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IMAGE STUDY AND MATERIAL CHARACTERIZATION OF THE TWO-SIDED PAINTING *THE CELLIST* AND *PORTRAIT OF BRANCUSI* BY AMEDEO MODIGLIANI

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Abstract

The cellist and the portrait of Brancusi were painted by Amedeo Modigliani in 1909. This canvas, which is painted on both sides, also contains preliminary studies for two of the most representative works of the artist's early days in Paris. In 2016, the collector Juan Abelló, agreed to conduct a complete image study at different wavelengths (Infrared, Ultraviolet and X-ray) as well as pigment analysis using X-ray fluorescence. The data collected revealed the preparatory drawing made in pencil, another underlying painting, and the use of previously unrecognised pigments in Modigliani's palette. This valuable information improves our understanding of the painter's early technique, which has received little attention to date, and thus contributes with critical scientific criteria to detect falsifications.

***Keywords**: Modigliani; Pictorial technique; Scientific analysis; X-ray fluorescence; Counterfeits*

Introduction

In 1907, after a year in Paris, Modigliani was almost bankrupt. In November, Doctor Paul Alexander, the son of a prosperous Parisian pharmacist, contacted Modigliani after seeing his work at the Salon [1]. Impressed by his artistic talent, he was his first customer and asked him to neither reuse nor destroy any of his works, and he began sponsoring Modigliani. For many years, until his death during the First World War, Paul Alexandre was his only client, admirer, and good friend. He kept about twenty-five oil paintings and several folders full of drawings dated to the period 1907–1912 [2], including this two-faced painting.

Amadeo Modigliani´s pictorial oeuvre is sparse. After his tragic death in 1920, he became a mythical figure, and his paintings gradually increased in market value until, with his ever-growing reputation among art historians, the auction of his paintings eventually reached record-breaking figures [3]. This encouraged the production of forgeries, some of which were created out of nostalgia and recognition yet marketed as authentic, while others were outright forgeries created to be sold in the market.

From a modern art history perspective, the only solution to this is to scientifically analyse his original paintings and compare them to suspected forgeries. Paintings made before or immediately after Modigliani's arrival in France in 1910 are often left out of these studies because variations in style and format make comparisons cumbersome, as the artist juggled with various artistic influences and changed his technique frequently. The goal is to identify patterns in the use

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of materials by identifying works with similar subject matter in the artist's early years [5]. In 1981, during a Modigliani exhibition held in Paris (1884–1920), the *Centre de Recherche des Musées de France* conducted an extensive material study of works hosted by fifteen institutional and private collections in France [6], including pieces painted by Modigliani from 1915 onwards. In 2018, the TATE Modern dedicated a major exhibition to Modigliani in London, which comprised one hundred of his works. A long-term plan to continue the analysis of the artist's works was set up, starting with some of the paintings lent for the exhibition and using the analytical techniques available to each lending institution. The results were published in several articles [5, 7-11].

To understand Modigliani's technical and material evolution and dispel possible doubts about the authenticity of his works, it is important to apply these results with a holistic view of his complex career [7]. In 2016, a doctoral thesis presented an analytical perspective on paintings from his early Paris years (1906–1909) [4]. In 2020, after the success of the Modigliani exhibition organised by *LAM de L'ille* in 2016 [12], the *Centre de Recherche des Musées de France* and the C2RMF (*Centre de Recherche et de Restauration des Musées de France*) organised a new exhibition entitled *Les secrets de Modigliani* [13], on the centenary of his death. The main aim of this exhibit was to present the results of a two-year research programme on 25 paintings and three sculptures by the artist from ten museums in France, expanding and updating the results obtained in 1981 (including the analysis of two works from 1909), and continuing the work initiated by TATE in 2018. Recently, the analytical study of a number of Modigliani's paintings in various institutions and the *Modigliani Up Close* exhibition, organised by the Barnes Foundation in Philadelphia, which also included several portraits from his early Paris years, were also published [14]. This article presents a comprehensive scientific analysis of two paintings, *The cellist* and *Portrait of Brancusi*, from the Spanish collection of Juan Abelló, carried out in 2016 [4].

In 1909, Modigliani painted the *Portrait of Brancusi* in the studio of a Romanian sculptor from whom he learned "the primitivity of his work," but which he never completed.

(…) *Modigliani may have been in contact with Constantin Brancusi, a Romanian sculptor staying at Cité Falguière, through Paul Alexandre. The Italian artist rented a studio there. He sculpted in the courtyard when the weather was good and visited the Romanian sculptor, who reaffirmed the need for him to go back to direct carving and guided him in the purely practical field.* [1].

Later, he painted *The cellist*, a one-of-a-kind model on the reverse side.

(...) The musician who played the cello lived in Cité Falguière in a studio on the second floor since 1909, where Modigliani also worked. His modelling sessions allowed the poor devil to practice in the warmth of his neighbours´ wood stove.

(...) His room was tiny, between the bed, fireplace and the cello, there was barely enough space to make his portraits, which were made from only one angle by opening the door [14].

Experimental part

Methodology

Our primary references were recent scientific studies on Amadeo Modigliani's paintings, focusing on those whose supports were reused [6, 8-14]. Both the front and back sides of the pieces in question were studied and recorded with imaging techniques working at various wavelengths, and the composition of their inorganic material was analysed by EDXRF. These

techniques were selected based on their suitability to capture visual data in the paintings and characterise the artistic materials used.

Photography with visible, direct, grazing, general, and macro light

It allows the visualisation of the artist´s handwriting, direction, and brushstroke thickness. The equipment used was a Canon EOS 1200D digital SLR camera with a 50 mm fixed and macro lens and extension rings.

