Stress Recovery During Exposure to Natural and Urban Environments. Journal of Environmental Psychology. 11: 201-230

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Subjects viewed sixty color slides of either (1) nature with water, (2) nature dominated by vegetation, or (3) urban environments without water or vegetation. The information rates of the three slide samples were equivalent. Measurements were taken of the effects of the slide presentations on alpha amplitude, heart rate, and emotional states. Results revealed several significant differences as a function of environment, which together indicate that the two categories of nature views had more positive influences on psychophysiological states than the urban scenes. Alpha was significantly higher during the vegetation as opposed to urban slides; similarly, alpha was higher on the average when subjects viewed water rather than urban content. There was also a consistent pattern for nature, especially water, to have more positive influences on emotional states. A salient finding was that water, and to a lesser extent vegetation views, held attention and interest more effectively than the urban scenes. Implications of the findings for theory development in environmental aesthetics are discussed.

NATURAL VERSUS URBAN SCENES
Some Psychophysiological Effects

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A persistent notion in different cultures has been that exposure to nature enhances psychological well-being. A large body of intuitive literature has expressed the idea that contact with nature is especially beneficial for urban dwellers; several writers and scientists have suggested that low levels of nature contact may be a factor in the higher rates of certain pathologies observed for urban populations as compared to rural groups (e.g., Stainbrook, 1968, 1973;

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Iltis et al., 1970; Driver and Greene, 1977). In America and other urbanized countries there is a strong intuitive belief, held by large segments of the public as well as planning and decision-making communities, that contact with nature is somehow good for people. What might be termed a "nature benefit assumption" underpins most actions establishing, for example, city parks, urban landscaping programs, and the provision of urban fringe nature areas (Driver and Greene, 1977). Research to evaluate this assumption may therefore prove useful in environmental planning and decision-making, as well as contribute to the development of theory in environment-behavior disciplines.

The study described here evaluates the nature benefit assumption for the specific case of visual exposure to outdoor environments. Environmental perception is, of course, multisensory and in addition to vision, senses such as hearing and smell are also of importance. Nonetheless, it is appropriate to focus on visual exposure, because vision is by far the most important sense in terms of yielding information about outdoor environments. The general premise underlying the study—the notion that visual contact with outdoor environments can influence well-being—has been supported by a previous investigation (Ulrich, 1979a). The study compared the anxiety-reducing effects of views of nature dominated by green vegetation with those of urban scenes lacking nature elements. Findings showed that the nature views significantly improved the emotional states of stressed individuals, whereas exposure to the urban scenes tended to work against emotional well-being. The results suggested that the importance of visual contacts with nature extends beyond aesthetic benefits, and includes a range of benefits in terms of psychological well-being.

In an extension of this line of research, the present study tests whether visual exposure to nature environments is

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more beneficial in a psychophysiological sense than exposure to environments lacking nature. More specifically, the experiment examines the psychophysiological effects of three categories of outdoor visual environment: (1) nature with water; (2) nature dominated by vegetation; and (3) urban environments without water or vegetation. Unlike the earlier investigation, the findings here are based on a study of unstressed individuals in normal arousal states. The major hypothesis prior to the data collection was that exposure to either type of nature content—water or vegetation—would have more positive influences on subjects' psychophysiological states than exposure to urban scenes lacking nature. Water has been described in a large body of intuitive literature as a visual element that is high in aesthetic value, and that also evokes positive feelings such as tranquility (Ryback and Yaw, 1976). Therefore it was anticipated that the most positive influences on well-being would be produced by the water views.

Although physiological measures have been employed by behavioral scientists for decades, this investigation is perhaps the first attempt to apply such measures—specifically, alpha wave amplitude and heart rate—to the study of exposure to different types of landscape scenes. The physiological findings are an important complement to the more subjective psychological data, because the physiological measurements are valid indicators of the arousal or activation state of an individual (Berlyne, 1971; Duffy, 1972; Ulrich, 1979b). Also, the physiological procedures offer the advantage of allowing continuous measurement of an individual's condition during an experiment. Hence the use of both psychological and physiological measures makes possible a deeper level of understanding and wider range of inferences (Ulrich, 1979b). It should also be pointed out that compared to studies based exclusively on intuitive or subjective procedures, investigations utilizing physiological or medical measures have been very much more successful in motivating governmental action and public concern regarding environmental quality. It is therefore possible that

human-environment research using physiological measures will prove to carry greater weight in planning and decision-making contexts, and be more effective in terms of implementation.

OVERVIEW

The basic research design involved exposing subjects under standard conditions to large numbers of views of the different types of environments. These experimental conditions necessitated the use of color slides as simulations of real visual environments. The first stage of the study therefore consisted of a program of landscape photography comprising several hundred slides of the different environmental categories. Next, a preliminary experiment using a semantic differential procedure was performed to obtain values for each slide regarding information rate and pleasantness. The results enabled comparisons among the nature and urban scenes in terms of pleasantness; however, the major purpose of the preliminary experiment was to make possible the selection of samples of slides representing each type of landscape that were equivalent in terms of information rate. The final samples each consisted of 60 slides, and there was one collection for each type of environment: (1) nature with water, (2) nature dominated by green vegetation, and (3) urban without water or vegetation. In the main experiment, subjects viewed the collections of slides, and measurements were taken of the effects of the different types of scenes on psychophysiological states. Before and after viewing each category of environment, the subjects rated their feelings on (1) semantic scales and (2) the Zuckerman Inventory of Personal Reactions (Zuckerman, 1977). Measurements of heart rate and alpha amplitude were taken before, during, and after the slide exposures. Because the experimental procedures were the same for each viewing session, the single difference in subjects' experiences stemmed from the variation in content among the three collections of scenes. This meant that the data would allow valid comparisons of the effects of nature

and urban views. The following sections contain more detailed discussions of the methods of the preliminary and main experiments, and set out the salient findings.

SLIDE SAMPLES

Given the major role of slides in the research, it should be noted at the outset that numerous studies have supported the use of slides and photographs as surrogates for real views of environments (e.g., Shafer and Richards, 1974; Zube et al., 1974; Sorte, 1975; Russell and Mehrabian, 1976; Coughlin and Goldstein, 1970). Also, theories of psychophysiological arousal assign major importance to visual properties of environments as factors affecting interest and other aspects of activation (e.g., Berlyne, 1971; Kuller, 1977a). Most importantly, the fact that feelings and responses related to visual properties of environments are of salient concern supports the validity of using slides as a simulation technique (Ulrich, 1977).

LANDSCAPE PHOTOGRAPHY

The scenes used in the experiment were selected from a group of approximately 400 slides taken in southern Sweden (provinces of Skåne and southern Småland) during summer. To ensure that the scenes were not generally familiar to the individuals participating in the study, no slides were taken in the city of Lund or its immediate vicinity, the area where the subjects lived. The vegetation scenes were located on the basis of a stratified sampling procedure that assured wide geographical coverage. A strict spatial sampling procedure was not followed in the case of the water or urban views, because areas with these scenes were far less extensive. The slides were taken in clear weather and insofar as possible under similar lighting and sun angle conditions. All slides were taken using Kodachrome 64 film and a 35 mm single-lens reflex camera with 50 mm lens. The slides were all taken from the ground; an attempt was made to avoid

composing the views. None of the views in the three landscape categories was aesthetically spectacular. No people or animals were visible in any of the pictures. The absence of people probably increased the pleasantness levels of the urban as well as the nature scenes (McClelland and Auslander, 1976; Carls, 1974; Sorte, 1978).

