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The Innovation Design of Traditional Chinese Auspicious Patterns Based on Shape Grammar

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ABSTRACT

The artistic expression of traditional Chinese auspicious patterns in modern design is unique and charming, and it is intersecting more and more with modern design, and there is a lack of scientific methods to analyse traditional Chinese patterns from the perspective of Western composition. The objective of this study is to explore the translation path of traditional Chinese auspicious pattern design and realize its protection and reuse. The literature analysis method is mainly used to analyse the theme and cultural connotation of the pattern, the pattern and colour are extracted by using the mapping software, the pattern and colour factor library are constructed, and the shape grammar is used to evolve the pattern design. As a result, a new pattern design scheme is generated by using the law of formal beauty, and the feasibility and effectiveness of shape grammar in the innovative design of traditional patterns are demonstrated.

Keywords: *Innovative design, shape grammar, traditional Chinese auspicious patterns*

1 INTRODUCTION

Traditional Chinese patterns and patterns have rich cultural connotations, long historical accumulation, outstanding national characteristics and cultural values (Wei, 2019). However, how to carry out innovative design based on inheriting tradition is an urgent problem to be solved (Toyong, Abidin, & Mokhtar, 2021). As a formal method, shape grammar can systematically describe and generate complex graphic structures, which provides new possibilities for the innovative design of traditional patterns. Creative Transformation and Innovative Development of Folk Art (Luo, 2024). In this paper, we will follow this logic (see Figure 1) by extracting patterns and classifying them according to their inherent cultural attributes and internal logic. Secondly, the most representative and unique pattern genes were screened out from the extracted patterns. Thirdly, with the structural gene, colour gene and meaning gene as constraints, the morphological genes of the screened patterns were deduced by shape grammar, and the new patterns were used in the design of different cultural and creative products. The overall graphic outline or modelling framework is fixed, and the variants continue to enrich the content by filling or replacing additional elements without changing the stable structure (Mei,2024). many design forms reflect compositionally, and there are many reorganizations and divisions(Zuo,2024).examination of the decision-making process at an early stage of conceptual design, which is critical to understanding the factors contributing to successful innovation(Li，2024).

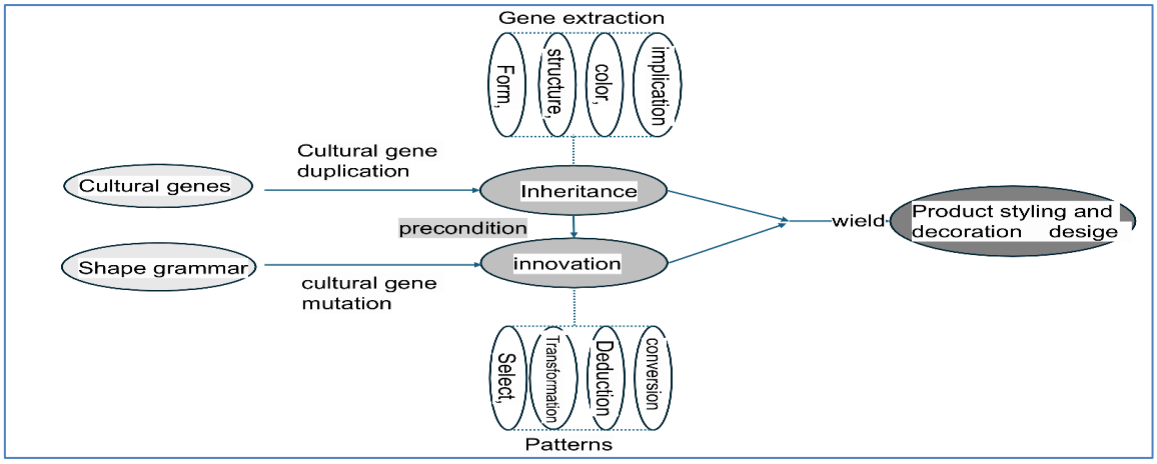


Figure 1 Research ideas (Source: original, 2024, Copyright Consent: Permissible to Publish)

2 TRADITIONAL CHINESE AUSPICIOUS PATTERNS

Traditional Chinese auspicious patterns are an important art form in Chinese culture, symbolizing good wishes and a happy life, and patterns express the blessings of people of different nationalities and regions for a better life (Chang, 2009). Common auspicious patterns include dragon and phoenix, unicorn, lotus, auspicious clouds, longevity words, blessing words, etc., animal patterns, both unicorns, lions, tigers, deer, jade rabbits, cranes and other sacred beasts and birds. Among the plant patterns, there are Ganoderma lucidum, peony, lotus, chrysanthemum, hibiscus, narcissus, orchid, plum blossom and other precious ... Some soar above the sea, and some walk through the auspicious clouds; Each pattern has a unique meaning and symbol (Wang, 2012). For example, the dragon and phoenix symbolize power and auspiciousness, the lotus flower represents purity and elegance, and the auspicious cloud symbolizes auspiciousness. Auspicious patterns are widely used in architecture, clothing, utensils and festival decorations, conveying wishes for happiness, contentment, longevity and prosperity through exquisite patterns, reflecting the Chinese people's pursuit of a better life and the inheritance of traditional culture.

