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THE EFFECTS OF SYMMETRICAL DECORATIONS ON THE ATTRACTIVENESS OF FACES AND ABSTRACT DESIGNS

By

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ABSTRACT

THE EFFECTS OF SYMMETRICAL DECORATIONS ON THE ATTRACTIVENESS OF FACES AND ABSTRACT DESIGNS

By

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Physical symmetry enhances physical attractiveness in several species. A proposed explanation of this effect is that symmetry is a phenotypic indicator of biological fitness. Another explanation is that it is a by-product of object recognition mechanisms. Throughout the world, symmetrical designs are also common in face and body painting as well as in the decorative arts. In three experiments, I asked whether attractiveness could also be enhanced by symmetrical decoration. In Experiments 1 and 2, subjects were shown photographs of pairs of human faces and instructed to choose the more attractive face in each pair. The photographs were of physically symmetrical and asymmetrical faces decorated with either symmetrical or asymmetrical designs. As indexed by the number of times they were chosen, symmetrical faces were judged to be more attractive than asymmetrical faces; adding asymmetrical designs to symmetrical faces decreased their attractiveness; and adding symmetrical designs to asymmetrical faces increased their attractiveness. In Experiment 3, subjects made similar choices from pairs of non-representational designs taken from several cultures and modified in shape, coloration, and orientation of design features. Symmetrical designs again were judged to be more attractive. The results are interpreted as partial support for the fitness hypothesis and suggest that the same mechanisms underlying the judgment of physical attractiveness also underlie cultural practices of face painting and non-representational art.

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INTRODUCTION

"…the eye prefers symmetry or figures with some regular recurrence. Patterns of this kind are employed by even the lowest savages as ornaments; and they have been developed through sexual selection for the adornment of some male animals."

Charles Darwin, *The Descent of Man and Selection in Relation to Sex*, 1882, p. 93.

People all over the world willingly transform the human face and body, through the use of decoration and ornamentation, into something more appealing, something closer to an ideal type. Certainly it was this behavior that inspired Charles Darwin in the passage quoted above as well as Franz Boas (1955) when Boas wrote, "aesthetic pleasure is felt by all members of mankind" (p. 9). Indeed, the decorative arts and body adornment are broadly acknowledged as universal features of mankind and as hallmarks of "modern human behavior" (e.g., Mithen, 1996; Henshilwood et al., 2002; Power, 1999), and among their most striking and common features is the use of symmetrical designs (e.g., for body adornment: Boas, 1955; Brain, 1979; Ebin, 1979; Gusinde, 1982; for decorative arts: Gombrich, 1984; McManus, 2002; Washburn & Crowe, 1988; Weyl, 1952).

This common use of and implied preference for symmetry in face and body painting and the decorative arts could be acquired through cultural processes, but that cannot be the whole story. One reason is that many cultures showing the preference are temporally and geographically isolated (Lévi-Strauss, 1963). Another reason is that symmetry is perceptually salient in human visual processing as indicated by its rapid and accurate detection in adults (Julesz, 1971; Evans et al., 2000; Tyler, 2002; Wagemans, 1999; Wenderoth, 1994), its prominence in memory (Attneave, 1955; Deregowski, 1972), and its high signal value even for infants (Bornstein et al., 1981). Preference for symmetry also appears to be unaffected by learning (Rentschler et al., 1999; Washburn & Humphrey, 2001). Finally, facial symmetry has the same effect in a variety of cultures: to enhance physical attractiveness (Grammer & Thornhill, 1994; Hume & Montgomerie, 2001; Jones et al., 2001; Koehler et al., 2002; Little et al., 2001; Mealy et al., 1999; Penton-Voak et al., 2001; Perrett et al., 1999; Rhodes et al., 1998, 2001a,b). Collectively, the evidence suggests that the preference for symmetry, while perhaps acquirable through cultural processes, is rooted more fundamentally in our evolutionary history. If so, it further suggests that the preference is an adaptive trait, perhaps related to sexual selection just as Darwin proposed.

Given the ubiquity of symmetrical designs, the salience of symmetry in vision, its effects on physical attractiveness, and the possibility that the preference is adaptive, the question is whether symmetrical designs, namely, decoration in the form of facial paint, can enhance facial attractiveness, that is, make faces more attractive than they would be otherwise, and, likewise, whether symmetry also can enhance the attractiveness of abstract, or non-representational, designs. To find out, I conducted three experiments, the first two with faces, the third with abstract designs.

In this thesis, I begin by discussing the conceptual framework behind this work in the context of current research in the anthropology of art. After that, I discuss research on the perception of symmetry. I then describe the three experiments and discuss the results as they bear on three different explanations for symmetry preference. Finally, in the conclusions, I propose new questions to be addressed in future research.

THE BIOCULTURAL BASIS FOR PREFERENCE FOR SYMMETRY IN ART

Like all species, human beings are biological organisms functionally shaped through evolution. Functional design implies that biological systems are endowed with physiological structures designed to enhance their own survival and reproductive success. Such structures could in fact embody cognitive architectures for perceiving and processing information, and, therefore, be tuned to allow organisms to interact effectively with their environment. As neuroscience research has shown, understanding the physiological characteristics and functional design of such structures is critical for understanding behavior.

Despite the growing body of evidence for the role of physiological structures in behavior, modern anthropology has not been much concerned with understanding how such structures can affect cultural behavior. This lack of concern is partly due to how cultural phenomena are studied by the dominant paradigm in social sciences, the so-called "Standard Social Science Model" (Tooby & Cosmides, 1992). This paradigm assumes that culture is a social construction determined historically by contextual social factors and that there are no relevant evolutionary forces or psychological mechanisms that contribute significantly to cultural behavior (an expression of Durkheim's claim that society is a *sui generis* reality). As a logical derivation from this assumption, the paradigm conceptualizes the human mind as a 'black box' (Locke's tabula rasa), an unbounded, unbiased learning machine (Sperber & Hirschfeld, 2004) whose functional design is not relevant for understanding cultural behavior.

This rationale has led anthropologists to focus exclusively on cultural differences across societies, leaving practically unexplored the similarities or universals of human behavior and their role in cultural dynamics. Many findings, however, cast doubt on the validity of the standard social science model. As mentioned above, there is growing evidence in neuroscience that the physiological structures that embody cognitive architectures are critical for understanding human behavior. Comparative neuroanatomy has shown the relationship between neurological structures and the presence or absence (and degree of development) of cognitive skills in different species. Neuroscience, including cognitive neuro-psychology, also has shown that normal behavior is disrupted when certain structures are damaged, and developmental studies have shown behavioral correlates between the development of physiological structures and the development of behavior.

The standard social science model has also substantially influenced the anthropological study of art. Even though art is ubiquitous in human societies, few attempts have been made by modern anthropology to examine the possible biological basis of art. Instead, anthropologists pay closer attention to the particularities of aesthetic behavior within each culture and predominantly to the meanings and values that artistic objects convey within a society, that is, the particularities of the social context that apparently gives rise to certain decorative patterns. Although the standard social science model acknowledges that our common human physiology can lead to universal features in the way people perceive decorative patterns, such features are excluded *a priori* from anthropological analysis.

Jeremy Coote (1992), for instance, argues that perception is a process in which "cultural factors play a dominant role;" in other words, "perceptions are cultural phenomena" (p. 247). As one may expect, however, Coote is not specific about where to draw the line where "physiological perception" ends and "cultural perception" begins. He proposes that the most fundamental motivation of the anthropology of art is to understand how artists and viewers see art.

In a similar vein, Howard Morphy (1994) argues that "the analysis of the objects must be framed in terms of their place and meaning within the producing culture" (p. 655). He recommends that the anthropological analysis of art should focus on the analysis of form, namely, "shape, componential structure and material composition", as a "point of entry" to understand art and other aspects of a given culture. For Morphy, many of the physical properties of objects can be apprehended cross-culturally, but the most critical aspect is to recognize the "non-material attributes" of objects, the ones that "presuppose cultural knowledge" (p. 673).

In general, the underlying assumption of such arguments is that it is possible to separate physiology from culture, to somehow depurate culture from biology, and that semantics and knowledge cannot be shaped by our cognitive architectures and mental mechanisms. This dichotomizing between biology and culture leads to the disembodiment of cultural behavior.

In recent years, there has been movement against the standard social science model as shown in increasing interest in understanding how evolved cognitive architectures shape cultural behavior. By framing questions about cultural practices in evolutionary biological terms, this perspective promises to shed new light on the nature of cultural behavior. In the case of art, for instance, we could ask: Is art unique to humans? Why is art so pervasive across cultures? What evolutionary forces and processes, if any, have contributed to set off and shape human art?

Such questions have been particularly intriguing to evolutionists concerned with the survival value of human behavioral traits. Some of them regard art as a more or less wasteful activity with no survival, or adaptive, value, merely a by-product of other sophisticated mental faculties for information-processing (e.g., Pinker, 1997). But if art was shaped by sexual selection, then it is also possible that it has a direct adaptive value (Darwin, 1882; Zahavi, 1978; Zahavi & Zahavi, 1997; Miller, 2000, 2001). In other words, an adaptive functional design may underlie aesthetic preferences where beauty and ugliness correlate with survival and reproductive success (Thornhill, 1998).

Thus, instead of separating biology and culture into separate domains, to understand cultural behavior, biology and culture can be integrated into a biocultural perspective, one that draws on convergent evidence from different scientific disciplines to provide an integrated view of human behavior in an evolutionary context.

One possible way to achieve this integration is through use of the framework proposed in 1963 by the Dutch ethologist Nikolaas Tinbergen. Tinbergen proposed that animal behavior could be studied by asking four types of complementary questions about an organism's behavior:

- How does it work? This question addresses the mechanistic causes of behavior, in other words, how a particular stimulus affects an organism's nervous system.
- How did it develop? This question addresses the developmental or ontogenetic causes of behavior, that is, how the mechanisms responsible for behavior develop in an organism.
- Why does it exist? This question addresses the selective advantage of the behavior.

- Why did it evolve? This question focuses on phylogeny, that is, on the evolutionary history of the behavior.

The first two questions are called "proximate" questions: they are the "how" questions, meaning that they ask how mechanisms work and develop in the lifespan of an organism, without looking directly at evolutionary processes. The last two questions are "ultimate", or "why" questions, which involve evolutionary and historical thinking. Thus, we could ask about decorative patterns: How does a particular pattern or design affect the nervous system of a given organism? When does the organism develop the perceptual mechanisms required for perception of the designs? For example, are they age specific? Why is the behavior functional, or adaptive, for the organism, in other words, what are its benefits? Finally, how did this behavior come about in the course of evolution?

The strength of this conceptual framework is that it considers all levels of explanation as complementary and not as mutually exclusive. It therefore avoids the simple dichotomy between nature and culture given that any behavior is supported by biological mechanisms.

