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Seeing double: Leonardo's Mona Lisa twin

J. F. Asmus[1] · V. A. Parfenov[2,3] · J. P. Elford[1]

Abstract The conventional scientific tests employed in authenticating paintings are useful in excluding a work if, for a particular artist, incorrect parameters are discovered. For example, the date may be wrong (e.g., radio carbon dating), a pigment may be wrong (e.g., modern formulation), or an implausible underpainting or sketch may be revealed (e.g., X-ray or IR image). In contradistinction, an original approach is proposed to identify individual "fingerprints" for particular artists' hands (brushwork). It entails extracting luminosity histogram statistics of a painting in order to quantify its sfumato/chiaroscuro properties for either entire compositions or particular features (e.g., eyes, noses, or lips.) It is proposed that a work may be associated with a particular artist, rather than be excluded from the generally accepted body of work. Paintings by Leonardo and Rembrandt as well as pertinent copies and forgeries are employed as test cases. Luminosity histogram statistics for several contemporary paintings are also included to enlarge the data library. In order to illustrate the utility of this approach in characterizing and identifying an artist's technique, particular attention was addressed to the issue of the possibility of two individual Mona Lisa portraits by Leonardo. This focused on an analysis of the properties of a painting formerly known as the Pulitzer/Isleworth Portrait and, subsequently, as the

✉ J. F. Asmus
   jfasmus@ucsd.edu

1   Department of Physics and Center for Advanced Nanotechnology, University of California, San Diego, 9500 Gilman Dr., La Jolla, CA 92093-0319, USA

2   Department of Quantum Electronics and Opto-Electronic Devices, St. Petersburg Electrotechnical University, Popova str., 5, St. Petersburg, Russian Federation 197376

3   Department of Laser Technological Systems, National Research University ITMO, Kronverksky pr., 49, St. Petersburg, Russian Federation 197101

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"Earlier Mona Lisa, EML" by Leonardo da Vinci, after protracted scientific, historic, aesthetic, and geometric investigations.

1 Background

It is a curious fact that Leonardo da Vinci painted two versions of what have become his most celebrated artworks. Most notable of these famous pictures are his "Virgin of the Rocks" (London National Gallery and Louvre), "Virgin and Child" (Hermitage and Munich Alte Pinakothek), and "The Virgin and Child with St. Anne" (London National Gallery and Louvre.) For centuries there has been speculation concerning the possible existence of a second Mona Lisa, as well. Countless Mona Lisa copies have surfaced through the ages and several have been advanced as the long-lost "Second Mona Lisa", only to be dismissed after failing scientific or historical scrutiny. Twenty-seven years ago the heirs of the late Henry Pulitzer asked us to examine a painting known as the "Isleworth Mona Lisa" that was in the family collection of fine art. This invitation was extended in response to our 10-year study of the varnishes, craquelure, and pentimenti of the Louvre "Mona Lisa." These studies led to the conclusion that the intricate geometrical principles employed in the two paintings were identical even though individual features are different in both size and proportion. Thus, it was clear that the Isleworth portrait was not a mere copy of the painting in the Louvre. In the subsequent 27 years the Isleworth painting has passed virtually every comparative scientific test available in art conservation science with respect to the "Joconde" portrait in the Louvre Museum. These tests include pigment analyses, multispectral and hyperspectral imaging, 3D imaging, isotopic measurements, geometrical analyses pertaining to the Vertruvian proportion and golden ratio, radiocarbon dating, infrared scanning, and digital-image age regression (employing FBI programs pertaining to facial recognition.) In addition the Isleworth Mona Lisa has been visually inspected by a number of notable Leonardo experts.

