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THE GAP BETWEEN ETHICS AND AESTHETICS IN ITALIAN RESTORATION: EXPERIENCES IN THE LABORATORIES OF THE OPIFICIO DELLE PIETRE DURE IN FLORENCE—DELLA ROBBIA SCULPTURE CASE STUDIES

LAURA SPERANZA AND SHIRIN AFRA

The question of the gap (the loss of materials and colors) is perhaps the most debated argument in the philosophy of restoration to this day. Although the numerous theories on filling the gap were sometimes contradictory, all are still current and applicable. How do we deal with the gap in Europe and especially in Italy? How much of it do we fill? Does the restoration have to be recognizable, should it hide the pictorial retouch, or should it stand out? Is there a common criterion that is applicable to all types of support? In other words, does ethics or aesthetics prevail? This article examines some exemplary cases of restoration of polychrome sculptures, including della Robbia works, at the restoration laboratories of the Opificio delle Pietre Dure in Florence. We analyze the discussion around the reconstruction of the gap in modeled works, including the use of three-dimensional scanning technique, and the pictorial retouching of the color gap. We also address what we call the “dual gap,” that is, the presence of both the modeling gap and pictorial gap, which opens the way for a new philosophical debate between ethics and aesthetics of restoration.

1. THE OPIFICIO DELLE PIETRE DURE CERAMIC AND PLASTIC MATERIALS DEPARTMENT

The Ceramic and Plastic Materials Laboratory is part of the National Institute of Restoration and Conservation at the Opificio delle Pietre Dure (OPD). The Opificio delle Pietre Dure (literally meaning “workshop of semi-precious stones”) is a public institute of the Italian Ministry for Cultural Heritage based in Florence. It is a global leader in the field of art restoration and serves as one of two Italian state conservation schools. The institute also maintains a specialist library, an archive of conservation, and a museum displaying historic examples of pietre dure inlaid semi-precious stone artifacts. A scientific laboratory conducts research and diagnostics and provides preventive conservation service (see appendix 1 for further information on the OPD). The OPD Ceramic and Plastic Materials Department has restored important artworks by Donatello, Iacopo della Quercia, Benedetto da Maiano, and Michelangelo. In recent years, we have focused our restoration and research on important glazed terracotta works related to the artists of the della Robbia family.

In this article, we will present the restoration of the first large statuary group modeled by Luca della Robbia (1399/1400–1482) representing the *Visitation*, the biblical encounter between the Virgin Mary and her cousin Elizabeth, before the births of Jesus and John the Baptist (fig. 1).

Additionally, we will discuss the restoration of the 10 *Putti* by Andrea della Robbia (1435–1525; fig. 2), located on the façade of the Ospedale degli Innocenti—the Hospital of the Innocents—one of the most representative historic buildings in Florence, designed by Filippo Brunelleschi (1377–1446), who received the commission in 1419. The hospital was originally a children’s orphanage and is regarded as a notable example of early Italian Renaissance architecture. The hospital, which features a nine-bay loggia facing the Piazza SS. Annunziata, was built and managed by the Arte della Seta, or Silk Guild of Florence. That guild was one of the wealthiest in the city and, like most guilds, took upon itself philanthropic duties. The façade is made up of nine semi-circular arches, upon whose spandrels are glazed blue terracotta roundels by Andrea della Robbia. They feature reliefs of babies, hinting at the function of the building.



Fig. 1. Luca della Robbia, *Visitation*, 1445, glazed terracotta. Church of Saint Giovanni Fuorcivitas, Pistoia (Courtesy of Opificio delle Pietre Dure)

Both works gave us the opportunity to experiment with and deepen our knowledge of new conservation solutions, especially the use of static stabilization systems, three-dimensional (3D) technology, and carbon fiber wall anchoring systems. The restoration has been divided into several different phases, but



Fig. 2. Andrea della Robbia, *Putti*, 1487, Ospedale degli Innocenti, Piazza SS. Annunziata, Florence (Courtesy of Opificio delle Pietre Dure)

this article will discuss how we tackled and solved both the aesthetic and technical aspects associated with the gaps in glazed terracotta works located outdoors. It will also touch on the concomitant issues related to exposure to atmospheric agents, stress caused by temperature changes, condensation, and pollution present in both air and rain water.

2. DELLA ROBBIA SCULPTURE CASE STUDIES

2.1 The *Visitation* of Luca della Robbia, 1445, Church of San Giovanni Fuorcivitas, Pistoia, Italy

2.1.1 *History and Description*

The sculptural group representing the *Visitation* is the earliest surviving freestanding statuary work in glazed terracotta by Luca della Robbia (figs. 1, 3). It consists of two large figures, each made in two sections, modeled for the altar of the Confraternity of Saint Elizabeth toward the end of 1445. The Virgin, represented as a simple and very beautiful girl, reaches out toward the elderly Elizabeth with care and affection while their gazes mutually transmit an intense humanity.

The sculpture is entirely glazed, even on its nonvisible side, though the details there are defined to a lesser extent (fig. 4). With this work of art we can affirm that a new chapter in art history is starting—the chapter of glazed sculpture.



Fig. 3. *Visitation* after the restoration, front side (Courtesy of Opificio delle Pietre Dure)

The group was fired in two sequential steps: the bisque firing, which transforms the clay into a ceramic body, and then a second firing, after the application of the glaze, at a temperature near 900°C (fig. 5).