Although the two types of nature scenes excluded built features, many of these slides were obviously man-influenced. For example, several slides in the water and vegetation groups showed parts of cultivated fields. It is important to note that none of the water features contained prominent debris, chemical foam, unnatural colorations, or other visible pollution. Similarly, the urban collection excluded scenes containing litter or other blight. The urban scenes primarily depicted commercial landscapes, and to a lesser extent industrial areas. They excluded residential areas, churches, funeral agencies, police stations, fire stations, and hospitals, because of the possibility that emotional associations would bias the results.

PRELIMINARY EXPERIMENT

Purposes

The preliminary experiment was designed to yield values for each slide regarding information rate and aesthetic pleasantness, in order to make possible the selection of samples to represent each type of environment. Information rate broadly refers to the amount of sensory information associated with a stimulus configuration. In this study the stimulus configurations are scenes of outdoor environments, and the information is visual. The information rate of a visual configuration is positively related to the number, intensity, and dissimilarity of independently perceived elements (complexity), and negatively related to the degree of order or patterning (unity) in the stimuli (Mehrabian and Russell, 1974: 77-81). The information rate of a visual array is known to affect the perceiver's level of psychophysiological arousal or activation (Berlyne, 1971). It was therefore

important in the preliminary experiment to obtain information rate data, so that slide samples of the three environments could be selected that were equivalent in terms of this property. Otherwise, if slide samples had been chosen that varied markedly in information rate, such differences alone could have produced significant variation in subjects' responses in the main experiment—thereby obscuring findings concerning the influences of the water, vegetation, and urban content.

Procedures of Preliminary Experiment

Values for information rate and pleasantness were obtained using a semantic differential procedure. The semantic scales were selected on the basis of research by Kuller (1972), and Mehrabian and Russell (1974). Information rate was assessed by two scales: one scale measured information rate in terms of complexity (lively-subdued), the other in terms of unity (whole-inconsistent). Two scales were also used to measure pleasantness (beautiful-ugly and unpleasant-pleasant). Swedish versions of the scales were used in the experiment.

Semantic ratings of 240 slides were made by 12 Swedish student judges (six males, six females) from the University of Lund and the Lund Institute of Technology. Six of the individuals were studying design or a planning-related field (three architects, three geographers); the other six were from disciplines not related to either planning or design. The judges ranged in age from 20 to 42 years. The data were collected in two experimental sessions; during a session, each judge rated the scenes on only one semantic scale.

Results of Preliminary Experiment

Values for information rate and pleasantness were computed for each slide on the basis of the judges' ratings. The information rate of a slide was calculated by subtracting its unity value from its complexity score. This procedure was followed because information rate is positively related to

TABLE 1
Pleasantness Results

PLEASANTNESS RESULTS (240 SLIDES)

SEMANTIC SCALE	(n = 68) WATER SLIDES MEAN S.D.	(n = 86) VEGETATION SLIDES MEAN S.D.	(n = 86) URBAN SLIDES MEAN S.D.
UGLY-BEAUTIFUL	5.10 (.72)	4.53 (.75)	2.76 (.78)
UNPLEASANT-PLEASANT	4.77 (.90)	4.43 (.90)	2.68 (.94)
MEAN OF TWO SCALES	4.93	4.48	2.72

complexity and inversely related to unity. Values for pleasantness were obtained by summing the scores for the two pleasantness scales and computing the means. The results revealed marked differences among the three categories of environment in terms of pleasantness (Table 1). Pleasantness values for both types of nature, especially water, were far above the levels of the urban scenes. The particularly wide gap between water and urban content was evident in the fact that only six water views had lower pleasantness scores than the urban scene rated highest in pleasantness. None of the slides in either nature category had a pleasantness score as low as the mean of the urban collection. These results meant that it was impossible to choose samples representing the different environments for the main experiment that were equivalent in pleasantness. The findings are interesting from the standpoint of a cross-cultural comparison because they are consistent with results obtained for American outdoor environments (e.g., Kaplan et al., 1972; Zube et al., 1975; Ulrich, 1974; Evans and Wood, 1980).

Compared to the findings for pleasantness, the information rate data revealed much smaller differences among the three landscape categories. The mean information rate of the urban collection was highest, largely as a result of lower levels of unity compared to the two types of nature views.

In contrast to the unity results, the complexity levels of the three environments were quite similar.[1]

SELECTION OF SLIDE SAMPLES

On the basis of the information rate data, a sample of sixty slides was selected for each of the three types of landscape content. The slides were chosen so that the information rates of these subcollections were equivalent. It proved possible to identify samples representing water, vegetation, and urban content that were virtually identical in terms of mean information rate, and similar with respect to the range and distribution of values for individual scenes.

The 60-slide samples of nature and urban scenes were also selected to represent diversity in terms of elements such as vegetation, water features, and building types. The urban sample showed structures that varied widely in age, style, and function, and depicted urban milieus ranging in scale from small towns to large cities. The water collection included small streams and ponds, rivers, canals, reservoirs, lakes of different sizes, and views of salt water. A few scenes in this collection showed water exclusively; most contained vegetation in addition to the water feature. The samples varied considerably in terms of predominant colors. Both types of nature scenes were dominated by shades of green and blue. By contrast, the colors of the urban scenes were primarily browns, grays, whites, and occasionally reds. Examples of the landscape scenes are shown in Figures 1, 2, and 3.

METHODS OF MAIN EXPERIMENT

PSYCHOLOGICAL MEASURES

Semantic Scales

The semantic questionnaire consisted of 36 scales that measure an individual's moods and feelings at the partic-

ular time the test is taken. The questionnaire, which was developed on the basis of research by Kuller (1977b), assessed feelings on four principal factors: dominance, wakefulness, attention/interest, and stability (affect). Examples of the scales are: dependent-independent, sleepy-wide awake, bored-interested, and tense-relaxed.

Zuckerman Inventory of Personal Reactions (ZIPERS)

The ZIPERS (Zuckerman, 1977) is a broad state affect test that assesses feelings on five factors: fear arousal, positive affect, anger/aggression, attentiveness, and sadness. The respondent indicates on a 5-point scale the degree to which each item describes the way he feels "now." Examples of the items are: "I feel sad," and "I feel affectionate or warm-hearted." The ZIPERS was translated into Swedish for the experiment.

PHYSIOLOGICAL MEASURES

Alpha Amplitude

By means of an electroencephalograph (EEG) apparatus, measurements were taken of brain electrical activity. An individual's intensity of an electrical rhythm called alpha (8-13 cycles per second) is a valid measure of cortical arousal, and correlates with states of consciousness and alertness (Shagass, 1972). High alpha amplitudes are associated with lower levels of physiological arousal as well as feelings of wakeful relaxation. Generally, feelings of anxiety are related to high arousal and accordingly to low alpha amplitude. Also, during very low arousal (i.e., drowsiness) alpha tends to become desynchronized and falls to low levels (Lindsley, 1952).

