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The pictorial technique in Ceruti's paintings: a holistic study based on multi-band imaging diagnostics and written sources review



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ABSTRACT

The paper presents the first monographic technical study of the pictorial technique of the 18th-century painter Giacomo Ceruti (1698–1767), based on a statistically significant corpus of twenty-four paintings spanning his entire career. Following a holistic approach, the research integrates technical data from full-field multi-band imaging investigations in the VIS, NIR, and SWIR range with information derived from historical records and bibliographical sources, as well as unpublished restoration reports, the latter representing a novel contribution to this study.

The multi-band imaging protocol allows the results to be presented according to the stratigraphy of the paintings. Combination of imaging diagnostics with art-historical methodology provides new insights into Ceruti's working practice, including last-minute support integrations, canvas preparation, preliminary sketchy outlines defining the poses, rapid paint handling, brush wiping marks, and minor *pentimenti* of aesthetic relevance. In addition, the analyses document the early adoption of Prussian blue. This integrated methodological approach enables a unified reconstruction of Ceruti's painting practice and underscores the potential of systematic imaging campaigns conducted within the framework of monographic exhibitions.

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1. Introduction and research aim

A comprehensive understanding of a painter's artistic technique requires the analysis of a significant number of his works, ideally spanning the entire chronological range of his career. The collected data can then be compared to draw general conclusions and to outline the artist's technical development along his stylistic evolution. Conducting scientific investigations on numerous paintings by the same artist within a single museum collection is feasible only for major institutions, especially those with an established internal scientific department [1–6]. However, an optimal opportunity arises during monographic exhibitions, where the artist's catalogue of artworks is assembled in one location, allowing for comprehensive diagnostic campaigns [7,8]. The principal methods are non-invasive, mainly including imaging techniques across differ-

ent spectral ranges (UV–VIS–IR and X-Ray), which can be complemented by targeted point analyses, such as Fiber Optics Reflectance Spectroscopy (FORS), or X-Ray Fluorescence (XRF) [8,9]. Advanced portable techniques and tools to perform in situ investigations are provided by heritage infrastructures, such as MOLAB, the mobile laboratory of the European infrastructure for Heritage Science (E-RIHS) [10–12].

In the framework of the “CINABRO” project, a formal agreement between Fondazione Brescia Musei and the University of Verona, the LANIAC Centre and the OpDATECH Lab of the University of Verona performed a systematic diagnostic campaign on a *corpus* of twenty-four Ceruti's paintings with a holistic approach, integrating non-invasive diagnostics and art historical methodology (stylistic and iconographic analysis, general literature review, research into documentary sources and conservation reports). The paintings analyzed were displayed within the major monographic exhibition *Miseria e nobiltà. Giacomo Ceruti nell'Europa del Settecento* (Brescia, 2023), with loans by public museums and private owners [13].

The Lombard painter Giacomo Ceruti (1698–1767), called “il Pitocchetto”, was a native of Milan, but he also lived and worked in

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Brescia and Venice, whose artistic *milieu* greatly informed his production, as well as in other minor cities, such as Bergamo, Padua, and Piacenza. He is best known as a painter of genre compositions depicting people on the social margins and scenes of ordinary life, and as a portraitist of the local nobility, even though he realized religious and mythological subjects and still-life pictures as well. Ceruti was almost forgotten after his death and only in the 20th century he was rediscovered as an appreciated artist by scholars [13]. So far, however, Ceruti was studied mainly from a traditional art historical perspective, and the investigation of his painting technique was limited to specific instances. In fact, from the literature review, in 2023, when a conservation treatment was carried out on six paintings realized by Ceruti for the Basilica of Santa Maria Assunta in Gandino, some scientific investigations were performed only on the two most relevant canvases of the cycle i.e., *Saint Pontianus* and *Saint Peter in Glory*, including optical imaging in reflected and transmission mode and portable digital microscopy [14]. In 2024, three X-ray examinations have been carried out on the paintings *Bravo*, *Portrait of Laura Vitali Aliprandi*, and *Portrait of Marquis Erasmo Aliprandi Martinengo*, all included in the Fondazione Brescia Musei collection.

The goal of the present research is to outline, for the first time, a comprehensive view of Giacomo Ceruti's artistic practice across his entire career by integrating technical data from multi-band imaging investigations with information derived from historical records and bibliographical sources, as well as unpublished restoration reports, the latter representing a novel contribution to this study. By adopting this holistic approach, the study provides a unified technical interpretation of Giacomo Ceruti's painting practice, based on a statistically significant catalogue of paintings covering the full chronological span of his career, and going beyond isolated technical case studies.

In the overall, the present methodological framework aims to highlight the potential of systematic imaging campaigns and documentary investigation carried out during monographic exhibitions. The replicability of this approach combining multi-band imaging and written sources can therefore provide a model for art historical research and technical reconstruction of an artist's working method across his entire *oeuvre*.

2. Material and methods

2.1. The diagnostic protocol

The diagnostic protocol was designed as a full-field survey with multi-band imaging in the visible and infrared (VIS-IR) spectral range. The campaign took place *in situ*, in the rooms of the museum.

IR imaging analyses were carried out by NIR photography and IR reflectography (IRR) working in complementary spectral bands (NIR and SWIR ranges) that have different penetration depth and provide correlative information from different layers of the painting, unveiling various features related to the material response.

High-resolution images in the VIS-NIR bands were collected through a modified 32 MP Full Spectrum digital camera (Nikon D800) with a CMOS sensor and nominal spectral sensitivity in the range 360–1100 nm. A Nikon Nikkor 50 mm f/1.8D AF lens was used. A set of filters is supplied for technical UV-VIS-IR photography: the bandpass VIS filter allows the 400–700 nm band (standard VIS photography), while the high-pass IR filter selects the 700–1100 nm range (NIR photography). The camera processes 16-bit depth images. The VIS-IR dataset was combined to obtain IR False Color (IRFC) mapping.

IRR was performed with the standard Osiris camera (Opus Instruments), equipped with an InGaAs (Indium Gallium Arsenide) sensor with spectral sensitivity in the 900–1700 nm range. The

camera works in wide band modality; the image size for each acquisition is up to 4096 × 4096 pixels. The lens has 150 mm focal length and selectable lens f/number to optimize the depth of field. The output is an 8-bit depth image. The exposure time was set at 10 ms.

Two 300 W halogen lamps were used as VIS-IR sources in reflection setup at two meters distance.

FORS technique (Ocean Optics HR2000 spectrometer, spectral range 200–1100 nm, spectral resolution 0.5 nm) was employed to target specific questions concerning the use of blue pigments.