Animal Ornaments and the Theory of Sexual Selection

In the animal kingdom, decorative patterns are common, as they identify the species and often also an individual's sex and age (Zahavi, 1978). A possible explanation for the evolution of animal ornaments is that they evolved from sexual selection pressures.

Darwin proposed the theory of sexual selection, which critics regard as its most original contribution to evolutionary theory, in 1871. He recognized that, contrary to the predictions of natural selection, many animal traits were detrimental to survival. To solve this puzzle, Darwin came to realize that organisms not only strive to survive but to reproduce, so that they may evolve traits that enhance their reproductive fitness even at the cost of their personal survival. He coined the term "sexual selection," therefore, to designate the type of selection produced by the differential success of given physical and behavioral phenotypes for acquiring mates. According to Darwin, sexual competition for mates occurs in at least two forms: in the form of fights among rivals of the same sex (intra-sexual selection) and in the form of mate choice, that is, in the capacity of individuals of one sex to attract mates of the other sex (inter-sexual selection). Darwin proposed that fights between rivals leads to the evolution of traits, such as weapons, that enhance the capacity for defeating rivals in agonistic competition, and that mate choice leads to the evolution of ornaments to attract mates.

Although the theory of sexual selection is a centerpiece of Darwin's view of evolution, it remained largely ignored and discredited until the 1970's (Cronin, 1991; Anderson, 1994). During the centennial commemoration of the publication of Darwin's book on sexual selection, new seminal work on sexual selection appeared. Trivers (1972), for instance, proposed that differences in mating behavior, such as the tendency of females to choose mates and of males to court mates, result from differences in parental investment: females invest more resources than males in raising their offspring. Several other ideas, such as the handicap principle, and new intellectual paradigms, such as sociobiology, also raised interest in sexual selection (Miller, 1998).

Among the hypotheses proposed for the evolution of ornaments are the "runaway sexual selection", the "good-genes hypothesis", and the "sensory bias hypothesis".

The runaway hypothesis, introduced by R. A. Fisher (1930), proposes that sexual selection could originate when females arbitrarily became attracted to some trait in males. Males with the preferred trait will be more successful reproducing, and females with the preference will have more attractive male offspring. Over generations, sexual selection would favor more extreme developments of the trait until equilibrium is reached because the males' survival is compromised.

The good-genes hypothesis, however, proposes that the attractive male trait is an indicator of mate quality, so that attractive mates have a better genotype for survival. One of the proposed good-genes hypotheses, the handicap principle, introduced by A. Zahavi in 1975, suggests that signals are not selected because they enhance survival but because they enhance the reliability of the message signaled. When it comes to mate quality, a signal can be reliable only if it is so costly for survival that poor-quality mates would not be able to fake it (because their survival is compromised), that is, when it become a handicap for its bearer.

The third hypothesis, the sensory bias, or receiver's bias, hypothesis, proposes that mate selection occurs thanks to a pre-existent sensory bias in females that leads to the evolution of more extreme signals in males (e.g., brighter colors, louder calls), in other words, without a necessary genetic correlation between a preference and trait (Ryan, 1998).

Human Ornaments

Like animal ornaments, human ornaments serve many purposes, some of them unique to humans. Indeed, the cultural selection and transmission of decorative patterns in a given population can operate at a much faster rate than the time required for biological patterns to spread in a population (e.g., fashion compared to birds' feather coloration). Moreover, culture can quickly change not only the structure of a particular ornament but its meaning as well.

Across cultures humans have undergone brutal pain and spent conspicuously precious time and resources with the aim of adorning their bodies. Potentially harmful procedures of body modification are well known and documented, such as scarification, tooth removal, tooth-chipping or filing, foot binding, piercing, and reshaping skulls and limbs. These practices can lead to a number of health problems, such as infectious diseases (particularly in geographic areas with high pathogen prevalence) or the disruption of normal physiological processes. The corset, for instance, designed to reshape the waist and abdomen, can lead to pulmonary disease and cause varicose veins because it restricts the return of blood from the legs (Brain, 1979, p.81).

Cosmetic decoration, of course is not unique to pre-industrial societies. Indeed, in industrial economies the resources spent on cosmetics are in no way diminished, as illustrated by the current economic success of the "beauty industry". The beauty industry represents a $160-billion-a-year global business with an estimated annual growth of 7%, which is more than twice the rate of the developed world's GDP (Anon. 2003, p.71). Americans, for instance, spend more each year on beauty that they do on education.

But what is the benefit of such costly behavior? Even though body decoration may serve physiological needs, such as protecting the skin with paint against cold weather (e.g., among the Thompson Indians of North America), body decoration serves social communication. Indeed, humans have developed an enormous variety of decorative designs that either lack any direct physiological function or are physiologically harmful but that serve social communication.

The communicative functions of body adornment are copiously documented in the ethnographical literature. Body adornment has been described as encoding cosmovision, or links to the supernatural world, warfare, mourning, marital status, physiological processes, age, social adscription, social inequalities (status, rank, property in the case of slavery), emotional states, for good luck, and for recovering from illness. Body decoration can became a tangible medium for making objective abstract concepts, such as social differences and religious ideas, and also as a way to enact a worldview.

As mentioned earlier, body adornment is widespread. Bobbi Low (1979) surveyed a sample of 138 societies from the *Human Relations Area Files* and found that all practiced some form of ornamentation, even those with a subsistence economy. The survey also revealed some sex differences in ornamentation, showing a tendency for female ornamentation to signal sexual availability (pubertal or marital status), while male ornamentation tended to signal rank and puberty, but seldom marital status (p. 486).

Similarly, an unpublished survey on 60 preindustrial societies shows that women are more likely than men to use body paint as a form of adornment (Alford, 1996). In about one-half of preindustrial societies, men and women are equally decorated, in 8% men are more decorated, and in 38% women are more decorated. The expression of rank through adornment, however, is more common for men (43%) than for women (13%).

Not all designs resemble a culturally standardized system of communication, and often that is the case with body ornamentation aimed at enhancing attractiveness. According to the ethnographical record, attractiveness can be enhanced in a number of ways. For instance, in his survey of the Tiv of Central Nigeria, Bohannan (1956) found that most decoration is cosmetic and that beauty can be achieved only when it is painful, through scarification. As Bohannan's informant stated: "of course it is painful. What girl would look at a man if his scars had not cost him pain?" (p. 121).

Age is also encoded in ornaments aimed to enhanced attractiveness. Among the Tiv, scarification style changes from one generation to the next, and young women's preference for young instead of old men is expressed in their preference for new types of facial marking (Bohannan, 1956).

Health is also related to attractiveness and encoded in body ornamentation. That is the case, for instance, for the Ommura of Eastern Highlands, Papua New Guinea, who signal health by adding pig fat to their body paintings to make them shine (Johnson, 2001). Body decoration can also signal health in more subtle ways. A survey of cross-cultural data on scarification showed that stomach scarification could act as a signal of female mate quality in societies with high prevalence of pathogens (Singh & Bronstand, 1997). The analysis showed that pathogen prevalence predicts female stomach scarification independent of polygyny, famine, and social class stratification, and that the relationship is not evident for males.

The resources expended in enhancing one's attractiveness are not without social consequences. Attractiveness is valued in many societies and particularly by men (Buss, 1989). At least in Western societies, attractive people are perceived, for example, as more intelligent and, perhaps partly for that reason, receive better grades and jobs (e.g., Zebrowitz et al., 2002).

Fitness and Fluctuating Asymmetry

In this thesis, I am interested in the frequent use of symmetrical designs in body decoration. Recent research suggests that symmetry can enhance attractiveness in many species by reflecting stability in development. In nature, no "bilaterally symmetrical" organism is perfectly symmetrical. Every creature instead shows what in biology is called "fluctuating asymmetry", small and random deviations from perfect symmetry of bilaterally symmetrical traits (Ludwig, 1932). Across a population, these deviations are normally distributed about a mean of zero (Swaddle, 2003; Palmer & Strobeck, 2003).

Because both sides of the body share the same genotype and are exposed to the same effects of the environment, it is hypothesized that fluctuating asymmetry reflects an organism's capacity to cope with developmental noise (e.g., metabolic rates, concentration of regulatory molecules, diffusion, thermal noise, and rates of cell division, cell growth, and cell death) (Palmer & Strobeck, 2003). In other words, morphological differences in body sides are believed to be due to the interaction between random forces perturbing development and mechanisms that reverse or stabilize development (developmental instability) (Lens et al., 2002). Therefore, the degree of symmetry is now typically used as a measure of an organism's developmental precision, that is, how closely an organism's structure approaches its expected phenotype for a given genotype and environment (Palmer & Strobeck, 2003). Fluctuating asymmetry therefore may serve as an indicator of fitness (Møller, 1992; Møller & Thornhill, 1998).

Fluctuating asymmetry has been found to affect mate selection in a number of species in a variety of environmental setting, including arboreal, terrestrial and aquatic, which suggest that fluctuating asymmetry plays the same role irrespective of the different visual demands required in different environments. However, not all research on fluctuating asymmetry shows a consistent relationship between fitness and fluctuating asymmetry: some show a clear relationship, others show weak relationships (trait or taxon specific), and still others show no relationship at all. These discrepant findings could be attributed to differences in the methodology used (fluctuating asymmetry is usually very subtle, around 1% or less of the size trait), or they could mean the relationship does not exist, but it is important to note that the idea is under current debate (Swaddle, 2003).

Thus, if fluctuating asymmetry is indeed a clue to fitness used for selecting mates, animals should be very good (or at least better than chance levels) at detecting it. Most symmetry detection studies have been with humans (Swaddle, 1999). The general findings of such studies are reviewed in the next section.

What is Symmetry?

The word symmetry is used in a wide range of intellectual domains —such as music, biology, and physics— to describe several kinds of patterns, a characteristic that has contributed the typical polysemy of the term symmetry. In art and design, for instance, symmetry loosely refers to 'balance' or to the effect of the artwork's elements being evenly distributed across a picture (therefore, it does not mean that identical elements are distributed across a picture). In music, conversely, it refers to a number of compositional patterns such as contrapuntal operations, for example, canon, counterpoint (operations common in Bach's music), and mirror chords. In this thesis, however, I use the term following its mathematical definition, according to which symmetry occurs when an object (a shape or pattern) is identical to a transformed copy of it. Four types of symmetry can be identified according to the type of transformation (Figure 1):

- *Reflectional* symmetry, also known as mirror or bilateral symmetry, occurs when the object is copied or reflected across a plane (the object is "flipped" over a line).
- *Rotational* symmetry occurs when the object is rotated around a center point.
- *Translational* symmetry occurs when an object is moved a given distance parallel to a plane (its orientation is not altered).
- *Glide-reflection* is a combination of reflection in a plane and movement a given distance parallel to that plane.

