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Investigation of the Acoustical Environment of the Elderly's Living Place

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A questionnaire survey was conducted in the residential quarters of Guangzhou, for which 582 elderly people over 60 years old were randomly recruited. The hearing impairment of the participants was evaluated using the Hearing Handicap Inventory for the Elderly (HHIE). The participants' subjective responses to the acoustical environment of their living place and the impact of the living acoustical environment (LAE) on the participants were investigated. The results show that the participants with a low HHIE score and no hearing impairment evaluated their LAE more favourably, and they considered that the effect of the LAE on their daily life was weak. However, those with a high HHIE score and severe hearing impairment evaluated their LAE poorly, and considered its effect on their daily lives to be significant. For the elderly, the worse the hearing is, the higher their demand for a better LAE. Traffic noise, construction noise, noise from residential quarters, and noise from next door or upstairs neighbours were the main noise sources in the elderly's living places, and traffic noise, construction noise, and noise from next door and upstairs were the most influential sources. 28.9% of the respondents had trouble hearing what their family said in their living place. The elderly without hearing impairment considered that continuous noise was the main reason that they could not hear what their family said in their living place, while those with hearing impairment believed that their own hearing problem was a contributing factor.

Keywords: elderly; hearing impairment; living space; acoustical environment; noise.

1. Introduction

Elderly hearing decreases with the increase of age. More and more elderly people are suffering from inconvenience in their daily communication due to hearing impairment. In the United States, the hearing loss of the elderly is the most common chronic disease following arthritis and hypertension, with incidence rates of 30% to 40%. According to the Second China Disabled Persons' Sampling Survey conducted by the China Disabled Persons' Federation from 2006 to 2007, hearing impairment is the second largest disability in China (Yu *et al.*, 2008), with 34.59% of people over 60 years of age suffering from varying degrees of hearing loss, 18.1% of which to a more serious degree than patients with severe hearing impairment (Ji *et al.*, 2015; Diao *et al.*, 2013), Studies show that hearing impairment causes inconvenience to the elderly's daily communication and affects their quality of life and family relationships (Gopinath *et al.*, 2012),

Neuman *et al.* (2010) confirmed that when the reverberation time and background noise level increase, the speech recognition ability of normal adults decreases. Due to the hearing loss, it will be more difficult for the elderly to understand people's speaking than young people in noisy and reverberation environment (Harris *et al.*, 1985), Akiko and Kiyoshi (2014) conducted both objective acoustical measurements and subjective questionnaires to evaluate the influence of the station's acoustical environment on elderly speech communication; the results showed that the elderly understand speech more easily when the signal to noise ratio is above 10 dB. Davies *et al.* (2001) conducted a survey of 207 elderly people with hearing loss, and the results showed that many respondents were plagued by hearing problems in building environments, the most common of which was the poor environment for oral communication, face-to-face and group conversations. The elderly tend to focus on their own hearing loss but do not pay attention to the specific acoustical conditions, which exacerbates the difficulty of communication they face. However, they considered the background speech, reverberation conditions and background noise is the

main cause of their speech communication difficulties.

In China, most of the studies have focused on the investigation of elderly patients' hearing status and hearing screening analysis (Zhang *et al.*, 2015; Zhai *et al.*, 2016; Liu *et al.*, 2014; Zhang *et al.*, 2011; Ma *et al.*, 2014), but studies concerning the impact of living acoustical environment (LAE) on the elderly are rarely reported.

The Hearing Handicap Inventory for the Elderly (HHIE) developed by Ventry and Weinstein (1982) has been widely used throughout the world for the investigation and screening of hearing disorders for the elderly (Lichtenstein *et al.*, 1998; Jupiter *et al.*, 2001; Lopez-Vazquez *et al.*, 2002; Salonen *et al.*, 2011; Sindhusake *et al.* 2001), and it appears to be sufficiently sensitive and specific to provide reasonable estimates of hearing loss (Sindhusake *et al.* 2001; Calviti *et al.*, 2009), Hu *et al.* (2014) and Wang *et al.* (2014) evaluated the reliability and validity of the Chinese version of HHIE, respectively. Sogebi *et al.* (2015) found HHIE scores correlated significantly with pure tone average thresholds. Diao *et al.* (2014) also investigated the relationship between HHIE scores and pure tone audiometry thresholds of the elderly people in China and found very high consistency and correlation.

