Experimental Verification of Relaxation Effect of Tree Planting using Eye Movement Tracking

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ABSTRACT

In the Japanese garden, a unique planting design has been used to improve visual harmony with the surrounding landscape by planting plants around the objects that are not harmonious with surrounding landscape. In this study, physiopsychological effects of plants caused by a traditional planting skill used in Japanese garden was verified in terms of visual relaxation using eye movement recording and semantic differential method. A total of fourteen Japanese volunteers(seven male and seven female) who have normal vision(aged 21～28) participated as subjects. Experiment was carried out in the sealed room of Chiba University in Japan. Four different types of scenery models were presented which were created by combination of the three landscape factors of the surrounding background, the object that disturbs visual harmony, and the trees planted for improving visual harmony with the surrounding landscape. In the results, significantly more gaze fixations were measured on the trees than on the object and higher values in positive feelings were recorded for the stimuli with proper planting combination. Our results indicated that proper tree planting can cause physiopsychological relaxation by improving visual harmony with the surrounding landscape and provided new evidence for supporting scientific validity of the traditional planting skills.

Key Words: Traditional Landscape Architectural Skills, Camouflage Planting, Visual Harmony, Eye Movement, Physiopsychological Relaxation

Ⅰ. Introduction

With the loss of useful traditional skills and knowledge, greater understanding, practices and applications of traditional techniques have become important issues in the area of landscape architecture. In the case of Japan, there have been many efforts to take advantage of the traditional landscape architectural skills like unique planting design patterns, which is one of the most important factors characterizing the landscape of the Japanese garden. One of the efforts includes the examination of scientific validity of traditional skills by reevaluating them in the sense of modern techniques as a new approach.

In the Japanese garden, pursuit of landscape harmonization is often a critical value in garden design and management (Bring and Wayembergh, 1981), which has been expressed with the presentation of natural-looking landscape. In order to realize the value of landscape harmony, plant materials have been used in variable and flexible ways, not only as a main landscape composition element but also as a subsidiary one. As an example, diverse kinds of plants are planted to improve visual harmony by partially hiding an object disharmonizing with surrounding landscape. Nitta(1975) calls this planting skill camouflage planting, one kind of functional planting technique, integrating something with the surrounding land-scape by improving visual harmony between them. A related

