Beneficial Effect of Forest Landscape on Relieving Stress Based on Psychological and Physiological Measures*

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심리적·생리적 측정에 근거한 산림경관의 스트레스 완화효과

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초록

본 연구의 목적은 산림경관의 스트레스 완화 효과를 생리측정(피부 돌출치와 심장박동시간)과 심리측정(ZIPER 설문지)을 통하여 조사하는 것이다. 연구가설은 두 가지로, 첫 번째 가설에서는 산림경관을 본 사람들의 스트레스 측정치가 인공경관을 본 사람들의 측정치보다 낮을 것이라고 예측되었다. 두 번째 가설에서는 산림경관을 본 사람들의 스트레스 해소가 인공경관을 본 사람들보다 보다 빠르고 완전하게 발생할 것으로 예측되었다.

실험에는 대학 학부학생 70명이 참여하였으며, 실험에 이용된 산림 및 인공경관은 예비설문을 거쳐 선정되었다. 실험결과를 보면 첫 번째 가설은 피부 돌출치와 긍정적인 심리요인 그리고 부정적인 심리요인에서 채택되었다. 두 번째 가설 중 스트레스 해소속도에 대한 가설은 피부 돌출치와 심장박동시간에서 모두 채택되었으나, 스트레스 해소의 완전성에 대한 가설은 피부 돌출치에서만 채택되었다. 비록 심장박동시간과 집중/호기심 요인에서 연구가설이 채택되지 못했지만 전반적으로 산림경관과 인공경관을 비교할 때 산림경관의 스트레스 완화효과가 더 크고 빠르고 완전함을 알 수 있다.

본 연구의 의의는 산림경관의 효과를 두 가지 측정(생리적, 심리적)을 이용하여 조사하였다는 점과 국외연구결과와 유사한 결과를 얻음으로써 이러한 효과가 지역에 관계없이 공통적임을 밝혔다는 점이다. 본 연구결과는 산림이 인간의 건강과 복지에 긍정적이라는 점을 입증함으로써 산림의 조성과 보존에 중요한 근거를 제공할 수 있다. 보다 발전적인 후속연구를 위해서는 다양한 종류의 인공경관과 일반시민들의 참여, 그리고 인지능력의 병행이 필요하다.

Key Words: Forest Landscape, Natural Landscape, Stress, ZIPERS, Physiological Measures

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I. INTRODUCTION

1. Forest Benefits and Previous Research

The benefits and values provided by a forest consist of wood and non-wood products and services. The non-wood benefits of forest are non-priced environmental and social values that include pleasant landscape, peace and quiet and potential recreational opportunities (Robinette, 1972; Miller, 1997). For a long time, wood production was the only component of forest values. However, new functions of forest, as a source of non-wood benefits, have appeared as urbanization proceeds. According to United Nations figures, only 14 % of the world's human inhabitants lived in cities around 1900. As late as in 1960, still two-thirds of the people lived in rural areas. By the turn of the century, however, over half of the world's population lived in urban areas (Giradet, 1992).

The urbanization has caused dramatic results in the environment by creating artificial landscape lacking amenities. With this spatial expansion of man-made landscape, the distance to natural world increased for most urbanites. As a distancing to natural world occurred with the urban expansion, society started to ask for more emphasis on the natural and environmental values of forest. Now, these non-market values are becoming the most important to society, and there is growing appreciation for these values, particularly in urban areas.

The benefits of the natural and environmental products of forest are recognized to be many. They include amenities that are aesthetic, ecological, and economic in nature, as well as those that have physical or psychological effects on human health. Thus, forests often become connected with the image of 'a modern wilderness' curing the physically and mentally exhausted (through information overload and stress) urban dweller. This therapeutic effect of forest has been empirically proved by a number of researches that investigated the beneficial effect of direct experience with forest in an abnormal population having emotional and mental problems (Bakana and Young, 1985; Neffinger et al., 1984; Shin and Oh, 1996) and other researches that examined stress -reducing effect of indirect experience with nature in a normal population (Ulrich, 1979; Ulrich et al., 1991; Parsons, 1991; Parsons et al., 1998; Lee and Lee, 2001).

