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A reliable and valid self-rating measure of the restorative quality of natural environments

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Abstract

The purpose of this study was to develop and test a self-rating restoration scale (RS) designed to measure the restorative quality of environments. Both the Kaplan and Kaplan [The Experience of Nature: A Psychological Perspective, Cambridge University Press, New York] and Ulrich [Aesthetic and affective response to natural environment, in: I. Altman, J.F. Wohlwill (Eds.), Behavior and Natural Environments, Plenum Press, New York] hypothesize that restorative environments are settings that facilitate the reduction of stress. Over the past decade, an increasing amount of empirical research has also shown that the restorative influences of environments manifest themselves in emotional, physiological, and cognitive responses of humans [J. Environ. Psychol. 11 (1991) 201]. Thus, the RS should cover, at least, these three dimensions. Moreover, the dimension of intended behavior in environments was also included. This RS was examined and revised through a two-phased experimental design. Forty-eight color slides selected from thousands of slides were used as the stimuli and the surrogates for the actual environments in the experiments. These 48 strictly controlled slides represented a proper and comprehensive sample of the six major terrestrial biomes of the world: desert, tundra, grassland, coniferous forest, deciduous forest, and tropical forest [Ecology and Our Endangered Life-Support Systems, Sinauer Associates Publishers, Sunderland], and varied as a function of high and low levels of three physical variables: complexity, openness, and water features. Five experiments with five groups of undergraduate students at Texas A&M University as subjects (total $n = 505$) were conducted to test the RS. Results of exploratory, confirmatory, analysis of moment structures (AMOS), correlation, principal component, and reliability analyses indicated that internal validity, convergent and discriminant validity, convergent and divergent construct validity, and reliability of the RS were all adequate. Thus, the operational definition and the construct of restorativeness developed in this study can be applied to future research on recovery from stress. Hopefully, this theory-derived and data-oriented RS will be eventually applied to various environments by any concerned individuals to examine the result of planning and design practice in terms of a desired state of recovery from stress.

Keywords: Restorativeness; Environment; Psychophysiology

1. Introduction

Modern life, particularly urban living characterized by crowding, traffic, overload of information, excessive stimulation, and lack of peace and quiet, is considered very stressful (Lewis, 1990; Francis and Cooper Marcus, 1991). Feelings of stress, anxiety, and worry have been shown to have negative impacts on both physical and psychological well-being of humans (Francis and Cooper Marcus, 1991). The physical and psychological ailments caused by the hassles

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and distress of everyday life, no matter how trivial or dramatic, influence all members of society (Nitzky, 1994). Health care expenditures on physical illness associated with stress have been estimated as at least 100 billion dollars each year (Satuter et al., 1990; O'Donnell and Harris, 1994). The need to reduce the rate of increase of health care costs caught the attention of politicians, legislators, and decision-makers nationwide in America, leading to the increased power of healthcare insurers and managed care in the 1990s (Nitzky, 1994). Since medical practitioners have long been aware that relaxation can help people cope with stress and that reducing stress can help the immune system to combat illness (Healy, 1986), restorative experiences that reduce stress might play an important role in health and healing (Kaplan and Kaplan, 1990). Therefore, both researchers and practitioners in environmental planning and design must understand the relationship between physical settings and recovery from stress in order to make sure that restorative environments are created and protected (Francis and Cooper Marcus, 1991).

Therefore, there should be a simple and straightforward method by which users, clients, designers, and researchers could examine how design practices achieve restorative environments. Currently, only the perceived restorativeness scale (PRS) (Hartig, 1993) is readily available to measure and test restorative qualities of environments. However, this scale originally had 44 items whose language is based primarily on the Kaplan and Kaplan's (1989) theory, which focuses only on recovery from mental fatigue (Hartig, 1993; Herzog et al., 1997). These 44 items covering four dimensions as proposed by the Kaplan and Kaplan are written in short sentences, among which some, such as extent and compatibility, seem to be phrases not commonly used by the general population unfamiliar with the Kaplan and Kaplan's work and jargon. When the measures do not resemble familiar human reactions to or experiences with landscapes, the reliability of the measure and the validity of its instrument may be questionable (Seamon, 1979; Daniel and Vining, 1983). Later, Hartig's group (Hartig et al., 1997) revised the PRS incorporating 16 items to cover the same four dimensions. They further developed a short version of the revised perceived restorativeness scale (RPRS) with 12 items to cover three dimensions (Hartig et al., 1997).

Although human beings and environments compose a mutually interacting system, environmental psychologists tend to put too much emphasis on the subjective rather than the physical environment, as pointed out in the early days of environmental psychology by Wohlwill (1973). He further advocates that research on environment and behavior should define the environment in "objective, physical terms ... via operations that are independent of the subject whose behavior is under study" (p. 169). Even though it is often difficult to operationalize physical environments as objective, tangible factors, it is important to assess and understand subjective experience as a function of objective factors in various environments. That is, people's reactions or judgments are analyzed in comparison to a range of manipulated physical features in the physical environments being judged. This is because some bio-physical features of environments, when experienced by human perceivers, produce psychological and physiological reactions in the perceivers. Such comparison is preferable to analyzing only the subjective dimensions of people doing the judging (Liben and Downs, 1991). A psychological approach to understanding the human–environment interaction is most valuable only when it contributes meaningfully to design and management by identifying objectively measurable physical features (Wohlwill, 1976; Daniel and Ittelson, 1981; Daniel and Vining, 1983). Thus, the purpose of this study is that a restoration scale, which has a small number of items, a broad perspective integrating both the Kaplan and Kaplan's (1989) and Ulrich's (1983) theories of restorative environments, a general application, and an attempt to place emphasis on tangible, measurable aspects of environment will be developed and its reliability and validity will be tested.

This study could contribute to the practice and research in the discipline of the environmental planning and design in at least two ways. First, the simple and straightforward RS developed in this study gives users, practitioners, researchers, managers, and policy-makers a tool to help ensure that restorative environments are protected and design practices achieve a desired state of restorativeness. With this instrument, the results of any environmental decision and design can be evaluated objectively. Consequently, people frequently experiencing stress in daily life will have more opportunities to recover from stress

and feel at ease. If the well-being of the public can be increased, billions of dollars spent on health care associated with stress may be reduced.

2. Definitions of restoration

Although "restoration" is not an unfamiliar or abstruse word, it is not commonly used in everyday life to describe environmental impact on human beings. Therefore, an introduction to what "restoration" means might be a good starting point. Random House Unabridged Dictionary (1993) defines restoration as "a return of something to former, original, or unimpaired condition", or "restitution of something taken away or lost" (p. 1641). Similarly, Oxford English Dictionary (1987) defines restoration as "the action of restoring a person to health or consciousness; recovery of physical strength" (p. 754). Thus, these definitions describe restoration as not only a result but also as a process. Also, they indicate that restoration of human beings from previous deprivation includes physical and psychological aspects. With this general idea of what restoration means, the discussion now shifts to the restorative effects of environments on human beings.

3. Empirical studies of environmental influences on restoration

As more empirical or experimental studies have accumulated quickly in recent years, findings from rigorous research have found sound evidence pointing to the restorative influences of environments, particularly natural scenes, on human beings (Hartig et al., 1991; Kaplan, 1995). In principle, findings have indicated that natural scenes promote positive emotion, physiology, cognition, and health (Ulrich, 1993; Ulrich et al., 1991; Ulrich and Parsons, 1992). Definitions of these terms and support for this statement will be summarized in the following sections.

3.1. Natural scenes

Natural scenes have been generally defined as the absence of artifacts, but not necessarily lack of human management, such as national forests or national parks (Balling and Falk, 1982). Hence, the domain of visually natural environments is by no means limited only to the wilderness (Ulrich, 1983). From a broad perspective, both Western and Asian adults tend to judge scenes as natural under three conditions: (1) if the presented landscape is dominated by vegetation, water, and mountains; (2) if artificial features are absent or concealed; and (3) if the dominant contours or visual profiles are curvilinear or irregular rather than rectilinear or regular (Ulrich, 1983, 1993; Wohlwill, 1983). Natural scenes thereby encompass a great variety of outdoor settings. Examples of natural scenes include parks and open spaces, street trees, vacant lots, back yards, fields, forests (Kaplan et al., 1998), pastures, cereal crops, and even golf courses (Balling and Falk, 1982; Ulrich, 1993).

