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Study on Objective Visual Complexity in Streetscape Composition in Algeria and Japan

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Visual Complexity Cognitive appraisal RMS Contrast
Objective Complexity Subjective Complexity

1. Introduction

This research attempts simultaneously to explore two aspects of complexity in the visual composition of streetscapes. (1) The subjective experience of complexity as seen by Algerian participants. (2) The intrinsic physical contrast in the composition of the visual arrays that represent series of different streetscapes from different physical environments in Algeria and Japan.

2. Method

The dataset was composed of 74 streetscape pictures. 37 pictures were shot in Al-Kantara and Batna cities in Algeria. The other 37 pictures were taken in Kyoto and Tokyo cities in Japan. Among the dataset, 40 pictures were acquired in daytime and 34 pictures in nighttime using a digital camera Nikon D300S. All images were taken between June and August 2011. The image quality was 14bits/pixel with a resolution of 4288 x 2848 pixels. The converted images were represented in large high resolution displays and subjectively evaluated by ten Algerian participants. Participants were asked to rate the images complexity using a general complexity scale from 1 to 3, and to divide them in three groups: simple, ordinary, and complex. Then, they were asked to rate them within each group according to an increasing order of complexity. For objective analysis, these images were transformed to grayscales and resampled to 1072 x 712 pixels.

2.1. Subjective Analysis of visual complexity

The descriptive statistical analysis of the data issued from the subjective evaluation helped in checking the variables and in understanding the characteristics of the collected results (Fig.1 & 2).The results of the subjective evaluation helped in analyzing the factorial structure of the cognitive appraisal related to the visual complexity within the collected streetscapes (Tab. 1). Cluster analysis was used in order to classify the resulting item scoring into different clusters related to subjective complexity (Fig.3, 4 & 5).

After gathering the ranked data from the participants, it was necessary to represent the divisions between complexity categories. These divisions could be identified by including two more imaginary items within the dataset, with additional ranking positions that represent two axes of separation. Rank positions *i*, where *i=1, 2, … ,76*, were scaled down to *c*-scores *c(i)*.

$$c(i) = 2.\frac{i-38.5}{22}+5 \qquad (1)$$

The final rank *r* of each picture was calculated based on its averaged positioning

$$r = \frac{1}{3}\sum_{i}^{76}\left[vi.c(i)\right] \qquad (2)$$

Where *vi* is the number of times the specific image was voted or located by the participants at position *i*. Figure 6 shows the range of *r*-values for each streetscape category. The category of simple streetscapes consists of 14 Algerian streetscapes; ten daytime streetscapes and four nighttime streetscapes. The category of ordinary streetscapes includes 35 scenes: 22 Algerian streetscapes and 13 Japanese streetscapes; 16 daytime streetscapes and 19 nighttime streetscapes. The category of complex streetscapes includes 25 scenes: one Algerian streetscape and 24 Japanese streetscapes; 14

Tab.1 Results of factor analysis (after Varimax rotation)

Variables	Factor I	Factor II	Communalities
AF1	0.73	0.24	0.57
AM1	0.71	0.53	0.79
AM2	0.69	0.56	0.81
AM3	0.66	0.54	0.75
AF2	0.59	0.06	0.36
AM4	0.57	0.35	0.43
AF3	0.25	0.24	0.15
AM5	0.1	0.92	0.73
AF4	0.4	0.82	0.82
AM6	0.52	0.63	0.65
Eigenvalue	5.728	1.094	
% of Variance	57.284	10.941	
Cumulative %	57.284	68.225	

Extraction Method: *Principal Axis Factoring*
Rotation Method: *Varimax with Kaiser Normalization*
Standard Deviation(-) / Mean / Standard Deviation(+)
AF Algerian Female
AM Algerian Male
1 Simple, 2 Ordinary, 3 Complex

