

On the Integration of Sense and Reason in the Relation Between Science and Art—Take the Influence of Mathematical Form on Art Design as an Example

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Abstract

Both science and art are the cornerstones of the development of human civilization. The former writes a rational chapter, while the latter describes a perceptual blueprint. It is precisely for the sake that the integrity of human civilization and human beings themselves are the coexistence of rationality and perception that science and art are interdependent and mutually reinforcing. Taking the influence of mathematical form on art design as an example, this paper expresses the dialectical relationship between science and art in a concrete way, and tries to explore how to use the relationship between science and art to convey the rational and perceptual connotations more accurately. This paper mainly consists of five parts: the first part is the preface, which introduces the background, content and significance of this study; the second part is the summary of research methods and their use; the third part is the display of the results of the selected case analysis, which is divided into the beauty of symmetry and the beauty of geometric figures; the fourth part is from the aesthetic characteristics and uses. The fifth part is in view of the results of the analysis to provide suggestions for the rational and emotional expression of modern design, and put forward the feasible direction of follow-up research.

Keywords: mathematical, art, design, science

1. Introduction

1.1 Background

In discussing the role of Science in art, Li Zhengdao pointed out in his article Science and Art published in Volume 19, Volume 1, of the Journal of Nature that science and art seem to be different from each other (Boulter, 2017). In fact, they have a common foundation—human creativity, science and art can't be separated. They originate from the noblest part of human activities and pursue profound universal truth. In the field of intersection of Mathematical Science and art, there is Kimberly Ila, a famous international design educator, who wrote Design Geometry (Shapiro, 2015). It expounds the proportion and golden section existing in human and nature, and the visual analysis of design works with examples.

In view of the above classical exposition and the current situation of related research, most of the domestic studies on the role of Science in art are about the importance of art to science in the relationship between science and art (Sgamellotti et al, 2014). As for the role of Science in art, academic research is relatively vague. On the other hand, while there are plenty of abstract generalizations of science and art in the general direction, there is relatively lack of research on concrete exploration of examples, and there is no pertinent research on Mathematical Science and art design.

1.2 Research Contents

Outstanding works of art must contain the laws of nature. Number is the basic language to reveal all the laws of

nature. Starting from the mathematical form, this paper explores its internal relationship with art design, and takes it as a concrete example to make a more accurate and in-depth analysis of the relationship between science and art (John, 2001). From the point of view of art design, classical design cases are taken as examples. From the point of view of mathematical thinking, the aesthetic characteristics of mathematical thinking and its influence on artistic behavior are summarized.

1.3 Research Significance and Innovation

In theoretical sense, this study is different from the current analysis of the convergence of the general direction of science and art, and carries out targeted research on Mathematical Science and art design (Cetinkaya, 2013). The dialectical relationship between them is embodied and the lack of relevant research on the importance of science to art is supplemented to a certain extent. In practical sense, this paper explores and summarizes the principles of mathematics existing in art design, and provides feasible suggestions for the expression of rational and perceptual blending in modern design by virtue of using mathematical thinking.

2. Research Methods

2.1 Literature Research Method

Widely consult and summarize the relevant information at home and abroad, especially the classical works, in order to understand the development axis and on this basis to carry out in-depth understanding and research. It is mainly used in the preparatory stage of formal research, and has profound significance for the overall standpoint and scientific nature of the study.

In ancient Greece, Pythagoras, a philosopher, was respected by virtue of Greek citizens for his extraordinary mathematical talent and founded the Pythagoras School, a philosophical sect of religion. Pythagoras was killed in the political struggle, but his school continued to exist for two centuries (about 300 years before the first 50 years). This school tries to explain everything with numbers, and holds that all things are numbered and that numbers are the foundation of the universe. The Pythagoras School first put forward the aesthetic concept of "harmony of numbers, harmony is the most beautiful". His basic theory is that the only principle of beauty lies in order and harmony, and order and harmony are nothing more than simple numerical proportions under which the whole universe operates. The right proportion is the root of harmony, and it creates order. Although the views of Pythagoras School are extreme, their Pythagorean Theorem, Golden Section and Unconventional Quantity have laid a solid foundation for Euclid's Geometric Origin. During the Renaissance, when artists depicted the world in front of people by virtue of means of representation art, they discovered a new geometry, projective geometry. This unique geometry derives from art rather than science or mathematics. It reveals the principles of Western painting and lays the foundation of Western realistic painting. Projective geometry discovered by virtue of Leonardo Da Vinci and Diller was not given any theorem, but summarized by virtue of French mathematician and architect Desargues. To this day, these theories are still ubiquitous in works of art.

