Decline of Perceived Beauty: Facial Representations between the 18th and 20th Century in Western Art

Javier de la Rosa, Natalia Caldas, Nandita Dutta and Juan Luis Suárez

Abstract
This study focuses on the question of beauty standards defined by scientific methodology in terms of face symmetry and averageness. This definition correlates with art history and the human faces depicted in a large set of artworks. Recent research in evolutionary psychology and neuro-aesthetics suggests that the attractiveness of a face can be conceptualized as the sum of a varied set of distinct features. These aspects are described in terms of averageness, symmetry, sexual dimorphism, pleasant expressions, and youthfulness. First we collected a dataset of more than 120,000 paintings and then applied industry standard face recognition algorithms to extract facial traits. Then we studied how portraits of faces could be considered more or less beautiful across time and lastly, we noted when beauty trends evolved. Our study focuses on 18th century painting styles such as Rococo and Neoclassicism, which adhere to strict conventions of symmetry and realistic depictions of the human anatomy. It extends until the Impressionist and the Avant-Garde eras that broke with these conventions. Our analysis reveals a particular decline in face averageness and symmetry that demonstrates a shift in artistic styles over time. It evolved from a naturalistic representation of the human face, which is to say, from bearing resemblance to the natural human anatomy to an abstract representation that deconstructed facial features, such as in Picasso's paintings. A face averageness graph exhibits a sharp decline in averageness and symmetry from the 18th century onward indicating that beauty conventions and standards regarding the representation of the human face in art varies greatly. The early 20th century marks a complete break in facial representation in portraits. This analysis also reveals a change in beauty perception and conventions arising at the beginning of the 20th century that expressed a newfound preoccupation for discovering and depicting facial features.

Key Words: Art History, digital humanities, beauty, facial recognition.

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1. On Beauty

In 2012, while working at a fish-and-chips bar in Deal, Kent (UK), Florence Colgate, an 18 years old student, was chosen to be a candidate for the 'Britain's Most Beautiful Face' competition. After naming her one of the three finalists among more than 8,000 contestants, judges awarded her this title because she presented the most features necessary for an ideal face. In this contest, judges

based their decision on measurements of symmetry, proportions and its subsequent relation to beauty. The standards determining natural beauty are a hot topic in the entertainment industry. As consumers, we are bombarded everyday with celebrities' faces that fit a specific pattern of beauty, one that can be studied and analysed through photography.[1] However, it is necessary to keep in mind that beauty is perceived in different ways by different people in various cultures. This raises questions about how original forms of human representation in art may have determined beauty standards and how beauty trends evolved over centuries and across art styles, including through scientific inquiry.

Unfortunately, photography only achieved popularity from the 19th century onwards and to analyse beauty in previous centuries we needed to take a different approach. We examined paintings where the representation of the human body usually takes a central role and examine paintings that depict faces. Questions about defining beauty needed to be answered as well as conditions required for a face to be perceived as beautiful. We aimed to define beauty in as objective a way as possible while, at the same time, avoiding restating the cliché notion that beauty is in the eyes of the beholder. Whether or not the consideration of beauty standards in artworks is deliberate or not was ultimately the question that guided this study. Recent research in evolutionary psychology and neuro-aesthetics suggests that the attractiveness of a face is perceived as the sum of a varied set of distinct features. This includes aspects from averageness, symmetry, sexual dimorphism, pleasant expressions, and youthfulness.[2]

2. Dataset

In order to examine these issues, we collected a dataset of more than 120,000 paintings from different cultures and from various eras. This sample of art works ranged historically from Egyptian and Byzantine paintings to modern representations of pictorial art. Regrettably, not all this artworks was relevant; the collection of paintings that we accessed was not as complete and extensive as we had anticipated. As we assessed an number of paintings (65% from the 20th century, 17% from the 19th century, and barely 3% from the 18th century), we refocused this dataset to encompass only the past three centuries of Western art, thus reducing its number to approximately 20,000 works. As we progressed, we observed a diminishing amount of paintings in our collection of artwork and an increase in the prevalence of other art formats. This trend coincided with a drop in the production of important media such as books. This trend may suggest the existence of a constant ratio between the production of artwork and an increase in human population growth (Figure 1).

