Physical Discomfort May Be Reduced in the Presence of Interior Plants

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SUMMARY. A well-known research report showed that being in a hospital room with a view of trees rather than a view of a building was linked to the use of fewer pain-reducing medications by patients recovering from surgery. The experiment reported here was designed to further examine the role of plants in pain perception. We found that more subjects were willing to keep a hand submerged in ice water for 5 min if they were in a room with plants present than if they were in a room without plants. This was found to be true even when the room without plants had other colorful objects that might help the subject focus on something other than the discomfort. Results from a room assessment survey confirmed that the room with colorful, nonplant objects was as interesting and colorful as the room with plants present, but the presence of plants was perceived as making the air in the room fresher.

Throughout history, people have benefited from interactions with plants. People customarily give flowers to the ill, and people report feeling happier in the presence of plants. Many hospitals include gardens and therapeutic programs using plants as part of their treatment plans. Studies have shown that people also benefit when exposed to plants in passive situations, such as simply viewing live plants or pictures of plants (Ulrich and Parsons, 1992).

Research is beginning to show that responses to plants can be linked directly to improved health. One study demonstrated that prison inmates who viewed nature had a lower rate of reporting to sick call compared with inmates who viewed the interior of the prison (Moore, 1981–82).

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In another study, hospital patients who viewed plants from their windows recovered more quickly from surgery than patients who viewed a building (Ulrich, 1984). More recently, research with cancer and Alzheimer patients has shown walking in a garden to be restorative (Cimprich, 1993; Mooney and Nicell, 1992).

