No. 2507

PREFERRED AIR SPEEDS FOR COMFORT IN WARM CONDITIONS

DR. DONALD A. McINTYRE

Indoor temperatures in summer may become too warm for comfort. The actual temperature elevation between indoor and outdoor temperatures depends on a number of factors involved in the building design. If the elevation is not too great, it may be possible to provide comfortable conditions by the use of increased air movement, rather than air conditioning.

An experiment was set up at ECRC Capenhurst to find if the combination of warm air temperatures and increased air movement was found comfortable, and whether there is a maximum air temperature above which the use of increased air movement cannot provide satisfactory conditions. Eleven subjects were exposed to temperatures in the range 22 to 30°C, and allowed to regulate the speed of an overhead ceiling fan. It was found that the subjects chose fan speeds which increased with air temperature, to a maximum of about 2 m/s at 30°C. The fan speeds chosen were less than those necessary to maintain thermal neutrality; the subjects' skin temperatures and warmth votes increased with air temperature.

It is shown that people's perception of the strength of an air flow increases as the square of the air speed, while the cooling effect only increases as the square root of the speed. This sets an upper limit to acceptable air speeds. Our subjects found a temperature of about 28°C to be the highest comfortable temperature; above this, overall comfort deteriorated.

INTRODUCTION

Even in a temperate climate, indoor temperatures may rise above comfortable levels in summer. Heat gain from occupants and lighting, and solar gain from sunshine, act to raise the temperature inside a building above the outdoor temperature. The actual temperature rise depends upon a number of factors involved in the building design. It is, of course, possible to design a building in temperate climates that is comfortable for most of the summer without air conditioning. However, the restrictions this places on the designer's freedom may make the building uneconomic, and it has become commonplace for commercial buildings to be air conditioned, even in Britain. With the recent increase in the price of energy, this trend has been questioned, and a return to the age-old method of combating high air temperatures with increased air movement is often proposed. Since people have come to expect high standards of comfort, the use of increased air movement must be considered in all its aspects, not just the provision of relief from overheating.

It is possible to predict the cooling effect of air movement on a person. Fanger's comfort equation (1) provides a comprehensive way of examining the combined effects of environmental variables. This shows that for a lightly clothed sedentary person, an increase in ambient temperature of 2.5°K is compensated by an air speed of 1 m/s. This has been confirmed experimentally. (2,3)

What the comfort equation does not tell us is whether such a condition is found acceptable. To what extent do people like the combination of air movement and warmer temperature? Is there

D.A. McIntyre, Electricity Council Research Centre, Capenhurst, Chester, CH1 6ES, U.K.

a maximum temperature elevation that may successfully be compensated by an increase in air movement?

To answer these questions, an experiment was set up at ECRC Capenhurst. Each subject sat in the chamber at a fixed temperature and was able to set the speed of an overhead fan to give optimum conditions. During the session, the subject answered questions about his feelings, and his skin temperature was measured. This was to investigate what criteria each person used in setting the fan speed.

THE EXPERIMENT

The experiment took place in the ECRC environment chamber. This is a room of dimensions 3.7 x 3.7 x 2.4m high. Air of controlled temperature and humidity enters through a porous floor, and is extracted at ceiling height. The temperatures of the ceiling and walls are independently controllable. In this experiment they were held equal to the air temperature.

The subject sat at a table in the centre of the room. The table and chair were placed on a 1.2m square piece of blockboard, to avoid any local air movement round the ankles.

A 1.2m diameter ceiling fan was suspended at a height 45cm below the ceiling. The fan was a standard fan sold for use in warm climates, (Simplex ceiling fan), which was modified by tapering the blades towards the tip, in an attempt to produce a more uniform radial distribution of air speed; the improvement was only small.

A 1.2 x 1.2m louvre was suspended below the fan at a height of 1.8m from the floor. The louvre had a grid size of 40 x 40mm and a thickness of 25mm. The louvre served primarily as a protective screen for safety purposes, but had an additional function in reducing swirl and directing the air stream from the fan downwards. The layout is shown in Fig. 1.

The fan speed was controlled by a variable auto transformer. During the session the subject controlled the fan speed himself. The transformer was mounted in a box, with only the hand wheel protruding; no scale markings could be seen, and the pointer was removed. This was to ensure that the subject adjusted the speed as a result of his sensation, rather than by remembering the transformer setting. Fan speed was measured by a photo-electric tachometer, and recorded on a chart recorder.

Skin temperature measurements were made on the male subjects only using copper-constantan thermocouples, held on the skin by elastic and Velcro 'garters'. Thermocouple emfs were recorded on a data logger; a melting ice reference temperature was used. Thermocouple emfs were converted to temperature using standard tables; checks showed the accuracy to be within 0.2°C. The placing of the thermocouples and the weighting factors used to calculate mean skin temperature are those recommended by Gagge & Nishi.(4)

Experimental Design

The experimental subjects were six young males and six young females, recruited through an employment agency. Mean ages were 19 for the males and 21 yr for the females. Each subject attended on two consecutive days, and experienced four conditions. The order of presentation of conditions was balanced so that each condition was given an equal number of times in morning and afternoon, with a different order for each subject. One male did not complete all sessions, and was removed from the analysis.

