Evaluation of Visual Preference for Seasonal Streetscape Design Using 3D Simulation Technology

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Abstract. As 3D technology advances, many designers are using 3D technology in their design research. Environment designers, in particular, conduct public design research using 3D simulation technology. In the field of environmental design, green space is an important factor in determining the image of public design. Green space, however, has different visual preferences as the seasons change. Thus, this research aimed to analyze the visual preferences of streetscape according to the seasons change using 3D simulation technology. The result of the study shows that the autumn image of maple background and ginkgo background are more preferred than the winter image of maple background and ginkgo background. In conclusion, the change of seasons is a crucial factor in determining the visual preference of the landscape. Designers, therefore, should consider the variation of seasons as well as the shape of streetscape to improve the visual preference of a streetscape. These findings could also be applied as theoretical data to conduct the public design.

1. Introduction

1.1. Research Background and Purpose
As 3D (3 Dimensions) technology advancing, it is being utilized in various fields. In the past, 2D technology were widely adopted in design fields. With the development of 3D technology, tremendous changes have been gone through in artistic design. 3D technology can visualize the hypothetical work in advance. Environment designers conduct public design research using 3D technology. In the meanwhile, environment designers use 3D simulation to create a suitable public space. In particular, green space is an important factor in determining the image of public design. However, green space has different visual preferences as the seasons change. In addition, trees have been planted without any design criteria according to seasonal changes. Thus, this research aimed to analyze the visual preferences of streetscape according to the seasons change using 3D simulation technology. These findings could be used as theoretical basis data to create the design scheme.

1.2. Literature Review
This study explored seasonal images and landscape preferences in public spaces. Previous studies carried out on streetscape were as follows. Shin Jae Yoon etc. (2014) analyzed preferences and visual
characteristics of each type of streetscape using 3D simulation [1]. Kim Ji Hye etc. (2009) studied various factors affecting the evaluation of the streetscape through the structural equation model [2]. Sung Hyun Chan (2003) analyzed if the environmental function and effect of trees along road was actually realized in city [3]. Jung Jin Hyung (2005) analyzed methods to improve the green space [4]. These studies had revealed that green space was the key factor in determining the visual preference of streetscape. However, most of these previous studies conducted analysis according to functional aspects of green space [1-4]. Since green space is made up of plants, visual preferences of streetscape may vary depending on the seasons change [5]. Thus, this study, unprecedentedly from the perspective of seasons change, analyzes the landscape preference of streetscape. These findings can also be employed as basic data for establishing streetscape plan.

2. Theoretical Background

2.1. Design Using 3D Technology
Designers use 3D technology in various fields. Previously, 3D technology was mainly used in product design, but nowadays 3D technology is used in most areas of design. Designers use various 3D programs such as Sketch up, 3D max, Auto cad, and Vector works. In particular, designers conduct design research using 3D simulation. In public design research, 3D simulation techniques are being used in a variety of ways. Recently, 3D technology becomes more important due to the development of 3D printing. Using 3D printers has the advantage of reducing the period and cost of design. So 3D printing technology will be used not only in product design but also in architectural design and environmental design in the future.

2.2. Characteristics of Public Design
Public design is to design not only public space but also public facilities. This public design shows the beauty of the region. Aesthetic, economic, and functional factors are of equal importance in public design. Aesthetically pleasing public space are landmarks, and their design is produced from a creative cognizance which designers pursue in order to match a streetscape to its surroundings [6].

3. Research Method

3.1. Selection of Background and Landscape Adjectives
In this study, background images, selected before 3D simulation was performed, were 40 photos taken with clear seasonal streetscape. The photo shoot was conducted on a streetscape of Korea, where there were many ginkgo and maple trees. Preliminary survey was conducted based on 40 photos. The subjects who participated in the survey were 30 graduates of the department of landscape architecture from Seoul National University. First, the subjects were given 40 photos and asked to select two of them, respectively representing the maple streetscape and the ginkgo streetscape. Among these selected photos, the highest number of times selected was chosen as background image. The selected pictures were as follows (figure 1, figure 2).

![Figure 1 Maple Streetscape](image1)

![Figure 2 Ginkgo Streetscape](image2)
Representative landscape adjectives were chosen to describe the landscape simulation to analyze the aesthetic of streetscape. The process of selection included several steps, the first, two of which were to understand the meaning of landscape adjectives through reviewing related literature [7-8] and then to select fifty pairs of landscape adjectives appropriate for analyzing streetscape. The third step was to conduct a primary survey for selecting pairs of adjectives that were most appropriate for evaluating the streetscape [7-8]. This research surveyed 25 graduate students of Konkuk University and 25 graduate students of Seoul National University; the total number of respondents equaling 50. Each respondent was given the pool of fifty adjective pairs and directed to select nine pairs which seemed most appropriate for describing streetscape. From the results of this survey, a total of nine pairs of landscape adjectives that were most frequently chosen by the respondents were taken for use in this experiment (Table. 1).

