Evaluation of Acoustical Environments in Eating Establishments

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The acoustical environments, and the acoustical conditions to which customers and workers are exposed, were evaluated in ten existing eating establishments. The perceived quality of the EE acoustical environments for customers and employees, and how respondent-related factors and the EE acoustical characteristics affect it, were investigated. These objectives were achieved by way of physical and acoustical measurements, and customer and employee questionnaires and their statistical analysis. Summary statistics, and the results of correlation and stratification analyses of the data, are reported and interpreted. A simple regression model for the reduction of customer enjoyment of the dining experience is presented. Lessons learned for EE design are discussed.

1. INTRODUCTION

Eating establishments (EEs—restaurants, bistros, cafeterias, seniors'-home dining rooms, etc.) are places where customers go to eat, but also for business, talking, reading, socializing, celebrating, etc. The employees, on the other hand, go there to work and earn a living.

The quality of the acoustical environment in an EE is an important factor that directly influences the health and well-being of workers and customers, the quality of the eating experience, and the reputation and commercial viability of the EE. EEs vary considerably in size, shape and acoustical characteristics. Customers and employees are all different (male, female, young, old, normal-hearing, hearing-impaired). Some people enjoy noisy environments, others hate them. Some activities may be enhanced by noise, others impaired. Many activities in an eating establishment involve talking and listening (i.e. verbal communication). Who has not dined in an EE that is so noisy that customers have to shout to communicate with friends and waiters? Excessive noise can bother customers who go to EEs with the expectation of being in a quiet area for reading and thinking, and who can't concentrate. People who are particularly 'acoustically-challenged' (the elderly, hearing-impaired and those using a second language) are seriously disadvantaged in noisy environments, which may be effectively inaccessible to them.

The acoustical environment is determined by the physical and acoustical characteristics of the EE, the strengths and locations of the noise sources, and the density, layout and demographic characteristics, etc., of the occupants. It is seldom considered in the design of eating establishments, and few studies have considered EE acoustical environments and their impacts on workers and customers. It is known that speech communication becomes more difficult in the presence of other speech. This phenomenon, called the 'Cocktail Party Effect', can be formulated as, 'How do we recognize what one person is saying (the speech signal to be heard) when others are speaking at the same time (the background noise)?' [1]. It is affected by the relative levels of the speech and the background noise, and the resulting signal-to-noise level difference. These depend on the EE seating density and

occupancy, the acoustical characteristics, the sources of noise, and talker voice levels. When there is a high density of people, noise levels are high and customers raise their voices to be heard over the noise (the 'Lombard effect') [2]. Customers raising their voices results in higher background-noise levels. A lower signal-to-noise level difference causes poorer speech intelligibility; however, it ensures higher speech privacy—customers do not feel that their conversation is being overheard at other tables. Customers and workers may have different expectations of the EE environment.

As for the EE employees, too much noise can affect their health and safety. Workers who work lengthy shifts with minimal breaks might be subjected to noise exposures that exceed levels permitted by applicable occupational-noise regulations. They may also experience fatigue, stress and voice problems, and could suffer hearing impairment and time away from work. Inability to communicate well or hear warning signals from colleagues or equipment may put staff in danger. Occupational noise is commonly measured in terms of the A-weighted, equivalent-continuous sound-pressure level over a daily work shift, $L_{eq,shift}$. Occupational-noise regulations specify maximum permissible noise exposures in term of L_{ex}, the corresponding 8-hour equivalent-continuous level, calculated as $L_{ex} = L_{eq,shift} + 10 \log t/8$, where t is the shift length in hours. For example, based on guidelines for occupational health and safety issued by WorkSafe BC [3], the jurisdiction in which the employees in the study EEs worked, the daily noise exposure of workers should not exceed $L_{ex,WCB} = 85$ dBA.

In summary, many complex factors determine what constitutes the optimal acoustical environment in an EE. A non-optimal acoustical environment can negatively impact the work and dining experience. Customers may be bothered by noise, and may suffer detrimental psychological and health effects like stress and voice strain. Verbal communication between customers and staff may be difficult. Workers may suffer fatigue, stress, voice strain and hearing impairment. Noisy conditions in eating areas can even reduce appreciation for the food [4]. However, a noisy environment ensures speech-communication privacy and gives a 'dynamic ambiance'.

