A Visual Interpretation Analysis Method of Visual Perceptive and Spatial Cognitive Study on the Deformation Process of Spatial Layout Plans through Space Syntax's Visibility Graph Analysis

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Abstract: The analysis in this research project compares the creation of spatial layout form to Chinese calligraphy, i.e. the lines in calligraphy are compared to walls. This research analyzes styles of spatial configuration comparing them to different calligraphic styles and further operates a digital tool during the process of transforming spatial form in order to clarify the relation between visual perception in different creative designs of spatial layout arrangement. This research applies visibility graph analysis of space syntax, which is developed from the university of London, to survey the creation of spatial form. It is useful for designer to comprehend the influence of the deep inner visual information objectively while creating the outer surfaces of spatial forms. In total ten types of calligraphic of spatial layouts are used. Each type of calligraphic spatial layout is drawn in a square. This square is subdivided in 9 small squares(3*3 matrix) that is a Chinese concept that underlies different forms of Chinese design and art, such as flow arranging, calligraphy, etc. The perception of visual differences between the squares is ten analyzed. This visual perception analysis is created to detect the range of visual integration of each square and the differences between corner squares, side squares and central squares(visual integration, this analytic parameter can be interpreted as the degree of visibility in space). The results show that for certain types of layout, the intelligibility is high, while for others it is low. When the range and differences of visual integration are low, then the visual intelligibility(this parameter can be interpreted as the cognitive capacity of space) turns out to be low and the opposite is true as well.

Key words: Calligraphic Styles of Spatial Form, Visual Perception, Visual Intelligibility, Cognitive Capacity of Space, Space Syntax

1. Introduction

1.1Motivation and Goal

Taking the spatial creativity as an analogy to Chinese calligraphic style and using visibility graph analysis of Space Syntax developed by Bill Hillier as a tool, this research tried to interpret the perception of spatial form objectively by rational analysis. This kind of analysis could help to clarify the interior visual features of different spatial styles. A spatial designer could then realize the influence of the manipulation of spatial form onto the information of visual perception, thus this research compares the spatial creation to Chinese calligraphy. This research analyzes styles of spatial configuration comparing them to different calligraphic styles and further

operates a digital tool in order to clarify the relation between visual perception and visual interpretation in different spatial arrangement. This research applies visibility graph analysis of space syntax to survey spatial form. In total ten types of calligraphic spatial layouts are used. Each type of calligraphic space layout is drawn in a square. This square is subdivided in 9 smaller equal squares (3x3 matrix) that is a Chinese concept that underlies different forms of Chinese design and art.

1.2 Research Viewpoint: Like Calligraphic Styles, The Creativity of The Spatial Form Could be Regarded as The Result of Visual Perceptual Decisions

Three essential factors for ideal calligraphic styles as defined by a calligrapher, Chang Hwai-Guan (張懷瓘), in the Tang Dynasty : First one is stroke use. This means the shape of each element. The second one is layout, which means the relationship of the overall arrangement. And the third is style, different calligraphic styles. When you have these three essential factors, you can then begin to write. (Chou, 2003) This study attempts to explain the different books of the same word the style elements forming elements such as Chang Huai-Guan said. As shown in the Figure 1, the Chinese word "永" shows six different writing styles of calligraphy. " stroke use " is the first stage which means morphological appearance of each elements of the word. The second stage is to identify potential writing unit layout relationship, finishing its constructive relations. The third one means different styles, this is a form of perception difference of style, it also means different visual experience. So one can explain the salient features of the visual difference, however, the subtle discrimination of the approximate form and style is still hard to explain by this calligraphic theory.

