STUDY ON THE COGNITIVE PATTERNS OF COMPLEXITY IN THE VISUAL COMPOSITION OF STREETSCAPES IN ALGERIA AND JAPAN

日本とアルジェリアの街路景観における複雑性の形態認識に関する研究

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This research is a comparative study of the cognitive patterns of complexity in the context of streetscape visual composition in Algeria and Japan. 80 visual arrays of streetscapes in Algeria and Japan have been collected and then presented to 20 subjects from different cultural backgrounds in order to be categorized according to their typology and degrees of complexity. The analysis has been structured according to 3 phases: 1) the typological clustering phase using cluster analysis; 2) the lexicon-based clustering phase using Hayashi quantification method type III as well as cluster analysis, which represents analyses oriented mainly towards the visual arrays as physical data. Finally, 3) the cognitive patterns clustering phase using factor analysis and cluster analysis, which is oriented towards subjects as Human data. The results showed that complexity, disorder, irregularity and disorganization are often conflicting concepts in the urban context. Algerian daytime streetscapes seem to be balanced, ordered and regular, and Japanese daytime streetscapes seem to be unbalanced, regular and vivid. Variety, richness and irregularity seem to characterize Algerian night streetscapes. Japanese night streetscapes seem to be more related to balance, regularity, order and organization. The research could figure out 3 basic factors, which are: 1) actors (man-made forms, human, etc.); 2) style; and 3) the combination of materials/activity/actors. The number of actors in each visual array reflects its degree of complexity. The higher the amount of actors the higher the degree of complexity.

Keywords: Streetscape, Nightscape, Complexity, Visual Array, Affordance, Cognitive Pattern.
街路景観，夜景，複雑性，視覚要素，アフォーダンス，形態認識

1. Introduction

Complexity is a concept that covers many aspects of the urban environment. Nowadays, city dwellers deal with an increasing complexity ascending from the smallest details to the whole urban scenery. The common question that emerges from this phenomenon is related to the origin of this complexity. This has been the subject of many researches dealing with a variety of aspects of the built environment, from its morphological aspects to its visual dimension. This research focuses on the determination of the cognitive patterns related to the degrees of complexity within series of different streetscapes from different physical environments in Algeria and Japan.

2. Conceptual Background

According to Rapoport (1987), a street is a more or less narrow and linear urban space lined by buildings, found in settlements and used for circulation and other activities. In the street scale, sidewalks permit local interactions and create a complex order dealing with the sensory overload and making the hu-

man nervous system stretched by the built environment. This research is a preliminary study about the concept of complex order within streetscape composition as a visual array. In environmental psychology, complexity is related to the involvement component, which means: "How much there is to see in a visual array?", and to the concept of affordance that refers to what a perceived scene has to offer as far as the perceiver is concerned (Kaplan, 1988). As complexity emerges from the collective behavior of many interactive units, this research considers a streetscape composition as a visual array within which many classes, all composed of smaller sub-systems, exist in a continuous interaction. "Sky, Ground, Buildings, Vegetation and Actors" could be identified as the 5 main classes within a streetscape visual array (Fig.1).

3. The Research Problem and Strategy

The aim of this study is to explore the degree of complexity that a streetscape composition can express and the evaluation of this complexity according to different subjects (individuals) with different cultural backgrounds.

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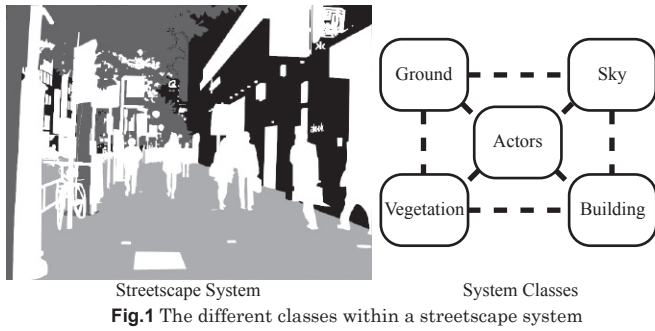**** Kajima Corporation, Dr. Eng.

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Streetscape System   System Classes