The alpha wave data were recorded by two bipolar pairs of electrodes (one pair for each brain hemisphere) placed "central parietal." The left pair was located at position C3-P3, and the right at C4-P4, according to the International 10-20 System (Jasper, 1958). The data were recorded on tape as a series of values for each electrode pair. The values

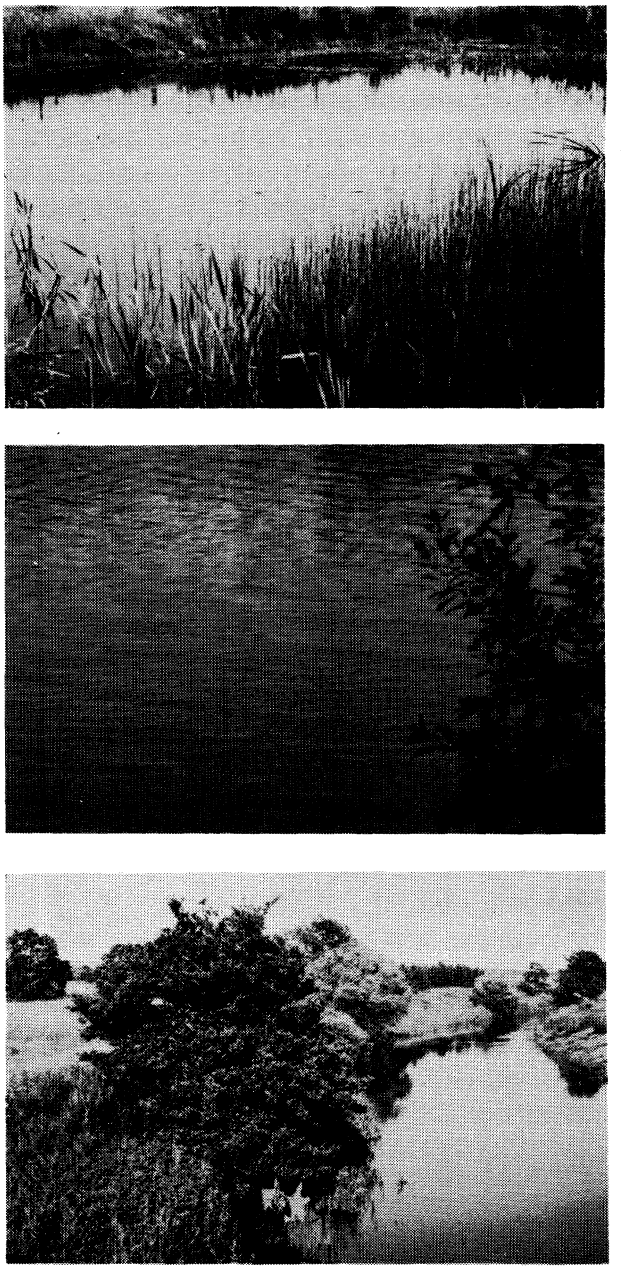

Figure 1: Examples of nature with water.

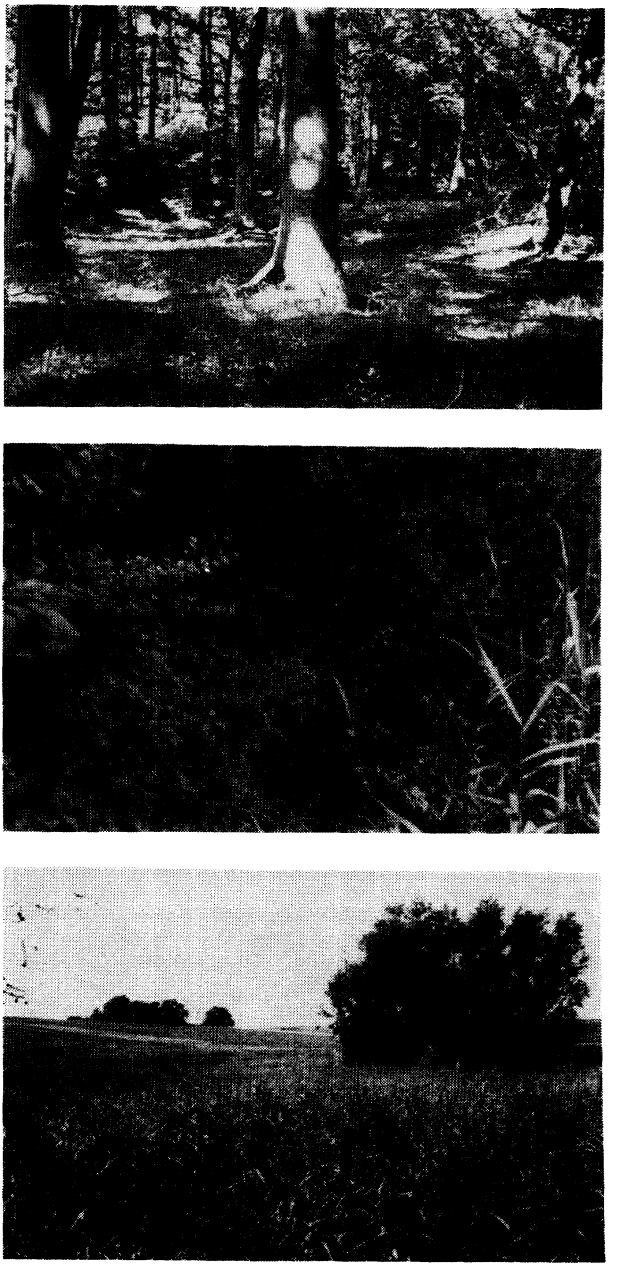

Figure 2: Examples of nature dominated by vegetation.

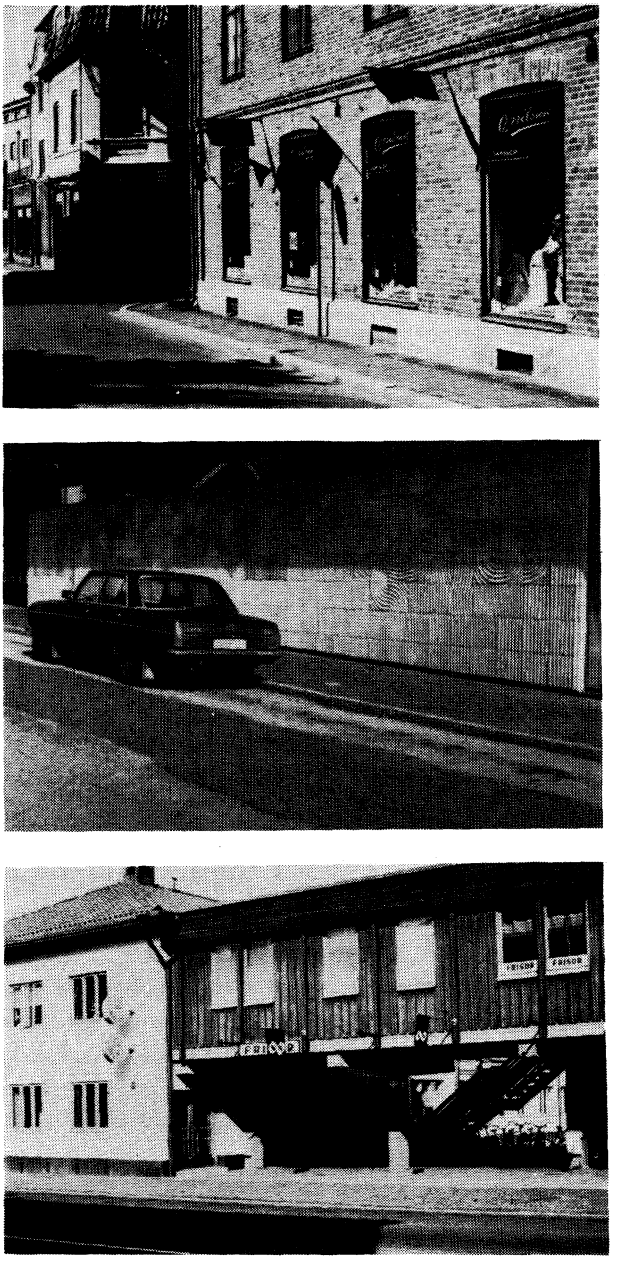

Figure 3: Examples of urban without water or vegetation.