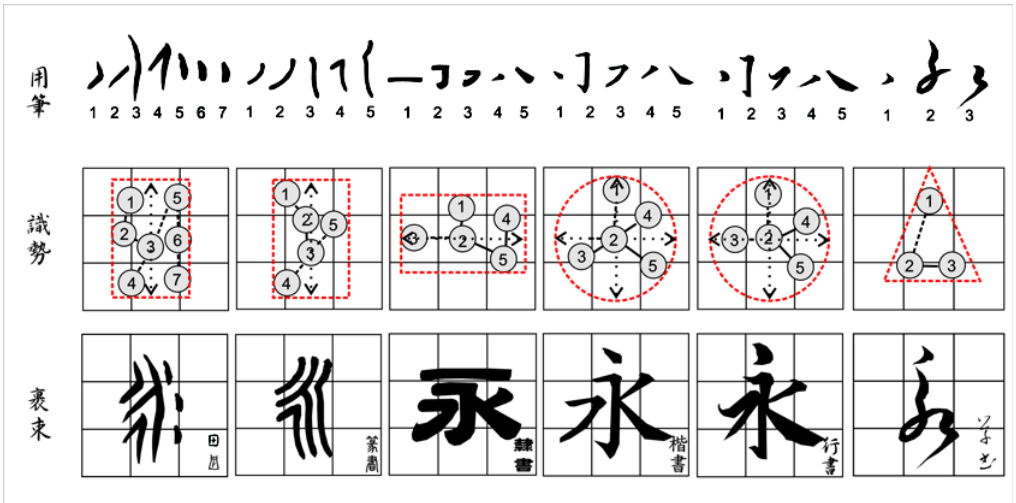


Figure1 The Calligraphy Style Differences of The Same Word

(The image is drawn by this research.)

It shows three spatial proposals by Frank Lloyd Wright in Figure 2. Even though the configuration of the spatial structures is the same, their forms will be quite different if the shape of each element is changed (from rectangular to circular or to triangular) or their layout is distorted and rearranged (Figure 2) Even though the

spatial form is exaggerated like in Frank Gehry's Guggenheim Museum Bilbao, the design is also the outcome from changing the shape of each element or spatial location after finishing the layout structure of those square volumes.

