Application of Semantic Differential Technique to Evaluate Kansei Image in Architectural Design

Tai-Fen Hung* Chih-Kao Nieh**

**Dept. of Architecture and Interior Design, Cheng-Shiu University of Science and Technology; Architect; Doctoral Graduate School of Design, National Yunlin University of Science and Technology. Republic of China (Taiwan), super5168@yahoo.com.tw*

*** Dept. of Architecture and Interior Design, National Yunlin University of Science and Technology. Republic of China (Taiwan), niehck@yuntech.edu.tw*

Abstract: Most impressive architectures bring perceptual images from morphological elements and affect people's feelings. Kansei, a Japanese word, means **"**consumer's psychological feeling and image" and Kansei Engineering has translated feelings into specific parameters for architectural design. Semantic Differential Technique (SD) is applied for measuring emotional content in where adjectives used to describe perception. These issues are in pursuit of methodology of evaluating substantial image on Semantics Environment Description (SED) to demonstrate significant correlation based on SPSS statistics by investigating restaurants as follows: 1) To concrete SD application for accumulating 20 opposing semantic adjectives-pairs for questionnaire. 2) To extract 3 independent factors "Evaluation, Activity, and Potency" by Factor Analysis procedure with Spearman's correlation coefficient, K-M-O, and Bartlett's test of sphericity. 3) To emerge Kansei words to examine major factors responding to dimensional orthogonal vector-space. 4) To conclude on relationship between façades and images, and analyze shape elements creating plus or minus image categories.

Keywords：Kansei Engineering, Semantic Differential Technique (SD), Semantics Environment Description (SED), Image evaluation, Principal component analysis.

1. Introduction

Osgood, Succi, & Tannenbaum (1969) developed a method of measuring the emotional content with words more objectively, called 'Semantic Differential Technique', which more than 30 years later became one of the foundations of Kansei Engineering. Actually Kansei Engineering was developed by Professor Misuto Nagamachi in the early 1970s in Japan. (Simon T. W. Schtte et al., 2004)

Kansei, a Japanese word, when translated into English, it means 'consumer's psychological feeling and image' (Nagamachi et al., 1997). And also Kansei means the impression which somebody gets from a certain artifact, environment or situation using all the senses as well as cognition.

In order to measure Kansei image, this research is engaged in pursuit of understanding cognitive image, and predicting successful measuring methods for perspectives sentiments. The aims of this paper are to demonstrate approaches in Semantics Environment Description (SED) based on Kansei Engineering schema, in qualifying links between architectural shape and Kansei image. By SPSS computer statistics, we will investigate restaurant buildings on Wu-Quan Parkway in Taichung City, Taiwan for architectural- cognitive evaluation from a Kansei point of view as follows:

1) To scratch application for Semantic differential technique accumulating semantic adjectives pairs in order to concrete Kansei image.

2) To build SD inquiry questionnaire for evaluating façades survey to extract a lower number constructs in Factor Analysis. The fundamentals are Spearman's correlation coefficients and K-M-O measured.

3) To emerge Kansei words pairs to examine the major factors spanning dimensional orthogonal vector-space through connecting the Semantic Space.

4) To conclude on relationship between building façade and image evaluation, and analyze different shape elements creating plus or minus image categories.

2. Kansei theories

Design development by 'Kansei science' or 'Kansei Engineering' is a new approach. We give attention to the behaviors of people, and study how their personal preferences to their feelings. (SeungHee Lee, 2000)

SED emerges out of meaningfulness of a built environment. (GÉZA FISCHL, 2004), and goes through validation process by multidimensional scaling (Gärling, 1976) in simulated environments (Janssens & Küller, 1986), urban places (Küller, 1988), work environments (Janssens & Küller, 1989), color spaces (Mikellides, 1989), and applications are presented in Table 1.

SD scales were defined with a number of contrasting adjectives at each end on which the participants checked the position as Kansei Evaluation. All word pairs are described from a physical and a semantic perspective as building a three-dimensional orthogonal vector-space.

Table 1. The applications of Kansei Engineering from Mitsuo Nagamachi.