Table 1. Landscape Adjectives

| Artificial - Natural | Unstable - Stable | Ugly - Beautiful |
| Flimsy - Sophisticated | Confusing - Orderly | Unfamiliar-Familiar |
| Charmless - Attractive | Boring - Interesting | Simple- Splendid |

3.2. 3D Simulation

3D simulation image model selected eight streetscape types, which were spring (figure 3), summer (figure 4), autumn (figure 5), winter (figure 6) of maple background and spring (figure 7), summer (figure 8), autumn (figure 9), winter (figure 10) of ginkgo background. The elements of 3D simulation such as camera, light's location, shape were in equal conditions; season was the only variable factor (Table 2). Landscape image for 3D simulation used computer programs such as Auto-CAD (Auto desk, 2005), Google Sketch-UP (Google Inc., 2007), Adobe Photoshop CS (Adobe System. 2003), 3D MAX. This research formed eight images, including the original maple streetscape and original ginkgo streetscape.

Table 2. Landscape Simulation

| Figure 3 | Figure 4 | Figure 5 | Figure 6 |
| Spring of Maple Background | Summer of Maple Background | Autumn of Maple Background | Winter of Maple Background |
| Figure 7 | Figure 8 | Figure 9 | Figure 10 |
| Spring of Ginkgo Background | Summer of Ginkgo Background | Autumn of Ginkgo Background | Winter of Ginkgo Background |

3.3. Selection of Survey Group and Method of Analysis
Data for this research was collected via three surveys from June 10th, 2018 to September 10th, 2018. All subjects saw the face of an image of standardized dimensions (210×297mm) for a length of 8 seconds per image [7-8]. Twenty-five graduate students of Konkuk University in Korea and twenty-five graduate students of Seoul National University in Korea were surveyed, for a total of fifty participants. The participants were majored in civil engineering and landscape architecture. Students of these majors were chosen on the basis of their technical experience in the field; participants of civil engineering understand streetscape design concepts with a degree of professional expertise. Participants of landscape architecture were chosen for their understanding of streetscape designs and estimation of the visual quality of such landscapes. After the participants fully understood the evaluation method and purpose of the study, they were then asked to evaluate the streetscape images according to image and preference. The visual image evaluation was a 7-point semantic differential scale; evaluation about visual preference used the 7-point Likert scale [7-8]. Statistical analysis utilized Excel and KESS (Korean Educational Statistics Software) to abstract descriptive statistical values about the streetscape images. This research conducted a two-way analysis of variance and Duncan's test (post hoc tests) to understand visual preference differences [7-8] according to background and season.

4. Results and Discussion

4.1. Assessment and Variation of Images According to Background and Season

The results of the survey of background and season assessment are summarized as follows. The images portraying spring and summer from maple background were both rated highly as ‘Beautiful’ and ‘Natural’, with the autumn image additionally rating high as ‘Beautiful’ and ‘Splendid’. The maple landscape of autumn gave a beautiful image to the surroundings. The winter image from maple background rated low as ‘Attractive’. Low ‘Attractive’ ratings were thought to occur because the bare branches and dull color of the winter image had a negative impact on the natural surroundings of the image (Table 3).

| Landscape Adjectives | Maple Background |
|-----------------------|------------------|
|                       | Spring image     | Summer image   | Autumn image | Winter image |
| Artificial - Natural  | 4.14             | 4.16           | 4.08         | 4.04         |
| Unstable - Stable     | 3.72             | 3.64           | 3.82         | 3.78         |
| Ugly - Beautiful      | 4.06             | 4.04           | 4.22         | 3.74         |
| Flimsy - Sophisticated| 3.88             | 3.65           | 3.86         | 3.72         |
| Confusing - Orderly   | 3.43             | 3.62           | 3.52         | 3.44         |
| Unfamiliar-Familiar   | 3.72             | 3.34           | 3.66         | 3.56         |
| Charmless - Attractive| 3.88             | 3.96           | 4.02         | 3.22         |
| Boring - Interesting  | 3.84             | 3.54           | 3.88         | 3.68         |
| Simple- Splendid      | 3.88             | 3.74           | 4.04         | 3.54         |

The images portraying spring and summer from ginkgo background were both rated highly as ‘Beautiful’ and ‘Natural’, with the autumn image additionally rating high as ‘Attractive’ and ‘Splendid’. The green landscapes of spring and summer from similar images. And the yellow leaves of autumn brought an attractive image. The winter image rated low as ‘Beautiful’. The summer from ginkgo background also rated highly as ‘Splendid’, and the autumn from ginkgo background rating also rated highly as both ‘Beautiful’ and ‘Splendid’. All bridges received a highly ‘Natural’ rating,
with the winter image from ginkgo background also rated low as ‘Beautiful’. As such, the landscape of autumn gives a more positive image than the landscape of winter. Because autumn had a positive effect on space by the leaf color of trees (Table 4).