When the subject arrived, the nature of the experiment was explained to him, and he was given a practice session of the two checking tasks. He then entered the chamber, and the skin harness was put on. The fan speed control was explained. The conduct of the session followed the timetable shown in Table 1. Every 15 min the subject was asked to make a change in the fan speed; the purpose of this instruction was to ensure that the subject did not tolerate a sub-optimal speed, but was forced to reassess his chosen speed at intervals.

During each session, the subject was given two checking tasks. The first was checking a number of complex ring patterns for a break in the line. The rings, known as Landolt rings, are a standard task used in visual performance research. This task was done for 5 min, the score being the number of correct checks made in this time. The second task, carried out for 10 min, consisted in comparing two columns of ten digit numbers and checking for mistakes. The function of the tasks was to provide the subject with an activity that required concentration, and in which the disturbance from the fan might cause annoyance.

Every half hr, the subject completed the questionnaire shown in Appendix 2. The method of answering was explained to the subject; he was also told that no action would be taken as a result of his answer to the final question.

The male subjects all wore a long-sleeved shirt, open at the neck, with no vest. Trousers, socks and shoes were worn. The female subjects wore a light summer dress. All the dresses were sleeveless or short-sleeved; most of the subjects wore a half slip and tights. The clothing insulations are estimated to be 0.48 for the males and 0.38 clo units for the females; the insulation was estimated from the components of the ensemble (5).

Conditions

The male subjects were exposed to four conditions of 24, 26, 28 and 30°C; the females to 22, 24, 26 and 28°C. Relative humidity was 50% in all cases. The temperature and humidity were measured at half-hourly intervals, using an aspirated Assmann psychrometer. Table 2 shows the conditions achieved in practice.

Calibration of Air Speed vs Fan Speed

The air flow pattern from the fan had a central core of relatively low speed. The subject therefore sat off centre, so that his head was under the centre of the blade; see Fig. 1. The air speed under the fan was measured using a thermistor anemometer (Prosser AVM 501). Measurements were made at two heights, 0.8 and 1.25m, over a grid of eight positions. As the air jet moves downwards, it expands slightly, both into the low speed core and outwards. The speed of the movement therefore falls.

The local air speed is not uniform over the body of the subject. The air speed from the fan varies with height and position, and the chair and desk distort the flow of air and partially shield the lower part of the body from the air stream. A uniform air flow would only be achievable by a special experimental arrangement, which would then not be representative of actual or possible conditions in an office. In this experiment the subject was positioned so that he sat in the most uniform part of the flow. Angular movement of the subject, e.g., leaning backwards or forwards, changes the interaction between air stream and body, and so alters the total cooling power. Because of these factors, it is impossible to give a complete and accurate measure of the air speed by a single figure. The air speed quoted in Fig. 2 is the average of the speeds measured at five positions at a height of 80cm. The air flow was fairly uniform over the lateral extent of the body, so this figure gives the air speed encountered by the upper half of the body. The variability with time of the air flow was measured at one point with a fast-response hot-wire anemometer, DISA 55M12. Fig. 3 shows the recordings obtained.

RESULTS

Fan Speed

A redrawn version of a chart recording of the fan speed is shown in Fig. 4. As will be discussed below, the subjects appear to respond both to the cooling effect of the air and to its pressure. Since the former varies as the square root of the air speed, and the latter as the square, it is not obvious how to average the speed over a session. The solution adopted has been to take the median speed. An additional reason for adopting the median is that the distribution of fan speed over a session is skewed. The effect of this skewness is that the median is greater than the mean at high temperatures, and lower than the mean at low temperatures. For instance, a subject who spent more than half the session with the fan off has a median fan speed of zero; the mean speed would be greater than zero because of the effect of the time spent with the fan on.

Table 3 lists the median and upper and lower quartiles of the fan speeds, measured over the final 2 hr of each session. The average speed by session and sex is plotted in Fig. 5. Taking the average of medians is legitimate, since this is determined by the distribution of medians over people, which we may suppose symmetrical. The figure shows a clear effect of air temperature on the fan speed selected. Analysis of variance shows the effect of temperature to be highly significant. Although the figure apparently shows that the sexes respond differently, the difference was not found to be significant upon analysis. See Table 4.

Skin Temperature

Skin temperatures of the male subjects were recorded at 10-min intervals. The weighted mean skin temperature was calculated at each interval, and averaged over the last hr of each session. Analysis of variance shows the effect of air temperature to be highly significant, and the variation of mean skin temperature, averaged over subjects, is shown in Fig. 6.

Rating Scales

The last three half-hourly responses were included in the analysis of variance. The male and female responses were analysed separately, using a two-way repeated measures design (6). Treatments were air temperature and time. No time effect was found significant. The results are shown plotted in Fig. 7. Scale 5 produced few reports of discomfort, with no hint of a significant effect; it has not been shown in the figure.

Estimation of Strength of Air Movement

The cooling effect of an air stream varies approximately as the square root of the air speed. The velocity pressure, i.e., the pressure produced when the air stream is brought to a stop, varies as the square of the speed. The perception of an air stream by a person may result from either or both of the two effects, i.e., cooling and pressure. This is evident in the results of the present experiment, where it is clear that the subjects did not use cooling power as the sole criterion for setting fan speed.

