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Relationships between sound pressure level, typical physiological parameters and perceptions of the elderly residents in aged care facilities in northeast China

Jingyi Mu[1], Jian Kang[2]

[1]School of Architecture, Key Laboratory of Cold Region Urban and Rural Human Settlement Environment Science and Technology, Ministry of Industry and Information Technology, Harbin Institute of Technology

[2]Institute for Environmental Design and Engineering, The Bartlett, University College London, London WC1H0NN, UK

ABSTRACT

Residential aged care facilities are places where the elderly conduct their daily activities, and different functional spaces result in various acoustic environments, and the role of sound quality is being increasingly recognized in the elderly's well-being. A series of surveys were conducted in 15 residential aged care facilities in northeast China, where the elderly's perception and physiological parameters were measured, to examine the relationships among the sound pressure level (SPL), the objective physiological indicators and the subjective evaluation of the elderly. The results revealed the influence of SPL on the elderly with different physical functions and had different degrees of correlation with the elderly's comfort votes. It is shown that the elderly with visual impairment have a higher demand for the acoustic environment. The elderly have a higher comfort value of the acoustic environment of the activity room. However, the fitting analysis between the comfort value and the SPL shows that 48dB is the critical value for the elderly to vote the comfort level of the bedroom acoustic environment, while the critical values of activity room, restaurant and rehabilitation room are 52 dB, 55 dB and 50dB respectively.

Keywords: Residential aged care facilities, Acoustic environment, Acoustic comfort level, Physiological parameters.

1. Introduction

With the aging of the China's population, research related to the living environment of the elderly has attracted much attention. One particular aspect of the living environment, the acoustic environment, is especially relevant, since it influences resident's experience and places such as residential care facilities, nursing homes, or hospitals are often occupied by fragile groups: people with disabilities or the elderly(1). The acoustic environment can seriously affect the health of the elderly (2,3,4). Too much harmful noise may harm their health; in particular, it may prevent elderly people with hearing loss in residential aged care facilities (RACFs) from functioning properly (5). Some studies have pointed out that long-term exposure to sounds above 65 dB (A) can cause serious health problems, such as sleep disorders, hearing loss, tinnitus, hypertension, and cardiovascular disease (6, 7). According to Du (8) the elderly have a higher tolerance for sound compared to younger people, but they are also more sensitive to it, since it can interfere with speech communication.

China is one of the countries with the largest aging population and the fastest growing aging rate in the world. With the increasingly serious aging of society, the number of visual impairment in the elderly population continues to increase. By 2018, China's visually

impaired and hearing impaired population were 4.1 million and 17 million respectively; and the number of visually impaired and hearing impaired people will continue to increase. The research of Alma et al. Shows that the elderly with visual and hearing impairments are affected by the decline or even loss of their visual and auditory perception, visual and auditory information recognition abilities, and their physical coordination, movement persistence, thinking and reaction abilities are also affected (9). Accidents such as slipping and tripping caused by vision and hearing impairment seriously endanger the life safety of the elderly. At the level of cognitive impairment, due to the deepening of cognitive aging, the acceptance ability and cognitive ability of the elderly, especially those with visual impairment, have significantly decreased. At the level of psychological disorder, the elderly with visual and hearing impairment not only face the obstacles in life, but also bear the psychological and mental pressure caused by the occlusion of the visual and auditory systems, and are more likely to produce negative psychological emotions such as self-isolation, sensitive anxiety, fear and depression, which seriously endangers the mental health of the elderly. As a social vulnerable group, a considerable number of the visually impaired and hearing impaired elderly have been neglected for a long time.

Due to the differences in physiological characteristics between the visually impaired elderly, hearing impaired elderly and the ordinary elderly, these three groups of older people have different perception on their living environment. There is need to explore the Relationships between sound pressure level, typical physiological parameters and perceptions of the elderly residents in aged care facilities.

2. Method

2.1 Sites

The field surveys were conducted in Three RECFs in Harbin, the capital cities of Heilongjiang provinces. Harbin has mid-temperate continental monsoon climates. The annual average temperature in Harbin is 4.5◦C, the average temperature in January in winter is approximately −19◦C, and the average temperature in July in summer is approximately 23◦C. The details of these Three RECFs are shown in Table 1.

