Reflections on Parmigianino’s *Self portrait in a convex mirror*: A computer graphics reconstruction of the artist’s studio

David G. Stork\textsuperscript{a} and Yasuo Furuichi\textsuperscript{b}

\textsuperscript{a}Ricoh Innovations, 2882 Sand Hill Road Suite 115, Menlo Park CA 94025 USA
and Department of Statistics, Stanford University, Stanford CA 94305 USA
\textsuperscript{b}Kanagawa, Japan

ABSTRACT

We built a full computer graphics model of Parmigianino’s studio, including convex mirror, in order to explore the artist’s likely working methods during his execution of *Self portrait in a convex mirror* (1523-4). Our model supports Vasari’s record that the radius of curvature of a convex mirror matched the radius of curvature of the wood panel support. We find that the image in the painting is consistent with a simple horizontal rectilinear room drawn from a slightly re-oriented and re-positioned mirror. Our optical analyses lead us to recommend an alteration to the current display arrangement in the Kunsthistorisches Museum.

Keywords: Parmigianino, *Self portrait in a convex mirror*, Mannerism, tableau virtuel, computer graphics, art analysis

1. INTRODUCTION

Parmigianino’s interest in psychological introspection, belief in a shifting impermanent visual reality, experimentation in the dark sciences of alchemy, wit, and youthful desire to demonstrate his artistic prowess all find their expression in his small *Self portrait in a convex mirror* (1523–4), a painting that stunned 16th-century Roman audiences (Fig. 1). Vasari wrote that the artist produced this “bizarre” work as follows: Parmigianino “...began to draw himself as he appeared in a barber’s convex glass [mirror]. He had a ball of wood made at a turner’s and divided it in half, and on this he set himself to paint all that he saw in the glass. Because the mirror enlarged everything that was near and diminished what was distant, he painted the hand a little large.” He also claims Parmigianino wanted the radius of curvature of the wood panel support to match that of the convex mirror. We confront the tasks of confirming Vasari’s record and answering some additional technical questions: What were the properties of this mirror (size, focal length, ...) and the artist’s pose and setting with the mirror in the studio? What were his likely working methods, for instance, did his hand block his view of its reflection? What artistic liberties and geometric non-optical distortions might the artist have applied in the work? What is the proper method to display the work in museum settings?

Computer graphics has been used to recreate artists’ studios to study mirrors depicted in paintings. For instance, Stork and Furuichi showed that the famous *plane* mirror on the rear wall of Velázquez’s *Las meninas* reflected the other side of the large canvas depicted within the tableau, not the position of the viewer in place of the king and queen.\textsuperscript{1} Previous analyses of *warped* images in convex mirrors depicted in paintings, such as van Eyck’s *Arnolfini portrait* and Campin’s *St. John and Heinrich von Werl*, were based on a distant or far-field studio configuration.\textsuperscript{2–6} That is, one can rely on the fact that the objects in Arnolfini’s room were many times the mirror’s focal length away from that mirror and thereby simplify the mathematics of the optical analysis and computational dewarping. Likewise, computer graphics methods for dewarping the mirror image in Memling’s *Virgin and Child and Maarten van Nieuwenhove* assumed a two-plane studio configuration, where the Virgin could be considered a plane at a fixed (but unknown) distance from the rear wall.\textsuperscript{7} Neither of those tableau models is appropriate for the Parmigianino portrait, where the mirror-object distances span a continuous range of over a factor of roughly 100; that is, the studio wall is likely 100 times as far from the mirror than is the artist’s left hand.

Send correspondence to David G. Stork, artanalyst@gmail.com.
We built a computer graphics model—or tableau virtuel—of the figure, mirror, and studio in Shade 10 and Poser 7, and incorporated natural constraints of figure’s body proportion, angles in the rectilinear room and its window, and lighting. We then iteratively refined these, the mirror’s parameters, as well as the viewing point so that the view from the artist’s eye in the tableau virtuel approximated the image in the painting. We then explored alternate configurations and viewpoints to address a number of technical questions.

We begin in Sect. 2 describing Parmigianino, his Self portrait, and the questions we address. Then in Sect. 3 we review the optics of convex mirrors that is incorporated into all computer graphics software, to reveal some of the principles governing the images in the artist’s mirror. In Sect. 4 we describe our computer graphics modeling and in Sect. 5 our results. Our optical analyses lead us to propose a modification of the museum display of the work, as we describe in Sect. 6. We conclude in Sect. 7 with some of the lessons learned and recommendations for displaying the work, and guidelines for further use of computer graphics in the study of fine art.