The germination of Chinese mathematics appeared at the end of primitive society. In the walk of the beginning of the exchange of goods, people began to have a concept of number. The development of mathematics in China is noteworthy all over the world. As early as the Western Zhou Dynasty, mathematics has become an independent subject as one of the "six arts". However, Chinese mathematics has always been in the stage of applied mathematics, and has not been involved in other professional fields too much. The entry point and discussion point of the famous book of Chinese mathematics "Nine Chapters of Arithmetic" are quite different from that of the Great Western mathematical work "Geometric Origin". Now many people have begun to study the relationship between these two fields. Kimberly Ilam, an internationally renowned design educator, wrote Design Geometry in 2001. It expounds the proportion existing in human and nature, golden section, various root rectangles and visual analysis of design works with examples. The book combines design, art, geometry, biology and other disciplines, reveals the important concept of design aesthetics innovation, and breaks away from the traditional teaching of "intuition" and "inspiration" and other non-teachable and non-learnable puzzles.

2.2 Draw Conclusion Through Examples and Analysis

Selecting the classical theory of symmetry and geometry in mathematics and combining with classical examples in art design. Such as the design of the Palace Museum pattern, the design works of Gunter Rambow, the representative figure of the "Visual Poet" school, the classical design in "Sacred Geometry" and "Design Geometry", etc. This paper makes an analysis one by one and horizontal comparison, and draws a elementary conclusion. Based on the objective of the study of concretization in this paper, this method is also very consistent with the most common analysis methods for works of art.

2.3 Inductive Summary Method

Combining geometric space theory, aesthetics and other related theories, after the analysis of specific works, the paper makes a longitudinal and in-depth analysis and comparison, and draws the basic conclusions of the study,

which is the core method of the paper.

3. Giving Examples

3.1 Beauty of Symmetry

Symmetry comes from natural phenomena in nature. We can see that many animal spots are also symmetrical, such as zebra stripes, Ladybug spots; human body is also a perfect example of symmetry. Complex symmetry has been deeply discussed and studied in philosophy, mathematics, physics and other aspects, and related theories have emerged in endlessly. However, theoretical research in art still stays on the accumulation of aesthetic perception and experience, and there is no theoretical summary of symmetry associated with it. The application of mathematical symmetry principle in art design can be divided into two categories: reflective symmetry and rotational symmetry.

3.1.1 Reflection Symmetry

In the overall layout of works, we often use reflection symmetry, also known as mirror symmetry, that is, an object can be divided into two parts of each other by a straight line (two-dimensional state) or a plane (three-dimensional state), such as butterfly symmetrical wings in nature, human facial structure and so on.

The application of symmetry in architectural design is quite common. In addition to structural stability, it also conforms to people's formal aesthetic sense of harmony, balance, solemnity, rigor and other concepts. It is also based on human exploration and discovery of nature and the universe.

There is a unique concept of the main axis in China's cultural concept. No country in the world has the same culture as China, with special emphasis on the existence of the main axis in its configuration. The Forbidden City of China is the most typical case (Figure 1). First of all, the Forbidden City is located on the central axis of Beijing at that time, dividing the city into two symmetrical areas, East and west. The inner part of the Palace Museum is also symmetrically arranged around the vertical axis and the horizontal axis. The main palace is on the central axis, and the secondary buildings are located in the corresponding pattern on both sides, reflecting the strict hierarchical system and organizational law of the feudal society.

