

The Scientific Detection of Forgery in Paintings*

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IN JUNE 2010, the National Gallery, London put on an exhibition entitled *Close Examination: Fakes, Mistakes and Discoveries*, which explored the art of forgery in paintings that had originally fooled their experts and have been identified by the Gallery's scientific department. Close to one year later, in October 2011, Wolfgang Beltracchi and three other forgers were sentenced, in Germany's biggest art forgery scandal, to several years in prison for forging a large collection of paintings attributed to Max Ernst, Fernand Léger, and other famous masters. The forgeries were discovered in 2008 after a buyer bought what was deemed to be a Campendonk and had the work scientifically tested. The tests showed that the painting contained a pigment that had not been invented when the artist was supposed to have painted it. Such events underscore the importance of modern science in lifting the lid and revealing some of the misconceptions of the past.

THE DETECTION OF FORGERIES

The *curator* and the *art historian* play a crucial role at the outset in the evaluation of a painting purported to belong to a famous artist.

It is the responsibility of the *curator* to study the work's provenance by determining a sequence of ownership all the way back to the artist who painted it. Forgers generally invent a story of a destitute family that has owned this painting for many generations and now needs to sell it while wishing to remain anonymous.¹ A price that is too good to be true might arouse the curator's suspicion.

The *art historian* on the other hand needs to make a stylistic analysis to determine whether the style and brushwork match that of the artist

* Read 25 April 2012.

to whom the artwork has been attributed. A clever forger will adequately grasp the artist's style and know how properly to emulate the painter's or the period's brush technique. The art historian may also opt to make a Morellian analysis of the painting, a technique introduced by the physician/art collector Giovanni Morelli.² Morellian analysis is based on the creation and mapping of formulae describing repeated stylistic details in the artwork and reflecting the particular approach of the artist in creating small features such as ears, eyes, and collars. This analysis generally focuses on the artist's technique in applying the paint and on his workmanship in large and small brushstrokes. These formulas are then matched with those that are known to belong uniquely to the artist and that are, irrespective of his own stylistic development, generally maintained throughout his life. The Rembrandt Research Project, which was founded in 1969, has used Morellian analysis to distinguish between authentic and forged Rembrandts.³

What would the *scientist* look for? In the last few decades a wide spectrum of scientific techniques have been developed and adapted to help unravel forgeries in paintings. The London National Gallery's state-of-the-art laboratory uses some of these modern techniques, which are wonderfully described in Marjorie Wieseman's book *A Closer Look: Deceptions and Discoveries*.⁴

Technical analysis of a painting principally entails a) the *surface examination* of the painting, b) the *analysis of its background* or the so-called *underpainting*, and c) a close *examination of its body* using a few selected techniques from the wide range of tools available for that purpose.

For the *surface examination*, optical microscopy and UV light have been widely used. The optical microscope (magnifying from five to fifty times) allows the art historian as well as the scientist to determine whether or not the *craquelure* (the network of fine cracks appearing after the passage of time) is genuine. The forger endeavors to mimic these fine cracks either by adding solvents to the painting, thus accelerating the drying process, or by drawing fine black lines on its surface.

A fascinating case in point here was the display side by side, at the 2010 National Gallery's exhibition, of two identical versions of *The Virgin and the Child with an Angel* by Francesco Francia (1450–1517) (fig. 1). One version was acquired in 1924 by the Gallery as a bequest from Ludwig Mond (1839–1909), a wealthy businessman who had allegedly bought it from a Roman dealer, its earlier provenance being unknown. The second version appeared in a London auction in 1954 and belonged to the art dealer Leonard Koetser. Optical microscopy revealed painted cracks on the surface of the 1924 version as well as fine pencil lines in some of the detailed areas. The latter technique is totally



FIGURE 1. Francesco Francia, *The Virgin and the Child with an Angel*⁵

inconsistent with Renaissance paintings,⁴ suggesting that the 1924 version might be a forgery.

