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Original Paper

Evaluation of Building Materials Individually and in Combination Using Odour Threshold

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Abstract

This paper presents results of an experimental procedure to observe the impact of building materials on perceived air quality. An untrained panel of 25 adult subjects perceived the quality of polluted air in small-scale chamber settings. The air pollution was generated by emissions from individual materials, by combinations of these materials and by mixtures of emissions from single materials. The results showed that the exposure response relationship varies for one of the tested materials compared with the others. The study also confirmed that interaction among building materials is often negligible from the perception point of view, which is in contradiction with the findings published in the literature. Further analysis of data indicated that linear addition of olfs of single materials is still a permissible simplified method to estimate the sensory pollution load in the presence of combinations of building materials in the absence of any other practical technique.

Introduction

More than several hundred different compounds have been identified in indoor air. Many are emitted from indoor building materials, construction products and other indoor pollution sources. Some are also present in outdoor air. The presence of these polluting compounds may make the environment unpleasant for occupants, and cause health risks and symptoms, referred to as the Sick Building Syndrome [1,2]. Therefore, it is important to keep the concentration of air pollution in indoor environments at the lowest possible level.

The state-of-the-practice to adjust required ventilation rate for acceptable indoor air quality (IAQ) is to follow the ASHRAE Ventilation Standard 62-2004 [3], which requires that the ventilation rate specification is based on the contribution from occupants as well as the building materials and equipment. Moreover, the ASHRAE Standard 62-2004 specifies that higher air ventilation rates are required when the emissions from indoor sources increase, which would result in higher energy consumption and increased risk of local thermal discomfort due to draft, as well as increase in greenhouse gases.

Controlling the sources of emissions by avoiding high polluting building materials, and so reduce emissions and

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minimise ventilation requirements, seems to be a more appropriate strategy to improve IAQ. This requires knowledge of the pollution sources and prediction of the impact of different materials on the perceived air quality during the design of a new building, or the renovation of an existing one. Fanger [4] proposed a method to quantify the acceptability of indoor air and identify the causes of building occupants' complaints when exposed to different building materials. He introduced the concept of perceived air quality and source strength by defining the units decipol and olf. Olf is a unit which quantifies the source strength of air pollution, while decipol is a unit which describes the perceived air quality [4]. Based on this concept, the perceived air pollution from any source is defined as the concentration of human bioeffluent or number of standard persons that would cause the same level of dissatisfaction as the actual pollution source. Fanger [4] also suggested that individual olf values of two sources emitting pollutants of the same nature can be added to predict the source strength of their combination. However, other studies have shown that the exposure response to different concentrations of air pollutants differ from one material to another and from the response to the human bioeffluent [5–8]. The discrepancy in the results obtained from different experiments leaves this area of research vague in offering a defined and predictable response for different building materials, which may need to be further investigated before any generalisation is possible.

On a further step to investigate the possibility of predicting the source strength of a combination of materials, an inconsistency in findings can be noticed. According to one approach, predicting the source strength of a combination of materials can be based on the linear addition of pollution loads generated by individual indoor sources [9–10]. However, further study showed that this simplification may not be an accurate approximation in determining air quality and the required ventilation rate, as it overestimates the actual values for combinations of materials when the addition of source strengths of individual materials is compared with the source strength of the combination of materials [6]. However, due to the limited number of studies, it is difficult to make a strong conclusion regarding the overestimation of the linear addition of individual source strengths versus the actual values. Moreover, the results are limited to the number and type of materials used, the specific test conditions, and the techniques used in interpreting data.

Interactions between building materials, causing the emissions generated by one material to be adsorbed on the surface of another, has previously been proven by using a numerical method, as well as analytical and sensory measurements [7,11,12]. However, this phenomenon and its effect on sensory assessment have not been studied in depth. In other words, no study has been conducted to show whether the interactions between different building materials will actually affect the perception. The shortcomings of previous investigations that observed the effect of sorption on perceived air quality leaves this phenomenon as a promising area of research.

This study aimed to evaluate the quality of perceived air when pollution was generated by three different building materials, and to examine the possibility of generalising the exposure response relationships of the three investigated building materials to the one from human bioeffluents. Furthermore, the addition theory of sensory pollution loads for different single materials to predict the level of acceptability in the presence of a combination of materials was validated for the examined building materials. Most importantly, the existence of any sensory interaction between building materials that influence the perception from a combination of materials as the responsible cause was further investigated.

Materials and Methods

Set-up

Figure 1 depicts the three types of set-ups considered to fulfil the aim of the present study. In the first set-up, called the *single set-up*, a sensory panel assessed the quality of air polluted by emissions from three individual building materials. This set-up (Figure 1(a)) considered the sensory impact of a single material at a time. Each material was placed individually in a single test chamber of CLIMPAQ type [13], with the inlet airflow being set to $0.9\,L \cdot s^{-1}$.

In the second set-up, the *combination set-up*, the concurrent effect of two or three materials was studied to evaluate if adsorption of pollution from one material onto another material would have an impact on the accuracy of the simple olf-based addition theory for pollution loads. For this purpose, materials were placed simultaneously inside one CLIMPAQ. The inlet airflow rate to test chambers in this set-up was also adjusted to $0.9\,L \cdot s^{-1}$. Figure 1(b) shows the *combination set-up* for two materials.

