Raphael's 'imperfect' viol: a question of perspective

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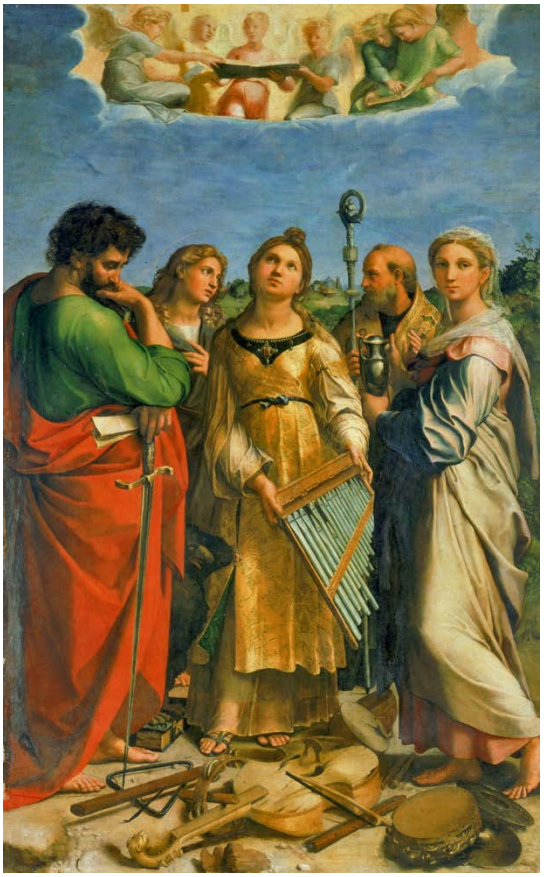


1 Raphael, *Saint Cecilia* (c.1515–18). Oil on canvas, transferred from panel, 236 x 149 cm (Bologna, Pinacoteca Nazionale, inv.no.577), with permission of the Ministero per i beni e le attività culturali e per il turismo – Direzione Musei Emilia Romagna

'La Viole parfaite', the perfect viol, is the title of an article published in 1993 by the music researcher and instrument maker Toon Moonen[i], in which he describes his reconstruction of an early viol on the basis of the instrument's depiction in Raphael's *Saint Cecilia*, after being asked to make a historically 'accurate' instrument from around 1500. A lightly revised English version of the article came out two years later in *The Strad* magazine entitled 'The art of the viol maker'. Here, Moonen also mentions the client who commissioned the reconstruction: the ensemble Capilla Flamenca, a group specialised in music of the 15th century.[ii] As the reason behind his choice of an iconographic source as a model, Moonen points, on the one hand, to the lack of suitable 'historically accurate' instruments in museums[iii] and, on the other hand, to the 'almost photographic accuracy' of the depiction of the viol in Raphael's *Saint Cecilia*. His hypothesis that this is a 'perfect' viol is based on a passage in Giorgio Vasari's *Vite* from 1550, which, according to Moonen, claims that *Saint Cecilia* is a 'perfect' image. However, consulting Vasari, whose artist biographies are an

important art history source for the Italian Renaissance,[iv] there is no actual mention of perfection. The original quotation is as follows:

> 'Era la tavola di Raffaello divina & non dipinta ma viva & talmente ben fatta & colorita da lui; che fra le belle che egli dipinse, mentre visse, ancora che tutte siano miracolose ben poteva chiamarsi rara.' / 'Raphael's panel was divine, not so much painted as alive, and so well wrought and colored by him, that among all the beautiful pictures that he painted while he lived, although they are all miraculous, it could well be called the most rare'.[v]

The German translation that Moonen uses, which is from the 19th century, is the only one where the original 'talmente ben fatta', which can be better translated as 'so well wrought', is inflated to 'perfection'.[vi] This is the origin of Moonen's theory that the viol depicted in *Saint Cecilia* must be 'perfect', 'as an imperfect viol does not fit in a perfect image'.[vii] On this basis and with the help of principles of proportion, numerical symbolism and mysticism, Moonen describes his method of reconstructing Raphael's viol in detail[viii] with the aim of providing the Capilla Flamenca with an instrument for performing Renaissance music.

A case study

In the 1970s, as described by Ian Harwood and Martin Edmunds in two *Early Music* articles,[ix] it was still assumed that the 'Renaissance' viols preserved in various museums were suitable models for reconstruction; from the 1990s a new finding predominated, in particular due to the research of organologist Karel Moens: all extant larger string instruments dated prior to the last quarter of the 16th century have been either so significantly modified that their original state is unrecognisable or are obvious counterfeits.[x]

To date, this finding has remained unchanged and therefore now as before, the only option is to draw on visual and textual sources for the reconstruction of an early viol.[xi] However, are the methods described by Moonen still usable in 2020 taking into account broadened scientific approaches and new technologies? The aim of this article is to examine this in a case study, with three authors covering different areas of expertise – Thilo Hirsch, the musicological and organological part; Marina Haiduk, the art historical background; and Bilge Sayim, the perceptual psychology aspects.

Raphael's *Saint Cecilia*[xii]

Raphael's *Saint Cecilia* was created between 1515 and 1518[xiii] as an altarpiece for the Cappella di Santa Cecilia in the Bolognese church of San Giovanni in Monte, which Elena Duglioli dall'Olio (1472-1520) had built as a sepulchral chapel. Elena was revered as a beatified person already during her lifetime.[xiv] Because she retained her virginity during her marriage and experienced religious revelations, she was considered to be like a second Cecilia. Her possession of a reliquary of the saint also played a role in the dedication of the chapel.

