Lateralization of kin recognition signals in the human face

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When human subjects view photographs of faces, their judgments of identity, gender, emotion, age, and attractiveness depend more on one side of the face than the other. We report an experiment testing whether allocentric kin recognition (the ability to judge the degree of kinship between individuals other than the observer) is also lateralized. One hundred and twenty-four observers judged whether or not pairs of children were biological siblings by looking at photographs of their faces. In three separate conditions, (1) the right hemi-face was masked, (2) the left hemi-face was masked, or (3) the face was fully visible. The $d'$ measures for the masked left hemi-face and masked right hemi-face were 1.024 and 1.004, respectively (no significant difference), and the $d'$ measure for the unmasked face was 1.079, not significantly greater than that for either of the masked conditions. We conclude, first, that there is no superiority of one or the other side of the observed face in kin recognition, second, that the information present in the left and right hemi-faces relevant to recognizing kin is completely redundant, and last that symmetry cues are not used for kin recognition.

Keywords: kin recognition, face perception, signal detection theory, cue combination


Introduction

An ability to recognize kin allows individuals in a species to favor close relatives (inclusive fitness theory, Hamilton, 1964a, 1964b) and avoid inbreeding (Pfenning, 2002). Kin recognition has been documented in many animal species from bacteria to humans (for reviews, see Chapais & Berman, 2004; Fletcher & Michener, 1987; Hepper, 1991).

DeBruine (2002) found that participants in an economic game tended to cooperate more with players whose faces were more similar to their own face. DeBruine (2004) and Platek et al. (2003) showed that observers were more willing to invest in children whose faces were more similar to the observer’s face. These studies both employed faces morphed to make them more or less similar to the participant’s face.

Some primates, including humans, can detect relatedness between individuals other than the observer (we refer to this ability as allocentric kin recognition). Vervet monkeys (Cheney & Seyfarth, 1989) become aggressive toward the relatives of monkeys that had been previously seen to dispute with one of the observer’s relatives. Chimpanzees, observing pairs of photographs portraying faces of unfamiliar and unrelated chimpanzees, can discriminate pairs of parent–offspring from pairs of unrelated chimpanzees (Parr & de Waal, 1999).

The same ability has been found in humans (Brédart & French, 1999; Bressan & Dal Martello, 2002; Nesse, Silverman, & Bortz, 1990). In these studies, adult observers were able to discriminate parent–offspring pairs from genetically unrelated adult–child pairs. Maloney and Dal Martello (2006) and DeBruine et al. (2009) found that human adult observers, in a signal detection task, could discriminate between pairs of humans who were biological siblings and pairs who were not (allocentric kin recognition), just by observing and comparing pairs of photographs of faces. This ability is even present across species: Vokey, Rendall, Tangen, Parr, and de Waal (2004) showed that human observers can detect kinship in pairs of mother–offspring chimpanzees.

Thus, the human face contains important kin signals and perceived kinship affects human behavior. Dal Martello and Maloney (2006) measured the amount of kinship information (quantified as a signal detection $d'$ measure) in different regions of the face and tested whether information present in different regions of the face (e.g., the upper half of the face and the lower) is redundant. We will describe this work in more detail in the Discussion section.

In this study, we ask if there is a difference in how kinship information is distributed laterally across the two sides of the face, to the left and to the right of the vertical line dividing the face in two parts. Following Simmons, Rhodes, Peters, and Koehler (2004), we will use the terms...
“left hemi-face” and “right hemi-face” to refer to the left and right sides of an individual’s face from the viewpoint of the individual. This usage is common in the medical literature and we will also refer to “left side of the face” as a synonym for “left hemi-face” and “right side of the face” as a synonym for “right hemi-face.”

We seek to determine whether one side of the face is dominant in a kin recognition task. We will measure human performance in an allocentric kinship task when viewing the full face and also when either the left or right hemi-face is masked. When the left or right side of the face is masked, any cues to kinship based on judgments of asymmetry are effectively eliminated. We therefore can test whether such cues are used by the observer. Would an observer who can only see the left side of children’s faces have a lower sensitivity to kinship than an observer who can see the full face?

