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Representation and Aesthetics of the Human Face in Portraiture

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Abstract

How do representations of the face in portraits relate to the natural face, and how does the aesthetics of portraits relate to the aesthetics of faces in photographs? Here we investigate these questions with regard to the frontal face. Frontal faces are of particular interest because they are by far the most commonly studied type of face image in psychology, yet frontal portraits have been little studied by psychologists. Using behavioral and statistical tests, we show that artistic representations of frontal female faces have representational properties that broadly match those of the natural face, but we also find properties unique to artworks. We report that, as with frontal faces, frontal portraits show norm-based coding properties with respect to preference: averaged portraits become more attractive in proportion to the number of portraits averaged together. However, averaged photographs of faces are preferred to averaged portraits, suggesting that faces in portraits and photographed faces show basic differences in aesthetics. Consistent with this notion, we found that average face width and height ratios in an extended sample of frontal female portraits were significantly different from those for photographed faces. This indicates that portraits on average are not faithful representations of the typical structure of the face. In a behavioral experiment where we manipulated the structural ratios in portraits, we found that the preferred width and height ratios were significantly different from those preferred in photographed faces, and that the preferred ratios for portraits were closer to the average ratios of the portrait sample. We evaluate a variety of possible causes of the observed differences. We conclude that despite the demonstrated differences between artistic representations and natural faces, fundamental properties of natural faces are preserved in artistic representations of the face.

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1. Introduction

Roman historians relate the tale of the Greek painter Zeuxis who was asked to paint Helen of Troy, the Homeric queen known for her surpassing beauty. Zeuxis was brought the fairest women to choose a model from, but he found he could not choose just one. Instead, he is said to have created what was perhaps the world's first composite portrait, using facial features from five different models to evoke Helen's beauty. Although Helen was a mythical figure whom Zeuxis himself never observed, this story raises interesting questions regarding the process of capturing facial beauty in painting. In particular, how do representations of the face in portraits relate to the natural face, and how does the aesthetics of portraits relate to the aesthetics of natural faces?

Visual art affords unique insight into the fundamental properties of visual perception. By studying the physical manifestations of object representations in artwork, we can gain insight into the dimensions underlying representations within an object class and measure how those representations relate to the depicted object. A variety of studies have shown that artwork matches natural images in terms of fundamental spatial statistics (Graham and Field, 2007, 2008; Redies *et al.*, 2007a) and higher order spatial statistics (Graham and Field, 2007, 2008; Graham *et al.*, 2011; Hughes *et al.*, 2011), and that perceptual judgments of similarity are correlated with variations in these same statistics (Graham *et al.*, 2010; Hughes *et al.*, 2011). Artists' representational strategies (whether adopted consciously or not) are thus effective at capturing the perceptually-relevant statistical structure of natural objects and scenes. However, artwork serves many purposes, not least of which is an aesthetic function. A large and growing body of work has shown that artwork in particular and aesthetic objects in general are subject to special perceptual and cognitive processing strategies (Belke *et al.*, 2010; Leder *et al.*, 2004).

Here we examine a class of artistic representation that has a history stretching back thousands of years: portraiture. Portraits are of special interest because the face is by far the most popular human body part to be depicted in art, and artistic representations of the human form rarely exclude the face. With regard to human psychology, frontal portraits are particularly relevant because the vast majority of what is known regarding the preferred properties of a face (but also in terms of recognition, identification, gender judgment, facial expression, etc.) has been gleaned from studies using frontal face photographs, frontal synthetic faces, or frontal schematic faces (see, e.g., Bruce and Young, 1998).

The basic structure of artistic representations of the frontal human face has been little studied by psychologists (see Cohen and Bennett, 1997; Hayes and Milne, 2011; Kozbelt *et al.*, 2010), although a number of other aspects of portraiture in general have been studied extensively in recent years, including spatial frequency orientation statistics (Redies *et al.*, 2007b), head tilt (McManus *et al.*, 2004), emotional aspects (Leder *et al.*, 2013), eye centering (McManus and Thomas, 2007; Tyler, 1998), and facing direction of the sitter (McManus and Humphrey, 1973; Schirillo, 2000, 2007; ten Cate, 2002; for a review, see Powell and Schirillo, 2009). The latter work on facing direction suggests that one possible reason why frontal portraits have been mostly ignored is due to their rarity in art history compared to 3/4-view or profile portraits. Schirillo (2007) found only 19 frontal portraits in a sample of 373 Rembrandt works. Likewise, ten Cate (2002) found that portraits of 1131 Dutch university professors spanning the years 1566 to 1956 were frontal in less than 5% of the sample. Costa and Corazza (2006) found that about 17% of a sample of fine art portraits was frontal, although this included faces turned somewhat to the left or right; and McManus and Humphrey (1973) said frontal portraits were 'rare' in a sample of nearly 1500 portraits in major museums.

Our investigation of frontal portraits is first aimed at understanding how faithful artists are to the typical structure of the human face and whether psychological representations of portraits are qualitatively similar to psychological representations of natural faces. One might view artists as "persons whose observation of sensuous impressions is particularly vivid and accurate" (Helmholtz, 1876) and thus, since artistic portraits are often highly recognizable as representations of the face — and of particular faces — it stands to reason that artistic representations of the face could follow the same typical representational principles as natural faces. Consistent with this view, faces in portraits and photographs show similar perceptual efficiency: both can be accurately discriminated from images of natural scenes with presentation times as short as 15 ms, even when the images are inverted or contrast negated (Graham and Meng, 2011a).