The acoustical design of rooms often involves optimizing speech-transmission performance, since speech communication is a basic function of public spaces such as EEs. Speech communication in EEs can be a difficult matter, since conversation at the tables becomes difficult due to high noise levels but, on the other hand, speech privacy is not ensured with low noise levels. The intelligibility of speech in rooms is influenced by both the signal-to-noise level difference and the amount of reverberation in the room.

The objectives of this study were to evaluate the acoustical environments, and thus the acoustical conditions to which customers and workers are exposed, in existing eating establishments. It was to investigate how the perceived quality of the EE acoustical environment—and the optimum EE acoustical characteristics—vary between workers and customers, and how respondent-related modifying factors affect it. It was to investigate the relationship between respondent perceptions of quality and the acoustical characteristics of the EE. These objectives were achieved by way of acoustical-parameter measurements, and by questionnaires and their statistical analysis.

2. LITERATURE REVIEW

Concern about poor acoustical conditions in eating establishments has

led to a number of initiatives around the world. Moulder [5] conducted a program to develop guidelines for restaurants and cafeterias, to provide quiet areas for hearing-impaired individuals. Measured noise levels in the restaurants surveyed ranged from 55 to 68 dBA. White [6] investigated the appropriate acoustical environment for an enjoyable meal. She performed acoustical measurements in five eating establishments, finding unoccupied background-noise levels that varied between 41 and 66 dBA, and occupied levels from 66 to 83 dBA with between 10 and 94 customers. Astolfi and Filippi [7] studied the optimal acoustical conditions in pizzerias. They used a speech source at a typical seating position 1 m in front of a receiver to study speech intelligibility and privacy. Acceptable values could be achieved only by decreasing the seating density—the number of seats divided by the floor area—from 1 to 0.2 seat/m. With 'normal' voice level and a noise level of 72.6 dBA, speech intelligibility was poor. A 'raised' voice level gave improved intelligibility, but inadequate speech privacy, with a distance of 1.5 m between the tables. Kang [8] studied the basic characteristics of speech intelligibility in dining spaces and how these can be optimized by architectural design. He used a radiosity model, and talkers with constant output levels, to model EEs. Christie [9] studied objective measures, and their ability to predict a subjectively-acceptable acoustical environment in bars, cafes, and restaurants. She found that eating establishments were too loud and 'undesirable,' due to excessive background-noise levels which were, on average, 57 dBA in bars, 65 dBA in restaurants, and 58 dBA in cafes.

3. EE CHARACTERISTICS

Ten typical eating establishments of four different types—restaurants, bistros, cafeterias and seniors'-home dining rooms—on and off of the University of British Columbia (UBC) campus—were studied. They were chosen on the basis of convenient location, access through existing contacts, their physical characteristics and customer demographics. Table 1 shows the main physical and acoustical characteristics of the ten EEs. Their volumes varied from 176 to 1176 m^3, with surface areas varying from 202 to 876 m^2, and floor areas from 30 to 294 m^2. The volume-to-surface-area ratios varied from 0.84 to 1.34 m. The number of seats varied from 40 to 126. The seating density varied from 0.4 to 1.3 seat/m^2. The eating establishments included two different areas in the UBC student cafeteria (C1 and C2). In both, the floor was carpeted; in C1, the ceiling was covered with acoustical tiles, whereas C2 had an unfinished ceiling with exposed wooden beams. Bistros B1 and B2, which serve UBC student and faculty customers, had large windows, and hard floors and ceilings without any acoustical treatment. The tables were metal with thick tablecloths, the chairs were metal with wooden seats. Bistro B3 had indoor and outdoor areas with very different acoustical environments. The indoor area was surrounded by large windows and contained wooden chairs and tables, and an open kitchen area which had a noisy ventilation fan and loud music. The outdoor area is partially enclosed by glass and concrete walls, had no roof and had loud music. Three restaurants on and off campus were enlisted to include a different clientèle. The majority of the wall area of restaurant R1 consisted of windows; the ceiling and floor were hard. The furnishings were also hard, with marble-topped tables and wooden chairs. Restaurant R2 had more acoustical treatment, with carpeted floor and some suspended drapes on the ceiling. The furnishings were wooden tables with padded chairs. Restaurant

