Acoustic Comfort in Large Dining Spaces

Xi Chen[1] , Jian Kang[1,2※]
(1 Heilong Jiang Cold Region Architectural Science Key Laboratory; School of Architecture, Harbin Institute of Technology; Harbin 150001, China)
(2 School of Architecture, University of Sheffield, Sheffield S10 2TN, UK)
E-mail address: j.kang@sheffield.ac.uk (J. Kang).
※**corresponding author**

Highlights:

- Determined the effect of background noise on the acoustic comfort of diners.
- Determined source types and dominant sounds affecting acoustic comfort.
- Determined affecting factors of dominant sound sources for acoustic comfort.
- Revealed the effects of demographic and social factors.

Abstract: This study carried out a questionnaire field investigation in two typical large dining spaces. The results suggest that the acoustic comfort of diners has an influence on the comfort evaluation of the overall dining environment, and background noise is an important factor affecting the acoustic comfort evaluation of diners. The role of various individual sound sources in background noise has been investigated, considering general background music, speech sound, activity sound, and mechanical noise, and it has been revealed that background music, other diners' speech sound and tableware's impact sound has a dominant impact on the acoustic comfort evaluation of diners. Compared with the existence of background music in background noise, diners' acoustic comfort evaluation is higher than that without background music. The loudness, articulation, noise level and preference degree of various individual sound sources are factors which affect diners' acoustic comfort evaluation on sound sources. In terms of demographic and social factors, gender and the frequency of dining out have a significant impact on diners' acoustic comfort evaluation.
Keywords: Large dining space; acoustic comfort; background noise; sound source

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1 Introduction

In the field of urban soundscape, sociological approaches have been taken to conduct many studies on the soundscape in urban public open spaces including open squares, underground spaces, residential areas, hospitals, schools and historical streets [1]. Dining spaces are an important component of urban public spaces, and the quality of the internal sound environment determines diners' comfort evaluation on the overall dining experience. This evaluation influences diners' satisfaction with the restaurant as a whole and influences decisions such as whether to return and whether to consume more [2-4]. Existing studies on the sound environment in dining spaces have mostly been conducted from the aspect of speech articulation. Field research by Zheng & Zhang found a generally poor sound environment, relatively long reverberation time and low speech

articulation in college canteens and put forward corresponding improvement strategies [5]. Kang & Lok found that the sound pressure level of background noise in dining spaces was 80 to 90dBA [6]. In the case of certain reverberation time, unintelligible speech sounds could be expected to be a masking sound so that language communication of diners around the same table would not be disturbed by the noise of diners at neighbouring tables, but the sound pressure level threshold range of background noise which sheltered the noise interference of diners at neighbouring tables and guaranteed the speech articulation of diners around the same table was found to be relatively narrow， at around 69-71dBA[7-9]. Kang carried out research into the sound environment of dining spaces from the aspect of speech articulation and proposed a strategy for improving speech articulation in dining spaces [10]. Acoustic comfort is an important aspect of diners' comfort evaluation on the overall dining environment, but few studies are conducted from the perspective of acoustic comfort of dining spaces.

Studies on acoustic comfort depend on listeners' perception and evaluation of their overall sound environment [11-12]. Chen & Kang adopted the method of subjective evaluation of customers in city malls to determine factors affecting subjective evaluation of acoustic comfort, including objective acoustic indexes and some subjective factors, such as retention time, purpose and type of sound sources [13]. Meng & Kang conducted studies on acoustic comfort in underground commercial streets [14-15]. They reached the conclusion that respondents' social characteristics (e.g., education background, income, and educational level), subjective factors (e.g., retention time and visit frequency) and various individual sound sources were influencing factors in the subjective evaluation of acoustic comfort. The sound pressure level of background noise was an important objective index influencing acoustic comfort evaluation [16]. In studies on acoustic comfort in underground commercial streets, Meng [17] found that the sound pressure level of background noise had an influence on subjective acoustic comfort evaluation; the curve of correlation between subjective acoustic comfort evaluation and the sound pressure level of background noise presented a parabola form. When the sound pressure level of background noise was high or low, subjective acoustic comfort evaluation decreased. In their studies on acoustic comfort in dining spaces, Chen & Kang determined the threshold of sound pressure level of background noise in dining spaces when the acoustic comfort of diners was acceptable，whcih was 70-75 dBA [18]. Various individual sound sources in background noise had a remarkable influence on the acoustic comfort evaluation of listeners [19-21]. However, studies on the influence of sound sources on the acoustic comfort of diners are very few [5-10].