2.1 The History of Traditional Chinese Patterns and Auspicious Patterns

Patterns appeared during the Shang and Zhou dynasties. During the Shang Dynasty, the inscriptions were relatively short, and most of them appeared in memorable symbols.... The change of dynasties has been inevitable since ancient times, and the content of continuous wars must also be recorded on bronzes, and the early inscriptions in Shang and Zhou bronzes inherit the patterns of pottery in primitive societies (Wang, 2023). From 27 A.D. to about 97 A.D., the materialist philosopher of the Eastern Han Dynasty, Wang Chong, the word Zhongren, once recorded in the "Treatise on Balance" that "King Wen is prosperous, and the red bird is suitable; The fish leaps and the bird flies, and the king of martial arts occasionally meets. Non-angel finches to white fish to come, auspicious things fly and holy encounters. After this sentence and the interpretation of the times, some patterns are attached to auspiciousness, blessings, auspiciousness and other good wishes (Mohamed Kamil & Abidin, 2015).

The popular patterns in the Tang Dynasty can be roughly divided into curly grass pattern, bead pattern, and lotus pattern. The curly grass pattern is based on the Chinese Western pattern Yuan Qi based on the foreign pattern (Chen, 2015). The predecessor of the curly grass pattern was the honeysuckle pattern, but the honeysuckle pattern was only popular in the Northern and Southern Dynasties, and with the evolution of the times, in the Tang Dynasty, it gradually developed into the well-known curly grass pattern. The description of the curly grass pattern can be borrowed from a passage in the book "The Sheltered Civilization" by Chen Shouxiang, a famous Chinese cultural

scholar, art historian and doctoral supervisor of the Chinese Academy of Arts, to describe that "it has become the most common and distinctive pattern in Chinese Buddhist decoration with the paradoxical flowers, branches and leaves that twist and turn, the spirit of auspicious clouds, and the attitude of taking Buddhist objects." "The bead pattern, which belongs to the silk weaving pattern school, was one of the most striking decorative patterns in the early Tang Dynasty.

After the beginning of the Shang and Zhou dynasties and the test of the Tang and Song dynasties, the "auspicious pattern" finally bloomed in the Ming and Qing dynasties. Weaving and embroidery, ceramics, lacquerware, clothing, jade, architecture, etc. are all without its figure. Its wide variety, brilliant colours, and various expressions emerge in an endless stream, interweaving an all-encompassing "ancient and modern aesthetics." "By the time of the Qing Dynasty, it had been greatly improved in the traditional composition methods of characters, patterns, and homophonies. It is worth mentioning that the traditional Chinese auspicious patterns also reflect the meaning of "folk customs". Traditional Chinese folk-art works all reflect unique folk customs in terms of shape and colour (Lei, 2008). The "auspicious pattern" not only contains the ritual music that Chinese culture attaches great importance to but also contains traditional etiquette. For example, the Book of Changes, an ancient classic with a long history that explains the changes between all things in the world; The Book of Rites, a book on the Chinese code system; The "Annotations on Customs and Customs" not only contain the "treasures" of the wisdom of the ancestors throughout the ages, but also contain precious materials about the customs and habits of all over the world (Ma, 2020).

2.2 The Cultural Connotation of Traditional Chinese Auspicious Patterns

Chinese auspicious patterns are unique to traditional Chinese patterns, which can best reflect the spirit of the Chinese nation, national emotions and aesthetics, and have profound cultural connotations. Auspicious patterns focus on the connotation of auspiciousness, so they are different from ordinary decorative patterns. The connotation of auspiciousness is an abstract concept (Li, 2015). "Cihai" cloud: "auspicious, also auspicious sheep." The Great Chinese Dictionary: "Auspicious stops: it means that festive and good things continue to appear." These interpretations still explain abstract concepts in terms of abstract concepts, while auspicious patterns are images of abstract concepts. With rich imagination and association, the wise Chinese first associate abstract concepts with a concrete beautified object, so that people can read that abstract concept in the picture. Taking the most common auspicious pattern of dragon and phoenix as an example, the dragon as a Chinese totem worship integrates the characteristics of many auspicious animals and exists in the traditional consciousness of the Chinese nation with its noble, heroic and mighty image (Xue, 2015). For a long time, it was a symbol of imperial power and rulership. The phoenix is the first of the hundred birds, symbolizing beauty and peace. In folklore, the dragon represents the male, and the phoenix represents the female, and the two match to mean the appearance of the talented woman, which is used to wish the newlyweds happiness and happiness (Liu, 2011).