Ulrich (1979) found that natural landscape held attention more effectively and fostered greater recovery for students mildly stressed due to final examinations. Ulrich et al. (1991) found that the participants who viewed videotaped surrogates of forest landscape recovered faster from stress than those who viewed video tapes with artificial urban landscape. Parsons et al. (1998) extended their research and found that only the perceptual encounters with natural landscape, not an active direct experience of it, could not only facilitate recovery from stressors, but could also prepare the participants for subsequent stressful experiences and lead to improved performance on a subsequent cognitive task, whereas urban landscape impeded recovery from stress compared to exposure to natural landscape. In domestic research, Lee and Lee (2001) found that interior plants scene facilitated greater stress recovery in both normal and abnormal populations than urban scene.

2. Theoretical Explanations for Stress-reducing Effect of Forest (Nature)

The theoretical explanation for the stress-relieving effect of natural environment is derived from both evolutionary and cultural learning theories. Cultural learning theory suggests that contemporary culture, developed with rapid urbanization, values natural environment as a refuge from stressful urban life. Therefore people have a universal tendency to revere nature and dislike cities (Tuan, 1974). Evolutionary theories argue that common evolutionary adaptations have predisposed humans to prefer and feel more psychologically and physiologically comfortable in a natural environment than an artificial one (Appleton, 1975; Ulrich, 1983; Orians, 1986; Kaplan, 1987).

Given the fact that the adaptation time to man-made environment was extremely short relative to the long evolutionary process in a natural environment, it is quite reasonable that humans have an unlearned predisposition to pay attention and respond positively to natural content (vegetation, water). Information overload theory, as one of evolutionary theories, suggests that humans might have some bias in their information processing system that favor natural stimuli because human brain and sensory system evolved in a natural environment (Kaplan, 1987). Wohlwill (1976) found that the complexity level of an artificial environment was evaluated much higher than that of a natural environment (forest), and further asserted that the evolutionary bias may influence humans to respond to a natural environment more easily and efficiently than to a man-made one.

Based on the three theoretical explanations, Ulrich (1983) insisted that natural environment had an intrinsic function to relieve human stress. On the other hand, Kaplan (1995) explained that natural environment relieves stress through holding attention without mental effort, which is pleasurable in nature and results in blocking out the demands and stresses. This involuntary attention to or "fascination" with nature is defined as a key mechanism in restoration from mental fatigue resulting from stress (Kaplan, 1995). Although these two positions are different in explaining the mechanism of the stress-reducing effect of nature, they have an agreement that stress is a meaningful concept and that stress reduction is aided by nature.

3. Research Purpose and Hypotheses

Most domestic researches examined the psychological benefits of natural landscapes, emphasizing such concepts as sense of relaxation, preference, scenic beauty, attractive image, and amenity (Kim et al., 1993; Shim and Kim, 1997; Sung and Lee, 1997; Im and Sin, 1998; Yi and Min, 1998; Suh and Choi, 1999). Although those verbal and psychological responses are valid evidence for the beneficial effects of natural (or forest) landscape, physiological responses, if they are used at the same time, would provide more objective and reliable proof for such effects.

Thus, the purpose of this present research is to examine whether forest landscape has beneficial effect on stressed Koreans, using psychological and physiological responses as research measures. Specifically, it aims to compare the stress-reducing effect of a forest landscape with that of an artificial landscape. Given this purpose, this research consists of two objectives. First, it examines the stress-reducing effect of a forest landscape on the Korean population so that the result can be used to demonstrate that the effect is universal. Second, it adopts two measures (psychological and physiological) at the same time and studies whether they reveal similar results, which can be used for a convergent validity of the effect. Baum et al. (1985) suggested that more than one mode should be used in order to understand stress or stress recovery in research. If the results from different modes show similarity, it would suggest convergent validity, and justify greater confidence in the findings. In the present study, two physiological measures (GSR: Galvanic skin conductance, and ECG: electrocardiogram) and one psychological measures of stress (ZIPERS: Zucherman Inventory of Personal Reactions) were used.

In order to carry out the research, two research hypotheses were formulated. The first was about the quantity of stress-recovery, and the second was about the speed and completeness of stress-recovery.

