INTERIOR PLANTS MAY IMPROVE WORKER PRODUCTIVITY AND REDUCE STRESS IN A WINDOWLESS ENVIRONMENT [1)]

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Abstract

This study documents some of the benefits of adding plants to a windowless work place - a college computer lab. Participants' blood pressure and emotions were monitored while completing a simple, timed computer task in the presence or absence of plants. When plants were added to this interior space, the participants were more productive (12% quicker reaction time on the computer task) and less stressed (systolic blood pressure readings lowered by one to four units). Immediately after completing the task, participants in the room with plants present reported feeling more attentive (an increase of 0.5 on a self-reported scale from one to five) than people in the room with no plants.

Index words: blood pressure, foliage plants, house plants, human issues in horticulture.

Significance to the Nursery Industry

Understanding the benefits of interior plants can help interior plantscapers sell their services. This study provides further justification for the use of interior plants in a variety of indoor settings. Many people feel that adding plants to interior spaces improves worker productivity and satisfaction, yet there are few, if any, concrete studies examining these impacts. Studies showing an impact on blood pressure, for example, have used videotapes of plants in natural settings, not live containerized plants in interior settings. This study, using common interior plants in a computer lab, confirms that interior plants can contribute to reduced stress. This study also documents that worker productivity on tasks requiring concentration and quick reactions can improve when plants are added to a work space.

Introduction

Interior plants are common in many homes, work places, and commercial settings. Interior-scaping is widespread in the hospitality industry, where its presence has been shown to boost occupancy rates and generate profit (3). Intuitively, people sense that contact with plants and nature is restorative and calming to the human spirit. This widespread belief is evidenced by the extensive landscaping in residential communities, the use of plants in theme parks and other segments of the tourist industry, the growth of urban and community gardening, and interior plantscaping of office and retail spaces (10, 13). In the 1960s, the

open-plan "office landscape" characterized by the abundant use of large potted plants to separate work spaces,
was popular (14). Although the office environment has changed over time, interior plants continue to be used in work spaces. As jobs become more technologically complex, the frequency of stress-related disorders in work environments increases (12). The need for a thorough understanding of the relationship between plants and human well-being is increasingly important (10).

Interaction with plants, both passive and active, can change human attitudes, behaviours, and physiological responses (10). The stress-reducing benefits of passively viewing plants in natural settings are well documented (5, 9, 15, 16); however, many workers labour in windowless office spaces with few opportunities to view nature. Research indicates that workers in such windowless environments have lower job satisfaction and rate the physical conditions of their work as less "pleasant and stimulating" than people in windowed settings (4). Plants are widely used to personalize and decorate offices, and they are important in improving satisfaction with indoor space (7, 13).

Accounts of studies conducted in Germany in the 1960s assert that improved employee morale, decreased absenteeism, and increased worker efficiency result when plants are added to office spaces compared to traditional, unplanted offices (1, 2). In the 1980s, reviews of the merits of interior landscaping continued to suggest that plants boost employee productivity, even by as much as 10% to 15%, when incorporated in offices and other work areas (8, 11). These reports of increased worker productivity in interiorscaped offices and work areas have been common; yet, we have been unable to find any research studies to substantiate these claims.

The goal of these experiments was to examine the impacts of interior plants in windowless working environment on human well-being and productivity. Responses of subjects in the presence and absence of plants were compared.

Materials and Methods

Experimental setting. Experiments were conducted in a Washington State University instructional computer laboratory with 27 computer workstations. The room was 13.5 m (44 ft) long, 7.3 m (24 ft) wide, and 2,6 m (8,5 ft) high. It had no windows and was illuminated with overhead fluorescent lights. The walls had no ornamentation and there was a white markerboard across the front of the room. Most of the interior of the room was off-white; the desk tops were burnt orange. The conditions in the room averaged 27C (80F), 38% relative humidity, and 420 lux (38 fc) at the work surface during both experimental treatments.

Subjects. A majority of the 96 participants were volunteers from an undergraduate agricultural economics class. They ranged from 18 to 46 years old, and 78% were less than 25 years old. Half of the subjects were male and half were female. Eighty-four percent of the subjects were university students; the remainder were university employees or members of surrounding communities.

All of the subjects had used computers before, and most used computers at least once a month. Half of the subjects reported their keyboarding skills as average and 30% felt that they were faster than average. When asked if they liked plants, 81% said "yes" and the remainder had either no opinion or said "no". Sixty-six percent had plants at their homes or offices.

