dunson, & Baird, 2000). Therefore, to further assure that subjects were tested during the times of interest, another reanalysis was conducted, excluding subjects who had either "very long" or very "short cycles," where "very long" was defined as longer than 31 days, and "very short" as shorter than 27 days. Twenty-three women comprised this subgroup, so that the reanalysis was conducted on the remaining 30 women whose cycle lengths ranged from 27 to 31 days. This reanalysis likewise did not change the results.

Finally, even though the Chilean and American students were recruited only as convenience samples and not because we had any a priori reason to expect them to differ in their preferences for symmetry (see Cárdenas & Harris, 2006), we compared them on the possibility that they differed nonetheless. The results showed that their preferences were very similar. The only apparent difference was in the high-fertility session, where the Chilean group's preference for symmetrical faces was weaker than the Americans' preference. This difference, however, was largely due to a strong preference by three Chilean subjects for *asymmetrical* female faces.

4. Discussion

The results for Condition 1 provide further evidence that symmetrical undecorated faces are more attractive than asymmetrical faces (e.g., Grammer & Thornhill, 1994; Perrett et al., 1999; Rhodes et al., 1998). They also provide the first confirmation of our finding that facial attractiveness is enhanced by symmetrical decoration and diminished by asymmetrical decoration (Cárdenas & Harris, 2006).

The results, like those of Koehler et al. (2002), however, failed to show that women's preferences for symmetrical faces change across the menstrual cycle. It could be argued that our study had insufficient power to detect a preference shift given that the preference for undecorated faces, while significant, was in the lower part of the range reported in previous studies, including our own. Although this possibility cannot be discounted, we would note that there was likewise no change across the cycle in the decorated face conditions, even though the overall preference was substantially enhanced by decoration. The negative results are also consistent with the results of Koehler et al., as already noted. Furthermore, we rigorously checked our subjects' self-report information of their menstrual cycles and used what we thought might be a more sensitive method of evaluation of cyclic changes. Based on the totality of evidence, we therefore conclude that preference for facial symmetry does not shift across the cycle, meaning that it is *not* enhanced during the high-fertility phase.[2]

In light of the evidence that attractiveness ratings do shift across the cycle for facial masculinity, voice pitch, and other traits, it is possible that testosterone markers are more critical for short-term mate selection than facial symmetry per se. If so, how could we account for preference shifts for the *scent* of more symmetrical men (e.g., Gangestad & Thornhill, 1998; Rikowski & Grammer, 1999), and how might this finding relate to those pertaining to facial symmetry? We can think of three possibilities. One is that scent better captures certain health or fitness indicators than does facial symmetry (or that the sensory system is better equipped for detecting olfactory than visual fitness cues). Another is that the benefits of preferring symmetry visually across the cycle (e.g., selecting a mate with good genes) outweigh the costs of cyclic shifts (e.g., not being able to determine accurately potential mate competitors). Finally, although judgments of facial symmetry appear to be focused on traits that may signal developmental instability (Simmons, Rhodes, Peters, & Koehler, 2004), proponents of the good-genes hypothesis, as mentioned earlier, claim that mate choice does not need to be associated with perceptual biases toward symmetry (Gangestad & Thornhill, 2003), so that judgments of symmetry in faces would not necessarily be expected to change across the menstrual cycle.

We hasten to add that the absence of a cyclic shift in preference does not contradict the good-genes hypothesis even if it assumes the existence of perceptual biases toward symmetry that are adaptive for mate selection. In other words, although the hypothesis proposes that the preference benefits reproductive success, it is not specific about how this mechanism operates across the menstrual cycle. That raises the possibility that the preference for symmetry is supported by a more general mechanism that is not tuned to shifts across the cycle, even though the preference still enhances reproductive success.

The overall results thus show that symmetrical faces are preferred and that the preference is enhanced by symmetrical decoration. Both findings can be accommodated by both the good-genes and receiver bias hypotheses put forward to account for the evolution of the preference for symmetry. Although a preference shift across the menstrual cycle as well as a preference shift across the sex of faces could be better accommodated by the good-genes hypothesis, no such shifts were observed in the current study; the results therefore can be equally accounted for by both hypotheses.

5. Questions for further research

The current study suggests several new questions for research. One has to do with how fertility is measured. We noted that at least one of the testing sessions for some of our subjects may not have taken place during the times of interest. Although reanalysis of the data with those subjects excluded did not change the overall pattern of results, self-report remains an imperfect measure of fertility status compared to physiological measures. If fertility status does affect preference for symmetry, it may be that the effect will be revealed only with physiological measures.

We also did not ask whether the subjects' preferences for symmetry were affected by two other factors known to play a role, namely, women who see themselves as more attractive show greater preference for symmetrical faces (Little, Penton-Voak, Burt, & Perrett, 2002), and, at ovulation, women who see their partners as unattractive express more interest in having extra-pair sex with physically attractive men (Pillsworth & Haselton, 2006). Both findings have been interpreted as mating strategies that are based on women's perceived current reproductive value (e.g., self-perceived mate value, reproductive gains with current partner) and that are oriented to maximize their reproductive success. If there are cyclic shifts in preference for symmetry, then they may be more likely to occur in

[2] In this connection, we have learned from Gillian Rhodes, one of the referees for our article, that a new study by Koehler, Rhodes, Simmons, and Zebrowitz (in press) again failed to find a shift in preference for symmetrical faces across the menstrual cycle.

women whose mating strategies place greater value on the physical attractiveness of the potential mate (as a consequence of perceived low gains with current partner or as self-perceived physical attractiveness).

Finally, further research should address the possibility of cross-cultural and ecological differences for symmetry preference. We did not expect our subjects—Chilean and US undergraduates—to differ in light of the many cultural characteristics they have in common, namely, being university students, being exposed to Western mass media, and living in countries with relatively good health care. Future studies should therefore draw samples from populations in a variety of ecological settings, particularly from regions with different degrees of developmental stress, on the possibility that in high-stress environments (e.g., high pathogen prevalence), symmetry will be a more reliable indicator of fitness than in low-stress environments. If so, and if there are menstrual shifts for symmetry preference, they perhaps are more likely to be found in high-stress environments.

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