EFFECTIVE VENTILATION

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Paper 18

EFFECTIVE VENTILATION IN OFFICES - THE OCCUPANT'S PERSPECTIVE

I.D. GRIFFITHS, J.W. HUBER, A.P. BAILLIE

Department of Psychology
University of Surrey
Guildford, GU2 5XH
United Kingdom

SYNOPSIS

Air quality and draught avoidance are fairly important to office staff; consequently, the occupant's perspective should be taken into account when assessing the relative merits of different methods of ventilation in office buildings. Environmental comfort ratings and a variety of other judgements were collected in interviews with 169 staff in two air-conditioned and three naturally ventilated office buildings. Comparison of the two building types showed that air conditions were judged to be less satisfactory in the air-conditioned buildings, and that these buildings also had a higher rate of reported 'building sickness' symptoms. However, the differences, although statistically significant, were small in magnitude. Furthermore, while a quarter of all staff interviewed in the air-conditioned buildings made unfavourable comments about the air-conditioning, evidence is reported which suggests that it is the absence of openable windows which is the basis of people's negative attitudes, rather than beliefs about unsatisfactory air quality. One building had air-conditioning designed to provide localised control in the form of supply outlets which could be shut off when air was not required. This design, however, was associated with the lowest recorded satisfaction with air conditions, primarily because the conditioned air was experienced as a cold draught.

1. INTRODUCTION

1.1 Air-conditioning or natural ventilation?

Building design pursues a multiplicity of objectives; among them, energy efficiency and comfort are of major importance. Given the tendency in recent years for new office buildings to be air-conditioned, attempts to reduce fuel costs have been predominantly met by new technological means, such as more efficient plant and energy management systems. Modern offices also tend to be predominantly of open-plan design and for this type of layout air-conditioning seems to be the first choice for space-conditioning. This approach to design can be characterised by its artificiality in that it attempts to exclude the impact of ambient conditions (Hawkes[1]) and it assumes that occupant comfort is best met by a constant and uniform environment. Specific parameters such as temperature are set by building services personnel; the degree of local control available to staff is usually very restricted or non-existent. This fully engineered approach to space conditioning is justified by a belief that employees would only disturb the finely tuned system and that they do not care about the energy implications of their behaviour. However, the use of air-conditioning in offices may not be without negative

consequences for staff; it has been linked by some researchers to the 'building sickness syndrome' (e.g. Finnegan et al.[2]; Robertson et al.[3]); this is a syndrome of minor health complaints, such as headaches and dry throats, associated with building occupancy.

Moreover, it is clear from informal communication with office staff that air-conditioning is frequently viewed in a negative light, with a variety of ills being attributed to it. It would therefore be useful to assess whether these complaints are restricted to a disaffected minority who have failed to adapt to technological change in buildings, or whether air-conditioned buildings do in fact give rise to wide-spread dissatisfaction. Thus this paper addresses the following question: is natural ventilation the most effective approach from the occupants' point of view, or is air conditioning equally effective? An attempt will be made to try and provide some initial answers to this question by examining relevant data from a small number of buildings.

These data were collected in the course of a two and a half year study designed to evaluate the success, as judged by occupants, of buildings with passive solar features; interviews and questionnaires were used to provide a broad evaluation of environmental comfort, with special emphasis being given to thermal comfort. While data from a variety of building types have been assembled, only the data from office buildings will be utilised in this paper. This part of the database provides a good opportunity to assess the impact of air-conditioning on office staff because the office sample consists of both air-conditioned and naturally ventilated buildings; some of these are conventional in that they were not designed as passive solar buildings, but nonetheless provide a useful comparison because of their high degree of glazing. Of particular interest from a design point of view is the fact that one of the buildings in the sample (Building A in Table 1) has an air-conditioning system in which air is supplied to the office space through twist air outlets located in the floor; these can be shut down by the occupant when air is not required.

