SUBJECTIVE ACOUSTICAL EVALUATION OF HEALTHCARE OFFICE FACILITIES

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1 Introduction

The work reported here evaluated the acoustical quality of healthcare office facilities by way of an occupant survey. The objectives were to determine: 1. the quality of the environments and the relationships of design features to it; 2. to what extent perceived acoustical quality is predictive of workplace-perception measures?

2 Site descriptions

The study sites consisted of 17 healthcare office facilities on 30 floors in 17 buildings. In these, administrative staff employed by four local health authorities work. The floors were generally 2.7-m high from the carpeted floor to the suspended, acoustical-tile ceiling (SAC). All buildings were mechanically ventilated. On five of the floors, professionally-designed sound-masking systems were installed in parts of the floors, and were in operation during testing. The spaces studied in these facilities included private offices (PO), shared offices (SO), open-plan offices (OPO), meeting rooms (MR), breakout and telephone rooms (B/TR) and lunchrooms (LR). OPOs varied considerably in size, shape and the number of cubicles/workstations. Many internal partitions (IP) were of conventional gypsum wall board, metal-stud, usually with glass-fiber insulation, in some cases of modular construction as opposed to built-in-place. Some partitions rose to the ceiling slab, but many stopped at the SAC. Entrance partitions contained solid wooden doors.

3 Questionnaire survey

A questionnaire survey to evaluate quality was developed based on work by Veitch [1] and Newsham [2], first by including their Environmental Features Rating (EFR). Factor analysis by Veitch [1] identified three workplace-perception factors: Satisfaction with Lighting (*Sat_L*), Satisfaction with Ventilation and Temperature (*Sat_VT*), and Satisfaction with Acoustics and Privacy (*Sat_AP*). The initial survey also included the following workplace-perception factors:
- Job Satisfaction (*Job_Sat*)
- Job Demands (*Job_Dem*)
- Physical-health symptoms, which involve the perceived frequency and intensity of 11 symptoms. This was grouped into two factors: *Health_Eyes* and *Health_Gen.*
- Emotions While at Work: The PANAS (Positive and Negative Affect Schedule) scale measures how much 10 positive (*PANAS_Pos*) and 10 negative (*PANAS_Neg*) emotions are experienced; from these, *Wellbeing* is calculated as *PANAS_Pos – PANAS_Neg*.

To the initial questionnaire, the following questions were added in preparation for further factor analysis:
- Workspace Overall Environmental Satisfaction section based on questions used by Veitch {1} and Newsham [2], but expanded to improve validity.
- MR/BR/LR-satisfaction section – questions were added to address sponsor interest in these spaces in this study.
- Workplace Related Needs Satisfaction section (WRNS) – this section was adapted from several existing scales with the objective of including questions relating to psychological factors found to be important to workplace satisfaction, including control, place attachment and person-environment congruence.
- respondent demographics section: age, sex, type of job, years in building, years in workstation, educational level.

4 Results

After data cleaning, valid response data was obtained from 635 respondents. Following are key results related to Satisfaction with Acoustics and Privacy (*Sat_AP*). Note that this workplace-perception factor combines acoustics and privacy, implying that the quality of the acoustical environment is uniquely associated with perceived privacy. However, in the questionnaire, privacy includes both acoustical and visual privacy. Attempts to differentiate between these two types of privacy using the questionnaire data were not successful; respondents appear to consider them to be equivalent. Following are some key results:
- Response distribution: Figure 1 shows the *Sat_AP* response distribution. More than 50% of respondents were dissatisfied, a more negative response than for either satisfaction with lighting or ventilation/temperature.
- Variation with office type: Figure 2 shows the *Sat_AP* response variation with office type; the differences were statistically significant. As expected, satisfaction was greatest in POs and worst in OPOs.
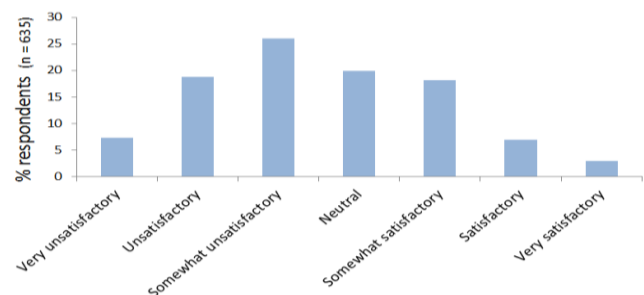

Figure 1: Distribution of responses for *Sat_AP*.
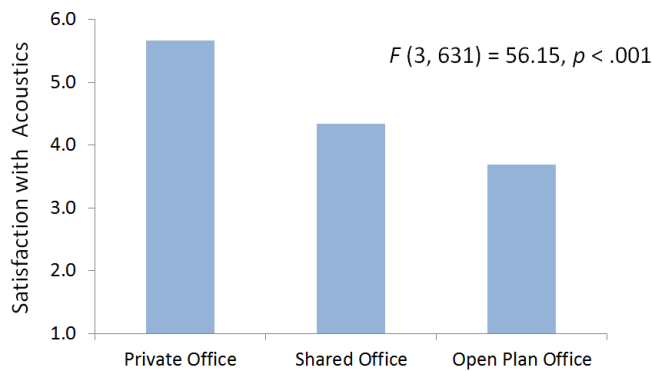
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Figure 2: Variation with office type of responses for *Sat_AP*.