Table 1- Details of the surveyed residential care facilities.

Name	Volume	Number of beds	Year of construction	Reconstruction (Y/N)	Ownership	Price range (RMB/Month)	Number of participants
XJ	6250	200	2017	N	Private	2000–7000	43
HQFL	8800	260	2004	Y	Public	1999–3199	32
JJS	10000	300	2016	N	Private	2500–3200	37

2.2 Participants

The participants in this questionnaire survey were randomly selected from RACFs in several areas and comprised 112 people aged 60 and above. These participants were all the elderly in good physical condition who could answer questions independently. Among three the RACFs surveyed, the number of female participants was almost equal to that of male participants; (54 male and 58 female participants). The age of the participants ranged from 60 to 90. The demographic characteristics of the questionnaire survey participants are presented in Table 2.

Table 2-Demographics of the participants in the questionnaire survey.

Social characteristics	Classification	Number	Percentage (%)
Gender	Male	54	48.2
	Female	58	51.8
Physical condition	Normal	49	43.8
	Hearing impairment	34	30.3

2.3 Hearing and vision level measurement

The hearing thresholds (average of thresholds at 500, 1000, 2000, 4000, and 8000 Hz) of the participants were first determined by standard pure-tone audiometry with a Grason-Stadler GSI-61 Clinical Audiometer and Sennheiser HD-600 headphones. The measurment was performed by an audiologist in a soundproof room and participants were instructed not to wear hearing aids during the test. The degree of hearing loss was defined as the hearing threshold in the better ear of the participant. Visual acuity measurement was conducted according to the group standard of Chinese Geriatrics Society - Specification for assessment of visual function decline for older audit.

2.4 Typical physiological parameters measurements

Heart rate and blood pressure were chosen as typical physiological parameters because they are significant indicators of cardiovascular disease and have been repeatedly measured to establish an association between environmental noise and cardiovascular diseases (10) Continuous recordings of the heart rate were obtained with a high accuracy heart rate monitor (Haier YK-80C) placed on the right index finger and expressed as beats per minute. The systolic and diastolic blood pressure were measured with a certified wrist blood pressure monitor (AVITA BPM15S) and placed on the left wrist. The measured data were stored by using the Biopac Physio meter MP100 at 1000 Hz and processed with AcqKnowledge5.1 on a computer (11).

The participants were exposed to sound sources while simultaneously measuring their heart rate and blood pressure. Sounds common in RACFs for older adults as described in literature were selected for this experiment. Generally, music, activity sounds, speech sounds, machine sound and traffic noise have been reported as most common. For the sound source, music, we downloaded a piano song from the Internet (Audioset) named: “Soothing and Peaceful Melody”. The other six sounds were obtained as described below in “sound materials”. All the sound sources were calibrated to duration of 4 min to observe the impact on typical physiological parameters over a longer period of time.

2.5 Questionnaire

The questionnaire focused on perception of different sounds. During the survey, participants could stay in the survey room for at least 15 min, after which they were interviewed through a one-on-one question-and-answer method and the data were collected. The participants completed the survey within 10 to 15 min (12). The survey used the 7- point Likert scales (13). After the questionnaire survey, the acoustic environment of the rooms that were investigated was measured.

3. Results

3.1 Relationship between sound pressure level and perception

Some researchers have noted that studies on auditory comfort depend on listener perceptions of the overall acoustic environment. A few suggestions based on these results have been made for future improvements to RACFs. To achieve these goals, models using curved fits were adopted to determine the correlation between sound pressure level and perception among three groups of the elderly.

The curve fit results of the perception on acoustic environment have a moderate degree of fit and better reflected the relationship between the sound pressure level and the perception (Figure 1). The relationship between the SPL and perception of different types of rooms shows different trends with various elder people groups. The curve relationship between the SPL in the bedroom’s perception was good, with the R^2 values of the sound pressure level and perception exceeding 0.5 at 0.575, 0.582 and 0.548 respectively. The curve relationship between activity room’s SPL and perception was poor, especially in group of normal older people (R^2 = 0.364) and the elder with visual impairment (R^2 = 0.378). In the restaurant, the elderly with visual impairment and hearing impairment have better degree of fit (R^2 = 0.548

and R^2 = 0.637, respectively). The elderly with visual impairment have better fitting result than the other groups of older people in rehabilitation room, which R^2 = 0.612.