In an attempt to isolate the non-cooling subjective effect of air movement, a subsidiary experiment was carried out. Subjects were exposed to five fan speeds, and asked to rate the 'strength' of the air movement. The method of magnitude estimation was used (7). This technique allows responses to be fitted to a power function of the fan speed

$$\psi = k\phi^{\beta} \qquad (1)$$

where ψ is the magnitude estimate given by the subject, and ϕ is the stimulus magnitude. The scaling constant k varies from person to person. The exponent β describes how the sensation grows with the stimulus, and is found to be a function of the sensory modality. It has been investigated for a wide range of senses. It can be below unity (0.3 for brightness) or above (3 for electric shock).

Nine subjects were used. The subjects included four females from the main experiment, and five other employees from ECRC. Each subject sat in the chamber under the overhead fan, as described for the main experiment. The instructions in Appendix 3 were read to the subject. The experimenter then presented five different fan speeds four times each to the subject, in a predetermined random order. Each speed was held for 30 sec before asking the subject for an estimate. The geometric mean of all the estimates at a particular speed was then obtained. On nine out of the thirty-six presentations at 50 rpm, the subject returned an estimate of zero (undetectable). In this case the geometric mean is inappropriate, and the median score was taken. This is a brief summary of the standard procedure for magnitude estimation experiments. Full accounts may be found elsewhere (8,7).

The results are plotted in Fig. 9. A least squares power curve fit for the five points gave

$$\psi = k\phi^{2.0} \qquad (2)$$

The value of k (4.29×10^{-4}) is of little interest. The value of β indicates that the subjects judged the strength of the movement as proportional to the wind pressure. The closeness of the exponent to 2.0 is remarkable, and must be regarded as fortuitous.

DISCUSSION

The subjects clearly found that it was an advantage in warm conditions to have the use of the fan, and the fan speed chosen was clearly linked to the temperature. Fig. 6 shows a steady increase of selected fan speed with ambient temperature. At the highest temperature of 30°C, the male subjects had the fan at maximum speed for most of the time. The lowest temperature of 22°C, experienced by the females, was on the cool side for the light clothing and sedentary activity of the subjects, and the subjects had the fan off for much of the time. The conditions therefore encompassed the whole range of temperatures over which the fan was satisfactory.

Fig. 5 shows that, on average, the females chose a lower fan speed at a given temperature than did the males. However, an analysis of variance, Table 4, shows that the difference is not significant. The relatively small number of subjects and the scatter in results prevents drawing a conclusion as to whether there is a difference in response between the sexes.

The skin temperature of the male subjects increased with ambient temperature. That is, the subjects did not use the fan to restore thermal neutrality, but set the air movement to some intermediate level of cooling. This conclusion is in agreement with the results of the questionnaire, Fig. 7. Both sexes showed a consistent increase in warmth vote with ambient temperature. As with the fan speed, there was no significant difference between the sexes.

Air movement over the subject produces two effects. It increases the cooling power of the air, and is also perceived directly by its pressure. We shall for the moment call this latter effect the 'force' of the air movement. Although there are times when the force of the wind is a pleasurable stimulus, it will generally be considered undesirable by a sedentary subject, particularly if he is engaged in a task such as reading or writing. Thus, when the subject adjusts the fan speed, he is altering a comfort which consists of two components: warmth and force. The result is that the chosen air speed will be less than that required to produce thermal neutrality, so that the air speed cannot be predicted using Fanger's comfort equation alone. In Fanger's own experiment (2) at an air speed of 0.8 m/s, the subject was required to adjust the air temperature, not speed. The discomfort from the force of the air movement was therefore constant, so that the subject changed the air temperature to bring himself into thermal neutrality.

Rating Scales

The warmth scale results (Fig. 7) show that 22^{o}C was found to be too cool by the female subjects. The subjects were lightly dressed at the minimum level which would be generally acceptable for office work; they were also sedentary, with somewhat less activity than would be found for normal office work. The results indicate that 24^{o}C would be quite acceptable as a temperature in an office. This is slightly higher than the customary temperature in a British office, and would require some change in general clothing insulation levels to become acceptable. 30^{o}C for the males is definitely too hot. The fan was usually on at full speed, producing a 2 m/s draught powerful enough to blow papers off the table. There is a fall in the pleasantness vote of males on going from 28 to 30^{o}C. It would seem from inspection of Fig. 7 that temperatures up to 28^{o}C may be satisfactorily alleviated using an overhead fan. At higher temperatures, a fan would be of great help, but would produce conditions definitely worse than having a lower air temperature.

Subjects' Comments

At the end of each session, the subject was asked for his general impressions. In the two hottest conditions, it was often remarked that the fan was noisy, and that the air movement was annoying. Two people said that they found the control too critical, and that they had difficulty setting the fan speed just right; this was not reported by other subjects, and the fan speed records indicated that most subjects were content to leave the speed constant for times up to 15 min, the maximum possible without making a change. Two people said they used the fan for 'freshness' at the lower temperature conditions. Observations of discomfort by the subject during this de-briefing were not always consistent with his questionnaire response. The subject often mentioned minor annoyances or discomfort which were not reflected in the questionnaire response.