In this study, the HHIE was used to evaluate the elderly's hearing impairment status, while, at the same time, a second questionnaire was used to assess the acoustical environment of the respondent's living place. The study's aim is to investigate the subjective perception and differences on the LAE of elderly with different hearing impairments and to gain insights into the main noise sources that affect the elderly's daily life and oral communication.

2. Experimental methods

2.1. Hearing Handicap Inventory for the Elderly (HHIE)

Pure Tone Audiometry is the gold standard for measuring hearing impairment. However, it is less suitable for the present study due to its lack of availability and limitation on the test conditions. For this study, the hearing status of the elderly participants was evaluated using the HHIE rather than an audiometer. The HHIE is a self-assessment tool and is designed to assess the effects of hearing impairment on the emotional and social adjustment of elderly people. The inventory comprises two subscales: a 13-item subscale which explores the emotional consequences of hearing impairment and a 12-item subscale which explores both social and situational effects (Ventry, Weinstein, 1982), The subjects were asked to complete the HHIE by selecting "yes", "sometimes" or "no" for each question, where each answer corresponded to 4, 2, and 0 points, respectively. The sum of the scores of all items constitutes the HHIE score, which ranges from 0 (no handicap) to 100 (maximum handicap), The higher the HHIE score is, the more severe the hearing impairment is. Based on the HHIE score, the degree of hearing impairment of the subjects falls into one of three classes: 0–16 points are considered as no handicap, 17–42 points are considered as mild-to-moderate hearing handicap, and scores in range 43–100 are considered as severe handicap (American Speech-Language-Hearing Association, 1989),

2.2. Questionnaire on acoustical environment

In order to evaluate the impact of the LAE on the elderly's daily life, a relevant questionnaire was developed. The questionnaire consisted of three parts. The first part was the subjective evaluation concerning the LAE for the elderly, which consisted of 7 questions concerning the surrounding and indoor acoustical environment in the living place, as shown in Table 1. Table 2 shows the options for these questions using a 5-level rating, where a score of −2 indicates that the evaluation of the questions is the most negative and

Table 1. The questions of the subjective evaluation of the LAE of the elderly.

Item No.	Question in details
Q1	What is the overall impression of the acoustical environment surrounding your living place?
Q2	Do you think that the surrounding acoustical environment in your living area has a great impact on your daily life?
Q3	What do you think of the acoustical environment in your house?
Q4	What evaluation will you make for the acoustical environment in your house?
Q5	Are you feel irritable when your house is too noisy?
Q6	Can you hear an echo in your house?
Q7	Can you hear what your family said at home?

Table 2. The corresponding options for the score for Table 1.

Item No.	−2	−1	0	1	2
Q1	Very noisy	Noisy	Neuter	Quiet	Very quiet
Q2	Very big	Big	Moderate	A little	None
Q3	Very poor	Poor	Neutral	Good	Very good
Q4	Very noisy	Noisy	Neuter	Quiet	Very quiet
Q5	Always	Often	Sometimes	Seldom	Never
Q6	Many	Some	A few	Few	None
Q7	Very unclear	unclear	Barely clear	Clear	Very clear

a score of 2 indicates that the evaluation is the most positive. The LAE score was the mean score of 7 questions for each participant, and higher scores indicated high satisfaction of the elderly with their LAE.