We review past work concerning anatomic asymmetries, asymmetries in perception of facial attributes, and what is known about the genetic basis of human facial asymmetry. While there is a considerable literature concerning facial asymmetry, there are no previous studies concerning judgments of kinship and facial asymmetry.

Anatomical asymmetry

The two sides of the human face are typically asymmetric (for example, Ferrario, Sforza, Poggio, & Tartaglia, 1994). The asymmetry can be quite pronounced and have clinical significance, but some degree of asymmetry is normally present in every face and even in the very attractive faces of models, actors, and beauty contest winners (Peck, Peck, & Kattaja, 1991). The face of the famous sculpture known as the Venus of Milo, a classical example of balance and beauty, has marked asymmetries (Fanghänel, Gedrange, & Proff, 2006; Hasse, 1882, 1887), illustrated in Figure 1.1

While there is agreement that the typical human face is asymmetric, there is no agreement about the nature of the asymmetries. The right side of the face in many studies is found to be larger than the left (for example, Ferrario, Sforza, Miani, & Serrao, 1995; Simmons, Rhodes et al., 2004; Song et al., 2007) and this asymmetry is found to be more pronounced in the middle and lower third of the face (Ferrario, Sforza, Miani, & Tartaglia, 1993; Ferrario, Sforza, Pizzini, Vogel, & Miani, 1993; Ferrario et al., 1994; Liukkonen, Sillanmäki, & Petolmäki, 2005). In other studies (for example, Ercan et al., 2008; Vig & Hewitt, 1975), the left hemi-face is found to be larger.

Facial mimicry is slightly lateralized as well. Both healthy young adult women and men express emotion in a lateralized way, with movements larger on the right than the left (Sforza, Galante, Shirai, & Ferrario, in press) for unilateral movements (for example, closing one eye) and larger on the left for bilateral movements as, for example, in raising the forehead (Coulson, Croxson, & Gilleard, 2002) and in spontaneous smiles (Wylie & Goodale, 1988). The faces of children (Ferrario et al., 1994; Melnik, 1992) and old people (Kobyliansky & Livshits, 1989) are no less asymmetrical as those of adults.

Perceptual asymmetry

There are also asymmetries in how the face is perceived. The right side of the female face is typically judged to be significantly more attractive than the left side, though there is no corresponding difference for male faces (Zaidel, Chen, & German, 1995). The right side of the female face is rated as more attractive even in fine arts portraits (Zaidel & Fitzgerald, 1994). The left hemi-face is judged to express emotions more intensely (e.g., Borod, Koff, & White, 1983; Sackeim & Gur, 1978), though the specific emotions are more recognizable in the right side of the face (Indersmitten & Gur, 2003).
Studies on lateralization with patients (e.g., De Renzi, Perani, Carlesimo, Silveri, & Fazio, 1994; Levine, Banich, & Koch-Weser, 1988) and normal right-handed adults in functional imagining studies (Kanwisher, McDermott, & Chun, 1997) and in experiments with chimeric stimuli all converge on the conjecture of Gilbert and Bakan (1973) that there is not a privileged side of the face in itself for face recognition, but that there is a dominance of the side of face presented in the left visual hemi-field (LVH) of the viewer.

In particular, using chimeric stimuli, it has been found that the recognition of identity (Rhodes, 1985), gender (e.g., Butler et al., 2005; Luh, Rueckert, & Levy, 1991), emotions (e.g., Coolican, Eskes, McMullen, & Lecky, 2008; Levy, Heller, Banich, & Burton, 1983), and age (Burt & Perrett, 1997) are better for the hemi-face presented on the LVH and that lip-reading is better for the hemi-face presented on the RVH (right visual hemi-field; Burt & Perrett, 1997; Campbell, De Gelder, & De Haan, 1996; Jordan & Thomas, 2007).

Intriguingly, Brady, Campbell, and Flaherty (2004, 2005) found that the right hemi-face is dominant for self-recognition even if, since one sees oneself usually in a mirror, the right side of one’s own face tends to fall in the right visual hemi-field. This finding, though, seems to contradict the results of other studies (Keenan, Freund, Haan, 1996; Jordan & Thomas, 2007) to develop a map summarizing the distribution of kinship information across the child’s face and its statistical structure.