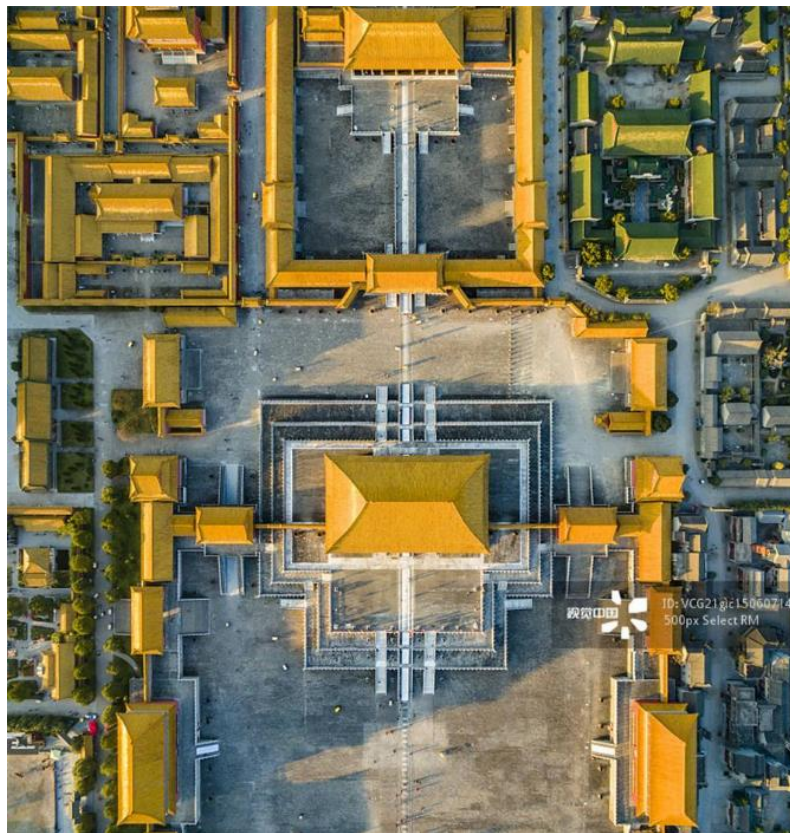


Figure 1. Aerial view of the Palace Museum (Image Source: Visual China)

3.1.2 Rotational Symmetry

Rotational symmetry refers to a plane in which a figure rotates around a fixed point at an angle of $360/n$ (n is a

positive integer greater than 1) and coincides with the original figure. This figure is called a rotational symmetry figure. This fixed point is called the center of rotational symmetry, and the angle of rotation is called the rotation angle.

Gunter Rambow, the German designer of the School of Visual Poets, is the most influential graphic designer in the 1960s and 1990s. His works use both surrealist methods and poetic metaphors to convey information without words. In the poster he designed for the German opera “The Rose Knight” (Figure 2), he did not render the pattern content from a commercial point of view, but through the rotational symmetry of a chair to make the overall composition of the picture. With the center of the bottom edge of the upright white chair as the rotational symmetry center, he rotated the whole 180 degrees through color. The distinction between colors has an ideological contradictory effect, which accurately conveys the complex emotional color of love by accident in opera because of the delivery of rose. In another of his posters, he used the same technique. When designing the poster for Sinn Watch Company (Figure 2), he combined the human brain with the mechanical parts and perfectly matched them through rotational symmetry, emphasizing the precision and preciseness of mechanization.