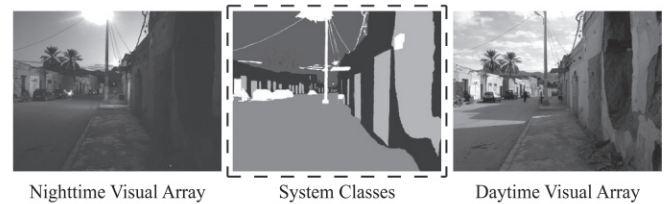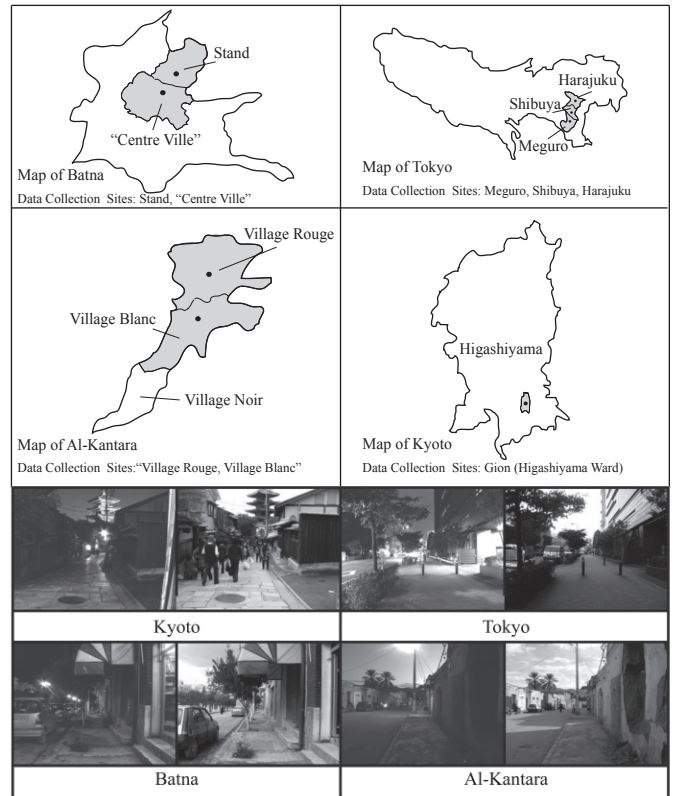**Fig.1** The different classes within a streetscape system

The strategy behind this study was structured throughout 3 general steps. First, collecting the visual arrays (samples). Second, conducting the experiments (3 experiments were done in this study). Third and finally, analyzing the results. The experimental and the analysis steps were done in parallel, following the logic and the objectives of each experiment. The Analysis step has been structured according to 3 phases. The first typological clustering phase, using cluster analysis. The second lexicon-based clustering phase oriented towards the visual arrays as physical data (Samples) and using Hayashi quantification method (type III) as well as cluster analysis. Finally, the third phase is related to the cognitive patterns clustering phase using factor analysis and cluster analysis, which is oriented towards subjects (Human data), (Fig.2).

Fig.2 The research steps and the analysis phases
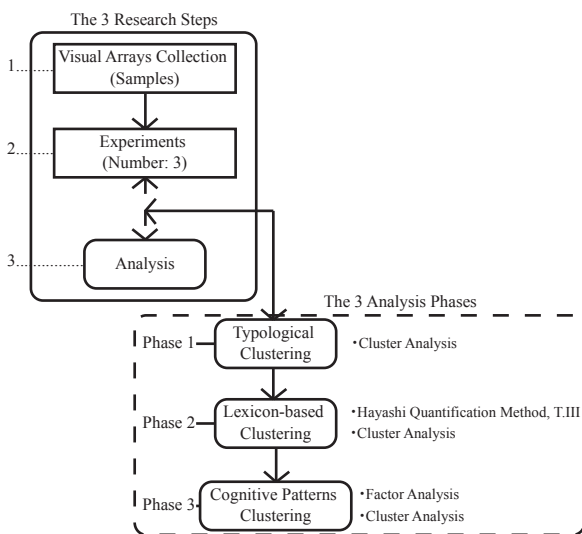
3.1 Visual Arrays Collection

Because of research feasibility in terms of means and time limits, this research could not cover a large number of cities in both Algeria and Japan. In order to avoid over-simplification and generalization of the concepts that will issue from this research, the authors based the collection of the samples (visual arrays) on the idea of selecting 2 cities from each country in which the collection will be done (Fig.3). Tokyo and Batna were chosen because they offer many urban landscapes with aspects of modernity. Kyoto and Al-Kantara were chosen as cities rich of traditional built environments. The process of samples collection was based on the idea of taking two visual arrays of the same streetscape, from the same shooting location, one in dayti-

Fig.3 The Samples Collection Sites

Nighttime Visual Array   System Classes   Daytime Visual Array

Fig.4 The Data Collection Method

me and another one in nighttime (Fig.4). The Collection of the different visual arrays was done in 2008 during 2 phases. The first phase was done in the 14th of september in Kyoto and in the 16th of October in Tokyo. The second phase was done in the 26th of November in Al-Kantara and in the 3rd of December in Batna. All the phases were done between 14:00-17:00 in daytime and between 19:00-21:00 in nighttime. The selection of shooting time and locations of the photos shooting areas respected the common features between the visual arrays in matter of activity (automobile, people), street size, lighting, etc., in order to avoid any fallacious judgment by the subjects. A total number of 176 visual arrays could be collected from different sites within these 4 cities. After a random selection, the authors selected 80 visual arrays with an equal number of 40 Pictures (20 daytime and 20 nighttime samples) from each country (Table.1). These samples will represent the object of the experimental phase in this study.

