The Investigation into Design Elements of Auditory Pleasure Experience for the Elderly Based on a Testing Tools Development

Delai Men(✉) and Lingfang Wu

School of Design, South China University of Technology, Guangzhou Higher Education Mega Centre, Panyu District, Guangzhou 510006, People's Republic of China
mendelai@scut.edu.cn

Abstract. The vision system of the elderly will undergo age-related changes. Hearing, as a sensory channel for processing external information second only to vision, will impair the use and perception of products or services. User experience is a hot topic in design research related to the elderly in recent years. Designers also pay more attention to thinking about the experience needs of the elderly from the perspective of multi-sensory channels. However, the research on auditory aging design has not been fully developed yet.

The purpose of this study was to investigate the design elements and characteristics of the elderly's auditory pleasure experience, so as to provide a reference basis for the auditory dimension of the aging design. The research methods include literature study, questionnaire, test, and interview. This study defined and extracted the elements that affect the pleasure auditory experience. A set of materials and tools was innovatively developed for the elderly auditory audio test. 40 elderly people took the hearing test. Through qualitative and quantitative analysis, the study had drawn the conclusion of the key features of the design elements of the elderly's auditory pleasure experience and proposed a suitable aging design strategy based on the elderly's auditory pleasure experience. In sum, the current study has guiding significance for aging design in different fields. The elderly's pleasant hearing experience test system developed and applied in this research is universal. The mapping relationship between the auditory design elements and the elderly's pleasant hearing experience revealed by it makes the sound more in line with the elderly's hearing experience preferences, which is helpful to enhance the interactive experience of products or services for the elderly.

Keywords: Elderly · Auditory experience · Aging design · Auditory preference · Hearing test for the elderly

1 Introduction

1.1 Research Background

Statistics show that the world's aging rate has accelerated significantly after entering the 21st century. The global aging trend is becoming severe and growing rapidly. By the end

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of 2019, China's population over 60 years old was about 254 million, accounting for 18.1% of the total population. The speed and scale of aging in China are unprecedented (National Bureau of Statistics, 2020). The increasing trend of the elderly population means that the demand of the elderly will gradually increase in the future. China is the most populous country in the world with a large base of an aging population. Therefore, it is of typical significance to research the Chinese elderly. From the perspective of design research, sorting out the characteristics of the elderly's perception preferences will help to improve the elderly's pleasure experience and quality of their life.

The auditory system of the elderly will undergo age-related changes, which will impair the use and perception of products or services. 'The degenerative changes of the elderly's hearing are mainly manifested as pure-tone hearing loss, high-frequency hearing loss, and language comprehension. Difficulty in sound localization' [14]. 'Research shows that the rapid decline after the age of 55, it declines rapidly, especially for the pitch discrimination of high frequency sounds' [1]. 'Severity of hearing loss is associated with reduced quality of life in older adults' [2]. Therefore, it is particularly important for the quality of life of the elderly to adapt the sound to the changes of listening comprehension.

Hearing is a sensory channel for processing external information second only to vision, accounting for 15%–20% of the five senses. Hearing helps human to extract interesting or important sound content from the complex background noise environment quickly and accurately. In some aspects, hearing has advantages that vision doesn't have [3]. Compared with visual language, auditory language has five distinctive features: invisible, audible, subjective, open, and slow-acting [4]. However, compared with the visual research, the research on the relationship between human auditory phenomena and design has been neglected. In terms of product and interaction design, Donald Arthur Norman put forward 'pay attention to the natural signals provided by sound to realize the implicit communication between products and people' [5]. He analyzed how to achieve emotional design in the auditory dimension. 'Design can use sound to enhance sensory effects, break the unconscious state of hearing, and make sound become the source of aesthetic pleasure' [6]. At present, with the continuous improvement of living standards, the people-oriented concept exerts a subtle influence on various industries. And pleasure is the highest principle of humanized design. Therefore, only by clarifying the law of elderly's auditory preferences, revealing the relevance of design and the elderly's experience of auditory elements, and respecting the elderly's hearing habits, can we truly do a good job in the subtle and in-depth design and services suitable for the elderly.

The majority of previous research on the elderly's hearing has focused on the changes of auditory physiology and function of the elderly, as well as some aging designs. It is obviously lacking in fully understanding the elements and characteristics of the elderly's personal auditory pleasure experience, especially in reasonably developing the elderly's auditory materials. There is some literature related to the interactive design of the elderly's hearing products, the design of the audiovisual perception of the environment and space, and the aesthetic preferences of music. They put forward constructive suggestions on enhancing the pleasant experience, which laid a solid foundation for this

research. Many results on the research hotspots of auditory interface and sound landscape, as well as the marketing value of sound communication, provide abundant cases for this research. However, there is currently no ready-made tool that can be directly used to obtain the hearing needs of the elderly. One work that supports the design progress of this research is the 'Study on the Aesthetic Preference of the Elderly for the Basic Elements of Music' [15], which takes pitch, rhythm, beat, interval, melody, and termination as examples from the perspective of music. In general, we know very little about the methods and tools of the research on the auditory preferences of the elderly.

1.2 Research Aim

Because the aging adaptation of auditory experience preference is rarely studied and there is scant tool for testing the auditory experience of the elderly. The research results are insufficient to meet the special needs of the elderly for high quality of life. The purpose of this exploratory study was to investigate the design elements and characteristics of the elderly's auditory pleasure experience, so as to provide a reference basis for the auditory dimension of the aging design.