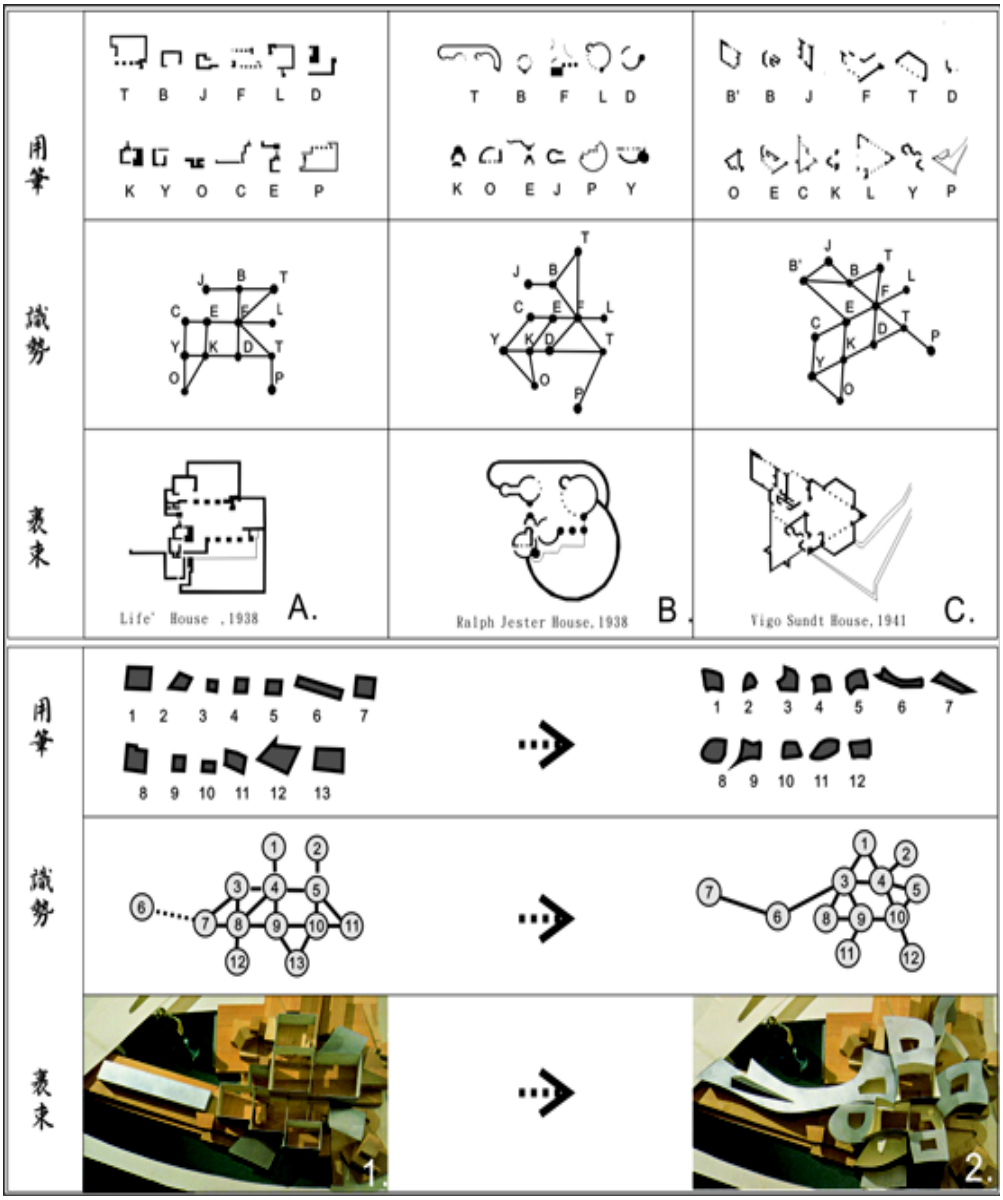


Figure 2. The Logical Interpretation of The Architectural Style

(The image is drawn by this research.)

2. Literature Review

2.1 Visibility Graph Analysis, Space Syntax

Space syntax methods use shape recognition to generate a topological or theoretic formal model of spatial configuration. Spatial configuration is simply the space where people can walk and that is always represented in plan. By decomposing the space in plan to its constituent units of analysis and giving these units numeric tags, the method helps identify both patterns and their variations in order to decode spatial ordering and relate these codes

to underlying social and economic logic. Space Syntax argues that space use can be predicted, and its concepts of spatial theory developed from two main theories, topology and mathematical graph theory. Topological space is a spatial concept developed in the nineteenth century and the concept of space is decomposed into a collection of elements and calculated by mathematical graph theory as the computing analytical basis to explore the spatial relationship. Space syntax is a quantization method to discuss the relationship between spatial units and the axial line organizations. Space syntax typically uses three elementary units of analysis, bounded spaces, convex spaces and axial lines—to decompose spatial configurations to a set of elementary shapes that function as units of analysis. Recently it extending the research to the visual analysis method that can analyze the user's visible isovist field, so this analytical method is called visibility graph analysis. Visibility graph analysis is a quantitative analysis of Space Syntax. It can analyze spatial users' visibility vision, computing visible isovist field of each point of view in space. The method is applied to the using evaluation and analysis of the large space system or complex spatial organizations of large public buildings.

2.2 The Spatial Field of Visual Force Theory

Paolo Portoghesi's spatial field of visual force is the visual concept that emphasizes the building structure and the sustained change of space. (Arnheim, 1977) The visual force of spatial form is expressed as the delivery of force, this is an extending of Gestalt psychology in visual research field(as shown in Figure 3）. Although that theory has redefined the relationship between space and architectural form, there were no discussions in depth due to lacking of a concrete description tool.

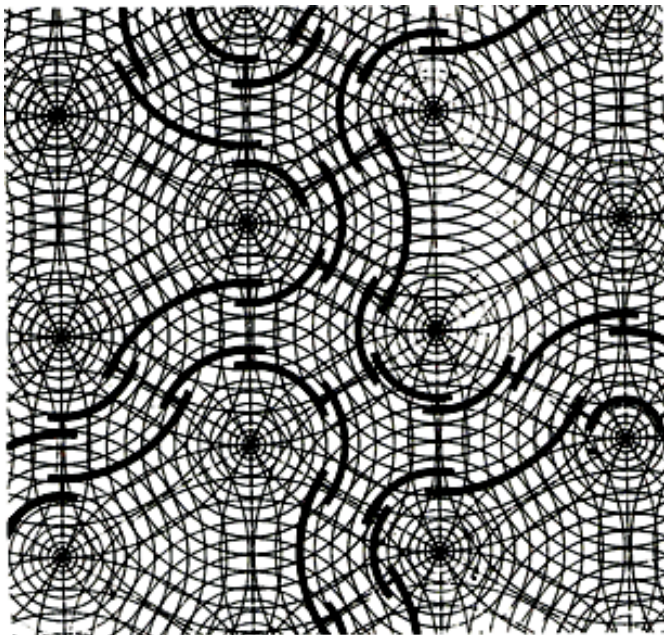


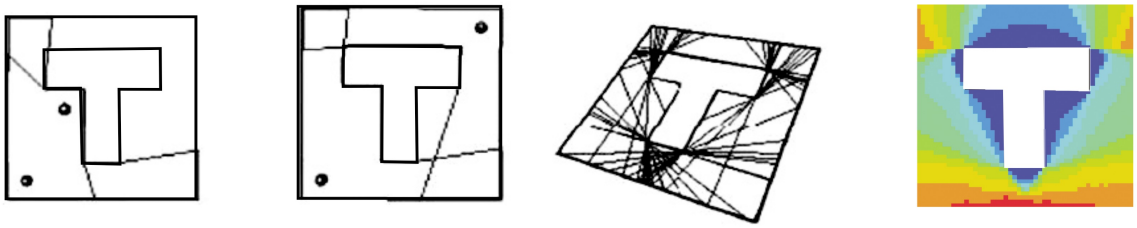
Figure 3. The Spatial Field of Visual Force Theory

