

STUDY ON NOISE PERCEPTION AND DISTRACTION IN OFFICE

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ABSTRACT:

Very much like Tokyo, Hong Kong is a densely populated city. Over 70% of gross floor area on non domestic buildings whether new built or alteration work in Hong Kong are for commercial purpose (Building Department 2007). The demand is continue to grow. Acoustics issues such as noise in the office remains one of the most prevalence annoying source in office whether in enclosed or in open plan office. Such noise issues, some how affect productivity, and had generated dissatisfaction at some level and they were not very well understood, and seldom put into discussion for acoustic improvement in the process of a design project.

There is very little information on noise perception in offices provided in Hong Kong since there is less Post Occupancy Evaluation was carried out to understand acoustic quality in most offices in Hong Kong. A study on understanding on what the noise is, with or without content and their relationship with spatial and physical attributes in regards with end users is essential. A field study and survey on the satisfactory on acoustic issues and quality were conducted for analysis and result and to inform potential solutions on space planning.

This paper is hoped to share a bit on the current situation of noise and its perception in workplace in Hong Kong in relationship to spatial organization and spatial attribute.

Keywords: Noise distraction, Acoustic quality

1. INTRODUCTION

In Hong Kong, office has undergone enormous changes in the last 30 years, in its setting and design, changing organizational philosophy and management strategies as well as operational modes.

The physical characteristic of office today can be traced to, changes in social norms, economics policies, technology and labor force. Such social norms are very much an influence of modernization. As such, escalating real estate and building costs forced a reduction in space allotted to each worker especially in situation in Hong Kong where space is in its limitation and high value; changing organizational philosophies with emphasis on increasing communication have developed in last decades, with preference on open plan offices rather enclosed offices; rapid development of computer technology which sets an impact on the workspace configuration and design today.

Noise is probably the most prevalent annoyance source in offices, and can lead to increased stress for occupants (Evans and Johnson 2000) (Sundstrom 1994). Yet, acoustics in most cases do not received the same level of design attention as thermal, ventilation and lighting as well as other architectural and engineering considerations. This can be justified in a Post Occupancy Evaluation (Salter et al. 2003), where acoustic quality is rated with as lowest satisfaction among other categories.

In order to take noise distraction and conversational privacy into consideration during design process to ensure all employees are distracting free from their working environment, noise is the first essential thing that needs to be examined and understood.

2. OVERVIEW OF HONG KONG OFFICES

2.1. OFFICE WORKSPACE STANDARD AND DENSITY

It is learnt from a study by Collier Internationals that rental for Grade A office in prime area in Hong Kong is reaching 100 Hong Kong Dollar per square feet. Due to escalating real estate and high building cost, high density setting and smaller workspace standard is expected, whether in small scale offices or large scale offices.

Office workspace standards for individuals in Hong Kong are rather small comparatively with 7m² in general, some are even as little as 5m² as compare to USA, of having 14m² (Gilleard and Tam

2002) which would even gain challenges for designers and planner to deal with office noise and conversational privacy when designing.

2.2. OFFICE SETTING AND LAYOUT PATTERN

Most offices in Hong Kong nowadays are in open office planning, whether small or large scale has becoming the norm for office design setting. This is because open plan allows flexibility in team communication and furniture arrangement; save space and allows better visual appearance of the space to remain spacious as well as causing a reduction in construction and churning cost as compare to using conventional enclosed offices.