This study defined and extracted the elements that affect the pleasure auditory experience. A set of materials and tools was innovatively developed for the elderly auditory test, which had been appropriately designed through preliminary tests. Through qualitative and quantitative analysis, we found the bias law of auditory preference of the elderly. The study had drawn the conclusion of the key elements of the design elements of the elderly's auditory pleasure experience and proposed a suitable aging design strategy based on the elderly's auditory pleasure experience. In sum up, this research has guiding significance for aging design in different fields.

2 Materials and Methods

We conducted our research through an auditory test conducted in a controlled environment. We let participants experience different audio materials and evaluate their preferences from the auditory dimension.

2.1 Participants

Participants were randomly recruited at local elderly care service centers and elderly activity centers. The effectiveness of participants is determined according to their age, physical and condition, and hearing status. Because this is an auditory test, the main selection criterion is the hearing health of the participants. The changes in hearing with age vary from person to person. Participants with normal listening, cognitive abilities and self-care ability can meet the basic requirements of the test.

We recruited 46 participants to participate in this auditory experiment, and 40 of them finally finished the test effectively and completely. They are between the ages of 60 and 87, come from two different regions of China. There were 30 women and 10

men among the participants. Their educational structure consists of 12 undergraduates, 8 junior colleges, 8 high schools (including high schools, technical secondary schools), 5 junior high schools, and 7 primary schools or below. Participants have the ability to take care of themselves, are in good physical and mental condition, and have normal hearing conditions, which meet the test requirements. As some items are related to music, the personal experience of music training will influence the evaluation results. Among the 40 participants, 1 had a professional background, 3 had music training experience, and the rest have non-professional background.

2.2 Definition of Auditory Elements and Development of Testing Tools

From a physical point of view, the sound is produced by the vibration of an object. In our life, we are always exposed to sound. According to their natural nature, they can be divided into: nature sounds, musical sounds and voice. (see Table 1) What is the auditory experience? Hearing experience is the feeling produced by a person after he perceives sound. People listen, then understand and then enter the perceptual experience of auditory aesthetics. Professor Meng [7] proposed that hearing be composed of six variables including pitch, sound quality, timbre, volume, duration, and sound source distance [7]. [15] concluded that the music industry believes that tempo, rhythm, pitch, melody, harmony, pitch, volume, timbre, theme, style, etc. Are some of the factors that affect music preferences? Yu [8] pointed out that auditory perception usually includes the experience and cognition of the loudness, timbre, tone, and predictability of sound. Their research provides an important reference for the research design of this article [8].

In this study, the volume, pitch, timbre, speed and other elements are extracted from the perspective of sound characteristics. According to the types of sounds that the elderly is frequently exposed to, they are divided into natural sounds, musical sounds, voices, and prompt sounds. From the perspective of music preference, music style also has a great influence on the listening pleasure of the elderly. According to these dimensions, we choose sound materials, or use the software 'FL studio' to make sound materials, as the main tool of hearing test. At the same time, we consult music professionals to ensure the professionalism of sound materials. In the volume test, sound materials are played on-site, and the volume that each participant feels comfortable with is determined. The test items of music genre, pitch, tempo and timbre were evaluated in five grades according to the experience preference of each participant.

Volume element. In the volume test items, we selected four sound types according to the living conditions of the elderly: music, natural sound, prompt sound, and voice. **'**There is a high correlation between music familiarity and preference**'** [9]. In the music volume test items, songs familiar to the elderly are selected as test materials. Natural sound is concrete sounds from the real world. Natural sounds include sounds from nature and life. The violent storm and the singing of birds and water are also natural sounds, but people's psychological feelings are different. For example, the sound from the operation of the product and the sound from the movement of objects. Our experience of these sounds is not aesthetic and not pleasant. In the research of the pleasure experience of the elderly, pleasant natural sounds are mainly selected as the sound volume test materials, such as birdsong, the sound of running water, and the rustle of leaves blown by wind. The prompt music that is more accessible to the elderly is cell phone ringtones, so

Table 1. Auditory test items list

Test item type	Details
Volume	Music sound/natural sound/prompt sound/voice
Pitch	Bass/alto/treble
Speed	Voice/music
Timbre	Voice/music
Music genre	Pop music/jazz/electronic music/regional folk songs/Chinese national music/ballad/traditional opera/classical music/ancient Chinese style/rock and roll/R&B/Bossa Nova/American country

we use the mobile phone ringtone to measure the volume. In the voice test, a piece of voice broadcast material is used to test the volume. In the experiment, we recorded and calculated the corresponding decibel value according to the comfortable and pleasant volume of each participant.

Music genre element. understanding and inquiring about the elderly and considering the more common music genre in the market, the music genre test includes popular music, jazz, electronic music, folk songs, folk music, Beijing opera, classical music, ancient Chinese style, rock and roll, R&B, Bossa Nova, American country, etc. Repertoires familiar to the elderly were first selected as experimental materials. The tempo and the audio duration of the song should be kept as consistent as possible. Only by understanding the elderly's preference for music genre more realistically and objectively, can we better meet the elderly's leisure and entertainment needs, even for recuperation and rehabilitation.

Pitch element. The pitch is determined by the frequency. The higher the frequency, the higher the pitch, which will affect people's mood. 'The bass is deep and heavy, the **alto** is broad and gentle, and the treble is bright and brisk' [16]. In this pitch test item, the piano sound is used as the experimental material, and the 9 sound groups of the bass, alto, and treble registers of the piano in the arrangement software are used to play pure music with the same melody, tempo, and duration.

