The effect of sound on productivity in offices

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ABSTRACT

There is a growing concern about noise in offices since noise is related to an employee's comfort, health and productivity. This study surveyed 259 office workers about the importance of sound, temperature, office layout, air quality and lighting for productivity in offices. It was reported previously (Mak & Lui 2012) that sound and temperature were the principal factors affecting office productivity. The most irritating noises were conversations, ringing phones and machines. The study also found that the environment mattered least to the younger participants. Those over 45 were more sensitive to it, and factors such as noise and temperature had a bigger effect on their productivity. This paper is an extended analysis of the previous paper (Mak & Lui 2012). This further analysis revealed that the female office workers were found to be more sensitive to the environmental and office design factors than male office workers. Participants were separated into low- and high-productivity groups with the mean productivity score of all participants as the cut-point. Similarly participants were separated into sound satisfaction and sound dissatisfaction groups with the mean score of sound factor of all participants as the cut-point. Strong and significantly positive correlations between productivity group (changes in low- and high-productivity groups) and sound group (changes in sound dissatisfaction and sound satisfaction groups) were found, meaning that an office worker who is not satisfied with the sound environment in the office is more likely to have low office productivity while an office worker who is satisfied with the sound environment in the office is more likely to have high office productivity. This indicates again the sound environment has important effects on the office productivity.

INTRODUCTION

Noise is a form of environmental pollution (Stansfeld & Matheson 2003). Owing to population growth, urbanization, industrialization and sustained growth in all kinds of transportation, it is increasingly severe and widespread in modern cities. The effects of noise are pervasive and persistent. Besides, its effect can be direct and cumulative. There is increasing concern about noise problems in offices, as they relate to an employee's comfort (Goines & Hagler 2007), health (Brookhouser 1996; Karchmer & Allen 1999; Muzzet 2007; Wong et al 2011) and productivity (Hancock & Pierce 1985; Mak & Lui 2012). As a result of these concerns, a large number of investigations have been sought to study noise problems in indoor air-conditioned spaces (Ayr 2001; Mak 2002; Mak 2005; Mak & Au 2009a; Mak & Au 2009b; Mak et al. 2009; Ou & Mak 2011;). It is known that the indoor environment and office design can enable or impede office work. This paper examines the principal environmental and office design factors affecting productivity at work and the relationship between office productivity and environmental and office design factors.

A review of past work conducted by the author (Mak & Lui 2012) a possible correlation exists between noise and office productivity and that a questionnaire is a direct and useful method for measuring productivity using a self-assessment approach. This paper is an extended analysis of the previous study. The aims of this study were thus to further examine the effect of sound on office productivity and to assess the relationship between office productivity and five environmental and office design factors, namely temperature, air quality, office layout, sound and lighting. A questionnaire survey was designed and used to study these factors.

METHODS

Questionnaire survey

A convenience sample was selected for this survey. Two hundred and fifty-nine office workers in thirty-eight air-conditioned offices in Hong Kong were recruited to participate. The workers completed a seven-part questionnaire themselves. The questionnaire was used to examine the effect of sound on office productivity and to assess the relationship between office productivity and office noise sources as well as five environmental and office design factors, namely temperature, air quality, office layout, sound and lighting. The first part of the questionnaire developed for this study consisted of items pertaining to demographic variables such as age and gender, as well as office layout. In Parts 2 through 6, participants answered questions on a scale ranging from 1 (strongly disagree) to 5 (strongly agree). Part 2 of the questionnaire comprised three statements regarding office layout, namely “Your workplace is well equipped for your basic needs,” “You are satisfied with the amount of work space and space for storage,” and “Your work desk and chair are comfortable enough that you can concentrate on your work.” Part 3 comprised three statements regarding office temperature, namely “Your workplace is hot most of the time,” “You need to wear a jacket in your workplace most of the time,” and “You are satisfied with the temperature in your workplace.” Part 4 comprised three statements regarding air quality in the office, namely “There is sufficient fresh air in your workspace,” “Humidity levels at your workplace are comfortable enough that you can concentrate on your work,” and “There is an odor in your workplace.” Part 5 comprised three statements regarding lighting in the office, namely “The artificial lighting in your workplace is good enough that you can concentrate on your work,” “There is abundant natural light in your workplace,” and “You are satisfied with the distribution of lighting in your workplace.” Part 6 of the questionnaire comprised two statements regarding office sounds and one question regarding the degree of annoyance of common noise sources in an office. The two statements were “You have a quiet working environment” and “You are satisfied with the sound quality in your office.” The question was “How annoying are the noise sources below: conversation, footsteps, human activity (e.g., coughing, sneezing, etc.), doors closing/squeaking, background noise (e.g., mainly noise from air-conditioning systems), phones ringing, machines (e.g., photocopiers, fax machines, printers, etc.), other noises inside the office (e.g., stapling, typing, etc.), other noises from outside the office (e.g., from the lift lobby, nearby offices, etc.), and noises from outside the office building (e.g., from vehicles, construction sites, streets, etc.)?” Participants answered the question on a 5-point scale ranging from 1 (very annoying) to 5 (not very annoying). The last part of the questionnaire comprised two statements regarding changes in office productivity: “Your office environment reduces your productivity at work,” and “Noise in your office reduces your productivity at work.”

