Assessing the ease of conversation in multi-group conversation spaces: effect of background music volume on acoustic comfort in a café

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Abstract

A "multi-group conversation space (MGCS)" refers to a space, such as restaurant or café, where more than one group of people share a space and make conversation within their respective group. From a field experiment in an actual café, we investigated the acoustic comfort in a MGCS considering speech intelligibility and speech privacy as major factors. In the experiment, noise measurements and a questionnaire survey taken by customers were conducted for four days. We were able to change the volume of the background music (BGM) during operating hours, setting the level on each of the four days to *low*, *mid*, *high,* and *none*. Indoor noise levels were measured at six representative points with six sound level meters hung from the ceiling. The questionnaire consisted of eight items for subjective evaluation, including ease of conversation, comfort, and room atmosphere. After having their meal or drinks, the customers were asked to fill in the questionnaire at their table. The occupancy of neighboring tables and the number of customers in the café were also recorded. Results show that: 1) overall, the respondents evaluated the café space positively; 2) *high* BGM volume levels together with occupied neighboring tables tended to elicit negative evaluations; and 3) customer clustering analysis identified certain influences of distance from loudspeakers, neighboring table occupancy, and personal characteristics.

Keywords: Background music volume, Café ambience, Ease of conversation, Multi-group conversation space

1. Introduction

Often in restaurants and cafés, a space must be shared between two or more groups wanting to make conversation within their respective group. We refer to such spaces as "multi-group conversation spaces (MGCSs)." In these circumstances, when the MGCS has little sound absorption, it is not easy to converse because of a poor speech intelligibility due to reverberation. Moreover, when the level of sound absorption in a MGCS is high, it may become uncomfortable because a conversation of a group, particularly a business talk or a talk of private matters, may be overheard. Therefore, one presumes that some optimal range of acoustic conditions afford a comfortable conversation in which both the intelligibility and the privacy of speech are adequately balanced. The goal of our study is to find this range of acceptance in regard to background sound and reverberation. A practical investigation on speech intelligibility in noisy confines, based on a parametrical modeling of the characteristics of conversation intelligibility in dining spaces, was conducted,[1] and a suitable density of diners and a certain level of sound absorption for such spaces was suggested. Rindel[2] proposed a simple prediction model for noise levels in restaurants depending on the number of groups conversing among themselves and taking in account the Lombard effect. He provided a recommendation for the minimum area of acoustic absorption per person. Rindel[3] proposed a simple evaluation index of the "acoustic capacity" for speech intelligibility in eating establishments. Astolfi and collaborators[4] investigated the acoustical quality in restaurants regarding the privacy and intelligibility of speech by conducting a survey in four "pizzerias" in which seat density and sound absorption were discussed based on subjective evaluations. Nahid and collaborators[5] performed a simulation in actual eating establishments to find a good balance between speech intelligibility among diners seated around a table and speech privacy between tables. The result indicated that tall and absorptive barriers are effective but may not be suitable in eating establishments in terms of space and interior design. Aside from architectural aspects, background music (BGM) is an important element in acoustic design of MGCSs, an aspect that has been studied considerably.[6]

In total, studies remain scant on the acoustic quality in MGCSs and more investigation of comfortable acoustic levels in terms of intelligibility and privacy of speech is needed with regard to background sounds and noises and sound absorption. In the present study, a field experiment with a questionnaire survey and acoustic measurements were conducted in an actual café under four different levels of BGM.

There were many limitations in the experiment because this field experiment should have been conducted under actual running conditions of the café. We were limited to controlling only the volume of the BGM. The number of customers, the customer location, speech level, the operation of the air-conditioner, and reverberation, which might be major factors contributing to the acoustic ambience in the café, were not manipulated. With these limitations, the purpose of this study was to explore how background sounds and noises, and other specific factors affected the subjective evaluations of customers with respect to a comfortable conversation in their respective MGCSs.

2. Setup of the experiment

2.1. Venue

Table 1. Room dimensions

Floor area (m^2)	92.3
Volume (m^3)	285.2
Surface area (m^2)	319.1
Height (m)	3.3 (partially 3.0 or 3.6)
Seats	43

Table 2. Interior surface materials

ceiling	Wood wool cement board
wall	Beton brut + emulsion paint finish
floor	Beton brut and carpet

Figure 1. Photo of the interior of the café U.

