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No. 3197

Indoor Environment Acceptability: The Development of a Rating Scale

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ABSTRACT

This paper presents an initial effort at developing a rating scale for indoor environment acceptability. Twelve features of the indoor environment representing the thermal, acoustical, lighting, and air quality constituents were rated according to their percentage contribution to the quality of the indoor space by 111 advanced engineering students and 89 clerical workers. The resulting mean percentages were: temperature, 15.8; brightness of the lighting, 11.0; tobacco smoke, 9.9; loudness of the sound, 8.7; noisy distractions, 8.6; lighting glare, 7.9; odor, 7.5; air movement, 7.2; humidity, 7.1; dust, 6.6; shadows, 5.1; and pitch, 4.6. The results showed that the thermal environment was judged to be significantly more important ($p < .01$) than the other three constituents, that the loudness and pitch of the sound were significantly ($p < .01$) more important to the student sample than to the clerical sample, and that temperature was perceived as more critical ($p < .05$) to the clerical sample than to the student sample. The rating scale uses the above percentages as loadings in an Environmental Acceptability Scale in which each item is rated on a six-point scale of acceptability ranging from 1 (very unacceptable) to 6 (very acceptable).

INTRODUCTION

Assessment of the indoor environment involves two approaches, the physical measurement of the environmental constituents themselves and the evaluation of those constituents by the occupants of the space in question. Whereas the measurement of the physical properties is objective and readily made with standardized equipment, assessment of the occupant's responses is subjective and lacks standardization. As a result, rating scales are traditionally employed for this aspect of the evaluation. This paper presents an initial effort at developing a rating scale for indoor environment acceptability that the occupant could use for assessing the occupied space. Acceptability of the space was the primary criterion.

PROCEDURE

Survey

In consultation with environmental professionals, four major attributes of the indoor environment were identified. These were acoustics, air quality, lighting, and thermal. Next, three sub-constituents or features of each of these were selected. These were: acoustics (loudness of the sound, pitch, and number of noisy distractions); air quality (odor, dust, and tobacco smoke); lighting (brightness, glare, and shadows); thermal (temperature, humidity, and air movement).

In order to determine the relative importance of these factors to the entire environment, the survey form shown in Figure 1 was developed. This was administered to 111 advanced engineering students and 89 clerical workers at a state university. The age and gender of the respondents were not recorded.

The responses were analyzed separately for each sample and also for both samples combined. Descriptive and inferential statistics were determined and will be discussed separately as they concern each of the survey items.

RESULTS

Major Constituents

With reference to Table 1, the thermal aspect of the environment was judged tc contribute more to the environment than the other three constituents. The mean of the thermal constituent was 30.1% and, as found in t-tests, this was significantly larger ($p < .01$) than the mean of any of the other three constituents. As shown in Table 2, tests of significance were also computed between the mean percentages of the student sample and the mean percentages of the clerical sample for the major constituents. In only one of these comparisons did a significant t-ratio result. This was in the thermal area, in which the mean

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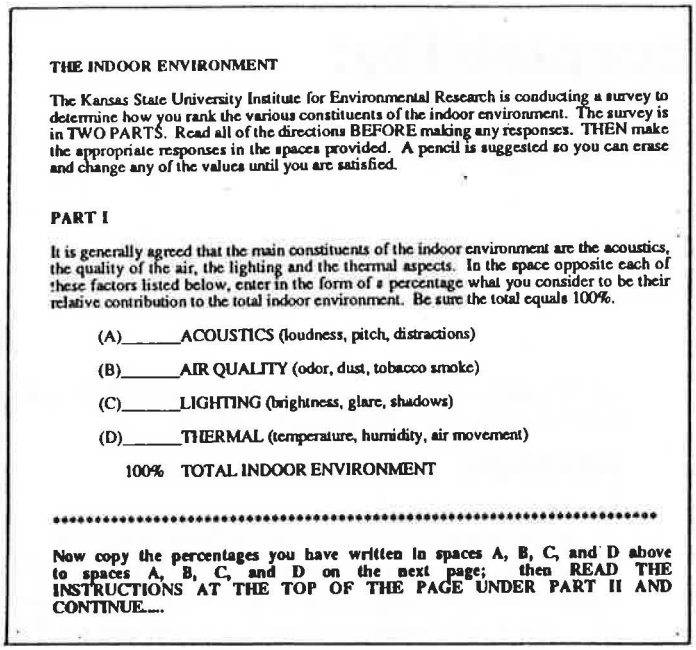

THE INDOOR ENVIRONMENT

The Kansas State University Institute for Environmental Research is conducting a survey to determine how you rank the various constituents of the indoor environment. The survey is in TWO PARTS. Read all of the directions BEFORE making any responses. THEN make the appropriate responses in the spaces provided. A pencil is suggested so you can erase and change any of the values until you are satisfied.