Participants answered the questions on a scale ranging from 1 (strongly agree) to 5 (strongly disagree). (Mak & Lui 2012).

Statistical analysis

Data were coded and analysed using the software package SPSS for Windows 17.0 (SPSS Inc., Chicago, IL, USA). The SPSS is a widely used program for statistical analysis in social science. It is also used by researchers in the fields of health, engineering, built environments and other fields.

RESULTS

Forty-eight percent of office workers were male, and the age bands used in previous published paper of the author (Mak & Lui 2012). It was found in previous analysis that there was no statistical differences appeared for gender between the high- and low-productivity groups. Differences in age groups between the low- and high-productivity participants were found to be significant, meaning that the environment impacts on the productivity of the younger age group (below 45) to a lesser degree. In this paper, further analysis of the questionnaire survey will be conducted.

Office environmental factors and office productivity

Table 1 shows the grades of the mean score and the standard deviation (SD) of the environmental factors. Strong and significant differences for gender were found with respect to temperature and air quality (*P*-value < 0.01), implying that the female participants were more unsatisfied with these factors. Although there are not significantly positive correlations between changes in office productivity and air quality (Mak & Lui 2012), it is still worth noting that the mean score of air quality by female participants was smaller than 3, indicating that female workers are not satisfied with the air quality in offices in Hong Kong. This should be carefully treated.

Table 1: Mann-Whitney U tests between gender groups, Mean (SD)

	Environmental factor	Male	Female	*P*-value
1	Office layout	3.37 (0.68)	3.35 (0.85)	0.936
2	Temperature	3.33 (0.63)	3.13 (0.63)	0.008
3	Air quality	3.11 (0.77)	2.66 (0.90)	0.000
4	Lighting	2.74 (0.87)	2.77 (0.87)	0.888
5	Sound	3.23 (0.61)	3.22 (0.62)	0.952

The relationships of the rank orders between changes in office productivity and scores of environmental factors according to different genders were analyzed using Spearman rank correlations as shown in Table 2. Table 2 is an extended analysis the previous paper (Mak & Lui 2012). It shows the effects of different environmental factors on office productivity of male and female. Only one factor (temperature) was found to be significantly positive correlated (*P*-value<0.01) to office productivity for male, while three factors (Temperature, office layout and sound) were found to be significant for female. This means the female workers were more sensitive to the environmental and office design factors including office layout, temperature and sound and the office should be more carefully designed especially for the female office workers.

Table 2: Spearman rank correlation coefficients of office productivity and environmental and office design factors according to different genders

		Office layout	Temperature	Air quality	Lighting	Sound
Male	Productivity	0.086	0.280**	0.147	0.117	0.109
Female	Productivity	0.280**	0.195*	0.057	0.120	0.285*

*Correlation is significant at the 0.05 level.

**Correlation is significant at the 0.01 level.

Sound and office productivity

In the previous paper (Mak & Lui 2012), participants were separated into low- and high-productivity groups with the mean productivity score (3.18) of all participants as the cut-point. In order to perform further analysis, participants were similarly separated into sound satisfaction and sound dissatisfaction groups with the mean score of sound factor (3.23) of all participants as the cut-point. Table 3 shows that no statistical differences appeared for age (and gender) between the sound satisfaction and sound dissatisfaction groups (P >0.05).

Table 3: Demographic characteristics of participants

Demographic characteristics	Sound satisfaction	Sound dissatisfaction	*P*-value
Age			
Under 25	17 (43.6%)	22 (56.4%)	0.186
25 to 34	60 (50.4%)	59 (49.6%)	
35 to 44	31 (54.4%)	26 (45.6%)	
45 to 55	13 (50.0%)	13 (50.0%)	
over 55	14 (77.8%)	4 (22.2%)	
Gender			
Male	58 (46.8%)	66 (53.2%)	0.734
Female	66 (48.9%)	69 (52.1%)	

[a]score for sound factor is larger than the mean score for sound factor of all participants.
[b]score for sound factor is not larger than the mean score for sound factor of all participants.