were arbitrary interval units linearly related to the voltage in the alpha frequency range. Each value represented the mean amplitude or voltage intensity of alpha during a 20-second measurement/integration period. The data analyses were performed on the averages of the electrical activity of both brain hemispheres.[2]

Heart Rate

An electrocardiograph (EKG) was used to record heart rate continuously during the experimental sessions. Data were recorded using a contact electrode placed over the subject's breastbone. In a manner similar to the alpha measurements, data were coded as average values for measurement/integration periods lasting 20 seconds. Heart activity is an objective indicator of states of psychophysiological arousal or activation. Strong emotions, such as marked anxiety or fear, are associated with high heart rate and increases in blood pressure. Mental problem-solving tasks requiring the storage, retrieval, and internal manipulation of information result in heart acceleration; tasks requiring only the observation of stimuli tend to reduce heart rate (Libby et al., 1973; Campos and Johnson, 1966; Obrist, 1963). Generally speaking, a decline in heart rate accompanies a decline in tonic or general arousal.

In the case of both heart rate and alpha amplitude, physiological activity was measured in eyes-closed as well as eyes-open states. It was expected that higher, comparatively short-term arousal responses would be recorded in the eyes-open condition because of the higher rates and changes in environmental stimulation associated with the slides. By contrast, an individual's general, more long-term arousal level was best measured in this experiment while the subject's eyes were closed—a condition that sharply reduces stimulation (Kuller, 1977c). It was especially important to measure alpha in eyes-closed as well as eyes-open states, because alpha activity tends to be very different in the two conditions. For most individuals, alpha is higher in amplitude when their eyes are closed rather than open.

PROCEDURES

The data were collected in a total of 54 experimental sessions, each lasting approximately one and one-half hours. In each session, a subject was exposed to one of the slide samples that depicted either water, vegetation, or urban content. During the session the subject sat in a comfortable armchair in an electrically shielded room of normal appearance measuring 4.3 meters long, 3.5 meters wide, and 2.5 meters high. The walls were painted pale yellow, a color that has little effect on psychophysiological arousal. The slides were projected by a carousel projector onto a back projection screen mounted two meters from the subject. The size of an image on the screen was 75 cm by 50 cm. The experimental procedures were the same for all sessions, which meant that the variation in subjects' experiences stemmed solely from the differences among the three samples of slides. Because several measures were employed, the schedule of procedures followed for each data collection was rather complex. The procedures for a single session are outlined in Figure 4.

As Figure 4 shows, each session began with a 20-minute period during which the subject received instructions and information concerning the experiment, and electrodes were affixed for alpha and heart rate. This period also served to relax the individual, so that initial arousal levels and moods were more similar across subjects. The electrodes were attached by two experimenters who were the same for every session. The experimenters were "blind" in the sense that they did not know what type of environment the subject would view in the session. This precaution greatly reduced the possibility that subject-experimenter interactions might bias the individual's reactions to the scenes.

Upon completion of the instructions and placement of the electrodes, the experimenters left the room and the individual rated his/her feelings on the semantic scales and ZIPERS. When the ratings were completed, a slide was projected with the instruction: "Close your eyes and relax." This signaled the beginning of a 5-minute period during

DURATION	ACTIVITY	ALPHA	HEART RATE
20 minutes	Subject receives instructions and electrodes are affixed for alpha and heart rate.	Not Measured	Not Measured
6 minutes	Subject rates feelings on semantic scales and ZIPERS.		
5 minutes	Subject relaxes with eyes closed.		
13 minutes	Subject views first half of slide sample (30 slides of one environmental category.)		
5 minutes	Subject relaxes with eyes closed.	Measured Continuously	
13 minutes	Subject views second half of slide sample (30 slides of same environmental category as earlier.)		
5 minutes	Subject relaxes with eyes closed.		
6 minutes	Subject rates feelings on semantic scales and ZIPERS.	Not Measured	Not Measured
15 minutes	Removal of electrodes.		

Figure 4: Schedule of procedures for one experimental session.

which eyes-closed alpha was measured. After this, an audible signal informed subjects to open their eyes. The person then viewed the first half (30 slides) of one of the samples. Each slide was projected for 25 seconds, of which the actual exposure time was 24 seconds and the changing time was one second. The instructions concerning the slide viewing were simple: "Pay attention to the scenes. Look at each slide . . . do not let your eyes wander from the screen." When the 30 slides were finished, the individual closed his/her eyes for a second 5-minute period. After this interval, a subject was exposed to the remaining 30 slides in the sample. The conclusion of the slides was followed by a third 5-minute eyes-closed period. Finally, subjects rated their feelings for the second time on the

semantic scales and the ZIPERS. During the course of the data collections, the presentation orders of the slide samples were changed at regular intervals.

In summary, subjects provided self-ratings of their feelings both before and after the slide exposures. Measurements of alpha amplitude and heart rate in the eyes-closed condition were taken immediately before and after the presentation of the slides, and also at the halfway point in the slide viewing. Eyes-open alpha and heart rate were measured continuously while an individual viewed the slides.

Procedures Concerning Subjects

In order to achieve a stronger experiment, a design was followed wherein each subject served as his/her own control. Rather than exposing a different group of subjects to each type of environment and comparing the responses of the three groups, the procedure here was to examine the influences of the three landscape categories on the same group of subjects. Each subject therefore viewed the three samples of slides in different sessions, and this in effect allowed individuals to be compared with themselves in terms of their reactions to the different environments. Such a strategy is widely used in psychophysiological research, and was especially appropriate in this study because different people often vary greatly with respect to, for example, alpha activity or feelings of anxiety.

Eighteen subjects (9 males, 9 females) took part in the experiment, which meant that data were collected in a total of 54 trials (18 subjects × 3 viewings per subject). It must be stressed that because each individual served as his/her own control, the findings based on this seemingly small group promised to be much more sound than if 54 different individuals divided into three groups had been studied, and probably as sound as if upwards of 100 subjects had been used in a conventional single trial design. The subjects, who ranged in age from 20 to 27 years, were students at

the Lund Institute of Technology in Sweden. None of the subjects was studying a discipline related to design or planning that might have imparted professional biases concerning outdoor visual perceptions or preferences. None of the individuals had low visual acuity, color weakness, or reported brain damage.

Each subject attended four experimental sessions, of which the first was a familiarization session. The purpose of this was to introduce the individual to the experience of wearing EEG and EKG electrodes, and to familiarize him/her with the procedures of the experiment. This ensured that the subject's feelings and arousal levels were more normal during the subsequent sessions in which the data were collected. The familiarization and data collection sessions were scheduled so that a given individual was always studied at the same time of day. This was an important consideration because a person's arousal level tends to vary diurnally in a marked fashion. Also, the schedule of sessions followed a design that was balanced in terms of sex, category of environment, and time of day. Concerning the latter, subjects were scheduled during mornings, afternoons, and evenings. By using each subject as his/her own control, diurnal variations in arousal were balanced out in the experiment.

At the conclusion of the final session, a one and one-half hour postinterview was conducted in which individuals were tested for visual acuity and color weakness, and questioned concerning their general background and experiences, particularly with respect to the three different categories of environment to which they had been exposed during the experiment.

