Psychophysiological Responses and Restorative Values of Wilderness Environments

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Abstract— Scenes of natural areas were used as stimuli to analyze the psychological and physiological responses of subjects while viewing wildland scenes. Attention Restoration Theory (Kaplan 1995) and theorized components of restorative environments were used as an orientation for selection of the visual stimuli. Conducted in Taiwan, the studies recorded the psychophysiological responses of 110 laboratory participants while viewing 12 images that hypothetically represented the Being Away, Extent, Fascination, and Compatibility components of restorative environments. Psychological responses were measured using the Perceived Restorativeness Scale and physiological responses were recorded by electromyography (EMG), electrocephalography (EEG), and blood volume pulse (BVP) measurements. Results revealed a large degree of congruency between the psychological measures of restorativeness and the three physiological responses. Improved scores on the Perceived Restorativeness Scale corresponded to increased EMG and EEG readings and lower BVP measurements. These findings provide some objective evidence toward the psychophysiological values, and perhaps benefits, of wildland-wilderness environments.

Attention Restoration Theory

Hiking and walking for pleasure in wildland/wilderness areas is strongly associated with viewing of the natural environment. Wilderness offers the best of natural environments for people to view, an experience ranked high in participation surveys of outdoor and wilderness users (Cordell 1999). Yet, we know little, in an empirical sense, about the visual perception and psychophysiological response of people while viewing the naturalness of wilderness environments.

An obvious research question concerning the popular activity of hiking and sightseeing in wilderness environments is, "what influences does the viewing of visual images of natural scenes and landscapes have on humans, and what are the benefits of this activity-experience?" Hiking for pleasure and relaxation are hardly sufficient, scientific answers. In this paper, attention restoration theory (Kaplan 1995; Kaplan and others 1998) was used to select images of natural environments that were hypothesized to have restorative character benefits (Ulrich and others 1991). The scenes from the hypothetical recreation-restorative environments were then investigated to see if they elicited improved psychological and physiological reactions in people. Because on-line measures of psychophysiological responses in the leisure sciences are rare, and large samples of these kinds of data even more rare, the data set represents a potentially valuable window into human responses to natural-wilderness environments.

It is largely out of research on natural environments that Attention Restoration Theory (ART) has emerged. ART, proposed by Kaplan (1995) and Kaplan and others (1998), builds on the assumptions of limited human cognitive capacity, mental fatigue, and the possibilities of psychological recovery when in restorative environments, such as natural areas. It is concerned with the directed attention capacity that individuals use in demanding and/or uninteresting environments, such as work and stressful interactions with people or places. Directed attention capacity is subject to fatigue, which leaves the individual less capable of dealing with uncertainty, confusion, and demanding tasks that are of little human interest. ART also posits that environments and functions requiring indirect attention allow for recovery from mental fatigue and thus the restorativeness of psychological processes and properties in individuals (Hartig and others 1997; Kaplan 1995).

Although ART, as proposed by the Kaplans, does not theorize any physiological aspects associated with psychological restorativeness, other researchers have suggested a link between psychological and physiological responses in natural environments (Ulrich 1988; Ulrich and others 1991). In addition, even though ART may not be directly intended for psychophysiological hypothesis testing, other Kaplan writings do suggest linkages between the psychological and physiological processes of individuals when functioning in natural environments (Kaplan and Kaplan1982). It seems reasonable to hypothesize that the psychological processes of recovery from mental fatigue could be associated with the physiological processes of brain and blood pulse activity during and/or resulting from the recovery/restoration process.

