Undergraduate Research Opportunity Programme in Science

Vermeer's Camera

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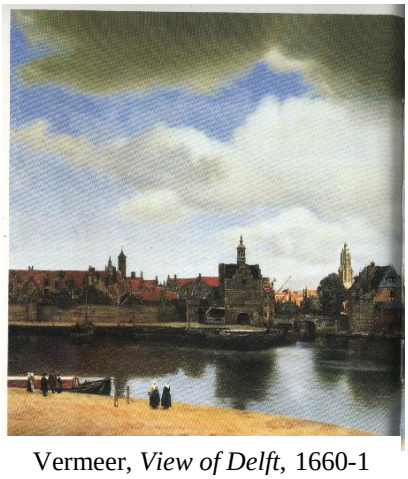
I. Introduction

Looking at The View of Delft by the 17th century painter Johannes Vermeer, we are impressed by resemblance between the painting and the actual scenery of the Netherlands today. Painted against the broad expanse of water and sky are the brick buildings with tiled roofs, the sunlit New Church, the wrinkled reflections of the skyline in the water, the dramatic cloud formations; all of these come together to give a living picture. Modern critics have long admired Vermeer's paintings for their acute observation of houses, light and atmosphere. In art, this reality effect is called realism or naturalism. Realism in art has not always existed, nor is it an easy feat; art historians see a general shift towards greater naturalism in art beginning from the 15th century and debate on the methods, technique that the artists employed as much as the meaning and reason of the paintings. To achieve realism really require not only great drawing and painting skills to put images down on paper, but accurate observation must precede it. A painting will only look real if the artists could transcribe what he sees of the world onto a piece of paper or canvas accurately. Encapsulated in the idea of seeing with accuracy are knowledge of optics and perspective, both of which are what the Renaissance scholars called the 'mixed sciences'. The 'mixed sciences' integrate mathematics - the language of accuracy - with theories in natural science was an important aspect of arts. In this paper we will look at the work of two people that reflect this spirit of the 'mixed sciences' - David Hockney and Philip Steadman. The first section will focus on artist David Hockey's work to confirm that use of optics



Vermeer, *View of Delft*, 1660-1

Modern view of Delft

in paintings. The second section examines art historian Professor Philip Steadman's work using perspective geometry to ascertain that Vermeer used an optical device called the camera obscura in his painting.

I.1. Distinction of Hockney's thesis

Artists and art historians, by the nature of their studies, are exerting that the methods artists use – be it the materials, tools, techniques, insights - have a profound, direct and instant influence on the nature of the work they produce. There is often much discussion on the techniques employed by a certain master; among these were the knowledge of linear perspective and optics. The former is generally agreed by art historians to emerge around the time of the Renaissance. The latter, however, remains controversial. Most are of the view that it emerge much later than linear perspective, perhaps sometime in the 17th century. Here lies Hockey's thesis: Optics in art emerged as early as mid-1420s, evidence of which we could detect from analysing optical traits in paintings over time.

Techniques used by artists could be classified broadly into two categories: those that are progressive in nature are usually methods perfected over time, or it could be a sudden phenomenon, often the cause of a technical innovation. Linear perspective is one such innovation of the first type. Invented in the early 15th century, it provided artists with a technique for depicting recession in space, with objects and figures scaled just as they would appear to the eye from a single point and seen as a gradual progression in space. But linear perspective does not allow you to paint curvature realistically, optics would.

Putting replications of paintings from the 14th – 19th century on the wall of his studio, Hockney built a 70 feet long gallery capturing European paintings across a time span of more than 400 years. Surrounded by the pictures and being a trained observant

artist himself, he was able to pinpoint the first use of optics to as early as 1425. Moreover, he detected that the phenomenon was not a gradual process – the optical look arrived suddenly, and was immediately coherent and complete. This abruptness suggests a discovery of some sort of innovation that introduced a new way of seeing.

I.2. Distinction in Philip Steadman's work

One optical device we will learn about in Hockney's work is the camera obscura. Philip Steadman supported his argument of Vermeer's use of the camera obscura by a splendid display of reverse construction of interiors by geometry. Although he included visual evidence in his finding, he substantiated his conjecture using perspective construction to recreate the space in Vermeer's paintings. The result shows that many of these paintings were painted in the same room. What is more, these pictures painted share a similar position for their viewpoints. This 'coincidence' takes place when the use of a camera obscura with a lens, with the position of the lens being the viewpoint. We will look into these geometrical working in section IV.

II.1. Linear Perspective

Giotto,1303

Linear perspective is a technique for depicting recession in space, with objects and figures scaled just as they would appear to the eye from a single point. Perspective gives one the perception of depth, that there is a distance into space on a piece of two dimensional papers. Art before linear perspective has a 'flat' look about them. They are generally expression of spiritual power and the importance of each character is portrayed through their size. Compare Giotto's 1303 full-length lady with Flagellation of Christ (1450s) by Piero della Francesca, a picture

Piero della Francesca, *Flagellation of Christ*, 1450s

where linear perspective is apparent. We know from looking at the picture that certain subjects are closer to us and some further away. This coincides with the natural way we see our world and we feel comfortable with this perspective. Linear perspective could be constructed with one single viewpoint, or many different ones.

Melozzo da Forli, 1475

Van Eyck's Ghent Altarpiece (1432) is an excellent example of the latter type. It displayed an astounding sense of depth. We look straight on at the Lamb of God, and we move above when looking at the fountain. We see each figure straight on, regardless of where they are in the scene, even those on the distant mountains. The left and right groups in the foreground are seen from the front, with a slight rise of viewpoint towards the centre. distance are seen head on, with very beautiful details of bushes and plants seen from the front, again head on. The angles are on the ground but their lovely shapes also suggest flying. The rays of the sun radiate out as thought the sun were the painting's vanishing point, yet a 'V' shape rises from the bottom of the picture to contradict this. It is a miraculous composition, around which we move from viewpoint to viewpoint. There is a sense of closeness to everything yet at the same time depth could be achieved. Multiple viewpoints create a far bigger space than can be achieved by one.

Van Eyck, *The Ghent Altarpiece*, 1432

Compare with the single viewpoint, we realised that our bodies may accept one central viewpoint, but out mind's eye actually moves around to look at different object closely (brought up to the picture plane), except the far horizon, which has to be near the top of the picture. Multiple viewpoints have a similar distancing effect on a 2-D surface as a bird's eye view.