RESULTS OF PSYCHOLOGICAL MEASURES

It will be recalled that subjects rated their feelings on the questionnaires both before and after viewing the slides. However, it is important to mention that the time positions

of the self-rating periods in the experiment were by necessity somewhat compromised by the fact that alpha amplitude was also measured. In order to obtain useful EEG data, it was essential that eyes-closed alpha be measured immediately after the slide presentations. This dictated the insertion of a 5-minute eyes-closed interval before the second self-rating period (see Figure 4), which meant that the self-ratings were separated from the slide viewings by five minutes. It was expected that this eyes-closed period would tend to level out differences in a subject's psychological states which might develop as a result of the slide exposures. Therefore, if the water, vegetation, and urban scenes did indeed have different effects on the individuals, the variations would have to be quite marked to be detected by the semantic scales and ZIPERS, because they would have to persist through the period of eyes-closed relaxation.

SEMANTIC QUESTIONNAIRE RESULTS

As the first phase in treating the data, the correlation matrix of the semantic ratings data was factor analyzed. An oblique solution yielded four independent factors that were interpreted as follows:

(1) WAKEFULNESS (e.g., sleepy-wide awake, lazy-alert)
(2) ATTENTIVENESS/INTEREST (e.g., not curious-curious, bored-interested, engaged-unconcerned)
(3) STABILITY (AFFECT) (e.g., peaceful-aggressive, calm-restless, safe-anxious, satisfied-unsatisfied, angry-friendly)
(4) DOMINANCE (e.g., dominated-dominating, self-assured-hesitant, dependent-independent)

Comparisons of the pre- and postslide factor scores revealed a great deal about the effects of the experimental conditions. Irrespective of the type of environment viewed, the individuals felt much less wakeful ($p < .001$), much less attentive and interested ($p < .001$), and less dominant ($p = .025$) at the conclusion of a session. The significant declines for the three factors are attributable to the long

duration of a session, to the large number of slides viewed, and probably also to the three 5-minute eyes-closed alpha periods. It is reasonable to assume that the total of 15 minutes of eyes-closed relaxation reduced arousal levels and made the subjects feel less wakeful and attentive.

The central question was whether a subject's states changed in different ways during the experimental sessions as a function of the type of environment viewed. Neither analysis of variance nor pairwise nonparametric Mann-Whitney tests revealed significant variations attributable to the different categories for the factors of Wakefulness, Stability, and Dominance. However, it is important that there was a general pattern for the differences between pre- and postslide ratings on the Attentiveness/Interest factor to vary as a function of environment. Whereas levels of Attentiveness/Interest dropped regardless of the type of landscape viewed, scores for this factor declined less when the subjects viewed the two types of nature scenes. Pairwise comparisons using the Mann-Whitney U test indicated that the effects of the water (versus urban) scenes were significantly different at the $< .01$ level; the difference between the vegetation and urban views was significant at the .04 level. The finding concerning the variation between the vegetation and urban samples is consistent with results from a previous study that compared the effects of vegetation and urban scenes on stressed individuals (Ulrich, 1979a). The scenes with water maintained Attentiveness/Interest slightly more effectively than the vegetation views, but the difference was not significant. In evaluating these results, it should be emphasized again that in order to be detected, the differences had to be strong enough to persist through the 5-minute eyes-closed period that preceded the self-ratings.

ZIPERS RESULTS

A total of ten ZIPERS items were used to measure feelings on five factors:

(1) FEAR AROUSAL (feel fearful)

(2) ANGER/AGGRESSION (e.g., feel angry; feel like hurting or "telling off" someone)
(3) SADNESS (feel sad)
(4) POSITIVE AFFECT (e.g., feel carefree or playful; feel affectionate or warmhearted)
(5) ATTENTIVENESS (feel attentive or concentrating)

The last factor, Attentiveness, roughly corresponds to the broader Attentiveness/Interest factor obtained from the semantic scales. The remaining four factors measure aspects of affect, and individually are more specific than the Stability/Affect factor in the semantic questionnaire. Each of the first four ZIPERS factors might be viewed as a cluster of intercorrelated feelings within a broader affect dimension.

Irrespective of the type of environment viewed, the subjects reported lower levels of Attentiveness ($p < .001$) at the end of a session, which is the same finding obtained from the semantic scales. Importantly, a series of Mann-Whitney U tests revealed that the water, vegetation, and urban scenes had quite different effects on psychological states. Whereas Attentiveness declined regardless of the type of environment viewed, the drop was significantly less when the scenes contained water. The difference between the influences of the water and urban scenes was significant at the .02 level. There was a tendency for the females' Attentiveness scores to decline less than those of the males when they viewed the vegetation scenes ($p < .10$). The ZIPERS results concerning the greater attention-holding properties of water are noteworthy because they support the earlier finding from the semantic questionnaire.

Mann-Whitney U tests also identified variations for the Sadness factor. Exposure to the urban scenes markedly increased feelings of sadness, whereas sadness increased only slightly during exposure to vegetation scenes, and remained constant when the views contained water. The difference between the influences of the urban and water scenes was highly significant ($p = .005$); the difference between the urban and vegetation views indicated only a tendency ($p = .07$). The finding concerning the variation between the urban and vegetation exposures is consistent

with results from the earlier study of stressed individuals which also employed the ZIPERS (Ulrich, 1979a).

Additionally, the three categories of environment had different influences on feelings of Fear Arousal. Scores on the Fear Arousal factor increased slightly during the urban exposures, decreased slightly during the vegetation scenes (not significant compared to the increase for urban views), and declined more sharply when the slides showed water ($p < .02$ for difference between the water and urban presentations). The pattern of variation on the Fear Arousal factor was the same as that observed for stressed individuals (Ulrich, 1979a).

A sex difference characterized the influences of the environments on Positive Affect. In the case of the males, levels of positive feelings declined slightly irrespective of the category of environment. By contrast, the females' levels of positive feelings declined sharply when viewing the urban scenes, declined less when viewing water, and remained unchanged during the exposures to vegetation. The variation between sexes in terms of the effects of vegetation was significant ($p = .02$).

Lastly, neither analysis of variance nor pairwise Mann-Whitney tests identified any significant differences for the Anger/Aggression factor which is also consistent with results from the earlier research using the ZIPERS (Ulrich, 1979a).

RESULTS OF PHYSIOLOGICAL MEASURES

ALPHA RESULTS

Analyses of the eyes-closed alpha data were performed using the amplitudes recorded for each subject during the three 5-minute measurement periods (see Figure 4). Analysis of variance and t-tests for related samples were employed to identify differences in mean alpha activity (1) among the three measurement periods during a session, and (2) across sessions as a function of category of environment. Irrespective of the type of environment viewed, the

results from the eyes-closed recordings revealed a significant ($p < .005$) pattern of decline of alpha amplitude during an experimental session. The most likely explanation for the declines is that the subjects tended to become sleepy during the sessions, and with the onset of drowsiness alpha gradually became desynchronized (Lindsley, 1952). This interpretation is consistent with the finding from the self-ratings that the individuals felt much less wakeful at the end of the sessions.

Repeated measures analysis of variance revealed no general differences in eyes-closed alpha amplitude as a function of the type of environment viewed. Also, analysis of variance gave no indication of differences between sexes, or of marked variations among individuals according to type of slide presentation.

