자연 패턴이 건축 조형의 미의식에 미치는 영향에 관한 인지 과학적 연구

Research on the Influence of Natural Patterns on the Aesthetic Consciousness of Architectural Modeling Based on Cognitive Science

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Abstract

The shapes created by nature are visually pleasing with their rich beauty, but also inspire designs that imitate these natural shapes. Architects also often introduce patterns in natural shapes into architectural design. It seems that the application of natural patterns to the design of architectural modeling has a potentially positive impact on people's aesthetic consciousness. Therefore, it is necessary to more scientifically analyze the structure of aesthetic pleasure in natural patterns. In the context of modern interdisciplinary knowledge, cognitive science can provide more scientific guidance and assistance for this research. And study the influence of natural patterns on the aesthetic judgment of architectural shape from the cognitive aspects of cognitive process and cognitive habits. Research has found that buildings using natural patterns can improve the aesthetic experience of their shapes from three aspects: cognitive habits, familiar stimuli, and the unity of diversity. Fully understand the value of aesthetic experience induced by natural patterns and apply them to the design of architectural shapes. Provide a sufficient theoretical explanation for the architectural modeling to imitate the natural model.

Keyword

Natural patterns, Architectural shape, Aesthetic consciousness, Cognitive habits

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요약

자연이 생성하는 형상은 풍부한 아름다움으로 시각적으로 즐거움을 줄 뿐만 아니라, 이런 자연 형상을 디자인에 모방하도록 영감을 주었다. 오래전부터 건축가들은 자연에서 영감을 받은 아름다움을 건축 조형에 투영해 왔다. 건축 조형의 디자인에 자연 패턴을 적용하는 것은, 인간의 미의식에 잠재적으로 긍정적인 영향을 미치는 것 같다. 따라서 자연 패턴이 심미적인 즐거움을 일으키는 구조를 과학적으로 분석할 필요가 있다. 학제적 지식 환경에서 인지과학은 이 연구 주제에 더욱 과학적인 지도와 지원을 제공할 수 있다. 인지 과정 및 인지 습관 등의 인지적 측면에서 자연 패턴이 건축 조형의 미학적 판단에 미치는 영향을 연구한다. 연구에 따르면, 자연 패턴을 적용한 건축은 인지 습관, 친숙한 자극, 다양성 통일의 세 가지 측면에서 조형에 대한 미적 경험을 향상시킬 수 있는 것으로 나타났다. 자연 패턴의 미적 가치를 충분히 이해하고 이를 건축 조형 디자인에 적용한다. 자연 패턴을 모방한 건축 조형에 대한 충분한 이론적 증거를 제공한다.

Contents

References

1. Introduction

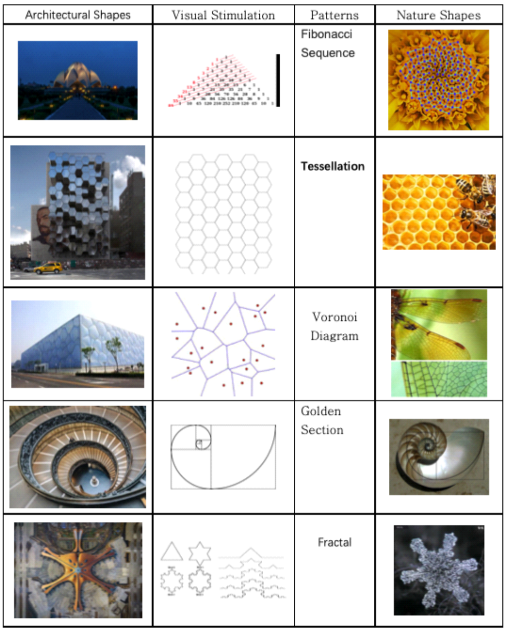
The patterns in natural shapes are a source of inspiration, both in terms of beauty and structure. Architects often copy their natural patterns into architectural shapes through cognition of the shapes of creatures and plants in nature. It seems that architectural shapes that imitate natural patterns will have a positive impact on human sensory systems and emotions. Regarding the aesthetic value of natural patterns, most domestic and foreign researches mainly focus on bionic architecture and the influence of natural shapes on the structure and function of buildings. It has not yet explained the basis for the aesthetic experience of architectural modeling using natural patterns from the perspective of cognitive science, and a complete theoretical system has not yet been formed.