Correlations between responses to the demographic survey and treatment assignment were examined. There were no significant correlations between any of the demographic variables and treatment, except for that of having plants at home or work. Approximately 75% of the subjects in the treatment without plants had plants in their homes or work areas, while only 58% of those assigned to the treatment with plants had plants at home or work. Statistics examining the treatment by demographic response for this variable and others that might have explained the results were also examined, and no significant or meaningful relationships were found. For example, people's levels of computer expertise did not influence how they responded to the treatments. These analyses confirmed that there were no meaningful differences between 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.

A preliminary experiment, with slightly different procedures, formed the basis for this experimental design. The majority of the 160 subjects in the preliminary experiment were volunteers from an upper level psychology class at WSU, and their average age was 20.

Productivity. A computer program to test productivity and induce stress was specifically designed for these experiments by the senior author and created by a computer specialist in Informa-tion Systems at Washington State University. Tests of reaction time are used to obtain an objective measure of mental processing (17). Our program randomly displayed one of three shapes of different sizes, in various locations, at random time intervals, on the computer screen. The variables that were incorporated into this program have been associated with differences in reaction times (17).

Participants were asked to press a key that corresponded with the shape on the screen as quickly as possible after they recognized the shape; therefore, subjects had a choice of three responses. Measures of reaction time where respondents have more than one possible response are associated with complex mental functioning and are considered appropriate instruments to measure performance under stressed or fatigued conditions (17).

One hundred symbols were presented in the same randomized sequence to each subject, thus keeping the complexity of the task identical for all subjects. The time interval after pressing the correct key, which cleared the screen, until the next symbol appeared varied from zero to five seconds. For each symbol presented, the number of wrong keys pressed and the time delay before pressing the correct key (reaction time) were automatically recorded in a computer file. In the preliminary experiment, only 50 symbols were presented, and the time delay between symbols ranged from one to 15 seconds, making the task somewhat more boring than the task used in the final experiment.

The computer program concept and content were reviewed by a psychologist who considered it an appropriate instrument to measure reaction time.
The program was pretested on various computers to ensure accurate recording of readings. A group of computer users also pretested the program to determine ease of usage. Blood pressure readings recorded while using the program confirmed that the program was effective in inducing stress.

Stress measures. Emotional states, blood pressure, and pulse were measured for participants during the experiment. The Zuckerman Inventory of Personal Reactions (ZIPER) was used to monitor emotional states (18). Respondents indicated, on a scale from one to five, the degree to which each statement, such as "I feel sad," described the way they felt at that moment. An Omron Model HEM-713C automatic oscillometric digital blood pressure monitor (Omron Healthcare, Inc., Vernon Hills, IL) was used to measure blood pressure and pulse. Increases in blood pressure indicate increases in stress (16). The cuff of the monitor was placed on the subject's non-dominant arm, so that readings could be taken while the subject was using the dominant hand for the productivity task. Subjects were asked to place the cuffed arm in a stationary and relaxed position during the measurements.

Table 1. Interior plants added to the computer lab during trials when plants were present.

Species	Quantity	Height or length (cm)
Aglaonema sp.	2	50
Chamaedorea seifrizii	1	125
Dracaena marginata	1	225
Dracaena deremensis 'Janet Craig'	1	125
Epipremnum aureum	2	75
Homalomena siesmeyeriana	1	25
Hoya sp.	3	50
Philodendron scandens	2	100
Sansevieria trifasciata	1	75
Scindapsus pictus 'Argyraeus'	1	50
Syngonium podophyllum	2	25

Treatments and procedures. There were two treatments in this experiment: plants present and plants absent. For the treatment with plants present, common low-light tolerant species of interior plants were added around the periphery of the room (Table 1). Floor plants, table plants, and hanging plants were added, and they gave the appearance of a well-designed, but not lush, interiorscape. Plants were positioned so that clusters would be present in the peripheral view of each subject sitting at a computer terminal, but would not interfere with the subject's activities.

Up to eight subjects were tested at one time. The subjects entered the room and sat at designated terminals. Assistants then led them through a series of tasks.

Measures were taken in the following order: pre-task ZIPER questionnaire, pre-task blood pressure and pulse readings, computer productivity task with blood pressure and pulse measured approximately halfway through the task, post-task ZIPER questionnaire, post-task blood pressure and pulse readings, and the demographic survey. Each subject was tested either in the presence or the absence of plants, not under both conditions.