Table 1 Samples Selection

Country	City	Period	Collected Data	Selected Data
Japan	Kyoto	9 -2008	24	20
	Tokyo	10 -2008	62	20
Algeria	Al-Kantara	11 -2008	58	20
	Batna	12 -2008	32	20
	Total		176	80

3.2 Experiments and Analyses

Twenty students from Nagoya Institute of Technology and Nagoya University agreed to participate in this research experiments (Table.2). The strategy was to have 2 groups of subjects; the first group is composed of 10 Japanese students and the second one is composed of 10 foreign students with different cultural backgrounds (Kenya, Brazil, Germany, Pakistan, Indonesia and Morocco).

Table 2 Number of subjects

Subjects	Japan	Germany	Morocco	Pakistan	Kenya	Indonesia	Brazil	Total
Japanese	10							10
Foreigners		1	1	2	2	1	3	10

3.2.1 Typological Clustering

The first analysis phase was the typological classification of the samples using cluster analysis (Ward method) in order to determine the typology of the samples that will be analyzed. The 80 visual arrays were printed out in A4 paper format (CMYK color format), then presented to 10 subjects (5 Japanese and 5 foreigners). They were requested, one by one, to categorize the 80 samples into different groups according to their physical and functional features (for example: residential streets, traditional streets, etc.). The data collected from their different classifications helped in designing a similarity matrix that connects all the samples together. This similarity matrix served as a basis for the application of cluster analysis (Ward method) to figure out the different types of streetscapes included within these 80 samples (Fig.5). The resulting typology could be summarized as follows:

Algerian Daytime Streetscapes: "GrD.1(Alg)": Traditional streetscapes. "GrD.2(Alg)": Avenues with green infrastructure. "GrD.3(Alg)": Quiet, residential streetscapes.

Japanese Daytime Streetscapes: "GrD.A(jp)": Avenues, Commercial streetscapes. "GrD.B(jp)": Quiet streetscapes with green infrastructure. "GrD.C(jp)": Traditional streetscapes.

Algerian Night Streetscapes: "GrN.1(Alg)": Quiet, wide, traditional night streetscapes. "GrN.2(Alg)": Dark, narrow, quiet, traditional night streetscapes
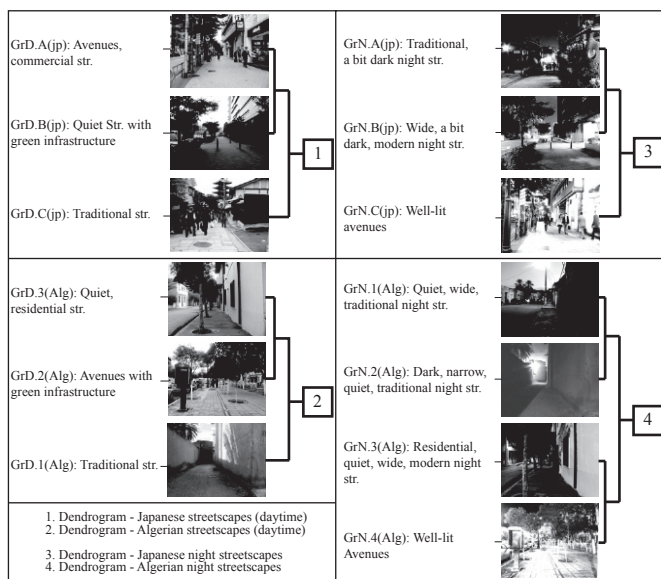

Fig.5 Typological clustering using cluster analysis

"GrN.3(Alg)": Residential, quiet, wide, modern night streetscapes. "GrN.4(Alg)": Well-lit avenues.

Japanese Night Streetscapes: "GrN.A(jp)": Traditional, a bit dark, night streetscapes. "GrN.B(jp)": Wide, a bit dark, modern night streetscapes. "GrN.C(jp)": Well-lit Avenues.

3.2.2 Lexicon-based Clustering

This phase is concerned with the study of samples as physical items. Hayashi Quantification Method (Type III) was applied in order to cluster these samples into different groups according to a lexicon based on the concept of complexity and to determine the characteristics of each typological group of samples (see typological clustering). This lexicon included many corollary concepts with complexity, such as: irregularity, heterogeneity, disorder, ambiguity, etc. The experiment was done individually by the main author according to a two points scale scoring (1,0). All the 80 samples were evaluated, one by one, following the list of adjectives of this lexicon. The results of the scoring served as a basis for the application of Hayashi Quantification Method (Type III) and Cluster Analysis (Ward method) in order to classify all the samples into groups according to their corresponding Complexity-based vocabulary (Fig.6).