On the other hand, aesthetic imperatives might instead alter the typical properties of artistic representations, perhaps in order to optimize artworks with respect to biological aspects of beauty or in order to achieve separate aesthetic effects related to expressive, emotional and/or stylistic goals. For example, Redies *et al.* (2007b) and Schweinhart and Essock (in press) have shown that despite having broadly similar statistical regularities compared to natural scenes, portraits show differences in spatial frequency orientation compared to photographs of faces, and Hayn-Leichsenring *et al.* (2013) have shown that perceptual adaptation effects for faces and portraits do not transfer between domains. Redies *et al.* (2007b) argue that these kinds of discrepancies between faces and portraits can be explained in terms of the aesthetic appeal of natural scene-like statistical regularities. Thus, the second aim of the present study is to understand basic aesthetic properties of faces in portraiture. However, rather than measure spatial frequency statistics (which have shown similar regularities in the above cited papers) we will examine face-specific properties, namely face structural ratios.

To investigate these questions, we conducted a series of three experiments that tested preferences for frontal facial portraits. In the first experiment, we investigate the effects of averaging frontal portraits together. In Experiment 2, we examine structural regularities in a diverse sample of frontal portraits. In Experiment 3, we manipulate the same structural ratios in portraits and in photographs of faces for the purpose of understanding patterns of preference.

2. Experiment 1: Averaging Effects for Portraits

Previous research shows that average faces, created by morphing together two or more individual faces, are perceived as more attractive than any of the original, individual faces (Langlois and Roggman, 1990; and others; reviewed in Rhodes, 2006). This effect is proposed to result from the nature of our psychological representations of faces, in which individual identity is defined by its difference from the norm (i.e., average) face (e.g., Catz *et al.*, 2009; Leopold *et al.*, 2001; Rhodes *et al.*, 2003; Valentine, 1991). In this 'face space' framework, greater distance from the norm corresponds with increased distinctiveness, better recognition, but also with decreased attractiveness. Likewise, increasing the similarity between a face and the norm, e.g., by creating averaged composite faces, shifts the face closer to the norm, resulting in an increase in typicality and perceived attractiveness. Yet, despite the fundamental role of this model in face processing, the relation of this model to portraiture remains uninvestigated. Indeed, it is not obvious why portraits should exhibit such an effect given the wide array of stylistic approaches to portraiture across art history. Therefore, we assessed whether this model also describes portrait preferences using a sample of frontal portraits spanning 500 years of art history and a diversity of styles.

Participants judged the attractiveness of composite averages derived from two to 16 portraits (Experiment 1A). This allowed us to determine whether portraits, like natural faces, are represented in a face space relative to a norm (i.e., average portrait). Then, since portraits could be created to be particularly aesthetically pleasing, we asked whether average portraits and average photographs of faces differ in their perceived attractiveness. Specifically, we had participants make relative judgments of attractiveness for average portraits and average photographs of faces (Experiment 1B).

2.1. Methods

2.1.1. Stimuli

Images of 16 color frontal portraits of white females were obtained through high-resolution scans of art books (image metadata shown online in Supplementary Table S1) or from http://commons.wikimedia.org. Using FantaMorph 4.0, each original portrait was averaged with one other original portrait to produce eight new averaged portraits. Within this set, pairs were then averaged together to make four new averaged portraits, each representing the average of four unique original portraits, and so on, resulting in 31 images (16 original, eight two-portrait averages, four four-portrait averages, two eight-portrait averages, and one sixteen-portrait average). In order to compare the effects of averaging portraits to the effect of averaging photographs of faces, we also created averaged face stimuli from photographs of white women using the same procedure. All faces were cropped and placed within a black oval frame; this eliminated all external, non-face influences on preference. Images were approximately 300 × 400 pixels with the vertical dimension equalized across all images. Images were presented in full color (on an Iiyama ProLite B19065 LCD display with a resolution of 1280 × 1024 pixels) in order to preserve regularities derived from artistic choice, since image statistics have been associated with preference in past work (Graham *et al.*, 2010; Graham *et al.*, 2013). However, we also performed the portrait-face comparison test again with luminance and root mean square contrast normalized, grayscale images (i.e., all 30 images were adjusted to have the same intensity mean and variance). Figure 1 contains example stimuli.

2.1.2. Participants

Eighteen undergraduate students at the University of Vienna participated for course credit in the experiment testing the effect of averaging on portrait preferences (Experiment 1A). A separate set of 33 undergraduates from the University of Vienna performed the comparison of portrait averages with photographed face averages (12 for unmodified color images, 21 for normalized grayscale versions of the same images; Experiment 1B). All participants had normal or corrected to normal vision.

2.1.3. Design and Procedure

We used a two-alternative forced choice method to test averaged portraits alone and to test averaged portraits in comparison to averaged photographs of faces.

2.1.3.1. The Effect of Averaging on Portrait Preferences (Experiment 1A). Participants simultaneously viewed two portraits, side-by-side from a distance of 0.5 m. Each image subtended approximately 8° of visual angle. Image pairs were located 10° apart horizontally, and were centered vertically. Participants

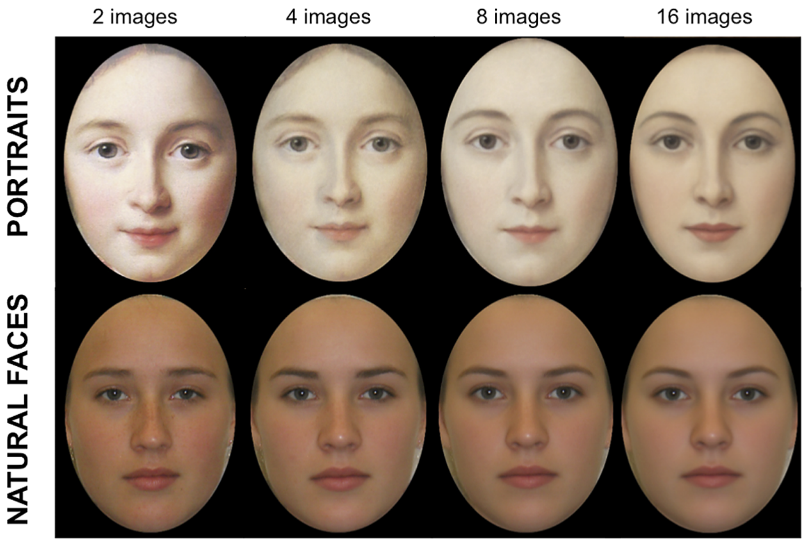

Figure 1. Examples of the average of two, four, eight, and 16 portraits or photographs of faces.

were asked (in German) to choose which image they found more attractive (as in Pallett *et al.*, 2010) on each trial by pressing the left or right arrow key. They were given as much time as needed to make each judgment and the participant's response ended the trial. There were 465 trials, one for each pairing of the 31 images. Pairs were randomly ordered and image location was randomized across the left or right sides of the display.

