

PLANTS AS ENHANCERS OF THE INDOOR ENVIRONMENT

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FORWARD

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ABSTRACT

Flowering and foliage plants were examined as a possible "non-thermal" factor influencing perception of the thermal environment. Four objective instruments were used to assess thermal response: (1) a category adjective rating scale measured thermal sensation, (2) a 7 adjective-pair semantic differential scale measured thermal comfort, (3) a 1 item questionnaire measured temperature preference, and (4) a 47 adjective-pair semantic differential scale was used for subsequent factor analysis. All tests were conducted in an environmental chamber modified with or without living plants. Within the environmental chamber, lighting, temperature, relative humidity, and clothing were controlled for 64 college students between the ages of 18 and 22.

No significant ($p \leq .05$) plant effects were found in college student's perception of thermal comfort, thermal sensation, or temperature preference in the controlled environment. Using a statistical scaling technique, the affective characteristics of the indoor environment and its features were evaluated. Subjects indicated that plants caused a significantly positive effect ($p < .02$) on perception of Occupied Space Quality (O.S.Q.). Further, males perceived the indoor environment as significantly ($p < .04$) more spacious than females.

Introduction:

Anecdotal evidence exists to suggest that plants have a positive influence on the human affective state (Horsbrough, 1972; Lewis, 1972; Menninger, 1972; R. Kaplan, 1978). The development of scaling techniques within the field of environmental psychology has lead to a procedure that permits the evaluation of the affective characteristics of an environment and the various features it contains (Rohles and Milliken, 1981). This procedure allows for quantitative substantiation of the positive effects of plants on both human feelings and environmental quality.

Research has also defined the factors that affect one's response to the thermal environment. Recent research (Rohles and Wells, 1977; Rohles, et al, 1980) has identified what has been called "non-thermal" factors which may also affect individual response to the thermal environment. In this study plants were examined as both a possible "non-thermal" factor affecting one's perception of the thermal environment and as an influence on the perception of environmental quality and affectivity.

It should be noted that both foliage and flowering plants were used in the study, representing two types of plants commonly used in the indoor environment.

Literature Review:

Conklin (1972) described a concept of office arrangement, initiated in West Germany known as "office landscaping" in which "each building floor is made up of office furniture, a few screens and many live plants and trees--all judiciously placed with the complete absence of partitions." Research on employee attitudes in planted versus traditional (unplanted) offices

determined that "a great majority of the employees in the planted offices stated that they felt more content, but in many instances could not explain why." Conklin further explained, "the response to scientific studies in the American offices seem to parallel those of Europe - morale was improved and absenteeism was reduced."

Mehrabian (1976) has viewed potted plants and flowers as contributing to the pleasure dimension, complexity, and novelty of a room. Rachel Kaplan (1978) has noted the importance of having nature "nearby"; she contends that the primary relationship is one of "appreciation" rather than "use." Stephen Kaplan (1978) in examining possible relationships between human needs or motives and the patterns of stimulation provided by the environment noted plants as having a "special claim" on human attention. This area of fascination has been reflected in gardens, (Lewis, 1977; R. Kaplan, 1978) parks, wilderness, and houseplants (Iltis and Andrews, 1970).

Charles Lewis (1977) stated that "the whole of horticulture exists not for the benefit of plants (because plants are interested in being grown) but rather to satisfy the people who are interested in plants." Rachel Kaplan (1978) in studying the satisfaction of a gardening experience, proposed that fascination was a major enticing factor of the experience. Kaplan also noted that flowers are grown primarily for their fascination as opposed to their practical value. Lewis (1977) exemplified this point noting that "Human curiosity and human intellect are pivots on which horticulture moves."

Talbott, et al (1976) investigated the effects of flowering plants upon the behavior of hospitalized psychiatric patients. It was found that the introduction of flowering plants in the dining room setting was followed by a significant increase in vocalization, time spent in the dining room, and amount of food consumed. Talbott, et al (1976) offered three implied explana-

tions for the effect of plants on humans: (1) as reflected in S. Kaplan's work (1978); the human perceptual apparatus is specifically primed for plants as direct positive stimulus objects; (2) plants are aesthetically pleasing and perceptually stimulating aspect of the environment, as Mehrabian (1976) suggested; and (3) plants engender nurturance from humans establishing a relationship involving responsibility for another living thing (O'Connor, 1958; Watson and Burlingame, 1960; Brooks and Oppenheim, 1973; Flournoy, 1975).