The research object of this article is the architectural modeling using natural patterns. The research scope focuses on the relationship between its shape and aesthetic favor ability. It studies the significance and influence of natural patterns on aesthetic judgments from cognitive aspects such as cognitive processes and cognitive habits. How the natural model affects the aesthetic value we assign to the architectural shapes, and how the natural model affects people's aesthetic evaluation and judgment of the architectural shapes. It is hoped that a sufficient theoretical basis for architectural shapes to imitate natural patterns will be provided. And to improve the aesthetic value of architectural shapes, provide more scientific guidance.

2. Shape Cognition and Aesthetic

2-1. Natural Patterns in Architectural

There are many beautiful orders in nature. Whether in terms of shape or structure, it is a source of inspiration. Complex science structured the order appearing in nature, such as the shape of snowflakes (fractal), the shape of nautilus shells (golden ratio), the texture of butterfly wings (Voronoi diagram), and the growth and arrangement of sunflower seeds (Fibonacci sequence) and so on.



[Figure 1] Natural Patterns and Architectural Shapes (Image source: www.google.com 2021.03.17)

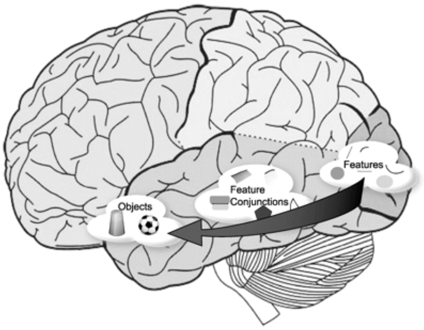
Human's love for nature will influence the conception of architectural shapes through memory.[1] The rational growth and arrangement pattern of natural organisms brings inspiration to the architectural design. Natural growth is manifested as the repetition of patterns, and architectural art often manifests as harmony.[2] Architects often draw inspiration from the shapes of plants or animals, imitating their structure or proportions (Kellert, 2003). The proportional relationship observed from natural shapes has been widely used in the design of architectural

1) Sarah Williams Goldhagen, [Welcome to Your World : How The Built Environment Shapes Our Lives], Harper, 2017, p.163,

2) Stephen Skinner, [Sacred Geometry: Deciphering',Sterling], 2009, p.6

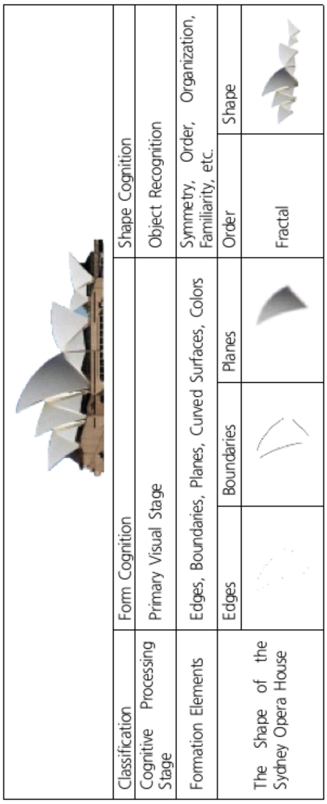
shapes. For example, Beijing Daxing International Airport (Fractal), Sydney Opera House (Fractal), Lotus Temple (Fibonacci sequence), Water Cube (Voronoi) etc., are all related to nature. A combination of nature shapes. The Figure 1 analyzes the natural patterns in architectural shapes. Architectural shapes are inspired by natural shapes, extracts the generative patterns in natural shapes, and makes new interpretations through architectural techniques (see Figure 1).

2-2. The Cognitive Process of Shape



[Figure 2] The Shape Recognition Process of the Ventral Pathway (Stephanie M. McTighe et al., Paradoxical False Memory for Objects After Brain Damage, Science, 2010, Vol.330, p.1409)

From a neuroscience point of view, the brain's visual system is composed of multiple parallel processing systems, each of which handles specific tasks, such as color or movement. The visual system is divided into two pathways, the ventral pathway and the dorsal pathway. Figure 2 shows how the brain recognizes objects. The ventral pathway composed of V1, V2, V4, etc. is mainly responsible for processing information such as the shape and color of the object (Ungerleider & Mishkin, 1982). Neurons in the primary visual area are sensitive to basic visual features. For example, V1 and V2 neurons extract features, such as edges and orientation (Hubel & Wiesel, 1962, 1968); V4 neurons play an important role in the neural mechanism of basic shape recognition.[3] Ventral temporal cortex (VTC) can recognize complex shapes in buildings, and then combine their information into the shape of the final architectural shape. Therefore, the ventral passage is very important for the cognition of the architectural shapes.