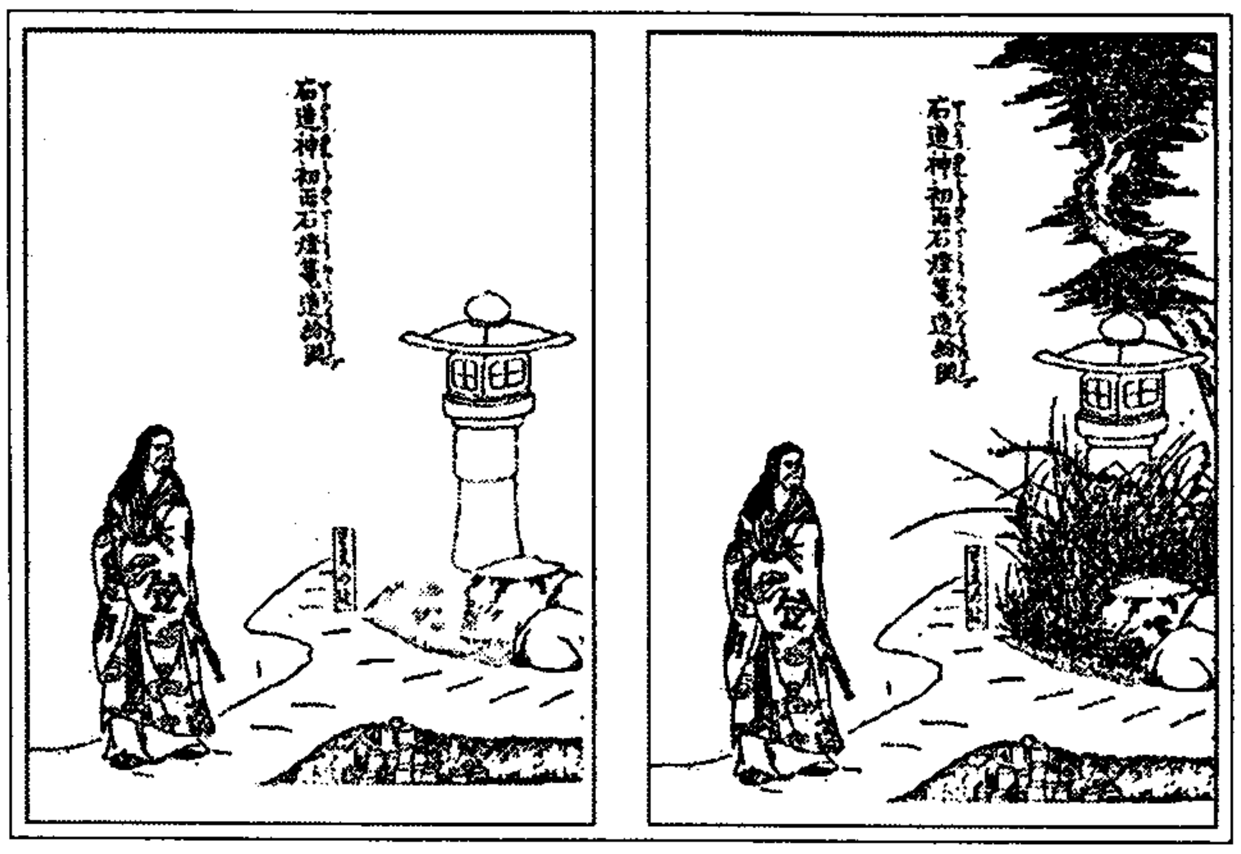

Figure 1. An example of planting skills illustrated in the Tsukiyama Teizouden, one of the most popular guidance documents for Japanese gardens.
Proper planting can improve visual harmony with surrounding landscape. Right is the original image and left is modified one.

skill is illustrated in the Tsukiyama Teizouden(interpreted version was referenced; Uehara, 1965), one of the most popular guidance documents for Japanese garden design written by E. Kitamura in 1735, using a kind of *yakugi*, that is, a tree having special roles in a garden(Figure 1).

There have been several approaches to try to reevaluate the planting skills used in the Japanese garden. Iijima(1965) surveyed the design characteristics of the Japanese garden and concluded that tree form can affect the feelings of people. Anbiru *et al.*(1988) made clear the positional characteristics and use of the *yakugi*. And Kotake(2001) analyzed the role of dwarf bamboo as a landscape composition element in traditional Japanese gardens. In addition to these, an experimental study examining the spatial relationships between garden lanterns and surrounding planting in Japanese gardens by surveying the viewer's eye movement tracking(Suzuki, 1989), supported the scientific validity of the planting skills more strongly. However, there are no sufficient studies on camouflage planting, an important planting skill characterizing the Japanese garden. Although there is a study investigating the hiding effects of tree planting using eye movements (Kaneko, 1991), psychological responses seemingly caused by hiding an object disharmonizing with surrounding landscape were not considered.

Therefore, aiming to provide new evidence for supporting the scientific validity of the traditional landscape architectural techniques, we investigated the physiopsychological relaxation effects expected by applying camouflage planting.

II. Subjects and Methods

1. Subjects and Stimuli

Fourteen volunteers(seven males and seven females; aged between 21~28 years old) with normal vision participated in this study. The experiment was carried out in a sealed room of Chiba University. Informed consent was obtained from each subject in accordance with a protocol reviewed and approved by the Human Investigation Committee of Chiba University.

Camouflage planting, in this study, means plants applied in front of an object to be hidden due to visual disharmony. In order to examine the effect of camouflage planting, four types of scenery models were prepared using three landscape composition elements. These included *background* that shows the surrounding scene, an *object* to be hidden that disturbs visual harmony, and *camouflage planting* that partially hides the 'object'(Figure 2). Two types of background were prepared: one was a white screen(210×260cm) and the other four trees of *Osmanthus fragrans* var. *aurantiacus*(height 120cm). As the *object*, a red fire extinguisher box was selected(height 55 cm) and as camouflage planting, one additional tree of *Osmanthus fragrans* var. *aurantiacus*(height 50cm).