2.3 The Source of The Theme of Traditional Chinese Auspicious Patterns

Traditional Chinese auspicious patterns cover a wide range of subjects, including politics, history, economy, literature, religion, and customs (Chen, 2011). These patterns give us the spiritual connotation of loving life, being positive, creating happiness and optimism, and are usually based on the images of people, birds, animals, flowers, trees, stones, hummingbirds, insects, fish, utensils and words, as well as folk auspicious sayings, proverbs, mythological stories, etc., using symbols, metaphors, analogies and puns to create a perfect combination of various patterns and auspicious words, expressing people's desire and love for a better life (Liu, 2008). Different targets have different pursuits for "beauty", for example, the common people expect "a bumper harvest" and "a surplus every year", while the ruling class hopes for "immediate feud" and "a good product as the dynasty". However, the aspirations and connotations of auspicious patterns are universal and not limited to a specific class. Chinese have high

requirements for auspicious patterns, not only in terms of graphic shape, structure and color to conform to the beauty of form, but also to be visually pleasant, and the graphics should have "sayings" and "reasons" to explain the meaning of the pattern, to place the meaning of beauty and auspiciousness, and to meet psychological needs (Miao, 2011).

For example, the "dragon and phoenix auspicious cloud pattern" combines the dragon, the phoenix and the auspicious clouds, symbolizing happiness and festivity; "Carp jumping dragon gate pattern" is composed of carp, dragon gate and water pattern, which means transfer and ascension, and is often used to symbolize the title of the gold list of the imperial examination; "Rich and prosperous, blessed longevity and longevity" symbolizes wealth and longevity with peonies and longevity peaches, expressing good wishes for life; The "Bottle of Wealth and Wealth" is composed of vases, bats and osmanthus flowers, with bats and "rich" homophonic and osmanthus homonyms, combined with coin patterns to enhance the meaning of wealth (Miao, 2011); The "Wishful Pattern" is composed of Ganoderma lucidum, white flowers and persimmons, the shape of Ganoderma lucidum resembles Ruyi, and the persimmon is homophonic with "thing", symbolizing that everything is satisfactory (Xue, 2015); "Songshan Baishou Pattern" combines longevity symbols such as peaches and pines and cypresses, implying high longevity; The "Festive Three Patterns" is composed of peaches, bergamot and pomegranates, implying longevity, blessings and children, symbolizing happiness; "Auspicious Celebration" is homophonic to "auspicious" and "fish" is homophonic to "Yu", implying auspicious celebration; The "Fu Shou Shuangquan Pattern" is composed of bats, double coins and longevity peaches, bats and "fu" are homophonic, shou peach symbolizes longevity, and double coins imply double completeness, expressing the good wishes of happiness and longevity (Miao, 2011).

2.4 The Composition of Traditional Chinese Auspicious Patterns

Traditional Chinese auspicious patterns express people's yearning and blessings for a better life through symbolic animals and plants, geometric figures, text patterns, mythological figures and their combinations, which are not only artistic beauty, but also contain profound cultural significance.

2.4.1 Laws of Composition

The composition form should be the perfect embodiment of the concept, and as a decorative pattern, it must also pay attention to the performance characteristics of its programmatic beauty, plane beauty, space beauty, and complete beauty in the art form (Hou, 2009). (See Figure 2)

(1) Program beauty

Traditional patterns have the characteristics of stylization and are rich in stylized beauty. Programs, that is, laws and orders. Decorative composition is to seek a unified factor in the changes of image, colour, organization, etc. It is necessary to use different components of shape, colour, structure and other modelling factors, plus factors such as form, and plot configuration are the basic characteristics expressed in the composition (Li, 2005). And through the unified image, coordinated colours, harmonious organizational rules, and consistent mood and trends, it visually produces a sense of rhythm and gives people a pleasing program beauty (Hou, 2009).

(2) Plane beauty

Traditional patterns pursue a sense of flatness, and do not deliberately pursue the three-dimensional effect of the depth of the picture, weakening or cancelling the volume and layering of the image. The image in the composition is mostly head-up. Firmly grasp the outer contour line to express it. He is good at turning the relationship between natural form and three-dimensional structure into the plane structure relationship of art form, paying attention to the layout and management of the position and area between the upper and lower sides of the picture, as well as the composition relationship of the plane (Liu, 2011).

(3) The beauty of space

Traditional patterns pay attention to the beauty of space. The image depends on the space. The distribution of space determines the composition of the image, and the composition of the image affects the organization of the space. Space, that is, the "blank space" with form and no image. Handle the relationship between image and space, image and image, and create a beautiful image and suitable space (Abidin, Bjelland, & Ritland, 2008).

(4) Vertical visual composition

Standing composition is a free-style composition evolved from the heads-up composition, and the integrity of the composition is based on the technique of romanticism, breaking the limitations of time and space, and paying attention to the independence and integrity of the picture. The fullness, fullness and completeness of the composition are also the appreciation habits and aesthetic requirements of the masses. Pay attention to the integrity of the composition and the perfection of the modelling, that is, to make the picture full, and the image must have a full and complete pursuit (Xue, 2002). The vertical visual composition is a unique form of composition in traditional patterns in China, such as the "Riverside Scene at Qingming Festival", which can be seen in the brick and stone composition of Han portraits. Later, it developed into a compositional method commonly used in Chinese painting.