3.2. Positive emotion

Emotions can be defined very generally as the feeling dimension of a person (Simon, 1982). Therefore, positive emotions include, in general, positive feelings such as pleasure, happiness, satisfaction, and tranquillity or, broadly speaking, a positively toned emotional state (Ulrich et al., 1991). Studies have shown that some specific, positive feelings can be evoked and some specific, negative emotions can be reduced by interaction with nature. The results of a survey of more than 4000 members of the American Horticultural Society showed that over 80% of the surveyed subjects indicated peacefulness and tranquillity as the most important feelings during interaction with nature in gardens (Kaplan, 1983). Other studies found that unspectacular natural scenes reduced negative feelings such as anger, fear, aggression, or arousal, and increased overall positive affects such as happiness, friendliness, or elation (Ulrich, 1979; Hartig et al., 1991, 1996; Ulrich et al., 1991; Honeyman, 1992). Also, Heerwagen and Orians discovered that, in the presence of a large nature mural on a wall of the waiting room at a dental clinic, compared with no mural, patients felt more calm and less tense, as shown by affective self-ratings (Heerwagen, 1990). Similarly, Ulrich et al. (1993) found that patients exposed to natural pictures showing an open view of water reported less postoperative anxiety whereas those exposed to abstract pictures experienced strong negative emotions.

3.3. Positive physiology

Positive physiological responses refer to positive changes in mobilization or activity in various physiological systems of the body (Ulrich et al., 1991). These changes can be either reduction of excessive physiological arousal, or return from understimulation to a normal or moderate state (Ulrich, 1993). Both laboratory studies (Hartig et al., 1991; Parsons, 1991b; Ulrich et al., 1991; Hartig, 1993; Parsons et al., 1998) and field experiments (Hartig et al., 1991; Hartig, 1993) using a battery of physiological measures have shown that stressed subjects exposed to visual simulations of real settings dominated by natural features recovered faster and more thoroughly from stressesor effects. Similarly, Coss (1990) found that patient's systolic blood pressure was 10–15 points lower when the mounted posters on the ceiling above the patients were primarily nature dominated by water, compared to views of people in sport activities, or no picture. Natural scenes benefit unstressed subjects' physiological mobilization as well. Ulrich (1981) found that the unstressed subjects who viewed slides of unspectacular natural landscapes had greater brain electrical activity (EEG) in the alpha frequency range than their counter subjects who viewed slides of non-blighted urban scenes. All these results suggested that subjects were less aroused physiologically and more relaxed but wakeful during exposure to natural simulations (Ulrich, 1981).

3.4. Positive cognition

Positive cognition involves recovery from mental fatigue (Kaplan and Kaplan, 1989), high levels of prolonged yet non-taxing attention (Ulrich et al., 1991), effective cognitive functioning, and deeper reflection (Kaplan et al., 1998). Both heart-rate data obtained from physiological measures and self-report attentiveness data in laboratory studies illustrated convergently that natural landscapes evoked higher levels of attention or information intake than urban scenes (Ulrich, 1979, 1981; Ulrich et al., 1991). Hartig et al. (1991) found that subjects exposed to nature had greater attentional restoration measured by proofreading outcomes than subjects exposed to urban environments. Tennessen and Cimprich (1995) found that dormitory students whose window views were more natural had stronger attentional capacity than those whose window views were man-made. In a recent experimental study, Parsons et al. (1998) found that subjects exposed to natural roadside landscapes had better performance on information processing, concentration, and attention span than those exposed to artifact-dominated roadside landscapes.

3.5. Positive health

Health can be considered as "the general condition of the body or mind with reference to soundness and vigor; or soundness of body or mind, freedom from disease or ailment" (Random House Unabridged Dictionary, 1993, p. 882). Both Moore (1982) and West (1985) found that prisoners whose windows looked out to nearby nature reported fewer sick calls than those whose window views looked out to built scenes. Ulrich (1984) compared health outcomes of matched patients who had undergone gall bladder surgery and were recovering with one of two types of window views. The postoperative patients whose rooms had window views out to a natural setting dominated by trees took fewer potent analgesics and were released from the hospital sooner than those whose windows overlooked a man-made setting dominated by brown brick walls. Another type of study that focused on indoor office workers and window accessibility using self-reports likewise showed that workers who had access to window views of nature reported fewer diseases and headaches than those who had no window access or had window views of built features (Kaplan et al., 1988; Kaplan, 1993).

4. Theories of restorative environments

4.1. The Kaplan and Kaplan's (1989) theory

In their theory, people need to maintain cognitive clarity in order to perform their day-to-day functioning efficiently (Kaplan and Kaplan, 1982). A lack of cognitive clarity will result in painful experiences, so to reduce this pain requires directed attention. However, people's capacity for directed attention is limited. It is depleted by extensive use. Kaplan and Kaplan call this exhaustion of directed attention "mental fatigue." Mental fatigue has negative influences

on people; mental fatigue manifests itself in negative emotions, irritability, impulsiveness, impatience, reduced tolerance for frustration, insensitivity to interpersonal cues, decreased altruistic behaviors, reduced performance, increased errors, lessened ability of taking in information, and increased likelihood of taking risks (Hartig et al., 1991, 1996; Hartig, 1993; Kaplan et al., 1993, 1998).

Generally speaking, directed attention fatigue results in reduced competence or decreased effectiveness in functioning (Hartig et al., 1991; Kaplan et al., 1993). Fortunately, the depletion of directed attention can be restored by rest. Thus, in the Kaplan and Kaplan's view, the restoration of effectiveness or competence is the measure of recovery from mental fatigue (Hartig et al., 1991; Hartig, 1993; Kaplan, 1995). Therefore, Kaplan and Kaplan's framework for recovery from mental fatigue is also called attention restoration theory (Kaplan et al., 1993; Hartig et al., 1997). The state of reduced fatigue of directed attention refers to restorative experience (Kaplan, 1995), while settings where mental fatigue is reduced are called restorative environments (Kaplan et al., 1998).

Restorative experiences can happen at various times and have different intensity levels (Kaplan et al., 1998), while restorative environments encompass a wide range of settings from wilderness to indoors and a variety of different scales (Kaplan et al., 1993, 1998). Kaplan and Kaplan (1989) have identified four common properties of restorative experience or settings—being away, extent, fascination, and compatibility—characteristic of both the imagined, mental domain and the actual, physical domain (Kaplan et al., 1998). In their perspective, people, being endowed with conceptual power, are capable of imagining themselves functioning in virtual worlds. Therefore, restorative environments can be either real or imagined places, while restorative experiences can happen either in a physical or an illusionary world, or a combination of both (Kaplan et al., 1998).

According to the Kaplan and Kaplan's (1989) theory, if an individual spends sufficient time in an environment possessing the four components intensively, he or she can experience four progressive levels of restoration. The first level is referred to as "cleaning the head" that allows random thoughts to wander in the head and gradually fade away (Kaplan and Kaplan, 1989, p. 196; Kaplan et al., 1998). The second level of restoration is recharging directed attention capacity. At the third level, one can hear unattended thoughts or matters on one's mind, due to reduced internal noise and enhanced cognitive quiet which are facilitated by soft fascination. The final and the deepest level requires not only an environment possessing the four components of restoration but also a longer time of involvement. It tends to evoke "reflections on one's life, on one's priorities and possibilities, on one's actions and one's goals" (Kaplan and Kaplan, 1989, p. 197).

