On the study of noise annoyance modifiers for city dwellers

H.N. Li, C.K.Chau and S.K.Tang

Department of Building Services Engineering, the Hong Kong Polytechnic University, Humg Hom, Kowloon, Hong Kong SAR

ABSTRACT

Annoyance has been identified as the most important psychological impact arisen from noise. Recent studies have shown that individuals having different socioeconomic status and residing neighbourhood characteristics perceive noise differently. To identify the potential modifiers for annoyance, six hundred and twenty four responses were collected through face-to-face interviews via questionnaire surveys. All the responses were analyzed using an ordered logit model with regard to the effects of some potential modifiers on noise annoyance encountered by home dwellers in Hong Kong. The examined factors include individuals' socioeconomic conditions and their own perception of nearby green areas. Results indicate that the respondents' education attainment level, noise sensitivity, self-rated health status and degree of perception of nearby green areas significantly affect the noise annoyance perceived at their homes. It is further reckoned that the perception of nearby green areas, among all the examined factors, exerts a stronger influence on perceived annoyance. The findings should be of paramount value to urban city planners.

Keywords: noise annoyance, greeneries, ordered logit model

INTRODUCTION

Noise is a worldwide problem, in particular for city dwellers. While major emphasis has been placed on noise mitigation measures, the issues in relation to actual health and psychological impacts arisen from noise are continually to be explored [1].

Noise may lead to heart diseases like myocardial infarction, ischemic heart disease, and hypertension. Notwithstanding some quantitative relationships and odd ratios have been determined for linking noise level with some health impacts [2-7], it is still uncertain as to whether noise can bring health impacts.

On the other hand, it is well accepted that noise can exert psychological effect through annoyance. Annoyance can be regarded as a feeling of displeasure associated with the presence of noise [9]. Individuals may also experience many other negative emotions when exposed to environmental noise, anger, disappointment, dissatisfaction, withdrawal, helplessness, depression, anxiety, or exhaustion [8]. In addition, annoyance can also cause disturbances in activities like sleeping, working and communication. As a conclusion, annoyance includes all subjective personal feelings towards noise.

Many studies attempted to determine a relationship for linking annoyance with decibel level [12,15,16], or make decibel level as a proxy for noise annoyance. However, evidences show that many other confounding factors besides decibel level may also influence the perception of annoyance. Age has been shown to be a modifying factor for annoyance level

[13]. Besides age, noise sensitivity has also found to moderate the perception of annoyance [12,14]. On the other hand, some suggested that the existence of nearby greeneries could reduce annoyance for city dwellers [10,11], despite solid evidences substantiating this claim are still lacking. Accordingly, there is a need for studying whether existence of greenies in surrounding of residential dwellings will moderate dwellers' perception on annoyance.

METHODOLOGY

Questionnaire was used as a major survey instrument in our study. It comprises two major sections. The first section contains an eleven-point numerical scale aimed at revealing the levels of annoyance perceived by respondents at their homes. Several questions in relation to air quality, dust and noise vibration are also included to remind respondents of other problems brought about by noise besides annoyance.

The second section of the survey contains a series of questions aimed at revealing personal socio-economic details such as age, education level, self-rated noise sensitivity and health status to facilitate the analysis of the effects of socio-economic backgrounds on perceived annoyance. Questions on respondents' perception of nearby green areas are also included to study its effect on noise annoyance.