PART I

It is generally agreed that the main constituents of the indoor environment are the acoustics, the quality of the air, the lighting and the thermal aspects. In the space opposite each of these factors listed below, enter in the form of a percentage what you consider to be their relative contribution to the total indoor environment. Be sure the total equals 100%.

(A)_____ACOUSTICS (loudness, pitch, distractions)

(B)_____AIR QUALITY (odor, dust, tobacco smoke)

(C)_____LIGHTING (brightness, glare, shadows)

(D)_____THERMAL (temperature, humidity, air movement)

100% TOTAL INDOOR ENVIRONMENT

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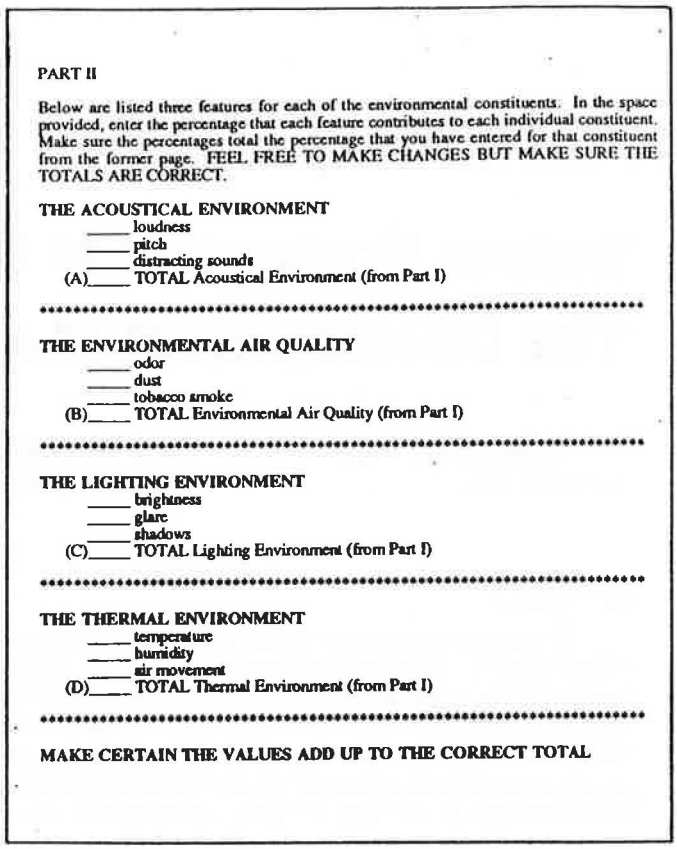
Now copy the percentages you have written in spaces A, B, C, and D above to spaces A, B, C, and D on the next page; then READ THE INSTRUCTIONS AT THE TOP OF THE PAGE UNDER PART II AND CONTINUE.....



PART II

Below are listed three features for each of the environmental constituents. In the space provided, enter the percentage that each feature contributes to each individual constituent. Make sure the percentages total the percentage that you have entered for that constituent from the former page. FEEL FREE TO MAKE CHANGES BUT MAKE SURE THE TOTALS ARE CORRECT.

THE ACOUSTICAL ENVIRONMENT

_____ loudness
_____ pitch
_____ distracting sounds
(A)_____ TOTAL Acoustical Environment (from Part I)

****

THE ENVIRONMENTAL AIR QUALITY

_____ odor
_____ dust
_____ tobacco smoke
(B)_____ TOTAL Environmental Air Quality (from Part I)

****

THE LIGHTING ENVIRONMENT

_____ brightness
_____ glare
_____ shadows
(C)_____ TOTAL Lighting Environment (from Part I)

****

THE THERMAL ENVIRONMENT

_____ temperature
_____ humidity
_____ air movement
(D)_____ TOTAL Thermal Environment (from Part I)

****

MAKE CERTAIN THE VALUES ADD UP TO THE CORRECT TOTAL

Figure 1a *Survey form (front side)*

Figure 1b *Survey form (reverse side)*

percentage of the clerical sample was significantly above ($p < .05$) the student mean.