R3, which served UBC faculty customers, had a ceiling covered with areas of acoustical tiles concealed behind large white drapes. The walls comprised large windows and painted drywall. The floor was wooden in the main area; however, there were some areas with carpeted floors. The tables were wooden with thick tablecloths, the chairs wooden with padded seats. Finally, the dining rooms in two seniors' homes, S1 and S2, were enlisted to involve more elderly, possibly hearing-impaired customers. Both dining rooms had carpeted floors. The ceiling in S1 was covered with acoustical tiles; in S2 it was of painted drywall. In S1, tables were wooden with upholstered chairs; the furnishings in S2 were wooden chairs and tables.

4. PHYSICAL MEASUREMENTS

4.1. PROCEDURES

In each EE, reverberation-time and noise-level measurements were made to characterize the acoustical environment, as follows:

- Reverberation time: reverberation times were measured in the unoccupied EE. Measurements of the impulse responses between various source and receiver positions were made using the MLSSA system, involving generating noise bursts fed to an amplifier and omnidirectional-loudspeaker system. Octave-band reverberation times based on 20 dB of sound decay were recorded from 125 to 8000 Hz at six different locations in each EE. The mid-frequency value $T_{mid,unocc}$ was calculated by averaging the 500-, 1000-, and 2000-Hz octave bands most relevant to verbal communication. In addition, diffuse-field theory was used to calculated average surface-absorption coefficients α_{av} from the average octave-band reverberation time and the EE dimensions. Of course, occupant absorption decreases the reverberation time.
- **Occupied noise levels:** A RION NA-29E sound-level meter was used to measure 31.5- to 8000-Hz octave-band, and total, A-weighted, background-noise levels $L_{eq,unocc}$ in the unoccupied EE (i.e., mainly due to ventilation-system and equipment noise, and music). Larson-Davis 700 noise dosimeters, usually hung from the ceiling in the centre of the EE, were used to monitor total, A-weighted noise levels in the occupied EE throughout one day of normal operation (the 'time history'). They measured noise due to customer and staff activity

Table I: Main physical and acoustical characteristics of the EEs.

	B1	B2	B3	R1	R2	R3	C1	C2	S1	S2
Volume (m^3)	692	384	333	176	180	960	619	412	1176	297
Surface area (m^2)	599	314	393	202	215	812	584	424	876	315
Floor area (m^2)	69.5	47	85	30	65	240	221	147	294	99
Volume/surface area (m)	1.16	1.22	0.85	0.87	0.84	1.18	1.06	0.97	1.34	0.94
Number of seats	72	46	70	40	54	126	120	100	106	56
Seat density ($1/m^2$)	1.0	1.0	0.8	1.3	0.8	0.5	0.5	0.7	0.4	0.6
$T_{mid,unocc}$ (s)	1.5	1.2	0.9	0.9	0.5	0.8	0.5	1.0	0.8	0.5
α_{av}	0.23	0.22	0.16	0.18	0.35	0.24	0.34	0.19	0.29	0.30
$L_{eq,unocc}$ (dBA)	51.5	60.0	61.5	53.3	57.4	54.7	42.9	55.1	49.1	55.2
$L_{eq,occ}$ (dBA)	67.1	69.0	74.5	70.3	70.4	69.2	69.8	70.4	59.4	55.3

and 'physical' noise sources, and indicate typical noise levels to which customers and employees were exposed. Equivalent continuous levels $L_{eq,occ}$ were calculated from the time histories.

