

The Application of Geometry in Leonardo's Works: Take the Annunciation for Example

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Abstract. There is a close connection between geometry and art. Since mathematicians discovered the Golden Ratio, it has been widely used in painting, design, architecture, and other fields. In the development of perspective, the mathematical principles explored by geometry played a very important role. This research uses observation and literature research methods to analyze Leonardo Da Vinci's Annunciation. The research proves that Leonardo's Annunciation used the Golden Ratio in composition and perspective in completing the narrative of the painting. In the end, the study demonstrates the impact of the application of geometry to art during the Renaissance. For paintings, the application of the Golden Ratio and perspective can produce a sense of time and space, showing the environment and process of events. For geometry, geometry application shows the geometry of the achievements in art, expanding the application field of geometry. In addition, the application of geometry also makes painting a special existence that is different from words.

Keywords: Leonardo Da Vinci; Golden Ratio; Perspective.

1. Introduction

The Renaissance took place between the 14th and 16th centuries. It originated in Italian cities and later spread to Western Europe, reaching its peak in the 16th century. This was a remarkable period of history, with major breakthroughs in mathematics, fine arts, music, literature, and other fields. Perspective was invented as early as ancient Greece, went through the long Middle Ages, and was rediscovered and applied during the Renaissance. Thanks to the contributions of many pioneers, linear perspective was no longer a fresh technique in the age of Leonardo.

Leonardo Da Vinci is a rare versatile genius in the history of mankind. Modern scholars believe that he is the most perfect representative of the Renaissance era. As a scientist, inventor, and painter, Leonardo possessed extensive knowledge and profound skills, so he could integrate scientific rigor into artistic creation and promote the new development of painting. Through the study of Leonardo's paintings and geometry, this paper can summarize the mutual influence of painting and geometry in the Renaissance, and provide more material analysis for the history of the exchange of art and science.

The purpose of this study is to analyze how Leonardo applied geometry in his work The Annunciation, and what impact such behavior would have had during the Renaissance in the process of research, this paper mainly uses the observation method and literature research method. In the first place, this article will start with the Golden Ratio and perspective, and briefly explain their invention, development, and application. Next, this research will focus on the Annunciation analysis and explain how the Golden Ratio and perspective work in a particular painting. Finally, this study will summarize and explain the influence of the combination of geometry and painting in the Renaissance.

2. Geometry and Art

2.1. The Golden Ratio and Art

Dividing a line segment into two parts, such that the ratio of the larger part to the full length is equal to the ratio of the smaller part to the larger part, this ratio is called the Golden Ratio. It is an irrational number, which is about 0.618. More than two thousand years ago, the Pythagorean school of ancient Greece regarded "number" as the source of all things, and established the world and even the entire universe according to the harmonious proportional relationship of numbers. They believed

that the beauty lies in the form, and carried out in-depth interpretation and research on the drawing method of the regular pentagon and the regular decagon in the 6th century BC. At this moment, the "Golden Ratio" and other aesthetic laws were discovered. Based on these developments, they deduced that beauty is harmony and proportion.

During the Renaissance, the Golden Ratio was spread by the Arabs to Europe, where it was highly respected by the locals and called the "Golden Law". Luca Paccioli equated the Golden Ratio with God in his book *De Divina Proportione* and invited his friend Leonardo Da Vinci to draw illustrations for this book [1]. It is believed that Leonardo Da Vinci, Piero della Francesca, and Albrecht Dürer are all associated with the Golden Ratio [2].

2.2. Perspective and Art

Filippo Brunelleschi is the founder of linear perspective; he discovered the law of linear perspective and the concept of vanishing point in practice. Later, Masaccio applied Brunelleschi's perspective theory to practical painting. Then, Italian painter Leon Battista Alberti explained the mathematical basis and importance of painting perspective. He also redefined the essence of painting according to the basic principles of geometric optics, which became the theoretical basis for later artists to use perspective [3]. Francesca made perspective theory mature further. In *De Prospettiva Pingendi*, he discussed in detail how to draw various two-dimensional and three-dimensional geometric figures according to the central perspective method, which promoted Alberti's perspective theory.

Albrecht Dürer, a contemporary of Leonardo Da Vinci, wrote a work on geometry and measurement, *Underweysung der Messung*. In this book, he emphasized the mathematical basis of perspective and advocated that drawing should follow mathematical principles of composition [4]. The establishment of a scientific perspective makes the two-dimensional plane graphics skillfully display the three-dimensional space effect, which provides favorable conditions for realism. In the age of Leonardo, linear perspective was no longer a fresh technique. In *A Treatise on Painting*, Leonardo gave a simple definition of linear perspective, carried out experiments related to it, and further proposed "air perspective" and "invisible perspective" according to the drawbacks of this technique [5].