In Raphael's painting, St Cecilia is portrayed as patroness of music with the organetto as her attribute, standing among four other saints with their respective attributes. Paul stands at her side (with his sword and the Corinthian epistles), as does Mary Magdalene (with her vessel of ointment). Behind her, Augustine (with his crosier) and John the Evangelist (with the eagle perched on a book) are visible. The book is not only an allusion to his role as author of the

Gospel of John, but also to the record of his revelation, thus creating a thematic link to the ecstasy of St Cecilia.[xv] Raphael illustrates this moment of raptured departure from the world, firstly, through the sudden lowering of the organetto, from which pipes are already loosened and seem about to fall to the ground. Secondly, the heavenly choir of angels, who nevertheless remain silent due to the medium of painting, are a visual analogue of this acoustic yet also wholly internal revelation.

2 Marcantonio Raimondi (after Raphael), *Saint Cecilia* (c.1514). Engraving, 270 x 151 mm (Washington, National Gallery of Art, inv.no.1947.7.100)

A sketch by Raphael's student and workshop employee Gianfrancesco Penni and an engraving by Marcantonio Raimondi show an earlier draft version of Raphael's image composition.[xvi] Here, three of the angels originally played instruments – fiddle (lira da braccio), harp and triangle. The later change in the composition had the consequence that all of the musical instruments – with the exception of the organetto – are depicted lying on the ground. The intention is perhaps to make a clearer distinction between the heavenly and earthly forms of musical expression, as Cecilia turns away from earthly music and towards the heavenly.[xvii] This circumstance is underscored by the desolate state of the instruments in the painting. This is an expression of earthly impermanence, and in Raphael it is also visible in the fact that the viol is already unplayable, although at this point in music history it was still a very new instrument. Lorenzo Costa had first created an altarpiece for the Capella Ghedini in the same church in 1497 that provided two of the earliest depictions of viols in Italy along with the patron saints of the church and monastery who also appear in *Saint Cecilia*, John the Evangelist and Augustine.[xviii]

It is not solely the depiction of the musical instruments in *Saint Cecilia* by which artist biographer Giorgio Vasari, who mentions the painting in several passages of his *Vite,*[xix] establishes the mimetic gift of the painter and the vitality of the representation. Vasari ascribes the instruments to Giovanni da Udine, but simultaneously stresses, 'fece il suo dipinto così simile a quello di Raffaello, che pare d'una medesima mano'/ 'he made his painting so similar to that of [Raphael], that the whole appears as if by one and the same hand'.[xx] The possibility that not Raphael himself but rather a member of his workshop is

responsible for the musical instruments remains under controversial debate to this day. It has been shown that the Giovanni da Udine in question was a highly specialised painter who was entrusted with the execution of still lifes in general and musical instruments in particular within Raphael's collaborative workshop.[xxi]
Raphael's *Saint Cecilia* retained its original role as altarpiece in the Cappella di Santa Cecilia until Napoleon had the work brought to Paris in 1796. Due to its precarious conservation status, the painting, originally on a wood panel, was transferred to a canvas in 1803. The fact that a large part of the painting layer was preserved in this process has since been demonstrated by means of infrared reflectography, which also made underdrawings visible.[xxii] After its return to Bologna in 1816, the painting was museumised and is now on exhibit in the Pinacoteca Nazionale.

Realistic and unrealistic elements of the image [xxiii]
The term 'photographic accuracy' used by Moonen is a decisive factor in his instrument reconstruction, implying that the figures and objects in the painting are depicted realistically according to the rules of central perspective. Nonetheless, if we examine this in relation to the overall image, there are numerous unrealistic elements in *Saint Cecilia* that can be divided into two categories upon closer inspection. The first category could be called 'obviously unrealistic depiction' and would include, for example, the opening of the heavens with the singing angels that can be understood as part of St Cecilia's vision. The eagle perched on the book beside St Cecilia is also only present to identify John the Evangelist, as it is his traditional symbol in the Christian context. This iconographic convention has just as little character of reality as the geographic and temporal gathering of these various saints. The second category would then be 'hidden unrealistic depiction' and covers elements of the image that are not realistically depicted but are perceived by the viewer as realistic, as long as he or she is not paying special attention. This takes us into the realm of the psychology of perception, which has identified a variety of phenomena that let us perceive 'real' objects in images or scenes that are actually undefined or only suggested (such as for example the identification of objects in cloud formations). In visual art as well, artists consciously or unconsciously use several of these effects investigated in perceptual psychology to 'play' with the perception of the viewer.[xxiv] An element that is relevant in this respect for all the persons and objects depicted in *Saint Cecilia* is the shadows.

The shadows
Shadows are important in many situations to perceive objects as real and not detached from the surrounding scene. Interestingly, however, empirical studies on the topic have shown that the perspectival correctness of shadows is not of major importance for human perception.[xxv] What matters is whether they are there.[xxvi] Precisely this effect can be seen in *Saint Cecilia*. Although the scene is set outdoors and the sunlight can actually only be coming from one direction, the angles of the shadows vary greatly. Thus, for example, Mary Magdalene is lit from the upper right and her shadow on the ground extends far to the left over the viol and all the way to the feet of St Cecilia. The shadow angle corresponds to the original display location of the painting in the Capella di Santa Cecilia in San Giovanni in Monte. The painting (today a copy made in the 19th century in the original frame) is lit during the day by a window located above and to the right (fig.3).[xxvii]

