

SPECIAL RELATIVITY: ALBERT EINSTEIN TO LEONARDO DA VINCI

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1. Introduction

Einstein's musicianship is widely recognized (Figure 1), whereas the role of the engineer, Michele Angelo Besso, in the "Theory of Special Relativity" is seldom appreciated in spite of Einstein's dedication at the close of his paper, which reads: "In conclusion I wish to say that in working at the problem here dealt with I have had the loyal assistance of my friend and colleague M. Besso, and that I am indebted to him for several valuable suggestions". For centuries the Besso family owned and operated an electrical-contracting business in Milan. Furthermore, Albert Einstein and Francesco Melzi found periodic employment in the Besso firms and also resided with the Besso family, as did Leonardo. Upon the death of Leonardo, his protegee and heir, Melzi, returned to Milan and, presumably, lived with the Besso family for a time. Naturally, he would have had in his possession both the inherited items from

Leonardo's estate as well as his personal belongings, including paintings he had produced as an apprentice and student under Leonardo's inspiration and guidance. It is clear from their more than fifty years of correspondence (Collection Savoir) that both Albert Einstein and Michele Besso were deeply interested in the intersection of art and science and the Besso family's art collection. Thus, it is more than plausible that the Besso family would have come into possession of at least a gift from Francesco Melzi, if not his entire material legacy, including his own paintings. As Leonardo's visitors to Château de Cloux in France on 10/10/1517, Cardinal Luigi of Aragon and Antonio de Beatis, wrote and spoke highly of a paint-

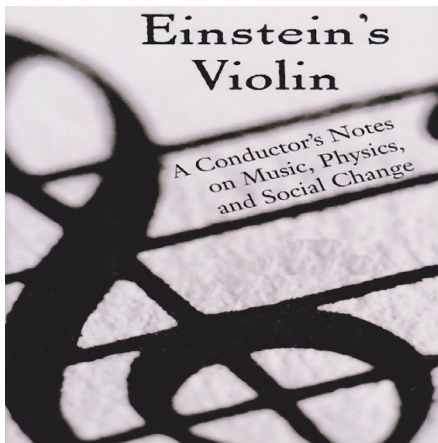


Figure 1. Einstein was the most famous physicist of the 20th Century and an accomplished violinist.

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Figure 2. The “Mona Lisa” painting in the Besso’s family art collection, originally located in their Milan residence for several generations.

ing now believed to be the Louvre “Mona Lisa,” there is little room for doubt that Melzi would have also executed a “Mona Lisa” study and copy as a Leonardo student, “family” member, and apprentice. The Besso family has assumed for several generations that a “Mona Lisa” painting in their possession (Figure 2) is in fact such a painting, executed by Melzi.

The current owner of the painting (Dr. Vittorio Besso, ophthalmologist) visually examined the painting a number of times and determined that there were signs of restoration and retouching. As a result of attending the international conference LA-CONA V (Lasers in Conservation of Artworks) in Paris in 2001, and excited by the efficiency of the laser cleaning technique for removing dirt layers and overpainting, Dr. Besso subsequently performed laser ablation of some overpainting, in his ophthalmological studio in Imperia, which revealed pentimenti.

He divested a small area of heavy impasto with his ophthalmological Nd:YAG laser and revealed what appeared to be faint hints of a signature. Then, infrared photographs were next taken of the laser-divested surface in order to enhance the visibility of the pentimenti.

2. Experimental results

2.1. Infrared imaging of the signature pentimenti

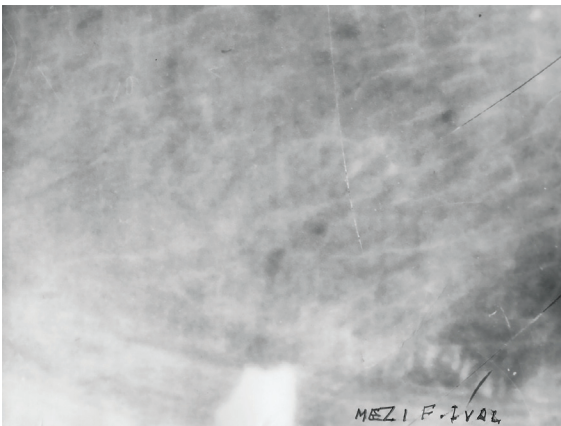


Figure 3. Annotated infrared photograph of the laser-divested bosom-region of the “Mona Lisa” painting in the Besso’s art collection.