Speed Element. *Musical Beats Tempo.* Liu and Wei [10] clarified that the generation of individual musical emotions is not only related to the individual's musical experience but also affected by the tempo of music rhythm [10]. In the tempo element of this study, we understood the tempo acceptance and preference of the elderly from the aspects of voice speed and music tempo. In the music tempo test, the piano was used to play pure music with the same melody but different tempo. The tempo sound material was between 55 and 155 beats per minute, and each test tempo audio differs by 10 beats per minute.

Voice Speed Item. There are 5 voice speed types. Refering to the voice speed used in artificial intelligence, it can be divided into very slow (about 132 *words/min*), slow (about 191 *words/min*), normal (about 210 *words/min*), and fast (about 251 words/min), very fast (approximately 289 *words/min*). The tempo audio is played with the same text content.

Timbre Element. On the basis of repeated learning and experience accumulation, the human brain has complex and accurate judgments on the sound information of different timbre. The timbre items in this experiment were tested in two dimensions: voice timbre and musical instrument timbre.

Voice Timbre. Considering the common use of human voice timbre, the classification was based on age and gender. The older the age, the timbre of the sound tends to be rougher, and the pitch tends to be deeper. The boy's timbre is immature and vigorous, while the girl's timbre is immature and crisp. The timbre of young men is just and energetic, and the timbre of young women is soft and beautiful. The middle-aged male timbre is generous and calm, and the middle-aged female timbre is mature and peaceful. In the test, different timbres were used to play the same text content at the same tempo.

Instrument Tmbre. The classification of musical instruments timbre refers to the modern musical instrument classification, which divides musical instruments into chordophones, aerophone, membranophones and idiophones according to the way of sounding. There are too many types of instruments that it is impossible to test them all. Considering the relationship between the preferences of the elderly in China and their living backgrounds, 15 kinds of musical instruments were selected.

2.3 Preliminary Experiment

Before determining the final auditory experiment materials and experimental procedures, we conducted pre-tests on 5 participants using a preset standard operating procedure (SOP). According the pre-test results, the design of the experimental materials was optimized to make the experimental range closer to the range of the elderly's hearing pleasure. Meanwhile, the experiment time is limited, so useless measurement items should be reduced as far as possible to improve the efficiency of the experiment.

The results (see Table 2) of the pre-experiment led us to reduce the number of test items, and the difference between test items should be within the perceptible range of the elderly, so that the test results will be more accurate and useful. (1) In the music genre's preference test, the elderly often mentioned some popular Internet songs. After consideration, it was necessary to add popular Internet songs to the music genre preference test. (2) In the pitch preference test, it was reasonable to delete the test items of the sub-contra octave and 5-line octave, and retain the 7 complete sound groups of the piano (see Fig. 1). Because in the experiment, all participants showed dislike to the pitch. Moreover, the sound materials were further optimized. The originally pure music segment with no melody was changed to a pure music segment with a different pitch. The reason was that in the pre-experiment, it was found that it is difficult for the elderly to evaluate the pure pitch segments without melody during the test. (3) In the test of the music beat tempo, each tempo option was changed from 10 beats to 20 beats, so the original 12 options were changed to 6 options. The reason was that participants often ask, 'Is this different from the previous one?' When there are many and similar options, the elderly were prone to doubts and difficult to make accurate evaluations.

Table 2. List of optimized auditory test items.

Test item type	Details		
Volume	Music sound/natural sound/prompt sound/voice		
Pitch	Bass	Contra octave/Great octave	
	Alto	Small octave/one-lined/two-line	
	Treble	Three-line/four-line	
Speed	Voice	Very slow/slow/normal/very slow/very fast	
	Music	55 *beats/min*, 75 *beats/min*, 95 *beats/min*, 115 *beats/min*, 135 *beats/min*, 155 *beats/min*	
Timbre	Voice	Female	Child/young/middle-aged
		Male	
	Instrument	Chordophones	Piano/guitar/violin/Chinese dulcimer/the lute/erhu
		Aerophone	Flute/trumpet/tuba
		Membranophones	Side drum/snare drum/bass drum
		idiophone	Triangle/cymbals/chime bells
Music genre	Pop music/jazz/electronic music/regional folk songs/Chinese national music/ballad/traditional opera/classical music/ancient Chinese style/rock and roll/Internet pop music/R&B/Bossa Nova/American country		

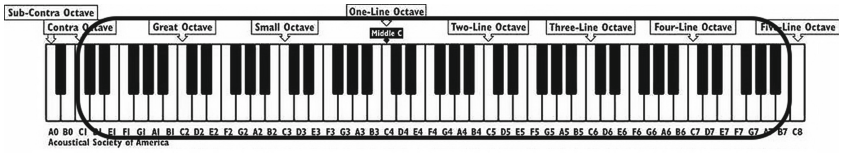

Fig. 1. Selection range of piano register.

2.4 Data Collection and Analysis

In this study, self-made auditory test tools and questionnaires were used to investigate. The sound materials include the above-mentioned sound materials for testing preferences, such as volume, music genre, pitch, tempo, and timbre. The speaker was used to play the sound material, and the decibel tester was used to test the volume of the environment and the audio material. Mobile phones were used to collect questionnaire data and record the volume data of volume test items on site. Finally, the data were analyzed by SPSS.