The second part was a survey of noise sources (A. Trains; B. Cars; C. Buses; D. Motorcycles; E. Aircrafts; F. Factories; G. Construction; H. Corridors or staircases; I. Next door neighbor; J. Upstairs neighbor; K. Residential quarters; L. Air conditioning and fans; M. Insects and birds; N. TV, radio, washing machines, etc.; O. Elevators, water pipes) in the living place for the elderly and the effects of these sources. The subjects were asked to list the noise sources that they heard and which had an impact on their lives in their living places.

The third part concerned the reasons due to which elderly people could not hear what their family said in their house. The participants had to answer this part if they had chosen "Very unclear", "Unclear" or "Barely clear" as an answer to question 7 of the first part. The participants were asked to select one or two options from the following: A. Too loud noise; B. Frequent noise; C. Lots of people speaking at the same time; D. unclear speaking or low speech level; E. Too many echoes in the house; F. the elderly's own hearing problem.

2.3. Participants

582 elderly people aged 60–99 were randomly recruited in the residential area of Guangzhou city to participate in answering the HHIE and the LAE questionnaire, comprising 306 females and 276 males, with an average age of 70.7 ± 8.0. Among the respondents, 13 were using single-ear hearing aids and 12 were using hearing aids on both ears. Before the interview, the participants' basic health information was also recorded. Those who had a medical history (such as noise exposure, otology surgery, ear infections, using ototoxic drugs, cardiovascular or cerebrovascular diseases, diabetes and tumor) were excluded.

3. Results

The HHIE scores were obtained from the interview questionnaire. The average value of the HHIE score of the 582 participants was 17.6, and the standard deviation (SD) was 19.6. Of the 582 participants, 337 respondents were classified as having no hearing handicap, 172 having a mild-moderate hearing handicap and 73 with a severe hearing handicap. The number, mean ages and HHIE scores of respondents for the different hearing impairment classifications are shown in Table 3, and the SDs were given in the brackets. Table 3 shows that as the age increased, the HHIE score and the hearing impairment also increased. An analysis of variance showed that gender had no significant effect on the HHIE score ($p = 0.341$), but age and the use of hearing aids did ($p < 0.001$).

Table 3. The statistics of the age and HHIE scores of the elderly for different hearing impairment groups.

Hearing impairment	Number	Mean age	HHIE scores
No handicap	337	68.07 (6.50)	3.74 (4.83)
Mild-to-moderate	172	72.54 (7.82)	27.87 (6.66)
Severe	73	78.73 (8.98)	57.21 (11.67)

Table 4 shows the results of LAE questionnaire evaluation according to the different levels of hearing impairment. Figure 1 shows the fitting curve between the scores from the questionnaire on the LAE and the HHIE score; the correlation coefficient was 0.76, and the SD was 0.54. Because the HHIE score reflects the hearing impairment status, the higher the HHIE score is, the worse the hearing ability is. As it can be seen from Table 4 and Fig. 1, the LAE scores decreased with the increase of HHIE score, so the more severe the hearing impairment is (i.e. the higher the HHIE score), the lower the LAE score is.

Table 4. The statistics of the results of questionnaire evaluation on the LAE of the elderly.

Hearing impairment	Min	Max	Average	SD
No handicap	−0.44	2.00	1.48	0.54
Mild-to-moderate	−1.14	2.00	0.52	0.61
Severe	−1.29	1.86	−0.06	0.68