An analysis of the perceived beauty of human faces could only be carried out after we extracted and annotated common features in a dataset of more than 100,000 paintings. This task would have become tedious and exhausting for us to accomplish without the help of computers. These machines, in fact, are now close

to outperforming people in facial detection and recognition.[3] Importantly, we relied on computer algorithms conceived for facial detection in photography and applied them to paintings produces a series of limitations. These algorithms are not designed to deal with a wide range of painting styles and their particularities. All faces in the data set,[4] amounted to less than 15,000 paintings, 14% less than the 25,000 originally gathered for this study (l–see Figure 2).

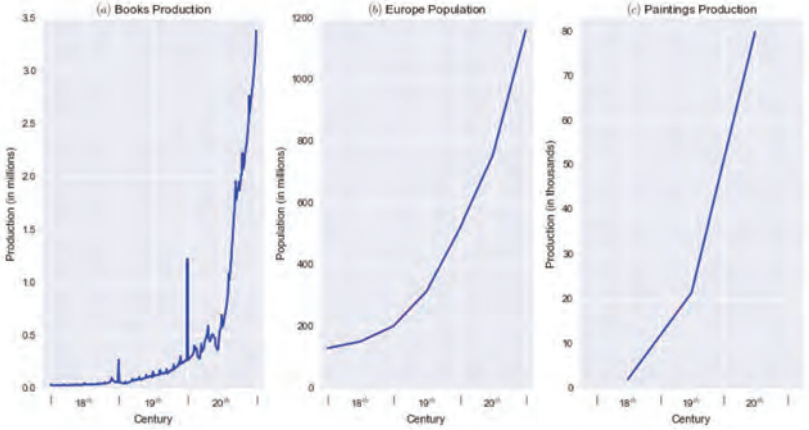

Figure 1: (*a*) Media production of books as contained in WorldCat since year 1700[5] (*b*) Population growth of Europe in the same period (*c*) Paintings in our dataset. Media production and population © 2014. Courtesy of Javier de la Rosa.

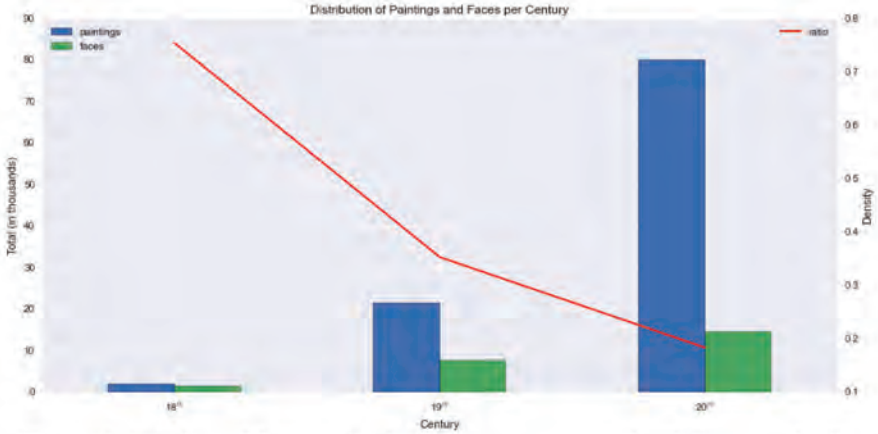

Figure 2: Number of faces and paintings per century, and ratio between both. Faces and paintings per century © 2014. Courtesy of Javier de la Rosa.

