Research Note

Building- and Work- Related Symptoms (BWRS) A Multivariate Exploratory Study of Office Environments

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ABSTRACT

We compared the work environment in different kinds of offices in Argentina and in Sweden. It was hypothesised that symptoms of discomfort would have multiple causes related to the physical conditions of the building and the psychosocial climate of the work force. It was further hypothesised that these responses would be influenced by the age. gender and cultural background of the office workers. Questionnaires were administered to the personnel during the morning in the middle of the working week. Measurements of lighting, temperature, humidity. and noise were carried out at the same occasion. The results showed that the Swedish offices were more illuminated, and that the Argentinean offices were noisier, comparatively speaking. Subjective reports of complaints were more prevalent in Argentina than in Sweden, and there were also more building-and-work-related symptoms in Argentina than in Sweden. However, the prevalence of BWRS was not only related to the physical environment, but also to the psychosocial climate. High values in social intensity and in familiarity seemed to reduce the symptoms.

KEYWORDS: cross-cultural comparison. lighting. noise, office environments, psychosocial climate

1. Introduction

Numerous investigations have shown that a considerable part of the working population suffers reduced health, comfort and productivity in office buildings[1-5]. Health problems related to buildings known as the Sick Building Syndrome (SBS), and particularly health problems at workplaces (BWRS) may have multiple causes[6][7].

A number of laboratory and field studies have rendered a list of recommended values for indoor climate and exposure levels[8]. Thermal conditions can influence the productivity of office workers[9]. Studies of acoustic conditions have shown effects on productivity. performance, and cognition[10][11]. Lighting conditions can have both psychological and physiological effects[12-14]. Perceived odour might trigger complaints about the indoor environment[15]. However, there is no substantial proof that different kinds of exposure may simply be added together[16].

Psychological stress-factors, such as workload and organisation may also contribute to the problems. and the psychosocial climate of the office environment can be of great importance[17-19]. Several studies have shown that single room occupancy generally gives more satisfied employees compared to landscape offices[20][21]. Even aesthetic and functional aspects of the office itself can be important[12][22].

Sensitivity to exposure and psychological stress vary between individuals with personality and lifestyle as mediating factors. For example, it has been shown that young, non-smoking and non-drinking individuals are more sensitive to flickering light[23]. Introvert persons are more easily disturbed than extravert persons when working in a landscape office[24].

Humans respond to environmental exposure through a holistic process, and if the total amount of exposure is beyond the capacity of the individual coping becomes difficult or impossible. However, in most studies the psychological and physiological effects have been assessed separately. In fact, the complex situation in modern office buildings has never been fully studied. The view of this paper is that an interdisciplinary approach will be required to understand the various building- and work-related symptoms (BWRS). This requires a multi-variate theoretical approach that includes measures of all the factors that may have a negative impact on the occupants.

The experimental design was based on Küller's model of Human-Environment Interaction (HEI)[25]. At the centre of the model is the basic emotional process linked to the biochemical and physiological functioning of the central nervous system. The process consists of four

steps: activation, orientation (attention), evaluation, and control, which are influenced both by the physical and social environment, and by the ongoing activities and characteristics of the individual. The theoretical model has been applied and tested in a large number of research projects[26].

2. Problem

It was hypothesised that symptoms of discomfort would have multiple causes related to the physical conditions of the building and the social climate of the work force. It was further hypothesised that these responses would be mediated by individual characteristics such as age, gender and cultural background. Considering the exploratory nature of the study, no directed assumptions were formulated, except in one case, where it was predicted that open-plan offices would give rise to more discomfort than cell offices.

3. Methods and procedure

The study was carried out by means of surveys at work places in Tucumán (northern Argentina, latitude 27° South) and in Lund (southern Sweden, latitude 56° North). Questionnaires were administered to the personnel in November (winter in Sweden and summer in Argentina) during the morning in the middle of the working week. Measurements of lighting, temperature, humidity, and noise were carried out at the same occasion.

3.1 Physical measurements

Lighting was measured as horizontal illuminance values (lx) at each work place by means of calibrated lux-meters. In Argentina ambient room temperature (°C) and ambient humidity (%) was measured by means of a Data Logger Mod. H 01-001-01 Code DTH 0B070, whereas noise (dBA) was measured by means of a calibrated digital Dbmeter with a range of 35 to 100 dB and 65 to 130 dB. In Sweden the ambient room temperature (°C) were measured by means of an ordinary thermometer type S 10071 and ambient humidity (%) was measured by means of Protimeter® Moisture Measurement System, whereas noise was measured by a calibrated analogue sound meter SM-7, Onsoku with a range of 30 dB to 100 dB.