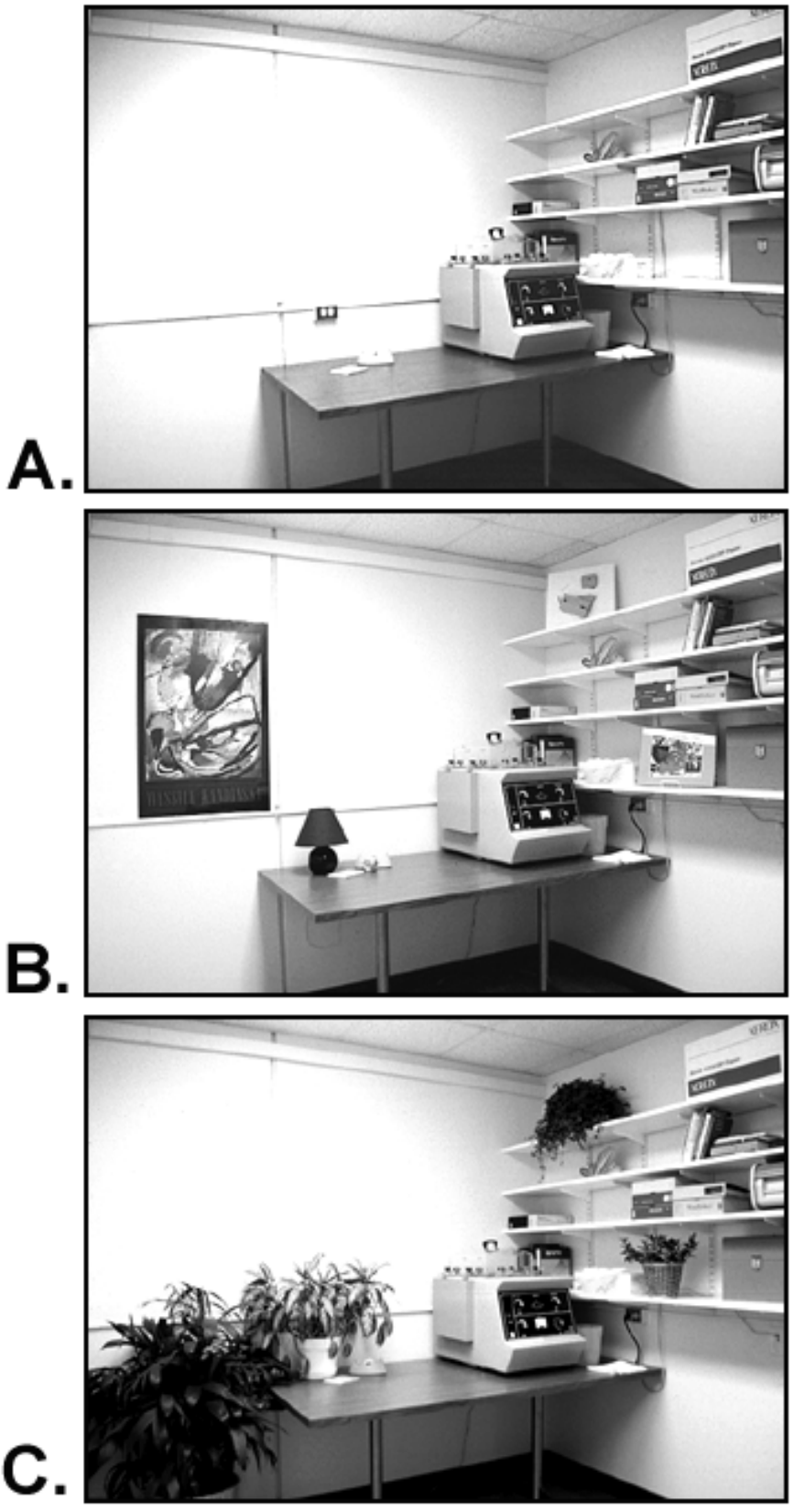

Fig. 1. Subjects were tested in three different interior room treatments: (A) control, (B) nonplant objects, and (C) plants.

Other research has shown that more complete recovery from stress can also occur in people working in rooms decorated with interior plants (Lohr et al., 1996). One of these studies demonstrated a specific link between plants and pain response in people (Ulrich, 1984). It reported that patients with a view of trees from their hospital windows used fewer potent pain-relieving drugs than did patients with a view of a brick wall. More research is needed to confirm this link to pain perception and to clarify the magnitude and breadth of this response.

This study was designed to examine further the ability of the presence of plants to relieve people's perceptions of pain or to increase people's tolerance of pain. The specific objective of this research was to determine if healthy adults who passively view interior plants under controlled conditions will tolerate experimentally induced physical discomfort (acute pain) longer than individuals in settings without plants. Acute pain was selected for this study, because it can be readily controlled in a laboratory setting, and it does not cause excessive discomfort for the subjects. The cold pressor method, one of the most widely used experimental pain-induction methods, was used; it involves placing the subject's hand in ice water for a brief period (Wolff, 1986). If being around plants can help people feel less pain or tolerate pain longer in an experimental setting, then these results may be applied to clinical settings, such as health care facilities, as well.

Materials and methods

EXPERIMENTAL SETTING. The experimental room was 3.5 m (11.5 ft) long, 6 m (20 ft) wide, and 2.4 m (8 ft) high. The walls were an off-white color. The room had no windows and was illuminated with overhead fluorescent lights. The conditions in the room averaged 23 °C (73 °F), 34% relative humidity, and 703 lx (70 fc) where the subject was seated during the experimental treatments.

TREATMENTS. Subjects were tested in three different interior room treatments: control, nonplant objects, and plants. The same room was used for the three treatments: plants or nonplant objects were added or removed as needed to achieve each treatment. For the control, the room was designed to repre-

Table 1. Interior plants and corresponding decorative, nonplant objects added to the experimental room during trials when additional stimuli were present.

Common name	Species	Container size (cm)	Container size (inches)	Nonplant object
Lipstick plant	*Aeschynanthus pulcher* (Blume) G. Don	10	4	Abstract art print
Chinese evergreen	*Aglaonema* Schott	15	6	Table lamp and paperweight
Bamboo palm	*Chamaedorea seifrizii* Burret	20	8	Abstract art poster
Heart-leaf philodendron	*Philodendron scandens* K. Koch & Sello var. *oxycardium* (Schott) Bunting	10	4	Weather station
Creeping Charlie	*Pilea nummulariifolia* (Sw.) Weddell	15	6	Architectural model

sent a typical office space (Fig. 1A). It contained conventional office furniture and supplies and the experimental equipment needed for this study. For the nonplant objects treatment, decorative and colorful items, including abstract art posters and a small table lamp, were added to the control room (Fig. 1B). For the plants treatment, interior plants were added to the control room (Fig. 1C). Items of similar size and impact were placed in similar locations in the nonplant objects and plants treatments (Table 1). The nonplant objects treatment was designed to be as visually interesting and colorful as the plants treatment, so that the effects of plants as simply a mental diversion from a dull room could be assessed. Each subject was randomly assigned to one treatment and was tested individually.