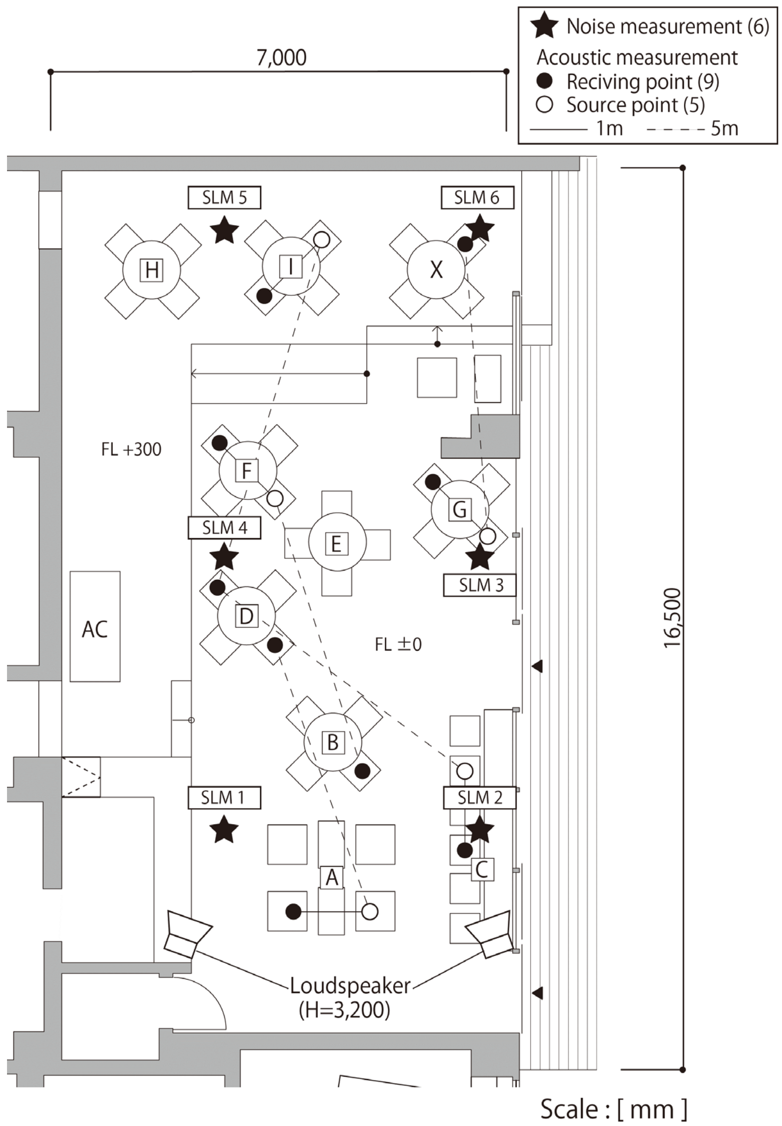

Figure 2. Floor plan of the café U.

The experiment was conducted over four days in December 2018 at a café in Kinosaki, Japan. The building originally was an old fire station with a reinforced concrete structure and converted into a café with a small adjoining art gallery in September 2018 (Figure 1). The floor plan, dimensions, and interior surface materials are presented in Figure 2 and Tables 1 and 2. Although a sound absorptive material (wood wool cement board) was installed in the ceiling, the space had a long reverberation time because of the high ceiling and other reflective surfaces, as described later. The café has ten tables (Figure 2). Identification labels from A to I were assigned to nine of the tables; the tenth labeled X was taken by the experimenters to administer the questionnaire.

2.2. Noise measurement without customers

Six sound-level meters (RION NL-42, SLM1-6 in Figure 2) were hung 1 m from the ceiling as receiving points for noise measurements. The A-weighted sound pressure levels (SPLs) at each of the nine monitored tables (L_{A_tbl}) was estimated from the level of the nearest receiving point or the energetic mean of the nearest two receiving points if the distances to the two point were similar (see Table 4, second column).

Table 3. BGM volume conditions

	Day 1 (Wed)	Day 2 (Fri)	Day 3 (Sat)	Day 4 (Sun)
BGM	*no*	*high*	*Mid*	*low*
level	—	±0 dB	-4.8 dB	-9.6 dB

Table 4. Estimated noise levels by AC or BGM at each table

ID	SLM	AC [L_{Aeq}, dB]	BGM [L_{Aeq}, dB]		
			low	*Mid*	*high*
A	1&2	57.8	58.3	63.1	67.9
B	1&2	57.8	58.3	63.1	67.9
C	2	57.8	59.0	63.8	68.6
D	3	59.8	53.8	58.6	63.4
E	3&4	59.1	54.1	58.9	63.7
F	3	59.8	53.8	58.6	63.4
G	4	58.2	54.4	59.2	64.0
H	5	56.5	52.0	56.8	61.6
I	5	56.5	52.0	56.8	61.6

* Background noise level was around 50 dB.

Table 5. RT and intelligibility indices

Distance [m]	$T_{30,\ 500\text{-}2k}$ [s]	STI	D_{50}
1.0	1.0 (0.02)	0.77 (0.01)	0.83 (0.03)
5.0		0.63 (0.02)	0.50 (0.08)

The main sources of background sounds and noises apart from customers were the BGM and the running noise of an air-conditioning (AC) unit. The BGM was played through two loudspeakers (Electro-Voice S40W) at one end of the room, creating SPL differences depending on the distances from the loudspeakers. The BGM volume was set at four levels (no BGM, *low*, *mid*, and *high* volume) and changed each day over the four days of the experiment (Table 3). To determine the BGM volume, first, the volume of the *high* level was adjusted at the upper limit of the subjectively comfortable level range by the experimenters sitting at the nearest seats at table C; the level was 68.6 dB (Table 4). As 1.6 dB was the smallest step on the volume dial, the *mid* and *low* levels were set at 4.8 dB and 9.6 dB lower than the *high* level, respectively. As the BGM playlist, we chose the *Carpenters channel* (named for a musical duo) provided by a cable radio company (USEN MPX-1 00032), from which several dozens of the *Carpenters* songs were randomly played.