Classification	Form Cognition			Shape Cognition	
Cognitive Processing Stage	Primary Visual Stage			Object Recognition	
Formation Elements	Edges, Boundaries, Planes, Curved Surfaces, Colors			Symmetry, Order, Organization, Familiarity, etc.	
	Edges	Boundaries	Planes	Order	Shape
The Shape of the Sydney Opera House				Fractal	

[Figure 3] The Cognitive Process of the Sydney Opera House

The cognitive process of shape can be divided into two stages: form recognition and shape recognition (Hwang Yeongji & Cho Taigyoun, 2018). American psychologist Herbert Alexander Simon believes that human cognition has three basic processes, one of which is the ability of pattern recognition.[4] As shown in the Figure 3, take the Sydney Opera Houseusing the principle

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3) Hui Wei & Zheng Dong, V4 Neural Network Model for Shape-Based Feature Extraction and Object Discrimination, Cognitive Computation volume, 2015, Vol.7, p.753

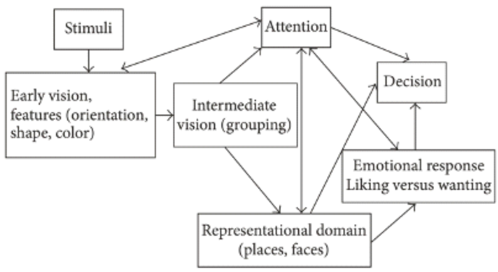
4) www.baidu.com(2021.05.27)

of fractal as an example. Form cognition is the perception of each forming element in the shape of a building, and it is also the first stage of visual aesthetic cognition; shape cognition is the perception of each forming element as a whole through the principle of fractal, so as to perceive the entirety of the Sydney Opera House Shape(see Figure 3).

2-3. The Neural Mechanism of Aesthetics

Zeki believes that beauty is something that conforms to the brain's aesthetic mechanism and argues for the unity of art and brain function from the perspective of neural mechanisms. The aesthetic experience of beauty and art is based on neurobiology (Chatterjee & Vartanian, 2016). Solo, a scientist engaged in the exploration of the neural mechanisms of aesthetics, also confirmed through brain imaging experiments that art appreciation is a result of brain involvement. The aesthetic ability required for art appreciation, which is the ability to discern the degree of beauty of objective objects, is a uniquely human higher cognitive function.[5] Aesthetic appreciation is a complex process that involves multiple processing processes such as perception, emotion, memory, and evaluative judgment.

Chatterjee (2004) was the first to put forward the cognitive neural basis model of visual aesthetics (see Figure 4). Like the general visual processing, this model divides the cognition of visual aesthetics into three stages. The first stage is the initial processing stage, which corresponds to the occipital cortex area. The visual information entering the brain is extracted in different brain functional areas and its basic visual elements are simply analyzed. Recent studies have also shown that the occipital lobe region is also involved in perceptual functions that may identify the interior and exterior of a building, such as building materials, Windows and architectural patterns (Marchette et al., 2015).[6] The second stage is the intermediate processing stage. This corresponds to the attention circuitry in the frontal lobe and parietal cortex. This stage automatically separates some elements and combines others to form a unified representation. The third stage is the expression of aesthetic preference and aesthetic judgment, corresponding to the dorsolateral and medial frontal cortex regions. The brain regions corresponding to emotional response include anterior medial temporal lobe, medial frontal lobe and orbital frontal cortex, subcutaneous structure and soon. In the third stage, some aspects of the aesthetic object are further selectively processed, and by activating memory, the aesthetic object is identified and given meaning. Then the aesthetic object induces the emotional response and gives feedback to the aesthetic processing system through the attention mechanism. Finally, the subject produces aesthetic preference and makes aesthetic judgment.