2. Data Acquisition and Analysis

Subjects were told to observe the randomly-presented

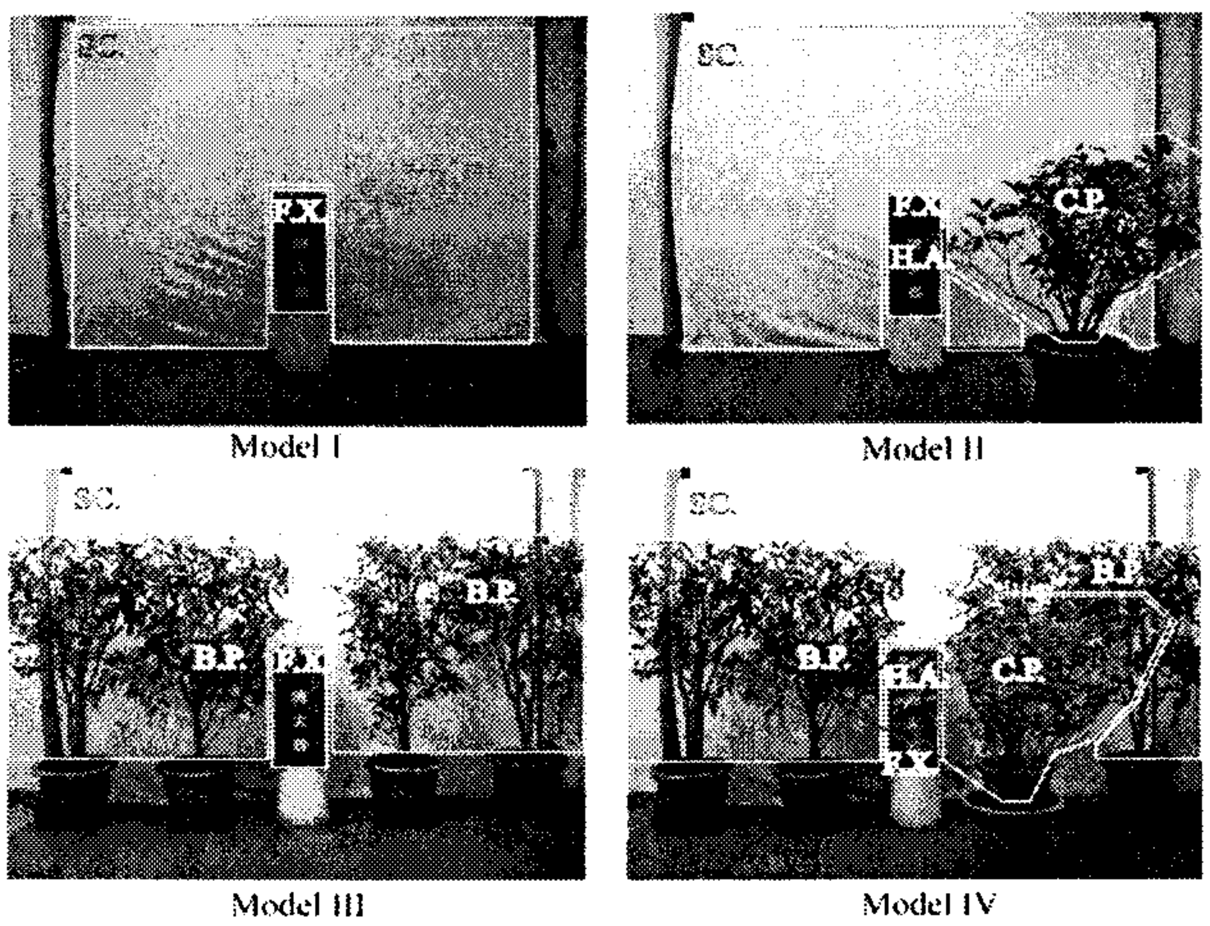

Figure 2. Four different scenery models and division of visual areas.
S.C.: screen, B.P.: background planting, C.P.: camouflage planting, F.X.: fire extinguisher box, H.A.: F.X. area partially hidden by a branch of the C.P., R.A.: the remaining areas not included above.