Besides calculating the boundaries of a face and the position of several facial traits – such as the eyes, nose, mouth, ears, or chin in a portrait –, this algorithm also guessed at the gender and age of the faces depicted. It based this estimation on the distribution and proportions of facial traits and provided a statistical threshold of confidence. The data did not show any differences in gender representation because women and men were depicted in equal number. Unlike the average estimated age per gender, where an important difference arose, a constant gap appeared between the estimated age of depicted women and men, amounting to about 4 years. Nevertheless both sets of gender results demonstrated an increase in the average estimated age of the person portrayed over time. Women's faces averaged from below 25 years of age in the 18th century to around 27 by the 20th century. Male faces averaged from 29 to 32 years of age following the same historical progression (Figure 3). Some studies link the perception of beauty to younger faces.[6] Accordingly, our brain seems prone to be attracted to faces of potential mates who demonstrate a strong probability of success in human beings' biological reproduction. Although our results suggested that perceived beauty declined since 18th century, we still needed to complete an actual analysis of the extracted faces in order to support these initial findings. We wondered how we could quantitatively measure beauty with such a massive dataset.

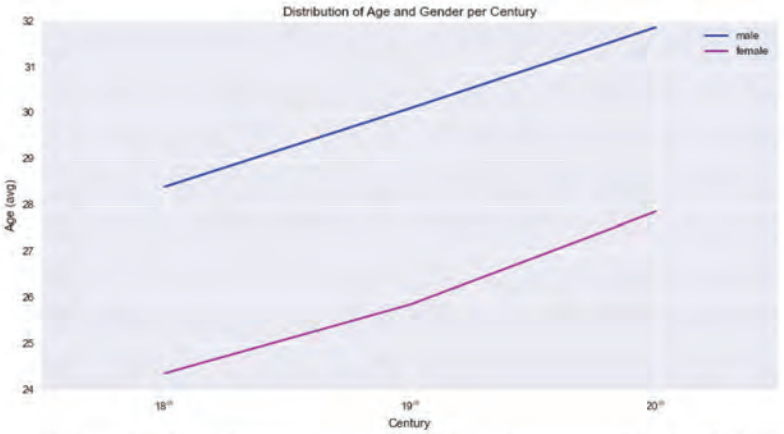

Figure 3: Distribution of age and gender © 2014. Courtesy of Javier de la Rosa.

3. Measurement

In this study, the scientific definitions of face symmetry and averageness determine the primary standards of its beauty focus. Healthy and non-problematic development during puberty seems to be indicated by the symmetry of the face and is the mark of a better offspring.[7] According to Darwin's theory of natural selection individuals with harmful mutations constitute less desirable mates. These genetic

differences are related to the averageness of a population whereby individuals with facial features closer to the mean of their group are preferred to others.[8] Sufficient evidence supports the fact that the perception of beauty is influenced by these two indices: the more average and symmetrical the face, the more beautiful it appears.[9] We relied on a Grammer and Thornhill's method to calculate facial symmetry, albeit with a few modifications.[10] This method typically examines 12 different key points of the human face (one more for averageness): two each for the eyes, the nose, the mouth, the cheekbones and the jaw. These points are connected by lines to each pair of facial features and their midpoints are then calculated. For a face to appear perfectly symmetrical, all midpoints must lie on the same vertical line. The algorithm used for our study is significantly limited compared to this method; we make use of three points for the mouth (left, centre, and right), one for each pupil, and one for the nose. We did not take the ears or the chin of the model into consideration because the number of faces in which these features were recognized with enough confidence (with accuracy higher than 80%) was fairly insignificant (6%). Besides these key features, the algorithm also calculated the centroid or geometric centre of all detected attributes (Figure 4a), that coincide with the centre of the face. This point can be used to set a straight line that splits the face into two sides, or hemi-faces. Figure 4b shows the following points: P1 for left eye, P2 for right eye, P3 for nose, P4 for mouth centre, P5 for left mouth corner, and P6 for right mouth corner. In addition, we assumed that line H acted as the axis of face symmetry. We traced the following segments: D1 between P1 and P2, and D2 between P5 and P6 (Figure 4c). We then assigned the midpoints of these segments: M1 and M2. Symmetry was calculated as the sum of the distance in pixels of M1, M2, P3 and P6 with respect to line H. Only lateral symmetry was estimated. For a face to be considered perfectly symmetrical, this value had to add up to zero; all symmetry values were normalized between 0 and 1. For our plots to be clearer we assigned this 1 to signify perfect symmetry and 0 to indicate total asymmetry.