Hypothesis # 1:

The first hypothesis tested whether forest landscape had similar psycho-physiological restoration effects on stressed Koreans as it did on Americans. It was expected that participants who viewed a forest landscape would show more positive responses in psycho-physiological measures, as compared to participants who viewed an artificial landscape. Specifically, forest landscape was expected to induce much more stress reduction than artificial landscape in both psychological and physiological aspects.

Hypothesis # 2:

The second hypothesis examined whether a forest landscape facilitated a restoration effect on physiological responses compared to an artificial landscape. It was expected that participants who viewed a forest landscape would show a faster and more complete recovery from stress than those who viewed an artificial landscape.

II. METHOD

1. Participants and Stressor

The participants consisted of seventy undergraduate students who volunteered after reading the paper that explained the purpose and the procedure of the experiment. The purpose of the experiment was explained to find out the psycho-physiological change of a body during interaction with various environmental stimuli. All the participants did not have any neurological or health disorders, and were paid ₩10,000 for their participation after the experiment. Among the seventy participants, the data of seventeen participants were lost due to severe body movement or experimenter error. As a result, the data of fifty three participants were used in the analysis. Thus, twenty six females (average age: 22.7) and twenty seven males (average age: 24.7) participated in the experiment. Since the purpose of present research was to examine the stress-reducing effect of a forest landscape on stressed individuals, the research participants should be stressed first. In order to make participants stressed, a 10-minute videotape which showed hip surgery was used as a stressor. The hip surgery videotape was proved to be an effective stressor by past research (Parsons, 1991).

2. Selection of Environmental Surrogates for Forest and Artificial Landscape

Following the stressor, participants viewed one of the two videotapes which showed forest or artificial landscapes. In order to select the environmental surrogates for forest and artificial landscape, a pretest was performed.

The pretest was comprised of three steps. First, a simple survey was conducted on 96 undergraduates in order to find out the representative physical characteristics of forest and artificial landscapes. The results showed that a forest landscape was heavily associated with water and trees (woods), whereas an artificial landscape was mostly associated with man-made constructions such as industrial, residential, and commercial buildings. Second, 30 forest landscapes with water and trees and 90 artificial landscapes (30 industrial, 30 residential, 30 commercial) were photographed. In the third step, the 120 landscape slides were evaluated by 152 undergraduates on a 11 point bipolar scale. One axis of the scale represented the naturalness of landscape with 5 point degree (1=a little natural, 2=somewhat natural, 3=fairly natural, 4=very natural, 5=most natural). The other axis represented the artificialness of landscape with 5 point degree (−1=a little artificial, −2=somewhat artificial, −3=fairly artificial, −4=very artificial, −5=most artificial). Between the two axis, there was 0 in order to prevent confusion. Data analysis showed that a valley landscape with water and vegetation was evaluated as the most natural and that an industrial landscape with a big factory building was evaluated as the most artificial (Figures 1 and 2). Then, the two landscapes were selected as environmental surrogates for forest and artificial landscapes. Since previous research showed that color/sound videotape of landscape was a valid environmental surrogate (Anderson et al., 1983; Ulrich et al., 1991; Parsons et al., 1998), the selected landscapes were videotaped.

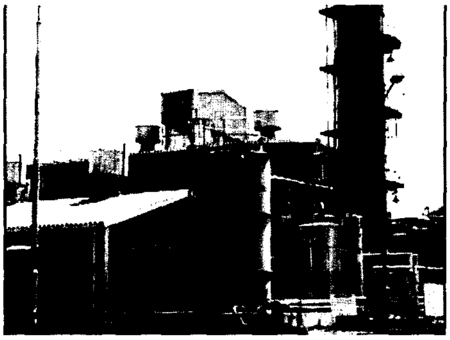

Figure 1. Artificial landscape

Figure 2. Forest landscape

3. Experimental Procedure

The experimental procedure was comprized of the following six phases: 1) preparation, 2) baseline measurement, 3) stressor measurement, 4) first ZIPERS, 5) landscape measurement, 6) second ZIPERS. In the preparation phase, all the electrodes were attached. In the baseline phase, the participant's physiological baseline was measured while he/she listened to peaceful music and viewed a black screen for 5 minutes. In the stressor phase, the participant experienced a mild stressor by viewing the hip surgery videotape for 10 minutes. In the first ZIPERS phase, the participant was asked to rate his/her feelings on the questionnaire. In the landscape phase, the participant viewed one of two landscape videotapes (forest or artificial) for 10 minutes. In the second ZIPERS phase, the participant filled out the questionnaire again.