The authors could realize that order characterized traditional streetscapes in the Algerian daytime category. The residential streetscapes and avenues seemed to be attractive; therefore richness was more related to Avenues. In the Japanese daytime category, disorder was the aspect of traditional streetscapes whereas avenues were characterized by balance and attractiveness. Complexity, heterogeneity, irregularity, unbalance and disorganization were more related to the Japanese streetscapes with green infrastructure. In the Algerian nighttime category, traditional night streetscapes as well as Avenues were irregular and disorganized. Therefore, wide traditional night streetscapes had some aspects of order and the narrow traditional night streetscapes were joyless and uninteresting. Balance was an aspect of avenues nightscapes and wide residential night streetscapes had some aspects of organization, regularity and variation. In the Japanese nighttime category, balance, disorder and irregularity characterized traditional nightscapes. Well-lit avenues were varied but unambiguous and wide modern night streetscapes had some aspects of disorder, balance and attractiveness (Table.3).

In a more general scale, Algerian daytime streetscapes were balanced, ordered, regular and organized with some aspects of simplicity and homogeneity. Japanese daytime streetscapes were vivid, attractive and beautiful with

Table 3 Streetscapes characteristics issued from lexicon-based clustering

| Category	Group	Characteristics
Algerian Daytime Str.	GrD.1(Alg)	(Balanced, Ordered, Organized) (Confusing, Depressing, Repulsive)
	GrD.2(Alg)	(Vivid, Active, Rich) (Attractive, Beautiful, Interesting)
	GrD.3(Alg)	(Calming, Inviting, Opened) (Attractive, Beautiful, Interesting)
Japanese Daytime Str.	GrD.A(jp)	(Attractive, Balanced, Expressive)
	GrD.B(jp)	(Irregular, Unbalanced, Disorganized) (Complex, Beautiful, Heterogeneous)
	GrD.C(jp)	(Irregular, Unbalanced, Disorganized) (Vivid, Disorganized, Interesting)
Algerian Nighttime Str.	GrN.1(Alg)	(Inviting, Soft, Ordered, Familiar) (Foggy, Heterogeneous, Disorganized)
	GrN.2(Alg)	(Foggy, Heterogeneous, Disorganized, Irregular)
	GrN.3(Alg)	(Organized, Regular, Active, Unambiguous)
	GrN.4(Alg)	(Foggy, Heterogeneous, Disorganized, Irregular)
Japanese Nighttime Str.	GrN.A(jp)	(Vivid, Attractive, Balanced, Beautiful, Disordered)
	GrN.B(jp)	(Vivid, Attractive, Balanced, Beautiful, Disordered)
	GrN.C(jp)	(Joyous, Varied, Clear, Unambiguous)
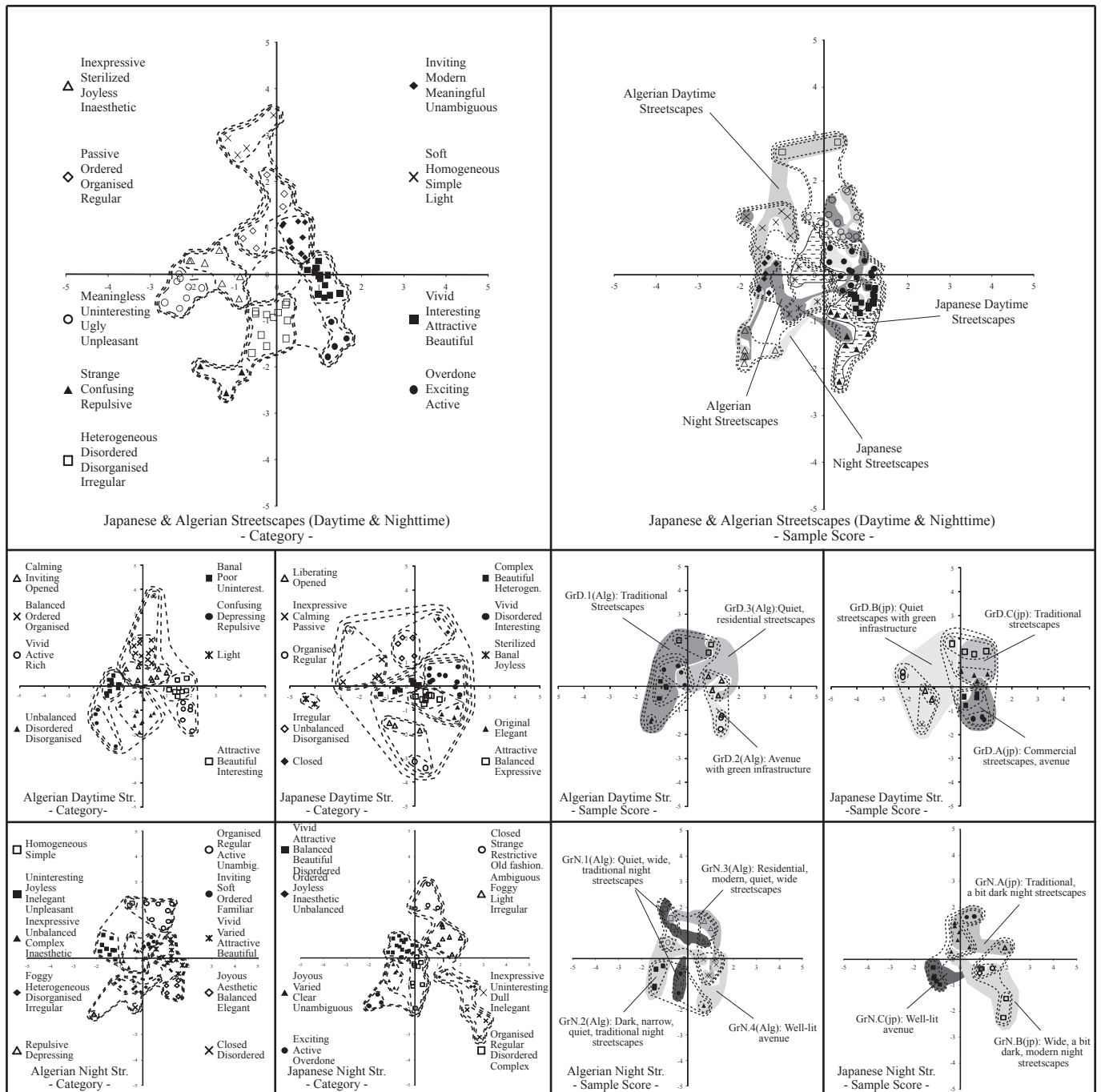
Fig.6 Hayashi Quantification Method (Type III) - category and sample scores -