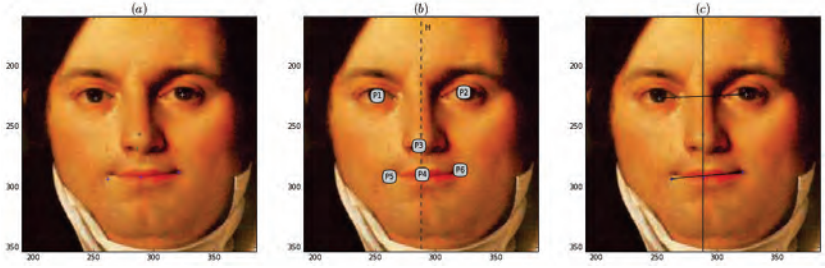

Figure 4: (*a*) Example of face and detected points for eyes, nose, mouth and centre (*b*) Vertical line, H, to divide the face into two hemi-faces, and enumerated points for all the features (*c*) Lines for calculating distances between midpoints and hemi face line. Symmetry calculation © 2014. Courtesy of Javier de la Rosa.

Obtaining values of beauty averageness involved completing a much more demanding task in terms of analytical power. We created an average composite face for each century under study, one male, one female and one combined face for both genders (Figure 5). The first step in generating the averaged composite face was to centre these faces along the centroid that had been determined by the facial recognition algorithm. Faces were then resized to make them fit into a (.png) canvas of 500 by 500 pixels at 300dpi of resolution, and given a height of 200 pixels; faces with height lower than 150 pixels were excluded to avoid blurred pixilation of the average face. This sizing process involved using affine and projective 2D transformations from the original painting to the desired canvas. Every face standardized by size was then converted into a 3D numerical matrix representing each of the layers of the (RGB) colour model. A regular statistical mean was then calculated over the set of faces of each century in order to obtain the average value for each pixel. Once the average matrix was calculated, it was converted back into a (.png) image. Resulting quality and averageness of the composite rely on the number of faces used in each century for generating the averaged face. The same face recognition algorithm used in the dataset was then applied on averaged composites. This allowed us to measure the averageness of an individual face as the difference between its symmetry and the symmetry of the average face for that particular period of history. Averageness refers to the degree to which a given face resembles the majority of faces. In our study averageness values varied from the most average, 1, to the least, 0.

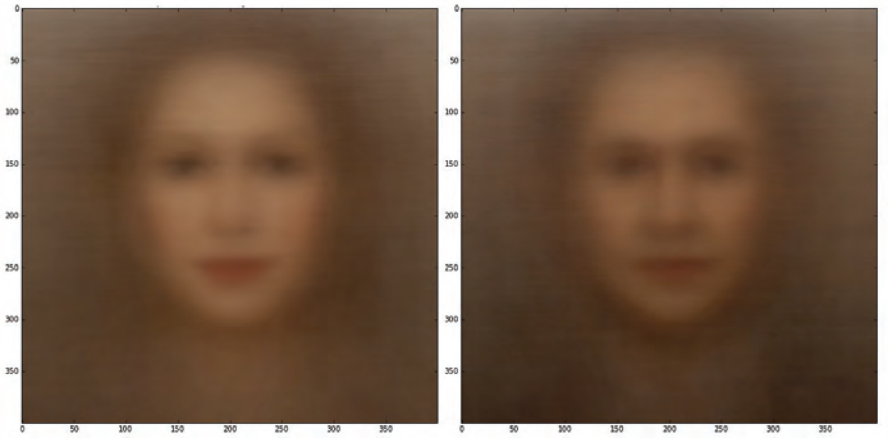

Figure 5: Average 20th Century female face from 1058 faces (left), and male from 1017 faces (right). Average 20th faces © 2014. Courtesy of Javier de la Rosa.