[Figure 4] The Cognitive Neural Basis Model of Visual Aesthetics Proposed (Anjan Chatterjee, Prospects for a Cognitive Neuroscience of Visual Aesthetics, Bulletin of Psychology and the Arts, 2004, Vol.4, p.57)

3. Cognition and Aesthetics Experience

5) Wang Naige et al., Neural Correlates of Aesthetics, Advances in Psychological Science, 2010, Vol.18, No.1, p.19

6) Alex Coburn et al., Buildings, Beauty, and the Brain: A Neuroscience of Architectural Experience , Journal of Cognitive Neuroscience , 2017, Vol.29, No.9, p.1523

3-1. The Difficulty of the Cognitive Process

The cognition of the shape of an object is the first step in the occurrence of aesthetics, and the difficulty of the cognitive process affects the occurrence of aesthetic favorability. The degree of difficulty affecting the cognitive process can range from order (Hwang Yeongji & Cho Taigyoun, 2018), familiarity (Rolf Reber, Norbert Schwarz, Piotr Winkielman, 2004), and presentation of stimuli (Reber et al., 2004; Alter & Oppenheimer, 2009) and processing fluency and other four aspects are analyzed (see Figure 5).

Factors	Classification	Cognitive Process	Aesthetic	Researcher
Order	Order	Easy	Improve	Hwang Yeongji & Cho Taigyoun, 2018
	Disorder	Difficult	decrease	
Familiarity	Familiar	Easy	Improve	Rolf Reber, Norbert Schwarz, Piotr Winkielman, 2004
	Unfamiliar	Difficult	decrease	
Stimulus Presentation	Repeatedly	Easy	Improve	Reber et al., 2004; Alter & Oppenheimer, 2009
	New Stimulus	Difficult	decrease	
Processing Fluency	Fluency	Easy	Improve	Reber et al., 2004; Russell, 2003; Lede et al., 2006, etc.
	Unfluency	Difficult	decrease	

[Figure 5] Factors Influencing the Difficulty of Cognitive Process

For regular shapes, the brain's cognitive process of its shape is relatively simple, and it is easier to feel good about it. On the contrary, the favorability will decrease (Hwang Yeongji & Cho Taigyoun, 2018). Psychologist Piotr Winkielman (Piotr Winkielman) said that for objects that do not seem out of the ordinary, the brain is relatively easy to process information from the outside world, so it appears attractive. The early experimental results of Norbert Schwarz and others of the University of Michigan in the United States also proved that the easier a thing or object is to be recognized, the easier it is to attract people (Rolf Reber, Norbert). Schwarz, Piotr Winkielman, 2004). People like familiar stimuli (John G. Seamon, Nathan Brody & David M. Kauff, 1983).[7]

The presentation of stimulus factors also has an important impact on the difficulty of the cognitive process. If a stimulus is repeated, it can be recognized more quickly (Reber et al., 2004; Alter & Oppenheimer, 2009). If people have been seeing pictures that follow the rules of a particular aesthetic style, and when they are presented with new stimuli, then they will spend a longer time judging whether these new aesthetic objects conform to the previous aesthetic form (Muth & Carbon, 2013; Wagner et al., 2014). Higher perceptual fluency will also lead to higher evaluations of beauty.[8] Reber, Schwarz, and Winkleman (2004) believe that “the more fluent the perceiver can process the aesthetic object, the more positive their aesthetic response will be”. That is, processing fluency can promote aesthetic pleasure. For example, if viewers can obtain more detailed descriptions or background information related to the painting when viewing a painting, their feedback on the painting will be more positive (Russell, 2003; Lede et al., 2006).

3-2. Cognitive Habits

Cognitive habits also have an important influence on aesthetic favorability. Shapes that conform to the cognitive habits of the brain will bring aesthetic pleasure; conversely, shapes that do not conform to cognitive habits will hardly bring aesthetic experience. By observing the shapes in nature, we have absorbed the ratio of trees and flowers through perceptual osmosis. Edward O. Wilson believes that the laws of nature have been engraved in our brains, and the connection with nature is structural. This view was also echoed by J.Z. Young, a well-known anatomist at Oxford University.[9] We are surrounded by nature, and the proportions

7) John G. Seamon et al., Affective discrimination of stimuli that are not recognized: II. Effect of delay between study and test, Bulletin of the Psychonomic Society, 1983, Vol.21, No.3, p.188

8) Rolf Reber et al., Effects of Perceptual Fluency on Affective Judgments, Psychological Science, 1998, Vol.9, No.1, p.46

of natural shapes are undoubtedly in line with our cognitive habits.