Ultraviolet (UV) fluorescence photography

Organic materials become more fluorescent as they degrade over time; i.e., the older they are, the more fluorescence they emit [17]. The level of fluorescence can identify some of the pigments [18], e.g., separating zinc white, lead white, and other white pigments such as titanium white. In this instance, a Canon EOS 1200D digital SLR camera with a 50 mm fixed lens was used, and the work was illuminated by a Silvana Backlight Blue F36 W-BLB with fluorescent tubes and UV yellow filter B + W 58 81-B 1.2 x.

Infrared (IR) reflection photography

This technique sees past the layers of varnish and sometimes paint (depending on the thickness and composition), revealing the underlying drawing (assuming that it is there), as is typically the case, and that it is made with materials that are compatible with the analytical technique chosen. If the equipment used for the study is suitable and the density of the layers of preparation materials allows it, the drawing made with graphite or fine brush wash becomes visible. In this study, we used a Nikon reflex digital camera without an internal IR filter (interposing a ruby filter B + W58 092 IR 69520-40x on top of the lens) that operates in the near-IR spectrum, approximately 900nm.

Radiographic study

All the layers become visible because the rays penetrate through the whole work. The original canvases can be identified, even down to the identification of the source roll of canvas as well as the fabric pictorial supports used in the lined canvas. With this technique, we studied the application of the preparatory layers, gesture and superimposition of paint brush strokes, presence of repainting beneath the varnish, loss of layers, and presence of superimposed compositions [19]. The X-ray photographs were taken using a veterinary Sedecal portable X-ray unit and a Can Plus CR rotary drum scanner. The working conditions were: 110 cm distance, 45keV, 32μA.

EDXRF

Analysis is used to analyse the chemical composition of the materials used without sampling. It is fast and performs a variety of analyses directly on the painting (pigments, materials on the pictorial layer, and primer) [20]. We used a portable X-ray fluorescence (EDXRF) device with an AMPTEK XR 100 Si-PIN detector and Eclipse III X-ray and tube controller (silver anode and beryllium window).

Results and discussion

Image analysis

The magnification of the photographs allows for the examination of minute details in the materials and contributes towards a holistic understanding of the pictorial surface by revealing information about brushstrokes, colours, glazes, and the thickness of the preparations [4]. Image studies working at different wavelengths thoroughly document the effects of plastic on used and reused supports. For instance, in the portrait of *Madame de Pompadour* at the Barnes Foundation, the artist reused a horizontally oriented landscape, resulting in a combination of highly textured and smooth areas [8]. This is also true of *The Double Portrait of Jacques and Berthe Lipchitz* at the Art Institute of Chicago. Even though it was finished in a matter of hours, Lipchitz asked Modigliani to continue working on it for two more weeks. In that time, Modigliani only modified Berthe´s face by softening her features, changed the paint texture, and dried or rubbed the paint

with paper with mordant oil to blend the colours, while leaving Lipchitz´s features untouched. Therefore, the painting is a hybrid of painting techniques: Jacques has the fine surface that characterises Modigliani´s early portraits, whereas Berthe´s face is dense, layered, and thoroughly worked on, although her softer features presage a new, naturalistic style for the artist [8].

In other instances, he reused the supports twice, for example in *The Pretty Housewife* at the Barnes Foundation, which reveals details of the painting technique used; in this painting, Modigliani did not completely cover the paint underneath but used its base colours for the flesh tones, hair, and basket in a manner that resembles early-Renaissance layering techniques to create skin tones with tempera. In this work, he also combined the application of paint deposited smoothly with fine washes between layers dried with blotting paper, sponges, and controlled rubbings. This manipulation of the surface to create texture and modulate tones is comparable to the technique used by Modigliani on his sculptural surfaces [8]. The use of grazing light brings out other details, as seen in the *Portrait of Lunia Czechowska* at the Museum of Grenoble [6], where the furrow marked by the brush tip is clearly visible in the hair, around the shoulders, and in the elbow crease. This is also visible in the hair of the *Blonde Nude*, in a private collection [6], a work that displays many of Modigliani´s most characteristic features.

The use of grazing light reveals the use of this technique in Modigliani's works. The study of both sides of the work at hand using this light displays the texture of the surface. In *The cellist,* the surface is three-dimensional and irregular because of the superimposition of layers. In some areas, these prominent features clash with the image on the surface, while in other areas, the brushstroke has volume and is applied to touches that leave the paint on the surface visible so that the form represented is perfectly recognisable. For example, the face presents several single stroke colour touches, for instance in the eyebrows and the cheekbones, which have a unique density. However, the washed-out light green base tone seems to have been applied on a lower layer to make it stand out, in different degrees, on layers that were not covered later, as seen in the flower pattern in the background, the base of the jacket, shirt, sheet, bow, and face, using the *verdaccio* technique (Fig. 1a).

However, in the *Portrait of Brancusi,* the painter uses the same aquamarine green background. The work is unfinished, and some areas, such as the background and the shirt, are stained with large and loose brushstrokes in a rapid zigzag pattern and only have the fine texture of this diluted brushstroke. However, the face, beard, and hair are modelled with brushstrokes that sculpt and build their features. Modigliani did not comb the paint but applied concentrated oil and spread it with a brush in different ways, depending on the area, as revealed by the grazing light (Fig. 1b).

a)  b) 

Fig. 1: Amadeo Modigliani. a) *The cellist* (detail). b) *Portrait of Brancusi* (detail). Photographs taken under direct and tangential light. Source: Authors' own

The UV fluorescence photography technique used on the paintings reveals reprints and the survival of the original varnish, which can be distinguished from the later one. *The cellist*

was restored before it entered the Abelló collection around 1981. Afterwards, it was entirely de-painted except for the lower right angle, where the signature is located (Fig. 2a). In this area, the oxidised varnish was preserved to keep the letters unaltered, as they were made with very diluted paint. The remaining varnish preserves small touches of chromatic reintegration (Fig. 3). In the *Portrait of Brancusi*, this illumination technique distinguishes the white zinc pigment from the white base of the preparation (Fig. 2b).