A large fan coil unit from the AC unit mounted on the ceiling emitted a noise when running (Figure 2). The unit ran intermittently being regulated by a preset temperature setting. The AC noise and BGM sound were measured separately when no customers were about. For each table, L_{A_tbl} values attributable to AC noise and to BGM separately are listed in Table 4. The AC noise level was rather high at 56–60 dB and higher than the BGM levels at tables other than A–C with *low* volume levels, and at tables D–F with *mid* volume levels. The BGM levels varied from 52 to 69 dB, a 17-dB difference, depending on the BGM levels and the table location. The 4–7 dB difference between tables A–C and D–I under the same BGM volume levels is similar to or greater than the difference of one step (4.8 dB) in the BGM volume level. The background noise without AC noise and BGM was around 50 dB (Figure 3, L_{A95} on Day 1) and therefore the AC noise and BGM were regarded as the dominant background sounds in the café.

2.3. Acoustic measurement

The room impulse responses were measured using a swept-sine signal emitted by an omnidirectional loudspeaker (handmade, twelve 10-cm loudspeakers: TOA BST-193) to calculate the reverberation time. Intelligibility indices (STI—background noise not considered, and D_{50}) were also measured to see the acoustic characteristics in the café but not used in the subsequent analysis. Five source points were set above a chair at five different tables and two receiving points were set at distances of 1 m and 5 m from each of the source points (Figure 2). The two receiving points were representing voices within a group and voices coming from distant tables. The mean values and standard deviations of these indices are listed in Table 5. The reverberation time averaged over the 500 Hz – 2 kHz octave bands was 1.0 s and the average sound absorption coefficient estimated by the Eyring formula was 0.14. The STI was 0.77 and 0.63 at distances of 1 m and 5 m and these values are rated as excellent and good, respectively. This indicated good speech intelligibility not only at a table but also between distant tables, which may be perceived as a lack in speech privacy when the background noise is low.

3. Implementation of experiment

3.1. Questionnaire survey

A questionnaire survey was conducted to elicit impressions from customers about the acoustic environment and to derive the relationship between impressions and acoustic properties. The questionnaire consisted of 13 items: eight items about the impressions of the acoustic environment with four or five step evaluation scales (Table 6), four items about the respondents (age, gender, nationality, purpose of visit), and an open question for free comment. Considering the possibility that the respondents might not know or notice the reverberation, the actual statement of the reverberation question was "To what level does sound carry in this café?". An option of "Difficult to judge" was added. As well as Japanese, the questionnaire sheet was prepared in English and Chinese for foreign visitors. The time required to fill out the questionnaire was 1–2 minutes.

The questionnaire survey was conducted during opening hours (8 AM – 6 PM). The experimenters (2 people) stayed at table X (Figure 2) for the entire duration and handed the questionnaire sheet to customers that had stayed a certain length of time conversing in the café, usually when they had finished eating or drinking. Customers were simply handed the questionnaire without explanation and responded to the questions by themselves. During the time, the experimenters recorded the number of customers in the café and customer seating locations every 10 minutes. In total, 265 customers (109 males and 156 females) responded and, among them, there were 12 foreign respondents from China (6), Hong Kong (2), Thailand (2), Taiwan (2), and Malaysia (2) (Table 7).

3.2. Noise measurement

Using the six sound level meters, the A-weighted SPL ($L_{A,F}$ was measured continuously every 0.1 s) during the opening hours of the four days and in a post

Table 6. Items of subjective evaluation

	Item title		Words designating scale		
Q 1	Comfort	:	Very comfortable	—	Uncomfortable
Q 2	Room atmosphere	:	Relaxed	—	Lively
Q 3	Ease of conversation	:	Easy to carry out a conversation	—	Difficult to carry out a conversation
Q 4	Noisiness	:	Not at all noisy	—	Extremely noisy
Q 5*	Bothered by nearby conversations	:	Not at all bothered by nearby	—	Extremely bothered by nearby
Q 6**	Room reverberation	:	Not at all reverberate	—	Extremely reverberate
Q 7**	Difficulty of hearing within the group	:	Not difficult to hear	—	Extremely difficult to hear
Q 8	Feeling about BGM volume	:	Low (BGM volume)	—	High (BGM volume)

* five-point bipolar scale ** four-point unipolar scale + "difficult to judge"

Table 7. Respondent characteristics

BGM			Age group						Total
			–24	25–34	35–44	45–54	55–64	65–	
Day 1	*no*	M	2	1	1	2	0	1	7
		F	4	3	0	4	6	3	20
Day 2	*high*	M	1	4	1	3	8	8	25
		F	2	4	2	3	8	4	23
Day 3	*mid*	M	4	7	1	4	6	2	25
		F	6	7	6	10	7	4	41
Day 4	*low*	M	19	9	4	2	10	8	52
		F	19	15	8	14	6	10	72
Total			57	50	23	42	51	40	265