To optimize visualization and comparison of the images for their interpretation, the VIS-IR imaging dataset of each artwork was spatially aligned using a web application designed for multimodal data ingestion and management [15]. The web-app, customized for the project, enables sharing and annotation of diagnostic imagery, providing the capability to record, for each painting, dedicated bibliographic references, archival sources, and restoration reports, together with user comments and annotations.

2.2. Studied paintings and art-historical research

Twenty-four Ceruti's paintings on canvas, created throughout the artist's career and representative of his artistic development, were analyzed (Table 1). The subjects include genre scenes depicting the poor (such as beggars, vagrants, and impoverished workers) in their everyday lives, portraits of members of prominent families, local ruling elite and clergy, as well as still-life compositions.

Most of the investigated artworks (15 out of 24) belong to the Fondazione Brescia Musei and are part of the Pinacoteca Tosio Martinengo collection. However, works on loan from other museums or private collectors, who granted permission for the diagnostic campaign, were also examined.

The scientific analyses were integrated with in-depth bibliographical and archival research conducted in the archives of the Fondazione, aimed at collecting historical documentation, photographs, and restoration reports of Ceruti's paintings held by the institution. It is worth noting that several paintings entered the Fondazione's collection only in recent years, with limited or no documentation regarding their prior conservation history.

The bibliographic sources used to retrieve information on Ceruti's technique include authoritative monographic studies on the painter, recent exhibition catalogues, and the published volume dedicated to the restoration of Ceruti's cycle for the Basilica of Gandino (Bergamo), executed in the 1730s. Additional information was obtained through consultation of archival materials cited in published documentary registers related to the cities where the painter was active, as well as through examination of restoration and technical examination reports on works held by Fondazione Brescia Musei.

These findings were further contextualized through comparison with the general practices followed by other painters, as recorded in contemporary European treatises on artistic techniques.

3. Results and discussion

An assessment of the paintings condition is not the goal of this paper, and the works are generally in good preservation state, with very few exceptions. The diagnostic data, therefore, provided significant insights into Ceruti's technique.

The results are presented according to the painting stratigraphy, from the support and the lower ground layers to the upper and superficial ones.

A table summarizing all the abovementioned written sources consulted (monographic studies, exhibitions catalogues, archival documents, restoration and X-ray examination reports), as well as a list of the historical annotations in the original Italian language,

Table 1

List of Giacomo Ceruti's paintings analyzed that were on display in the exhibition.

Title	Year (exhibition catalogue)	Location	Support, technique and dimensions
<i>School for Girls</i>	1720–1725	Brescia, Pinacoteca Tosio Martinengo	Oil on canvas, 194 × 170.5 cm
<i>Women Working on Pillow Lace (The Sewing School)</i>	1720–1725	Private collection	Oil on canvas, 165 × 192 cm
<i>The Laundress</i>	1725	Brescia, Pinacoteca Tosio Martinengo	Oil on canvas, 131 × 145 cm
<i>The Basket Porter</i>	1725	Brescia, Pinacoteca Tosio Martinengo	Oil on canvas, 117 × 92 cm
<i>Bravo</i>	1725 c.	Brescia, Pinacoteca Tosio Martinengo	Oil on canvas, 77 × 90 cm
<i>Portrait of a Gentleman</i>	1725 c.	Private collection	Oil on canvas, 103 × 79 cm
<i>Card Players</i>	1720–1730 c.	Brescia, Pinacoteca Tosio Martinengo	Oil on canvas, 161.7 × 186.5 cm
<i>Portrait of Two Girls (The Two Sisters)</i>	1725–1730 c.	Brescia, Pinacoteca Tosio Martinengo	Oil on canvas, 134 × 84 cm
<i>Portrait of a Young Lady with a Fan</i>	1725–1730 c.	Bergamo, Fondazione Accademia Carrara	Oil on canvas, 65.5 × 54.9 cm
<i>Mother with Child</i>	1730 c.	Brescia, Pinacoteca Tosio Martinengo	Oil on canvas, 117 × 93 cm
<i>Cobblers</i>	1730–1733 c.	Brescia, Pinacoteca Tosio Martinengo	Oil on canvas, 170 × 194.5 cm
<i>The Spinning Woman</i>	1730–1733	Brescia, Pinacoteca Tosio Martinengo	Oil on canvas, 128 × 145.5 cm
<i>Portrait of Abbot Angelo Lechi</i>	1730–1733 c.	Montichiari (BS), Museo Lechi	Oil on canvas, 128.3 × 95.7 cm
<i>Woman Mending a Sock</i>	1730–1733	Montichiari (BS), Museo Lechi	Oil on canvas, 126.7 × 145 cm
<i>Two Beggars</i>	1730–1733	Brescia, Pinacoteca Tosio Martinengo	Oil on canvas, 135 × 173 cm
<i>Two Beggars (Encounter in the wood)</i>	1730–1733	Brescia, Pinacoteca Tosio Martinengo	Oil on canvas, 156 × 190 cm
<i>Portrait of Marina Cattaneo</i>	1732–1736 c.	Brescia, Pinacoteca Tosio Martinengo	Oil on canvas, 112 × 87 cm
<i>Still Life with Fish, a Lobster and Shellfish</i>	1736	Private collection (Ginevra, Rob Smeets Gallery)	Oil on canvas, 62.9 × 67.6 cm
<i>Self-Portrait as a Pilgrim</i>	1737	Abano Terme, Museo Villa Bassi Rathgeb	Oil on canvas, 64.7 × 46.8 cm
<i>Portrait of Laura Vitali Aliprandi</i>	1740 c.	Brescia, Pinacoteca Tosio Martinengo	Oil on canvas, 98 × 75 cm
<i>Portrait of Marquis Erasmo Aliprandi</i>	1740 c.	Brescia, Pinacoteca Tosio Martinengo	Oil on canvas, 98 × 75 cm
<i>Portrait of a Lady (Countess Begioioso)</i>	1745–1755 c.	Torino, Musei Reali – Galleria Sabauda	Oil on canvas, 118 × 88 cm
<i>Portrait of a Gentleman (Count Belgioioso)</i>	1745–1755 c.	Torino, Musei Reali – Galleria Sabauda	Oil on canvas, 118 × 88 cm
<i>Portrait of a Young Gentleman</i>	1760 c.	Brescia, Pinacoteca Tosio Martinengo	Oil on canvas, 99 × 71 cm



Fig. 1. G. Ceruti, *The Laundress*, Brescia, Pinacoteca Tosio Martinengo. a) VIS photograph; b) NIR photograph; c) IRR. It is possible to notice the horizontal canvas joint and the sweeping marks in the ground.

is provided in Appendix A. Imaging data discussed in the paper but not included in the main text are provided in Appendix B. A summary table of the provenance, conservation treatments and analytical investigations performed on the paintings belonging to Fondazione Brescia Musei, together with the FORS spectra used to confirm the identification of the blue pigments, is included in Appendix C.