4. Measures

ZIPERS (Zuckerman Inventory of Personal Reactions: Zuckerman, 1977) was used to record psychological responses. The ZIPERS was used in the previous research (Ulrich et al., 1991) and was proved to be an effective questionnaire for assessing stressful feelings. The ZIPERS consists of 11 statements that assess feelings on fear, positive affects, anger/aggression, attentiveness/interest, and sadness on a 5 point Likert scale.

As physiological measures, Galvanic Skin Response (GSR) and Electrocardiogram (ECG) were selected. These measures were continuously recorded throughout the three experimental phases, such as baseline, stressor, and landscape phase. The ECG records information about cardiovascular activity such as interbeat interval of heart rate (IBI), and GSR measures activity in the sweat glands lying under the recording devices. Both measures record activity that is controlled by autonomic nervous system (ANS). The autonomic nervous system is subdivided into the sympathetic nervous system and the parasympathetic nervous system. The main function of the sympathetic system is to mobilize the body for action, in order to deal with challenging situations effectively. Thus, sympathetic system consumes energy and thus, is physically stressful. On the other hand, parasympathetic system functions to restore and maintain bodily energy resources, which is physically stress-relieving (Johnson and Anderson, 1990).

Dawson et al. (1990) suggested that in studying autonomic nervous system, GSR and heart rate response are the most common choices, GSR for its neuroanatomical simplicity, trial-by-trial visibility, and utility as a general arousal/attention indicator and heart rate for its potential differentiation of more subtle psychological states. GSR is reported to increase during stress and decrease during recovery. Heart rate is known to decrease when the environmental stimuli induces attention/interest in individuals (Lacey and Lacey, 1970). Ulrich et al. (1991) also found that the exposure to natural landscape caused a lower heart rate that suggested higher attention. These findings supports Kaplan's (1995) assertion of the role of involuntary attention on stress reduction. Based on these findings, GSR and ECG were used as physiological indicators in the present research.

5. Physiological Recording and Data Reduction

The measuring tool was Biopac that was made in U.S.A. GSR was measured through two transducers attached on the skin surface over the thenar eminence of the distal phalanges of the 3rd and 4th fingers of left hand. ECG was measured through three transducers, two of which were attached on the right collar bone and on the lowest left rib bone. The other transducer was attached on the right ankle, which served as a ground. Each phase of physiological recording was divided into four non overlapping consecutive epochs of different absolute lengths. The baseline phase was 5 minutes, so it was divided into four 1.25-minute epochs. Both stressor and landscape phases were divided into four 2.5-minute epochs.

6. Experimental Design

Thus, the full experimental design consisted of two between-subject factors and one within-subject factor. The between subject factors were Gender (male, female) and Landscape type (forest, industrial). The within-subject factor was Epoch (4). Since 10 subjects was suggested to be enough for experimental design (Cozby, 1989), it was planned that participants were randomly assigned to conditions resulting in no fewer than 12 participants in each of the 4 cells defined by the two between-subject factors. The total of 53 subjects satisfied this condition.

III. RESULTS

1. Relative Changes in the Two Physiological Measures during experiment

Before testing the two hypotheses, Relative changes in the two physiological changes from base line were analyzed (Figures 3 and 4). In order to find the unbiased change patterns from baseline to stressor and landscape phases, all the physiological data of each participant was standardized from his/her baseline. Then, the data in the two figures represents mean value across subjects based on arithmetic differences from individual baselines. The change patterns in the two figures indicated that the participants who viewed forest landscape recover from stress more than the participants who viewed indus-