Paintings can also be examined by impinging *UV light* on their surface. If the painting is old the natural varnish layers will fluoresce strongly, whereas areas of retouches in an original old painting will fluoresce very weakly or may not fluoresce at all. A famous painting by Rubens, *The Gerbier Family*, indicated, upon the analysis of certain areas, varnishes that contained the anachronistic synthetic blue ultramarine. Examination by UV light showed that these regions fluoresced much less than the rest of the painting and therefore indicated later retouches.^{6,7}

Master artists have often used their canvases many times over, with sometimes more than two paintings on top of each other. The scientist using either the techniques of *X-ray radiography* or *infrared reflectography* can penetrate the surface of the painting and observe some of these underdrawings, which occur both in forgeries and in authentic paintings. In the case of X-ray radiography a photographic plate is generally placed in contact with the painting's surface, and X-rays, in the wavelength range used in medical radiography, are made to impinge behind the canvas support. In infrared reflectography, infrared rays penetrate the surface of the painting and are reflected back into a specially designed sensitive camera, which reveals details of the underdrawings. This technique is particularly valuable in showing undersketches drawn in carbon black or charcoal. An underdrawing may reveal a painting that is anachronistic with the artist's own stylistic development, may show a painting attributed to an artist who belonged to a period after the purported painter's death, or may even give details on the materials used to prepare it. A cubist work observed under a painting belonging to Picasso's blue or pink period would certainly suggest a forgery!

Analysis carried out at the National Gallery laboratory on the 1924 version of *The Virgin and the Child with an Angel* revealed an underdrawing made of graphite, a material used for drawing only since the sixteenth century.⁴ This was not observed in the 1954 version of the painting, strongly suggesting that the 1924 version is a forgery.

The *body of the painting* can be tested with a wide spectrum of tools. They range, to name a few, from X-ray diffraction (XRD), Raman spectroscopy, high performance liquid chromatography (HPLC), scanning electron microscopy, energy dispersive X-ray fluorescence (SEM/EDX), pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS) to laser desorption ionization-time of flight-mass spectrometry (LDI-TOF-MS) and gamma-ray spectroscopy.

When Van Meegeren, the notorious Vermeer forger, made his first attempt at forging *The Laughing Cavalier* by Frans Hals (1580–1666), *X-ray diffraction* (a technique reliant on the scattering of incident X-rays by a crystalline pigment producing a characteristic diffraction pattern) revealed that the collar was painted with zinc oxide and the coat in synthetic ultramarine, which were discovered only in 1782 and 1828, respectively.⁷

Today *molecular Raman spectroscopy*^{8,9} (an *in situ* tool that makes use of the inelastically scattered light from a laser beam that strikes the surface of the painting) is preferred to X-ray diffraction because of its totally nondestructive nature. The data obtained are generally compared with reference spectra, allowing the identification of organic and inorganic pigments as well as binding media.

Pyrolysis–gas chromatography–mass spectrometry (Py–GC–MS)¹⁰ is particularly useful in the analysis of the paint-binding medium. Through pyrolysis, large molecules are broken down and separated by gas chromatography. In the gas chromatograph, different components of a mixture are carried by an inert gas through a column coated with a stationary phase where they are separated. Each compound is then eliminated or “eluted” at a different time referred to as “the retention time.” Information from the mass spectrometer, which is attached to the gas chromatograph, as well as from the retention times, is crucial in the identification of the components of the mixture.

Laser desorption ionization-time of flight-mass spectroscopy (LDI–TOF–MS)¹¹ identifies molecular species and elements in samples based on their fragmentation patterns and on their mass. These are then compared with standard spectra.