The sculptures are hollow and were created in sections in order to allow firing in furnaces with limited dimensions, but also for easier handling and transportation. The four sections interlock perfectly thanks to connecting joints between the parts, which are concealed under the folds of the draperies. The arms of the two figures are incorporated within the body of the other figure (figs. 6, 7). The gap between the two figures is concealed by a slight widening of the outer folds of the draperies. In this way, the edges of one figure are incorporated within the contours of the other figure.

Despite being hollow, it was always possible that the sculpture could crack in the first phase of firing. The wood-fired kilns did not distribute heat evenly. The *Visitation* is the first large-scale sculptural work of the della Robbia workshop. Thus, there are technological mistakes, such as firing cracks, that would become gradually less frequent in their subsequent artworks until they disappear altogether. In this specific case,



Fig. 4. *Visitation* after the restoration, back side (Courtesy of Opificio delle Pietre Dure)

there were numerous microfractures and some major fractures, especially in the lower parts of the two figures, that went on to cause further breakages.

2.1.2 Previous Repairs and Interventions

Due to early technological problems in firing such large-scale works, microfractures and large-scale breaks have necessitated that the work be restored several times over the last centuries. The largest fractures were filled by Luca himself: the stannic lead enamel used for the glaze was used as an “adhesive” to repair the fractures caused by the first firing, and some small terracotta wedges were also inserted inside the fractures to fill the losses. It is a kind of “proto-restoration.” At a temperature of about 880°C, during the vitrification process of the surface, the glaze created a rigid adhesive in all of those breakages and fractures (fig. 8).



Fig. 5. *Visitation* after it arrived at the Laboratory of the Opificio (Courtesy of Opificio delle Pietre Dure)

Inside the artwork there is, however, another purplish glaze. Analysis revealed that this glaze contains manganese and traces of an organic material. It is thought that during the second firing, other fissures opened. Thus, a manganese glaze—being much tougher, more resistant, and more hard-wearing than a tin glaze—was applied along with organic components used to further reinforce the enamel. Then, the sculpture was fired a third time, again inserting the same kind of terracotta wedges inside the fractures.

In addition to these original “restorations,” a thick layer of colored gypsum plaster reinforced with straw was found inside the sculptures, whose function was to keep all of the fragments joined together. Over this first layer of gypsum plaster, there is a second, more recent coating, which does not contain any straw. This second coat of plaster was colored red and ochre to imitate the terracotta.

This sculptural group underwent a very quick restoration before being displayed in the exhibition *Una scuola per Piero* (A School for Piero), held at the Uffizi Gallery beginning in September 1992, on the occasion of the celebrations for the fifth centenary of the death of Piero della Francesca. The intervention was realized at the Opificio by Beatrice Angeli, who wrote a conservation report: basically, the glazed surface was cleaned with a neutral nonionic surfactant, a solution of acetone and alcohol and poultices of ammonium carbonate. After reducing and resurfacing the old altered fills with Polyfilla Fine Surface, a stucco made of cellulose fibers, plaster, and acrylic gouache colors was added to match the original glaze. The artwork was, in fact, very soiled, with evident glue lines along the fractures. The lines had been filled but had also discolored noticeably and, in the lower part of the figure of Saint Elizabeth, many alterations of the old fills were present (fig. 9).



Fig. 6. *Visitation*: The upper section of Mary during the restoration (Courtesy of Opificio delle Pietre Dure)



Fig. 7. *Visitation*: Detail of the bust of Saint Elizabeth (Courtesy of Opificio delle Pietre Dure)

In preparation for celebratory events related to Pistoia being named capital of culture in 2017, a new restoration of the artwork was begun, assisted in large part by funding received from the Museum of Fine Arts, Boston (fig. 10). In this new intervention, the Opificio revisited the restoration of 1992, which had altered considerably, and realized new procedures aiming to improve the artwork's stability and its aesthetic appearance. Our intervention foresaw new fills that are less visible and certainly more long-lasting thanks to the use of watercolors instead of gouache and a 3D consolidation system.



Fig. 8. *Visitation*: Small terracotta wedges inserted inside the firing fractures (Courtesy of Opificio delle Pietre Dure)



Fig. 9. *Visitation*: The lower section of Saint Elizabeth before the 1992 restoration (Courtesy of Opificio delle Pietre Dure)

2.1.3 Examination and Condition

The sculpture comes from the church of San Giovanni Fuorcivitas in Pistoia, where it is housed inside a niche and protected by a thick glass (see fig. 1). The microclimatic conditions, lack of air recirculation, and water condensation caused the formation of superficial molds, deposited on the layer of dust on the white glaze. The sculpture has shifted several times over the centuries and has undergone disassembly interventions that, coupled with tensions due to the original fractures, have compromised its integrity, causing further fractures and microfractures. Probably due to incorrect handling, the back of the legs of Saint Elizabeth broke and fragments were lost. The robe that falls to the floor near her feet has been modeled *ex novo* in a recent restoration. Even other unaffected small portions of the Virgin Mary were remodeled. Under ultraviolet radiation, all of these old material additions are clearly visible as well as widespread cracking that is most prominent in areas of higher tension, that is, between the legs and the busts, especially on the back of Elizabeth. Here, a “spider web” of fractures radiates vertically and



Fig. 10. Dismantled *Visitation* at the OPD Laboratory with the Boston colleagues (Courtesy of Opificio delle Pietre Dure)

horizontally (fig. 11). Due to the presence of reinforcing gypsum, the cohesion between the parts is still effective except for a weakness along the upper edges of the two large pieces of the legs.