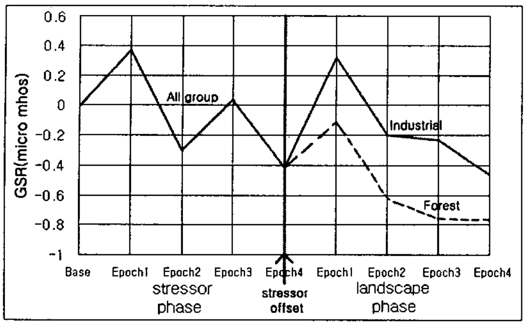

Figure 3. Relative changes in Galvanic Skin Response during stressor and landscape

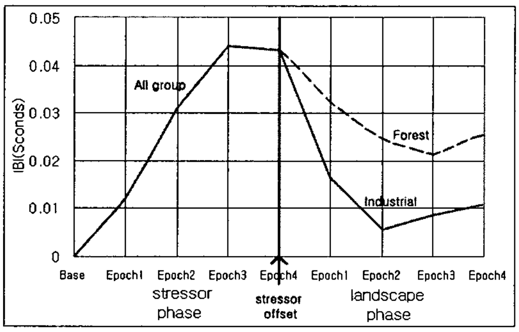

Figure 4. Relative changes in Interbeat Interval during stressor and landscape

trial landscape. The figures not only indicate that the stressor video failed to successfully induce stress except the first epoch in stressor phase (Figure 3), but also shows that it held the attention of participants stronger than the two landscape videos (Figure 4).

2. Test result for hypothesis # 1

The test results are summarized below according to the two measures.

1) Physiological measures

It was hypothesized that participants who viewed a forest landscape would show more positive responses in physiological measures (GSR, IBI), as compared to participants who viewed an artificial landscape. Thus, two separate ANOVAs were conducted in order to examine the effect of landscape on physiological responses. The general statistical model was comprized of the factors of Gender (2), Landscape type (2), Epoch (4), and each participant's physiological changes that was expressed as the difference. The physiological changes due to landscape were calculated by subtracting the average data of each epoch in the landscape phase from the average data of the four epoch in the stressor phase(i.e., average data of the four epochs in the stressor phase - average data of each epoch in the landscape phase).

The ANOVAs revealed that the significant effect of landscape was found for only GSR, not for IBI (Tables 1 and 2). For GSR, landscape had only main

Table 1. Result of ANOVA for Galvanic Skin Response

Source	df	Sum of squares	Mean square	F	p
Gender	1	7.527	7.527	3.265	0.072
Landscape	1	8.994	8.994	3.902	0.050
Epoch	3	15.971	5.324	2.309	0.078
Gender×Landscape	1	3.920E-04	3.920E-04	0.000	0.990
Gender×Epoch	3	0.936	0.312	0.135	0.939
Landscape×Epoch	3	0.339	0.113	0.049	0.986
Gender×Landscape ×Epoch	3	1.131	0.377	0.164	0.921
Error	196	451.836	2.305		
Corrected total	211	486.456			

Table 2. Result of ANOVA for Interbeat interval

Source	df	Sum of squares	Mean square	F	p
Gender	1	1.461E-02	1.461E-02	5.599	0.019
Landscape	1	5.472E-04	5.472E-04	0.210	0.647
Epoch	3	3.025E-03	1.008E-03	0.387	0.763
Gender×Landscape	1	1.059E-04	1.059E-04	0.041	0.841
Gender×Epoch	3	5.435E-04	1.812E-04	0.069	0.976
Landscape×Epoch	3	3.883E-04	1.294E-04	0.050	0.985
Gender×Landscape ×Epoch	3	2.923E-04	9.745E-05	0.037	0.990
Error	196	0.511	2.608E-03		
Corrected total	211	0.531			

effect (F(1, 196)=3.902, p=0.050), and did not interact with any other factors. The GSR difference of the participants who viewed a forest landscape (0.4206 micro ohlms) was bigger than that of the participants who viewed an industrial landscape (0.0155 micro ohlms). Since GSR decreases when stress is relieved, bigger difference (i.e., stressor phase - landscape phase) in GSR means greater stress recovery. This finding indicated that although stress was reduced by both forest and artificial landscapes, much more stress reduction was induced by a forest landscape. Thus, this finding supported the first hypothesis.