3.2 Questionnaire

The questionnaire contained five-grade rating scales for assessments of a number of environmental factors[27]. These included disturbing noise, bad air, unpleasant smells, smell of mould, draught and cold, excessive heat, dry air, moist air, static electricity, tiring working positions, organic solvents (ether, petrol, oil, etc.). The questionnaire also included a section for detailed assessment of the indoor lighting by means of the following three scales: unwanted reflections from the general illumination; flicker from the general illumination; unwanted reflections from the visual display screen[23].

The psychosocial climate of the work environment was assessed with a standardized test developed by means of factor analysis[28]. The test consists of 24 seven-grade rating scales giving estimates of the following five qualities: Social intensity, social stability, familiarity, coherence, and friendliness of the social situation. Furthermore, the questionnaire included questions about type of office and background information about the participants in the study.

Finally, the questionnaire contained a detailed list of building-and work-related symptoms (BWRS). This list had been developed as part of the European Union Joule Project[29]. It consists of 41 symptoms which were to be rated on five-grade scales: tears in the eyes, heartburn, shivering, tired eyes, neck ache, headache, dry eyes, shoulder ache, migraine, blurred vision, back ache, dizziness, light sensitivity, muscle ache, feeling of sickness, eyestrain, prickly hand/arms, stomach ache, buzzing in the ears, prickly feet/legs, lack of concentration, sound sensitivity, dry skin, anxiety, prickly nose, blushing, irritation, itching nose, burning skin, stress, dry nose, itching skin, depression, running nose, eczema, tiredness, metal taste, shortness of breath, allergy, dry mouth, perspiration.

4. Subjects and premises

The localities were offices belonging to old (since 1910), and new (renovated in 1990) buildings of the National University of Tucumán (open plan offices) and Tetra Pak in Lund (cell-offices in the old building) (since around 1950) and open plan offices in the new building (renovated in 1990). In Tucumán, all offices were lit by fluorescent lamps with conventional ballast (day light and warm white 36 W and 40 W), without louver in the old building. Daylight contribution was scarce at most of the premises. In Lund the open plan office was mainly lit by fluorescent tubes, with louvers and both conventional and HF ballasts, while the cell-offices either were lit by fluorescent tubes with and without HF ballasts or incandescent lamps. The fluorescent tubes were mainly warm white 36 W or 40 W.

The Argentinean sample (N=67) was made up of 38 females and 29 males with a mean age of 42 years (SD=10.1). The Swedish sample (N=139) consisted of 27 females and 112 males with a mean age of 46 years (SD=9.9). The participants of the main study had obtained information beforehand about the general aim and procedure of the study. Participation was by informed consent, and adhered to the ethical standards set down by the Swedish Psychological Association.

5. Statistics

The data were treated by means of parametric statistical tests such as analysis of variance and hierarchical regression analysis. All calculations were carried out with SPSS 9.0.

6. Results

6.1. Physical properties of the environments

Concerning the physical measurements, illuminance values were higher in Lund than in Tucumán. The ambient temperature was generally within the comfort zone, thanks to heating during the winter in Sweden and cooling during the summer in Argentina. The relative humidity was according to norms in both countries. However, the indoor noise levels were higher in Argentina, mainly due to heavy traffic close to the office buildings (Table 1).

In order to get an overall impression of the quality of the indoor environment in the four buildings an index was created based on the following eleven scales: disturbing noise, bad air, unpleasant smells, smell of mould, draught and cold, excessive heat, dry air, moist air, static electricity, tiring working positions, organic solvents (ether, petrol, oil, etc.). This general index revealed the existence of a significant difference between the two countries with more complaints in the Argentinean offices (Figure 1).

In order to get an estimate of the lighting quality an index was created of the following three scales: unwanted reflections from the general illumination; flicker from the general illumination; unwanted reflections from the visual display screen. There were considerable differences between the four buildings (Figure 2). Many of the complaints about the general illumination could be ascribed to the lack of louvers and the use of conventional ballasts.