(The image from Arnheim, 1977)

3. Analytical Method: Visibility Graph Analysis

3.1 The Concept of Visibility Graph Analysis

Cliff Tandy's Landscape analysis is the first to use the concept of visibility graph analysis, and Benedikt is the first person who used it in analyzing architectural space. He defined that isovist field as the area which people could see. Hillier & Alaster developed this concept further, covering the plane with grids (60cm×60cm) which represented the view point of space. The First step of visual analysis is to define the isovist field of each view point, and see the overlapping area of isovist field. When ones are in the overlapping area of isovist field, they can see each other, or they can't. The position of the overlapping area of isovist field will be changed when people move in space. The overlapping area of isovist field will be different so that some areas will have high visibility, some haven't. Then the second step is to calculate the overlapping area of isovist field. Finally the result of calculating the overlapping area is the value represented by color from red to blue (as shown in Figure 4). The value shows the spatial visibility. They then got its visibility by calculating the overlapping area of the isovist fields and the degree of overlap is called Visual Integration (Turner & Penn, 1999).



The first step of visual analysis is to define the isovist field of each view point,

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Some areas will have high visibility, some haven't. Then calculate the overlapping area of isovist field.

Finally the result of calculating the overlapping area is the value represented by color from red to blue.

Figure 4. The Process of Visibility Graph Analysis
(The image from Turner & Penn, 1999)

3.2 The Introduction of analytical Parameters

[1] Visual integration (Hillier/Hanson): the visibility of each viewpoint to see each other in space is represented by color from red to blue. This paper uses this analytical parameter to explain the position of the visibility of shopping stores through different interventions (Turner, A.& Penn , A. , 1999.).

[2] VI-CN Scatter Plot : VI-CN Scatter Plot is the table showing the correlation between Visual Integration (VI) and Visual Connectivity (CN). When the R-squared value is high, it means that the correlation of VI-CN is high. When R-squared value greater than 0.5, the users in that kind space could recognize their spatial position in terms of the visual judgment so that the value is called Visual Intelligibility. This paper uses this analytical parameter to see that the whole spatial relationship is becoming better or not (Turner, A.& Penn , A. , 1999.).

4. The Framework of Visual-sensory Cognitive Analysis

4.1 The Calligraphy Extending Concept: Substances in The Field of Space Visual Analysis

Calligraphy uses nine squares for judging calligraphic styles and likewise this research uses nine squares for analyzing spatial form by Chinese calligraphy as the discussion of the basic layout of the building, its purpose in seeking operations and clarify the surface morphology, the visual qualities of change. Constitutes a discussion in terms of the text as the layout of the building space form of Chinese characters with rich symbolic expression. Spatial possibilities seem endless during the process of transformation. Calligraphy uses nine squares for judging calligraphic styles and likewise this research uses nine squares for analyzing spatial form.

The nine grids the Calligraphy concept is the important concept of this study. This paper argues that by space type constitutive theory of sight analysis methods can identify as the visual qualities of the interpretation and presentation of Chinese calligraphy. Comparative results for seeking space morphological changes required in order to discuss the framework available to the sight of the form of drill. This format explored for deformation to eighty-one grids (9 * 9), the Optional to investigate deformation eighty-one grids format. There are the following reasons:

[1] Due to it should have the intermediary relationships in the overall patterns, so that there will be the mediator in the overall patterns, as shown in Figure 5.

[2] 81 observation benchmark formats for spatial deformation, each grid visualization grid point (60 cm × 60cm) placed in the wall thickness is 12cm, as shown in Figure 6.

[3] The various stages of the deformation process will be symmetrical relationship changing, shown in Figure 7.

[4] Because of the limitations of human visual identification that the degree of rotation can not be lower than 15 degree, or it will be meaningless in visual perception and recognition cognitive study. This research will use 15 degrees and 45 degrees for per rotation of four deformation steps, shown in Figure 8.