In 2005, when Alex Matter, the son of Herbert Matter, who was a close friend of Jackson Pollock, discovered in his parents’ attic thirty-two works allegedly painted by Pollock, he asked Harvard University’s Center for the Technical Study of Modern Art to analyze three of the works. The Harvard research team reported in 2007 that analysis by Raman spectroscopy, SEM/EDX LDI–TOF–MS, and Py–GC–MS indicated three postdated pigments, some in the binding media, that were not available during Pollock’s lifetime (1912–1956).¹²

High performance liquid chromatography (HPLC)¹³ is another chromatographic technique used to separate a mixture of compounds and is particularly useful in the identification of organic dyes, whereas *scanning electron microscopy* (SEM) *coupled with energy dispersive X-ray fluorescence* (EDX)¹⁴ can yield information on the sample’s topography and elemental composition. In SEM, images of the surface of the sample are produced by scanning it with a high-intensity beam of electrons. These in turn cause the emission of X-rays that characterize the elements present (EDX).

Going back to Francia’s *Virgin and the Child with an Angel*, HPLC revealed on a sample from the red curtain an anachronistic red lake pigment based on madder, whereas the SEM/EDX analysis suggested “that the green lining of the Virgin’s robe contained a green copper resinate which was mixed with brown and black to darken the color, a technique never observed in Francia’s time.”⁴ In assessing all this evidence (which was not observed in the 1954 version), the scientist would certainly rule that the 1924 version is a forgery.

A new technique, which is outlined below, was developed in 2008 by Russian scientists and could be applied to any artwork purported to have been painted prior to 1945. This novel approach tests for the presence of the radioactive isotopes Cs¹³⁷ and Sr⁹⁰ (not formed naturally)

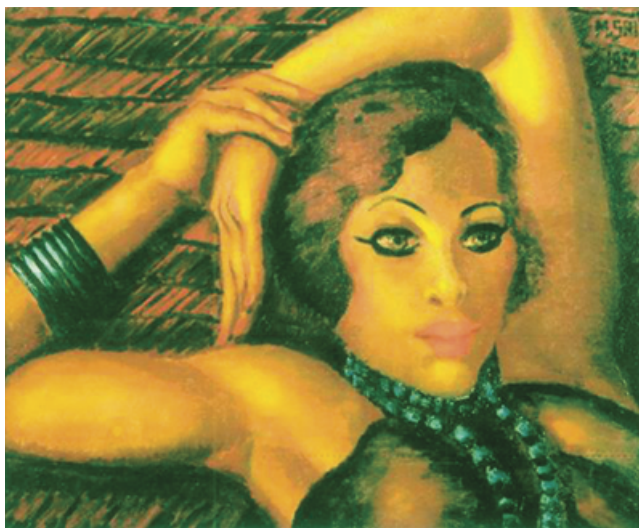


FIGURE 2. Mahmoud Said, *The Girl with Green Eyes*¹⁷

that were released from the 1945 bombings of Hiroshima and Nagasaki as well as from the nuclear tests that followed. According to the Russian scientists, Cs^{137} and Sr^{90} “when released in the environment permeated soil and plant life and ended up in all post-war paintings through natural oils used as binding agents for paints.”¹⁵ Their presence, as determined by *gamma-ray spectroscopy*, would indicate a forgery in any artwork.

This technique could be ideally applied to the painting entitled *The Girl with Green Eyes* (fig. 2) attributed to the famous Egyptian painter Mahmoud Said. In October 2007 this art work, which was painted in 1932 and sold to the Egyptian government in 1950, appeared in Dubai at a Christie’s auction. *The Girl with Green Eyes* was originally hanging in the Egyptian embassy in Washington and was moved to the residence of the Egyptian ambassador to the United Nations in New York.¹⁶ Having heard of the sale, the alarmed Egyptian government contacted Interpol and the sale was cancelled.¹⁷ Questions were raised and are still ongoing with regard to the authenticity of this painting.

Today a clever forger will anticipate scientific analysis and endeavor to avoid all the possible mistakes that would lead to the discovery of his forgery. Han Van Meegeren (fig. 3), the notorious art forger, after his initial blunder with Frans Hals’s *Laughing Cavalier*, meticulously carried out his plan of ridiculing the Dutch art establishment by producing a quasi-perfect forged Vermeer. He had been embittered by what he perceived as the unfair evaluation of his own art and wanted to prove to the world the ignorance of the Dutch art critics.