One of the limitations of linear perspective we could see from a single viewpoint is that in concerning ourselves with the illusion of depth, not everything is depicted equally, some movement of the subjects have to be sacrificed into for it to be included in the correct viewpoint. This is similar to capturing everyone in a picture (one single focus and thus vanishing point) and same would be asked by the photographer to lean or squat to be included in the photograph. Van Eyke's multi window perspective, on the other hand, allows us to see everything in equal measure, because we are constantly moving –or floating- from one part of the painting to the next, never still. Though quite different, both pictures are beautiful depictions of very sophisticated spaces. The usefulness of multi-focus as we look at another branch of the mixed sciences in this paper: optics.

II. 2. Optics

Although linear perspective is useful in achieving spatial realism, it does not allow us to paint curvature such as patterns following folds, or the shades of lighting that we naturally discern. This is the role of optics – the study of the laws of sight. Unlike linear perspective, it is commonly assumed that the technology and knowledge did not exist until after the 16th century. We will show in this section that optics, as part of a progression towards greater realism, emerged alongside linear perspective, beginning from 1430s.

The basic of seeing is light. Light travels in straight lines. Using this principle together with some basic materials, we could achieve various optical effects.

Optics need strong lighting and strong lighting creates deep shadows. Optics is also closely related to technology related to mirrors and lenses. A combination of lighting, shadows and use of optical devices create a certain specific tonalities, shading and colours found in the optical projection. To an artist six hundred years ago, looking at a reflection from a mirror projected unto the wall or through a lens would have demonstrated a new vivid way of looking at and representing the material world. Optics gives artists a new tool to see with which to put images down on paper. We will look at some of these optical effects. These would include optical artefacts created by limitation of the devices in use.

II.3. Comparative studies of Optical Effect

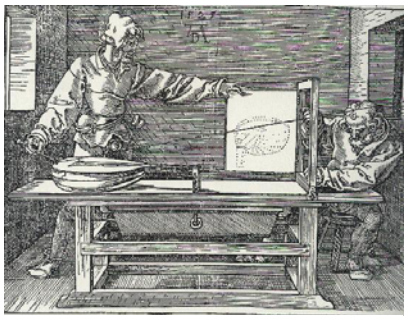
In this section, we will examine the following clues we could deduce the use and the advent of optics in paintings. These effects are not stand-alone traits and we could usually find them appear in combinations.

1. Curved Surfaces
2. Lighting and shadows
3. Clothing and armour
4. Artefact in perspective
5. Evidence of mirror and lenses in picture
6. **Technique revealed: Concave mirror method**
7. Dark Background
8. Groping
9. Collage
10. **Technique revealed: Mirrors to lens**
11. Left-hand drinker
12. Lighting: soft focus and shadows
13. Wider angle

14. Smiles
15. **New instrument: Camera Lucida**

II.3.1. Curved Objects

Some of the most difficult things to paint with linear perspective are curved objects such as lutes. Durer's famous woodcut of 1525 suggested that some artists used technical aids to help them, but this method is tedious if not impossible for some items. For example, Hans Holbein's The Ambassadors (1553), just eight years after Durer's print, is filled with curved and spherical objects, including a lute which Durer's method illustrated. It would be a great task, not to say impractical, to apply the woodcut method for each of the curved objects: the writings on both the celestial globe and the geographical globe follows the curvature with great precision, marking, on the latter, the word AFFRICA clearly. The notes on the music bent with the page. Notice how the anamorphic skull, when compressed to its accurate position, showed clues of shadows. Moreover, in the hand of the man on the left is an ancient version of the



Durer's woodcut, 1525

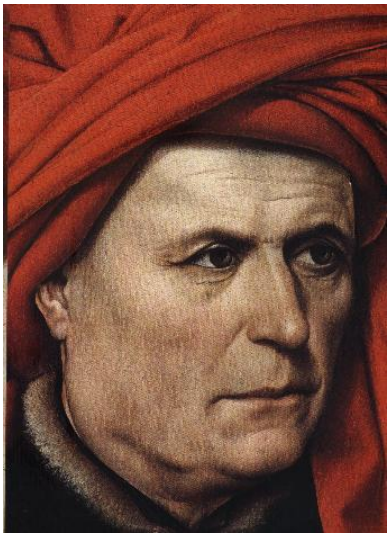
Hans Holbein's The Ambassador, 1533. Notice how accurate the curved surfaces were portrayed, and shadows was evident where the skull lies

binoculars – an optical instrument. We will look at evidence of shadows and optical devices in the paintings in the following sections.

II.3.2 Lighting and Shadows


1300


1425


1430

Similar subjects are shown here, but their looks are quite different. In 1300, there is minimum notation of lighting and shadow. In 1425, the look on the man's face looks more realistic – with more depth. 5 years later, the man in the picture suddenly looks 'modern'. There is clear lighting, with shadows under the nose. The folds in the headdress look natural compared to that in 1425. The contour of the face, with the slight double chin, was realistically depicted. Here we could detect the sudden change in the quality of images between 1425 – 1430.

II.3.3 Clothing


1303-6


1425


1438


1467


1545


1553

In 1303-6, the full-length lady was done in a simple graphic way. In 1438, the clothing followed form in a more accurate way, although still somewhat stiff. By 1467, the fabrics were shown to be elaborate with subtle highlights and shadows following patterns of folds.

II.3.3 Armour

1302-5 1448 1450 1460 1501 1557 1625-7

Here are three centuries of depiction of armours. The first three did not reflect the shine on the armours as realistic as that starting from 1460. By 1625, the picture is almost as good as photograph.

Photograph of an armour part taken in 2000

II.3.4. Errors in perspective

Paintings drawn using principles of linear perspective would usually have a clear point of focus. However, in some paintings starting from Memling's 1485 – 90 picture of a vase, Hans Holbein's 153's picture with coin on a table, errors in vanishing point - usually two viewpoints very close to each other – start to appear.

Lorenzo Lotto, *Husband and Wife*, 1543

Shown here is Lorenzo Lotto's *Husband and Wife*, where the pattern in the oriental carpet goes out of focus, i.e. it has two vanishing points. Had linear perspective been used, the pattern would have receded in a straight line, with one single vanishing

point corresponding to a single viewpoint. Such mistakes would be unlikely had the artists painted according to geometry.