(5) Metrical composition

The grid is based on the geometric bone grid of rice character grid, nine-square grid, and curved square circle, creating a pattern with strict rhythm. The use of programs rather than being confined to programs reflects the unity of different compositional forms and the style and interest of the conception. This is an unconventional, extremely varied spiritual labour, and the harmonious and unified arrangement of individualized factors in the picture to seek differences and differences is the basic task of solving the formal beauty in the composition (Li, 2005).

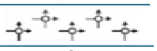
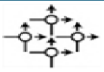
Type	Photo	Name	Attributes	Structure
Individual patterns		Shang Dynasty gluttonous moire	Symmetrical up and down	
		Majiayao swirl faience	Centrally symmetrical	
		Ming Dynasty entwined branch lotus pattern	Balanced/radial	
Two-way continuous		Dunhuang pattern of the Tang Dynasty	Polyline	
Quartet continuous		Yunjin diamond-shaped lotus pattern	Overlapping	
Suitable for patterns		Edge pattern on a bronze mirror	Edge pattern	
		Qing Dynasty decorative horn flowers	Corner pattern	

Figure 2 The composition of traditional patterns (Source: original, 2024, Copyright Consent: Permissible to Publish)

2.4.2 Methods of Presentation

(1) The image is regular and organised

The so-called regularization is to extract the characteristics of natural form and beauty, and use means and forms suitable for people's imagination to summarize and organize order through the changing laws of points, lines, surfaces, colours, and textures (Li, 2015). For example, the head of a

flower is summarized into a circle, and the pattern image expressed is standardized by this law. Whether it is a curve or a straight line, or a point or surface to standardize and sort out the natural form, it should conform to the ecological law of the natural form, so that change, and unity are coordinated.

(2) Exaggeration and omission, strengthening and weakening

Exaggeration is the amplification and rendering of the characteristics of things. Highlight the most essential and typical parts of the form (Abidin, Warell, & Liem, 2011). Use surreal proportions, scales, colours, surface textures, dynamic and static means to make it more concentrated and prominent, and more decorative and beautiful. For example, the tail feathers of an exaggerated peacock, the tail of a squirrel, the trunk of an elephant and so on.

In short, exaggeration focuses on highlighting its inner and outer essential characteristics, spiritual character, and image structure.

Omission – also known as simplification. Omission is refining and sublimation, subtracting the non-essential and cumbersome parts and retaining the typical and exaggerated parts. Simplification is not about simplifying; it's about keeping the essence of it.

(3) Addition and idealization

Natural forms provide a source of beauty for pattern design, and art pursues idealized and creative patterns. Therefore, the idealized pattern changes that also transcend reality and are full of creative beauty in the pattern modelling, while giving the form of beauty, enjoy more and richer spiritual connotations than the natural form of reality, and addition and idealization are important means to achieve this goal (Jamaludin, Zulkapli, & Zainal Abidin, 2013).

Add – is a means of "changing" beyond the true form of nature. It can add other images to the changing graphics according to the subjective assumption to form a complete pattern form (Zainal Abidin, Sigurjonsson, Liem, & Keitsch, 2008).

Idealization is the subjective addition that gives the graphic a higher level of connotation, and it is also the biggest feature of traditional Chinese patterns. In many cases, people's subjective yearning is used to combine different space, time, different forms, different laws, and even fantasy forms and surreal to express people's subjective ideal images.

2.4.3 Formal rules in graphic composition

The composition of the pattern includes: the primary and secondary content, the composition of the virtual and real gathering and dispersion, the size of the shape, the length and thickness of the line, the light and dark of the colour and other elements of the relationship, these contradictory relationships, make the pattern vivid and lively, dynamic, but not good handling, and easy to messy.

Variation: Refers to the differences between the various components of the pattern.

Unity: refers to the intrinsic connection of the various components of the pattern.

3 THE CURRENT RESEARCH STATUS OF PATTERN DESIGN

Traditional pattern design is limited by the aesthetic requirements of manual design and has the characteristics of low design efficiency. Over the past few decades, with the development of computer graphics, computer-aided design (CAD) technology, and the combination of digital and graphic design, designers have improved their comprehension and perceptual design capabilities, promoted the development of related CAD tools, and made pattern and pattern design more scientific and reliable. The basic methods commonly used in computer graphics design are shape grammar and fractal algorithms. The genetic algorithm (IGA) proposed by Lai et al. in computer science was applied to the

