Analyzing Spatial Image of Digital Architecture

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Abstract: In the design process, it is an important step to know the features which impact the visual image of the design work. To find out the effects of design concept communicated in the digital architect by their works, we take the contemporary digital architecture design works to be the objects. Firstly, we use the Semantic Differential method to analyze the adjective collected from the architects. Secondly, we invite 40 subjects who educated professional architectural design education to execute the image examine. Finally, we use the Cluster Analysis and Factor Analysis methods to analyze the data we collect from architects. The result shows that subjects have different visual image about the digital architectural works with the architects. The results also point out the communicative gaps between architectural designer and viewer.

Key words: Visual Image, Kansei Engineering, Digital Architecture

1. Introduction

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The wave of globalization makes the collaborative design activity becomes more frequently between design teams from different countries. The Group Architectural Creativity becomes a new model in the architectural circle. This research chooses the NEXT-GENE, an international group architectural creativity was held in 2008, to be our case to analyze the design communication and the visual image between designers and viewers [1].

In the previous studies of visual image, there are a lot of researches used the concepts of Kansei engineering or emotional design in the product field. Following the development of digital technology, designers also could build the free-form architecture like product design work [5-7]. However, there are very less researches discussing the visual image of digital architecture [2-4].

Due to these reasons, this research takes the NEXT-GENE to be our digital architecture case [8]. By observing these cases which made by the designers who educated in the professional architecture design field, this research could obtain the communicative effect of design concepts from designers to viewers and the features which effect visual image.

2. Methodology

There are two purposes of this research: The first one is finding the effects of communicating from digital architecture design concepts. And the second one is discussing the visual images of digital architecture from designer educated in the professional architecture field. This research, firstly, obtains the image adjectives used to represent design's concept of digital architecture. Then we use the semantic differential method to execute the image survey of the digital architecture design. Thirdly, we analyze the survey data with cluster analysis method to get the similar image clusters. Finally, we use the factor analysis method to get the special images correspond with different clusters. The result of this research shows the visual image of digital architecture by comparing designer and viewer.

In the stage of collecting research samples and image adjective pairs, this research invite three experts in the architecture design field. Considering the scale, function, site and environment of digital architecture might affect visual image, this research chooses the Next-Gene to be our samples. And then according to the completeness of data of design, nine of all samples, A1 to A9, more suitable are selected by experts. In the other hand, following the main purpose, this research tries to figure out the effect of concept communication from designer to viewer. The experts are asked to select the image pairs from the designers' descriptive words from the posters, design collections and books. For example, the descriptive words in the sample A1 are listed as below:

... the outline of architecture becomes indistinct makes the building integrate into the environment... even we use transparent materials on the wall, the shape of building still exists. The image becomes harder to make people feel shocked. The shape could not been indistinct at all...

Three adjectives could be chosen in the above words, which are "indistinct", "transparent" and "hard". Following this rule, fourteen adjectives could be obtained from the descriptive words: "indistinct", "simple", "comfortable", "free-form", "penetrant", "congenial", "ecological", "curving", "public", "hard", "closed", "wide", "natural" and "transparent".

To avoid repeated meanings, all of the adjectives are reviewed by experts. Firstly, experts think that the adjective "natural" and "ecological" are similar in the visual image. And "natural" is used more frequently in daily life. So they decide to use the adjective "natural" to replace "ecological".

In the same reason, the adjective "transparent" is replaced by "penetrant". In the other hand, "free-form" can convey more accurate in not only shape but also image of digital architecture than "curving". So "curving" is replaced by "free-form". After experts" reviewing and editing, eleven pairs of image adjectives, J1 to J11, are shown in the table 1.

This research invites 73 master students to be our subjects. All of them already have professional bachelor degree in the architecture design field. They are 39 males and 34 females and their average age is 23.6 years old. All of subjects are asked to view the nine samples of digital architecture. There are two colorful pictures in each of sample to present the appearance of architecture design in the different angles. After they finish the viewing of one sample, they are asked to evaluate the visual image of the sample by giving points in the questionnaire with eleven adjectives. This research uses the 7-point Likert scale, from 0 to 6, in the evaluative questionnaire. Higher points a sample gets, closer that subject feels to the concept of designer. To avoid effecting subject on determining visual image, there is no information about the design and designer in the questionnaire.