Therefore, this paper, through a questionnaire survey in two typical large dining spaces, aims to examine the acoustic comfort in such spaces and their affecting factors. Firstly the general evaluation of the sound environment in dining spaces is examined, in particularly considering the role of background noise. Then the impact of different types of sound sources are examined and dominant sound sources are determined, and their affecting factors are then explored. This is followed by an examination of social and demographic factors' effects.

2 Methodology

Research samples in two large dining spaces [22] were collected in Harbin, which was considered a representative urban area in China. As a political, cultural and economic centre, Harbin has an urban population of 9.94 million. The research sites (Xue Yuan Canteen and New World Food Court) selected for the research are dining

spaces which provide people with daily dining and undertake the main food and beverage service function of central business districts and office areas in Harbin. Covering a floor area of 2,330 m^2, with a floor-to-ceiling height of 4.2m, Xue Yuan Canteen is a three-storey and single-family staff canteen of Harbin Institute of Technology, where the main users are university students and staff. New World Food Court is a one-storey dining space covering a dining area of 5,000 m^2, with a floor-to-ceiling height of 4.5m, and its users are for general public. Fig. 1 shows the two dining spaces in their typical operation conditions, where the density of occupation can also be seen.

a）

b）

Fig.1 the two dining spaces in their typical operation conditions: (a) Xue Yuan Canteen; and (b) New World Food Court.

The questionnaire survey was conducted from March to December 2015 in Harbin， China. It was divided into two parts, namely diners' recognition of sound sources in background and diners' evaluation on the overall sound environment and various individual sound sources. Firstly, interviewed diners were asked to fill "Please write down the type of sounds you can hear at the moment" in a preliminary questionnaire, to determine the type of sound sources in background noise. Then, a formal questionnaire on studying the acoustic comfort of dining spaces was prepared by combining the results of preliminary questionnaires and based on the result of grounded theory of studying the sound environment in dining spaces. The formal questionnaire adopted a five point scale [23], whose content covered background information, diners' comfort evaluation on the overall environment in dining spaces, subjective feeling of reverberation, sound volume of communication with dining companions, and evaluation on the acoustic comfort, loudness, articulation, noise level, and preference degree of various independent sound sources, as shown in Table 1. It is noted that the original survey was carried out in Chinese. Before making an evaluation on various individual sound sources in dining spaces, respondents needed to determine whether they could hear the sound sources and if so make a corresponding evaluation on the individual sound sources.

The preliminary survey generated 300 valid questionnaires in total. During the formal survey 926 valid questionnaires were completed.

Through analysing and processing survey data with the SPSS software[24], research results were obtained. Firstly, an analysis on Pearson correlation was conducted to

determine the factors and dominant sound sources affecting diners' comfort evaluation on the sound environment; then, the influence of the existence or non-existence of dominant sound sources in background on diners' acoustic comfort was confirmed through conducting independent samples *t*-test. Secondly, Pearson correlation analysis and regression analysis were applied to determine the factors affecting acoustic comfort of dominant independent sound sources from the characteristics of the sound sources. Finally, one-way ANOVA was adopted to ascertain the factors affecting diners' acoustic comfort evaluation from the aspect of demographic and social factors.