2.1.3.2. Portraits vs. *Photographs of Faces (Experiment 1B).* The procedure for Experiment 1B was identical to Experiment 1A with one exception. When comparing averaged portraits (eight two-portrait averages, four four-portrait averages, two eight-portrait averages, and one sixteen-portrait average), participants judged all 15 portrait averages *vs.* the corresponding set of all 15 face averages (225 comparisons). Ordering and placement of images was fully randomized for each participant as in Experiment 1A.

2.2. Results

Responses were combined across participants and ranked using both a percent preference (i.e., total number of trials where a given image was preferred divided by total number of trials $*$ 100) and a Bradley–Terry–Luce ranking algorithm applied to the preferences (see, e.g., Palmer *et al.*, 2007). Because the two ranking methods were almost perfectly correlated ($r^2 = 0.99$), we report only percent preference herein for clarity.

2.2.1. *Results for the Effect of Averaging on Portrait Preferences (Experiment 1A)*

We found a robust effect of averaging on preference. A linear fit ($r^2 = 0.95$) to the data comparing the $\log_2$ number of portraits averaged *versus* percent preference showed significant increases in preference with the number of portraits in the composite average ($F(1, 3) = 60.0$, $p < 0.005$). These results clearly mirror earlier studies of averaging face photographs suggesting that, like natural faces, artistic portraits are processed in a norm-based manner (Fig. 2).

2.2.2. *Results for Portraits* vs. *Photographs of Faces (Experiment 1B)*

For our comparison of portrait and face photograph averages, we found that results for the full color and normalized grayscale images were non-significantly different; thus, we combined the data across both experiments. The mean percent preference for all portraits considered together was significantly lower than that for all photographed faces (mean portraits = 1.78, SD = 1.35; mean photographed faces = 4.89, SD = 0.92; $t(14) = 10.9$, $p < 0.001$). Our results show that despite the qualitative similarities between preferences for portraits and photographs of faces — and despite equating low level image statistics — averaged photographs of faces are preferred at all levels of averaging tested (Fig. 2B). These results also replicate the finding in Experiment 1A, in which averaging more portraits together increased participants' preferences.

However, we also find that the averaging effect is stronger for portraits than photographed faces at a near significant level (portraits slope = 0.52, faces slope = 1.16, $t(4) = 2.65$, $p = 0.057$). These results could occur if the majority of portraits are scattered at a greater distance away from the mean, with larger overall variation. If true, this could suggest that portraits represent a car-

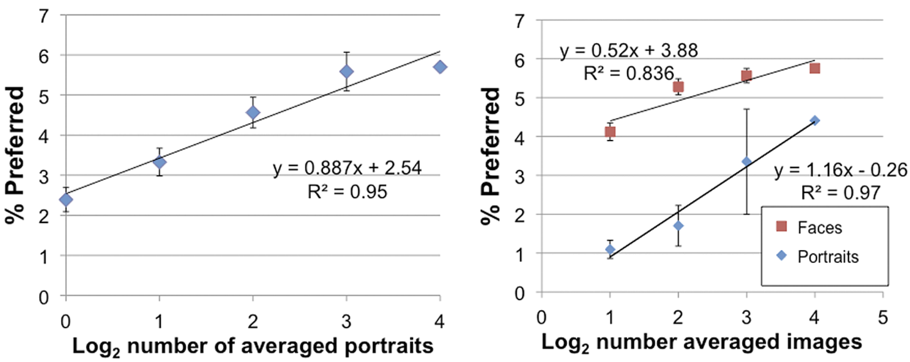

Figure 2. Left: Plot showing relationship of the number of portraits averaged together and empirical preference (percent preferred) tested with 2AFC procedure. Right: Relationship of the number of images averaged together and empirical preference (percent preferred) for faces compared to portraits. This figure is published in color in the online version.

icature of the natural face, or at least a more extreme version of the face-space employed for artworks.

2.3. Discussion

We find that portraits follow the same pattern of norm-based encoding as that found in faces, but we find that photographed face averages are preferred to portrait averages across all levels of averaging. Halberstadt and Rhodes (2000, 2003) found that norm based coding (as evidenced by increasing preference for greater averaging) was not limited to images of humans: other animal forms also show such effects (albeit in the form of highly reduced sketches, so this may not be a fully comparable result; curvature and other low level features were also not controlled in these experiments). Halberstadt and Rhodes (2003) suggest that identifying average members of other species, as with humans, *via* innate preference helps us evolutionarily by selecting not only healthy potential mates but also identifying healthy prey, avoiding diseased animals, and so on. Alternatively, a domain general object encoding system could be at work (Principe and Langlois, 2011).

Thus, the results in Experiment 1 may have been simply a case of a general averaging effect for images of living creatures. In order to elucidate whether this is the case, we performed an investigation of how salient features characteristic of the human face are represented in portraiture. In particular, we measured basic structural ratios of the face, namely the eye-separation ratio (width ratio) and eye-mouth distance (length ratio) in an expanded sample of portraits.

Why might faces be preferred to portraits across different numbers of averages? One answer could be that faces in portraits have different structural properties compared to real faces. We investigated this by measuring face ratios in a sample of frontal portraits.