3. The Application of Geometry in Annunciation

The Annunciation is a masterpiece of Leonardo's youth when he was working in the workshop of his teacher Verrocchio. This piece of work can be seen in figure 1. It is believed that he completed this work without assistance from anyone. When some people believe that "Annunciation" is Leonardo's first independent painting, others think that this work is the result of cooperation in Verrocchio's studio [6]. In spite of that, this piece of work is still a great achievement, a testament to Leonardo's early painting skills and talent. It can represent the most authentic level of Leonardo at that time, although it was so immature compared to *The Last Supper*. In this painting, Leonardo simultaneously applied two methods derived from mathematics, namely "the Golden Ratio" and "perspective".



Fig 1. Leonardo da Vinci, The Annunciation, about 1472-1474.
Oil and tempera on poplar, 100×221.5cm. Florence, Galleria degli Uffizi.

3.1. The Application of the Golden Ratio

A lot of traces of the Golden Ratio are hidden in the Annunciation.

First, Leonardo used the Golden Ratio to compose. According to the Golden Ratio, the whole picture can be divided into three areas as shown in figure 2: the golden rectangle on the left and right sides and the square in the middle. If the diagonal AB and CD of two golden rectangles are made, the triangles ABG and CDF will just cover the general outline of the two characters. The diagonal EF and HG of the two larger rectangles intersect AB and CD at two points, which fall around two important locations: Gabriel's wings and the Virgin's left hand.

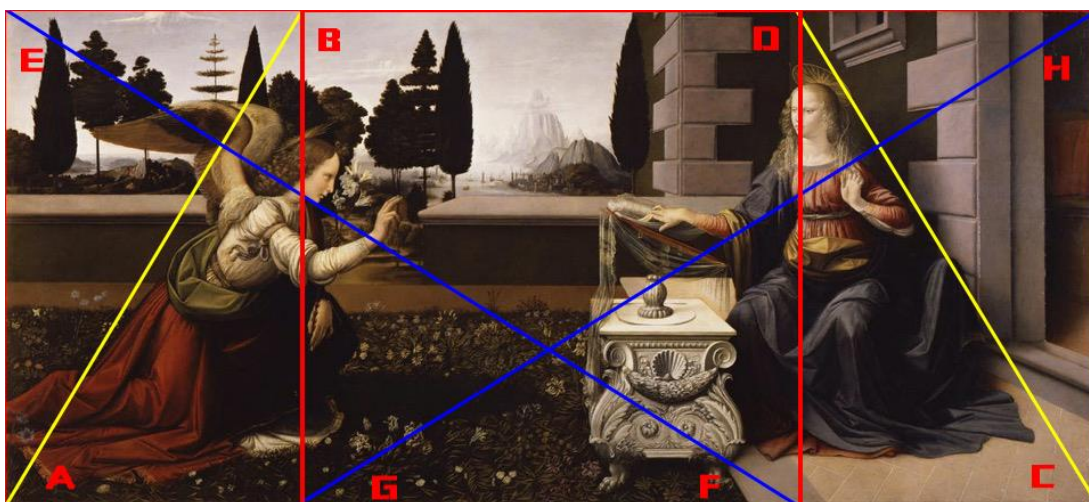


Fig 2. Leonardo used the Golden Ratio to compose.

When Leonardo used the Golden Ratio to design the layout, he also took the observation inertia of humans into account. It can be seen in figure 3. If the viewer's eyes are at the same level as the painting, the sight falls first into the space between lines a and lines b, the Virgin Mary and the angel Gabriel. The human's sight line is affected by inertia, and many times it moves horizontally and then vertically. Therefore, objects in the horizontal direction are often the first to be seen by people. In the horizontal direction, people's visual habit is to move from left to right, so Leonardo took advantage of this feature to paint the angel on the left and the Virgin Mary on the right. The eyes of the angel and the Virgin are almost at the same level, and the viewer first follows the horizontal line from the angel's eyes to see the Virgin Mary's shocked and slightly shy expression. The desk is located on the golden dividing line, drawing the viewer's attention. Next, the viewer's gaze moves further to the right to see the subtle use of light and shadow in Mary's bedroom. The angel in his ornate robes leans forward slightly, at the diagonal of the golden rectangle. The winged god points his finger at Mary and also directs the

viewer's gaze to the focal point of this scene, which is also located on the golden dividing line. Compared with other artists in the 15th century [7]. Leonardo guides the viewer's attention and vision through the hidden structural lines created by the Golden Ratio, making his narrative process very smooth. The main meaning of the picture is to be conveyed through an abstract style.