3 Bologna, San Giovanni in Monte, Cappella di Santa Cecilia. Photo: T. Hirsch, 2013.

In contrast to Mary Magdalene's shadow, the shadow of St Cecilia's right foot falls much more obliquely backwards, while the shadow of the apostle Paul's sword tip falls horizontally to the left. The shadows of the instruments at the feet of the apostle are, in the case of the recorder and the neck of the viol, almost under the objects themselves, whereas the shadow of the head of the viol curves quite far to the left. The bridge of the viol and the bow both cast shadows forward at an angle that would require a light source located between Mary Magdalene and Cecilia. In part, the 'false' shadows can perhaps be explained by the fact that the shadows would otherwise be covered up by the objects themselves (as in the case of the recorder and the neck of the viol) or that the aim was to better distinguish the instruments from the ground. For the bridge of the viol, this is clearly not the case. A clue about the 'flexible' use of shadows appears in an article from 2005 about the infrared reflectography examination of the painting,[xxviii] which was able to show that Paul's sword was originally somewhat shorter and the sword shadow, which had an angle comparable to Mary Magdalene's, originally fell above Paul's foot to the ground. After the sword was extended to reach the ground, the corresponding shadow would have fallen across the foot. It is perhaps for this reason that the sword shadow in the definitive version is painted almost horizontally in front the foot, extending to the left over Paul's robe, although this does not match the angle of the other shadows. The 'correct' shadow here was seemingly made secondary to the image composition. It seems therefore that the painter knew that the viewer does not perceive these unrealistic shadows as 'false' or 'bothersome'. This divergence from reality potentially even piques an unconscious interest prompting a closer look at the image.

The musical instruments

A further type of a 'hidden unrealistic depiction' is seen in the 'reversed' organetto held by St Cecilia. The assignment of the deeper pipes to the keys on the right of the keyboard does not match with what is conventional for keyed instruments (normally the lower notes are on the left, the higher notes on the right),[xxix] but most viewers would likely only notice this if explicitly made aware of it.[xxx] In the image composition, however, the unusual arrangement of the organ pipes makes more sense; with a conventional arrangement, the majority of the deeper pipes would be concealed by the gown of Mary Magdalene, who is standing perspectivally in front of St Cecilia, instead of just a few of the higher pipes. Also, without

this reversal, the diagonal of the painting created by the lower pipes, which is continued by the forearms of Cecilia and Paul and creates a connection between the heavenly and earthly spheres, would otherwise be lost. The organetto was, in a manner of speaking, 'staged' for its visual impact.[xxxi] The photomontage in figure 4 and the diagonal line in figure 5 illustrate this point.

4 Raphael, detail of *Saint Cecilia*, organetto reversed. Photomontage: T. Hirsch.

5 Raphael, *Saint Cecilia* with diagonal line. Illustration: T. Hirsch.

And yet, what is the situation if we focus on the viol itself. Is it, as Moonen implies, 'perfect'? The instrument's realistic depiction, despite its poor condition, is also confirmed by organologists other than Moonen. Some details of the viol (for example the clearly visible thicknesses of the top plate through the sound holes and at the edge of the body), when combined with other sources, provide important clues to the construction of early string instruments.[xxxii] Other elements of the instrument are unequivocally 'imperfect' in their depiction, whereby these are all 'hidden unrealistic depictions' as referred to above, which generally only stand out to an organologically trained viewer (fig.6).

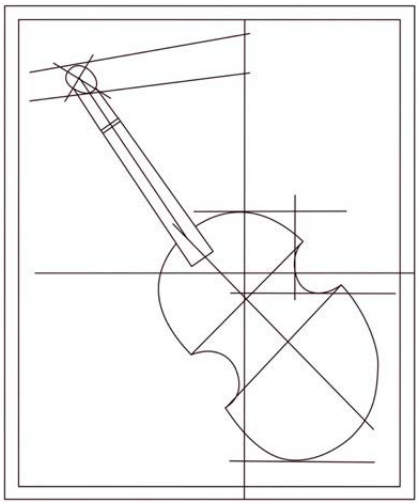
6 Raphael, *Saint Cecilia,* detail.

In this context the oddly still upright bridge should be mentioned, which is held in place only by the string tension and would actually have to fall down after all of the strings have broken. Also the tuning pegs, which are too close for a real instrument crowded, a fact which Moonen described without questioning his concept of the 'perfect' viol. Other elements, such as the proportionally incorrect depiction of the six frets, which would provide important information about the relationship of the neck to the body length, in contrast, receive no mention from Moonen. As the frets are normally affixed at half-tone intervals, the fifth fret (five half tones = perfect fourth) would have to be at 1/4 of the string length. In the painting, however, the fifth fret is placed at around 1/3 of the string length. This is a true physical discrepancy, meaning that either the neck was shortened in the picture or the distance between the frets was not accurately rendered.

Moonen's reconstruction of the viol outline is based on the premise of the painter's correct depiction of the viol in central perspective. At first glance most viewers and even viol players would probably confirm it to be such. Yet, if they were called on to draw an imaginary centre line from the nut, down the fingerboard to the bridge, an initial 'problem' in the instrument structure becomes apparent: the neck is bent off to the side in relation to the instrument body. Some viewers might additionally notice the asymmetrical body outline.