Table 1: Relative contributions of (correlation coefficients beween) IEQ aspects and workplace-perception factors.

Factor	*Sat_L*	*Sat_VT*	*Sat_AP*
WorkSatExt	0.525	0.428	**0.759**
Detach	-0.224	-0.208	**-0.421**
Control	0.344	0.422	**0.582**
Health_Eyes	-0.334	-0.**366**	-0.340
Health_Gen	-0.293	-0.**404**	-0.381
PANAS_Pos	0.207	0.217	**0.329**
PANAS_Neg	-0.161	-0.218	**-0.291**
Wellbeing	0.244	0.291	**0.406**
Job_Sat	0.262	0.244	**0.368**

- Effect of sound-masking system: Figure 3 shows how a sound-masking system affects *Sat_AP*. Satisfaction was statistically significantly lower on floors with a system in operation. Note that this result does not mean that the masking system is responsible for the decreased satisfaction.

- Factor analysis was done on the responses to 39 questions. Existing previously validated scales discussed above (EFR, Physical health, PANAS, job demands) were excluded. The 39 questions included those in these sections:

• Workspace (overall environmental) satisfaction
• Workspace-Related Needs Satisfaction section
• Section with MR/BR/LR-specific questions, since these were of particular interest to the sponsors of this study.

The new workplace-perception factors identified were *WorkSatExt*, *Detach*, *Control*, *BRMR_L*, *BRMR_VT*, *BRMR_AP* and *LR_Overall*. *WorkSatExt* is an extended version of the Work Satisfaction factor used by Veitch and Newsham. *Detach* is a measure of perceived detachment from the workplace. *Control* is a measure of perceived control over the workplace.

5 Correlation analysis and regression modelling

Demographic factors (e.g., age and gender were not correlated with any workplace-perception factors.

Correlations between workplace-perception factors: Pearson's correlation coefficients between each pair of workplace-perception factors were calculated:

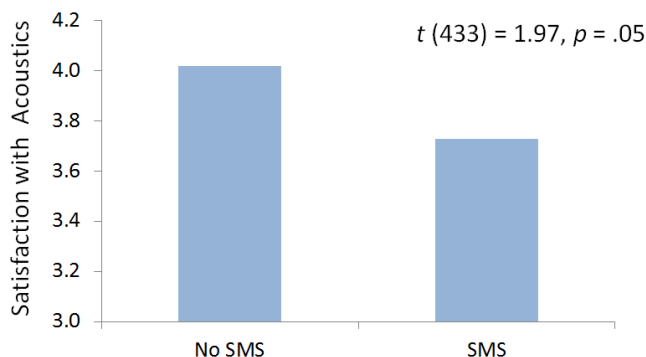- as indicated by the correlation coefficients, to what

Figure 3: Average *Sat_AP* score on floors without and with a sound-masking system in operation.

extent does *Sat_AP* appear to contribute strongly ($|r|>0.4$) to various workplace-perception factors?: *WorkSatExt* = 0.759; *Control* = 0.582; *Sat_L* = 0.503; *Detach* = -0.421; *LR_Overall* = 0.414; *BRMR_AP* = 0.412; *Wellbeing* = 0.406; *Sat_VT* = 0.404. It strongly affect many factors.

- as indicated by the correlation coefficients, what are the relative contributions of satisfaction with the three aspects of IEQ (lighting, ventilation/temperature and acoustics/privacy to other workplace-perception factors? Table 1 shows that *Sat_AP* is the strongest contributor to *WorkSatExt*, *Detach*, *Control*, *PANAS_Pos*, *PANAS_Neg*, *Welbeing* and *Job_Sat*, but not to *Health_Eyes* and *Health_Gen*, for which *Sat_VT* makes the greatest contribution.

- multi-variable linear regression was used to develop an optimal model for predicting *WorkSatExt* from the other factors. Following is the optimal model obtained. Note that *Sat_AP* is the strongest predictor factor:

$$WorkSatExt \ (R^2= 0.706) = 2.229 + 0.415(Sat\_AP)$$
$$- 0.218(Detach) + 0.216(Control) + 0.154(Sat\_L)$$
$$+ 0.116(Job\_Sat)$$

6 Conclusion

The results of this subjective evaluation have shown that occupant satisfaction with the acoustical environment often low, but is a major factor in determining the perceived quality of the workplace.

Acknowledgments

References

[1] J. A. Veitch, K. E. Charles, K. M. F. Farley and G. R. Newsham, "A model of satisfaction with open-plan office conditions: COPE field findings", *J. Env. Psych.* **27** (2007) 177-189.

[2] G. Newsham et al., "Do green buildings outperform conventional buildings? Indoor environment and energy performance in North American offices", Research Report RR-329, National Research Council Canada (2012).