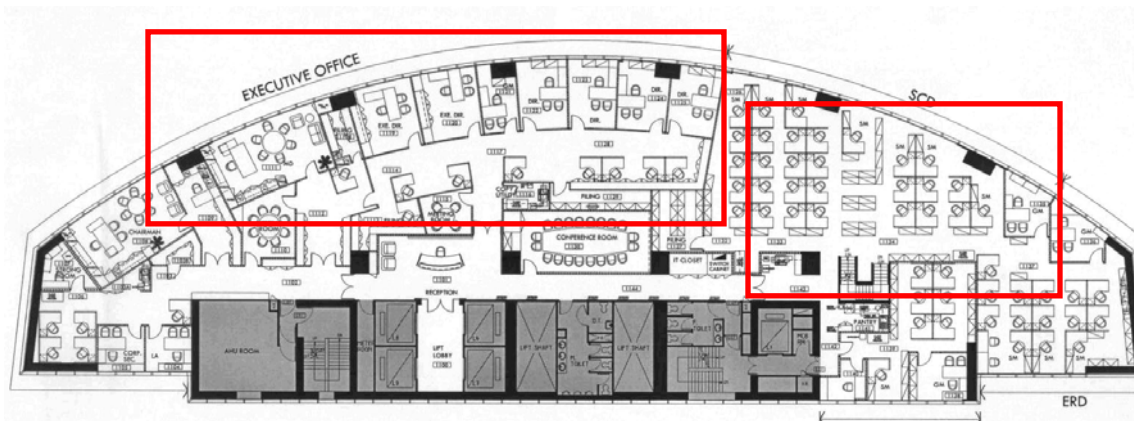


Figure 1: Typical Office Layout Pattern.

Enclosed offices along the building envelope (as indicated on left box) and grid-like workstation layout (as indicated on right box), whether with high or low partition, in between the core and envelop are the typical setting. (Fig.1)

Despite the fact that the grid like layout is well accepted by the designers and the users, these layout settings and changes in space planning from enclosed offices to open plan offices induced issues on noise distraction and conversational privacy.

3. NOISE ISSUES, EFFECTS AND IMPACTS

Noise is an expression for 'unwanted' sound. Since noise is a subjective judgment, the amount of noise caused distraction produced is subjective, psychological and proportional to the loudness of the noise.

Noise distraction is defined as events which disturb or irritate occupants including overheard conversations, equipment noise, and people moving through the space. Severe distraction may classify as annoyance (Evans and Johnson 2000). It is understood that the most annoying sounds are high frequency rather than low frequency and intermittent rather than continuous noise.

(Parkin et al. 1979)

There are typical types of noise in most interior office environment such as

- Human generated noise- human conversation and conversation on the phone.
- Machine generated noise- fax, copier and shredder; ringing phone.
- Impact noise- impact on door push bar during opening/closing, walking on hard surfaces.
- Background noise-low frequency MVAC system and equipment and surrounding context.

Noise source generated from human, indeed brought much distraction compare to all other generated noise within the office environment since noise generated are audible and can be understood. The type of noise-based annoyance is defined as "a feeling of resentment, displeasure, discomfort, dissatisfaction or offence that occurs when noise interfere with someone's thoughts, feeling or daily activities" (Passhier 1993).

Machine generated noise, and impact noise in contrast is less distractive as there is no content with it. Background noise, would cause even less distraction, perhaps no distraction as it assists in masking the noise around since it has no uniformity.

Although noise generated in the office bring no conclusive evidence to physical health impact to the employee after long hour exposure, but studies shown that it brings psychological distraction and annoyance to the employee which may reduces their productivity (EPA 1981) (Cherow1991).

The review of literature indicated that there is evidence annoyance in populations exposed for more than one year to sound levels of 37dB (A) and severe annoyance at about 42dB (A). These studies have been carried out in Western Europe, and USA, but there are no comparable studies in developing countries (de Hollander et al 2004) (Lendrum et al 2004). Low-level noise in open plan offices seems to result in higher levels of stress and lower task motivation, according to a study by a Cornell University environmental psychologist (Evans and Johnson 2000).

There is little doubt that distraction from noise adversely affects human well-being. However, no interior noise standard has been promulgated in local regulations so far. However, under Hong Kong Building Environmental Assessment Method (HKBEAM) performance criteria, guidelines for office premises where privacy is important recommending at level of 48dB (A).

4. NOISE AND NOISE LEVEL IN SMALL SCALE OFFICES AND LARGE SCALE OFFICES

It is understood that normal quiet and low density office in Hong Kong, noise pressure level are measured in the range of 35dB (A) -45dB (A), and busy occupied large office are measured in 45dB (A)-60dB (A). Noise under these sound levels has different characteristics as indicated as following study (Parkins et al 1979). The study proved to be valid until today.

In (Fig. 2) and (Fig. 3), larger office with higher and constant ambient sound levels, workspace characteristic may be more related to the perception of people generated distraction but noise passing between individual are less noticeable. In smaller office, occupational noise is more sporadic and therefore, tends to be more intrusive.