2.1.4 Restoration

The restoration work was organized into different stages: cleaning, consolidation, filling, retouching, and static adjustment.

The first cleaning phase included the microsuction of overall dirt and dusting with soft brushes. The glazed surface was cleaned with a mixture of ethyl alcohol and water, using natural sponges and cotton wool.

After the cleaning, the old integrations were removed, but the red-painted gypsum plaster fills inside the sculptures were almost completely maintained for structural purposes and cleaned with water. However, enough of the upper part of the red-painted gypsum plaster near the edge was partially removed to allow for the injection of consolidating resins in the open faulty fractures. The glaze and the craquelure were consolidated with a fluoroelastomer resin (Fluoline CP¹) applied with a brush. The fractures that seriously compromised the solidity of the sculptures were consolidated by injecting a two-component epoxy resin at 50% in ethyl alcohol (Uhu-Plus). The gypsum plaster inside the sculptures was also consolidated, using an acrylic resin (Acril 33)² at 10% in water. Plasticine and a latex film were used to avoid resin leakage, thus preventing irreversible marks on the terracotta surface. All gaps and losses were filled and shaped



Fig. 11. *Visitation*: Comparison under visible light and UV radiation (Courtesy of Opificio delle Pietre Dure)

with a white acrylic filler, which guarantees a safe and easy reversibility and resists humidity, and then smoothed with sandpaper, taking great care not to touch the surrounding glazed areas (figs. 12, 13). The firing defects were not filled, as is the normal practice of the methodology adopted at the Opificio (see figs. 3, 4).

The retouching on the integrations was carried out with small color dots, using the pointillism technique in watercolor (fig. 14).

2.1.5 Laser Scanning and 3D Printing for Documentation and Assembly Solutions

Three-dimensional digital technologies played an important role in the restoration process of the *Visitation* sculpture of Luca della Robbia: first, as a means of documenting the work and second, for the creation of a 3D-printed cushion used to protect the parts of the sculpture from damage when reassembled.

The terracotta sculpture was scanned with a 3D scanner belonging to the Opificio delle Pietre Dure. A full survey of both outer and inner surfaces was obtained in order to create a complete set of documentation that would complement the photographic records. The della Robbia sculpture was scanned with a Structured Light handheld 3D scanner; the texture was also acquired. The acquisition has a maximum precision of 0.5 mm. The data are collected as OBJ and STL files, useful for studying and planning the restoration intervention, and serve as complete documentation of the conservation conditions before the restoration. The 3D files allowed for the measurement of the various parts and the evaluation of the new assembly system.

Originally, the *Visitation* was assembled with a layer of plaster between the upper and lower sections (busts and legs). Over the centuries, this thick layer was gradually removed and not replaced. By the time of our restoration, the pieces of terracotta were in direct contact along only limited areas, increasing the risk of damaging the fired clay and glaze due to impact and friction. There was another important risk



Fig. 12. *Visitation*: Mary's foot, before and after the restoration (Courtesy of Opificio delle Pietre Dure)



Fig. 13. *Visitation*: Detail of the arms, before and after the restoration (Courtesy of Opificio delle Pietre Dure)