4.2. Ulrich's (1983) theory

Ulrich claims that restoration is derived from the reduction of stress but not from replenishment of directed attention fatigue. His theory encompasses a wide range of diverse emotional and physiological as well as cognitive responses to explain and predict the restorative effects of environments on human beings (Parsons, 1991a). Although restoration is not restricted to stress recovery alone (Hartig, 1993), Ulrich's (1983) theory is based on a broader context of well-established stress theory and research (Parsons, 1991a). In general, stress can be defined as a process perceived by people when their response capabilities do not or cannot keep up with environmental demands (Lazarus, 1966; Lazarus and Launier, 1978; Evans and Cohen, 1987). If an event or situation is perceived or appraised as harmful, threatening, or challenging for their well-being, then stress occurs and it is usually accompanied by emotion. Stress and emotions, especially negative feelings, seem to be highly related (Brannon and Feist, 1997). Also, under aversive conditions physiological responses are the disruption of some internal equilibrium in the body systems (Evans and Cohen, 1987). These body systems, which mobilize people to deal with stress, consume energy or resources and may consequently cause fatigue (Ulrich et al., 1991). Other results of stress include behaviors such as avoidance or degraded performance outcomes (Cohen et al., 1986).

Ulrich et al. (1991) view stress as "the process by which an individual responds psychologically, physiologically, and often with behaviors, to a situation that challenges or threatens well-being" (p. 202). Ulrich's group (1991) considers stress as a negative condition that people try to avoid, and whose influences on human performance, functioning, welfare, and health

cause harm. In Ulrich's perspective, restoration from stress is not just limited to recovery from excessive psychological and physiological arousal. It also includes recovery from extremely low psychological and physiological arousal as well as recharging of energy consumed in psychophysiological reactions to stresses. Since people live in and interact with physical settings, physical environments play an important role in stress and coping responses (Evans and Cohen, 1987). The physical environment can be a source of either stress or relief, and the physical environment interacts with other personal and/or social factors which either worsen or improve restoration (Hartig, 1993).

Ulrich's theory focuses on physical settings, which facilitate recovery from any kind of stress, not just environmental stressors and mental fatigue. It is hypothesized that scenes that immediately evoke feelings of mild to moderate interest, pleasure, and calm are helpful for restoration from stress (Hartig et al., 1996). When exposed to these kinds of settings, people's attention is easily held by scenes which may block pessimistic thoughts, replace negative emotions by positive ones, and re-equilibrate physiological disturbances (Parsons, 1991a; Hartig et al., 1996). Following positive changes in affect, cognitive functioning or performance which has declined may be regained (Ulrich, 1993; Parsons, 1995). In summary, Ulrich et al. (1991) consider that "recovery from stress involves numerous positive changes in psychological states, in levels of activity in physiological systems, and often in behaviors or functioning, including cognitive functioning or performance" (p. 202) (for a more detailed review of the Kaplan and Kaplan's and Ulrich's theories see Han, 2001).

5. Research plan

This study was a two-phased experimental design. Phase 1 of the study (internal validity) focused on the development and preliminary tests of the RS by running exploratory and confirmatory data analyses. Phase 2 of the study (construct validity) comprised Experiment 1 (divergent construct validity), Experiment 2 (convergent construct validity), and three (reliability). In Phase 2, the confirmed and accordingly revised RS, the short-version revised restoration scale (SRRS) was examined further in terms of validity and reliability. All experiments were conducted with small groups of subjects in the auditorium in the College of Architecture at Texas A&M University by the author following standard procedures. Since landscape contents, natural or urban, have substantially different effects on human responses (Zube, 1974; Ulrich, 1979, 1984, 1993; Kaplan, 1987), this study focused only on natural scenes of the six major terrestrial biomes. The goal was to eliminate potential biases due to landscape contents and diverse types and levels of artifacts. The research plan of the various experiments is summarized in Table 1.

6. Forty-eight landscape slides

The strategy used in this study to collect landscape images that cover a comprehensive sample of natural environments was based on the classification of biomes. Biome classification is a widely accepted organization of natural environments. There is general agreement that our complex world at ground level can be distinguished in relation to temperature and rainfall into six biomes: desert, tundra, grassland, coniferous forest, deciduous forest, and tropical forest (Odum, 1989). Therefore, a collection of landscape images based on biome classification should cover a comprehensive sample of natural environments. Also, this landscape image collection changes systematically as a function of manipulation of three physical features.

Four procedures were used to select appropriate landscape images that met the above stated goal. First, the author selected 200 slides from thousands of color slides according to four criteria: natural landscapes, terrestrial biomes, good photographic quality, and horizontal shots at eye level. Then, four different groups of judges were invited to further evaluate the 200 landscape slides. The first group of three judges evaluated 200 slides in terms of photographic quality to ensure the selection of appropriate landscape slides that did not have any distortion of colors or shapes. The second group of another three judges were asked to evaluate the 200 landscape slides in terms of three physical variables which have been known to have strong impacts on human's psychophysiological reactions: complexity, openness, and water features (Berlyne, 1971; Mehrabian and Russell, 1974; Ulrich, 1979, 1983, 1993). The purpose of this procedure was to help

Table 1
Research design

Experiment	Instrument and location	Dimension and item	Question of interest	Data analysis
Phase 1				
Exploratory	Restoration scale (Table 2)	Four dimensions, 17 variables	Internal validity	Principal component
Confirmatory	Restoration scale (Table 2) Short-version revised restoration scale (Table 6)	Four dimensions, 17 variables Four dimensions, eight variables	Internal, discriminant, convergent, construct validity	Principal component, correlation, reliability, and AMOS
Phase 2				
Experiment 1	Familiarity and typicality	One dimension, one variable	Divergent construct validity	Correlation, principal component, and reliability
Experiment 2	Revised perceived restorativeness scale (Table 7) Short-version revised perceived restorativeness scale	Four dimensions, 16 variables Three dimensions, 12 variables	Convergent construct validity	
Experiment 3	Short-version revised restoration scale (Table 6)	Four dimensions, eight variables	Reliability	

select appropriate landscape slides as controlling variables that changed systematically in manipulable dimensions. The third group of four judges evaluated each of the 200 landscape slides according to its appropriateness as a biome type to help ensure the selection of suitable slides of each biome. The evaluation of appropriateness was based on Odum's (1989) definitions of terrestrial biomes and the judges' expertise.

On the basis of the judges' scores, 48 slides were chosen for use as visual stimuli in the later investigations. Each of the six biomes was represented by eight slides, which had been judged to have good photographic quality, were appropriate samples for that biome, and varied systematically in terms of the three physical variables (see Scheme 1). The eight slides of each biome characterized high or low levels of each of the three physical variables; that is, a ($2 \times 2 \times 2 = 8$) combination of the levels (high or low) of the three physical variables. After the 48 landscape slides had been selected, they were duplicated digitally and

Scheme 1. Sample slides of the six biomes.

printed out on Kodak film. Another group of three judges examined the 48 printout slides to ensure the photographic quality was acceptable after the digital process. Finally, the landscape slides were randomized into two different presentation orders of which no more than two slides of the same biome were shown in sequence (Herzog et al., 1997). Which set of slides was used in each of the experiments were determined at random.

7. Development of restoration scale

Previous empirical research has demonstrated that restorativeness of environments changes people's negatively toned emotions into more positively toned emotions, reduces physiological arousal, and improves certain types of cognitive functioning (Ulrich, 1993; Hull and Michael, 1995). Similarly, both the Kaplan and Kaplan's (1989) and Ulrich's (1983) theories of restorative environments propose that stress recovery is manifested in affects, physiology, and cognition. Therefore, the RS should measure at least emotional, physiological, and cognitive responses of humans. Moreover, since the RS is a self-report measure which might lack emotional and cognitive involvement (Lazarus, 1984; Nasar, 1997), one type of question was included to assess expected behavioral tendency (Nasar, 1997) in order to, hopefully, increase the sensitivity and the reality of the utilization of this RS. Behavioral tendency, such as approach or avoidance, is also mentioned in the Kaplan and Kaplan's (1989) and Ulrich's (1983) theories of restorative environments. Many environmental researchers and practitioners, however, may wish to know what kind of settings can influence people's action intentions or even actual behaviors. After the four dimensions of the RS had been decided, the next step was to select measuring items for each dimension. These items should be few in number, straightforward, user-friendly, and free of jargon.