Table 1 Content framework of survey questionnaire

Content		Selection and quantitative information
Background information	Gender	Male Female
	Age	<17 18–24 25–34 35–44 45–54 55–64 >65
	Education background	Below junior college Junior college Undergraduate Postgraduate
	Character	Active Quiet Fall in between
	Whether dine out frequently	Yes No
	Whether they are dining companions	Yes No
	Income （unit: RMB Yuan）	<1,000 1000-2000 2000-3000 4000-5000 >5000
	Occupation	Employed Unemployed Pensioner Student
Comfort of the overall environment	A five point scale: 1 Very uncomfortable—5 Very comfortable	
Comfort of various physical environmental indexes (sound environment, lighting effect, temperature, humidity and air quality)	A five point scale: 1 Very uncomfortable—5 Very comfortable	
Sound volume of communicating with dining companions	A five point scale: 1 Very soft—5 Very high	
Whether hear echoes or not	A five point scale: 1 Very weak—5 Very strong	
Evaluation on the overall sound environment	A five point scale: 1 Very noisy—5 Very quiet	
Acoustic Comfort of various individual sound sources	A five point scale: 1 Very uncomfortable—5 Very comfortable	
Loudness of various independent sound sources	A five point scale: 1 Very low—5 Very high	
Articulation of various independent sound sources	A five point scale: 1 Very clear—5 Very unclear	
Noise level of various independent sound sources	A five point scale: 1 Very noisy—5Very quiet	
Preference degree of various independent sound sources	A five point scale: 1 Dislike a lot—5 Like a lot	

3 Results

3.1 Evaluation on the Sound Environment in Dining Spaces

Fig. 2 illustrates the diners' subjective evaluation on the comfort of the overall dining environment and includes the mean and standard deviation of evaluation on the comfort of the overall environment and various physical parameters. It can be seen that the comfort of the overall environment in dining spaces was acceptable (mean value was 3.57); however, evaluation of the comfort of temperature and humidity was relatively higher (mean values were 3.81 and 3.72 respectively), and diners' evaluation of the comfort of the sound environment was slightly lower (mean value was 3.28). An analysis using Pearson correlation between diners' comfort evaluation on the sound environment and diners' comfort evaluation on the overall environment was conducted, and the correlation coefficient was 0.509 (P <0 .01). In other words, there is significant positive correlation between diners' acoustic comfort evaluation and diners' comfort evaluation on the overall environment, namely, the acoustic comfort evaluation affected comfort evaluation on the overall environment.

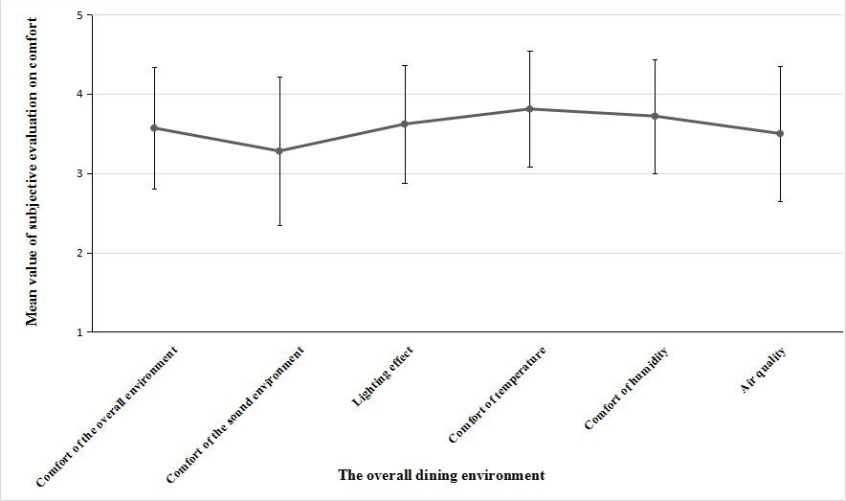

Fig. 2 Mean and standard deviation of comfort evaluation on the overall dining environment