In a comfort study, Rohles and Wells (1977) reported that 72°F (22.2°C) in one environmental chamber was perceived to be cooler than 72°F (22.2°C) in a second chamber. After determining that the thermal characteristics of both chambers were identical, modifications to the chamber that was perceived cooler were made yielding a more "natural-like" indoor environment. These embellishments included acoustical tile, carpeting, wood paneling, indirect lighting, and over-stuffed chairs. Another group of subjects was exposed to the same temperature conditions as before the modifications. Using the Comfort Model, Rohles and Nevins (1971) estimated that the addition of the embellishments to the chamber was equivalent to raising the temperature 2.5°F (1.4°C) indicating that components of the indoor environment modify perception of that environment.

Flynn and Spencer (1977) examined "subjective responses to colors of 'white' light that are produced by commonly available electric light sources in interior spaces." The results demonstrated that various lighting configurations can create different feelings. As noted by Rohles, *et al* (1980) it "is conceivable that they could affect feelings usually attributed solely to the thermal environment."

Rohles and Milliken (1981) outlined a procedure for measuring the affective characteristics of an environment and the various features it contains.

Rohles, et al (1981) used this procedure in a study to determine the effects of lighting, color and room decor on thermal comfort. In this study 432 college students (aged 18-22) were examined in various controlled environmental conditions using the scaling procedure outlined. From this procedure five factors were generated, one of which was environmental quality.

This study examined effects of foliage and flowering plants on subject's thermal response and their perception of environmental quality and affectivity. This study appeared only logical in view of, (a) anecdotal evidence (Horsbrough, 1972; Lewis, 1972; Menninger, 1972; R. Kaplan, 1978) suggesting positive plant influences on human affectivity, (b) previous investigations of plant/man interactions (Conklin, 1972; Brooks and Oppenheim, 1973; Talbott et al, 1976; R. Kaplan, 1978) and (c) previous comfort research (Rohles and Nevins, 1971; Rohles and Wells, 1977).

Design:

Two environmental treatments were selected for study: (1) 68 FET* (20 CET*) - 68°F / 50% rh (20°C / 50% rh) with plants, (2) 78 FET* (25.6 CET*) - 78°F / 50% rh (25.6°C / 50% rh) with plants. Lighting in the chamber was 78 footcandles, measured at table height. The plant modifications to the chamber were: 2 Boston ferns (Nephrolepis exaltata "Bostoniensis") in 25 cm pots (hung in opposite corners) and 2 flowering pink ivy geraniums (Pelargonium peltatum) in 25 cm pots (hung in opposite corners) and 1 flowering pink geranium (Pelargonium hortorum) in a 10 cm pot placed in the center of the table. The control environments were the same as the experimental, but contained no plants.

Both environmental treatments (and controls) were replicated 4 times with 4 subjects (2 male and 2 female) within the environmental chamber; the

total number of subjects in the experiment was 64.

Method and Procedure:

Facilities and Equipment. The study was conducted in an environmental chamber at the Institute for Environmental Research, Kansas State University. The chamber interior was 2.74 x 2.13 m with a ceiling height of 2.74 m. The chamber was modified with wall paneling, pictures, a table, 4 chairs, and carpeting. Each subject was provided with a clothing ensemble consisting of a cotton-polyester shirt, trousers, sweat socks, and slippers, when worn over underwear (bra and panties, shorts or briefs), its insulation value was 0.6 clo (Rohles, et al, 1973). One clo. is "the amount of insulation necessary to maintain comfort and mean skin temperature of 92°F (33.3°C) in a room at 70°F (21.2°C) with air movement not over 10 ft./min. (3.05 m/min.), humidity not over 50% with a metabolism of 50 calories per square meter per hour" (resting condition) (Newburg, 1968, p. 445).

Four objective instruments were used: (1) a category adjective rating scale measured thermal sensation, (2) a 7 adjective-pair semantic differential scale measured thermal comfort, (3) a 1 item questionnaire measured temperature preference and (4) a 47 adjective-pair semantic differential scale, used for subsequent factor analysis. Instruments are presented in Appendix 1.

Subjects. 32 male and 32 female college students were recruited through newspaper advertisement. After signing the Explanation of the Experiment Procedure Form (Appendix 2) concerning the purpose of the test, they reported to The Institute for Environmental Research and the experimenter read the Orientation Statement (Appendix 2) concerning the purpose of the test, the procedure to be followed and the rules of conduct during the experiment.

Following this the subjects changed into the provided clothing, went into the environmental chamber and the test began. After 0.5, 1.0, 1.5, and 2.0 hours had elapsed, the subjects completed the Thermal Sensation Ballot, the Thermal Comfort Ballot, and the Temperature Preference Questionnaire. After 1.0 hour and again after 2.0 hours had elapsed, the subjects filled out the 47 Adjective-pair Semantic Differential Scale. After each vote was taken the tests were collected.