The data for the eyes-open alpha consisted of the series of mean amplitudes recorded for each subject on the basis of the 20-second measurement/integration periods. These values in turn were used to compute for each subject a mean slide amplitude for (1) each 60-slide presentation of one landscape category, and (2) for subsequences of every 10 and 30 slides of each category. Irrespective of the type of environment, results showed that amplitudes were sharply lower when the subjects were in eyes-open as opposed to eyes-closed conditions. This finding implies validity for the alpha recordings, because it is consistent with the well-established point that most individuals produce lower alpha when their eyes are open rather than closed.

Repeated measures analysis of variance and t-tests for related samples were employed to identify possible differences in mean slide alpha intensity (eyes-open) as a function of landscape category. It is extremely interesting that the three types of landscapes had different effects on alpha in the eyes-open condition. Specifically, amplitudes were consistently higher when the individuals viewed the vegetation slides rather than the urban scenes. The differences are shown in Figure 5; each data point in the figure represents the average alpha amplitude recorded during the

presentation of ten slides of a particular category of environment. The pattern of significantly higher eyes-open alpha for the vegetation scenes, as compared to the urban scenes, represents one of the most important findings of the experiment ($p < .05$ for the difference between the first 30 slides of each category; $p < .01$ for the second 30 slides). The results also revealed that the differences between the vegetation and urban scenes were stable across sexes and time of day. It will be recalled that alpha is a valid indicator of brain activation, and is associated with feelings of wakeful relaxation. The results therefore support the conclusion that the subjects felt more wakefully relaxed while viewing the vegetation as opposed to urban scenes, and that the two environments had different effects on electrocortical activity.

In contrast to the results for the vegetation and urban scenes, a simple general conclusion concerning the effects of the water scenes on eyes-open alpha is not warranted because the influences of these views fluctuated according to time of day of the session. This implies the possibility that the effects of viewing water were more dependent on the initial arousal levels of the individuals, which varied diurnally to some extent. Nonetheless, alpha amplitudes during the water exposures were higher on average than during the urban presentations (Figure 5), and the difference was significant ($p < .05$) for 12 trials during the morning (six water sessions versus six urban sessions in the morning hours). The fact that alpha during the water exposures was on average lower than during the vegetation scenes may have been due to the attention-holding properties of the water views. It is well known that alpha is reduced when stimuli maintain or increase attentiveness (e.g., Mulholland, 1969). The strong attention/arousal maintenance effect of water possibly desynchronized alpha to some degree, thereby reducing amplitudes.

HEART RATE RESULTS

The data for evaluating eyes-closed heart rate consisted of the values recorded during the series of integration inter-

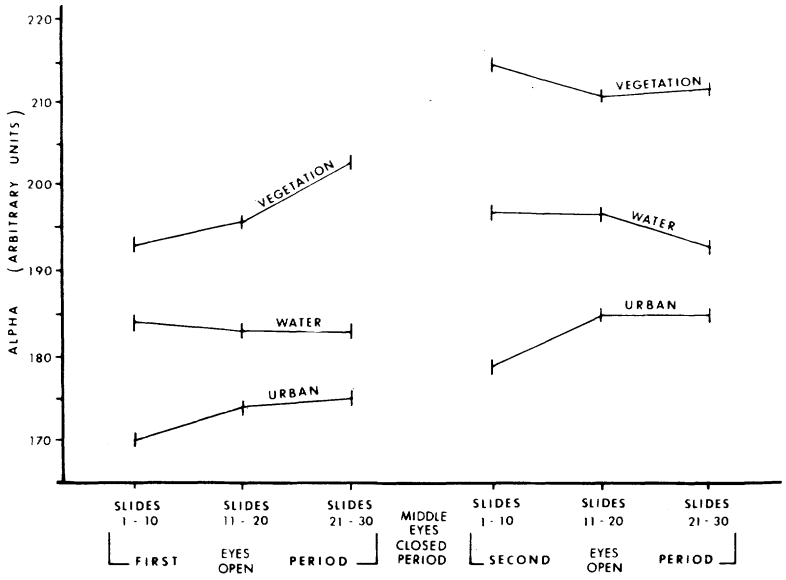

Figure 5: Eyes-open alpha as function of environment viewed.

vals comprising the 5-minute eyes-closed measurement periods. These values were converted to beats per minute, and analysis of variance was used to identify differences in heart rate means both during a session and across sessions as a function of category of environment. Irrespective of the type of environment viewed, heart rate in the eyes-closed condition reflected a highly significant ($p < .001$) pattern of decline during an experimental session. This is consistent with the results from the other measures, which indicated that the experimental conditions had arousal-reducing effects on the individuals.

Repeated measures analysis of variance identified no significant differences in heart rate in the eyes-closed condition as a function of environment. Also, analysis of variance gave no indication of variation between sexes, or of marked differences among individuals, according to type of slides. Therefore, despite the evidence from the other measures indicating that the three categories of environment had different psychophysiological effects on the subjects, it is clear that the variations did not produce heart rate

differences that persisted into the eyes-closed periods following the slides.

Repeated measures analysis of variance also identified no statistically significant differences in eyes-open heart rate as a function of type of environment. Despite the absence of significant differences, it should be mentioned that there was a general pattern of variation in eyes-open heart rate consistent with the results from other measures. Heart rate was higher on the average when subjects viewed either water or vegetation, as opposed to urban scenes (water = 71.3 beats per minute for 60 slides; vegetation = 71.1; urban = 70.2; $p < .20$). This pattern is consistent with the earlier conclusion that the two categories of nature scenes were more effective in sustaining arousal/attention.

SUMMARY AND DISCUSSION

The central question addressed by the research was whether the subjects' psychophysiological states changed in different ways during the slide presentations as a function of the type of environment viewed. It is important that the findings revealed several differences in the influences of the three environments. Concerning psychological effects of the three environments, the results reflect a clear-cut pattern. Compared to the influences of the urban slides, exposures to the two nature categories—especially water—had more beneficial influences on psychological states. In the case of feelings of attentiveness and positive effect, there was evidence that influences of the vegetation scenes were stronger for the females than for the males. The differences among the psychological influences of the environments are especially impressive in light of the fact that the variations were sufficiently strong and persistent to be detected after a 5-minute period of eyes-closed relaxation that preceded the self-ratings. If the subjects had filled out the self-ratings immediately upon completion of the slides, the results probably would have revealed even more ex-

treme variations in the effects of the different environments.

Importantly, the difference revealed by the alpha results is consistent with the conclusion based on the self-ratings, that the most positive influences on well-being were produced by the nature scenes. The finding concerning eyes-open alpha strongly suggests that the subjects felt more wakefully relaxed while viewing the vegetation scenes than while viewing the urban environments. Similarly, alpha amplitudes were higher on the average during the water exposures than during the urban presentations, and the difference was significant during part of the day. This variation occurred despite water's strong attention-holding properties which probably desynchronized alpha to some degree and accordingly reduced amplitude. Although the pattern of psychological and physiological evidence favoring the nature scenes is impressive, it is clear that exposure to the nature environments did not have a global, or comprehensively beneficial effect on the individuals' states. Rather, the findings from the psychological measures suggest that, compared to the influences of the urban scenes, exposure to water or vegetation views have more positive effects on rather specific clusters of emotions—such as sadness and fear arousal. For the case of other types of feelings, such as dominance and stability, the influences of nature and urban scenes may be similar. Likewise, the alpha and heart rate findings suggest that the differences in physiological influences of nature versus urban scenes are not global in character.[3] Although there was a general pattern for eyes-open alpha to be higher during the vegetation as opposed to urban exposures, it is possible that many physiological responses associated with visual perception of a particular environment show wide variation between individuals, perhaps partly as a function of observers' initial arousal states. Because psychophysiological arousal levels are influenced by several factors—including personality, the experiences of the observer prior to exposure, and time of day—it is possible that some effects of outdoor visual exposures interact in a complex manner with these variables.

