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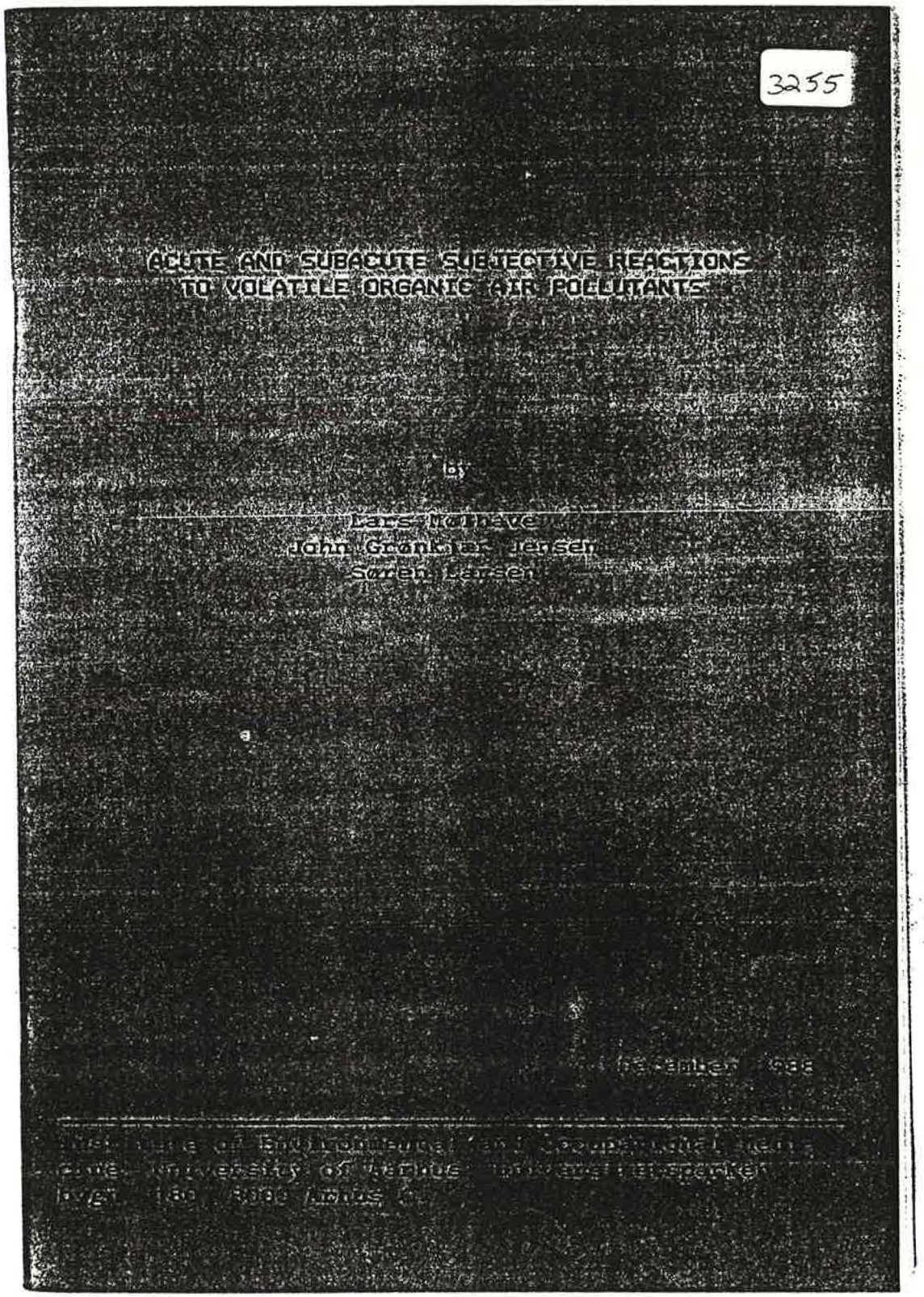
Acute and subacute subjective reactions to volatile organic air pollutants



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Acute and subacute subjective reactions to volatile organic air pollutants.

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I. INTRODUCTION.

I.a. background.

The indoor air quality in buildings used for offices or dwellings has attracted increasing attention during the recent years. This increased attention appears both in the general population, among health and welfare officers and among those in charge of buildings. One of the reasons is an alarming number of indoor climate complaints appearing at the same time as our use of buildings, our construction traditions and the ventilation standards have been changed in a way which favour an increasing level of indoor air pollution with gasses, vapours and particulates.

The complaints reported by occupants in buildings with indoor climate problems have been described as a sick building syndrome (1). This syndrome is characterized by irritation or sensation of dryness in the mucous membranes in eyes, nose and throat, cough, increased mucous secretion in the respiratory system, shortness of breath and airway restriction. More rarely itching and reddening of eyes are seen. Nonspecific neurological symptoms like headeache, reduced capability to concentrate and tiredness are frequent as well as non-specific hypersensitivity reactions in the form of itching and skin dryness.

These symptoms can all be caused by a variety of factors related both to the indoor climate or to the occupants. Suspected causes in the indoor climate are sensory reactions due to high levels of pollutants emitted from building materials, (defective) ventilation systems, high or low air humidity or air temperature, overcrowding, improper use of the room, intruding pollution from the surroundings etc. A number of personal factors have been related to the symptoms (1). Among these are age of the occupants, sex, type of occupation, smoking habits, education, previous or existing illnesses or tiredness, medication and hobbies.

Investigations have indicated cases of mucous membrane irritations where a weak physical/chemical stimulation caused by e.g. an air pollutant seemed to be a more likely explanation. Building materials are known to release chemical compounds to the air (2). Particularly volatile organic compounds (VOC). Their number and concentrations have been shown to decline as the building grows older (2,3). The increasing number of complaints have been correlated to the use of new building materials as the frequency of complaints is highest in new and newly renovated buildings. Investigations of the emission of volatile organic air pollutants from 42 building materials have shown concentrations which in dwellings would correspond to about 3 mg/m³ (3). Of these compounds 84% were known as mucous membrane or eye irritants. 28% were possible carcinogens and 22% were found in concentrations which exceeded their odor threshold (2).

The combined effect on humans of these many simultaneously appearing compounds is unknown. Additive effects are considered to be likely, but synergistic effects cannot be excluded especially among more sensitive persons.

The major aim was to establish relations between VOC-concentrations and subjective reactions on odour and irritation. Investigations of such reaction related to the occupants' sensation of indoor air quality have for many years been done at our Institute of Environmental- and Occupational Medicine (IMA) and the Laboratory of Heating and Airconditioning at the Technical University of Denmark (DTH). The two laboratories did, however, use different approaches and questionnaires and their results are therefore not directly comparable. One of the aims of this project was therefore to compare the two questionnaires used at the two laboratories (IMA) (3) and (DTH) (4).

I.b. The aims.

The general purpose of the project was to establish a dose response relationship between human reactions and exposure to concentrations of volatile organic compounds (VOC) known to be emitted from building materials. Investigations have indicated the sick building syndrome to be correlated to irritative symptoms and headache (5). This experiment therefore focused on the dose response relations of these two symptoms. Further their importance for the general well-being is examined because it is expected that irritation of mucous membranes in eyes, nose and throat affects the well-being of subjects and results in tiredness, headache and concentration difficulties. Specific aims was to estimate the thresholds for irritation and headache to be estimated. The threshold concentration for an effect indicates the highest exposure concentration below which no significant variation in effect can be measured if the exposure is varied. Such a threshold may be useful as a guideline for indoor air quality.

1) The first goal therefore was to test if a exposure concentration exists below which exposed subjects would show no or only insignificant irritative symptoms and headache. The effect of adaptation and the exposure-time on these threshold concentrations will be investigated as well.

2) Another aim was to investigate if the sensitivity of the olfactory sense (n. olfactorious) would be reduced due to adaptation when the nose is exposed to irritative compounds.

3) It is expected that continuous exposure to irritating compounds may lead to an increasing sensation of irritation in the mucous membranes due to an increased absorbed dose. It was therefore investigated if such prolonged exposures result in a decreasing feeling of general well-being.

4) A further aim was to intercalibrate the two questionnaires used for measurements of odour and sensory irritation at the Institute of Environmental- and Occupational Medicine (IMA) and The Danish Technical Highschool (DTH).

5) Finally it was the aim to investigate if co-factors or confounders like sex, age, smoking habits, school- and occupational educations had any effect on the human reactions.

II. MATERIALS AND METHODS.

IIa. The exposure.

A number of exposure variables were controlled during the experiments. These (constant) parameters were maintained at the following values: Air change: 10 ACH, air temperature: 22C°, air humidity: 45%RH, Globe temperature: 23C°.

The exposure to VOC in the experiments was established by an exposure to 22 well-known indoor air pollutants of the solvent type. These are all known to be emitted from building materials. This mixture of volatile organic pollutants has been used in a previous exposure experiment (3) and is shown in table 1.

Each of the exposures consisted of the same 22 compounds in the same relative concentrations. Only the total concentration (TVOC) of VOC was changed. The TVOC concentrations were 0, 1, 3, 8 and 25mg/m^3.

No single compound was dominating the exposure and no single compound is expected alone to be able to provoke effects. The highest total exposure concentration 25 mg/m^3 corresponds to the highest concentration found in new danish buildings.(1).