2. THE WORK AND QUESTIONS ADDRESSED

This small self portrait in oil on a circular section of a wood sphere was executed by Parmigianino at age 21 as a showpiece to demonstrate his skill to Rome (Fig. 1). Although the image is somewhat chaotic, especially to 16th-century viewers’ eyes, his youthful feminine face shows little or no distortion. His left hand looms forward, projecting toward the viewer’s space, and the window hovers above the artist’s head at the left. The circular edge of the painting itself and part of its supporting easel are visible at the right. The palette spans a narrow range of muted browns on the walls and overcoat to the pink of the cheeks and the white of his shirt. Such a limited palette typically allows the viewer to read better the distorted forms.

While Caravaggio’s Medusa (c. 1598) is likewise executed on a convex shield-like surface and bears a disturbing image, Parmigianino’s self portrait disturbed contemporary viewers because of its trompe l’œil realism of a mirror and the distortions it would (apparently) produce. The self portrait shows hints of Parmigianino’s later Mannerist
distortions, such as in *Madonna del Collo Lungo* (also called *Madonna with the long neck*) (c. 1533–40), where both the Madonna and the Christ Child are elongated and distorted for compositional and expressive ends. Early Mannerist paintings focused more on art from art rather than on art from nature. For example, Pontormo’s *Deposition from the cross* (c. 1525–28) depicts a complex and physically impossibly set of figures in interlocking positions, all in unnatural pastel colors. Tintoretto’s *Last supper* (1594) contains cascading figures in a space of inconsistent perspective and inconsistent lighting. Finally, El Greco’s *Laocoön* (c. 1610–14) depicts sinuous and impossibly elongated nudes unencumbered by the laws of gravity.

But how much of the distortions in Parmigianino’s self portrait are due to the artist’s expressive ends and how much due to the optical distortions by the mirror before him? The answer to this question will help art historians better understand how much of the distortions in later Mannerist art can be traced back to the simple optics of Parmigianino’s convex mirror. The overarching question leads to the following technical questions, which we address below:

- Did the artist faithfully (i.e., geometrically accurately) render the view in the convex mirror before him? If not, what liberties or deviations did he make?
- Is the radius of curvature of the likely convex mirror equal to that of the wood sphere on which the painting was executed?
- Is the lighting in the tableau consistent with that in the likely studio?
- Could the artist see his left hand in reflection, or did he have to adjust his pose to see it?
- How should the work be best displayed in museums?

3. CATOPTRICS

The study of the optics of image formation can divided into three subdisciplines: dioptrics (lenses), catoptrics (mirrors), and catadioptrics (combinations of mirrors and lenses). Here we review elementary catoptrics of the image formation by the convex mirror in Parmigianino’s work.

Figure 2. A convex spherical mirror produces a virtual, erect image, smaller than the object. The focal length \( f \) (here, by convention, positive) is the distance from the focal point \( F \) to the mirror. In the paraxial ray approximation, \( f = R/2 \) where \( R \) is the sphere’s radius of curvature. The virtual image, \( I \), is erect, smaller than the object and always lies between the focal point and the mirror itself. Note that this figure and the graph in Fig. 3 all show that Vasari is incorrect when he claimed that such a mirror “enlarged everything that was near...” In fact, such a convex mirror diminishes everything, but it diminishes distant objects more than nearby ones. (Moreover, Vasari is surely wrong, too, when he wrote that Parmigianino “divided [the sphere] in half” for his painting—it was a section far smaller than a half sphere.)

Figure 2 illustrates the image forming properties of a convex spherical mirror. The mirror is a section of a sphere with center \( C \) and radius of curvature \( R \); an optical axis is shown by the horizontal dashed line. The
distance from the focal point, $F$, to the mirror is the focal length, $f$. In the paraxial ray approximation, a convex mirror’s focal point, $F$ is halfway between the sphere center $C$ and the mirror itself; thus the focal length obeys $f = R/2$.\(^{10}\) An object, represented by the vertical arrow $O$, sends light toward the mirror; two rays of such light are shown. The ray arriving parallel to the optical axis reflects from the mirror and leaves the mirror as if it had come from the focal point $F$. The ray arriving toward the focal point leaves the mirror parallel to the optical axis. The intersection of these two reflected rays, which occurs behind the mirror, specifies the location of the image of the object arrow, marked $I$. Such an image formed by a convex mirror is always:

**virtual** There is no light passing through the image $I$.

**erect** The image arrow is pointing in the same orientation as the object, i.e., upward.

**smaller** The virtual image is smaller than its corresponding source object.

![Image](image.png)

Figure 3. The magnification, $M$, is the ratio of the sizes of the image and its corresponding object, i.e., $M = h_i/h_o$, here plotted as a function of the ratio of the object distance to the focal length of the mirror. When an object is very close to the mirror ($x_o \to 0$), the curvature of the mirror is negligible and the mirror acts as a plane mirror and thus the magnification is nearly 1.0. As the object distance becomes large, the magnification becomes smaller. In the case of extremely large object distances ($x_o \to \infty$), the image lies at the focal point and is a mere point and thus $M \to 0$.