The infrared photographs of the Besso “Mona Lisa” painting were taken by one of the authors of the paper (John Asmus) with a conventional 35 mm photo-camera loaded with infrared-sensitive film and employing a visible-light-blocking filter. Figure 3 displays the IR image of the bosom area that was laser-divested of heavy overpainting. Dr. Besso added the hand-written annotation displaying a customary Melzi signature which appears similar to the enhanced pentimenti geometry of that region.

2.2. Comparison of signatures

The initial approach to the possible Melzi authorship of the Besso Mona Lisa was the study of the autograph (signature), which was found as a result of IR imaging of the pentimenti. We resolved to compare the pentimenti image with known autographs by Melzi. Some authentic Melzi signatures were found in the book “Leonardo da Vinci on painting” written by Carlo Pedretti [1]. In this book Pedretti reproduced several of Melzi’s signatures including one of 1511 (Figure 4). This seems to be a strange writing of his name (“Francesco di Melzo”), but in any case, the style of this writing script differs significantly from that of the pentimenti.



Figure 4. Signature of Melzi (a) and pentimenti in the Besso Mona Lisa(b).

2.3. Comparison of chiaroscuro data of the Besso Mona Lisa with Melzi paintings

To more deeply investigate the hypothesis of the authorship of Francesco Melzi to the Besso “Mona Lisa”, we applied our approach to image processing, which is based on the use of luminosity histograms of digitized images. This approach is based on the following general concept. As any painting requires a great many brushstrokes in its execution, it follows that the resulting painted surface will have spatial and spectral morphologies that are characteristic of that artist’s eye for composition, the types of brushes used, the palette, the mixing technique, the speed of execution, the use of glazes, the care in blending, the viscosity of the paint medium, etc. This means that paintings may possess spatial and spectral characteristics that are typical for one particular individual. One possible way of portraying statistical characteristics of an image is through an amplitude (luminosity) histogram. An amplitude histogram is a graphical plot that indicates the distribution of brightness levels throughout a pictorial scene. Histograms are essentially “fingerprints” of the distribution of light and dark shading in the image of a painting. In other words, it is a *quantification* of chiaroscuro, which is of central significance in the paintings of some artists (see, for instance [2] and [3]). It is possible that every artist in executing his works develops an envelope of shadings that are a unique characteristic of his hand and eye. If so, one can find a digital “fingerprint” for each artist by means of histograms from digital images of his paintings.

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 correlated 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. From this point of view, luminosity histograms provide an alternative and/or supplement to conventional stylistic analyses, because it can be done objectively and with mathematical precision.

Pixels in all typical digital image formats range over 256 intensity levels. Many digital image-processing computer 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 an amplitude 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 paintings of masters, which are characterized by a very precise technique (i.e. exhibiting sfumato/chiaroscuro) should be smooth without discontinuities or abrupt transitions. In such a case, if another painting, which was most likely created by the same artist, also has similar very uniform distribution of histograms, there is a high probability that this is a “fingerprint” candidate. It is important to add that each luminosity histogram is characterized by two main mathematical parameters: mathematical mean and standard deviation. The latter is an important parameter for the characterization of chiaroscuro. Therefore, obtaining histograms of digital images of different paintings allows one to compare the shape of the distribution of intensities and value of their standard deviations. It is obvious that paintings created by the same artist may have similarities in technique following these two criteria. This is the central concept of our method for quantifying style. Previously, we successfully applied this approach to analyses of a number of paintings by various artists [4-8].