It is shown that the elderly with visual impairment have a higher demand for the acoustic environment. The elderly have a higher comfort evaluation value of the acoustic environment of the activity room. However, the fitting analysis between the perception and the SPL shows that 48dB is the critical value for the elderly to vote the comfort level of the bedroom acoustic environment, while the critical values of activity room, restaurant and rehabilitation room are 52 dB, 55 dB and 50dB respectively. In bedroom, the highest perception on the sound pressure level of the elderly with hearing impairment is 50 dB, while the critical values for the normal group of older people is 47dB; It should be noted that the critical values of SPL of the elderly with hearing impairment is generally lower than that of the elderly with visual impairment. In the activity room, the restaurant and the rehabilitation room, the SPL corresponding to the highest perception of the elderly with hearing impairment is 48dB, 52 dB and 50 dB respectively

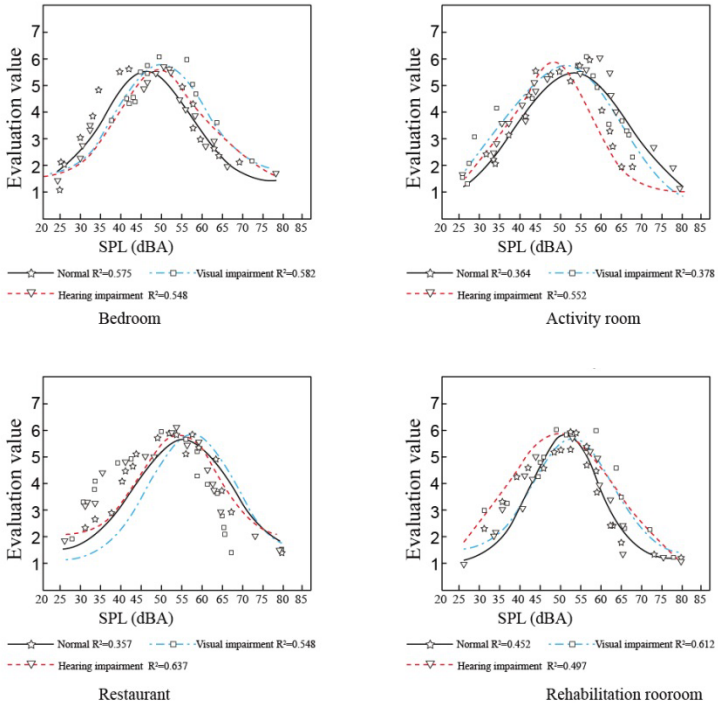
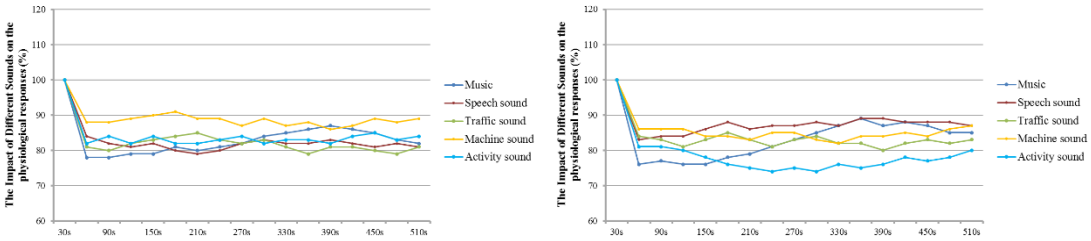