The exposure and dosage was controlled by a calibrated fla-

me ionisation detector (FID-detector) which continuously measured the TVOC-concentration.

II.b. The experimental design.

Each exposure day consisted of five identical treatments of five subjects.

The exposure treatments were arranged in a balanced latin square experimental design. The design is shown in table 2. Each day a new group of five subjects were exposed in the climate chambers to each of the five concentrations (treatments), but in a different sequence. The exposure concentrations were not revealed to the staff or the subjects. The design was thus double blind.

All other exposure variables were intended to be constant during each exposure period. These parameters are shown in table 3. During each of the five treatments the subjects performed the same sequence of air quality evaluations in the exposure chamber.

Baseline measurements under clean air conditions in a separate 30 m^3 stainless steel climate chamber (10 ACH, 23°C, 45%RH) were performed for some of the measurements prior to the first treatment in the morning. These baseline measurements included olfactory selectivity and threshold for n-Butanol. After this acclimatization-period the group of subjects entered the large stainless steel climate chamber (within a few seconds) (80 m^3, 23°C, 45%RH) through an air lock. They went to the other end of the chamber and immediately evaluated the indoor air quality and a number of indoor climate factors in two questionnaires. These questionnaires were the questionnaire used at IMA (3) and the questionnaire used at The Technical University of Denmark (4).

Irritative symptoms were further registered through a linear a-

nalog rating scale (3), called the potentiometer rating or the L.A.R.S. box. These registrations were performed four times (four runs) during each new treatment; the first time immediately after entrance into the climate chamber and subsequently with intervals of fifteen minutes.

Each evaluation run lasted about 5 minutes. Each total exposure treatment in the climate chamber thus had a duration of 50 minutes.

After each exposure treatment the five subjects returned to neutral conditions for 20 min. in the adjaent clean air climate chamber. Here their threshold for n-Butanol was measured again. During this period the exposure concentration in the unoccupied exposure climate chamber was changed according to table 2.

Between the exposure treatment 3 and 4 an extra 20 minutes were allowed for lunch. During this lunchhour the subjects were served food and liquids with no strong taste or odour. No alcohol was allowed.

After lunch another acclimatization period took place in the clean air chamber, this time ten minutes and without measurements. The subjects then went into the exposure chamber for the fourth and fifth exposure period.

Fruit and orangejuice were available for the subjects all day during the rest periods in the clean air climate chambers. During the stay in this clean air chamber the smokers were allowed to leave the building to smoke, when they had performed the odour threshold measurements. The subjects were asked to abstain from smoking as much as possible. They had to note the time, duration and amount of tobacco smoked each time they smoked. Visits to the toilet were allowed in between exposures and after the measurements of n-Butanol sensitivity. The exposure day had a total duration of about 8 hours starting from 8.00 o'clock until 16.00 o'clock.

II.c. The subjects.

The panel of subjects consisted of 25 persons (five subjects for each of five days) who were paid a standard salary. Some of the subjects were selected among subjects who had participated in previous experiments at the institute. Others were recruted among friends. They should all have an acceptable health status and the subjects were supposed to be equally distributed on the four age groups from 16 to 28 years, 29 to 41 years, 42 to 53 years, and 54 to 64 years. The ratio of males to females and smokers to non-smokers was intended to be 1:1. They covered educations from no education to an academic degree. The subjects were randomly divided into five groups of five subjects - one group for each experimental day. Caracteristica of the subjects are summarized in table 4.

The subjects were called by phone the day before the experiment in order to motivate them to appear the subsequent day and to ensure that they were without common cold or other changes in their general health condition.

When the subject first agreed to participate in the experiment they were mailed a questionnaire in which they were asked a number of questions related to factors from their daily life like smoking habits etc. which may be related to their sensitivity to the exposures.

II.d. The measurements.

The analytical registrations and measurements performed are summarized in table 5.

The selectivitity of the n-olfacturous was measured in a procedure according to which the subject had to recognize the well-known odour stimuli like coffee, cinnamon, kerosine, marmelade, cocoa, moth balls, liquorice, soap and menthol (3). The result of this test was rated as the percentage of errors.

Only one subject showed significant reduced selectivity compared to the other subjects. No other deviations were found. The same subject was later found also to have reduced sensitivity to n-Butanol.

Olfaction threshold of n-Butanol was measured in a triangle olfactometer which is a standard instrument for measurement of odour sensitivity (6). In the instrument a number of different dilutions of n-Butanol vapours are presented to the subjects. These measurements are normally reported as the concentration causing 50% of the subjects to perceive an odour. In this experiment the lowest concentration positively recognized by each individual subject was used as his or hers score.

In average the subjects identified level two of n-Butanol. Subjects at level one or two were given the responce score "0" and the rest the responce score "1". The variable based on differences of the scores before and after each exposure (values (-1, 1,0) was analysed.

The linear analogue rating scale (L.A.R.S.-box) was used to register the subjective evaluation of the indoor climate expressed in the question "do you right now feel dryness, itching or a smarting sensation in the nose or eyes?". The subjects rating was indicated on a 58 mm linear potentiometer which could be moved between "no complaints at all" to "unpleasant strong complaints". Each subject had his own box. The rating had to be done each time the two questionnaires had been filled in. The subject were, however, free to change the setting whenever he wanted it. The method has previously been described (3).

The IMA-subjective questionnaire (3) (see appendix A) on general comfort was used to measure the subjective sensation of indoor air quality and well-being. The questionnaire included subject identification, questions related to constant indoor climate factors, questions related to variable indoor climate conditions, questions related to irritation and dryness complaints and questions related to neurological- and psychic complaints.

The questions are shown in appendix A and table 6. The questions were answered in two ways. First a mark on a 60 mm linear analogue rating scale indicated the intensity of the complaints.

Then a cross for "yes" or "no" indicated the acceptability of the condition. The responds were rated as number of millimeters from left end of the rating line to the mark. "Yes" or "No" answer was given the values 0 and 1.

The DTH questionnaire (DTH) (see appendix B) had six questions related to air quality and odour intensity only (4). The questions were related to air quality, odour intensity, irritation in eyes, nose and throat. This questionnaire had two parts (A and B) and was filled in immediately after the IMA questionnaire. The questionnaire included a linear analogue rating scale with well-defined end-points, but with another length than the IMA questionnaires and with five intervals indicated on the line with six verbal gradings for each of the complaints. The subjects were instructed that the whole line and not only the verbal gradings were to be used for the votation. The intensity was measured as the mm of the rating mark length from one end of the line. "Yes" and "No" answers were used to measure acceptability of the same questions. They were given values "0" and "1".

Both questionnaires were collected immediately after they had been filled in and the subjects therefore could make no direct references to previous ratings.

II.e. Statistical analysis.

The statistical analysis differs for the discontinuous and continuous variables measured in this experiment. The discontinuous variables were the answers "Yes" and "No" for acceptability on the IMA-questionnaire, the question 1 and 6 in the DTH questionnaire and the Butanol Triangle Olfactometer which had 7 possible outcomes. The discontinuous variables were all examined in a chi^2 analysis.

When the expected number of data in each cell of the 2 x 2 contingens tables were less than five Fishers exact test (7) was used. A significance level of five procent was adapted in these analysis.

The continuous variables which were the line measures in the IMA questionnaire, the questions 2, 3, 4 and 5 in the DTH questionaire and the potentiometer registrations were examined in an analysis of variance. The statistical analysis were performed as F-tests, and a five procent level of significance was used.

In the analysis of variance, the concentration (0, 1, 3, 8 and 25 mg/m^3), subject number, day and time of the day, treatment number was used as parameters of interest in the analyses while age and sex, smoking habits, school- and occupational education were used as explaining variables.

The statistical analysis were done with Genstat (8) and SPSS (9).

The term dose-effect will be used if differences were significant between the five levels of exposure (treatments). The term concentration group is used for the five groups of pooled results of all the 25 persons from the exposures to 0, 1, 3, 8 or 25 mg/m^3 respectively disregarding that the pooled results were obtained at different times during the day.

III. RESULTS.

III.a. Exposures.

The exposure of the subjects in the climate chamber was performed as planned in table 2 and only minor deviations were observed from the intended values shown in table 2 which shows the average exposure levels. Only level 3 was significantly different from the intended concentration (3 mg/m^3) as the concentration in average was 2.84 mg/m^3 (SD: 0.09).

A number of indoor climate variables were continuously monitored during the experiment to show if any excessive variation in the indoor climate conditions occured.

The average for parameters in each exposure group did not differ significantly. Some of these measurements were not analysed statistically in detail due to an obvious stability of these variables. Table 3 shows average and standard variations of air temperature, air humidity and globe temperature.

III:b. Discontinuous measurements.

Butanol thresholds was measured 6 times during the day. The first measurement was used as a baseline for the values obtained after each of the five exposures throughout the day.

The olfactory sensitivity was expected to decrease as the exposure concentration increased. No such relation was found between the exposure and the sensitivity of olfactory. The results indicate that smoking habits, sex and age did not affect the olfactory sensitivity.