Other Work

Burton et al. (9) carried out an experiment in Australia which was very similar to this one. The subject sat at a desk under the centre of a ceiling fan. The fan speed was controlled by an autotransformer, which was slowly rotated by an electric motor. The direction of rotation could be changed by the subject. The air speed thus continually increased or decreased, until the direction of change was altered by the subject. The subjects wore shirt, vest and shorts, and were males with an age range from 44 to 62 yr. Four temperature conditions were used, from 26.3 to 29.1^{o}C. The experiment was therefore very similar to this one, except that neither subjective assessments nor skin temperature measurements were taken.

Olesen et al. (3) and Fanger et al. (2) have done what might be called the inverse experiment. The subject sat in a constant air speed of 0.8 m/s, and adjusted the temperature of the chamber to his preferred temperature. In this case, any force discomfort from the air flow remains constant, and we would expect the subject to achieve thermal neutrality. The results of the experiments are shown in Fig. 9. 'Still' air has been plotted as v = 0.15 m/s. It is seen that the results of Olesen and Burton are in good agreement, in spite of the difference in technique (fixed air speed vs fixed air temperature). The results for females at ECRC are in reasonable agreement, but the males chose higher air speeds. It must be remembered that there is no significant difference between the speeds chosen by males and females.

Increased air movement can compensate satisfactorily for increased air temperature over a limited range of temperature. The dry heat from radiation and convection is given by

$$R + C = h_r\ (T_{cl} - T_a) + k\sqrt{v}(T_{cl} - T_a) \qquad (3)$$

where h_r is the linear radiation transfer coefficient and T_{cl} the mean clothing temperature. It is assumed that the mean radiant temperature is equal to the air temperature. It can be seen that as $(T_{cl} - T_a)$ reduces with increasing air temperature, the increase in air speed to maintain the necessary heat loss is rapid. Since the perceived force of the air movement increases as the square of the air speed, the force of the air movement necessary for temperature control increases very rapidly with increasing air temperature. This non-linear behaviour means that it is not possible to extrapolate experimental results to higher temperatures; e.g., the finding (2,3) that an increase in temperature of 2.5 K may be compensated by an air speed of 1 m/s cannot be extrapolated to higher temperatures. This discussion has ignored sweating. When people are sweating, increased air movement will produce a large increase in the rate of evaporation and cooling. We have assumed that conditions as hot as this are outside the scope of this experiment, which is concerned with satisfactory indoor conditions.

The slope of air speed vs air temperature is lower for the ECRC experiment than for the predictions of the comfort equation. This is explained by the subjects under-compensating for the increased air temperature, to avoid discomfort from the force of the air. What is more puzzling is the considerable air speed chosen by the male subjects at the lower temperatures. A temperature of 24°C would not normally be found too warm by a sedentary, lightly clothed person, yet the male subjects chose a mean fan speed of 0.7 m/s, and reduced their mean warmth vote below 4. Inspection of Table 3 shows that the high average fan speed for males is due to two subjects - S2 and S3. The other male subjects chose fan speeds within the range of those chosen by the females. There seem to be two possible explanations. Either the subjects felt that they 'ought' to choose a substantial fan speed, to please the experimenter, or else they positively liked the air movement for some non-thermal reason.

CONCLUSIONS

1. In warm ambient temperatures, the subjects found the use of an overhead fan reduced discomfort.

2. The air movement chosen did not fully compensate for the increase in air temperature. At the higher air temperatures subjects felt warmer and had higher skin temperatures than they did at the lower air temperatures.

3. The perceived strength of an air flow is proportional to the square of the speed.

4. The upper limit of air temperature for comfort is about 28°C. Above that temperature, the air speed necessary to reduce warmth discomfort produces too much disturbance.

5. Some subjects chose air speeds at low temperatures which were too high for thermal comfort; possibly there was a benefit from 'freshness'.

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TABLE 1

Timetable

09.30	Welcome subject. Outside chamber, explain procedure, give practice rings and number test.
10.00	Enter chamber. Put on harness. Explain fan speed control.
10.30	First questionnaire.
11.00	Questionnaire.
11.20	Landolt rings, followed by Q.
11.45	Random numbers, followed by Q.
12.20	Q. Any comments on session?
12.31	Release subject.
13.30	Back in chamber and repeat morning procedure.

The experiment took place during July and August 1977.

TABLE 2

Physical Conditions

Condition:	C1	C2	C3	C4	C5
Males					
Mean T_a (^oC)	30.6	28.3	26.1	24.1	
s.d. (^oC)	0.2	0.3	0.4	0.4	
Mean RH (%)	50	49	53	50	
Females					
Mean T_a (^oC)		28.2	26.2	23.9	22.3
s.d. (^oC)		0.3	0.3	0.3	0.3
Mean RH (%)		50	52	52	49

TABLE 3

Fan Speeds

The table shows the lower quartile, median, and upper quartile of the fan speeds (in r.p.m.) selected by each subject.