Figure 1-Fitting results for sound pressure level and perception

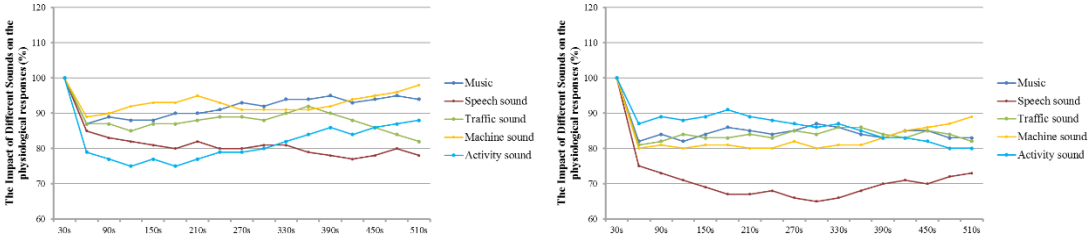
3.2 Relationship between sound and typical physiological parameters

To evaluate the changes in typical physiological parameters over time, the mean changes of the heart rate and blood pressure were calculated following exposure to different sounds ranging from 30 s to 500 s. The results in Figure 2-4 show, in general, evident fluctuations in the physiological parameters. After exposure to each different sound, the heart rate first declines during the initial 90 s. statistically significant differences were found with ANOVA in all 5 different types of acoustic stimuli across the elderly with different groups of the elderly. The most significant results were seen in music ($F=11.240$, $p<0.01$), speech sound ($F=13.672$, $p<0.01$). In the group of the elderly with visual impairment, machine sound (mean=89%, SD=3.413) is associated with fewer fluctuations in heart rate and blood pressure in comparison to music (mean=92%, SD=4.064) and activity noise (mean=93%, SD=3.857). However, in comparison with the response to music (mean=92%, SD=2.007) in the hearing impairment group, there was a stronger decrease in heart rate after 350 s of exposure to traffic sound (mean=96%, SD=1.412) and significant decline in blood pressure after first initial 50s of exposure to speech sound.



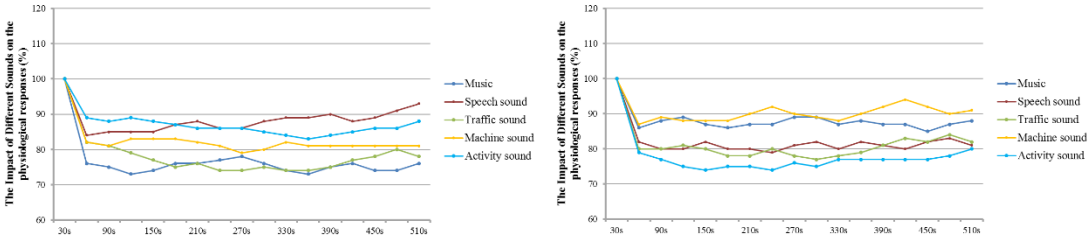
(a). Heart rate (b). Systolic blood pressure

Figure 2-Physiological responses to sounds over time in the group of normal older people.



(a). Heart rate (b). Systolic blood pressure

Figure 3-Physiological responses to sounds over time in the older people with hearing impairment



(a). Heart rate (b). Systolic blood pressure

Figure 4- Physiological responses to sounds over time in the older people of visual impairment

4. Conclusions

The residents of three facilities from Harbin in northeast China were invited to participate in this study. The elderly with different physical conditions (normal group, older people in visual impairment and older people in hearing impairment) have different perception on the acoustic environment of the RACFs. The present study also measured and analyzed the relationship between different sound and typical physiological parameters (heart rate and blood pressure) and the perception of the elderly with different physical conditions. In general, exposure to different sound resulted in fluctuations and inconsistent trends in heart rate and blood pressure.

The elderly with visual impairment have a higher demand for the acoustic environment. The elderly have a higher comfort value of the acoustic environment of the activity room. However, the fitting analysis between the comfort value and the SPL shows that 48dB is the critical value for the elderly to vote the comfort level of the bedroom acoustic environment, while the critical values of activity room, restaurant and rehabilitation room are 52 dB, 55 dB and 50dB respectively.

These results can provide data-based support as a reference for acoustic environment research on the elderly with different physical conditions in RACFs. In addition, this study also explored the correlation between sound pressure level, typical physiological parameters and perceptions of the elderly residents, which helped maintain the accuracy of perception. The typical physiological parameters have found to be inconsistent and fluctuating, indicating to a complex interaction between sound source and physiological health.

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