2 Introduction

Even the most superficial perusal of the literature on art history convinces one that no other artwork is embedded in as much controversy, speculation, and mystery as the *Mona Lisa* (Clark 1952, 1973; Gombrich 1967; Pedretti 1973; McMullen 1975). Among these issues are its chronological position in Leonardo's works, its meaning, the symbolism, and the identity of the woman in the portrait. Through the ages prodigious energies have been absorbed into controversies about the execution date (or dates) of the portrait. The artistic, historical, and philosophical concerns that hinge on this are too numerous, convoluted, and erudite to be summarized adequately here. Suffice it to say that on largely stylistic grounds, Pedretti dates the Louvre painting to 1513–1516. The position taken by Lord Kenneth Clark dates it to after 1510 on stylistic grounds, but the historical evidence points to 1503 (Clark 1952, 1973).
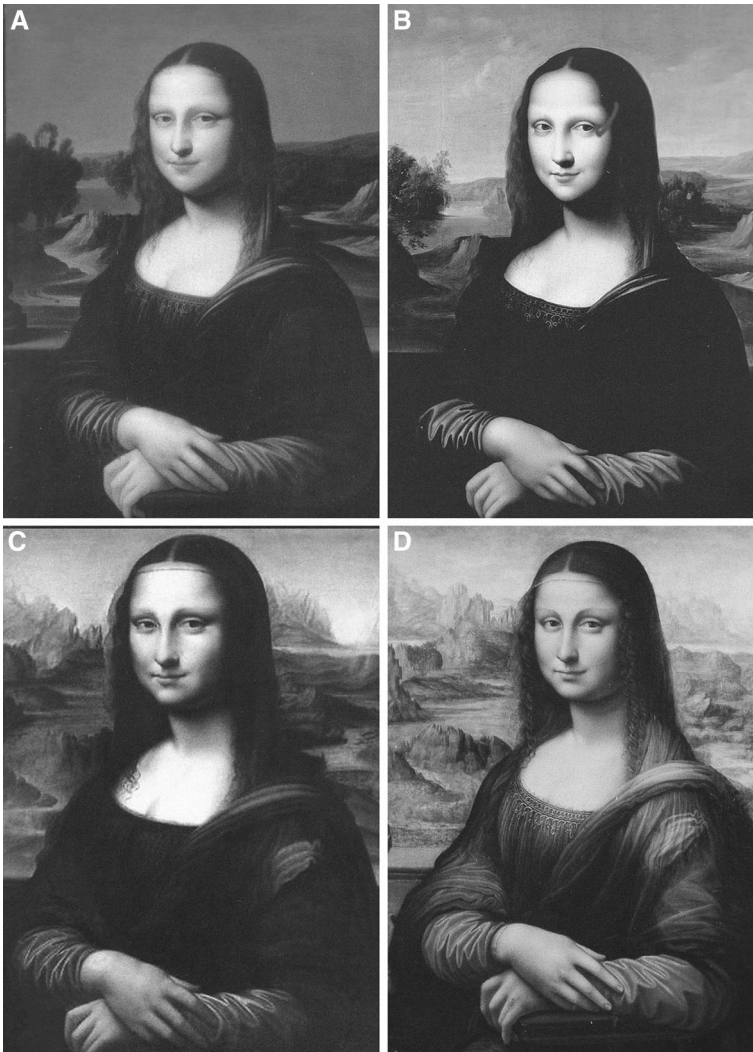
Fig. 1 Four well-known copies of the Leonardo *Mona Lisa*: Oslo (**a**), Flemish (**b**), Reynolds (**c**), and Prado (**d**)

Leonardo's reason for producing duplicate versions of three of his other significant works is unclear. These are his *Virgin of the Rocks*, the *Virgin and Child,* and the *Virgin and Child with St. Anne*. Through the ages this recognition has triggered speculation that there may have been a second *Mona Lisa* by Leonardo, as well. A number of paintings have been advanced as a second Mona Lisa, especially since the historical documentation points to two commissions and two separate paintings. Figure 1 shows four famous examples of *Mona Lisa* copies.

The art connoisseur Hugh Blaker acquired a Mona Lisa painting in 1913 and placed it on display at his Isleworth studio near London. The apparent youth of the lady compared to
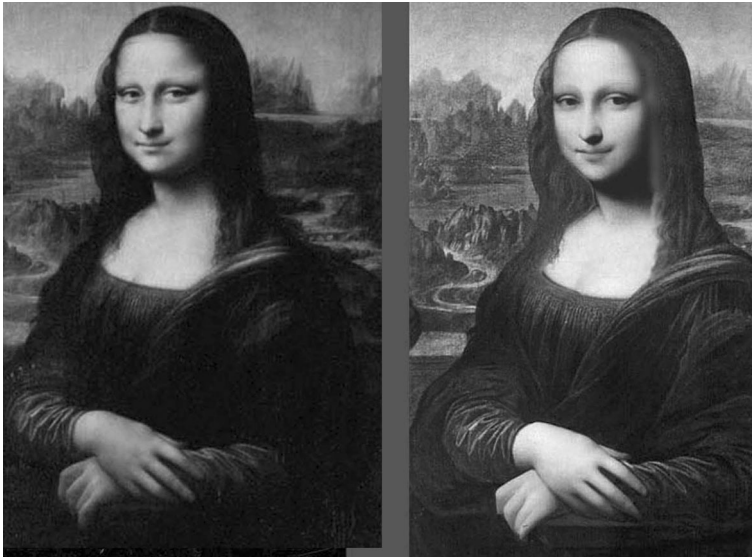
Fig. 2 The *Mona Lisa* in the Louvre Museum (*L*) and the Isleworth (Earlier) version (*R*) embedded in the background of the Louvre painting