Diners mainly reported "medium" (41.4%) and "comfortable" (30.3%) acoustic comfort. However, 18.6% of diners thought that the sound environment in dining spaces was "uncomfortable" and "very uncomfortable". A previous study showed that reverberation time and background noise were significant factors affecting the subjective evaluation of acoustic comfort, and the relation between reverberation time and the subjective evaluation showed a monotonous exponential function [13-18,25]. Therefore, this paper used questionnaires to examine diners' subjective feelings about reverberation. Results indicated that evaluations of only "6.8%" and "1.5%" of respondents in typical dining spaces on reverberation sense were "strong" and "very strong" respectively, which showed that diners' subjective reverberation sense was not high and the reverberation issue could not be further discussed as a main issue in studies on acoustic comfort, which might be because for very large spaces, the critical distance, where reverberation sound field equals to the direct sound field, tends to be large and reverberation then tends not to be dominant. This result was consistent with the result of Chen and Kang [18] following studies on acoustic comfort in underground dining spaces.

Diners' evaluation on background noise mainly focused on "medium" (41.8%) and "noisy" (40.0%). A few (7.5%) diners thought that background noise was "very noisy".

In analysing whether the sound volume of communication between diners and dining companions would influence diners' evaluation on background noise, it was found that diners' evaluation on background noise varied because of different sound volumes necessary for communicating with dining companions ($P < 0.05$). Using ANOVA homogeneity test of variance, the quiet-feeling evaluation of diners communicating with dining companions softly on background noise was the highest and the mean value was 3.5; the quiet-feeling evaluation of diners increasing their sound volume to communicate with dining companions on background noise was the lowest and the mean value was 1.69. This indicated that diners would make a lower quiet-feeling evaluation on background noise and feel they were noisier as they increased their sound volume to communicate with dining companions, just as interviewed diners said, "We will become noise sources in a noisy environment".

Through conducting an analysis on Pearson correlation between diners' evaluation on background noise and diners' acoustic comfort evaluation, the correlation coefficient was 0.587 ($P < .01$), which showed that there was significant positive correlation between the low evaluation of diners on background noise and the evaluation on acoustic comfort. Background noise was an important factor affecting diners' acoustic comfort evaluation. Existing research indicated that the sound pressure level of background noise in dining spaces was an important objective index affecting diners' acoustic comfort evaluation in the presence of composite sound sources [16]. Meanwhile, background noise was formed under the combined action of various sound sources, and various independent sound sources exerted an influence on participants' acoustic comfort evaluation to different degrees [13, 19-21]. As a result, the following part focuses on studying the influence of various independent sound sources in background noise on diners' acoustic comfort evaluation.

3.2 Acoustic Comfort of Different Types of Sound Sources

Interviewed diners were required to list the sound that they heard at that moment, in order to identify various independent sound sources in background noise and determine the type of sound sources from the perspective of diners. To avoid the differences of respondents in perception of sound sources in background noise, sound sources which were mentioned less than five times were removed [21]. Finally, various individual sound sources in dining spaces could be divided into four types, namely general background music, speech sound, activity sound, and mechanical noise.

As a key sound, general background music constituted the keynote in the soundscape of dining spaces and highlighted other sounds including background music and TV sound. Speech sound sources consisted of the sound of diners (the speech sound of dining companions and other diners, and the speech sound, shout and phone call of people moving around) and sound caused by staff (speech and cries). Among them, the speech sound of other diners could be considered as a soundmark，which features the characteristics of dining spaces, and this sound was mentioned most (115 times) by respondents. Cries (33 times) and the speech sound of staff (12 times) were also mentioned, which could be regarded as foreground sound. Activity sound sources were caused by users in dining spaces because of activities, including the impact sound of tableware, footsteps made by diners in the dining process, and the sound of food preparation made by staff. Mechanical noise sources include the sound of kitchen ventilators, the sound of elevators running and the friction sound of dining trolleys (the sound of pushing dining cars).