Facial asymmetries and genetics

Some but not all facial asymmetries are the result of genetic factors (including inherited tendencies to failures in normal development of the face). Others are due to environmental factors including disease, toxins, and injury (Bishara, Burkey, & Kharouf, 1994; Livshits & Kobylansky, 1989; Scheib, Gangestad, & Thornhill, 1999). It is plausible that some types of facial asymmetry are more genetically loaded than others. The precise relative contribution of genetic and non-genetic factors to different facial symmetries is not known (Livshits & Kobylansky, 1989). Moreover, while genetic factors may influence the degree of asymmetry in the face, it is unclear that they influence the direction of asymmetry.

Facial asymmetries that have no genetic bases carry no useful information about genetic relatedness. Moreover, facial asymmetries common to a population are of no value in discriminating degrees of kinship (see Rhodes, Louw, & Evangelista, 2009). Consequently, while the human face is typically asymmetric and this asymmetry has some genetic basis, we cannot predict in advance how much weight observers will or should give to facial asymmetries in judging kinship or which asymmetries will be given greatest weight.

**Experiment**

**Material and methods**

**Participants**

One hundred and twenty-four people, recruited in public places at the University of Padova (Italy), were alternately assigned to one of three conditions: right hemi-face masked (RHM), left hemi-face masked (LHM), or full face (FF), described below. There were 22 males and 19 females in the FF condition, 23 males and 19 females in the RHM condition, and 20 males and 21 females in LHM condition. Their ages ranged from 19 to 36 years (median age 22.5 years).

**Photographic material**

We used 72 color photographs, each depicting a child from the neck to the top of the head. These pictures were taken by the experimenters under controlled lighting conditions. Of the 72 children depicted in the pictures, half were girls and half were boys. We used Adobe Photoshop to obliterate all background detail, replacing it by a uniform dark gray field (33% of maximum intensity in each of the R, G, and B channels). The faces were approximately centered in the photograph with the children looking straight in front of them. The facial expressions were close to neutral. The children ranged in age from 17 months to 15 years. All of the children came from three adjacent provinces of Northern Italy: Padova, Mantova, and Vicenza. All were Caucasian in appearance. The parents of each child gave appropriate permission for their child’s photograph to be used in scientific experiments. We asked for and received separate parental permission to use the photographs in Figures 2 and 3 as illustrations here.

**Conditions**

There were three conditions in the experiment. In the FF condition, the pictures were presented without any alteration so that all the face was visible (Figure 2, FF). In the other two conditions, we altered the pictures by covering part of them. In the RHM condition (Figure 2, RHM), we added a trapezoidal blue figure to each photograph that
covered the right part of the face (from the child’s point of view) leaving visible the left side of the face. In the LHM condition (Figure 2, LHM), we covered the left part of the face leaving visible the right side of the face. The straight line dividing the picture in two parts ran longitudinally through the middle of the face, passing through the middle point of the nose bridge and tip, upper lip, and chin.

Picture pairs

Sixty out of 72 of the photographs were used in the main part of the experiment. The remaining 12 were used only in the familiarization and training parts of the experiment. These phases will be described below. The 60 photographs used in the main part of the experiment included 15 pairs of biological siblings and 15 pairs of children who were not. We refer to the pairs in the first group as related and in the second as unrelated.

Within each group of 15, five pairs depicted two boys, five pairs depicted two girls, and five pairs depicted a boy and a girl. The 12 photographs used in the familiarization and training stages included three pairs of biological siblings and three pairs of unrelated children. For the Full Face condition, all of the 72 photographs (comprising the 12 for the familiarization and training phases) were not masked, for the other two conditions they were all altered as described above. The distributions of age differences for related and unrelated pairs were matched.

For privacy reasons, we did not verify whether the sibling pairs shared two parents by DNA fingerprinting. Recent research using DNA fingerprinting shows that the median rate of “extra-pair paternity” is <2% (see Simmons, Firman, Rhodes, & Peters, 2004 for a review). Consequently, it is likely that a large proportion of our siblings share two parents. In any case, the presence of half-siblings would have little effect on the outcome of our experiment. Such half-siblings would have 25% of their DNA in common, rather than 50%, but they would still be more closely related than non-half pairs, and their presence in the sample across all conditions should not affect the comparisons across conditions that are central to our analyses.