FIGURE 3. Han Van Meegeren (fifty-eight years old) two months before his death¹⁸

After four years of arduous experimentation Van Meegeren was successful in developing a technique that would produce a perfect craquelure. He familiarized himself with Vermeer's palette and embarked on the clever creation of a new Vermeer that would fit all the predictions of Bredius, the most important art critic of the time. Bredius had predicted that there were still some undiscovered Vermeers, that these would probably have some religious connotations, and that they would be influenced by Italian art.¹⁹ Van Meegeren went so far as to travel to Italy to closely study Caravaggio's art and compositions.

He then created his first Vermeer forgery, *Christ and the Disciples at Emmaeus* (fig. 4), which was received and authenticated enthusiastically by Bredius, who wrote in the *Burlington Magazine*, "It is a wonderful moment in the life of a lover of art when he finds himself suddenly confronted with a hitherto unknown



FIGURE 4. *Christ and the Disciples at Emmaeus*²⁰

painting by a great master, untouched, on the original canvas, and without any restoration, just as it left the painter's studio! And what a picture! Neither the beautiful signature 'I. V. Meer' (I.V.M. in monogram) nor the *pointillé* on the bread which Christ is blessing, is necessary to convince us that we have here a—I am inclined to say—the masterpiece of Johannes Vermeer of Delft, and, moreover, one of his largest works (1.29 m. by 1.17 m.), quite different from all his other paintings and yet every inch a Vermeer.”²¹

As a result of such an important authentication Van Meegeren sold the *Emmaeus* for an impressive price, reconsidered his scheme of ridiculing the whole art establishment, and subsequently forged several Vermeers, six in all.

In creating his forgeries Van Meegeren was meticulously cautious; he used badger brushes instead of bristle ones,²² worked so secretly that he avoided life models, and in some cases copied photographic and painting models. (One of his faces bore a strong resemblance to Greta Garbo, another was reminiscent of the face of Vermeer's *Girl with the Pearl Earring*.)

In spite of his technical dexterity, Van Meegeren made the fatal mistake of giving one of his forgeries, *The Adulteress*, to Hermann Goering, Hitler's close associate and commander-in-chief of the Luftwaffe, in exchange for four hundred Dutch paintings that had been taken by the Germans during the war. Goering committed suicide after World War II, having been sentenced to death by hanging at the Nuremberg trials, and the Allies got hold of all the artwork he had collected. *The Adulteress* was traced back to Van Meegeren, who was accused of high treason for collaborating with the Nazis, a crime that would result in the death penalty.

To save his neck Van Meegeren admitted to the lesser crime of forgery and offered to create another Vermeer under close supervision. The result was *Young Christ Teaching in the Temple*, the style of which was very much in keeping with the other Vermeer forgeries. Having fooled the Nazis, restituted four hundred Dutch paintings, and made fun of the art establishment, Van Meegeren gained immediate notoriety and support, becoming a sort of “folk hero”¹⁹ and was sentenced to only one year in prison for having forged a signature (fig. 5). He did not serve his prison term as he died of sudden cardiac arrest.



FIGURE 5. Han Van Meegeren at his trial¹⁸



FIGURE 6. Wolfgang Beltrachi²⁴

Peter Landesman in the *New York Times* may help us understand Van Meegeren's actions: "A forger's chief motivation is typically intellectual gamesmanship. Embittered by the spurning of his own work, he takes satisfaction in suckering the entire art world en masse, then pulling aside the curtain, exposing himself as a renegade genius and the art experts as the frauds and fools."²³

Recently, in one of the greatest art scandals in Germany, Wolfgang Beltrachi surpassed Van Meegeren's notoriety both in the faultless execution of his forged paintings of twentieth-century artists and in the scope of his forgeries (fig. 6). From provenance to production of the artwork, the whole scheme was executed with "Mozartian perfection."²⁵