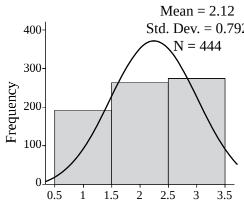

Fig.1 Histogram of Algerian Males

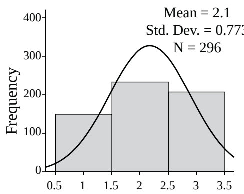

Fig.2 Histogram of Algerian Females

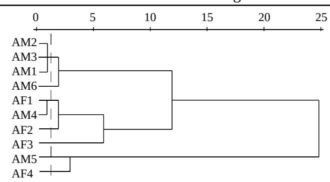

Fig.3 Subjects dendrogram

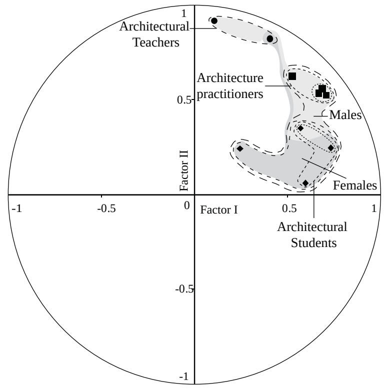

Fig.4 Subjects Clustering

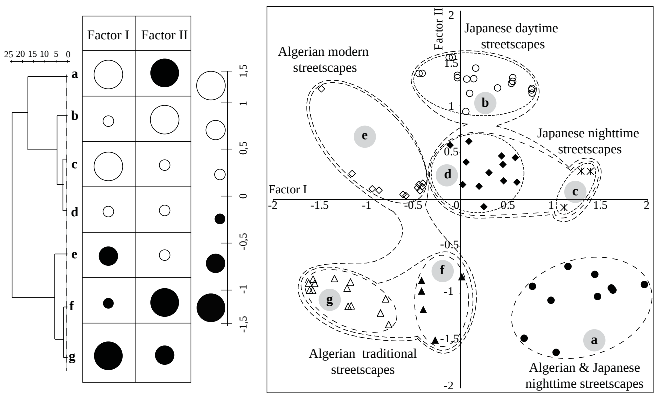

Fig.5 Streetscapes Clustering (Factor I & II)

日本とアルジェリアの街路景観構成の資格形状における複雑性に関する研究

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daytime streetscapes and 11 nighttime streetscapes. The Algerian streetscapes dominate the low level of the rating scale, in which they represent all the simple category and the lower part of the ordinary category. The Japanese streetscapes dominate the higher level of the rating scale, where they represent the major part of the complex scenes group and the higher part of the ordinary group.

2.2. Objective analysis of visual complexity

The proposed objective measure of visual complexity was based on the statistical analysis of contrast distribution within the visual composition of each streetscape (Fig.7).

Around every pixel **I**(i,j) of the input image, let us consider a neighborhood of 2N x 2N pixels denoted by the vector **n**. σn represents the standard deviation of luminance values in a neighborhood **n**. σn is also called RMS contrast of luminance values.

$$\sigma_n = \sqrt{\frac{1}{4L^2}\sum_{i=1}^{4L^2}(n_i - \bar{n})^2} \tag{3}$$

Where each n_i represents one pixel inside the neighborhood **n** and $\bar{n}$ is the mean value of **n**. The contrast map **C** is calculated as:

$$C(i,j) = \sigma_n \tag{4}$$

For an objective appraisal of visual complexity, this study considers the following measure.

$$\alpha = \mu_c . \sigma_c \tag{5}$$

Where μ_C and σ_C are the mean and standard deviation of RMS contrast values **C**(i,j).

3. Results

Figure 8 shows an example of contrast map for a streetscape image. Where 8.a represents the original image, 8.b its contrast map and 8.c its histogram. In the contrast map, sharp changes of luminance receive very high values. In this way, the contrast map highlights features such as image contours. The differences between the different contrast maps were quantified using their histograms. Figure 9 shows how objective measure α correlates with subjective ranking given by *r*-values of Algerian participants ($R = 0.50$). Compared to daytime streetscapes, most of nightscapes have lower mean contrast (Tab. 2). The reason is that contrast is naturally lower during the night due to the lack of light. Since many nightscapes have indeed high *r*-values, humans do not seem to judge their visual complexity only on the basis of parameters derived from contrast information. The mean μ increases as the number of high-contrast features increases. Since μ exhibits a positive correlation with subjective ranking, the perceived complexity is likely to increase with the presence of high-contrast features. The standard deviation σ is a measure of contrast variety within the visual composition. It increases with the presence of features that generate **C**(i, j) values, either higher or lower than μ.