The IMA-questionnaire included discontinuous values for "Yes" or "No" acceptability for lighting, sound level, air temperature, air humidity and air movement which were supposed to be constant. No dose effect was found although a difference was found between the responses of men and women. More women than men found conditions in the chamber unacceptable. This tendency reappeared in questions 10, 11, 16, 19, 20, 21, 22, 23 and 24 (see table 6 and appendix A & B for identification of questions). The tendency was the same in each exposure group and is supposed to reflect a difference in the use of the word "acceptable" between men and women and not a dose-exposure-effect. The time of the day for the exposure had no impact on the results. Neither had school education.

The results from the Chi² test of dose-effect is summarized in table 6 and 7. A dose-effect was found for the questions IMA 8, 9, 27, DTH1, DTH6 and in run 2 and 4 for IMA26. For these six questions the number of no "Yes" answers were increasing with the exposure concentration as exemplified on figure 1 and 2 which shows the effect of exposure on IMA 8: air quality, IMA 9: odour intensity. DTH 1: air quality and DTH 6: irritation of eyes.

A tendency was found for a co-factorial interaction of occupational education in questions IMA 9, DTH1 and DTH6. If each category of occupational education is considered, only occupational education level 2 corresponding to more than zero and less than four years occupational education allows a conclusion. Too few observations are found in the other catagories. The dose-effects found are the same if only subjects in occupational education 2 are considered.

A difference was found in scores for smoker and non-smokers for the questions IMA 8 to IMA 11, IMA 17, IMA 26, IMA 27, DTH1 and DTH6. Smokers more often voted non-acceptance than non-smokers. If the differences from each of the two groups, smokers and non-smokers, are analysed separately, smokers are found to react more strongly than non-smokers as shown in table 8.

Differences in scores among the four age groups used in the analysis were found for all questions. Younger subjects had a higher level of non-acceptance for questions showing a dose effect. Only subjects belonging to the age group 16 to 28, 29-41 and 42-53 years can, however, be used in this analysis as the group 54-64 years contained too few observations. Table 9 shows of an analysis containing the three youngest age-groups. Only in the age-group 29-41 years is the dose-effect still found. An increasing number of non-acceptance with increasing exposure was, however, also found in the two other age-groups.

The analysis of the confounders showed confounding effect of occupational education, smoking habits and age, for most of the questions showing significant dose effect. However, the number of observations in these non-continuous measurements were in most cases too small to allow an acceptabel statistical analysis.

III.c. Continuous measurements.

The potentiometer rating: Subjective ratings of the intensity of irritation in eyes and nose were done on a linear potentiometer. The resulting ratings were reduced to an average for each exposure period (treatment), see figure 3. A variance analysis was performed including person, day, dose and exposure period as factors while sex, age, smoking habits, school and occupational education were used as explaining variables. The statistical analysis showed that only age and smoking habits were needed to explain the variations. The ratings on the linear rating scale were higher for smokers and increased by increasing age of the subjects. The final analysis of variance including smoking habits and age as explaining variables showed a significant effect of doses ($p < 1\%$).

The analysis showed that only the average potentiometer ratings at concentrations 8 and 25 mg/m^3 were significantly different from the average ratings at 0 mg/m^3.

A linear regression model using the logarithm of the exposure concentrations as the regression variable indicated that the response increased linearly with the logarithm of the concentration.

Each exposure period lasted 50 min. Figure 4 shows the variation for each of the five exposure levels. No adaptation appears to be present. On the contrary the ratings at lower exposure levels seem to increase with increasing exposure time. This, however, also appears for the clean air.

Statistical analyses of the continuous variables on IMA- and the DTH-questionnaires are summarized on table 10. The analysis of variance was performed on the raw data obtained directely from the questionnaires. The analysis included person, day, dose, exposure period as explaining factors while sex, age, smoking habits, school and occupational education was used as explaining variables. These explaining variables turned out to have no significant effect on the results shown in Table 10.

Figure 5 shows the average differences between clean air exposure and exposure for each exposure level. The analysis of the average responses in the five exposure groups showed that only some of the questions on the questionnaires were significantly related to the exposure. The average response for each dose minus the average value in clean air was tested for dose dependency.

Dose-response curves were established for each questions showing significant dose response. For the questions IMA 8 to IMA 11, IMA 14, IMA 17, IMA 25 to IMA 27 and for DTH5 a linear dose response was found for the logarithm of exposure concentrations. For DTH3 a linear response was found for the square root of the doses, as shown in figure 7.

IV. DISCUSSION

IV.a. The experimental set up.

Two major aims of this experiment were the determination of the dose-respond relations for air quality reduction due to exposure and the intercalibration between odour and irritation measures used at the DTH and our institute (IMA). The design of the experiment therefore focused on both dose-response relationships and a number of possible confounders are only used as explaining variables.

This experiment therefore does not reveal to what extent the odour impression affects the intensity of complaints about mucous membrane irritation, nor the extend to which temperature, humidity, illumination etc. influence the sensation of mucous-membrane irritation. The mucous-membranes does not only react to air pollution, but may also react to dryness. Atopic or allergic persons may further react differently than non-allergic persons. Such effects were not investigated. Neither was the possibility of an objective changed memory due to the exposure as indicated in previous experiments.

Further the experiment only focused on acute or sub-acute reactions results from a one hour exposure. The experiment did not deal with reactions due to chronic or accumulated exposure.

The exposure in the climate chamber was arranged according to a double blind design and the subjects were not allowed to discuss the exposure conditions in the climate chamber and their reaction to these exposures. Even during clean air exposure, a distinct background odour was noticeable for both subjects and experimentors in the climate chambers. A majority of the subjects found this unacceptable. This background odour was probably due to highly odourous impurities in the exposure chemicals. These impurities were absorbed by chamber surfaces during exposures and subsequently reemitted during clean air exposures. The absolute concentration of these strong odourants was neglectable. These odours reduced the possibility of an experimental bias to a minimum.

The experimental design reduced the possibility of different reaction to the exposures on different week days and of different times of the day. No such effect was therefore found in the statistic analysis. Some of the measured variables (IMA 10,11,14,17 and DTH 5) had a tendency to show the highest effect of the exposure in the second exposure period. If this is a true effect, it may be deduced that the subjects were most sensitive for irritation between 10 and 12 a.m.

There were no deviations from the planned experimental design. Only the total exposure concentration of 3.0 mg/m³ deviated from the intended value as a concentration of 2.84 mg/m³ ± 0.09 mg/m³ was obtained. All other intended constant indoor climate parameters like temperature, humidity etc. were so close to intended values that further statistical analysis was considered unnessecary.

The groups of subjects were composed to have the same ratio of smokers to non-smokers, males to females and had a broad representation of occupational- and school education. Further there were equal numbers of representatives of the four age groups from 16 to 46 years. Subjects failing to appear on the intended exposure-day were replaced by other similar subjects. This procedure was succesful on the four first exposure days, but on the fifth day the subjects were generally younger and were all non-smokers. This was due to missing proper substitute persons. The three dimensional contingency tables contained in some cases too few observations. As the result the CHI^2- test may be unreliable in these cases. This is indicated in the text where it appears.

One subject performed very poorly in measurements of the Butanol sensitivity. The subject was allowed to participate in the experiment despite this. This subject did not differ from the other subjects in other measurements.

Very few subjects smoked during the experiment and their consumption was so low that no statistical analysis was possible of this co-variable.

The general conclusion about the experimental conditions is that few deviations from the intended experimental design occured and that they were so minor that they did not compromise the experiment and its intentions.

IV.b. The hypothesis.

Hypothesis 1: Does a threshold exist. The questions of the questionnaires showing a significant dose response relationship had different thresholds for the effects. Table 11 summarizes the results. The questions related to odour intensity (IMA9 and DTH5) showed a significant response at 3 mg/m³, and the responses increase with increasing concentrations. The questions related to air quality and the need for ventilation (IMA8 and IMA27) showed significant responses at 8 mg/m³ and an increasing response for increasing concentrations. Questions related to irritation of eyes, nose and throat (IMA 10, IMA11, IMA17, IMA25, IMA26 and DTH3) indicated a significant response at the concentrations 25 mg/m³. In all cases the general trend indicated an effect also at lower concentrations. This trend would probably have been significant if more subjects had been examined or larger exposure time used.

The potentiometer ratings of dryness, itching and smarting of eyes and nose showed a significant response at 8 mg/m³. This response increased with increasing exposure concentration.

The lower threshold obtained with the potentiometer when compared to similar questions in the questionnaires is explained by the greater sensitivity of this type of measurement. The subjects reactions indicate that a significant odour is registered at a concentration of 3 mg/m³, although an unpleasant odour is observed only at concentrations at or above 8 mg/m³ where the need for ventilation is significant. Irritation of the mucous membranes is significant only at concentrations at, or higher than 8 mg/m³. This indicates that the lower limit for complaints due to this type of air pollution in general living spaces is at or below the concentration 3 mg/m³. It should, however, be noted that this conclusion only referes to short term exposure of fifty minutes duration. (See discussion of hypothesis 5).

The hypothesis 2: Calibration of the two questionnaires. No general conversion function between DTH questions and IMA questions could be established. The ratio of Yes and No answers were, however, similar for the two types of questionnaires at all exposure levels.

It appeared that subjects when using linear rating had a higher threshold for irritation etc. on the DTH questionnaire, but approached the maximum response at a lower concentration. On the IMA questionnaire they seemed to have a wider dynamic range of responses and a higher sensitivity.