Author	Year	Topic	Resource
K.Nishikawa,Y.Hairasawa, and M. Nagamachi	1996	A study of Kansei Engineering as a Method for Evaluating the Thermal Environment	Human Factor in Organizational Design and Management, Elsevier Science B. V.
Yukihiro Matsubara, Mitsuo Nagamachi	1996	Kansei Virtual Reality Technology and Evaluation on Kitchen Design	Manufacturing Agility and Hybrid Automation-IR.J Koubek and W. Karwowski (Eds) IEA Press
Yukihiro Matsubara, Shigekazu Ishihara and Mitsuo Nagamachi	1998	A Fundamental Study on Evaluation System of Landscape for Kansei-Analysis	Human Factor in Organizational Design and Management, Elsevier Science B. V.
K.Nishikawa. Y. Hirasawa and M. Nagamachi	1998	A Study on Comfort of Bathroom Space on Kansei Engineering	Human Factor in Organizational Design and Management, Elsevier Science B. V.
Makoto ICHITSUBO, Koji Komatsu and Mitsuo NAGAMACHI	1998	Kansei Designing Analysis on Basic Bridge Struture	Human Factor in Organizational Design and Management, Elsevier Science B. V.

3. S.D Questionnaire Investigation for Kansei Image

3.1 Investigated examples

Generally speaking, many costumers approach shops because of importance of facade design matching their images. This article explores 16 façade images of photographs for restaurant buildings on West-Three Street and West-Four Street of Wu-Quan Parkway in Taichung City, Taiwan.

3.2 Image adjectives and semantic differential scales

Kansei words were collected by focus group with questionnaire submitted to 10 professionals. We built 20 opposing adjectives pairs (in Table 2) inquiry in 1-7 pointed interval scale from right to left with 56 participants received effectively in accordance with first author's research. (Tai-Fen Hung et al., 2008)

Table 2. The selected 20 adjective phrases

No.	Adjectives	No.	Adjectives	No.	Adjectives	No.	Adjectives
A 01	Urban-Rural	A 06	Grand-Trifling	A 11	Delicate-Rough	A 16	Individualized-general
A 02	Beautiful-Hideous	A 07	Vigorous-Dead	A 12	Contemporary-Classical	A 17	Orderly-Chaotic
A 03	Brilliant-Gloomy	A 08	Artistic-Vulgar	A 13	Dynamical-Static	A 18	Steady-Unsteady
A 04	Glowing-Naive	A 09	Newfangled-Superannuated	A 14	Symmetrical-Dissymmetrical	A 19	Sliding-Twisting
A 05	Transparent-Closed	A 10	Concise-Complicated	A 15	Gorgeous-Simple	A 20	Magnificent-Undersized

3.3 Result of exploratory Factor Analysis

Exploratory Factor Analysis (E.F.A.) is a multivariate analysis to analyze inherent factors by SPSS 12.0 statistics. Principal components analysis gives main image factors by reducing original 20 sets of adjectives.

3.3.1 Test of correlation coefficient matrix and Kaiser-Meyer-Olkin

The both fundamentals of Factor Analysis are Spearman's correlation coefficients statistically significant (p= < .01**), and Kaiser-Meyer-Olkin (K-M-O) value measured acceptably. The interpretations of the magnitude of K-M-O value teat are:K-M-O=80~0.89meritorious, K-M-O=0.70~0.79middling, K-M-O=0.50~0.59miserable (Sharma, 1996). Table 3 indicates that K-M-O values of 16 examples are acceptable, except that Example2 is miserable. Total K-M-O is measured of Sampling Adequency＞0.7, and result of Bartlett's test of sphericity is high significantly. Following guideline of Hair (2006), we identify with communalities less than .50 to delete indicators A06 (0.318) and A14 (0.445).

3.3.2 Factor loading analysis

1. Proper number of semantic axes factors

We used Factor Analysis to establish dimensionality with Eigen-value≧1 to get 3 factors. Scree plot reveals elbow before 3rd factor, because Eigen-value of 4th factor=0.820<1, and variance=4.556% < 5%.

2. Revealed constructs of best split

This solution explains 63.00% overall variance and alpha Coefficients are 0.735, 0.814, 0.913 separately. Cronbach $\alpha < 0.7$, and total alpha equals 0.931. The 3 extracted factors which were labeled, "Metal Feeling, Physical Feeling, and Tendency Value", spanning a three dimensional orthogonal vector-space, are considered for Evaluation, Activity, Potency. (Simon T. W. Schtte et al., 2004)

3. Results of factor loadings

1) Factor 1- Metal Feeling (Evaluation) is constructed by 9 Kansei words: They are belonging to cognitive range of psychology to architectural shape, including: design style, aesthetic feeling, material, texture, color, etc.