After 2 hours the subjects were allowed to leave the chamber, change into their own clothes, paid, and dismissed.

Data were analyzed using General Linear Model, Chi-square, and Factor Analysis Programs of the Statistical Analysis System (SAS) computer program (SAS Institute Inc., 1979).

Results:

The results are divided into four major sections: (1) the Thermal Sensation Ballot, (2) the 7 Adjective-pair Semantic Differential Scale, (designated as Thermal Comfort), (3) the Thermal Preference Questionnaire, and (4) the 47 Adjective-pair Semantic Differential Scale.

Thermal Sensation (TS) Subjects felt significantly warmer at 25.6 CET* than 20.0 CET* at both 1 hour ($p < .0001$) and 2 hour ($p < .0001$) responses as indicated by analysis of variance of the 1 hour and 2 hour Thermal Sensation votes. This was expected since the two temperatures 20 CET* (68 FET*) and 25.6 CET* (78 FET*) were selected for the main purpose of yielding different thermal responses. The mean thermal sensation for 20.0 CET* (68 FET*) after 1 hour was 3.4 (cool:3.0); for 25.6 CET* (78 FET*) the mean vote was 5.7 (neutral: 5.0).

As shown in Table 1, males felt significantly warmer than females at

both 1 hour ($p < .02$) and 2 hour ($p < .005$) responses.

As shown in Table 2, the mean 1 hour thermal sensation of the males and females at 25.6 CET* (78 FET*) was similar. At 20 CET* (68 FET*) both males and females felt significantly cooler than 25.6 CET*. However, the females felt significantly ($p < .05$) cooler than the males at 20 CET* (68 FET*).

Thermal Comfort (TC). The Thermal Comfort scale, loadings, and Percent Comfort formula were derived by Rohles and Milliken (1981). In analyzing these votes, values ranging from 1 for the least desirable adjective (i.e., uncomfortable) to 9 for the most desirable adjective (i.e., comfortable) were assigned to each of the 7 adjective-pairs on the semantic differential scale. The loadings were as follows: comfortable-uncomfortable, 0.555; bad temperature-good temperature, 0.693; pleasant-unpleasant, 0.628; cool-warm, 0.579; unacceptable-acceptable, 0.521, uncomfortable temperature-comfortable temperature, 0.726; satisfied-dissatisfied, 0.568. Percent Comfort was determined by the following formula:

$$\text{Percent Comfort} = \left[\sum(\text{rating} \times \text{loading}) - 4.270 \right] 2.92.$$

The warmer (25.6 CET*) temperature produced significantly ($p < .001$) higher thermal comfort responses after hours 1 and 2. As shown in Table 3, the mean percent thermal comfort [TC (%)] for 1 and 2 hours are higher at 25.6 CET* than at 20.0 CET*.

As shown in Table 4, after 1 hour males were significantly ($p < .05$) more comfortable at 20.0 CET* than females. Females were significantly less comfortable at 20.0 CET* than 25.6 CET*. This is not true for the males in which no significance ($p > .05$) was reported between 20.0 CET* and 25.6 CET*. After 2 hours, both males and females were significantly ($p < .05$) more comfortable at 25.6 CET* than 20.0 CET*.

As shown in Table 5, although non-significant at $p \leq .05$ TC (%) scores at 1 and 2 hours were consistently higher in the plant conditions at both 25.6 and 20.0 CET*.

Preference Questionnaire. The preference questionnaire, "would you like the temperature to be warmer, cooler, or no change?" was administered after 0.5, 1.0, 1.5, and 2.0 hours of the test. The mean combined frequencies of response for the four test times at 20.0 CET* are listed in Table 6. Due to limiting sample size, the data was too sparse for a valid Chi-square test. As shown in Table 6, at 20.0 CET* the mean female vote for warmer (expected response) was 5.75 in the plant environment and 7.00 in the non-plant environment.

The 47 Adjective-pair Semantic Differential Scale . After the completion of testing values ranging from 1 for the least desirable of the pair of adjectives to 9 for the most desirable was assigned to each of the 47 adjective-pairs on the 2 hour test. This response was used as the dependent variable in 47 separate analyses of variance. As outlined by Rohles and Milliken (1981), residuals were computed from each analysis of variance model and the residuals were used to construct a correlation matrix. The data set consisting of this correlation matrix was then subjected to a factor analysis which yielded 5 factors accounting for 60.5% of the variance. A varimax rotation was carried out on these five factors. After the factors were rotated the factor loadings (the values corresponding to each of the variables in the adjective-pairs) greater than .5 (ignoring signs) were used in order to determine which dimension the factor was measuring. From this two clearly defined factors were retained. Next a factor score was generated for each of the retained factors for each subject. This was accomplished by taking the loadings for factor one and multiplying them by the response corresponding

to each adjective-pair. This was repeated for the second factor.