Data were collected through auditory tests and oral interviews. The Likert scale was used to obtain the participants' evaluation data on sound materials. In the pre-experiment, the elderly often found it difficult to evaluate. Therefore, we made a reference table for auditory experience evaluation to provide the elderly with more evaluation-related words, which were showed and introduced to the elderly during the experiment (see Table 3). The higher the score, the higher the degree of preference. The purpose was to help the elderly to more quickly determine and evaluate the current listening experience more quickly. The observation method was also used to record participants' expressions, language, and physical reactions to collect data.

Table 3. Auditory experience evaluation reference.

Score	1	2	3	4	5
Experience evaluation	Very bad	Bad	Fair	Good	Particularly good
	Boring	Not satisfied	Just so so	Satisfied	Like it very much
	Hate	Dislike	Common	Prefer	Love it
	Very poor	Fail	Pass	Well	Excellent

2.5 Procedure

Every experiment follows the same SOP. In a quiet indoor space where the noise does not exceed 35 dB, the author tested participants one by one. The participants sat at the table, 60 cm away from the speaker. The experience evaluation reference table was placed in front of the participants. The author first ex-pressed gratitude to the participants and introduced the experimental process and evaluation criteria: their real experience of hearing every sound material. Do not introduce the purpose of the experiment to participants to avoid affecting the evaluation. The participants were asked about their ear health and hearing health in different conditions to confirm whether they are suitable for a complete test.

There were 6 groups of test items in the experiment. In the first group, each kind of sound material was played separately in the volume preference test. The button was adjusted from the smallest volume to the volume that the participant considers appropriate according to the participant's prompts, and then the current volume value of the speaker was recorded. After the experiment, the decibel tester was placed on the head of the subject, and the readings of the decibel tester were recorded. The acoustic calculation method was used to calculate the decibels of the sound material over a period of time. Finally, the decibel value of the volume deemed appropriate by each subject was obtained.

The 2nd to 5th groups were music genre, pitch, tempo, and timbre test groups. They were all tested by the same way: playing the audio materials separately, and evaluating the current experience according to the degree of preference after listening to the sound material. They scored values from 1 to 5 according to the Likert scale. Participants were

interviewed after each test item. Group 6 mainly included basic personal information and auditory habits.

3 Results and Analysis

In order to verify the consistency and validity of the results of the questionnaire, this study used SPSS23.0 to analyze the reliability and validity of 57 items of the questionnaire except for demographic variables, as shown in Table 4. The reliability coefficient value in the table is 0.947, which is greater than 0.9, indicating that the reliability of the research data is high. KMO = 0.938 means the validity of the questionnaire is also very high. The analysis results show that the test items and results of this questionnaire are reliable and effective.

Table 4. Cronbach reliability analysis and Reliability statistics.

Number	Sample size	Cronbach α coefficient	Cloning Bach Alpha based on standardized terms	Clone Bach Alpha
57	40	0.937	0.938	0.928

3.1 Music Genre Preference

The data shows that the elderly's preference for pop music and regional folk songs is obviously higher than other types, followed by Internet pop music and Chinese national music (see Fig. 2). When the elderly listened to these songs, humming and laughing, and his bodies moved with rhythm. These behaviors also echoed the findings of the survey. 'Music preference is an individual's emotional response, which is related to the characteristics of music itself (such as pitch, tempo, rhythm, style, etc.). At the same time, music preference also reflects the listener's main music-related experience, emotional state, personality traits, values and social environment and other factors.' Besides, they showed a moderate to high preference for jazz, traditional opera, classical music, ancient Chinese style and Bossa Nova.

From the above, it can be found that pop music is the most popular music genre. Popular songs are industrialized and consumer cultural products that are easy to understand and accept. Internet pop music has a lower threshold of creation, which is widely spread and sung through the network. It is easier to understand and close to life. In general, there are several reasons why the elderly like it. (1) The pitch is appropriate and easy to sing. (2) It is brainwashed by deliberately repeating and undulating melody. (3) The lyrics are simple and straightforward which do not require deep thinking and insight. (4) The most important thing is that the melody is simple and the lyrics are easy to understand. The culture and living standards of the majority of the elderly are poor. These songs are within the scope of their understanding.

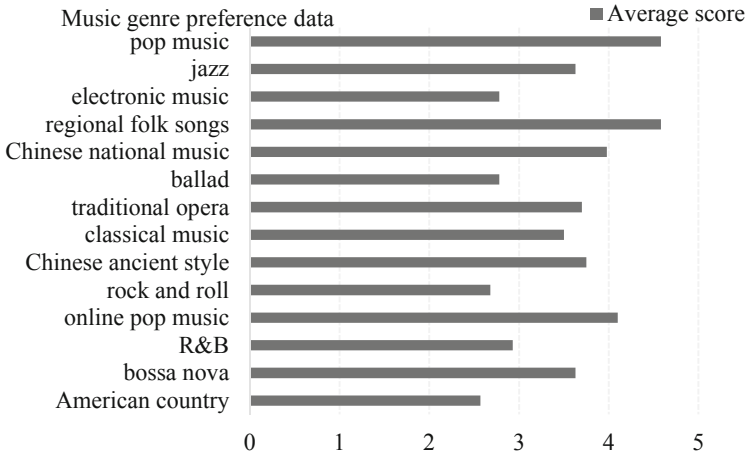

Fig. 2. Comparison of music genre preference evaluation.

Regional folk songs are traditional songs of laborers. The art of songs produced and developed by the people through extensive oral singing in daily life practice is full of rich life-breath. The preference for Chinese national music stems from experience. It sounds familiar and matches their life background and age. The preferences for traditional opera, classical music, and Bossa Nova is polarized. The elderly has strong subjective view on these three types of songs. Therefore, the application of these types of songs cannot meet the preferences of most elderly people, but it can be preferred by some elderly people [11].