3. Experiment 2: Facial Feature Arrangement in Portraits

The encoding of face configuration, i.e., relative placement of the eyes, nose and mouth, is uniquely important for face recognition (e.g., Leder and Bruce, 2000; Leder *et al.*, 2001; reviewed in Maurer *et al.*, 2002). As such, in this experiment, we determine whether the natural distribution of facial feature arrangements in frontal portraits conforms to the same average as that in photographs of faces.

3.1. Methods

We obtained frontal portraits of 51 white females spanning 500 years of art history (see Table S1 for list of works and Fig. 3 for images of examples). Images were scanned at high resolution from books or were high-resolution

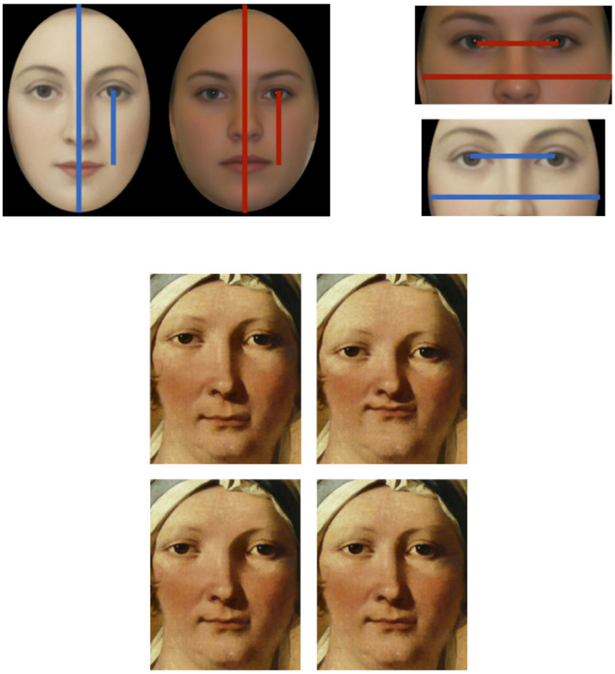

Figure 3. Top. Examples of the length ratio (left) and width ratio (right) in portraits and photographed faces. Bottom. Example portraits with altered length ratios (top row) and width ratios (bottom row).

images from Wikimedia Commons (http://commons.wikimedia.org). We used Adobe Photoshop to measure the distances between the facial features in each portrait. This included four key measures: (1) *face length* (D_L), the distance between the hairline and the base of the chin, (2) *face width* (D_W), the distance between the left and right edge of the face when measured through the top of the nares and the cheekbones, (3) *eye-to-mouth distance* (D_{EM}), the distance from the midpoint between the pupils to the center of the mouth where the lips meet, and (4) *interocular distance* (D_{EYES}), the distance between the center of the pupils. We then computed length ratios and width ratios for each face using equations (1) (for further detail see Pallett *et al.*, 2010). From these, we obtained the average frontal portrait length ratio (LR) and width ratio (WR).

$$\mathrm{LR} = D_{\mathrm{EM}}/D_{\mathrm{L}}, \tag{1a}$$

$$\mathrm{WR} = D_{\mathrm{EYES}}/D_{\mathrm{W}}. \tag{1b}$$

3.2. Results and Discussion

The average portrait length ratio was 0.371, SD = 0.022, and the average portrait width ratio was 0.490, SD = 0.031. These ratios are significantly dif-

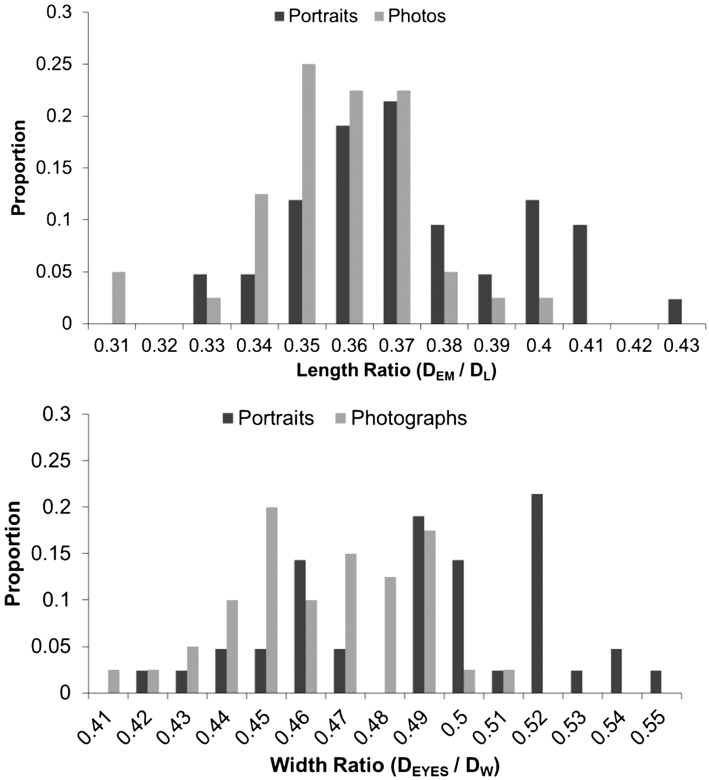

Figure 4. Distribution of length ratios (top) and width ratios (bottom) for 51 frontal portraits and 40 frontal photographs of white females.

ferent from the average length and width ratios obtained from photographs of 40 white female faces (LR: $M = 0.357$, SD $= 0.017$; WR: $M = 0.464$, SD $= 0.022$) reported by Pallett *et al.* (2010) (LR: $t(65) = 3.34$, $p < 0.001$; WR: $t(65) = 4.20$, $p < 0.001$). This suggests that artists do not paint portraits that reflect the mean, attractive ratios of the general population. See Fig. 4 for distributions of the ratios for faces and portraits.