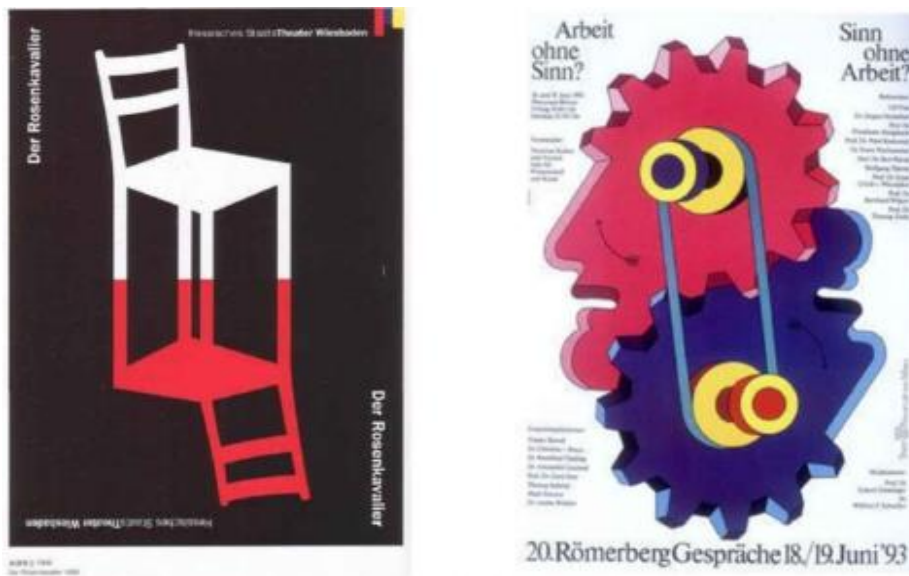


Figure 2. The Rose Knight and the Sin Watch Poster (Graph Source: Design Geometry)

3.2 Beauty of Geometric Graphics

Geometry originally originated from Euclid’s book Geometry, which abstracted the concepts of point, line, surface and body from the real world, found out the relations and theorems between them, and solved the practical problems of space and quantity.

Plato once wrote in Timeo that God saw the chaos and incongruity of the universe and tried to establish order. In geometry, he drew a square on the two central axes of a circle (Figure 3). Therefore, he had the first two coefficients of geometry: n , the ratio of circumference to diameter: the diagonal line of a square. Ratio to side length.

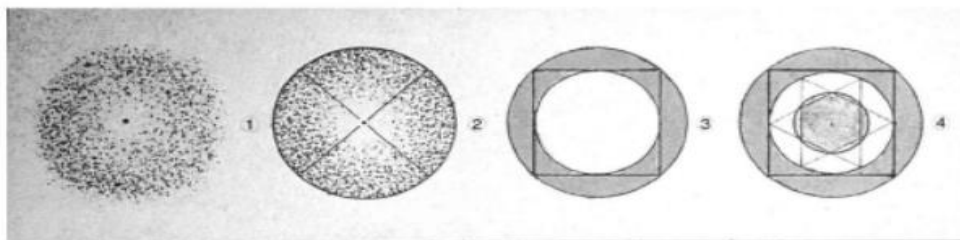


Figure 3. The creation of Divine Geometry (Source: Sacred Geometry)

In Islam, the idea of “Allah’s Uniqueness” is also the most primitive and plain geometric plan with a circle. Set up

a point on the plane without spatial dimension, then form a line segment with the point as the starting point, then draw a circle with the line segment as the radius and the fixed point as the center of the circle, and then draw a circle with any point as the center of the circle. The circle passes through the center of the first circle six times so that each new intersection point is repeated six times. Make a circle for the center of the circle, and finally form six identical circles around the first circle. This is the best manifestation of the idea of “Allah created heaven and earth in six days” in the Koran (Figure 4).

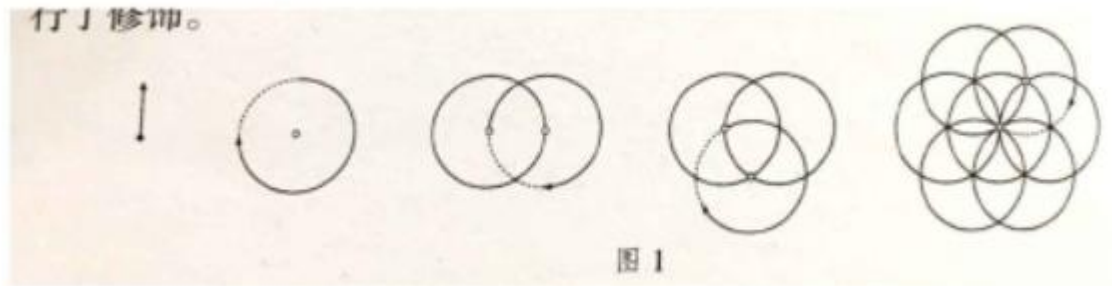


Figure 4.