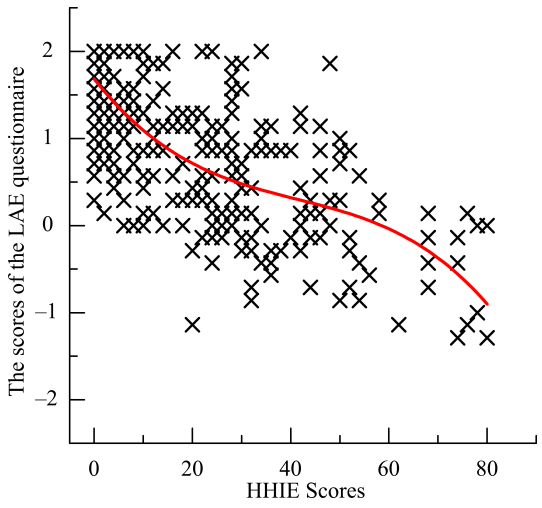
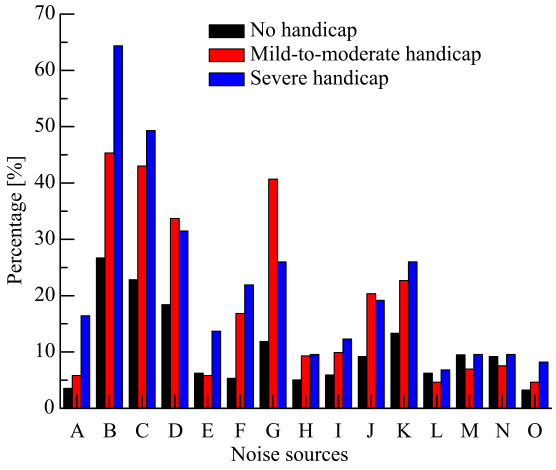


Fig. 1. The optimal curve fit between the scores from the questionnaire on the LAE and the HHIE scores for the elderly.

Figure 2 shows the statistics of the 582 participants on the various sounds and the impact of these sounds. The main noise sources in the living place were traffic (cars and buses) noise, construction noise, noise from residential quarters, and the noise from next room and

a)



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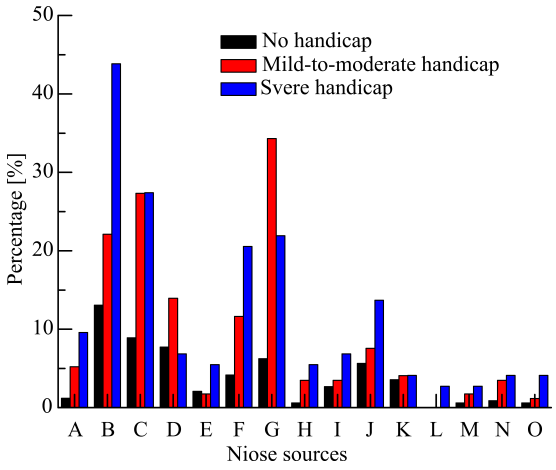

Fig. 2. The statistics of the noise sources heard by the elderly in their living places (a) and the effect of these noises on the elderly's daily life (b).

upstairs. The main noises that affected the participants' daily life were traffic noise, construction noise and noises from next door and upstairs. The survey demonstrated that traffic noise was the most common, and the proportion of elderly people with severe hearing handicap affected by it was higher than that without hearing handicap or mild-to-moderate hearing handicap. More than 40% of respondents with mild-to-moderate hearing handicap could hear construction noise in their living places, and more than 35% of respondents with mild-to-moderate hearing handicap thought construction noise affects their life. The noise from air conditioning, fans, insects, birds, TV, radios, washing machines, elevators and water pipes had little effect on the elderly's daily life.

Of the total amount of respondents, there were 33 with no hearing handicap, 79 with mid-to moderate hearing handicap and 56 with severe handicap that stated that they could not hear other people talking during family conversations at home; they accounted for 28.9% for all respondents. Figure 3 shows that the distribution of the reasons for which these participants stated they could not hear their family talking clearly. As it can be seen from Fig. 3, participants with different levels of hearing impairment were affected by different factors in their oral communication. Those without a hearing handicap thought that the frequent noise, unclear speaking or low speech level and their own hearing problem inhibited their conversations with their family. Participants with mild-to-moderate hearing handicap thought the reasons that they could not hear what their family said in their living place were their own hearing problem, unclear speaking or the low speech level and too many people speaking at the same time. Those with severe hearing handicap concluded that the reasons are their own hearing problems, frequent noise, and unclear speaking or low speech level.