In the third set-up, the *mixing set-up*, sensory subjects assessed the quality of air when polluted by mixtures of emissions from two or three materials. In this set-up
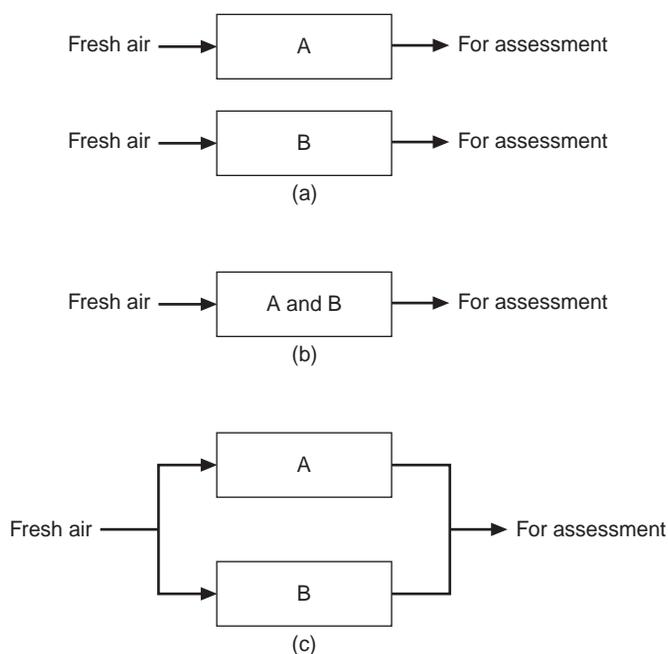
Fig. 1. Principal scheme of the experimental set-up for two materials; (a) *single set-up*, (b) *combination set-up*, (c) *mixing set-up*.

Fig. 2. Dilution system installed on CLIMPAQ.

(Figure 1(c)), two or three single materials were placed separately in different individual test chambers to eliminate the effect of interaction among them. The exhausts from these chambers were mixed in a separate chamber before being assessed by panel members. Inlet airflow to the test chamber was adjusted to $0.45\,L\cdot s^{-1}$ in the case of two building materials, and $0.3\,L\cdot s^{-1}$ in the case of three building materials. The airflow rate adjustments, along with the adjustments in the samples' areas (which will be described in detail in following sections), were made to keep a constant area-specific airflow rate (Q/A) inside test chambers for every set-up throughout the experimental procedures.

An empty single chamber assessment was also performed to provide the level of acceptability in the absence of building materials (background level).

Chamber Description

Twenty-one CLIMPAQ type test chambers were used for this experimental study. The inlet air to the CLIMPAQs and test room were provided by an air conditioning system being supplied with outdoor air. The supply air to the air conditioning system was filtered using a class EU7 fine filter, a charcoal filter and an additional class EU7 fine filter, in series. The exhaust air from each CLIMPAQ was led to a cone for sensory assessment. The mean value of airflow rate through the cones
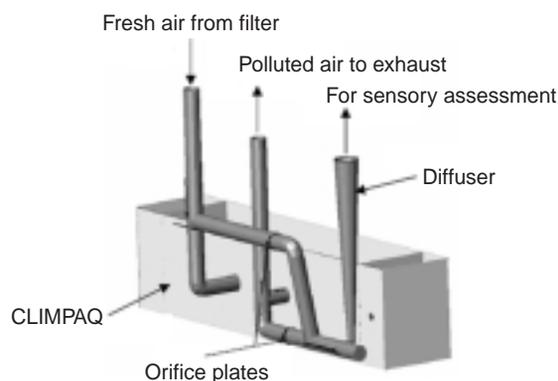
was $0.87\,L\cdot s^{-1}$ with a standard deviation of 0.04, which was close to the recommended airflow rate for sensory studies [13].

The area-specific airflow rate (Q/A) in the CLIMPAQs was identical to the one of a model room with dimensions of $3.2 \times 2.2 \times 2.4\,m$ (length, width and height, respectively) and an air change rate of $2\,h^{-1}$ as defined by the Nordtest Method [13]. An air dilution system was installed on all set-ups in order to attain different concentrations of pollutants for sensory assessment [8]. Four sets of orifice plates were used to achieve 1, 1/2.5, 1/10 and 1/20 of the concentration of the pollutants in test chambers. In the *mixing set-up*, this system was installed solely on the mixing chamber. Figure 2 shows the test chamber with an installed dilution system used for the experimental procedure.

Building Products and Sample Preparation

Painted gypsum board, carpet with a textile backing and linoleum were selected as the materials used in this study, representing major groups of building products often used indoors. All the building products were new and came in sealed packages to minimise the loss of odour before the initiation of experimental work. Samples of materials were prepared immediately upon purchasing and they were cut to the required size (Table 1) based on the model room defined by the Nordtest Method [13]. Samples were preconditioned for 4 weeks at an air temperature of $21.9 \pm 1.8\,°C$ and a relative humidity of $56.7\% \pm 5.6\%$ by hanging in a large well-ventilated room.