2. RESEARCH DESIGN

2.1 The office sample

The data on which the analysis is based are derived from staff in five office buildings, two with air-conditioning and three naturally ventilated. All the buildings are in southern England. Brief descriptions of the buildings, together with the number of staff interviewed in each are given in Table 1. All interviews were carried out in the autumn of 1987 and winter 1987/88. In each building staff were selected for inclusion in the survey by means of a quota designed to ensure proper coverage of the following physical and social variables: all orientations of the building, floor level, distance from the nearest window, different levels of

staff and a proportion of men and women corresponding to the actual proportion working in the building. Altogether data from 169 people are available for analysis.

Table 1: List of office buildings in sample

Building	
	Air-conditioned
A	3 storey U-shaped building with double-skinned 'solar wall' on south elevation. 100% glass curtain walls. Open-plan. 42 staff interviewed.
B	6 storey deep-plan building; mild steel structural frame clad with glass curtain walling on 3 elevations, triple-glazed. Open-plan. 35 staff interviewed.
	Naturally ventilated
C	6 storey building on courtyard plan, with central atrium which acts as solar collector & to induce ventilation across office areas. Mainly open-plan. 42 staff interviewed.
D	3 storey shallow-plan building with all-cellular office accommodation facing south and north; higher proportion of glazing on south elevation. Mechanical ventilation with heat recovery, but windows openable. 24 staff interviewed.
E	2 storey shallow-plan building with all-cellular office accommodation facing east and west. 26 staff interviewed.

2.2 The evaluation criteria

Data were collected by means of personal interview and self-completion questionnaire. Occupant comfort was assessed using a specially developed technique called the Environmental Comfort Assessment Procedure. Aspects of the procedure used to collect the data reported below are as follows:

1. Self-generated comments about the good and bad points of building. These were elicited at the start of the interview and thus were not influenced by the researcher's questions.

2. Judgements of specific features of the person's office/work environment; these comprise satisfaction ratings of 17 aspects of the environment, carefully selected on the basis of pilot research to represent those features of office environments which people naturally think about when judging indoor comfort; additionally, ratings of the ventilation level and its perceived effectiveness of control.

3. A measure of general satisfaction with the office as a whole. This consists of three items which are 'facet-free' in the sense of not referring to any specific aspect of the office (e.g. 'all things considered, I am very satisfied with my office') rated on a 7-point Likert agree-disagree scale. There are both theoretical and empirical reasons for supposing that a scale constructed from such items measures general affect associated with a building which is not entirely a function of what a person feels about its specific features.

4. Ratings of 3 ventilation related aspects of the building as a whole. Three items were used (e.g. this building is badly ventilated), rated on a 7-point Likert agree-disagree scale.

5. The incidence of seven minor symptoms associated with the building sickness syndrome. The reported symptoms were summed to provide an overall score for each individual.

The judgements thus have two distinct foci: most are concerned with the person's immediate work environment which is of course the most salient part of the building from a subjective point of view; some judgements, however, relate to the building as a whole.

3. RESULTS.

3.1 Relative importance of air conditions

Before comparing the five buildings on the basis of the available criteria, it is worth asking how important to people are those aspects of an office which are most likely to be affected by the ventilation system present. This question can be answered by examining the importance ratings made by the whole sample of each of the 17 aspects; these ratings were made prior to the ratings of satisfaction. The importance ratings were made on an eleven point scale ranging from 0 (aspect of no importance whatsoever) to 10 (aspect of utmost importance); these ratings thereby express the demands people make of their work surroundings. The mean importance rating received by each of the 17 aspects is shown in Table 2, together with the percentage of people rating each aspect as being of some importance to them (ratings greater than 5). The three aspects likely to be influenced by the type of ventilation system present are shown in bold in Table 2. Avoiding draughts and having fresh air have mean importance ratings of 7.70 and 7.59 respectively, indicating that they are both regarded as being of medium importance; relative humidity received a mean rating of 6.25, indicating that aspect is considered to be of lesser importance by the average person.