The golden ratio is a common ratio in natural shapes. Cinzia Di Dio et al. (2007) did an experiment in aesthetic evaluation of this ratio. The experimental results show that the proportional relationship that conforms to people's cognitive habits can have a positive impact on aesthetic judgment. When the proportional relationship is destroyed and does not conform to cognitive habits, it will have a negative impact on aesthetic judgment. However, the eyes are tolerant to changes in shape, and the brain cannot distinguish the changes in the proportional relationship before the difference in proportion changes as much as 6%.[10)] Therefore, the proportional relationship conforms to cognitive habits, even if the proportional relationship has subtle changes. However, if the ratio change is kept within 6%, it can still be regarded as a proportional relationship that conforms to cognitive habits. The imitation of the natural shape of an architectural model is usually expressed as an imitation of its shape or proportional structure. Therefore, this also provides a certain tolerance for the application of natural shapes in architectural shapes.

4. Research on Aesthetic Factors

4-1. Shapes Conform to Cognitive Habits

Through long-term observation of nature, humans have absorbed the ratio of trees and flowers in perceptual osmosis. The proportions and structure of natural shapes are imprinted in our brains. Complex science also summarizes the proportional relationship and structure observed from natural shapes into a series of beautiful rules or principles. The proportional relationship of natural shapes conforms to our cognitive and aesthetic habits. Therefore, when the proportional relationship that conforms to cognitive habits is perceived from the architectural modeling, it will promote the aesthetic feelings of it. As mentioned above, the eyes have a certain degree of tolerance in terms of shape harmony. The proportional relationship that conforms to cognitive habits changes before 6%, the eyes have a certain degree of tolerance for it, and the brain cannot recognize it. Therefore, when the proportional relationship of the natural model is applied to the architectural modeling, the brain can still recognize the proportional relationship that conforms to cognitive habits and promote the aesthetic experience of it before the difference change reaches 6%.

Classification	Architectural Shapes	Vary	Cognitive Habits?	Aesthetic Pleasure ?
Golden ratio		<6%	Y	Y
		>6%	N	N
Fibonacci Sequence		<6%	Y	Y
		>6%	N	N
Fractal		<6%	Y	Y
		>6%	N	N

[Figure 6] The Relationship Between Cognitive Habits and Aesthetic Pleasure (Image source: www.google.com 2021.04.25)

In Figure 6, the architectural shapes using

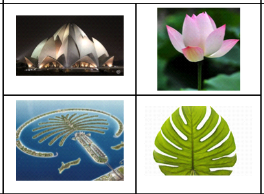
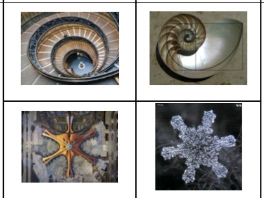
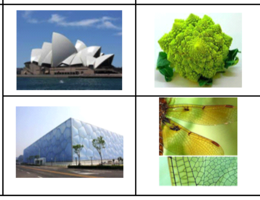
9) John Zachary Young, [Programs of the Brai], Oxford University Press, 1978, p.243

10) Smith Peter Frederick, [Dynamics of Delight: Architecture and Aesthetics], Routledge, 2003, p.72

natural patterns are taken as an example to analyze the proportional relationship in these shapes. The proportion of the original architectural modeling changes below 6%, which is in line with cognitive habits and therefore brings aesthetic experience. The change of the proportional relationship of the changed architectural shape is greater than 6%. This will destroy the familiar proportional relationship, which does not conform to cognitive habits, and will lead to a decline in aesthetic experience. Therefore, when applying natural patterns to the design of architectural shapes, it is important to maintain their shapes or proportions in line with the cognitive habits of the brain. Excessive destruction of its proportional relationship or structure will lead to a decline in aesthetic experience (see Figure 6)

4-2. Familiar Stimuli

Architectural shapes directly or indirectly imitates the pattern and order in natural shapes, and copies natural shapes or orders into architectural shapes. This is an aesthetic structure that is imprinted in the human brain and re-emerged in the shape of the building. This is the application of natural patterns as a familiar visual stimulus to the design of architectural shapes to evoke human memory of natural shapes. Natural mode, as a familiar stimulus, will directly affect the cognitive process of architectural modeling using natural mode. Natural patterns are usually applied to the design of architectural shapes from three levels of shape, proportion and structure. One is to directly imitate the shape of nature; the other is to apply its proportional relationship to the shape of the building by observing the observation of the natural shape. The third is to apply its structural relationship to the design of architectural shapes through the natural patterns summarized by the science of complexity. As mentioned in the previous article, the difficulty of the cognitive process has an important influence on the occurrence of aesthetics. Figure 6 takes architectural shapes that mimics natural shapes, proportions, and structures as an example, and analyzes the influencing factors (order, familiarity, presentation mode of stimulus factors, and perceptual fluency) that can improve the cognitive process in architectural shapes.