II.3.5. Evidence of mirrors and lenses in pictures


1434


1436


1438


1518-19


1533


1630

In the painting of 1434, we see at the background reflection from a convex mirror. In 1436, we see the man in the picture holding what resembles the modern day spectacles. In 1518-19, the Pope in the picture had a magnifying glass in his hand. All these are examples of optical instruments that were made and designed with the principles of optics. We can also confirm that the artists were aware of the images these mirrors and lenses produced – the view of the whole room was captured in the convex mirror in 1434. We can thus argue that while mirrors and lenses might have been rare, artists were aware of their existence, even if they were oblivious to the possibilities these devices could offer. The last point seems unlikely, especially since artists would by training have an eye for images and projection. They would have spotted the strange effects the mirrors produced and fascinated that in the space of such a curved surface a whole room could be contained. In fact, the first instance of spectacles for correcting long-sightedness has been traced to Italy towards the end of the 13th century. By the 16th century spectacles were being produced in quantity and the manufacture of lenses had become an industry. Another interesting fact to note is that painters and mirror-makers were both members of the same guild during that time.

II.3.6 Concave Mirror Method

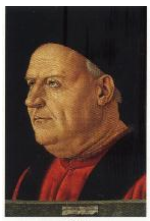




In 2000, in the midst of this project of tracing the origin of optical effects in paintings, David Hockney had a 'Eureka!' moment after a casual remark made by a friend. The result is that discovered a method by which the old masters might have worked. This is the Concave Mirror method. A window is cut in a board and put at the door of a room to block out all light except from the window. Inside the darkened room, an image is formed on the wall facing the window. It is upside down and very clear. If he put a concave mirror at the position of the image formed on the wall, and a piece of paper next to the window. Adjusting the mirror towards the paper, the image is now reflected unto the paper. After tracing the outline of the image, he could then turn the paper right side up and have a complete drawing. He realised that the painting that would result from this drawing greatly resembles those of Netherlandish portraits from 15th – 16th century. The principle behind this technique is the forerunner of the camera obscura, which we will discuss in greater details later.

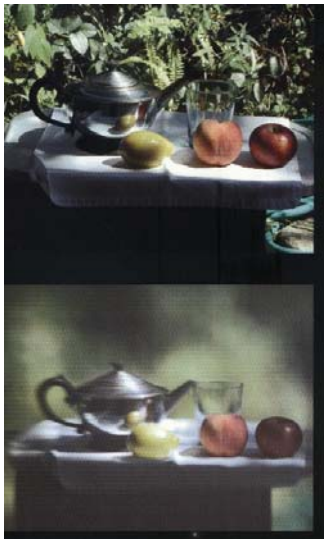
II.3.7. Dark background & Through- a-Window look Portraits



1446 1475 1480 1487 1494 2000

II.3.8 Collage technique



One limitation of the Concave Mirror method is the difficulty to obtain a uniform focus for objects at different distance. The other pictures show, if you arrange some objects farther back than others, it is impossible to have everything in focus at once. This is because the mirror has a limited depth of field (area of focus). But by moving the mirror or the paper you can change the point of focus. This is a problem a painter using optics has to overcome. One way they have done it is by painting each subject separately with a unique focus and put them all together in relation to one another. This is effectively a collage, where we see each subject head on. But the overall effect is not extremely uncomfortable. Notice the top left corner of the picture where we see window with a ledge – a clear trait of the concave mirror method.

Image projected in the darkened room.

Dieric Bouts, 1464-1468 and the 'Collage' method

II.3.9. Groping

Honthorst, 1623

Compare these two pictures. Both were by Gerrit van Honthorst in 1623. The most remarkable difference between the two is way the lines were drawn. The left shows signs of 'groping' – it is as though the artists is looking up and down from the model to the paper, in a attempt to adjust the precise position of each line. There were signs of hesitation and uncertainties. This fumbling of sketches for the exact position of a part in relation to the other, bigger whole is the usual way of an artist. However, if optical devices were used, the artist's lines could be more precise, because he is tracing the outline from the projected image. The left sketch is an example of sketching without the use of optical devices; the right is one, by the same painter, that would have used optical aids. It has the look of a modern black and white photograph.

Honthorst, 1623

II.3.10 From Mirrors to Lenses

Hockney's still life projections with a mirror had a distinctive look: objects seen head on, a unifying totality with strong highlights and shadows, a dark background and restricted depth – all characteristics imposed by the limitations of the equipment. Artists found ways of overcoming these limitations by 'collaging' various elements together to make a larger painting – but those elements are still seen head on and close up. It is the artist's compositional; skills that convince us everything is placed within a coherent space. When conventional lenses became large enough and of good enough quality to use instead of a concave mirror (some time in the 16th century), an artist already schooled in the use of concave mirror projection would see one distinct advantage: a wider filed of view. One example of an artist that made the

mirror to lens transition is Caravaggio. In the Sick Bacchus in 1594, Caravaggio painted with the collage technique: we look down on the table but see the still of fruit head on, the fruit also seem remote from the figure, as if it were a separate composition, the head and shoulders seem very close to us, where the collage method brings all subjects nearer to the picture plane.

Caravaggio, *Sick Bacchus*, 1594

In another Bacchus picture of 1595-6, the subject seems to be farther back. This is an effect you would expect from a conventional lens, which can project a wider field of view and therefore more of the figure in one go. Also, the figure is holding the glass in his left hand – this could be attributed to the use of a lens, which unlike the mirror reverses everything. These two paintings make a radical shift. Perhaps at some point in mid-1590s Caravaggio came into the possession of a lens, perhaps given to him by his powerful patron Cardinal del Monte, who had given advice to Galileo about how he could improve his telescope. The Cardinal was therefore clearly knowledgeable about optics, and no doubt owned several lenses.

Caravaggio, 1595-6. The picture on the left is the original picture, while the right has been reverted left to right.

II.3.11. Left Handed Drinkers

At the end of the 16th century, when lenses were first used by painters, there were two noticeable traits about the new images. First, the subject seems much further to us, the viewers. (Compare the pictures in this section with that of the last). Secondly, there was a sudden increase in left-handed drinkers depicted in pictures. This is exceptionally unusual given that most people – both left and right-handers – tend to

lift a glass with their right hand because glasses and cups are usually laid out on the right at dinner. This could be explained by the use a lens whereby the artists simply painted what they see in the projected image.

Annibale Carracci, 1582-3. The picture on the left is the original picture, while the right has been reverted left to right.