Figure 3. A viewer with a head set for investigating eye movements.

scenery models sitting on a chair 3.5m away from the scenery setting. Eye movements for each visual stimulus were recorded using an eye mark recorder(EMR-8, NAC image technology) for sixty seconds(Figure 3). For each scenery model, to analyze the distributional attributes of gaze movement and fixation, the visual area was divided into 3~6 parts(Figure 2) depending on the scenery type: screen (hereafter, SC.), background planting(hereafter, B.P.), camouflage planting(hereafter, C.P.), fire extinguisher box (hereafter, F.X.), F.X. area partially hidden by a branch of the C.P.(hereafter, H.A.) and the remaining areas not included above(hereafter, R.A.). Gaze movement and fixation for each visual area in each scenery model was investigated. Gaze fixation time was set as 0.2 seconds and more. Considering individual differences, gaze fixation rate was calculated by the percentage of the fixation point number on each visual area based on the total number of gaze fixation points in a scenery model. After the test of eye movements, the semantic differential(SD) test was carried out to investigate the viewer's evaluation of visual impression by showing pictures of the scenery models used in the eye movement tests. The t-test with Bonferroni correction was used to compare gaze fixation characteristics and the Kruskal-Wallis test and Wilcoxon rank-sum test were applied for the SD results.

III. Results and Discussion

1. Evaluation of Visual Impression

In the results of the semantic differential(SD) test(Figure 4),

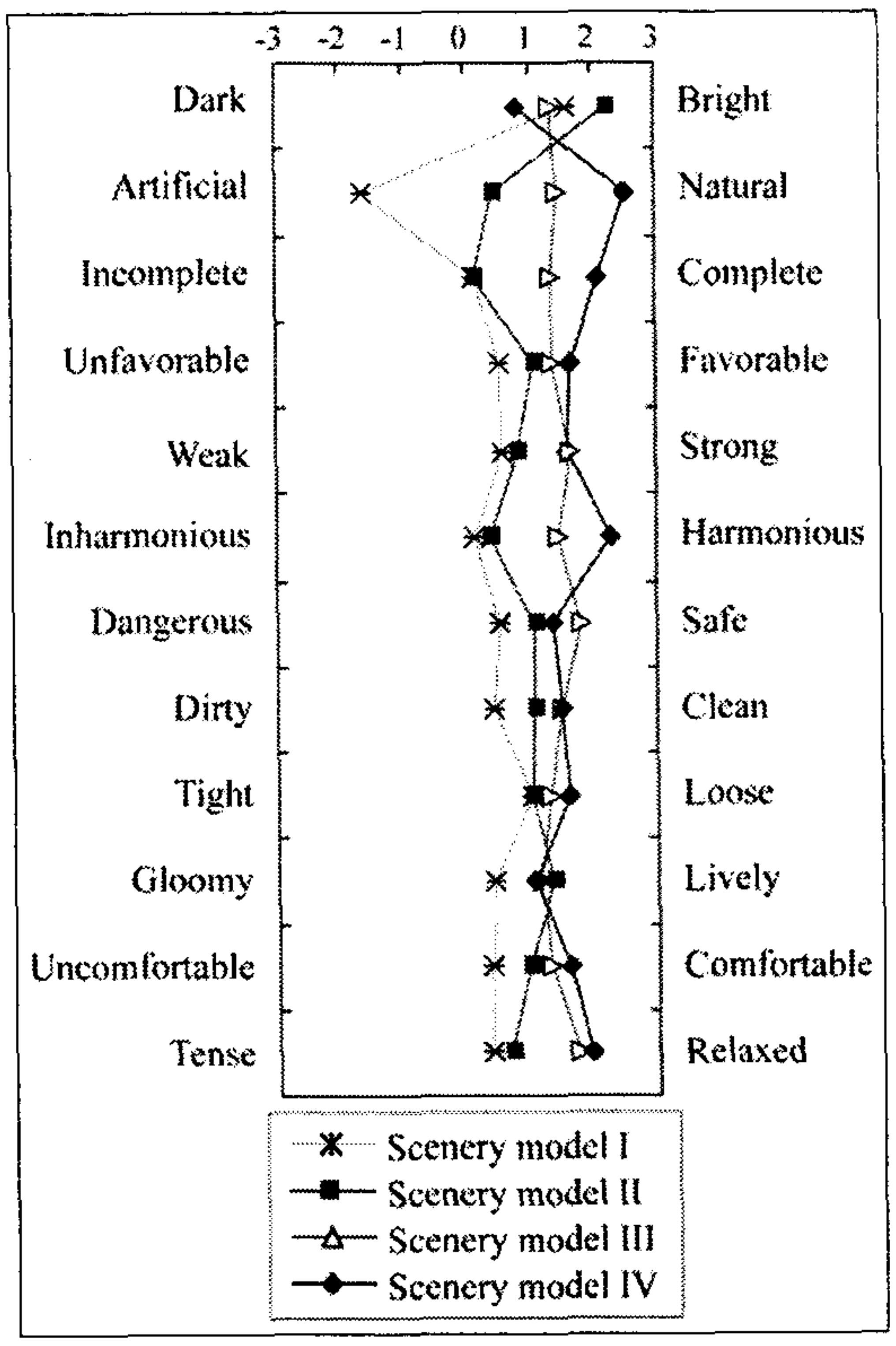

Figure 4. The results of impression evaluation by the Semantic Differential method for the four different scenery models.

significant differences were found in terms of naturalness, safety, completeness, comfortableness, relaxation and harmoniousness among models(Figure 5). We also could detect a tendency in which the values in these terms increased with a growing volume of trees in scenery models. Given that the model with no trees had the most negative evaluation in the SD results, viewer's evaluation may be correlated with the existence of the plants. It is generally known that plants have a positive effect on human physiopsychological responses(for example, Ulrich 1986, Nakamura 1992). These positive effects of plants may be associated with relaxed brain activity caused by slower and more relaxed eye movement patterns(our unpublished data). For maximizing these effects, proper selection of planting density and a balanced planting scheme would be needed.

2. Characteristics of Eye Movement and Fixation Pattern

Individual differences were seen in eye movement regimes among subjects during observation of each scenery model. However, there were some important common patterns in