Fig. 2. Amedeo Modigliani. a) *The cellist.* b) *Portrait of Brancusi*. UV fluorescence.

Fig. 3. Amedeo Modigliani. *The cellist*. UV fluorescence. Close up of the signature.

Modigliani's underdrawings represent the ideas that he was to develop in the painting that eventually covered them [19]. IR photographic studies of Modigliani´s work reveal that the preparatory drawings were sometimes done in pencil or in fine brush lines made with paint of distinct colours, or both [6, 15]. Recent studies, such as that concerning *The Young Apprentice* (1918) and *Woman with velvet ribbon* (1915), at the *Musée de L´Orangerie* in Paris, have found clear underdrawings that sketch the main elements, such as the face, the hands, and the table on which the character rests his elbow [16].

When applied in parallel to Modigliani's preparatory drawings (sketches) in ink and graphite, IR reflection photography reveals complementary information about *The cellist* and the *Portrait of Brancusi* (Fig. 4a and.b).

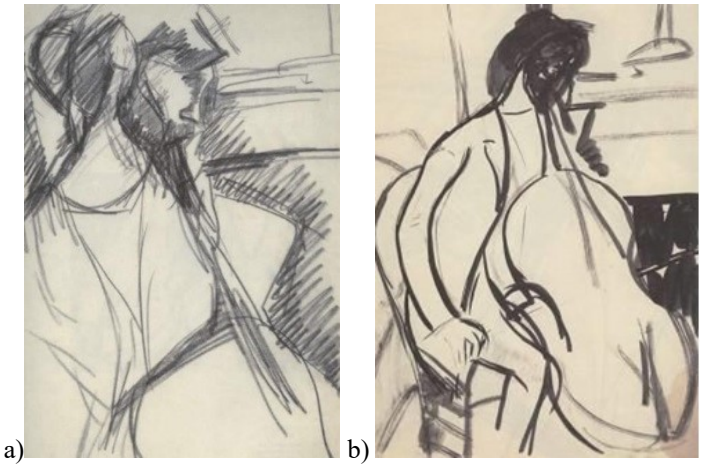

Fig. 4. a) and b) Amedeo Modigliani. Preparatory drawing and watercolour for *The cellist*, made with grease pencil. Paul Alexandre Collection. Source: ALEXANDRE, Nöel. Unknown Modigliani.1994

In the painting *Madame de Pompadour*, at the Barnes Foundation, a white background was applied over to cover an earlier painting; the same holds for *The cellist*, in which the preparatory drawing was made in graphite pencil with subtle, fine, and confident strokes whose positions do not match those of the final oil painting (Fig. 5a, b, c and d). A comparative study, using IR photography, between the underlying drawing and the preparatory graphite and ink drawings on paper allows for a deeper understanding of the stroke and accuracy of the lines, which were first observed in existing photographic records and macro-photographs [6].

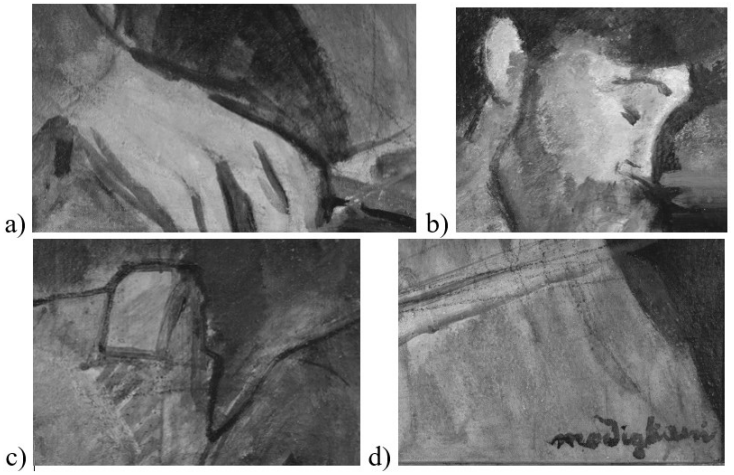

Fig. 5. a), b), c) and d) Amedeo Modigliani. *The cellist*. IR image of the hand, face, chair and signature.

Also, it is possible to identify the use of purple organic lacquer pigments, which are transparent to IR radiation, in the decorative flowers in the background. However, in the *Portrait of Brancusi*, it was impossible to view the underlying drawing in the face area, which is the most thoroughly worked on, as it was made with a cobalt blue brush, like the rest of the figure, which is not covered in paint and visible to the naked eye. The cobalt blue pigment is invisible in IR images.

Radiographic study

The radiographic studies carried out on Modigliani's paintings reveal that, in many instances, he not only reused supports from his earlier works but also from other painters. Furthermore, he used lead white or zinc white pigment (common in the early twentieth century) as a base [5]. The X-ray of the *Double portrait of Jacques and Berthe Lipchitz*, painted after their wedding in 1916, reveals that the "old canvas" used bears an underlying early portrait of a woman, which bears some resemblance to Modigliani's early portraits of women with large locks of hair, painted around 1908 [8].