4. Analysis

Our analysis reveals a particular decline in face averageness and symmetry that seems to corroborate changing tendencies from one artistic style to another (Figure 6). Interestingly, the ratio of faces per painting in the past century is at its lowest level in our study; one encounters many paintings from that era, but not many that depict human faces.

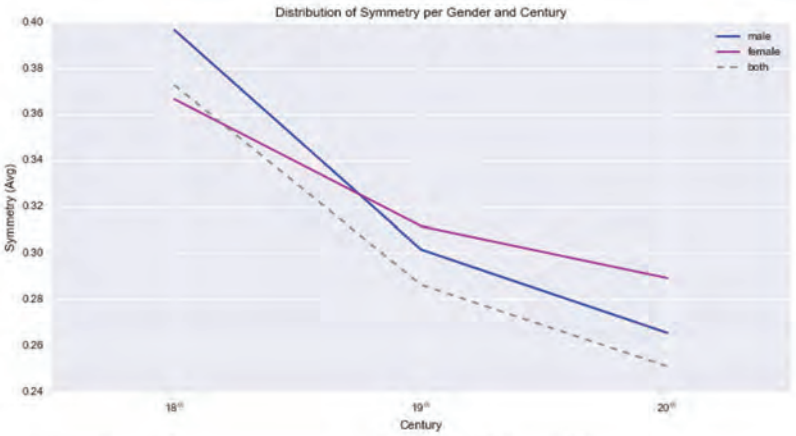

Figure 6: Values of symmetry per gender from 18th to 20th century (symmetry of 1 indicating perfect symmetry; 0 meaning total asymmetry). Values of symmetry © 2014. Courtesy of Javier de la Rosa.

The face averageness graph exhibits a sharp decline from the 18th century onwards; it demonstrates a complete break from artistic representations of beauty established according to conventions of symmetry (Figure 7). Results of this analysis highlight a change in beauty perception in the 20th century and a newfound preoccupation for discovering and depicting varying types of facial representations.

The objectivist conception of beauty, defined in terms of balance, proportion, and symmetry among other elements, reached its peak during the 16th century.[11] At that time, canons of beauty were printed in books for artists to follow in order that they too achieve similar beauty in their work. Throughout the next century, painting styles continued to adopt these patterns, although artists gradually favoured a representation of the human body that appeared closer to reality. The 18th century Rococo and Neoclassicism styles adhered to strict conventions of symmetry and realistic depictions of the human anatomy, in comparison to Impressionism and Avant-Garde styles that broke with this rule. Our findings indicate that the representation of individuals depicted in art deviated from the classical canon, changing from the realistic to the abstract, from bearing

resemblance to natural human anatomy to highlighting facial features particular to Picasso's paintings, for example.

Our study also indicates that people's features were most attractive in the 18th century according to the data we collected and analysed. This art style focused on a realistic depiction of subjects unlike in the 20th century but like the Renaissance, Romanticism, or Gothic eras.[12] These art movements occurred in a period of considerable scientific development that enabled an expansion of knowledge about the composition of the human body. An example of this is apparent in the famous 17th century painting by Rembrandt, where the Dutch painter depicted Anatomist Dr. Nicolaes Tulp during an anatomy lesson. New intellectual inquisitiveness flourished among artists that led them to innovate in art, notably in painting. Manipulations in style and content were facilitated by technological advances of the time influencing art forms.