2) Factor 2- Physical Feeling (Activity) is defined by 5 Kansei words: These adjectives describe physics description characteristics abo ut building volume and construction; except "A 08 artistic-vulgar" psychological relatively.

3) Factor 3- Tendency Value (Potency) is formed by 4 Kansei words: These semantic adjectives are of high relevance with the value scene of the building or fashion ability. (Total results are summarized in Table 4)

3.3.3 Analysis of individual example semantic

According to image category a nd factor score in Table 5; it is generalized of these findings by analyzing individual image evaluation corresponding to Semantic Space factors in Table 7.

Table3. K-M -O and Bartlett's test

	Example01 E	xample02 E	xample03 E	xamle04	Example05 E	xample06 E	xample07 E	xample08
Kaiser-Meyer-Olkin Measure of Sampling Adequancy.	0.743	0.586	0.805	0.751	0.760	0.795	0.755	0.790
Bartlett's Test of Sphericity--Approx.Chi-Square	420.029	2.301	7.047	5.873	7.152	5.290	1.487	1.643
	Example09 E	xample10 E	xample11 E	xamle12	Example13 E	xample14 E	xample15 E	xample16
Kaiser-Meyer-Olkin Measure of Sampling Adequancy.	0.888	0.844	0.784	0.843	0.826	0.854	0.862	0.861
Bartlett's Test of Sphericity--Approx.Chi-Square	780.465	0.311	5.450	4.622	3.966	4.752	2.282	5.597

Table 4. Factor loadings after Varimax rotation

Factor name	Semantic Adjectives	Factor 1	Factor 2	Factor 3	Communality
A05	Transparent-Closed	0.769	0.167	0.176	.633
Metal	A01 Urban-Rural	0.753	0.117	0.134	.587
Feeling A	03 Brilliant-Gloomy	0.75	0.161	0.314	.683
(Evaluation) A	12 Contemporary-Classical	0.722	0.125	0.297	.613
A	02 Beautiful-Hideous	0.67	0.376	0.296	.672
	A09 Newfangled-Superannuated	0.653	0.318	0.413	.697
A0	7 Vigorous-Dead	0.591	0.116	0.544	.666
A10	Concise-Complicated	0.584	.553 -0	.177	0.652
A1	1 Delicate-Rough	0.523	.521	0.309	.622
A	18 Steady-Unsteady	-0.015	0.807	0.076	.615
Physical	A17 Orderly-Chaotic	0.436	0.723	.012	.726
Feeling A1	9 Sliding-Twisting	0.148	0.666	.251	.540
(Activity) A	20 Magnificent-Undersized	0.111	0.661	.346	.547
A0	8 Artistic-Vulgar	0.509	0.517	.322	.613
A	15 Gorgeous-Simple	0.121	0.32	0.724	.643
Tendency	A13 Dynamical-Static	0.459	0.02	0.613	.580
Value A	04 Glowing-Naive	0.525	0.056	0.563	.582
(Potency) A1	6 Individual-General	0.231	0.392	0.546	.485
	Eigen values	8.489	1 .765	1 .086	
	% of Variance	28.43%	19.43%	15.13%	
	Cumulative %	28.43%	47. 87%	63.00%	
	K M O	0.946			
	Bartlett's Test of Sphericity Ap	prox. Chi-Squre=8783.674 Sig. (p=< .00* **)			

Table 5. Image category and factor score for analysis

Example	REGR factor score 1 for analysis 1	REGR factor score 2 for analysis 1	REGR factor score 3 for analysis 1
1	-0.231	0.237	-0.758
2	0.439	-0.432	-0.467
3	-0.678	0.279	-0.522
4	-0.419	-0.126	0.221
5	-0.081	-0.219	-0.263
6	-0.723	0.496	-0.206
7	0.678	-0.098	-0.161
8	0.487	-0.126	0.264
9	0.356	0.081	0.040
10	0.023	0.796	-0.290
11	1.187	-0.039	0.590
12	-0.942	-1.044	0.115
13	-0.239	-0.139	0.452
14	0.392	0.273	0.385
15	-0.173	0.105	0.477
16	-0.105	-0.077	0.052