Interestingly, we found that the traditional Greek golden ratio ($\Phi =$ approx. 1.618) seemed to be typical of the length ratio of portraits in our sample. This Classical golden ratio (Φ) occurs when

$$\mathrm{LR} = 1 - 1/\Phi. \tag{2}$$

A similar golden ratio can be defined for inter-ocular distance and face width. Thus, in this golden face, both the LR and WR equal 0.382. A one-tailed t-test confirms that the average LR of our portraits is not significantly different from the classic golden LR ($t(29) = -1.93$, $p = 0.065$). However, the average portrait WR is significantly different from the classic golden WR ($t(26) = 19.31$, $p < 0.001$).

In summary, faces in portraits appear to have fundamentally different average properties compared to photographs of faces. Given that the average ratio for photographed faces is preferred when the ratios are artificially manipulated, this begs the question of whether the empirical average ratio for portraits is also the preferred ratio for portraits, which we test in Experiment 3.

4. Experiment 3: The 'Golden Ratios' for Portraits

Pallett *et al.* (2010) demonstrated that a natural face's attractiveness is maximized when the LR and WR are identical to the average. Yet, in Experiment 2 we found that the natural distribution LRs and WRs in portraits and in photographed faces conform to significantly different averages. Thus, here we tested whether portrait preferences are determined relative to a portrait average or a photographed face average. First, in Experiment 3A, we identify the maximally attractive LR and WR for portraits. Then, in Experiment 3B, we assess the relationship between portrait face space and natural face space by directly assessing whether participants have different attractiveness ideals, i.e., different LR and WR preferences, for each face type.

4.1. Experiment 3A

4.1.1. Methods

4.1.1.1. Participants. Twenty-nine undergraduate students at Dartmouth College participated for course credit. All participants had normal or corrected to normal vision.

4.1.1.2. Stimuli. We selected ten of the frontal portraits from Experiment 2 and used Adobe Photoshop to increase or decrease the D_{EM} in each portrait by 10% or 20% of the original distance. This produced 40 new faces that differed only in terms of their D_{EM}. The internal and external facial features remain constant (i.e., identical eyes, mouth, nose, face contour, and hair). We also created an additional two new faces for each original portrait by adjusting the D_{EM} to create faces with the average LR for portraits obtained in Experiment 2 and the average LR for photographed faces found by Pallett *et al.* (2010). Note that each of these faces retained their original WRs. Thus there were 70 test faces, six derived faces and one original face for each portrait. For each portrait, the six derived faces and the original face were then paired with each other to create 21 face pairs with identical facial features but different LRs.

Following this, we created another new set of 40 faces in which the D_{EYES} in each portrait were increased or decreased by 10% or 20% of the original distance. We also created an additional two new faces for each original portrait by adjusting the D_{EYES} to create a faces with the average WR for portraits obtained in Experiment 2 and the average WR for natural faces found by Pallett *et al.* (2010). Note that each of these faces retained their original LRs. Thus there were 70 test faces, six derived faces and one original face for each portrait. For each portrait, the six derived faces and the original face were then paired with each other to create 21 face pairs with identical facial features but different WRs.

Figure 3 contains example frontal portrait stimuli. Portrait length was set to 440 pixels for all images, but portrait width was allowed to vary so as to maintain the original aspect ratio (mean width = 320 pixels, SD = 22.1 pixels). Thus, the portraits were on average $6.87° \times 9.43°$ visual angle. Faces were presented side-by-side on a gray background using a 61 cm HPRZ24w Widescreen LCD monitor with a resolution of 1920×1200 pixels. Participants were seated at a distance of 72 cm. Faces were centered 3.76° to the left or right of center and 0.32° above or below center.

4.1.1.3. Design and Procedure. Each trial began with a 500 ms fixation, followed by a pair of faces. Participants judged which face appeared more attractive (left or right). Stimuli remained on display until the participant responded. Each face pair was presented twice to counter balance display location. Participants viewed both LR face pairs and WR face pairs, with face pair order randomized across trials. Because we were interested in isolating preferences for facial portrait configuration, participants never judged the relative attractiveness of faces with different facial features. There were 840 total trials: 2 directions (WR *vs.* LR) $\times$ 10 identities $\times$ 21 pairs per identity $\times$ 2 sides of the display.

4.1.1.4. Data Analysis. For each participant, we obtained the number of trials a given LR or WR was preferred relative to the number of trials in which that ratio was viewed and converted this to % preference. We computed this separately for each combination of LRs and WRs (i.e., +10%, +20%, −10%, −20%, portrait average, photographed face average, and original). For example, a portrait with an average portrait LR was presented in 120 trials. If a participant indicated a preference for the average portrait LR in 100 of those trials, then the % preference would be $(100/120) * 100 = 83.3\%$. Using a regression analysis, we then determined the exact relation between the % preference and LR, and % preference and WR. Data were also analyzed using a mixed model linear fit with portrait identity as a random subjects variable to account for any unexpected effects of portrait identity; however since the results were identical to those obtained using regression analysis, we report only the regression analysis.

4.1.2. Results and Discussion

Length ratio predicted portrait preference with the following function:

$$\% \text{ Preference} = -46.0\text{LR}^2 + 35.5\text{LR} - 6.24. \tag{3}$$

This function was a strong predictor of % preference ($R^2 = 0.61$, $F(2, 67) = 53.2$, $p < 0.001$) and is displayed in Fig. 5. The LR for the maximally attractive portrait according to equation (2) was 0.386. While this ratio is significantly different from the average portrait LR measured in Experiment 2 ($M = 0.371$; $t(50) = 4.92$, $p < 0.001$), it is remarkably similar to the Classical 'golden' LR [0.382, equation (2)]. This suggests that the observed optimal LR for a portrait may reflect participants' preferences for an aesthetic ideal, i.e., the same ideal venerated by the ancient Greeks (Phi, Φ).