Table 2 (see column A) is the mean and standard deviation of diners' acoustic comfort evaluation on various sound sources in background noise. It could be noticed that general background music was acceptable to diners and the mean values of acoustic comfort evaluation on the sound sources of background music and television sound were close to 3 (medium). Interviewed diners reported, "Western restaurants, coffee houses and fast-food restaurants have background music", "Chinese restaurants focus on talking without background music", "We can accept musical sound in the dining process" and "soothing musical sound is preferred, but background music should not influence normal exchange". Speech sound sources (the speech sound of dining companions, other diners, and people moving around) caused by diners were acceptable and acoustic comfort evaluation on sound sources was close to 3 (medium). The standard deviation of acoustic comfort evaluation on the speech sound of other diners was slightly higher (SD=1.15), which might result from the differences of diners in their expectations of the sound environment in dining spaces. Some diners expressed their opinions in interviews, "Communication is needed in the dining process", "Relatively quiet dining environment is needed" and "Communicating with dining companions softly is necessary". Other diners held different opinions, "Quietness would produce a sense of depression" and sometimes they "chat with diners at a neighbouring table".

Speech sound sources (the speech sound, cries and shouts) caused by staff were the type of sound sources resulting in a high degree of annoyance (low comfort) of diners. The mean value of acoustic comfort evaluation on the sound sources of cries and shouts was slightly lower, at 2.27 and 1.99, respectively, which might be attributed to the high sound pressure level of the sound source increasing the annoyance degree of diners. Interviewed diners said, "We hate the occurrence of high-pitched sounds", "We dislike hearing shouts" and "We dislike being interrupted in conversation". The mean value of acoustic comfort evaluation on the speech sound of staff was 2.84 (SD=1.05). The slightly high SD might arise from the speech content of staff. Interviewed diners reported, "Good service attitude and tasteless food are acceptable", "We like hearing service expressions", "We need service guides" and "We can accept the slogan shouting of restaurants". Sometimes interviewed diners would "be touched by waiters", but they hated to hear "the sound of quarrelling with service staff".

Activity sound sources were the type of sound sources accepted by diners in the aspect of acoustic comfort, and the comfort evaluation on sound sources approached 3 (medium). However, acoustic comfort evaluation on the impact sound of tableware was slightly lower and the mean value was 2.64 (SD=0.95), which might be due to the impulsive properties of some of the impact sounds (e.g., the sound of tossing pans and breaking tableware) and their startling effect.

Mechanical sound sources were the type of sound sources where evaluation was low. Among mechanical sound sources, comfort evaluation on the sound of pushing dining cars was the lowest and the mean value was 2.65 (SD=0.88).

In conclusion, foreground sound (cries and shouts) drawing the attention of diners, the speech sound of staff, the impact sound of tableware and mechanical noise in keynote were types of sound sources which resulted in high annoyance degree (discomfort) of diners.

Table 2 (see column B) also provides a statistical analysis using Pearson's correlation between the acoustic comfort evaluation on various individual sound sources and the comfort evaluation on the overall sound environment in dining spaces ($P < .01$). Results showed that there was a positive correlation between acoustic comfort

evaluation on background music, the speech sound of other diners, and the impact sound of tableware with the comfort evaluation on the overall sound environment. The correlation coefficient was 0.25 to 0.5. To determine the influence of background music, other diners' speech sound and the impact sound of tableware on the comfort of the overall sound environment, independent samples t-test were conducted in the presence and absence of the sound sources. According to the results, diners' comfort evaluation on the overall sound environment in the case of the presence or absence of background music displayed a marked difference (P = 0.035 < .05). Diners' comfort evaluation (mean value was 3.55) on the overall sound environment in dining spaces in the presence of background music was higher than that (mean value was 3.18) in the absence of background music, which was consistent with the result of Meng & Kang [20] in their studies on the influence of various individual sound sources in underground commercial streets on the comfort of the sound environment. The presence or absence of other diners' chatting sound and tableware's impact sound in background noise showed no significant difference in the comfort evaluation on the overall sound environment.