Provenance, he claimed, could be traced back to the wealthy industrialist Werner Yaeger, who died in 1992. Yaeger had allegedly bought the artworks at a bargain price from the famous Jewish art dealer Alfred Flechtheim, who had fled the Nazis in 1933 and lived in exile in Paris. The story was credible as two of Beltrachi's female collaborators were Yaeger's granddaughters, who claimed they had inherited the collection from their grandfather. Further credibility was gained when the famous art expert Werner Spies issued certificates of authenticity for a large number of the forgeries, having also been fooled by the story of the two sisters and by the fraudulent Flechtheim labels on the back of the paintings. This lent great legitimacy to the artwork and made it easier for Beltrachi to produce further forgeries.²⁶

To capture the essence of the art piece, Beltrachi, who admitted forging more than fifty paintings, meticulously studied the artist he intended to forge. He went to museums where the artwork was displayed, got to know how much time it took the painter to complete a work, visited the place where he lived, and tried to feel the atmosphere surrounding him. In an interview he explained that he tried to observe with the artist's eyes and to penetrate his creative soul so that he could identify with him.²⁷ He even claimed that he did not only copy or emulate the style of an artist but wanted to add to it and *improve it*. He arrogantly exclaimed that nothing was easier than to forge a Pollock, which led some critics to refer to his vanity and egomania.

In spite of a forger's painstaking efforts at producing the *perfect*

forgery, a time always comes when one single fatal mistake is made. Beltrachi was familiar with the palette of Campendonk and chose zinc oxide as a white pigment in one of his forged paintings, but he was totally oblivious to the fact that the zinc oxide was contaminated with traces of titanium dioxide, a pigment that had not been invented when Campendonk was supposed to have created the art piece. His oversight unveiled the whole scam.

Beltrachi's chief motivation to carry out such actions, apart from financial gain, was to punish what he perceived as the greed and vanity of the art market. He wanted to expose the arrogance of the art world, which, according to him, did not really understand the meaning of true art, and made decisions in an arbitrary manner as to which painting was worth millions and which one was worthless.²⁷

The light sentences that Van Meegeren and Beltrachi received for their crimes seem somewhat astonishing at the outset. Van Meegeren, as mentioned earlier, was sentenced to only one year for having forged a signature, whereas Beltrachi and his wife, in spite of the very large number of forgeries carried out and the number of collectors they defrauded, including the actor Steve Martin, were respectively sentenced to only six and four years in a German "open prison": that is, they are both allowed to hold a daytime job and can expect their sentences to be further reduced as first-time offenders.

The notoriety of the two cases, and the success of the perpetrators at ridiculing the art world, might have subconsciously influenced the judges. Wasn't Van Meegeren perceived as a hero to the Dutch people, a man who had fooled the Nazis and ridiculed the art establishment, and hadn't Beltrachi been portrayed by the German media as a modern Robin Hood and "rogue genius"?²⁸

The Van Meegeren and Beltrachi sagas as well as all other notorious forgeries feed into the ongoing debate as to what the public most values in art.^{19, 22, 30} Once again we pose the crucial question: Is a work of art praised for its intrinsic aesthetic value or because it is perceived to be the work of a famous artist?

According to the philosopher Denis Dutton, art appreciation is "a matter of experiencing a new vision of a familiar subject provided by a painter," i.e., a perception of a new "creative" approach to the artistic endeavor.²⁹ The psychologist Paul Bloom would add to this rationale that humans are natural "essentialists"³⁰ and that our simplest pleasures depend on our belief in them: "We don't just respond to things as we see them, or feel them, or hear them. Rather, our response is conditioned by our beliefs, about what they really are, where they came from, what they're made of, what their hidden nature is."³¹

CONCLUSION

The foregoing examples culminating in the Van Meegeren and Beltrachi experiences demonstrate the synergistic approach between the curator, the art historian, and the scientist that is required in the authentication of a work of art. The connoisseurship and years of experience of the art experts and curators are necessary but not sufficient conditions for the fulfillment of this task. The role of the scientist will be more one of falsification as opposed to authentication. His approach will be to focus on finding the *one or two fatal mistakes* that will unravel the forgery.

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