In response to preceding arguments, we have compared the digital chiaroscuro statistics of the Besso portrait with those of accepted Melzi paintings, as well as Leonardo works, in order to discover the provenance of this painting. These results may reinforce the contention that the Besso “Mona Lisa” may have been painted by Melzi. This result is also consistent with the supposition that as student, heir, and companion, Melzi would certainly have produced his own version of what became Leonardo’s most notable work. With the autograph on the Besso “Mona Lisa” it is possible that the portrait (Figure 3) in the Besso family collection was painted by Melzi. However, it may not be rigorously possible to distinguish whether the faint signature pentimenti revealed in the Besso painting is by the hand of Melzi, a forger, or a restorer.

An initial “baseline” was established through a comparative analysis of the Besso “Mona Lisa” and the Louvre “Mona Lisa”. Significant differences between histograms of these 2 paintings (Figure 5) leads to the conclusion that the Besso “Mona Lisa” was not created by Leonardo Da Vinci.

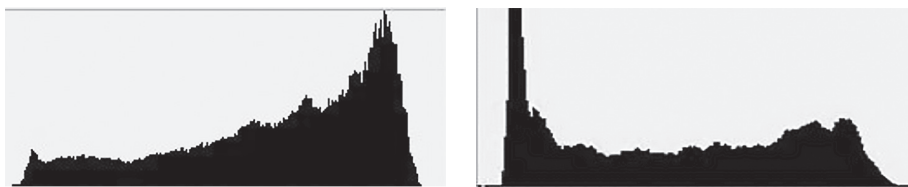


Figure 5. Histograms of image of the Mona Lisa face: Louvre Mona Lisa (left), Besso Mona Lisa (right)

The next stage in this study was to carry out a comparative analysis of the Besso “Mona Lisa” and some of the most famous paintings by Melzi: “Flora” (The State Hermitage Museum, St. Petersburg, Russia), “Vertumnus and Pomona” (The Gemäldegalerie, Berlin) and “Madonna and Child in a Jasmine Bower” (The Frick Art Museum, USA),

which are most reliably attributed by art experts to a Melzi authorship. However, these analyses did not reveal any matches between histograms of the Besso “Mona Lisa” and all the Melzi paintings. However, it must be noted that histograms of all 3 of the Melzi paintings fail to match, as well: indicating possible limitations in such analyses (Figure 6).