7.1. Emotional dimensions

In general, researchers have many different opinions regarding the number of the basic emotions and how to classify them (Russell and Snodgrass, 1987; Carlson and Hatfield, 1992). Nevertheless, many researchers agree that emotional dimensions appear to be bipolar rather than unipolar (Osgood et al., 1957; Bentler, 1969; Russell, 1979; Russell and Snodgrass, 1987) or simply categorical. Hence, mood scales should cover both positive and negative feelings (Lorr and Wunderlich, 1988). Moreover, the number of dimensions of moods used in studies may be related to convenience (Russell and Snodgrass, 1987). Among existing emotional scales, Lorr and Wunderlich's (1988) five-dimension scale of moods (cheerful–depressed, energetic–tired, good natured–grouchy, confident–unsure, and relaxed–anxious) balances positive and negative mood states, although it may not be complete with a reasonable number of five dimensions. Thus, Lorr and Wunderlich's five-mood scale seemed the most suitable for the RS and probably could provide detailed insight into specific affects derived from restorativeness.

7.2. Physiological dimensions

Given that direct measures of human physiology are intrusive, time-consuming, cumbersome, expensive, and more suitable to conduct in laboratories (Thayer, 1986; Ulrich et al., 1991), they are not appropriate to the RS. Nevertheless, research has shown a reasonable amount of overlap and a clear relationship between direct measures and self-report measures of human physiology (Thayer, 1986; Coren and Mah, 1993). Thayer (1967, 1970, 1989) has even argued that controlled self-rating measures of physiological states, which tend to encompass the most basic information of general bodily activation, are better than direct measures, particularly better than any single peripheral physiological indicator. Therefore, the RS includes the four variables most often measured in physiological research for this study. These variables are respiration, muscular tension, sweating, and heart rate (Thayer, 1989; Ulrich et al., 1991; Parsons et al., 1994), which may be perceived or perceivable by individuals. Among these four physiological items, heart rate and breathing have been applied in the self-rating scale ZIPERS (Zuckerman, 1977). Psychometric research has indicated that ZIPERS as a whole has good reliability and validity (Hartig et al., 1991). Following the question format of ZIPERS, the above four elements constitute the physiological dimension of the RS.

7.3. Cognitive dimensions

The cognitive dimension of the RS attempts to measure more variables in addition to attention. Kaplan and Kaplan (1989) postulate four stages of cognitive states with respect to restorativeness. Following the Kaplan and Kaplan's notions of attention plus four cognitive states, the cognitive dimension of the RS measures similarly attention plus four cognitive states: clearer head, mental fatigue, soft fascination, and reflection. However, given the difficulty for the general public of understanding the jargon of "clearer head" and "soft fascination," these terms are replaced by concentration and interest, respectively. Compared with the attentional function index (Cimprich, 1990, 1992) based on the Kaplan and Kaplan's theory, which emphasizes executive functions of attention such as goal formation, planning, carrying out activities,

Table 2
Restoration scale (with 17 variables measuring four dimensions of factors F1–F4)

(F1) Emotional Dimension: *Imagine you were in the projected scene. How would you describe the effect the landscape has on you in terms of the following emotions?*			
V1	Depressed	1 2 3 4 5 6 7 8 9	Elated
V2	Unsure	1 2 3 4 5 6 7 8 9	Confident
V3	Grouchy	1 2 3 4 5 6 7 8 9	Good natured
V4	Anxious	1 2 3 4 5 6 7 8 9	Relaxed
V5	Fatigued	1 2 3 4 5 6 7 8 9	Energetic
(F2) Physiological Dimension: *Imagine you were in the projected scene. How would you describe the physiological response that the landscape elicits in you?*			
V6	My breathing is becoming faster.		
V7	My muscles are becoming tenser.		
V8	My hands are sweating.		
V9	My heart is beating faster.		
(F3) Cognitive Dimension: *Imagine you were in the projected scene. How would you describe the landscape's influence on your cognition?*			
V10	I am interested in the presented scene.		
V11	I feel attentive to the presented scene.		
V12	My mental fatigue is decreasing.		
V13	I feel concentrated in my mind.		
V14	I feel reflective of myself.		
(F4) Behavioral Dimension: *Imagine you were in the projected scene. How would you agree with the following statement?*			
V15	I would like to explore this place further.		
V16	I would like to visit here more often.		
V17	I would like to stay here longer.		

self-regulation of performance, and attentional difficulties, the cognitive dimension of the RS not only focuses on human beings per se, but also on the relationship between the environment and the individual. Among the five cognitive items of the RS, two are oriented towards landscapes: attentive to and interested in, and the other three are directed to individuals: mental fatigue, concentration, and self-reflection.

7.4. Behavioral dimensions

Generally speaking, most researchers have agreed that human behavioral tendency can be referred to as one dimension whose extremes are approach and avoidance (Horney, 1945; Schneirla, 1959; Mehrabian and Russell, 1974; Thomas and Chess, 1977). According to Mehrabian and Russell (1974), approach behaviors include seeking out, exploring, and staying in an environment. Although researchers tend to be in general agreement on the behavioral tendency, there are not many self-rating measures. Only Mehrabian and Russell's (1974) verbal measures of approach/avoidance seem to be available, but they do meet the purpose of the RS. Their scale has four elements: desire to stay in, desire to explore, desire to work in, and desire to affiliate in an environment, though the latter two are inappropriate for the RS. Thus, the behavioral dimension of the RS incorporates only Mehrabian and Russell's first two factors. In addition, one more item is included which is specially derived from Mehrabian and Russell's notion of seeking out. However, the term "seeking out" seems somewhat unfamiliar and is rephrased as "visit more often."

7.5. Restoration scale

After the combination of the emotional, physiological, cognitive, and behavioral dimensions, the RS is finally ready to test. The 17 items of the RS are written in short sentences or phrases accompanied by a nine-point Likert scale (see Table 2).

8. Phase 1 study (internal validity)

The focus of the Phase 1 study, which included the exploratory and confirmatory stages, was two-fold. First, it was to examine the internal validity of the original version of the RS. This examination involved looking at the interrelations of the 17 variables among the four dimensions proposed by the theories to measure the construct of restorativeness. Second, a shorter version of the RS with fewer questions but which still explained much of the variance in restorativeness would be developed for practical use. Principal component analyses (PCAs) were selected as the major means of data analysis for the RS in Phase 1 (internal validity). Though the development of the RS is based on several conceptual notions which are related, they have not been integrated and undergone any empirical examinations. Therefore, the data-driven procedure of PCA could contribute to the refinement of the RS from a strict and realistic approach. In this way, the obtained shorter version of the RS would be both theory- and data-oriented.

8.1. Exploratory data analyses

The exploratory stage of the data analyses had two aims. First, it would explore the underlying structure of the principal components without specifying beforehand the number of principal components and their loading. Second, it would explore the data for possible data summary (Kim and Mueller, 1978). The experiment and data collection of the exploratory stage were conducted during the summer of 1999 at Texas A&M University. A total of 111 undergraduate students participated in the experiment. The subjects' task was to view each of the landscape slides presented, respond to all ratings of the RS on a questionnaire, and mark their responses on scantrons. The questionnaire had four versions, which had the same introduction but different sequences of the four dimensions of the RS. Each version of the questionnaire was distributed as evenly as possible among participants. Among the 111 participants, two provided invalid data and were eliminated from the database. As a result, 109 subjects provided useful data on the RS for the data analyses. These 109 participants included 49 males and 60 females, whose average age was 21.16 years for all participants. Of these participants, 55 subjects (20 males and 35 females) saw the landscape slides in the presentation order one, while 54 subjects (29 males and 25 females) viewed the landscape slides in another presentation order. The data sets representing all combinations of the two slide presentation orders

and the four questionnaire versions were organized into a database as a three-dimensional matrix of participants, landscape slides, and variables of the RS.

8.1.1. Data analyses within biomes

Since PCA could not analyze the three-dimensional data matrix, the alternative was to run PCA using a two-dimensional data matrix of the subjects and the 17 variables biome by biome. The scores of each of the 17 variables across the slides were averaged to form an index score within each biome. Next, six PCAs were conducted separately using SPSS program in order to identify components within the biomes. These six PCAs gave very similar results for the six biomes. These results suggested using four principal components to summarize the data, which explained about 84% of the variance. Later, these six PCAs underwent oblique rotation to find the simplest possible component structure. The oblique rotation assumes that principal components may be correlated and does not impose the restrictions of assuming uncorrelated components (Kim and Mueller, 1978). The theoretical notions propose that restorative reactions are manifested in emotion, physiology, cognition, and behavior. Thus, the underlying components across the 17 variables measuring restoration would be unlikely to be orthogonal. Again, the rotated pattern matrices of the six biomes demonstrated very similar component structures. In general, these component structures still suggested that the internal validity of the RS was satisfactory; the 17 questions empirically loaded on four principal components in accordance with the four dimensions derived from theoretical notions of restorative reactions. Moreover, the almost identical component structures across the six biomes showed the possibility of running further analyses using the entire three-dimensional data matrix by pooling all the data together across the six biomes.