Procedure

The experiment was conducted in a computer classroom at the University of Padova. Observers viewed all stimuli on a computer monitor and responded by marking forms provided. The experiment consisted of three phases.

1. Familiarization. The observer was first asked to perform a recognition memory task that involved all of the experimental stimuli for their condition. The purpose of this part of the experiment was to familiarize the observers with the range of faces they would see in the main part of the experiment. All 72 photographs of faces were shown in groups of six per display in random order. The observers were asked to study the display and were told that, immediately after studying each group, they would be shown a probe photograph and would be asked to report whether this photograph had been among the group of six just studied. The probe photographs were the non-experimental photographs described above, which were not used in the main part of the experiment.

2. Training. The observers practiced the response for their condition (FF, RHM, or LHM) on six pairs of photographs that did not overlap with the photographs used in the main part of the experiment. These pairs were drawn from the non-experimental photographs organized so that there were three pairs that were biological siblings and three that were not. The purpose of this part of the experiment was simply to let the observers become comfortable with the procedure and response required. In this phase, the observers were told that half of the pairs portrayed genetic siblings and were asked to classify each pair as related or not related.

3. Main. The observers then were told that half of the pairs of the set of photographs in the main phase were genetic siblings and half were not. Their task, as in the training phase, was to classify each pair as “related” or “not related.” We presented the 30 pairs of photographs to the subject in random order. We used two separate
randomizations and observers were assigned to one or the other at random.

Results

Signal detection estimates of sensitivity $d'$ and likelihood criterion $\beta$ were used to measure performance in the different conditions (Green & Swets, 1966/1974). These values are reported in Table 1. We will first discuss the $d'$ values. In carrying out the hypothesis tests below, it would be appropriate to correct for multiple tests by a Bonferroni correction. However, for all of the tests in this experiment, a Bonferroni correction would not change any conclusions as the reader can verify. Consequently, we simply present the $p$-values for each test.

A $d'$ value of 0 corresponds to chance performance, and a $d'$ value of 3.5 corresponds to an effectively perfect performance. The $d'$ value (1.079) in the FF condition was significantly different from 0 ($z = 14.115, p < 0.0001$, one-tailed). The one-tailed test is justified as it is plausible to assume $d' \geq 0$. The participants, when able to observe the entire face, could classify the pairs as siblings or not siblings markedly above chance level. The $d'$ values are similar to those that we have found in earlier related work (Dal Martello & Maloney, 2006; Maloney & Dal Martello, 2006). The $d'$ value (1.024) in the LHM condition was also significantly different from 0 ($z = 13.551, p < 0.0001$; one-tailed). When the left side of the face was masked, observers could detect kin markedly above the chance level. There was a slight kin recognition decrement in the LHM condition compared to the FF condition, but this difference was not significant.

The $d'$ value (1.004) in the RHM condition was significantly different from 0 ($z = 13.517, p < 0.0001$; one-tailed). Participants could also correctly classify kin from non-kin at a level markedly above chance when the right side of the face was hidden. The $d'$ value for the RHM condition was slightly smaller than in the other conditions but did not differ significantly from either the LHM or FF condition nor did the LHM and FF conditions differ significantly from each other ($z$-tests; $p > 0.05$; two-tailed). Observers detected kinship between children equally well in all three conditions; they were not hindered by the masks. Their performance was not affected by the side of the masks.

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<td>0.888</td>
<td>0.038</td>
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<tr>
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<td>0.076</td>
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<tr>
<td>RHM</td>
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<td>0.074</td>
<td>1.102</td>
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Table 1. Results for Experiment 1, by condition. The $d'$ estimate and the likelihood criterion $\beta$ for the signal detection analysis are shown. Standard deviations were estimated by a bootstrap procedure (Efron & Tibshirani, 1993) based on 10,000 replications.

The $\beta$ values reported in Table 1 measure the bias of the response toward classifying the children as kin or not kin. The $\beta$ value in the RHM was significantly different from both the value in the FF ($z = 3.733, p < 0.001$, two-tailed) and in the LHM conditions ($z = 3.695, p < 0.001$, two-tailed). We tested the $\beta$ values against 1. The $\beta$ value in the RHM is significantly higher than 1 ($z = 2.380, p < 0.05$, two-tailed). The $\beta$ values in both the FF ($z = 2.943, p < 0.01$, two-tailed) and LHM conditions ($z = 2.916, p < 0.01$, two-tailed) are significantly lower than 1.

