Characterizing noise sensitivity of inhabitants of cities

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ABSTRACT

Noise sensitivity of people depends on individual attributes that are associated with physiological and psychological factors and the environment in which they live. This paper aims at exploring the underlying factors of noise sensitivity among inhabitants in Hong Kong and Macao, two special administrative regions of China. Using the Weinstein's noise sensitivity scale, we identified that four factors contributing to noise sensitivity of people in Hong Kong and Macao. The factors are the response towards noise, living condition, noise from other people's activities, and noise interference on work or life. Some suggestions on noise awareness and education are also given.

INTRODUCTION

Noise is an environmental stressor and adversely affects the quality of human life (Stansfeld & Matheson, 2003). Different groups of people respond differently to the same noise exposure (Anderson & Miller, 2005). In addition, an individual has different responses to the same noise under different circumstances. The individual difference and intra-individual difference are not unexpected because noise is defined as unwanted sound. Sound such as music and songs that are enjoyable at most of the time for a person can become an unbearable noise during some other times and some other situations such as studying and sleeping.

Physiological and psychological studies (Pearson & King, 2000) demonstrate that people are adaptable. Human response will change due to different environmental exposures and psychological adjustments. When an individual is exposed to certain stimulus for a prolonged period of time, s/he may lose sensitivity to this specific stimulus (Dalton & Wysocki, 1996; Mirabella et al., 1967). In a built environment, people are exposed to a wide range of noises including road traffic noise, rail noise, construction noise, noise from commercial and community activities, noise from ventilation systems, noise from neighbor, among others (Chan et al., 2012; Chung & To, 2002, 2011; Mak et al., 2010, 2014; To & Chan, 2000; To & Yung, 1999; To et al., 2002; Tse et al., 2012). In Hong Kong, the outdoor noise level $L_{eq,15\text{-}min}$ in residential areas ranged from 40 to 78 dBA during the daytime, from 46 to 79 dBA in the evening, and from 40 to 75 dBA at night (HKEPD, 2006). When the indoor noise level was measured with household activities taking place, the $L_{eq,15\text{-}min}$ noise level ranged from 60 to 65 dBA during the daytime and at night while the noise level ranged from 60 to 70 dBA in the evening. Occasionally the noise level reached over 80 dBA when occupants played mahjong (HKEPD, 2006). In Macao, the outdoor noise level $L_{eq,1\text{-}hr}$ ranged from 65 to 75 dBA during the day-time and in the

evening while the noise level ranged from 52 to 72 dBA at night in urban areas (DSPA, 2012). One may wonder under such noisy environments how sensitive of inhabitants of these two cities toward noise. The paper aims at identifying the characteristics of noise sensitivity and its underlying factors of people living in Hong Kong and Macao. The paper also explores whether demographical characters such as gender, age, marital status, occupation, and personal traits have an effect on noise sensitivity.

The remainder of the paper is structured as follows: First, the next section presents a literature review on noise sensitivity of people and its antecedents. Then, the method including sample and measurement instrument are presented, followed by the results and analysis. The paper concludes with implications and future research.

LITERATURE REVIEW

Noise sensitivity has attracted the attention of many researchers in the past decades (Bregman, 1972; Heinonen-Guzejev et al., 2013; Job, 1996, 1999; Miedema & Vos, 2003; Stansfeld, 1992; Weinstein, 1978; Zimmer & Ellermeier, 1999). It is an important topic because as the population in cities grows continuously, the intensity of human activities and their by-products including 'noise' increase. van Kamp and Davies (2008) performed a meta-analysis on environmental noise and mental health. They indicated that although environmental noise is not directly associated with mental health, anxiety and depressive symptoms seems to be more prevalent in people living in the vicinity of noisy infrastructures such as airports than people who live further away. They argued that noise annoyance is consistently found to be an important mediator between noise and mental health. As noise sensitivity has been considered as an antecedent of noise annoyance (Stallen, 1999), van Kamp and Davis (2008) suggested that noise sensitivity of children and adults need to be further explored and the restorative effect of quiet areas on noise sensitive individuals shall be studied. Nevertheless, epidemiological studies show that noise sensitivity is associated with coronary heart and cardiovascular mortality among women, but not among men (Heinonen-Guzejev et al., 2007), and may be a potential risk factor for disability retirement (Heinonen-Guzejev et al., 2013). So, what exactly is noise sensitivity?