Table 1. Results of factor analysis

	Adjective	Factor 1	Factor 2	Factor 3
	words	Interactive	Spatial	Formal
J6	Uncongenial & Congenial	0.968	0.138	0.045
J7	Artificial & Natural	0.942	0.061	-0.174
J3	Restrained & Comfortable	0.792	0.357	0.294
J1	Distinct & Indistinct	0.597	-0.338	0.596
J9	Hard & Soft	0.564	0.556	0.475
J8	Private & Public	0.158	0.923	0.252
J11	Narrow & Wide	0.258	0.914	-0.228
J5	Obstructive & Penetrant	0.435	0.530	0.394
J10	Open & Closed	-0.220	0.490	0.351
J2	Complex & Sample	-0.172	0.204	0.933
J4	Orthogonal & Free-form	0.221	0.113	0.770
	R2 (%)	44.541	19.986	16.654
	R2 (cumulative)	44.541	64.527	81.181

3. Result and Analysis

3.1 Image Analysis

After analyzing the visual point which each adjective gets, we find there are six of nine samples get points higher than 3 the average of 7-point Likert scale. That means most of the visual images evaluated by subjects who educated in the professional architecture field are similar with designers. However, sample A4, A5 and A9 get the lower point than average. The designers of A4 use "penetrant" to describe his work only get 2.3 point. Also, the "congenial" used in A5 gets 1.4 point and "natural" used in A9 gets 2.3 point. These show the different in the visual image communication between designer and viewer in these three samples.

By analyzing the visual image point of these three samples, subjects think A4 is more complex (4.7) and open (4.2), and A5 has the same image that both visual images by getting point 5.2. Also, the sample A9 is more complex to subjects. These show A4, A5 and A9 are more complex to subject and different with the original concept that the designers want to transmit to viewer.

In the other hand, although the sample A7 gets 4.5 point this is higher than the average. The image adjective "public", which is one of four adjectives used in descriptive words by designer, only gets 2.6 point. This shows that subject feels more "private" to this sample. Besides, subject feels more "distinct"(4.6), "restrained" (4.7) and "uncongenial" (4.8) to the sample A7.



Figure.1 Line Chart of Points of Visual Image



Figure.3 Scree plot factor analysis

3.2 Cluster Analysis

In the stage of cluster analysis, we firstly put the similar samples in the same cluster. Then we find out the higher visual image point in each cluster to obtain their same feature. In the first step, classifying the design samples, this research use the between-groups linkage method and set the nine samples to be the label cases.

The second step is to obtain the same feature in each cluster. The image is centralized if the different between highest and lowest value is less than 1. Following this rule, the adjective pairs "restrained - comfortable" and "hard - soft" are more centralized and getting higher point in the sample A2, A6, A7 and A3 in the cluster one. So this cluster has "comfortable" and "soft" visual images. In the same way, we could obtain the "simple", "orthogonal" and "natural" visual images from the A1 and A8 in the cluster two, and the "distinct" visual image from the sample A4, A5 and A9 in the cluster three.

3.3 Factor Analysis

In the stage of factor analysis, this research chooses the Principal Component Analysis method (PCA) to obtain the factor with feature value bigger than 1. And then use the varimax to obtain phenomena of eleven visual image pairs distributed over the space of factors. The result of factor analysis is shown as table 1.

By observe the result of factor analysis, we could know the gradient becoming gradual after the 6th component, and three factors' variance of feature are bigger than 1. The adjective meanings of each factor are defined as below:

Factor 1: Interactive Factor

This factor includes four adjective pairs in the significance level: "uncongenial - congenial", "restrained - comfortable", "distinct - indistinct" and "hard - soft". All of these visual images are coming from the feeling about

interactive description between the digital architecture and outside. Thus, we define the factor one as Interactive Factor which means the interactive visual image from the digital architecture to the viewer.

		J1	J3	J6	J7	J9	mean
1	A2	2.1	5.4	5.3	5.5	4.9	4.64
	A3	2.9	4.7	2.9	1.3	5.5	3.46
	A6	2.3	5.2	4.9	4.1	5.4	4.38
	A7	4.6	4.7	4.8	3.6	4.9	4.52
2	A1	5.2	4.3	4.7	4.9	3.2	4.46
	A8	1.9	5.6	5.6	5.0	4.6	4.54
3	A4	1.3	2.2	2.6	1.7	1.2	1.80
	A5	0.9	3.6	1.4	0.9	1.3	1.62
	A9	0.4	2.4	2.5	2.3	3.5	2.22

Table 2. Cluster analysis of Factor 1

Factor 2: Spatial Factor

This factor also includes four adjective pairs in the significance level: "private - public", "narrow - wide", "obstructive - penetrant" and "open - closed". All of these visual images are coming from the spatial impression of viewer to the digital architecture works. So, we define the factor two as Spatial Factor which means the spatial feeling from viewer's visual image of digital architecture.