Frans Hals, 1626-8, original

Hals, reverted left to right

II.3.12. Soft Focus

Compare the famous Mona Lisa of 1503 with the portra

Leonado da Vinci, Ginevra de'Benci, 1474-6

Leonado da Vinci, Mona Lisa, 1503

Mona Lisa is captured in a softer light with features that look less mythological than that of the girl. Leonardo is known to have used optics and written thesis on them. Next, take a look at Vermeer's Milkmaid. Notice a certain halo effect on the basket, the bread and the milk jug. Vermeer would not have been able to see that with his naked eye. Also compare the basket in the foreground with that at the top. The one at foreground has been painted out of focus or in soft focus.

Vermeer, The Milkmaid, 1658-60

The basket at the bottom is out of focus compared with the one at the top.

Moreover, the flowing of the milk seemed to have been captured at the right moment. Looking at images through a lens would produce that effect.

II.3.14. Smiles

1303-6 1452 1470 1500 1580 1624 1628-9

Artists who 'eyeballed' tend to need more time to fix the essential features, and thus record more static expressions. However, with the help of optics, if the painter is quick enough, he would be able to record a fleeting moment. The earliest smile recorded is recorded in 1305, and by 1470, the smile is captured naturally on canvas.

II.3.15. Camera lucida (19th Century)

In the 19th century, a new optical device called the camera lucida was invented. It is a portable instrument with a prism on a stick. The image created is virtual, and one needs to look through the prism from a single point to see the image formed. Putting a piece of paper at where the image is cast, a quick sketch of the image could be made. This image is upright and right way round, but much reduced in scale. This method gives the virtues of accuracy to the picture. We could see the evidence of the use of camera lucida in sketches of Ingres – the portraits are small, but with great degree of accuracy.

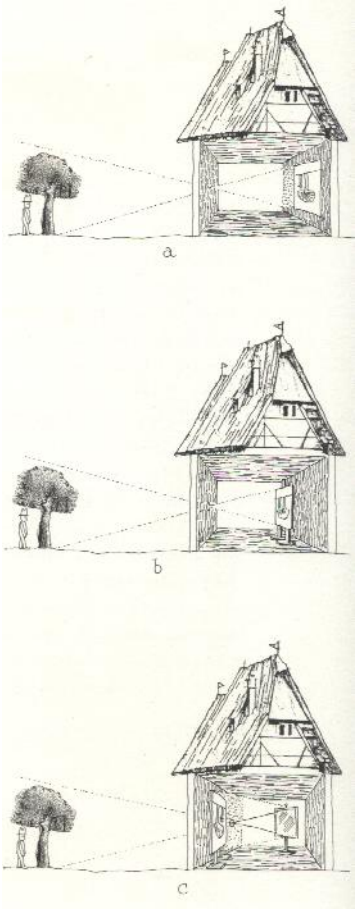
III. Putting things together

So far we have looked at numerous categories of visual evidence for the use of optics in art, starting as early as mid 1420s. In the next section, we will look at evidence of another nature – geometrical perspective and optics together. We will examine Philip's Steadman's work to confirm Vermeer's use of the camera obscura using perspective geometry. From the previous sections, we can be certain that by

Vermeer's time, optics and optical devices are not new to him. In fact, many of Vermeer's paintings reflect optical characteristics that we have discussed.

Prior to that, however, I would like to discuss certain principles of optics which will be useful to understand the working of the camera obscura.

III.1 Camera Obscura



The set-up we discussed in the Concave Mirror method is the predecessor of the camera obscura. Both function on the principle that light travels in straight lines and an image is formed when light rays intersect. The main difference between the two set-ups lies in the **size** of the opening where light enters into the enclosure to form an image. In the Concave Mirror set-up the opening is large, bundles of light rays parallel to each other travel perpendicularly towards the opening and on to the opposite wall. The

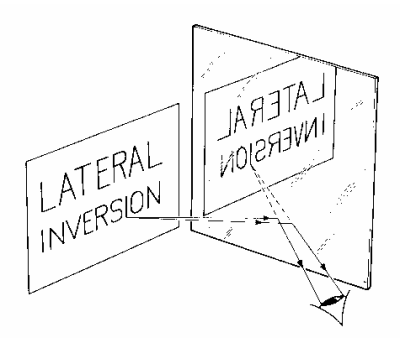
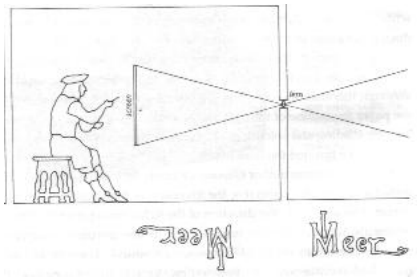


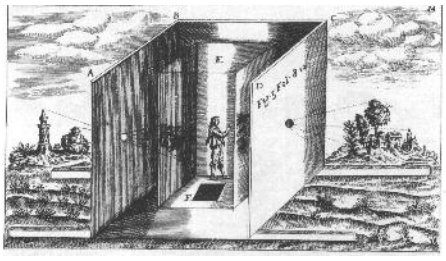
image formed from these myriad of rays are thus blur and unfocused. To resolve this, a mirror that converges light rays (concave mirrors, versus a convex mirror where it diverges) is needed to focus the image and reflect the focused image unto the opposite wall. For the image to be sharp the hole must be small and this is set-up for the camera obscura. The opening is tiny and it is referred to as a pinhole. The light rays

that enter such an opening is restricted and in fact only two rays of light, each crossing the other at the pinhole are responsible of the image formed. This image is focused and could be observed on a screen within the path of light [Diagram (a)]. This image is upside down and reversed left to right**.** It is usually very dim in the room because of limited amount of light within the room. With the advent of lenses, however, we can place a lens at the hole to adjust the distance of the lens in relation to the room based on the principle of equivalent triangle as well as to adjust the opening to allow the desired amount of light for the image.

We know from pictures of later period that this problem of laterally reverse image is resolved. This could be several ways as suggested by Leonardo da Vinci, in his notebooks on optics in 1490. The image could then be traced and turned upside down to their correct orientation. There were many generations of the camera obscura. With each successive modification the image projected was made realistic to the way we see them in real life.