Table 2: Importance ratings of 17 aspects of the office

Rank	Aspect	Mean Rating	% rating aspect important	Aspect subscale
	Highest importance			
1.	Seating	8.58	93	Other
2.	Room temp.	8.54	94	Thermal
3.	Artificial lighting	8.17	91	Other
4.	No glare	8.02	88	Other
5.	Space	7.97	89	Other
	Medium importance			
6.	Furniture	7.80	86	Other
7.	No draughts	7.70	87	Thermal & air
8=	Fresh air	7.59	83	Air
8=	Daylight	7.59	79	Other
10	No distraction	7.14	79	Other
11	No direct sunlight	6.87	70	Thermal
12	No change in room temp.	6.53	66	Thermal
	Lowest importance			
13.	Privacy	6.28	63	Other
14.	Relative humidity	6.25	63	Thermal & air
15.	Indirect sunlight	5.99	58	Other
16.	View from window	5.41	45	Other
17.	Cosy surroundings	5.19	42	Other

Scale range is from 0 (of no importance whatsoever) to 10 (of utmost importance)

3.2 Environmental comfort

For the purposes of analysis the satisfaction judgements of each of the 17 office aspects listed in Table 2 were weighted by their corresponding importance rating; the rationale for this step was that satisfaction with subjectively unimportant features is unlikely to be of the same order of psychological significance as satisfaction with features which are subjectively important. Because the features represent a diverse range of building-related characteristics, the subjective judgements corresponding to each feature have been combined to form three indices of different global aspects of the indoor environment: air conditions, thermal conditions and a miscellany of other features representing office furnishing and fittings, working conditions (e.g. amount of space available) and a number of amenity factors such as view from the window and amount of daylight.

The far right-hand column in Table 2 indicates which index each of the 17 office aspects contributes to; item analysis shows that each of the indices formed by their constituent items forms a statistically acceptable scale. The air conditions scale correlates .07 (N.S.) with the thermal scale, and .42 ($p<.001$) with the 'other factors' scale. The satisfaction scores for all 17 aspects have also been summed to yield a measure of overall environmental fit; this assesses the extent to which the physical work environment as a whole meets the requirements placed upon it by members of staff. The total scores derived from each of the indices have been divided by the number of constituent items to produce a common range.

Tables 3 and 4 show how the air-conditioned and naturally ventilated buildings in the sample compare in terms of the four environmental comfort indices. Table 3 shows that staff satisfaction (mean score = -1.63, indicating that the average person is dissatisfied) with air conditions in two air-conditioned buildings, both considered together, is significantly lower than in the three naturally ventilated buildings considered

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Table 3: Building types compared on environmental comfort criteria

Building type	Air aspects	Therm. aspects	Other aspects	Overall environ. fit
Air-condit. Mean values	-1.63**	3.31	10.55	7.50*
Nat. vent. Mean values	7.27	3.21	14.25	11.77

Scale range is from -50 (completely dissatisfied) to 50 (completely satisfied).
** & * Indicate that mean value for the 2 building types are significantly different at the 1% & 5% levels respectively.

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together (mean score = 7.27). There are no differences between the two types of building in staff satisfaction with the thermal environment and 'other' aspects (working conditions and amenity factors). Nonetheless, the overall environmental fit for the average person in the air-conditioned buildings is significantly lower than in the naturally ventilated buildings; the mean scores are 7.50 and 11.77 respectively. Table 4 provides a breakdown by building of the scores shown in Table 3; in this and in all other data tables, the buildings labelled A to E correspond to the buildings briefly described in Table 1. Table 4 shows which buildings differ significantly from each other on the various criteria using the Scheffe test of a posteriori comparisons; it shows that air-conditioned Building A received a significantly lower mean satisfaction rating of air conditions than did naturally ventilated Building E. 'Other' aspects in air-

Table 4: Offices compared on environmental comfort criteria

Building type	Air aspects	Therm. aspects	Other aspects	Overall environ. fit
Air-condit.				
A	-4.62[X]	3.23	12.87	8.50
B	2.66	3.40	7.89[X]	6.77
Nat. vent.				
C	4.76	3.22	10.42	8.53
D	9.59	3.30	16.87	14.23
E	9.95[X]	3.08	17.83[X]	14.76

Scale range is from -50 (completely dissatisfied) to 50 (completely satisfied).
x indicates that building mean significantly different at 5% level from other building mean in same column similarly marked.

conditioned Building B received a significantly lower mean rating than other aspects in naturally ventilated Building E. No building is significantly different from any other in terms of satisfaction with thermal conditions or overall environmental fit.