Hypothesis 3: Adaptation. No reduced sensitivity of the olfaction was seen in the n-Butanol test. Such an effect was seen in a previous exposure experiment (3) and it is not clear if the missing effect is a result of the design with short duration exposure repeated several times through the day or due to other factors.

Hypothesis 4: Irritation is related to the feeling of wellbeing. The continuous evaluation of the question IMA 25 of the general well-being showed a dose-effect indicating the possibility of a changed perception of general well-being of subjects. This question correlated to the IMA questions on irritation of mucous membranes, odour intensity, air quality and the desire of ventilation, which indicates that irritation is an important part of general well-being.

Hypothesis 5: Effect of exposure time. For questions related to odor intensity, dryness, stinging and smarting of the eyes (IMA11) and the need for ventilation (IMA27) an increasing response is observed at 1, 3, 8 and 25 mg/m³ with increasing exposure time (run 1 to run 4). This indicates that longer exposure periods than the fifty minutes used here could have resulted in lower thresholds for response. It further indicates that an accumulation of VOC exposure may occur. No "carry over" effect was, however, seen.

No significant effect was found of the time of the day for the different exposure-levels. An indication of higher sensitivity between 10 and 12 AM was found. We had expected a "carry-over"--effect of high exposure concentrations in such a way that high exposure concentration would have been followed by higher effects of preceeding lower exposures. Similarly we unexpectedly found no effect of exposure on the sensitivity of the olfactory sense.

The hypothesis 6: Co-factors. Table 12 summarizes the cofactors identified in this experiment.

Discontinuous measurements: The analysis tested if sex, occupational- and school education, age and smoking habits were confounders for the odor threshold measurements.

The questions IMA3-7 were not expected to be related to exposure. No such effect was found, but women were generally more sensitive as more women rated "not acceptable" than men. The same tendency was found for questions IMA 10, 11, 16, 19 to 24. This tendency was found for all concentrations which was interpeted as a difference in level of acceptability and not as a difference in the dose-response relation.

There was no effect of school education on the intensity of the reactions. The level of previous occupational exposure affected the responses of subjects in questions IMA 9 and on DTH 6 and 1. This, however, could only be tested for subjects with from zero to four years of occupational education. This confounding effect may indicate that subjects with higher education responded with more non-acceptable evaluations. Only for the educational zero to four years was, however, a sufficiently large number of observations available.

Smoking habits were expected to reduce the sensitivity of the mucous-membranes to irritants. In contrast to this we found that smokers responded stronger than non-smokers to the questions on IMA questions nr. 8 - 11, 17, 26 and 27 and on DTH questions nr. 1 and 6. The dose effect disappeared in certain questions for non-smokers and was reduced for smokers. Smokers may have both a stronger reaction to air exposure levels and a lower threshold for reactions. The dose effect disappeared on certain questions for non-smokers and was reduced for smokers.

The age of subjects confounded the results too. On all questions where a significant dose-effect was found that older people responded less than younger people. In the group 48 to 64 years, however, too few observations were available.

Continuous measurements: A dose effect with a linear dose-response relationship between the logarithm of the response and exposure was found for continuous measurements in the IMA questionnaire, questions 8 - 11, 14, 17, 25 - 27 and in the DTH questionnaire, question 5. In DTH question 3 the dose response was a linear function of the square root of the doses. None of these questions was effected by age, sex, smoking habits or occupation.

On the linear analogue rating scale (the L.A.R.S. potentiometer) smokers and older subjects responded more than other subjects. No effect was found of sex, occupation status or school education.

It was investigated if the IMA or the DTH questionnaire could identify subjects who were hypersensitive to VOC exposure. Four such subjects were identified. These subjects also reacted most strongly in the potentiometer test. These subjects included one man and three women, three smokers and one former smoker. One of these had had asthma and was often affected by bad indoor climate in the form of dry mucous membranes, tiredness, sluggishness, cough and stuffy nose (nasal congestion).

Both this subject and one of the three others often experienced difficulty in breathing. No statistical evidence could, however, be drawn from this small group of subjects.

Table 13 shows the variation of responses with concentration in the four runs of each treatment. The analyses of differences (contrasts) between responses to exposures and clean air showed that increasing exposure time caused increased significance of response in IMA 9, 11, 27. Figure (8 + 9) shows, however, that odour intensity (IMA 9) and air quality (IMA 8) decreased with increasing exposure time. An adaption is therefore indicated. Such an adaptation was also found IMA 27: "Ventilation needed" and DTH 5: "Odour intensity".

The consistency of answers to each IMA question was examined by a comparison to answers to another question which may be supposed to correlate and to one which may not be expected to correlate. The results are shown in table 14. Most of the results shown in table 14 confirm the initial hypothesis that some of the questions are correlated and others not.

Some diviations from the expected correlations in table 14 are, however, observed. Ratings of illumination and sound level which was constant turned out to be correlated with headache. Illumination and sound level may therefore directly or indirectly influence the subjects' probability of developing a headache due to the VOC exposure. Alternatively subjects may react more strongly to unfavorable light and sound intensities when they have a headache.

In future experiments it will therefore be important to test if this is a true effect and to arrange the exposure in such a way that questions related to headache, sluggishness, tiredness and dizziness are used only when illumination and sound levels are constant and optimal. Another unexpected correlation was found between rating of the physically constant sound level, and the feeling of sluggishness, tiredness or dizziness. The reason for this interaction cannot be explained.

A significant correlation was found between general well-being (IMA 25) and irritation of mucous membranes, odour intensity, air quality and the need for ventilation.

The feeling of sluggishness correlated with irritation of mucous membranes and need for ventilation, but not with odour intensity and air quality. The feeling of tiredness and sleepiness correlated with irritation, but not with odour intensity, air quality and ventilation. Headache only correlated to irritation of eyes. No correlations were found for ability to concentrate.

No correlations were found between temperature in the room, skin temperature on the body or in the face, the level of sweating of the subjects, air humidity or air movement. Nor was a correlation found between irritation or itching in the facial skin and the perception of general well-being or irritation in eye, nose or throat. This lack of correlation may be due to the possibility that these skin areas are affected by different irritant compounds or that the thresholds for different irritants vary.

The acceptabiliy ratings (Yes/No) and intensity ratings (mm) for each questionnaire were compared. Figure 10 shows for air quality (IMA 8) and irritation of nose (IMA 17), that the two different rating methods yield the same results. Such consistent relationships were found for questions IMA 9, 10, 11, 14, 21, 22, 25, 26, 27 and DTH5 with DTH6. Too few observations made conclusions impossible on other questions.

Table 15 shows the correlation between answers to the two questionnaires. The correlation was calculated for each of the treatments as the results could not be pooled. In the table +2 to -2 it is indicated that a correlation was found in respectively almost all and almost none of the treatments. DTH questions on odour intensity and eye, nose and throat irritation were highly correlated to their direct IMA counter-parts.

They are, however, also correlated with the three other similar IMA-questions. All four DTH questions also correlated with other IMA questions like air quality (IMA 8), sluggishness (IMA 21), dizziness (IMA 22), headache (IMA 24) and general well-being (IMA 27). It therefore appears that neither of the questionnaires specifically addresses any single aspect of indoor climate.

Acknowledgement.

The project was performed in cooperation with prof. P.O. Fanger, Lab. for Heating and Air Conditioning, The Technical University of Denmark (DTH).

References.

1) Mølhave, L.: Indoor air quality in relation to sensory irritation due to volatile organic compounds; paper 2954 dec. 1986; ASHRAE Transactions v. 92(1); 1986, paper 2954.

2) Mølhave, L.: Indoor air pollution due to organic gases and vapours of solvents in building materials; Environment International, 1982, p. 117-127.

3) Mølhave, L., Bach, B., Pedersen, O.F.: Human reaction to low concentrations of volatile organic compounds; Environm. Internat. Vol 12 p. 167-175, 1986.

4) Fanger, P.O., Lauridsen, J., Bluyssen, P., Clausen, G.,; Air Pollution in Offices and Assembly Halls quantified by the Olf Unit. Energy and Building 12 (1988) p. 7-17.

5) Mølhave, L.: Indeklima og Sundhed. Thesis for medical PhD. submitted to the Medical Faculty, University of Aarhus, 1988. (In danish with english summary).

6) Dravnieks, A., Prokop, W.H.; Source emission measurements by a dynamic forced Triangle of olfactometer; APCA Journ. 25.1:3-10 1975.

7) Clark, R.E.: Critical values in 2 x 2 tables. Periodic series. The department of sociology, Pennsylvania State University, USA, 1969.

8) Genstat: A general statistical program. Rothansted Experimental Station, Harpenden, England 1977.

9) SPSS: SPSS-manual, MC.Graw-Hill, 1975, 2.ed.

Table 1. List of 22 exposure compounds and their relative concentrations.

Compound	Weight ratios
n-Hexane	1
n-Nonane	1
n-Decane	1
n-Undecane	0.1
1-Octene	0.01
1-Decene	1
Cyclohexane	0.1
3-Xylene	10
Ethylbenzene	1
1.2.3. Trimethylbenzene	0.1
n-Propylbenzene	0.1
Alpha-Pinene	1
n-Pentanale	0.1
n-Hexanale	1
Iso-propanole	0.1
n-Butanole	1
2-Butanone	0.1
3-Methyl-2-Butanone	0.1
4-Methyl-2-Pentanone	0.1
n-Butylacetate	10
Ethoxyethylacetate	1
1.2. Dicholrethane	1

Table 2: The experimental design for five treatments (mg/m^3) on each of five experimental days.

day		1	2	3	4	5
Treatment number	1	3	1	0	25	8
	2	25	8	3	1	0
	3	1	0	25	8	3
	4	8	3	1	0	25
	5	0	25	8	3	1

Table 3: Intended and obtained values of experimental parameters.