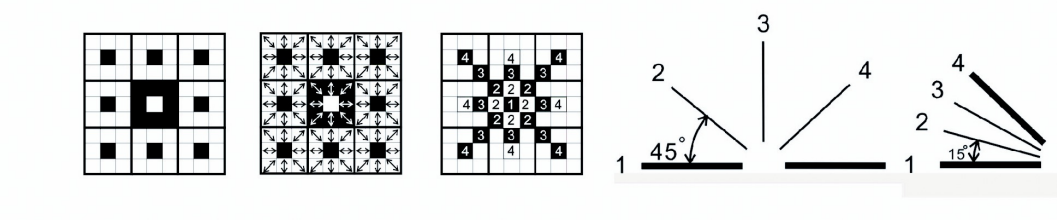

Figure 5 Figure 6 Figure 7 Figure 8

(Figure 5 , Figure 6, Figure 7, Figure 8 are drawn by this research.)

4.2 Overlapping Boundaries of Visual Integration of Each Step

In order to compare the process of transformation, this research turns the color map into a simple map of boundary lines which represent the data by the thickness of lines. During the deformation process, regional distribution of rapid change each other depending on the degree of the various stages of each other depending on the degree of change in locus will drive in the messy, shown in project B which is significantly messy when it is compared to project A .The distribution of visual integration is changing a lot during the process of transformation, the map of the traces will be more disordered, as Figure10 shown.

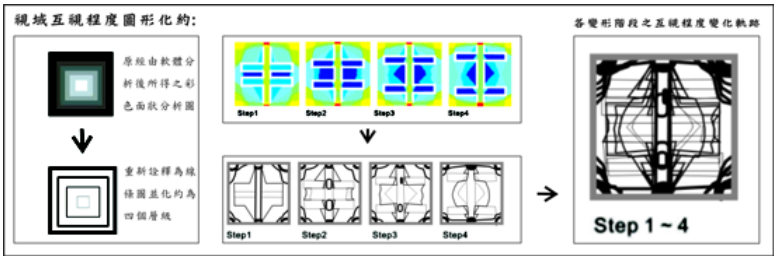

Figure 9. The Trace of Visual Integration During Transformation

(The image is drawn by this research.)

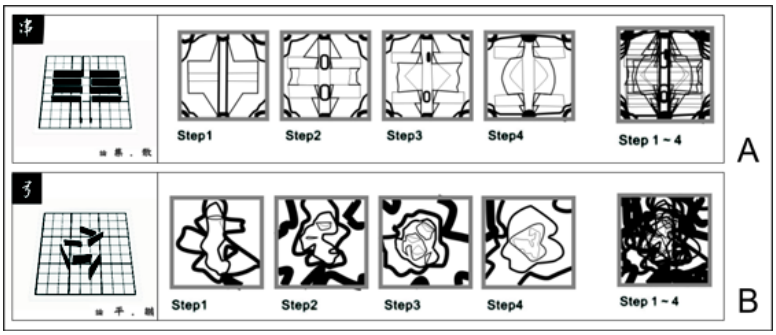

Figure 10. The Comparison of Two Spatial Transformations

(The image is drawn by this research.)

4.3 Visual Waveform Map : The Quantification of The Variation of Visual Integration

Viewing the variations of the nine square areas' visual integration of each step and analyzing the variations of visual integration of partial space during the process of transformation shows the stimulus of visual perception of various spatial forms.

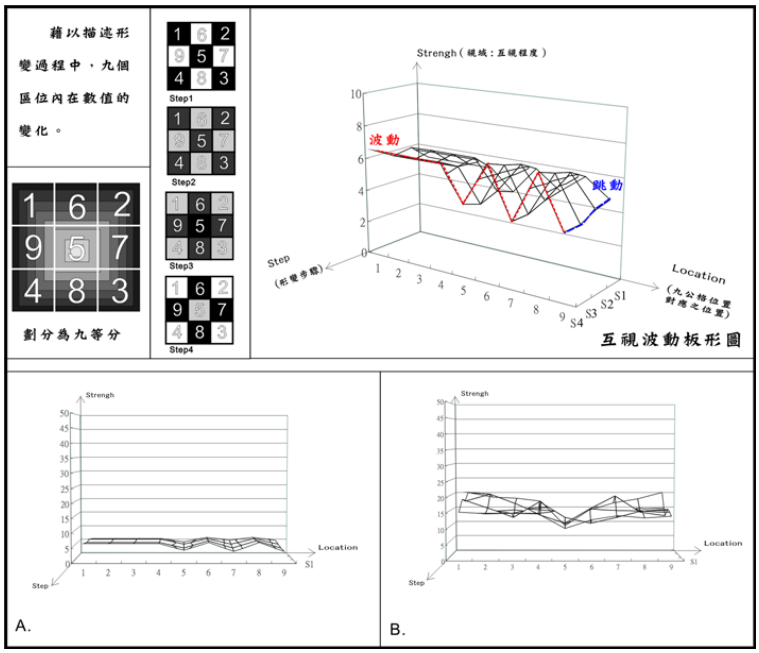

Figure 11. Visual Waveform Map: The Quantification of Visual Integration

(The image is drawn by this research.)