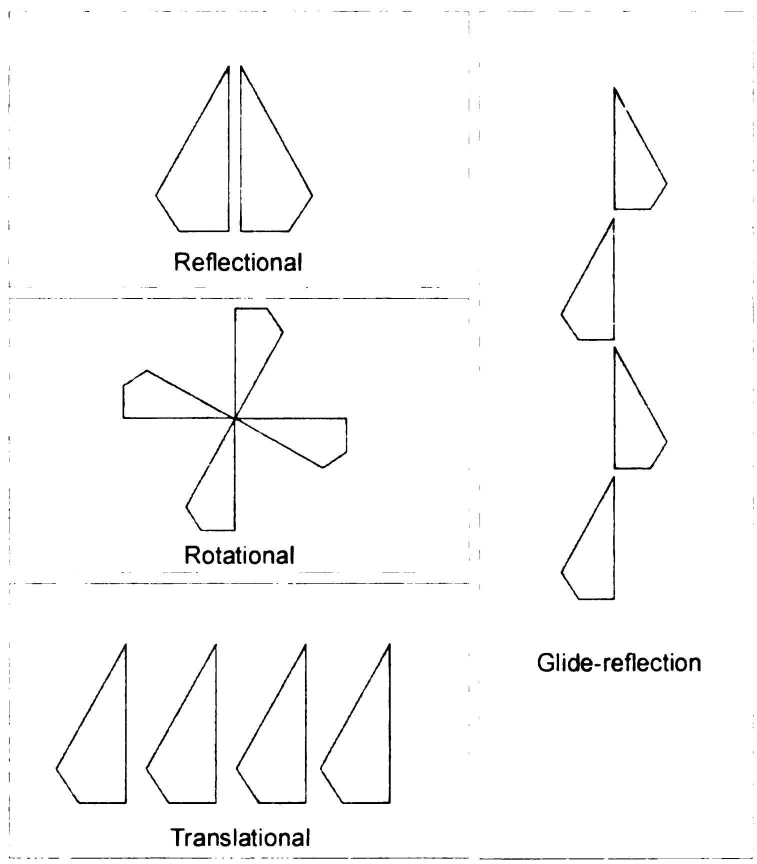

Figure 1. The four types of symmetry in the plane.

In the following section I review some findings from visual science on how humans detect symmetry.

Symmetry Detection

As Pascal defined it, symmetry is "what is perceived at a glance". Understanding symmetry's ubiquitous salience for the visual system has motivated studies on the detection of symmetry since the early days of visual science (e.g., Mach, 1959).

Despite the diversity of methods used to study how humans detect symmetry, most studies assume that the underlying perceptual and cognitive processes are directly reflected in people's accuracy ("error rate") and decision time ("reaction time") in determining whether or not a given figure (stimulus) is symmetrical. It is possible, therefore, to examine how people detect symmetry by measuring changes in their performance associated with changes in the structure of the stimuli (e.g., number of elements comprising the design, coloration, shape, and orientation), changes in their time of presentation (e.g., 100 milliseconds, or until symmetry is detected), as well as with changes in where the stimulus is presented in the visual field, for example, in the area where the person is looking (fixation, centered at the fovea) or outside that area (eccentricity).

Typically the stimuli correspond to dot patterns or shapes, like those depicted in Figure 2.

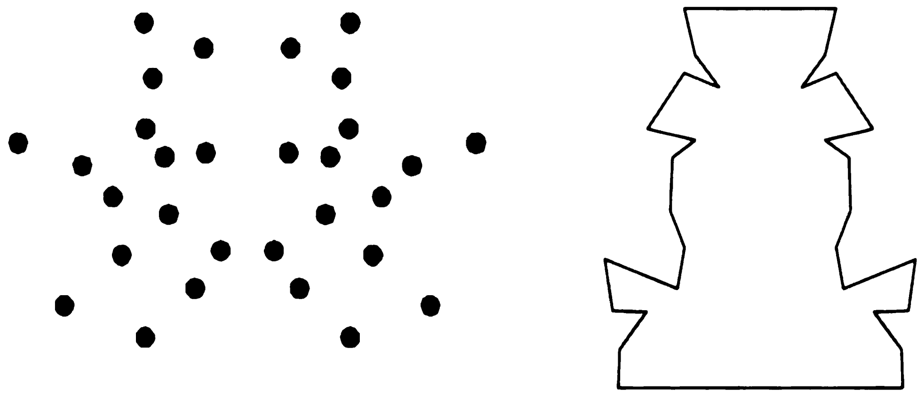

Figure 2. Examples of stimuli used in symmetry detection research.

Most studies have focused only on how people detect reflectional symmetry. The results show that people are remarkably accurate and fast, particularly when the axis of symmetry is oriented vertically. Although research on symmetry detection shows several consistent findings, certain findings have puzzled researchers for decades, and, as a result, there is no current unifying theory (Wagemans, 1995, 1997). In what follows I briefly review some of the main finding in this research.

Symmetry and Orientation

Studies comparing peoples' performance at detecting mirror symmetry with other kinds of symmetry have found that mirror symmetry is perceptually more salient than rotational or translational symmetry (and therefore glide-reflection) (Julesz, 1971; Corballis & Roldan, 1974; Royer, 1981; Baylis & Driver, 1994; Wagemans et al., 1993).

Performance at detecting symmetry changes depending on how the axis of symmetry is oriented (e.g., vertical, horizontal, diagonal). People are best at detecting vertical symmetry (90°), then horizontal symmetry (0°, 180°), then symmetry whose axis is oriented at the main oblique diagonals (45°, 135°), and then any other orientation (Mach, 1959; Julesz, 1971; Barlow and Reeves, 1979; Wenderoth, 1994).

One factor that might explain why vertical symmetry is perceptually salient is the structure of the visual world. Analyses of large samples of images of real world scenes (indoor, outdoor, and natural scenes) have shown that the vertical and horizontal orientations are the most prevalent (Switkes et al., 1978; Coppola et al., 1998). This finding has been suggested as the basis of the "oblique effect" (Coppola et al., 1998): better discrimination of visual stimuli oriented horizontally or vertically compared to stimuli oriented obliquely (Appelle, 1972). The neurological correlates of the oblique effect suggest that the salience of vertical symmetry is hardwired: cortical cell populations responsive to vertical stimuli are more abundant than cells tuned to horizontal or oblique orientations (Beh & Latimer, 1997; Hubel & Wiesel, 1968; Li et al., 2003), and vertically and horizontally symmetrical patterns show a different pattern of brain activity than the activity produced by oblique axis orientations (Beh & Latimer, 1997). However, the oblique effect does not explain why people are also better at detecting symmetry oriented at 45° and 135° over other orientations.

Additionally, the advantage of detecting vertical symmetry over any other orientation appears to be due not only to a fixed neural architecture but also to people's attentional strategies (Wagemans, 1997). Wenderoth (1994), for instance, showed people a set of figures whose axis of symmetry ranged from 0° to 90° and from 90° to 180°, meaning that the mean of the distribution of orientations was not a vertical axis. He found that people were not better at detecting vertical symmetry but instead were faster and more accurate detecting symmetry around the axis of symmetry that was more likely to occur (the one representing the mean of the frequency distribution of the stimulus set). Similarly, Pashler (1990) found that people were faster at detecting non-vertical symmetry when cued about the figure's orientation that they were going to see. These studies show that people's attentional strategies are important for understanding their performance at detecting symmetry at different orientations.

Thus, although it is not completely clear why symmetry at certain orientations is more salient to the visual system, it seems clear that evolved neural architectures and attentional strategies are orchestrated for understanding the structure of the visual world.

Location in the Visual Field

Reflectional symmetry is detected faster and more accurately when the axis of symmetry is at fixation, that is, directly located where the eyes are focused (centered at fovea). However, the effect seems less critical for closed shapes than for dot patterns.

People are faster and more accurate at discriminating symmetry when the figure's elements are near the axis of symmetry, or midline (Julesz, 1971, Bruce & Morgan, 1975; Barlow & Reeves, 1979; Jenkins, 1982), as well as near the edge or outline of the figure (Barlow & Reeves, 1979).

Parallel or Serial Process

The salience of symmetry has led some researchers to hypothesize that symmetry is perceived in a parallel rather than a serial process (Wagemans, 1999). To perceive symmetry as a serial process means that the detection time is proportional to the number of elements comprising the stimulus because every feature-point of the design needs to be examined individually and independently of other points in the design. Consequently, increasing the number of feature-points comprising a design would increase the time required to determine the symmetry of a design. In a parallel process, on the other hand, detection of symmetry occurs independently of the number of elements comprising a design, for that symmetry can be determined at the same speed even when the number of elements increases.

Recent research suggest that people use a parallel process for extracting general features of the stimulus but use a serial, or point-by-point, process for comparing more detailed features. This is suggested by a study showing that small perturbations of a symmetric display are not readily perceived (Huang & Pashler, 2002).

Additionally, when research is conducted with figures with multiple features to be checked for symmetry (e.g., several colors), that is, figures more complex than monochromatic figures (dots and lines), the results show that people cannot judge simultaneously the symmetry of more than one feature or dimension of a figure (Morales & Pashler, 1999; Huang & Pashler, 2002). For instance, when shown a figure with two colors (two features), people first judge the symmetry of one color and then the symmetry of the other color (Morales & Pashler, 1999). The same is found for other features, such as two shapes comprising the design (Huang & Pashler, 2002). These results corroborate the view that attentional mechanisms are needed when judging symmetry.

In sum, although there is no unified theory of how people perceive symmetry, research on symmetry detection shows that symmetry is a very salient feature of the visual system and that people are quite proficient at detecting symmetry, particularly when it is oriented vertically and centered at the fovea. Symmetry detection research also demonstrates the importance of attention. The salience of symmetry covers the entire human lifespan, as indicated by its salience for infants (Bornstein et al., 1981; Fisher et al., 1981), but it seems to decline for adults over 60 years old (Herbert et al., 2001).

Does Symmetrical Decoration Enhance Attractiveness?

As previously noted, although the preference for symmetry may be due to cultural factors, in the traditional sense of the word, many findings suggest that this cannot be the whole story. As also noted, many species show a preference (or a distinctive behavior) for symmetry and humans are endowed with a visual system tuned to detect symmetry fast and accurately. Thus, it is possible that symmetrical decorations are very common across cultures because humans are endowed with perceptual mechanisms very sensitive to symmetry detection that affect the way designs are produced and judged around the world, such as the use of specific colors, contrast and patterns in order to enhance the display of symmetrical designs. However, if symmetry signals fitness, then people, along with having perceptual mechanisms tuned to detect symmetry efficiently, would have different perceptual biases in how symmetry affects the attractiveness of mate-relevant compared to mate-irrelevant stimuli.

To address such possibilities I performed three experiments to test the hypothesis that symmetrical decoration also enhances the attractiveness of faces (Experiments 1 and 2) and geometric designs (Experiment 3). I was particularly interested in investigating whether people actually prefer symmetry when judging decorated faces and geometric designs that were manipulated according to general properties for symmetry detection in vision (color, shape and orientation of design features) and according to the stimulus's relevance for mate choice (same or opposite sex as their own). Although studies find that people judge symmetry to be more attractive than asymmetry, no study has been conducted to determine whether other factors relevant for symmetry detection, such as orientation and color, are also attractive. This issue was addressed in Experiment 3.