3.3 Attitudes to the building and symptom rates

Table 5 compares the two building types on three further criteria: general attitude to the office, symptom rates and an index of ventilation-related views of the building as a whole. It shows that the two air-conditioned offices, considered together, received a significantly more positive rating on the 'attitude to the office' scale than did the three naturally ventilated offices; the mean scores are 5.34 and 4.53 respectively. A similar difference in favour of the air-conditioned buildings was found with regard to the 'attitude to air conditions in the building' scale; the mean scores are 4.64 and 4.12 respectively.

Table 5 also shows, however, that the air-conditioned offices have a slightly higher rate of minor symptoms, with approximately two symptoms per person being reported on average; the rate in the non-air conditioned buildings is approximately one and a half symptoms per person; this difference, although small, is statistically significant. In the air-conditioned offices the most frequently reported symptoms were headaches and dry throats,

each recorded by approximately two thirds of staff. In the non-air-conditioned-buildings the most frequent symptoms were lethargy and stuffy noses, reported by 46% and 33% of staff respectively.

Table 5: Building types compared on attitude to office and symptom rates

Building type	Attit. to office[1]	Symptom rates[2]	Attit. to air condits. in building[1]
Air-condit.			
Mean values	5.34**	2.05*	4.64*
Nat. vent.			
Mean values	4.53	1.42	4.12

** & * Indicate that mean value for the 2 building types are significantly different at the 1% & 5% levels respectively.
1 Scale range is from 1 (low score) to 7 (high score)
2 Range of possible symptoms = 0 - 7

Table 6 shows the frequency of answers to a single question about air movement in the office. This required people to indicate whether they thought the air movement in their office was 'about right', 'too much' or 'too little'. Because only six people in the whole sample reported having too much air movement, their answers have been combined with those indicating too little, to yield a 'not alright' category. The buildings differ significantly in the proportion of replies expressing satisfaction with the amount of air movement experienced ($chi^2=10.2$; $p<.05$). Air-conditioned Building B has the highest percentage of staff (71%) indicating that the air movement is about right. In only one building, Building C which is naturally ventilated, was this view recorded by less than half the staff interviewed.

Table 6: Frequency of views about air movement in office

Building type	About right	Too much or too little
Air-condit.		
A	22 (54%)	19 (46%)
B	25 (71%)	10 (29%)
Nat. vent.		
C	15 (36%)	27 (64%)
D	14 (58%)	10 (42%)
E	13 (50%)	13 (50%)

$Chi^2=10.2$ 4df $p<.05$

3.4 Good and bad points of the building.

Table 7 presents the results of another criterion available for comparing the two building types. It shows the frequency with which statements about eight building features were spontaneously mentioned by staff as being either good or bad points of their building. These eight features have been selected as being possibly affected by the type of ventilation present out of 130 different points differentiated on the basis of content analysis. Table 7 shows that in the naturally ventilated buildings a significantly greater proportion of staff made negative comments about air quality and air movement than staff in the air-conditioned buildings; the differences are 12% vs. 4% and 12% vs. 0% respectively. A significantly greater number of staff in the air-conditioned offices made negative remarks about air conditioning and the fact that windows could not be opened (25% vs. 7% and 12 vs. 2% respectively). On the other hand, positive comments about air-conditioning were also made by a significantly higher proportion of staff who worked in an air-conditioned office (17% vs. 1%). There were no significant differences between the two building types in the rates of mention of either positive or negative comments about draughts, the method of ventilation, physical health effects or psychological effects.