The study of the paintings at hand shows that a white high-lead preparation was applied on both sides of the work. The radiographic image revealed little about their execution, as the X-ray image is mostly white with no contrast, unlike the X-ray image of the *Girl portrait* from the TATE Modern in London, which was reused only on one side and the image was imperceptible to the naked eye [5]. In *Portrait of Brancusi*, wide horizontal brush strokes were used to apply layers of lead white to cover the support before reusing it. This makes it difficult to study how different brush strokes were used in each area. However, a portrait of a woman with long hair can be seen in the foreground, occupying the whole pictorial surface (Figure 6.a–6.b), probably a female portrait from 1906–1907 (Fig. 7a, b and c), like the *Double portrait of Jacques and Berthe Lipchitz*. Two years after painting it, probably because he needed a new support, he covered it with a dense white layer of preparation before painting the *Portrait of Brancusi*.

Shortly afterwards, unsatisfied, he unpinned the canvas from the stretcher, turned it over to its reverse side, covered it with a layer of white preparation, and painted *The cellist*, which was to remain on the front side. In this instance, the support was used three times. Considering the chronological evolution of the artist's work in this first period, his biography, and the location of each representation in stratigraphic order, the logical sequence is: 1st *Woman portrait* (1906–1907); he applies a layer of white primer; 2nd *Portrait of Brancusi* (1909), which he unhooks from the stretcher, turns the canvas around, and sticks it back onto the stretcher; 3rd *The cellist* (1909), painted on the opposite side of the support to remain thereafter on the front side (Fig. 8a, b and c).

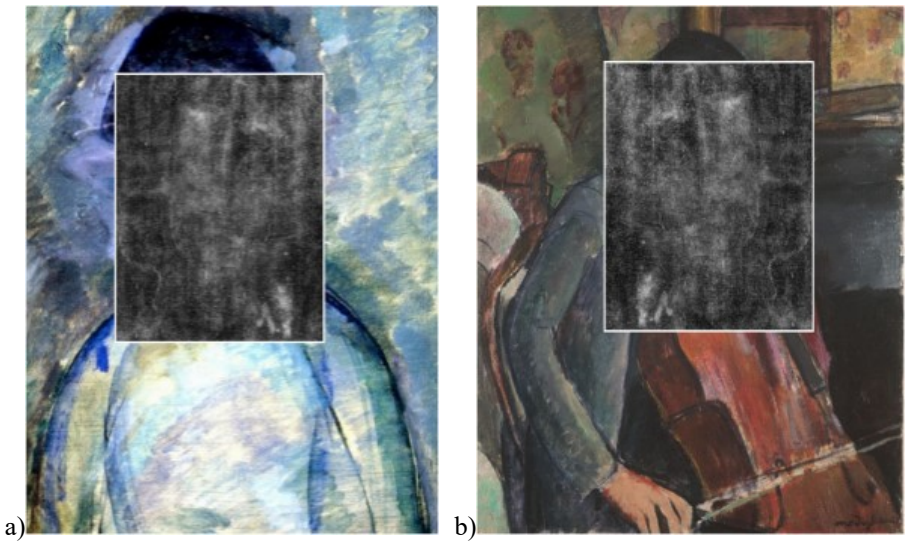

Fig. 6. Amedeo Modigliani. a) *The cellist*. b) *Portrait of Brancusi*.
X-ray images showing the underlying face on each side of the canvas. Source: Authors' own

Fig. 7. Three portraits of women from the same period recognized in Ceroni's Catalogue Raisonné. a) Amedeo Modigliani. *Bust of a woman* (1906-1907) 32.7cm×24.8cm. Private Collection. C.R. Ceroni nº. 1. b) Amedeo Modigliani. *Woman with blue shawl* (1907) 33cm×24cm. Private Collection. C.R. Ceroni nº 5. c) Amedeo Modigliani. *Woman's head* (1906-1907) 33cm×24cm. Private Collection. C.R. Ceroni nº. 2

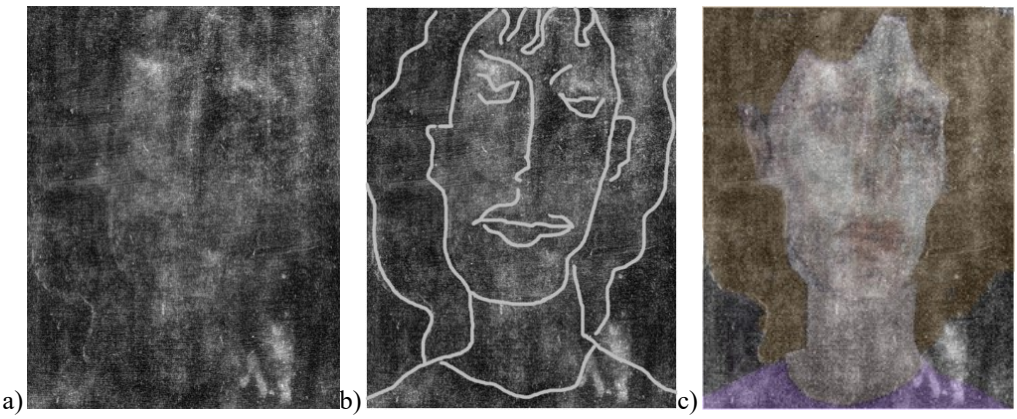

Fig. 8. Amedeo Modigliani. *The cellist* and *Portrait of Brancusi*. a) X-ray image showing the underlying face, b) with the shapes outlined for easier visualisation and c) a hypothetical virtual reconstruction based on other preserved portraits from the period.

Identification of pigments

There are few publications on the pigments originally used by Modigliani, most of which use sampling-free, non-destructive analytical techniques. In 1981, the *Centre de recherche et de restauration des musées de France* extracted only one microsample from each of the fifteen paintings analysed, and the remaining surfaces were analysed using X-ray fluorescence (EDXRF). The 2016 [4] and 2018 analyses [5, 7-11] included microsamples taken from the folded edges of some of the canvases, in addition to the EDXRF study of the central areas, which increased our knowledge about the palette used by Modigliani. The analyses from 2020 extracted a few microsamples from key areas of each work [13]. Therefore, as no permission was obtained for micro-sampling extraction in our study, EDXRF was chosen as the most suitable technique to characterise pigments on each face of the support.