Analyzing the relationship between music genre preference and background variables, pop music, regional folk songs, and Internet pop music has no difference in gender, age, and education level, showing greater universality. Men showed a higher degree of preference for Chinese national music, jazz, ancient Chinese style, and Bossa Nova. Women have higher preference for traditional opera and classical music. Older people who have received higher education and music training have a higher preference for classical music. Their past experience and the types of music they have listened to indirectly influence their familiarity and acceptance of classical music.

In the interview, they also expressed, 'Because I understand', 'because I can keep up with the tune', and thus prefer certain music.' There is a high correlation between music familiarity and preference. And it is the most obvious of the factors that affects preference' [9]. In the interview, they also mentioned that 'this kind of music is suitable for me to dance in public square dance', especially for women. They imply that they like dynamic music with a sense of rhythm. 'The music rhythm in Chinese square dance is obvious, which is well known to the masses. Its rhythm is usually brisk, clear and full of joy' [12]. Because of their daily music activities, they are more likely to come into contact with this kind of music genre. Its familiarity and usefulness affect the degree of preference for similar music. In addition, most elderly people mentioned that they are disgusted with loud, harsh, hard-sounding, and too intense music, such as rock and roll

and electronic music. For music like ballad, the elderly pointed out that it is difficult to understand, as plain as speaking which should be liked by young people.

3.2 Volume Preference

As shown in the volume preference data Table 5, the volume results of the participants for the 4 sound types are that the volume of voice is higher than the prompt sound, and the volume of prompt sound is higher than the music and the natural sound. It can be seen that the volumes that need to be heard clearly and with specific information is higher than the volumes that need to be heard, followed by the sound types of appreciation, leisure and entertainment (such as music and nature sound, etc.). By calculation, the average variation range of several kinds of audio is 72.94 to 79.19 decibels, and the average perceived volume is 74.8 decibels.

Table 5. Volume preference evaluation data.

Sound type	Music sound	Natural sound	Prompt sound	Voice
Average equivalent decibel value (*dB*)	73.38	72.94	73.78	79.19
Median (*dB*)	72.98	74.70	69.86	79.86

3.3 Pitch Preference

The elderly's preference order for the pitch of the seven groups is: 1-lined, small octave, 2-line, 3-line, great octave, 4-line, contra-octave (see Fig. 3). The preference of the elderly for 1-lined octave is significantly higher than for other octaves, followed by the preference for small octave and 2-line, which are all above the middle. Comparing the pitches into bass, alto, and treble, the elderly like the alto register the most (see Fig. 4). According to the comparison table of piano pitch and frequency, the frequency ranges corresponding to small octave, line 1 and line 2 are (220.00 to 415.31 Hz), (440.00 to 830.61 Hz), (880.00 to 1661.22 Hz).

The treble register is crisp and bite. Alto register is soft and open, and the bass register is thick and heavy. In the interview, the elderly said that they 'like to listen to the pitch that they can keep up with'. Alto sound is bright and dexterous which is the most frequently used sound. The frequency range of speech and chat is usually in the alto register. Due to the extremely high frequency of use, alto has naturally become the most used and comfortable sound.

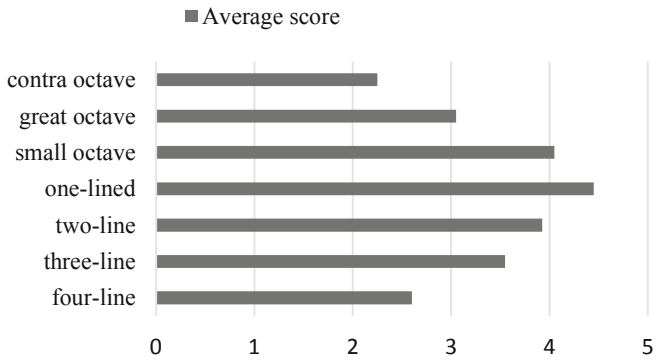

Fig. 3. Comparison of pitch preference evaluation.

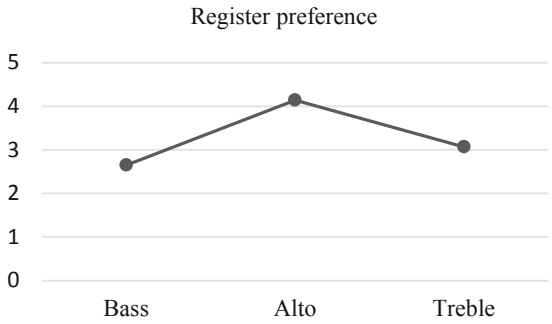

Fig. 4. Register preference.

3.4 Speed Preference

Music tempo preference. The average order of the elderly's preference for the 6 kinds of beats is: 115 beats/min, 95 beats/min, 135 beats/min, 155 beats/min, 75 beats/min, and 55 beats/min (see Fig. 5). Among them, the elderly's preference for tempo at around 115 beats/min is significantly higher than the others, followed by 95 beats/min and 135 beats/min, all of which are above the middle. There are significant differences in preference for 'slow', 'medium', and 'fast'. That is, the elderly prefers medium speed, followed by fast speed, and slow speed (see Fig. 6).