	C1 (30°C)			C2 (28°C)			C3 (26°C)			C4 (24°C)			C5 (22°C)		
Males:															
S1	155	195	215	95	120	155	65	125	145		55				
S2	195	245	245	235	245	245	85	155	215	155	205	245			
S3	245	245	245	205	215	215	205	215	225	185	195	195			
S4	235	245	245	115	125	145	125	135	145	55	65	75			
S5	195	245	245	35	155	195	0	75	225	0	0	95			
Mean		235			172			141			104				
Females:															
S7				95	115	125	75	105	105	35	65	85	25	35	55
S8				135	145	145	50	65	85	0	0	25	0	0	0
S9				165	175	200	135	155	175	55	55	95	0	0	25
S10				105	215	235	120	185	185	55	95	105	0	45	125
S11				0	75	145	15	65	115	20	45	65	0	55	65
S12				0	55	95	35	65	115	0	0	35	0	0	35
Mean					130			107			43			22	
Overall mean					149			122			71				
Mean air speeds (m/s)															
Male		1.86			1.31			1.04			0.71				
Female					0.94			0.74			0.18			0	

TABLE 4

Analysis of variance of fan speed

The median fan speeds for the central three conditions (C2, C3 and C4) were analysed to investigate whether there was any significant difference between the sexes. The analysis was an unequal group size, least squares solution.(6)

Summary table:

Source of variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Sex	17063	1	17063	1.98 N.S.
Subjects within groups	77510	9	8612	
Temperature	34723	2	17361	17.9 **
Sex x temperature	1001	2	500	
Temperature x SWG	17477	18	971	

N.S. = not significant

** = significant $p < 0.01$

The effect of temperature on the chosen fan speed is highly significant; there is no significant effect of sex.

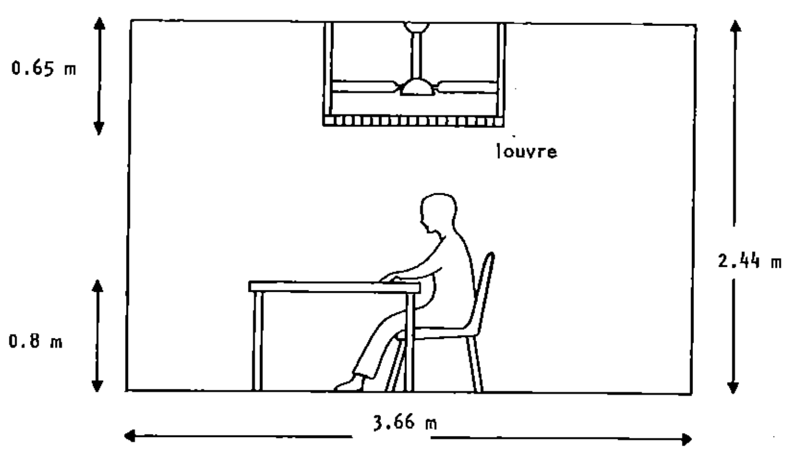


Fig. 1(a) Section of chamber

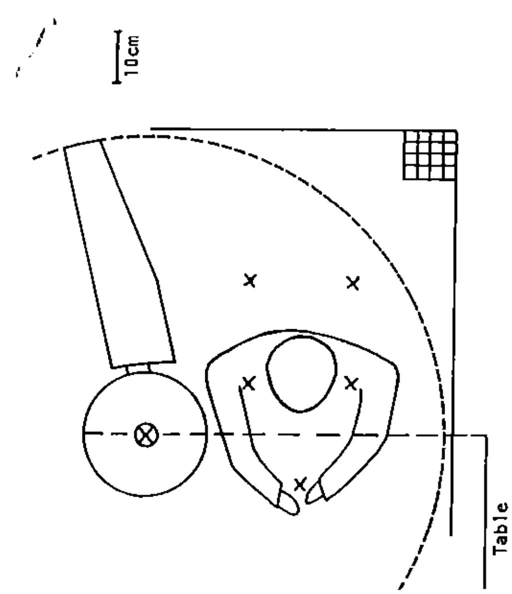


Fig. 1(b) Plan view of fan and subject. The measurement points for the air speed are marked X.

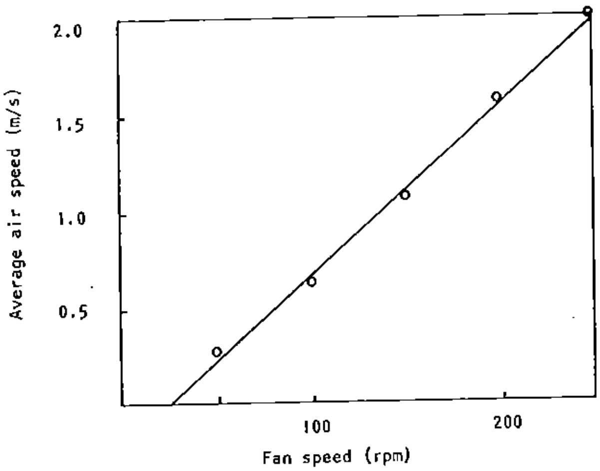


Fig. 2 Average air speed (v) as a function of fan speed (w); regression line is v = 0.0099w - 0.20