A $\beta$ value higher than 1 shows a bias toward classifying children as unrelated and a $\beta$ value less than 1 shows a bias toward classifying children as related. The actual prior odds that the pairs are related are 1:1 (half of the pairs portray siblings), and the observers were given this information. Observers adopted a stricter criterion when the right side of the face was not visible than when either the entire face or the left side of the face was visible. That is, while their ability at judging kinship was identical when only the left or right side of the face was visible, their willingness to judge children to be related when the right side of the face was not visible was markedly decreased.

Discussion

Faces can be asymmetrical in size (e.g., Song et al., 2007) and shape (e.g., Ferrario, Sforza, Miani et al., 1993; Ferrario, Sforza, Pizzini et al., 1993; Ferrario et al., 1994; Liukkonen et al., 2005). Facial asymmetries are no less pronounced in children than adults (Melnik, 1992). The two halves of the face are also perceived asymmetrically by the observers: identity, gender, age, beauty, emotions, and lip-reading signals seem to be lateralized.

We investigated the possibility that one side or the other of children’s faces is dominant in a kin recognition task. Participants were shown thirty pairs of photographs of children’s faces in random order. Half of the pairs portrayed siblings and half did not. A total of 124 participants were asked to judge whether each pair of photos portrayed siblings in a yes–no signal detection task. Pairs of photographs were either presented with both faces fully visible (the unmasked condition) or with opaque masks covering corresponding parts of both faces. There were three conditions, one unmasked and two masked. In the first masked condition, masks covered the left hemi-faces of both children in each pair. In the second, masks covered the left hemi-faces. Observers participated in only one of the conditions. We analyzed the data using standard signal detection methods (Green & Swets, 1966/1974).

We found that performance did not deteriorate significantly when either the right side or the left side of the face was masked. This result is consistent with the claim that information concerning kinship in the left and right sides of the face is completely redundant. It also demonstrates
that configural cues that would be disrupted by masking either the left or right hemi-face do not contribute to kin recognition. These would include detection of differences in corresponding facial features on the left and right sides of the face, i.e., the detection of asymmetries.

An informational map of the child’s face

In previous work, Maloney and Dal Martello (2006) measured performance in signal detection tasks where human subjects judged kinship based on viewing pairs of children’s facial photos. Half of the pairs portrayed biological siblings. Maloney and Dal Martello found that adult’s sensitivity in this kin recognition task was about $d' \approx 1.1$.

Dal Martello and Maloney (2006) repeated these measurements and analyses with either the upper or lower half of the children’s faces masked by a homogeneous mask. They found that the upper face contains markedly more kinship information, consistent with the observation that, although upper and lower half-faces have the same genetic loading (Kohn, 1991), the lower face, developing considerably later in childhood (Enlow & Hans, 1996), is more variable during development, and therefore less informative about kinship.

Dal Martello and Maloney (2006) also found that kinship information extracted from the lower and upper halves of the face were statistically independent. They quantified the information available from the upper half of the face and the lower half of the face and tested whether the sum of information from the two halves of the face could be used to predict performance in the unmasked full face condition. Additivity could have failed for one of two reasons. Either the information available from the two halves of the face is not statistically independent or there are cues to kin recognition that are disrupted by the presence of a mask covering either the upper half of the face or the lower half-face, for example, configural cues that extend across a large part of the face. Both of these possibilities would lead to sub-additivity. The sum of information from the two halves of the face would predict worse performance with the unmasked face than actually observed.

However, Dal Martello and Maloney found that information from the two masked halves of the face combined additively, consistent with statistical independence and also indicating that hypothetical configural cues disrupted by masking either the upper and lower halves of the face played no detectable role in kin recognition.

We can combine the results of the current study with those of Dal Martello and Maloney (2006) and Maloney and Dal Martello (2006) to summarize what we know about the distribution of kinship information in the child’s face. The mask conditions for Experiment 1 of Dal Martello and Maloney (2006) are shown in Figure 3A and those for Experiment 2 are shown in Figure 3B.