Parameter	intended Value	obtained (x ± SD) Value	unit
Air change	10	10 ± 5%	h^{-1}
Air temperature	22,0	22,5 C° ± 0,2	°C
Globe temperature	23,0	23,0 ± 0,2	°C
Air humidity	45,0	45,2 ± 1,1	%RH
VOC (C1)	0	0.14 ± 0,13	mg/m^3
(C2)	1	1,08 ± 0,14	mg/m^3
(C3)	3	2,8 ± 0,08	mg/m^3
(C4)	8	8,2 ± 0,58	mg/m^3
(C5)	25	25,3 ± 0,43	mg/m^3

Table 4.

Average characteristic parameters for the 25 subjects.

Variable	Unit	Average of 25	SD
Sex	M=1 F=2	1.52	0.51
Age	Years	36.3	13.2
Smoker	daily 1, occationally 2, non smoker 3	1.96	1.02
Matrimonial status	single 1, cuple 2	1.76	0.44
Report often complaints about			
A. Indoor climate	yes 1, no 2	1.84	0.37
B. Dry mucous-membranes	yes 1, no 2	1.75	0.44

Table 5.

Analytical registrations and measurements.

1) Olfactometric selectivity of odour sense (3).

2) Odour threshold for n-Butanol, (5).

3) Linear analogue rating scale for subjective indoor climate complaints (L.A.R.S. box), (3).

4) Questionaire (IMA) on subjective comfort and general well-being, (3).

5) Questionaire (DTH) on indoor air quality and odour, (4).

6) Questionaire mailed to each subject prior to the experiment (3).

7) Measurements performed from the controlroom.

   a) exposure concentration and duration.

   b) air temperatures, humidity, air exchange and globe temperature.

Table 6. The relation between answers of "Yes" and "No" acceptability (Y/N) and the exposure concentration.

Questions		X^2 test
IMA3-7	Constant indoor climate variables	-
IMA8	Air quality	+++
IMA9	Odor intensity	+++
IMA10-13	Complaints related to eyes and skin in face	-
IMA14	Irritation in throat and nose	-
IMA15	Cough	-
IMA16	Shortness of breath	-
IMA17	Nose irritation	*)
IMA18	Running nose	-
IMA19	Skin temperature	-
IMA20	Excessiv sweating	-
IMA21	Mental tiredness, heavy head, sluggishness	-
IMA22	Physical tiredness	-
IMA23	Sleepiness	-
IMA24	Must concentrate to perform	-
IMA25	Headache	-
IMA26	General well being right now	*)
IMA27	Irritation level in nose and throught	*)
IMA28	More ventilation needed	*)
DTH1	Air quality acceptability	+++
DTH6	Odour intensity	+++

+++ P < 1.0%
++ 1% < p < 2.5%
+ 2.5% < p < 5.0%
o 5% < p < 10%
- p > 10%

*) See table 6.

Table 7. CHI^2-test for significance of dose-responces in questions IMA17, IMA26 and IMA27 on the general comfort questionaire (Yes/No-question). The test probability of the CHI^2-test is shown. See table 6 for identification of questions.

Questions	run 1	run 2	run 3	run 4
IMA17	9%	10%	16%	12%
IMA26	7%	0.4%	17%	4%
IMA27	4%	1%	0.7%	0%

Table 8. Significance for the Yes/No question of acceptability corrected for differences in smoking habbits. See table 6 for identification of questions. The four runs refer to four runs in each exposure period.

Questions		run 1	run 2	run 3	run 4
IMA8	smokers	2.4%	1.8%	3.1%	1.0%
	non-smokers	10.3%	7.1%	2.2%	1.7%
IMA9	smokers	0.1%	0.01%	0%	0.4%
	non-smokers	0.4%	0.2%	2.2%	1.7%
IMA17	smokers	24.0%	26.9%	27.3%	19.9%
	non-smokers	16.0%	30.4%	73.5%	61.1%
IMA26	smokers	4.3%	1.5%	36.0%	14.5%
	non-smokers	22.2%	4.3%	31.1%	2%
IMA27	smokers	2.8%	2.5%	0.1%	0.04%
	non-smokers	32.9%	24.5%	60.2%	3.4%
DTH1	smokers	1.0%	0%	0%	0.01%
	non-smokers	1.0%	4.0%	14.8%	5.8%
DTH6	smokers	0.6%	0.01%	0%	0.03%
	non-smokers	1.6%	2.5%	14.8%	1.1%

Table 9. Significance of Yes/No questions related to general comfort. The analysis is corrected for differences in age. See table 6 for identification of questions.

Questions	age-group	run 1	run 2	run 3	run 4 1
	1	37.2%	53.3%	24.9%	12.7%
IMA8	2	5.3%	0.03%	0.05%	0.07%
	3	10.1%	69.5%	47.3%	63.0%
	1	26.9%	10.5%	0.6%	14.5%
IMA9	2	0.05%	0.07%	0.01%	0.2%
	3	0.9%	10.7%	52.3%	20.3%
	1	45.3%	32.9%	15.0%	1.2%
IMA17	2	5.7%	7.3%	1.4%	10.7%
	3	16.9%	70.4%	85.6%	30.4%
	1	45.3%	42.6%	59.0%	56.5%
IMA26	2	7.3%	2.7%	1.8%	4.2%
	3	48.6%	58.3%	72.4%	33.6%
	1	60.8%	68.3%	67.6%	39.1%
IMA27	2	40.6%	24.6%	2.5%	0.2%
	3	30.0%	6.2%	30.0%	17.2%
	1	47.4%	16.4%	5.0%	9.3%
DTH1	2	6.2%	0.03%	0.1%	0.2%
	3	10.7%	4.7%	40.6%	7.3%
	1	10.3%	6.1%	2.5%	1.2%
DTH6	2	9.8%	0.05%	0.1%	0.4%
	3	1.7%	5.0%	47.3%	17.7%

Age groups: 1 = 16-28 years
2 = 29-41 years
3 = 42-53 years
4 = 54-64 years (too few observations)

Table 10. The comfort questionnaire (DTH & IMA). Variance analyses on raw data from linear analog rating scale (L.A.R.S.)

L.A.R.S.	Run 1	Run 2	Run 3	Run 4
IMA8	+++	+++	++	+++
IMA9	+++	+++	+++	+++
IMA10	-	-	++	++
IMA11	-	0	+	+++
IMA14	+	+++	-	0
IMA17	+++	+++	+++	++
IMA21	-	-	-	0
IMA22	-	-	-	-
IMA23	-	-	-	-
IMA25	++	++	-	-
IMA26	+++	+++	+++	+++
IMA27	+++	+++	+++	+++
DTH3	+++	+++	+++	+++
DTH5	+++	+++	+++	+++

+++ P < 1.0%
++ 1% < P < 2.5%
+ 2.5% < P < 5%
0 5% < P < 10%
- P> 10%

Table 11. Lowest exposure concentration-threshold leading to significant effects in this experiment.

Variable	Lowest effect level mg/m³
Odour (IMA9 + DTH5)	3
Air quality (IMA8)	8
Need for ventilation (IMA27)	8
Irritation in throuth (IMA17)	8
Irritation in eye, nose,throuth (pot.meter)	8
Irritation eyes IMA10	25
nose IMA11	25
Headache IMA25	25
General well-being IMA26	25
Nose irritation DTH3	25

Table 12. List of identified Co-factors

Cofactors	Related to	
Sex	Air movements	(IMA 7)
	Eye irritation	(IMA 10)
	Drynes etc.	(IMA 11)
	Shortness of breath	(IMA 16)
	Body temp.	(IMA 19)
	Sweating	(IMA 20)
	Sluggishness	(IMA 21)
	Dizziness	(IMA 22)
	Diffucult to concentrate	(IMA 23)
	Headache	(IMA 24)
Age	All questions and potentiomter	
School education	----	
Occupational education	Odour intensity	(IMA 9)
	Odour acceptability	(DTH 6)
	Nose irritation	(DTH 3)
Smoking habits	Air movements	(IMA 7)
	Odour quality	(IMA 8)
	Air quality	(IMA 9)
	Eye irritation	(IMA 10)
	Dryness etc.	(ImA 11)
	Nose irritaiton	(IMA 17)
	Irritations of mucous membranes	(IMA 26)
	Ventilation need	(IMA 27)
	Air quality	(DTH 1)
	Odour intensity	(DTH 6)
	Irritation Pot. meter	

Table 13. The IMA questionnaire; the analyses of contrasts.The table shows significances of the differences between the response to exposure concentration X mg/m³ and the clean air exposure.