8.1.2. Data analyses across biomes

Using the entire database across the biomes, a PCA was conducted using SAS program. Again, this solution suggested that the minimum number of four principal components would account for approximately 81% of the correlation among the observed variables. Next, the PCA underwent an oblique rotation. As indicated by the resultant pattern matrix, the five emotional items, the four physiological variables, three of the five cognitive indicators, and the three behavioral questions formed one clear principal component, respectively. However, two cognitive items were equivocal as one loaded on two components (cognition and behavior) and the other loaded on the three behavioral variables (see Table 3). Nevertheless, this component structure still suggested that the internal validity of the RS was adequate; of the 17 variables, 15 were

Table 3
Obliquely rotated solution of the principal component analysis across biomes

Variable number	Description	Component 1	Component 2	Component 3	Component 4
1	Emotion	0.16489	0.00611	0.00192	0.04077
2	Emotion	0.27687	−0.01014	0.01805	−0.01813
3	Emotion	0.23488	0.00165	0.00202	0.01303
4	Emotion	0.29945	−0.02309	0.01125	−0.03088
5	Emotion	0.21684	0.03492	−0.00515	0.00331
6	Physiology	0.02163	0.28424	−0.00374	0.00308
7	Physiology	−0.01018	0.27341	0.00324	−0.00442
8	Physiology	−0.00396	0.24057	−0.00662	−0.00880
9	Physiology	−0.01280	0.28210	0.01331	0.00222
10	Cognition	−0.05370	0.01067	0.07408	0.18512
11	Cognition	−0.06008	0.01257	0.15420	0.14304
12	Cognition	−0.02124	0.02738	0.30007	0.02525
13	Cognition	0.02752	0.00047	0.36226	−0.03919
14	Cognition	0.02192	−0.02422	0.35649	0.01299
15	Behavior	−0.00131	−0.00836	−0.04949	0.24443
16	Behavior	0.01183	−0.00560	−0.04276	0.24670
17	Behavior	0.02103	−0.01189	−0.04825	0.25444

See Table 2 to identify the 17 questions.

empirically loaded on four principal components congruent with the four dimensions derived from theoretical notions.

8.2. Confirmatory data analyses

A confirmatory data analysis requires a detailed initial model that is a priori (Bollen, 1989; Kline, 1998). This a priori statistical model is based on "an understanding of the nature of the variables under consideration, as well as on expectations concerning which factor is likely to load on which variables" (Kim and Mueller, 1978, p. 55). Consequently, the confirmatory data analysis allows researchers to test whether the structure of the collected data deviates from that of the hypothesized model (Kim and Mueller, 1978; Bollen, 1989; Kline, 1998). Recall the RS derived from theoretical notions has four dimensions and 17 underlying items as a hypothesized priori. The experiment and data collection of the confirmatory stage were conducted during the fall semester of 1999 at Texas A&M University. A sample of 123 undergraduate students participated in the experiment. Once again, there were eight data sets in terms of the unique combinations of the two slide presentation orders and the four questionnaire versions in this confirmatory stage. Among the 123 participants, one provided unusable data and was, therefore, dropped from the database. As a result, 122 subjects' data were analyzed. Among these 122 participants, 60 were males and 62 were females, with an average age of 19.27 years. In presentation order one, $n = 60$ (31 males and 29 females), while in presentation order two, $n = 62$ (29 males and 33 females).

8.2.1. Data analyses within biomes

As before, the format of the collected data, which has three dimensions, made it very difficult to run the confirmatory analysis. Hence, the alternative, as before, was to conduct six confirmatory analyses biome by biome, using a two-dimensional data matrix of subjects and variables. The six confirmatory analyses within biomes showed very similar results for each biome. All of this suggested that the six data matrices of the biomes shared a very similar structure. That is, the collected data fit the hypothesized model adequately. The results of the confirmatory analyses within biomes indicated the possibility of conducting further analysis using the entire database by pooling the six data matrices together.

8.2.2. Data analyses across biomes

After the six data matrices of biomes were pooled, an overall confirmatory analysis across biomes was conducted using SAS program. Conventionally accepted statistical measures of model fit were applied. The results of the confirmatory analysis across biomes met most of the model fit criteria (see Table 4). All of these results indicated an adequate fit between the hypothesized model and the collected data. The confirmed fit between the collected data and the hypothesized model appeared to be very satisfactory, given that an initial model usually does not fit the data well (Kline, 1998). Moreover, the confirmatory analysis provided an investigation of the convergent validity and the discriminant validity of the hypothesized model. Convergent validity was supported by high loadings ($R^2 > 0.50$) of a set of the variables on their common underlying factor (Kline, 1998). All the squared multiple correlations (R^2) of the 17 variables of the RS were greater than 0.50, which indicated reasonably good convergent validity (see Fig. 1). Discriminant validity was indicated by the estimated correlations between different factors to be not excessively high ($r < 0.85$). Therefore, there is a distinction among factors measured by different sets of variables (Kline, 1998). There were six pairs of relations among the four dimensions of the RS. Among the dimensions measured pairwise, only the cognition–behavior (F3–F4) correlation was greater than 0.85 (Fig. 1). This result indicated that the discriminant validity of the RS was, in general, acceptable except for the

Table 4
Model fit criteria of the restoration scale

χ^2/d.f. (favorable value <3.0)	Root mean square residual (favorable value <0.10)	Bentler's CFI (favorable value >0.90)	Bentler and Bonett's NNFI
2.9573	0.1061	0.9277	0.9130