Previous analysis showed that strong and significantly positive correlations (P-value < 0.01) between changes in office productivity and office layout, temperature and sound were found (Mak & Lui 2012). In addition, it was found that among the environmental and office design factors, the temperature and sound factors had a principal influence on office productivity. The relationship of the rank orders between productivity group (low- and high-productivity groups) and sound group (sound dissatisfaction and sound satisfaction groups) were analyzed using Spearman rank correlations as shown in Table 4. Strong and significantly positive correlations (*P*-value<0.01) between productivity group (changes in low- and high-productivity groups) and sound group (changes in sound dissatisfaction and sound satisfaction

groups) were found, meaning that an office worker who is not satisfied with the sound environment in the office is more likely to have low office productivity while an office worker who is satisfied with the sound environment in the office is more likely to have high office productivity. This indicates again the sound environment has important effects on the office productivity.

Table 4: Spearman rank correlation coefficients of productivity group (low- and high-productivity groups) and sound group (sound dissatisfaction and sound satisfaction groups)

	Sound group
Productivity group	0.192**

*Correlation is significant at the 0.05 level.

**Correlation is significant at the 0.01 level.

CONCLUSIONS

A seven-part questionnaire survey was conducted. Two hundred and fifty-nine office workers in thirty-eight air-conditioned offices in Hong Kong were recruited to participate.

In the previous paper (Mak & Lui 2012), it was found that sound and temperature were the principal factors affecting office productivity. The most irritating noises were conversations, ringing phones and machines. The study also revealed that the environment mattered least to the younger participants. Those over 45 were more sensitive to it, and factors such as noise and temperature had a bigger effect on their productivity.

In this extended analysis, strong and significant differences for gender were found with respect to temperature and air quality, implying that the female participants were more unsatisfied with these factors. Although there are not significantly positive correlations between changes in office productivity and air quality, female workers are not satisfied with the air quality in offices in Hong Kong. This analysis also revealed that the female workers were found to be more sensitive to the environmental and office design factors including office layout, temperature and sound and the office should be more carefully designed especially for the female office workers. Participants were separated into low- and high-productivity groups with the mean productivity score of all participants as the cut-point. Similarly participants were separated into sound satisfaction and sound dissatisfaction groups with the mean score of sound factor of all participants as the cut-point. No statistical differences appeared for age (and gender) between the sound satisfaction and sound dissatisfaction groups. Strong and significantly positive correlations between productivity group (changes in low- and high-productivity groups) and sound group (changes in sound dissatisfaction and sound satisfaction groups) were found, meaning that an office worker who is not satisfied with the sound environment in the office is more likely to have low office productivity while an office worker who is satisfied with the sound environment in the office is more likely to have high office productivity. This indicates again the sound environment has important effects on the office productivity.

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REFERENCES

Ayr U (2001). An experimental study on noise indices in air conditioned offices. Applied Acoustics 62: 633-643.

Brookhouser PE (1996), Sensorineural hearing loss in children. Ped Clin N Amer 43: 1195-1216.

Goines L, Hagler L (2007). Noise Pollution: A Modern Plague. Southern Medical Journal, 100: 287-294.

Hancock PA, Pierce JO (1985). Combined effects of heat and noise on human performance: a review. Am. Ind. Hyg. Asscoc. J. 46(10): 555-566.

Karchmer M, Allen T (1999). The functional assessment of deaf and hard of hearing students. Am Ann Deaf 144: 68-77.

Mak CM (2002). Development of a prediction method for flow-generated noise produced by duct elements in ventilation systems. Applied Acoustics 63(1): 81-93.

Mak CM (2005). A prediction method for aerodynamic sound produced by multiple elements in air ducts. J. Sound Vib. 287: 395-403.

Mak CM, Au KC (2009a). Normalized spectrum for flow-generated noise prediction using computational fluid dynamics. Building Services Engineering Research and Technology 30(4): 319-328.

Mak CM, Au WM (2009b). A turbulence-based prediction technique for flow-generated noise produced by in-duct elements in a ventilation system. Applied Acoustics 70: 11-20,.

Mak CM, Lui YP (2012). The effect of sound on office productivity. Building Services Engineering Research and Technology 33(3): 339-345.

Mak CM, Wu J, Ye C, Yang J (2009). Flow noise from spoilers in ducts. J Acoust Soc Am 125: 3756-65.

Muzzet A (2007). Environmental noise, sleep and health. Sleep Medicine Reviews 11: 135-142.

Ou DY, Mak CM (2011). The effect of elastic supports on the transient vibroacoustic response of a window caused by sonic booms. J Acoust Soc Am 130(2): 783-790.

Stansfeld SA, Matheson MP (2003). Noise pollution: non-auditory effects on health. British Medical Bulletin 68: 243–257.

Wong HM, Mak CM, Xu YF (2011). A four-part setting on examining the anxiety-provoking capacity of the sound of dental equipment. Noise & Health 13(55): 385-391.