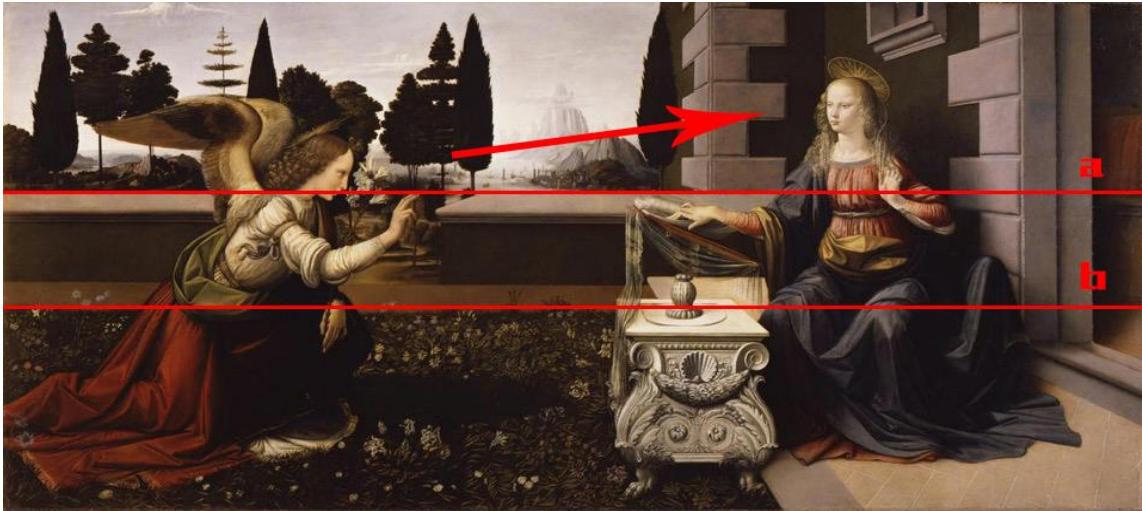


Fig 3. Leonardo also took the observation inertia of humans into account.

3.2. The Application of the Perspective

The Virgin Mary and the angel Gabriel have always been figures in religious paintings. It can be seen in figure 4. During the Renaissance, they transitioned from rigid, stylized images to three-dimensional images of reality. The composition method of Leonardo's Annunciation is still horizontal composition, with a fixed symmetrical pattern. But with the appliance of perspective, the horizontal composition has a broader vision. When the angel is kneeling on one knee, Maria was reading a book. Her expression was calm, but her body movements revealed her surprise and amazement. Leonardo changed the way of narration, providing the audience with this process, no longer giving the audience the result of this event. While many Renaissance artists depicted this classic theme, Leonardo's Annunciation dramatized the moment when the angel Gabriel visits Mary. Compared with the previous works, the timidity of the Virgin disappeared. She no longer blocked the angel with her hands or gestures but listened attentively in a submissive posture. By removing the barrier between the two actors in a drama, the artist strengthens their psychological connection to each other and to the audience [8].