Width ratio predicted portrait preference with the following function,

$$\% \text{ Preference} = -27.8\text{WR}^2 + 27.6\text{WR} - 6.21. \tag{4}$$

This function was a strong predictor of % preference ($R^2 = 0.60$, $F(2, 67) = 49.3$, $p < 0.001$) and is displayed in Fig. 6. The WR for the maximally attractive portrait, using equation (4), was 0.496. Unlike our findings for LR, this 'ideal' WR is not significantly different from the average portrait WR measured in Experiment 2 ($M = 0.490$; $t(50) = 1.48$, $p = 0.15$). This suggests that the observed optimal WR for each portrait may reflect participants' preference for the average portrait, consistent with a norm-based representation of faces. Interestingly, although these results are consistent with the attractiveness preferences for natural faces reported by Pallett *et al.* (2010), the value of the preferred WR is the average for portraits, not natural faces. These results suggest that participants may represent portraits in a distinct face space,

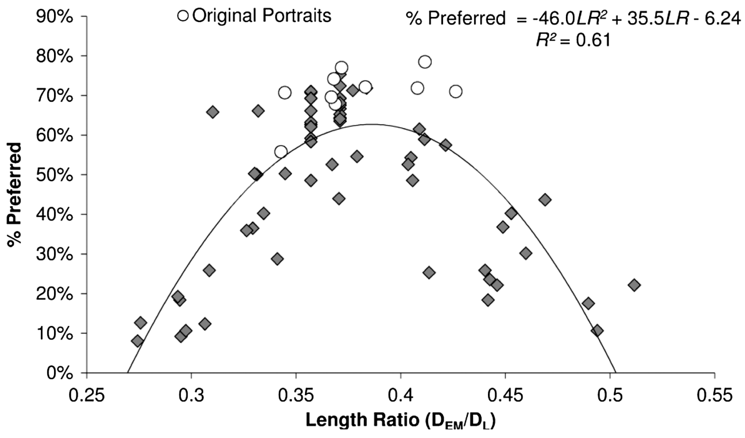

Figure 5. Individual portrait preferences as a function of length ratio, $N = 29$. White circles represent the original portraits; gray diamonds represent the portraits with altered length ratios.

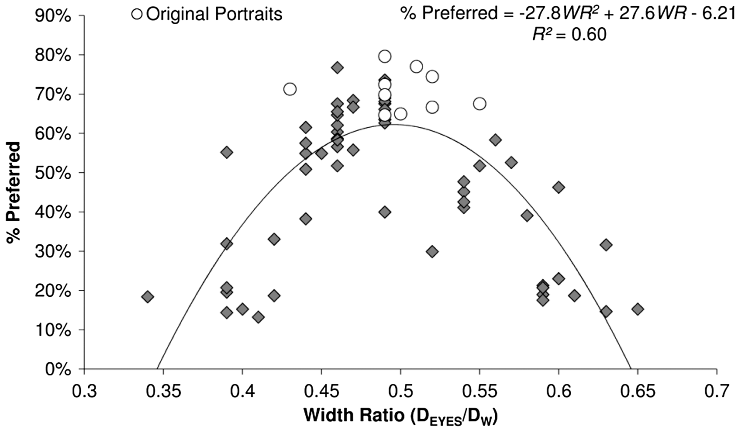

Figure 6. Individual portrait preferences as a function of width ratio, $N = 29$. White circles represent the original portraits; gray diamonds represent the portraits with altered width ratios.

i.e., separate from that used to represent natural faces. Moreover, this portrait face space appears to contain many of the same characteristics as the natural face space (i.e., qualitatively similar), but its axes are defined relative to a quantitatively different average.

To further explore the structure of portrait face space and better understand the disparity between preferences for photographed faces and portraits, in Experiment 3B we tested participants' preferences for photographed faces with either the average photographed face LR and WR or the average portrait LR and WR, and likewise for portraits. Note that although the average portrait LR is not optimal for portraits, we chose to use this ratio rather than the ideal portrait LR, because the results for averaging effects in Experiment 1 and for WR preferences in Experiment 3A suggest that the average plays an important role in natural face and portrait representation. We do not anticipate this to be a problem for our results, since Experiment 3A suggests the average portrait LR should be preferred to the average photographed face LR.

4.2. *Experiment 3B*

4.2.1. *Methods*

Experiment 3B proceeded in the same manner as Experiment 3A with the following exceptions.

A new set of 21 undergraduates from Dartmouth College participated in exchange for course credit or $5.

First, using the stimuli from Experiment 3A, we selected the frontal portraits with the average LR for portraits. Then, we adjusted the D_{EYES} in each portrait to create a new face containing both the average portrait WR and average portrait LR. Thus, each portrait contained the average facial feature arrangement (i.e., face configuration) derived from 51 frontal white female portraits (see Experiment 2). Next, we selected the frontal portraits with the average LR for photographed faces from Experiment 3A. Then, we adjusted the D_{EYES} in each portrait to create a new face with both the average photographed face WR and average photographed face LR. Thus, each portrait contained the average facial feature arrangement (i.e., face configuration) derived from 40 frontal white female photographs (Pallett *et al.*, 2010). For each identity, we paired the portrait containing average portrait ratios with the portrait containing average photographed face ratios. This resulted in 10 portrait pairs.

Next we selected ten full-color white female photographs from the set of photographed faces used by Pallett *et al.* (2010). We then adjusted the LR and WR in each face to create average portrait configurations and average photographed face configurations, as described for portraits (above). This resulted in ten face pairs.

There were 40 total trials (10 pairs $\times$ 2 face types $\times$ 2 display locations).

Data were analyzed in a 2 (face type: natural *vs.* portrait) $\times$ 2 (configuration: photographed face average ratios *vs.* portrait average ratios) repeated measures general linear model.

4.2.2. Results

Results showed a significant interaction between face type and configuration ($F(1, 20) = 16.5$, $p < 0.001$). To better understand the nature of this interaction, we conducted two paired-samples t-tests, one for photos and the other for portraits. Results for photographed faces show a clear preference for the average photographed face ratios ($t(20) = 11.0$, $p < 0.001$). In contrast, both the photographed face average ratios and the portrait average ratios were preferred in portraits ($t(20) = 0.59$, $p = 0.56$). These results are displayed in Fig. 7.