some aspects of unbalance and regularity. Algerian night streetscapes seemed to be ambiguous, unbalanced and ordered with some aspects of confusion and repulsion. Attractiveness, order, organization and regularity characterized Japanese night streetscapes with some aspects of confusion, repulsion and inelegance.

3.2.3 Cognitive Patterns Clustering

The main aim of this phase was the study of the subjects (participants) and to figure out the way they see complexity within the range of the collected samples. 20 subjects were asked to classify and categorize 80 samples according to a seven points scale of complexity. The idea was to open the boundaries of the research from a two (1,0) scales scoring method (lexicon-based clustering) focused on physical data (samples) to a wider range of scoring (1 to 7)

analysis focused on human data (subjects). The Japanese subjects classified the pictures according to a 7 points scale written in Japanese: "非常にシンプル、かなりシンプル、ややシンプル、どちらでもない、やや複雑、かなり複雑、非常に複雑", whereas foreign subjects classified the pictures according to a seven (7) points scale written in English (Fig.7). Before the experimentation, the authors explained the aim of the experiment to the subjects and asked them to consider first each visual array as a whole set of interacting classes and elements. Then, to classify these visual arrays according to the given scale of complexity, with regard to their feelings towards each set of interacting classes (actors, vegetation, building, sky, ground).

The results of this experiment were collected into a large matrix that includes the scoring of the samples from each subject. Factor Analysis (focu-
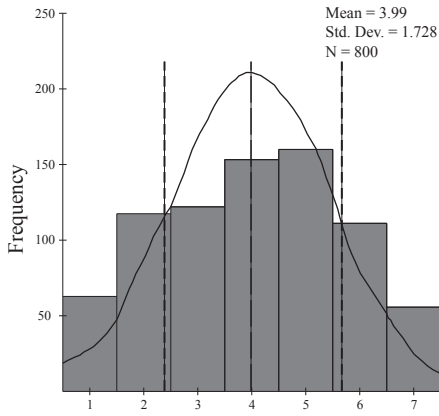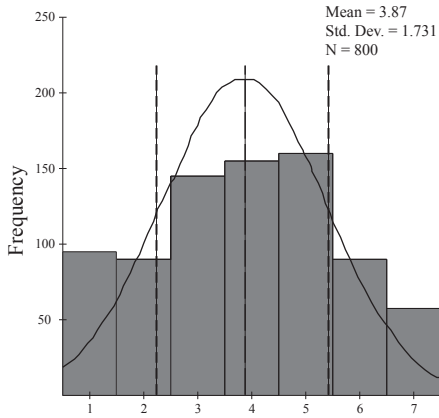
Fig.8 Japanese subjects