Table 2 Mean and standard deviation SD of acoustic comfort evaluation on sound sources and an analysis on Pearson correlation between the acoustic comfort of sound sources and the overall sound environment comfort evaluation (with ** representing P<0.01)

Type of sound sources		A	B
		Mean and standard deviation STD of acoustic comfort evaluation on sound sources	Correlation coefficient and significance level of acoustic comfort evaluation of various sound sources and the overall sound environment Comfort evaluation
General background music	**Background music**	**3.51/0.68**	**0.496/0.000(**)**
	TV sound	3.02/0.83	0.089/0.233
Speech sound sources	Speech sound of dining companions	3.29/0.76	0.231/0.023
	Chatting sound of other diners	**2.84/1.15**	**0.25/0.000(**)**
	Speech sound of staff	2.84/1.05	0.222/0.022
	Speech sound of people moving around	3.23/0.80	0.139/0.095
	Shout	2.46/0.93	0.23/0.012
	Phone call	2.59/0.89	0.218/0.041
	Cry	2.73/0.95	0.0217/0.011
Activity sounds	**Tableware's impact sound**	**2.64/0.95**	**0.383/0.000(**)**
	Sound of food preparation	3.35/0.86	0.153/0.072
	Footstep	3.11/0.79	0.283/0.015
Mechanical noise	Sound of smoke ventilators	2.83/0.88	0.304/0.041
	Sound of dining trolleys' friction with the ground	2.65/0.88	0.245/0.027
	Running sound of elevators	2.75/0.89	0.12/0.149

3.3 Acoustic Comfort of Dominant Sound Sources

In Section 3.2, dominant sound sources affecting diners' comfort evaluation on the overall sound environment were determined. Existing research showed that the acoustic comfort of sound sources was related to some sound characteristics like loudness, articulation and preference degree [26-27]. Therefore, this section examines the factors affecting the acoustic comfort of dominant sound sources from the perspective of sound characteristics (loudness, articulation, noise level and preference degree).

(1) Acoustic Comfort of Background Music

The correlation, significance level and coefficient of determination R^2 of subjective loudness, articulation, noise level and preference degree of background music and the subjective acoustic comfort of background music are shown in Table 3. It reveals the mean difference of diners' evaluation on various factors influencing acoustic comfort evaluation on background music. Results showed that the preference degree and noise level of background music significantly influenced the comfort evaluation of the sound source ($P < .05$). The evaluation on the preference degree of background music and its acoustic comfort evaluation showed the highest correlation and the correlation coefficient was 0.559. Through regression analysis, it was shown that 31.2% of change in acoustic comfort evaluation on background music resulted from the difference in diners' preference degree of the sound source. Evaluation on the noise level and acoustic comfort of the sound source, showed the correlation coefficient was 0.411 and the mean difference was -0.6133, which indicated that the mean value of diners' evaluation on the noise level of background music was significantly lower than that of diners' acoustic comfort evaluation on the sound source. It can be seen that although the diners have a feeling of noisiness (i.e noise level) on background music, the acoustic comfort evaluation of such sound source is still acceptable, with a mean value of 2.97. A possible reason is that, diners could clearly hear background music and increase their acoustic comfort evaluation on background music when music was very loud. A correlation analysis on the evaluation on the articulation and acoustic comfort of such sound source indicated that evaluation on the articulation of background music was significantly and positively correlated with acoustic comfort evaluation of background music, and the correlation coefficient was 0.271. The clearer the background music, the higher the diners' acoustic comfort evaluation on the sound source.