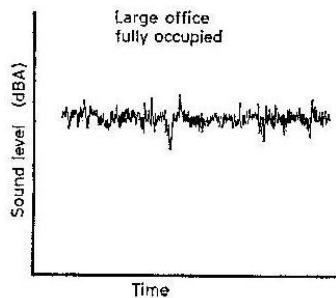


Figure 2: Noise in Large Offices
Source: Parkins et al (1979)

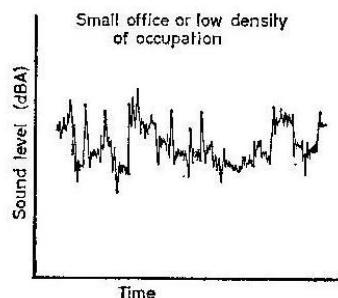


Figure 3: Noise in Small Offices

Some other review shows that occupants in totally open offices are more satisfied with noise level than occupants in cubicles. (Jensen and Arens 2005) Therefore open plan in larger scale office tends to be more successful than in smaller scale office since the activity of people creates background noise.

5. RESEARCH STUDY AND METHODOLOGY-

It is assumed that predictors of perception of noise, acoustic quality in enclosed offices would be different from predictors of noise in open office. It is hypothesized that there is a high difference and more satisfaction on noise distraction from employee in enclosed offices than employee in open plan office.

5.1. SUBJECTIVE QUALITATIVE SURVEY

A survey was conducted between 9th September 2006- 16th September 2006, within 2 working groups who have different individual job nature and work in 2 different setting but similar office scale in Hong Kong. One working group works in enclosed offices setting, and another group works in open plan offices setting.

The aim of the survey is to understand the relationship between noise distraction, speech privacy in open offices and enclosed offices and the physical attributes that contribute to noise generation. 158 copies of questionnaires were sent to these groups, and 55 sets of completed returned survey were collected for statistical analysis and results. Response rate is 34.8%. From the 55 sets of returned survey, 23 sets are from working groups in enclosed office, and 32 sets are from working groups in open office.

The first part of the survey questions informants about themselves that is age, sex and job nature. The second part of questionnaires referred to noise issues, workplace acoustic satisfaction and effects of noise distractions as well as satisfaction in productivity. (See Appendix)

5.2. OBJECTIVE FIELD MEASUREMENT

Noise pressure level was measured by noise meter recorder in these selected offices as a documented field reference. 4 sets of measurement were collected. 2 sets are from Office A and Office B as indicated respectively. (Fig.4) (Fig.5) These offices do share some similarities, such as office scale; nature of daily operations mode; use of materials; number of employee and system furniture heights.



Figure 4: Office A- Project Administration Office

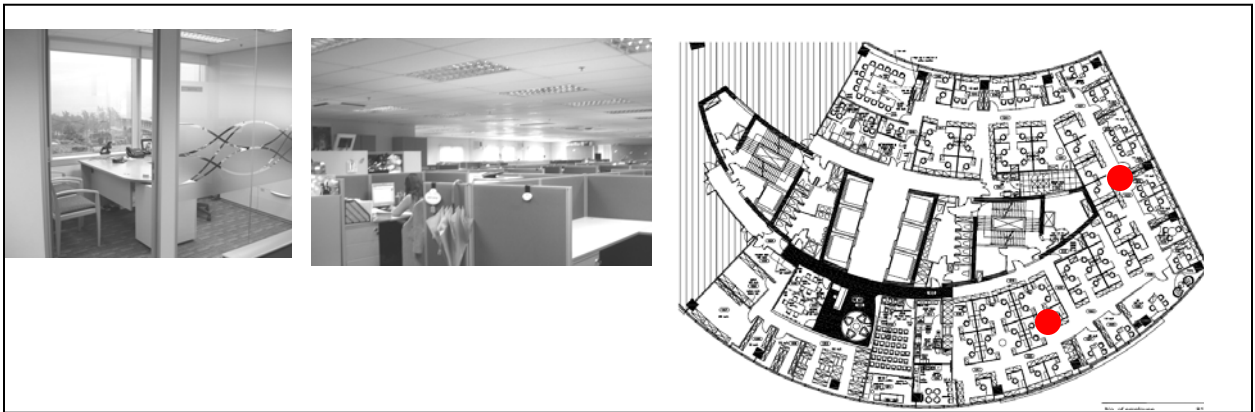


Figure 5: Office B- Accounting Office

6. ANALYSIS AND RESULTS-

6.1. SURVEY FINDINGS

It is clear that there are differences on the perception of noise distraction between the 2 groups. From the statistic chart in (Fig. 6) - vote on noise source, it is found that perception on the most annoying noise in both open plan and enclosed office would be human generated noise-conversation and machine generated noise-ringing phone and copier. Similar to another study conducted earlier (Namecek and Grandjean 1973), that over one third of their samples were greatly disturbed by noise; the most disturbing sounds were overheard conversation.