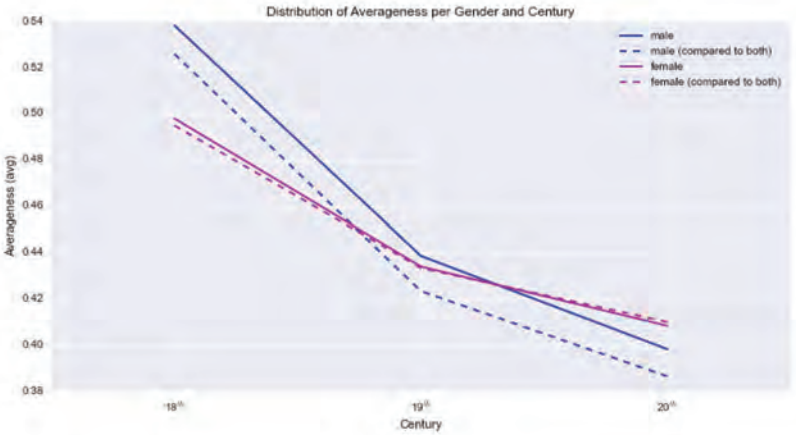

Figure 7: Values of averageness per gender from 18th to 20th century (averageness of 1 indicating the most average face; 0 meaning not average at all). Values of averageness © 2014. Courtesy of Javier de la Rosa.

5. Discussion

This study reveals a decrease in perceived beauty since the 18th century. We speculate that the highest values of facial attractiveness in paintings, as approximated by symmetry and averageness, occurred somewhere in between 16th and 17th centuries. This was the period when the first guidebooks were produced demonstrating to artists how to combine different techniques and methods to achieve aesthetic beauty. It was a time when significant knowledge about the human body was established. Unfortunately, due to a lack in accuracy and an

insufficient number of sample paintings in our dataset, we do not have enough confidence to support this assertion quantitatively.

Other factors, as well, seem to affect our understanding of these findings. The first is the use of algorithms designed to recognize faces in pictures, but applied to artwork. Commonly, algorithms help with face recognition, notably to detect skin, but their performance seems to differ depending on the colour spaces they help assess.[13] This may produce some false negative results compared to painting styles of the last century. In addition, any algorithm suitable to detect faces in pictures is involuntarily biased against new expressions of art, such as Cubism and Surrealism. Nevertheless, faces depicted do not necessarily need to maintain a faithful representation.

As well, the sampling issue warrants discussion. Regardless of the extent of the dataset collected, we concluded that we will never know whether people depicted in paintings are representative of the population they were sampled from. And the problem is further complicated when one realizes that the subjects in a painting are very often angels, virgins, saints–common in the Baroque style–or even mythological creatures with human faces.

Moreover, we do not know for certain if the same result applies in a broader sense, or if it is even applicable to subjective measurements of beauty determined by algorithms. To this end, Graham et al. maintain that humans perceive and rank images of beauty differently when viewing real or depicted faces.[14] This effect, they suggest, is due to people's overexposure today to works of fine art. This could be true, depending on the socio-economic level of the subjects as well.

6. Further Research

This study demonstrates that it is possible to extract information and draw conclusions about attractiveness by examining subjects' facial traits in paintings. It indicates that the introduction of the concept of virtual physical space presents further possibilities in the analysis of paintings. As discussed by Zaidel and FitzGerald,[15] a link exists between perceived beauty and the head orientation of the women and men portrayed. The human head is limited to three degrees of freedom in a pose, which can be described by a pitch angle (forward to backward movement of the neck), a roll angle (frontal lateral bending), and a yaw angle (right to left rotation of the head). One possibility is to plot histograms from -90º (right profiles) to 90º (left profiles), for each angle throughout different time periods and art styles. A value of 0º in all of the three angles will indicate perfect frontal faces. If the assumptions made by Zaidel and FitzGerald are correct, we should find that the most beautiful faces, especially those of the women according to this theory, are turned into one direction rather than the other. Therefore, this result could be either supported or rejected by analysing the pose of the heads identified in our study. Importantly, though, we noted a limitation with respect to the representational fidelity of subjects portrayed in paintings

Because this study has demonstrated a decreasing trend in perceived beauty from the 18th century to the present day, we question what else could be determined about the subjects depicted in the paintings. We see potential beyond the issue of perceived attractiveness and wonder whether we could somehow rely on the subjects in the paintings as a source of demographic information. This constitutes a very interesting line of investigation for future research that could shed light on social distribution in the past. Painting style demography is thus a concept that needs to be further explored. Comparisons between results like those we obtained and the demographic data gathered from historical registries and censuses could help boost historical demographic research. Similarly, one could also examine the preferences of different painters in terms of people they depicted. Age pyramids could be plotted that describe and summarize what one could call 'representational demography'.

