SD and EEG Evaluation of the Visual Cognition to the Natural and Urban Landscape

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The color and structure of urban constructions is a factor of urban landscape and shows their characteristics. Hence the modern buildings deal with their materials and external appearance as an important factor, making up the urban image. But it was nearby impossible to evaluate the value of visual landscape with objective measuring method. Most of all, it depends on the subjective estimation of a few talented or high educated experts with a sense of beauty. Such kinds of estimation can in some cases include arbitrary interpretations. In relation to this kind of problems, it is tried here in this study to analyse the human response of brain wave pattern (EEG) with use of SD method, while the tested persons watch the urban landscape scenery constructed in a visual reality.

The tested persons were 20 adult male and female with no color blindness and intact cognitive function. Light source with color filter was used for color environment in a dark soundproof chamber. The signal of EEG is analysed digitally and grouped into the α and β waves. The result showed that relative power of α wave ratio increased in the natural landscape scenery with blue and green color. From these results it was possible to evaluate the human response, which is affected by urban and natural color and structure stimulation and it might be useful as an indicator of visual cognition amenity toward the design of urban construction environment.

Key Words : Semantic Differentia (SDI) Method, Electroencephalogram (EEG), Visual Cognition, Natural & Urban Landscape

1. Introduction

1.1. Research Background and Purpose

All of human beings do environmentally pursue the more comfortable and lovely life under the surrounded circumstance. Accordingly, it is increased all the effort and interest for the preservation of natural environment and the improvement of urban landscape[1]. This kind of try can be described as an expression of human basic desire to be free from the sensory pollution, which causes an unpleasant feeling to the visual sensory organ[2].

In this context, it needs to suggest an objective method of the estimation for the natural landscape scenery and the urban construction by means of

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Approach of Human Sensibility Ergonomics[3,4]. It means that most of all it failed to numerically evaluate the visual value of the natural and urban landscape scenery till now. On the contrary, most studies are inclined to depend on the subjective estimation of a few experts. In order to overcome such kind of problems, this study shows an analysis tool "Semantic Differential Method (SD Method)", which is used to analyze the urban construction images based on the visual reality. With the SD Method, it is analyzed the impact of visual cognition on the human response of brain wave pattern[5].

For the signal analysis on brain waves, it is used the digital analytic method. The digital analysis means that the signal of brain waves are analyzed with the method of Fast Fourier Transform (FFT) and the various frequencies of brain waves as like as α, β, θ and δ waves are expressed with their distribution and growth at the histogram. The characteristics of these

brain waves can be described as follows[6]. The brain wave a breaks out in the scope of *8~13Hz* and shows the characteristics of calm and stable cerebrum condition in the awakening of unhandicapped persons. The brain wave β normally breaks out in the scope of *14~30Hz* and sometimes *50Hz* in case of strong physical and mental activity. This β wave is divided into *β-I* and *β-II*. The wave *β-I* is mainly influenced by mental activities and the wave *β-II*, by the central nerve system in tense condition. The wave θ breaks out in the scope of *4~7Hz* and shows the characteristics of psychologically stressed condition of adults. like as disappointment and frustration. And the wave *δ includes* all waves below the scope of *3.5Hz* and breaks out by deeply sleeping babies. The result of the research is expressed in form of estimation index of the visual cognitive amenity toward the natural and urban landscape scenery.

1.2. Research Process

This study is made up of 5 steps. The first step is as field survey to make some pictures and image programs of natural and urban structure and color with a digital camera and camcoder in order to use as visual materials in visual reality. The second step is to build an agreeable and dark soundproof chamber to be excluded the outside influences as like as noise and light. In this chamber, the image pictures and programs can be stably displayed to the tested persons and it is measured the brain waves of them. The measured value of brain waves are transformed into an objective numerical data for estimating the physical amenity of the tested persons. The forth step is to make a sheet of questionnaire for the Semantic Differential analysis, made up of various adjectives in relation to the visual feelings as like as colors and structures. The final fifth step is to compare the measured value of the brain waves with the result of Semantic Differential analysis, whether their result data is meaningful or not. In this whole process the research result value is finally verified.