- Employee noise exposures: Noise dosimeters monitored full-shift noise exposures of sixteen employees in different job categories who volunteered to be involved. Total, A-weighted noise levels in the workers' hearing zone were monitored using Larson-Davis 700 noise dosimeters, using sampling parameters relevant to the prevailing occupational-noise regulations (criterion level = 85 dBA, threshold level = 80 dBA, exchange rate = 3 dBA, time constant = 'slow') [3]. The dosimeter recorded equivalent-continuous ('average') noise levels every 60 s, from which full-shift values $L_{eq,shift}$ were calculated. Daily, 8-hour noise exposures (L_{ex}) were calculated from the full-shift values and daily shift lengths, for comparison with the maximum acceptable level ($L_{ex,WCB}$ = 85 dBA) specified by the local occupational-noise regulations [3].

4.2. RESULTS

Table 1 summarizes the main acoustical measurement results. $T_{mid,unocc}$ varied from 0.5 to 1.5 s (average = 0.81 s; lowest in R2 and S2, highest in B1). Average surface-absorption coefficients α_{av} varied from 0.16 to 0.35 (average = 0.23, lowest in B3/in, highest in R2 and C1). $L_{eq,unocc}$ varied from 42.9 to 61.5 dBA (average = 53.4 dBA, lowest in C1, highest in B2, B3/in). $L_{eq,occ}$ varied from 55.3 to 74.5 dBA (average = 68.7 dBA, lowest in S1 and S2, highest in B3/in).

Table 2 summarizes the employee noise-monitoring results. It shows the job title, shift lengths, measured Leq,shift values and corresponding daily 8-hour noise exposures L_{ex}. $L_{eq,shift}$ varied from 61.7 to 83.7 dBA. L_{ex} varied from 59.7 to 83.7 dBA, with

Table 2: Employee job titles, shift lengths, measured average full-shift noise levels, $L_{eq,shift}$, and daily noise exposures, L_{ex}.

Eating Establishment	Job title	Shift length (hours)	$L_{eq,shift}$ (dBA)	L_{ex} (dBA)
B1	Cashier	4.5	73.5	71.0
	Cook	7.5	80.8	80.7
B2	Cashier	6.5	70.5	69.5
B3	Cook	7.5	83.6	83.4
	Cashier	4.0	86.7	83.7
R1	Cook	6.0	76.4	75.1
	Waitress	7.0	76.5	76.5
R2	Cook	3.5	75.4	72.4
	Waiter	4.0	75.8	72.8
R3	Cook	6.5	79.9	78.9
	Waitress	4.0	80.0	77.0
C1/2	Janitor	3.5	83.0	79.4
	Cook	6.5	76.0	75.0
S1	Server	5.0	61.7	59.7
	Server	5.5	81.4	79.0
S2	Server	7.0	71.4	70.9
	Minimum	**3.5**	**61.7**	**59.7**
	Maximum	**7.5**	**86.7**	**83.7**
	Average	**5.4**	**77.0**	**75.3**
	Standard deviation	**1.0**	**6.0**	**6.0**

an average of 75.3 dBA. The server in seniors' home S1 who worked the morning shift had the lowest exposure; the cook and cashier in B3 had the highest exposures. The noise exposures of the employees in the bistros, restaurants and cafeteria were, on average, 7 dBA higher than in the seniors' homes.

5. QUESTIONNAIRE SURVEY

5.1 METHODOLOGY

Questionnaires were developed to determine EE-occupant perceptions of the acoustical environments, the factors that might affect them and how they are correlated. Two different versions of the questionnaire (for customers and employees) were developed. They both comprised two major parts—respondent-related questions and an acoustical evaluation of the eating establishment. The respondent-correlated questions solicited information about the respondent (age, sex, English first language, hearing status, the number of people in their party, the reason for visit, music and noise preferences, seat preferences, etc.). The acoustical-evaluation questions asked respondents about the perceived quality of the acoustical environment of the EE, about annoyance due to sources of noise (e.g. people talking or moving, cell phones, the ventilation system, clinking sounds, music, reverberation, etc.), about detrimental psychological and health effects (e.g. reduced enjoyment, broken concentration, fatigue, stress, tinnitus, voice strain, etc.), and about ease of verbal communication and privacy. At the end of the questionnaire, they were asked for their comments on acoustical improvements to the establishment, and on any other important issues they wished to comment on. The questions asked, and the associated response categories, are presented in the Appendix. Note that questions relate to both the incidence and amount of effects, and that hearing impairment is self-reported, not measured.