On the other hand, there was no significant effect of landscape for IBI at all, which indicated that a forest landscape did not induce involuntary attention that has been suggested by Kaplan (1995) to lead to stress reduction. Instead, there was a significant effect of gender (p=0.019). The result of t-test for the effect of gender revealed that IBI of female participants were longer (0.025 second) than that of male participants (0.009), which meant that the level of attention of females was higher than that of males. As a result, the first hypothesis was accepted only in GSR.

2) Psychological measures(the ZIPERS)

It was hypothesized that the participants who viewed a forest landscape would show more positive responses in psychological measures, as compared to participants who viewed an artificial landscape. In order to test this hypothesis, the changes of each 11 ZIPERS ratings were calculated by subtracting the ratings after the landscape phase from those before the landscape phase (i.e. first ZIPERS - second ZIPERS). Then, factor analysis was applied to the 11 changes in order to categorize the data. The 11 changes were divided into three factors; positive feeling factor, negative feeling factor, and attention/interest factor.

Then, MANOVA were conducted in order to examine the effect of landscape on the three psychological factors. The general statistical model was comprized of the factors of Gender (2), Landscape type (2), and each participant's psychological data on the three factors. As indicated in Table 3, the results of MANOVA revealed only significant main effect of landscape for both the positive feeling factor (F(1, 33)=16.316, p=0.000) and negative feeling factor (F(1, 33)=16.836, p=0.000), not for the attention/interest factor (F(1, 33)=2.218, p=0.146). There was no other significant main or interaction effect. Table 4 shows the factor score changes in the positive and the negative feelings. It was found that much more stress recovery was produced by a forest landscape than by an industrial landscape. Thus, the second hypothesis was supported only in positive and negative feeling factors, not in the attention/interest factor.

3. Test Result for Hypothesis # 2

The second hypothesis investigated whether forest landscapes facilitated a restoration effect on physiological responses compared to an artificial landscape. It was expected that participants who viewed a forest landscape would show a faster and more complete recovery from stress than those who viewed an artificial landscape.

In order to examine this hypothesis, recovery was defined as a feedback (return) to the average of the baseline. Thus, the data were re-expressed in the following manner to derive such new dependent variables as speed and completeness of recovery. First, the data of each epoch in the landscape phase was converted to the difference according to the formula (data − average of baseline). Second, the speed of recovery was operationalized as the epoch in which the converted value either crossed or were equal to zero, and the completeness of recovery was opera-

Table 3. Result of MANOVA for the three psychological factors

Source	Dependent variable	df	Sum of squares	Mean square	F	p
Model	positive feeling	3	16.706	5.569	5.491	0.004
	negative feeling	3	13.210	4.403	6.335	0.002
	attention/interest	3	1.714	0.571	0.934	0.435
Intercept	positive feeling	1	4.644	4.644	4.579	0.040
	negative feeling	1	10.576	10.576	15.215	0.000
	attention/interest	1	7.385	7.385	12.078	0.001
Landscape	positive feeling	1	16.547	16.547	16.316	0.000
	negative feeling	1	11.702	11.702	16.836	0.000
	attention/interest	1	1.356	1.356	2.218	0.146
Gender	positive feeling	1	0.103	0.103	0.101	0.752
	negative feeling	1	1.704	1.704	2.451	0.127
	attention/interest	1	0.274	0.274	0.448	0.508
Landscape ×Gender	positive feeling	1	0.188	0.188	0.185	0.670
	negative feeling	1	1.026E-02	1.026E-02	0.015	0.904
	attention/interest	1	0.126	0.126	0.205	0.653
Error	positive feeling	33	33.468	1.014		
	negative feeling	33	22.937	0.695		
	attention/interest	33	20.178	0.611		
Corrected total	positive feeling	36	50.174			
	negative feeling	36	36.147			
	attention/interest	36	21.892			

Table 4. Effect of landscapes on the three psychological factors: factor score change from before- to after-landscape

Psychological factors	Forest landscape	Industrial landscape	F	p
Positive feeling	-1.0175	0.3148	16.316	0.000
Negative feeling	1.0877	-0.0280	16.836	0.000
Attention/interest	0.2632	0.6389	2.218	0.146

tionalized as the actual values at this point of recovery. For each physiological data, two separate ANOVAs were conducted in order to find the effect of landscape type on the speed of recovery and on the completeness of recovery.