If the preference for symmetry has a biological basis, the preference ought to be universal, that is, people from all societies should show similar preferences toward such stimuli. Demonstrating such universality, however, was not the goal of this work. Instead it was to investigate whether people show biases toward stimuli that were manipulated, as just mentioned, according to mate-relevancy and the properties for symmetry detection in vision.

The first experiment tested undergraduate subjects from the city of Punta Arenas, Southern Chile. Due to possible methodological shortcomings in the manipulation of images of that study, I conducted a second experiment with American undergraduates at Michigan State University using an improved methodology for image manipulation. Along with assessing the validity of the first study's findings, it also addressed additional questions that had emerged in the course of carrying out the first study. Given their methodological differences, these studies cannot be regarded as providing for a cross-cultural comparison of symmetry preferences. Additionally, although there are social differences between American and Chilean students, both societies have many commonalities such as being industrial-western societies exposed to Western mass media and capitalist patterns of consumption. Thus, although comparing the populations is informative, it is not conceived as a critical test of the cross-cultural validity of either the experiment or the findings.

EXPERIMENT 1: DOES SYMMETRICAL DECORATION ENHANCE FACIAL ATTRACTIVENESS?

Given the effect of symmetry on attractiveness and its possible adaptive function, its salience in vision, and the ubiquity of symmetrical designs in face and body ornamentation, Experiment 1 was designed to test the hypothesis that symmetrical designs, in the form of facial paint, can enhance facial attractiveness.

If facial attractiveness can be enhanced by symmetrical paint, the effect could either depend on or be independent of the attractiveness of the faces themselves. For instance, symmetrical paint could enhance the attractiveness of symmetrical faces by making the symmetrical features more salient and therefore more easily perceived; it could enhance the attractiveness of asymmetrical faces by making their asymmetrical features look more symmetrical; and it could enhance attractiveness independently of facial features by enhancing the attractiveness of all faces, whatever their degree of asymmetry.

If the preference for symmetry is adaptive and related to sexual selection, then enhancement effects also could depend on the sex of the person judging the faces as well as the sex of the faces being judged. The literature on symmetry provides several examples of a sex-related effect, including reports that symmetry affects attractiveness judgments more strongly for faces of the opposite than the same sex as the person judging the faces, in other words, for faces that are mate-relevant (Little et al., 2001; Penton-Voak et al., 2001), and that for both men and women, ratings of perceived health are more strongly correlated with symmetry of opposite- than same-sex faces (Jones et al., 2001).

To address these different possibilities, men and women were asked to judge the attractiveness of symmetrical and asymmetrical faces (as indexed by facial features) of both sexes decorated with either symmetrical or asymmetrical facial paint.

Subjects

The subjects were undergraduate students from the Universidad de Magallanes, Chile: 20 men (18-25 years old) and 20 women (18-26 years old). Subjects were recruited from public areas of the university during the months of June and July of 2002. All signed a consent form. All procedures were approved by the Michigan State University Committee on Research on Human Subjects.

Materials and Methods

Faces

The faces were produced from digital images of 16 faces, all of young adults (8 male and 8 female), all with naturally asymmetrical facial features, selected from the AR Database (Martinez & Benavente, 1998). All were frontal view faces with "neutral" expression, standard illumination, and a resolution of 768 by 576 pixels and 24 bits of depth. Faces were resized, translated, and rotated to a standard center position.

Following the method used by Rhodes et al. (1998), each image was manipulated to produce 16 faces with symmetrical features. The procedure was as follows: from each of the original asymmetrical 16 faces, two chimeric faces (mirror reflections of the face's right and left sides) were created. Each pair of chimeric faces was then "averaged" into a new face by manually placing 145 points on each chimera to indicate to a morphing-software, WinMorph 3.01, the location of the facial features to be averaged. This procedure yielded 16 new "average faces" with perfectly symmetrical features. Finally, using Corel PHOTO-PAINT 9, each new face was manually retouched to have the same hairstyle, visible clothing, and skin texture as the original face. Together, the 16 symmetrical faces and the 16 original faces gave a total of 32 faces.

To each of the 32 faces, two designs of facial paint were manually applied with Corel PHOTO-PAINT 9, one symmetrical, the other asymmetrical, using a reference-mask containing the pixel coordinates of the areas to be painted on each face. The symmetrical design 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 produce the asymmetrical design, the stripe and circle were vertically displaced on one side by 3mm (10 pixels). By this method, 64 faces with facial paint were produced, 32 asymmetrical and 32 symmetrical.

Experimental Conditions

A within-subjects design was used with the variables *symmetry of paint* (two levels: symmetrical paint, asymmetrical paint), *symmetry of face* as indexed by facial features (two levels: symmetrical features, asymmetrical features), and *sex of face* relative to sex of subject (two levels: same-sex, opposite-sex). Combining the variables of symmetry of paint and symmetry of face, two experimental conditions were defined as shown in Figure 3.

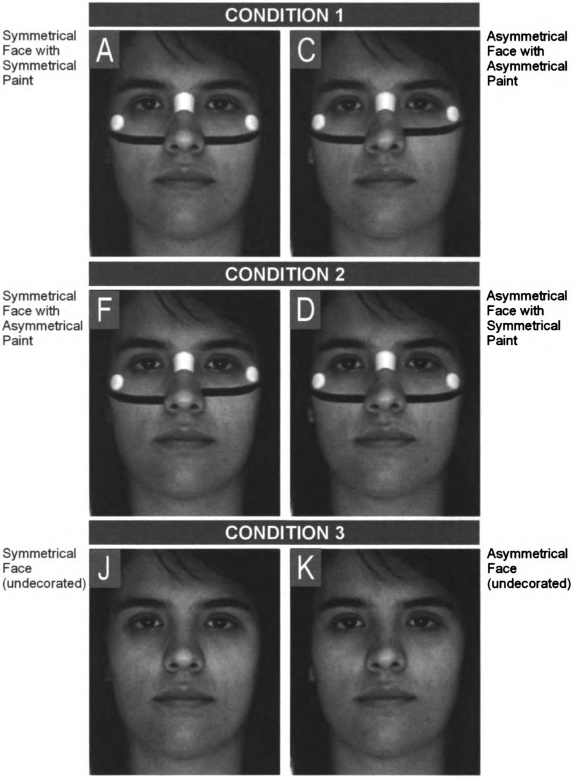

Figure 3. Experiment 1. Design of symmetrical and asymmetrical faces by manipulation of symmetry of face and symmetry of paint.

In Condition 1, a symmetrical face decorated with symmetrical paint (face A) was paired with an asymmetrical face decorated with asymmetrical paint (face C). In Condition 2, an asymmetrical face with symmetrical paint (face D) was paired with a symmetrical face with asymmetrical paint (face F).

To control for possible interaction effects of individual faces and experimental conditions (e.g., the possibility that symmetry of paint affects the attractiveness of 'face x' in Condition 1 but not in Condition 2, and vice versa for 'face y'), the subjects were divided into two groups so that each face appeared as Condition 1 for one group and as Condition 2 for the other.

To check whether, as in prior reports, faces with symmetrical features are judged as more attractive, a control condition, Condition 3, was added, consisting of pairs of unpainted symmetrical and asymmetrical faces (faces J and K). This condition also was used to provide a base line against which to compare the effect of symmetry of paint on subjects' judgments.

Each of the three conditions consisted of 8 trials, so that each subject judged a total of 24 face-pairs. The 8 trials included 4 trials of 4 different pairs of male faces and 4 trials of 4 different pairs of female faces. Total preference scores for each condition (i.e., the total number of judgments, or choices, of the more symmetrical face of each pair as the more "attractive") therefore could range from 0 to 8 (0-4 for face-pairs of the same sex as the subject and 0-4 for face-pairs of the opposite sex as the subject). Across conditions for both groups of subjects, the faces comprising each pair were left-right counterbalanced for position of the faces with symmetrical and asymmetrical features and for position of the faces with symmetrical and asymmetrical paint.

Procedure

Subjects were instructed to "choose the face that is physically more attractive in each pair of faces". Before starting, subjects were given 5 practice trials using faces with and without facial paint (no faces from the experimental set were included). Faces were presented on a LCD screen (215 x 285 mm) of a laptop computer. Subjects triggered the image presentation by a key-press and advanced the series of images at their own pace, without time limits. Subjects were tested individually in an empty, quiet room at the university, and all completed the session in about 10 minutes.

Results

The results are summarized in Figure 4. They show that for Condition 3, the control condition with unpainted faces, symmetrical faces were preferred, or judged to be more attractive, than asymmetrical faces, as indicated by the finding that the mean number of symmetrical faces chosen was significantly greater than chance (5.8 > 4) [$t(39) = 3.56$, $P = 0.001$]. A mixed factorial ANOVA showed that, although men and women alike chose symmetrical faces more, the margin of preference was greater for women ([$F(1,38) = 4.588$, $P = 0.04$]), and that for all subjects the preference score was unrelated to the sex of the face [$F(1,38) = 1.639$, $P = 0.21$] or to whether it was the same as or different from the sex of the subject [$F(1,38) = 0.02$, $P = 0.89$].

For Conditions 1 and 2, the experimental conditions with painted faces, a mixed factorial ANOVA showed a significant effect across conditions for the variable symmetry of paint [$F(1,38) = 6.769$, $P = 0.01$], indicating that symmetrical faces with symmetrical paint were the most attractive (mean preference = 6.2); that applying an asymmetrical design to a symmetrical face decreased its attractiveness (mean preference = 4.8); and that asymmetrical faces with symmetrical paint (Condition 1) were more attractive (mean preference = 3.2) than asymmetrical faces with asymmetrical paint (mean preference = 1.97). Symmetrical paint alone, however, did not guarantee that a face would be judged as the more attractive. In condition 2, the mean preference score for symmetrical faces still exceeded chance (4.8 vs. 4.0; [t(39) = 2.278, P = 0.02]), indicating that when faces were painted, the degree of symmetry of their physical features still influenced the subjects' judgments.

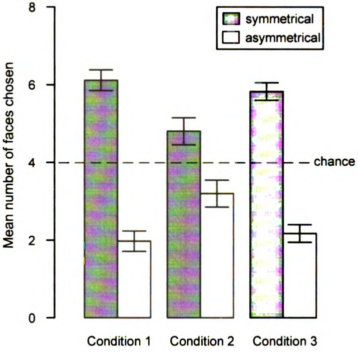

Figure 4. The effect of symmetry of paint on facial attractiveness. Mean number of symmetrical and asymmetrical faces judged as more attractive in Conditions 1, 2, and 3 (8 trials for each condition).