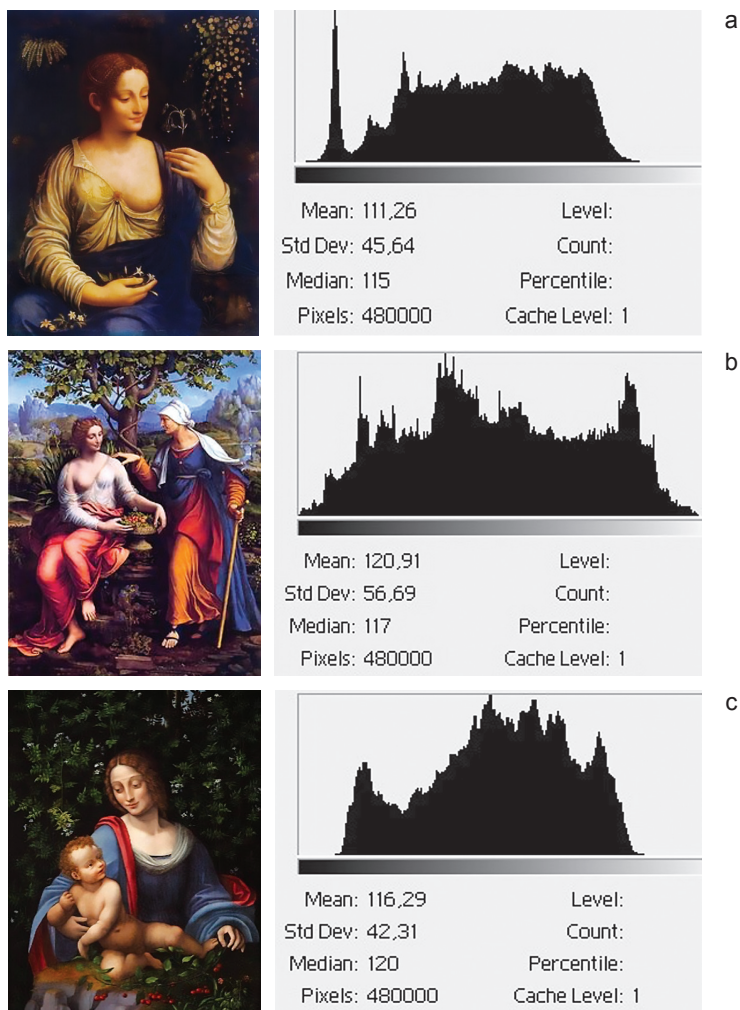


Figure 6. Histograms of paintings by Melzi: a) “Flora”; b) “Vertumnus and Pomona”; c) “Madonna and Child in a Jasmine Bower”.

3. Conclusion

The story of Besso’s “Mona Lisa” is an unusual and interesting case of the “mixing” of science, history, art and cultural heritage. In the Besso Mona Lisa story, Albert Einstein, Leonardo Da Vinci, LACONA and laser techniques unpredictably intersect. In the

studies, described in the paper, there was an effort to find similarities in histograms of the Besso “Mona Lisa” and other paintings by Melzi as well as similarities of the signature in pentimenti and images of signatures in manuscripts written by Melzi. Unfortunately, no clear matches were found between histograms, histogram statistics, or signature appearances. Of course, differences in histograms cannot be considered as a reliable way to conclude that the Besso “Mona Lisa” was not executed by Melzi but by some other painter. However, for these analyses, the available digital images of the Besso “Mona Lisa” and other Melzi paintings were of poor quality. In addition, it should be taken into account that all had been restored and it is obvious that restoration interventions would have changed both the chiaroscuro and histograms, respectively. However, differences between signatures argue against any assumption that Melzi created the Besso “Mona Lisa”. However, all of the previous experimental data are not sufficient to support a final conclusion stating that the Besso “Mona Lisa” was painted by Melzi. This issue remains an open question until higher-quality digital images are employed. Further study is needed to reach clearer indications concerning the hypotheses on the creation of the Besso “Mona Lisa” by Melzi.

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Biographical notes

John Asmus is Emeritus Professor, University of California, San Diego. Since 1973 John Asmus has been a Research Physicist with the Department of Physics at the University of California, San Diego. He earned his PhD from the California Institute of Technology (physics and quantum electronics) and is a co-founder of the Center for Art/Science Studies at UCSD. Prior to 1973 he held positions with The US Naval Ordnance Laboratory, General Atomic, The Institute for Defense Analyses, and SAIC International (VP and Bd. Mbr.) In 1990 he was awarded the Rolex Laureate for Enterprise

(Xi'an Terra Cotta Warriors) and became a Fellow of the Explorers Club. He has published 140 articles in professional journals and holds 25 patents in the fields of astrophysics, high-energy plasma physics, high-energy lasers, and laser applications. During his career Prof. Asmus has performed pioneering research in the use of holography, lasers, ultrasonics, inside-out (X-ray and NMR) imaging, and digital image processing in art conservation. He has applied these tools to the problems of divestment, analysis, interpretation, and presentation associated with diverse art conservation activities. He has also been instrumental in the founding of professional art conservation and laser societies. He is a member of UNESCO and EU conservation commissions on World Heritage Sites and the Parthenon, respectively.