The tempo of music directly affects emotions and images. Generally speaking, the elderly prefers music with lively tempo and cheerfulness. The medium tempo is exciting which is close to our heart beat and breathing when we are excited [13]. Most of the square dances enjoyed by the elderly have a beat of around 100 beats per minute. The preference for music tempo is influenced by experience and listening habits.

By analyzing the relationship between music tempo preferences and background variables, it is found that gender shows significance at the 0.05 level for music tempo. The specific difference shows that the average value of men is obviously higher than that of women. Men may prefer fast music than women.

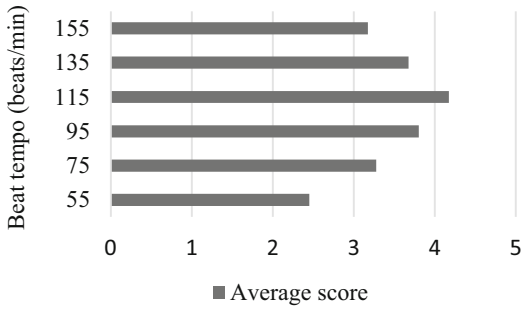

Fig. 5. Comparison of music tempo evaluation.

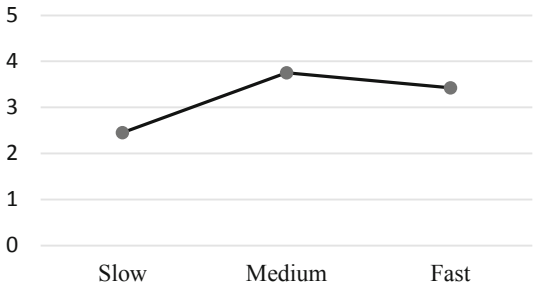

Fig. 6. Register preference

Voice speed preference. The elderly's preference for the 5 kinds of voice speed is in order: normal, slow, fast, very slow, and very fast (see Fig. 7). The corresponding voice seed quantization is about 210 words/min, about 191 words/min, about 251 words/min, about 132 words/min, about 289 words/min. The preference for normal and slow voice speed is obviously higher than the others, and the overall preference of the elderly is slow.

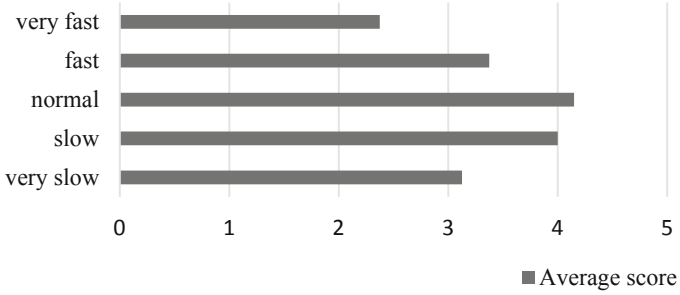

Fig. 7. Voice speed preference evaluation.

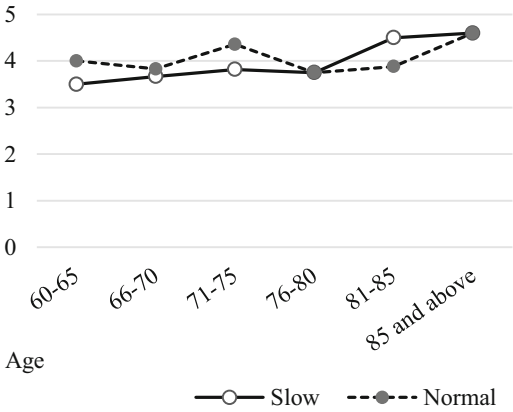

Fig. 8. Intersection analysis of voice speed and age.

Analyzing the relationship between voice speed preference and background variables, age is significant at the 0.05 level ($F = 3.095$, $p = 0.013$) for normal speaking rate (210 words/min). Figure 8 shows that the elderly under the age of 76 prefer normal speech speed (210 words/min). Elderly people over 76 prefer to more slowly speech speed (251 words/min). Therefore, the voice speed used by the elderly over 76 years old should be slowed down.

Analyzing the relationship between voice speed and music tempo, the results show that music tempo '55 beats/min' and voice speed 'very slow' (289 words/min) are significant, and the correlation coefficient values are 0.727, which is greater than 0. It means that there is a positive correlation between 55 beats/min and 'very slow' voice speed. Similarly, music tempo '155 beats/min' has a positive correlation with 'very fast' (289 words/min) and fast (251 words/min). People who prefer slower music tempo have a slower voice speed preference. The elderly's speed preferences for music and voice are habitually consistent.

3.5 Timbre Preference

Voice timbre preference. The average order of the elderly's preference for the six voice timbres is: middle-aged female, young female, young male, middle-aged male, girl, and boy. It is obvious that the timbre preference for middle-aged women is significantly higher than the others (see Fig. 9).

The timbre of voice will gradually change with age. Different voice timbre causes different subjective feelings. The children's voice timbre is crisp and immature. The young voice timbre is vigorous and energetic. The middle-aged vocal timbre sounds steady and heavy. The middle-aged female has mature and intelligent timbre, which is the favorite of the elderly. The elderly have rich life experience and accumulated more life experience, so they also prefer the mature and stable voice timbre.