For questionnaire administration, customers were recruited via posters placed in each establishment, or were asked by the EE employees to participate in the study. Questionnaires were taken by customers from a designated place on the reception/cashier desk, or were given to the customers by the EE employees. With the help of the EE manager, employees were asked to complete the questionnaire on the study day. Completed customer and employee questionnaires were checked for completeness. Questionnaires with more than ten missing responses were rejected; in the case of the 12 questionnaires with between one and ten missing responses, missing responses were replaced with the average response to the question concerned on the other questionnaires. The total number of questionnaires analyzed was 185. Questionnaire responses were coded numerically for use in statistical analysis.

5.2 RESULTS

In this section the questionnaire responses are discussed. Results are generally presented individually for each EE; however, in many cases average results for the bistros, restaurants and cafeteria—these will be referred to as 'eateries' (thus, Av_Eat)—and for the seniors' homes (Av_SH) are also presented separately.

5.2.1 Customer questionnaire

The number of completed questionnaires returned by customers in each EE varied from 6 in S2 to 26 in C1, with an average of 17. Thus the statistical power is not high. In this section, average responses are discussed, as well as their ranges, in part to identify the characteristics associated with the best and worst EEs.

Customers were asked about their personal characteristics such as sex, age, if English is their first language, eating-environment preference and hearing status. 58% of the customers in all of the eateries were female (94% in C2, 35% in B1 and B3/out); in seniors' homes, there were approximately equal numbers of males and females. The majority of the customers were between 20 and 30 years old. The youngest customers (average age around 21) were in C1 and C2, the two university cafeterias. The next youngest (average age 25 to 30) were in B2 and B3, two university bistros. In B1 customers were typically between 25 and 30 years old. Customers in the three restaurants on and off campus had average ages between 45 and 55. No customers older than 75 years old completed questionnaires in the eateries; however, the average age of the customers in seniors' homes was over 80.

Customers were asked whether English was their first language. On average, 73% of customers in the EEs had English as their first language, with less than average in B1, B2, C1 and C2 (with a minimum of 31% in C2), and more than average in B3, the restaurants and seniors' homes (with a maximum of 95% in R3); on average, 95% of the customers in the seniors' homes had English as their first language. Only a small number of customers reported a hearing impairment in the eateries (the highest proportion was 21% in R3, with its older clientèle); in the seniors' homes, on average, 45% of the respondents reported a hearing impairment. However, on average they reported that the severity of their hearing-impairment wasn't greater than 'moderate'. In seniors' homes, on average 33% of customers wore a hearing aid; no hearing-aid use was reported in eateries.

Customers were asked to indicate the reason(s) for their visit to the EEs, and how well the sound environment met their expectations of an ideal environment with respect to each reason. As expected, the most common reason for visiting was *eating/drinking* (85% on average, but 100% in S1, and only 37% in R3), followed by talking (65% on average, but 90-100% in C1 and C2, and only 35-50% in B3/in and the restaurants), and *relaxing* (54% on average, over 80% in R2 and C2, but only 21% in R3, and none in S2). The least-reported reasons for visiting the EE were to hold a *business meeting* (21% on average—much less in the university bistros and cafeterias, much more in R3, the university faculty restaurant) and *celebrating* (much less in B3 and R3). Not surprisingly, a greater proportion of customers in senior's home than in eateries visited the EE for *eating/drinking, talking and celebrating*, but a lower proportion visited for *business meetings, studying/working and relaxing*.