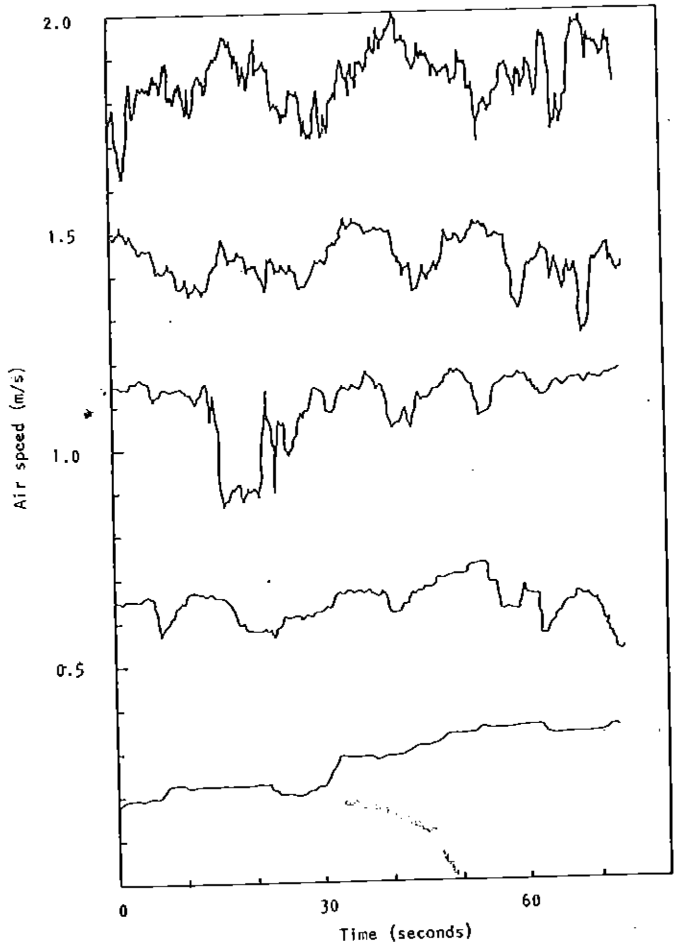


Fig. 4 Record of air speeds chosen by subject (subject 11, condition 2)

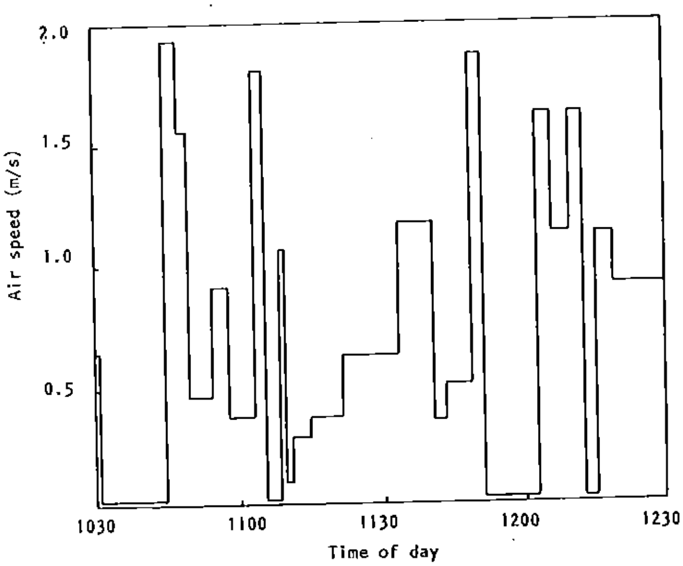
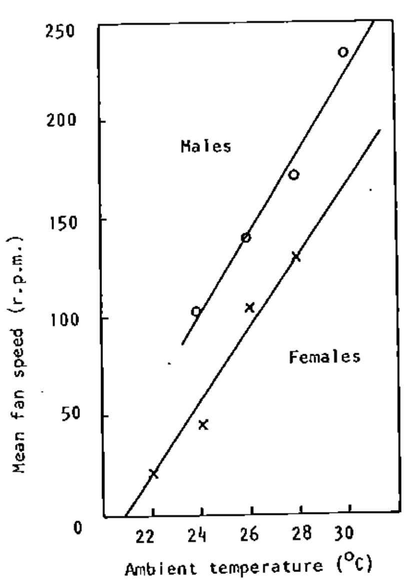


Fig. 3 Fluctuations of air speed, measured with a hot-wire anemometer

Fig. 5 Fan speeds chosen as a function of ambient temperature



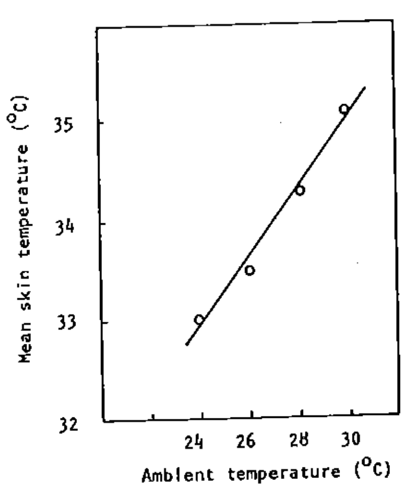


Fig. 6 Mean skin temperature in different conditions (males only)

