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Zhang, D., Zhang, M., Liu, D. et al. (1 more author) (2016) Soundscape evaluation in Han Chinese Buddhist temples. Applied Acoustics, 111. pp. 188-197. ISSN 0003-682X

https://doi.org/10.1016/j.apacoust.2016.04.020

Soundscape evaluation in Han Chinese Buddhist temples

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Abstract: In this study, surveys were conducted at four typical Han Chinese Buddhist Temples. These surveys were then analysed to identify the subjective and objective factors of soundscape evaluation. Field measurements of the four temples' sound levels were taken over the course of an entire day, and the representative sounds in temples were recorded. Soundscape evaluation questionnaire surveys were distributed at the temples. The analytical results of the questionnaire and measurement data showed that the sound preferences in temples are significantly correlated with sharpness value of the sounds in terms of psychoacoustic parameters，and the average sound levels at the four temples over the course of an entire day were between 47.0 and 52.7 dBA, and approximately 70% of those surveyed tended to evaluate the temples' soundscapes as comfortable and harmonious. Regarding the objective factors, there was a significant correlation between the measured sound levels and the soundscape evaluations. When the sound level of a temple was higher than 60 dBA, respondents were more likely to feel uncomfortable, and the correlation between the sound level and the evaluation of acoustic comfort substantially increased. Regarding the subjective factors, the respondent's age, occupation, religious belief, purpose, frequency of visiting the temples, and educational level significantly correlated with the soundscape evaluation with correlation coefficients ranging from 0.13 to 0.35.

Keywords: Han Chinese Buddhist, temple, soundscape, evaluation, influencing factor.

2016 Applied Acoustics
Date Received: 2 January 2016 **Date Accepted**: 24 April 2016

1. Introduction

Han Chinese Buddhist temples are the most numerous and most important religious sites in China's inland regions. Historically, studies on such temples have focused on the development process and the visual environment of the spaces inside and outside the temples [1-4]. However, the acoustic environments of traditional Buddhist temples also make a strong impression on visitors. In Chinese Buddhism, ceremonies emphasizing the pursuit of the spiritual realm, chanting and the playing of music for a long period of time as well as other methods are used to purify a Buddhist's mind. Both a good acoustic environment and a good visual environment are important means of creating a religious atmosphere within the temple.

Compared with traditional acoustic environmental studies, soundscape studies are focused on people's perceptions of the acoustic environment. In recent years, the objects of soundscape research have included parks, residential areas, and hospitals. In studies on soundscape evaluation, Kang found that the degree of acoustic comfort and sound level evaluation in city squares is correlated with the measured sound level and has a certain threshold. When the sound is lower than a certain sound level, the degree of acoustic comfort does not significantly change with an increase in the sound level [5]. Zannin and Marco studied the relationship between the degree of acoustic comfort and the sound level in Brazilian public school classrooms using a process that involved measurements, acoustic simulations, and interviews [6]. Memoli et al. took acoustic measurements at two parks in London and proposed that a higher sound level value does not necessarily correspond to a worse perception [7]. Weinstein found, however, that individual differences in college dormitories affect a person's reaction to noise [8]. Gulian and Thomas found that noise affects males and females to different degrees during tasks requiring mental mathematical calculation [9]. Moreira and Bryan propose that an individual's personality characteristics can affect the degree of his or her annoyance with certain types of noise [10]. Dubois found that soundscape evaluation is influenced not only by sound intensity but also by a variety of human factors [11]. Yu and Kang propose that, within urban open spaces, some of an individual's social, demographic, and behavioural factors affect his or her evaluation of sound levels [12]. Cain et al. found that two independent emotional dimensions of a soundscape related to its "Calmness" and "Vibrancy" [13]. Rychtarikova and Vermeir evaluated urban soundscape by the objective analysis of binaural sound recordings, and classified the sound samples collected in urban public into 20 soundscape categories [14]. Yu and Kang examined the effects of cultural factors on the evaluation of acoustic quality of residential areas through questionnaire surveys in Taiwan and UK [15]. Schwarz explored Israeli tourists' preferences regarding the appropriate and desired soundscape in nature sites, and the result shows that the comprehension of noise depends on their social identification, and also on the mode of touristic engagement they employ [16]. Ellermeier et al. suggested that self-reported noise sensitivity captures evaluative rather than sensory aspects of auditory processing [17]. The studies noted above show that, in different places, the objective sound level and the respondents' many subjective factors produce a certain effect on people's soundscape evaluations.

Recently soundscape studies have been carried out on the sound environment of historic sites and traditional buildings. Escobar et al. systematically investigated and analysed the acoustic environment of the medieval centre of Cáceres in Spain, and the results show that the old part of Cáceres is a quiet area [18]. Chourmouziadou studied the sonic quality of performance spaces in ancient Greek theaters using computer simulation [19]. Huang and Kang surveyed the sound environment of the Lhasa historic centre [20]. The findings of these studies, both qualitative and quantitative, are helpful to the soundscape preservation of historic regions and traditional architecture.

Different from ordinary public buildings, most of the people in the interior of religious buildings are there because of their religious beliefs or for tourism and leisure. The buildings' acoustic fields and acoustic environments can affect the general emotional states of various types of people in religious buildings. Several studies have been conducted on the acoustic fields and soundscape of religious spaces and buildings such as churches and mosques. Desarnaulds et al. took acoustic measurements at six churches and analysed speech intelligibility in the churches under the field conditions (both occupied and unoccupied) [21]. Alvarez-Morales et al. combined measurement and simulation to understand the acoustic environment of historical churches and analyse the effects of different sound source positions on the acoustic field [22, 23]. Orfali and Ahnert measured and analysed the acoustic field parameters in two mosques [24, 25].