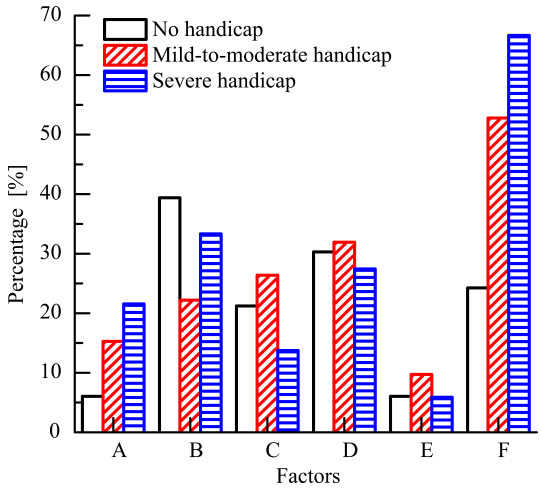

Fig. 3. The statistics of the reasons that elderly people cannot hear what their family said in their house.

4. Discussion

With the development of medicine and the acceleration of the aging of society, the elderly pay more attention to their own quality of life, which includes listening ability. An *et al.* (2015) conducted a survey on the quality life of elderly patients with hearing impairment and found that the greater the degree of hearing impairment is, the greater its impact will be on their emotions and ability to adapt to society. Elderly people with better hearing thought that their LAE has a weaker impact on their daily lives, while the older elderly people with poor hearing believed that the LAE has a greater impact on their daily lives. For the elderly, the worse the hearing impairment status is, the higher demand they have for a better LAE. In order to obtain the same subjective evaluation of the LAE as the elderly with a low HHIE score (no hearing handicap), those with a high HHIE score (severe hearing

handicap) needed a quieter living place so as to reduce the impact of noise on their daily life.

Compared with young people, the elderly were more likely to have hearing impairment due to noise (Esko *et al.*, 2001). For elderly people, the combination of noise and age is bound to deepen the hearing impairment, and they need a lower background noise level in their living place. Locations with high background noise levels are harmful to the elderly's quality of life. In their daily lives, the most common noise sources were traffic, construction, nearby residential quarters and next door or upstairs neighbours. To mitigate this situation, standardizing the public's entertainment times, planting green belt appropriately, improving the sound insulation of the house and setting sound barriers to reduce noise transmission are recommended (Tian *et al.*, 2016). This means that the buildings for the elderly should also be located far away from the main traffic arteries and crowded places.

With the increase of age, physical functions gradually degrade and high-frequency perception in particular, which is an important reason that prevents elderly people, especially those with severe hearing handicap, from hearing their family's talking. If there is continuous background noise in their living places and the speech level is too low, middle and high-frequency parts of speech are more easily covered by noise, preventing the elderly from hearing what their family says in their living place. In order to create a satisfactory living environment for the elderly, a low-noise and quiet living environment should be provided as far as possible.

5. Conclusions

To explore the subjective response of the elderly with different hearing impairment status on the LAE of their living place and the influence of the LAE on their daily life and verbal communication, a questionnaire survey was conducted among 582 elderly over 60 years old in the residential quarters in Guangzhou to investigate their subjective responses on the LAE and its effects. The hearing impairment status of the participants was obtained using the HHIE. From the results of the study, the following conclusions can be drawn.

The elderly with different degrees of the hearing impairment provided different responses. Those with a low HHIE score (no hearing impairment) evaluated their LAE more favourably and considered its impact on their daily lives to be weak. However, those with a high HHIE score (poor in hearing) evaluated their LAE poorly, and its effect on their daily lives was strong. For the elderly, the more serve the hearing impairment is, the higher the demand for a quieter living environment.

The main noise sources in the elderly's living places were traffic, construction, noise from residential quarters, and the noise from next door or upstairs neighbours, of which all but the noise from residential quarters were considered as affecting their daily lives.

28.9% of the participants stated they had trouble hearing their family in their living place, and those without hearing impairment believed that the continuous noise was the main reason for this problem. However, those with hearing impairment also concluded that their own hearing problem was another contributing factor.

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