The mirror equation relates the object distance, $x_o$, and the image distance, $x_i$, by

$$
\frac{1}{x_o} + \frac{1}{x_i} = \frac{1}{f}.
$$

(1)

The magnification, $M$, is the ratio of the image to object sizes, that is,

$$
M = \frac{h_i}{h_o} = \frac{x_i}{x_o}.
$$

(2)

where throughout we ignore some optical conventions on signs of distances and the focal length that would needlessly complicate our discussion. Figure 3 shows that the magnification decreases as an object becomes farther from the mirror. Note that the magnification by a convex mirror is always less than or equal to 1.0—images in a convex mirror can never be larger than their source objects. Moreover, the image distance, $x_i$, is always less than the focal length, $f$, and thus all images are fairly close to the mirror surface. Thus a convex mirror flattens out the depth in a scene, thus making it easier for an artist to study the scene, almost like an image projected onto a screen. Finally, a painting (which of course has its image on its surface) can better match the shallow depth of images in a convex mirror than the large depth of images in a plane mirror.
4. METHODOLOGY

The general problem of creating a three-dimensional model from a two dimensional image is formally ill-posed. Since there are an infinite number of three-dimensional scenes that project to a given two-dimensional image it is impossible to deduce the “true” three-dimensional scene from the image alone. As such, one must impose prior knowledge and constraints when creating such a three-dimensional model, always vigilant to avoid imposing such knowledge in a way that would bias the answers to the question at hand. Thus, for instance, when Johnson et al. created a model of Vermeer’s Girl with a pearl earring to explore consistency in lighting, their assumption that the girl’s face was nearly left-right symmetric did not bias the estimate of the direction of illumination.\textsuperscript{11}

Figure 4. Four views of the basic studio setup for Parmigianino’s Self portrait in a convex mirror, rendered in Shade 10 and Poser 7. There is a window and a candle at the artist’s left. The artist’s left hand lies on a table, close to the mirror; his right hand is toward the wood support on the easel, as would be natural for a right-handed artist. The primary illumination, from the window, would illuminate the painting on the easel in the studio. A candle or other artificial lamp, rendered in the middle two figures, would illuminate the artist’s left hand.

In the present case, we explicitly imposed natural physical constraints, such as the known dimensions of the painting, traditional designs for an easel, rectilinearity of the room, and so on. Other physical constraints are directly imposed by the computer graphics software, for instance the optics of shadows, reflections and illumination. We worked iteratively, refining our model, adjusting the positions and orientations of objects, always ensuring physical constraints were obeyed and that the view from the artist acceptably “matched” the tableau. Figure 4 shows a basic studio setup, which we explore in Sect. 5, and Fig. 5 shows the match between one of our models and the painting. We stress, though, that we are aware that Parmigianino likely deviated from “accurately” rendering the optical image before him; that is, we do not assume the artist was rendering a “photographic” copy of the studio. Indeed, our modeling can reveal qualitatively and quantitatively where the artist took expressive liberties.

Figure 5. Parmigianino, Self portrait in a convex mirror (1523–4). At the left is one of our computer graphics models and at the the right the painting. The middle figure is a weighted mixture or alpha blend of the flanking pictures.
5. RESULTS

We now turn to our results for individual questions.

5.1 Facial radii of the inferred mirror and the painting support
The diameter of the painting is 24.4 cm. If Parmigianino sought the greatest trompe l’œil effect, it is likely that he would match the sizes of his painting and mirror. The central evidence relevant here is the size of the painting itself, and the image of the painting support and gold frame as reflected at the right in the painting. The radius of curvature of the mirror, and the distance of the painting support from the mirror in the studio, all affect the size of the painting arc in the mirror. The constraints we imposed included ensuring that the artist could reach the painting on the easel from his sitting position, the sizes of a typical (young) man in the 16th century, and so on. Indeed, with these constraints we found could construct consistent configurations in which the facial size of the painting matched that of the inferred mirror, as shown left of Fig. 4. We did not explore the full range of mirror sizes that could be consistent with the image in the painting but our results support, but cannot prove, Vasari’s claim that Parmigianino matched the facial sizes of his mirror and painting.

5.2 Lighting
We found that the broad, diffuse illumination from a papered window, as appears in the painting, is generally consistent with the shading on the artist’s face and the shadow of the cuff cast onto the artist’s wrist and hand. The shadow cast by the tip of the artist’s nose onto his right cheek and by his left jaw onto his neck are fairly consistent with the location of the window, even if the mirror was slightly tipped (cf. Sect. 5.5). We found that the pattern of light on the artist’s face indicates a candle or small lantern might have been used, as seen in the center images of Fig. 4. We find that some of the illumination that appears on the hand was reflected from the convex mirror itself. Our models reveal that the highlight on the frame of the painting at the right should be lower, to be commensurate with the higher window light source.