2. Methodology

2.1. Construction of the dark soundproof Chamber for displaying the Visual Reality

The tested persons can be influenced not only by the change of their own feelings, but also by the change of outside environment. Therefore, it is neces-

sary to construct a chamber for the experiment, in order to minimize the outside influences like as noise and light. The dark soundproof chamber has a scale in 400×300×250cm and is mainly composed of equipments like as Biopac system, EEG and displaying screen. The Fig. 1 shows the configuration of visual reality system in the dark soundproof chamber. In this chamber, the tested persons watch the image data of natural and urban landscape scenery and in the same time their signal of brain waves are measured.

The Fig. 2 shows the measuring situation of brain waves, while each of the tested persons watches the image graphics of natural and urban landscape scenery.

Under this circumstance, the natural and urban image sceneries are displayed in the dark soundproof chamber.

The following pictures show the urban and the natural landscape sceneries. In order to select the typical type of urban landscape pictures, it is tried to exclude the pictures with natural background, as far as possible. And the typical natural landscape pictures had to in-
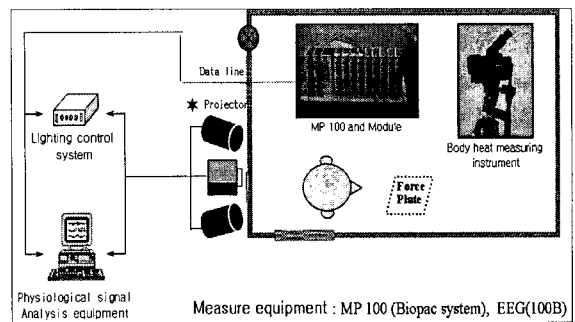

Fig. 1. Configuration of Visual Reality System.

Fig. 2. EEG Measurement.

clude the natural situation without any kind of artificial facilities. The Fig. 3 shows the selected pictures.

2.2. Examination of Brain Waves as Physical Signal

The tested persons are made up of 20 male and female university students and selected under the condition, that they are neither color-blind, nor unhandicapped at the physical cognitive functions. Their Electrode is measured with the hole cup, produced by Genuine Grass Company and their brain wave conduction, with method of international IO-20. The measured points are Frontal(Fp1, Fp2), Central(Cz) and Occipital(O1, O2) parts of brain.
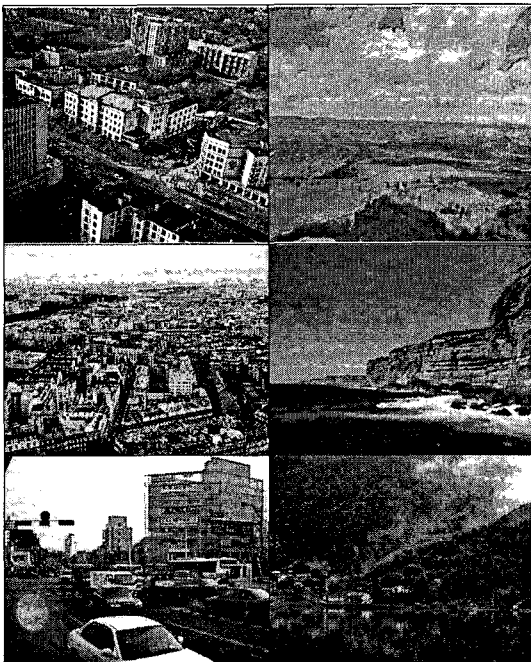

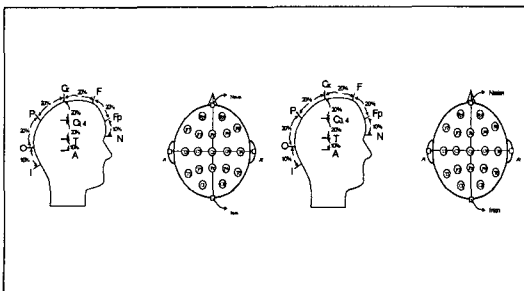Fig. 3. Visual reality of Urban and Natural Landscape Scenary.