In addition, in the poster “Never compromise”, geometry is also the main language of design works (Figure 5).

Cassandrel is particularly aware of the visual power of the circle. He abstracts and simplifies many elements of the picture. He uses the power of the circle and the straight line to match the shore to attract and guide the viewer’s attention. The circular arrangement is also carefully designed. The angle between the eye and the full circle of the mouth is equal to the angle between the first insulator circle and the inner ear and the lobe circle, which is 45 degrees. Each insulator circle intersects with every 30-degree telegraph wire.

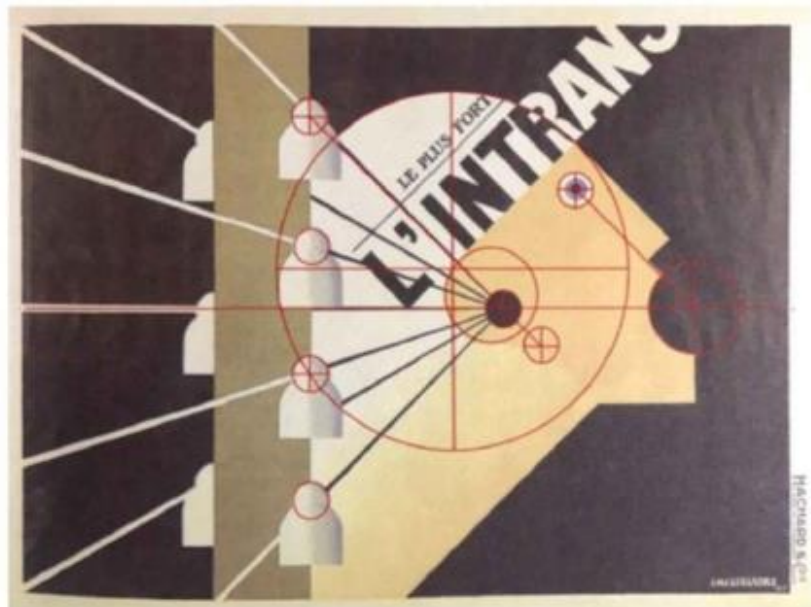


Figure 5. No compromise

4. Analysis and Discussion

4.1 Summary Results

Flexible use of symmetry and geometry as decorative language in art design is a unique way of design. Influential design works usually convey emotions and influence audiences from a perceptual point of view. It is feasible that geometric graphics full of rational color be sensibly transmitted, simultaneously, it can produce rational communication with the audience and help the audience understand the work more quickly and efficiently, which also make them establish a resonance with the author. In this case, mathematical form is an important weapon to

express the connotation of ideas in art design.

4.2 Analysis Purpose

Starting from the mathematical form, this paper explores its internal relationship with artistic design and gives examples of classical design cases from the perspective of artistic design. This paper makes a comparative analysis from the point of view of mathematical thinking, which obtains certain results, that is, this paper completes the pertinent research on Mathematical Science and art design (Milojević, 2016). What's more, it embodies the dialectical relationship between science and art. For the above results, this paper further explores the practical significance from the aesthetic characteristics of mathematical thinking and its impact on artistic behavior by using inductive summary method. To sum up, this paper provides feasible suggestions for the expression of rational and perceptual blending by virtue of using mathematical thinking in modern design.