Table 7: Percentages of staff commenting on building-related features

	Air-condit. buildings		Naturally vent. buildings	
Feature	+'ve comments %	-'ve comments %	+'ve comments %	-'ve comments %
Air quality	0	4	0	12*
Air movement	0	0	1	12**
Draughts	1	9	0	3
Ventilation syst.	0	6	2	15
Air-conditioning	17	25	1**	7*
Openability of windows	0	12	11	2**
Phys. health effects	0	6	0	2

** & * indicate that differences between the 2 building types in proportion of people making positive or negative comments significantly different at 1% and 5% levels respectively

4. DISCUSSION

Data have been presented in the form of occupant judgements of a variety of building-related features and conditions in offices which might be affected by the method of ventilation present; as far as air conditions are concerned, it is clear from Table 2 that having fresh air and avoiding draughts are requirements which the average occupant regards as fairly important. The data provide a representative picture of occupant satisfaction in two air-conditioned and three naturally ventilated offices. With regard to evaluating the relative effectiveness of these two methods of ventilation the limited number of buildings providing data for the analyses reported in the previous section clearly limits the conclusions which can be drawn. Nonetheless, the first indications are that air-conditioning in office buildings is not, or at least need not be, a source of numerous problems giving rise to widespread dissatisfaction.

Occupant satisfaction with air conditions in the two air-conditioned offices, considered together, was significantly lower than that in the three naturally ventilated offices. A posteriori comparisons of the individual means shows that it is Building A which is responsible for the marked difference with the best of the naturally ventilated buildings. It is worth noting that the air conditions mean score for Building A is the only criterion in Table 4 to have a negative value, indicating that the occupants in Building A were, on average, dissatisfied with the air conditions in their offices. Inspection of the data relating to the three items making up this scale reveals that these occupants were particularly dissatisfied with the perceived freshness of the air and the presence of draught. The other criterion which the air-conditioned offices score significantly less well on is the overall rate of building sickness symptoms. However, the differences on both these criteria, although statistically significant, are small; thus, from a practical point of view they should not give rise to immediate concern. Nonetheless, the incidence of most frequent symptoms in both types of building is about twice that reported by other studies (e.g. Finnegan et al.[2]; Robertson et al.[3]).

It is worth noting that while both air-conditioned buildings received lower ratings with regard to air conditions than the three naturally ventilated offices, there is overlap on the 'other' aspects ratings and environmental fit scores; Building A received a mean rating of 'other' aspects which is as good as that received by Building C, and it's mean environmental fit score is also as good as that received by Building C. The data suggest that the particularly low rating of air conditions in Building A is to some degree compensated for by the relatively positive view its occupants take on average of 'other' aspects. Supporting this interpretation is the finding that satisfaction with the office as a whole was significantly higher in the air-conditioned offices despite the lower satisfaction with the air conditions.

Table 7 shows a significantly higher incidence of negative comments about air-conditioning expressed by staff in the air-conditioned buildings; this indicates that these people are very aware of this aspect of their working environment, and have negative views about it; why might this be so? An answer is suggested by the overall pattern of spontaneously expressed comments shown in Table 7. Even though the most frequently expressed negative comment in air-conditioned offices (made by 25% of staff) was about the air-conditioning, the majority of negative comments about air quality and air movement were expressed by people working in naturally ventilated offices. This suggests that some additional attribute or consequence is at least partly responsible for the negativism people express about air-conditioning. What it might be is suggested by the fact that the second most frequent negative comment made by staff in air-conditioned offices concerned the 'openability' of windows, referring to the absence of openable windows. In contrast, 'openability' was the positive feature most frequently mentioned by staff in naturally ventilated offices, meaning that they regarded having windows they could open as one of their building's good points.

This suggests that what people particularly dislike about air-conditioning is the loss of one potential means of control they have over indoor conditions when they can open windows. This interpretation is supported by the fact that 45% of staff in the two air-conditioned buildings perceived themselves to have no control over ventilation, whereas only 3% of staff in naturally ventilated offices held that view. The psychological literature in general shows that control is a very significant psychological dimension; similar indications can be found in the building science literature; for example, Sterling and Sterling[4] found that the rate of building sickness symptoms was lower in buildings with openable windows.