For GSR, the ANOVAs (Tables 5 and 6) revealed no significant main effect of landscape for both speed and completeness of recovery. Instead, there was a significant interaction effect for Landscape×Gender for both speed ($F(1, 152)=4.351$, $p=0.039$) and

Table 5. Result of ANOVA for the recovery speed (GSR)

Source	df	Sum of squares	Mean square	F	p
Model	3	11.991	3.997	8.125	0.000
Landscape	1	0.600	0.600	1.220	0.271
Gender	1	8.067	8.067	16.397	0.000
Landscape*Gender	1	2.141	2.141	4.351	0.039
Error	152	74.778	0.492		
Corrected total	155	86.769			

Table 6. Result of ANOVA for the recovery completeness (GSR)

Source	df	Sum of squares	Mean square	F	p
Model	3	100.738	33.579	4.619	0.004
Landscape	1	13.573	13.573	1.867	0.174
Gender	1	19.503	19.503	2.683	0.104
Landscape×Gender	1	55.739	55.739	7.667	0.006
Error	152	1105.010	7.270		
Corrected total	155	1205.748			

completeness (F(1, 152)=7.667, p=0.006). Further analysis showed that landscape had significant main-effect both on the speed and completeness of recovery only in females (t=3.876, p=0.000). Table 7 shows that females who viewed a forest landscape showed a faster and more complete recovery from stress than females who viewed an industrial landscape.

For IBI, the ANOVAs (Tables 8 and 9) showed a significant main effect of landscape only on the speed of recovery (F(1, 172)=9.634, p=0.002). Mean of the epochs where the first recovery occurred for forest landscape group was 1.04, whereas it was 1.21 for industrial landscape group. It meant that participants

Table 7. The epoch and the measures of GSR at the first recovery in female participants

Landscape	Mean of the epochs where the first recovery occured	GSR measure at the first recovery
Forest	1.08	3.498 micro ohlms
Industrial	1.44	5.297 micro ohlms

Table 8. Result of ANOVA for the recovery speed (IBI)

Source	df	Sum of squares	Mean square	F	p
Model	3	1.710	0.570	4.082	0.008
Landscape	1	1.345	1.345	9.634	0.002
Gender	1	0.454	0.454	3.250	0.070
Landscape*Gender	1	8.152E-03	8.152E-03	0.058	0.809
Error	172	24.017	0.140		
Corrected total	175	25.727			

Table 9. Result of ANOVA for the recovery completeness (IBI)

Source	df	Sum of squares	Mean square	F	p
Model	3	0.332	0.111	12.417	0.000
Landscape	1	2.562E-04	2.562E-04	0.029	0.866
Gender	1	0.316	0.316	35.392	0.000
Landscape*Gender	1	5.484E-04	5.484E-04	0.061	0.804
Error	172	1.535	8.923E-03		
Corrected total	175	1.867			

who viewed a forest landscape showed a faster recovery than those who viewed industrial landscape. Thus, the second hypothesis was partly supported. Specifically, the expectation concerning the speed of recovery was supported both in GSR and IBI, while the expectation related to the completeness of recovery was supported only in GSR.

IV. DISCUSSION AND CONCLUSION

In summary, the research findings are consistent with both research hypotheses and with previous research performed in foreign country (Ulrich, 1979; Ulrich et al., 1991; Parsons, 1991; Parsons et al., 1998). The results from both psychological and physiological measures converge to indicate that forest landscape has stress-reducing effect in Koreans, even though they partly supported the two hypotheses. Thus, the results not only demonstrate that the effect is universal across population with different nationalities. Also, they attest the convergent validity of the effect.