4.3 The Impact of Mathematical Thinking on Art Design

4.3.1 Aesthetic Characteristics

Mathematical thinking is not the ability that only mathematicians need. Mathematics is the basis of natural sciences, technological sciences and Humanities and social sciences. The basic position of mathematics lies in the fact that it has been widely used as a scientific language and tool in almost all fields of human knowledge. But more importantly, it also lies in the cultural function of mathematics to human society, that is, the cultivation and development of people's thinking ability, especially precision thinking ability. Mathematical thinking in aesthetics can be embodied in its logical rigor, abstractness and high generality. These characteristics help people seek the essential attributes of things in the process of art design. They do have abilities in exploring the relationship between things and grasping the structure of matter. By virtue of flexibly using mathematical language, principles and methods in art, people can reveal the law of development and change of things in the relationship between mathematics and shape. For example, around the same theme, some designers just express surface features, while some designers can reflect the deep connotation. Besides, other designers can better integrate surface features and connotations to achieve internal and external integration. This difference comes from the author's grasp of the perceptual inspiration and further thinking, organization and expression. The stronger ability of the latter, the richer and more perfect connotation and thinking expression of the work.

Alahambra Palace in Spain, was built by the Nazaries Dynasty after seven generations. The architectural and decorative styles here are full of Islamic style. The decoration on the wall has no concrete patterns, only absolute geometry. The conciseness and inevitability of these Islamic geometric patterns make people mistakenly think that they can be identified with no effort. In fact, these decorations include many combinations of different basic geometric figures and different combinations and transformations of logical modes. Not only should craftsmen understand the concepts of "point-line" and "geometry", they are also supposed to have clear logical thinking and reasoning ability. In the course of the evolution of different patterns, they used hexagonal (angle), octagonal (angle) and twelve-sided (angle) shapes. The combination of patterns also includes symmetry and self-similarity in mathematics. Escher visited the Palace of Alhambra in Spain twice. After that, he facsimiled several mosaic patterns of the walls of the Alahambra Palace (Figure 6) and studied their mathematical basis. On this basis, he used self-created tangible images to create, thus forming a unique artistic style. Escher's works have also been extensively studied by mathematicians, cosmologists and other scientists.



Figure 6. Mosaic patterns on the walls of the Alahambra Palace

4.3.2 Artistic Behavior

Greek mathematics has produced mathematical thinking. A series of thoughts, such as rationality, certainty and eternal irresistible law, which the mathematical thinking advocates, occupy an important position in the history of human cultural development. The combination of mathematical thinking and artistic behavior is just like the combination of reason and perception. Rationality and sensibility are two components of human thinking that complement each other. The perception of unity of opposites is the first perception ability that art practitioners possess. Design works need to communicate with the audience emotionally to achieve the same level of recognition, so that they can accurately convey the design content. Artistic behavior can't be short of inspiration, inspiration is the embodiment of the development of perceptual thinking. The flash of inspiration is not fabricated out of thin air, but the creators themselves have a certain artistic foundation and a long time of artistic precipitation, and they open up the design ideas under the external influence. To turn instantaneous, intangible inspiration into a successful design work, the creator also needs sufficient experience accumulation and profound theoretical knowledge. Edward Bubba, a famous French photographer has said, "Photographing does not happen only when the shutter is pressed." Artists use perceptual thinking to put forward creative ideas. Besides, it is feasible that rational thinking helps artists grasp inspiration, so that they can better reflect the content of expression to achieve good quality of works. Mathematical thinking urges people to seek the truth of things and study the essence through the surface.

During the Renaissance of the 15th century, for the sake of its origin, art rather than science, the projective geometry discovered by artists was unique in all geometry. Throughout the Middle Ages, European artists have been trying to develop a visual language with rich connotation. Erenow, paintings mainly focused on religious themes, aiming to spread religious culture and influence. Hence, the characters in the picture are often depicted out of proportion to the surrounding environment, the light source is not uniform, the picture is stiff and so on. Leonardo Di ser Piero Da Vinci, the representative of the Renaissance, has put forward the view that "the eyes can only see things in the form of light vertebra" in solving the problem of how to depict three-dimensional fields on two-dimensional surfaces. The vertex of the light vertebra is a little point inside our eyes, and the bottom is the outline of the object that the observer sees (Figure 7). Leonardo Da Vinci also used this point of view to explain why objects farther away look smaller. The contemporaneous famous painter, sculptor and theorist Dürer also emphasized the application of mathematics in perspective. Therefore, he published *Course in the Art og Measurement*, a book about the importance of geometry and measurement in the art of representation. They realized that art is imitating nature, so they should put art on the basis of natural science.