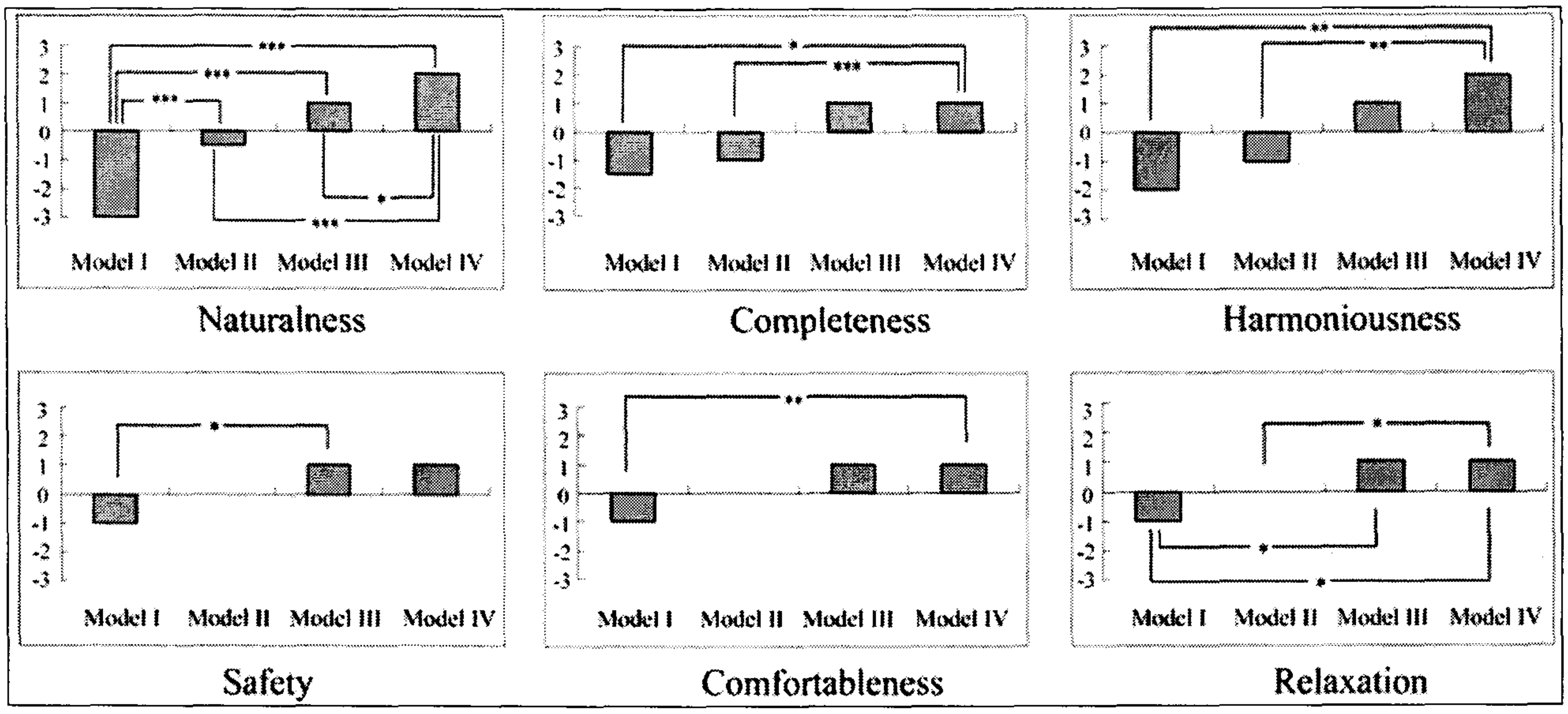

Figure 5. Differences in the impression evaluation among the four scenery models for six feelings.
*,<0.05: **,<0.01: ***, < 0.001.