SUBJECTS. Adults from the local and university communities were solicited for this study. Each subject was paid $10 for participating in the experiment. A total of 198 subjects completed the experiment (67 in the control treatment, 62 in the nonplant objects treatment, and 69 in the plants treatment). Thirty-six percent of the subjects were male and 64% were female; 84% were 24 years old or younger; and 89% of the subjects were university students, while 11% were university employees or members of surrounding communities. When asked if they liked plants, 90% said "yes" and the remainder had either no opinion or said "no;" 59% owned plants. There were no significant differences among the treatment groups for these characteristics.

VARIABLES MEASURED. A demographic questionnaire was developed to obtain information from the subjects about factors such as their gender, age, and self-described ability to tolerate pain.

A room assessment survey was designed to evaluate the subject's initial impressions of the experimental space. The survey was developed and pretested after reviewing a similar environmental assessment by other researchers (Rohles and Milliken, 1981). Respondents were asked to judge their perceptions of the room against 17 polar opposite pairs of terms or phrases, using a Semantic Differential Scale (Anderson, 1987). The order of the terms or phrases in each pair was randomized. Each pair was scored from 1 to 5, with a rating of 1 most associated with the more negative characteristic in the pair and 5 most associated with the other paired characteristic.

Physiological responses were monitored by recording skin temperature and blood pressure. The subject's skin temperature was monitored using a digital thermometer (model 61220-670; VWR Scientific Products Corp., Seattle, Wash.) equipped with a skin temperature probe (YSI 409B; Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio). The probe was taped to the upper surface of the dominant hand. The subject's blood pressure was measured using an automatic oscillometric digital blood pressure monitor (model HEM-713C; Omron Healthcare, Inc., Vernon Hills, Ill.). The cuff of the monitor was placed on the subject's nondominant arm, so that readings could be taken while the dominant hand was being used to complete the surveys and skin temperature also could be monitored. Subjects were asked to place the cuffed arm in a stationary and relaxed position during the measurements.

Subjects' emotional states were measured by a modified version of the self-report Zuckerman Inventory of Personal Reactions (ZIPERS) (Zuckerman, 1977). Modifications included clarifying some of the wording and shortening the survey by one statement. Respondents indicated, on a scale from 1 to 5, the degree to which each statement, such as "I feel sad," described the way they felt at that moment.

The level of discomfort (pain tolerance) was measured by recording whether subjects held their hands in ice water for a full 5 min. Procedures for measuring this variable are described below.

PROCEDURES. Upon entering the experimental room, subjects were given time to desensitize from the outside environment and become accustomed to the room's decor. During this time, subjects received general instructions about the experiment. The skin temperature monitor and blood pressure cuff were placed on the subject. The demographic questionnaire, room assessment survey, and the ZIPERS were also administered. When 10 min of the desensitizing period had elapsed, blood pressure and skin temperature were recorded.

Following the desensitizing period, subjects immersed their nondominant hands for 2 min in a warm water bath [37 °C (98.6 °F)]. The warm water bath was maintained at normal body temperature to ensure that all subjects' hands were at a similar temperature prior to placement in the ice water bath and to sensitize their hands for the ice water. Subjects were then instructed to immerse their hands up to their wrists in an ice water bath (Wolff, 1986) and to keep their hands in the ice water until "you feel uncomfortable." They were reminded that they could remove their hands from the ice water at any time. We limited the maximum length of the ice water immersion to 5 min for the comfort of the subject and to prevent the hand from becoming numb. Subjects were told that the water bath would be monitored to prevent any harm to their hands, but were not told of the 5-min time limit.

Skin temperatures of the nonimmersed hands were measured while the subjects' hands were immersed in ice water. After removing their hands from the ice water bath, the subjects completed a posttest ZIPERS, and their

skin temperatures and blood pressures were again measured.

STATISTICAL ANALYSES. Data for subjects tested in the presence of plants were compared to those for subjects tested in the control and nonplant objects rooms.

Noncontinuous data (room assessment, ZIPERS, and pain tolerance) were analyzed in a two-step procedure. The first step looked for differences among the treatments. If significant differences were detected, then the second step was implemented to make two specific comparisons among the treatments: plants compared to the control and plants compared to nonplant objects. When the noncontinuous data had more than two response categories possible (room assessment and ZIPERS), we used the Kruskal-Wallis test in the NPAR1WAY procedure in SAS to obtain a chi-square statistic for the first step (SAS Institute Inc., 1988). The multiple comparisons procedure of Conover (1980) was used to compare differences among the three treatments for the second step. Pain tolerance data had only two categories and were analyzed first via two-way chi-square contingency tables from the FREQ procedure in SAS (SAS Institute Inc., 1988). These data were subsequently analyzed using two-way chi-square contingency tables for reduced treatment data sets for Step 2.