Table 6. Factor transformation matrix

Factor	1	2	3
1	.725	.508	.466
2	-.462	.860	-.219
3	-.512	-.056	.857

Extraction Method: Principal Axis Factoring. Ro tation Method: Varimax with Kaiser Normalization

1. Example 9 and Example 14 impress people strongest Metal Feeling, Physical Feeling and highest Tendency Value.

Elements of Example 9 consist of: timber floor, slice of glass, vertical stuff, stucco washing, white and green color. Shape elements of Example 14 are constituted to: veranda of oblique entry, semicircle arch window, glass windowsill, semicircle arch, whitewashed, timber, white color, etc.

2. Example 10 impresses plus Metal Feeling, plus Physical Feeling and minus Tendency Value.

The modern shape elements of Example 10 are constructed from: enormous Nframe entry, exposed horizontal beams, steel tube railing, horizontal belt stone, imitating brick, white and gray color, etc.

3. Example 8 and Example 11 impress plus Metal Feeling, minus Physical Feeling and plus Tendency Value.

The shape elements of Example 8 are composed of: rectangular glass curtain, concrete signboard, steel, cement, white and brown color, etc. And shape elements of Example 11 are made of: glass curtain wall, spatial extensity, the mass of rectangle solids, stucco washing, white and red color, etc.

Table 7. Example Semantic-Space configuration

Factor 1	Factor 2	Factor 3	Example
Metal Feeling+	Physical Feeling+	Tendency Value+	9  14 
Metal Feeing+	Physical Feeling+	Tendency Value-	10 
Metal Feeling+	Physical Feeling-	Tendency Value+	8  11 
Metal Feeling+	Physical Feeling-	Tendency Value-	2  7 
Metal Feeling-	Physical Feeling-	Tendency Value-	5 
Metal Feeling-	Physical Feeling-	Tendency Value+	4  12  13  16 
Metal Feeling-	Physical Feeing+	Tendency Value-	1  3  6 
Metal Feeling-	Physical Feeling+	Tendency Value+	15 

4. Example 2 and Example 7 affect people plus Metal Feeling, minus Physical Feeling and minus Tendency Value.

The Shape elements of Example 2 comprise: cuboids, oblique rain drips, large mass, eaves, cement, glass, false glazed tiles, gray and green color, etc. The shape elements of Example 7 are: rectangular glass, dull and stereotyped frame of twill, rectangular windows, canvas, glass, white and blue color, etc.

4. Discussion and conclusion

We have conclude from these observations that impression rated by using Semantic Differential Technique (SD) structure in Kansei model demonstrates high valid and reliable measurements, and relevance between the Kansei image and façade evaluation is more qualitatively and objectively. This research conceived the idea of SD technique for application to evaluate architectural image constructed with a scientific and objective approach.

Future research can be addressed to further understand the differences of testee's influential cues and attributes of background. Not only by focus group analysis, but also by constructing appropriate Kansei pairs through literature review, we could increase the widespread of adjectives. It is also important to distinguish stimuli by high similarity, and contrast with the classifications of architectural shape design by cluster analysis with Ward law of the image characteristics. These contributions from this research towards methodologies of qualifying links between architectural shape and Kansei image by application of Semantic Differential Technique can be divided into four parts as follows:

1. The semantic adjectives evaluation demonstrates high statistical correlation.

It is an inevitable reality that Spearman's correlation coefficients for semantic pairs are considered statistically significant to concrete the fundamental of Factor Analysis. Each K-M-O measured of Sampling Adequency displays between 0.751 and 0.882 (greater than 0.7) and Bartlett's test of sphericity (> 390) is high valued quantitatively.

2. E.F.A. analysis summarizes three factors with high validity and reliability.

Exploratory Factor Analysis (E.F.A.) revealed a construct structure of rating semantic adjectives, and it

extracted three factors- Metal Feeling (contribution ratio: 28.43%), Physical Feeling (19.43%), Tendency Value (15.13%). Furthermore Cumulative contribution of 3 factors approves variance achievement 63.00%. Besides total reliability investigation calculating Cronbach's alpha achieves 0.931 high degrees of acceptability.