Noise Sensitivity

According to Job (1999), noise sensitivity refers to the internal states - physiological, psychological, or lifestyle determined - of an individual, that increase their degree of reactivity to noise in general. Noise sensitivity is an important non-acoustical factor concerning the subjective reactions to a wide range of noise such as noise from indoor activities (Ryu & Jeon, 2011), nocturnal traffic noise (Marks & Griefahn, 2007), aircraft noise (Schreckenberg et al., 2010), among others. In fact, noise sensitivity shall be differentiated from noise annoyance that focuses on the respondent's "attitude towards a specified noise" (Anderson, 1971). van Kamp and Davis (2008) indicated that the percentage of people estimated to be extremely sensitive to noise varies between 12 and 15 percent while Belojevic and Jakovljevic (2001) reported approximately 19 percent of urban population to be sensitive to noise. van Kamp et al.'s (2004) demonstrated that

the prevalence and influence of noise sensitivity is generic among the populations living in the vicinity of airports in Amsterdam, Sydney, and London. Lam et al. (2009) found that noise sensitivity is one of the secondary contributing factors of noise annoyance toward mixed transportation noise in Hong Kong. However, the prevalence and the underlying factors of general noise sensitivity among Chinese in Hong Kong and Macao have yet to be thoroughly studied.

Noise Sensitivity Measures

Noise sensitivity is usually measured by self-report in one of the following two ways. First, respondents are asked directly to rate their own noise sensitivity with a single question. For example, Stansfeld et al. (1993) used the question: “Would you say you were more sensitive or less sensitive than other people to noise?” and provided the following four options: “More, Less, Same, and Don’t know.” Second, noise sensitivity is measured using a multi-item scale such as Weinstein’s Noise Sensitivity Scale (NSS; Weinstein, 1978) or Zimmer and Ellermeier’s Noise Sensitivity Questionnaire (NSQ; Zimmer & Ellermeier, 1999). Weinstein’s NSS consists of 21 items that explore respondents’ attitudes toward noise in general and emotional reactions to a variety of environmental noise encountered in the everyday life. For each item, six response options ranging from strong disagreement to strong agreement are provided. Zimmer and Ellermeier’s NSQ consists of 52 items that explore respondents perceptual, cognitive, affective, and behavioral response towards a wider range of noise encountered in the everyday life, recreation, health, sleep, communication, work, and others. For each item, four response options ranging from strong disagreement to strong agreement are provided. Although both Weinstein’s NSS and Zimmer and Ellermeier’s NSQ have similar reliability and construct validity (Zimmer & Ellermeier, 1999), literature (Belojevic & Jakovljevic, 2001; Miedema & Vos, 2003; Paunovic et al., 2009; Stansfeld et al., 1993; Ryu & Jeon, 2011; van Kamp et al., 2004) shows that Weinstein’s NSS or its simplified version are the mostly popular measure of noise sensitivity.

METHOD

Population and Sample

The target respondents are people living in Hong Kong and Macao, two special administrative regions of China. Convenience sample was used because the study was exploratory in nature. Copies of questionnaire were distributed to students of the authors’ institutions and to participants who attended continuing professional courses at the institutions. In total, 200 questionnaires were distributed in Hong Kong and 350 questionnaires were distributed in Macao.

Measurement Instrument

A questionnaire that included three parts was developed. Part one included 12 items that characterize a respondent personality. The items were adopted from Francis et al. (1992)

with 6 items for extraversion-introversion and 6 items for unstable-stable i.e. neuroticism. Part two included twenty-one items that measure noise sensitivity of the respondents. All items were adopted from Weinstein (1978). These items were measured using a 6-point Likert-type scale, ranging from disagree strongly (1) to agree strongly (6). Part three had five questions collecting the demographic characteristics including gender, age, marital status, education, and occupation of the respondent. The original questionnaire was developed in English. Following the procedures suggested by Brislin et al. (1973), a bilingual researcher translated the questionnaire to Chinese and another independent bilingual professional translator back-translated the Chinese version to English. The original and back-translated versions were compared and there was no significant difference between these two versions.

RESULTS AND ANALYSIS

Out of the 550 questionnaires distributed, 79 and 252 completed questionnaires were returned in Hong Kong and Macao respectively, representing an overall response rate of 60 percent. The mean score of Weinstein's NSS was 80.56 $\pm$ 2.33 for Hong Kong's sample and 80.83 $\pm$ 1.33 for Macao's sample, respectively. Hence, the two samples were combined because there was no significant difference between the mean scores of Weinstein's NSS in the samples. Table 1 shows the demographic characteristics of the sample.