the figure in the Louvre *Mona Lisa* (see Fig. 2) as well as a completely different background clearly established that this painting was not simply a copy of the portrait in the Louvre. A number of art experts asserted that the painting, identified then as the *Isleworth Mona Lisa*, was of such a high quality that it had to be by hand of Leonardo da Vinci. In a NY Times column, P.G. Konody was unrestrained in his enthusiasm for the quality of the piece as well as its proportions and the arrangement of its elements:

From the New York Times, February 15, 1914

"Another version, in a far purer state and possibly by the hand of the master himself, is, or was until recently, in a private collection at Isleworth… Let it be said at once, the picture in question has nothing whatever to do with any of the innumerable early or late French copies which have from time to time been boomed into prominence. It is not only vastly superior to all of them, but it is of such superb quality that it more than holds its own when compared with the much-restored and repainted Louvre masterpiece. What is even more significant is that it is in no sense of the word a "copy", but varies in some very important points from the Paris 'Mona Lisa'. The design is altogether different. There is far more background; the spacing is infinitely more pleasing; the head is inclined at a different angle; the background is quite different and far less assertive than in the Paris picture; the features are more delicate, and, let it be boldly stated, far more pleasing and beautiful than in the Louvre version."

This passage was contributed by **P. G. Konody**, the widely-known and internationally respected art expert and critic.[1]

3 Early scientific analyses of the Isleworth Mona Lisa

By 1989 the Isleworth Mona Lisa was in the hands of the Pulitzer Estate and an arrangement was made for a cursory scientific examination to determine whether the visual features of the painting were consistent with Leonardo's style and technique. This initial study was necessarily of limited scope as the artwork could not be touched or removed from its storage vault. Consequently, the analyses were performed on photographs taken at the storage facility in Lausanne. Upon digitizing these photographs and inspecting proportions and alignments it became evident immediately that the Isleworth painting was not a copy of the Louvre *Mona Lisa* that we had been studying and analyzing for the previous 10 years (Asmus and Katz 1988; Asmus 1989). On the other hand it was clearly demonstrated that the artist's strategy in aligning elements in the compositions followed identical rules. It was also found that major contours in both paintings were composed of nested ellipses. Although the elliptical nesting principles were the same, the major and minor axes are different. Figure 3 displays illustrations of these observations. Of course
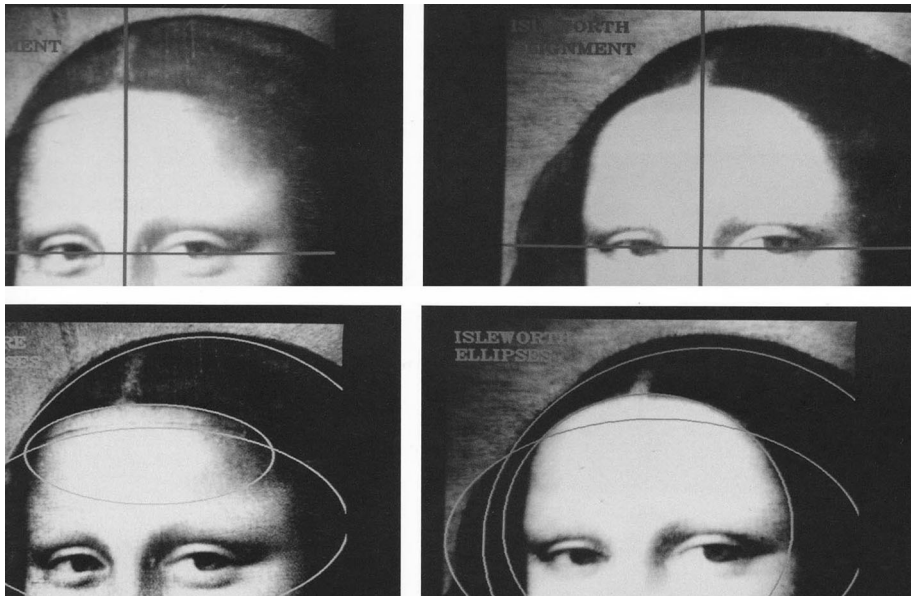
Fig. 3 The Examples of the initial comparisons of the geometries of the Louvre (*L*) and Isleworth (*R*) *Mona Lisas*