Finally, as shown in Figure 5, neither the sex of the subject nor whether it was the same as or different from the sex of the faces influenced the faces' perceived attractiveness (no main effect for sex of subject [F(1,38) = 0.294, P = 0.59] and no interactions between sex of subject and sex of face [$F(1,38) = 0.01$, $P = 0.92$], and this was so whether the face painting was symmetrical or asymmetrical [$F(1,38) = 0.228$, $P = 0.63$]). Symmetrical paint, however, enhanced facial attractiveness more for faces of the opposite than the same sex as the subject (significant interaction between the variable symmetry of paint, sex of subject, and sex of face [$F(1,38) = 4.19$, $P = 0.04$]), and this was equally true for the male and female subjects.

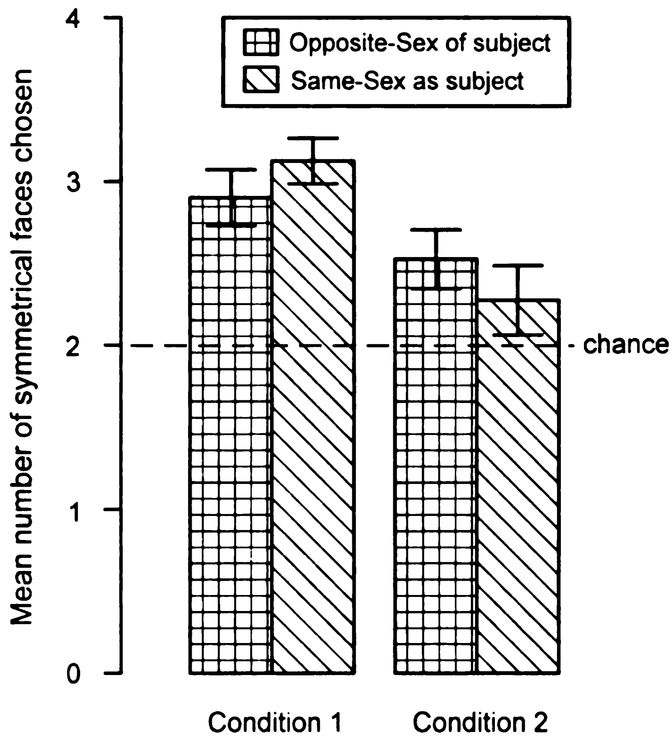

Figure 5. The effect of symmetry of paint on facial attractiveness. Interaction between *same-opposite sex of face* (sex of subject compared to sex of face being judged) and *experimental conditions* (Conditions 1 and 2) in the mean number of symmetrical faces chosen across 4 trials (scores for asymmetrical faces are not shown but are in the same direction as the scores for symmetrical faces).

Discussion

The results are consistent with a wide range of studies showing that more symmetrical faces are more attractive than less symmetrical faces (Grammer & Thornhill, 1994; Hume & Montgomerie, 2001; Mealy et al., 1999; Scheib et al., 1999; Jones et al., 2001; Koehler et al., 2002; Little et al., 2001; Penton-Voak et al., 2001; Perrett et al., 1999; Rhodes et al., 1998, 2001a, b). They also show that facial attractiveness can be enhanced by symmetrical facial paint and reduced by asymmetrical facial paint. This appears to be the first experimental demonstration of this effect. Finally, they show that, whether the paint is symmetrical or asymmetrical, subjects' judgments are more affected by feature symmetry, and more for faces of the opposite than the same sex as their own. Feature symmetry, therefore, appears to be more influential than paint symmetry on perceived attractiveness, especially of opposite-sex faces. In sum, the results show that symmetry's effect on attractiveness varies with respect to the symmetry of face and that the effect is modulated by the combination of sex of the subject and sex of the face being judged.

For this experiment, it is possible that the method of producing symmetrical faces yielded faces with smoother skin texture than the original face, meaning that the manual-retouching method did not sufficiently reduce the differences in skin texture between the original and symmetrical faces. If so, preferences for symmetrical faces might have been confounded with preferences for faces with smoother skin texture. Even if that happened, it probably did not weaken the obtained effects of the symmetrical facial paint on attractiveness because symmetrical faces were manipulated in the same way across experimental conditions, meaning that the changes in the attractiveness of symmetrical faces can be attributed only to the concomitant changes in the symmetry of paint. Still, to be sure, a second experiment was conducted, Experiment 2, to see whether the results remained the same for faces with identical skin texture.

The second experiment also provided an opportunity to ask whether facial attractiveness would be affected even when the difference between the asymmetrical and symmetrical facial paint conditions is smaller than the difference in Experiment 1. Defining the level of asymmetry in Experiment 1 as "high", two levels were created in Experiment 2, one "high", matching the level in Experiment 1, and one "low", with half that level.

EXPERIMENT 2: DOES SYMMETRICAL DECORATION ENHANCE ATTRACTIVENESS IN FACES WITH IDENTICAL SKIN TEXTURE?

Experiment 2, therefore, tested the effects of symmetrical decoration found in Experiment 1, using an improved method for the manipulation of facial features, and also tested the idea that the effect of symmetry on attractiveness varies according to the degree of asymmetry of decorations.

To find out whether symmetrical facial paint affects the perceived attractiveness of faces with identical skin texture, a synthetic skin texture was produced for each pair of faces (original and symmetrical face) by blending the left and right chimeras (mirror faces) of each original face. Using WinMorph 3.01, this skin texture was remapped (warped) to fit the facial features of the original face and its symmetrical version. As just noted, to compare the effect of degree of difference in symmetry on perceived attractiveness, two levels of asymmetrical designs were created, one matching that in Experiment 1, one with half that level.

The subjects also were asked to provide information about their socioeconomic status, art capital, and sexual orientation. The purpose was to provide descriptive information about the subjects and not to address the question of whether such variables affect symmetry preferences or not. This is because the primary question was whether symmetrical decoration affects facial attractiveness, and not whether socio-structure influences aesthetic preferences. Socioeconomic variables were chosen because they are normally used to provide a raw indicator of how socio-structural variables affect behavior. Art capital was included because education and art training are relevant factors of aesthetic preferences, particularly since modern art favors asymmetrical forms (or forms other than bilateral symmetry).

Subjects

The high-asymmetry group included 20 men (20-23 years old) and 20 women (18-23 years old); the low-asymmetry group included 20 men (18-24 years old) and 20 women (18-22 years old). All subjects were undergraduate students at Michigan State University recruited from undergraduate psychology and linguistic classes during the Spring semester of 2004. All signed a consent form and received class credit for participating. All procedures were approved by the Michigan State University Committee on Research on Human Subjects.

Questionnaire

Sexual orientation. Given than symmetry may be used for choosing mates, subjects were also asked about their self-perceived sexual orientation, so to provide a basis for categorizing the stimuli as either mate-relevant or mate-irrelevant. Subjects were asked to identify themselves as heterosexual, homosexual or bisexual.

Country of origin. To provide information about the place of origin and residence of subject, they were also asked to indicate the country and city were they were born as well as the place where they have lived most of their lives.

Socioeconomic status. Socioeconomic status (SES) is traditionally used to indicate the position of an individual or group within a social stratification system. Different indicators are used, some better than others depending on the social field being studied (health research for instance). Here, because the goal was to provide a raw description of the subjects, descriptors of income, level of education, and occupation were used.

Given that undergraduate students normally are in the process of acquiring a more stable SES (e.g., they are acquiring new skills that will affect their future income, they may or may not be economically dependent on their parents), I also asked for information about their family SES, including, parents' income, level of education as well as occupation. Globally, these indicators provide a raw estimate of household position (number of people living at home, geographic or residence area, or other possible indicators of wealth were not identified). Therefore, in this study, resources are combined with prestige-based measurements. These multiple indicators were included because of the reported tendency among people in the United States to not respond to questions about income, especially if their income is high (Krieger, Williams, & Moss, 1997, p.358).

Questions were formulated and answers were tabulated to match similar information asked in the United States 2000 census, so as to facilitate comparison of the student sample with characteristics of the Michigan population.

Art capital. I use the term "art capital" to indicate how people's conventional art training and interest in arts may affect their preference for symmetry. Thus, questions were asked about formal art training (art courses taken), how knowledgeable the subjects feel in art (how well they expect they will do in a general art test), and their interest in art (e.g., how frequently they visit art museums, number of art books owned, art works owned, how frequently they produce art work).

Sexual Orientation and Country of Origin

With respect to sexual orientation, 78 people (97.5%) reported that they were heterosexual, 1 person identified herself as bisexual, and one person identified himself as homosexual. Seventy-two subjects were born in the United States and lived most of the time in Michigan (90%), while 4 (5%) lived in another state, and 4 (5%) were born outside the US.

SES and Art Capital

Family income (see Table 1) was measured by summing subjects' income with their parents' income. Ten subjects did not report family income. The median family income of the sample is almost double that of the median family income of Michigan, and also shows a distribution skewed toward high-income levels.

The data on educational attainment (see Table 2) shows that the education level of the subject families was also higher than that for the average Michigan resident of 25 years old or older.

Most subjects (55%) reported not having any formal art training (see Table 3). For those with art training, most of had 1 high school class (32.5%), and some had more than 1 high school course or 1 college level course (10%). Only 2 subjects reported having more than 1 art college class.

It not surprising, therefore, that most students did not feel competent in art history (see Table 4). When asked "If right now you were given an exam on art history (e.g., painters, styles), how do you think you would do?" most people reported that they expected to do poorly (82.5%).

Table 1. Subjects' family income compared to Michigan family income.

	Subjects		Michigan	
Income	N	%	N	%
Less than $10,000	0	0	123,861	4.8
$10,000 to $14,999	0	0	91,412	3.5
$15,000 to $24,999	2	2.86	249,241	9.6
$25,000 to $34,999	1	1.43	292,656	11.3
$35,000 to $49,999	5	7.14	434,128	16.8
$50,000 to $74,999	12	17.14	608,663	23.5
$75,000 to $99,999	11	15.71	366,946	14.2
$100,000 to $149,999	20	28.57	287,956	11.1
$150,000 to $199,999	9	12.86	70,576	2.7
$200,000 or more	10	14.29	65,873	2.5
Total	70			
Median family income	100,000		53,457	

Table 2. Subjects' family educational attainment compared to Michigan population

	S's Mother		S's Father		Subject		MI
Educational Level	N	%	N	%	N	%	%
Less than 9th grade	–	–	–	–	–	–	4.7
9th to 12th grade, no diploma	–	–	–	–	–	–	11.9
High school graduate	26	32.5	21	26.25	–	–	31.3
Some college, no degree	5	6.25	1	1.25	69	86.25	23.3
Associate degree	8	10	5	6.25	6	7.5	7
Bachelor's degree	29	36.25	30	37.5	5	6.25	13.7
Graduate or professional degree	12	15	23	28.75			8.1

Table 3. Subjects' number of art courses taken

Number of art courses	N	%
None	44	55
1 High school course	26	32.5
1 college or more than 1 high school course	8	10
More than 1 college course	2	2.5
Total	80	100

Table 4. Subjects' self-expected art test performance

Self-expected art test performance	N	%
Poor	66	82.5
Good	12	15
Very Good	2	2.5
Excellent	0	0
Total	80	100

Another potential indicator of subjects' interest in art is the number of art-related items they own (see Table 5). I therefore asked subjects to report the number of original artworks they had at home (e.g., paintings), the number of art reproductions (e.g., poster of paintings), and the number of art reference items (e.g., books, videos). The sample showed that most people did not own any such items, particularly original artwork, and when they owned such materials, they had only a few items.