This implies that open plan offices induced less conversation privacy and more noise distraction than enclosed offices. Employee without adequate enclosure may be more aware of conversation, noises, and actions outside their spaces which may be a source of distraction.

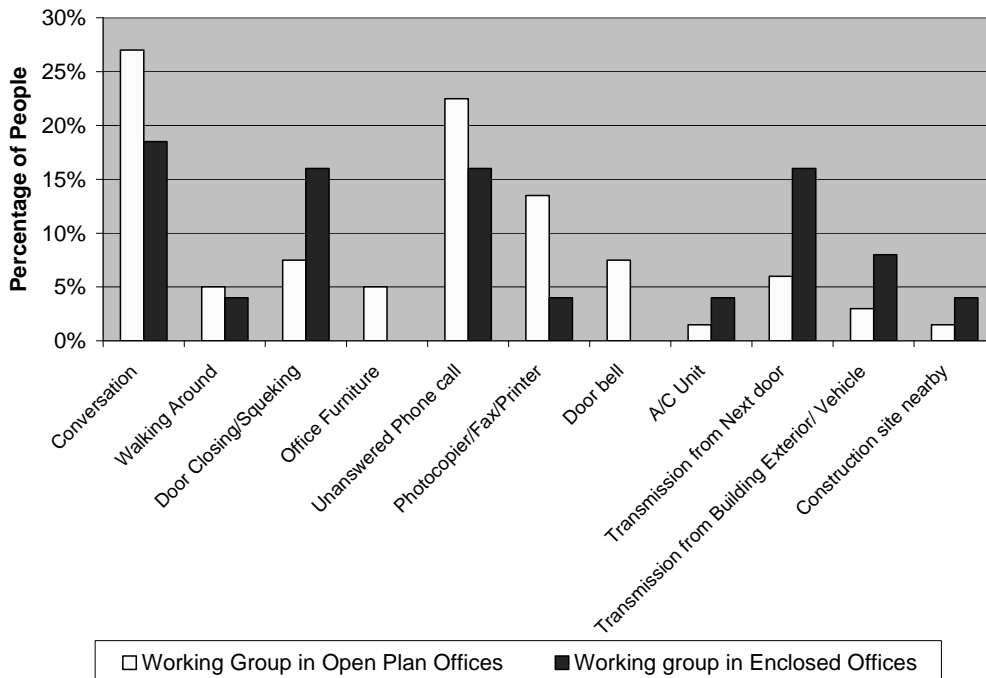


Figure 6: Vote on Noise Source

In the database, people are significantly more dissatisfied with conversation noise. However, it is learnt that those who work in enclosed offices do distract by noise from building exterior and neighbor but less distraction to the group who are in open plan offices.

This can be explained by their seating orientation and workspace are very close to envelope of building or share a demise wall with the neighbor and their offices are at a low level in the building. Other factors would be the building envelope materials and weak insulation that permit noise transmission from the exterior. There is also significant difference in distraction on impact noise such as door closing and opening, between the 2 groups. This may be explained by the working group in enclosed offices are very close to the noise source as compare to the others.

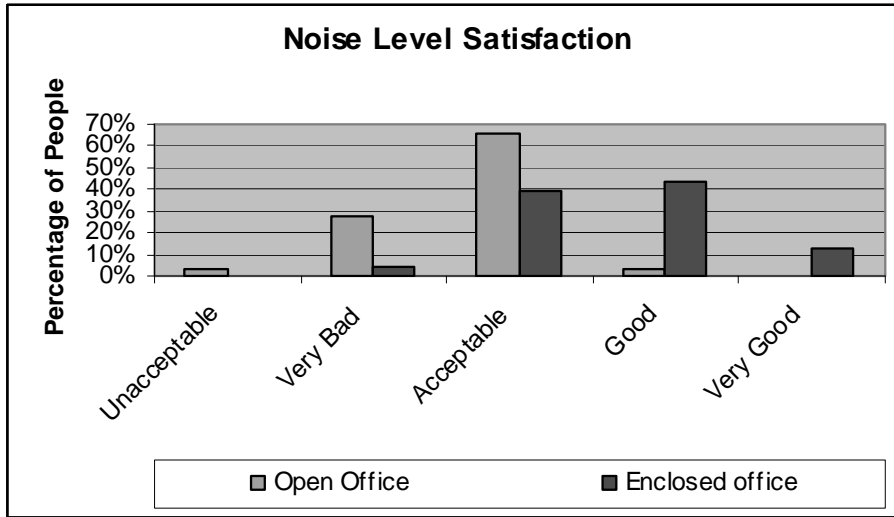


Figure 7: Noise Level Satisfaction.