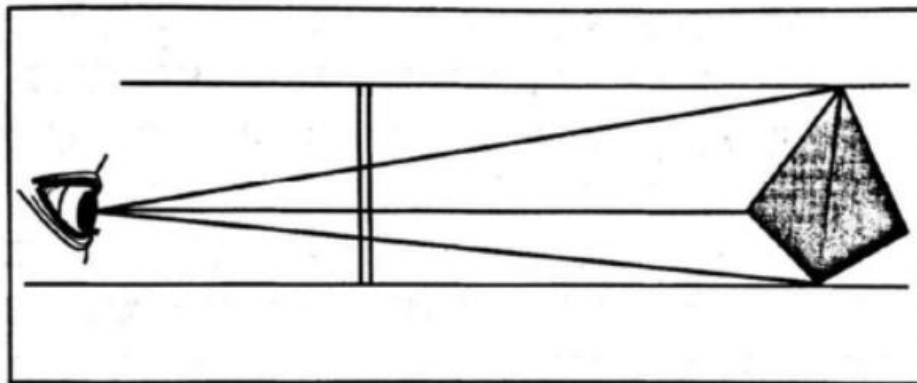


Figure 7. Light cone form (Source: *Geometry*)

4.4 Discussion Results

The core and essence of artistic design thinking is creativity. This is a pioneering and breakthrough mode of thinking. The process of design is to form a design plan with creative thinking. This is a process of "selection", "deconstruction", "breakthrough" and "reconstruction" to ultimately complete the design work. Robert Crawford, an American scholar, pointed out in his 1954 book *The Method of Creative Thinking* that all new things in the objective world originate from the old, and everything develops from something else. Innovation is the transformation and inheritance of some elements of old things. Logical thinking in the form of mathematical thinking is a process of thinking in which logical conclusions are drawn through analysis and inference. This process follows the rigorous logical law, which is the best embodiment of rationality. Comparatively speaking, creative thinking mainly relies on intuition and inspiration, which is more divergent. Nevertheless, creative

thinking lacks rigorous analysis and logical deduction, which is the direct embodiment of perception. Emotional creative thinking puts forward new ideas in design. It plays a leading role in creative activities. It is rational logical thinking that support the creative thinking. It makes further reasoning analysis and test demonstration on new ideas. Hence, they coexist in the process of design. In addition, they are interrelated and complementary. Simultaneously, the dialectical relationship between science and art is undoubtedly revealed (Pac, 2016).

5. Conclusion

5.1 Research Review

In view of the dialectical relationship between science and art, together with the lack of relevant research on “the importance of science to art”, this paper conducts targeted research on mathematical science and art design, supplements and promotes them to a certain extent, as well as trying to explore the principles of numbers existing in art design. It provides feasible suggestions for the expression of rational and perceptual blending by virtue of using mathematical thinking in modern design.

In the process of practical research, a series of appropriate and scientific research methods have been adopted to advance step by step: above all, the current research situation and background are controlled more accurately by virtue of using literature analysis method; then, the classical theories of symmetry together with geometry in mathematics are selected and the classical examples of art design are combined, such as the design of the Palace Museum pattern, the design works of German designer Gunter Rambow, the representative figure of the school of “Visual Poets”, the classical designs in Sacred Geometry and Design Geometry. By virtue of analyzing and comparing them one by one, two preliminary conclusions are drawn: “the beauty of symmetry” and “the beauty of geometry”. Conclusively, through using inductive summary method as well as combining them with geometric space theory, aesthetics and other related theories, after the analysis of specific works, a longitudinal and in-depth analysis together with comparison is made, and the conclusion of mathematical thinking in the two aspects of “aesthetic characteristics” and “artistic behavior” is drawn.