Stregmål	Run nr.	C2	C3	C4	C5
	1	-	-	+	+++
IMA8	2	-	-	0	+
	3	-	-	0	+
	4	-	+	+	++
	1	-	-	++	+++
IMA9	2	-	+	+	+++
	3	-	+	++	+++
	4	0	++	+++	+++
	1	-	-	-	0
IMA10	2	-	-	-	-
	3	-	-	-	+
	4	-	-	-	+
	1	-	-	-	0
IMA11	2	-	-	-	0
	3	-	-	0	+
	4	-	-	+	++
	1	-	-	-	0
IMA14	2	-	0	-	+
	3	-	-	-	-
	4	-	-	-	0
	1	-	-	+	++
IMA17	2	-	0	-	++
	3	-	0	+	++
	4	-	-	0	+
	1	-	-	-	-
IMA21	2	-	-	-	-
	3	-	-	-	0
	4	-	-	-	0

Table 13 continued.

Stregmål	Run nr	C2	C3	C4	C5
	1	-	-	-	-
IMA22	2	-	-	-	-
	3	-	-	-	-
	4	-	-	-	-
	1	-	-	-	-
IMA23	2	-	-	-	-
	3	-	-	-	-
	4	-	-	-	-
	1	-	-	-	+
IMA25	2	-	-	0	+
	3	-	-	-	0
	4	-	-	-	0
	1	-	-	-	++
IMA26	2	-	+	+	+++
	3	-	0	0	+
	4	-	-	-	++
	1	-	-	+	+++
IMA27	2	-	0	+	+++
	3	-	+	+	+++
	4	0	0	+	+++
	1	-	-	+	++
DTH3	2	-	-	0	+
	3	-	-	0	+
	4	-	0	0	+
	1	-	+	+++	+++
DTH5	2	-	+++	++	+++
	3	-	+	+++	+++
	4	-	++	+++	+++

+++ P < 1.0%
++ 1% < P < 2%
+ 2% < P < 5%
0 5% < P < 10%
- P > 10%

Table 14. Test of correlations between IMA questions.

	Expected correlation	no correlation expected
IMA 3. Illumination	Headache +2	Shortness of breath -2
IMA 4. Sound level	headache +1	air change -1
IMA 5. Air temperature	body temperature -1	shortness of breath -1
IMA 6. Air humidity	sweating -1	illumination -1
IMA 7. Air movement	facial temp. -1	illumination -1
IMA 8. Air quality	air change +2	illumination 0
IMA 9. Odour intensity	air quality +2	illumination -1
IMA 10. Eye irritation	dryness, smarting, ithcing of eyes +2	sound level 0
IMA 11. Dryness, smarting, ithcing of eyes	irritation in eyes/ nose /throat +2	sound level -2
IMA 12. Facial temperature	sweating -1	sound level 0
IMA 13. Irritation/itching of facial skin	irritation in eyes/ nose/throat -1	sound level -1
IMA 14. Irritation of throat	cough +1	sound level -1
IMA 15. Cough	irritation in throat +1	sound level -2
IMA 16. Shortness of breath	irritation in throat +1	illumination -2
IMA 17. Irritation, dryness of nose	irritaion in eyes/ nose/throat +2	illumination -1
IMA 18. Running nose	irritation in eyes/ nose/throat 0	illumination 0
IMA 19. Body temperature	sweating 0	illumination -1
IMA 20. Sweating	facial temp. -1	illumination -1

Table 14 continued.

IMA 21. Sluggishness	dizziness +2	sound level +1
IMA 22. Dizziness	lack of koncen-tration +1	sound level +1
IMA23. Lack of concentration	sluggishness +1	illumination 0
IMA 24. Headache	sluggishness +2	air movement 0
IMA 25. General well beeing	irritation in eyes/ nose/throat +2	illumination 0
IMA 26. Irritation in eyes, nose and throat	ventilation needed +2	sound level -1
IMA 27. Ventilation needed	odor intensity +2	illumination -1

Significant:

+2	correlated in almost every test.
+1	correlated in most test
0	no conclusion
-1	no correlation in most tests.
-2	correlations only in very few tests.

Table 15. Correlation between the IMA-questions and the questions on eye irritation, nose irritation, throat irritation and odour intensity as measured with the DTH-questionnaire. (L.A.R.S.-scale).

	Eye irritation (DTH2)	nose irritation (DTH3)	throat irritation (DTH4)	odour intensity (DTH5)
IMA3 Illumination	-2	-1	-1	-2
IMA4 Sound level	-1	0	0	+1
ImA5 Air temp.	-2	-2	-2	-2
IMA6 Air humidity	-2	0	-2	-2
IMA7 Air movement	-2	-2	-2	-2
IMA8 Air quality	+1	+2	+2	+2
IMA9 Odour intensity	+2	+2	+2	+2
IMA10 Eye irritation	+2	+2	+2	+2
IMA11 Dryness,smarting ithcing of eyes	+2	+2	+2	+2
IMA12 Facial skin temp.	-2	-1	-2	-2
IMA13 Irritation/itching of facial skin	-2	0	-2	0
IMA14 Irritaion of throat	+2	+2	+2	+2
IMA15 Cough	-2	-2	-2	0
IMA16 Shortness of breath	+1	0	0	+1
IMA17 Irritation/itching or dryness of nose	+2	+2	+2	+2
IMA18 Running nose	-1	-1	0	-1
IMA19 body temp.	-2	-2	-2	-2
IMA20 Sweating	-1	-1	-1	+1

Table 15 continued.

IMA21 Sluggishness	+2	+2	+2	+2
IMA22 Dizziness	+2	+2	+2	+2
IMA23 Lack of concentration	-1	-2	-1	-2
IMA24 headache	+1	+1	+1	+1
IMA25 General well-beeing	+2	+2	+2	+2
IMA26 Irritation in eyes,nose or, throat	+2	+2	+2	+2
IMA27 Ventilation needed	+1	+2	+2	+2

Figure 1. The effect of exposure concentrations 0, 1, 3, 8 and 25 mg/m³ on subjective rating in run 4 of acceptability of a) IMA 8 air quality and b) IMA 9 odour intensity. The ordinate is % responding "Yes".

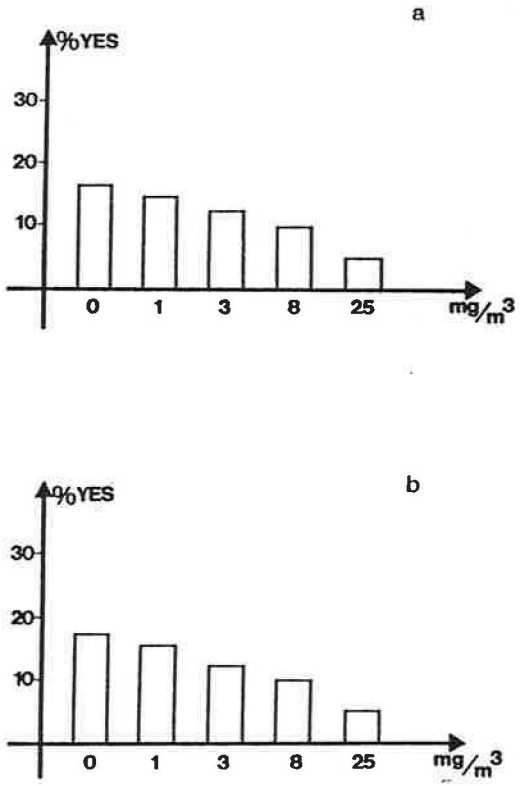


Figure 2. The effect of exposure concentration 0, 1, 3, 8 and 25 mg/m³ on the 25 subjects rating of acceptability in run 4 of the DTH 1: air quality and DTH 6 odour intensity. The abscissa is exposure concentration in mg/m³ and the ordinate % responding "yes".

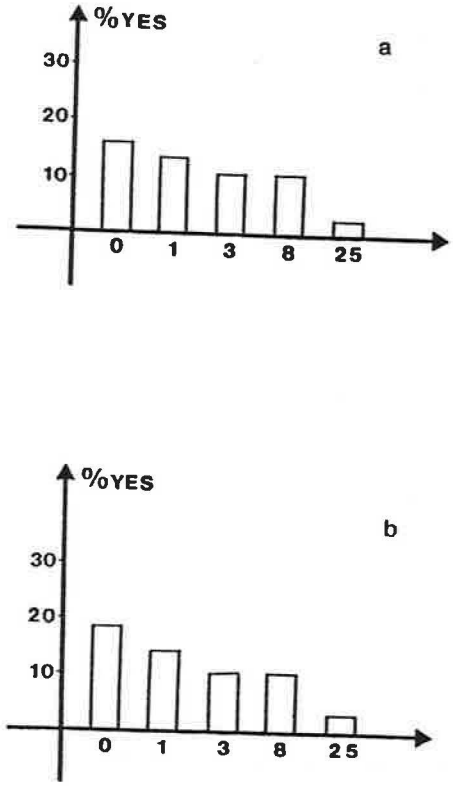


Figure 3. Potentiometer registration (L.A.R.S.-scale) of discomfort for all 25 subjects. The ordinate is average response over the whole exposure period of potentiometer setting in mm (Fullscale = 60 mm). The abscissa is exposure-level 0, 1, 3, 8 and 25 mg/m³.