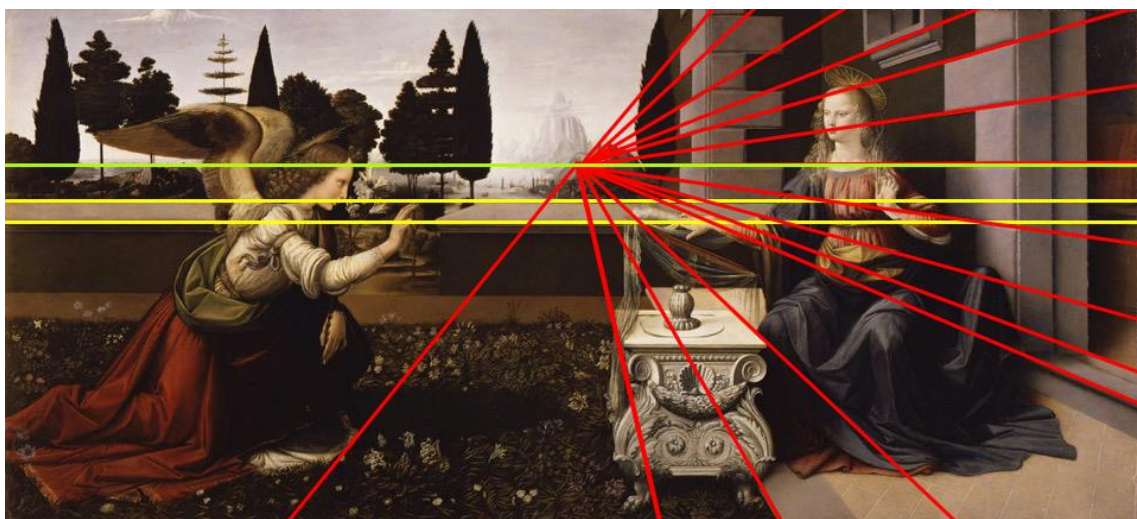


Fig 4. The application of the perspective.

Leonardo broke the structure of the early Renaissance picture and used the landscape in the background to express the atmosphere. The angel knelt on one leg to speak to the Virgin Mary, who is reading leisurely, making this event full of fun and drama. The expression of the Virgin Mary is a little calm, and the movement of the left hand drawn back at this moment shows the psychological activity of Mary's inner feelings. Mary seemed unable to understand, suspecting that she had misheard the angel's message. With the help of perspective, the courtyard is neat, clean, and beautiful, and the ornate architecture, the carved table separating the Virgin and the angel, is carefully thought out with perspective. The Virgin Mary and the angel are set outside, on a soft lawn, and the angel kneels respectfully on the grass, pulling the viewer's perspective to the scene and getting closer to nature. The landscape in the background is used to express the air atmosphere, from which can also see Leonardo's exploration and pursuit of objective things, and his imitation of nature retains its original appearance as much as possible. The table and the wall, painted precisely in accordance with the principle of perspective, help the picture reach into the far space. The angel and the Virgin are separated by a flower bed, forming different spaces, one layer at a time to the wider view. The sea and mountains in the distant view appear in blue fog, which truly and naturally reflects the visual reflection of the distant landscape. The environment shaped by the painting is the natural scenery of the world in which the viewer lives. The familiar scenery provides a world in which the viewer can enter and search for meaning. In this way, the artist has narrowed the distance between the story in the painting and the viewer. The importance of natural scenery was strengthened in the Renaissance, and unlike the Middle Ages, which was bathed in a golden light, there was beautiful natural scenery behind the Mary in this period, and the miracle in the foreground and the nature in the rear scene were cleverly combined, greatly increasing the interest and poetry of the picture. Leonardo used all the techniques of painting to create a very realistic garden that the viewer can immerse himself [9].

4. The Influence of the Integration of Geometry and Art

In this painting, Leonardo uses science and technology to break through the limitations of the written narrative. Due to the application of the Golden Ratio, Leonardo cleverly arranged and adjusted the position of the main characters and objects in the picture, so the viewer had a certain reading order and the picture had a sense of time. At the same time, due to the application of perspective, the natural environment is reasonably created by the painter, the story that only exists in the text is placed in a real scene, and the picture has a sense of space. Compared with the description of the story of the Annunciation in the original Bible, Leonardo added personal understanding to the posture and state of the angel and the Virgin Mary. The painter also concretized the environment of the story. Apparently, these all reflect the connection between mathematics and painting and prove that painting has a unique meaning different from words. As Leonardo said, "That science is the most useful whose fruit is most communicable, and conversely, that is less useful which is less communicable. The result of painting is communicable to all generations of the universe because it depends on the visual faculty... The painting presents the works of nature to an understanding with more truth and accuracy than do words and letters, but letters represent words with more truth than painting [10]." In addition, due to the application of scientific means such as the Golden Ratio and perspective, Leonardo could convey more valuable and breakthrough information through painting, which is undoubtedly conducive to improving the status of painting.

5. Conclusion

The study demonstrates the impact of the application of geometry to art during the Renaissance. For paintings, the application of the golden ratio and perspective can produce a sense of time and space, showing the environment and process of events. For geometry, geometry application shows the geometry of the achievements in art, expanding the application field of geometry. In addition, the application of geometry also makes painting a special existence that is different from words.

This study specifically expounds how Leonardo Da Vinci combined geometry with painting in the Annunciation, and analyzes the influence of the combination of geometry and painting in the Renaissance, providing examples of the integration of science and art in the Renaissance for later researchers. In future research, the study of artists of Leonardo's time is expected. By studying the application of geometry by other artists, the differences between artists will be discovered. At the same time, the history of combining art and science will get more material.

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