Table 1: Demographic characteristics of respondents

	Number (percent)		Number (percent)
Gender		Occupation	
Male	185 (55.9%)	FT students	211 (63.7%)
Female	146 (44.1%)	White collars	70 (21.1%)
Age		Professional	29 (8.8%)
<20	28 (8.5%)	Others	21 (6.4%)
20-29	250 (75.5%)		
30-39	30 (9.1%)	Industry	
40-49	16 (4.8%)	Retailing	15
>49	7 (2.1%)	Banking/fin.	23
Education		Constr/manuf.	8
UG students	290 (87.6%)	Hotels/casinos	14
Bachelor	27 (8.2%)	Others	60
Masters or above	14 (4.2%)		

A number of *t*-tests and ANOVA were performed to explore whether gender, age,

education, and occupation have any effect on the score of Weinstein's NSS. The analyzed results showed that each of the demographic variables had no significant effect on Weinstein's NSS score.

Correlation analysis was performed between the scores of extraversion-introversion, neuroticism (unstable-stable), and Weinstein's NSS. Results showed that there was no significant relationship between extraversion-introversion and Weinstein's NSS (p>0.05) while there was a weak, significant relationship between the scores of neuroticism and Weinstein's NSS (r=0.132, p<0.05). These results were consistent with the findings reported by Belojevic and Jakovljevic (2001).

The sample was subjected to exploratory factor analysis. Only the 1st to 20th items of Weinstein's NSS was included in this analysis because the last item 'I am sensitive to noise' would be used as an explanatory variable in the subsequent regression analysis. Items with communalities less than 0.5, factor loadings less than 0.5, and cross-loading values greater than 0.4 on more than one factor, were deleted iteratively (To et al., 2013). Table 2 shows the EFA results.

Table 2: Results of exploratory factor analysis

Items	Factor loadings			
I get mad at people who make noise that keeps me from falling asleep or getting work done.	0.794			
Sometimes noises get on my nerves and get me irritated.	0.776			
I get annoyed when my neighbors are noisy.	0.661			
It matters if an apartment you are interested in renting is located across from a fire station		0.782		
I would not mind living on a noisy street if the apartments I have is nice. ®		0.738		
I would not mind living in an apartment with thin walls. ®		0.576		
It would not bother me to hear the sounds of everyday living from neighbors. ®			0.769	
I am good at concentrating no matter what is going on around me. ®			0.757	
I get used to most noises without much difficulty. ®			0.571	
I am more aware of noise than I used to be.				0.783
If it's noisy when I am resting/studying. I try to close the door or move someplace else.				0.566
Variance explained (%)	20.3%	15.1%	14.3%	12.9%
Cumulative variance explained (%)	20.3%	35.4%	49.7%	62.6%
Cronbach's alpha value	0.73	0.57	0.57	0.44

Notes: ® represent items that their scores were reversed before being analyzed.

Items that were deleted in the EFA included:

- No one should mind much if someone turns up his stereo full blast once in a while. ®
- At movies, whispering and crinkling candy wrappers disturb me.
- I am easily awakened by noise.
- Even music I normally like will bother me if I'm trying to concentrate.
- When I want to be alone, it disturbs me to hear outside noises.
- In a library, I don't mind if people carry on a conversation if they do it quietly. ®
- There are often times when I want complete silence.

- Cars ought to be equipped with effective silencers (or mufflers).
- I find it hard to relax in a place that's noisy.

The first factor represents the respondents' response towards noise. The second factor refers to living condition, the third factor noise from other people's activities, and the last one noise interference on work/life.

A multiple regression analysis was performed using the four identified factors (based on the average scores of items) as input variables and the 21st items of NSS 'I am sensitive to noise' as dependent variable. The analyzed result showed that respondents' response towards noise and living condition were very significantly related to 'I am sensitive to noise' ($p<0.01$) and noise interference on work/life was significantly related to 'I am sensitive to noise' ($p<0.05$). Equation 1 shows the relationship between these independent variables and dependent variable.

$$\begin{aligned}\text{I am sensitive to noise} \\ &= 0.46[\text{Response towards noise}] + 0.179[\text{Living condition}] \\ &+ 0.135[\text{Interference on work/life}] + 0.59\end{aligned}$$

Equation (1)

The adjusted R^2 of Equation (1) was 30 percent, representing that 30 percent of the variation of dependent variable could be explained by the variations of input variables.