Acoustical Features

Of the three features of the acoustical aspect of the environment, the loudness of the sound and the number of distractions were similar with mean percentage contributions of 8.7% and 8.6%, respectively. The pitch of the sound was judged to contribute only 4.6%. As shown in Table 2, loudness and pitch were judged to be significantly more important ($p < .01$) by the students than by the clerical workers.

Air Quality Features

The three features that contributed to the quality of the air were odor, dust, and tobacco smoke. Their percentage values were as follows: tobacco smoke, 9.9%; odor, 7.5%; and dust, 6.6%. There was little difference between the means of the student and clerical workers' samples.

Lighting Features

Of the three attributes of the lighting environment, brightness, with a mean percentage value of 11.0%, was judged to be the most important. Glare was second with a mean of 7.9% followed by shadows with a mean of 5.1%. Little difference was observed between the means of the students' sample and clerical workers' sample.

Thermal

As might be expected, temperature, with a mean of 15.8%, was judged to be the major contributor to the indoor environment. Humidity and air movement had values of 7.1% and 7.2%, respectively. A t-test between the temperature means for the student sample and the clerical workers' sample showed that the mean percentage of the clerical workers was significantly higher ($p < .05$) than that of the students.

Overall Percentages

The judged percentage contribution of the various indoor environment features is summarized in Table 3. When ranked by their percentage value, as shown in Table 4, the judged importance of temperature and brightness of the lighting account for more than one-fourth of the percentages.

The Scale

On the basis of this survey the scale presented in Figure 2 is suggested for measuring the acceptability of the indoor environment. On this scale the occupant is asked to indicate on an "acceptance continuum" range from 1 to 6 the acceptability of the 12 features of the environment. When these responses are made, they should be multiplied by the loadings presented in Table 5. Summing these products will yield a value ranging from 1.000 (very unacceptable) to 6.000 (very acceptable).

DISCUSSION

As the literature indicates, the thermal aspect of the environment has been the focus of much of the environmental research over the past 20 years. As a result, the human response to the three other features of acoustics, air quality, and lighting has been neglected. The purpose of this exercise was to develop an empirically derived

TABLE 1
Reliability of the Differences between the Mean Ratings of the Major Constituents

Constituents	Percent Mean	S.D.	t-ratio of constituent mean vs. Air Quality	Lighting	Thermal
Acoustics	21.9	9.8	2.14*	2.13*	8.05**
Air Quality	24.0	10.7	—	.00	5.76**
Lighting	24.0	8.4		—	6.60**
Thermal	30.1	11.0			—

*p < .05;
**p < .01

Table 2
Reliability of the Differences between the Means (%) of the Two Samples

Constituent	Student Sample (%) N	Mean	SD	Clerical Sample (%) N	Mean	SD	t-ratio
ACOUSTICS	111	22.8	9.5	89	20.7	10.2	1.46
loudness	103	9.6	4.9	86	7.6	5.2	2.63**
pitch	103	5.4	3.2	86	3.9	2.7	3.26**
distractions	103	8.3	4.8	86	9.0	6.2	0.92
AIR QUALITY	111	24.5	11.6	84	23.4	9.4	0.79
odor	108	7.8	4.3	87	6.9	3.7	1.68
dust	108	6.5	4.3	87	6.8	4.1	0.46
tobacco smoke	108	10.1	6.4	87	9.8	7.7	0.23
LIGHTING	111	23.8	8.0	89	23.7	8.9	0.07
brightness	107	11.1	6.1	85	10.8	6.7	0.35
glare	107	7.4	4.0	85	8.1	4.9	0.35
shadows	107	5.1	3.0	85	5.1	3.6	0.15
THERMAL	111	28.6	10.5	89	32.3	11.4	2.36*
temperature	108	14.7	8.0	86	17.4	8.3	2.28*
humidity	108	7.3	3.3	86	7.2	4.1	0.16
air movement	108	7.2	3.5	86	7.6	4.7	0.74

*p < .05
**p < .01

Table 3
Contribution (%) of the Major Constituents

Constituent		
ACOUSTICS		
loudness	8.7	
pitch	4.6	
distractions	8.6	
total		21.9
AIR QUALITY		
odor	7.5	
dust	6.6	
tobacco smoke	9.9	
total		24.0
LIGHTING		
brightness	11.0	
glare	7.9	
shadows	5.1	
total		24.0
THERMAL		
temperature	15.8	
humidity	7.1	
air movement	7.2	
total		30.1
TOTAL		100.0