5. Visual-sensory Cognitive Analysis on The Deformation of Calligraphic Layout Plan

5.1 Spatial Form Writing

This study uses ten analog calligraphic spatial configurations to interpret the complex morphology of the varied architectural space layouts. The three basic configuration mode, were inside intermediary cortex. These ten spatial configuration examples, their original configurations can be divided into concentric to the heart, clusters, dual-core, dual-heart, nest shape. Deformation techniques are Add & Reduction, Rotated, Parallel Shift, Elasticity, Mesh Smooth. This ten spatial configurations of calligraphy writing, the development process as Figure 12 shown.

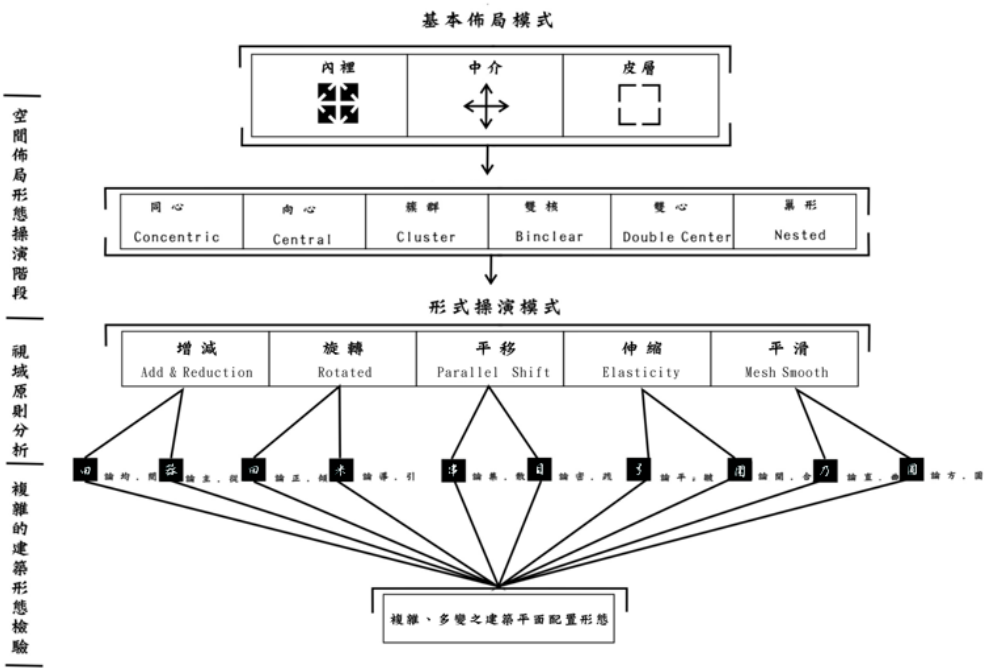

Figure 12. Ten Spatial Configurations of Different Calligraphic Style
(The image is drawn by this research.)

5.2 The Analysis of Visual Perception and Spatial Cognition

The visual integration will be influenced when changing the spatial form. By this analysis, we could read the visual information of each step and the differences of the nine squares. We also can realize the relationship between visual perception and spatial cognition (as shown in Table 1).

The trace of visual integration / the visual waveform map: The trace of visual integration of each step during the process of transformation can be seen in the result of the visual waveform map of possible transformation techniques (as shown in Table 2).

5.3 Research Finding: The Relationship Between Visual Perception and Spatial Cognition

The visual waveform of spatial types which are belong to Inside and intermediary is flatter than the ones which belong to surface. When the trace of visual integration is more regular, the visual waveform map will also

be flatter like the Chinese word,田、回 and 目. The shape of the visual waveform map of spatial types which belong to surface shocks obviously like the Chinese word,弓 and 圍. When the shape of the visual waveform map is flatter, its value of Visual R-squared will also be low. The result shows that it is hard to recognize the spatial position for spatial users when the influence of visual perception is small like the Chinese word, 器、米 and 串. On the other hand, it will be easy for users to recognize the spatial position when the shape of the visual waveform map shocks a lot. And those value of Visual R-squared of that kind spaces will also be high like the Chinese word, 弓 and 圍(as shown in Table 3).