Continuous data (physiological measures) were analyzed using the GLM procedure in SAS (SAS Institute Inc., 1988), with contrast statements to make the same two specific comparisons among the treatments mentioned above: plants compared to the control and plants compared to nonplant objects.

Different alpha levels were set for different parts of this experiment, depending on the variable, to ensure that important relationships would not be overlooked. For most of the results, an alpha level of 10% was set. For the emotional state data (ZIPERS), an alpha level of 15% was set, because people's emotional states can be highly influenced by conditions outside of the experiment. For the pain tolerance variable, the alpha level was set at 5%, because it is important to be cautious in interpreting this important potential impact of plants on people.

For the room assessment data, the characteristics "fresh air" and "calming" were significant at the 10% level in Step 1. At the 5% level in Step 1, the following room assessment characteristics were significant: "interesting," "cheerful," "colorful," "pleasant," "attractive," "safe," "comfortable," "inviting," "ornate," and "tasteful." These room assessment characteristics were analyzed further in Step 2.

For the ZIPERS data, the following statements were significant at the 15% level in Step 1: "carefree or playful," "friendly or affectionate" (both before ice water), and "happy or pleased" (after ice water). "Fearful" (before ice water) and "my heart is beating fast" (after ice water) were significant at the 10% level in Step 1. These ZIPERS statements were analyzed further in Step 2.

Pain tolerance data were significant at the 5% level in the first step of the analysis. These data were subsequently analyzed in Step 2.

Responses on the demographic survey were examined using the Kruskal-Wallis test in the NPAR1WAY procedure in SAS (SAS Institute Inc., 1988) to look for differences by treatment assignment. To examine whether a demographic variable helped explain the subjects' responses on the pain tolerance variable, we used the CATMOD procedure in SAS to look for a significant interaction between the demographic variable and treatment.

Results and discussion

DEMOGRAPHICS. There were no significant relationships between any of the demographic survey variables and treatment, except for physical health. About 71% of the subjects in the room with plants reported their overall physical health as above average to excellent, while only 52% of those in the control room and 56% of those in the nonplant objects room described their physical health as such. Statistics examining the treatment by demographic response for this variable and others that might have explained the results also were examined, and no significant or meaningful relationships were found. For example, people's self-described ability to tolerate pain did not influence how they responded to the treatments. Similarly, whether they owned or liked plants did not influence their response to the treatments. These analyses confirmed that there were no meaningful differences among subjects in the treatment groups and that the demographic variables were not useful in interpreting the results. For this reason, only the results for all subjects within a treatment will be reported, and the statistics for responses will not be categorized based on demographic responses.

ROOM ASSESSMENT. The room with plants present was rated significantly differently from the control treatment on 12 of the 17 characteristics (Table 2). When plants were present, the room was more associated with positive characteristics, such as "cheerful," "calming," and "attractive," on most of the descriptive scales than the control room. These results are consistent with the findings of other researchers who have shown a positive attitude towards rooms with plants (Larsen et al., 1998; Laviana et al., 1983; Shoemaker et al., 1992).

When the room with plants was compared to the nonplant objects room, the plants treatment still was rated more positively, but the difference between the two treatments was not as great (Table 2). In this comparison, the plants room was rated as more associated with positive attributes on 6 of the 17 descriptive scales. A comparison of the specific features indicates that the nonplant objects treatment was comparable to the plants treatment on visual characteristics, including "interesting," "colorful," and "ornate." This indicated that the nonplant objects treatment was an effective comparison room to the plants treatment, since both rooms would provide a comparable level of mental interest compared to the dull control room. The plants treatment was significantly different from the nonplant objects treatment on other variables that indicate other positive contributions of plants, including "fresh air" and "calming."

PHYSIOLOGICAL MEASURES. There were no significant differences in the subjects' blood pressures or skin temperatures (data not shown) among treatments at any time during the experiment. People in all treatments had similar blood pressure and skin temperature readings before the cold pressor was administered, and there was little change in these measures during the course of the experiment. Skin temperature decreased slightly in all treatments while the unmeasured hand was held in ice water. Prior to submerging their hands in ice water, the average blood pressure for all subjects was 117 / 75 and the average skin temperature was 84 °F (29 °C).