Table 3 Relationship between subjective loudness, articulation, noise level, preference degree and the acoustic comfort of background music (with * representing P<0.05)

Type of sound sources	Influence factor	Pearson correlation coefficient and significance level	Coefficient of determination R^2	Mean difference (with the evaluation of acoustic comfort)
Background music	Loudness	-0.127/0.12	—	**-0.24/0.01(*)**
	Articulation	**0.271/0.001(*)**	**0.074(*)**	**0.25/0.005(*)**
	Noise level	**0.411/0.000(*)**	**0.151(*)**	**-0.6133/0.000(*)**
	Preference degree	**0.559/0.000(*)**	**0.312(*)**	**-0.28/0.000(*)**

(2) Acoustic Comfort of Other Diners' Speech Sound

The correlation, significance level and coefficient of determination R^2 of the subjective loudness, articulation, noise level and preference degree of other diners' speech sound and the acoustic comfort evaluation of other diners are shown in Table 4.

It reveals the mean difference of diners' evaluation of various factors which influence the comfort evaluation on other diners' speech sound. The acoustic comfort and preference degree of other diners' speech sound showed a high correlation and the correlation coefficient was 0.648. Through regression analysis, it is found that 42% of evaluation on other diners' speech sound was influenced by the preference degree of the acoustic sound. However, there was a remarkable negative correlation between the loudness of other diners' speech sound and the comfort of the sound source. Namely, the higher the evaluation on the loudness of the sound source, the lower the acoustic comfort of the sound source. Diners possibly felt the increasing noise level of the sound source and became increasingly uncomfortable as the volume of other diners' speech became gradually higher. A correlation analysis on the noise level and acoustic comfort of other diners' speech sound showed that correlation coefficient was 0.359, and diners' acoustic comfort decreased with the increase in noise level. Regression analysis showed that change in diners' evaluation on the noise level of other diners' speech sound could explain the variation of 12.5% of acoustic comfort evaluation on sound sources.

Table 4 Relationship between subjective loudness, articulation, noise level, preference degree and the acoustic comfort of other diners' speech sound (with * representing P<0.05)

Type of sound sources	Influence factor	Pearson correlation coefficient and significance level	Coefficient of determination R^2	Mean difference (with the evaluation of acoustic comfort)
Other diners' speech sound	Loudness	**-0.113/0.033(*)**	**0.013(*)**	**0.264/0.000(*)**
	Articulation	-0.007/0.893	—	**0.21/0.003(*)**
	Noise level	**0.359/0.000(*)**	**0.125(*)**	0.07038/0.24
	Preference degree	**0.648/0.000(*)**	**0.42(*)**	**-0.195/0.000(*)**

(3) Acoustic Comfort of Tableware's Impact Sound

Shown in Table 5 is the correlation, significance level, and coefficient of determination R^2 of the subjective loudness, articulation, noise level and preference degree of tableware's impact sound and the acoustic comfort of tableware's impact sound. It illustrates the mean difference of diners' evaluation on various factors influencing the acoustic comfort of tableware's impact sound. Diners' preference degree of tableware's impact sound influenced the evaluation on the acoustic comfort of the sound source and the correlation coefficient was 0.657. Regression analysis showed that a change in 43.2% of diners' acoustic comfort evaluation on tableware's impact sound resulted from differences in sound preference. There was remarkable negative correlation between the articulation and acoustic comfort evaluation on the sound source. Namely, diners would make a lower evaluation on acoustic comfort when they could hear tableware's impact sound more clearly, which might be related to diners' sound expectation [28-30]. Interviewed diners said, "We do not want to hear the sudden sound of breaking dishes". There was a significant negative correlation between the loudness of tableware's impact sound and the acoustic comfort of the sound source, which might be because the high level of tableware's impact sound would intensify diners' feelings about the noise level of the sound source. Correlation analysis on the noise level and acoustic comfort evaluation of the sound source showed that these factors in tableware's impact sound presented a marked positive correlation. Namely, the stronger diners felt about the noise level of the sound source, the lower the acoustic comfort of the sound source.