1544



1646

1786

IV. Vermeer

Johannes Vermeer (1632-75), Dutch artist. Despite being greatly admired for his artistry during this lifetime – having been appointed the headman of the Guild of

Vermeer's known oeuvre

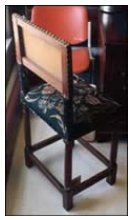
Saint Luke at the age of twenty-nine - his fame receded to the background as compared to his contemporaries de Hooch and Matsu. This is partly due to his relatively small oeuvre (of about 35 known paintings), most of which are privately

owned. On the rare occasions that the general public do get to see his art at auctions, most would marvel at the resemblances between his paintings and modern photographic prints. With the invention of photography in 1839, interest in Vermeer's art rekindled. In 1866 Theophile Thore published a catalogue of his known oeuvre, and in 1891, a first public identification of photographic traits in Vermeer's painting was made by the American lithographer Joseph Pennell, in the British Journal of Photography.

Around 1657, when Vermeer was about 25, the subject of his painting started to shift from Biblical and mythological theme to snapshots of Dutch provincial life. It is in this latter group of pictures that the optical characteristic is most apparent. The soft focus that is the signature of Vermeer's art stands out in these paintings. Moreover, it is known that Vermeer painted some details extremely accurately. Paintings, maps, chairs, were painted to exact details with those that we see in museums today. This





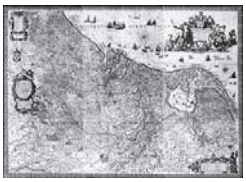



Table

Map

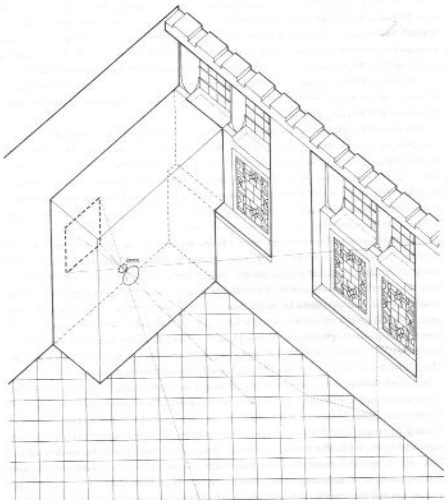
Chair

On the left of each of these items are the real life objects in museums, the right are extracted from Vermeer's paintings.

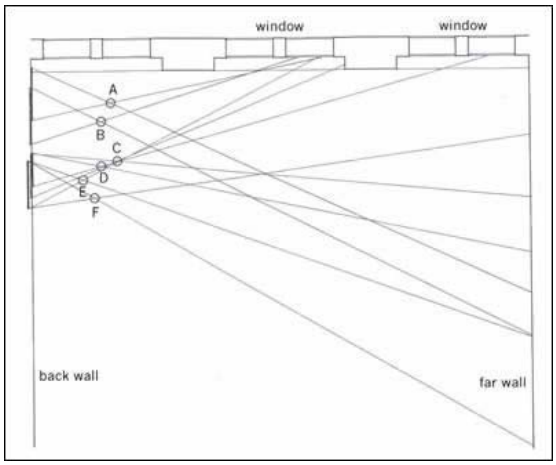


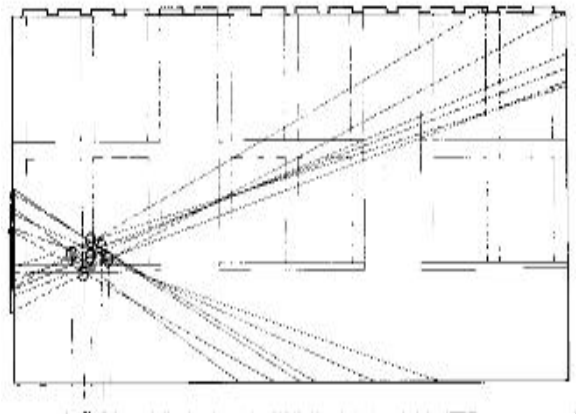

will be a useful tool for us to have an idea of the scale his paintings are reduced to relative to real life. Out of the total 35 pictures of his known oeuvre, 4 were of biblical theme, 2 were sceneries, and 2 were 'head-shot' portraits. The rest showed interiors. Out of these 27 pictures, 11 showed interiors with tiled floor. These tiles give clue of a linear perspective construction of the space where the ground plane (bottom edge)

is divided equally. Moreover, each of these 11 paintings has a ‘central’ perspective. This means that when we stand in front of the picture with our line of view perpendicular to the picture plane, we see a far wall without windows. This wall is parallel to the picture plane in space. Often a wall is seen at the left, with one or two windows visible, and even if the windows cannot be seen, the light comes from this direction. The top and bottom of the wall are horizontal in the picture, as well as the ceiling joists and the top and bottom edges of any maps and paintings that hang on the wall. From these, we conclude that were there a second wall at the left of the picture, this wall will be at right angles to the picture plane. These walls and ceilings give the painting a vanishing point, where the images of lines receding away from the viewer converge.



Speculated position and form of Vermeer’s camera

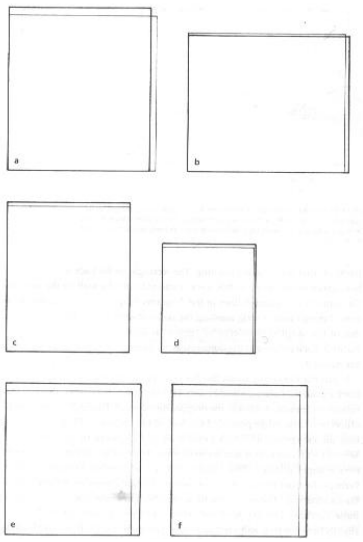




Plan and side view of Vermeer's room with viewpoints (small circles) marked for six paintings: (a) 'The Girl with a Wineglass', (b) 'The Glass of Wine', (c) 'Lady Writing a Letter, with Her Maid', (d) 'Lady Standing at the Virginals', (e) 'The Music Lesson', (f) 'The Concert'. The diagonal lines mark the extent of what is visible in each picture. The heavy lines at the back wall mark the widths of the six projected images: each is the width of the respective painting.