3.1. Supports

All the investigated paintings are realized on canvas, which was the main typology of support used by Ceruti. In most cases a single piece of canvas was sufficient, but for larger works IR imaging was useful to observe the joints of multiple canvases pieced together, such as in *The Laundress* (Fig. 1), or in *School for Girls* (Fig. 5). Of particular interest is the narrow canvas addition to the top border of *Cobblers* (Fig. 2). IRR revealed that here the style and the pictorial material are consistent with the overall picture, suggesting that the extension was made by Ceruti himself at a later stage of the work to provide further compositional space. Canvas integration during the painting process were not unusual [16], and several examples have been found also in paintings by artists chronologically and geographically closer to Ceruti [17]. The posthumous inventory of Ceruti's belongings lists raw canvas pieces [18], which may have

been used for such last-minute adjustments. Imaging analyses further support this hypothesis, as the added strip shows a different weave and lacks a preparatory ground, in agreement with the restorer observations from the 2017 conservation treatment.

IRR did not provide useful information regarding the nature or the structure of the textile support. However, thread-count analysis performed on the three X-radiographs of *Il Bravo* and the portraits of the Aliprandi spouses revealed that all three paintings were executed on plain-weave canvases, with different thread counts in the warp and weft directions. *Il Bravo* was executed on a coarsely woven canvas (9 × 9 threads/cm²), whereas the portraits of the Aliprandi couple were painted on canvases with a medium-density weave (*Portrait of Laura Vitali Aliprandi*: 12 × 8 threads/cm²; *Portrait of Marquis Erasmo Aliprandi Martinengo*: 10–11 × 8 threads/cm²). Restoration reports provide further evidence of the variability of the supports: *The Laundress* was painted on a robust, tightly woven canvas, whereas *Two Beggars* was executed on a relatively lightweight canvas with a rather loose weave.

To place these findings in a broader historical context, during Ceruti's lifetime Lombardy was renowned for the production of high-quality linen canvases, which were also highly appreciated outside the region [19,20]. Payments relating to the Gandino cycle indicate that the canvases used for these works were supplied from Brescia [21,22], while the conservation treatment of

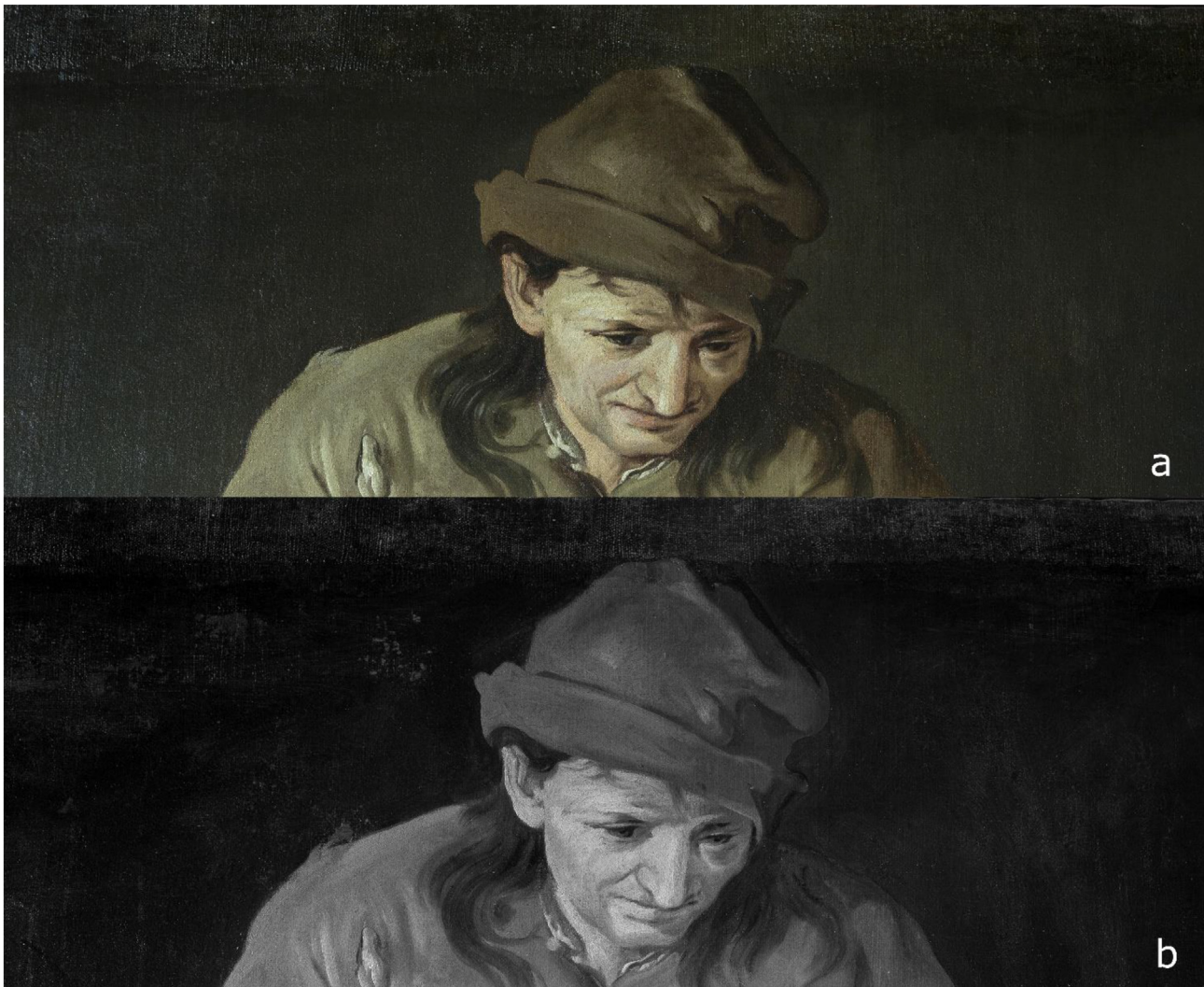


Fig. 2. G. Ceruti, *Cobblers*, Brescia, Pinacoteca Tosio Martinengo. a) VIS photograph; b) IRR with canvas integration made by the artist himself to paint the hat of the man in central position and to allow spatial balance within the composition.

Saint Pontianus and *Saint Peter in Glory* indicated that both paintings were executed on hemp canvas with a relatively open weave (9×9 threads/cm²) [23]. Finally, several pieces of linen canvas are listed in Ceruti's *post-mortem* inventory, together with a debt owed to a certain Gioanna Campazza, who appears to have been a weaver supplying canvases to the artist [18].