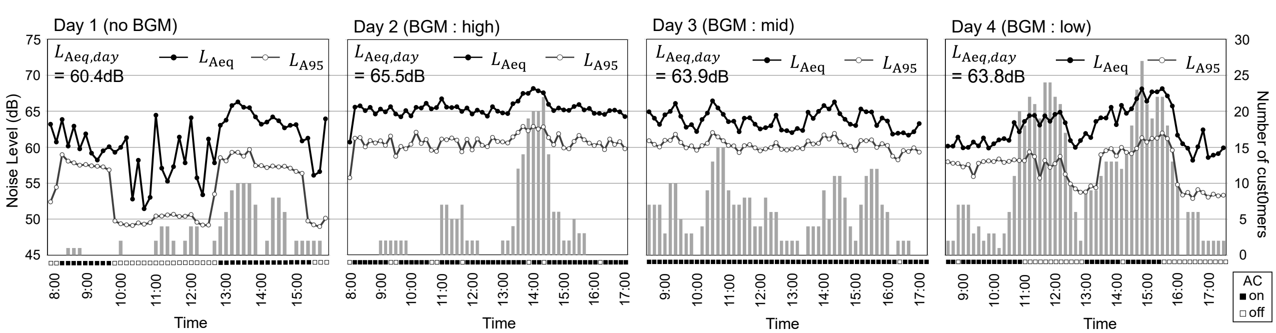

Figure 3. Noise level (L_{Aeq}, L_{A95}), number of customers, and operation status of the air conditioning unit.

analysis $L_{Aeq,10min}$ and $L_{A95,10min}$ were calculated. Whereas recording the sound for a detailed analysis would be better, this was not possible in the café because of privacy reasons; therefore, only the SPL was measured.

4. Results and discussion

4.1. Noise level

Both $L_{Aeq,10min}$ and $L_{A95,10min}$, which are the arithmetic means of the six receiving points, the number of customers, and the turning on/off of air-conditioning unit registered during each day were graphed (Figure 3). For each day, L_{Aeq} ranged from 60 dB to 66 dB, which is lower than that of Astolfi's study (67–76 dB)[4] but similar to that of Novark's study (59–70 dB).[6]

On Day 1, the fluctuation in L_{A95} was greater than those on other days because the intermittent operation of the AC unit greatly affected L_{A95} in the absence of BGM. This fluctuation was also seen with *low* BGM on Day 4 but L_{A95} was quite stable when the BGM level was in the *mid* or *high* volume levels as the BGM sound level exceeded the AC noise level.

From Figure 3, L_{Aeq} fluctuated along with the number of customers. Figure 4 depicts the relationship between L_{Aeq} and the number of customers every 10 min with the regression lines for each of the BGM volume levels. (Data from time periods with no customers present were excluded from the plot and regression.) The slope of the regression line was steepest with no BGM and the slopes were gentler with higher BGM volume levels. This result seems natural as talking was the main sound with *no* BGM and the BGM was the more dominant higher volume contribution. The contribution from the number of customers (r^2) was small with *no* BGM and *mid*-level BGM. The former seemed also natural because the AC noise affected L_{Aeq}. The reason for the latter was probably because the peak in the number of customers was lower than those for Days 2 and 4, and therefore the rise in noise level by the customers was less obvious.

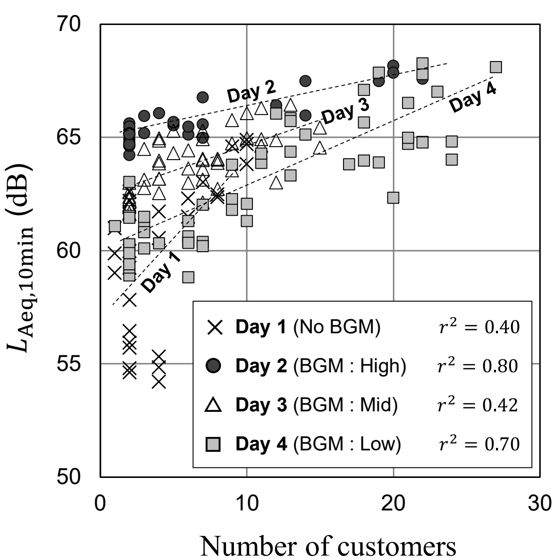

Figure 4. Noise level vs. number of customers

Rindel[3] proposed the acoustical capacity (N_{max}), which is defined as the maximum number of persons in a room in regard to sufficient acoustic quality for verbal communication. N_{max} is calculated from the reverberation time (T) and room volume (V): $N_{max} = V / 20T$, which in this case was 14. The acoustic quality is estimated from the ratio of the actual number of customers to N_{max}. The ratio for this café is 3.0 if all the seats (43) were occupied, and the actual ratio during the experiment was 0.6 on average and 2.0 at its maximum. A ratio < 1 is assessed as being "sufficient." The ambient noise level at the ratio = 0.6 is estimated at 65 dB according to Rindel, this value being rather close to the actual level (Figure 3).

4.2. Overview of subjective evaluation

Results of the evaluations of the eight subjective questions are presented in Figure 5 for each of the BGM volume levels. The number of respondents varied and increased on Day 3 (Sat.) and Day 4 (Sun.) being the weekend (Table 7). In general, negative responses were few, as seen for Q1 as the acoustic field for the café was perceived as comfortable. The response of "lively" in Q2 and some negative responses for Q4, Q7, and Q8 were given for the day with the *high* BGM volume level. The responses to Q8 greatly changed with BGM levels whereas only a few uncomfortable responses were found in Q1, indicating the BGM volume levels were adequate. The feeling of a higher reverberation responses to Q6 correlates with the higher BGM level, indicating that the customer tended to evaluate not the room reverberation but the volume of sound in the space.