The idea that it is the absence of openable windows which leads people to dislike air-conditioning rather than necessarily adverse air conditions is further supported by two other results. First, it is clear from the pattern of answers shown in Table 6 that while the buildings differ considerably in terms of satisfaction with air movement, the differences are not directly associated with presence or absence of air-conditioning. Second, there is the finding that attitudes to ventilation-related aspects of the building as a whole were, on average, somewhat more favourable in the two air-conditioned buildings.

It is clear, however, that the absence of openable windows is not a shortcoming for all staff in the air-conditioned buildings. Table 7 shows that working in an air-conditioned environment is associated with a significantly higher rate of favourable as well as unfavourable comments.

In addition to enabling a comparison to be made of two methods of ventilation, the results reported above can be used to evaluate the success of the air-conditioning system in Building A; this is of interest because its design represents a bold attempt to

provide occupants with a degree of localised control not present in more conventional air-conditioning systems, as installed in Building B for example. The air flow from the floor outlet can be shut off when not required. Furthermore, the outlet is designed to create a miniature vortex which entrains the local air to provide a zone of conditioned air where it is wanted.

Given the importance of localised control to people, it might be predicted that the air-conditioning system in Building A would produce a higher level of satisfaction than that in Building B. However, this is not the case; the two buildings are virtually indistinguishable in terms of the evaluation criteria reported above. One exception can be found in Table 6 which shows that a higher proportion of people in Building A than Building B were dissatisfied with the amount of air movement in their office. This provides a clue as to why the air-conditioning in Building A did not find more favour with occupants. While carrying out the survey in Building A, the researchers were struck by the number unfavourable comments about the floor outlets that staff made incidentally while being interviewed. In particular, people complained that they experienced the air being blown from the floor vents as draughts which were uncomfortable at foot level. Fanger and Christensen[5] have demonstrated experimentally that turbulent air flow is more uncomfortable than laminar air flow.

It is therefore evident that designers of air-conditioning should seek to reduce rather than increase turbulent air flow. However, the fact that women also complained that the outlets were unsafe for wearers of high-heeled shoes suggests that designers should also take into account how their designs might affect the use of space by occupants. The researchers also gained the impression that it was management policy in Building A not to encourage the staff to adjust the floor vents. Thus it is likely that the success of any given design is to some extent contingent upon the information management gives its staff about the building they occupy.

In comparing the relative effectiveness as judged by occupants of air-conditioning and natural ventilation, the results of this study support the claim by Griffiths et al.[6] that research into the subjective impacts of the indoor environment must take complex interrelationships into account if substantial progress is to be made. By using a broad range of multidimensional measures this study has been able to show that dissatisfaction with air conditions does not necessarily result in overall dissatisfaction with an office, possibly because the dissatisfaction is compensated by other aspects of the work environment. This type of approach is required because people react to their surroundings as a complex whole, and not simply in terms of single factors which might be of interest to building scientists.

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Discussion

Paper 18

P. Charlesworth (AIVC, Warwick Science Park, UK) Is there a direct link between "importance" and dissatisfaction? e.g. Do people in cramped conditions rate "space" high, and people away from windows rate "daylight" high?

A.P. Baillie (University of Surrey, UK) We have examined this important question for only 2 office buildings so far. The results showed that for most criteria, importance and satisfaction ratings were not correlated, although for two or three (e.g. room temperature) there were low correlations, but no greater than Ø.35.

J. Van Der Maas (Ecole Polytechnique Federale de Lausanne, Switzerland) An important psychological aspect is the ability of an occupant to influence his environment, e.g. by window opening. Has any system been devised which allows occupants to change local temperature and air changes as controlled by the HVAC system as a substitute for window opening? What were the results?

A.P. Baillie (University of Surrey, UK) Yes, there are buildings with HVAC systems which provide occupants with some degree of control: we have studied one such building in the City of London, but have yet to analyse the results.

P. Hartmann (EMPA Duebendorf, Switzerland) Which physical parameters (temperature, comfort, plant conditions etc.) did you measure: (a) in all office buildings (b) in some cases only?