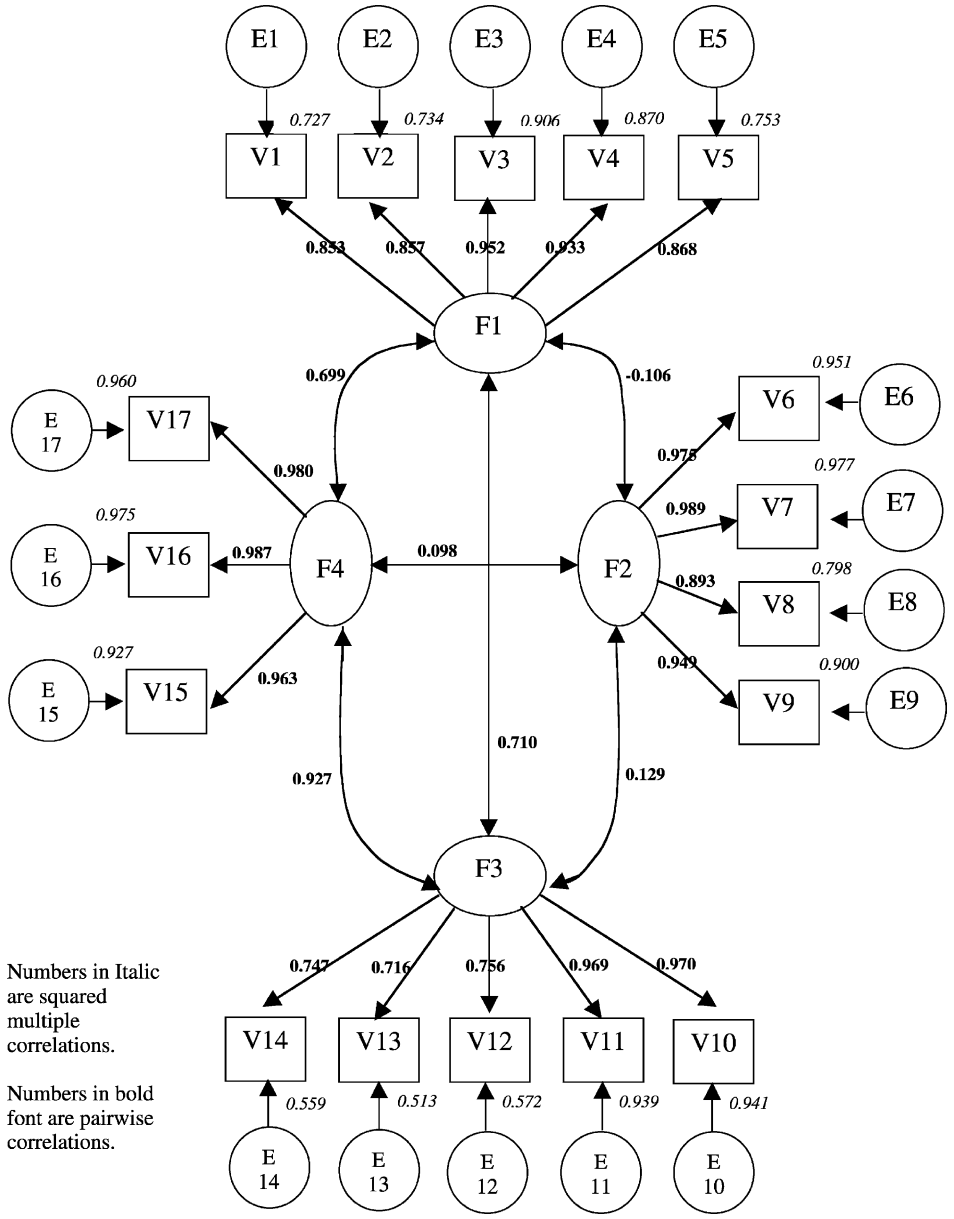

Fig. 1. Measurement model of the original restoration scale (with 17 variables V1–V17 measuring four dimensions of factors F1–F4).

difficulty discriminating cognition from behavior. Given that the internal validity as well as the convergent and discriminant validity of the RS were shown to be satisfactory by exploratory and confirmatory analyses, the development of a short-version revised restoration scale was shown to hold promise.

8.3. Revision of restoration scale

8.3.1. Four criteria

Since the RS, which had 17 variables, might still have too many items for practical utilization, a revised version with fewer variables was developed. The

revision for a short-version RS should meet four criteria. First, for any multifactor models, in the revised version each factor should have at least two variables in order to make the entire model still function properly. Second, the remaining variables should still explain sufficient variance in the factor that they are estimating. Third, the remaining variables should be a reliable measurement of the factor. Fourth, the short-version scale should still maintain the characteristics and the integrity of the original scale (Bollen, 1989; Kline, 1998). Accordingly, the revised RS would have a total of eight items evenly distributed across the four dimensions in order to have an equal and minimum number of variables for each dimension.

8.3.2. Narrowing down possible candidate variables

Three statistical coefficients provided guidance for identifying possible candidate variables for the SRRS. The first guide was the squared multiple correlations (R^2). The second guide was the reliability coefficients of the variables of a dimension. The third guide was modification indexes. The squared multiple

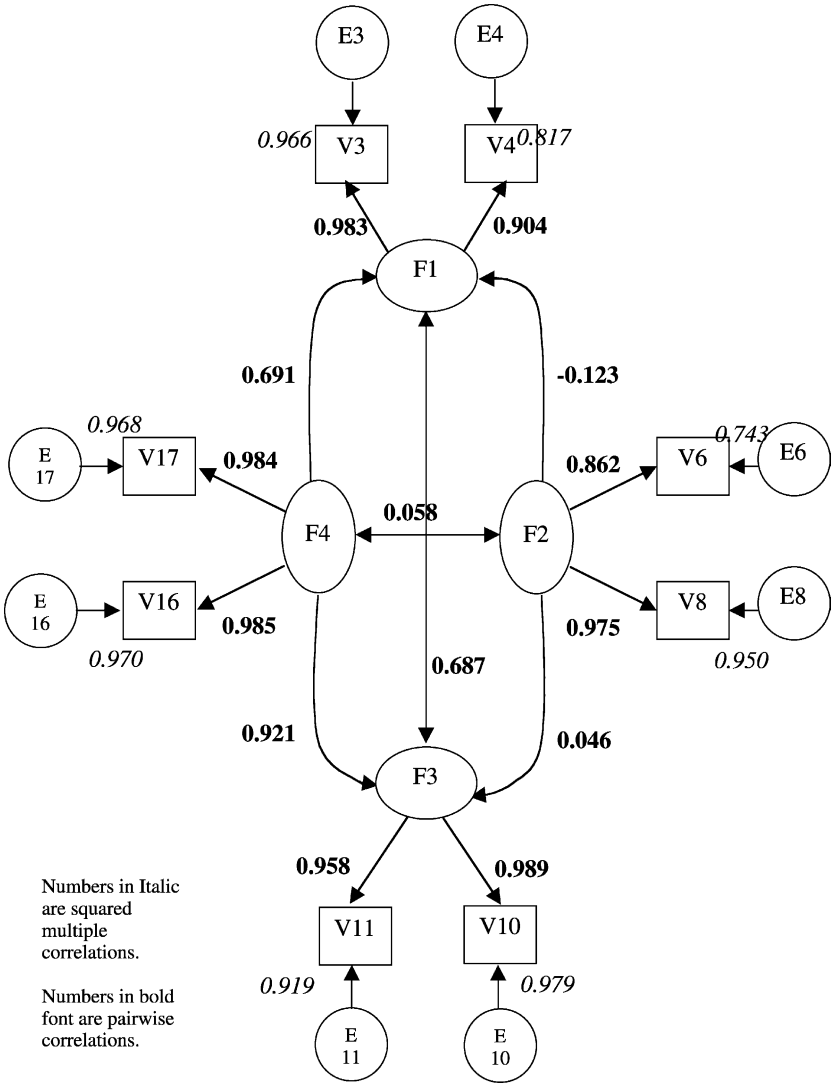

Fig. 2. Measurement model of the short-version revised restoration scale (with eight variables measuring four dimensions of factors F1–F4).

Table 5
Model fit criteria of the short-version revised restoration scale

χ^2/d.f. (favorable value <3.0)	Root mean square residual (favorable value <0.10)	Bentler's CFI (favorable value >0.90)	Bentler and Bonett's NNFI
1.401	0.031	0.995	0.991

correlations and the reliability coefficients provided guidance for selecting the variables within a factor, while the modification indexes took into account the entire model to help select appropriate variables. Based on the *R*-squares, the reliability coefficients, and the modification indexes, the most favorable candidate variables for inclusion in the SRRS were identified. They included variables 3 and 4 of the emotional dimension, variables 6 and 7 of the physiological dimension, variables 10 and 11 of the cognitive dimension, and variables 16 and 17 of the behavioral dimension.

8.3.3. Selections and tests of the final eight variables

The final selection of the eight items for the SRRS depended on using analysis of moment structures (AMOS) on SPSS program. AMOS allows analysts to quickly specify and modify a measurement model and then to assess the fit of the modified model (Arbuckle and Wothke, 1999). The pairs of the most favorable variables for each dimension were tested by running AMOS to see if these eight items still retained the characteristics and the integrity of the initial 17-variable model and functioned well together. The results of the first round AMOS test showed that all pairs of the these candidate items functioned well together except for the variables 6 and 7 of the physiological dimension. Therefore, five more rounds of AMOS tests were conducted using the same pairs of most favorable items of the emotional, cognitive, and behavioral dimensions, as well as all possible pairs of the physiological items. Only one admissible solution for the SRRS was obtained, which consisted of the most favorable variables of the three dimensions as well as the variables 6 and 8 of the physiological dimension.

8.3.4. Obtained model of the short-version revised restoration scale

Fig. 2 is a visual representation of the obtained model of the SRRS. All of the squared multiple correlations (R^2) of the eight items were >0.50, which indicated good convergent validity (Kline, 1998). Only one of the six relations among the four dimensions was >0.85, which showed that the discriminant validity of the SRRS was acceptable (Kline, 1998). Moreover, the SRRS met all the model fit criteria (see Table 5). As indicated by these model fit criteria, the SRRS performed even better than its original version (Table 4). In addition, one minor change was made in the wording of the SRRS. The wording of the four questions about the four dimensions was changed to be all the same. Finally, the SRRS was ready for further examination in the Phase 2 study (construct validity) (see Table 6).