5.3 The radius of curvature of the inferred mirror and the painting support
Recall that Vasari stated that Parmigianino wanted the radius of curvature of the wood panel support to match that of the convex mirror. Here the evidence we incorporated included the known size of the painting and the image of the frame reflected in the mirror at the right, and the unknown radius of curvature of the mirror and distance from the mirror to the painting in the studio.

5.4 Visibility of the reflection of the artist’s left hand
Parmigianino’s large, distorted left hand seems rather close to the convex mirror surface and it is unclear whether he would have been able to see the reflection of his hand. Our model suggests, however, that indeed the artist could have just barely seen the reflection of his hand over the top of his hand itself. Thus the artists likely set his studio configuration carefully to achieve the design without having to move to view different portions of the scene.

5.5 Geometry of the studio
The distortion and placement of the window, and especially the sloping arc of the line joining the rear wall and the ceiling in the painting are indeed broadly consistent Parmigianino executing the work in a rectilinear studio. It would be hard indeed for any artist to imagine or create the distorted image in the painting such that it was consistent with a rectilinear room. (Likewise, the broad consistency between the dewarped image in van Eyck’s Arnolfini portrait and the undistorted view of the room very strongly suggests that van Eyck painted this portion of the work within a real—not fictive—room with the mirror image as a referent.) As such, it seems likely that Parmigianino fairly accurately recorded the distorted image before him rather than deliberately distorting the scene. The distortions in the painting are due to optics, not to the artist’s imagination.

Figure 6 shows the rectilinear studio from outside, the artist in the studio, and the associated image he would have seen in the convex mirror.
6. MUSEUM DISPLAY OF THE WORK

A consideration of simple optics has implications for the museum display of this work; indeed we recommend a re-hanging of the work in the Kunsthistorisches Museum. We assume that for maximum tromp l’œil effect, the proper viewing of the work should reproduce the setup of the artist viewing the mirror in his studio. The left figure in Fig. 7 shows a tall museum visitor standing next to the work. Notice that his eye is roughly the height of the center of the work. The eye of a museum visitor of normal height would be lower than the center of the work. Simple optics dictates that in Parmigianino’s studio, the center of curvature of the mirror sphere, the position of the artist’s eye projected onto the sphere surface, and the eye of the artist must be colinear. (In just this way, you always see your own eye at the point towards the center of a convex spherical mirror.)

Figure 7. For maximum trompe l’œil effect, the center of curvature of the painting sphere, \( C \), the position of the artist’s eye on the painting surface, and the eye of the viewer should be colinear—as was the case when the artist executed this work. Left: The eye of a 190.5 cm tall museum visitor (i.e., taller than the average visitor) is roughly at the height of the center of the painting as it is currently displayed in the Kunsthistorisches Museum. Thus the painting is hung too high for such a visitor to experience the maximum trompe l’œil effect and of course much too high for visitors of normal height. Right: The computer graphics rendering shows the proper height for hanging the work; moreover, the viewing distance should match that of the artist viewing the mirror, roughly 40 cm.
7. CONCLUSIONS

In summary, the consistency between the image in Parmigianino’s painting and our plausible studio model suggests that Parmigianino reproduced most portions of his tableau fairly faithfully. The illumination is fairly consistent, save for the highlight on the frame at the right, which is too high in the painting. Our optical and computer graphics research leads us to recommend a re-hanging of this work (lower), such that the average museum visitor can replicate the artist’s studio setup with his mirror and thus experience the maximum trompe l’œil effect.

Our results may have broader implications to the understanding of art history, specifically the development of Mannerism. Mannerist works, such as those of Pontormo, Tintoretto, El Greco and Parmigianino himself throughout the 16th century, reject the geometrically accurate rendering of objects and figures and instead elongate and distort figures, who often float in physically impossible ways. There are of course many cultural, social, and art historical forces that led to this movement. It may be, though, that the simple convex mirror—and Parmigianino’s convex mirror in early 16th-century Rome—played a small role in revealing a compelling, distorted world to artists and their public—artists primed to exploit and then extend and elaborate such distortions. Artists did not need to invent optical projectors to be influenced by optics. Rather, these artists needed only open their eyes and behold the new visual world in their hands.

Our technical results are mere first steps towards more thorough analyses of this painting, ones that might include modeling the reflectance properties of the wall, the diffusion of light from the window, and more. We leave the full interpretation of these consistencies and inconsistencies for later research, research that will incorporate more fully the social, cultural and artistic context surrounding Parmigianino in general and this painting in particular. We hope that our the research presented here enriches the developing dialogue between art scholars and computer scientists toward identifying problems and developing new digital techniques in the study of fine art.

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REFERENCES