EMOTIONAL STATE. Before the cold pressor was administered, there were significant differences for the ZIPERS responses for people tested in the presence of plants compared to those in the

Table 2. Subjects' assessments[z] of the experimental room with no decorative objects present (control) or with nonplant decorative objects compared to subjects' assessments with plants present.

Room characteristic	Control	Nonplant objects	Plants
boring . . . . . interesting	2.49*	3.13NS	2.94
gloomy . . . . . cheerful	2.54*	2.98y	3.23
stale air . . . . . fresh air	2.97*	2.90*	3.26
crowded . . . . . uncrowded	3.88NS	3.69NS	3.55
drab or dull . . . . . colorful	1.72*	2.82NS	2.81
hectic . . . . . calming	3.27*	3.42y	3.59
unpleasant . . . . . pleasant	3.07*	3.23*	3.54
noisy . . . . . quiet	2.82NS	2.90NS	3.10
confined . . . . . spacious	2.22NS	2.42NS	2.51
ugly . . . . . attractive	2.30*	2.71NS	2.83
frightening . . . . . safe	3.69*	3.92NS	4.04
uncomfortable . . . . .comfortable	3.18*	3.56NS	3.58
drafty . . . . . still	3.79NS	3.63NS	3.58
messy . . . . . neat	3.81NS	3.56NS	3.81
uninviting . . . . . inviting	2.37*	2.87*	3.19
plain . . . . . ornate	1.54*	2.18NS	2.16
tacky . . . . . tasteful	2.85*	3.02*	3.42

[z]Means are based on a scale of 1–5, with 1 most associated with the first term in the pair and 5 most associated with the second term in the pair.
NS,y,*Score is nonsignificant (NS) or significantly different from score with plants at $P \leq 0.10$ (y) or 0.05 (*), respectively.

control and nonplant objects rooms (Table 3). People in the room with plants generally reported higher levels of positive emotions, such as feeling carefree or friendly, than those in the control or nonplant objects rooms. These results are similar to those found for the room assessment in this study and in other studies (Laviana et al., 1983). At the start of an experiment, subjects are probably feeling apprehensive about what will actually occur during the experiment; perhaps they feel this more strongly when the experiment is conducted in a room without plants than in a room with plants. This positive emotional response to the presence of plants was not found in a study by Lohr et al. (1996) and the response was weak in the study by Shoemaker et al. (1992); reasons for variations in this response in different studies may require further investigation.

Before placing their hands in ice water, people in all treatments generally reported low levels of negative emotions, such as feeling sad or feeling like hurting someone (Table 3). One negative emotion, feeling "fearful," was stronger in the control room than in the room with plants. There were no significant differences between the negative feelings reported in the plants room and the nonplant objects room.

After the cold pressor was administered, there were no differences on most ZIPERS items between those tested in the presence of plants compared to the control or nonplant objects rooms (Table 3). One exception was for the item "I feel happy or pleased." People continued to feel happier in the presence of plants compared to the other two treatments. In general, however, most of the room treatment effects on

Table 3. Subjects' self-reported emotional states[z], as measured on the Zuckerman Inventory of Personal Reactions (Zuckerman, 1977), before and after immersing their hands in ice water in an experimental room with no decorative objects (control) or with nonplant decorative objects compared to states when plants are present.

	Before ice water			After ice water		
Emotional states	Control	Nonplant objects	Plants	Control	Nonplant objects	Plants
Carefree or playful	2.46*	2.52y	2.81	2.61NS	2.54NS	2.72
Friendly or affectionate	3.06*	3.08y	3.38	3.01NS	3.02NS	3.23
Happy or pleased	3.13NS	3.23NS	3.43	3.01*	3.07y	3.35
Attentive or able to concentrate	3.78NS	3.66NS	3.72	3.48NS	3.41NS	3.58
Like getting through with this situation	2.87NS	2.72NS	2.86	2.81NS	2.51NS	2.59
My heart is beating fast	1.82NS	1.69NS	1.59	1.93NS	1.56y	1.77
I am breathing fast	1.36NS	1.34NS	1.23	1.46NS	1.33NS	1.30
Angry or defiant	1.12NS	1.08NS	1.03	1.03NS	1.07NS	1.04
Fearful	1.37y	1.20NS	1.17	1.04NS	1.05NS	1.07
Sad	1.15NS	1.15NS	1.06	1.13NS	1.15NS	1.06
Like hurting or telling off someone	1.12NS	1.08NS	1.03	1.12NS	1.15NS	1.06
Like getting out of this situation or avoiding it	1.16NS	1.13NS	1.10	1.21NS	1.23NS	1.16

[z]Means are based on a scale of 1–5, with 1 being "not at all" and 5 being "very much."
NS,y,*Score is nonsignificant (NS) or significantly different from score with plants at $P \leq 0.10$ (y) or 0.05 (*), respectively.