In regard to the questions related to conversation, negative answers to Q3—ease of conversation—were fewer with *low* and *mid* BGM levels than with *no* or *high* BGM levels. Responses of "moderately bothered" to Q5, related to speech privacy, were fewest with *mid* BGM levels and increased with *high*, *low*, and *no* BGM levels in that order. The responses to Q7, related to speech intelligibility, showed a different trend in that there was no negative responses to the absence of BGM. Indeed, the number of negative responses increased

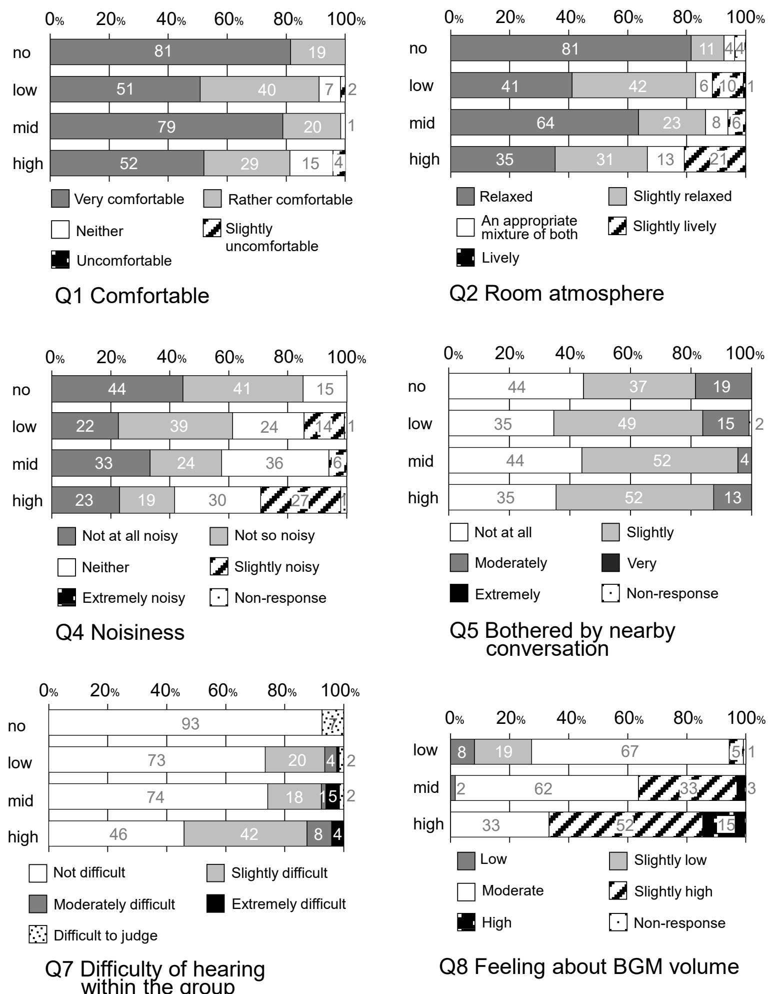

Figure 5. Results of subjective evaluation

with BGM volume level. On the whole, these result implied that a comfortable environment for conversation may include both intelligibility and privacy of speech.

4.3. Perceived BGM volume levels at each table

We examine next the correspondence between the measured BGM level (Table 4), and the mean value of evaluation of Q8—"feeling about BGM volume"—at each table (Figure 6). In this scatter plot, shading of the symbols denote the three groups of tables grouped by their distance from the loudspeaker (Figure 2). The circles, squares, and triangles signify the results for *high*, *mid*, and *low* BGM volume levels, respectively.

A positive correlation ($p<0.05$) was seen at tables A–C, close to the loudspeakers (less than 4 m away), whereas almost no correlation appears for the other tables. This result may be interpreted as indicating that only the respondents close to the loudspeakers were able to evaluate the relative BGM volume levels

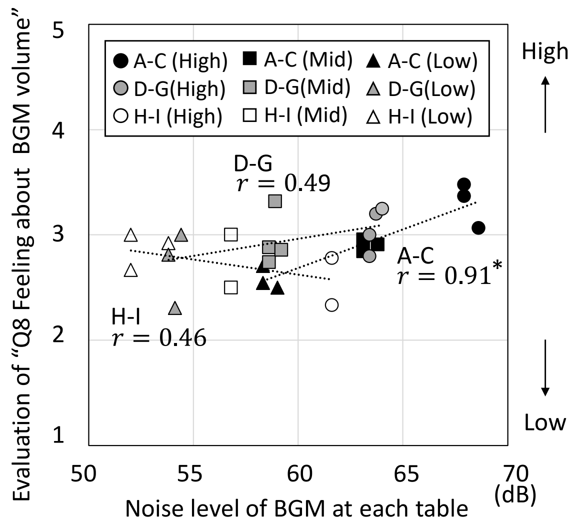

Figure 6. BGM volume level for each group of tables vs evaluation of the "feeling about BGM volume."

because they could directly see the loudspeakers and hear the BGM, whereas the other respondents evaluated the BGM without such references.

4.4. ANOVA of the subjective evaluation

An analysis of variance (ANOVA) was conducted as a preliminary analysis to examine which factors affected the subjective evaluations. The explanatory variables were: 1) BGM volume level (4 levels: *no*, *low*, *mid*, *high*); 2) respondents' personal characteristics of gender (2 levels) and age group (3 levels: younger than 35, 35–54, and older than 54); and the occupancy of the neighboring table (2 levels: "unoccupied" if no one was seated at any of the adjacent tables and "occupied" otherwise).