Table 5. Subjects' report on the number of art items they own

	Original Art		Art Reproduction		Art References	
Amount	N	%	N	%	N	%
0	43	53.75	23	28.75	33	41.25
1-4	22	27.5	23	28.75	27	33.75
5-10	11	13.75	26	32.5	14	17.5
More than 10	4	5	8	10	6	7.5

In sum, the sample represented a population with a social status relatively higher than the mean social status of Michigan as indicated by income levels and family educational attainment. The survey also shows that most people perceived themselves as not very knowledgeable about art history and that they have not invested considerable economic capital or time in acquiring art items or formal education in art.

Materials and Methods

As in Experiment 1, subjects were asked to judge the attractiveness of symmetrical and asymmetrical faces of both sexes decorated with either symmetrical or asymmetrical facial paint. The subjects were divided into two groups: a high-asymmetry group judged faces with high-asymmetry designs, and a low-asymmetry group judged faces with low-asymmetry designs.

Faces

Thirty-two faces (16 male and 16 female) were selected from the *AR Database* and then resized, translated, and rotated to a standard center position. The facial features and skin texture of each face were manipulated using methods similar to those described elsewhere (Perrett et al., 1999; Rhodes et al., 2001b). First, the position of facial features of each original face was recorded by manually placing 304 reference points on each image. For each original face, left and right chimeras were created, and, using a computer script, 304 points were placed on each chimeric face. A morphing software, Winmorph 3.01, used this information to produce 32 synthetic skin textures by averaging (morphing) each pair of chimeric faces. 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 32 faces with asymmetrical features and 32 faces with symmetrical features.

To each of the 64 faces, three designs of facial paint were applied: symmetrical, high asymmetry, and low asymmetry. As in Experiment 1, these designs were created using a reference-mask containing the pixel coordinates of the areas to be painted in each face. To produce designs with high asymmetry, the black horizontal stripe and white circle were again displaced on one side of the design by 3 mm (10 pixels); to produce designs with low asymmetry, the same elements were displaced by 1.5 mm (5 pixels). This method yielded 192 faces: 64 with symmetrical designs, 64 with low-asymmetry designs, and 64 with high-asymmetry designs.

Experimental Conditions

Subjects in the high-asymmetry and low-asymmetry groups were asked to judge faces that had been manipulated according to three experimental conditions as shown in Figure 6.

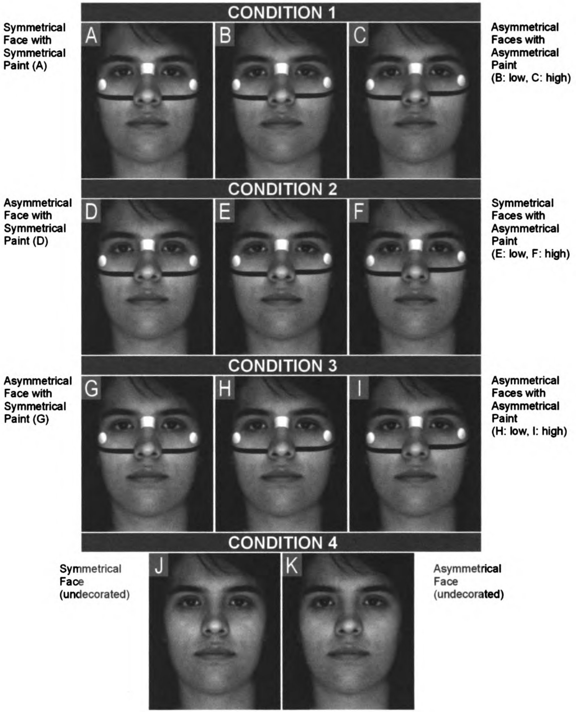

Figure 6. Experiment 2. Design of symmetrical and asymmetrical faces with synthetic skin texture by manipulation of symmetry of face and symmetry of paint.

In *Condition 1*, a symmetrical face decorated with symmetrical paint (face A) was paired with an asymmetrical face decorated with asymmetrical paint (face B in the low-asymmetry group, face C in the high-asymmetry group). In *Condition 2*, an asymmetrical face with symmetrical paint (face D) was paired with a symmetrical face with asymmetrical paint (face E-low or face F-high). Because all pairings in Experiment 1 were of symmetrical and asymmetrical faces, a check was made to see whether symmetrical facial paint enhances the attractiveness of faces with the same degree of symmetry. To do this, a new condition, *Condition 3*, was added, which paired an asymmetrical face with symmetrical paint (face G) with the same asymmetrical face with asymmetrical paint (face H-low or face I-high).

As in Experiment 1, as a control for possible interaction effects of individual faces and experimental conditions, the subjects were divided into two subgroups, so that each face appeared as Condition 1 for one subgroup and as Condition 2 for the other. Condition 3 stimuli were identical for both subgroups. For the low-asymmetry group a control condition, *Condition 4*, was added, consisting of pairs of undecorated symmetrical and asymmetrical faces (faces J and K). Because a different technique was used in Experiment 2 to manipulate the symmetry of facial features, this control condition provided a new base line against which to compare the effect of symmetry of paint on subjects' judgments.

Each of the 4 conditions consisted of 8 trials (4 trials of male faces and 4 trials of female faces), so that each subject in the high-asymmetry group judged a total of 24 face-pairs, and each subject in the low-asymmetry group judged a total of 32 face-pairs. Total preference scores for each condition therefore could range from 0 to 8 (0-4 for same-sex pairs and 0-4 for opposite-sex pairs). Stimulus presentation was left-right counterbalanced for symmetry of face, symmetry of paint, and sex of faces.

Procedure

Subjects were instructed to "choose the face that is physically more attractive in each pair of faces." Before starting, subjects were given 5 practice trials of faces with and without facial paint. Faces were presented on a LDC screen (216 x 285 mm) of a laptop computer. I designed a computer interface for stimulus presentation and data recording. Subjects triggered the image presentation with a mouse-click under the face they considered more attractive and advanced the series of images at their own pace, without time limits. Their answers were automatically recorded in a database. Subjects were tested individually in a quiet room at the university and completed the session in about 15 minutes. Additionally, they filled out a brief questionnaire.

Results

SES and Art Capital

Although the information collected was intended only for descriptive purposes, it is important to notice that socioeconomic status, and art capital were not correlated with subject's preferences ($P>0.05$).

High-Asymmetry Group

The results are summarized in Figure 7. For Conditions 1 and 2 in the high-asymmetry group, a two-way repeated measures ANOVA showed a significant effect for *symmetry of paint* [$F(1,38) = 17.65$, $P < 0.001$], indicating that symmetrical paint enhanced attractiveness while asymmetrical paint decreased attractiveness, to the extent that symmetrical faces were no longer preferred when decorated with asymmetrical paint ([t(39) = -0.36, P = 0.72]). Symmetrical paint also affected the attractiveness of male faces more than female faces [F(1,38) = 10.05, P = 0.003]; and this was true both for men's and women's judgments across conditions [F(1,38) = 0.179, P = 0.675].

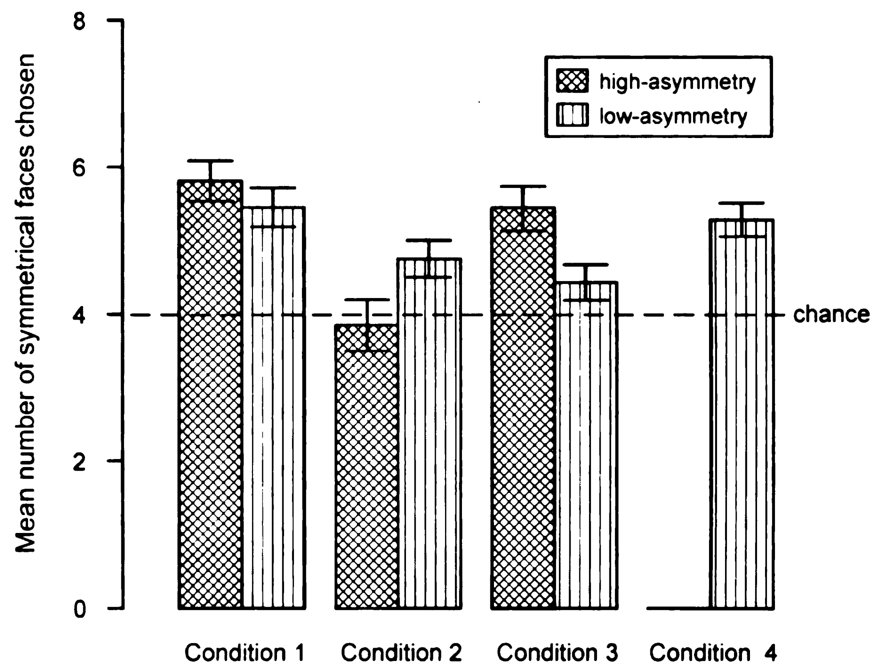

Figure 7. The effect of symmetry of paint on facial attractiveness. Mean number of symmetrical faces chosen as more attractive in each condition (8 trials / condition). Conditions 1, 2, and 3 consisted of faces painted with either high-asymmetry or low-asymmetry designs.

For Condition 3, which paired an asymmetrical face with symmetrical paint with the same asymmetrical face with asymmetrical paint, the results showed that asymmetrical faces with symmetrical paint were considered more attractive [t(39) = 4.913, P < 0.001]. Finally, a repeated measures ANOVA showed that whether the sex of each pair of faces was the same as or different from the sex of the subject did not influence their perceived attractiveness [$F(1,39) = 0.687$, $P = 0.412$].

Low-Asymmetry Group

For the low-asymmetry group, the results for Condition 4 (undecorated faces) showed that symmetrical faces were more attractive than asymmetrical faces (mean preference for symmetrical faces was greater than chance [$t(39) = 5.631$, $P < 0.001$]), and a mixed factorial ANOVA showed that the score was not affected by sex of face [$F(1,38) = 0.693$, $P = 0.41$], sex of subject [$F(1,38) = 2.875$, $P = 0.09$], or by whether sex of faces was the same as or different from sex of subject [$F(1,38) = 0.354$, $P = 0.55$].