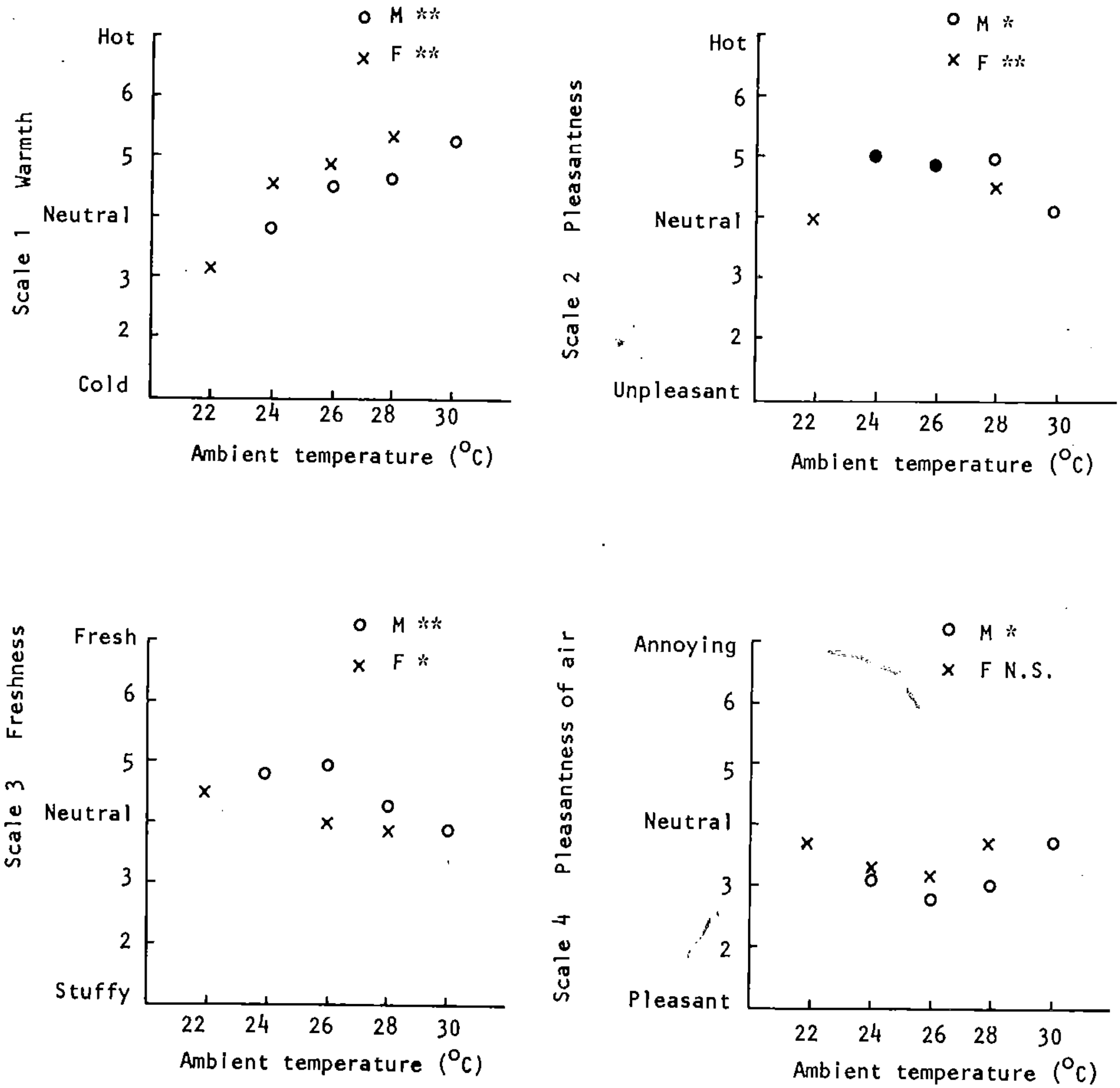


Fig. 7 Questionnaire responses

*Overall significance of temperature on response indicated by * (p <0.05) and ** (p < 0.01)*

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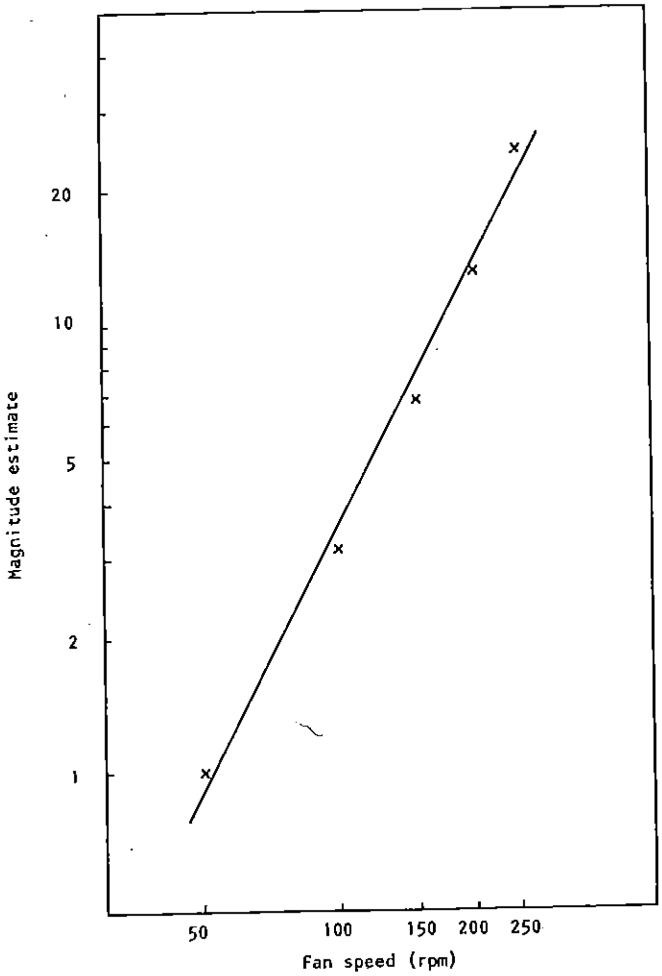