Statistical analyses. Data for subjects tested in the presence of plants were compared to that for subjects tested in the absence of plants. A univariate analysis of variance was performed on the productivity data, while a multivariate analysis of variance was performed on changes in blood pressure readings over time. Differences between treatments for responses on the pre-task and post-task ZIPER questionnaires were evaluated using the non-parametric Mann-Whitney 'U' test in the NPARIWAY analysis in SAS (Cary, NC). For ZIPER items with significant between treatment differences and with pre-task to post-task score changes of more than 0.3 units, the within treatment change was also evaluated using a t-test. An alpha level of up to 10% was chosen for this experiment for all parameters, to ensure that important relationships would not be overlooked (6).

Results and Discussion

Stress measures. On the pre-task ZIPER survey, there were no significant differences between people tested in the presence of plants compared to those tested in the absence of plants. People generally reported moderate levels of positive emotions, such as feeling carefree or elated. They reported low levels of negative emotions, including anger and fear. After completing the productivity task, there were still no differences on most items between those tested in the presence of plants compared to those tested without plants. There were differences on the item "I feel attentive or concentrating" (Fig. 1). After completing the task, people in the presence of plants reported feeling more attentive (an increase of 0.5 units on a scale from one to five) than those in the absence of plants. Comparisons within a treatment revealed that subjects tested in the presence of plants showed significant increases in their post-task attentiveness scores over their pre-task scores (also an increase of 0.5 units, $P < 0.01$), while there were no changes in attentiveness for those in the absence of plants. This is noteworthy, because attentiveness is an important attribute for employees in most jobs.

There were no significant differences in pulse readings (data not shown). Significant differences between treatments were noted for systolic blood pressure (the upper number in a typical blood pressure reading), based on the multivariate analysis comparing changes among readings.

People in both treatments had similar systolic blood pressure readings before beginning the computer productivity task (Fig. 2). Systolic blood pressure rose for subjects in both treatments while they were performing the productivity task. This suggested that the task was inducing stress. The rise in blood pressure was less for those subjects tested in the presence of plants than for those subjects tested without plants present (+1 and +4 units, respectively). Subjects in both treatments experienced a drop in systolic blood pressure after completing the final set of surveys, and the decrease was greater for those tested in the presence of plants than for those tested without plants present (-4 and -2 units, respectively). In the preliminary study, blood pressure was measured only before and after the task, not during the task. Similar trends in systolic blood pressure were noted, but the changes were not significant. In this study, as well as in the preliminary study, changes in diastolic blood pressure were not significant, but the trends were similar to those seen for systolic readings.

These results of a moderating influence of plants on blood pressure are consistent with research conducted by others. Ulrich and others (16) examined recovery rates in pre-stressed subjects viewing videotapes of natural or urban settings. He reported quicker and more complete recovery from stress, using measures including pulse transit time, a correlate of systolic blood pressure, in subjects who viewed nature scenes compared to those who viewed urban scenes. This study confirms that live interior plants in containers can induce the same response as videotapes of natural settings.

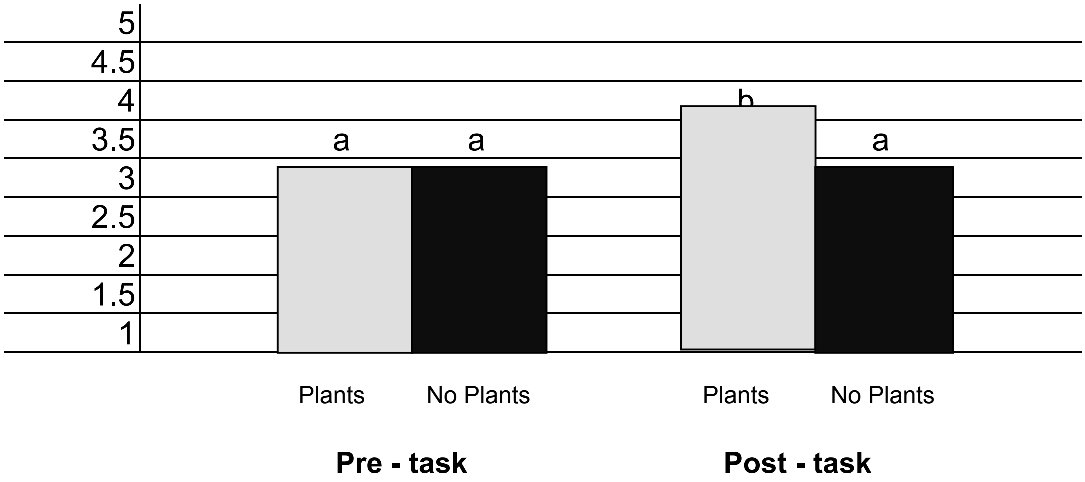
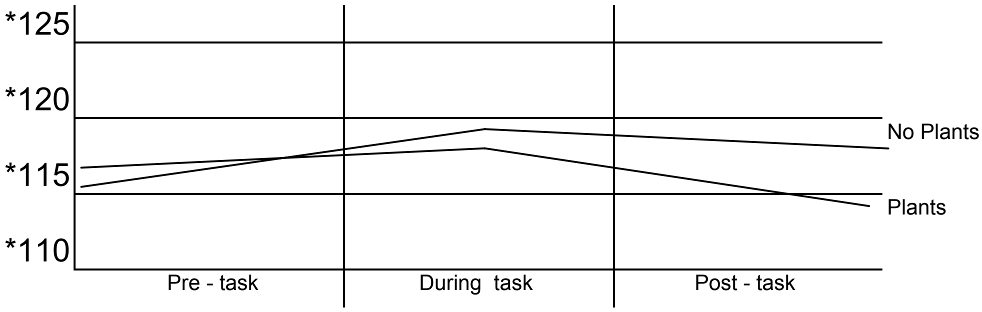