3.2. Preparatory ground and priming layer

Several parallel faint curved strokes, resembling long blades of grass, are visible by NIR photography and, more evidently, by the SWIR reflectogram in the lower part in *The Laundress* (Fig. 1). The traces, usually better detected by X-ray [24–26], although to a lesser extent also by IRR [27], are related to the leveling of the priming layer by means of a priming knife or, more generally, a smoothing tool. At that time primed canvases ready to be painted were regularly sold to artists [17,22,28,29]. However, the concentration of sweeping marks exclusively at the bottom of the picture, in an area corresponding to the ground, might suggest that they were somewhat useful to the artist, perhaps to achieve specific effects during the pictorial stage. If this were the case, it may be suggested that Ceruti himself applied a second preparatory layer in this area. The features visible in the IRR would thus provide ev-

idence of his technical skill and of the care he paid to the preparation of the supports. As reported in the literature, painters working on pre-prepared canvases sometimes applied an additional priming layer, or a localized colored priming, over the existing one to enhance brighter tonal passages or to obtain greater chromatic depth [30].

Canvas grounding and priming, indeed, was a crucial preliminary stage in the painting process, and specific procedures are extensively discussed in old technical treatises [31]. Detailed instructions are provided, for instance, by Giovanni Battista Volpato (*Modo da tener nel dipingere*, c. 1680–1690) [32], Francesco Lana Terzi (*Prodromo*, 1670) [33], Richard Symonds (*Segrete intorno la pittura vedute e sentite dalla pratica del sig. Angelo Canini in Roma*, 1649–1651) [34] and Theodore Turquet de Mayerne (*Pictoria, sculptoria, tinctoria*, 1620–1646) [29,35].

However, it is likely that in the initial stages of major and extensive commissions Ceruti was assisted by collaborators to lighten his workload and accelerate the painting process. In the contract drew up for the creation of numerous paintings and frescoes for the Basilica of Santa Maria Assunta in Gandino, it is declared that the commissioner (the clerics of the Basilica) would have provided Ceruti with the canvases and the stretchers. In the payment records, however, are reported payments not only for the above-

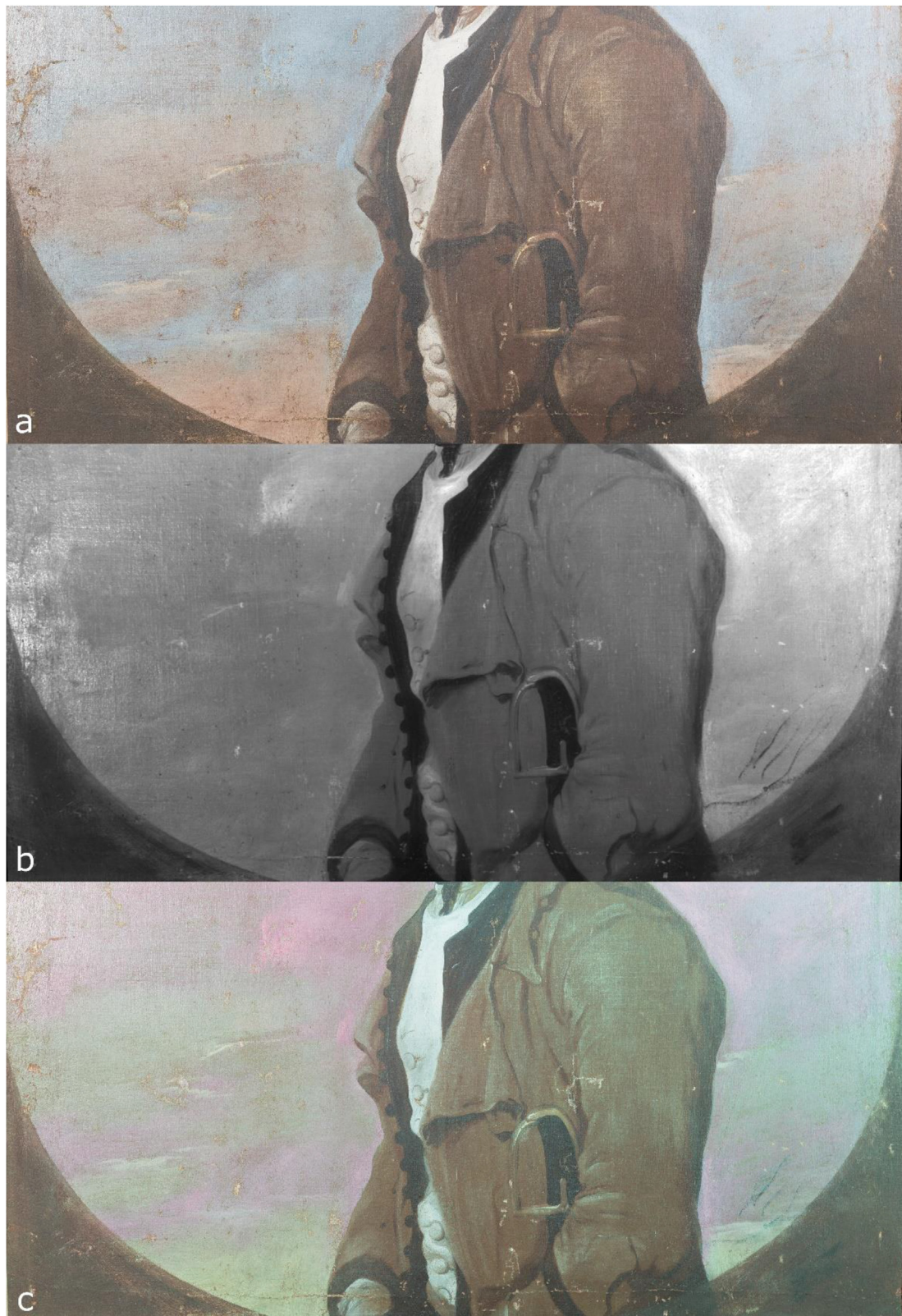


Fig. 3. G. Ceruti, *Bravo*, Brescia, Pinacoteca Tosio Martinengo. a) VIS photograph; b) IRR with brush wiping marks; c) IRFC image, where priming earth-based pigments employed a *risparmio* to achieve the reddish color in the clouds turn green, and the ultramarine blue mixed with a white pigment in the sky becomes pink.