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Attention restoration theory describes restoration occurring in environments and situations that involve four components: Being Away, Extent or Coherence, Fascination, and Compatibility (Kaplan 1995). Restoration requires psychological and geographical distancing from aspects of one's usual environs, routines and situations (being away), immersion in a coherent physical or conceptual environment that is of sufficient scope to sustain exploration (extent), effortless attention as drawn by objects in the environment or engaged in the process of making sense of the environment (fascination), and a good match between personal inclinations and purposes, environmental supports for intended activities, and environmental demands for action (compatibility). Environments with elements of all four components promote the involuntary attention mode of information processing, and can lead to restorative experiences in which individuals may develop a state of cognitive clarity, enabling a pleasurable and contemplative state of mind (Korpela and others 2001). While ART proposes that all four of the restoration components must be present in an environment for it to be restorative (Kaplan 1995), it does not posit that all must be present in equal proportion.

As mentioned, much of the research that ART developed from has been conducted in natural environments, including wilderness-type environments (Kaplan 1984; Kaplan and Talbot 1983; Talbot and Kaplan 1986). Wilderness recreation and natural environments tend to rank high in the four properties of restoration environments and restorative experiences. However, there are other types of environments besides wilderness that have restorative properties or benefits, and these have been researched, as well. Rather than review the many studies that involve ART, the reader is referred to two recent special issues of journals that include 16 articles on restorative environments (Hartig 2001; Hartig and Staats 2003).

Methods

Study Area and Participants

The research was conducted in the psychophysiological laboratory at the National Chung-Hsing University at Taichung, Taiwan. The laboratory is well equipped for psychophysiological research and several studies have been conducted with a focus on natural recreation areas, and psychophysiological response (Chang 2003; Chang and Perng 2000; Chang and Van 1999; Chang and Yzeng 1998). This particular study was completed in 2001 with 110 participants, consisting of mainly students and faculty of Chung-Hsing University.

Visual Stimuli

The four components of Kaplan's (1995) attention restoration theory—being away, extent, fascination, and compatibility—served as indicators for choosing pictures of landscapes with hypothetical attention restorative capability. Images were chosen according to the theorized features and suggested examples of restorative environments mentioned and illustrated in Kaplan and Others (1998). Although these authors do not specify particular landscapes at the exclusion of others to exemplify the four restorative components, they do attempt to apply the concepts to environment design and management, and offer practical guidance through illustrative media and landscape examples. As an illustration, when discussing the component of extent, the authors of ART suggest that extent can be found in extensive environments, such as mountain wilderness; in small environments, such as Japanese gardens; and/or abstract environments, such as a view from the window. We used this type of guidance to select three photos to represent extent. Similarly, the hypothesized being away set of three photos illustrated a sense of remoteness where one could forget the tasks and routines of everyday life (for example, lying on the beach, lakeviews, mature forests). Fascination scenes were selected to illustrate the theorized elements of soft fascination (for example, sunsets, flowing water) and organism fascination (for example, fishing). Kaplan and others (1998: 69) provide illustrative scenes and text that guided our selection of fascination photos by stating, "open woods and rushing streams are just two of the many patterns of nature that can be fascinating" and that "fishing, canoeing, and wildlife viewing are activities that involve quiet fascination." Compatibility scenes depicted functional opportunities, such as shorelines and fields-trails to walk. In total, 12 images (3 per each of the 4 restorativeness components) were shown to participants on a large screen.

Materials and Procedures

Viewing Images. To encourage participants to relax, soothing music was played during the instructional-explanation stage of the study, before the viewing of study images. Participants were also seated on a couch at a 3m (10 ft) distance from the picture screen. In order to eliminate the influence of the viewing order of pictures, the images were projected randomly in 12 different combinations. Participants viewed each slide for 10 seconds, with measurement scores based on the entire viewing period. The nonviewing time between slides consisted of a solid blue image, projected for an equal time of 10 seconds. An AELTA (AV 600) digital projector was used to show the visual scenes. The projector and physiological equipment were all placed behind participants to decrease annoyance of the machines on participant response.