After 4 weeks of preconditioning, and before being put inside CLIMPAQs, samples of each of the flooring materials were stapled together, back to back, to reduce emissions from their back sides. Samples of building

Table 1. Supply airflow rates and test specimen areas corresponding to the model room

Type of material	Type of set-up	Model room	CLIMPAQ	
		Area specific airflow rate $(m^3 \cdot h^{-1} \cdot m^{-2})$	Supply airflow rate $(L \cdot s^{-1})$	Area of specimen (m^2)
Linoleum	single set-up	4.76	0.9	0.68
	mixing/combination set-up of 2		0.45	0.34
	mixing/combination set-up of 3		0.3	0.23
Painted gypsum board	single set-up	1.42	0.9	2.28
	mixing/combination set-up of 2		0.45	1.14
	mixing/combination set-up of 3		0.3	0.76
Carpet	single set-up	4.76	0.9	0.68
	mixing/combination set-up of 2		0.45	0.34
	mixing/combination set-up of 3		0.3	0.23

Table 2. Physical conditions in the test room on each day of the experiment

Day of experiment	Temperature (°C)		Relative humidity (%)	
	Average value	Standard deviation	Average value	Standard deviation
First day	23.34	1.88	55.58	7.05
Second day	24.94	0.67	45.96	1.99

materials were placed in the chambers 14 days prior to the experiment. The lengths of preconditioning and conditioning periods were set to reach a steady-state situation in the test chambers. The average measured temperature inside the test chambers was 23.9 °C with 0.2 °C standard deviation, and the average relative humidity was 55.0% with 5% standard deviation. The temperature differences in the air exhausted from diffusers in different set-ups were almost negligible with a standard deviation of 0.16 °C. This shows that all samples were conditioned in similar physical conditions.

Procedure

The experiments were carried out over two consecutive days, and consisted of two rounds of 12 assessments on each day. In each round, the acceptability and intensity of the air from a specific chamber with a certain dilution rate in the outlet air were assessed. Physical conditions of the test room on each day of the experiment are presented in Table 2. The air temperature was on average higher in the diffusers than in the test room, with an average difference of 2 °C on each day, which was due to heat generated by the chamber mixing fans. Sense of smell deteriorates after exposure to an odour source for a period of time. The problem associated with this fact is partially inevitable. However, to overcome the

short time available because of weariness to odour exposure, the air-exchange rate (ACH) in the main test room at the time of the experiments was set to $6 \, h^{-1}$, which was higher than the standard air change rate of $2 \, h^{-1}$ as suggested by the Nordtest Method [13]. This provided fresh and odour-free air in the test room and near the diffusers. Similarly, the air-exchange rate in the room next to the main room where panel members were exposed to clean air (pre-test room) was $7 \, h^{-1}$.

Sensory Panel

A naive sensory panel of 25 participants performed the sensory assessment for all the experimental rounds. Panellists aged between 18 and 79 years, with an average of 45.68 years. Fifty-six percent were male and 20% were smokers. The panel members were instructed on the measurement procedure and the use of the acceptability scale [14] and intensity scale [15], on which they were asked to express their perceptions of air quality (Figure 3). They were asked "how they would accept the quality of the air they were exposed to, if they had to work/live in that environment". The "clearly unacceptable" vote on the acceptability scale was designated −1, while the "clearly acceptable" was designated 1. The "just acceptable" and the "just unacceptable" votes were both designated 0. Any votes in between were scaled to the (−1, 1)
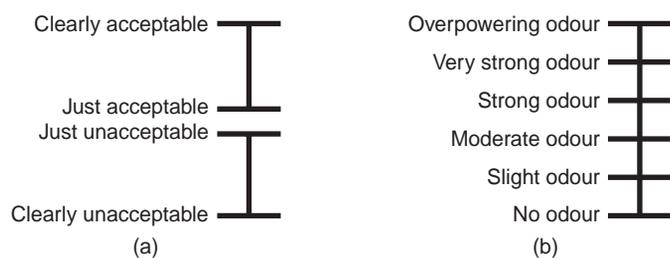
Fig. 3. (a) Acceptability scale, (b) intensity scale.

interval using a linear scaling. The intensity scale was a continuous line divided into six different categories ranging from "no odour", designated 0, to "overpowering odour" designated 5. The panel members assessed the immediate acceptability and intensity of the air in the test room and from the diffusers. During the experiments the test chambers were covered from outside with aluminium plates to hide the building products from the view of the sensory panel.

Two-factor ANOVA with replication was used for comparison between different treatments (set-ups). The level of significance was considered to be 0.05 for data analysis purposes.

Results

Assessments of the main test room and the empty chamber were conducted in each round on both days of the experiments, to provide a comparison base and a background level regarding the acceptability of the air in the test chambers. This also evaluates the possibility of the background as being a contributing factor in perception from building materials. Acceptability votes (mean ±

standard deviation) were 0.72 ± 0.28 and 0.69 ± 0.34 for the main test room and the empty test chamber, respectively.

Improvement in acceptability by increasing the dilution rates was noticed for all set-ups except at dilution rates of 2.5 and 20 for the *combination* of painted gypsum board and carpet. A technical break-down in *combination set-up* of painted gypsum board and carpet on the second day of experiment is the reason for this unusual tendency. Due to this reason, the acceptability results obtained from dilution rates of 2.5 and 20 for the *combination* of painted gypsum board and carpet are excluded from statistical analyses.