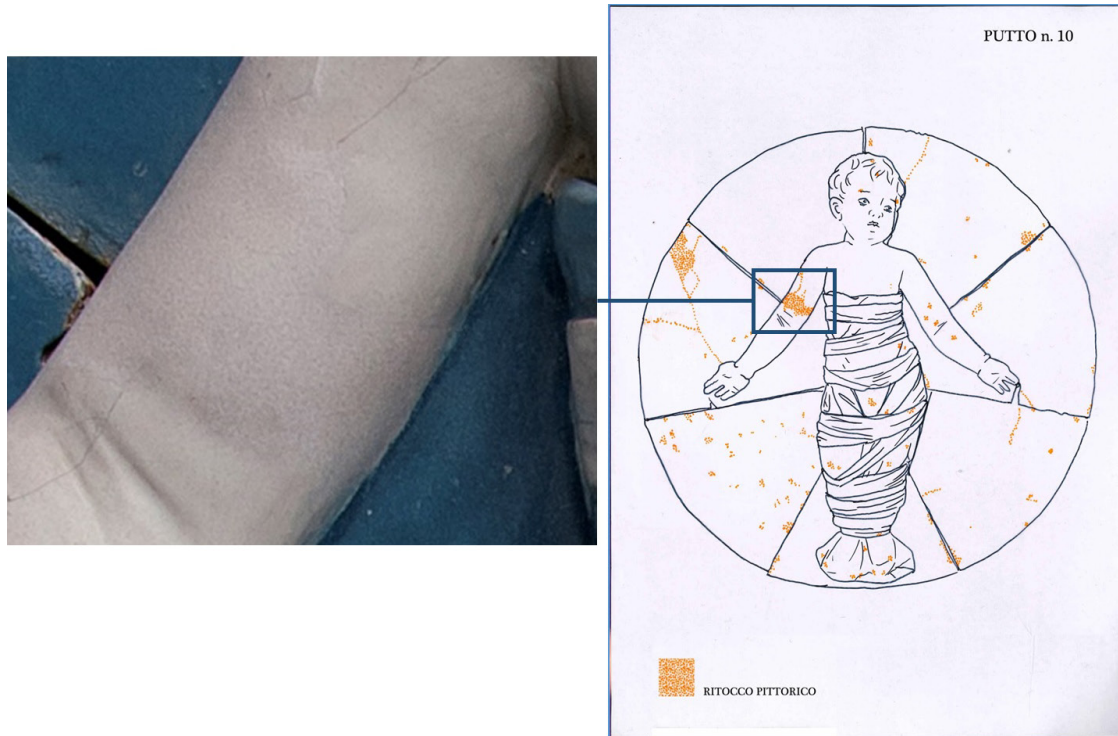


Fig. 14. *Putto* number 10's pictorial retouching (Courtesy of Opificio delle Pietre Dure)

factor to consider in the sculpture's preservation: the contact points between the border sections were few and of a smaller size than those required for stable conditions—only a half dozen points in the statue of Saint Elizabeth and even fewer in the figure of the Virgin Mary. The weight of the busts (more than 45 lbs./20 kg each) creates an excess of pressure above these reduced contact points on the lower parts of the sculpture. Furthermore, the fragility is increased by the breakages and fractures in the legs: the busts' weight is a real factor of risk for the structural integrity of the statue as a whole.

In order to ensure the correct weight distribution of the busts, we created a resin gasket that bridges all of the gaps between the contact surfaces. Possible available solutions were either a protective silicone layer or a printed “cushion” made of resin. The first option is commonly used by the Opificio but requires rapid moving and handling of the sculpture's parts, as silicone curing times are relatively quick. The second option is based on an important currently available resource, 3D printing technology, which allows multiple solutions in the field of restoration. We therefore decided to create an inner gasket with this second method, a solution that allowed for reduced handling of the original pieces compared with the creation of a protective silicone layer.

The procedure of arriving at the new assembly method was carried out in various steps. The first step started with scanning each separate section: the interior of the two sections of the Virgin Mary and the two of Saint Elizabeth were also scanned to obtain an adequate survey of the matching contact profiles (fig. 15). The second step consisted of scanning the surface of the exteriors of both assembled figures. The scanned area was limited to the surface surrounding the joins. Thanks to these scans, we obtained a precise 3D file that stores the correct position and orientation of the upper pieces above the lower ones.

The next step was the modeling of a new protective inner gasket (or “cushion”) with 3D editing software. The scans were edited and virtually oriented: a minimum distance of 0.08 in./2 mm was created between

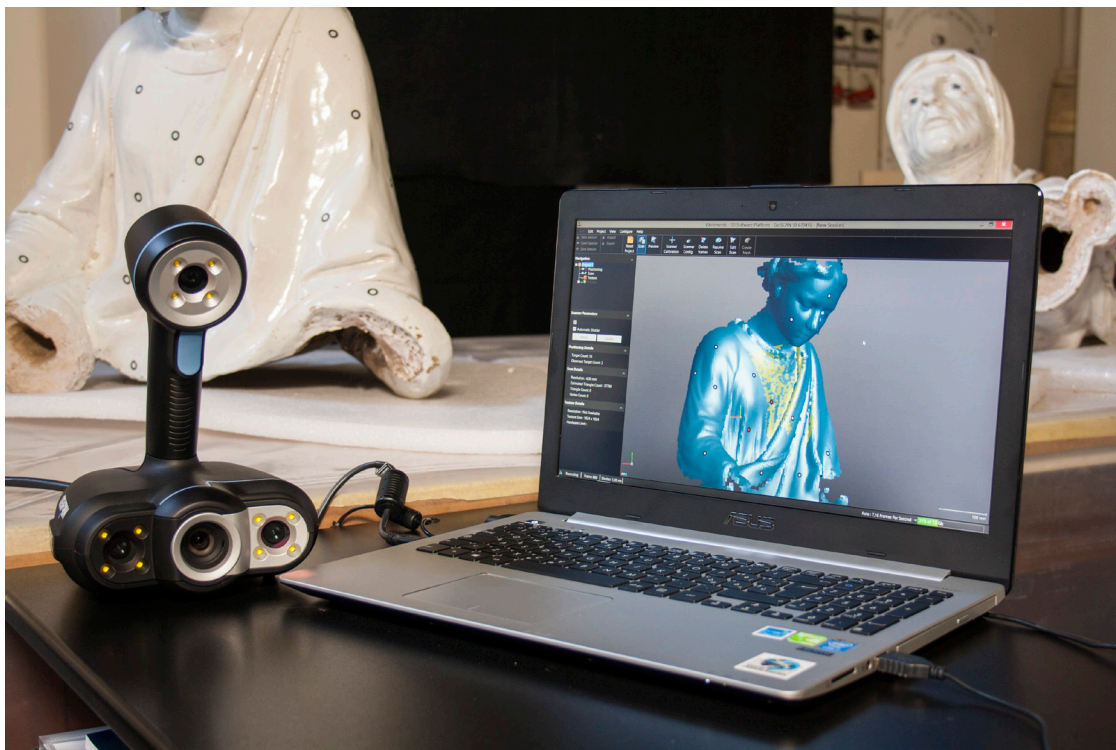


Fig. 15. The real-time 3D scanning of *Visitation* (Courtesy of Opificio delle Pietre Dure)

the contact areas. The empty space between the lower edge of the busts and the upper edge of the legs was filled virtually with a new volumetric shape—a fill perfectly matching the contours of the join.