The analysis of the relationship between voice speed preference and background variables shows that gender difference of middle-aged female's timbre is significant at the 0.05. The specific difference shows that male elderly prefer 'female middle-aged'

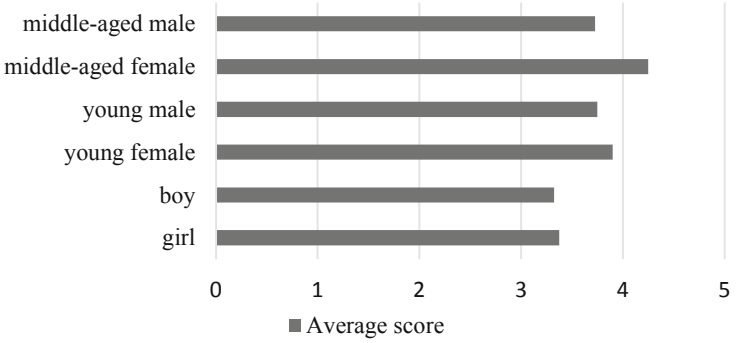

Fig. 9. Evaluation of voice timbre preference.

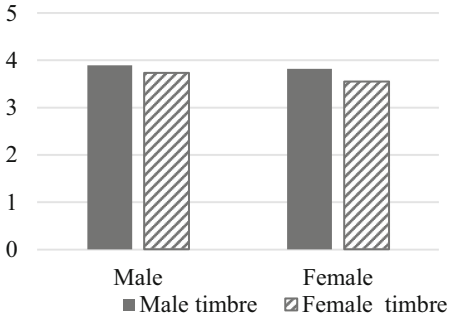

Fig. 10. Gender and voice timbre preference.

timber than females. Generally speaking, the elderly prefers the timbre of female (see Fig. 10). This is also consistent with the research conclusion of Professor Clifford Nass of Stanford University. Relatively speaking, people prefer female voices. The human brain also tends to prefer female voices.

Instrument timbre preference. The order of the elderly's preference for musical instruments timbre is: chime bells, guitar, piano, Chinese dulcimer, the lute, erhu, tuba, violin, bass drum, trumpet, flute, sidedrum, triangle, snare drum and cymbals (see Fig. 11). Among them, the preference of chime bells, guitar and piano is obviously higher than that of other musical instruments. The timbre of the chimes is ethereal and distant. The timbre of the guitar is warm and translucent. The register of the piano is regarded as be within the most comfortable range of human hearing. Its timbre conveys feeling of warmth and sincerity. By classifying and comparing the average values, it is found that the chordophones is the favorite of the elderly, followed by aerophone (see Fig. 11). Membranophones and idiophones are not good choices. The elderly also expressed their preferences in the interviews, such as 'clear voice', 'not too harsh', 'comfortable', and 'not muddy'. This means that the elderly like the pure and pleasant timbre (Fig. 12).

Analyzing the relationship between timbre preference and background variables shows that the satisfaction of 'life happiness' is significant at the 0.05 level for the bass drum ($F = 2.723$, $p = 0.045$). The specific difference shows that the higher the

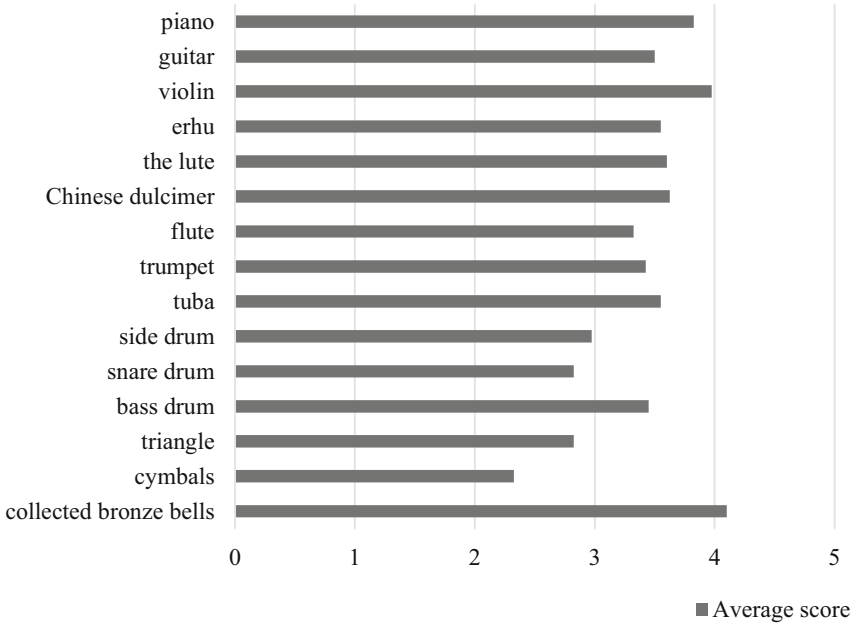

Fig. 11. Evaluation of musical instrument timbre preference

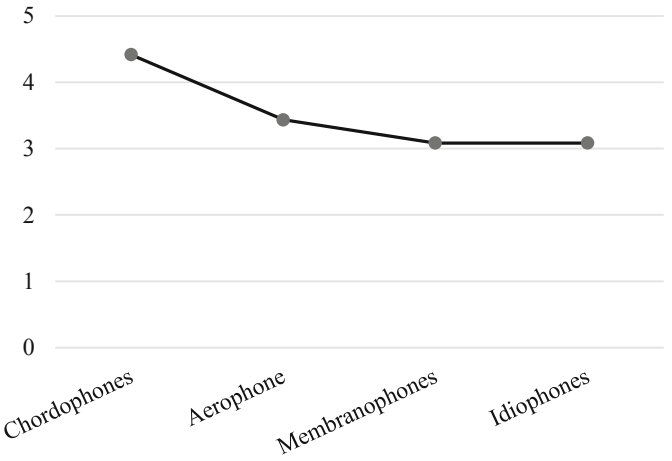

Fig. 12. Music instrument type preference.

satisfaction of 'life happiness', the higher the degree of love for bass drum. This may be related to the application scenarios of drums. With the development of society, drums are used more and more widely, such as ethnic bands, various dramas, song and dance, boat racing, lion dance, and festive gatherings. Perhaps it is the elderly's impression and cognition of drums that influence their evaluation of their preference.