The average acceptability level of different parts of experimental set-ups are shown in Table 3 and in the corresponding figures (Figures 4 and 5). However, statistical analyses are based on total votes for a certain configuration, not the average points. Error bars shown in the figures throughout this paper reflect standard deviations, unless otherwise stated.

Exposure Response Relationship for Single Materials and Human Bioeffluent

The curve of human bioeffluent in Figure 4 was achieved by considering the pollution generated by one person to be one olf. Using the comfort equation developed by Fanger [16], perceived air quality was calculated:

$$G = 0.1Q(C - C_0) \tag{1}$$

where:
G is the sensory pollution load (olf)
Q is the outdoor airflow rate to the chamber (L·s^{-1})
C is the perceived air quality in the test chamber (decipol)

Table 3. Average acceptability level in different set-ups and for different materials

Material	Set-up	Dilution rates			
		1	2.5	10	20
Carpet	Single	−0.38	−0.31	0.45	0.60
Linoleum		−0.30	−0.27	0.26	0.30
Painted gypsum board		−0.27	−0.23	0.11	0.30
Carpet and painted gypsum board	Combination	−0.27	−0.53	0.27	0.035
	Mixing	−0.37	−0.19	0.23	0.41
Linoleum and painted gypsum board	Combination	−0.26	−0.26	0.24	0.25
	Mixing	−0.38	−0.21	0.25	0.29
Carpet and linoleum	Combination	−0.46	−0.05	0.41	0.44
	Mixing	−0.33	−0.32	0.47	0.40
Carpet, linoleum and painted gypsum board	Combination	−0.14	−0.11	0.37	0.46
	Mixing	−0.18	−0.20	0.38	0.37

C_0 is the perceived air quality of the empty chamber (decipol).

Furthermore, the percentage of dissatisfied people was determined [4]:

$$C = 112(\ln(PD) - 5.98)^{-4} \qquad (2)$$

where:
C is the perceived air quality (decipol)
PD is the percentage of dissatisfied people (%).

The mean of acceptability votes in each set-up and dilution rate was calculated as a function of the percent of dissatisfied people [14]:

$$PD = \left(\frac{\exp(-0.18 - 5.283\,Acc.)}{1 + \exp(-0.18 - 5.283\,Acc.)} \right) 3\,100 \qquad (1)$$

where:
PD is the percentage of dissatisfied people (%)
$Acc.$ is the mean of acceptability votes.

Using arbitrary values for olfs in Equation (1), corresponding acceptability levels can be calculated, which lead to an exposure response curve for human bioeffluent as shown in Figure 4.

Using a logarithmic regression technique, the equations of exposure response curves ($Acceptability = a\log(Dilution\ Rate) + b$) based on the experimental data for the three single materials were obtained (Table 4). Figure 4 shows the exposure response relationships for the three single materials, i.e. carpet, painted gypsum board and linoleum, along with the level of air acceptability in the presence of one standard person, defined as human bioeffluent [4].

Statistical analysis was performed in order to investigate the potential differences between the acceptability levels caused by emissions from the materials investigated. This investigation showed that:
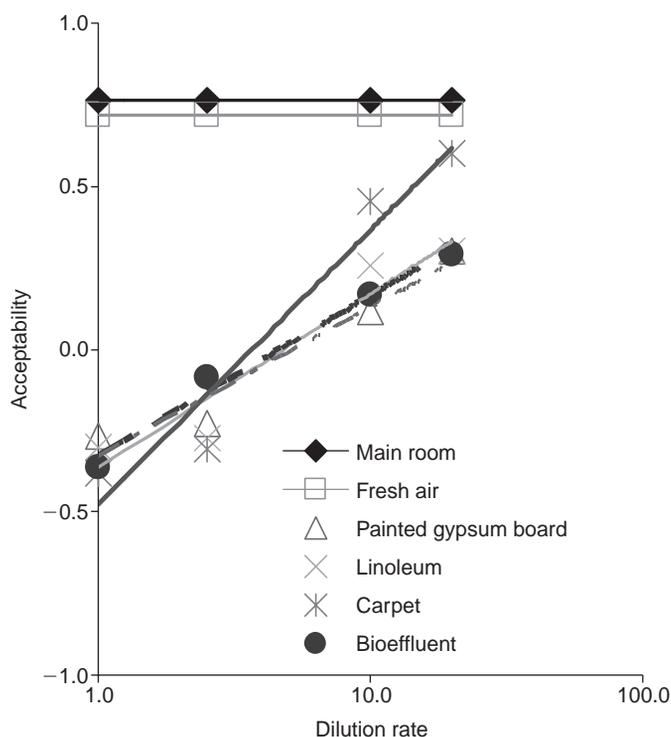

Fig. 4. Mean acceptability of single materials and human bioeffluent.

- The differences of acceptability votes for painted gypsum board and human bioeffluent (*P*-value = 0.6), and linoleum and bioeffleunt (*P*-value = 0.88) were not statistically significant.
- For carpet and human bioeffluent a difference with *P*-value of 0.04 was noted.
- Linoleum and painted gypsum board were not significantly different as *P*-value equalled 0.8.
- There was no statistical difference between carpet and painted gypsum board, with *P*-value of 0.06.
- In general, no statistical difference existed between carpet and linoleum with *P*-value of 0.12.