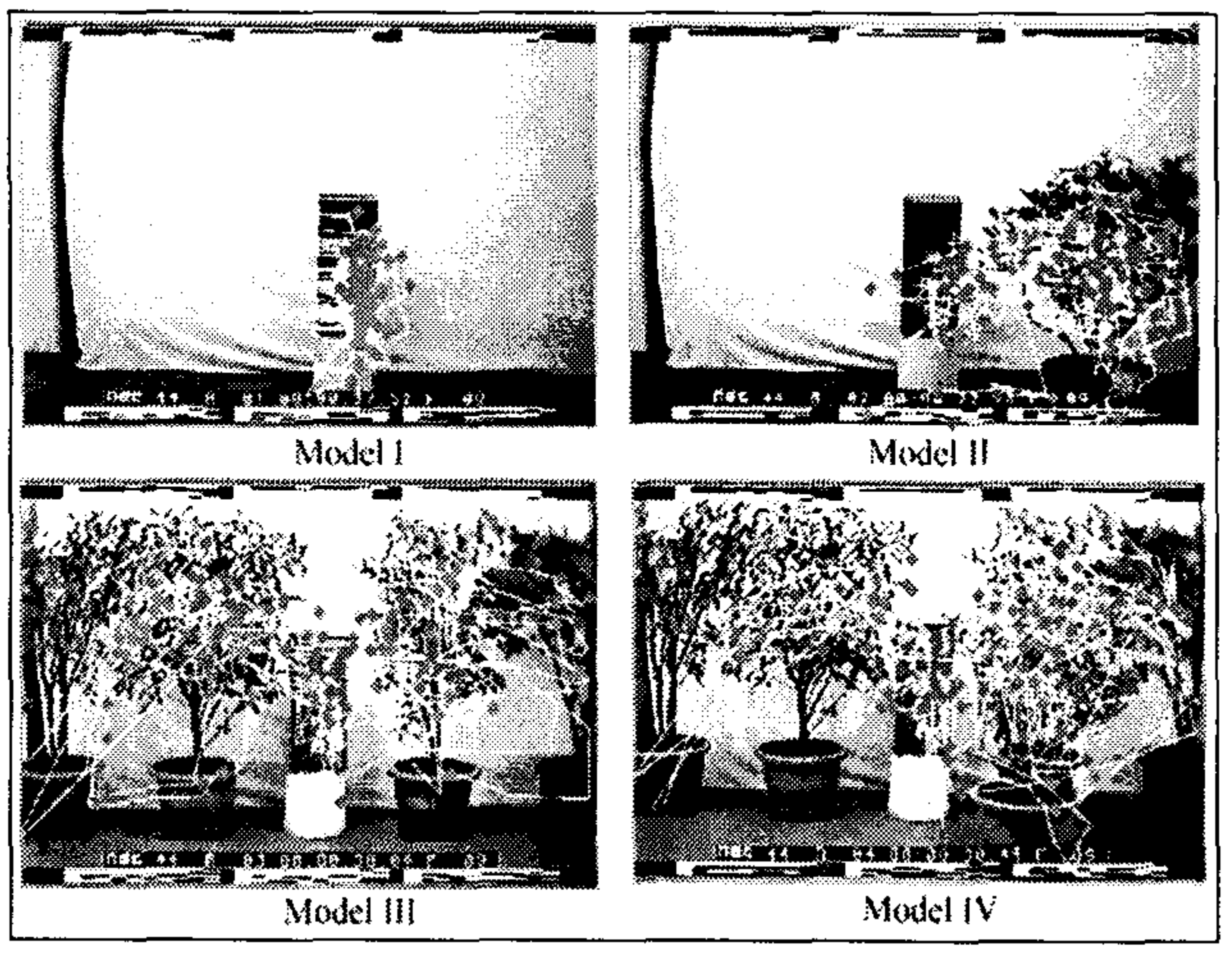

Figure 6. An example of gaze movement and fixation distribution in the scenery models. White lines indicate eye movement trajectory and gray points, gaze fixation points.