Vadim Parfenov is a Professor at St. Petersburg Electrotechnical University (ETU LETI). He holds a Ph.D. in Quantum Electronics (2002) and degree of Doctor of Sciences (2018), both from ETU LETI. He has worked on research areas of diverse or cross-disciplinary interest, ranging from laser material processing to studies on phase conjugation, non-linear optics, wavefront sensing and laser 3D scanning, and development of laser-based systems for interferometry and holography. For the last 15 years he has been involved in research on the use of lasers and opto-electronic techniques in Cultural Heritage preservation. He has worked collaboratively with museums including The State Russian Museum, The Hermitage Museum, The museum-preserve "Tsarskoye Selo" and St. Petersburg State Museum of Urban Sculpture, as well as with The State Tretyakov Gallery, Moscow, in the use of 3D laser scanning for documentation and replication of artworks. He has organized and co-chaired several conferences and workshops such as: "Light for Artworks conservation" (2006, 2010 and 2012, St. Petersburg) and "Laser Cleaning and Artworks Conservation" (2007, 2013 and 2016, St. Petersburg). From 2005-2006 he was a member of the Management Committee of the European Union COST Action G7 "Artwork Conservation by Laser", and since 2014 he is a member of the Permanent Scientific Committee of LACONA (Lasers for Artwork Conservation). He is the author and co-author of more than 100 articles and several books.

Summary

The final printing of "*Albert Einstein Correspondence avec Michele Besso 1903 - 1955*" was released by Collection Savoir, Hermann, Paris, on "Nine-Eleven" 2001. Upon collecting the full printed run of the Einstein/Besso correspondence, the heir to the Besso estate, Dr. Vittorio Besso, was invited to attend the scientific conference LACONA V (LACONA is the abbreviation of the words Lasers for Artworks Conservation, which is the name of the most important international conference in the field) where he became aware of the laser technique for the divestment of restorations from paintings. Thereafter upon returning to his ophthalmological studio in Imperia, Italy, Dr. Besso performed laser ablation of overpaints revealing pentimenti of the painter's autograph on a "Mona Lisa" painting in the family collection of inherited Renaissance paintings. An IR photograph of the faint signature pentimenti was then compared with validated autographs of Leonardo's assistant and companion, Francesco Melzi, and found to be geometrically inconsistent with validated signatures. Amplitude histograms of features of this "Mona Lisa" were next compared with comparable validated original portraits by Melzi, revealing chiaroscuro "fingerprints." Any potential Melzi attribution would be consistent with the Besso family history as illuminated in the fifty-two years of Einstein/Besso correspondence concerning both art and science.

Riassunto

La stampa finale di “Albert Einstein Correspondence avec Michele Besso 1903 – 1955” è stata pubblicata da Collection Savoir, Hermann, Parigi, su “Nine-Eleven” nel 2001. Dopo aver raccolto l’intera tiratura della corrispondenza Einstein/Besso, l’erede del Besso Estate, il Dott. Vittorio Besso, è stato invitato a partecipare al convegno scientifico LACONA V (LACONA è l’abbreviazione delle parole Lasers for Artworks Conservation, che è il nome del più importante convegno internazionale del settore) dove ha conosciuto la tecnica laser per il restauro dei dipinti. Successivamente, al suo ritorno nel suo studio oftalmologico a Imperia, in Italia, il Dr. Besso eseguì l’ablazione laser di pitture superficiali rivelando pentimenti dell’autografo del pittore su un dipinto della “Monna Lisa” nella collezione di famiglia di dipinti rinascimentali ereditati. Una fotografia IR della poco leggibile firma è stata quindi confrontata con autografi convalidati dell’assistente e compagno di Leonardo, Francesco Melzi, e risultata geometricamente incoerente con le firme convalidate. Gli istogrammi di ampiezza delle caratteristiche di questa “Monna Lisa” sono stati successivamente confrontati con ritratti originali convalidati comparabili di Melzi, rivelando “impronte digitali” in chiaroscuro. Qualsiasi potenziale attribuzione a Melzi sarebbe coerente con la storia della famiglia Besso come rivelata nei cinquantadue anni di corrispondenza Einstein/Besso riguardante sia l’arte che la scienza.