Fig. 4. International 10-20 Method. (Points of EEG Measurement)[7]

From the acquired data of brain waves it is removed the Electro-oculogram (EOG) as pre-processing. And then, all the remaining data pass the high pass filter in 0.5Hz and the natch filter in 60Hz. And it is accomplished the FFT (fast fourier transform), after dividing each data into 512 sections. In this process, it is acquired the power of a wave, which breaks out in physically stable awakening, and the one of β wave, which breaks out on the contrary in physically active movement. The following formula shows how to analyze the relative power of a and β waves as analysis variable.

$$RP(a) = \frac{P(a)}{P(a) + P(\beta)}$$

$$RP(\beta) = \frac{P(\beta)}{P(a) + P(\beta)} \tag{1}$$

And finally the standardized formula 2 is derived from the expansion, that exclude the relative power during the break time from the one during the stimulation.

$$NRP = stimulusRP - restingRP \tag{2}$$

These data are processed with use of the program LabVIEW 6.1. The Fig. 5 shows a captured scene of the front panel that analyses the brain waves.
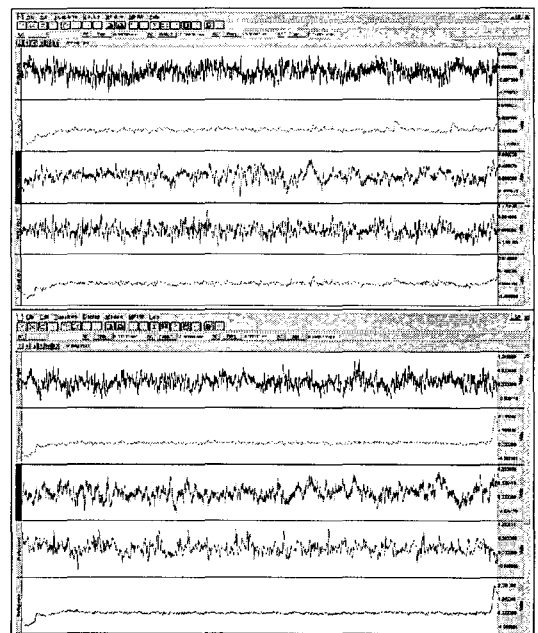

Fig. 5. LabVIEW program for EEG analysis. (upper: Result of Natural Scenery, below: Result of Urban Scenery)

As a result, the 1st and 2nd column shows the result value of brain waves measured at the Frontal lobe. It takes charge of the whole cognitive command system. The 3rd column shows the one of the Central lobe. At this lobe, it is mainly measured the emotional responses. The 4th and 5th column shows the one of the Occipital lobe. It takes charge of the function of visual cognition.

2.3. SD Method, its theoretical Characteristics and Application

The Semantic Differential Method (SD Method)[8] is an analysis method, which investigates the feelings of human beings toward all kind of image. For this survey, it is necessary to gather and select the appropriate ergonomical adjectives, as much as possible. These adjectives shall express the feelings of human beings toward any kind of materials, like as "cool - warm" or "good - bad" etc[9]. After selecting 33 adjectives, it shall be made up of a questionnaire in accordance with 3 cognitive characteristics, in which each contrary adjective is evaluated in a 7 scalar by the tested persons.

The cognitive characteristics at the questionnaire are divided into the sheets of the psychological feelings, the tactile feelings and visual feelings. The Tab. 1 shows as a sample the sheet of the psychological feelings.

The tested persons evaluate each adjectives subjectively in their own judgement, after watching the natural and urban landscape scenery. Here in this process, the items of questionnaire are verified, whether they are statistically reliable or not. And the Cronbach's Alpha was 0.613. It means reliable. Accordingly, all the subjective evaluation of the tested persons are transformed into the objective numerical data through the statistical processing.

3. Measured Value of Visual Cognition Amenity

3.1. The Value of Brain Waves

The measured values of brain waves are divided into the 2 step relative powers of the a waves. The one is the Before-Stimuli, namely, before the natural landscape scenery is displayed. And the other is the On-Stimuli. As it can be confirmed at the Fig. 6, the Frontal and the Central brain part, which express the emotional feelings, increase the relative power of the a brain waves On Stimuli in comparison with the one Before Stimuli. It means that the tested persons feel stable and pleasant, so that the a brain waves are active. Most of all such kind of activity of the a brain waves is stronger On Stimuli of natural landscape scenery than the urban landscape scenery.
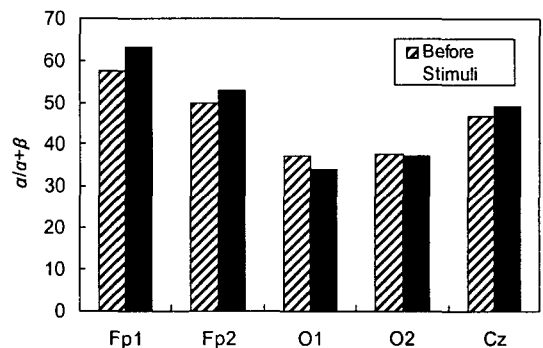

Fig. 6. a wave power spectrum of resting and stimulus.