One experiment in Maloney and Dal Martello (2006) and both experiments in Dal Martello and Maloney (2006) included the same full face (FF) condition as the current experiment. We used the identical stimuli but presented in a different random order in the FF conditions of all these experiments. The three resulting estimates of $d'$ for the FF condition (0.999, 1.187, 1.023) are similar with mean 1.070 and very close to the value (1.079) found in the present study.

We summarized the $d'$ values for each masked condition normalized by the $d'$ value for the corresponding full face condition. That is, we divided each $d'$ value in each condition by the corresponding $d'$ in the FF condition in that experiment. We refer to these as relative $d'$ measures. The relative $d'$ measure for the FF condition is, of course, 1. The relative $d'$ measures for the upper and lower parts of the face from Dal Martello and Maloney’s (2006) Experiment 1 are shown in Figure 4 in black with those for the left and right sides of the face from the experiment reported here in red. Kinship cues are predominantly found in the upper half-face. There are equal amounts of kinship information on left and right sides of the face. Blocking the eye region reduces $d'$ by 20% while there is negligible kinship information in the mouth region.

There are three main conclusions of our study. First, allocentric kin recognition is very robust with little reduction in performance even when just one side of face is visible. The present study does not find any improvement of kin detection when asymmetry cues were present (the entire face is visible) compared to when they were not present or markedly reduced (just one side visible). This outcome is consistent with what we know about the importance of kinship. Hammel (2005, p. 2248), for
example, observes that many human societies are "structured by ‘status’ rather than ‘contract’" and most animal groupings are based more on collateral kinship, i.e., aggregations of relatives of the same generation (siblings and cousins) than on lineal kinship (parents, children, grandparents, etc.).

Second, while one or the other side of the face is dominant in many kinds of tasks (recognition of identity, genre, age, emotions, and attractiveness), we do not find any dominance of one side of the face for kin recognition. Last, we could not reject the hypothesis that kinship information of the left and right children’s hemi-faces is completely redundant. There was no detectable benefit of viewing the full face over viewing the face with left or right side masked.

While we find that the left and right faces carry the same amount of kinship information, it is still possible that viewers prefer to judge kinship by looking at only the left side of the face, only the right side of the face, or looking at both sides of the face. Since we have no reason to expect one viewing strategy to do better than another, we have no predictions as to whether viewers will show perceptual asymmetries (focusing on one side to the exclusion of the other when both sides of the face are visible).

Maloney and Dal Martello (2006) conjectured that, in judging kinship, the visual system gives greater weight to facial features that are largely genetically determined and that are expressed early in development. As discussed in the Introduction section, both genetic and environmental factors contribute to facial asymmetry (see Bishara et al., 1994; Gangestad & Thornhill, 1999; Johnson, Gangestad, Segal, & Bouchard, 2008). To the extent that facial asymmetries are due to non-genetic factors, they cease to be reliable indicators of kinship. The genetic signal is buried beneath environmental “noise.” Although the relative balance of genetic and non-genetic factors is not yet known, we may propose a “reverse” conjecture. The outcome of the current study suggests that, even though children’s faces are often asymmetric, the asymmetries carry little useful information about degree of kinship either because most facial asymmetries are common to all individuals in the population (Rhodes et al., 2009) or are the result of environmental insults (accidents, illness, toxins).

If so, the visual system wisely ignores facial asymmetry in judging kinship.

Acknowledgments

MFDM was supported by funds from MIUR (Italian Ministero dell’Università e della Ricerca Scientifica e Tecnologica). We thank Ela Tollkuci for assistance in collection of data.

Commercial relationships: none.
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Footnotes

\(^1\)Güntürkün (1991) reports that Hasse was the first to challenge with an empirical study the assumption of artists and anatomists that the face is normally symmetric. Previously, asymmetries were assumed to be rare; the
results of pathologies (Henke, 1886). Henke had dismissed the Venus of Milo as an inferior manufacture and, according to Güntürkün (1991, p. 148), he advised that an anatomist be first consulted before indulging in reflections on works of art.

A chimeric face is composed of the left half of one face and the right half of another.

We note that our method of masking half-faces may not have eliminated all cues to asymmetry such as those that might be signaled by the shape of the bisected nose.

References