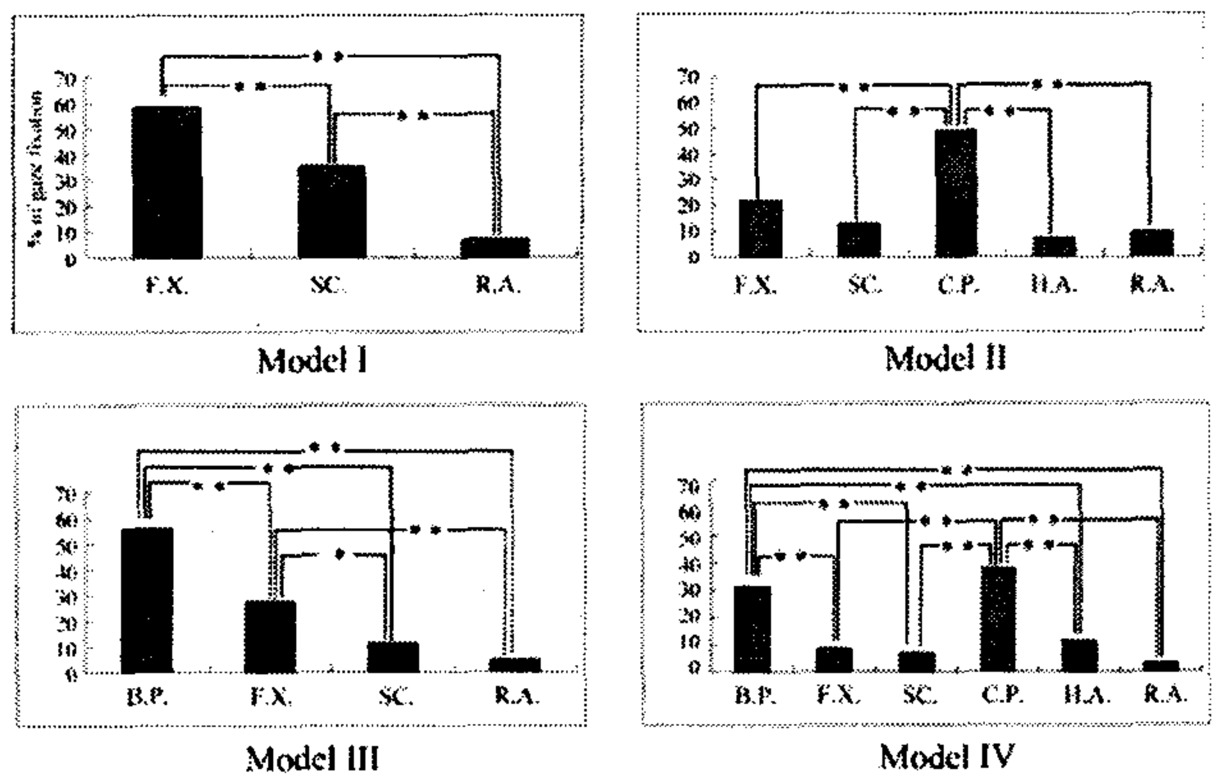

Figure 7. Differences in the percentage of gaze fixations among each visual area.
S.C.: indicates screen, F.X.: fire extinguisher box, B.P.: background planting, C.P.: camouflage planting, H.A.: F.X. area hidden by a branch of the C.P., R.A.: the remaining areas not included above.
*, <0.05: **, <0.01.

gaze movement(Figure 6). For the scenery model I, many or most of the gaze movements were concentrated on the F.X. area with short and dense horizontal and vertical moves in a linear way. For the model II, gaze movement and fixation tended to be mainly distributed around the H.A. and the C.P. areas. For the model III and IV, gaze movement and fixation had a significantly broader distribution than model I and II, and most gaze fixations were generally detected on the B.P. area in model III and on the C.P. areas in model IV. There was also a tendency in which scenes with more trees had more scattered and curved eye movements. Our results on the gaze fixation pattern showed significant differences in fixation distribution between model I with higher fixation rate on F.X. and the models II, III and IV with the predominance of fixation on plants(Figure 7). Model IV with camouflage planting had a significantly lower percentage of gaze fixations on the F.X. than model III. It is worth noting that the highest percentage of fixations was recorded not on the B.P. but on the C.P., despite lower volume. Our results support the theory that the gaze tends to move rather to plants than to an artificial object and that eye movement patterns can be more varied on plants as seen in the previous study(Suzuki, 1989). The short and acute gaze movements seen in model I are likely to be related to the negative evaluation in the SD test.

In contrast, the broadly-distributed and slow eye movement pattern seen in model IV can be associated with the high scores in a positive way. These correlations can be supported by the idea that eye movement is deeply correlated with brain activity, an important index representing psychological conditions(Brignani *et al.* 2007). Our results indicated that proper tree planting can improve visual harmony with surrounding landscape by spreading eye movement over the plants, thus causing physiopsychological relaxation.

Ⅳ. Conclusion

In this study, we examined the scientific validity of camouflage planting, one of the traditional landscape architectural skills, in terms of physiopsychological relaxation. Our results support that camouflage planting could help people to feel relaxed by improving visual harmony. The relaxation effect, in addition, would be maximized by harmonized planting regimes, including background space(Suzuki 1989). In order to make clear the design characteristics of harmonized planting regimes, more understanding on traditional planting skills and the application of them would be required. Our results may provide important possibilities for the utilization of traditional techniques for present urban landscape planning.

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