Wood analysed the soundscapes at Jerusalem's Western Wall which is a Jewish visual and religious icon [26]. Ge et al. used the methods of measurement and the distribution of questionnaires to survey the acoustic environment of the Han Chinese Buddhist Jingci Temple at West Lake [27]. Wang et al. measured the physical environment, which includes the acoustic environment, of the Tibetan Buddhist Labrang Monastery [28]. Soeta et al. studied the effects of sound source location and direction on the acoustic fields of Japanese Buddhist temples [29]. Kumar et al. studied the acoustic characteristics of musical pillars in Indian Buddhist temples [30]. Prasad analysed sound spectra of several instruments which were used both individually as well as collectively in Hindu worship spaces [31]. Jeon et al. used social surveys and soundwalks to compare the soundscape of around a Catholic church with that of a Buddhist temple in South Korea and proposed that, compared to the church, the sounds of religion and nature in the temple are more easily understood as basic elements [32]. Through methods such as measurement, reverberation time, and questionnaire surveys, Kang analysed the degree of acoustic comfort inside several churches in Sheffield [33]. Kiser and Lubman studied the important role played by the sound of traditional church bells in community identification in the City of London [34]. Westermeyer probed the soundscape of churches from the perspective of the typical sounds from inside a church—the singing of hymns [35]. Burgess and Wathe studied ancient English church music and soundscape maps and proposed that music and ceremonial activities play an important role in integrating a church with its surrounding community [36]. Garrioch studied the effects that the sound of church bells had on the soundscape of early modern European towns [37]. Brink et al. carried out a field study to analyse the church bell noise and sleep disturbances of nearby residents, suggesting that a reduction of the maximum sound pressure level or an interruption of ringings during night-time might reduce awakenings [38]. Zhang et al. analysed the acoustic environment in Han Chinese Buddhist temples from the perspective of evaluating the degree of quietness [39]. In general, however, studies that focus on the acoustic environment of religious buildings are at present not comprehensive. There are relatively few studies that specifically focus on the evaluation and acoustic field characteristics of Han Chinese Buddhist temples; therefore, there is a lack of understanding regarding the various influencing factors of Buddhist temple soundscape evaluation.

This paper aims to analyse the soundscape evaluation in Han Chinese Buddhist temples and the influencing factors thereof. First, day-long sound level measurements were taken at four typical Han Chinese Buddhist temples and the basic characteristics of the acoustic fields were summarized. Then, a large number of soundscape evaluation survey questionnaires were distributed and recovered inside the temple as the sound levels were synchronously measured. As a result, the temples' sound levels, the characteristics of the respondents (including age, occupation, belief, purpose, frequency of visiting the temples, educational level, and gender), and the effects of the subjective and objective factors on the soundscape evaluation of the temples were analysed; subsequently, the special features of the soundscape evaluation of Han Chinese Buddhist temples, the most important traditional religious buildings in China, were summarized.

2. Research method

2.1. Survey subjects

Han Chinese Buddhist temples typically feature a traditional Chinese courtyard-style layout and can be divided into the mountain type and the city type according to geographical location. This study selected the following four typical Han Chinese Buddhist temples as research objects: Xiantong Temple on Wutai Mountain in Shanxi Province, Longquan Temple on Mount Qianshan in Liaoning Province, Ci'en Temple in Shenyang, Liaoning Province, and Xiangguo Temple in Kaifeng, Henan Province. Figure 1 shows the site

plans of Xiantong Temple and Longquan Temple.

Xiantong Temple is the largest Han Chinese Buddhist temple on the famous Buddhist Wutai Mountain. Longquan Temple and Xiantong Temple are mountain type temples. Xiangguo Temple in Kaifeng is one of the 10 most famous Han Chinese Buddhist temples; it occupies an important place in and has had a broad influence on China's Buddhist history. Xiangguo Temple and Ci'en Temple, a key national temple, represent the city type temple. In addition, Xiantong Temple and Xiangguo Temple are located in central China; Longquan Temple and Ci'en Temple are located in northern China; and Puji Temple on Putuo Mountain, which was surveyed during the initial research period, is located in southern China. These temples represented different regional locations. See Table 1 for each temple's type and basic spatial conditions. Currently, these temples are both places for monks to practice Buddhism and popular tourist attractions that are open to the public.

2.2. Acoustic measurement and sound recording

Two types of measurement were taken to evaluate the sound levels in the temples. The first type was a day-long sound level measurement. The most important courtyard in each temple was chosen as the measurement point—the geometric centre of the main hall's front courtyard. This area was selected because the temple's most important chanting and religious rites occur in the main hall and front courtyard. The measurement point was at a distance greater than 1 meter from the main surrounding reflective surfaces and 1.5 m from the ground. The measurements all occurred in the spring and summer. The process consisted of the following: from 04:00 in the morning to 20:00 at night, a group of sound level measurements was taken every half hour, with more than 10 measurements taken per group, and the mean value was calculated. The interval between each measurement was five seconds. The instantaneous sound pressure level instead of LAeq was used in this research as the curiosity of visitors may influence the measurement results. Because there are large differences in the acoustic environment in the temples on ordinary days and religious festivals, this study also measured the temple sound levels in Ci'en Temple during Buddha's birthday, one of the most important religious festivals for Han Chinese Buddhism. The other type was a survey questionnaire. The sound level measurements and the survey were conducted at the same time; as the respondents completed the questionnaire, the on-site acoustic environment was simultaneously measured in exactly the same manner as the day-long sound levels, averaging after more than 10 measurements.

In this study, 15 kinds of common natural and the man-made sounds in four Han Chinese Buddhist Temples were recorded by high-fidelity recorder (Fostex FR-2LE). The natural sounds include wind, leaves rustling, bickering and tweeting. The man-made sounds include chanting, instrumental sounds, drum, bell, prayer, background music, footsteps, tour guide speech, vehicle sound, tourist conversation, and the sound of construction.