4.2.3. Discussion

These results can be understood in the context of a face space framework as follows. Experience with faces is fundamental to the development of a stable face space, and our participants had a lifetime of experience with natural faces. Accordingly, preferences within photographed faces were very clear. By contrast, our participants' exposure to portraits is very limited. Our data clearly show that participants do not make attractiveness judgments of portraits based solely on similarity to the photographed face average. Rather, there is a clear preference for the portrait average, suggesting that participants are flexible in their representations and preferences for portraits. Accordingly, we suggest that portraits are represented in a weakly formed subspace of the natural face space, and that as a result participants show a preference for both the local average and the grand face space average.

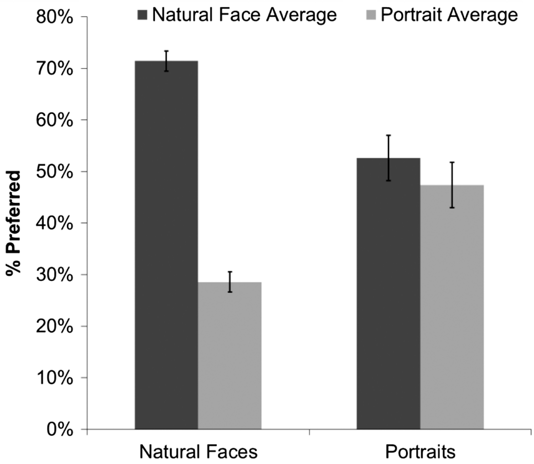

Figure 7. The attractiveness preferences of 21 participants. Participants made paired comparisons of attractiveness for photographed faces with either average photographed face ratios or average portrait ratios, and likewise for portraits. Error bars denote ±standard error of the mean.

5. General Discussion

We have found that frontal painted portraits show a strong effect of averaging on attractiveness, but that averaged photographed faces are preferred to averaged portraits at all levels of averaging tested. These results suggest that there exist basic differences in aesthetics for the two image classes. We also found that the facial feature arrangements of painted portraits differ significantly from those of photographed faces, such that preferences for structurally altered portraits peaked nearer to the average portrait configuration than to the average natural face configuration. These results provoke new and interesting questions, which we address below.

5.1. Why Are Faces and Portraits Different?

5.1.1. Artistic Canons and Mere Exposure

One explanation of why faces and portraits are different in the respects tested here is that the aesthetic ideal for portraits results from and is reinforced by artistic mnemonics for portraiture (e.g., always place the eyes two-third up in a circle), which do not reflect typical human proportions (see Farkas and Kolar, 1987; Farkas, 1994) but are rather a system of imposed aesthetic ideals (see Vegter and Hage, 2000, for a review). A number of formulae for sketching the face have been used through the ages (see Balas and Sinha, 2007; Gombrich, 1977). Differences in facial feature arrangement (i.e., length and width ratios) could thus be due to agreed standards that have been adopted and passed on from master to student, either by explicit reference to measurable standard, or they could have led to preference through exposure. If a system to construct portraits is explicitly taught as a canon (see Gombrich, 1977, also regarding the golden section) then this canon could provide its own prototype and face-space. This would then create an artificially distinct feature of artistic portraits. Also, the style per se could affect how portraits are perceived. For example, Leder (1996) showed that sensitivity to certain configural features changed when natural portraits were transformed into line drawings of faces. Moreover, the difference in preference for facial feature arrangement in faces and portraits could ultimately be the result of exposure effects. For example, canon formation has strong historical biases (Cutting, 2003). Accordingly, this exposure could create a norm different from the natural face average. However, even in Western art, artistic canons for face representation show a great deal of variation (Vegter and Hage, 2000), so other explanations may be necessary.

5.1.2. Biased Perception

It could also be the case that portraits reflect perceptual biases in face perception. Balas and Sinha (2007) found that humans are poor at guessing from memory the correct placement of eyes and mouth in famous faces (at least in the absence of the external contour of the face). There is also evidence of consistent overestimation of facial feature distances by human observers (Schwaninger *et al.*, 2003), especially eye–mouth distance. We can extrapolate this finding to artistic portraits: Cohen and Bennett (1997) found that drawing accuracy for faces among novice drawers was predicted not by motor skills or the choice of what features to depict, but rather on their perception of the to-be-drawn face. Our results showing that the ratio of eye–mouth distance is higher for portraits compared to faces would seem to agree notion that these differences are due to misestimation.[1] But if artists consistently misestimated the structure of the face and replicated this in their portraits, we would still expect humans to prefer the average facial feature arrangement of natural faces in portraits, since both photographed faces and faces in portraits would be subject to this perceptual distortion. The idea that misestimation shapes preference is thus a variant of the El Greco fallacy (see Anstis, 2002; Firestone, 2013; Graham and Meng, 2011b).

Therefore, perceptual misestimation of face structure provides at best an incomplete explanation of our findings: the fact that ratio preference in portraits is closer to the empirical average ratios for portraits than to that of photographed faces suggests aesthetic goals may be involved.

[1] Because we have measured ratios, and not absolute distances, it could also be the case that artists are underestimating distances between facial features and external contours. However, there is some evidence for overestimation by artists. The innovative study by Hayes and Milne (2011) comparing portraits by an artist and photographs of the same individuals suggests overestimation of some facial internal distances and feature sizes, including nose length and mouth width.