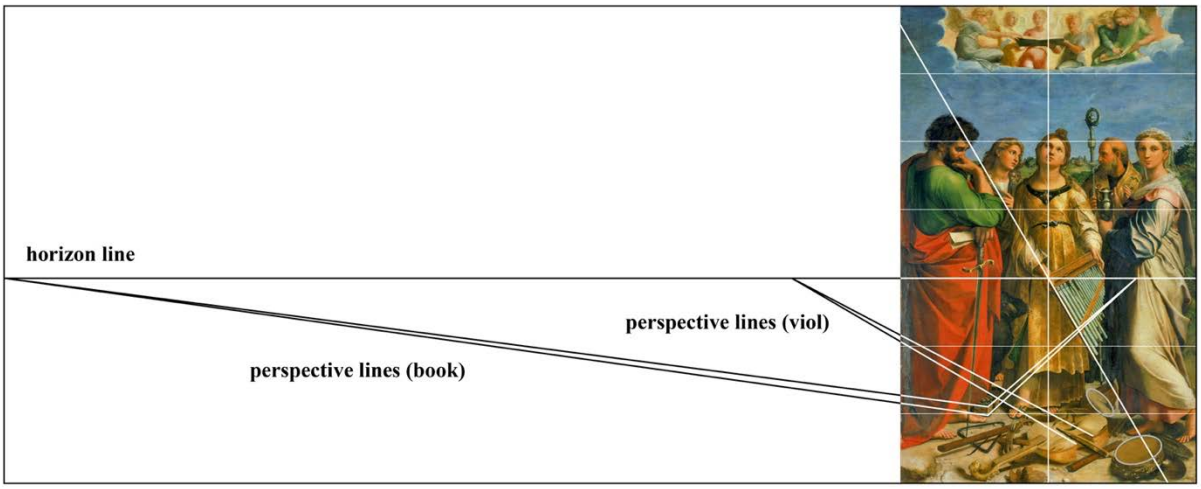
It was not without reason that Albrecht Dürer used a lute as a demonstration object in a 1525 woodcut illustrating a correct perspective drawing.[xxxiii] String instruments in particular are very difficult to depict correctly in perspective drawing due to their frequently complex outlines – especially when they are lying diagonally in the image. That the painter of musical instruments in *Saint Cecilia* painted the viol 'freehand' is highly probable. If one assumes no incompetence or disinterest, insights from perceptual psychology also provide a possible underlying mechanism here: as the viol lies at a severe slant in the painting, a viewer (without using auxiliary lines) would have to first mentally 'reconstruct' the frontal outline before he or she could make any judgment about the symmetry. Interestingly, although viewers are generally very good in classifying objects as symmetrical or asymmetrical, there is a general bias in the direction of symmetry.[xxxiv] In the case of objects that the human brain has learned are normally symmetrical, it is to be expected that this tendency is even more pronounced. Consequently, a freehand depiction of the instrument outline could have been adequate for the painter to achieve the appropriate 'reality effect'. Analogous to the shadows, it could be that this not immediately perceptible asymmetry provokes conscious or unconscious irritation in the viewer, thus subtly highlighting the unplayable quality of the instrument.

Moonen's hypothesis on this was that the viol was first painted symmetrically, and then its treble side (in the image above) was made smaller so that it did not cover St Cecilia's foot, which was added later. This assumption about the painting timeline was refuted by the infrared reflectography findings published in 2005, which clearly show that the musical instruments were initially painted after the figures.[xxxv] But is Moonen's outline of the viol, which he still had to 'manually' measure out in 1993 (fig.7), even correct in terms of perspective drawing?



7 Viol outline after Raphael, T. Moonen, 'La Viole parfaite', p.20, fig.3. Redrawing: T. Hirsch.

To clarify this question, the 3D specialist Arndt von Koenigsmarck was asked to attempt a reconstruction of the instrument using 3D software.[xxxvi] Determining the perspective in an image requires the definition of a horizon line.[xxxvii] In 3D software programmes, objects with parallel edges and right angles are ideally used for this. The only object in *Saint Cecilia* that fulfils these conditions is the book the eagle is perching on at lower left. The horizon line based on this is at about the level of the lower corner of the organetto. This form of perspective with two vanishing points is called 'two-point perspective' or, as in Jean Pèlerin's 1509 teaching work *De Artificiali perspectiva*, 'cornuta'.[xxxviii]

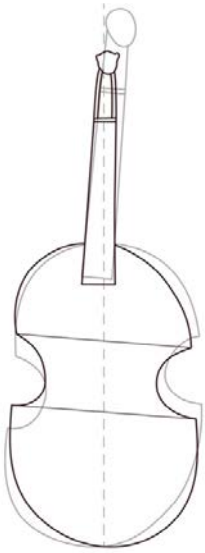


8 Raphael, *Saint Cecilia,* reconstruction of perspective, Image: T. Hirsch.

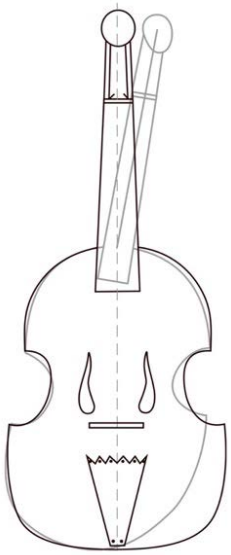
To confirm the horizon line, the corners of the viol were also taken as reference points, which theoretically should lie on parallel lines and also, in fact, intersect with one another at the horizon line identified based on the book.[xxxix] Although proportional image analyses should be applied with caution, based on the horizon line (which is at the ratio 3 to 4 of the image height), the image can be divided into seven sections, each containing different elements of the image. In the first uppermost section is the window into heaven with the music-making angels; in the second, the sky; in the third, all of the heads[xl]; and in the lowest section, the

section opposite to heaven, are the music instruments that are literally lying on the earth (fig.8).