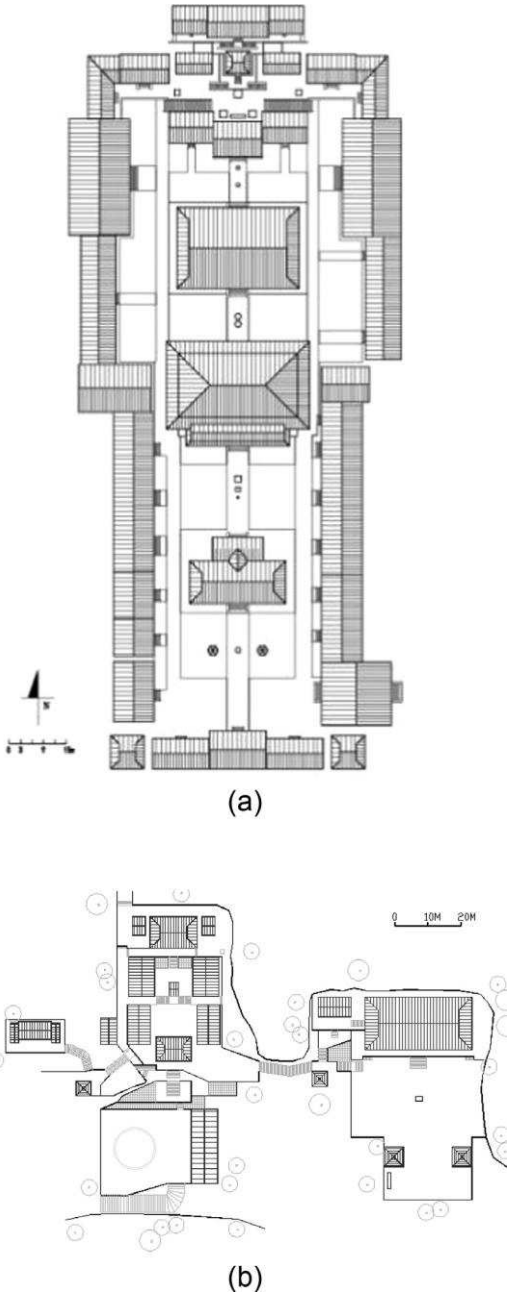

Fig. 1. Site plan of temples. (a) Xiantong temple in Wutai Mountain. (b) Longquan temple in Qian Mountain.

Table 1. Basic spatial information on the case study sites

No.	Name	Location	Type	Total size of temple (width×depth)	Main hall's front courtyard size(width×depth)	Questionnaire sample size
1	Xiantong temple	Wutai Mountain, Shanxi	Mountain type	80 m×190 m	40 m×25 m	177
2	Longquan temple	Mount Qianshan, Liaoning	Mountain type	125 m×95 m	11 m×15 m	170
3	Xiangguo temple	Kaifeng, Henan	City type	60 m×290 m	45 m×55 m	160
4	Ci'en temple	Shenyang, Liaoning	City type	90 m×125 m	35 m×25 m	178
5	Puji temple	Putuo Mountain, Zhejiang	Mountain type	100 m×210 m	85 m×25 m	70 (test)

2.3. Questionnaire survey and analysis

First, a preliminary investigation on the acoustic environment was performed at Puji Temple, and 70 test questionnaires were distributed. Adjustments were made to the questionnaire items after the statistical results were obtained and analysed. In general, items that were invalid or lacked reliability and validity were revised to produce the final version of the questionnaire. The preferences of 15 common sounds in the temples were surveyed in the questionnaire. Two indices—the degree of comfort and the degree of harmony—were selected to evaluate the temple's soundscape in the questionnaire. The degree of comfort, which is a commonly used item for soundscape evaluation at all types of venues, can reflect people's intuitive feelings toward the acoustic environment. The degree of acoustic harmony was chosen as an index mainly in consideration of the fact that the Han Chinese Buddhist temple is a place of religion; whether its interior sound harmonized with the corresponding religious atmosphere was an important component of the evaluation. In the survey, the questions on soundscape evaluation were all presented in single-choice form using a five-point scale. For example, the respondents were asked to make a single choice on their degree of comfort with the acoustic environment at the temple they were visiting: 1=comfortable; 2=somewhat comfortable; 3=neither comfortable nor uncomfortable; 4=somewhat uncomfortable; and 5=uncomfortable. At the four temples, 685 valid questionnaires were distributed and recovered. Table 1 shows the number of samples at each temple. The number of questionnaires was determined based on prior studies in which 100-150 soundscape survey questionnaires could be considered to be representative [40]. The questionnaires were distributed at various courtyards in the temples. The survey subjects were randomly selected tourists and worshippers in the temples. Figure 2 presents the distribution of the respondents' characteristics, including gender, age, educational level, the number of times they have come to the temple, purpose, etc. The questionnaire listed 15 types of commonly found occupations. Students accounted for 27.9% of the respondents, teachers 8.6%, workers 7.2%, self-employed individuals 7.2%, managerial staff 6.3%, technical staff 5.6%, retired staff 5.6%, and service staff 5.3%; the number of people in other professions accounted for less than 5% of respondents.

Non-parameter test of related samples were made in terms of the respondents' characteristics among four temples, indicating that the asymp.sig. values (p) of Friedman test are 0.896 (gender), 0.782 (age)，0.392 (frequency of visiting temple)，0.943 (education levels)，0.589 (purpose)，0.801 (religious beliefs)，namely, all are greater than the critical value of 0.05. In other words, there is no significant difference among the four temples. Meanwhile, the variances of the characteristics of respondents in the four temples were analysed, and the result is showed in Figure 3, where the differences of variances range from 0.1 to 0.4, except for the frequency of visiting. Overall, those results suggest that all the questionnaires could be analysed as a whole.

The 685 formal questionnaire survey results were imported into the SPSS 19.0 software program. In the statistical analysis, because the independent and dependent variables were of different categories (including ordinal level variables and categorical variables), different computational indices were used for the correlation coefficients, including Pearson, Cramer's V, and Gamma. Table 2 shows the calculation methods of independent and dependent variables.