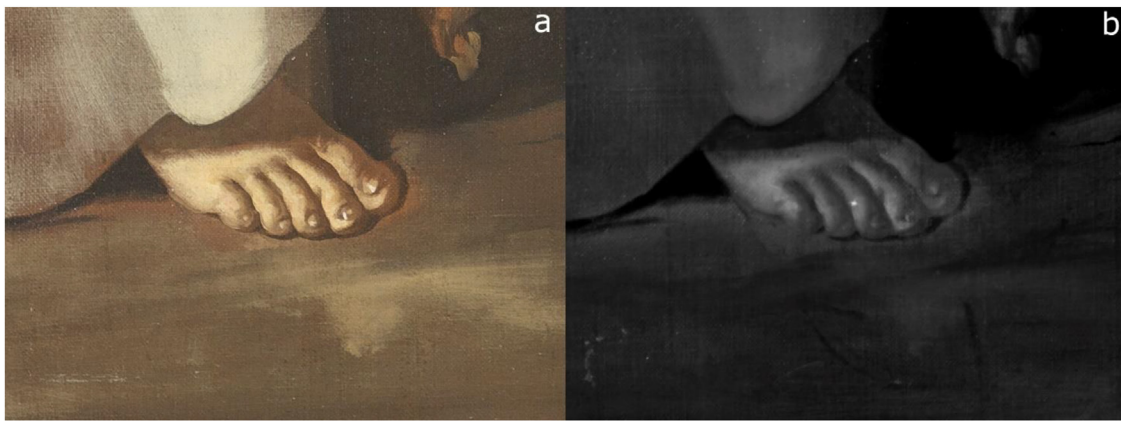


Fig. 4. G. Ceruti, *Two Beggars*, Brescia, Pinacoteca Tosio Martinengo. a) VIS photograph; b) IRR showing dark sketchy brushstrokes near the foot that can be interpreted as a loose outline marking out the original position.

mentioned materials (raw canvases and wood for the stretcher), but also for the sewing of the pieces of fabrics and for the priming realized by a local painter [21,36]. It is therefore plausible that the parallel scratches filled with paint, observed under raking light in the Gandino paintings [14], are the result of a collaborator's intervention.

Colored priming layers were commonly used in the 18th century, as painters were well aware that the perception of the tones and hues of superimposed pigments is influenced by the color of the ground to which they are applied [17,37–39]. Volpato directions for priming preparation include the use of earth pigments mixed with linseed oil and applied with a knife in two layers, the first without grinding the pigments and the second with the pigments ground [32]. On the other hand, in his treatise Lana highlighted the result that can be achieved by leaving the ground visible and exploiting the color for shadows and dark areas of the painting [33].

Historical accounts also document this practice in Ceruti's work. Specifically, records concerning the commission of an altarpiece for the Church of Sant'Alessandro in Piacenza note the day on which Ceruti began preparing the canvas with a brown-colored priming [40].

Evidence of reddish-brown colored grounds in Ceruti's paintings can be observed through close visual examination, as the priming layer frequently emerges beneath the pictorial layer, especially in dark backgrounds (e.g., *Portrait of Two Girls (The Two Sisters)*), shadowed areas (e.g., *Saint Peter in Glory*) [14], or in zones affected by paint loss (e.g., *Mother with Child*). Among the paintings analyzed for this research, it is significant the chromatic effect of the sky at sunset obtained by exploiting the visible priming layer for the final outcome in *Bravo*. The greenish color of the clouds in IRFC imaging suggests the use of earth-based pigments (Fig. 3).

3.3. Preparation for painting and underdrawing

No conventional underdrawing was detected by IRR in any of the investigated paintings, except for some sketchy dark brushstrokes near the right foot of the man on the left in *Two Beggars* (Fig. 4), later painted differently. This might suggest that Ceruti used to produce only a rapid sketch to roughly define the poses and spatial arrangement of the figures, subsequently covering the marks with dense layers of paint, making them usually not visible in IRR.

The use of a light graphic medium, such as gypsum, which would contrast with the dark priming might also be considered, although this cannot be confirmed for the paintings discussed here, as the gypsum traces are erased when painted over, making them

undetectable by IR imaging. In the Gandino cycle, it has been hypothesized that a cartoon whitened with powdered gypsum on the verso was used for the mechanical transfer of the composition [14]. If this were the case, it is likely that the use of cartoons was confined only to extensive commissions, in which he might have been helped by collaborators to speed up the production.

Ceruti did not, as a rule, produce preparatory drawings on paper to work up his designs. The documents relating the Piacenza commission hint at this practice. It is declared, in fact, that the patrons did not expect to approve a preliminary draft of the composition provided by the artist because it was well known that Ceruti was not accustomed to preparing sketches in advance [40].

It is also well established that Ceruti made use of prints as sources of inspiration, or to directly derive various compositional elements, such as architectural settings, animals, and human gestures [41]. In addition, several sheets of paper with drawings or prints by various artists, as well as books likely containing reproductions of artworks by notable painters, such as Paolo Veronese or Tiziano Vecellio, were itemized in Ceruti's *post-mortem* inventory [18]. They were very probably provided to Ceruti by his wife, Matilde de Angelis, who was a bookseller [41]. For instance, the building (an almshouse) in the background of *The Basket Porter* is the same as the one engraved in Jacques Callot's *L'hospice* (from the series *Les Caprices*, 1617), and in this case as well no traces of underdrawing were revealed by the IR imaging analyses.

3.4. Paint layers

A key aspect of Ceruti's technique that emerged from the analyses is his quick and confident application of paint. Depending on the spectral range of the device employed, different depths of penetration into the pictorial layers were achieved, unveiling various features. By way of example, the results obtained on two canvases of similar subjects i.e., *School for Girls* and *Women Working on Pillow Lace (The Sewing School)*, will be presented (Fig. 5). Both scenes are set in a bare, unfurnished room, where a group of seated female figures is intent on sewing, embroidering, and spinning. The longer SWIR wavelengths of IRR were particularly effective in detecting lively and rapid brushstrokes in the back wall and ground of both paintings. Specifically, in *School for Girls* the reflectograms revealed also bold, vigorous, dark-colored brushstrokes applied somewhat randomly with a wide brush, later covered with a uniform superficial layer. They were barely and only partially visible in the NIR photograph (Fig. 5a, b, c). Ceruti exploited these brushstrokes to enhance spatial depth and to create a sense of movement across the otherwise flat surfaces of the walls and floors, as well as to emphasize the material texture of the



Fig. 5. G. Ceruti, *School for Girls*, Brescia, Pinacoteca Tosio Martinengo. a) VIS photograph; b) NIR photograph; c) IRR revealing bold, vigorous, dark-colored brushstrokes in the background. The vertical canvas joint can also be observed. G. Ceruti, *Women Working on Pillow Lace (The Sewing School)*, private collection. d) VIS photograph; e) NIR photograph showing cracks in the paint surface; f) IRR with absorbing background.

surfaces. Conversely, owing to the lower penetration of NIR radiation, IR photography proved useful for inspecting the condition of the artworks. For instance, in *Women Working on Pillow Lace (The Sewing School)*, several cracks in the paint film can be observed along the upper edge in the NIR image, while this area appears dark in IRR, as the pigments here employed are absorbing in the SWIR range (Fig. 5d, e, f).