Testing of Physiological Reactions. Physiological reaction values were recorded by using the Procomp+/Biograph V2.0 Biofeedback System made by Thought Technology Ltd., a system with a multi-modality 8-channel system. Guidelines for the facial and head placement of electrodes on subjects followed those specified by Cacioppo and others (2000). Testing procedures and instrument application also followed procedural guidelines specified by Cacioppo and others (2000). The resulting information was sent directly to the computer via a fiber-optic cable. Computer analysis software and precise sensors are included as part of the equipment.

Skeletomuscular (muscle tension) or electromyography (EMG) response was measured using the facial muscles of the forehead. Facial muscles on the forehead can reflect mental and emotional stress better than other muscles. Tension felt by the forehead extends to other parts of the body, even while other parts of the body are relaxed. Therefore, three electrodes were placed 4 cm (1.5 inches) above the eyebrows of each participant, the middle one was "the reference," a reference point of the other two electrodes, called "source 1" and "source 2." By using the potential difference between the reference and source 1 as well as source 2, unrelated information is eliminated. An increase in EMG amplitude indicates a level of muscle tension increase, and vice versa.

Bioelectrical (brain wave) or electroencephalography (EEG) response was detected by placing the electrodes on the scalp, through which the brain waves produced by the cerebral cortex, are amplified and recorded by the electroencephalograph. The medial prefrontal cortex is the main position where the EEG is performed; therefore the electrodes are attached, at equal distance, at the front, back, left, and right of the forehead. An increase in EEG values indicates an increase in level of alpha brainwave activity.

Cardiovascular (blood volume pulse, BVP) was measured using an infrared detector, which senses the degree of cardiovascular change by emitting infrared waves, which in turn are reflected by blood cells in participants' fingertips. A sensor was placed on the middle finger of the non-dominant hand to measure BVP. By analyzing the spectrum of the signals reflected by the blood cells, it is possible to know a participant's pulses and his/her speed of blood circulation. An increase in BVP amplitude indicates decreased sympathetic arousal and greater blood flow to peripheral vessels.

Testing Psychological Reactions. The perceived restorativeness scale (PRS) proposed by Hartig and others (1991) was translated into Chinese and used for the evaluation of participants' psychological reactions. Based on the four components of restorative environment (being away, extent, fascination, and compatibility), 23 items such as "This place is a refuge from unwanted distractions," "This place is fascinating," and "This place does not place demands on me to act in a way I would not choose" were used to test degree of attention restorativeness after viewing each image. The 23 items were rated on a 5-point scale of agreement ranging from 1 = Very Much Agree, 3 = Neutral, 5 = Very Much Disagree.

In summary, previous psychological research concerning ART has shown that the PRS has had success at measuring the theoretical, restorative components in natural landscapes/environments. Psychophysiological research, associated with measuring stress recovery/restoration response to natural environments, has also suggested a relationship between improved psychological restorativeness and physiological condition. Oriented by this theoretical perspective and past research findings, the following hypotheses were developed for investigating the psychophysiological responses to visual images of natural and wilderness environments.

1. Although restorative environments must contain all four of the theorized components of ART, visual landscapes selected to hypothetically rate higher on a particular component will receive higher perceived restorativeness scores (PRS) on that specific component, as compared to the other three components present.
2. Viewing of the restorative environment images will produce improved physiological responses over the non-viewing control image.

Results and Discussion

Psychological Response

The internal consistency (reliabilities) for the four restorative components was computed by calculating the Cronbach's alpha for all 23 PRS item ratings that were completed for each of the four trio of photos selected to represent the four restorative components. The Cronbach alphas were acceptable, being 0.86 (Being-Away), 0.90 (Extent), 0.95 (Fascination), and 0.91 (Compatibility). After each trio of component images was established as being a reliable measure, the PRS mean values for the four restorative components were computed for each trio of images, and the means compared within each trio of slides to determine if the images selected to hypothetically represent a component of restorativeness scored higher on that specific component as compared to the other three components (Hypothesis 1). Congruent results were obtained for the being away, extent, and fascination image categories, with each set of photos ranking first on its respected restorative component (see table 1). In the case of the compatibility category, the images ranked first on the PRS fascination component and second on compatibility. Laumann and others (2001) found, using verbal stimuli, that compatibility was not always differentiated from fascination by respondents. Although some of the comparisons were not statistically significant, these results provide an element of construct validity and offer partial support for Hypothesis 1.