5.2 Research Conclusions

It is feasible that mathematical form and mathematical thinking should effectively improve the efficiency of design and the quality of design works. Starting from the final draft of the first step in design, we can choose a scale that is more in line with the law of public vision. The first impression of the work is the expression of comfort. In the process of composition, the dissemination efficiency and influence of the work will be improved by virtue of rigorous layout such as putting the important content in the golden segmentation position of the picture, building a reasonable proportion of the picture, and correctly handling the relationship between the overall together with part of the picture pattern. We inject perceptual creation into rational composition. The most important part of a design work is the core content of its design, and the most impressive part is the design concept of the designer. It is feasible that rationalized analysis should help to improve the quality of works, but it cannot become the doctrine of imprisoning perceptual thinking. Sensibility is the basis of all artistic acts. On this basis, rational factors such as emotion, technology and concept are used to process, transform and rebuild perceptual gains, so that perceptual and rational can be perfectly combined, thus being integrity artistic behavior.

By virtue of referring to various proportional relations, basic geometric principles and the analysis results of representative works of art and design at home and abroad in the field of mathematics, there are two main conclusions.

5.2.1 Proportion in Mathematics Is an Important Design Basis in Picture Composition

Hamlin once said: “To achieve a good proportion is a painstaking task, but it is also a minimum requirement”. The balance of appearance proportion and aesthetic feeling of art design are extremely important to the overall aesthetics of products. The most common thing is that some art designers also use golden section ratio for product design.

Golden section is widely used in the field of art design, and there are many categories in visual communication design that skillfully use the golden section ratio, and have achieved good results in graphic design of logo design, poster design, web design and so on are all affected by virtue of the golden section, especially in the design of some abstract beauty, the probability of using golden section is very high. In visual communication, the concepts of balance, symmetry, proportion, diversity and unity in the rules of formal beauty proposed by virtue of us are also consistent with the abstract beauty characteristics of golden section proportion.

In practical art design, not only the golden section rule but also some mathematical proportional thinking methods such as Boolean operation will be used. What tests the designer’s own aesthetic accomplishment more is that it also needs to use spiral, proportion segmentation and other techniques to assist the design. In the design of picture composition, it is inseparable from the proportional relationship and geometric figure right from the start. Today’s major design companies have reached a consensus on this, simultaneously, even in presenting the design results,

they will also introduce to customers whether the golden section is used in the design. The golden section was only paid attention to the field of painting, architectural design and industrial design, but now the designers of visual communication specialty begin to attach importance to its application.

5.2.2 Using Different Symmetry and Geometric Transformation Can Produce Ingenious Composition and Improve the Quality of Artistic Design

“Fractal art”, which lies in the intersection of Mathematical Science and general art theory, is extremely representative. Fractal is an art, even a science. Through the mathematical thinking methods of unit and structure, combination of number and shape, iteration and mapping in fractal art, it is feasible that we should create abstract paintings, decorative patterns, realistic flowers and so on, thus centrally embodying unity and change, symmetry and balance, rhythm and rhythm, proportion and scale.

Thus it can be seen that fractal graphics using different symmetry methods and geometric graphics transformation almost embody all the rules of formal beauty, and it seems to have inherent beauty and artistry. In brief, where there is beauty, there is mathematics. The relationship between number and quantity is the basic attribute of all things as well as the foundation of beauty. Each fractal image is an image of a set of numerical values with fractal characteristics. The layout and organization of the image are generated by virtue of corresponding fractal algorithm, and the composition of color is related to the value and operation of color variables. Therefore, the fractal figure of beauty is produced under the principle of “number”, so it is feasible that the fractal figure of beauty should embody the law of beauty.

5.3 Future Prospects

In the theoretical sense, the paper states “the importance of science to art” through concrete examples in a certain sense, but it still needs more representative examples to put forward and construct an argumentation system together. In practical sense, we have seen that the combination of scientific rational thinking and perceptual thinking of artistic design can make the artistic expression more accurate as well as smooth, and give some main suggestions. More comprehensive and detailed exploration of practical experience is still the top priority of the next research.

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