field of fractal art design, and the application of genetic algorithm in fractal patterns was discussed (Chao, 2020). Shape grammar is a mechanism that uses visual substitution rules to explore graphic derivative design and can effectively output many rich graphic designs by formulating rule functions. Committed to the development of a visual symbol grammar based on formal rules. This approach provides an intuitive mechanism for grouping dimensions through multiple aspects, including derived relationships (Borgo, 2013). At present, most of the research on shape grammar focuses on enriching the transformation rules and improving the computational power of the graph transformation (Xie, 2022), and the research focuses on the model checking of the graph transformation system, like other grammar rules, in every state, and the pattern shape is a node-rich pattern graph (Zambon , 2013). Chau et al. combined shape grammar with lattice theory to solve the problem of the complexity of geometric operations for specific grammatical shapes in shape calculation. Nasri et al. generate template themes through parametric shape syntax. In addition to the transformation rules, the shape grammar is limited by the parameter features of the initial shape and is mostly used to study the derivative design of finite shape sets in a two-dimensional plane (Xie, 2022). Fractal is another graphic design method that combines mathematics and graphics, founded by the famous mathematician Benoit Mandelbrot. Fractals have been used to decorate in all ages and cultures, these wonderful geometric objects, discovered by Mandelbrot (Frame，2002）。 The fractal design has high requirements for the initial shape, which is suitable for some patterns with self-similarity, which is generated by iterative algorithm. Based on the Mandelbrot set in fractal design, Dou Xiaojing et al. proposed a pattern design method that imitates the structure of tie-dye patterns. Zhang Mingchun et al. combined the recursive algorithm and the iterative function system algorithm to develop the decorative pattern design application under the UG platform. The basis of the formation of fractal graphs is the mathematical characteristics of the pattern itself, and by this method, the computer can create a variety of self-similar patterns with infinitely fine structures, which have fine structures at any small scale, and the self-similar fractals contain small copies of the entire fractal (Geng，2010). However, the evolution rules of fractals are also limited by the structural characteristics of the initial pattern, so its applicability is not strong when dealing with multiple patterns (Xie, 2022). According to the existing research results, the compositional properties of the initial shape are rarely involved. As an important part of the composition of the pattern, the initial shape contains the cultural connotation of the pattern, and its structure also determines the overall modelling attributes of the pattern to a certain extent. In the derivative design of traditional pattern structure, we should not rely too much on the graphic algorithm and should be based on the original cultural connotation and characteristic attributes of the pattern, and the derivation and application of excellent patterns should be carried out, to promote the modern development and output of traditional culture. At the same time, starting from the structure of the pattern itself, exploring the spatial attributes of three-dimensional patterns because of two-dimensional patterns is conducive to the application research of traditional patterns in three-dimensional space and products, and provides new ideas for other graphic design methods. In addition, in addition to the induction, deconstruction and extraction of the modelling elements and composition methods of the pattern itself, it is also necessary to have strong data mathematical ability, and the introduction of parametric design concept will effectively improve the parameter extraction ability and derivative design efficiency of the pattern. The benefits of combining parametric modelling with patterns are related to the capabilities described and are a means of knowledge extraction, as patterns are often generic (Turrin, 2011).

4 TRADITIONAL CHINESE PATTERN DESIGN METHOD BASED ON SHAPE GRAMMAR

4.1 The Concept of Shape Grammar

Shape Grammar is a formal system of rules for generating and analysing design forms, especially in the field of architecture and design. Proposed by computer scientist George Stiny and architect James Gips, this approach aims to define the process of generating and transforming shapes through a set of rules. The conditions defined at the beginning of the design and during the design process are eliminated by improving the shape grammar. The generation of a class of shapes consists of a shape grammar (Lee,

2009). The core concepts of shape grammar include shapes, rules, the generation process, and termination conditions.

Shapes are the basic elements that make up a design and can be simple geometric shapes such as lines, rectangles, circles, or more complex combinations. The simplest geometric shape and the most complex combination (Wolchonok，1969). Rules define instructions on how shapes change and combine, and each rule contains a precondition (the shape on the left) and a condition on the back (the shape on the right). When a shape satisfies a precondition, you can apply rules to convert it to a postcondition. The generation process is to recursively apply these rules, starting with an initial shape and progressively generating complex designs. The termination condition defines when the build process ends, perhaps to a certain shape or to meet a specific condition.

Shape grammar has important applications in several areas:

Architectural Design: Through shape grammar, different styles of buildings and urban plans can be generated. For example, you can start with a simple geometric shape and gradually apply rules to generate complex building facades or city block layouts.

Industrial design: Used to design the appearance and function of products, such as furniture, automobiles, etc. Designers can use shape grammar to explore different design possibilities, ensuring innovative product appearance and functional practicality.

Computer Graphics: Shape grammar plays an important role in generating complex graphics and animations and is widely used in games and filmmaking. With shape grammar, you can create detailed and realistic virtual environments and characters.

4.2 Shape Grammatical Reasoning Formulas

The inferential computation of shapes by shape grammar is performed by a quadruple formula, which is SG = (S, L, R, I). where SG represents the set of shapes derived from S through rule operations such as substitution, mirroring, copying, and miscutting; S is a finite set of shapes; L is a finite set of symbols; R is a finite set of inference rules; I is the initial shape (Sun, 2018). In the actual grammatical reasoning process of pattern shape, the initial shape I is a typical pattern extracted from the pattern database (Ma, 2024).