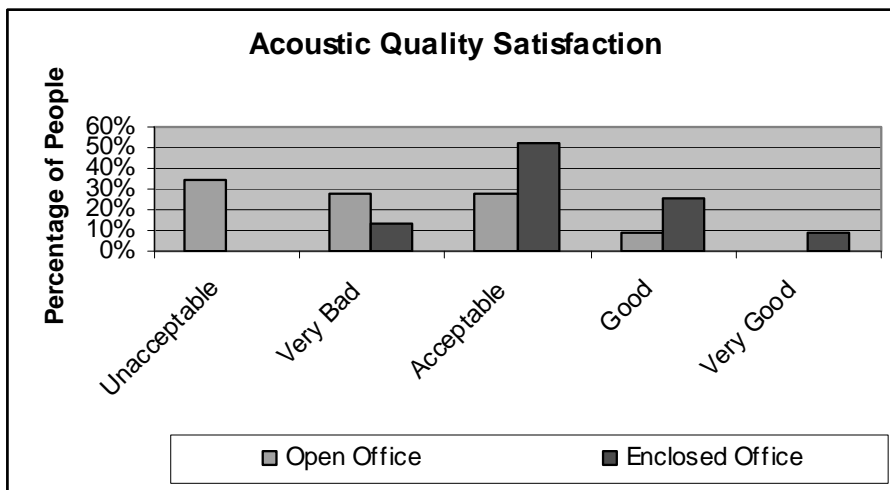


Figure 8: Satisfaction on Acoustic Quality in Existing Offices

From the chart in (Fig.7) (Fig.8), it is found that high percentage of people perceived noise and acoustic quality at an “acceptable” range/level from both working groups. However, it seems none of the working group is unsatisfied with the enclosed office noise level and acoustic quality. In contrast, there is high percentage of people in open plan office are not satisfy with the noise level. The result may be different than what other study suggested (Jensen and Arens 2005), because of the difference of system furniture height and office scale. However, the result here implies that enclosure workplace is a significant determination of noise level satisfaction and acoustic quality for both groups.

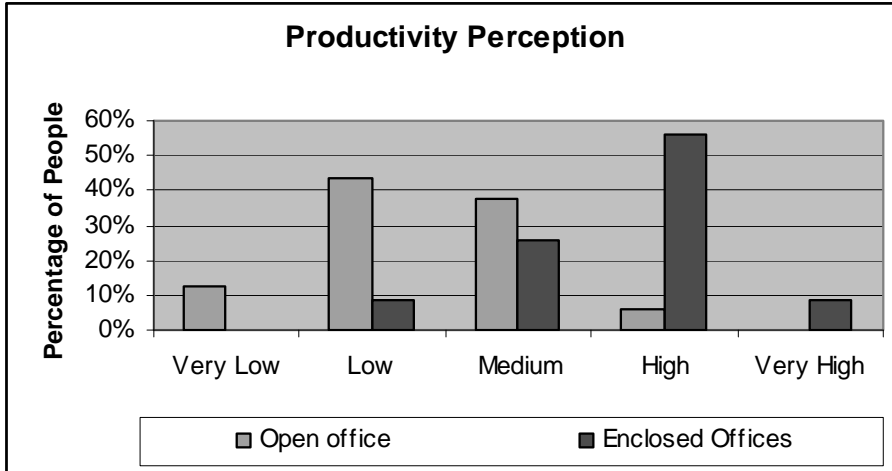
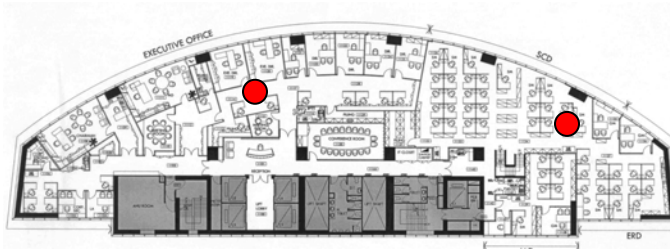