Moonen also had to first define a horizon line for his reconstruction and he explains his approach as follows: 'One of the rules of perspective is that the eye level marks the horizon for the picture'.[xli] Although this is theoretically correct, it actually means that the horizon line (sometimes called the sight line) is normally at the eye level of the viewer.[xlii] As Mary Magdalene seems to look directly at the viewer, Moonen mistakenly concludes that the horizon line of the painting is at this height. He does comment that the vanishing points of the longitudinal and transverse axes of the viol should intersect at this horizon line. However, the corners of the centre bout of the viol, when extended, do not intersect at a horizon line at the eye level of Mary Magdalene, but rather at a much lower horizon line (see above), and the longitudinal axis of the viol provides no parallel lines which would allow for identifying a vanishing point. These varying perspectival points of departure are the reason for the strongly differing results of the outline reconstructions. In figure 9, a black line shows the outline as calculated using the 3D software; the gray line is Moonen's outline from 1993.



9 Outlines of the Raphael viol: 3D reconstruction by A. von Koenigsmarck (black), reconstruction by T. Moonen (grey). Image: T. Hirsch.

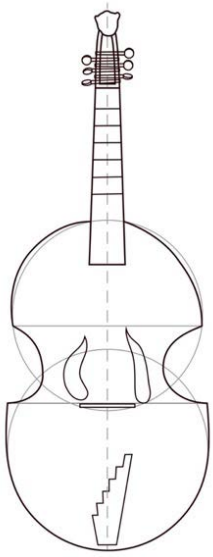


10 Outlines of Moonen's Raphael viol: reconstruction (grey), extrapolated outline (black). Image: T. Hirsch.

One of the few commonalities of the two outlines is their asymmetry. Moonen's has a much longer neck with a stronger bend to the side; the middle bout corners, much lower on the bass side and higher on the treble side, give different curves to the upper and lower bouts. In order to obtain a symmetrical instrument outline, Moonen mirrors over the 'good' bass side and thus extrapolates a 'perfect' viol outline, which nonetheless has very little in common with one determined by rules of perspective (fig.10). [xliii]

In our view, it would make more sense for the outline reconstruction to rotate the connecting lines of the middle bout corners used to determine the perspective at a 90° angle to the central axis of the body and to straighten the neck of the instrument. This leads to an instrument

outline with the lower part of the lower bout forming a perfect circle and an upper bout that is close to circular. These circles can be easily retraced in the painting as reclining ovals (fig.11 and 12).



11 Raphael viol. 3D reconstruction with corrections (see above). Image: T. Hirsch.

12 Raphael, *Saint Cecilia,* viol with retraced ovals. Image: T. Hirsch.

In summary, it can be said that 3D graphics can be an important aid for the outline reconstruction of musical instruments from visual sources. A precondition for this is the determination of a horizon line that can be verified using various objects in the image. Nonetheless, as can be seen in the present case, careful 'interpretation' of the results is still necessary and should also be well-documented.

Instrument reconstruction

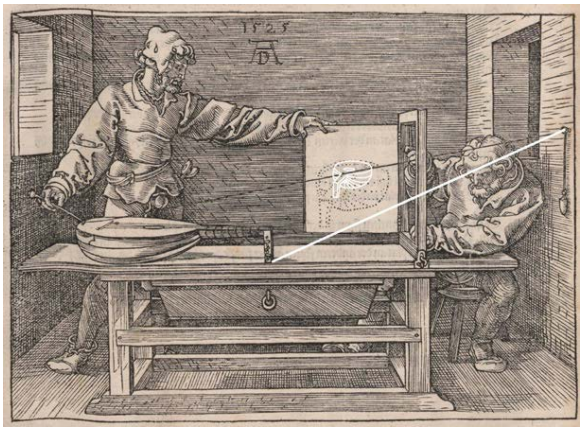
This is also true for many other elements of the viol depicted in *Saint Cecilia*, which Moonen adapts without explicit mention, as for example the discrepancy of the six frets, the length of the neck and the form of the tailpiece. This shows the necessity of being able to use as many additional visual sources for comparison as possible.[xliv] Moonen, for instance, reconstructed the tailpiece with a jagged upper edge like a crown (see fig.10). But when one integrates the viol depiction in Luca Longhi's painting *Madonna and Child enthroned with Saints Paul and Anthony of Padua* (1538) in the reconstruction,[xlv] it becomes clear that in both cases the tailpiece is one with a stair-like graduated upper edge.[xlvi]

After the creation of a plan for the instrument, Moonen continues by calculating the size of the instrument on the basis of the estimated length of the face and overall height of Mary Magdalene (18 cm / 167 cm). Using principles of proportion and numerical symbolism,[xlvii] he calculates a Venetian *oncia* of ±26.85 mm as a basic unit, which finally leads him to the conclusion that this is a Venetian viol that was likely even made by Giovanni da Udine himself (on the argument that the city of Udine belongs to the province of Venice). In the 1995 article, Moonen is somewhat more cautious, writing: 'Given the number of assumptions made, the resulting dimensions can only be regarded as approximate; however, the relative proportions should be reasonably accurate'. [xlviii] Surprisingly, in this article he mentions the

Roman *oncia* of 26.78 mm as the probable basic unit, this time with the reasoning that Raphael worked in Rome from 1508 until his death in 1520.
These cascading hypotheses and their already unstable starting point – the unknown length of the face of a Biblical figure – cannot yield robust results. The principles of proportion and numerical symbolism should also be applied with caution, as they can easily be misleading and frequently have several possible interpretations.
Nonetheless the intent of this case study is not to show that the reconstruction of a musical instrument on the basis of iconography is not useful. Quite the opposite. If this were not an option, we would not even be able to approach the particular sound quality and instrumental practice of most of the music of the Middle Ages and Renaissance, as in most cases no instruments suitable for replicating have been preserved and textual sources do not provide the necessary detailed information. However, the research required for the reconstruction of a musical instrument is such that it can hardly be accomplished by a single person. In our view, an interdisciplinary approach is necessary, integrating musicology, art history, psychology of perception, the use of new technologies (such as reflectography, 3D graphics, iconographic databases, acoustic simulations and measurements) and musical practice (instrument makers and musicians).