In this case, the EDXRF analysis of two paintings on the same canvas could generate problems with the interpretation of the data, mainly to know where the x-ray fluorescence comes from: *The cellist* or the *Portrait of Brancusi*. Fortunately, the radiographic study showed two lead white paint layers applied to cover the support as ground layers before painting the two

paints, so these layers of lead white made a kind of barrier for the x-ray florescence. In this way, if the *The cellist* was analysed, the two ground layers would block the x-ray florescence that the excitation beam could generate in the portrait's paint layers, so the data acquired came mainly from *The cellist* mainly, and vice versa.

Obverse. The cellist

In the EDXRF analysis of *The cellist*, eleven areas representing all the shades present were chosen (Fig. 9) (Table 1). Once the EDXRF spectra were acquired, they were analysed to obtain information about the materials and execution techniques used in the work.

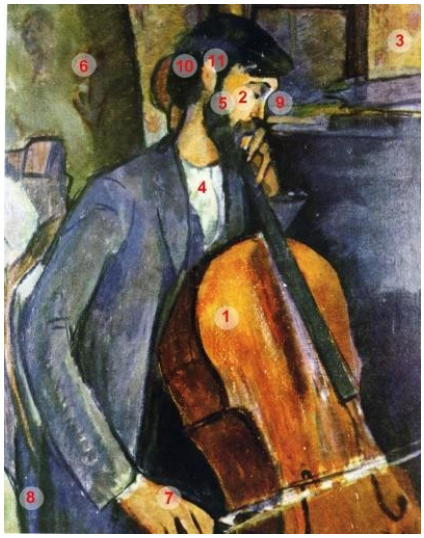

Fig. 9. Amedeo Modigliani. *The cellist*. Sampling map and table of the analysed areas.

Table 1. Description of the analysed areas

Area	Description
1	YELLOW ORANGE Cello
2	LEMON YELLOW temple
3	YELLOW green bottom corner. Top right
4	GREEN shirt chest
5	DARK GREEN beard
6	DARK RED back curtain flower top left corner.
7	RED right hand reddish tone
8	BLUE jacket bottom left
9	MILKY BLUE on the right of the head
10	BLUE hair on the right of the head
11	ORANGE ear

In the spectra of the lemon-yellow area of the temple (area 2), the peaks associated with zinc stand out, alongside smaller peaks of calcium and iron. This suggests the use of an organic yellow pigment, although the study also indicates the presence of iron in the pictorial layer, which is compatible with the use of earth pigments (Fig. 10a).

In the greenish-yellow area (area 3), the analysis suggests that a yellow organic pigment mixed with zinc white was used. Although the presence of copper and arsenic was detected, it is likely that the green pigment was made with Paris green (emerald-green) (Fig. 10b). The presence of zinc indicates that zinc white was used to lighten the shade.

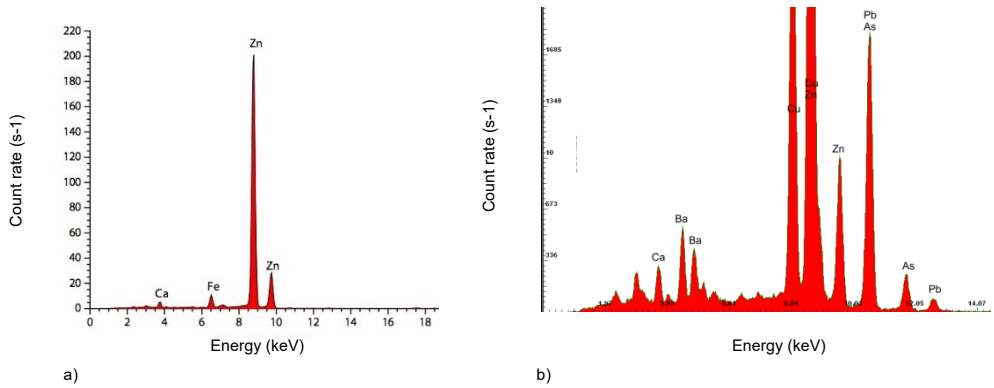

Fig. 10. EDXRF. a) Spectra of area 2, lemon yellow temple. b) Spectra of area 3, greenish yellow background. Source: Authors' own

The spectrum of the dark green zone (area 4) shows the presence of chromium, iron, cobalt, zinc, and lead (Fig. 11a). This suggests that the green pigment was either made with a green based on chromium oxides mixed with cobalt blue, earth, and zinc white for shading, or that it was obtained by mixing chromium yellow with cobalt blue and lightening with zinc white.

The spectrum of the dark red zone of the flower in the background (area 6) shows prominent peaks of zinc as well as smaller peaks of iron, cobalt, chromium, and calcium (Fig. 11b). The presence of iron suggests the use of a red pigment based on iron oxides mixed with zinc white. The intense red hue in the area also suggests that a red lacquer-like pigment was used. The same result is also seen in the analysis of the red zone identified as Area 7.