The final step was to make this new fill real. By means of a stereolithographic 3D printer, we prototyped the cushion. The printer cures a photosensitive resin (a mixture of methacrylated monomers and oligomers plus photoinitiators) and converts the virtual 3D mesh into a real, solid and durable resin piece.

A brief explanation of the stereolithography process that we used can help to better understand the technique. A liquid resin is placed into a Plexiglas tank with a transparent bottom; then, a building plane is mounted on a vertical motorized axis and starts its path from inside the tank and slides slowly out of it. Meanwhile, a system of mirrors orients and moves a UV spotlight generated by a laser (405 nm). The resin is cured sequentially layer after layer and comes out of the tank, attached to the build plate. The printing software generates supports and structures automatically to build the pieces correctly. These supports can be easily removed by the users at the end of the printing process. The uncured liquid resin is removed from the sheath by means of baths of isopropyl alcohol and is then post-cured under UV light in order to increase its full structural properties.

The chosen resin has the following values, suitable for our purposes: tensile strength 9380 psi/65 MPa, Young's modulus 402 ksi/2.8 GPa, flexural modulus 320 ksi/2.2 GPa, notched IZOD impact strength 0.46 ft.-lbf/in./25 J/m. These values ensure that the 3D print has the properties necessary to perform the necessary functions: to hold and distribute the weight of the busts and to protect the terracotta from impacts and self-collisions (fig. 16).



Fig. 16. *Visitation*: The 3D-printed cushion placed above the lower section of Saint Elizabeth (Courtesy of Opificio delle Pietre Dure)

The resin gasket fills the gaps along the entire join so that there are no longer just a few contact points, but rather all the weight is continuously and evenly distributed. Its custom shape keeps the pieces in place and avoids unwanted movements or rotations of the busts. The resin's hardness is less than that of the terracotta; thus, if an accident should happen, this layer is sacrificial, saving the sculpture's border without stressing the glazed surface.

We used a white resin, as it has a suitable visual impact within the white color of the *Visitation's* glazing. Once put in place between the parts, the cushion is barely visible.

Another advantage of this solution over that of the molded silicone layer is that if the printed cushion should ever be damaged, it will be possible to reprint it. Stereolithographic machines are becoming ubiquitous around the world at all levels of accessibility. In the event that a new cushion needs to be created, it will not need to be printed in a specific place or country: this will drastically reduce working times and simplify logistics.

2.2 The 10 *Putti* by Andrea della Robbia from the Facade of the Hospital of the Innocents in Florence

2.2.1 *History and Condition*

Andrea della Robbia's cycle of glazed polychrome terracotta bas reliefs depicting "putti in swaddling clothes" was commissioned by Francesco Tesori, Prior of the Hospital dedicated to Saint Mary of the Innocents, to decorate the outer loggia of the Hospital facing onto the Piazza SS. Annunziata, built according to a project by Filippo Brunelleschi. The reliefs were placed in the façade in 1487, documented on the 21st of August of that year in a transaction in which Antonio di Marco della Robbia (Andrea's brother) was paid "*per sua fatica d'aver aiutato mettere i bambini di terra ne' tondi sopra la loggia di fuori*"—for his efforts in helping to put the children from the ground into the tondos above the outer loggia—surrounded by a frame in pietra serena.⁴

The glazed medallions, each one unique, are executed partly in relief with the paleness of the flesh tones contrasting with an intense cobalt blue background. For almost 600 years, the *Putti* have stood as the symbols of the historical Florentine Institute that takes care of abandoned children. In 1845, when the loggia was extended on the two sides, four copies of the della Robbia medallions were added, realized in porcelain by the Ginori Manufactory. The four Ginori tondos were not treated as part of our restoration.

Each ceramic medallion was supported by thin metal brackets, some of which were not stable, fixed in the masonry inside the stone frames. Mortar and plaster fills in the joins between the component sections and the retaining bracket had various gaps and a weak grip on the tondos. The precarious mounting system was very different from the usual technique implemented for the glazed reliefs of the della Robbia sculptors; it seemed to be the result of a subsequent restoration, probably carried out in the post-war period. The artworks showed visible signs of degradation in both the body and the glaze.

The causes of the degradation can largely be ascribed to outdoor exposure and accidental factors over the years but also to faults related to the original manufacture of the works. Exposure to atmospheric agents induced physical degradation that increased the aperture of the cracks and exacerbated the loss of the glaze.

After the restoration, the 10 *Putti* were exhibited in the Innocenti Museum from June to December 2016 (fig. 17).