The two factors identified included 25 of the 47 adjective-pairs. These together with the loadings, are as follows: Factor 1 - Perceived Spaciousness: spacious-confined, .920; free space-restricted space, .792; huge-tiny, .864; open space-closed space, .640; large-small, .872; cramped-roomy, .647; adequate size-inadequate size, .502; uncrowded-crowded, .609.

Factor 2 - Occupied Space Quality (O.S.Q.): Appealing room-unappealing room, .727; happy-sad, .553; colorless room- colorful room, .578; repelling room-inviting room, .780; elated-depressed, .685; good mood-bad mood, .604; comfortable feeling-uncomfortable feeling, .514; satisfied with room - dissatisfied with room, .809; unstylish room-stylish room, .812; bored-interested, .700; good room- bad room, .810; cheerful-gloomy, .759; unpleasant room-pleasant room, .809; ugly room-beautiful room, .788; good feeling-bad feeling, .735; like room-dislike room, .897; dingy room-sparkling room, .568.

Factor 1 - Perceived Spaciousness (PS): Due to the difficulties often encountered in understanding raw scores, Perceived Spaciousness was expressed in the form of a percent--PS (%). The procedure for obtaining the equation for the conversion of the raw scores to a percent is outlined by Rohles and Millikin (1981). From this procedure the following equation was developed:

$$PS (\%) = [\Sigma(\text{rating} \times \text{loading}) - 5.846] 2.138.$$

When the responses of the PS (%) scale were subjected to an analysis of variance, the F-ratio for sex ($p < .04$) was the only source of significance. As shown in Figure 2, males perceived the room to be significantly more spacious than females, in terms of PS (%) the males perceived the environment to be 8.71% more spacious than females.

Factor 2 - Occupied Space Quality (O.S.Q.). As for factor 1, an equation for the conversion of raw scores to a percent was generated yielding the following formula:

$$\text{O.S.Q. (\%)} = \left[\sum(\text{rating} \times \text{loading}) - 12.126 \right] 1.013$$

When the responses of the O.S.Q. (%) scale were subjected to an analysis of variance, the F-ratio for plant/non-plant ($p < .02$) was the only source of significance. As shown in Figure 3, the mean O.S.Q. (%) scores for the plant environment were perceived as 10.68% higher in relation to environmental quality and affectivity.

Discussion:

This study indicates that plants in the indoor environment are not an influence on an 18-22 yr. old subject's thermal response. Therefore it is concluded that plants are not a "non-thermal" factor influencing the perception of thermal comfort. The lack of a significant effect in regard to thermal sensation is not surprising in light of earlier research by Rohles, et al (1980), where the following conclusion was suggested: "The thermal sensation is not affected by the starkness or 'plushness' of the environment." The effects of sex and temperature on thermal sensation lend further credence to earlier findings (Rohles et al, 1981).

Plant effects in relation to the perceived spaciousness scale were not significant. Plants neither contributed to a feeling of openness in the interior environment, nor did their presence or space consumption contribute to a "closed in" feeling.

The most significant finding of this study was the positive plant effect exhibited on Occupied Space Quality. While the data presented offer no

insight into the agencies by which plants exert this effect, they do establish that plants have a significantly positive effect on a subject's feelings toward and evaluation of the indoor environment. In this study the subjects feeling toward and evaluation of the plant environment was 10.68% higher than that of the non-plant environment.

The findings provide empirical evidence of the affective impact of plants in the indoor environment. Continued investigations using the procedures outlined in this study, and the O.S.Q. scale generated will enable determination of the plant densities and types in the indoor environment, help contribute to the understanding of the man/plant relationship, and further all fields involved in designing or assessing optimum interior living space.

Table 1
Comparison of mean Thermal Sensation
response by sex at 1 and 2 hours*

Sex	Mean Hour 1	Mean Hour 2
Male	4.8	4.3
Female	4.2	3.9
	<u> </u> p < .02	<u> </u> p < .005

* rating of 3 = cool; 4 = slightly cool; 5 = neutral

Table 2
 Duncan's Multiple Range Test
 for the 1 hour Thermal Sensation
 responses of male and female subjects
 at 25.6 CET* and 20.0 CET*

Temp. (CET*)	Sex	Mean	Groupings**
25.6	Male	5.7	A
25.6	Female	5.7	A
20.0	Male	3.9	B
20.0	Female	2.8	C

** Means with the same letter designation are not statistically different from one another at $p < .05$.

Table 3
 Comparison of mean Thermal Comfort responses
 for hours 1 and 2 at 25.6 CET* and 20.0 CET*