The images proposed as examples of the four restorative components were generally rated as hypothetically selected, although not cleanly enough to be treated as *representing* those components. Although Kaplan and others (1998) do not necessarily expect the exemplar environments offered in their text to be clean representatives of the different components, our findings do largely uphold their notions, enhancing our confidence in the validity of the restorative components. Perhaps this is the contribution of our research; that there is a degree of congruence between the actual PRS scores of participants and the theorized examples of restorative environments of Kaplan and others.

Physiological Response

Because the restorative environment images cannot be a pure example of certain specific restorative components, we cannot interpret the physiological changes as responses to a particular component of the restorative images. The responses are likely a complex response to a combination of the restorative components. This is a reality despite our attempt to select visual stimuli to perhaps represent certain restorative components over others within the images, based on literature guidance. Therefore, the physiological changes to be reported for the trio of photos selected to represent the restorative components represent, at most, physiological changes in response to restorative images, in general.

Table 2 reports four physiological measurements for the four sets of restorative images and the non-viewing control image, thus reflecting the degree of change from the non-viewing condition. All four of the physiological responses reveal an improved condition over the non-viewing measurements, with EEGa, EEGb, and EMG measures increasing and BVP decreasing (Hypothesis 2). When examined for

Table 1—The mean value of the attention restoration score for each restoration component (PRS items) while viewing the four sets of images depicting each component.

Restorative features	Attention restoration score	Mean[a]	SD	Rank	Pairwise comparisons[b]
Being away	Being away	1.90	0.56	1	Being away/extent
	Extent	2.24	0.55	4	Being away/compatibility
	Fascination	1.99	0.55	2	Extent/fascination
	Compatibility	2.18	0.65	3	Fascination/compatibility
Extent	Being away	2.75	0.71	3	Being away/extent
	Extent	2.42	0.61	1	Being away/fascination
	Fascination	2.55	0.75	2	Extent/compatibility
	Compatibility	2.79	0.66	4	Fascination/compatibility
Fascination	Being away	2.36	0.82	2	Fascination/compatibility
	Extent	2.40	0.55	3	N.S.
	Fascination	2.27	0.82	1	N.S.
	Compatibility	2.47	0.93	4	N.S.
Compatibility	Being away	2.02	0.50	4	Being away/fascination
	Extent	2.01	0.59	3	Extent/fascination
	Fascination	1.88	0.58	1	N.S.
	Compatibility	1.94	0.63	2	N.S.

[a] Means based on a 5 point scale of agreement, where 1 = very much agree, 3 = neutral, 5 = very much disagree.
[b] Pairwise comparisons that were significantly different, $p \leq 0.05$; N.S. = not significant.

Table 2—The mean value of respondents' physiological responses.

Physiological responses	Landscape feature	Mean	SD
EEGa[a]	Being away	22.14	28.76
	Extent	19.04	25.46
	Fascination	19.05	26.72
	Compatibility	19.53	29.28
	Non-viewing	6.18	4.01
EEGb[b]	Being away	23.86	35.48
	Extent	20.21	28.06
	Fascination	18.72	26.74
	Compatibility	17.36	24.40
	Non-viewing	6.03	3.60
EMG	Being away	11.45	7.70
	Extent	10.96	8.01
	Fascination	9.63	7.05
	Compatibility	10.03	8.08
	Non-viewing	8.67	7.77
BVP	Being away	25.02	0.53
	Extent	25.04	0.50
	Fascination	25.01	0.52
	Compatibility	25.02	0.46
	Non-viewing	25.22	0.73

[a] Alpha wave of left side of brain.
[b] Alpha wave on right side of brain.

significant change over the non-viewing condition, the differences were found to be statistically significant, $p<0.05$ (table 3).