The results concerning the different psychological influences of the environments are consistent with those of a previous study that assessed the effects of vegetation versus urban scenes on stressed individuals (Ulrich, 1979a). The accord between the findings is noteworthy because the investigations were performed in different countries—America in the first case, and Sweden in the present instance. A major implication of the agreement is that theoretical perspectives stressing either cultural conditioning or environmental adaptation are inadequate for explaining psychophysiological effects of visual perception of outdoor environments. In Sweden, nationwide comprehensive planning of urban and residential areas has produced built landscapes that vary considerably from those of the United States, both in terms of land-use patterns and appearance (e.g., Popenoe, 1977). Additionally, cultural traditions and attitudes with respect to nature—as expressed, for example, in folklore, holidays, and common law—are very different in the two countries. Under these circumstances, the cross-cultural similarity with respect to differential effects of nature versus urban scenes argues strongly against a simple explanation based on culture or adaptation.

Based on the results from the previous study and the findings of this investigation, it is reasonable to propose tentatively that people benefit most from visual contact with nature, as opposed to urban environments lacking nature, when they are in states of high arousal and anxiety. For individuals experiencing stress or excessive arousal, nature views appear to reduce arousal more effectively than urban scenes, and hence are more beneficial in a psychophysiological sense. Views of urban areas lacking nature may inhibit recuperation from high arousal, and there are clear indications that such exposure aggravates some aspects of anxiety (Ulrich, 1979a). The benefits of visual exposure to nature, compared to urban content, may be less for unstressed people in normal arousal states. However, as the findings of the present study suggest, the effects of nature exposures even on unstressed individuals can be significantly more positive than the influence of urban views. In

addition to having more beneficial influences on affective states, views of vegetation and especially water appear to be more effective in maintaining attention and arousal when an individual's initial arousal state is in the middle ranges. For the case of individuals experiencing low arousal and understimulation, it is an open question as to whether visual contact with nature has more beneficial influences than urban exposures. One possibility is that urban views may increase arousal levels more effectively than nature scenes when people are understimulated. Alternatively, it might be the case that the temporal variety and visually dynamic qualities of many real-world nature scenes—e.g., moving water surfaces, wind-blown vegetation, and changes associated with seasons—are highly effective in terms of stimulating individuals in low arousal states to more optimal middle levels of arousal. An implication of this latter point is that the psychophysiological benefits of views of nature may in many instances be greater under real conditions. Although the findings and these comments clearly favor the nature scenes relative to the urban views, this should not be simplistically interpreted as an indictment on psychophysiological grounds of urban visual environments in general. In the present study it is likely that the variations between the effects of the nature and urban scenes would have been less if the city views had contained prominent amounts of nature elements such as trees. This possibility suggests that an objective for both researchers and planners should be to determine whether different urban visual environments vary markedly in terms of influences on emotional and physiological states. City life will continue to be a feature of human societies for the foreseeable future, and an understanding of responsiveness to views of built versus nature elements may contribute to the design of more livable urban settings.

The results have a number of implications for theory development in environmental aesthetics, and in particular for the work of Berlyne and his colleagues (e.g., Berlyne, 1960, 1971, 1974). According to Berlyne's theory—the dominant framework in experimental aesthetics—one of

the most important properties of a visual stimulus is complexity, which refers generally to the number of independently perceived elements and their degree of dissimilarity (Berlyne, 1971: 198-201). Numerous experiments using nonlandscape stimuli, such as random polygons, have shown that as complexity increases, so does the viewer's interest and attention. The findings of the present study conflict in fundamental respects with these results. The water views proved much more effective than the urban scenes in holding attention/interest, despite the fact that the different slide samples were equivalent in terms of complexity and information rate. Berlyne's framework does not account for the possibility, for example, that even a low complexity view of calm water can be more attention-holding than an urban scene of high relative complexity of information rate. It might be argued that this anomaly arises because the complexity of outdoor scenes is different from the complexity of randomly generated stimuli. However, a study by Libby (1971) suggests that the type of complexity measure used in this experiment corresponds to the measures employed by Berlyne and his colleagues, and Libby has further concluded that the complexity of meaningful pictures can be equated with the complexity of Berlyne-type figures (Libby et al., 1973: 291). Therefore, the present findings support the conclusion that complexity is a less important factor in attention/interest than is environmental content.[4] Berlyne's legacy of theory and empirical findings continues to be invaluable; however, it appears that central aspects of his framework will require modification if they are to be successfully applied to real world scenes. The results here suggest that attempts to develop realistic and accurate models of responsiveness to outdoor views should include the differential effects of nature versus built content.

NOTES

1. American urban environments appear to have generally higher levels of visual complexity than nature landscapes (Wohlwill, 1973). The similarity in complexity levels found here is partly due to the fact that a conscious attempt was

made during the photography phase to include a large number of high complexity nature scenes. Also, Swedish urban landscapes are generally lower in visual complexity than American urban environments because virtually all utility wires are underground, and signs and facades are subject to strict controls. In the case of the water scenes, the major sources of complexity were probably not the water features, but rather vegetation, stones, and other natural elements also present in the views.

2. Using an oscilloscope, an experimenter monitored subjects' brain wave activity continuously, and rejected the coding of integration period values when movement artifacts were apparent. Also, in order to obtain more accurate measurements, the EEG and EKG apparatuses were connected electrically to the slide projector, and at the end of each 20-second integration period the projector automatically changed to a new slide. Data were not recorded during the slide change (one second) and the first four seconds of exposure. Thus, the actual exposure time for each slide was 24 seconds, and alpha and heart rate were recorded during the last 20 seconds of exposure. The fact that the first four seconds of each slide exposure were not recorded meant that the data excluded the comparatively sharp arousal increases and alpha blocking associated with orienting reactions. A 4-second deletion was appropriate because Janssens (1976) has shown that orienting eye movements occur with greatest frequency during approximately the first four seconds of exposure to an outdoor scene. It should be pointed out that phasic reactions—that is, arousal reactions occurring during the first few seconds, or fraction of a second, of exposure to a visual stimulus—have been of most concern in psychophysiological experiments (e.g., Baker and Franken, 1967; Libby et al., 1972). By contrast, this experiment focused on what might be termed the "residual" phasic effects produced by exposure to the outdoor scenes. The residual or long-term influence of a scene was judged as the most important indication of the effect of its environmental content on arousal and emotional states in the eyes-open condition.

3. Apart from alpha amplitude and heart rate, a number of additional, potentially fruitful physiological measures could be used in future research on landscape aesthetics, and for shedding light on a very wide variety of other environment-behavior questions. The author has elsewhere surveyed these measures, and discussed strengths and limitations of psychophysiological approaches (Ulrich 1979b). The present findings support Wohlwill's speculation that the most productive physiological techniques in landscape aesthetics research will prove to be measures of activity in the electrocortical, rather than autonomic, system (Wohlwill 1976). It should be noted that in this experiment EEG equipment limitations prevented determination of other electrocortical indicators such as peak frequencies in the broader EEG wave frequency range derived from procedures such as power spectrum analysis. It is very likely that such procedures would have yielded additional insights concerning brain wave activity in response to the landscape scenes.