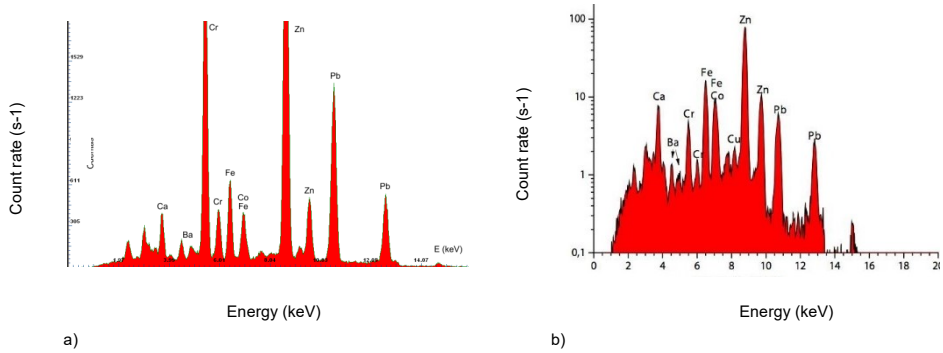

Fig. 11. EDXRF. a) Spectra area 4 (the dark green at the height of the beard). b) Spectra area 6 (the dark red of the background curtain flower). Source: Authors' own.

The blue hues in the spectrum around the jacket (area 8) show prominent peaks of cobalt, zinc, and lead (Fig. 12a). This suggests that cobalt blue mixed with zinc white was used as a blue pigment. The radiographic study showed that a layer of lead white was applied to cover the support before reusing it, so the prominent peaks of lead are probably from that ground layer and are indicative of a thinner pictorial layer than other areas. Comparable results were obtained in the analysis of the other two blue tones, where cobalt blue was identified as the blue pigment, with varying amounts of lead.

Finally, in the analysis of the black tone (area 10), the spectrum shows prominent peaks of cobalt, zinc, lead, calcium, chromium, and iron, as well as smaller peaks of barium (Fig. 12b). In this case, EDXRF cannot identify the black pigment used, as the spectrum recalls that of both

organic black and bone black. The presence of zinc white and cobalt blue, used to shade the black hue, was found in the area.

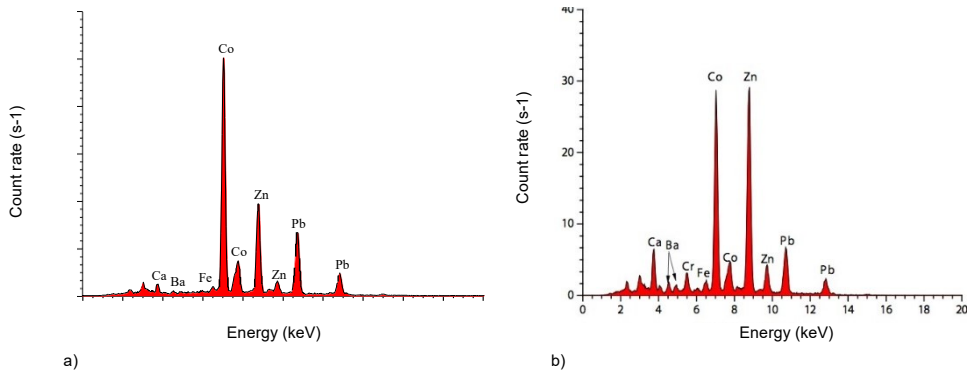

Fig. 12. a) EDXRF spectra of area 8 (blue area) of the jacket. b) EDXRF from area 10 (almost black) blue hair.Source: Authors' own.

Reverse: Portrait of Brancusi

The analysis of the *Portrait of Brancusi* on the reverse side of the painting comprises five areas representing the tones present in the painting, as illustrated and described in figure 13 and Table 2, respectively.

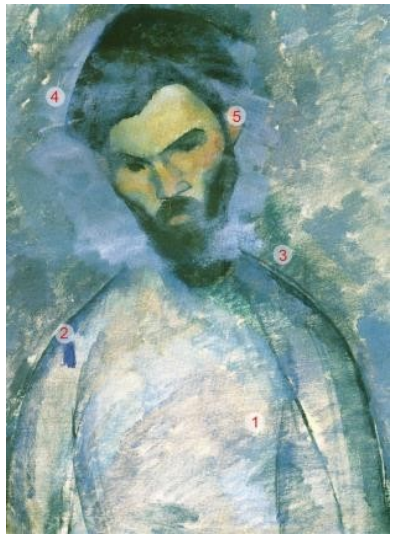

Fig. 13. Amedeo Modigliani. *Portrait of Brancusi*. Sampling map and table of the areas analysed.

Table 2. Description of the areas analysed

Area	Description
1	WHITE PREPARATION chest
2	BLUE right man
3	GREEN background
4	VIOLET GREY background (at hairline)
5	ORANGE ear

The X-ray fluorescence spectrum of the unpainted bottom preparation area shows prominent peaks of lead and zinc, as well as smaller peaks of barium, indicating the use of lead white, zinc white, and a small amount of barite and/or lithopone (Fig. 15a).
In the blue area on the right shoulder (area 2), the EDXRF spectrum presents prominent peaks of cobalt, zinc, lead, and barium, suggesting the use of cobalt blue as a blue pigment, mixed with zinc white. The intensity of the lead peaks gives an idea of the thickness of the historical paint layer, while the intensity of the barium peaks suggests the presence of this element in the pictorial layer (Fig. 15b).