Mean = 3.99
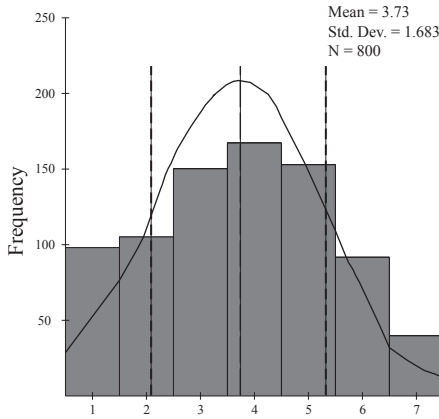Std. Dev. = 1.728
N = 800

Fig.9 Foreign subjects

Mean = 3.87
Std. Dev. = 1.731
N = 800

Fig.10 Female subjects

Mean = 3.73
Std. Dev. = 1.683
N = 800

Fig.11 Male subjects

Mean = 4.14
Std. Dev. = 1.753
N = 800

Very Simple	Considerably Simple	A bit Simple	Ordinary	A bit Complex	Considerably Complex	Very Complex
1	2	3	4	5	6	7
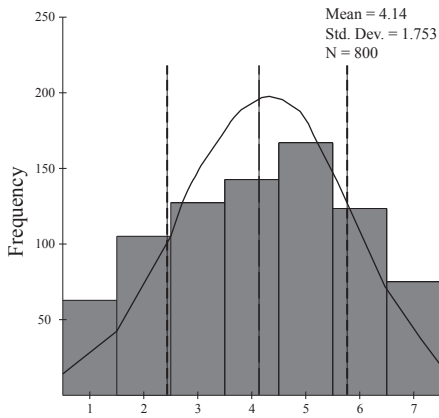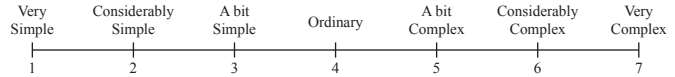
Fig.7 Complexity ranking and categorization scale

- - ◄ - St. Dev (-)
— ◆ — Mean
- - ■ - St. Dev (+)

JM Japanese Male
JF Japanese Female
FM Foreign Male
FF Foreign Female

Fig.12 Samples general chart

— ◆ — Algerian Daytime Streetscapes
— ■ — Algerian Nighttime Streetscapes
- - ▲ - - Japanese Daytime Streetscapes
— ✕ — Japanese Nighttime Streetscapes

Fig.13 Samples' categories chart
(Daytime & Nighttime)

Table 4 Results of factor analysis (after Varimax rotation)