2.2.2 *Restoration Intervention*

In May 2016, the 10 *Putti* were removed from the hospital's facade and transported to the Restoration Workshops of the Opificio. This required the consolidation of the reliefs prior to taking them down, removing the mortar around the edges of the sections, removing both of the metal pins used to anchor the *Putti* to the wall, and disassembling the central part of the relief with the putto's body. After disassembling all of the various sections, the reliefs were packed and taken to the Opificio.



Fig. 17. *Putti* on exhibition at degli Innocenti Museum after the restoration (Courtesy of Opificio delle Pietre Dure)

The restoration work was articulated in several phases. The most complex phase dealt with the creation of a carbon fiber support that was made under vacuum pressure with seven layers of carbon tissue and epoxy resin.

Each putto was inspected under the microscope and the top layer of surface dirt was removed. The old stucco infill was removed using an ultrasonic dental scaler, the old oxidized metal pins were taken out, and the ceramic body consolidated.

The cleaning started with the use of specifically formulated gels and delicate cotton wool swabs, removing the special coating applied to protect the glazing when taking the reliefs off the façade. The back of the relief was cleaned with a pneumatic microchisel to reduce the mortar bed and any inappropriate stucco infill.

The broken fragments were glued with an epoxy resin and the gaps filled with an acrylic stucco with features suitable for outdoor exposure. We inpainted these fills using watercolor paint in a dotted, almost “pointillist” style.

In our work, we decided to use reversible materials for both consolidation and surface treatment. The fill, pigments, protective film, and varnish were subjected to accelerated aging tests in a climate chamber, reproducing solar radiation and temperature and humidity fluctuations in an outdoor environment. These tests confirmed excellent characteristics: absence of yellowing, inalterability of colors, and overall resistance.

3. A MATTER OF ETHICS AND AESTHETICS

The terracotta polychrome sculptures, just like similar ones in wood, are a particular type of artwork in which two meanings, the three-dimensional meaning and the pictorial one, coexist and help to establish an instant communication with the observer. Not by chance, these artifacts often have a religious or highly symbolic value. For this reason, for centuries, attempts have been made to maintain original polychromy on these works, contrary to what has happened to marble sculpture, whose colors and therefore meanings were often changed completely for reasons of style or moral rigor. The modern interpretation of conservation arises from the consciousness of this complementarity between volume and color. In this sense, the gap assumes a new value, which we call “double gap”: material gap and pictorial loss.

In the theory of Italian restoration, starting from the 1972 “Italian Restoration Charter”—the first ministerial document attempting to regulate restoration practices from a methodological and ethical point of view—restoration theorists wanted to “allow” or “ban” certain restoration practices, placing the main focus on what was morally but also aesthetically right about a restoration intervention. The answer, which has seen its application through different styles and proposals, has always been to denounce the restorer’s intervention and make it visible to the viewer.

Retouching made distinguishable from the original surface is now widely accepted in the Italian restoration of pictorial artworks. *Selective retouching*, made with thin little vertical lines of color, allows one to minimize the visually disfiguring effects of a loss and at the same time ensure that it is easily recognizable on close inspection. To achieve coherence in the method of restoring various materials, we tried to apply selective retouching to the restoration of 3D works. Sometimes this did not yield very satisfactory aesthetic results, because linear retouching tends to flatten volumes and make the loss too visible even from a distance.

In the field of ancient Greek and Roman ceramic vessels, a philological and archaeological criterion has for a long time prevailed that discourages pictorial reconstructions. Beginning in the early 1990s, the restorer Giovanna Bandini proposed and applied the *pointillist* method for the retouching of fills on archaeological artifacts (Bandini 1992). Subsequently, the Opificio adopted this method, which was then extended to the restoration of terracotta statuary, using watercolor paints to achieve the original color tones. Viewing at a certain distance returns a whole and unified image and hence its best reading, while a close inspection makes it easy to understand which parts have been added during restoration.

Various gap-filling materials have been tested at the Opificio for their ability to return the brilliance, especially to glazed surfaces. These include alkyd resins, acrylic colors, and varnish colors. In light of these experiments, watercolor is preferred today for its durability over time compared with resins and varnish colors.

In a glazed ceramics restoration, the glossy surface sheen of the glaze is suggested by the materials used to protect the watercolor retouching. Initially, an epoxy resin used in glass restoration, Hxtal NYL-1, was tested for its very liquid consistency, which can be applied by brush or spraying. In the recent restoration of Andrea della Robbia’s *Putti*, we produced many mockups of various materials, which then underwent accelerated aging. It was seen that the epoxy resin used in glass restoration has the serious drawback of being sensitive to UV radiation. Such a disadvantage in the restoration of glass windows can be avoided by the use of protective glass that shields the UV rays, but we decided to avoid its use for terracotta-glazed statuary that would be located outdoors. Following these tests and research, we opted for

watercolor retouching with the application of Regalrez 1126,³ a glossy, protective, anti-UV coating, in white spirits.

For the integration of cobalt blue, the pictorial retouching was made with cerulean blue, ultramarine blue, yellow, brown, and ochre dots. For the integration of white glaze, the retouching was made with carminium, primary yellow, cerulean blue, brown, cobalt blue, and burnt sienna. At a certain distance, the many dots blend together and are visually well connected with the white of the della Robbia glaze, while a closer look will reveal areas of retouching.