Notes

[1] John Bates and Brian Cleese, *The Human Face* (London: Dorling Kindersley, 2001).

[2] Rolf Reber, Norbert Schwarz, and Piotr Winkielman, 'Processing Fluency and Aesthetic Pleasure: Is Beauty in the Perceiver's Processing Experience?' *Personality and Social Psychology Review* 8.4 (2004): 364-382; Vilayanur S. Ramachandran and William Hirstein, 'The Science of Art: A Neurological Theory of Aesthetic Experience,' *Journal of Consciousness Studies* 6 (1999): 6-7.

[3] Yanig Taigman, Ming Yang, Marc Aurelio Ranzato, and Lior Wolf, 'Deepface: Closing the Gap to Human-Level Performance in Face Verification,' *Computer Vision and Pattern Recognition* (2014): 1701-1708.

[4] These extractions were made possible thanks to the application program interface provided by the service Face.com, a company acquired and shut down by Facebook in 2012.

[5] See https://www.worldcat.org/

[6] John F. Cross and Jane Cross, 'Age, Sex, Race, and the Perception of Facial Beauty,' *Developmental Psychology* 5.3 (1971): 433.

[7] Extensively covered in the literature; some relevant sources are derived from Karl Grammer and Randy Thornhill, 'Human (*Homo Sapiens*) Facial Attractiveness and Sexual Selection: The Role of Symmetry and Averageness,' *Journal of Comparative Psychology* 108.3 (1994): 233; David I. Perrett, Kieran J. Lee, et al., 'Effects of Sexual Dimorphism on Facial Attractiveness,' *Nature* 394.6696 (1998): 884-887; Gillian Rhodes and Leslie A. Zebrowitz, 'Facial Attractiveness: Evolutionary, Cognitive, and Social Perspectives,' *Advances in Visual Cognition*, 1 (New York: Ablex Publishing Corporation, 2002).

[8] See Judith H. Langlois and Lori A. Roggman, 'Attractive Faces are Only Average,' *Psychological Science* 1.2 (1990): 115-121. Very attractive faces are usually considered non-average, as concluded by Thomas R. Alley and Michael R. Cunningham, 'Averaged Faces are Attractive, but very Attractive Faces are Not Average,' *Psychological Science* (1991): 123-125.
[9] Studies by Nancy Etcoff, *Survival of the Prettiest: The Science of Beauty* (New York: Random House, 2011); Gillian Rhodes, 'The Evolutionary Psychology of Facial Beauty,' *Annu. Rev. Psychol.* 57 (2006): 199-226; David I. Perrett, et al., 'Symmetry and Human Facial Attractiveness,' *Evolution and Human Behavior* 20.5 (1999): 295-307, partially support this result and complement to each other.
[10] See the famous work by Grammer and Thornhill, 'Human (*Homo Sapiens*) Facial Attractiveness and Sexual Selection: The Role of Symmetry and Averageness,' *Journal of Comparative Psychology* 108.3 (1994): 233.
[11] Ernst H. Gombrich, *The Story of Art* (London: Phaidon Press, 2006).
[12] Ibid.
[13] According to José M. Chaves-González, et al., 'Detecting Skin in Face Recognition Systems: A Colour Spaces Study,' *Digital Signal Processing* 20.3 (2010): 806-823, HSV model, and the models YCgCr and YDbDr, are the colour spaces that better behave in skin detection problems
[14] Daniel Graham, et al., 'Representation and Aesthetics of the Human Face in Portraiture,' *Art & Perception* 2.1 (2014): 98.
[15] Dahlia W. Zaidel and Peter FitzGerald, 'Sex of the Face in Western Art: Left and Right in Portraits,' *Empirical Studies of the Arts* 12.1 (1994): 9-18.