Philip Steadman used a ‘reverse’ perspective construction, together with a mirror image from The Music Lesson, to

reconstruct the space that Vermeer depicted painted (in). We could also use the exact size of the 'props' that Vermeer had used for his pictures as an absolute scale for the pictures. We could thus obtain a collect of plan and side views from these calculations. What was remarkable is that these plan views and side views suggest 6 of these pictures showed evidence that they are the same room. What is even more extraordinary is that the viewpoints of these 6 pictures were clustered around a specific area and height in the room. Suppose Vermeer used the camera obscura – of the booth with a lens type – to paint, then these evidence falls together. The lens would have been the viewpoint for the pictures. In addition, we realised that, by calculation of the size of the projected image on the walls for each of the picture, the dimension is very similar to that of the actual paintings.



Comparison of actual sizes paintings with the calculated size of projection.

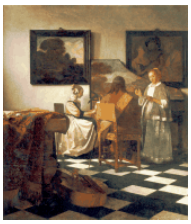
V.1. Vermeer's Interiors, reverse constructions and The 'Coincidence'

The Girl with the Wineglass 1659-60

Lady standing at the Virginals 1673-75

Lady writing a Letter with her Maid 1670

The Music Lesson 1662-65

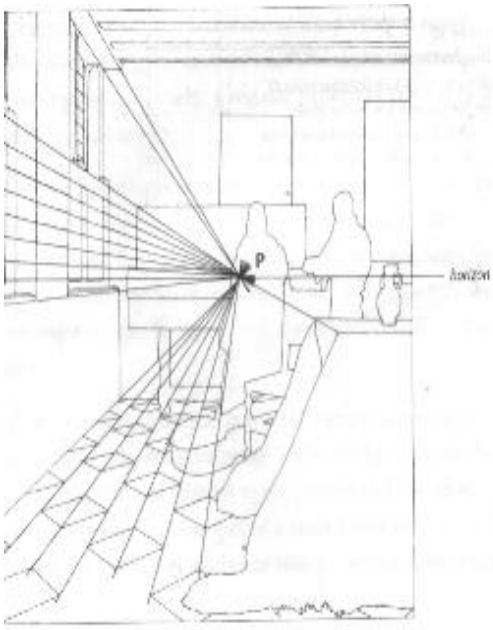


The Concert 1665-66

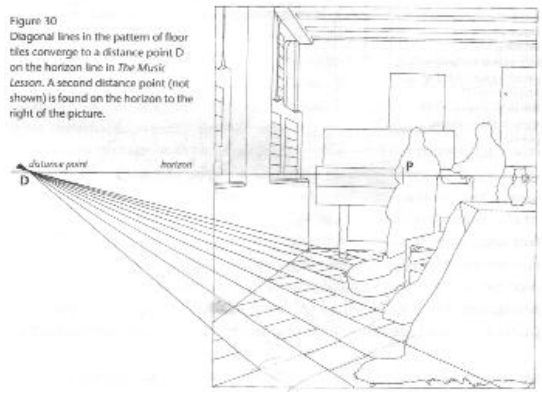
The Glass of Wine 1658-60

Below is a procedure for obtaining the plan and side views of the paintings, using The Music Lesson. The same method was used for all the six pictures above.

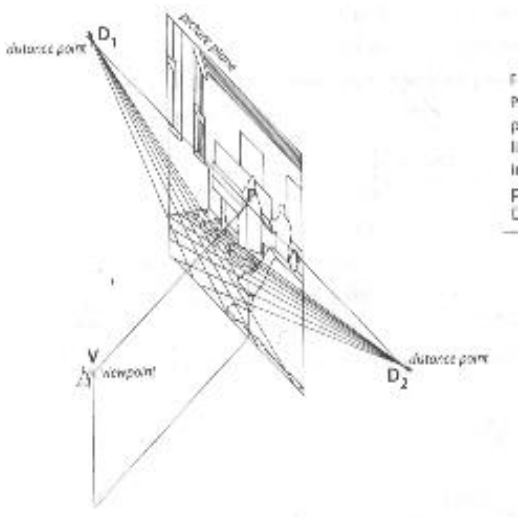
First, let's locate the central vanishing point of the picture. By drawing the lines of direction provided by the window sills, the wall, the ceiling and especially the tiles which act as orthogonals, we could join all of these lines of direction to one point. This is the central vanishing point. In The Music Lesson, this point of convergence is at P, the position of the girl at the virginal. Next, we draw a horizontal line through this point to denote the theoretical horizon.



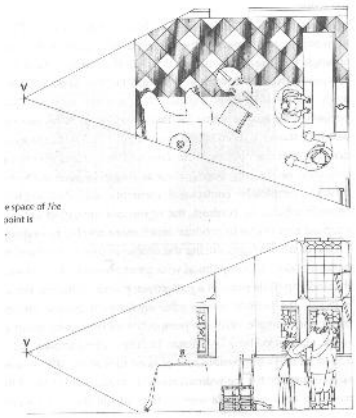
Using the grid provided by the floor tiles, we do step 1 again in two directions outside of the picture. This will locate the distance points that lie to both sides of the picture. These two points will lie on the horizon and are equi-distance from the central vanishing point.



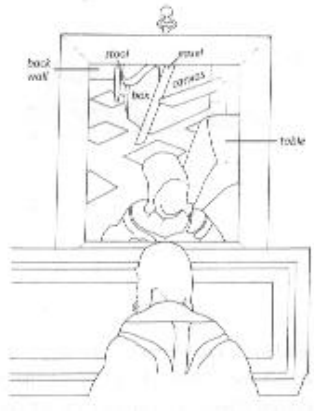
From the distance points we could locate the picture's theoretical viewpoint. This is the perpendicular distance to the picture plane and is the same distance as either of the distance points from the central vanishing point. If we join up V and D2 (or D1), we see that it is an isosceles triangle where the angle subtended from the vanishing point-viewpoint-distance point is 45 degrees (the patterns of the tiles). This viewpoint is the distance at which Vermeer would have had put his eye in order to see the scene in the precise perspective view represented in the picture.



With Step 1 – 4 in place, we could proceed to construct, first the plan view (step 5-6), and afterwards the three-dimensional side view (step 7), of the room in which The Music Lesson is painted.



Moreover, using the mirror image in The Music Lesson, we could obtain in addition, the back wall of the room.