In order to study the effect of the individual perception of greeneries on noise annoyance, respondents were randomly selected from several residential estates, from which greeneries in their surroundings could be perceived by some but not all of their residents. The selected estates are located in Tin

Shui Wai, and Tsuen Wan in Hong Kong. The whole interview process lasted for about five minutes.
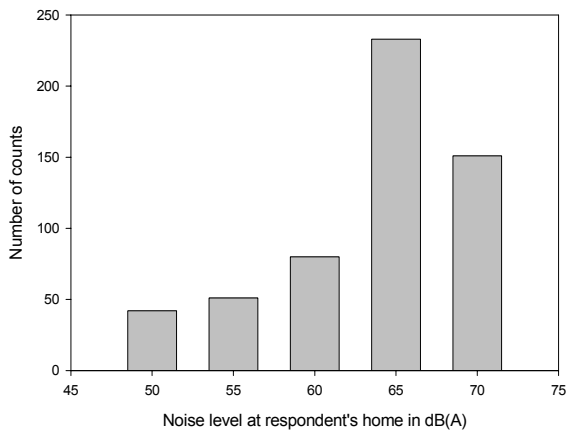

Figure 1. Frequency distribution of respondents' noise exposure at home

The responses were analyzed to explore the relationship between the perceived noise annoyance at the respondents' home and its determinants using an ordered logit model. Prior to our model formulation, the noise level at the roadside facing each respondent's home was predicted using the CRTN method and calibrated using on-site measurements carrying out at both the ground level and the roof level of each residential building concerned.

RESULTS AND DISCUSSION

Prior to full-scale surveys, a trial run was conducted in September 2008 to remove any ambiguities on the content of the questionnaire design and on the method of delivering the survey. A full-scale survey was undertaken between October 2008 and August 2009. Seven hundred and eighty-two interviews were successfully administered, and 560 of which provided sufficient information for more accurately predicting their home noise levels.

Table 1. Socioeconomic characteristics of the respondents

Description	Number of counts (Proportion)
Gender	
Male	*246 (44%)*
Female	*314 (56%)*
Age	
<29	*60 (11%)*
30-39	*180 (32%)*
40-49	*191 (34%)*
50-59	*93 (17%)*
>60	*36 (6%)*
Education attainment	
Elementary and high school	*301 (54%)*
College or above	*259 (46%)*
*Monthly individual income (HK$)**	
≤4999	*42 (8%)*
5000-9999	*141 (25%)*
10000-19999	*123 (22%)*
20000-29999	*45 (8%)*
30000-39999	*32 (6%)*
≥40000	*26 (5%)*

*Total not sum to 100% as some respondents refuse to reveal their household income

Respondents' Socioeconomic Characteristics

Table 1 shows the summary characteristics of all our respondents. More than half of the respondents were over 40 years old. About half of the respondents attained only elementary or high school education. More than a half of the respondents had an individual income level of less than HK$20,000 per month. The noise level at the roadside facing each respondent's home was predicted using the CRTN method after being calibrated using on-site measurements. Figure 1 shows the frequency distribution for different ranges of noise exposure levels predicted at the respondent's home.

Data collected from these 560 interviews was employed for formulating an ordered logit model, which has the following functional form:

$$Y*_i = \sum_{k=1}^{K} \beta_k X_{ki} + \varepsilon_i = Z_i + \varepsilon_i \quad (1)$$

where β_k represent the coefficient estimates of the parameters like age, education level, gender, individual income, self-rated sensitivity, self-rated health status, the perception of greeneries and noise level LEQ in dB(A) at the respondents' home.

Validity of the constructed ordered logit model

Table 2 lists the results of the constructed ordered logit model. The McFadden's ρ^2 value of 0.18 suggests that the model is reasonably fit and is valid for portraying the effects of the factors under study on the perceived noise annoyance of the surveyed respondents.

Table 2. Socioeconomic characteristics of the respondents

Model fitting information		
Log likelihood function		-976.45
McFadden's ρ^2		0.18