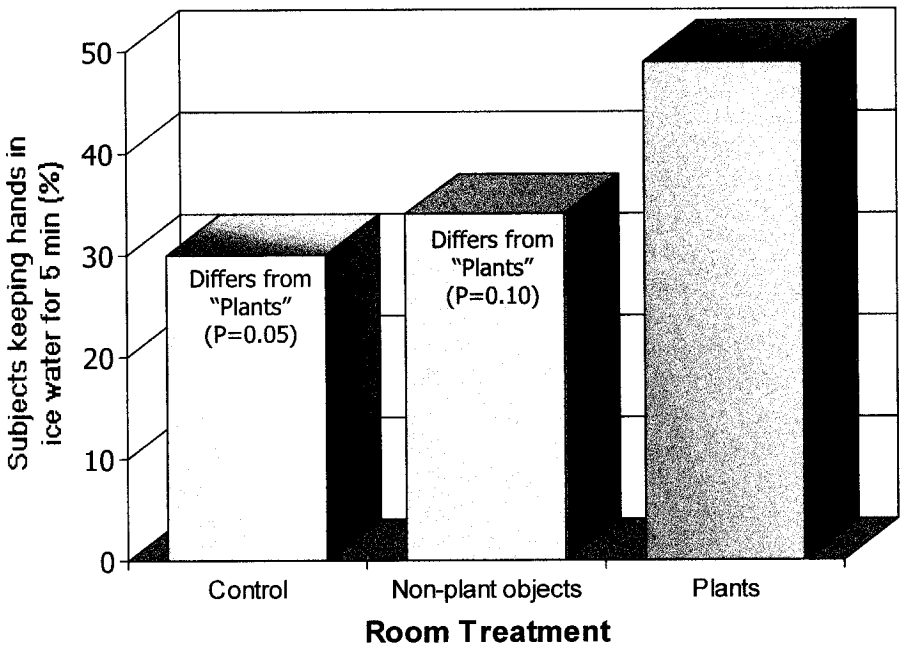

Fig. 2. Percent of subjects in the experimental room with no decorative objects present (control) or with nonplant decorative objects who kept their hands in ice water for 5 min compared to percent who kept their hands submerged for 5 min with plants present. The proportion of subjects in the control or nonplant objects treatment who kept their hands in ice water for 5 min was compared to the proportion in the plants treatment using a chi-square analysis.

ZIPERS responses appear to diminish over time. This is consistent with the idea that subjects beginning an experiment in a room without plants are more apprehensive about what will happen than subjects in a room with plants; at the end of the experiment, such apprehension would be gone. Another possible explanation is that the discomfort experienced during the ice water bath may have had a moderating effect on the positive emotional responses produced when plants were present.

PAIN TOLERANCE. The proportion of subjects who kept their hands in ice water for 5 min (the maximum allowable time) was significantly larger in the room with plants than the proportion in the control room (Fig. 2). Subjects in the room with plants were able to tolerate the cold pressor longer than subjects in the control treatment, and, therefore, exhibited a higher level of pain tolerance. This is consistent with Ulrich's report (1984) of patients needing fewer doses of strong medication to recover from surgery when in hospital rooms with a view of trees than when in rooms with a view of a building wall. The proportion of subjects who kept their hands in ice water for 5 min was also significantly higher in the room with plants than the proportion in the nonplant objects room (Fig. 2). This demonstrates that the positive benefits of plants are not simply associated with their decorative value.

This research indicates that people's impressions of a room and their mental well-being can be significantly improved when plants are added. When people perceive a room as calming and cheerful, their outlook likely will be positive. This study also indicates that decorative objects are not as effective as plants in improving people's perceptions of a room. Further studies are needed to fully determine the potential usefulness of incorporating plants in a variety of interior environments to enhance human perceptions of well-being.

This research confirms previous studies documenting the stress-reducing benefits of passively viewing plants. More importantly, it expands earlier research which showed that people tolerate severe pain for a few days after major surgery better in the presence of plants (Ulrich, 1984) by demonstrating that people also tolerate short-term discomfort (icy hand for 5 minutes) better in the presence of plants. If people can tolerate various kinds of pain better when plants are present, then, for example, their need for analgesics may be reduced.

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