5.1.3. Biased Sampling

It is possible that artists sample from the population in a biased way, such that the average ratio in portraiture does not correspond to that in the larger population. Perhaps the population of those who can commission a portrait of themselves does not reflect the average of the population at large, much as averages of attractive faces are preferred to averages of all faces (Cunningham, 1991; Perrett *et al.*, 1994). For example, many portraits were commissioned by royalty and nobility, for whom royal intermarriage was a common practice (e.g., Alvarez *et al.*, 2009). Over time, however, this practice may have produced distinctive appearances through the chronic reproduction of certain facial traits, an extreme example of which is the Habsburg (or 'Austrian') lip. Thus, we should be aware of potential biases in the sample of sitters, and also bear in mind that despite our efforts to ensure a large and diverse sample of paintings, our portrait set may not be fully representative of artistic production of frontal portraits.

5.1.4. Limitations of Representation in Portraiture

One perspective that could offer some novel insight into these results is the idea that on average, artists are making the best representation they can create given the medium's limitations in depth (Cavanagh, 2005) and dynamic range (Graham, 2011), which leads to a distinct aesthetic system that is grounded in basic neural mechanisms of face perception. That is, the differences in empirical and preferred structural ratios for portraits compared to photographed faces could be related to constraints imposed in rendering 3D objects in pigment on a 2D canvas (Cavanagh, 2005) and/or constraints related to dynamic range limitations in paint (see Graham, 2011; Graham *et al.*, 2009, 2010; Graham and Meng, 2011a). In this view, such differences stem from consistent attempts to represent the natural face when limited to reflective pigment on flat canvas. Such representations would retain fundamental properties related to face perception but could comprise a distinct aesthetic experience due to their fundamentally different structure and statistics.

5.2. Is There a Role for the Golden Ratio?

As noted earlier, the preferred length ratio in portraits is not significantly different from the classical Golden ratio (Phi, Φ), although the width ratio is significantly different from this value. If there is any importance to this finding for the length ratio, the fact that the width ratio for portraits is different from the Golden ratio may simply be due to the fact that the average face width ratio is itself quite a bit larger than the golden ratio. Notably, other studies of the aesthetics of the Golden ratio (e.g., Di Dio *et al.*, 2007) have only considered length ratios, and the artistic canons of face depiction related to Φ place more emphasis on proportions of face length than face width. In a related vein, Goffaux and Rossion (2006) found that vertical configural information is more sensitive to inversion than horizontal configural information. And Dakin and Watt (2009) found that horizontal spatial frequencies are especially important for facial identity information. Thus, it may be the case that the width ratio is less prominent in the aesthetics of the face. However, much research has been aimed at elucidating the possible influence of the Golden ratio on aesthetics, with mixed and often contradictory results (Green, 1995). We therefore limit ourselves to simply noting this interesting feature of our data.

5.3. Why Are Frontal Portraits Rare?

Finally, we return to our observation that frontal portraits are puzzlingly rare. This fact has implications for face research. Non-frontal poses may disguise facial asymmetries (as suggested in the recognition studies of Laeng and Rouw, 2001; Carbon and Leder, 2006; see also Liu and Chaudhuri, 2002) and thus non-frontal views may be more salient with regard to the biological or evolutionary determinants of facial beauty. Alternatively, non-frontal views may simply be easier for the artist to capture on canvas, since salient internal face contours stand out against the background. Thereby, non-frontal views might capture more of a face's individuality, e.g. the protuberance of the nose. Thus, we encourage future research on the representation and aesthetics of non-frontal faces and portraits. While there is an emerging interest in non-frontal poses among face perception researchers (Kietzmann *et al.*, 2013), we advocate a more comprehensive evaluation of non-frontal face images.

Interestingly, Perona (2013) provides evidence that optimal frontal portraits involve multiple perspectives, and that such images may succeed because of the ability to capture a feelings of intimacy by photographing from close by the sitter (Bryan *et al.*, 2012). Artists are also likely to paint from a distance very near to the sitter. Variation in viewing distance may have played a role in our studies, and we advocate further investigation of the role of viewing distance in aesthetic and face research. Thus, preference even for frontal portraits may be subject to a number of additional factors beyond the few considered in the present study.

We also note that the rarity of frontal portraits in art history is a challenge to arguments from neuroaesthetics and evolutionary biology regarding the attractiveness of symmetry (Chatterjee, 2011; Grammer and Thornhill, 1994; Jacobsen and Höfel, 2002; Tinio and Leder, 2009). Indeed, one might expect frontal portraits would be very common since they are more visually symmetric (more symmetric faces are preferred: e.g., Jones *et al.*, 2001; Perrett *et al.*, 1999; Rhodes *et al.*, 1999), and more exact symmetry is limited only by the artist's skill. But because they are rarely frontal, portrait paintings in particular are rarely symmetrical (nor are other types of painted artwork typically symmetrical). This further supports the idea that aesthetics in the natural world and aesthetics in art show distinct properties, and regularities in one realm cannot automatically be assumed to transfer to the other.

5.4. Conclusion: Can We Use Portrait Painting to Understand Face Perception?

Much as the study of the quantitative structure of and response to music has provided important insights into auditory perception, visual art holds unique evidence regarding human visual perception. We have shown that averaged portraits become more attractive in proportion to the number of faces averaged together. However, averaged faces are preferred to averaged portraits, suggesting that faces in portraits and photographed faces show basic differences in representation, despite the fact that portraits are representations of the human face. We also showed that average face width and height ratios in an extended sample of frontal female portraits were significantly different from those of photographed faces. This indicates that portraits are not faithful reproductions of the typical structural properties of the face. But in a behavioral experiment where we manipulated the structural ratios in portraits, we found that the preferred width and height ratios for portraits were also significantly different from those for photographed faces, and the preferred ratios for portraits were closer to the average portrait ratios. Thus, artistic portraits may appeal to a distinct aesthetic ideal — one perhaps dictated by representational limitations of the medium — while at the same time they preserve fundamental structural and featural regularities germane to perceptual processing of faces.

We conclude by noting that when representational strategies and aesthetic goals converge in art and in nature, we are likely to find basic knowledge about human psychology. Yet differences between art and nature also hold important insights into human vision, as well as for aesthetics and art appreciation.

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