Table 1 Means, SD and range of physical measurements in the four buildings

Country	Sweden	Sweden	Argentina	Argentina
Building type	Old building	New building	Old building	New building
Office type	Cell-offices	Open plan	Open plan	Open plan
Illum. (lx) M	565	534	211	198
Illum. SD	303	243	75	118
Illum. Range	194-1750	40-1008	85-404	78-575
Temp. (°C) M	24	23	25	24
Temp. SD	.84	.70	1	.91
Temp. Range	22-25	21-24	22-26	23-26
Humidity (%) M	39	44	33	50
Humidity SD	11	3	3	5
Humid. Range	27-59	37-49	26-41	38-54
Noise (dBA) M	42	41	61	62
Noise SD	3	6	6	6
Noise Range	35-48	35-53	50-70	52-70

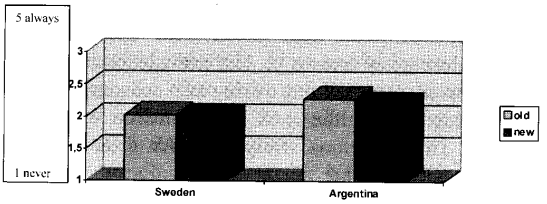

Figure 1 Over all complaints about the environment in the four buildings (Five-grade scales; Difference between countries: $F_{1,177}$=6.1, p=.014)

6.2 Social properties of the environment

The psychosocial climate of the work was assessed in terms of the following five qualities: social intensity, social stability, familiarity, coherence, and friendliness of the social situation (Figure 3). The familiarity was experienced as higher by those, who worked in the old Swedish building, where the workplaces consisted of cell-offices ($F_{3,177}$=3.56, p=.015). Both the coherence and

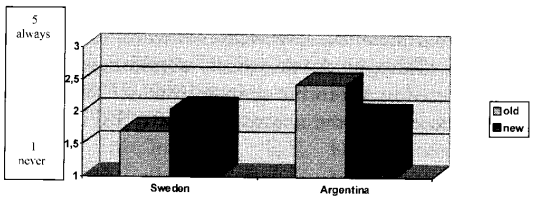

Figure 2 Reported complaints of the illumination in the four buildings (Five-grade scales; Difference between buildings: $F_{3,185}$=7.9, p<.001)

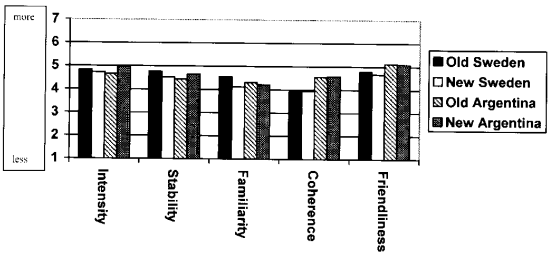

Figure 3 The psychosocial climate at the four offices

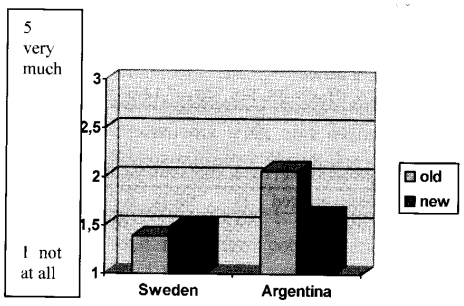

Figure 4 Number of reported symptoms in the four buildings (Five-grade scales; Differences between buildings: $F_{3,171}$=18.0, p<.001; Differences between countries: $F_{1,173}$=45,4, p<.001)

the friendliness of the social situation were experienced as higher in Argentina than in Sweden ($F_{1, 185}$=16.2, p<.001; $F_{1, 189}$=4.85, p=.029).

6.3 The building- and work-related symptoms (BWRS)

For the purpose of the present, exploratory study the 41 building-and work-related symptoms were compiled into one index. There were significant differences between the four buildings, with most symptoms reported in the old Argentinean office building (Figure 4).

6.4 Factors underlying the building- and work-related symptoms

In order to probe further into the relationships, three regression analyses were performed with the index of symptoms (BWRS) as the dependent variable. In the first regression analysis, background factors and subjective environmental assessments were entered as predictors (Table 2). As previously stated more BWRS were reported in Argentina than in Sweden. The elderly office workers reported slightly more BWRS, but there was no overall difference between males and females. Not surprisingly, there was as strong correlation between BWRS, on one hand, and the subjective complaints about the building, on the other hand. However, subjective lighting did not stand out as a problem. However, the psychosocial climate of the workplace also influenced the prevalence of BWRS. High values in social intensity and in familiarity seemed to reduce these symptoms.