Classification	Natural Patterns in Architectural Shapes	Factors	Aesthetic Pleasure ?
Shape		Familiarity, Processing Fluency	Y
Proportion		Familiarity, Order, Processing Fluency	Y
Structure		Familiarity, Order, Processing Fluency	Y

[Figure 7] How Natural Patterns Improve the Aesthetic Experience of Architectural Shapes (Image source: www.google.com 2021.05.17)

Therefore, the natural patterns can affect the aesthetic feeling of architectural shapes from three aspects: shape, proportion and structure. . The Figure 7 analyzes the architectural shapes that uses natural shapes in the design from the three levels of shape, proportion and structure. As an example, analyzes the influencing factors (order, familiarity, and stimulus factors in the modeling that can improve the cognitive process). Method and fluency of perception), the impact of memory on aesthetic experience. The results show that the architectural shapes that imitates the natural patterns can improve the cognitive process of its modeling from multiple levels, and therefore it is easier to obtain aesthetic pleasure(see Figure 7).

4-3. Unity of Diversity

A common opinion in academics believes that the highest beauty is achieved through the "unity of diversity" (Dickie, 1997). This is because when processing is considered difficult but actually easy, it will produce a particularly strong aesthetic pleasure experience (Gombrich, 1984). Evolutionary psychology research shows that: relatively simple shapes, people prefer shapes with a certain degree of complexity. Dr. Ary Goldberg believes that when people see a shape with a specific complexity or repetitive pattern, it will stimulate aesthetic sensitivity and show a positive psychological response.[11]

Classification	Diversity	Unity	Perceptual Fluency	Aesthetic Pleasure
Geometric Symmetry	N	Y	High	Low
Natural Patterns	Y	Y	High	High
Chaos or Disorder	Y	N	Low	Low

[Figure 8] Evaluation Standards of Aesthetic Favor

As discovered by Berlyna (1971), it is believed that interests and preferences increase linearly with visual complexity. An order that is too single and unchanging often brings aesthetic boringness. But the order is too complicated or disordered, but it will lead to a decline in the degree of love. This is because a further increase in complexity will eventually reduce the fluency of perception, leading to a decrease in aesthetic interest and goodwill. Figure 8 using the above as the standard, evaluates the aesthetic favorability of geometric symmetry, natural mode and chaos or disorder from the three aspects of diversity, unity and perceptual fluency. The unity of diversity is a universal view of aesthetics, and higher perceptual fluency can more promote the occurrence of aesthetic feelings. Therefore, it can be concluded that the natural patterns have a higher possibility of inducing aesthetic favorability, and the same is true for the architectural shapes using nature patterns.

11) Esther M. Sternberg, 서영조 역, 『공간이 마음을 살린다 Healing spaces : the science of place and well-beings』, 더퀘스트, 2013, p.79

5. Conclusion

Based on the interdisciplinary theoretical knowledge, this article analyzes the positive influence of natural patterns on the aesthetic experience of architectural shapes from the perspective of cognition, and the theoretical basis for how to promote the aesthetic experience. The natural shapes are well known by people, and it is undoubtedly in line with cognitive habits. The architecture that uses natural patterns re-emerges a shape and structure imprinted in the human brain into the shape of the building. This is the application of natural patterns as a familiar stimulus to architectural shapes to evoke human memory of natural shapes and to promote the aesthetics of their modeling. The natural pattern is a shape that has both diversity and unity. The unity of diversity is a common point of view in aesthetics. Therefore, the natural model has a higher possibility of inducing aesthetic favorability. Natural patterns are beautiful, and the proportional relationship and structure of natural shapes are also the reference principles in architectural and artistic design. However, the application of natural patterns must not be reduced to a certain algorithm. It is necessary to analyze the influence of natural pattern cognition on aesthetic judgment from the cognitive neural mechanism of the brain. Summarize the factors and conditions that promote the occurrence of aesthetic experience, and apply its internal principles and laws to the design.

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