Conclusions

Moonen's assumption at the outset of reconstructing the viol in *Saint Cecilia* was its 'photographic accuracy'. But even if a painter is acquainted with 'i termini buoni della prospettiva'/ 'the best principles of perspective', as Vasari reports for Raphael[xlix] (and as one can plainly see in the perspectival construction of his *School of Athens* for example),[l] this does not mean that he therefore had to always depict reality mimetically. One of the distinctive qualities of painting is that it is not forced to show things 'photorealistically', but can instead create its own 'reality' or 'staging' of reality. This is very clearly illustrated in Dürer's woodcut (mentioned above) on the perspectivally correct depiction of a lute. By showing the 'real' instrument, the method for drawing it and finally the dotted 'true-to-life' depiction of the lute, these levels are visible simultaneously. The remarkable thing here is that the lute on the foldable drawing surface is, ultimately, 'incorrect' according to the rules of perspective drawing and is depicted much too large. (The white line added to fig.13 shows where the lower end of the pegbox would be in the measuring frame. The white outline of the lute on the canvas shows the perspectivally correct size.)



13 Albrecht Dürer, *Underweysung* (Nuremberg, 1525), fol. Qiiir. Image: T. Hirsch.

Dürer's 'staging' of reality is not difficult to comprehend: the lute is thus much more visible in relation to the overall size of the woodcut and still appears 'realistic'.
This example vividly shows how important it is to consider the possibility of 'artistic licence' in any iconographic study with the aim of reconstructing musical instruments. Yet with all possible analytical diligence and an interdisciplinary reconstruction approach, the path from depiction to a playable musical instrument requires numerous interpretive steps in which we can only approximate the historical 'reality'.[li] Raphael's viol will thus remain forever 'imperfect'.

Translation: Jessica Plummer

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[i] T. Moonen, 'La Viole parfaite', *Cahiers Suisses de Pédagogie Musicale*, i (1993), pp.18–23.
[ii] T. Moonen, 'The art of the viol maker. Toon Moonen recreates a Renaissance viol based on a painting by Raphael', *The Strad*, cvi (1995), pp.506–510.
[iii] Moonen, 'The art of the viol maker', p.506. Moonen cites the work of musicologist and organologist Karel Moens on the authenticity of string instruments here (see note 10). This also made him aware of the viol depiction in *Saint Cecilia* (Moonen, 'La Viole parfaite', p.18).
[iv] In both editions of his artist biographies (1550 and 1568), Giorgio Vasari traces the development of Italian painting from the late Middle Ages to his contemporaries by describing artists and their styles (*maniere*) in relation to one another. Inaccuracies in this undertaking are due to the scope and time intervals in completing it. A point in favour of Vasari's credibility with regard to Raphael's *Saint Cecilia* is the fact that he personally met Giovanni da Udine between 1550 and 1564 and thus was able to gather first-hand information on his work on the painting (D. Cauzzi, C. Seccaroni: 'Progettazione, elaborazione ed esecuzione della pala', in *La Santa Cecilia di Raffaello. Studi e indagini*, ed. D. Cauzzi, C. Seccaroni ([San Casciano], 2015), pp.77–106, at p.85).
[v] Giorgio Vasari, *Le vite de' più eccellenti architetti, pittori, et scultori italiani, da Cimabue insino a' tempi nostri* (Florence, 1550), p.537, and Giorgio Vasari: *Lives of the most eminent Painters, Sculptors & Architects*, 10 vols., ed. G. du C. de Vere (London, 1912–15), IV, p.29.
[vi] Giorgio Vasari, *Leben der ausgezeichnetsten Maler, Bildhauer und Baumeister von Cimabue bis zum Jahre 1567*, trans. L. Schorn und E. Förster, new ed. with introduction from J. Kliemann (Worms, 1983) (reprint of edition 1832–1849), vol.II, 2, p.352: 'Das Werk Raffaels war göttlich, nicht als ob es gemalt, sondern als ob es lebend sey, und mit solcher Vollkommenheit ausgeführt, daß man es unter seinen schönen Arbeiten, die alle bewundernswerth sind, doch noch als ausgezeichnet rühmen kann'.
[vii] Moonen, 'La Viole parfaite', p.18: 'parce qu'une viole imparfaite ne devait figurer dans un tableu parfait'.
[viii] Moonen, 'La Viole parfaite', p.22: 'La construction de cet instrument était une recherche de la perfection, à travers les proportions, le symbolisme et le mysticisme'.
[ix] See I. Harwood, 'An Introduction to Renaissance Viols', *Early Music,* ii (1974), pp.234-246; I. Harwood and M. Edmunds, 'Reconstructing 16th-Century Venetian Viols', *Early Music*, vi (1978), pp.519-525.
[x] See K. Moens, 'Authenticiteitsproblemen bij oude strijkinstrumenten', *Musica Antiqua*, iii (1986), pp. 80-87 and pp. 105-111; K. Moens, ''Renaissancegambas' in het Brussels Instrumentenmuseum. Vragen rond toeschrijvingen, verbouwingen en authenticiteit', *Bulletin van de Koninklijke Musea voor Kunst en Geschiedenis Jubelpark Brussels*, lxvi (1995), pp.161–237; K. Moens, 'Problems of Authenticity in Sixteenth-Century Italian Viols and the Brussels Collection', in *The Italian Viola da Gamba,* ed. S. Orlando (Turin, 2002), pp.104–108.
[xi] See T. Hirsch, 'Zur nachweisorientierten Rekonstruktion einer Renaissance-Viola da gamba nach Silvestro Ganassi', *Basler Jahrbuch für Historische Musikpraxis* xxxv (2016), pp.271–274.
[xii] There are already detailed publications on Raphael's *Saint Cecilia.* The aspects considered here are only those that support this article. The focus therefore is on thematic links to music.
[xiii] Raphael (Raffaello Sanzio), *Saint Cecilia* (c.1515–18). Oil on canvas, transferred from panel, 236 x 149 cm (Bologna, Pinacoteca Nazionale, inv.no.577). The dating remains a subject of controversy. See F. Valli, 'Raffaello Sanzio: Estasi di santa Cecilia', in *Pinacoteca Nazionale di Bologna: catalogo generale*, vol.1: *Dal Duecento a Francesco Francia*, ed. J. Bentini/ G.P. Cammarota/ D. Scaglietti Kelescian (Venice, 2004), pp.418–427, no.283.
[xiv] Pope Leo XII performed the official beatification in 1828.
[xv] There are similar links to Paul and Mary Magdalene. See R. Williams, *Raphael and the Redefinition of Art in Renaissance Italy* (New York, 2017), p.138: 'since both St. Paul and the Magdalen were privileged to hear heavenly music during their lives, we can assume that they too share in Cecilia's "vision"'.