DISCUSSIONS AND CONCLUSION

Weinstein (1978) reported that the scores of NSS ranged from 25 to 89 with a mean value of 54.6 obtained from 155 U.S. students. Our results showed that the scores of NSS ranged from 55 and 119 with a mean value of 80.8 from 331 respondents in Macao and Hong Kong. 211 of the respondents were full-time undergraduate students. The results implied that people living in built environment in fact were more sensitive to noise, probably due to the fact that their exposure makes them more alert the negativity of noise on the quality of life. The results of the study also confirmed that extraversion-introversion had no effect on noise sensitivity while neuroticism was weakly, significantly associated with noise sensitivity. Factor analysis confirmed that noise sensitivity was a higher-order construct and it might not be appropriate to sum all items numerically to determine one's noise sensitivity. The results of exploratory factor analysis also indicated that items asking respondents about noise from stereo, whether cars ought to be equipped with effective silencers, noise in a cinema/library, and complete silence shall be modified to reflect people exposure in a built environment. Finally, it is suggested that more empirical data shall be collected and a more thorough confirmatory factor analysis shall be performed to reveal the underlying structure of "Noise Sensitivity Scale".

REFERENCES

Anderson CMB (1971). The measurement of attitude to noise. NPL Acoustics Report, Ac 52, National Physical Laboratory, Teddington, Middlesex.

Anderson GS, Miller NP (2005). A pragmatic re-analysis of sleep disturbance data. In: Proceedings of the 19th National Conference on Noise Control Engineering 2005, 15-17 October, Minnesota, USA, pp.948-955.

Belojevic G, Jakovljevic B (2001). Factors influencing subjective noise sensitivity in an urban population. Noise & Health 4(13):17-24.

Bregman HL (1972). Development of a noise annoyance sensitivity scale. National Aeronautics and Space Administration.

Brislin RW, Lonner WJ, Thorndike RM (1973). Cross-cultural Research Methods. John Wiley & Sons, New York, NY.

Chan YH, Choy YS, Leung RCK (2012). Design of compartmental silencer for HVAC system. In: Proceedings of Acoustics 2012, Hong Kong, China, Paper No. 1aEA6.

Chung AWL, To WM (2002). Accurate prediction methodology for finite barrier insertion loss for construction noise impact assessments. In: Proceedings of the 9th National Noise and Vibration Control Engineering Conference, Nanjing, 28-30 October 2002, pp.60-62.

Chung AWL, To WM (2011). NM2: noise mapping and monitoring. Technical Acoustics 30(2): 167-172.

Dalton P, Wysocki CJ (1996). The nature and duration of adaptation following long-term odor exposure. Perception & Psychophysics 58(5):781-792.

DSPA (2012). Report on the State of the Environment of Macao 2011. Macao Environmental Protection Bureau, 2012. Available at: http://www.dspa.gov.mo/tc/05/2011/pdf/sc/06.pdf

Francis LJ, Brown LB, Philipchalk R (1992). The development of an abbreviated form of the Revised Eysenck Personality Questionnaire (EPQR-A): its use among students in England, Canada, the USA and Australia. Personality and Individual Differences 13(4): 443-449.

Hair JF, Anderson RE, Tatham RL, Black WC (2006). Multivariate Data Analysis, 6th ed. Prentice Hall, Englewood Cliffs.

Heinonen-Guzejev M, Vuorinen HS, Mussalo-Rauhamaa H, Heikkila K, Koskenvuo M, Kaprio J (2007). The association of noise sensitivity with coronary heart and cardiovascular mortality among Finnish adults. Science of the Total Environment 372:406-412.

Heinonen-Guzejev M, Koskenvuo M, Silventoinen K, Mussalo-Rauhamaa H, Vuorinen HS, Heikkilä K, Kaprio J (2013). Noise sensitivity and disability retirement: a longitudinal twin study. Journal of Occupational and Environmental Medicine 55(4):365-370.