In the same paintings, as well as in numerous other works by Ceruti (e.g., *Bravo, Portrait of Two Girls (The Two Sisters)*), IR imaging disclosed another aspect that was recurrent in the painter's practice, as thin, random strokes were detected, especially in the right-hand area of the paintings (Fig. 3, 6). In some cases, to a careful visual inspection, the brush marks can be observed through the paint (e.g., *Bravo, Women Working on Pillow Lace (The Sewing School)*) (Fig. 6). In another work, not investigated for the present research, the brushstrokes are clearly visible to the naked eye, being executed directly on top of the pictorial surface layer (e.g., *Portrait of Elisabetta Albrici (Lady Bonometti)* [42]. These traces bear witness to Ceruti's characteristic habit of wiping the brush on the canvas to quickly remove excess of paint and thus accelerate the painting process, while keeping the focus on the realism and emotional depth of the genre scenes, or on the expressiveness of his portraits (Fig. 6).

Ceruti's rapid execution was a hallmark of his *modus operandi*, as evidenced by the imaging analyses and confirmed by historical sources. Indeed, this quality was particularly appreciated by the patrons, and in the case of the Piacenza commission, it was cited as the main reason for hiring the painter [40]. However, it must be emphasized that Ceruti's swift working method was neither hasty nor careless and the final result was admired by the commissioners.

Another record concerning the same commission provides additional insight on the artist's painting process that can be validated by the imaging investigation. The document indicates that the altarpiece was not completed with the painter's customary rapidity, as he was simultaneously engaged in numerous other commissions. Consequently, he suspended work on the altarpiece after only 15 days. Nevertheless, this period was sufficient for him to cover all the figures with paint [40].

This information is particularly significant, as it suggests that Ceruti initially focused on painting the figures. On this basis, the working sequence of some of the examined paintings can be reconstructed through the analysis of brushstrokes and sequence of

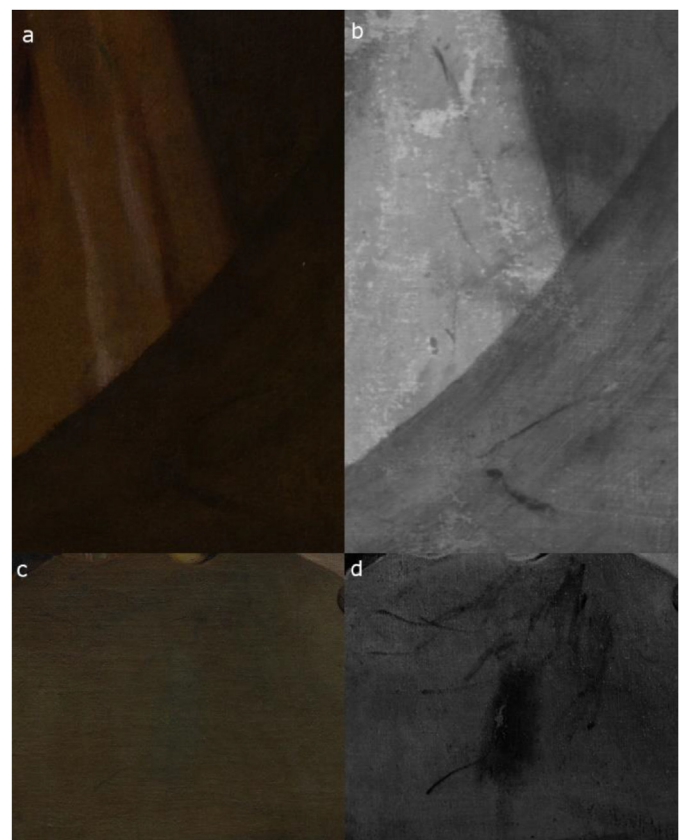


Fig. 6. G. Ceruti, *Portrait of Two Girls (The Two Sisters)*, Brescia, Pinacoteca Tosio Martinengo. a) VIS photograph; b) IRR. G. Ceruti, *Women Working on Pillow Lace (The Sewing School)*, private collection. c) VIS photograph; d) IRR. Details showing Ceruti's characteristic brush unloading marks.

gestures in IRR images. Specifically, after completing the figures, Ceruti appears to have executed the background using loose and lively brushstrokes, leaving areas in reserve around the contours of the figures, which were subsequently filled with more controlled strokes. However, a gap along the outline of most figures (especially in the heads), where the priming is visible, can be observed with the unaided eye. See, as outstanding examples, the different

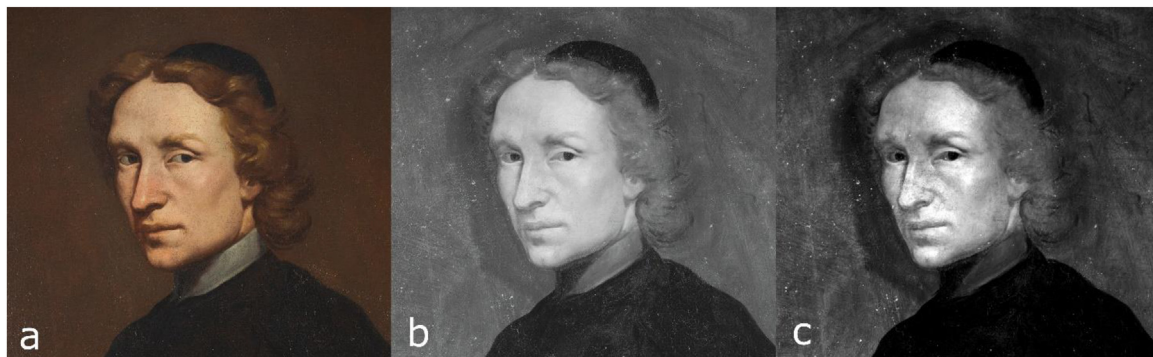


Fig. 7. G. Ceruti, *Portrait of Abbot Angelo Lechi*, Montichiari (BS), Museo Lechi. a) VIS photograph; b) NIR photograph; c) IRR. Dark halo around the sitter's face used as tonal reference.