[xvi] Gianfrancesco Penni, *Saint Cecilia* (c.1514). Pen and ink, 271 x 161 mm (Paris, Musée du Petit Palais, Coll. Dutuit, inv.no.980). Marcantonio Raimondi, *Saint Cecilia* (c.1514). Engraving (for example Washington, National Gallery of Art, inv.no.1947.7.100, see fig.2). That Raphael 'had the rejected composition engraved' could be demonstrated also in other cases (J. Shearman, 'Raphael's Unexecuted Projects for the Stanze', in *Walter Friedlaender zum 90. Geburtstag: Eine Festgabe seiner europäischen Schüler, Freunde und Verehrer*, ed. G. Kauffmann/ W. Sauerländer [Berlin, 1965], pp.158–180, at p.158).
[xvii] R. Hammerstein, 'Raffaels Heilige Caecilia. Bemerkungen eines Musikhistorikers', in *Begegnungen: Festschrift für Peter Anselm Riedl zum 60. Geburtstag*, ed. K. Güthlein (Worms, 1993), pp.69-79.
[xviii] Lorenzo Costa, *Madonna and Child enthroned with Saints Augustine, John, Francis and Posidonius* (1497). Oil on panel, 220 x 140 cm (Bologna, San Giovanni in Monte, Cappella Ghedini).
[xix] Vasari mentions the painting not only in his life of Raphael, but also in the biographies of Francesco Francia and Giovanni da Udine.
[xx] Giorgio Vasari, *Delle vite de' più eccellenti pittori, scultori et architettori: Secondo, et ultimo volume della terza parte, nel quale si comprendano le nuove vite, dall'anno 1550 al 1567* (Florence, 1568), p.577, and Vasari, *Lives*, VIII, p.74.
[xxi] On Giovanni's monopoly position and his depictions of musical instruments in the loggias of the Vatican, see H. Myers, 'The Instrument Trophies of Giovanni da Udine in the Vatican', *The Galpin Society Journal*, lxiii (2010), pp.3–15, 236–240, and C. Ruggeri, 'Giovanni da Udine riparografo: alcune proposte per una 'pittura di cose'', *Bollettino dei monumenti musei e gallerie pontificie*, xxxiv (2016), pp.231–265, at p.256.
[xxii] D. Cauzzi, C. Seccaroni, 'La tecnica esecutiva', in *La Santa Cecilia di Raffaello* 2015, pp.107–123.
[xxiii] The term pair 'realistic/unrealistic' is used in this article in a generic sense to denote a mimetic imitation of nature or reality. On the different meanings of the terms realism and naturalism depending on era and location, see: B. Röhrl, *Kunsttheorie des Naturalismus und Realismus* (Hildesheim, Zürich, New York, 2014).
[xxiv] See D. Gamboni, *Potential Images: Ambiguity and Indeterminacy in Modern Art* (London, 2002).
[xxv] Y. Ostrovsky, P. Cavanagh, P. Sinha, 'Perceiving illumination inconsistencies in scenes', *Perception* xxxiv (2001), pp.1301-1314.
[xxvi] For example, photographs taken outdoors when the sun is at its zenith are often perceived as unrealistic because the objects cast no shadows.
[xxvii] Apparently at an earlier date there was a large window on the right side of the Capella that is bricked over today. See C. Gardner von Teuffel, 'La *Santa Cecilia* di Raffaello e la sua cornice originale in San Giovanni in Monte a Bologna', in *La Santa Cecilia di Raffaello* 2015, pp.17–34, at p.22. Whether Raphael knew about the lighting situation at the place of display is unknown. In the draft version by Penni, this was certainly not yet taken into account.
[xxviii] R. Bellucci, D. Cauzzi, C. Seccaroni, 'L'Estasi di Santa Cecilia' di Raffaello. Novità in merito all'iconografia, alla genesi e all'esecuzione del dipinto', *Bollettino d'arte,* cxxxi (2005), pp.101–110, at p.109.
[xxix] Theoretically it would also of course be possible that this is a left-handed instrument, where the left hand is used to play the keys while the right pumps the bellows. There are for example string instruments built for left-handers, where the player holds the bow in the left hand and uses the right hand on the fingerboard.
[xxx] In graphic reproduction, the reversed depiction of the musical instrument is frequently seen, although in these cases it is likely a mistake in the reverse cutting of the block (or plate), such as numerous keyboard instruments in Sebastian Virdung's, *Musica getutscht* (Basel, 1511). Compare J. Eisenberg, 'Virdung's Keyboard Illustrations', *The Galpin Society Journal* xv (1962), pp.82-88, and E.M. Ripin, 'A Reevaluation of Virdung's 'Musica getutscht'', *Journal of the American Musicological Society* xxix (1976), pp.217–221.
[xxxi] This observation was already made by Willibald Gurlitt in 1938 in his article 'Die Musik in Raffaels Heiliger Caecilia'. Reprint in: *Musikgeschichte und Gegenwart. Eine Aufsatzfolge*, ed. H.H. Eggebrecht (Wiesbaden, 1966), vol.1, pp.31–45.
[xxxii] See K. Moens's publications cited above (note 10) and T. Hirsch (note 11).
[xxxiii] Albrecht Dürer, *Underweysung der Messung, mit dem Zirckel und Richtscheyt, in Linien, Ebnen und gantzen Corporen* (Nuremberg, 1525), fol. Qiiir.
[xxxiv] M. King, G.E. Meyer, J. Tangney, I. Biederman, 'Shape constancy and a perceptual bias towards symmetry', *Perception & Psychophysics* xix (1976), pp.129–136.
[xxxv] R. Bellucci, D. Cauzzi, C. Seccaroni, 'L'Estasi di Santa Cecilia''.
[xxxvi] The 3D reconstruction using MAXON Software Cinema 4D was already completed in 2016 as part of the SNSF research project 'Groß Geigen, Vyolen, Rybeben' at the Schola Cantorum Basiliensis (co-project head: T. Hirsch) without further work on the material.
[xxxvii] Horizon line here is not referring to the place where the hills touch the skies in the background of the painting – it is the line intersected by the vanishing points of the central perspective.
[xxxviii] Jean Pèlerin, called Viator, *De Artificiali perspectiva*, (Toul, 1509), fol.[A8]v. Two depictions of 'cornuta' can also be found here.