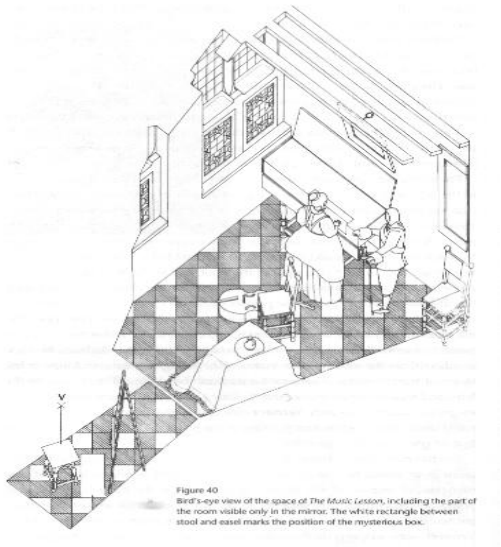
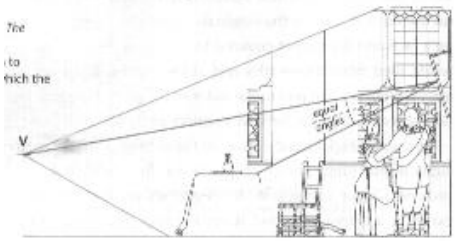
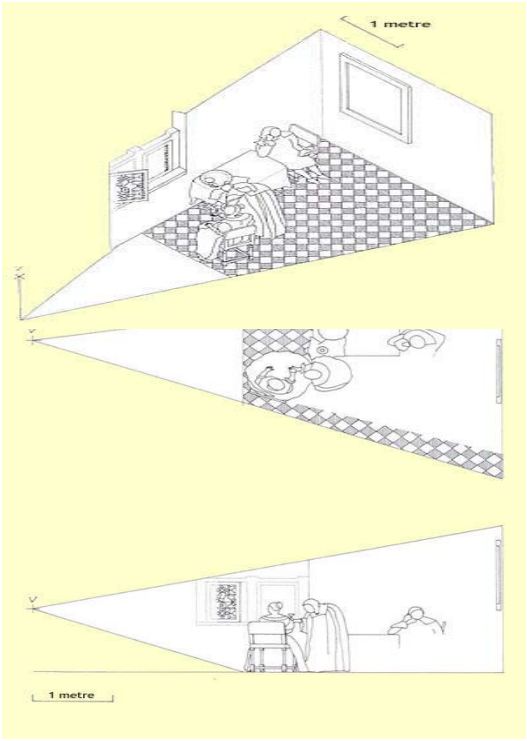


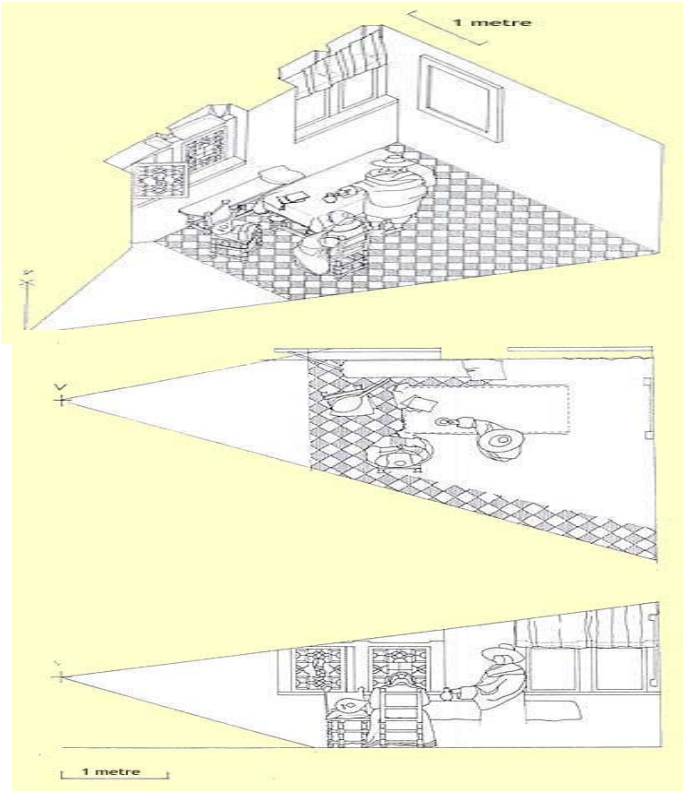
Figure 40
Bird's-eye view of the space of *The Music Lesson*, including the part of the room visible only in the mirror. The white rectangle between stool and easel marks the position of the mysterious box.