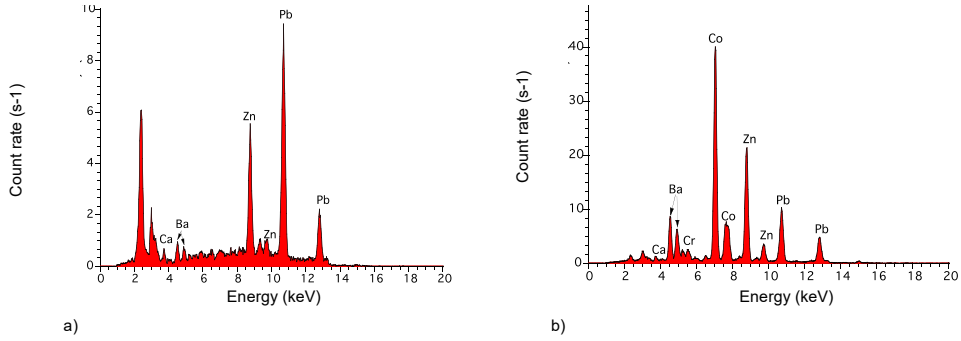

Fig. 15. EDXRF. a) Spectra of area 1 (unpainted background) and b) Spectra of area 2 (blue right shoulder). Source: Authors' own.

The dark green tone in the background of the beard (area 3) is a mix of a green pigment based on chromium oxides with zinc white, as seen in the EDXRF spectrum (Fig. 16a). As for the greyish tone, the analysis shows high peaks of zinc as well as a small peak of calcium. In this case, EDXRF falls short of identifying the black pigment used, as the spectrum is compatible with both organic black and bone black (Fig. 16b). Due to the device's very low efficiency to detect energies below 2keV, it was very difficult to identify the presence of phosphorus in the analysed area.

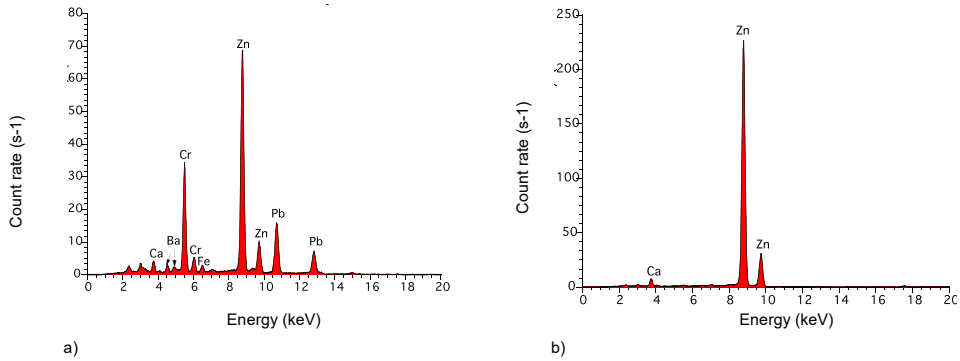

Fig. 16. EDXRF. a) Spectra for area 3 (green background) and b) Spectra for area 4 (violet grey background). Source: Authors' own.

Finally, in the orange area of the ear, prominent peaks of zinc, iron, and lead stand out. Also, smaller peaks associated with mercury, calcium, and chromium indicate that the orange pigment was obtained by mixing vermilion with a yellow pigment such as chromium yellow or that chromium orange was used and tinted with vermilion (Fig. 17). The presence of iron points to the use of earth pigments.

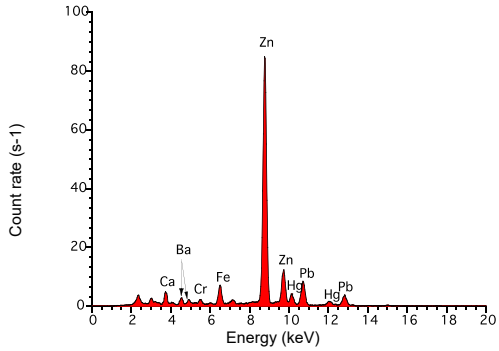

Fig. 17. EDXRF. Spectra for area 5 (orange ear).

The pigments identified in both works are summarised in Table 3, where differences in yellow, green, and red pigments can be observed.

Table 3. Pigments identified in the analysis of the two faces. Source: Authors' ow

Colour	Pigments identified	Pigments identified
	The cellist	*Portrait of Brancusi*
WHITE	Zinc white	Zinc white
YELLOW	Yellow lacquer?	Chrome yellow?
GREEN	Green based on chromium oxides Paris green	Green based on chromium oxides
BLUE	Cobalt blue	Cobalt blue
RED	Iron oxide red (red earth) Organic lacquer	Iron oxide red (red earth) Vermilion Chrome orange?
BROWN/ OCHRE	Ochre (earth pigments based on iron oxide)	Not analysed
BLACK	Black pigment of an organic nature	Black pigment of an organic nature
PRIMER	Lead white and lithopone	Lead white, lithophane or zinc white

The net area of the peaks of the various X-ray fluorescence lines from the EDXRF spectra yielded by both works was compared to collect information concerning execution techniques. The relationship between them can be used to establish how the different pictorial layers were applied.

The net area ratio of lead X-ray fluorescence lines $L\alpha_1$ and $L\beta_1$ constantly lies between 2.5 and 3.5, which suggests that lead white is present beneath the pictorial layer except for area 1 of both *The cellist* and *Portrait of Brancusi* (Fig. 18), where the higher net ratio suggests the presence of white lead in the pictorial layer too.

Similarly, the ratio of $K\alpha_1$ lines for iron and $L\alpha_1$ for lead was calculated to determine the presence of iron in the preparation (Fig. 19). Notably, this ratio is smallest in areas 1, 8, and 10 in *The cellist*, suggesting that iron may be present under the layer of paint. However, the ratio in area 2 suggests the presence of iron in the layer of paint, as does the ratio in areas 3, 6, 7, and 9, although in smaller quantities. This points to the use of an iron oxide-based pigment in these areas. As for the portrait, the white preparation (area 1) is the reference point. Therefore, in areas 4 and 5, a pigment based on iron oxides is present in the pictorial layer.