In the second regression analysis, physical environmental factors were entered as predictors (Table 3). The strongest impact on BWRS emanated from noise, and somewhat more symptoms were reported in the open-plan offices than in the cell-offices.

Finally, in the third regression analysis, the most important factors from the former two regressions were entered as predictors, which basically supports the previous results. However, noise and office type are no longer significant, probably because this variation is accounted for by the building complaints. All in all the regression models predicted more than 40% of the variance in BWRS (Table 4).

Table 2 Regression with background factors and subjective assessments as predictors

Variables entered	B	SE B	β	P
Country*	.43	.08	.35	.000
Age	.007	.003	.14	.026
Gender**	-.07	.07	-.07	n.s.
Indoor experience	.31	.07	.35	.000
Lighting experience	.05	.05	.08	n.s.
Social intentsity	-.13	.04	-.23	.004
Interpersonal stability	-.05	.04	-.11	n.s.
Familiarity	-.10	.04	-.17	.014
Coherence	-.03	.04	-.06	n.s.
Friendliness	.08	.05	.16	n.s.
R^2=.48, R^2adj=.44, F(10,155)=13,23 p=.000				

*1=Sweden, 2=Argentina; **1=Males, 2=Females

Table 3 Regression with physical factors as predictors

Variables entered	B	SE B	B	p
Illuminance	.000	.000	.10	n.s.
Noise	.02	.005	.36	.001
Temperature	.003	.04	.006	n.s.
Humidity	-.01	.006	-.13	n.s
Type of office***	.20	.10	.17	.048
R^2=.20, R^2adj=.18, F(5,140)=7,14 p=.000				

***1=Cell-office; 2=Open plan office

Table 4 Regression with most important factors as predictors

Variables entered	B	SE B	B	p
Country*	.42	.15	.36	.006
Age	.007	.003	.15	.026
Indoor experience	.34	.06	.37	.000
Social intensity	-.09	.04	-.15	.022
Familiarity	-.11	.04	-.19	.007
Noise	.002	.007	.04	n.s.
Type of office***	.02	.08	.02	n.s.
R^2=.45, R^2adj=.42, F(7,134)=14,9 p=.000				

*1=Sweden, 2=Argentina; ***1=Cell-office; 2=Open plan office

7. Discussion

In this paper we have taken a multivariate approach in order to investigate building- and work-related symptoms (BWRS) in office buildings. In contrast to most of the earlier research, we did not restrict the study to the physical environment, but also included the social environment of the offices. The methods included both physical and subjective measurements, and the results of the former showed that the Swedish offices were more illuminated, and that the Argentinean offices were noisier, comparatively speaking. Subjective reports of complaints were more prevalent in Argentina than in Sweden, and this concerned both the overall environment in the office buildings and the indoor illumination. There were also more building-and work-related symptoms in Argentina than in Sweden.

Based on previous research[20][21] we had predicted that open-plan offices would give rise to more problems than cell offices, and there is some support for this hypothesis. However, the sample is restricted in this respect and does not allow any firm conclusion.

One aspect that we have not mentioned so far is the possible impact of season on the prevalence of BWRS. The study was carried out during two seasons, in Sweden during the winter, and in Argentina during the summer. In a previous study we have found that in countries situated far north of the equator there are significant variations in psychological mood over the year[12]. This may account for some of the differences between Argentina and Sweden that were found in the present study.

Perhaps the most interesting results of this study concern the psychosocial climate at the offices. Differences were found in most of the five factors, perhaps indicating the existence of cultural differences. Notably, the familiarity of the social situation was experienced as highest in the one workplace that consisted of cell-offices. Furthermore, the prevalence of building-and work-related symptoms was not only related to the physical environment, but also to the psychosocial climate. High values in social intensity and in familiarity seemed to reduce the symptoms. This is an exploratory study, and we will not enter into speculation about the rational behind these results, which definitely call for further research.

8. Conclusion

Environments for office work are presently going through a rapid change. Group-orientated work is getting more common, and the trend is away from personal offices towards landscape offices. New types of management put different requirements on building layout and on social organisation in order to fulfil performance requirements. In population studies this will make it increasingly difficult to define groups that have a common and distinctive set of exposure patterns. This will put severe demands on the experimental design of future studies and, we believe, necessitate a more holistic theoretical approach than those normally used in the study of healthy and sick buildings.

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