these findings do not prove that the Isleworth portrait was executed by the hand of Leonardo, but they are consistent with Leonardo's principles of composition. It is certainly probable that other artists, and especially Leonardo's students, might have adopted similar rules of design. Consequently, further analyses were undertaken with the digitized images to investigate the statistics of the shading and contrast profiles of the two portraits and evaluate their conformity as another marker for the hand of Leonardo. These ''Histogram'' studies are described in the next section.

4 Luminosity histograms to characterize Leonardo's sfumato/chiaroscuro technique

Artistic paintings possess spatial and spectral characteristics. The issues of sfumato and chiaroscuro are emphasized in the writings of Leonardo da Vinci on the subject of the painters' technique (Pedretti 1973). Basically, sfumato/chiaroscuro pertain to the blending of color saturation and albedo from one region of a painting to adjacent zones. When a connoisseur visually assesses a painting, this spatial blending and contrast are significant features that the expert perceives and mentally evaluates. This impression is then correletated in the inspector's mind with impressions of similar authenticated works by the relevant artist. The problem with this approach to attribution is that it is highly subjective.

Fortunately, in modern times the process of attribution may be augmented in several ways including through the application of a range of scientific analyses. For the most part currently employed scientific examinations focus on materials. For example dating techniques (e.g., radio carbon 14) reveal whether the artwork (usually the support) matches the period when the artist in question was active. Similarly, pigment compositions (trace
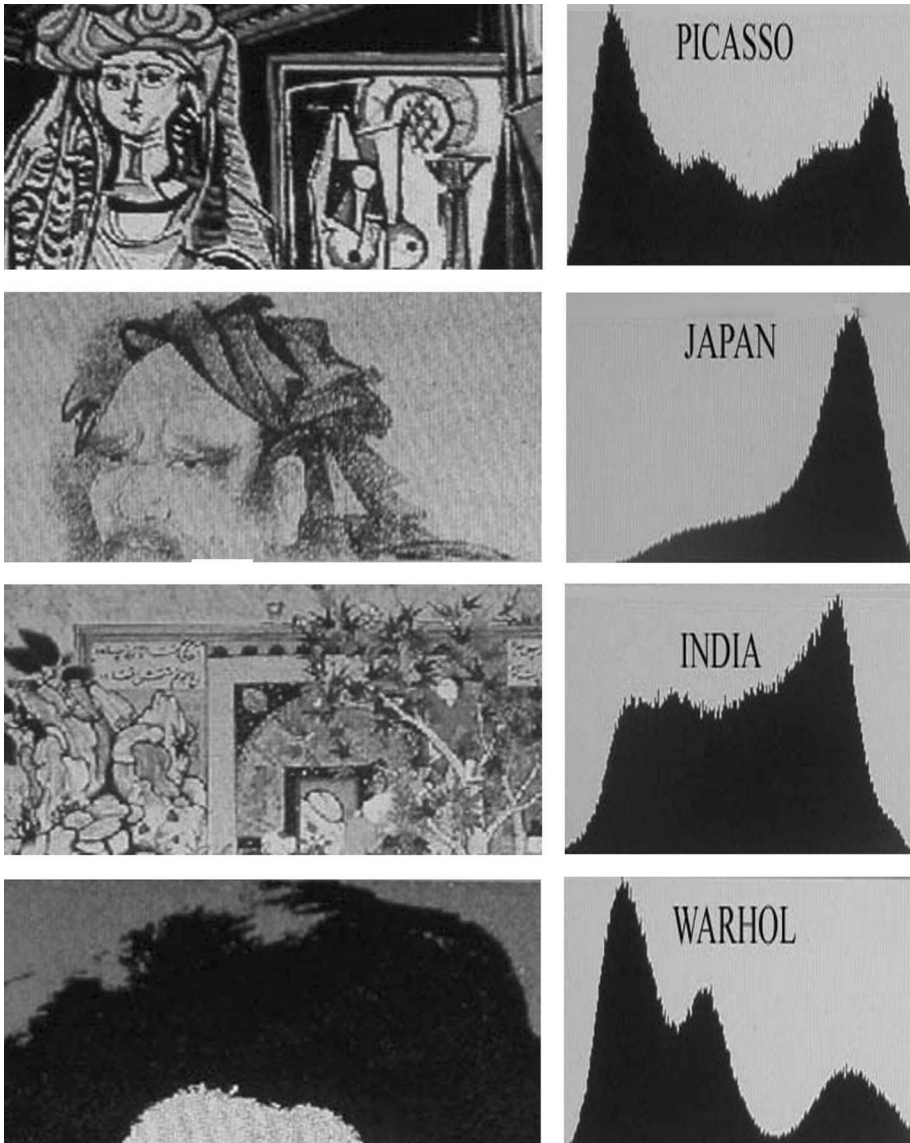
Fig. 4 The Examples of paintings and drawings that are devoid of any measure of blending