Temp. (CET*)	Mean Hour 1	Mean Hour 2
25.6	70.0	71.6
20.0	48.5	42.6
	$p < .001$	$p < .001$

Table 4
 Duncan's Multiple Range Test for the mean
 Thermal Comfort Responses of the male and female
 subjects at 25.6 and 20.0 CET* after 1 and 2 hours

Temp. (CET*)	Sex	Mean Hr. 1	Groupings**	Mean Hr. 2	Groupings**
20.0	Female	40.0	A	36.6	A
20.0	Male	57.1	B	48.7	A
25.6	Male	64.5	BC	66.4	B
25.6	Female	75.9	C	77.2	B

** Means in columns with the same letter designation are not statistically different from one another at $p < .05$

Table 5
 Duncan's Multiple Range Test for mean
 Thermal Comfort Responses to plants within or absent
 from 20.0 and 25.6 CET* conditions at hours 1 and 2

Condition	Temp (CET*)	Mean Hr. 1	Grouping**	Mean Hr. 2	Grouping**
Plant	20.0	49.6	A	47.0	A
Non-plant	20.0	47.5	A	38.3	A
Plant	25.6	71.2	B	72.9	B
Non-plant	25.6	68.7	B	70.3	B

** Means in columns with the same letter designations are not statistically different from one another at $p < .05$

Table 6
Comparison of combined mean Preference Questionnaire
frequencies of response at 20.0 CET*

<u>Condition</u>		<u>Preference</u>		
		<u>Cooler</u>	<u>No Change</u>	<u>Warmer</u>
Plant	Male	0.50	3.75	3.75
	Female	0.25	2.00	5.75
Non-plant	Male	0.25	3.75	4.00
	Female	0.00	1.00	7.00

Fig. 1 Interior view of experimental chamber



Fig. 2 Comparison of mean percent perceived spaciousness PS (%) for males and females.

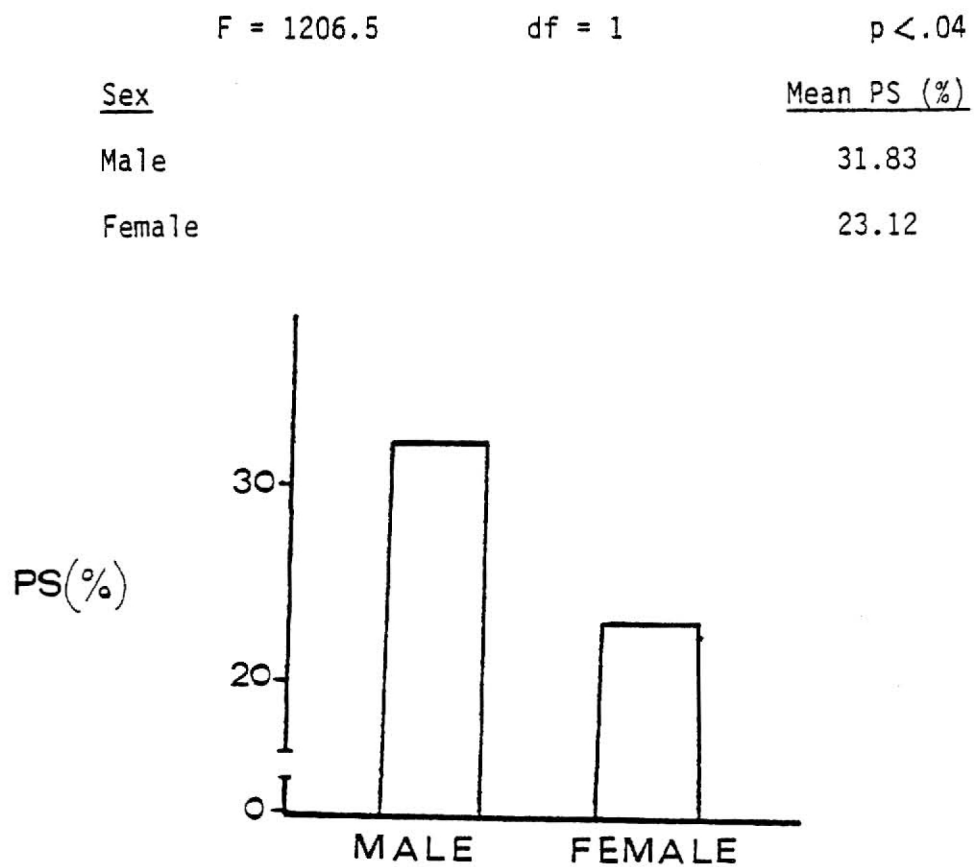
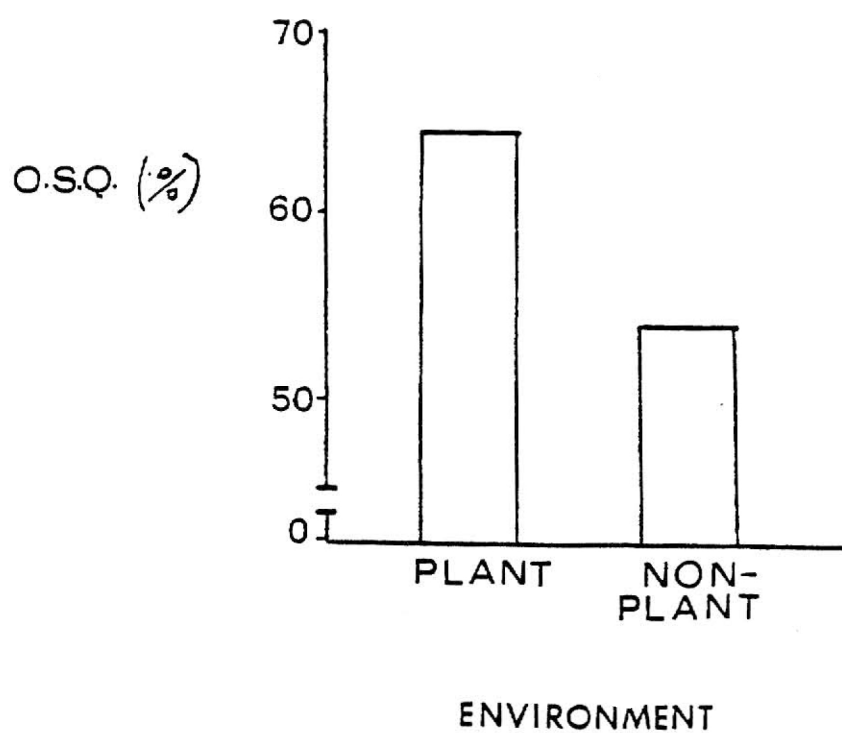