Finally, the ratio of the lines Kα1 for calcium and Lα1 for lead was calculated to determine the presence of calcium in the pictorial layer (Fig. 20). Based on the analysis of the lemon-yellow spot in *The cellist*, calcium is present in the pictorial layer in areas 2 and 9 of *The cellist* and area 4 of the *Portrait of Brancusi.*

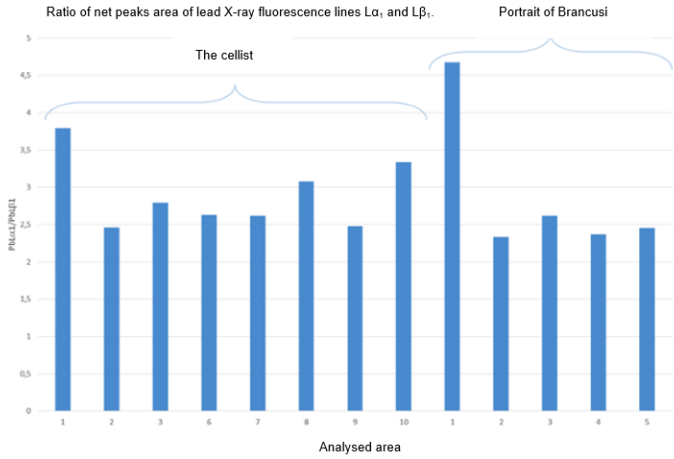

Fig. 18. Ratio of net peaks area of lead X-ray fluorescence lines $L\alpha_1$ and $L\beta_1$

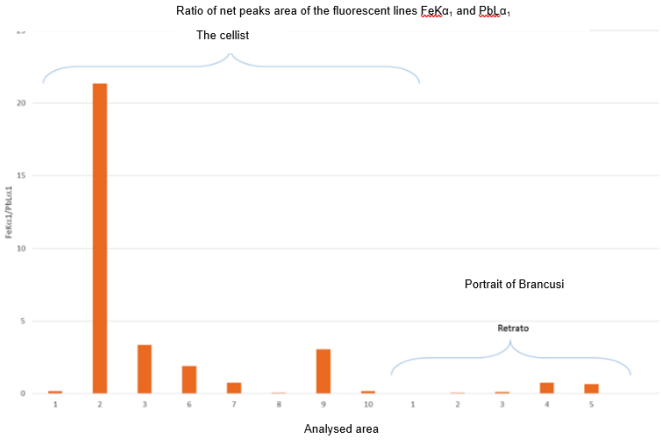

Fig. 19. Ratio of net peak areas of the fluorescent lines $FeK\alpha_1$ and $PbL\alpha_1$

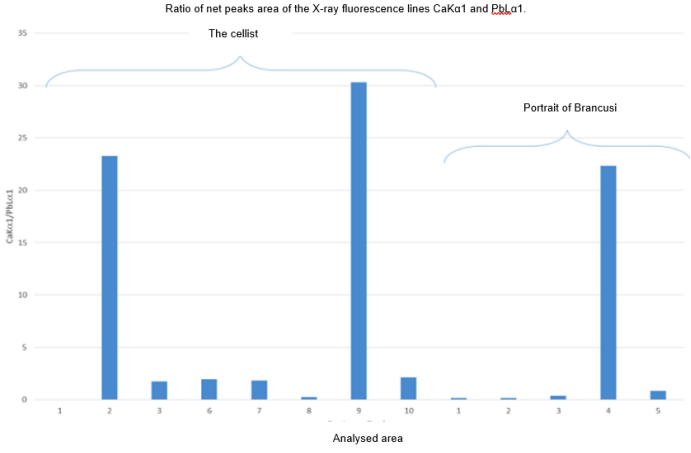

Fig. 20. Ratio of net peak areas of the X-ray fluorescence lines CaKα1 and PbLα1

Stemming from the analysis of the green area in 2016 [4], which detected copper and arsenic, the use of Paris green (emerald-green) pigment has been identified for the first time (Figure 10. b). Copper-based green had not previously been identified in Modigliani's palette, and this contradicts an EDXRF study carried out in 1981, which suggested Modigliani only used chrome green. This would later be confirmed in 2018 in the analyses of the *Portrait of Beatrice Hastings* at the Art Institute of Chicago (where striking touches of emerald green paint were applied around the edges of the face, in the hollows of the neck, and under the shadow of the hat to increase the contrast and give additional volume to the forms) and the *Portrait of Beatrice Hastings* and *The beautiful housewife*, both at the Barnes Foundation in Philadelphia [8, 10].

Conclusions

The studies carried out on this two-sided painting in 2016 revealed a hitherto unknown underlying drawing in pencil beneath one of the two works, *The Cellist*, from his early period in Paris. To that date, publications only addressed paintings produced from 1915 onward [6]. In this instance, the preparatory drawing was carried out using graphite with subtle, fine, and confident strokes. The analysis also attested that the final work was displaced with regard to the preparatory drawing. The organic lacquer pigments used were identified and proved to be transparent to infrared radiation. It could be confirmed for the first time that they were used in the decorative flowers of the curtain in the background, which were made with a purple lacquer.

The simultaneous X-ray of both paintings revealed a complex sequence, as the support was not only reused and mostly covered with lead white but also bears an underlying female portrait from 1906–1907. That is, the analysis discovered a third painting by Modigliani on the same support.

Pigment analysis added two more pigments, i.e., cobalt blue and Paris green, to the artist´s known palette.

The study carried out on the two paintings made it possible not only to gain a better understanding of the materials and painting technique used by Amedeo Modigliani from 1908 to 1909 but also to locate a portrait from 1906–7 that was discarded by the artist. This information, yielded by an indisputably authentic piece, increases the number of works analysed and, among other purposes, is immensely valuable for comparison and reference in the characterization of other paintings whose authenticity is in question.

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