4 Conclusions and Recommendations

In the elderly's experience of products, services, and the environment, hearing is an experience channel that plays an important role. The purpose of this study was to investigate the design elements and characteristics of the elderly's auditory pleasure experience, and provide a reference basis for the auditory dimension of the aging design. The following conclusions have been drawn from this research.

First of all, this study identified 5 groups of 7 specific auditory experience elements from the main sound types such as music and voice. The innovative development of auditory testing tools is an important medium for obtaining the auditory needs of the elderly and determining the characteristics of the auditory experience elements. Through qualitative and quantitative analysis, the bias law of the elderly's auditory pleasure was found. The study had drawn the conclusion of the key features of the design elements of the elderly's auditory pleasure experience and proposed a suitable aging design strategy based on the elderly's auditory pleasure experience. When others need to explore the auditory needs of the target elderly group through similar methods, this research can provide them with ready-made tools and targeted auditory aging design references, and enhance the pleasure experience of the elderly. At the same time, the research results are universal which can provide convenience and reference for the exploration of auditory needs of other ages. The following are the main results and key design strategies of this research.

The music genre preference test results show that when choosing a music genre, pop music and regional folk songs can be preferred, followed by Internet pop music, Chinese national music, and then jazz and ancient Chinese style. Try to choose one that matches the old people's life background. The lyrics should be easy to understand and the melody is simple and repeatable. If it is the familiar music they have heard, they may prefer it. The music genre is a complex. The preference results of music genre can provide references for music education, health care, music activities, and leisure and entertainment environment for the elderly. Music plays an important role in film and television, radio, nursing homes, shopping malls, restaurants, and other public places related to the life of the elderly, and even mobile phone ringtones. People who play music also want to cater to the preferences of the elderly. It can mobilize the emotions of the elderly, exaggerate the atmosphere and even play a healing role. It subtly influences the elderly's experience of products, services, and the environment.

In the volume test, the average perception range of several sound volumes by the elderly is 72.94–79.19 dB. The average perceived volume is 74.8 dB. For functional sounds that need to be heard clearly and with specific information (such as voice), it is suggested to choose a higher volume within the range for the elderly to hear clearly. The second is the prompt sound, which should be loud enough for the elderly to hear and avoid missing the prompt.

The results of the pitch preference test show that the elderly prefer the 1-lined pitch (440.00 Hz–830.609 Hz), followed by the small octave (220.000 Hz–415.305 Hz). When using or creating music for the elderly, it is suggested to give priority to the pitch of the 1-lined octave. Small octave and 2-line pitch are also good choices.

Although the physiology, psychology, and cognition of the elderly will undergo degenerative changes, it does not mean that the slower the music tempo and voice speed, the better. The music tempo preference test results show that the elderly prefer the cheerful and lively mid-beat tempo. The beats between 95 beats/min to 135 beats/min are preferred by the elderly. 115 beats per minute is a safe option. If there are more male users, you can choose the one with a faster rhythm within the range. Using or creating music with appropriate tempo can make the elderly happy.

The overall preference for voice speed of the elderly is relatively slow. Among the 5 types of voice speed, 191 words per minute is considered to be the most appropriate. 119–210 words/min is an appropriate range of speaking speed. When choosing the voice timbre, you can give priority to the mature and calm female middle-aged timbre. Generally speaking, the elderly prefers female timbre. You can choose female timbre first, especially in scenes with more male users. The suggestions on voice speed and timbre can provide voice reference for artificial intelligence and broadcasting for the elderly.

In terms of musical instrument timbre preference, the timbre of Chinese chime bells is the favorite of the elderly, followed by piano and guitar. Different musical instruments timbre conveys different emotional experiences. The elderly's preferences for chime bells, pianos, and guitars indicate that the emotions expressed by these musical instruments cater to the experience preferences of the elderly. In the timbre application that wants to arouse the pleasure of the elderly, such as the sound feedback design for the successful operation of the product, it is recommended to give priority to these three instruments. In the type of musical instrument, the elderly most like the timbre of chordophones. Therefore, chordophones can be selected first in the choice of instrument matching.

In short, through an in-depth understanding of each experience element and its characteristics, designers can refer to and apply them to hearing-related situations in the elderly market. For example, in the design of products for the elderly, familiar, simple and easy-to-understand music that meets the life background of the elderly can be used as the starting music or reminding bell, or for leisure and entertainment. It is reasonable to adjust a higher volume in the reference range, use the medium pitch and choose the cheerful tempo. At the same time, it is better to adjust the volume at different distances automatically. The female or middle-aged female voices used in voice interaction has the characteristics of calmness and peace of mind. The voice speed slows down slightly, but it is recommended not to be too slow. In the aspect of positive feedback, chime bells, pianos, guitars are preferred. Stringed instruments are a good match. Sound is an important design element of some products. The sound of aging products needs to adapt to the auditory characteristics of the elderly, meet the auditory needs of the elderly, enhance the auditory experience of the elderly, and ultimately enhance the quality and user experience of the product.

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