Fig. 8. G. Ceruti, *Still Life with Fish, a Lobster and Shellfish*, Private collection (Ginevra, Rob Smeets Gallery). a) VIS photograph; b) IRR unveiling the presence of the terracotta pot in the original composition.

paint handle between background and outline of the profiles in the reflectograms of *School for Girls and Women Working on Pillow Lace (The Sewing School)* (Fig. 5), and the gap around the waves of the hair with the reddish-brownish ground that emerges around the head of the poor man on the left in *Two Beggars*.

In the *Portrait of Abbot Angelo Lechi*, IR photography and, in particular, IRR unveiled a dark halo framing the prelate's head in an early stage of the painting process (Fig. 7). At first glance, this broad dark outline might be interpreted as a patch covering a *pentimento* of the face (also suggested by the fact that in the reflectogram the contour of the abbot's profile was initially drew larger), as the projection of the sitter's shadow against the background (although no shadow is visible in the visible image of both paintings), or even as part of the preliminary compositional phase to estimate and define the volume of the head before painting. Similar halo-like shapes around figures and objects have also been observed in works by 17th-century Flemish painters, such as Rubens, Van Dyck and Sweerts [43,44], suggesting that this feature was not a personal stylistic trait but rather an established element of the general artistic practice. In recent research on Sweerts paintings, the presence of the halo was explained by considering the 17th-century working sequence in which the main figures were painted first, and the background was added at a later stage. Blocking out the contours of the sitters's head with a dark paint in an early phase of the painting process was therefore necessary to establish a tonal benchmark for highlights, midtones and shadows. In addition, in portrait painting, the dark underpainted halo facilitated the soft blending of the outer contours into the background, al-

lowing the artist to achieve a more naturalistic effect [44]. Similar technical conclusions can be assumed also for Ceruti's portrait here presented.

IRR in the SWIR allowed the investigation of modifications and additions in the process of painting. However, in the overall, it is worth noting that in such a rapid and relatively "instinctive" artistic procedure, *pentimenti* are generally limited to small adjustments, suggesting that the artist had a clear composition in mind. X-ray analysis also confirmed that the pictorial arrangement was defined in advance, showing that certain elements, such as the hat of *Il Bravo*, as well as secondary details, such as the locks of hair falling onto the forehead of Laura Vitali Aliprandi, were not added after the execution of the heads of the figures but were already established during the painting stage, with only slight subsequent changes.

Notable examples of these minor revisions include the upper part with the handle of the cane held by the old man in *Two Beggars (Encounter in the wood)*, which was added over the already painted branches of the wood background, as well as the puffed cuff of the young man's shirt in *Portrait of a Young Gentleman*, which was at first painted smaller and modest. Similarly, in the *Portrait of a Lady (Countess Belgioioso)* the IRR analysis revealed that a false beauty spot was initially painted on the sitter's forehead, and that a curl of the wig extended down to the lady's left shoulder. Furthermore, in the area near the left ear, several brushstrokes can be attributed to a decorative element (possibly floral) of the hairstyle, later concealed beneath the light green halo around the woman's head. This latter feature, which appears as a

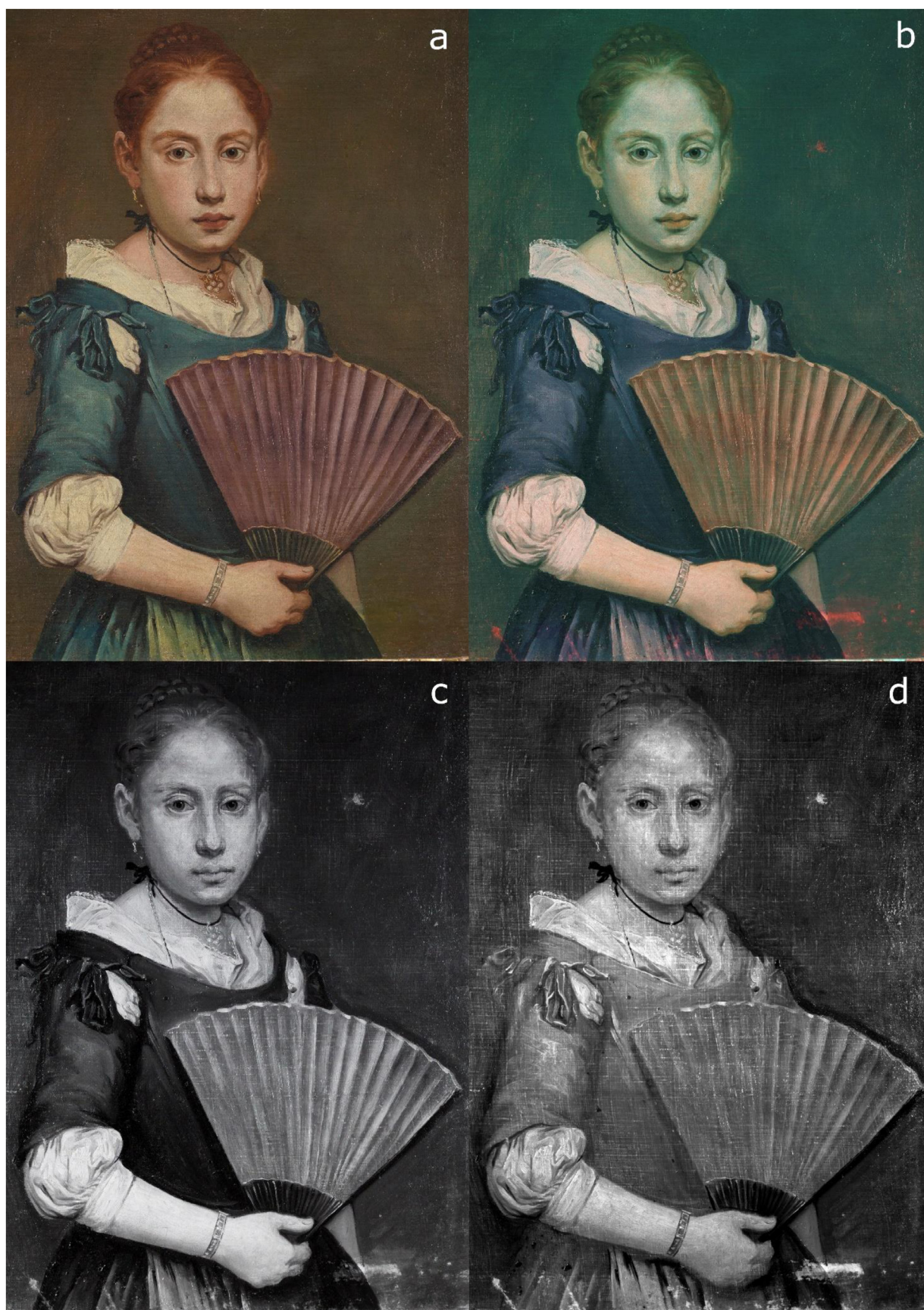


Fig. 9. G. Ceruti, *Portrait of a Young Lady with a Fan*, Bergamo, Fondazione Accademia Carrara. a) VIS photograph; b) IRFC image showing dark blue rendering of Prussian blue in the girl's dress; c) NIR photograph, where the dress is dark, thus the pigments is strongly absorbing; d) IRR where the dress is light grey, thus the pigments is reflecting.

light area in the IR photograph, is a superficial patch to cover the *pentimento*, and is different from the abovementioned dark halo outline used as tonal reference in portraits.