Table 1. Sheet of SD questionnaire "Evaluation on the visual cognition to the natural and urban landscape scenary"

Afformative Adjectives	Scalar of Evaluation							Negative Adjectives
pleasant	1	2	3	4	5	6	7	unpleasant
clean	1	2	3	4	5	6	7	unclean
friendly	1	2	3	4	5	6	7	unfriendly
refreshing	1	2	3	4	5	6	7	unrefreshing
lyrical	1	2	3	4	5	6	7	not lyrical
stable	1	2	3	4	5	6	7	unstable
cool	1	2	3	4	5	6	7	uncool
natural	1	2	3	4	5	6	7	unnatural
peaceful	1	2	3	4	5	6	7	unpeaceful
close	1	2	3	4	5	6	7	disclose
comfortable	1	2	3	4	5	6	7	discomfortable
favorable	1	2	3	4	5	6	7	unfavorable

3.2. The Value of SD Analysis

After measuring the brain waves, the subjective evaluation with use of the SD Method is carried out by the tested persons. In this process, 8 adjectives, which are most importantly answered, are selected. The Fig. 7 shows the result value of SD analysis. As the urban landscape scenery is presented, the adjectives, like as dark, cold and hard, rule over the cognitive feeling of the tested persons most importantly. On the contrary, as the natural landscape scenary is presented, the adjectives, like as pleasant, stable and natural rule over the cognitive feeling of the tested persons most importantly.

4. Result and follow-up Research

Consequently, all the result values come to an agreement not only to the brain wave analysis but also to the SD Analysis. Above all, this kind of research approach prove that it is able to evaluate the visual cognition objectively and numerically. And based on the relative importance of SD methodologically evaluated adjectives, each structure and color of natural and urban facilities can be improved and reconstructed in the viewpoint of human amenity.

However, it is still yet not to lightly declare that this SD method can solve all of the weakness of the subjective evaluation by a few well-trained experts. Because this has still some problems by itself. Firstly, this experiment isn't carried out in the natural open space or field directly, but under the artificial condition, where the tested persons watch the image scenery of the screen. In this case, It is sure that the tested persons can be tolerably free from all kind of noise and disturbance outwardly. But that is the very weakness, that the results of the test can't reflect all the implications of real conditions. Secondly, it is relatively easy to evaluate the brain waves with the still scenery, but not with the moving scenery, because it is quite difficult to match and analyse each result of brain waves with their momentary scenery. Thirdly, it is still quite unclear, what concretely the number of the scalar in the SD analysis has to mean. Fourthly, the value of the SD analysis is expressed in a numerical scalar, but the brain waves isn't expressed in the same numerical scalar. Hence at the follow up research, it is important to increase the variables one by one and to measure the change of response of brain waves. Nevertheless, it is expected some positive effects. The evaluation of the natural and urban landscape may not depend on just a few experts any more. And based on the human mental response by brain waves, the natural and urban scenery can be evaluated numerically, statistically and scientifically, how much the amenity of human life can be improved.
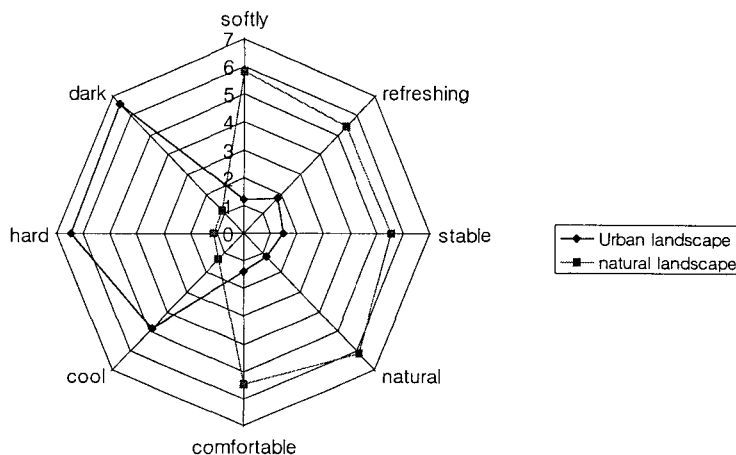
Fig. 7. Factor of urban landscape and natural landscape.

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