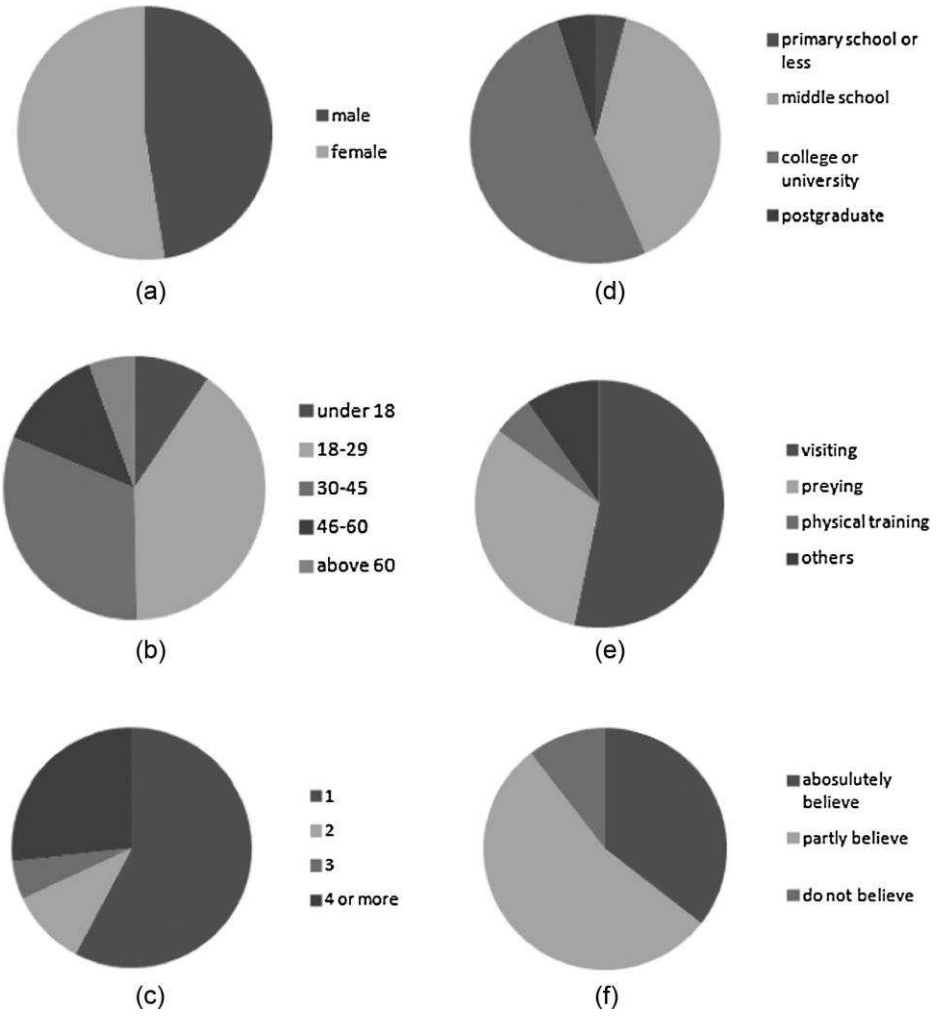

Fig. 2. Distribution pie chart of the respondents' characteristics in questionnaire. (a) Gender (b) age (c) frequency of visiting temple (d) education level. (e) Purpose (f) religious belief.

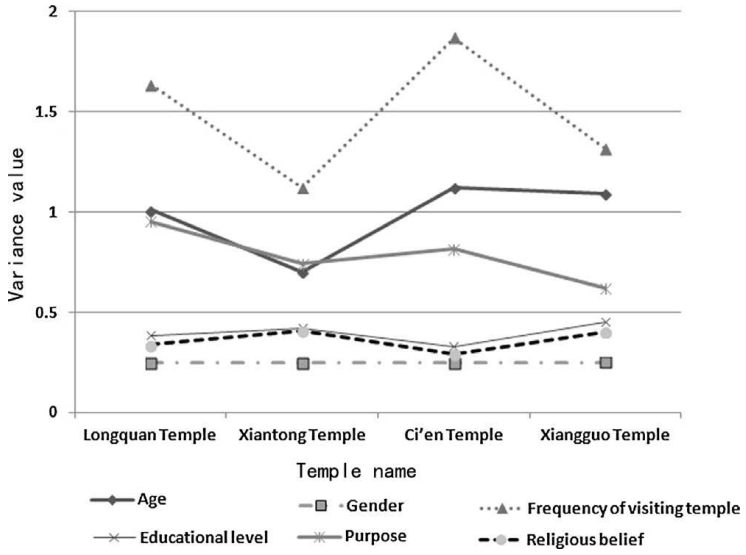

Fig. 3. Variances of respondent' characteristics in the four temples.

Table 2. Calculation method of independent and dependent variables

Independent and dependent variables	SPSS calculation approach	Index	Variables type
Respondents' characteristics in the four temples	Test for several related samples （non-parametric tests）	Friedman	Continuous related variable
Sound levels in different temples at the same time Sound levels by synchronous measurement with questionaire vs comfort (harmony) evaluation	Bivariate correlation	Pearson	Continuous variable/ continuous variable Continuous variable/ordinal variable
Mean value of psychoacoustic parameters / Mean value of sound preference	namely Bivariate correlation （non-parametric tests）	Spearman	Continuous variable/ continuous variable
Purpose, occupation vs comfort (harmony) evaluation	Crosstabs	Phi and Cramer's V	Nominal variable/ ordinal variable
Age, education levels, frequency of visit, religious beliefs vs comfort (harmony) evaluation	Crosstabs	Gamma	Ordinal variable /ordinal variable
Gender vs comfort (harmony) evaluation	Independent-samples T Test	Mean difference	Dichotomic (nominal)variable/ ordinal variable

Factor analysis was performed on the soundscape evaluation item results from the questionnaire, resulting in KMO=0.778. Accordingly, two factors were extracted with characteristic roots greater than 1, and their cumulative contribution to all eight variables was 52.1%. Bartlett's test of sphericity indicated $p<0.001$, which met the requirement for construct validity [41]. Moreover, the SPSS software's reliability analysis was used to perform a confidence test on the questionnaire's soundscape evaluation type questions, resulting in a Cronbach's α of 0.727, which was within an acceptable range [41].

3. Measurement results and discussion

3.1. Acoustic and psychoacoustic results

The mean values of the measured day-long sound level on an ordinary day at the central points of the courtyards in the four temples (from 04:00 in the morning to 20:00 at night) were between 47.0 and 52.7 dBA. Normally, it was quieter during the early and late time segments. The 26.0 dBA recorded at 04:00 in the morning in Xiangguo Temple was the minimum instantaneous sound level. The maximum instantaneous sound level reached 93.8 dBA. This measurement was taken at Longquan Temple at 04:30 in the morning when the monks struck the wake-up board (a Buddhist musical instrument). The secondary sound level high point was typically reached in the time segments when religious rites and activities were occurring within the main hall of a temple or when there was a concentration of visitors. The four temples were all famous scenic points. Differences in the density of the flow of people at different time segments would lead to a relatively great range in sound level variations at the temples. Especially on Buddhist religious assembly days, there was an influx of people participating in all types of Buddhist religious activities into the temples. The day-long sound level mean value on a religious assembly day in Ci'en Temple was higher than an ordinary day by 7.8 dBA. Correlation analysis was performed on every two groups of sound level data at each time segment on an ordinary day at the four temples. The results showed that four of the six groups of

data had significant correlations and that the correlation coefficients were between 0.4 and 0.5. This finding is likely due to the similar working and resting times adopted by monks within each Buddhist temple. Table 3 presents the daily schedule of monks at Xiantong temple.