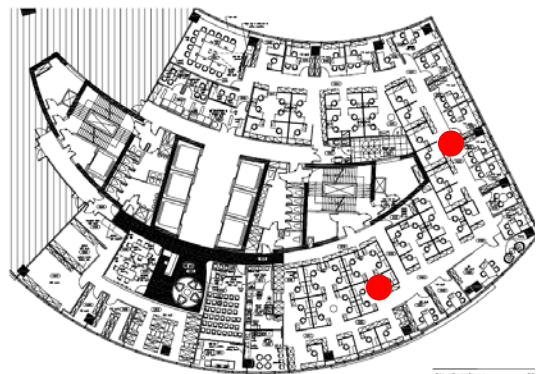
Figure 9: Productivity Perception under Noise Distraction

There are obvious differences in perception on productivity under noise distraction between the 2 groups. It is learnt that more “low” productivity performance is found in the open plan working group than in enclosed offices. The productivity in working group of enclosed offices tends to be on higher side (Fig.9). The study seems support Cherow’s study (Cherow 1991). This indicates that productivity is correlated to the amount of perceived distraction.

6. 2. FIELD MEASUREMENTS FINDINGS



Office A



Office B

From the field measurement on the sound level within the Office A and B, it is found that the readings of sound level meter are varies in between 55 dB (A)-65 dB (A) at the open office over the entire day over the week, while the reading were measured average in distribution of 40dB (A)-45dB (A) at the area of enclosed offices. The reading is in fact, far below reaching a maximum allowable noise level according to OSHA, which could cause health impact such as hearing

impaired and the reading, and it is in a category of “clearly acceptable” range, (Tam 2000) but above given guidelines from HKBEAM.

6.3. CORRELATIONSHIP BETWEEN FINDINGS

Although the actual field measurements readings from both offices (A and B) collected are in the “clearly acceptable” range, there is still small percentage of unsatisfactory perception of noise level and acoustic quality reflected in the survey under category of “very bad” and “unacceptable” in both enclosed and open plan offices. This implies that there are differences occur on the perception result between individual subjective opinion and objective field measurement. Extra effort may be needed for further investigation if high percentage of unsatisfactory perception on noise level is found.

7. DISCUSSIONS

7.1. LIMITATION OF RESEARCH

Time taken for data collection (survey) on psychological perception on noise distraction is too limited. Since there is variation in noise distraction perception from time to time, the results may only represent the responder’s noise perception at that certain time period.

Field measurements serve only a reference, and may be highly variable from time to time, since the time in relation to daily operation is not clearly understood.

The physical attribute of the interior surfaces, space planning and office conditions and materiality were not part of the exercise, and therefore, have not been included as part of analysis although they make important contribution to perception of noise and distraction.

7.2. RESULT RELIABILITY

The study of perception on noise needs strong statistical analysis and affected by variable factors of psychology and physical characteristics of the working environment and individual differences. The extremely small sample size limited the numbers of variables, and restricted the number of anticipation in reaching precise significance.

However, from the statistical test, it indicates that the results from the survey are reliable.

Results of the t-test show below:

Acoustic quality: At 55 degree of freedom, in t value table, 4.769 is found greater than the tabulated value of 3.476 (P=0.001).

Speech Privacy: At 55 degree of freedom, in t value table, 4.775 is found greater than the tabulated value of 3.476 (P=0.001).

Noise Level: At 55 degree of freedom, in t value table, 5.009 is found greater than the tabulated value of 3.476 (P=0.001).

Productivity: At 55 degree of freedom, in t value table, 5.969 is found greater than the tabulated value of 3.476 (P=0.001).

The difference between the mean is very highly significant. Clearly, satisfaction perception on acoustic quality, noise level and productivity is significantly different and higher in the enclosed offices than satisfaction perception does in open plan offices.

7.3. NOISE PERCEPTIONS AND DISTRACTIONS

The result of the study tells us on the significant differences and relationship of noise perception for employees in open plan offices and enclosed offices.

Equipment generated noise is usually transient and the sensitivity to equipment sounds varies from person to person. For example, the noise generated by a photocopier may not annoy the operator but it may bring distraction to the people in adjacent workplaces.

