Reliability of cross-seasonal memory of environmental conditions and symptoms

Gary J. Raw* and Sara K.D. Coward

BRE, Watford, UK

ABSTRACT
In some indoor environment surveys, respondents are asked to recall conditions across seasons (e.g. to recall summer conditions during a winter survey). This study assessed the reliability of such recall, based on a survey of 728 people in 12 UK office buildings. In both winter and summer, the questions addressed both summer and winter conditions, and building-related symptoms. Correlations were calculated between equivalent responses in each season (e.g. odour in winter, as rated in the summer and winter surveys). The best correlated IAQ questions were those concerning specific smells (e.g. musty, sharp) or general satisfaction with IAQ. Non-specific IAQ factors (e.g. smelly, irritating, stuffy) were less well correlated. Correlations for symptoms also ranged from high to not significant. Building symptom indices, integrating data from all symptoms, were well correlated between seasons; such indices therefore provide a relatively stable measure of the building.

INDEX TERMS
Questionnaire; Building-related symptoms; SBS; Perceived air quality; Office building

INTRODUCTION

This paper describes work to refine a questionnaire-based approach to assessing IAQ. In some questionnaire approaches, respondents are asked to recall environmental conditions across seasons (for example, they might be asked about summer conditions during a survey carried out in the winter). This study assessed the reliability of the information collected by this kind of question. Some additional aspects of the study are described by Raw *et al.* (2002).

METHOD

Questionnaire surveys were conducted in 12 office buildings in England and Scotland, in both winter and summer. The fieldwork ran from January to September 2000. On each occasion the questions asked about both summer and winter conditions, and about specified building-related symptoms. The main questionnaire items are shown in Table 1. The environmental ratings were provided on seven-point semantic differential scales. A building-related symptom is recorded if the respondent has experienced the symptom on at least two occasions during the preceding 12 months, and the symptom gets better when away from the office. The frequency of experiencing symptoms was also recorded.

BRE staff handed out the questionnaires in the morning and collected them in the afternoon in accordance with the method specified for the Office Environment Survey (Raw, 1995). During the first survey, which was in the winter, each person was given an identity number, which was listed against his or her name and marked on a floor plan. In order to ensure the best possible comparison between winter and summer data, the same people in the same locations were approached for each survey whenever possible.

*Corresponding author. E-mail: rawgj@bre.co.uk

The analysis reported here is based only on the 728 people from 10 buildings who completed a questionnaire in both seasons. The mean of the responses to each question was calculated for each building, and correlations were calculated between equivalent responses in the two surveys (e.g. the correlation between ratings of winter air quality, based on responses in the summer survey and responses in the winter survey).

RESULTS

The results are given in Table 1(a)–(d). Unsurprisingly, the highest correlations concerned the more permanent features of the office (e.g. whether windows could be opened, the amount of control over temperature, ventilation and lighting, privacy and layout), and management factors such as the speed and effectiveness of response to requests for improvements. The average correlation (root mean square, corrected for negative correlations) was 0.91 for this group of questions, shown in Table 1(d). For other groups of symptoms, as shown in Table 1(a)–(c) the average was between 0.53 and 0.61, but with a wide range within groups.

Of the questions related to indoor air pollution, the best correlated were those concerning either definite smells (e.g. musty, sharp, smoky and dusty) or general satisfaction with IAQ. Non-specific characteristics (e.g. smelly, strong, annoying, dangerous, irritating, perfumed, dry, fresh, stuffy) were less well correlated.

Other well-correlated environmental ratings included some aspects of temperature, noise, vibration and general comfort, but correlations often differed greatly between ratings of summer and winter conditions—see items marked + in Table 1(c).

Of the symptoms, itchy/watery eyes and headache were well correlated but other symptoms were not significantly correlated. Nose and throat symptoms were particularly poorly correlated.

The building symptom index (BSI) is the mean number of symptoms reported by all the respondents in a building. BSI_5 includes only five symptoms (dry eyes, dry/stuffy nose, dry throat, headache and lethargy) which have been said to be most fundamental to sick building syndrome and allows comparison with a much wider database of other buildings (Raw, 1995). Both indices were well correlated between seasons (Figure 1). These measures are, therefore, reliable whether based on summer or winter surveys, and there is little seasonal effect.