Table 4. Exposure response relationship data and standard deviation of single materials and human bioeffluent

Materials	a	b	R^2-value	Dilution rate, standard deviation			
				1	2.5	10	20
Carpet	0.34	−0.48	0.94	0.47	0.49	0.32	0.37
Linoleum	0.23	−0.37	0.92	0.52	0.45	0.38	0.38
Painted gypsum board	0.20	−0.33	0.95	0.42	0.42	0.44	0.41
Human bioeffluent	0.21	−0.33	1	–	–	–	–

Exposure Response Curves of Combination and Mixing Set-ups

In order to investigate the existence of interaction between building materials from a perception point of view, results from the *combination set-up* were statistically and visually compared to the *mixing set-up* for different building materials and at different dilution rates. Performing the analyses at different dilution rates provide enough data points for comparison purposes, although the actual condition in a real building is at dilution 1. Furthermore, it evaluates whether or not the differences between perceptions from two different set-ups are dilution dependent.

Table 5 presents insignificant differences between different set-ups of identical materials, by maintaining *P*-

Table 5. The cut-off *P*-value for the difference between combination and mixing set-ups

Set-ups	*P*-value
	Combination and mixing
Carpet and painted gypsum board	0.41
Painted gypsum board and linoleum	0.97
Carpet and linoleum	0.66
Painted gypsum board, carpet and linoleum	0.38

values higher than 0.05 in all cases. As noted earlier, the dilution rates of 2.5 and 20 were excluded from analyses in the combination case of carpet and painted gypsum board, due to technical breakdown. Figure 5 presents the
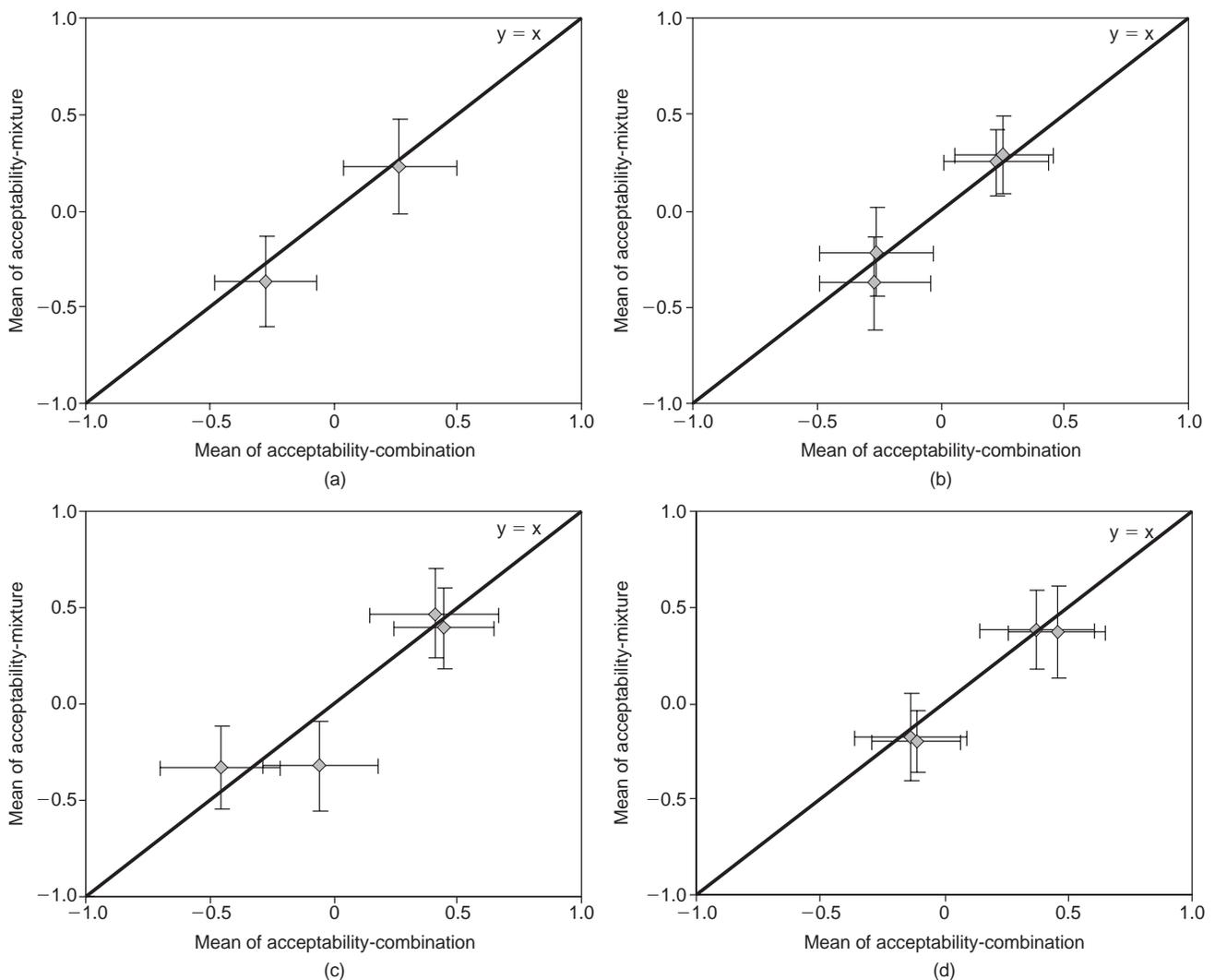