The first hypothesis examined whether forest landscape induced much more stress reduction than artificial landscapes. This hypothesis was accepted only in GSR, positive feeling factor, and negative feeling factor, but it was not accepted in IBI and attention/interest factor. Given the fact that IBI is closely related to "involuntary attention and interest", this result reveals that the effect of forest landscape was consistent within the two measures. The forest landscape was found to have more restorative influences than industrial landscape only on GSR and the two psychological factors. On the other hand, the forest landscape did not induce attention and interest in both psychological and physiological measures. The study results on the function of nature to evoke attention and interest has not been consistent. While Ulrich et al. (1991) found the evidences for the nature's capacity to hold attention and interest, it was not found here and other study by Parsons et al. (1998).

The second hypothesis investigated whether forest landscape fostered more complete (completeness) and faster (speed) stress recovery than industrial landscape. In GSR, it was accepted fully both for speed and completeness, but it was accepted only for speed in IBI. GSR measures showed that participants who viewed forest landscape returned their baseline level more quickly and completely than participants who viewed industrial landscape. However, IBI measures showed that participants who viewed forest landscape returned their baseline level more quickly, but not more completely, than the other group.

On the whole, the study findings supported that forest landscape has beneficial effect in relieving Koreans' stress psycho-physiologically, even though they failed to support the function of forest landscape to induce involuntary attention. The findings also prove that only the visual encounters with forest landscape, not a direct experience of it, can cause stress reduction in both psychological and physiological aspects. Stress is induced when informational stimuli exceed an individual's capacity to deal with them (Baum et al., 1985). As Kaplan (1987) and Wohlwill (1976) suggest, the visual information by which modern human being is surrounded far exceeds the information processing system, given the fact that it has evolved in a natural environment. Based on this theoretical ground, it is reasonable that viewing forest can give human being a chance to escape from stress and lead to stress reduction. This therapeutic effect generated only by visual contact with forest landscape is important in estimating the non-wood environmental benefits of forest these days. The environmental value of forest has been understood mainly in terms of aesthetic quality of landscape, recreational opportunities, and ecological functions. But the findings show that the total value should extend beyond these functions to include the therapeutic effect.

The findings have two implications for forest conservation, provision, and management. First, they can provide reasonable grounds to plan or reserve forest (natural) areas in extensively developed environments, such as urban and industrial. Since highly developed environments are filled with an inordinate array of physical, social, and information bearing stimuli, stress reduction caused by forest is more valuable in these areas. Environmental planners and designers should consider the negative results from land development, such as loss of environmental values of nature. One of the key questions is whether the provision or conservation of forest is in balance with the economic benefits of development projects. The findings showed that pleasant living environment with natural landscape could improve people's mental and physical health and further suggested that it could results in savings in health care for the society.

Second, the findings can be used in forest management. Forest managers need knowledge about people's perceptions and responses to different types of forest landscapes in order to properly manage forest. They should know both what kinds of landscapes evoke pleasant feelings and enhance people's well-being and also what kinds of landscapes create displeasing emotions. In the study, a forest landscape was represented by a valley landscape with water and trees that was selected as the most natural in the pretest. The valley landscape had a natural feel with an absence of human intrusion. The findings suggest that to guarantee this stress-reducing effect and achieve high social valuation, forests may need to be of an appropriate size and structure to allow such a natural feel.

Further suggestions for the future research include subject selection, environmental surrogate for artificial landscape, and response measures. First, general public is suggested as appropriate participants. Although undergraduate students provided valid results for this study, general public would provide stronger ecological credibility for the future research. Second, various types of artificial landscapes are suggested to be included in the future research. The industrial landscape chosen for artificial landscape in the present study was ugly as well as artificial. It may be argued that participants who viewed the industrial landscape showed less stress reduction than those who viewed the forest landscape because the industrial landscape was much uglier than the forest one. Thus, it is necessary to include attractive artificial landscapes in the future research. If forest landscape induces greater recovery even when it is compared to an attractive artificial landscape, the results would provide more valid evidence for the therapeutic effect of forest (or nature). Third, cognitive measures are suggested as a good measurement tool. If cognitive measures are used in addition to the psychological and physiological measures, the results can provide more valid evidence for the benefits of forest. Last, as mentioned, the evidence for the capacity of nature to hold involuntary attention was not consistent. Thus, more research should be oriented to this function of nature in order to understand the full benefits of forest.

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