In the restoration of polychrome wooden sculpture, the coexistence between *selezione cromatica* (chromatic selection) and pointillist retouching has been researched to overcome the risk of an ambiguity in the reading of the artifact: with the traditional chromatic selection, the viewer can recognize a loss of paint layers, while the dotted retouching indicates a loss of both volume and paint layers. In the field of restoration of glazed terracotta, in which the polychrome surface is not painted but rather fired with clay, we think it is fair to interpret the lack of glaze as a double loss. Therefore, we opted for a dotted retouching, harmonizing the retouching with the original surface and applying a finishing glossy varnish that also has the characteristic of protecting the watercolor paints from UV rays and aging.

This debate is still open, and the department continues to experiment with materials and methods, orienting its research toward natural and mineral materials that will be the subject of future publications.

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Visitation Restoration Credits:

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 Director and Coordinator of the Restoration—Ceramic and Plastic Materials Department
 Conservation: Laura Speranza
 Restorers: Shirin Afra, Mattia Mercante, Filippo Tattini
 Diagnostic Investigations: Monica Galeotti
 Photography Campaign: Marco Brancatelli and the Restorers

Ospedale degli Innocenti – *Putti* Restoration Credits

OPD Superintendent: Marco Ciatti
 Director and Coordinator of the Restoration—Ceramic and Plastic Materials Department
 Conservation: Laura Speranza
 Technical Direction: Rosanna Moradei, Stefania Agnoletti
 Restorers: Shirin Afra, Daniele Angellotto, Maria Grazia Cordua, Chiara Gabbriellini, Chiara Fornari, Francesca Rossi, Filippo Tattini
 Diagnostics, OPD Scientific Laboratories, Chemical Analyses: Monica Galeotti
 Photography Campaign: Antonio Quattrone and the Restorers
 Digital 3D Scanning: Mattia Mercante

APPENDIX 1: The Opificio delle Pietre Dure: A Brief History and Current Conservation Activities

The Opificio delle Pietre Dure is an autonomous institute of the Ministry of Cultural Heritage and Activities and Tourism, specializing in conservation, research, and education concerning cultural heritage. It began as a national agency in 1975 when two Florentine institutions active in the fields of artistic production and conservation of works of art were merged. These were the historic and renowned Opificio delle Pietre Dure, founded in 1588 as a grand-ducal workshop and transformed into a restoration center toward the end of the 19th century, and the Laboratori di Restauro (restoration laboratories), created in 1932 as part of the Florentine Soprintendenza and greatly expanded after the 1966 flood.

THE MODERN OPIFICIO

The reinvigorated Opificio had authority throughout Italy and, since 2007, it has been recognized as an essentially autonomous institute of the Ministry, under the General Secretariat.

Today, the Opificio extends its research and conservation across many fields, divided into 11 departments: Bronzes and Ancient Weapons, Ceramic and Plastic Materials, Stone Materials, Mosaics and Semi-Precious Stone Artifacts, Goldsmithery, Canvas and Panel Paintings, Paper and Parchment, Polychrome Wooden Sculpture, Mural Paintings, Tapestries, Textiles, and Laboratories and Archaeological Artefact Services. It also has a scientific research laboratory subdivided into competence fields: chemistry, physics, biology, geology, climatology, and preventive conservation, in addition to other offices and general services.

The Opificio employs 89 individuals, among these: art historians, conservator-restorers, conservation scientists, laboratory technicians, and administrative and auxiliary personnel. Its activities take place in three different sites in Florence as well as beyond Italian borders, both contributing directly to conservation projects and consulting for technical and scientific problems. The OPD also has a School of Higher Education and Research that offers a five-year education program leading to the equivalent of a master's degree as well as 13 international professional development and 15 internship courses. The overall aim is to provide knowledge and competencies concerning all aspects of conservation for the different cultural heritage materials and their related artistic techniques. The Opificio carries out research collaborations on cultural heritage, especially in the fields of technical art history and the study of conservation materials. Institutional partners include national and international public entities, universities, and research institutes. In some instances, these collaborations have resulted in the stipulation of conventions establishing common lines of research.

For more than 20 years, the Opificio has published its annual journal, *OPD Restauro*, dealing with technical, scientific, analytical, theoretical, and historical aspects of conservation, availing itself of contributions by specialists and external institutions. Additionally, complex, high-profile conservation treatments are often presented in monographs, such as those in the series entitled *Problemi di conservazione e restauro*.

CONSERVATION SCIENCE: ANALYSIS AND RESEARCH

Conservation science and, in general, the application of scientific disciplines to the conservation of cultural heritage represent an important and well-established part of the Opificio. The scientific laboratories provide assistance to the conservators while at the same time carrying out research in the fields of technical

art history and conservation science for cultural heritage. They also are responsible for science education and training in the Scuola di Alta Formazione (Higher Education School). These laboratories have been active for many years, and they constitute an important authority in conservation science for conservator-restorers, scientists, art historians, architects, and archaeologists at both national and European levels.

The two departments working in diagnostics, analysis, and research are the Laboratorio Scientifico (Conservation Science Department) and Climatologia e Conservazione Preventiva (Environmental Management and Preventive Conservation Department).