A Shapiro–Wilk normality test was performed on the subjective evaluations, and normality of all the variables was denied. Nevertheless, we decided that this ANOVA was effective because the ANOVA is known to be rather robust against deviations from a normal

Table 8. Results of the ANOVA

Factor	Q1 Comfort	Q2 Room atmosphere	Q3 Ease of conversation	Q4 Noisiness	Q5 Bothered by nearby conversation	Q6 Room reverberation	Q7 Difficulty of hearing in the group	Q8 Feeling about BGM volume
BGM	***	***	*	**	n.s.	***	***	***
Gender	*	**	**	*	n.s.	n.s.	n.s.	n.s.
Age	***	n.s.	n.s.	n.s.	*	n.s.	n.s.	n.s.
Occupancy	*	***	n.s.	***	***	n.s.	**	n.s.
BGM × Gender	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
BGM × Age	**	*	n.s.	n.s.	*	*	**	n.s.
BGM × nei. Table	**	n.s.	n.s.	*	n.s.	n.s.	*	n.s.

*:5%, **:1%, n.s.:not significant.

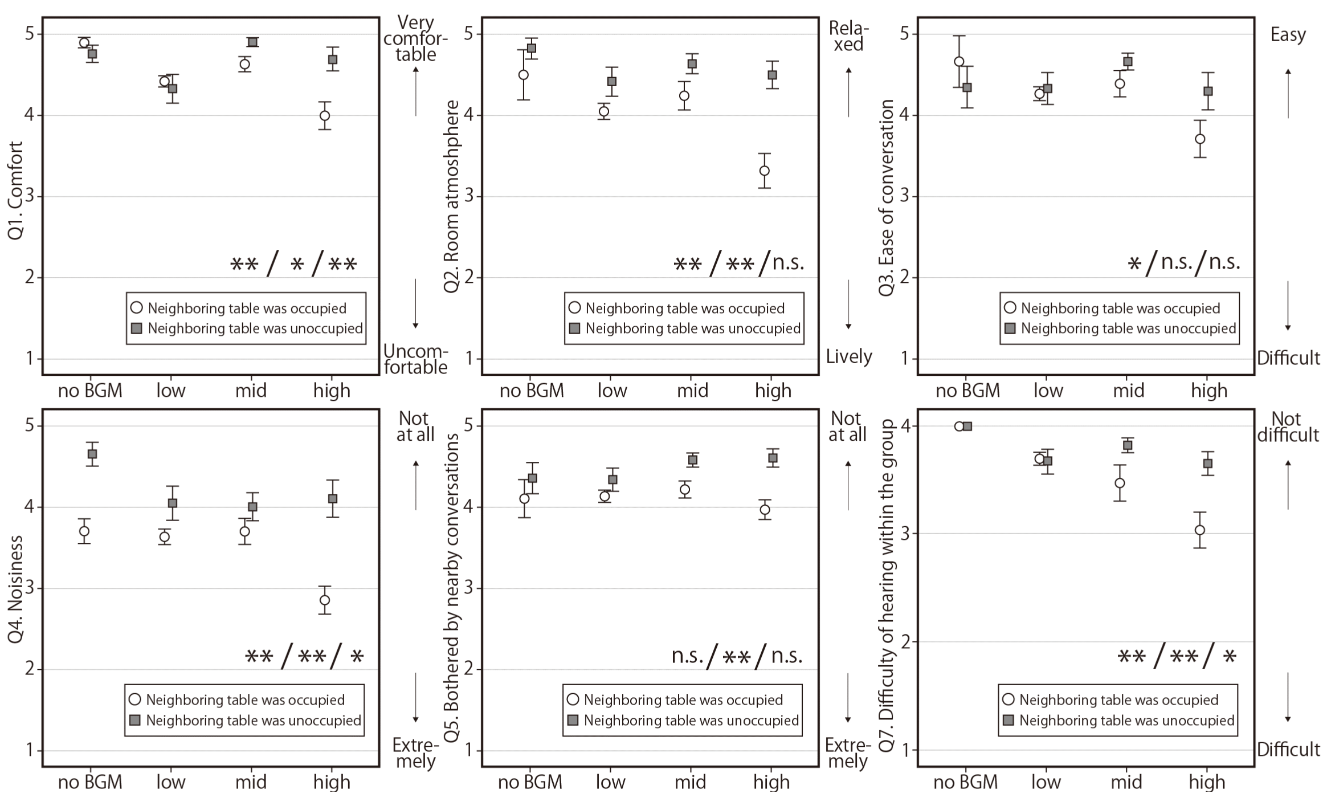

Figure 7. Subjective evaluations of the BGM volume levels and the occupancy of neighboring tables (error bar = SE). The effects of BGM / Occupancy / BGM×Occupancy from the ANOVA of data presented in Table 8 indicated as *: 5%, **: 1%, and n.s.: no significance.

Table 9. Number of respondents in each BGM conditions by the occupancy of neighboring table

	no BGM	*low*	*mid*	*high*
Occupied	10	100	33	28
unoccupied	17	24	33	20

distribution.[7] In addition, the purpose of this analysis was as a preliminary assessment and not only to find statistical significances, as mentioned above.

The results are summarized in Table 8. The BGM volume level affected significantly all the evaluations other than Q5. Other than BGM, the occupancy of neighboring tables determined the evaluation of Q2, Q4, and Q5 and some effect were seen that depended on personal attributes (gender and age). Therefore, the occupancy of neighboring tables was further analyzed (following section). Personal attributes are discussed based on a cluster analysis in Section 5.