The only major compositional change can be identified in *Still Life with Fish, a Lobster and Shellfish*, where two concentric dark ovals, traced with a brush and partially overlapping the terracotta pot, are visible in the reflectogram (Fig. 8). This feature indicates that the original design included a lid, whose contours were only preliminarily outlined, leaning against the pot. Probably unsatisfied with the result – which would have rendered the pictorial arrangement excessively full by closing off the background on the left and restricting the night sky only to the right portion – Ceruti chose to omit this element in the final version.

Some portraits are characterized by a painted oval frame. IRR and X-ray analysis revealed that this element was executed at a later stage, applied over the already completed figure, often hiding parts of the composition. For instance, in the pendant pictures *Portrait of Laura Vitali Aliprandi* and *Portrait of Marquis Erasmo Aliprandi Martinengo*, a portion of the lady's voluminous mantle in the lower right, and parts of the gentleman's sleeve and outer garment are concealed by the overpainted frame.

3.5. Focus on blue pigments and Prussian blue

IRFC imaging was effective for qualitative pigments identification and mapping, while punctual spectrometry (FORS) investigation was useful for confirmation. The most interesting results concerned the blue-colored areas, where through IRFC imaging and FORS analysis four different blue pigments were discriminated. The characteristic red false color response of ultramarine blue was recognized in secondary details, such as the folded sleeve of the dress worn by the girl in the foreground looking directly toward the observer in *Women Working on Pillow Lace (The Sewing School)*, or the garment of one of the sketchily painted poor men in the background of *The Basket Porter*. Ultramarine blue mixed with a white pigment (most likely lead white, given its high radiopacity in the X-ray image) was also employed in light blue shades of the sky in *Bravo*, as indicated by its pink appearance in the IRFC rendering (Fig. 3c). Conversely, the purplish-blue color obtained in the sky of *Mother with Child* was indicative for the use of azurite. The reddish tone visible on the pleats of the mother's skirt in the same painting might suggest the presence again of ultramarine blue for this secondary detail, but through FORS analysis indigo was identified. The blue color of the girl's dress in *Portrait of a Young Lady with a Fan* resulted to be dark blue in IRFC rendering, meaning that another blue pigment was present in Ceruti's palette (Fig. 9). The garment appears dark in the IR photo and light grey in IRR, suggesting that the pigment is strongly absorbent in the VIS-NIR photograph region (up to 1 μm), while its reflectance increases in the SWIR range of IRR [45]. According to the imaging results, it was proposed the use of Prussian blue here. Punctual spectrometry investigation confirmed this suggestion.

It is worth emphasizing that Prussian blue, the first purely synthetic pigment, was a recent discovery, having been synthesized between 1704 and 1707 [46,47]. Even though its method of manufacture was published only in 1724 [47,48], historical accounts and scientific analyses proved that it was commercialized and employed by artists across Europe well before that date [49,50]. In the Venetian milieu, the presence of Prussian blue, even before its widespread use, has been confirmed in a number of paintings by Canaletto and Tiepolo [51–54]. The pigment was also used in the Roman artistic context by the early 1730s [55]. Ceruti's *Portrait of a Young Lady with a Fan* is dated, based on stylistic ground, between 1725 and 1730, thus before the painter's stay in Venice. Therefore, Ceruti's relatively early adoption of Prussian blue indicates not only

his awareness of newly available materials, but also his willingness to experiment with this brand-new alternative to traditional blue pigments.

4. Conclusions

The monographic exhibition dedicated to Giacomo Ceruti (Brescia, 2023) allowed, for the first time, the execution of a systematic, non-invasive diagnostic campaign on a statistically significant corpus of the artist's works. Twenty-four paintings, considered representative and covering the full chronological span of Ceruti's career, were investigated using multi-band imaging techniques (VIS-IR photography, IRR, IRFC mapping) and targeted point analyses (FORS). The results allowed a coherent reconstruction of Ceruti's *modus operandi*, confirming the consistency between the technical imaging analyses and the historical sources.

Analyses provided significant new information on the supports, Ceruti's *modus operandi* (his sequence of gestures, the way he applied the paint, his habit of wiping the brush on the canvas, the intentional exploitation of the visible ground layer a *risparmio* to achieve specific pictorial effects), and changes and *pentimenti* halfway through the process.

Exploiting the different and complementary penetration depths of the NIR and SWIR ranges it was possible to investigate features in different layers in relation to the materials' response in different spectral bands. The integration of the achieved information was useful to outline the stages of Ceruti's painting process: using NIR photography the condition of the superficial paint layers can be examined and the final paint touches can be better appreciated; with IRR, preliminary brushstrokes in the inner layers, which have been then covered by another film of paint, can be distinguished, as well as modifications and *pentimenti* can be noticed.

The integration of scientific data with archival, iconographic and art-historical research has allowed to verify the correlation between Ceruti's artistic procedure and the painting norm of his time as outlined in written historical accounts concerning the artist and technical literature.

The immediate embracing of Prussian blue shortly after it became widely available to artists is a further novel aspect revealed by the present research, highlighting Ceruti's awareness of newly introduced materials.

The consistency between imaging evidence and historical records strengthens the interpretation of Ceruti's technique, emphasizing how technical examination and documentary sources can support each other. In this perspective, IR imaging proves to be not only a diagnostic tool, but also a valuable methodological aid for reconstructing artistic processes and intentions, while archival records are useful to address analyses interpretation.

The methodological framework adopted in this study underscores the potential of systematic imaging campaigns carried out in single-artist comprehensive exhibitions; the approach could be a replicable model for art history research aimed at technical reconstruction of artists' practices at the monographic scale.

Authors' contributions

N.d.M.: conceptualization, writing – original draft, editing and revision, interpretation and discussion, resources; **P.A.:** conceptualization, investigation, writing – review and editing, interpretation and discussion, resources; **L.M.:** writing – review and editing, resources; **C.D.:** conceptualization, methodology, writing – review and editing, resources; **M.M.:** conceptualization, writing – review and editing, resources, supervision, funding acquisition. All authors have read and agreed to the published version of the manuscript.

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Supplementary materials

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