Table 3. Cluster analysis of Factor 2

	1	1	1	1	1	
		J5	J8	J10	J11	mean
1	A2	2.3	3.1	3.2	4.4	3.25
	A3	5.5	5.2	2.3	4.2	4.30
	A6	2.9	2.7	3.5	3.2	3.08
	A7	2.9	2.6	5.2	3.0	3.43
2	A1	3.9	2.1	3.7	2.8	3.13
	A8	5.7	4.8	4.9	5.3	5.18
3	A4	2.3	1.3	4.2	2.5	2.58
	A5	0.7	2.1	5.2	3.1	2.78
	A9	1.3	3.1	2.9	4.1	2.85

Factor 3: Formal Factor

In the same way as the factors above, this factor includes tow adjective pairs in the significance level: "complex - simple" and "orthogonal - free-form". Both of the adjective pairs are used to describe the form of digital architecture. Thus, we define the factor three as Formal Factor which means the formal feeling from viewer's visual image of digital architecture.

In the cluster one, only the adjective J3 and J9 are centralized visual image. Other adjectives, J1, J6 and J7, are shown as dispersed phenomena. Thus, the visual image of interactive factor in the cluster one shows comfortable and soft. In the same way to observe data, the visual image of interactive factor in the cluster two are shows natural. And the visual image of interactive factor in the cluster three shows distinct.

Following the method above, we find the features of visual image in the spatial factor could not be able to centralize in all the clusters. But we could still find out the adjective J11 shows a little wide in the visual image representation. Moreover, the adjective J10 shows more closed in the cluster two, and the cluster three shows obstructive and private. In the same way to analyze the data, the formal factor in the cluster one shows free-form.

And both of the cluster two and three show simple and orthogonal in the visual image. All the phenomena of three factors to the three clusters and their corresponding digital architecture samples are organized in the table two.

By comparing the data in the table two, we could find out the cluster one is more curving and smoother in the detail of design like angle and line. Moreover, all these samples in the cluster one have more open relationship between digital architecture and environment. These features could make viewer feel more comfortable and soft in the interactive visual image. The form of architecture let viewer feel more free and wide.

Un-similar to cluster one with curving form, the feature of architecture in the cluster two shows more simple and natural between the architecture and environment. These kinds of design make viewer feel natural in the interactive visual image. The formal are shown as simple and orthogonal as well as closed in the spatial image.

The orthogonal design concept in the cluster three are also let viewer feel simple in the architectural form. The relation between building and environment are distinct. And the orthogonal setting of the volume of building makes viewer feel more obstructive and private.

Table 4. Cluster analysis of Factor 3

		J2	J4	mean
1	A2	5.2	5.6	5.40
	A3	1.8	5.8	3.80
	A6	4.8	4.5	4.65
	A7	3.9	5.2	4.55
2	A1	4.8	1.1	2.95
	A8	5.4	0.4	2.90
3	A4	4.7	0.8	2.75
	A5	5.2	2.0	3.60
	A9	5.8	0.2	3.00

Table 5. Feature	es of Groups
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Factors	Cluster 1 Interactive	Cluster 2 Spatial	Cluster 3 Formal
Interactive factors	Comfortable and soft	Natural	Distinct
Spatial factors	A little wide	More closed	Obstructive and private
Formal factors	Free-form	Sample and orthogonal	Sample and orthogonal
Samples			

4. Conclusions

The result of this research shows that the communicative effect of design concept from architect has some differences with the viewer educated in the professional architecture field. Through the processing of discussion about the visual image of digital architecture, we could generalize some methods to execute the architectural design with feeling factor considering. These results could be used in the related studies of architecture design in the future.

However, due to the limitation of resource, this research only focuses on the communicative effect between designer and viewer who educated in the architecture field. The regular viewer's feelings are worth to be research in the future. Moreover, the oral protocol recorded by interviewing the designer would be stronger to the words on the publications. And the number of samples as well as the categories of architecture design could also be developed in the feature.

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