These findings provide an element of converging psychophysiological evidence for restoration when viewing natural images. The findings also support and extend previous findings related to stress recovery and restoration in natural environments (Parsons and others 1998; Ulrich and others 1991) where the authors have found faster, more complete, and longer lasting improvements in physiological conditions after viewing natural-restorative environments. More specifically, measures in autonomic activity (for example, blood pressure) have decreased while somatic activities have increased.

However, the evidence of our findings is not without limitations. For example, one concern is the valid interpretation of the EMG findings. Some previous research has yielded reduced EMG, which was interpreted as a reduced level of stress. Other research has produced increased EMG, interpreted as indicative of a restorative, relating stimulus. Therefore, our finding concerning change in EMG is open to differing interpretations.

Conclusions

What influences does the viewing of visual images of natural scenes and/or wilderness environments have on humans, and what might be the psychophysiological response and value/benefit to this activity-experience? This was the general question that was the driving force behind this study. It was proposed that natural environments (images) selected to contain features of the four restorative components of being away, extent, fascination, and compatibility, would elicit improved psychological (PRS values) and physiological (EEG, EMG, BVP values) responses from viewers, inferring that visual resources of wilderness environments produce nature related restorative-leisure benefits (Ulrich and others 1991). Results from the psychophysiological responses lend support for this proposed relationship, and confirms previous research demonstrating the value of natural and wilderness environments at producing restorative experiences.

Our research, though but one narrow investigation into the potentially rich field of recreation-restorative environments, offers several future research questions. For example, to what extent do different wildland recreation environments evoke different psychophysiological responses? Do favorite places and wilderness areas of extreme naturalness rank higher in value/benefits from a psychophysiological perspective? And, what environmental features and/or recreation settings yield the “higher” responses? From a “negative” response perspective, what are the psychophysiological repercussions when daily hassle and conflict settings (for example, crowding) occur in wilderness environments? Urban environments are not the only sources of stress; there are examples within wilderness and other recreation environments! How does recovery from stressful settings in recreation environments occur in

Table 3—ANOVA of participant’s physiological responses on different restorative environments.

Source	Type III SS	df	F	Significance	Pairwise comparisons[a]
EEGa[b]	17386.36	3.41	11.09	0.000	Being away/non-viewing Extent/non-viewing Fascination/non-viewing Compatibility/non-viewing
EEGb[c]	19858.99	2.86	12.01	0.000	Being away/non-viewing Extent/non-viewing Fascination/non-viewing Compatibility/non-viewing
EMG	530.97	2.77	18.58	0.000	Being away/fascination Being away/compatibility Being away/non-viewing Extent/fascination Extent/compatibility Extent/non-viewing Fascination/non-viewing Compatibility/non-viewing
BVP	3.54	2.31	10.45	0.000	Being away/non-viewing Extent/non-viewing Fascination/non-viewing Compatibility/non-viewing

[a] Pairwise comparisons that were significantly different, $p \leq 0.05$.
[b] Alpha wave of left side of brain.
[c] Alpha wave on right side of brain.
Note: The Mauchly’s W Statistic was significant in all four cases (i.e., $0.000<p<0.05$, Mauchly’s Test of Sphericity), and therefore, the Greenhouse-Geisser correction was used.

a psychophysiological sense? Secondly, to what extent do individuals differ in their responses to a given wilderness environment? Do individuals prone to stress or those with a strong coping strategy repertoire respond differently? Does experience use history and specialization influence psychophysiological response? Thirdly, given that these data are on-line, how do responses develop and/or change over time? To what degree can physiological response be recorded as a wilderness environment and experience unfolds in the field?

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