At present, the application research on shape grammar in the field of design in China mainly focuses on product design and pattern design. Taking the field of traditional patterns studied in this paper as an example, Wang Weiwei et al.'s "Research on the Application of Shape Grammar in the Evolution Design of Traditional Patterns" provides an important reference for subsequent scholars to apply shape grammar for evolutionary design. Sun Fei took the "Qin embroidery needle method" as the research object, used the research method in the field of statistics to analyse the data in the early stage, and used the shape grammar method to deduce, execute and derive the design of the extracted Qin embroidery patterns. Through the study of the More decoration of lacquerware in the Han Dynasty, Luo Xi used the shape grammar to extract the basic morphological elements of more, and deduced them to form new patterns and patterns, which were applied to cultural and creative carriers. From the above research, shape grammar is of great significance to the innovative design of patterns, and new shapes with infinite creativity can be produced after the deduction of different rules of shape grammar. Shape grammar is an effective strategy to generate new patterns because of retaining the characteristics of patterns.

The reasoning rules of shape grammar can be divided into generative deduction and derivative deduction. Taking the shape grammar as the design method, the crescent moon shape was selected as the initial factor for demonstration, and the corresponding derivative graphics were constructed by using specific deduction rules. These rules include: R1 for translation, R4 for scaling, R2 for vertical mirroring, R5 for horizontal mirroring, R3 for rotation around a point, R6 for rotation around an axis,

and so on, a process called generative deduction; By continuing to deduce the generated basic graphics according to the deduction rules, a process that can create richer new graphics is called derivative deduction (Wang, 2021) (Figure 3).

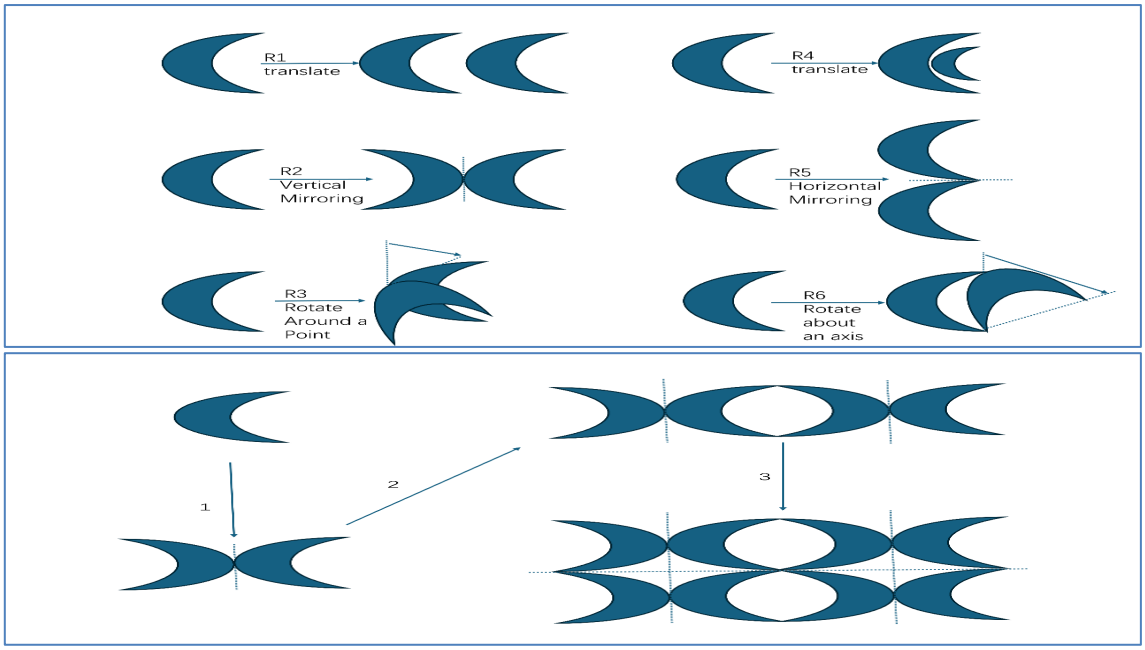


Figure 3 Shape grammar reasoning rules (Source: original, 2024, Copyright Consent: Permissible to Publish)

4.3 Introduction to The Application Process

Stage 1: Typical gene patterns are selected from the pattern gene database as the basic pattern.

Stage 2: The selected gene pattern is further modified and refined as the initial shape I of the subsequent transformation deduction design. When drawing patterns using vector drawing software, the prototype of traditional patterns is objectively reproduced.

Stage 3: Use the generative rules in shape grammar to deduce the first pattern of the selected initial shape and deduce the new basic unit shape. After the first pattern deduction, the derivative rules of shape grammar are used for the second deduction, and the selection of deduction rules (such as displacement, scaling, copying, mirroring, etc.) and the number of deductions is determined according to the specific design requirements of the pattern.