Fig. 3 Comparison of mean percent occupied space quality O.S.Q. (%) for the plant and non-plant conditions.

F = 1444.3		df = 1	p < .02
<u>Environment</u>	<u>Mean O.S.Q. (%)</u>		
Plant	64.89		
Non-plant	54.21		



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Appendix 1

Thermal Sensation Ballot
Thermal Comfort Ballot
Temperature Preference Questionnaire
47 Adjective-Pair Semantic Differential

Vote No. _____ Test No. _____

Number _____ Sex _____ Name _____

Circle the number beside the adjective
that describes how you feel.

9	Very Hot
8	Hot
7	Warm
6	Slightly Warm
5	Neutral
4	Slightly Cool
3	Cool
2	Cold
1	Very Cold

Thermal Sensation Ballot

Vote No. ____ Test No. ____	
Number ____ Sex ____ Name _____	
comfortable	_____ uncomfortable
bad temperature	_____ good temperature
pleasant	_____ unpleasant
cool	_____ warm
unacceptable	_____ acceptable
uncomfortable	_____ comfortable
temperature	_____ temperature
satisfied	_____ dissatisfied

Thermal Comfort Ballot

Vote No. _____ Test No. _____
Number _____ Sex _____ Name _____

Do you desire the room to be;

1. Warmer
2. Cooler
3. No Change

Temperature Preference Questionnaire

47 ADJECTIVE-PAIR SEMANTIC DIFFERENTIAL

Name: _____

No: _____

good temperature	_____	_____	_____	_____	_____	_____	_____	_____	_____	bad temperature
appealing room	_____	_____	_____	_____	_____	_____	_____	_____	_____	unappealing room
happy	_____	_____	_____	_____	_____	_____	_____	_____	_____	sad
stale odor	_____	_____	_____	_____	_____	_____	_____	_____	_____	fresh odor
colorless room	_____	_____	_____	_____	_____	_____	_____	_____	_____	colorful room
directed space	_____	_____	_____	_____	_____	_____	_____	_____	_____	non-directed space
inefficient space	_____	_____	_____	_____	_____	_____	_____	_____	_____	efficient space
repelling room	_____	_____	_____	_____	_____	_____	_____	_____	_____	inviting room
glaring surfaces	_____	_____	_____	_____	_____	_____	_____	_____	_____	non-glaring surfaces
spacious	_____	_____	_____	_____	_____	_____	_____	_____	_____	confined
elated	_____	_____	_____	_____	_____	_____	_____	_____	_____	depressed
well scaled	_____	_____	_____	_____	_____	_____	_____	_____	_____	poorly scaled
good mood	_____	_____	_____	_____	_____	_____	_____	_____	_____	bad mood
comfortable temperature	_____	_____	_____	_____	_____	_____	_____	_____	_____	uncomfortable temperature
lively room	_____	_____	_____	_____	_____	_____	_____	_____	_____	non-lively room
tense	_____	_____	_____	_____	_____	_____	_____	_____	_____	relaxed
pleasant odor	_____	_____	_____	_____	_____	_____	_____	_____	_____	unpleasant odor
cluttered	_____	_____	_____	_____	_____	_____	_____	_____	_____	uncluttered
poor acoustics	_____	_____	_____	_____	_____	_____	_____	_____	_____	good acoustics
free space	_____	_____	_____	_____	_____	_____	_____	_____	_____	restricted space
comfortable feeling	_____	_____	_____	_____	_____	_____	_____	_____	_____	uncomfortable feeling
poorly planned room	_____	_____	_____	_____	_____	_____	_____	_____	_____	well planned room
disorganized space	_____	_____	_____	_____	_____	_____	_____	_____	_____	organized space
poor ventilation	_____	_____	_____	_____	_____	_____	_____	_____	_____	good ventilation

GO TO THE NEXT PAGE AND CONTINUE

poor lighting	_____	good lighting
anxious	_____	calm
satisfied with room	_____	dissatisfied with room
unstylish room	_____	stylish room
huge	_____	tiny
bored	_____	interested
good room	_____	bad room
bright lighting	_____	dull lighting
clear room	_____	hazy room
cheerful	_____	gloomy
unpleasant room	_____	pleasant room
ugly room	_____	beautiful room
good feeling	_____	bad feeling
warm temperature	_____	cool temperature
like room	_____	dislike room
open space	_____	closed space
large	_____	small
dingy room	_____	sparkling room
tidy room	_____	untidy room
cramped	_____	roomy
adequate size	_____	inadequate size
uncrowded	_____	crowded
soft lighting	_____	harsh lighting