Table 4. Average Value of Image Assessment in Ginkgo Background

| Landscape Adjectives | Ginkgo Background |
|----------------------|-------------------|
|                      | Spring image | Summer image | Autumn image | Winter image |
| Artificial - Natural | 4.12         | 4.12         | 4.08         | 4.14         |
| Unstable - Stable    | 3.82         | 3.86         | 3.76         | 3.84         |
| Ugly - Beautiful     | 3.94         | 3.82         | 4.22         | 3.64         |
| Flimsy - Sophisticated | 3.88     | 3.65         | 3.74         | 3.72         |
| Confusing - Orderly  | 3.54         | 3.62         | 3.64         | 3.44         |
| Unfamiliar-Familiar  | 3.72         | 3.64         | 3.72         | 3.56         |
| Charmless - Attractive | 3.88      | 3.96         | 4.12         | 3.46         |
| Boring - Interesting | 3.82         | 3.74         | 3.76         | 3.88         |
| Simple- Splendid     | 3.84         | 3.76         | 4.02         | 3.52         |

4.2. Assessment and Variation of Images According to Background and Season

This study analyzed visual preferences according to different backgrounds and seasons. The results were taken at a significance of less than 0.05, and showed that, above all, autumn image of maple background and ginkgo background were more highly preferred than other images. The summer image in maple background received the highest preference rating, and the winter image in maple background had the lowest preference. In maple background, the autumn image had the highest preference rating, and the preference of winter image had the lowest rating. In ginkgo background, the autumn image had the highest preference rating, and the winter image was, again, the lowest. In both of maple and ginkgo backgrounds, the autumn image was highly evaluated for visual preference because the color and fallen leaves of these image seem to have a good correspondence with the surroundings. These results suggested that different seasons and backgrounds would give different visual preferences for streetscape, even if the shape of landscape was the same (Table 5).

Table 5. Statistical Analysis of Visual Preferences

| Landscape       | Average | Standard deviation | F-Value | Significant probability | post hoc tests a=0.05 |
|-----------------|---------|--------------------|---------|-------------------------|----------------------|
| Maple Background| Spring image | 4.02                | 1.18    |                         | b                     |
|                 | Summer image  | 3.88                | 1.14    | 15.120                  | 0.002                | c                     |
|                 | Autumn image  | 4.36                | 1.06    |                         | a                     |
|                 | Winter image  | 3.32                | 1.02    |                         | d                     |
| Ginkgo Background| Spring image | 4.10                | 1.12    |                         | b                     |
|                 | Summer image  | 3.96                | 1.32    | 7.224                   | 0.001                | c                     |
|                 | Autumn image  | 4.32                | 1.14    |                         | a                     |
|                 | Winter image  | 3.88                | 1.18    |                         | c                     |
This study also conducted a Duncan test (post hoc tests) to analyze the variation in landscape according to background and season. The level of significance was less than 0.05, and it was apparent that the different visual preferences according to background and season were significant. The spring images in maple background and ginkgo background also had a similar evaluation in visual preference. The autumn images in maple background and ginkgo background received a similar evaluation in visual preference. The visual preference for the summer image in maple background, ginkgo background and winter image in ginkgo background were also similar across the board. These results proved that visual preferences changed according to background and season.

5. Conclusion

Streetscape is an important factor in regional landscape. However, when designing a street, designers often don’t carefully consider the aesthetic function of street, so some inappropriately designed streetscapes frequently destroy the beauty of the regional landscape. Preferences of streetscape may vary depending on the season. Thus, the landscape preference of streetscape was analyzed according to the season in this study. The result of the study on visual preference according to season and background showed that the autumn image of maple background and ginkgo background were more highly preferred than the winter image of maple background and ginkgo background. The statistical analysis on visual preferences according to background and season showed that the autumn image of maple background was preferred with the highest overall score. The visual preference of the autumn image of ginkgo background received the second highest score, and the winter image of maple background was the lowest. To conclude, variation of seasons is an important element in visual preference. Therefore, to improve the visual preference of a streetscape, designers should consider the variation of season as well as the shapes. Further research is needed to determine the visual preference of many different components such as light and shape. Therefore, further researches will be done to thoroughly analyze other factors determining the visual preference of streetscape.

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