For Conditions 1 and 2, a mixed factorial ANOVA showed a significant effect for *symmetry of paint* [$F(1,38) = 3.785$, $P = 0.05$], indicating that symmetrical faces with symmetrical paint were more attractive (mean preference = 5.45) than asymmetrical faces with asymmetrical paint (mean preference = 2.55) and that applying an asymmetrical design to a symmetrical face decreased its attractiveness (mean preference = 4.75) compared to an asymmetrical face with a symmetrical design (mean preference = 3.25). Neither sex of subject [$F(1,38) = 0.286$, $P = 0.59$] nor whether sex of faces was the same as or different from sex of subject [$F(1,38) = 0.27$, $P = 0.87$] influenced the faces' attractiveness, and there were no interactions between sex of face and symmetry of paint [$F(1,38) = 0.695$, $P = 0.41$] or between symmetry of paint, sex of face, and sex of subject [$F(1,38) = 0.315$, $P = 0.57$]. The analysis also showed that the number of female symmetrical faces preferred fluctuated more across Conditions 1 and 2 than the number of male symmetrical faces [$F(1,38) = 7.873$, $P = 0.008$].

For Condition 3, the results showed that asymmetrical faces with symmetrical paint were not considered significantly more attractive than the same faces with asymmetrical paint (mean number of faces with symmetrical paint preferred, 4.43, was not significantly greater than the number expected by chance [$t(39) = 1.752$, $P = 0.088$]). A mixed factorial ANOVA showed that attractiveness judgments were not significantly affected by sex of face [$F(1,38) = 2.567$, $P = 0.11$], sex of subject [$F(1,38) = 0.857$, $P = 0.36$], or by whether sex of face was the same as or different from sex of subject [$F(1,38) = 0.137$, $P = 0.71$].

Across Experiments 1 and 2

A comparison of the judgments of the subjects in the low asymmetry group in Experiment 2 with the Chilean students in Experiment 1 showed no significant difference in judgments of faces without paint [$F(1,76) = 3.084$, $P = 0.08$]. It did, however, show that women chose symmetrical faces more often than men [$F(1,76) = 7.4$, $P = 0.008$]. No other interactions were significant.

Judgments were also similar for both samples when judging faces with paint, such that male attractiveness tended to be affected more than female attractiveness by the symmetry of the paint [$F(1,76) = 5.44$, $P = 0.02$]. This effect also was greater, but not significantly, for the American students in Experiment 2 [$F(1,76) = 4.15$, $P = 0.06$].

When comparing all groups in both experiments, the only significant interaction preserved was between the sex of the face and the symmetry of the paint, indicating again that male faces were affected more than female faces by the symmetry of the paint [$F(1,114) = 13.69$, $P < 0.001$].

Discussion

The results of Experiment 2 confirm again that faces with more symmetrical facial features are judged as more attractive. They also confirm the finding from Experiment 1 that facial attractiveness is enhanced by symmetrical facial painting and reduced by asymmetrical facial painting. All other things being equal, they also suggest that the smoother skin texture of the faces in Experiment 1 had a minor (but not statistically significant) effect on facial attractiveness, given that the mean number of choices of symmetrical faces without paint was only slightly higher in Experiment 1 than in Experiment 2.

The results also show that the influence of symmetry of paint on attractiveness is modulated by the degree of asymmetry of the designs. This was seen in Condition 3, where attractiveness was significantly affected in the high asymmetry condition but not in the low asymmetry conditions (although faces with symmetrical paint were chosen more often than faces with asymmetrical paint).

Finally, the experiments showed that the magnitude of the effect of decoration on attractiveness depends in the sex of the face, indicating that male faces were affected more by symmetrical decoration. These findings, however, differed from those in Experiment 1 and therefore must be regarded with caution.

EXPERIMENT 3: SYMMETRY PREFERENCES WITH NON-REPRESENTATIONAL DESIGNS

In the Introduction I noted the widespread use of symmetrical designs in the decorative arts as one piece of evidence that the preference for symmetry has an evolutionary basis. Studies also find a positive relation between the perceptual salience of symmetrical designs and the aesthetic preference for these designs (Eisenman & Gellens, 1968; Jacobsen & Höfel, 2001; Rentschler et al., 1997; Washburn & Humphrey, 2001) and between bilateral symmetry about a vertical axis (i.e., left-right symmetry), the kind most salient to the human visual system (Wenderoth, 1994; Evans et al., 2000), and preference for bilaterally symmetrical stimuli. The preference, furthermore, does not seem to change after training (Rentschler et al., 1999; Washburn & Humphrey, 2001), which suggests an *a priori* and stable preference for symmetry. That symmetry is perceptually salient, however, does not necessarily mean that it will always enhance attractiveness. For instance, under some circumstances, asymmetry might be preferred because, being visually less redundant than symmetry, it looks more "complex" (Berlyne, 1971; Krupinski & Locher, 1988).

If the design of the visual system is sufficient to account for the preference for symmetry, one would not expect symmetry to be preferred when the stimuli are not salient to 'bottom-up' mechanisms of symmetry detection. In Experiment 3, I tested this prediction by examining adults' preferences for abstract designs varying in three kinds of symmetry: shape, color, and axis of symmetry. If bottom-up mechanisms can fully account for the preference, I can predict the following: a) because symmetrical stimuli are detected fast and accurately, stimuli with symmetrical shape should be preferred to stimuli with asymmetrical shape; b) because color is not tuned to symmetry detection (Morales & Pashler, 1999), preferences for symmetrically colored stimuli should be random; and c) because left-right, or vertical, symmetry is most salient to the visual system, stimuli with a vertical axis of symmetry should be preferred to stimuli of any other orientation.

Subjects

The subjects were undergraduate students from Michigan State University: 20 men (18-24 years old) and 20 women (18-22 years old). These individuals comprised the low-asymmetry group in Experiment 2, and the tests with abstract designs were administered in the second part of that experiment. All procedures were approved by the Michigan State University Committee on Research on Human Subjects.

Materials and Methods

Designs

The designs were digital images of geometric designs from several non-western cultures (e.g., Aonikenk, Navajo, Yoruba). Using vector-based illustration software, Corel Draw 9, I produced a symmetrical and an asymmetrical version of the same design (totalling 800 X 570 pixels). Their positions in the display were counterbalanced across the experiment.

Experimental Conditions

Three experimental conditions were defined as shown in Figure 8:

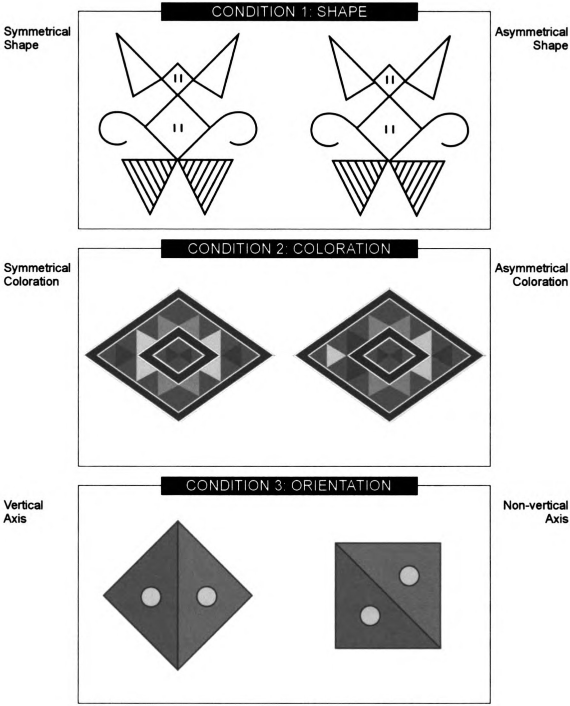

Figure 8. Experiment 3. Abstract designs whose symmetry was manipulated according to three experimental conditions: Shape, Coloration, and Orientation.

Condition 1: *Shape*. Designs with symmetrical shape compared to designs with asymmetrical shape.

Condition 2: *Coloration*. Designs with symmetrical color compared to designs with asymmetrical color.

Condition 3: *Orientation of symmetrical design features*. Designs with vertical axis of symmetry compared to designs with non-vertical axis of symmetry (45^{o} and 135^{o}).

Each condition consisted of 10 trials, so that each subject judged a total of 30 pairs of designs. For each condition, subjects received a score from 1 to 10 to indicate the number of symmetrical designs chosen as more attractive.

Procedure

Subjects were instructed to "choose the design that is more attractive in each pair of designs." Before starting, practice trials were given with 3 pairs of designs (these trials did not include any designs from the experimental set). Again, no time limits were set; all subjects triggered the image presentation by a key press and were tested individually in a quiet room at the university.

Results

Men's and women's preferences did not significantly differ from each other across the three conditions ([$F(1,38) = 0.58$, $P = 0.81$] or for interaction between sex of subject and experimental condition [$F(1,38) = 0.544$, $P = 0.46$]). The men's and women's scores, therefore, were combined for further statistical analyses. The results are summarized in Figure 9.

In Condition 1, designs with symmetrical shape were judged to be more attractive than designs with asymmetrical shape (the mean number of designs with symmetrical shape preferred, 6.93, was greater than expected by chance [$t(39) = 6.976$, $P < 0.001$]).

In Condition 2, symmetrically-colored designs were judged to be more attractive than asymmetrically-colored designs (the mean number of symmetrically-colored designs preferred, 7.6, was greater than expected by chance [$t(39) = 8.34$, $P < 0.001$]).

In Condition 3, designs with a vertical axis of symmetry were chosen as more attractive than designs with a non-vertical axis of symmetry (the mean number of designs with vertical axis of symmetry preferred, 7.1, was greater than expected by chance [$t(39) = 6.121$, $P < 0.001$]).

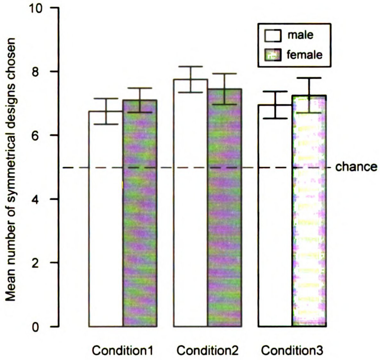

Figure 9. Mean number of designs chosen in each condition by male and female subjects.

Discussion

The results of Condition 1 confirm prior findings that stimuli with symmetrical shape are seen as more attractive (Eisenman & Gellens, 1968; Jacobsen & Höfel, 2001; Rentschler et al., 1997; Washburn & Humphrey, 2001). They also are compatible with the profuse use of symmetrical design in the decorative arts across cultures (Washburn & Crowe, 1989). The results of Condition 3 show that designs with a vertical axis of symmetry were preferred over designs with a non-vertical axis of symmetry, which suggests that the preference for symmetry is compatible with the design of the visual system. Finally, the results of Condition 2 show that even though color, unlike monochromatic stimuli, is not tuned to symmetry detection, color symmetry does significantly enhance attractiveness. In combination, the results suggest that mechanisms of symmetry detection affect visual preferences but do not totally constrain the preference for symmetry and that other mechanisms also contribute. There is independent support for this view in lateralization studies using ERP (Evoked-Related Potential). Jacobsen and Höfel (2001) found that although the separate acts of perceiving symmetry and judging the attractiveness of symmetry were strongly correlated, aesthetic judgments were associated with a more pronounced right-hemispheric lateralization of neural activity than was the perception of symmetry *per se*.