Fig. 8 Magnitude estimates of the strength of airflow. Each point represents data from 9 subjects.*

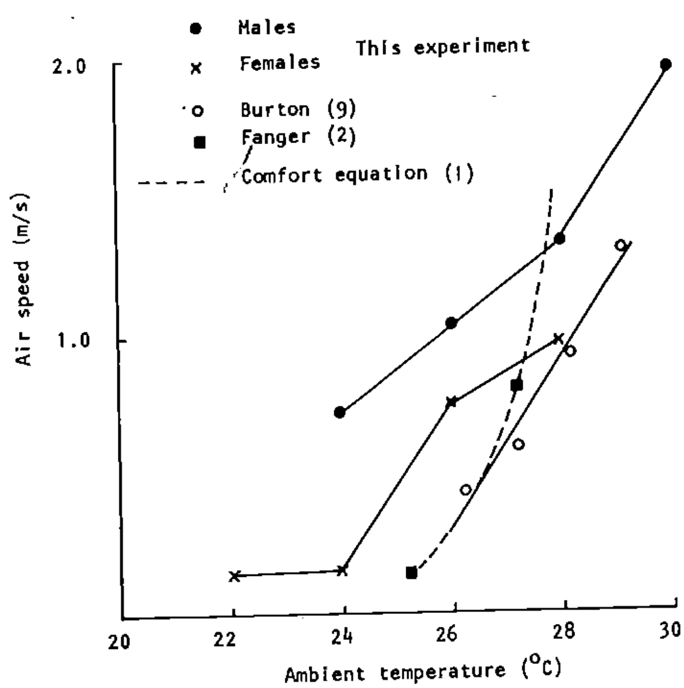

Fig. 9 Comparison of different experiments. The dotted line shows the prediction of heat balance.

APPENDIX 1 INSTRUCTIONS TO SUBJECTS

This project is concerned with finding out what sort of air movement people like. You are asked to sit at the desk in the chamber, and adjust the speed of the overhead fan so as to make yourself as comfortable as possible. You may adjust the fan speed - or turn it off - as often and whenever you like. Every now and then you will be asked to make a change in the fan speed - faster or slower as you choose. You may of course readjust the speed whenever you choose.

Your skin temperature is being recorded. The thermocouples which measure the temperature have to be held next to the skin by the elastic 'garters'. If during the session you notice one slip out of place or become loose, please tell the experimenter.*

An experimenter is always in attendance outside; you may talk to him at any time through the intercom.

*This paragraph was deleted for female subjects.

APPENDIX 2 QUESTIONNAIRE

Name Date Time Condition

Overall, how warm do you feel?

Hot	7
Warm	6
Slightly warm	5
Neutral	4
Slightly cool	3
Cool	2
Cold	1

How fresh do you find the conditions?

Fresh	7
	6
	5
Neutral	4
	3
	2
Stuffy	1

Are you comfortable?

Yes	1
No	2

How pleasant do you find the thermal conditions?

Pleasant	7
	6
	5
Neutral	4
	3
	2
Unpleasant	1

What do you think of the air movement?

Annoying	7
	6
	5
Neutral	4
	3
	2
Pleasurable	1

Would you like a change in air temperature?

Warmer	1
No change	2
Cooler	3

APPENDIX 3 INSTRUCTIONS FOR MAGNITUDE ESTIMATION

I am going to present to you a number of air movements of different strength. Your task is to tell me how strong each air movement feels, by assigning a number to it.

After the fan has been going at a certain speed for a short time, think how strong the air flow feels, and give this strength a number - any number you think appropriate. I will then present another speed to which you will give another number, and so on.

Try to make the ratios between the numbers you give the same as the ratios between the strengths of the air flow. For instance, if the second air flow feels twice as strong as the first, give a number twice as big. If it is half the strength, give a number only half as big.

Try to judge the strength of the movement, i.e., how hard it is blowing, rather than its temperature.

You may assign any number, big or small, fractions, decimals.

DISCUSSION

R.B. McKEE, Professor, University of Nevada at Reno, Reno, NV: Skin temperature is shown as a linear function of air temperature. Was this relation independent of air velocity?

D. McINTYRE: No response.