4.5. Effects of neighboring-table occupancy on the subjective evaluation

The occupancy of the neighboring table may affect the acoustic comfort of respondents by interfering with intelligibility and privacy of speech, with the BGM level possibly mitigating this effect. Figure 7 shows the mean plots of the subjective evaluations with standard error bars. The results of the ANOVA (based on data in Table 8) are also presented. Here (and later in Figure 8), Q6 and Q8 are omitted because the results of these questions did not reflect the reverberation or the BGM level as mentioned earlier.

As a conclusion, the evaluation tended to be negative concerning the occupancy of the neighboring table, in general, with a significant difference (p<5%) in the evaluations other than Q3. The difference in the evaluation on occupancy tended to be wide with *high* BGM volume levels with a significant interaction of BGM and occupancy in the evaluations of Q1, Q4, and Q7, indicating that the respondents felt uncomfortable and uneasy when conversing, and had difficulty hearing within the group with the *high* BGM level when a neighboring table was occupied. Presumably, the BGM would mask surrounding sounds and, therefore, the conversation from other tables were expected to become less bothering with the *high* BGM level. However, the results were contradictory as the evaluations were particularly negative with the *high* BGM level. This may mean that BGM had not masked the conversations at neighboring tables so the mixture of *high* BGM and conversations of neighbors may have disturbed the respondents. If so, this situation may be mitigated by wider intervals between tables and a more suitable BGM level.

4.6. Customer clustering

A correlation matrix for items relevant to the subjective evaluations is shown in Table 10. Seven items other than Q8 were correlated at r = 0.3–0.5. To

Table 10. Correlation matrix for the items in the questionnaire and factor loadings

Item	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Q1 Comfort								
Q2 Room atmosphere	0.52							
Q3 Ease of conversation	0.41	0.52						
Q4 Noisiness	0.44	0.59	0.40					
Q5 Bothered by nearby conversations	-0.41	-0.39	-0.40	-0.49				
Q6 Room reverberation	-0.36	-0.35	-0.37	-0.39	0.34			
Q7 Difficulty of hearing within the group	-0.33	-0.30	-0.45	-0.36	0.31	0.34		
Q8 Feeling about BGM volume	-0.08	-0.13	-0.11	-0.16	0.00	0.30	0.19	

Item	F1	F2
Q2 Atmosphere	**0.83**	0.16
Q4 Noisiness	**0.76**	0.24
Q1 Comfort	**0.71**	0.24
Q5 Bothered	**0.65**	0.25
Q7 Hearing	0.13	**0.86**
Q6 Reverberant	0.28	**0.66**
Q3 Conversation	**0.51**	**0.54**
Contribution	36%	24%

Table 11. Percentage of respondents for each factor obtained using clusters

Cluster	Gender		Age			Location			BGM level				Occupancy		Total number
	M	F	≤34	35-54	55≤	A-C	D-G	H-I	*no*	*Low*	*Mid*	*high*	Occ.	Unoc.	
C1	51%	49%	36%	25%	39%	42%	42%	15%	6%	60%	16%	18%	82%	18%	85
C2	47%	53%	39%	23%	39%	61%	30%	9%	4%	35%	33%	28%	61%	39%	57
C3	32%	68%	46%	26%	28%	29%	57%	14%	16%	43%	28%	13%	53%	47%	120
Total	41%	59%	41%	25%	34%	40%	46%	13%	10%	47%	25%	18%	65%	35%	262

Table 12. Results of the ANOVA exclusively for C3

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
BGM	**	*	n.s.	**	**	**	**	**
Cluster(C1,C2)	**	**	n.s.	**	*	**	**	n.s.
BGM×Cluster	n.s.	n.s.	n.s.	n.s.	n.s.	*	n.s.	*

*: 5%, **: 1%, and n.s.: no significance.

classify the items, a factor analysis was performed for these seven items, with Q8 being regarded naturally as a single independent item affected by simply the BGM level. The first three factors were extracted with eigenvalues of for example 3.41, 0.81, and 0.70, respectively. Therefore, we made a varimax rotation for the top two factors. The resultant factor loadings are presented in Table 10. The first factor was interpreted as related to the comfortableness or noisiness, which is highly correlated with Q2: "room atmosphere (lively/ relaxed)," Q1: "comfort," and Q5: "bothered by nearby conversations." The second factor was interpreted as related to speech intelligibility, showing high correlations with Q7: "difficulty of hearing within the group" and Q6: "room reverberant."

To elicit patterns in the evaluation tendencies of respondents, a *k*-means cluster analysis (k=3) was applied using the two factor scores of each respondent as a Euclidean distance. From the cluster profile (Table 11), C1 had relatively many respondents having either a neighboring table occupied or registering *low* BGM, C2 had relatively many respondents close to the loudspeakers or experiencing *high* or *mid* BGM levels, and the respondents of C3 were relatively young females at tables far from the loudspeakers.

Figure 8 presents mean plots of the subjective evaluations with standard error bars. An ANOVA was performed with the cluster and the BGM level as explanatory variables; the result is summarized in Table 12 and also graphed in Figure 8. In this ANOVA, the data of C3 was excluded because their evaluation (which was also statistically tested) was obviously different from the other two groups to be discussed below.