CONCLUSIONS AND GENERAL DISCUSSION

All together, the results show that symmetry enhances the attractiveness not only of faces *per se* and of faces decorated with symmetrical paint but also of artistic-cultural products like those seen in the decorative arts. They also show that the effect of symmetrical face-paint is weaker for female faces and that symmetry enhances attractiveness even in stimuli that do not fit the apparent design of visual mechanisms of symmetry detection.

If the results support the hypothesis that the preference for symmetry has roots in our evolutionary history, the next question is: Is the preference adaptive, that is, a direct product of selective forces, or is it a by-product of other adaptations? At least three hypotheses address this question: the 'receiver bias' hypothesis, according to which the preference is a by-product, and the 'good genes' and 'extended phenotype' hypotheses, according to which it is a direct product of selective forces. Although my experiments were not specifically designed to test these hypotheses, I shall note to what extent the results, along with other findings, fit the predictions that can be derived from each one.

Receiver Bias

According to the 'receiver bias' hypothesis (Enquist & Arak, 1994; Johnstone, 1994; Enquist & Johnstone, 1997), preference for symmetry is a by-product of the common properties of biological systems of recognition, so that symmetry becomes perceptually salient when the mean of a population of stimuli with random fluctuating asymmetries corresponds to a symmetrical stimulus. Preference for symmetry therefore emerges from a generalization process (Enquist & Johnstone, 1997; Jansson et al., 2002), which helps recognition systems identify objects in different positions and orientations.

As such, symmetry does not signal 'fine-grained details' such as the quality of a potential mate (Enquist et al., 2002).

There is broad support for the receiver bias hypothesis. Simulations using artificial neural networks show that a preference for symmetry emerges when the network has been exposed to asymmetry (Johnstone, 1994, Enquist & Arak, 1994); domestic fowl choose novel symmetrical stimuli after repeated exposure to asymmetrical stimuli (Jansson et al., 2002); and humans find 'average faces' and 'average non-face' stimuli attractive. In this last group of experiments, the face and non-face stimuli were composites with symmetrical features produced by blending many exemplars superimposed on each other (Halberstadt & Rhodes, 2000; 2003; Langlois & Roggman, 1990; Langlois et al., 1994; Rhodes et al., 1999).

Even though the attractiveness scores for symmetry and averageness are correlated, averageness and symmetry contribute independently to facial attractiveness (Rhodes et al., 1999), and attractive average stimuli do not have to be symmetrical (see Halberstadt & Rhodes, 2003). Nor is the relationship between averageness, familiarity, and attractiveness constant across stimuli. A study by Halberstadt and Rhodes (2003) suggests that averageness has a stronger effect on attractiveness when people judge biological as opposed to non-biological stimuli (it remains significant after partialling out the effect of familiarity only when people judge biological stimuli). Finally, Little and Jones (2003) have shown that preferences for symmetrical faces are stronger for upright than for inverted faces, indicating that preference for symmetrical faces is not constant across orientations.

The results of Experiments 1 and 2 show that, even though symmetrical decoration in faces enhances facial attractiveness, the effect depends on the sex of the face (stronger for same-sex faces in Experiment 1 and stronger for male faces across experiments). The receiver-bias hypothesis would not predict this diminishing of the effect for men or women, but it does predict the findings in Experiment 3, where subjects showed a preference for symmetrical over asymmetrical geometric designs, a preference that may be irrelevant for mate-choice (but see the "extended phenotype" hypothesis below). However, the premise of the hypothesis that a preference for symmetry emerges as a result of generalization implies that the preference depends strongly on visual experience. The subjects in Experiment 3 preferred symmetry in designs that were presumably unfamiliar, but because their familiarity was not assessed beforehand, we cannot be sure.

Good Genes

According to the "good genes" hypothesis, the symmetry of morphological traits reliably signals an animal's fitness. Because environmental stressors such as parasites and mutations can produce morphological asymmetries, the symmetry of a given phenotype can indicate an individual's capacity to cope with such environmental stressors (its developmental instability). Thus, individuals who use this information in mate selection would increase their offsprings' chances of survival. By this hypothesis, symmetrical faces are preferred because they signal stable development and, therefore, high mate quality.

Support for the 'good genes' hypothesis comes from studies on several species showing that individuals with symmetrical features have greater reproductive success

(Møller & Thornhill, 1998), that symmetrical faces are attractive (Grammer & Thornhill, 1994; Rhodes et al., 1998, 2001a,b; Mealy et al., 1999; Perrett et al., 1999; Hume & Montgomerie, 2001; Jones et al., 2001; Little et al., 2001; Penton-Voak et al., 2001; Koehler et al., 2002), that facial symmetry is positively correlated with perceived health (Jones et al., 2001), and that symmetry's influence on attractiveness varies according to the sex of the subjects and the sex of the faces (Jones et al., 2001; Little et al., 2001; Penton-Voak et al., 2001).

Not all findings, however, support the hypothesis (e.g., Koehler et al., 2002), and it appears that the relationship between morphological asymmetries, genes, and environmental stressors is taxon- and trait- specific (Swaddle, 2003).

This hypothesis, however, does not address the question of why symmetry is also preferred in decorative art. One possibility is that the adaptive value of detecting symmetry in potential mates generalizes to other objects (Little & Jones, 2003). If facial symmetry signals developmental stability and if symmetrical facial decoration does not signal fitness (or is a less reliable indicator of fitness), the 'good genes' hypothesis also might account for the greater importance of facial morphology in judgments of female faces, namely, that female faces are less affected by decoration because, in general, their *physical* features are more important for assessing their quality as mates (or as competitors for mates). Clearly, further studies are needed to address the reliability and nature of the proposed interaction between a generalized preference for symmetry in mate-irrelevant stimuli and a specific preference for morphological symmetry in mate-relevant faces.

Extended Phenotype

According to the extended phenotype hypothesis, symmetrical art, instead of being mate-irrelevant, signals the fitness of the artist on the premise that perfectly symmetrical designs are hard to produce (Miller, 2000; Miller, 2001; Zahavi, 1978; Zahavi & Zahavi, 1997). Because I did not ask the subjects in any of the three experiments, "Who is the best artist?", I could not directly test this hypothesis. But if it is correct, then, for example, in the case of Experiments 1 and 2, the artist's skill in applying the facial paint cannot have been the only basis for the perception of facial attractiveness. First, whether decorated or not, faces with symmetrical features were perceived as more attractive than asymmetrical faces. Second, the effect of symmetrical paint, rather than being constant across faces, depended on the sex of the face and the sex of the subject.

As mentioned, symmetrical decoration does not completely outweigh the influence of symmetrical facial features. Given that, on average, asymmetrical faces tend to benefit the most from symmetrical decoration, symmetrical decoration seems to act as a 'handicap' for symmetrical faces (Zahavi, 1978; Zahavi & Zahavi, 1997) because only symmetrical faces can afford to have their competitors enhance their attractiveness with symmetrical paint and still be considered more attractive overall. If symmetrical facial features indicate biological fitness, the results suggest that they can reliably communicate the fitness of the signaler.

Future Studies

The finding that symmetrical decoration enhances physical attractiveness opens a number of questions for future studies:

Decoration and Location Effects. Further research needs to be conducted to determine whether or not the effect of symmetry is dependent on the specific kind of decoration used in this study, in other words, whether the effect can be replicated with other kinds of designs. In this regard, new studies should address the question of whether the location of the designs has different effects on attractiveness; for instance, is decoration in the region of the eyes more important that decoration in other regions of the face? Relatedly, are the effects of facial decoration also found in body decoration?

Individual Differences. From the standpoint of evolutionary theory, variation is integral to evolutionary change so that it would be expected that the degree of symmetry would vary in any population of faces. To the extent that symmetry contributes to facial attractiveness, some faces will be intrinsically more attractive than others. In the same way, some individuals might be affected more by facial symmetry than others. In the current study, for instance, 10% of the subjects who were asked to judge faces without paint (n=80) did not show a preference for symmetrical faces. Similarly, about 28% of the total number of subjects (n=120) did not follow the tendency showed by the rest of the subjects when judging decorated faces; that is, they chose symmetrical faces more often when decorated with asymmetrical paint that when decorated with symmetrical paint. Besides the possibility of measurement error (e.g., individuals who for one reason or another were not fully involved in the task, so that their answers are not entirely trustworthy), such variability indicates the need for studying individual differences systematically. It is possible, for instance, that the preference for symmetry partly depends on self-perceived attractiveness (e.g., less attractive people might place less emphasis on facial attractiveness for mate selection).

Sexual Orientation. The more general question of individual orientation raises the more specific question about sexual orientation. For this study, I asked subjects about their self-perceived sexual orientation so as to provide a basis for categorizing the face stimuli as either mate-relevant or mate-irrelevant. All but two subjects, one man and one woman, identified themselves as heterosexual. This number precluded any systematic assessment of the role of sexual orientation on symmetry preference, but this might be a promising area for further research on the premise that if symmetry is a factor, sexual orientation would be relevant for the categorization task. For example, if for a male homosexual, only the male face would be mate-relevant, then symmetry in a male face might be expected to be more salient than symmetry in a female face with respect to judgments of attractiveness.

Further exploration of the role of symmetry in mate choice is also necessary. An interesting question, for instance, is whether the preference changes over the menstrual cycle given that mate selection strategies would be expected to differ according the female's fertility status. Finally, future research must address the limits of the effectiveness of symmetry on attractiveness, that is, is symmetry always more attractive? if so, why are "beauty marks" often asymmetrical?

In sum, the results show that adults prefer symmetrical faces and abstract designs and that symmetrical decoration enhances facial attractiveness, that is, that the preference for symmetry extends to the cultural products of facial paint and the decorative arts. This does not mean that all types of face painting or decorative art will tend to be symmetrical; certain types, such as those used for mourning or warfare, probably do not have the enhancement of physical attractiveness as their goal. The results do suggest, however, that when that *is* the goal, the designs will tend to be symmetrical. They also suggest that even though symmetrical art is very common, the preference for symmetrical facial features is more likely to be constant than the preference for symmetrical art.

If the biological fitness hypothesis is correct, the results provide indirect evidence for the influence of evolutionary biases towards symmetry and for the effect of such biases on cultural practices. Further indirect support for the hypothesis will require showing that, like the perception of attractiveness of other physical traits (Yu & Shepard, 1998; Marlowe & Wetsman, 2001), the results are replicable across cultures. The comparability of results for Experiment 1 with Chilean subjects and Experiment 2 with American subjects is a small step in this direction.

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