Table 3. The daily schedule of monks at Xiantong temple

Time	4:10	4:15	4:30	5:00	6:00	7:05	7:30	8:30	8:50	9:35
Activity	Play morning clapper	Play bell and drum	Get up and wash	Morning chanting	Breakfast time	Burn incense	Meditate on the Zen	Rest time	Dhyana	Rest time
Time	10:10	10:15	10:55	11:00	12:00	12:20	13:35	13:50	14:25	14:35
Activity	The call of nature	Dhyana	Rest time	Lunch time	Tea time	Burn incense	Tea Time	Burn incense	Play summoning clapper	Evening chanting
Time	17:30	17:40	17:55	18:00	19:20	19:45	20:10	20:15	21:00	21:30
Activity	Burn incense	Tea time	The call of nature	Meditate on the Zen	Dinner time	Burn incense	The call of nature	Play drum and bell	Extinguish incense	Sleep time

The psychoacoustic parameters of 15 recorded sounds were analysed using Artemis software [42], including loudness，sharpness，roughness and fluctuation strength. The correlation coefficients between the mean value of sound preferences and the psychoacoustic parameters were calculated, showing that the correlation coefficient with " loudness" is 0.12（p=0.67），with "sharpness" is 0.53 (p=0.04)，with "roughness" is 0.15（p=0.59），with "fluctuation strength" is 0.15（p=0.60）. In other words, the sound preferences in those temples are only significantly correlated with sharpness, but not loudness, roughness and fluctuation strength, which is in agreement with a previous study [43].

3.2. Overall evaluation of the acoustic environment

In the questionnaire, the survey targeting the physical environment showed that the respondents thought that the temperature environment in the temples was most important, with the acoustic environment a close second, followed by the light environment and the humidity. These findings show that the acoustic environment in the temples is significantly affects visitors' feelings.

Figure 4 reports the results on the degree of acoustic comfort and degree of acoustic harmony evaluation from the questionnaire. Approximately 70% of respondents evaluated the degree of acoustic comfort at the temples as comfortable or somewhat comfortable and thought that the acoustic environment harmonized or harmonized somewhat with the religious atmosphere. There was a significant correlation between the degree of acoustic comfort and the degree of acoustic harmony evaluation; the correlation coefficient was R=0.67 ($p<0.001$).

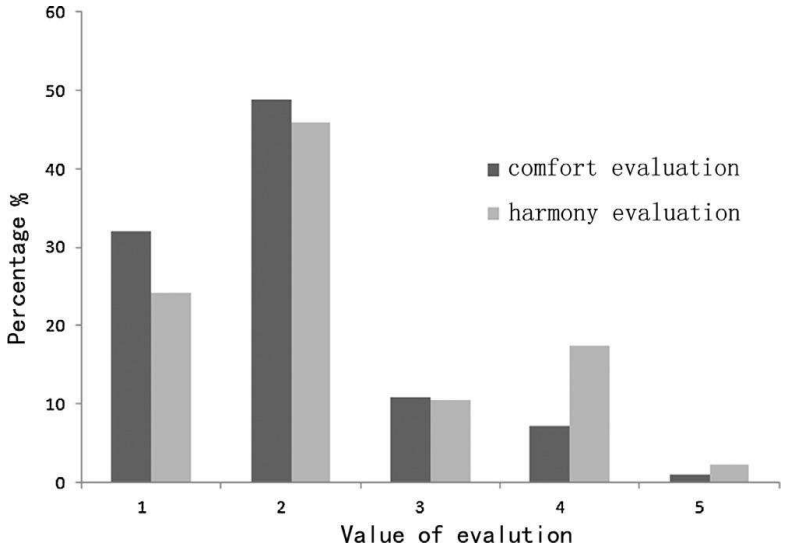

Fig. 4. Overall evaluation of the acoustic environment in the temples.

Table 4. Temple soundscape evaluation values and measured sound level values

Category	Sound Level value and evaluation value at different temples (standard deviation)			
	Longquan temple	Xiantong temple	Ci'en temple	Xiangguo temple
Degree of comfort **e**valuation of the Temple	1.68 (0.725)	2.05 (0.887)	1.95 (1.005)	2.18 (0.895)
Degree of harmony evaluation of the temple	1.98 (0.945)	2.24 (1.143)	2.35 (1.019)	2.55 (1.129)
Average sound level simultaneously measured with the questionnaire survey	54.2 dBA (7.1)	57.4 dBA (5.1)	58.9 dBA (9.0)	56.9 dBA (6.9)

Table 4 presents the soundscape evaluation data obtained. The four temples' degrees of comfort and degrees of harmony evaluation had a similar order, but these were inconsistent with the descending order of each temple's sound level simultaneously measured with the questionnaire survey.

Longquan Temple, situated in a mountain, had the lowest sound level and was evaluated as the most comfortable and harmonious temple; however, although Xiangguo Temple did not have the highest sound level, its acoustic environment was thought to be the least comfortable and harmonious. This finding may be the result of the relatively poor religious atmosphere inside Xiangguo Temple.

3.3. Temple soundscape evaluation and measured sound levels

Figure 5 shows the relationship between the degree of comfort evaluation on the acoustic environment in the temples and the measured the sound level synchronous with the questionnaire. As the sound level increased, the degree of acoustic comfort evaluation mean value showed an upward trend. The correlation coefficient between them was $R=0.118$ ($p<0.01$). The average sound levels when comfortable and relatively comfortable were selected both corresponded to approximately 56.5 dBA. When "neither comfortable nor

uncomfortable" was selected, the average sound level was 57.6 dBA. When "somewhat uncomfortable" was selected, the average sound level was 59.7 dBA. When uncomfortable was selected, the sound level had risen to 63.4 dBA. These findings show that it would be easy to create an uncomfortable experience for people when exceeding a sound level of 60 dBA in Buddhist temples.