Appendix 2

Explanation of Experimental Procedure
Agreement and Release Form
Orientation Statement

EXPLANATION OF EXPERIMENTAL PROCEDURE

The purpose of the study in which you will be participating is to evaluate a person's perception of the thermal environment. If you elect to participate you will be scheduled to be at the Institute for Environmental Research at a specific 2½ hour period. When you report for the experiment you will be required to change into a set of clothes which we will provide for you. You will then be taken into a climate controlled room and be required to stay there for 2 hours. During the experiment you will be asked to complete ballots describing how you feel. After 2 hours are completed you will be free to change into your clothes and leave. After completion of the experiment you will be paid and dismissed.

If after reading the above you wish to volunteer as a test subject and are between the ages of 18 and 22, you must sign below and complete the attached Agreement and Release Form. When these are accomplished you will be scheduled for the tests.

I certify that I have read and understand the above and wish to volunteer to be a test subject.

Signature

Print name

Social Security number

Date

AGREEMENT AND RELEASE

1. I, _____ volunteer to participate in a project in connection with research studies to be conducted by Kansas State University.
2. I fully understand the purpose of the study as read to me in the orientation statement and realize that participation in the study may impose physical and / or mental stresses upon me and / or other subjects. I believe that I am physically and mentally fit to withstand any such stresses.
3. I understand that I will be observed during my participation and that my conduct and / or voice may be recorded by photographic and / or recording devices. I may have attached to my person sensors to measure temperature, pulse, blood pressure, etc. I also realize that public reports and articles may be made of the experiments and all of the observations and I consent to publication of such including the use of photographs.
4. I also understand that my performance as an individual will be treated as research data and will in no way be associated with me for other than identification purposes, thereby assuring anonymity of my performance and response.
5. I understand that I will be permitted to leave the evaluation exercise at any time that I find that I am unable to withstand the conditions and request to be relieved.
6. As compensation for my voluntary services as a participant in the aforesaid studies, Kansas State University will pay me. It is clearly understood and agreed, however, that in no event am I to be considered an employee of Kansas State University during such participation. Therefore, no Social Security, income tax, retirement or other benefits of employment will be deducted or accrued.
7. I hereby agree, under penalty of forfeiture of all compensation due me, not to give information regarding these studies to any public news media nor to publicize any articles or other accounts thereof without prior written approval by Kansas State University.

I have signed the herein Agreement and Release, This _____ day of _____, 19____.

Signature

ORIENTATION STATEMENT

"A National Institute of Mental Health Grant Project (# 5-T24-MH-16068-03) in conjunction with Kansas State University is conducting a series of tests related to how individuals respond to their thermal environment. At the outset, you should be fully aware of the fact that the conditions to which you will be exposed entail no physical risks. Second, you have volunteered to act as a subject and are participating on your own volition. Third, you may leave the experiment any time you wish; and fourth, your identity as a subject will not be disclosed and anonymity will be maintained.