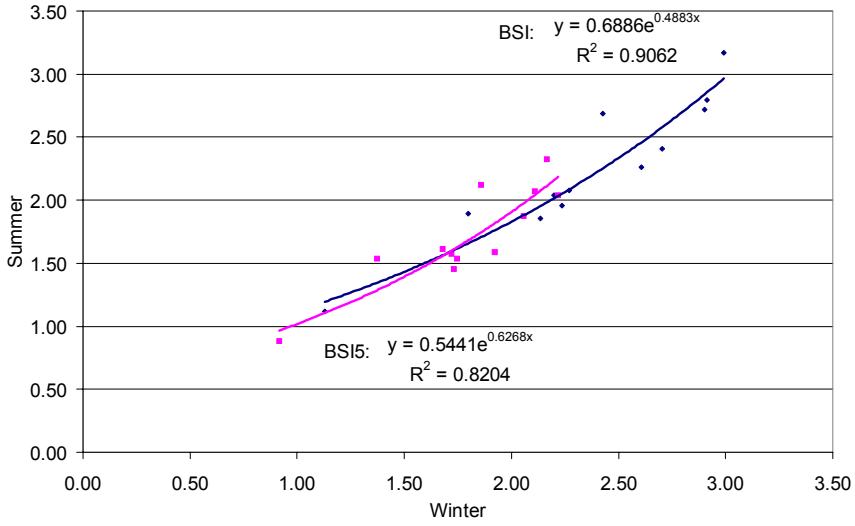

Figure 1 Summer BSI as a function of winter BSI.

Table 1 Correlations between winter and summer building means[1]

(a) Questions related to indoor air pollution

Questionnaire item	*r*	*p*
Air smoky S*	0.96	<0.001
Air smoky W*	0.95	<0.001
Air stifling W*	0.91	<0.001
Air quality sat/unsat W	0.91	<0.001
Air fresh/stuffy S	0.87	<0.001
Air quality sat/unsat S	0.84	<0.01
Air satisfactory W*	0.84	<0.01
Air musty W*	0.83	<0.01
Air likeable S*	0.82	<0.01
Air dusty S*	0.72	<0.05
Air satisfactory S*	0.71	<0.05
Air dusty W*	0.71	<0.05
Air has chemical smell S*	0.69	<0.05
Air sharp W*	0.67	<0.05
Air musty S*	0.65	<0.05
Air likeable W*	0.65	<0.05
Air fresh/stuffy W	0.65	<0.05
Air perfumed S*	0.62	n.s.
Air fresh W*	0.59	n.s.
Air stuffy S*	0.57	n.s.
Air has chemical smell W*	0.52	n.s.
Air stifling S*	0.51	n.s.
Air perfumed W*	0.49	n.s.
Air odourless/smelly S	0.49	n.s.
Air stuffy W*	0.49	n.s.
Air dangerous W*	0.44	n.s.
Air odourless/smelly W	0.40	n.s.
Air smelly W*	0.36	n.s.
Air sharp S*	0.32	n.s.
Air strong S*	0.29	n.s.
Air smelly S*	0.22	n.s.
Air annoying S*	0.21	n.s.
Air irritating W*	0.19	n.s.
Air dangerous S*	0.17	n.s.
Air fresh S*	0.16	n.s.
Air irritating S*	0.13	n.s.
Air annoying W*	0.08	n.s.
Air strong W*	0.04	n.s.
Root mean square	0.61	