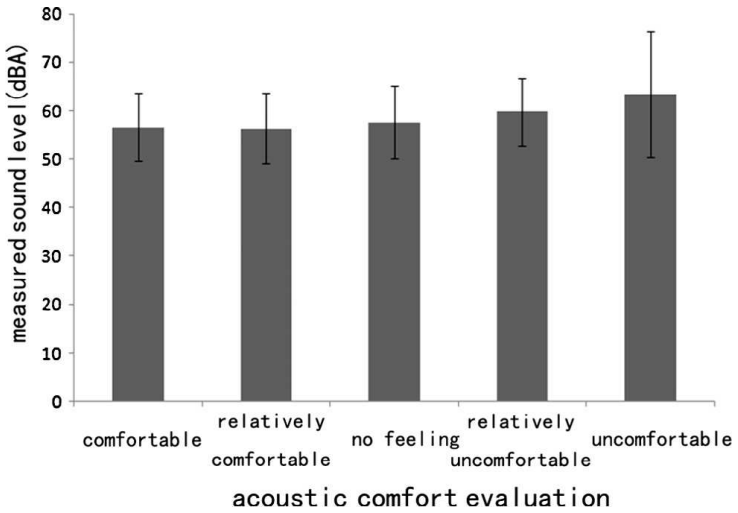

Fig. 5. Correlation between the measured sound level and the evaluation of acoustic comfort.

To reduce error, after the sound level data were rounded, every integral sound level would correspond to a number of questionnaires, then the evaluation results from less than 10 questionnaires with adaptive sound levels were removed. At this time, the correlation coefficient between the questionnaire measured the sound level, and the degree of acoustic comfort evaluation was $R=0.561$ ($p<0.05$). See Figure 6 for the regression analysis results for both items. The fitting formula for the items was

$$Y= 0.0285*X+1.6644.$$

In the equation, Y is the mean value of the degree of acoustic comfort evaluation, and X is the measured sound level value synchronous with the questionnaire.

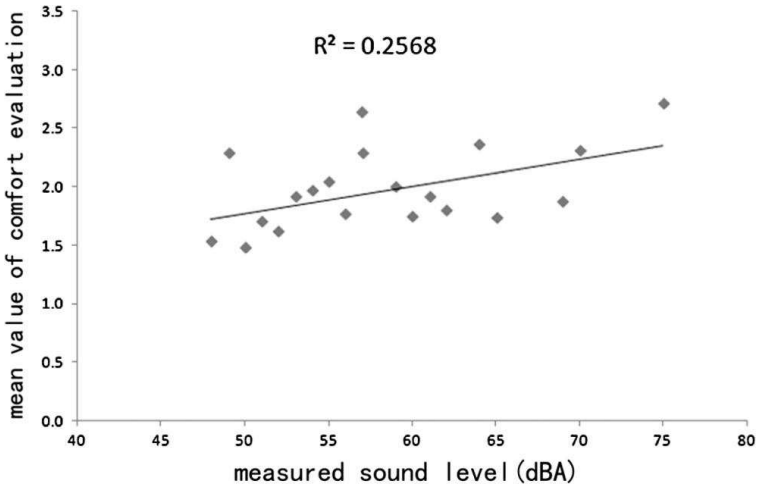

Fig. 6. Linear regression of measured sound level and the evaluation of acoustic comfort.

Using 60 dBA as the boundary, when the sound level was lower than 60 dBA, the correlation coefficient between the sound level and the degree of comfort evaluation value was only 0.451, and there was no significant correlation ($p=0.164$); however, when the sound level was greater than or equal to 60 dBA, the correlation coefficient between them was as high as 0.741 ($p<0.05$). This finding shows that when the sound levels in Buddhist temples change within a relatively low range (not exceeding 60 dBA), changes in sound levels do not significantly affect people's evaluation of the degree of acoustic comfort at the temple; however, after the sound level exceeds 60 dBA, they show a stronger linear correlation. This argument is similar to the concept of the "sound level threshold" discussed in previous studies on outdoor squares [5]. However, the correlation between sound level and subjective evaluation would become insignificant when the sound level exceeds 73 dBA, which is the sound "threshold" of an outdoor square. Accordingly, this study speculates that, within a certain sound level range, there is a significant positive correlation between people's subjective soundscape evaluations and sound levels; the correlation decreases when the sound level is higher or lower than this range, and this sound level range differs across locations.

The correlation between a temple's degree of acoustic harmony evaluation and measured sound level was not significant. After the evaluation results from less than 10 questionnaires with adaptive sound levels were removed, the correlation coefficient between the degree of acoustic harmony evaluation and measured sound level was computed to be 0.353 ($p=0.138$). A possible reason for this result is that people have different expectations regarding the amplitude of a temple's sound level and therefore may not consider that the sound level detracts from the overall atmosphere of the temple simply because it increases.

3.4. Soundscape evaluation and subjective influencing factors

Some of the subjective factors in the questionnaire that might affect the degree of acoustic comfort and the degree of harmony evaluation were analysed, including the respondents' age, gender, occupation, educational level, the frequency with which they come to the temple, their purpose, and their attitude towards Buddhist thought.

3.4.1. Age

Some studies have shown that age affects soundscape evaluation, especially in outdoor spaces, and that the resulting differences in the evaluation results are relatively large [44,45]. Similarly, the questionnaire results of this study confirmed that the age affected the temple soundscape evaluation. The respondents' ages were divided into three categories—younger than 30 years, 30 to 45 years, and older than 45 years—and the mean values of the 3 categories of the respondents' degree of acoustic comfort evaluation were 2.02, 1.92, and 1.90, respectively. The standard deviations were 0.821, 0.909, and 1.015, respectively, and the correlation coefficient was -0.138 ($p<0.05$). The mean values of the three categories of people's degree of acoustic harmony evaluation were 2.37, 2.23, and 2.11, respectively. The correlation coefficient between age and the degree of acoustic harmony was -0.152 ($p<0.01$), which indicates that, with increasing age, the respondents' evaluation of the temple's acoustic environment increasingly tended toward comfort and harmony.