Regarding the evaluation trends, respondents of C3 answered very positively to every question. Female or young respondents far from the loudspeakers seemed to be satisfied with the atmosphere of the café. In contrast, from the responses to Q2 and Q4, C1 indicates the room atmosphere as lively and noisy whereas from the Q7 responses, C2 indicates that conversations were difficult to hear. Nevertheless, the evaluation of C1 was affected by the occupancy of neighboring tables and that of C2 was affected by the BGM level. The responses of C2 to Q3—"Ease of conversation"—were negative in the absence of BGM, implying that some customers might not have preferred a quiet situation when making conversation. However, there were only two respondents in this situation and is therefore not considered a decisive result. Through customer clustering, the effects of acoustic factors (loudspeaker location and neighboring table occupancy) and personal factors (gender and age) were roughly observed.

5. Conclusions

For this study, a field experiment was conducted in an actual café with different BGM volume levels. The subjective evaluations of customers regarding aspects particularly addressing comfort in conversation in a MGCS were investigated in relation to acoustic conditions and the seating location of customers.

The results are summarized as follows:

1) The respondents, in general, evaluated the café space positively overall and most of the few negative evaluations were related to *high* BGM volume levels

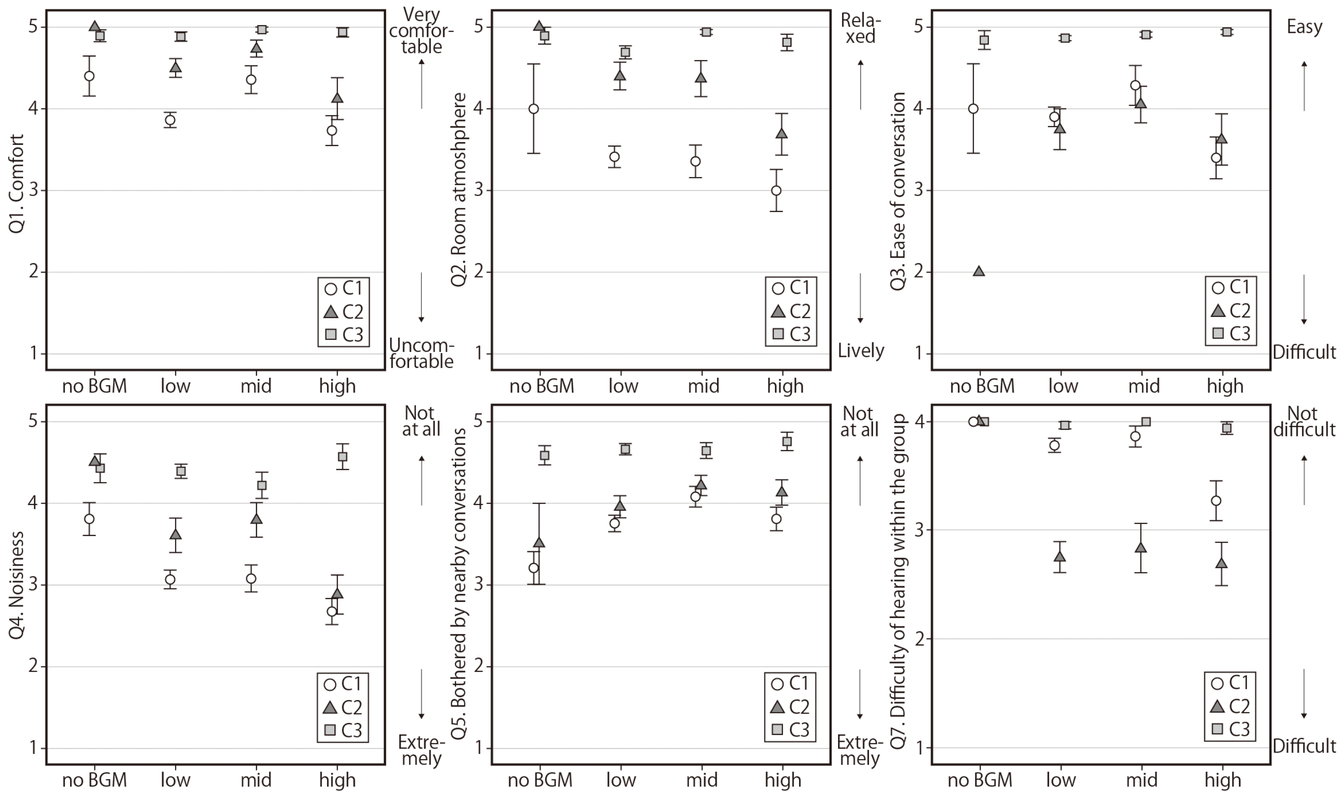

Figure 8. Subjective evaluations by BGM condition and respondent cluster (error bar = SE).

2) *High* BGM volume and occupancy of neighboring tables tended to affect the evaluations negatively, reporting uncomfortableness, unease in conversing, and difficulty hearing the conversation within the group.
3) With regards to customer clustering, various influences on the subjective evaluation of loudspeaker location, neighboring table occupancy, and personal characteristics were identified.

This study is among the first trials with investigations in an actual MGCS and the results are not decisive nor conclusive due to the limited control over the conditions in the café setting. Nevertheless, the results suggested some optimum conditions, such as an adequate BGM volume level and distance between tables, for easy and comfortable conversations to take place in a MGCS. Further investigations should be undertaken.

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