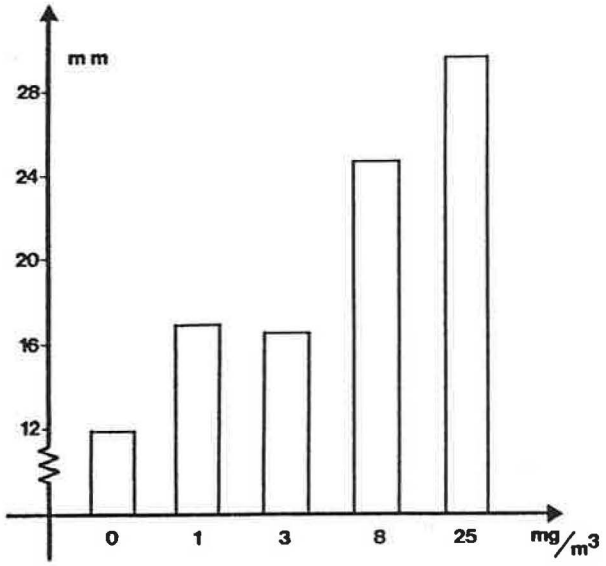


Figure 4. The variation through one exposure period (50 min.) of the ratings (potentiometer setting in mm (Fullscale = 60 mm) on irritation in eyes, nose and throat at each of the five exposure levels. 0, 1, 3, 8 and 25 mg/m³.

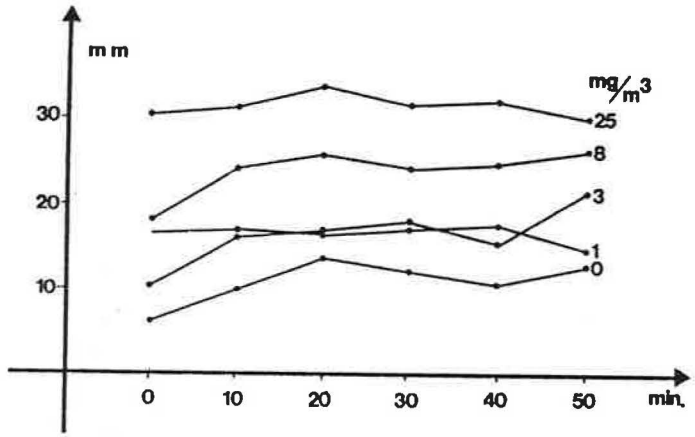


Figure 5. The effect of exposure on air quality (IMA 8 run 1), odour intensity (IMA 9 run 4); The ordinate mm (Full-scale = 60 mm) abscissas are differences between clean air exposure and exposure to 1, 3, 8 or 25 mg/m³.

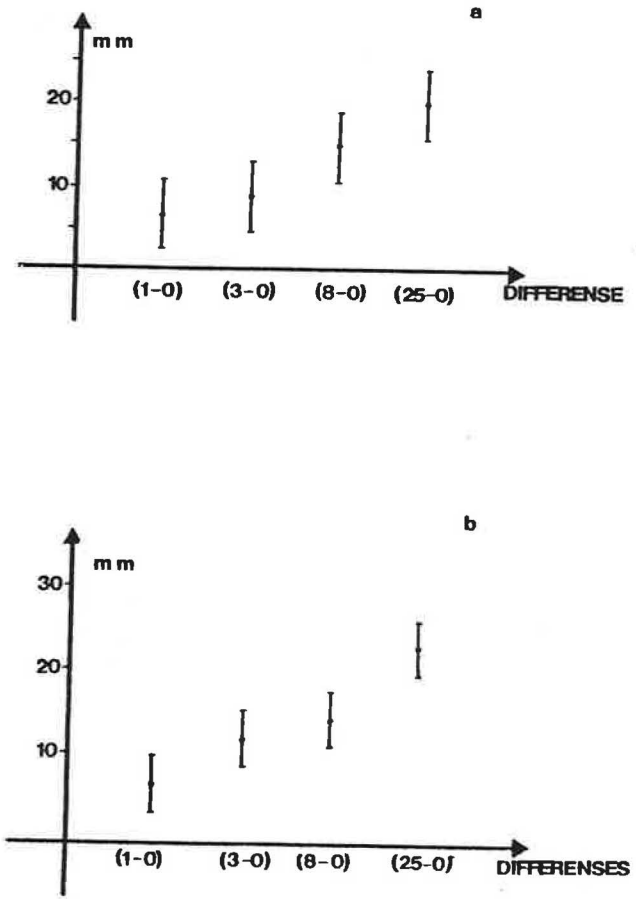
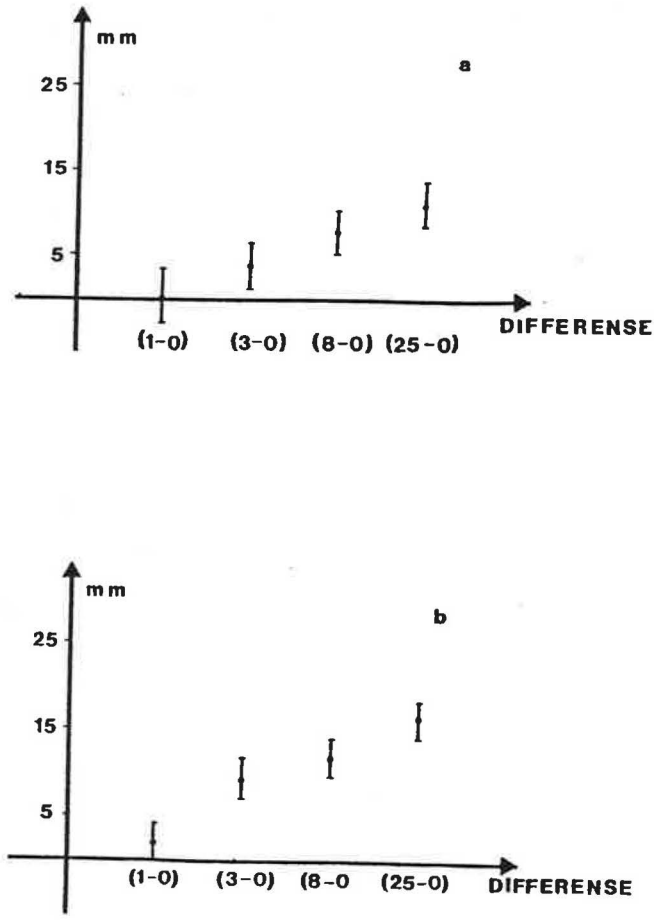


Figure 6. The effect of exposure on (DTH3) nose irritation and DTH (5): odour intensity. The ordinates are (Fullscale = 60 mm) and abscissas differences between zero exposure and exposure to 1, 3, 8 or 25 mg/m³.



Figur 7. Regression model for the effect of exposure on nose irritation (DTH3) during the first run of the exposure treatments. Ratings in mm. The abscissas is $(mg/m^3)^{-1/2}$. The slope of the regressionline is 2.54 (95% confidence ± 0.99).

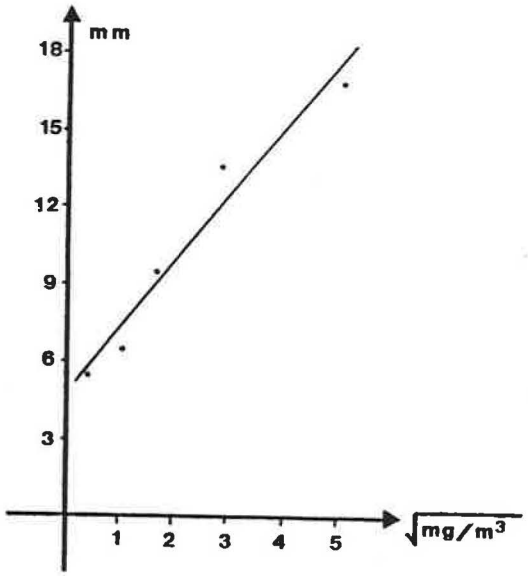
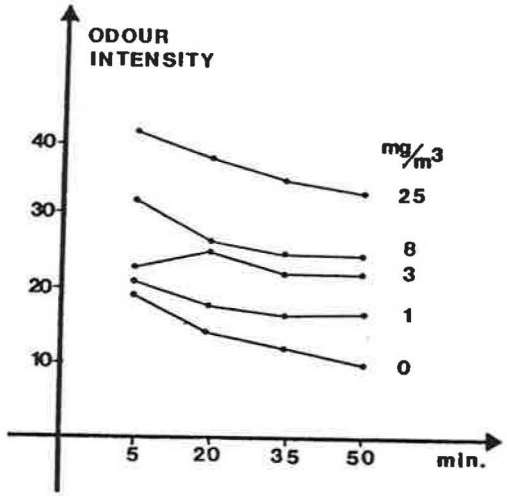


Figure 8. The variation of perceived odour intensity with exposuretime (min.). The ordinate is the ratings (mm) of odour intensity (IMA 9). Each curve represents one exposure level.



... the ordinate is the ratings (m.m.). Each curve represent one exposure level.