3.4.2. Occupation

The questionnaire results showed that the respondents' occupation factor significantly correlated with the temple soundscape evaluation. The correlation coefficient of the degree of acoustic comfort was $R=0.190$ ($p<0.01$). The correlation coefficient of the degree of acoustic harmony was $R=0.182$ ($p<0.01$). Table 5 presents a comparison of the evaluation mean values after the occupation types of less than 15 people were

removed from the survey numbers, showing that physical labourers (workers, etc.) tended to evaluate the temple soundscape as more comfortable but mental labourers (students, teachers, etc.) had higher expectations regarding the degree of comfort in the acoustic environment. In analysing the degree of acoustic harmony evaluation, the everyday acoustic environment of individual businesspeople, workers, and so on is often relatively noisy; thus, their expectations regarding the degree of harmony with a religious atmosphere may be low. The evaluation of the degree of acoustic comfort and the degree of harmony perceived by people with different occupations was not completely consistent.

Table 5. Relationship between occupation and temple soundscape evaluation

Category	Evaluation mean value sequence of different occupations		
	Tendency toward comfortable/harmonious	No feeling	Uncomfortable/Inharmonious
Degree of comfort evaluation of the temple	Workers (1.69), Farmers (1.73), Technicians (1.81)	Individual Businesspeople (1.84), Retired Staff (1.86), Housewives (1.92), Service Staff (1.94)	Students (2.10), Teachers (2.11), Cadre or Managers (2.13)
Degree of harmony evaluation of the temple	Workers (1.80), Individual Businesspeople (1.96), Retired Staff (1.97)	Housewives (2.25), Service Staff (2.30), Teachers (2.33), Students (2.38)	Technicians (2.53), Farmers (2.56), Cadre or Managers (2.65)

3.4.3. Religious beliefs

In the questionnaires, the respondents' attitudes towards Buddhist thought were divided into complete belief, partial belief, and no belief. The first 2 types accounted for approximately to 90% of all respondents. Table 6 presents the analytical data on the correlation between the factors of religious belief and the degree of acoustic comfort evaluation in the four temples. Only for Ci'en Temple was there no significant correlation; the correlation was significant for the other three temples. Respondents who believed more in Buddhist thought had a greater tendency to evaluate the temple acoustic environment as comfortable, showing that Buddhists were more accepting of a temple's acoustic environment. Figure 7 analyses the relationship

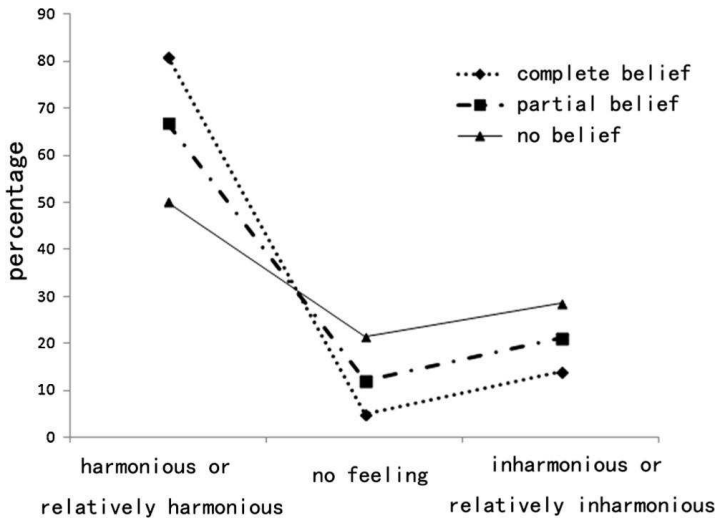

Fig. 7. Correlation between the religious belief factors and the degree of acoustic harmony evaluation.

between the religious belief factors and the degree of acoustic harmony evaluation. Respondents who believed more in Buddhist thought had a greater tendency to evaluate the temple acoustic environment as harmonious. The correlation coefficient between them was 0.337 ($p<0.001$).

Table 6. Correlation between the Respondents' Understanding of Buddhist Doctrines and the Degree of Acoustic Comfort Evaluation

Location	Correlation coefficient	Level of significance	Degree of acoustic comfort evaluation mean value (standard deviation)		
			Complete belief	Partial belief	No belief
Four temples	0.343	0.00 (**)	1.76 (0.924)	2.04 (0.855)	2.29 (0.893)
Xiantong temple	0.28	0.02 (*)	1.94 (0.932)	2.06 (0.831)	2.43 (0.945)
Longquan temple	0.44	0.00 (**)	1.40 (0.689)	1.83 (0.729)	1.62 (0.506)
Xiangguo temple	0.46	0.00 (**)	1.67 (0.736)	2.30 (0.906)	2.45 (0.827)
Ci'en temple	0.15	0.23	1.89 (1.028)	1.95 (0.916)	2.50 (1.291)

3.4.4. Purpose

The questionnaire results showed a significant correlation between the purpose of coming to the temple and the soundscape evaluation. The correlation coefficients of purpose and the soundscape evaluation were both 0.142 ($p<0.001$). The degree of acoustic comfort evaluation mean value for visitors who were at the temple to worship the Buddha or redeem a vow was 1.76 (standard deviation 0.953); that of visiting tourists was 2.06 (0.841); that of people who came to exercise was 1.83 (0.747); and that of people who were there for other purposes was 2.17 (0.986). People who were there to worship Buddha or redeem a vow gave the best degree of acoustic comfort evaluation to the temple; they also believed that the temples' acoustic environment harmonized best with the religious atmosphere. Their degree of acoustic harmony evaluation mean value was 1.96 (standard deviation 1.045); that of visiting tourists was 2.44 (1.048); that of those who came to exercise was 2.20 (0.964); and that of those who were there for other purposes was 2.48 (1.193). These data show that the purpose of worshipping the Buddha or redeeming a vow may help believers be less sensitive to outside noise interference and enhance the degree of acoustic comfort and the degree of harmony.