Fig. 1. **Responses to statement 'I feel attentive or concentrating', on a scale from 1 (not at all) to 5 (very much), before and after completing a computer-based productivity task in the presence or absence of plants. (P< 0,05).**



***Systolic blood pressure (mm Hg)**

Fig. 2. **Systolic blood pressure before, during and after completing a computer-based productivity task in the presence or absence of plants. (lines differentent, P= 0.076).**

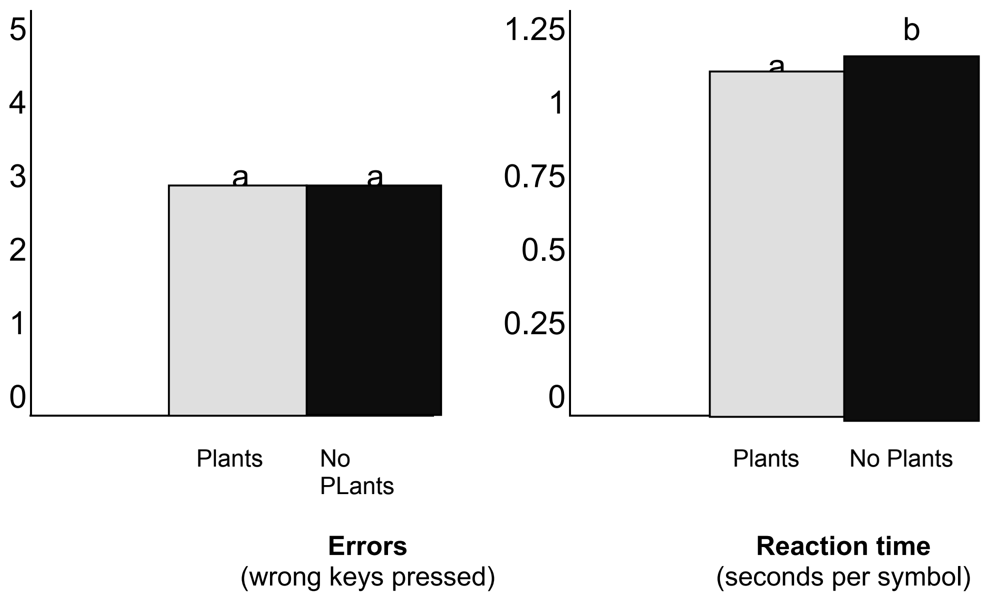


Fig. 3. **Errors and reaction time on a computer- based productivity task in the presence or absence of plants . (P < 0,06).**

Computer productivity test. The presence of plants had no effect on the number of errors made on the productivity test; subjects in both treatments made a similar number of errors. (Fig. 3). Reaction time in the presence of plants was 12% faster than in the absence of plants, indicating that plants may have contributed to increased productivity (Fig. 3).

In the preliminary study, using a version of the computer productivity task presenting fewer symbols with longer delays, reaction times in the presence and absence of plants were not significantly different; however, the means were consistent with the results of this study (6% faster with plants than without plants).

These findings of quicker reaction times with plants present than when absent on a task requiring some visual concentration are consistent with claims of increased worker productivity in the presence of plants (1, 2, 8, 11). We have found no scientific studies documenting increased productivity in the presence of plants. The results of this study are promising, indicating that there is truth in these claims. The task used to measure productivity in this study involved visual concentration, mental processing, and manual dexterity. The factors contributing to the productivity of actual employees are complex and multifaceted. The full impact of plants on worker productivity cannot be estimated from this study, which examined only limited and short-term aspects of productivity, but these results clearly demonstrate that this area of research warrants more study.

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