elements, chemicals, and isotopic ratios) can be matched with those known to be employed by the artist and available at the time. X-ray and IR imaging reveal underlying strata that often yield clues to the provenance and execution of an artwork. The principal limitation to virtually all of these analytical techniques is that they can lead to the exclusion of a work from consideration as being from the hand of the artist of interest (e.g., wrong age, wrong pigments, wrong support, or inappropriate under drawing), but are unable to prove that a work is by a particular artist. What is needed is a positive test that is akin to DNA matching in forensic science.
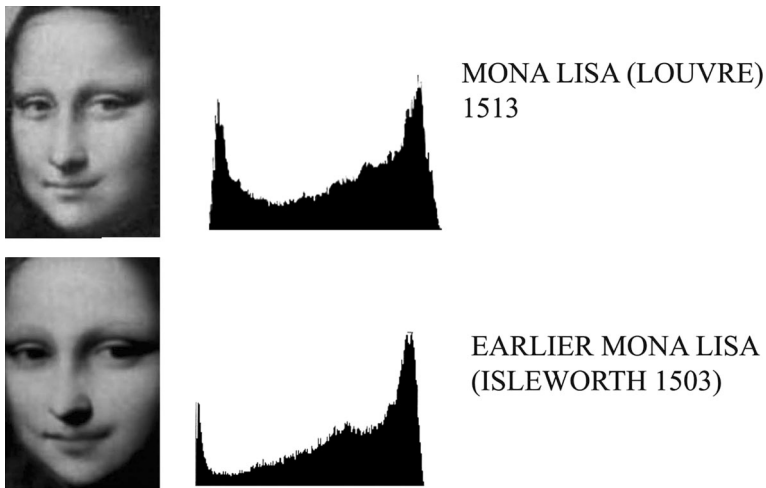
Fig. 5 The Luminosity histograms of the faces of the Louvre *Mona Lisa* (*top*) and the Isleworth Earlier Mona Lisa (*bottom*)

The intent of the analysis described next is to explore a positive test (in contradistinction to customary exclusionary tests) to substantiate hypotheses pertaining to connections between particular artists and particular artworks with the Isleworth *Mona Lisa* as a test case. In other words the goal is to establish a rigorously scientific, rather than subjective, "finger print" that identifies the brushwork of an individual artist.

Pixels in typical digital image formats range over 256 intensity levels. Many digital image-processing (IP) programs incorporate a "histogram" feature. The histogram "luminosity" option counts the number of pixels (of an image or a specified region of an image) for each of 256 intensity levels. The graphical plot of these counts versus intensity is known as a histogram. When there is a high degree of pigment blending extending from the light to dark portions of a painting, this will yield a uniform and gentle gradient in pixel distribution between the highest and lowest intensity values. Thus, histograms of features in Leonardo paintings exhibiting sfumato/chiaroscuro should be smooth without discontinuities or abrupt transitions. This is best illustrated through histograms of paintings where there has been no attempt at soft blending of features as in the following examples (Fig. 4). The Picasso piece has a high-intensity peak (R) and a low-intensity peak (L) with an irregular distribution in between. The Japanese drawing is essentially monochromatic with a single peak. The Indian art lacks any hint of chiaroscuro, as there is no evident shift between light and dark. Finally, the Warhol painting has three intensity levels, without evidence of any blending.