Table 4
Ranked Importance (%) of the Major Constituents

Rank	Constituent	%
1	Temperature	15.8
2	Brightness of lighting	11.0
3	Tobacco smoke	9.9
4	Loudness of sound	8.7
5	Noisy distractions	8.6
6	Lighting glare	7.9
7	Odor	7.5
8	Air movement	7.2
9	Humidity	7.1
10	Dust	6.6
11	Shadows	5.1
12	Pitch	4.6

Table 5
Loadings for Scale Items

Loading	Item
0.072	air movement
0.067	amount of dust
0.098	amount of tobacco smoke
0.110	brightness of lighting
0.079	glare
0.071	humidity
0.087	loudness of sounds
0.085	number of noisy distractions
0.075	odor
0.047	pitch of sounds
0.158	temperature
0.051	shadows in work place
1.000	

instrument that could be used to evaluate the indoor environment. To this end we believe that we have been successful. This is not to imply that all of the features of the indoor space have been incorporated in the scale. Obviously there are more than the four addressed in this instrument, but by evaluating these we have taken a major step toward expanding an area that was restricted primarily to the thermal features.

The approach we used in developing this scale represents a departure from our recent scaling procedures. In those (Rohles and Milliken 1981; Laviana and Rohles 1987) an extended list of adjectives is used to describe a single environmental attribute, i.e., thermal. A similar procedure could have been used in developing the present scale; however, the developmental process would have been lengthy, and the potential tedious and monotonous evaluation could possibly affect the validity of the final scale.

One criticism that might be directed toward the present scale is that a "very unacceptable" rating on one of the 12 items would not surface and indeed may be hidden by acceptable and very acceptable ratings on the remaining 11 items. This is true. However, it would be well for the user to examine the responses to the individual items and, in fact, this procedure could ferret out potential areas of environmental concern; moreover, the major constituents —acoustics, air quality, lighting, and thermal—could be similarly examined.

Acceptability was selected as the focal point of the scale because of the emphasis that ASHRAE places on it

ENVIRONMENTAL ACCEPTABILITY OF THE WORKPLACE

Listed below alphabetically are 12 items related to the environment of the area in which you work. In front of each item, enter a number from the following acceptability scale that best describes the acceptability of your work area at this time. THEN rate the overall quality of your work area in the space provided.

IMPORTANT: look the scale over before making any ratings

6 = very acceptable
5 = acceptable
4 = somewhat acceptable
3 = somewhat unacceptable
2 = unacceptable
1 = very unacceptable

_____ air movement

_____ amount of dust

_____ amount of tobacco smoke

_____ brightness of the lighting

_____ glare

_____ humidity

_____ loudness of the sounds

_____ number of noisy distractions

_____ odor

_____ pitch of the sounds

_____ shadows

_____ temperature

_____ OVERALL QUALITY

Figure 2 *Rating scale—final form*

in the ventilation and comfort standards. Thus, if after administering this scale 80% of the occupants rate the environment as 5.000 (acceptable) or better, the environment will be assumed to meet the requirements set up in the ASHRAE Standards.

It should also be pointed out that while acceptability is implied in other scales, it is the primary criterion in the present instrument. In other words, the environment or a feature thereof is either acceptable or not acceptable; no inferential judgment beyond this is required.

The dominance in terms of importance of temperature and brightness of the lighting was expected. That together with tobacco smoke they contribute more than one-third to the overall percentage should be pointed out to architects and designers. Another finding of the survey that should not be overlooked is the difference in the percentage

values assigned to temperatures by the two samples. The clerical sample was older and was comprised mostly of women although age and gender were not listed by the respondents. Nevertheless, it suggests that future surveys should pay particular attention to the make-up of the sample. For example, a group of institutionalized elderly might assign different values to the environmental constituents than a group of workers on an assembly line.

The findings of the survey are also interesting when compared to the Harris Survey of Office Environments for Steelcase in 1980. In that survey it was reported that the workers thought that heat, air-conditioning, and ventilation were important to productivity. Next listed was the need for quiet and privacy—a factor that was ranked fourth in the current survey. Smoking was judged to have an effect on worker comfort and productivity and top priority was given to lighting and a comfortable chair. In general then, the results of our survey agree favorably with those of the Harris report. But with this agreement we were able to assign the relative importance of the environmental constituents and place numbers in the form of a percentage to their overall contribution to the indoor environment. Nevertheless, the effectiveness of the scale must await its use in the field. Only then will its value be recognized.

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