4. The importance of environmental content in influencing attention/arousal is further suggested by the fact that the landscape categories varied in color in a manner that should have worked against the findings obtained here. The two types of nature were dominated by shades of green and blue, and results from laboratory studies suggest that these colors can have arousal-reducing effects (e.g., Wilson, 1966). By contrast, the urban collection contained very little green, less blue, and some pictures included arousal-increasing reds. In this light, the stronger attention/arousal maintenance effect of nature is all the more striking.

REFERENCES

BAKER, G. and R. FRANKEN (1967) "Effects of stimulus size, brightness and complexity upon EEG desynchronization." Psychonomic Science 7: 289-290.

BERLYNE, D. E. [ed.] (1974) Studies in the New Experimental Aesthetics. Washington, DC: John Wiley.

——— (1971) Aesthetics and Psychobiology. New York: Appleton-Century-Crofts.

——— (1960) Conflict, Arousal, and Curiosity. New York: McGraw-Hill.

CAMPOS, J. J. and H. J. JOHNSON (1966) "The effects of verbalization instructions and visual attention on heart rate and skin conductance." Psychophysiology 2: 305-310.

CARLS, E. C. (1974) "The effects of people and man-induced conditions on preferences for outdoor recreation landscapes." J. of Leisure Research 6: 113-124.

COUGHLIN, R. E. and K. A. GOLDSTEIN (1970) "The extent of agreement among observers on environmental attractiveness." Regional Science Research Institute Discussion Paper Series, No. 37. Philadelphia: Regional Science Research Institute.

DRIVER, B. L. and P. GREENE (1977) "Man's nature: innate determinants of response to natural environments." Children, Nature, and the Urban Environment. USDA Forest Service Report NE-30. Upper Darby, PA: Northeastern Forest Experiment Station.

DUFFY, E. (1972) "Activation," in N. A. Greenfield and R. A. Sternbach (eds.) Handbook of Psychophysiology. New York: Holt, Rinehart & Winston.

EVANS, G. W. and K. W. WOOD (1980) "Assessment of environmental aesthetics in scenic highway corridors." Environment and Behavior 12: 255-273.

ILTIS, H., O. LOUCKS, and J. ANDREWS (1970) "Criteria for an optimum human environment." Bull. of Atomic Scientists 26: 2-6.

JANSSENS, J. (1976) "Hur man betraktar och identifierar byggnadesexteriorer—methodstudie." LTH, Sektionen for Arkitektur, Rapport 2. School of Architecture, Lund Institute of Technology, Sweden. (in Swedish)

JASPER, H. H. (1958) "The ten twenty electrode system of the International Federation." Electroencephalography and Clinical Neurophysiology 10: 371-375.

KAPLAN, S., R. KAPLAN, and J. S. WENDT (1972) "Rated preference and complexity for natural and urban visual material." Perception and Psychophysics 12: 354-356.

KULLER, R. (1977a) "The use of space—some physiological and philosophical aspects." Proceedings of the Third International Architectural Psychology Conference, Strasbourg, France.

——— (1977b) Unpublished research concerning a semantic procedure for measuring psychological states. Lund Institute of Technology, Lund, Sweden.

——— (1977c) "Social crowding and the complexity of the built environment—a theoretical and experimental framework." Presented at the Symposium on Human Consequences of Crowding, Antalya, Turkey.

——— (1972) A Semantic Model for Describing Perceived Environment. Stockholm: National Swedish Institute for Building Research.

LIBBY, W. L., Jr. (1971) "The relative effects of physical-perceptual and of psychological properties of pictorial stimuli upon the pupillary response." Presented at the 43rd Annual Meeting of the Midwestern Psychological Association, Detroit, Michigan.

——— B. C. LACY, and J. I. LACY (1973) "Pupillary and cardiac activity during visual attention." Psychophysiology 10: 270-294.

LINDSLEY, D. B. (1952) "Psychological phenomena and the electroencephalogram." Electroencephalography and Clinical Neurophysiology 4: 443-456.

McCLELLAND, L. and N. AUSLANDER (1976) "Determinants of perceived crowding and pleasantness in public settings," in P. Suedfeld and J. A. Russell (eds.) The Behavioral Basis of Design. Stroudsburg, PA: Dowden, Hutchinson, & Ross.

MEHRABIAN, A. and J. A. RUSSELL (1974) An Approach to Environmental Psychology. Cambridge, MA: MIT Press.

MULHOLLAND, T. B. (1969) "The concept of attention and the electroencephalographic alpha rhythm," in C. R. Evans and T. B. Mulholland (eds.) Attention in Neurophysiology. London: Butterworths.

OBRIST, P. A. (1963) "Cardiovascular differentiation of sensory stimuli." Psychosomatic Medicine 25: 450-459.

POPENOE, D. (1977) The Suburban Environment: Sweden and the United States. Chicago: Univ. of Chicago Press.

RUSSELL, J. A. and A. MEHRABIAN (1976) "Some behavioral effects of the physical environment," in S. Wapner, S. B. Cohen, and B. Kaplan (eds.) Experiencing the Environment. New York: Plenum.

RYBACK, R. S. and L. YAW (1976) "The magic of water." Man-Environment Systems 6: 81-83.

SHAFER, E. L. and T. A. RICHARDS (1974) "A comparison of viewer reactions to outdoor scenes and photographs of those scenes." USDA Forest Service Research Paper NE-302. Upper Darby, PA: Northeastern Forest Experiment Station.

SHAGASS, C. (1972) "Electrical activity of the brain," in N. S. Greenfield and R. A. Sternbach (eds.) Handbook of Psychophysiology. New York: Holt, Rinehart, & Winston.

SORTE, G. (1978) Personal communication concerning unpublished crowding research.

——— (1975) "Methods for presenting planned environment." Man-Environment Systems 5: 148-154.

STAINBROOK, E. (1973) "Man's psychic need for nature." National Parks and Conservation Magazine 47: 22-23.

——— (1968) "Human needs and the natural environment." Man and Nature in the City. Symposium sponsored by the Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior, Washington, DC.

ULRICH, R. S. (1979a) "Visual landscapes and psychological well-being." Landscape Research 4: 17-23. Manchester, England.

——— (1979b) "Psychophysiological approaches to visibility." Proceedings of the Workshop in Visibility Values, Fort Collins, CO. USDA Forest Service Report WO-18.

——— (1977) "Visual landscape preference: a model and application." Man-Environment Systems 7: 279-293.

——— (1974) Scenery and the Shopping Trip: The Roadside Environment as a Factor in Route Choice. Michigan Geographical Publications. Ann Arbor: Department of Geography, University of Michigan.

WILSON, G. (1966) "Arousal properties of red versus green." Perceptual and Motor Skills 23: 947-949.

WOHLWILL, J. F. (1976) "Environmental aesthetics: the environment as a source of affect," in I. Altman and J. F. Wohlwill (eds.) Human Behavior and Environment, Vol. 1. New York: Plenum.

——— (1973) "Factors in the differential response to the natural and manmade environments." Presented at the annual meeting of the American Psychological Association, Montreal.

ZUBE, E., D. G. PITT, and T. W. ANDERSON (1975) "Perception and prediction of scenic resource values in the Northeast," in E. Zube, R. Brush, and J. Fabos (eds.) Landscape Assessment: Values, Perceptions, and Resources. Stroudsburg, PA: Dowden, Hutchinson, & Ross.

——— (1974) "Environmental simulation, landscape values, and resources." Man-Environment Systems 4: 245-246.

ZUCKERMAN, M. (1977) "The development of a situation-specific trait-state test for the prediction and measurement of affective responses." J. of Consulting and Clinical Psychology 45: 513-523.