Attribute	Coefficient (β)	*p*-value
Index function for probability		
Constant	*-2.771*	*0.000*
AGE	*0.232*	*0.000*
EDU	*0.386*	*0.000*
GENDER	*0.145*	*0.133*
IND_INCOME	*0.000*	*0.569*
SEN	*-0.207*	*0.001*
HEALTH	*-0.431*	*0.000*
GREEN	*-0.568*	*0.000*
LEQ	*0.092*	*0.000*
Threshold parameters for index		
δ_1	*0.000*	*0.000*
δ_2	*0.634*	*0.000*
δ_3	*1.497*	*0.000*
δ_4	*2.420*	*0.000*
δ_5	*3.016*	*0.000*
δ_6	*3.652*	*0.000*
δ_7	*4.135*	*0.000*
δ_8	*4.684*	*0.000*
δ_9	*5.392*	*0.000*
δ_{10}	*6.064*	*0.000*

Identification of the potential annoyance modifiers and modifier effects

Results shown in Table 2 suggest that respondents' age, education level, noise sensitivity, health status, perception of green areas and home noise level exert influences on how individuals perceive noise annoyance at their homes.

Generally, older respondents and those having higher education attainment, inter alia, reported higher annoyance. Conversely, individuals reporting better health status and lower noise sensitivity generally had low annoyance.

Table 3. Standardized coefficient estimates from the ordered-logit model

Attribute	Unstandardized coefficient (β)	Standardized coefficient (β)
Index function for probability		
AGE	*0.232*	*0.081*
EDU	*0.386*	*0.104*
GENDER	*0.145*	*0.024*
IND-INCOME	*0.000*	*0.000*
SEN	*-0.207*	*-0.064*
HEALTH	*-0.431*	*-0.119*
GREEN	*-0.568*	*-0.093*
LEQ	*0.092*	*0.169*

The effect magnitude of the annoyance modifiers

Since different scales are employed for revealing the socioeconomic status and residing neighbourhood characteristics of the respondents, their respective coefficients have been normalized for facilitating a direct comparison of the effects among the attributes using the following equation:

$$\beta'_{xy} = \beta_{xy} * S.D._x * R^2 / S.D._y \qquad (3)$$

where β'_{xy} = standardized coefficients
 β_{xy} = unstandardized coefficients
 S.D._x = standard deviation of independent variables x
 S.D._y = standard deviation of logit y
 R^2 = coefficient of determination of the logit model

It can be revealed from Table 3 that the home noise level was the most important anoyance modifier, being followed by self-rated health, eduation level, green perception, age and noise sensitivity. Conversely, gender and individual income have negligible effects on noise annoyance.
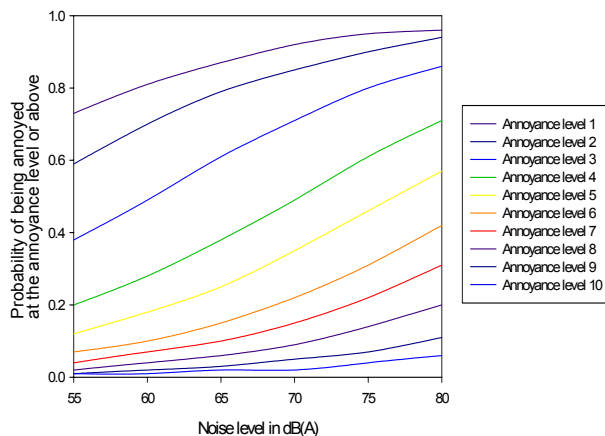

Figure 2. Frequency Probability curves resulted from the ordered logit estimates

Probability of being annoyed at a particular annoyance level or above

As Z_i assumes different values at different noise level *i*, the probability of being annoyed at a particular level or above can be computed by:

$$P(Annoyance = y) = 1 - \frac{1}{1 + \exp(Z_i - \delta_y)} \qquad (2)$$

where δ_y is the threshold value for annoyance level *y* estimated for the ordered logit model and *y* ranges from 1 to 10. The results were shown in Figure 2.

CONCLUSION

Our results suggest that the perceived greenness can substantially affect how a city dweller perceives annoyance from noise. The order of influences of the perceived greenness is comparable to education level and self-rated health. As expected, the actual noise level experienced by a city dweller has the greatest effect on how a city dweller perceives noise annoyance.

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