3.4.5. Frequency of visiting

First, the relationship between the factor of the frequency of visiting temple and the degree of acoustic comfort evaluation was analysed. People who had visited that temple one to three times had relative similar mean evaluation values, all at approximately 2.00; however, the evaluation mean value from people who had visited the temple at least four times changed to 1.85, meaning that the evaluation tended toward comfort. The correlation coefficient between the number of visits and the degree of comfort evaluation was -0.161 ($p<0.01$). An analysis of the relationship between the frequency factor and the degree of acoustic harmony evaluation showed that the respondents who thought the acoustic environment was the most harmonious were also those who had visited at least four times. The correlation coefficient (GAMMA) was -0.133 ($p<0.05$). This finding might also correspond to the ancient Chinese saying, "hearing something for a long

time, one does not notice the noise." In addition, those who visit the temple multiple times each year were more likely to be Buddhists or residents in the surrounding area; thus, they might have been more used to the temples' acoustic environments.

3.4.6. Educational background

Previous studies have shown that respondents' educational levels correlate with their soundscape evaluation. For example, as educational background increases, the degree of acoustic comfort in users of underground shopping streets decreases [46]. The current study shows similar result. As shown in Figure 8, people with different educational levels have different perception of acoustic environment. The correlation coefficient between comfort evaluation and educational level was 0.176 ($p<0.01$), and as to the degree of acoustic harmony evaluation, it is 0.185 ($p<0.001$).

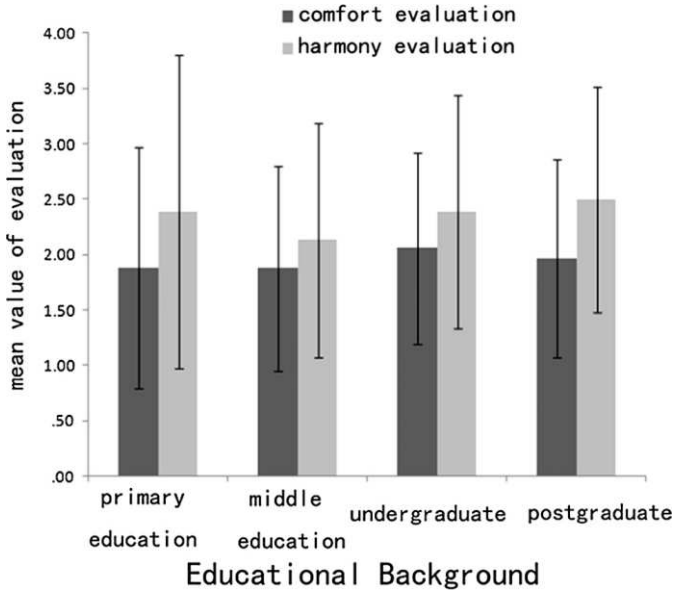

Fig. 8. Correlation between acoustic evaluation and respondents' education level

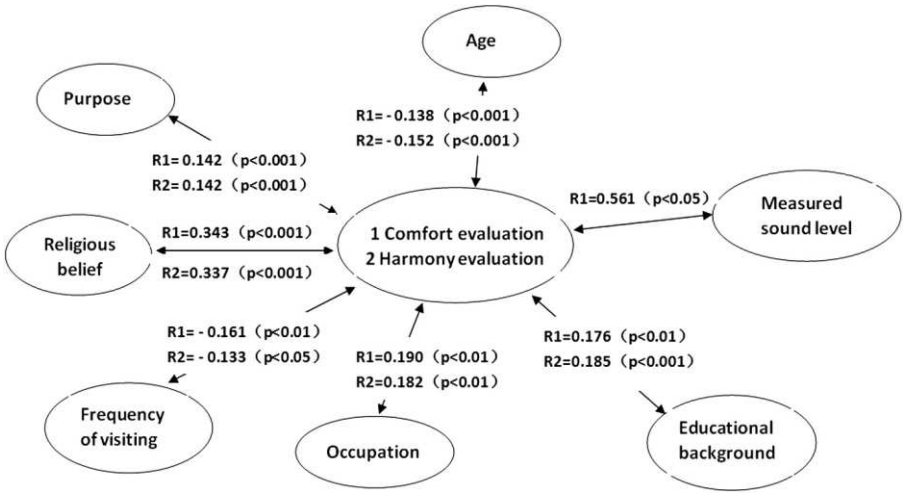

Fig. 9. Correlation diagram between influencing factors and soundscape evaluation.

Figure 9 presents the correlation coefficients between the subjective and objective factors identified in this study and the temple soundscape evaluation. Apart from this, the study showed no significant effect of the factor of gender on the temple soundscape evaluation. This finding verifies the previously proposed argument that gender has no significant effect on the soundscape evaluation of outdoor spaces [47,48].

4. Conclusions

Focusing on the soundscape in Han Chinese Buddhist temple, and based on the sound level measurements and the soundscape questionnaire survey conducted in four typical Han Chinese Buddhist temples, this study reached the following conclusions:

(1) There was little difference among the mean values of the day-long sound level measurements of the four temples, and there was a significant correlation in the sound levels between each temple. The sound preferences are significantly correlated with sharpness value of the sounds in temples.

(2) Approximately 70% of the respondents thought that the temples' acoustic environments were comfortable or relatively comfortable and that the acoustic environment harmonized or relatively harmonized with a religious atmosphere in the temple.

(3) Regarding the objective factors, there was a significant correlation between the measured sound level that synchronized with the time when the questionnaires were distributed and the degree of comfort evaluation. When the sound level exceeded 60 dBA, the correlation between the degree of acoustic comfort evaluation and sound levels substantially increased (the correlation coefficient rose from 0.451 to 0.741*); however, the measured sound levels did not correlate with the degree of harmony evaluation. Regarding the subjective factors, the respondents' age, occupation, religious belief, purpose, frequency of visiting the temples, and educational background significantly correlated with the degree of acoustic comfort and the degree of harmony evaluation (the absolute value of the correlation coefficient was between 0.13 and 0.35).

This study shows that in terms of the soundscape evaluation, the situation in Han Chinese Buddhist temples is similar to that in other public places, for example, in terms of the effects of sound levels and the social characteristics of respondents. In the meantime, it is important to note that religious relevant factors, such as religious belief of respondents, and frequency and purpose of visiting the temples, play a significant role in soundscape evaluation of Chinese Buddhist temples.

Acknowledgements

The work was supported by the fundamental research funds for the Chinese central universities (Grant No. N151104001).

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