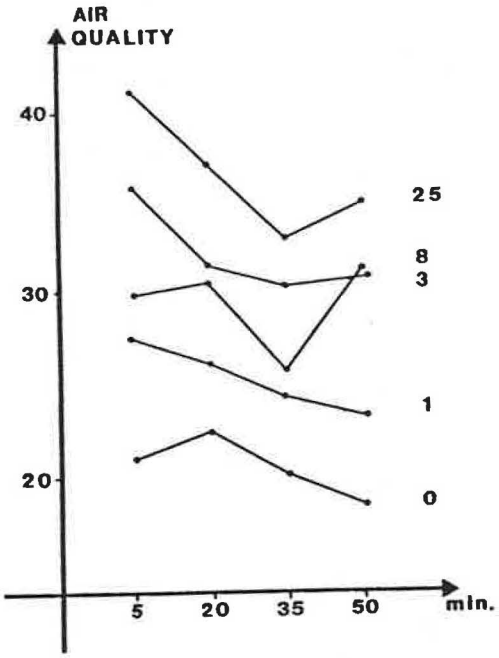
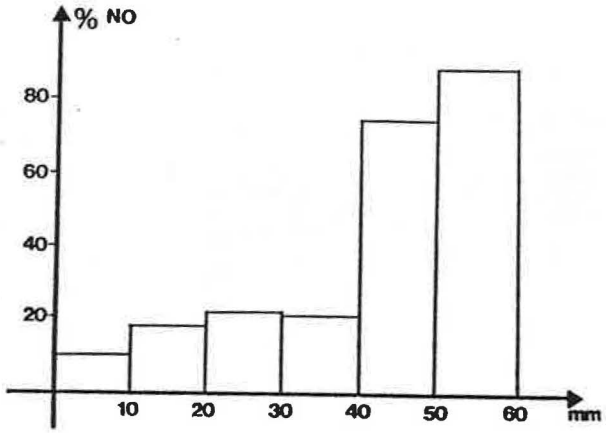
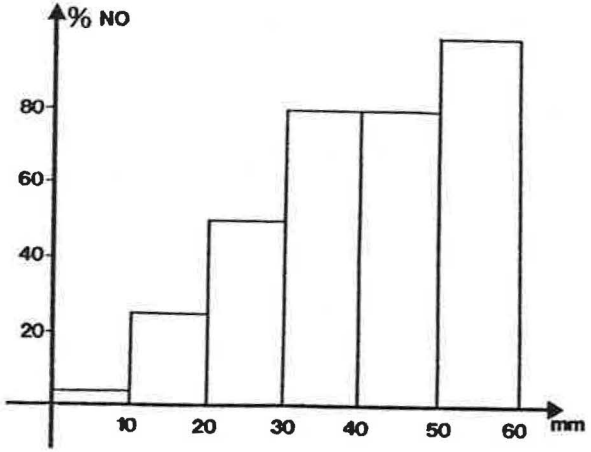


Figure 10. The correlation between the all ratings of acceptability (% answering "no".) and the corresponding continuous rating (mm) for air quality (IMA 8) and irritation of the nose (IMA 17).





BILAG

1. AB-skema fra IMA
2. Skema fra DTH

21/8-1986
Lars Mølhave/bh

EXPO: AB-SKEMA, PERSONINSTRUKTION

Dette skema skal du udfylde adskillige gange i løbet af dagen, og i skemaet findes en række spørgsmål angående dit velbefindende netop nu. Alle spørgsmålene skal besvares hver gang du får et skema, og det sker når der lyder en summer fra det hjørne.

De 24 første spørgsmål besvares efter samme princip. Yderst til venstre står spørgsmålet, f.eks. "Hvordan bedømmer du temperaturen?. Dette skal besvares på to måder:
Først skal du sætte et mærke på stregen mellem "generende koldt" og "generende varmt". Du sætter mærket midt på, hvis du finder temperaturen passende, eller lidt eller meget mod højre, hvis det er lidt eller meget varmt. Dernæst skal du i højre side sætte et kryds enten i "Ja" eller "Nej"-firkanten alt efter, om du finder temperaturen acceptabel eller uacceptabel.

I spørgsmål 25 til 28 er der ingen streger at sætte mærke på. Her svarer du ved at sætte krydser ud for de rigtige svar.

Praktiske råd:

Du skal tage dig den nødvendige tid til at udfylde skemaet. Du skal stille dig selv hvert enkelt spørgsmål, før du svarer på det. Sæt mærke med en lille streg på tværs af linien.

Husk at undlade at kommentere dine egne svar. De andre må ikke blive påvirket.

Skemaerne ligger på din plads i kammeret, men du skal skrive forsøgsnummer, dato og klokkeslet øverste på alle tre ark.

Det udfyldte skema og skemaer fra andre prøver afleveres i en kasse anbragt i kammeret.

Husk at lægge bagsiden opad.

EXPO: ALMENBEFINDENDE SKEMA Forsøgsnr.: (1) Dato: Run: (2) P.).

HAR DU ANDRE GENER NETOP NU?				FØLES DETTE ACCEPTABELT? JA	NEJ	
24) Har du hovedpine?	INGEN	———	Generende STÆRK	☐	☐	24)
25) Hvordan synes du alt i alt, du har det nu?	GODT	———	DÅRLIGT	☐	☐	25)
26) Føler du alt i alt irritation i øjne, næse eller svælg?	INGEN	———	Ubehagelig STÆRK	☐	☐	26)
27) Ville du lufte ud, hvis du var hjemme?	SLET IKKE	———	MEGET	☐	☐	27)

Navn _____ Nummer _____ Dato _____ Tid _____

Marker med en streg på skalaen, hvor kraftig du synes, at lugten i rummet er.

- Ingen lugt
- Svag lugt
- Moderat lugt
- Stærk lugt
- Meget stærk lugt
- Overvældende lugt

Forestil dig at du i det daglige vil blive udsat for denne lugt. Hvordan vil du da bedømme lugten?

Acceptabel ☐

Ikke acceptabel ☐

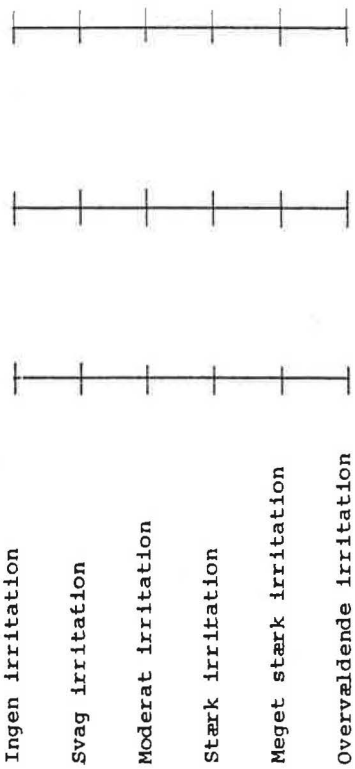
HVORDAN BEDØMMER DU:			ACCEPTABEL ? JA	NEJ	
3) Belysning	Generende SVAG	Generende STÆRK	☐	☐	3)
4) Lydstyrke	Generende LYDDØDT	Generende STØJENDE	☐	☐	4)
5) Temperatur	Generende KOLDT	Generende VARMT	☐	☐	5)
6) Luftfugtighed	Generende TØR	Generende Fugtig	☐	☐	6)
7) Luftbevægelse	Generende STILLESTÅENDE	Generende TRÆK	☐	☐	7)
8) Luftkvalitet	BEHAGELIG	UBEHAGELIG	☐	☐	8)
9) Lugtstyrke	INGEN	Overvældende STÆRK	☐	☐	9)
HAR DU GENER I:					
Øjne:					
10) Øjenirritation	INGEN	Generende STÆRK	☐	☐	10)
11) Øjentørhed	Øjnene er TØRRE	Øjnene løber I VAND	☐	☐	11)
Ansigt:					
12) Hvordan er hudens temperatur?	Generende KOLD	Generende VARM	☐	☐	12)
13) Hvordan er hudens fugtighed?	Generende TØR	Generende FUGTIG	☐	☐	13)
14) Føles irritation eller kløe i huden?	INGEN	GENERENDE	☐	☐	14)

Navn _____ Nummer _____ Dato _____ Tid _____

Forestil dig, at du til daglig skulle opholde dig i et rum med tilsvarende luftkvalitet som her og nu. Hvordan vil du da bedømme luftkvaliteten?

Acceptabel ☐ Ikke acceptabel ☐

Marker med en steg på hver af skalaerne, hvordan du har det lige nu i øjne, næse og hals.



HAR DU NETOP NU GENER I FORM AF:

				ER DET ACCEPTABELT? JA	NEJ	
14) Irritation i hals og svælg?	INGEN		Generende STÆRK	☐	☐	14)
15) Har du hoste-fornemmelser?	INGEN		Vedvarende STÆRKT	☐	☐	15)
16) Har du åndenød?	INGEN		Generende STÆRKT	☐	☐	16)
17) Føler du irritation, svie eller tørhed i næsen?	INGEN		GENERENDE	☐	☐	17)
18) Løber næsen?	SLET IKKE		Generende MEGET	☐	☐	18)
19) Hvordan er hudens temperatur på kroppen?	Generende VARM		Generende KOLD	☐	☐	19)
20) Sveder du?	SLET IKKE		Generende MEGET	☐	☐	20)

ANDRE GENER NETOP NU?

21) Føler du dig tung i hovedet	SLET IKKE		Generende MEGET	☐	☐	21)
22) Er du træt eller døvning?	SLET IKKE		Generende MEGET	☐	☐	22)
23) Skal du koncentrere dig meget for at udføre opgaverne?	SLET IKKE		MEGET	☐	☐	23)