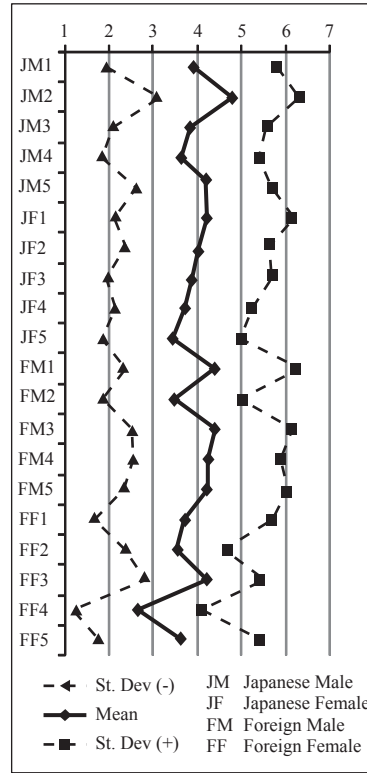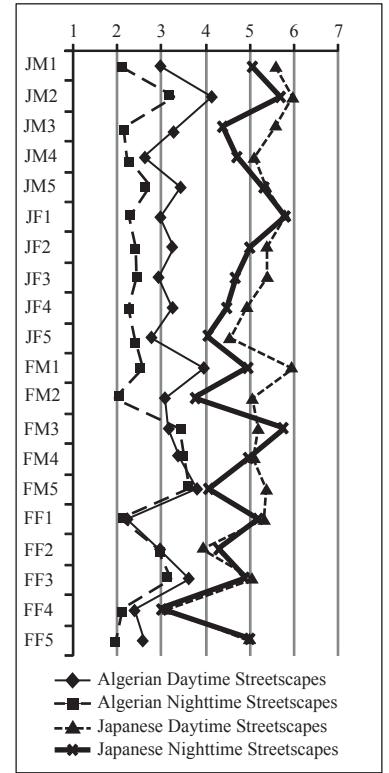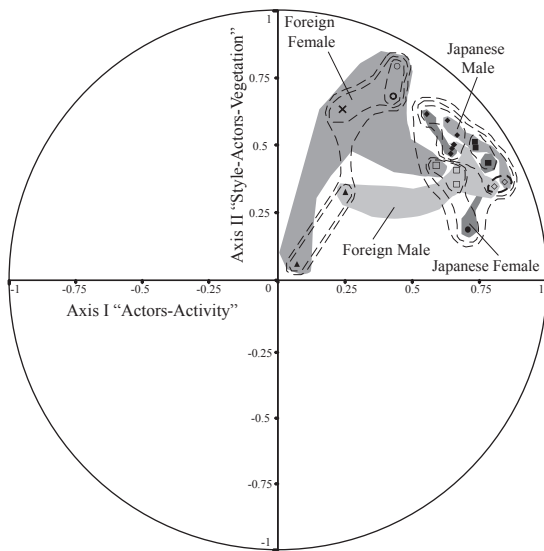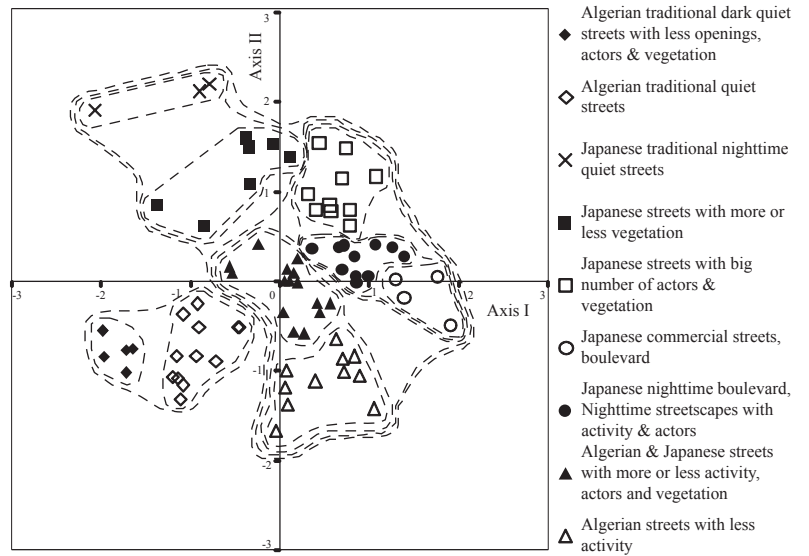| Variables	Factors			Communalities
	1	2	3	
JM3	**0.843**	0.365	0.280	0.918
FM1	**0.805**	0.349	0.168	0.817
JF4	**0.782**	0.438	0.304	0.901
JM1	**0.733**	0.494	0.284	0.879
JM2	**0.730**	0.515	0.277	0.896
JF5	**0.704**	0.188	0.422	0.739
JM4	**0.666**	0.539	0.362	0.861
FM5	**0.665**	0.356	-0.276	0.649
FM2	**0.665**	0.408	0.324	0.790
FM3	**0.655**	0.502	0.218	0.798
JF2	**0.646**	0.489	0.493	0.901
JF3	**0.641**	0.469	0.367	0.829
JM5	**0.629**	0.594	0.281	0.846
FF2	**0.589**	0.425	0.036	0.656
FF1	0.444	**0.795**	0.102	0.782
FF5	0.430	**0.681**	0.261	0.739
FF3	0.240	**0.633**	0.120	0.475
JF1	0.553	**0.616**	0.336	0.860
FF4	0.071	0.061	**0.689**	0.444
FM4	0.250	0.327	**0.487**	0.591
Eigen Value	13.438	1.385	0.928	*Extr. Method: Principal Axing Factoring*
% of Variance	67.190	6.923	4.641	
Cumulative Contribution Rate	67.190	74.113	78.755	*Rot. Method: Varimax with Kaiser Normalisation*
Factors Description	Actors-Activity	Style-Actors-Vegetation	Materials-Activity-Style	

Fig.14 Subjects Clustering Chart (Factors I & II)
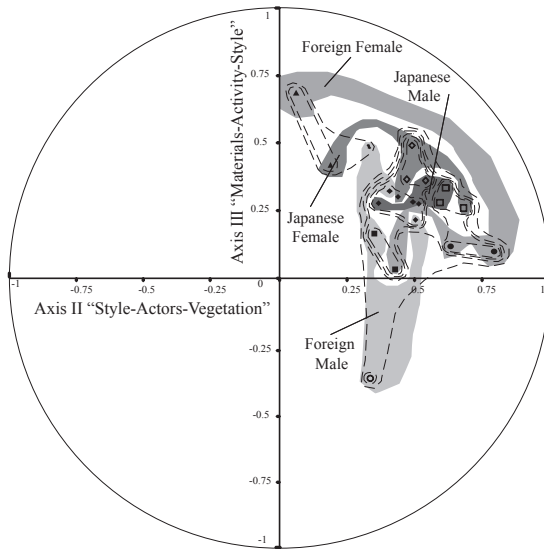

Fig.17 Samples Clustering Chart (Factors I & II)

Algerian traditional dark quiet streets with less openings, actors & vegetation

Algerian traditional quiet streets

Japanese traditional nighttime quiet streets

Japanese streets with more or less vegetation

Japanese streets with big number of actors & vegetation

Japanese commercial streets, boulevard

Japanese nighttime boulevard, Nighttime streetscapes with activity & actors

Algerian & Japanese streets with more or less activity, actors and vegetation

Algerian streets with less activity

Fig.15 Subjects Clustering Chart (Factors II & III)