The way the test will proceed is this; in about 20 minutes you will be taken in the test room behind me where you will perform various activities according to the instructions we give you. From time to time you may stand or stretch your legs; however you cannot sleep nor leave the room during the tests.

After being in the test room for $\frac{1}{2}$ hour, 1 hour, $1\frac{1}{2}$ hours and 2 hours you will be asked to complete a series of questionnaires (pass these out and demonstrate by reading the directions). After completing the ballots I shall collect them. When you complete the last questionnaire, you will return to this room, change into your own clothes, will be paid and will be dismissed.

Are there any questions?"

Appendix 3

Intercorrelations between the Adjective-Pairs in the
Occupied Space Quality Scale

Intercorrelations between the Adjective-Pairs in the
Perceived Spaciousness Scale

Intercorrelations between the adjective-pairs in the Occupied Space Quality (0.S.Q.)

	* 3	5	8	11	13	21	27	28	30	31	34	35	36	37	39	42
2 appealing-unappealing	.47	.44	.77	.54	.48	.31	.67	.45	.67	.59	.71	.67	.67	.63	.68	.50
3 happy-sad		.37	.54	.72	.83	.50	.48	.42	.50	.63	.68	.54	.46	.78	.52	.42
5 colorless-colorful			.53	.41	.44	.54	.51	.62	.55	.61	.58	.45	.48	.58	.59	.28
8 repelling-inviting				.61		.41	.67	.65	.53	.69	.53	.62	.76	.73	.74	.55
11 elated-depressed					.69	.40	.54	.51	.56	.66	.67	.58	.65	.74	.57	.50
13 good mood-bad mood						.48	.47	.40	.54	.65	.75	.63	.48	.78	.60	.53
21 comfortable feeling-uncomfortable feeling							.58	.47	.49	.53	.59	.49	.38	.61	.56	.16
27 satisfied with room-dissatisfied with room								.75	.62	.85	.65	.68	.61	.72	.89	.33
28 unstylish room-stylish room									.62	.71	.58	.60	.67	.61	.78	.43
30 bored-interested									.62	.68	.56	.52	.49	.60	.70	.26
31 good room-bad room											.69	.64	.66	.82	.88	.42
34 cheerful-gloomy												.76		.66	.71	.58
35 unpleasant room-pleasant room														.72	.78	.43
36 ugly-beautiful															.70	.26
37 good feeling- bad feeling															.88	.42
39 like room-dislike room															.66	.71
42 dingy-sparkling															.56	.59
															.78	.59
															.68	.62
															.41	.39
															.76	.39

* Numbers refer to position on 47 adjective-pair semantic differential

Intercorrelations between the adjective-pairs in the Perceived Spaciousness Scale.

	* 20	29	40	41	44	45	46
10 spacious-confined	.80	.80	.57	.77	.63	.50	.57
20 free space-restricted space		.62	.53	.58	.50	.55	.48
29 huge-tiny			.47	.88	.65	.44	.56
40 open space-closed space				.49	.41	.54	.60
41 large-small					.62	.33	.48
44 cramped-roomy						.38	.32
45 adequate size-inadequate size							.61
46 uncrowded-crowded							

* Numbers refer to position on the 47 adjective-pair semantic differential

PLANTS AS ENHANCERS OF THE INDOOR ENVIRONMENT

by

JOSEPH EDWARD LAVIANA

B.S., THE UNIVERSITY OF CONNECTICUT, 1979

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Flowering and foliage plants were examined as a possible "non-thermal" factor influencing perception of the thermal environment. Four objective instruments were used to assess thermal response: (1) a category adjective rating scale measured thermal sensation, (2) a 7 adjective-pair semantic differential scale measured thermal comfort, (3) a 1 item questionnaire measured temperature preference, and (4) a 47 adjective-pair semantic differential scale was used for subsequent factor analysis. All tests were conducted in an environmental chamber modified with or without living plants. Within the environmental chamber, lighting, temperature, relative humidity, and clothing were controlled for 64 college students the ages of 18 and 22.

No significant ($p \leq .05$) plant effects were found in college student's perception of thermal comfort, thermal sensation, or temperature preference in the controlled environment. Using a statistical scaling technique, the affective characteristics of the indoor environment and its features were evaluated. Subjects indicated that plants caused a significantly positive effect ($p < .02$) on perception of Occupied Space Quality (O.S.Q.). Further, males perceived the indoor environment as significantly ($p < .04$) more spacious than females.