SCHOOL OF HIGHER EDUCATION AND RESEARCH: THE OPIFICIO'S ACADEMIC PROGRAM

The school at the Opificio began teaching conservation in 1978, becoming a School of Higher Education and Research in 1992. Acceptance to the school is contingent on a rigorous and competitive entrance examination, also open to international candidates, publicized each year by the Ministry of Culture. The five-year program offers five specialized curricula for professional formation. Courses include theoretical lessons taught by both internal staff and other specialists involved in research, preservation, and conservation of works of art. Nonetheless, the emphasis is on practical and applied conservation problems, with hands-on experience offered both within the Opificio's laboratories and on external worksites. As of 2006, the diploma issued by the Opificio is equivalent to a master's degree (a five-year university degree).

NOTES

1. Fluoline CP is a ready-to-use consolidant/protective product based on fluoroelastomers and acrylic polymers in acetone, which is reversible and resistant to UV rays. It can be used for the consolidation and protection of architectural elements without changing their chromatism.

Physical and chemical properties

- Appearance: Colorless, transparent liquid
 - Drying time: Approximately 10 hours (at 23°C)
 - Specific gravity: 0.86 ± 0.03 kg/l (ASTM D 792)
2. A 100% pure acrylic resin in aqueous dispersion characterized by excellent resistance to atmospheric agents and chemical stability. Thanks to its high alkali resistance, Acril 33 is particularly suited for applications with hydraulic binders (hydrate-hydraulic limes, cement, plaster). It is a resin used in the restoration field as an additive for injection and filling mortars, a binder for pigments, glazes, and whitewashes, an adhesive, and a consolidant and fixative of paint layers.

Properties and characteristics

- Excellent freeze-thaw stability
- Good pH stability
- Excellent binding power
- High resistance to yellowing

Physical and chemical properties

- Appearance: White, milky liquid
 - Solids content: $46 \pm 1\%$
 - Viscosity: 3750 mPas at 20°C
 - pH: 9.5
3. Regalrez 1126 is an aliphatic resin of low molecular weight, characterized by high resistance to aging and optical properties that are comparable to those of natural resins. It is ideally used as a bland consolidant for wood artifacts. A solution with low viscosity and high penetration can be obtained by dissolving in solvent amounts ranging from 10% to 20% of resin by weight. Regalrez 1126 is soluble in medium- and low-polarity solvents (white spirit, petroleum essential oil, butyl acetate); it is insoluble in water and polar solvents.

Physical and chemical properties

- Appearance: Colorless flakes
 - Density at 21°C: 0.97 kg/l
 - Glass transition temperature (T_g): 65°C
 - Softening point: 122°C–130°C
4. Pietra serena is a gray sandstone used extensively in Renaissance Florence for architectural details. The material obtained at Fiesole is considered the best and it is also quarried at Arezzo, Cortona, and Volterra. Examples of its use in Florence include the interior pilasters, entablatures, and other decorative elements of Brunelleschi's Pazzi Chapel and Michelangelo's Medici Chapel.

REFERENCE

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FURTHER READING

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SOURCES OF MATERIALS

Fluoline CP, Acril 33, and Regalrez 1126
 CTS Srl (<https://www.ctseurope.com/en/index.php>)

Uhu-Plus
 UHU BOSTIK SpA

LAURA SPERANZA graduated in Art History with Roberto Salvini at the University of Florence, where she also obtained a specialization in Medieval and Modern Art History. Winner of the public competition at the Ministry of Cultural Heritage, she held the role of Art Historian Inspector to the Superintendence of Arezzo where, for 10 years, she curated exhibitions, museum installations, and publications and directed two State Museums: Casa Vasari in Arezzo and Palazzo Taglieschi in Anghiari. She has collaborated in the restoration of wall paintings with the Legend of the True Cross by Piero della Francesca, the Cross painted by Cimabue in the Church of San Domenico, and the stained-glass windows by Guillaume de Marcillat in Arezzo. She moved in 2000 to the Opificio delle Pietre Dure in Florence and currently directs the Restoration Department of Ceramic, Plastic and Glass Materials and the Restoration Department of Bronze and Ancient Weapons. She co-directs the Magazine of the Opificio delle Pietre Dure and Restoration Laboratories of Florence, and she is a member of the editorial board of the same magazine. She is involved in publications and conferences, especially on the theme of conservation. Other important work she has performed on glazed terracotta pieces are the 10 *Putti* in swaddling clothes by Andrea della Robbia in the Ospedale degli Innocenti of Florence and the *Visitation* by Luca della Robbia in the San Giovanni Fuorcivitas church in Pistoia.

SHIRIN AFRA is a restorer of ceramics and terracotta sculptures, objects, glass, and stained glass. She graduated from the School of Higher Education and Research of the Opificio Delle Pietre Dure in Florence, the National Institute of the Italian Ministry of Cultural Heritage, responsible for conservation, research and education concerning cultural properties. She is currently working toward a permanent position as Senior Restorer-Conservator of the Ceramics, Objects and Glass Conservation Department of the Opificio delle Pietre Dure and is also involved in teaching OPD School of Higher Education and Research students. The most significant recent professional work she has performed on glazed terracotta pieces includes the restoration of the 10 *Putti* in swaddling clothes by Andrea della Robbia in the Ospedale degli Innocenti of Florence and the restoration of the *Visitation* by Luca della Robbia in the San Giovanni Fuorcivitas church in Pistoia.