4. Conclusion

The analysis of visual complexity, based on subjective evaluation of participants and on objective measure of RMS contrast information, could show the following:

- Algerian streetscapes were characterized by a lower visual complexity compared to Japanese streetscapes.
- Visual complexity α showed a correlation coefficient of R = 0.50 with the subjective ranking of images in the dataset.
- Perceived complexity is likely to increase with the presence of high-contrast features.
- Since objective measures reflect different "information" dimensions, visual complexity likely depends on the relationship between many physical features within a streetscape.

Future researches aim to investigate different physical parameters within streetscape composition and their relationship with subjective evaluation of visual complexity.

References

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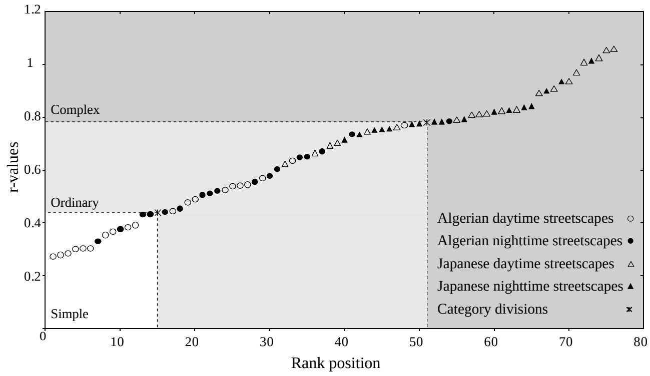

Fig.6 Subjective ranking analysis

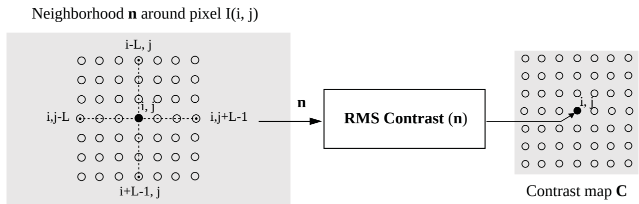

Fig.7 Block diagram of the objective ranking system.

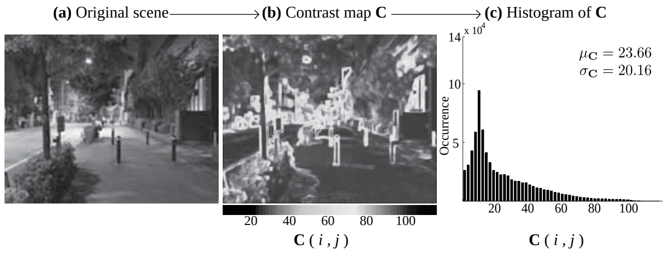

Fig.8 Statistics of contrast map

Tab.2 Correlation coefficients between objective and subjective ranking

	Algerian streetscapes	Japanese streetscapes	Daytime streetscapes	Nighttime streetscapes	All streetscapes
Algerian participants	0.08	0.48	0.84	0.42	0.50

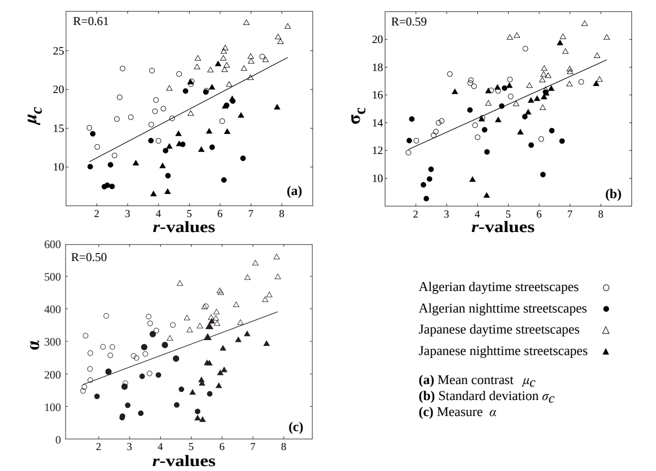

Fig.9 Objective ranking analysis

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