Fig. 5. Mean acceptability of *mixing set-up* versus mean acceptability of *combination set-up*; (a) carpet and painted gypsum board, (b) painted gypsum board and linoleum, (c) carpet and linoleum, (d) painted gypsum board, carpet and linoleum.

acceptability level caused by the mixture of odours in the *mixing set-up* versus the acceptability level of the *combination set-up* for different investigated materials. As can be observed in these figures, data points representing the mean of acceptability in the *mixing set-up* versus the mean of acceptability of the *combination set-up* are very close to the line of equity, y = x.

Addition of Olf Values

Converting acceptability levels to olf values was based on the hypothesis that the source strength generated by different building materials can be compared with the number of standard persons required to generate the same level of dissatisfaction. In order to perform the conversion, the percentage of dissatisfied people was calculated as a function of the mean of acceptability votes in each set-up and the dilution rate using Equation (3). Furthermore, the perceived air quality in decipols was determined by implementing Equation (2). The sensory pollution load in olfs was later calculated from the comfort equation, Equation (1).

Calculated olf values for the *combination* and *single set-ups* for three types of materials at different dilution rates were used to evaluate the theory of addition of sensory pollution loads. In the case of two building materials, the area-specific ventilation rate is the same in each of the single chambers. Accordingly, the source strength of the *combination set-up* is comparable to the source strength from one single chamber. In order to compare the *combination* to addition of single materials in single chambers, the average olf values should be used. The case of three materials also follows the analogous principle. Based on this, the source strengths in the *combination set-up* of two materials were comparable to half of the addition of pollution loads from the two *single set-ups*. For the case of three materials, the source strength in the *combination set-up* was compared to one third of the addition of olf values from the *single set-ups*. The comparison of results was performed by conducting a series of data analyses for every group of materials to clarify if the prediction of sensory pollution loads for the *combination set-up* was possible by the simple summation of olf values from single materials.

P-values representing the statistical differences are presented in Table 6. As can be noted, these values are higher than 0.05, the cut-off *P*-value, which show insignificant differences between predicted source strengths and actual source strengths.

Figure 6 also confirms the results, as the data points representing the relation between the mean of actual

Table 6. The cut-off *P*-value for the difference between predicted source strength and actual source strength of combination set-up

Set-ups	*P*-value
Carpet and painted gypsum board	0.94
Painted gypsum board and linoleum	0.93
Carpet and linoleum	0.86
Painted gypsum board, carpet and linoleum	0.07

source strength and the mean of predicted source strength in all cases are very close to the line of y = x.

Discussion

The slope of exposure response curve for the *single set-up* of carpet was slightly different from the slope of the bioeffluent but statistically similar to other materials investigated (Figure 4). Based on this investigation, the dilution rate required to achieve a certain acceptability level may differ from carpet to human bioeffluent. However, this difference is more noticeable at higher dilution rates or at higher acceptability levels. The results from this investigation suggest that setting the required ventilation rate based on the number of standard persons to simulate the actual pollution generated by carpet may underestimate the actual required rate of ventilation at higher dilution rates. In contrast, it may overestimate the required ventilation rates at dilution rate of 1. A similar observation was reported by Haghighat et al. [7] earlier. However, the exposure response curve of other materials investigated can be closely simulated by the exposure response curve for bioeffluent. The discrepancy between the results obtained may be explained by introducing a limitation to the olf theory that it is incapable of generalising the exposure response of all building materials by one standard curve, defined as the exposure response curve of human bioeffluent.