Conversely, people generated distractions are caused by people walking around in work area and overheard conversation. In most cases, workspace characteristic were unrelated to the perception of distraction from other people. The reason outcome may be related to characteristic of the distraction. In this case, workplace enclosure, larger area, and less crowded setting may not change the disruptions of overheard conversation. For example, in quieter places, human speech is easier to decipher and understand. Even if only part of a conversation is audible. It may be enough to distract others from their work.

In contrast, those people who work together and feel a sense of belonging may not decide that conversation and activities of co-worker are not disruptive to them. This can be implied the strong sense of community within the office culture.

In most cases, human-generated and machine-generated noise occurred. This is because of the lack of consideration in between colleagues which can be adjusted to lower tone and the bad

conditions and physical attributes within the space, such as inappropriate materials application to the interiors setting and type of enclosure as well as space planning within the office. This may be the important reasons for the earlier satisfaction results on noise level and acoustic quality.

From the survey results, employee in more dense setting and those with less square footage in their workspace tended to complain more about bothersome of noises from the machine (copies/fax/printer) as compare to those in enclosed offices and shared private offices. This would indicate that changing the physical attributes of the environment and space enclosure, can possibly reduce noise distraction and increase productivity for employee.

7.4. WORKPLACE ENCLOSURE

The most important variable in an explanation of machined generated distraction is workplace enclosure. Employee in enclosed office experienced less distraction from machine than their colleagues in open offices. Workspace enclosure, wall and door do provide a barrier to the noise transmission and may alleviate some of distraction potential of equipment.

Statistically, it shows that satisfaction on acoustic quality decreases as the space becoming more open. This implies that, open office planning should be limited in size and the determination of 'amount of enclosure' needs to be carefully determined.

From the survey results, most responders think that chances of getting distraction are higher in open plan offices, and affecting their productivity. As a consequence, the company is to reserve the right to decide if the open plan systems should be adopted and how much it can be adopted in order to set freedom of noise distraction to the staffs.

8. RECOMMENDATIONS

If acoustic is the priority in a setting, a sensible recommendation would be providing more privacy in order to decrease noise distraction from equipment and machine noise as well as conversation. Since physical feature of the office environment is highly correlated to the predictive of privacy and distraction from the machines. Localize noise source into one area will help to avoid distraction. Machinery and equipment that is relatively noisy should be separated from the production area and workplace.

This also refers to keep individual workspace as enclosed as possible, with the maximum possible partition height and proper sound insulation. This can minimize the sound transmission while giving visual privacy.

The acoustical design of an interior should provide for sound and vibration isolation between noisier and quieter areas of activity. Careful space planning, introduction of special quiet areas are also justified, and the use of sound-deadening finishes, white noise, and staff training, can all help (Marmot and Eley 2000).

It is believed that the increased noise level was attributed to the increased staffing density, use of low partitions, and little sound masking in the form of office landscape. Since sounds tend to break up over distances, increasing space between workspaces (decreasing density) also could lessen noise distraction.

9. CONCLUSIONS

Setting up additional workspace, lower density and more enclosure may be the preference but it may bring high cost on top of the high rental. Efforts should be made to reduce level of noise in the workplace to the lowest economically and technologically reasonable values.

Although perception of noise level is only one of the many concerns in office design, the benefits of open plan which encourage informal exchange of ideas, are often jeopardized by noise and distraction. How to design an open office plan that has an acceptable level of speech privacy and perceived noise level with appropriate level of openness which also encourage productivity is somewhat the challenge for all designers and stakeholders to achieve in the near future.

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APPENDIX

Survey on Noise and Acoustic Quality in Working Environment

For questions below, please indicate "X" or make appropriate indication as your choice to the box.

1. Age

Below 20	21-30	31-40	Above 40

2. Gender

Male	Female

3. Office type that you are working in

Enclosed Office	Open Plan Office

4. Indicate 5 most annoying noise in your working environment in chronological order

(The Most)

(2nd Most)

(3rd Most)

(4th Most)

(5th Most)

5. How satisfy you are on the acoustic quality in your office?

Unacceptable	Very bad	Acceptable	Good	Very Good

6. How satisfy you are on the noise level in your office?

Unacceptable	Very bad	Acceptable	Good	Very Good

7. How satisfy you are on the speech privacy in your office?

Unacceptable	Very bad	Acceptable	Good	Very Good

8. How productive you are under noise distraction and low speech privacy in your office?

Very Low	Low	Medium	High	Very High