A.P. Baillie (University of Surrey, UK) The following were measured in all 5 office buildings described in the paper: (i) air temperature (ii) radiant temperature (iii) air flow (iv) relative humidity. These took the form of spot measurements at the person's desk. The following were also measured: (v) distance of desk from nearest window (vi) ratio of window to floor area (vii) floor area available to each occupant (viii) distance to nearest co-worker.

D.J. Croome (University of Reading, UK) (a) How does this study evaluate interactive responses, for example to fresh air and temperature? (b) Were there any differences between: (i) the lighting systems (ii) the sound levels (iii) the average air temperatures? (c) What were the floor to ceiling heights in each office, and the volume and floor area per person?

A.P. Baillie (University of Surrey, UK) (a) Given the broad range of subjective factors measured, multivariate statistical analysis will be carried out to determine whether or not satisfaction with room temperature depends in part on the level of satisfaction with other aspects of the environment, e.g. perceived

effectiveness of control of temperature and visual attractiveness of office decor. (b) No information was collected concerning the lighting system or sound levels. Radiant and air temperatures only were measured on a spot basis at each respondent's desk at the time of the interview. (c) Floor to ceiling heights were not measured. Floor areas per person were measured but we have yet to examine whether this variable is correlated with any satisfaction variables. There was however considerable variation in floor area available to each person interviewed.

M. Holmes (Arup Research and Development, London, UK) I believe building C is in Basingstoke. If so, did the fact that the occupants had recently moved from an air conditioned building have an influence on them, I also understand that occupation levels are greater than originally specified at the design stage, and that more partitioning has been introduced, which may restrict cross flows. Did you observe this?

A.P. Baillie (University of Surrey, UK) Building C is in Basingstoke. The experience of their recent move from an adjacent building certainly coloured people's comments about what they believed to be good and bad parts of the new building. Likewise it is true that occupation levels were higher than the original design. We have yet to assess whether or not this partially accounts for lower satisfaction with "other aspects" (of which space is a part) in building C. It was also our impression that extensive use of relatively high partitions restricted cross-ventilation, but we cannot demonstrate that. The relatively low level of satisfaction with air conditions could also be partly caused by failure to open windows when required, due to poor window design.

C-A. Roulet (Ecole Polytechnique Federale de Lausanne, Switzerland) There is a German study which shows clearly that people do not like climatised (air conditioned) buildings. Also Fanger has shown that maintenance and cleaning of the mechanical ventilation systems have a great influence on indoor air quality of climatised buildings. Do you have any information on cleanliness of the installations in your buildings?

A.P. Baillie (University of Surrey, UK) Only the efficiency of the filters used and the frequency with which they have been replaced. Our impression was that the air conditioning systems in buildings A and B were relatively well maintained.

P. Appleby (Paul Appleby Chartered Engineer, Norwich, UK) In your list of parameters and their relative importance to occupants: (a) was the wording your own or suggested to the occupants? (b) how can the occupants make an assessment of fresh air rate? This is possible with openable windows, but only manifests itself with air conditioned or mechanically ventilated buildings by the dilution of contaminants and the resultant air purity and odour level - perhaps odour level would be a more useful parameter.

A.P. Baillie (University of Surrey, UK) (a) The wording is ours, based on extensive pilot research, i.e. we became aware of how people themselves described the aspects. (b) Perceived freshness of the air was rated. Yes, odour level would be an important aspect. We have obtained ratings of odour level for each building as a whole, being one of three aspects assessed to give a picture of overall air conditions.

J. Uyttenbroeck (Belgian Building Research Institute) Why did you not include questions concerning the acoustic environment? The choice between openable windows and air conditioning frequently revolves around noise.

A.P. Baillie (University of Surrey, UK) We did not consider the influence of outdoor noise, only distraction caused by the activities of other people in the office, e.g. making telephone calls. The main reason that satisfaction with outdoor noise levels was not assessed was to restrict the number of aspects evaluated. We also anticipated (rightly as it turned out) that all the office buildings surveyed would be either in relatively quiet locations or would be well insulated acoustically due to the presence of double or triple glazing.