3. This three extracted factors are corresponding to Semantic Space.

That three factors "Metal Feeling, Physical Feeling, Tendency Value" represent "Evaluation, Activity, Potency" associated with three factors of Semantic Space formulated by Osgood (1957) originally. Moreover, these Kansei words have illustrated this three constructs with individual semantics absolutely.

4. Different shape elements create plus or minus image categories.

Kansei images are symbolized of design elements conscientiously by factor loading for individual image category- plus or minus Metal Feeling, Physical Feeling and Tendency Value. These research pursuits have made some contribution by statistic computer-aided architectural design. Example 9 and Example 14 impress people strongest Metal Feeling, Physical Feeling and highest Tendency Value extremely.

5. Reference

[1]Carmen Llinares, Alvaro Page (2007) Application of product differential semantics to quantify purchaser perceptions in housing assessment, *Building and Environment* 42, pp 2488–2497.

[2]Gärling, T. (1976) A multidimensional scaling and semantic differential technique study of the perception of environmental settings, *Scandinavian Journal of Psychology,* 17, pp 323-332.

[3]GÉZA FISCHL (2004) A Psychosocial Approach to Architectural Design: A Methodological Study, *Division of Engineering Psychology*, Department of Human Work Sciences, Luleå University of Technology, Sweden, p 7.

[4]Hair, Jr. F., Black, W.C., Babin, B.J., Anderson, R.E., & Tatham, R.L. (2006) *Multivariate data analysis*, 6th ed., NY: Macmillan Publishing Company, p 131.

[5]Hung-Cheng Tsai, Shih-Wen Hsiao, Fei-Kung Hung (2006) An image evaluation approach for

parameter-based product form and color design, *Computer-Aided Design* 38, pp 157–171.

[6]Janssens, J. & Küller, R . (19 86) Utilizing an env ironmental si mulation labo ratory in Swed en, In R. C. Smardon, J. F. Palmer & J. P. Felleman (Eds.), *Foundations for visual project analysis*. Wiley, New York.

[7]Janssens, J. & Kü ller, R. (1 989) Väd ertjänstens arb etsmiljö. Miljö psykologi studie av förh ållandena vid Sturup flygp lats. (Meteoro logists' work en vironment. A p sychological stu dy of t he con ditions at Stu rup Airport). *Environmental Psychology Monograph.* No . 7, School of architectu re: Lund In stitute of technology, Lund, Sweden.

[8]Mikellides, B. (1989) *Emotional and behavioural reaction to colour in the built environment*. Ph. D. Thesis, Oxford: Oxford Polytechnic.

[9]Nagamachi, M (1997) Kansei E ngineering: t he framework and m ethods, in M . N agamachi (ed.), *Kansei Engineering* 1,Kaibundo Publishing co. Ltd, Kure., pp 1-9.

[10]Osgood,C.E. (1969) T he nat ure a nd m easurement of meaning, i n C .E. Os good and J . G . Sni der (eds), *Semantic differential technique- a source book*, Aldine publishing company, Chicago, pp 3–41.

[11]SeungHee Lee, Akira Harada, Pieter Ja n Stappers (2000) *Pleasure with Products: Design based on Kansei,* Delft: Netherlands.

[12]Sharma, S. (1996) *Applied multivariate techniques*. New York: John Wiley.

[13]Simon T. W. Schtte, Jgen Eklund, Jan R. C. Axelsson and Mitsuo Nagamachi (May –June 2004) Concepts, methods and tools in Kansei Engineering,*Theor. Issues in Ergon. Sci.,* vol. 5, no. 3, 214–231, pp 1–22.

[14]Tai-Fen Hu ng, Chih-Kao Nieh (2008) A Research on I mage Evaluation o f Architectural Sh ape Thr ough Theory in Kansei Engineering-Taking Restaurant Buildings of Wu-Quan Parkway in Taichung City as Examples, *ISAIA 2008,* thesis Ⅱ, pp 495-501.

[15]Tai-Fen H ung, Chih-Kao Nieh (2 009) A S tudy on Relationship bet ween Modern Arc hitectural Sha pe and Kansei Image Evaluation -- Taking Diversity for Distinctive Customers as Example, *WhoseEA2009(SAHT)*