Stage 4: To determine the constraints for the innovative transformation of traditional patterns. Since the morphological genes, structural genes, colour genes and meaning genes of traditional patterns are integrated and mutually characterized, the new patterns deduced by generative rules and derivative rules will be constrained by structural genes, colour genes and meaning genes. In addition, the establishment of constraints can also more effectively deepen the cultural genetic imprint of traditional patterns after innovative transformation.

4.4 Innovation, Transformation, Deduction and Design

Traditional pattern genes are mainly divided into plant patterns, animal patterns, character patterns and geometric patterns. The use of shape grammar can transform traditional patterns into new patterns, to implement pattern form innovation. Here, the plant patterns in the traditional patterns are selected as

the deduction objects for transformation and deduction examples, and other types of patterns can be similarly deduced and designed.

1) Preparation before deduction. According to the requirements of the design scheme, the patterns in the theme gene database were selected as the deduction objects. POTOSHOP image processing software is used to process the pattern of the selected object, deepen the contrast of the selected object, strengthen the outline of the main pattern, and prepare for generative deduction and derivative deduction.

2) Generative deduction. The generative deduction link can be replaced or added or deleted separately, or two rules can be used at the same time, and one or more substitutions, additions and deletions can be performed for the local nodes or overall contours of the deduction object. The areas that need to be replaced, added or deleted in the pattern of the deduction object are identified, and the four regions represented by a, b, c, and d (see Fig. 4). Generative deduction step: Deduction 1, the A and B regions are added or deleted commands, and the new patterns are replaced at the same time; Deduction 2, the C area executes the addition and deletion commands; In the third deduction, the D area executes the addition and deletion commands, and the new pattern is replaced at the same time. In this link, attention should be paid to retaining the salient characteristics of the pattern genes of the deduction objects, to maintain the integrity and consolidate the foundation.

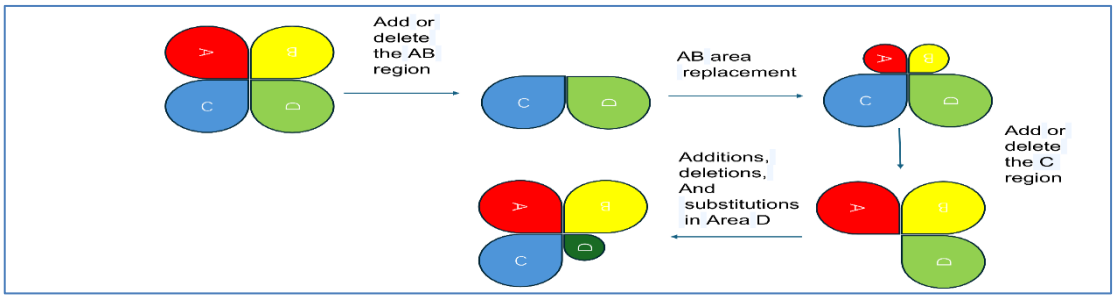


Figure 4 Generative deduction of patterns (Source: original, 2024, Copyright Consent: Permissible to Publish)

3) Derivative deduction. Derivative deduction is the re-deduction of the deduction object I1 obtained by generative deduction. This part is divided into 2 parts, the first part is to carry out detailed derivative deduction, and the second part is to carry out overall derivative deduction.

The first part of the deduction is mainly for the deduction of the pattern contour, so it is necessary to first number the nodes selected to perform derivative deduction in the outer contour of the deduction object I1, and the numbering order is clockwise from the twelve o'clock direction of the pattern, and the number is ..... to nodes (1) (2) (3) (4) (5), and the number of numbers is determined according to the complexity of the selected pattern contour (see Fig. 5). In the first step of the deduction, use the Bezier command to make the bending amplitude of the three nodes (1) (2) and (3) more obvious, then use the Bezier command to bend the curves of the three nodes (3) (4) and (1) inward, and finally, use the Rotate command to rotate the node (3) counterclockwise by 15°. In the second step of deduction, the copy command is executed for nodes (5) and (6), and then the copied nodes (7) and (8) are rotated by 10° with (6) as the origin, and the management command is executed to form a new pattern I2 again.

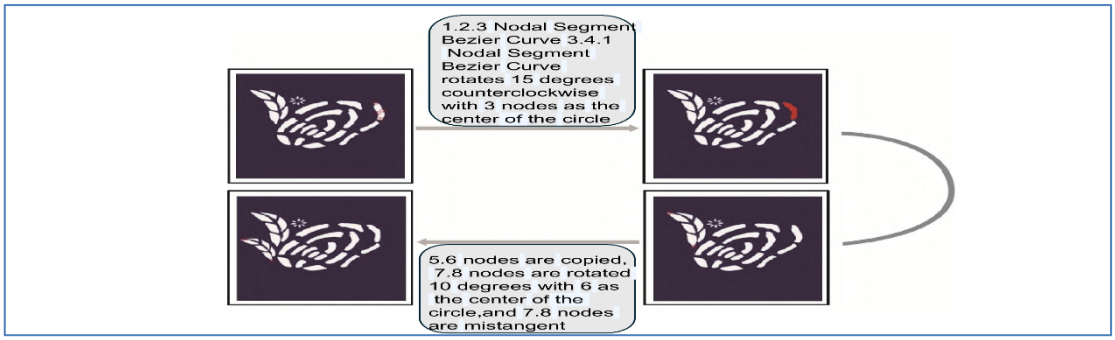


Figure 5 Pattern generative deduction (detail) (Source: original, 2024, Copyright Consent: Permissible to Publish)