(b) Other aspects of indoor environment

Questionnaire item	*r*	*p*
Comfort sat/unsat W^{+}	0.95	<0.001
Temperature comfortable/uncomfortable W	0.90	<0.001
Temperature too hot/cold W^{+}	0.89	<0.001
Temperature comfortable/uncomfortable S	0.84	<0.01
Noise sat/unsat W	0.84	<0.01
Light sat/unsat S^{+}	0.83	<0.01
Noise sat/unsat S	0.83	<0.01
Comfort sat/unsat S^{+}	0.82	<0.01
Vibration sat/unsat W	0.82	<0.01
Air dry/humid S^{+}	0.75	<0.05
Temperature stable/varies W^{+}	0.75	<0.05
Vibration sat/unsat S	0.72	<0.05
Air dry S*$^{+}$	0.71	<0.05
Temperature stable/varies S^{+}	0.56	n.s.
Air warm S*	0.49	n.s.
Air still/draughty W^{+}	0.48	n.s.
Light sat/unsat W^{+}	0.40	n.s.
Air warm W*	0.36	n.s.
Air humid W*	0.27	n.s.
Air cold W*	0.18	n.s.
Air humid S*	0.16	n.s.
Air cold S*	-0.04	n.s.
Air dry/humid W^{+}	-0.12	n.s.
Temperature too hot/cold S^{+}	-0.15	n.s.
Air still/draughty S^{+}	-0.37	n.s.
Air dry W*$^{+}$	-0.39	n.s.
Root mean square	0.61	

(c) Building-related symptoms

Questionnaire item	*r*	*p*
Itchy/watery eyes	0.83	<0.01
Headache	0.81	<0.01
Dry/itching/irritated skin	0.54	n.s.
Dry eyes	0.50	n.s.
Lethargy/tiredness	0.45	n.s.
Runny nose	0.34	n.s.
Blocked/stuffy nose	0.10	n.s.
Dry throat	0.01	n.s.
Root mean square	0.53	

[1] S = In summer; W = In winter; sat/unsat = satisfactory/unsatisfactory overall.

*Scale from 1 = Not – 7 = Very (e.g. Not stuffy–Very stuffy).

$^{+}$Difference between summer and winter $r^2 > 0.2$.

Table 1 (Continued)

(d) Other questions

Questionnaire item	*r*	*p*
Are windows openable?	1.00	<0.001
Do others in the immediate environment smoke in office?	0.99	<0.001
No/full lighting control	0.99	<0.001
How many people in room?	0.98	<0.001
No/full temperature control	0.98	<0.001
Privacy sat/unsat	0.97	<0.001
Cleanliness sat/unsat	0.96	<0.001
Do you smoke in the office?	0.96	<0.001
No/full ventilation control	0.96	<0.001
Ever requested improvements to HVAC in your office?	0.92	<0.001
Speed of response to HVAC requests sat/unsat?	0.92	<0.001
Effectiveness of response to HVAC requests sat/unsat	0.90	<0.001
Layout liked very much / not at all	0.86	<0.01
Ever requested improvements to aspects other than HVAC?	0.84	<0.01
Speed of response to non-HVAC requests sat/unsat	0.81	<0.01
Decor liked very much / not at all	0.67	<0.05
Effectiveness of response to non-HVAC requests sat/unsat	0.65	<0.05
Root mean square	0.91	

CONCLUSION

Many questions about symptoms, or the environment in a particular season, are reasonably reliable only if asked in the season to which they refer. The building symptom index is, however, a relatively stable measure of the building. This, in turn, lends support to the concept of an underlying malaise (often called sick building syndrome), expressed as different symptoms in different people and at different times.

ACKNOWLEDGEMENTS

The authors would like to thank the all the building management and staff who took part in this study; Claire Aizlewood, Kathryn Rathouse and David Wilde for work on the development of the method; and Lynda Sargent, Lorna Hamilton and Alex Wright for assistance with distributing and collecting questionnaires. The study was funded by the UK Department of the Environment, Transport and the Regions.

REFERENCES

Raw, G.J. (ed.) (1995). *A Questionnaire for Studies of Sick Building Syndrome. BRE Report*. London: CRC.

Raw, G.J., Coward, S.K.D., Aizlewood, C.E., Rathouse, K. and Wilde, D.J. (2002). What do 'real people' mean by indoor air quality? *Proceedings of Indoor Air 2002*, Vol. 3, pp. 156–161. Monterey, California.