HKEPD (2006). A Comparative Study of Noise Levels in Hong Kong. Hong Kong Environmental Protection Department, February 2006. Available at:
http://www.epd.gov.hk/epd/english/environmentinhk/noise/studyrpts/noise_studyrpts.html

Job RFS (1996). The influence of subjective reactions to noise on health effects of the noise. Environment International 22(1):93-104.

Job RFS (1999). Noise sensitivity as a factor influencing human reaction to noise. Noise & Health 1(3):57.

Lam KC, Chan PK, Chan TC, Au WH, Hui WC (2009). Annoyance response to mixed transportation noise in Hong Kong. Applied Acoustics 70(1):1-10.

Mak CM, Leung WK, Jiang GS (2010). Measurement and prediction of road traffic noise at different building floor levels in Hong Kong. Building Services Engineering Research & Technology 31(2):131-139.

Mak CM, To WM, Tai TY, Yun Y (2014). Sustainable noise control system design for building ventilation

systems. Indoor and Built Environment, DOI: 10.1177/1420326X13512144.

Marks A, Griefahn B (2007). Associations between noise sensitivity and sleep, subjectively evaluated sleep quality, annoyance, and performance after exposure to nocturnal traffic noise. Noise & Health 9(34):1.

Miedema HM, Vos H (2003). Noise sensitivity and reactions to noise and other environmental conditions. Journal of the Acoustical Society of America 113:1492.

Mirabella A, Taub H, Teichner WH (1967). Adaptation of loudness to monaural stimulation. Journal of General Psychology 76(2):251-273.

Pearson C, King S (2000). Passive environmental control for small cultural institutions in Australia. Australian Academic & Research Libraries 31(2):69-78.

Paunovic K, Jakovljevic B, Belojevic G (2009). Predictors of noise annoyance in noisy and quiet urban streets. Science of the Total Environment 407:3707-3711.

Ryu JK, Jeon JY (2011). Influence of noise sensitivity on annoyance of indoor and outdoor noises in residential buildings. Applied Acoustics 72(6):336-340.

Schreckenberg D, Meis M, Kahl C, Peschel C, Eikmann T (2010). Aircraft noise and quality of life around Frankfurt Airport. International Journal of Environmental Research and Public Health 7(9): 3382-3405.

Stansfeld SA, Matheson MP (2003). Noise pollution: non-auditory effects on health. British Medical Bulletin 68(1):243-257.

Stansfeld SA (1992). Noise, noise sensitivity and psychiatric disorder: epidemiological and psychophysiological studies (Vol. 22). Cambridge, Massachusetts: Cambridge University Press.

Stansfeld SA, Sharp DS, Gallacher J, Babish W (1993). Road traffic noise, noise sensitivity, and psychological disorder. Psychological Medicine 23: 977-985.

Stallen PM (1999). A theoretical framework for environmental noise annoyance. Noise & Health 1(3):69.

To WM, Chan TM (2000). The noise emitted from vehicles at roundabouts. Journal of the Acoustical Society of America 107(5):2760-2763.

To WM, Ip RCW, Lam GCK, Yau CTH (2002). A multiple regression model for urban traffic noise in Hong Kong. Journal of the Acoustical Society of America 112(2):551-556.

To WM, Tam JFY, Cheung MFY (2013). Explore how Chinese consumers evaluate retail service quality and satisfaction. Service Business 7(1):121-142.

To WM, Yung SM (1999). Power estimation of sound sources on low speed electric trains using a deconvolution approach. Journal of the Acoustical Society of America 105(4):2350-2358.

Tse MS, Chau CK, Choy YS, Tsui WK, Chan CN, Tang SK (2012). Perception of urban park soundscape. Journal of the Acoustical Society of America 131(4):2762-2771.

van Kamp I, Davis H (2008). Environmental noise and mental health: five year review and future directions. In: Proceedings of the 9th International Congress on Noise as a Public Health Problem (ICBEN) 2008, Foxwoods, C.T.

van Kamp I, Job RFS, Hatfield J, Haines M, Stellato RK, Stansfeld SA (2004). The role of noise sensitivity in the noise response relation: A comparison of three International Airport Studies. J Acoust Soc Am 116:3471-3479.

Weinstein ND (1978). Individual differences in reactions to noise: a longitudinal study in a college dormitory. Journal of Applied Psychology 63(4):458.

Zimmer K, Ellermeier W (1999). Psychometric properties of four measures of noise sensitivity: a comparison. Journal of Environmental Psychology 19(3):295-302.