After the detailed derivative deduction is completed, the overall derivative deduction begins. Deduction Steps: Deduction object I2 rotates 20° clockwise; Execute the mirror along the x-axis command after rotation; After using the copy command to copy, execute the mirror command along the y-axis (see Figure 6).

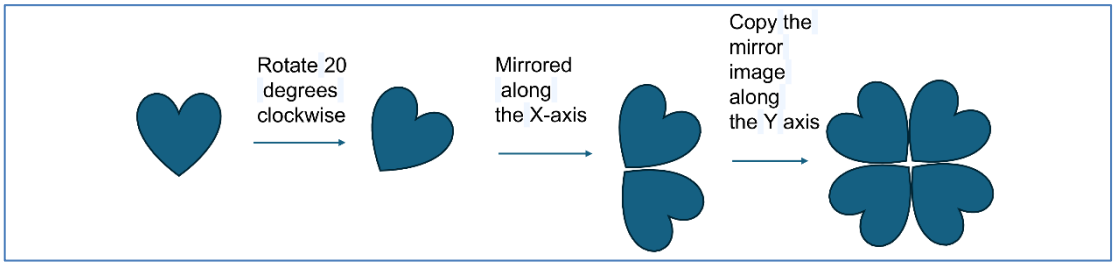


Figure 6 Pattern generative deduction (overall) (Source: original, 2024, Copyright Consent: Permissible to Publish)

4) Constraint setting. Pattern design using new patterns obtained by generative and derivative deduction is not arbitrary, but must also be constrained by structural genes, colour genes and meaning genes. Structural constraints, colour constraints and implication constraints are the "boundaries" of pattern design innovation, and their purpose is to maintain the authenticity of cultural genes. It should be noted that the reason why "material" is not taken as a constraint is that the material is only a material carrier carrying pattern information, and does not have the nature of cultural genes, that is, "material" is not a necessary condition for reflecting the recognition of the pattern. Therefore, the diversification of materials can also be used as another breakthrough in product innovation.

The pattern deduced by the shape grammar is only the basic pattern that is evolved on the basis of the pattern gene, and the final formation of the work also needs to be arranged and combined with this as the main element. According to the viewpoint of Gestalt psychology, graphic design should follow the principle of the bottom of the picture, the principle of gestalt, the principle of heterogeneous isomorphism, etc., and should be carried out according to the psychological structure and visual laws of people and pursue the identity of the shape and connotation of the image and the emotion and psychology of the person. In the design, we should focus on three kinds of relationships: the "theme-background" relationship in the graphics, the visual "have" and "no" relationship, and the relationship between different "shapes" and "shapes" and "meanings". In addition, consumers' psychological preferences, aesthetic preferences, and emotional appeals are also external constraints that need to be considered.

5 CONCLUSION

The research on the innovative design of traditional Chinese patterns based on shape grammar fully proves the effectiveness and potential of shape grammar in the innovative design of traditional patterns. Through the systematic application of shape grammar, researchers could inherit and reproduce

the unique aesthetic characteristics of traditional Chinese patterns within the framework of formalization. This method not only retains the cultural connotation and historical value of traditional patterns but also makes the design process more systematic and controllable, ensuring that the resulting patterns are both traditional and meet modern aesthetic needs.

Shape grammar provides a structured way to automatically generate and mutate patterns by defining basic shapes and rules. This formal approach enabled designers to flexibly innovate and improve based on inheriting traditional patterns, to achieve diversified development of patterns. For example, by tweaking rules or introducing new shape elements, designers can create patterns that are both traditional and modern. This not only broadens the range of applications of traditional patterns but also provides a wealth of inspiration and resources for modern design.

In addition, the application of shape grammar in the innovative design of traditional patterns can also promote the automation and intelligence of the design process and improve the design efficiency and effect. In today's rapid development of digital technology, the combination of shape grammar with computer-aided design (CAD) and other digital tools has brought unprecedented possibilities to pattern design. With the help of the powerful computing power of computers, designers could quickly generate many pattern designs in different styles and forms, to better meet market needs and user preferences.

In general, the research on the innovative design of traditional Chinese patterns based on shape grammar not only provided a scientific and effective method for the protection and inheritance of traditional patterns but also injects new vitality and creativity into modern design. The application of this method marks an important milestone in the transformation of traditional pattern design from manual creation to digital and intelligent and lays a solid foundation for future design innovation.

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CONFLICT OF INTEREST

The author declares no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

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