Earlier histogram studies of an artist's technique were performed on the Rembrandt self-portraits (Asmus 1992). This study was performed through a collaboration with the Rembrandt Research Project and the results for the Rembrandt self portraits were consistent with the results from analytical, historical, and stylistic evaluations. Figure 5 displays the histogram for the face of the Isleworth (Earlier, EML) *Mona Lisa* (Asmus et al. 1987) and for a "corrected" image of Louvre *Mona Lisa* (LML). The "corrected" image was utilized as the EML is well conserved whereas the LML has been heavily restored and revarnished with numerous webs of cleavage (Asmus 1990). It is seen that the histograms for the two paintings have a very similar smooth character.
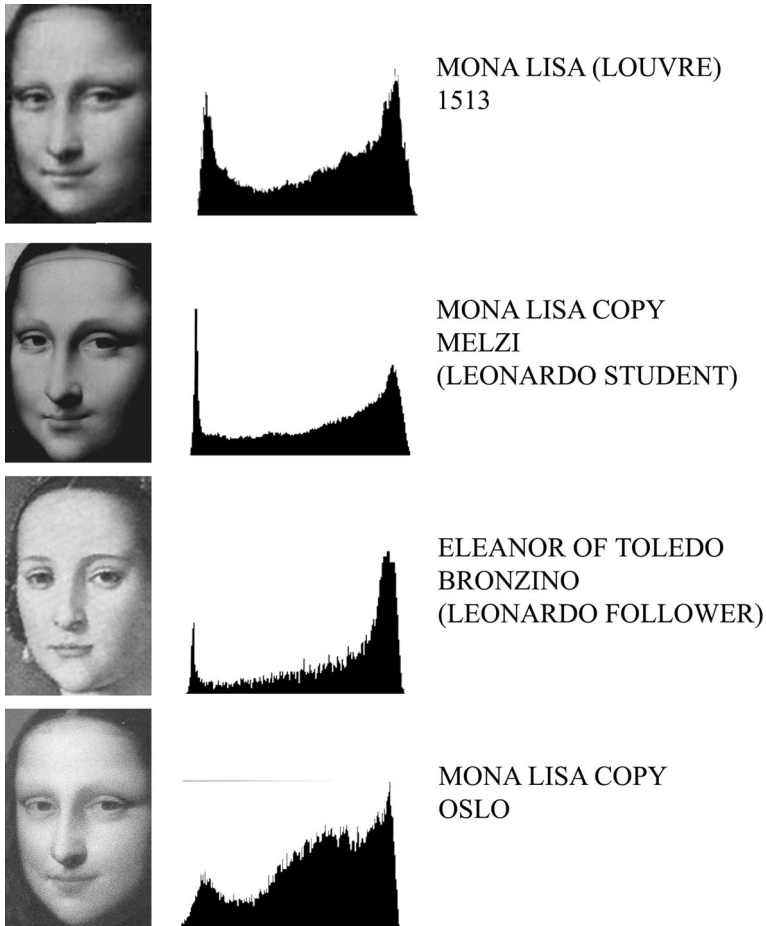
Fig. 6 Luminosity histograms for the Louvre *Mona Lisa* (LML) at the *top* and three copies

Figure 6 displays the LML histogram with those for three related paintings (copies and/ or Leonardo school). The histograms of the related paintings have a distinctly different character from that of the LML. It is possible to determine the mathematical mean and variance of a histogram in order to attempt a rigorous comparison, but these values are subject to minor differences in the composition of a figure. Unfortunately, the act of interpreting and comparing histograms is also somewhat subjective, just as is a visual inspection by an expert.