5.4 Research Discussion

This research uses the visual waveform map in order to represent visual perception, and uses Visual Intelligibility to represent spatial cognition. In this way the researcher can see whether the space will be a maze or not. When the shape of the visual waveform map shocks a lot, that means its visual perception is strong. It will be easier for the users to recognize the space.

The spatial designer could create the space by intuition just like a calligrapher who pays attention to personal calligraphic styles. But spatial design and pure art form are quite different. The object of pure art form doesn't consider the users' visual perception and spatial cognition. Balancing perceptual creativity and rational thinking in design is really a difficult, complicated issue worthy to be discussed in depth.

6. References and Citations

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Table 1. The Visual Integration Values of The Spatial Form Deformations

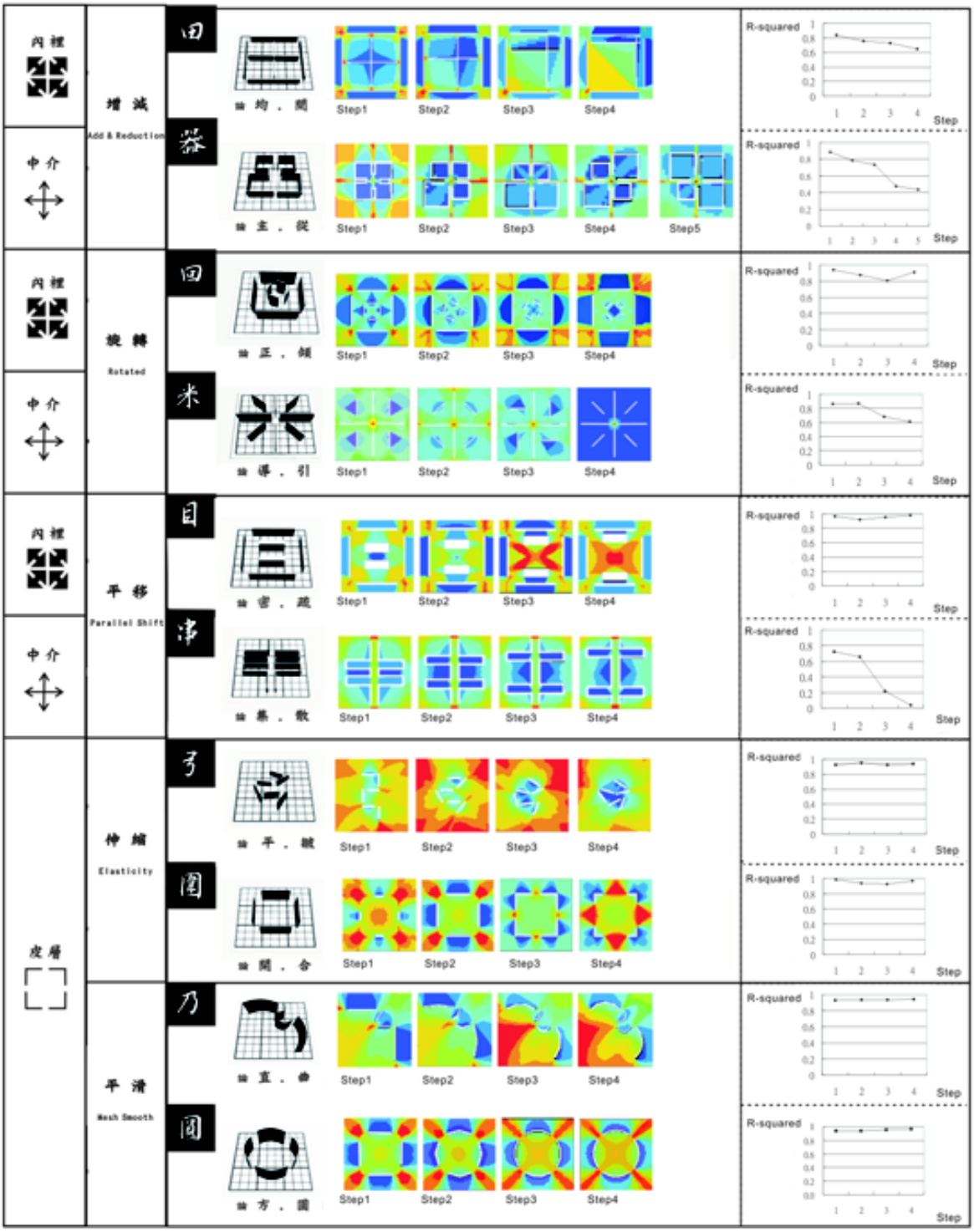

Table 2. The Visual Waveform Maps of The Spatial Form Deformations

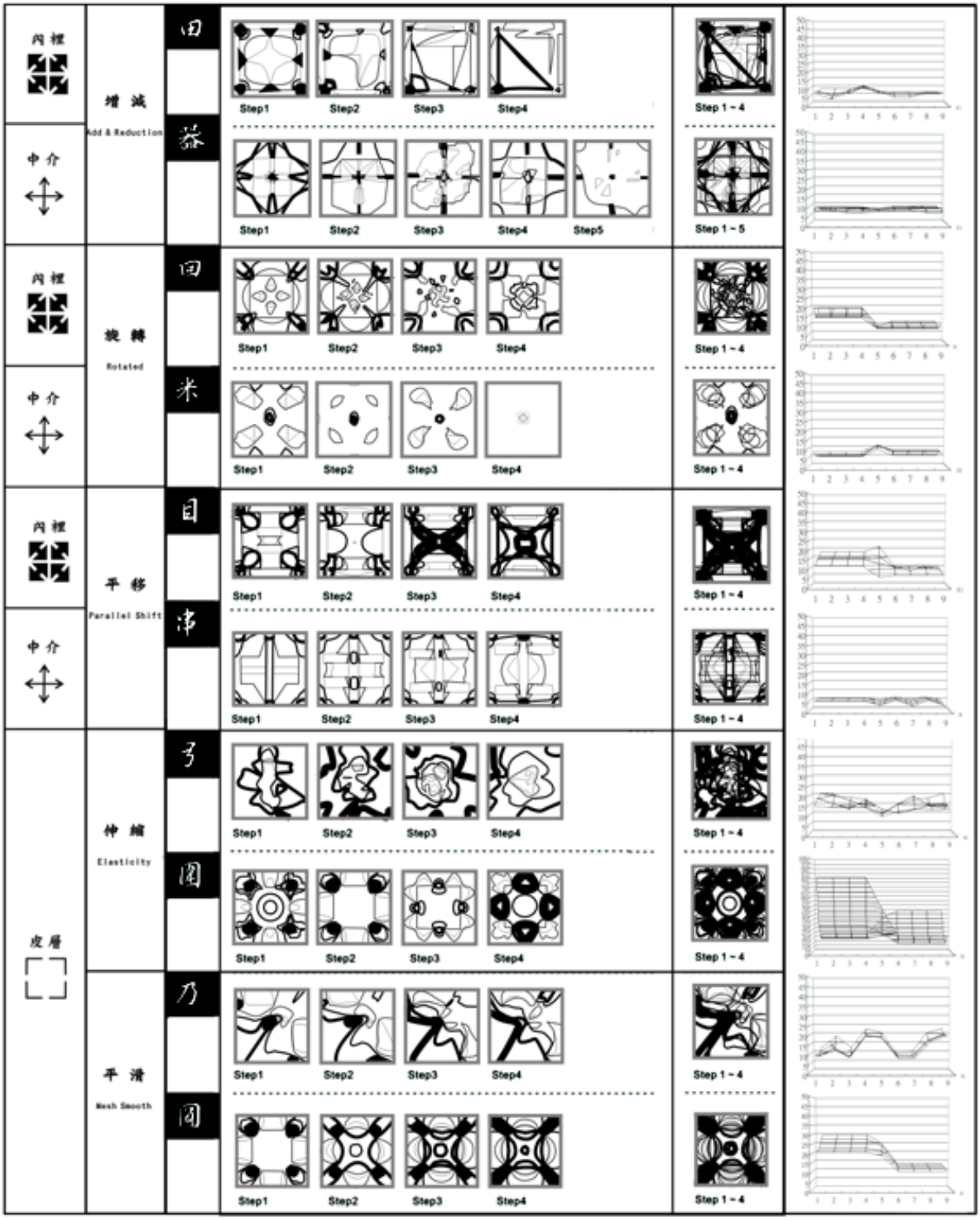

Table 3. The Comprehensive Analysis of Visual Perception and Spatial Cognition