[xxxix] The horizon line found in this manner was also checked against other geometric objects in the painting like the timpani in the foreground and the tambourine at the lower right.
[xl] Isocephaly (heads at the same level) is a style technique that was already recognised in ancient times.
[xli] Moonen, 'La Viole parfaite', p.20: 'L'une des règles de la perspective veut que l'horizon se trouve au niveau des yeux'. See also Moonen, 'The art of the viol maker', p.508.
[xlii] 'Perspektive', in *Das große Kunstlexikon von P.W. Hartmann*, <http://www.beyars.com/kunstlexikon/lexikon_6891.html> [28 January 2020].
[xliii] He also, for example, does not mention his adaptation of the middle bout to something resembling a shape that was common from the 17th century, with the radius of the upper curve significantly smaller than the lower.
[xliv] The iconographic database for early string instruments used by the authors has been built up by T. Hirsch since 2011. It contains metadata on each artwork and controlled vocabulary for description of instrument morphology (ca. 450 criteria). To date, 1840 datasets/artworks and 4489 photographs have been recorded (status as of January 2020).
[xlv] Luca Longhi, *Madonna and Child enthroned with Saints Paul and Anthony of Padua* (1538). Oil on panel, 235 x 175 cm (Milan, Pinacoteca di Brera, inv.no.127). Shown in: A. Mazza, 'Padre Martini e lo studio degli strumenti musicali nei dipinti antichi', *L'Arciginnasio* ci (2006), pp.176–225, at p.194, fig.9.
[xlvi] The tailpiece was added into the reconstruction of the outline (fig.11) in this form. All other elements such as the upper and middle bout outlines, sound holes, neck length, pegbox were 'uncorrected'.
[xlvii] Thus, for example, Moonen's outline reconstruction has corpus widths that have a relation of 6:4:7, where the individual numbers are, according to him, to be understood symbolically: 6 (3+2+1) stands for perfection and paradise, 4 for the world (four seasons, four elements, etc.) and 7 for wholeness (the creation of the world in seven days, seven planets, etc.). See Moonen, 'La Viole parfaite', p.21–22. He refers here to H. Heyde *Musikinstrumentenbau* (Leipzig, 1986), pp.20–22.
[xlviii] Moonen, 'The art of the viol maker', p.510.
[xlix] Giorgio Vasari, *La terza et ultima parte delle vite degli architettori, pittori et scultori* (Florence, 1550), p.603: 'Venne in questo tempo Raffaello da Urbino pittore a imparare l'arte a Fiorenza, et insegnò i termini buoni della prospettiva a fra' Bartolomeo', and Vasari, *Lives*, IV, p.155: 'At this time the painter Raffaelo da Urbino came to Florence to study his art, and taught the best principles of perspective to Fra Bartolommeo'.
[l] Raphael, *The School of Athens* (c.1510–11). Fresco, 500 x 770 cm (Vatican City, Apostolic Palace, Stanza della Segnatura).
[li] For methodological support, the SNSF research project at the Hochschule der Künste in Bern entitled 'Rabab & Rebec – Exploration of skin-covered string instruments of the late Middle Ages and the early Renaissance and their reconstruction' is developing practical guidelines on the reconstruction of musical instruments on an iconographic basis. See <https://www.hkb-interpretation.ch/projekte/rabab-rebec>.