9. Phase 2 study (construct validity)

Phase 2 consisted of three experiments, which together aimed to investigate convergent and divergent construct validity as well as reliability of the SRRS. The procedures and apparatus of the three experiments conducted in Phase 2 (construct validity) were almost identical to those of the two experiments in Phase 1 (internal validity). In each of the three experiments of Phase 2, four versions of the questionnaire listed the dependent variables of interest accompanied by a nine-point Likert scale in different sequences and two presentation orders of landscape slides were prepared. All experiments were conducted in the spring semester of 2000 at Texas A&M University.

9.1. Experiment 1 (divergent construct validity)

Experiment 1 was designed to test the divergent construct validity of the SRRS by collecting data on human responses to the 48 landscape slides in terms of the constructs of two dependent variables: familiarity and typicality. The rationale is: if the SRRS really measures the construct of restorativeness, then restorativeness should be distinguishable from other constructs (Kaplan and Saccuzzo, 1989). The definition of the construct of familiarity selected for this research

Table 6
Short-version revised restoration scale (with eight variables measuring four dimensions of factors F1–F4)

(F1) *Imagine you were in the projected scene. How would you describe your emotional response?*

V3 Grouchy Good natured
(very much) 1___2___3___4___5___6___7___8___9 (very much)

V4 Anxious Relaxed
(very much) 1___2___3___4___5___6___7___8___9 (very much)

(F2) *Imagine you were in the projected scene. How would you describe your physiological response?*

V6 My breathing is becoming faster.
(not at all) 1___2___3___4___5___6___7___8___9 (very much so)

V8 My hands are sweating.
(not at all) 1___2___3___4___5___6___7___8___9 (very much so)

(F3) *Imagine you were in the projected scene. How would you describe your cognitive response?*

V10 I am interested in the presented scene.
(not at all) 1___2___3___4___5___6___7___8___9 (very much so)

V11 I feel attentive to the presented scene.
(not at all) 1___2___3___4___5___6___7___8___9 (very much so)

(F4) *Imagine you were in the projected scene. How would you describe your behavioral response?*

V16 I would like to visit here more often.
(not at all) 1___2___3___4___5___6___7___8___9 (very much so)

V17 I would like to stay here longer.
(not at all) 1___2___3___4___5___6___7___8___9 (very much so)

is how well known the presented landscape is, based on either personal or secondhand information (Kaplan and Kaplan, 1989). Typicality can be considered as the representativeness of the presented landscape in its own class (Herzog, 1992). Experiment 1 (divergent construct validity) used 92 undergraduate students as subjects. Among the 92 subjects, 47 were males and 45 were females, with an average age of 19.30 years for all participants. Forty-eight participants, of whom 25 were males and 23 were females, viewed the landscape slides in order one, while 44 participants, of whom half were males viewed, the landscape slides in order two.

9.2. Experiment 2 (convergent construct validity)

Experiment 2 was designed to collect data on human restorative responses to the landscape slides. This time, however, restorativeness was measured by Hartig's (Hartig et al., 1997) revised perceived restorativeness scale. Hartig's RPRS has four dimensions—being away, fascination, extent, and compatibility—represented by two, five, four, and five variables, respectively (see Table 7). The purpose of Experiment 2 was to test the convergent construct validity of this experiment's SRRS by comparing it to Hartig's RPRS. Both Hartig's RPRS and the SRRS by this author supposedly measure the construct of restorativeness, although the RPRS focuses only on recovery from mental fatigue and the SRRS focuses on recovery from stress from a broader perspective. Despite different measures of restorativeness, these two instruments should be at least moderately correlated. Experiment 2 (convergent construct validity) of Phase 2 used 93 undergraduate students as participants. The

Table 7
Hartig's revised perceived restorativeness scale (RPRS) (Hartig et al., 1997)

Imagine you were in the presented landscape, how would you agree with the following statements?	
(F1) Being Away:	
V1	It is an escape experience.
V2	Spending time here gives me a good break from my day-to-day routine.
(F2) Fascination:	
V3	The setting has fascinating qualities.
V4	My attention is drawn to many interesting things.
V5	I would like to get to know this place better.
V6	There is much to explore and discover here.
V7	I would like to spend more time looking at the surroundings.
(F3) Extent:	
V8	There is too much going on.
V9	It is a confusing place.
V10	There is a great deal of distraction.
V11	It is chaotic here.
(F4) Compatibility:	
V12	I can do things I like here.
V13	I have a sense that I belong here.
V14	I have a sense of oneness with this setting.
V15	Being here suits my personality.
V16	I could find ways to enjoy myself in a place like this.

93 participants included 45 males and 48 females, with an average age of 18.87. Among them, 47 subjects (22 males and 25 females) viewed the landscape slides in presentation order one, while 46 subjects (23 males and 23 females) viewed the landscape slides in presentation order two.

9.3. Experiment 3 (reliability)

Experiment 3 was designed to collect data on human restorative responses to the landscape slides using the SRRS developed by the author. The data collected here, when compared with the data collected in Experiment 2, tested the convergent construct validity and the reliability of the SRRS. Eighty-nine subjects participated in Experiment 3 (reliability). The 89 subjects included 43 males and 46 females, with an average age of 18.94 for all participants. Among them, 45 participants (22 males and 23 females) were exposed to the landscape slides in presentation order one, while 44 participants (21 males and 23 females) saw slide presentation order two.

9.4. Data analyses

9.4.1. Data processing

In Experiment 1 (divergent construct validity), the 92 subjects' scores on the variables were averaged to form index scores of familiarity and typicality. In Experiment 2 (convergent construct validity), the scores of the variables within each of the four dimensions of Hartig's RPRS were first averaged across the 93 subjects to form composite scores for each of the four dimensions for each slide. After reversing the composite score for dimension three (extent) because that dimension is negatively worded, all the composite scores were then averaged to form one final index score for each slide. Although Hartig's RPRS had four dimensions and 16 items, its developers and revisers later suggested using only three dimensions (1, 1, and 4) to form a general restorativeness score (Hartig et al., 1997). Therefore, a second index score of Hartig's short-version revised perceived restorativeness scale with only three dimensions was also calculated for each slide. In Experiment 3 (reliability), calculating the index score of the SRRS was similar to that for Hartig's RPRS. First, the scores of the two variables of the four dimensions were averaged across the 89 participants to form the composite scores. Next, the composite score of dimension two, physiological, was reversed. This was because this dimension measures physiological arousal, which is the opposite of restorativeness. Then, all the composite scores were averaged to form the final index score and prepared for data analysis.

9.4.2. Correlation analysis

A Pearson correlation analysis was conducted on SPSS using the index scores of familiarity, typicality, Hartig's RPRS, Hartig's SRPRS, and the author's SRRS. All correlations of these index scores were significant ($P < 0.05$). However, the SRRS was more

related to the RPRS ($r = 0.964$, $P = 0.000$) and the SRPRS ($r = 0.957$, $P = 0.000$) than to familiarity ($r = 0.318$, $P = 0.028$) and typicality ($r = 0.414$, $P = 0.003$). This indicated that the convergent construct validity and divergent construct validity of the SRRS were adequate. Meanwhile, as the index scores of Hartig's RPRS and its short version, Hartig's SRPRS, were highly correlated ($r = 0.978$, $P = 0.000$), and as its developers and revisers suggested using the short version to measure general restorativeness (Hartig et al., 1997), only the index score of the SRPRS was applied to later data analyses.

9.4.3. Principal component analysis

A PCA with oblique rotation using the index scores of the SRRS, the SRPRS, familiarity, and typicality was conducted on SPSS. The obliquely rotated solution clearly indicated two components with two instruments, the author's SRRS and Hartig's SRPRS, loaded on one component and the constructs of familiarity and typicality loaded on the other component. Again, the results of the PCA showed that the convergent and the divergent construct validity of the SRRS were satisfactory.