Adding the source strength of pollutants from the *single set-ups* generally revealed values close to the calculated olfs based on the votes from the *combination set-up*. This finding proposes that the level of dissatisfaction when the indoor air is polluted by several building materials can be predicted by a simple addition of the olf values of individual materials as the first approximation. This finding confirms the hypothesis previously proposed by Fanger [4], and the conclusions drawn by Bluyssen and Fanger [9] and Wargocki et al. [10]. The results from this study are only valid for the selected types of materials and cannot be generalised without further investigation.
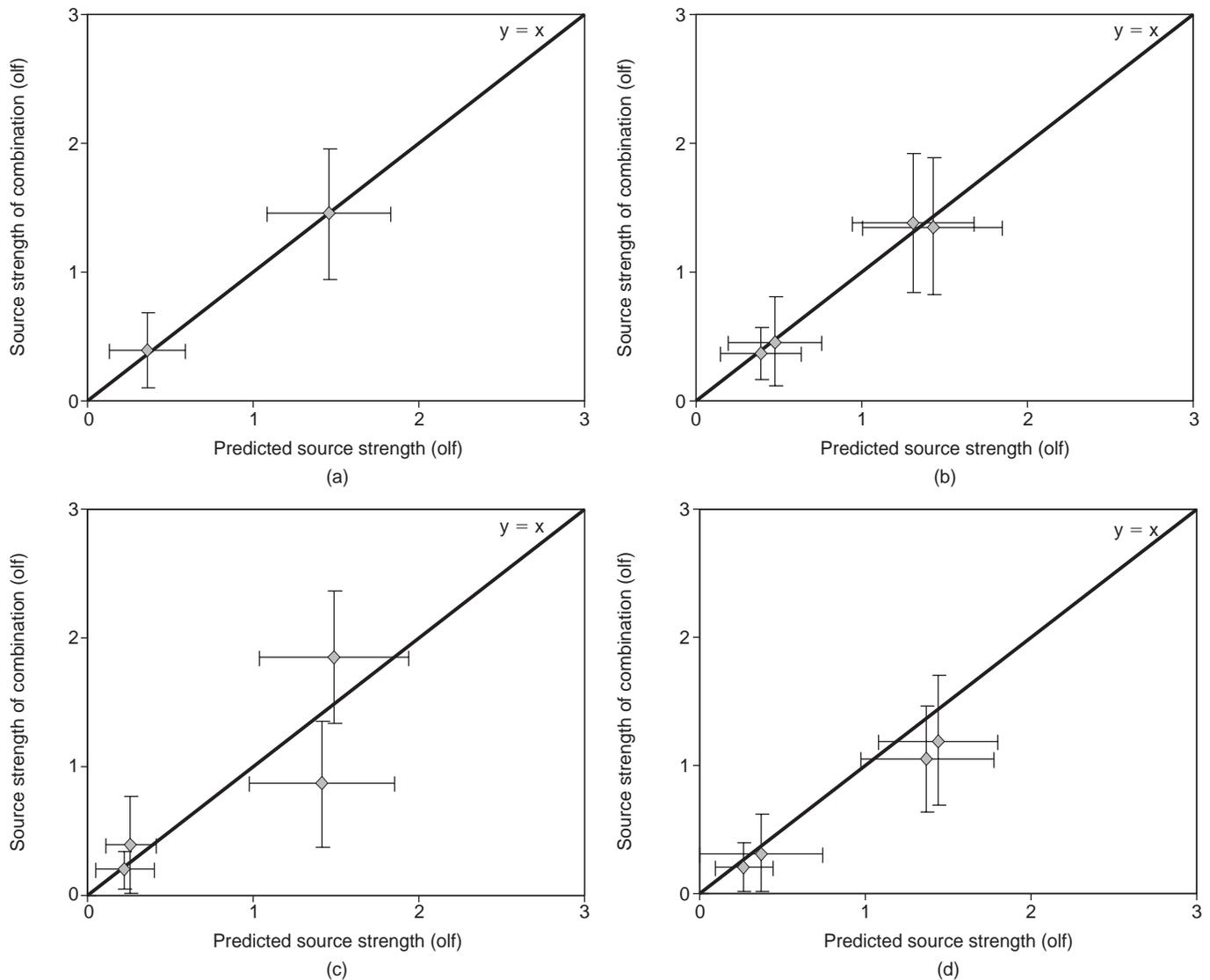
Fig. 6. Actual source strength of combination set-ups versus predicted source strength; (a) carpet and painted gypsum board, (b)painted gypsum board and linoleum, (c) carpet and linoleum, (d) painted gypsum board, carpet and linoleum.

Interaction between different building materials has been studied previously and characterised numerically, experimentally and from sensory points of view [7,17,11]. However, this phenomenon and its impact on sensory assessment had not been studied from the perception aspect. In the present study, this phenomenon was investigated by placing the building materials in combination in a single test chamber, and then comparing the results with the case of the mixture of odours from single materials. The comparison of the results of *mixing* and *combination set-ups* of similar types of materials revealed very similar acceptability votes in all cases. These results suggest that the interaction effect among these three

building materials, causing the compounds emitted by one to be adsorbed by other(s), is almost negligible from a perception point of view.

There was a slight difference in temperature and relative humidity in the room and inside the chambers on different days of the experiment, as shown in Table 2. This might suggest a partial contribution of physical conditions to different levels of acceptability of air [18,19]. However, previous findings have introduced the mutual effect of temperature and humidity in the form of enthalpy as the influential factor rather than as a single impact of these physical conditions. The correlated enthalpy for different physical conditions (temperature

and relative humidity) on different days of the experiment using a psychometric chart reveals constant values. This result was expected, as it was the objective of the air conditioning system to maintain a constant enthalpy of inlet air to the room at all time. Based on this argument, the differences of votes on the two days of the experiments cannot be justified by the differences in temperature and relative humidity. Moreover, the difference in temperature and humidity also has little impact on emission, since the emission will be only slightly temperature-dependent after materials have been ventilated for a long period of time. In this case, the VOC emission will be controlled by diffusion through the material which will be very slow [17,20] and temperature and humidity had little influence on either chemical or sensory emissions [19].