5 A 3D statistical fingerprint

It is desirable to compare histograms in a more rigorous and mathematical manner than is described above. Thus, by noting that it was customary for master artists such as Leonardo to concentrate on important features of portraits themselves and frequently leave less important aspects to assistants, it follows that in portraits it would be eyes, nose, and mouth

Fig. 7 3-D plot of the statistical variances of three regions (eyes, noses, and mouths) of five *Mona Lisa* paintings (Louvre, LML, and Earlier/Isleworth, EML, versions as well as the Prado, Oslo, and Flemish copies)
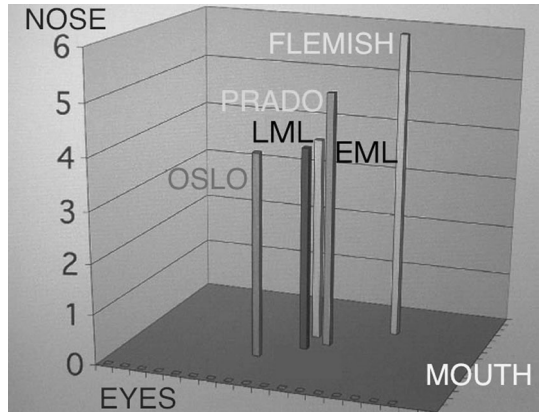
that Leonardo would have focused upon. It may be supposed that individual artists would each have an aesthetic sense of the shading and the relationships of these three important features. Consequently, histograms were generated of eyes, noses, and mouths of the ladies in several portraits. The mathematical statistical variances of the three features for each painting were entered on a 3D plot. It was reasoned that this diagram of the statistical spread would reveal an explicit display of different artists' sense of shading, sfumato, and chiaroscuro. In the Fig. 7 example it is evident that EML (Earlier *Mona Lisa*) and LML (Louvre *Mona Lisa*) have almost identical "fingerprints" and are far removed from the statistical properties of the Prado, Oslo, and Flemish-school copies. More research is currently underway establishing a more extensive data base, which should lead to a reliable test for the eye and hand of Leonardo.

6 Conclusion

In concert with the facial age regression studies, the series of comprehensive scientific histogram investigations described above have demonstrated that Leonardo painted two Mona Lisas: the Isleworth/Pulitzer being the first (1503) and the Louvre portrait (1513) being the second. The totality of the evidence, both scientific and historical, promoting this conclusion exceeds that associated with almost any other major attributed work of art. In addition, the mathematical characterization of an artist's hand (a style and technique "fingerprint") through histogram statistics has been validated for paintings by Leonardo and Rembrandt for which there are copious supporting data from other analytical tests. Thus, if validated for still additional artists, rigorous application of digital mathematical histogram statistics will aid in advancing connoisseurship from a more subjective to a more objective discipline.

7 Future investigations

At this point there are only a small number of paintings for which the variance statistics of lumosity histograms have been investigated. There are countless cases where authentic and forged paintings of particular artists have been rigorously documented. The next step in our

efforts to verify this method of characterizing an artists hand will be to broaden and extend the data base of examples. However, the results reported here add considerable weight to extensive body of analytical evidence establishing that the Isleworth painting is in fact Leonardo's earlier version of the *Mona Lisa* (1503) and the version in the Louvre is from 1513 (The Mona Lisa Foundation 2015).

References

Asmus, J.F.: Computer studies of the Isleworth and Louvre Mona Lisas. Opt. Eng. **28**(7), 800–804 (1989)

Asmus, J.F.: Computer studies of the Isleworth and Louvre Mona Lisas. *SPIE Milestone Ser.* **MS 13**, 652–656 (1990)

Asmus, J.F.: Computer image studies of rembrandt self portraits. Hum. Vis. III **1666**, 436–445 (1992)

Asmus, J.F., Katz, N.F.: Digital image processing applied to problems of art and architecture. Appl. Digit. Image Process. XI **974**, 278–282 (1988)

Asmus, J.F., et al.: Computer enhancement of the Mona Lisa. Perspect. Comput. **7**, 11–22 (1987)

Clark, K.: Leonardo da Vinci. Univ. Press, Cambridge (1952)

Clark, K.: Mona Lisa. Burlington Magazine Press, Cambridge (1973)

Gombrich, E.H.: The Story of Art. Phaidon, London (1967)

McMullen, R.: Mona Lisa. Houghton Mifflin, Boston (1975)

Pedretti, C.: Leonardo: A Study in Chronology and Style. Univ. of Cal. Press, Berkeley (1973)

The Mona Lisa Foundation: Leonardo da Vinci's Earlier Mona Lisa. The Mona Lisa Foundation, Zurich (2015)