EVALUATION OF THE NOISE-MASKING SYSTEM IN A COMMUNITY HEALTH-CARE FACILITY

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1. INTRODUCTION

In open-plan offices speech is often the most distracting cause of noise even though a main aim of open-office design is to attenuate speech propagating between workstations so that it does not disturb the workers' concentration (Larm *et al*., 2005). In order to achieve adequate speech privacy in open offices, appropriately designed noise-masking systems are often used (Hongisto, 2008). Noise-masking systems consist of loudspeakers located behind the suspended acoustical ceiling distributed throughout the office area; they generate a background noise over a certain area, to mask the unwanted sounds. That should result in increased speech privacy, eliminating the imposition of unwanted sound, and enhancing the general level of acoustical comfort and productivity in the space.

This pilot study was done to evaluate the advantages and the disadvantages of the noise-masking system recently installed on one of the two floors in the Vancouver Coastal Health Community Health-Care facility (CHC). In order to achieve this general goal it was important to determine the effects of this noise-masking system on background-noise levels, speech privacy, and on the workers' performance.

2. LITERATURE REVIEW

2.1 Effects of office noise

Impaired concentration or being distracted is the first major effect of speech noise in offices. Colle (1980) clarified that speech intelligibility can cause disturbance or impaired concentration. Sundstrom (1994) found that of over 2000 participants (office workers) questioned, 54% said they were often bothered by people talking and telephone ringing. Sabine and Jurgen (2009) stated that office noise can reduce verbal short-term memory and make memory retention more difficult.

2.2 Noise-masking-system effects in open offices

Installing a proper noise-masking system has been considered as a cost-effective method to achieve the above objective (Mohammad *et al*., 2000). Lewis (2003) studied how a noise-masking system affected 136 office workers. He found that worker performance was increased and speech distraction was diminished. He found that the perceived acoustical conditions were enhanced by noise control. Hongisto (2008) investigated the effects of a noise-masking system on workers in a small department by measuring the speech privacy, and questioning the workers before and after installation of the system. The results showed that after installing the noise-masking system, speech privacy was significantly improved, speech distraction reduced, and noise-related stress was eliminated.

3. METHOD

This study was conducted at the North Shore Community Health-Care (CHC) facility of Vancouver Coastal Health on the 5th and the 6th floors of a building in North Vancouver. A noise-masking system was installed on the 5th floor only.

Acoustical measurements and calculations were carried out to estimate the background-noise levels and speech privacy for a number of workstations on both floors at the CHC. Moreover, Speech Intelligibility Index (SII) was calculated from measured noise and speech levels and reverberation times.

A questionnaire was developed especially for this study, to investigate the effects of the installed noise-masking system on the workers' performance, comfort and satisfaction with the work environment. A total of thirty-one employees from both floors, out of one-hundred and seventy (18%), returned completed questionnaires.

Different statistical analyses were used to find the relationships between the physical measurements and the questionnaire responses for the two floors. These statistical methods included Spearman correlation, T-test, Mann-Whitney test and single- and multivariable linear regression.

4. RESULTS and DISCUSSION

Total background-noise levels for both floors under occupied conditions were higher than those under unoccupied conditions by about 9 dBA. On the fifth floor, the total A-weighted background-noise levels (unoccupied condition) were 40 and 44 dBA when the noise-masking system was off and on, respectively. On the sixth floor, the total A-weighted background-noise level was 49 dBA under occupied conditions, which is higher than the A-weighted background-noise level under unoccupied conditions. It was also found that the noise-masking system alone generates a sound level of about 41.8 dBA (see Figures 1 and 2).

Speech at short distances (1 and 5 m) was more intelligible than at larger distances on the fifth floor. The noise-masking system reduced the values of SII at all distances. However, speech is always intelligible at most distances of communication when it is occupied on the sixth floor. Statistical results showed that on the fifth floor the relation-

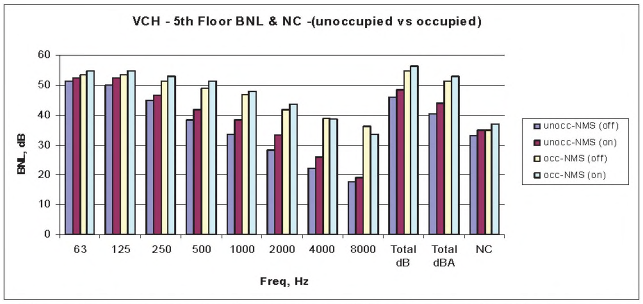

Figure 1: Background-noise levels and NC values on the 5th floor.

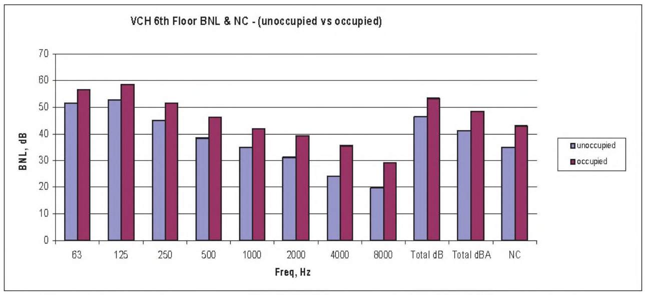

Figure 2: Background-noise levels and NC values on the 6th floor.

ship is highly significant ($p \leq 0.01$) and negative between the measured background-noise levels when the noise-masking system was on (unoccupied) and the difficulty of having confidential conversations in workstations. There is also a highly significant ($p \leq 0.01$) and negative correlation between the background-noise levels when the noise-masking system was on (occupied) and Speech Intelligibility Index values at 1, 5 and 10 m when noise-masking system was on (occupied). Speech Intelligibility Index values at 1, 5 and 10 m were statistically different between the two floors. According to the Speech Intelligibility Index results on the fifth floor, there was a significant ($p \leq 0.05$) difference between SII with the noise-masking system on and SII with noise-masking system off (calculated using casual and normal voice levels at 1, 5 and 10 m) in the unoccupied condition; however, SII at 20 m (either with normal or casual voice) didn't differ significantly. In other words, the noise-masking system seems to be effective when the workplace is unoccupied at 1, 5 and 10 m but, at much higher distances, the effect of the noise-masking system seems to decrease.

Statistical test results also showed that the employees from the two floors showed similar numbers of complaints about speech privacy in the presence or absence of the noise-masking system.

Questionnaire results showed that more than 60% of the participants on both floors were dissatisfied with the acoustical environment. Moreover, employees on the fifth floor are more bothered than those on the sixth floor by speech from other rooms. Employees are more distracted and stressed on the fifth floor than those on the sixth floor.

5. CONCLUSION

The final results showed that the background-noise levels and the noise-criterion values on the fifth floor were higher when the noise-masking system was on (occupied or unoccupied) than when it was off. Moreover, it was found that the noise-masking system provided acceptable speech privacy at short distances of 1, 5 and 10 m between workstations. The system noise levels also provided confidential speech in some workstations. However, the noise-masking system seems to be ineffective at longer distances. Due to the small sample size, statistical-analysis results (Spearman and T-test) didn't indicate significant differences between the two floors regarding the dissatisfaction with the overall environmental quality, the acoustical conditions and the speech privacy. Finally, the regression models show that it is very important to consider the acoustical conditions to achieve overall satisfaction with the workplace environmental quality in a health-care facility. In addition, intermittent noises can also affect work performance directly.

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