Although the building materials used for this experimental work were newly purchased, it was expected that they had been manufactured at different times and might have partially lost their odours. In order to minimise this effect and to reach a steady-state level of emission from different materials, as has already been mentioned, a long period for conditioning was considered. Moreover, a long period of conditioning produced an experimental situation similar to a real situation, rather than amplifying the condition by performing the experiment in the early stages of emission by a material. Area-specific flow rates were also kept constant throughout the set-ups, by adjusting the inlet flow rate and the area of the samples. This value was analogous to the area specific flow rate of the model room defined in the Nordtest Method [13], which represents an actual situation in a real building with ACH of $2\,h^{-1}$.

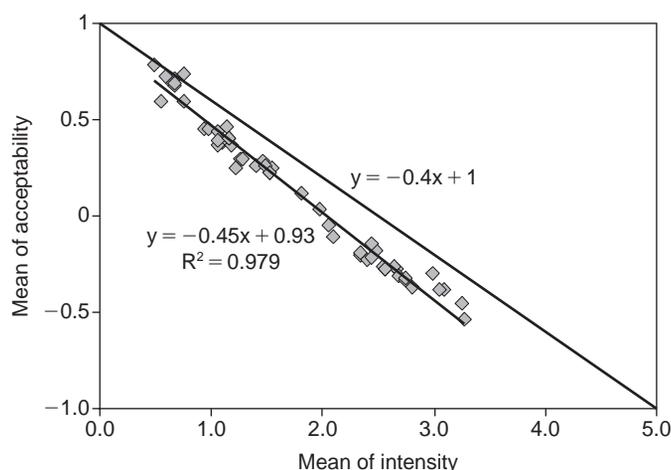Figure 7 shows that the mean of acceptability votes

and the mean of intensity votes are finely correlated. In this condition, no odour intensity defined as 0 should be perceived as the most acceptable air quality (air acceptability = 1), and vice versa. As can be noted from this figure, the experimental data follow the expected trend as more intense odours were assessed to be less acceptable by panel members and less intense odours were perceived more acceptable.

Figures 8 and 9 show the variation of the observations by the standard deviations, around the means. By observing these figures, it can be concluded that more variation in votes occurred with less acceptable or more intense odours. Accordingly, votes were more united in less intense or more acceptable ranges (Figures 8 and 9).

Conclusions

This paper presents an investigation to study the impact of three different building materials on perceived air quality by means of an untrained panel. The results of the investigation showed that:

- The interaction effects between three investigated building materials, causing the compounds emitted by one to be adsorbed by other(s), are too small from a perception point of view to be significant when all other sources of variation in perceived air quality including interpersonal differences is included.
- The source strength when the indoor air is polluted by several building materials can be approximated by simple addition of the source strengths of the individual building materials, measured in olfs.
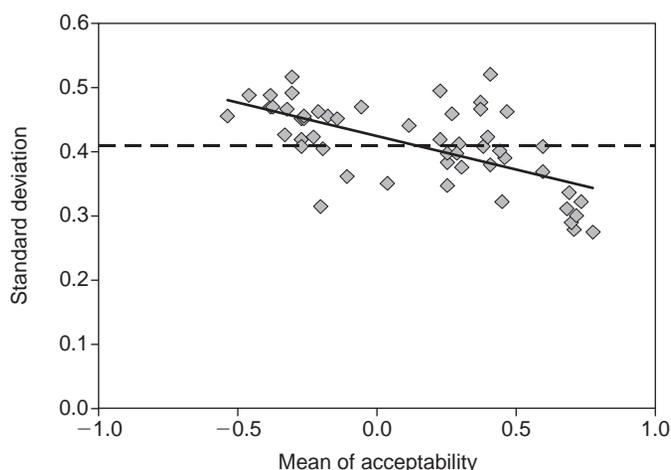

Fig. 7. The mean of acceptability votes as a function of the mean of intensity votes.

Fig. 8. The standard deviation of acceptability votes versus the mean of acceptability votes.
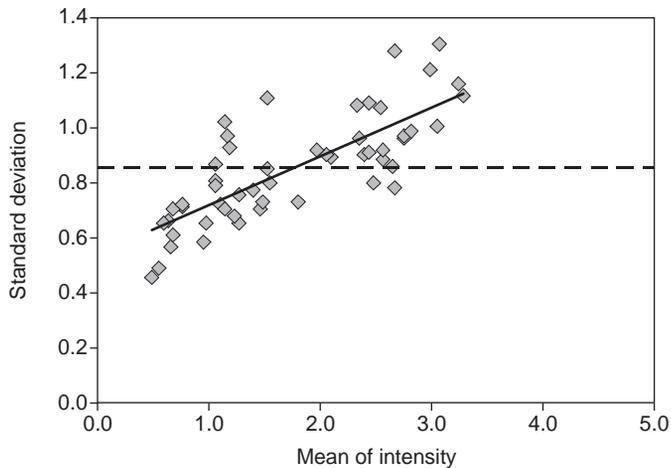
Fig. 9. The experimental standard deviation of intensity votes versus the mean of intensity votes.

The exposure response curve of the carpet investigated was slightly steeper than and statistically different from the curve for human bioeffluents. This finding introduces a limitation to the general use of addition for sensory pollution loads. However, since the curves for linoleum and painted gypsum board could be closely correlated to the curve of bioeffluent, it is believed that in spite of some limitations, the use of sensory pollution loads seems still a permissible simplified method to estimate the sensory pollution load in the presence of combinations of building materials in the absence of any other practical technique.

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