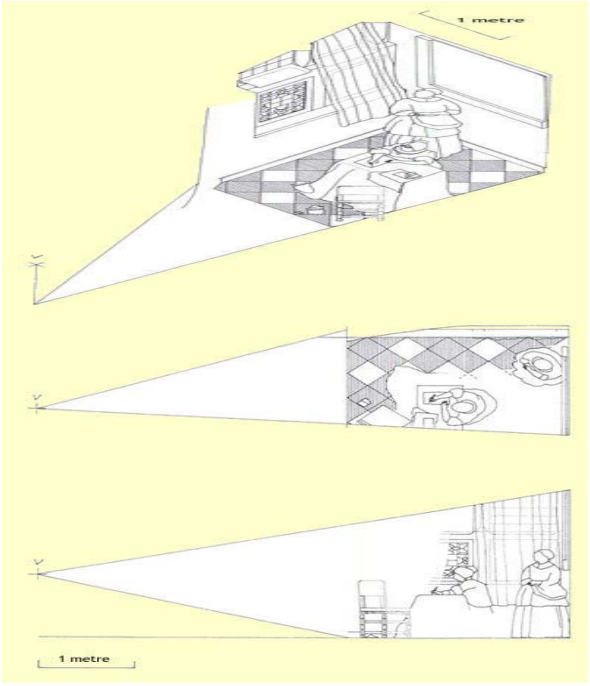
Girl with a Wineglass



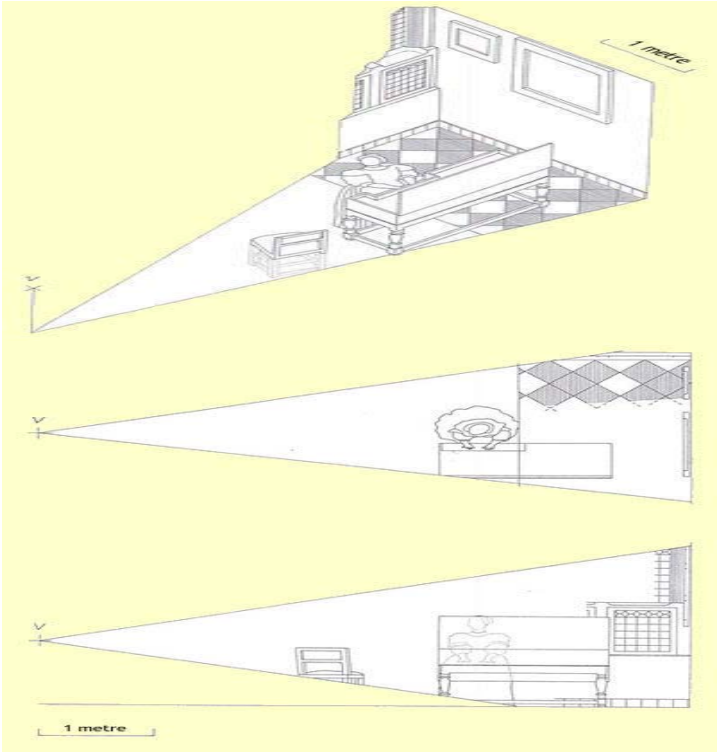
The Glass of wine



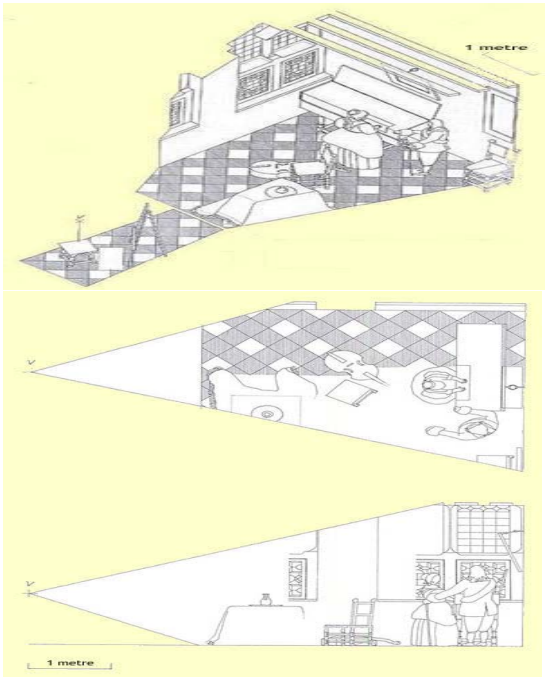
Lady Writing a Letter, with her Maid



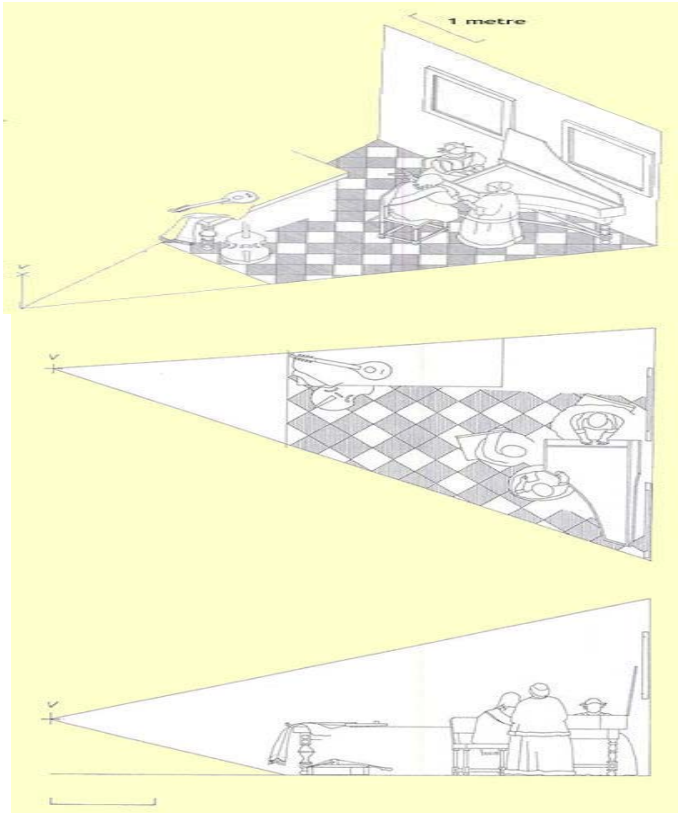
Lady Standing at the Virginals



The Music Lesson



The Concert



V. Summary

Although art historians has long debated on whether artists used optical devices to as a method to paint, David Hockney demonstrated they must have done so as early as mid 1420s. This he analysed optical effects of paintings with a pictorial gallery spanning from early 1300s to late 1900s. The analysis of these optical looks (imposed by the limitation and benefit of the mirror and lenses) could be broadly classified into the following categories:

1. Curved Surfaces
2. Lighting and shadows
3. Clothing and armour
4. Artefact in perspective
5. Evidence of mirror and lenses in picture
6. **Technique revealed: Concave Mirror method**
7. Dark Background
8. Groping
9. Collage
10. **Technique revealed: Mirrors to lens**
11. Left-hand drinker
12. Lighting: soft focus and shadows
13. Wider angle
14. Smiles
15. **New instrument: Camera Lucida**

Vermeer's paintings have always been cited in art circle to have been done with of optical devise, particularly the camera obscura. Philip Steadman confirmed this by using perspective geometry to reconstruct the interiors of each painting. He found definitely that at 6 of 11 interior-tiled-floor painting were done in the same room; all of them have viewpoints that cluster around a particular area of the room. If we further extend the line of projection (equivalent to the light rays in optic diagrams) to the end

wall to obtain the size of each picture, we find that the projection have similar sizes as that of the actual paintings as they stand today. These support the conjecture that Vermeer used a camera obscura of the booth type.

End Note

In 2003, Lions Gate Films made a movie based on Vermeer's *Girl with a Pearl Earring*. The camera obscura shown to aid Vermeer's painting in the movie was shape like a portable box. In view of the evidence of this project, I do not agree with that type of camera obscura. Not only because The Coincidence argument put forth by Steadman will crumble in the case of that type of camera obscura; but more simply, the type shown in the movie was the camera obscura of about 1850. Vermeer died in 1675.

Vermeer, *The Art of Painting*, 1662-65. Kunsthistorisches Museum, Vienna. Vermeer never sold this painting but kept it at home. One year after his death, his widow deeded this painting to her mother, to keep it in the family rather than sell it to settle the painter's remaining debt.

VII. REFERENCES

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