Fig.18 Samples Clustering Chart (Factors II & III)

Japanese streets with many actors, important activity, more or less vegetation

Japanese streets with more or less actors, activity & vegetation

Quiet Algerian streets

Algerian streets with many natural elements & few activities

Open Algerian streets with few activities

Japanese nighttime streets with a lot of furniture, light and vegetation

Large streets with more or less activity

Large streets with less activity, important amount of actors & vegetation

Fig.16 Subjects Clustering Chart (Factors I & III)

Fig.19 Samples Clustering Chart (Factors I & III)

More or less large streets with less activity & vegetation

Japanese daytime boulevard, with many actors and activity

Streets with less activity and many actors

Japanese streets with a lot of activity, many actors & a lot of vegetation

Large streets with few activity but more actors and furniture

Quiet Algerian streets without activity & less actors

Quiet streets with less activity and some natural elements

Traditional streets with some activities, natural elements, vegetation and some actors

Traditional quiet streets with no activity

Nighttime Algerian traditional streetscapes without activity

sed on the human scoring (subjects)) was used in order to find out the factors that may reflect possible cognitive patterns related to the estimation of complexity within the visual composition of the collected streetscapes. The results of factor analysis served also as a basis for cluster analysis (Ward method) in order to categorize the samples as well as the human cognitive patterns (Fig.8, 9, 10, 11, 12 & 13). Three factors could be identified as a result of factor analysis (Table.4). The first factor was the one of "Actors-Activity" (Fig.14, 16, 17 & 19). "Actors" mean the set of components that include any kind of man-made elements, urban furniture, vehicles, human, creatures, etc. This study found a relationship between the number of "actors", as a class, and the degree of complexity of a visual array. The higher the number of "actors", the higher the degree of complexity. Complexity increases also with the number of openings and activity, as a result of the dynamic components (human, vehicles) within the "Actors" class. The second factor was characterized by "Style-Actors and Vegetation" (Fig.14, 15, 17 & 18) that determine the degree of complexity. Within this factor, almost all Japanese streetscapes were classified as complex, whereas the Algerian streetscapes were classified as simple or ordinary. Finally, the third factor represented a combination of 3 features: "Materials-Activity-Style" (Fig.15, 16, 18 & 19). Materials, details and Style make Japanese streetscapes look more complex than the Algerian ones.

4. Conclusion

Complexity is a multidimensional concept. Throughout this study, many results could show that some concepts related to complexity, such as disorder, irregularity and disorganization are often conflicting and contradictory. In many cases, order was related to disorganization and complexity was related to regularity and organization. Therefore, this study could notice that concepts, such as: variety, richness and irregularity with some aspects of order and organization seem to be the major aspects of Algerian night streetscapes. Japanese night streetscapes tend to be attractive, balanced, regular, ordered and organized with some aspects of confusion and ambiguity. Concepts like: balance, order, regularity and homogeneity seem to characterize Algerian daytime streetscapes, whereas unbalance, regularity, vividness and attractiveness seem to be the major characteristics of Japanese daytime streetscapes.

As a factor, "Actors" seems to be a generator of complexity in streetscape composition. It has other corollary factors such as Activity, reflected by human and urban components. Vegetation, natural elements as well as building style and materials represent also components that contribute in generating this complexity.

Research about complexity is a touchy subject because of its close dependence on many different corollary concepts. This study tried to explore complexity in streetscape composition through three methods of data clustering related to typology, lexicon and cognitive patterns. The authors believe that the use of other methods, such as semantic differential method, would open the boundaries of this research on other perspectives. Therefore, exploring the geometric logic and the origins of this complexity should be the aim of future researches about complexity and disorder in streetscape composition.

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和文要約

本研究は、日本とアルジェリアの街路景観における複雑性の認識を比較したものである。まず、80枚の街路景観の写真を収集し、これらを20人の被験者に見せた。なお、文化的背景の違いによって分類するために、被験者は様々な文化的背景を持っている。続いて、被験者に対して対象とした都市の写真を提示し(1)写真を類似したグループに分類、(2)写真を評価する形容詞対の分類(数量化Ⅲ類)、(3)写真に対する評価をもとにした被験者の認識パターンの分類の手順で解析を進めた。数量化の結果、複雑性、不規則性、無秩序性などが都市の不調和をもたらす概念であることが明らかになった。アルジェリアの日中の街路景観はバランスが良く規則正しいと見られているのに対し、日本の日中はバランスが悪く躍動的である。そして、アルジェリアの夜は多彩かつ豊かであると見られているのに対し、日本の夜は乱雑であいまいである。因子分析の結果、「主体 (ドア、家具、自動車など)」、「スタイル」、「材料、人間や主体の組み合わせ」の3因子が複雑性に関係していることが明らかになった。特に主体の数は複雑性の度合いに関係し、主体数が増えるほど複雑になっていくのである。