Table 5 Relationship between subjective loudness, articulation, noise level, preference degree and the acoustic comfort of tableware's impact sound (with * representing P<0.05)

Type of sound sources	Influence factor	Pearson correlation coefficient and significance level	Coefficient of determination R^2	Mean difference (with the evaluation of acoustic comfort)
Tableware's impact sound	Loudness	**-0.27/0.000(*)**	**0.037(*)**	**0.47/0.000(*)**
	Articulation	**-0.139/0.01(*)**	**0.019(*)**	**-3.7/0.000(*)**
	Noise level	**0.288/0.000(*)**	**0.083(*)**	-0.07250/0.243
	Preference degree	**0.657/0.000(*)**	**0.432(*)**	**0.71/0.000(*)**

3.4 Effects of Demographic and Social Factors

The sensitivity of individuals to noise is regarded as a stable human characteristic and reflects individuals' attitude towards and opinion on a wide-range of environmental noise [31]. Diners perceive the sound environment in dining spaces differently due to variations in demographic and social factors. Existing research demonstrates that the demographic and social factors of listeners present significant differences in acoustic comfort evaluation [32]. The demographic and social factors of diners are composed of gender, age, education background, frequency of dining out, and the presence of dining companions. Through adopting the method of one-way ANOVA, this section determines the factors affecting diners' acoustic comfort evaluation from the aspect of demographic and social factors.

Males and females showed significant difference in acoustic comfort evaluation in dining spaces ($P < .05$). ANOVA homogeneity test of variance $P = 0.968$ ($> .05$) showed that diners' comfort level is generally acceptable with the sound environment in dining spaces, but female diners' comfort level of the sound environment (3.45) was higher than that (3.13) of male diners.

The frequency of dining out caused a significant difference in diners' evaluation on the comfort of the sound environment in dining spaces ($P < .05$). ANOVA homogeneity test of variance $P = 0.085$ ($> .05$) showed that diners who dined out frequently（the mean value was 3.38）could accept the comfort of the sound environment in dining spaces more easily than diners who did not（3.14）, which might be caused by individuals' sound experience [33].

Age, education background and the presence of dining companions presented no significant difference in diners' comfort evaluation on the overall sound environment in dining spaces. Demographic and social factors did not show significant differences in diners' acoustic comfort evaluation on various independent sound sources in background noise.

4 Conclusions

This study used field questionnaire surveys in typical large dining spaces and analysed various independent sound sources affecting diners' acoustic comfort evaluation in background noise. According to the results, acoustic comfort evaluation had an influence on diners' comfort evaluation on the overall environment, and the correlation coefficient was 0.509(P <0 .01); background noise was an important factor affecting diners' acoustic comfort evaluation, and the correlation coefficient was 0.587($P < 0.01$).

Background noise in dining spaces was composed of four types of sound sources including general background music, speech sound, activity sound and mechanical

noise. Among them, background music, other diners' speech sound and tableware's impact sound had dominant impact on the acoustic comfort evaluation of diners.

The acoustic comfort evaluation on dominant sound sources significantly influenced diners' comfort evaluation on the overall sound environment. Compared with the presence of background music in background noise, diners' acoustic comfort evaluation was higher than that without background music. The loudness, articulation, noise level and preference degree of various individual sound sources were factors which affect diners' acoustic comfort evaluation on sound sources.

In the aspect of demographic and social factors, gender and frequency of dining out was a significant difference in diners' comfort evaluation on the overall sound environment. Female diners had a higher evaluation on the comfort of the sound environment than male diners. Diners who dined out frequently had a higher evaluation on acoustic comfort than diners who dined out infrequently. There was no significant difference in acoustic comfort evaluation on various independent sound sources.

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