9.4.4. Reliability analyses

Using the data matrix of the 48 landscape slides and the scores of the eight variables of the SRRS averaged across the 89 subjects in Experiment 3, five reliability analyses were conducted using SPSS. The first analysis tested the overall reliability of the eight items of the SRRS, which was 0.9191. The other four analyses tested the reliability of the two variables within each of the four dimensions of the SRRS. The reliability coefficients of the four dimensions—emotion, physiology, cognition, and behavior—were 0.9755, 0.8670, 0.9975, and 0.9982, respectively. Given that reliability coefficients around 0.90 are considered excellent (Kline, 1998), the reliability analyses indicated that both the individual dimensions and the entire scale were very reliable to measure the restorative quality of various environments.

Another reliability analysis was conducted using SPSS to test the inter-rater (intra-class) reliability of the 89 subjects with respect to the 48 landscape slides. The inter-rater reliability is a measure of the consistency or agreement of the scores within the group of subjects (SPSS Inc., 1999). This inter-rater reliability analysis used a data matrix in which the rows were the 89 subjects and the column was the index score of the SRRS with respect to the 48 landscape slides. The reliability coefficient was 0.9654. This result suggested that even if diverse subjects applied the SRRS to measure the restorative quality of various natural environments, the inter-rater reliability would still be excellent.

10. Summary of results

The exploratory analyses showed that the internal validity of the RS was satisfactory as indicated by the explained variance (above 80%) of the four components congruent with the four dimensions derived from theory. Later, the confirmatory analyses indicated that the fit between the collected data and the a priori model of the RS was acceptable as judged by a set of model fit criteria. The confirmatory analyses also demonstrated that both the discriminant validity and the convergent validity of the RS were adequate. Following the exploratory and confirmatory analyses, the RS underwent a serious of revisions to develop a more consistent and parsimonious version (SRRS). The SRRS performed even better than the original version on the multiple model fit criteria. For this reason, the SRRS was used and tested further in the three experiments of Phase 2 (construct validity). Both correlation analysis and PCA showed that the convergent construct validity and divergent construct validity of the SRRS were satisfactory. In addition, reliability analyses demonstrated that the SRRS was very reliable. All the results together suggested that the SRRS is a valid and reliable measure to quantify the restorative influence of various natural environments on human beings.

11. Discussion

In Phase 2 (internal validity), 109 subjects participated in the exploratory analyses and another 122 subjects participated in the confirmatory analyses of the RS. The sample sizes were slightly smaller than the recommended sizes of 150 or more (Bollen, 1989). Nevertheless, given that the RS had at least three items per dimension, sample sizes of between 100 and 150 are not ideal but acceptable (Kline, 1998). Meanwhile,

the subjects recruited in this study were undergraduate students at Texas A&M University. Numerous studies have demonstrated that college students are, in general, representative of the common population for research on such areas as environmental perception or landscape assessment (Daniel and Boster, 1976; Anderson and Schroeder, 1983; Judd et al., 1991). In addition, several studies have shown that digitized images, particularly with relatively small modifications, appear to be as good as the customary color slides for representing actual landscapes (Vining and Orland, 1989; Hetherington et al., 1993; Bergen et al., 1995). Nevertheless, the carefully selected 48 landscape slides might still not be a representative sample of natural environments. Although the external validity of the RS was important, it was beyond the scope of this study, which focused on its internal and construct validity.

Given that this study demonstrated the internal validity, construct validity, and reliability of the RS and the SRRS as adequate, future research using the SRRS can shift the emphasis to its generalizability. Studies of the external validity of the SRRS should focus on the effects of demographic variations, such as gender, age, ethnicity, education, occupation, and residence. Anyway, the development and the refinement of a psychometric scale cannot be achieved in a single study. Replications involving various groups of subjects, assorted sets of visual stimuli or physical settings, at different locations and time frames, are needed to examine the validity, reliability, and generalizability of any research (Cook and Campbell, 1979). The following are discussions of possible future research using the SRRS.

Since the SRRS takes an interactive perspective of emotional, cognitive, physiological, and behavioral responses to recovery from stress, a direct and simultaneous measure of these dimensions along with the SRRS will provide a deep insight into the validity of the SRRS. This is where the research field of psychophysiology can play a role in further testing the SRRS. Psychophysiology studies associations among various dimensions of human responses: affect, subjective experience, attention, cognition, physiology, and behavior (Ulrich et al., 1990; Carlson and Hatfield, 1992). Using sophisticated and sensitive equipment, people's facial muscle activity has been related to emotional expressive behavior (Ekman and Freisen, 1975; Fridlund and Cacioppo, 1986). Brain electrical activity and heart rate have been associated with attention and cognition (Lacey and Lacey, 1970; Ulrich, 1981). Skin conductance, respiration, blood pressure, and even cortisol level related to physiological mobilization can be monitored and measured (Hartig, 1993). Comparisons of direct and objective psychophysiological measures with the self-report SRRS will further examine its validity.

Also, placing subjects in the actual physical settings and conducting field experiments can enhance the ecological validity of the research (Hartig, 1993). However, field experiments lose some degree of the control over exogenous variables as compared with laboratory experiments (Campbell and Stanley, 1963; Cook and Campbell, 1979). Every research design has its own strengths and weaknesses. Only through the application of multiple approaches can comprehensive findings be reached (Campbell and Fiske, 1959; Cook and Campbell, 1979). Given that the laboratory approach to the SRRS starting with visual perception had satisfactory results, the following studies can extend to more human perceptions in more realistic settings after the validity, reliability, and generalizability of the SRRS have been further demonstrated. Also, although this study used the biome classification system to collect a comprehensive sample of the natural landscapes, the SRRS is intended to apply to all kinds of settings, including urban, artificial, and indoor. Therefore, the SRRS should be further tested for its usefulness in a variety of physical settings.

Furthermore, once the restorative influence of environments can be quantified, then we can seek the answers to the next important questions. For example, what are the characteristics of a restorative environment and what are the measurable physical elements contributing to the restoration? Multiple regressions using restorativeness as the dependent variable and any factors of interest as the independent variable will answer part of the "what" questions. Eventually, those characteristics and measurable elements will be identified, and designers can manipulate them wisely in order to create a high-quality restorative setting. Also, quantifiable measures of restoration are the key to understanding how and why restorative mechanisms work. Are the current theories, such as the Kaplan and Kaplan's (1989), or Ulrich's (1983), adequate to explain restorativeness, or do we need more conception-directed research to develop further

theories? Though the results of this study can not provide conclusive support for either the Kaplan and Kaplan's (1989) or Ulrich's (1983) theory, they do offer some thoughts for the conceptualization of restoration. The finding that four dimensions of restoration emerged as expected could be interpreted as support for Ulrich's more holistic perspective. Moreover, the largest and the second largest egienvalues and explained variances of the emotional and the physiological dimensions appear to favor Ulrich's emphasis on emotion and physiology in restoration. On the other hand, the overlap among emotional, cognitive, and behavioral dimensions, particularly the strong correlation between the last two, might defend the Kaplan and Kaplan's view that restoration is primarily cognitive. Furthermore, the close correspondence between the SRRS and Hartig's scale (Hartig et al., 1997) which are intentionally designed to capture the Kaplan and Kaplan's version of restoration would seem to add support to their theory. Nevertheless, the SRRS is only a starting point, which just opens the door to the "what," "how," and "why" questions regarding restoration.

12. Conclusion

Although restorative reactions do happen in bodily systems, restoration is often triggered by surrounding settings. Therefore, research on restorative environments cannot ignore the role of settings in restoration. The multi-dimensional, self-report SRRS is demonstrated to be a valid and reliable measure to quantify the restorative influences of various environments elicited in humans. As a result, the operational definition and the construct of restorativeness developed in this study can be applied to future research on recovery from stress. Due to its both theoretical and practical significance, the SRRS is a tool to help achieve a deeper and more comprehensive understanding of restorativeness and to improve human well-being. Nevertheless, the ultimate test of the SRRS or Hartig's scale (Hartig et al., 1997) depends on how well results match up with real people (not just students) who experience actual restoration (not just self-reports of how they think or feel) from actual stress (not just experimental manipulations) in real environments (not just simulations at laboratories using slides or videos).

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