Bibliography

Alley, Thomas R. and Michael R. Cunningham. 'Averaged Faces are Attractive, but very Attractive Faces are Not Average.' *Psychological Science* (1991): 123-125.

Bates, Brian and John Cleese. *The Human Face*. London: Dorling Kindersley, 2001.

Chaves-González, Jose M., Miguel A. Vega-Rodríguez, Juan A. Gómez-Pulido, and Juan M. Sánchez-Pérez. 'Detecting Skin in Face Recognition Systems: A Colour Spaces Study.' *Digital Signal Processing* 20.3 (2010): 806-823.

Cross, John F. and Jane Cross. 'Age, Sex, Race, and the Perception of Facial Beauty.' *Developmental Psychology* 5.3 (1971): 433.

Etcoff, Nancy. *Survival of the Prettiest: The Science of Beauty*. New York: Random House, 2011

Gombrich, Ernst H. *The Story of Art*. London: Phaidon Press, 2006.

Graham, Daniel, Pamela M. Pallett, Ming Meng, and Helmut Leder. 'Representation and Aesthetics of the Human Face in Portraiture.' *Art & Perception* 2.1 (2014): 98.

Grammer, Karl and Randy Thornhill. 'Human (*Homo Sapiens*) Facial Attractiveness and Sexual Selection: The Role of Symmetry and Averageness.' *Journal of Comparative Psychology* 108.3 (1994): 233.

Langlois, Judith H. and Lori A. Roggman. 'Attractive Faces are Only Average.' *Psychological Science* 1.2 (1990): 115-121.

Murphy-Chutorian, Erik and Mohan M. Trivedi. 'Head Pose Estimation in Computer Vision: A Survey.' *Pattern Analysis and Machine Intelligence, IEEE Transactions On* 31.4 (2009): 607-626.

Perrett, David I., Kieran J. Lee, Ian S. Penton-Voak, Duncan A. Rowland, S. Yoshikawa, D. Michael Burt, S. P. Henzi, D. L. Castles, and S. Akamatsu. 'Effects of Sexual Dimorphism on Facial Attractiveness.' *Nature* 394.6696 (1998): 884-887.

Perrett, David I., D. Michael Burt, Ian S. Penton-Voak, Kieran J. Lee, Duncan A. Rowland, and Rachel Edwards. 'Symmetry and Human Facial Attractiveness.' *Evolution and Human Behavior* 20.5 (1999): 295-307.

Ramachandran, Vilayanur S. and William Hirstein. 'The Science of Art: A Neurological Theory of Aesthetic Experience.' *Journal of Consciousness Studies* 6 (1999): 6-7.

Reber, Rolf, Norbert Schwarz, and Piotr Winkielman. 'Processing Fluency and Aesthetic Pleasure: Is Beauty in the Perceiver's Processing Experience?' *Personality and Social Psychology Review* 8.4 (2004): 364-382.

Rhodes, Gillian. 'The Evolutionary Psychology of Facial Beauty.' *Annu. Rev. Psychol.* 57 (2006): 199-226.

Rhodes, Gillian and Leslie A. Zebrowitz, 'Facial Attractiveness: Evolutionary, Cognitive, and Social Perspectives,' *Advances in Visual Cognition*. Vol. 1. New York: Ablex Publishing Corporation, 2002.

Taigman, Yaniv, Ming Yang, Marc'Aurelio Ranzato, and Lior Wolf. 'Deepface: Closing the Gap to Human-Level Performance in Face Verification.' *Computer Vision and Pattern Recognition* (2014): 1701-1708.

Zaidel, Dahlia W. and Peter FitzGerald. 'Sex of the Face in Western Art: Left and Right in Portraits.' *Empirical Studies of the Arts* 12.1 (1994): 9-18.

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