Customers were asked about their preference of having their meal in a noisy or quiet environment. On average, more than 58% of customers in EEs prefer to dine in a quiet environment, for more than 38% of the customers it doesn't matter, and just 4% of respondents preferred to have their meals in a noisy environment. A quiet environment was especially preferred in the restaurants and seniors' homes; in seniors' homes no-one preferred to have their meal in a noisy environment. Customers were asked whether or not they would prefer to have music with their meal. Customers in B3/out, C2 and S2 mainly preferred having music. In R2, R3 (a quality restaurant), C1 (with many customers there for *talking*, and S1 (a seniors' home), customers mainly preferred not having music. On average, respondents in the eateries preferred music more than in seniors' homes. Even customers in B3/out who preferred to have music with their meal didn't want it to be played at louder than 'moderate' level. On average,

customers in R3 who preferred music with their meal, preferred it to be played at below 'low' level. Customers were asked whether they preferred a particular seat location because of noise concerns. Generally they did not, except in B3/in (apparently because of the noisy HVAC system and loud music from loudspeakers), and in S1 (apparently because of noise breaking out of the kitchen area). More than twice as many customers in senior's homes had seat preferences as in eateries.

Figure 1 shows the customers' reports of how well the acoustical environment of the EE met their expectations with respect to their reason for visit(s). On average, expectations were best met for those customers who visited EEs for *studying/working* and *business meetings* (on average, between 'average' and 'well', but 'very well' in R1, less well in B1, R2 and R3), for *celebration* (on average, 'average', but 'well' in S1, and 'poorly' in B3/out and R2), and less well for those who visited EEs for *eating/drinking* and *relaxing* (on average, between 'poorly' and 'average', but almost 'well' in B3/in, R1 and S2, and less than 'average' in R2, R3 and C2) and for *talking* (on average, a bit better than 'poorly', but 'average' in R1 and S2, between 'very poorly' and 'poorly' in B3/out and R2). The expectations of customers in eateries were met more than in seniors' homes for *business meetings and studying/working*, but less well for other reason for visits.

In the acoustical-evaluation part of the questionnaire, customers were asked to indicate which sources of noise in the EE bothered them during their visit, and how much they were bothered by them. On average, in all eateries, over 80 to 100% of the customers were bothered by all sources of noise, except in R3 (less, 75 to 85%). In seniors' homes, the most customers reported being bothered by *people speaking* (59%), *adjacent-table conversation* (55%) and *clinking sounds* (45%), with other noise sources reported by 5 to 35% of customers.

As shown in Figure 2, on average customers were most bothered by *people speaking* and by *adjacent-table conversation* (on average, a bit more than 'a little', but more in C1 and C2, and less in B3/out). They were bothered a bit less than 'a little' on average by *people moving* (but less in B3 and S1, more in S2), by *cell phones* (much more in B3/in, much less in S1), by *clinking sounds* (much more in R1, much less in B3/out and C2), by *music* (more in B3/in and R1, less in C2 and S2), by *reverberation* (more in R1, not at all in S2), by *HVAC* (more in R3, less in R1), by *kitchen activity* (more in B2 and R1, almost 'not

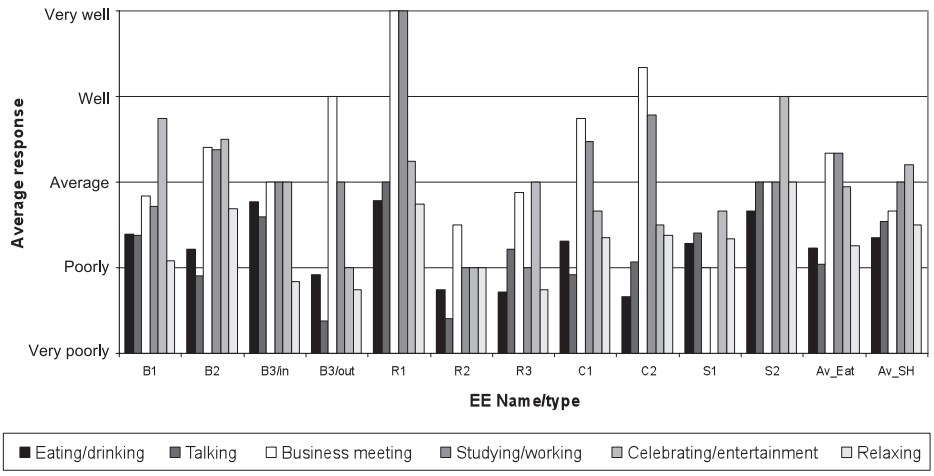

Figure 1. How well the acoustical environment met customer expectations with respect to an ideal environment for each reason for visit.

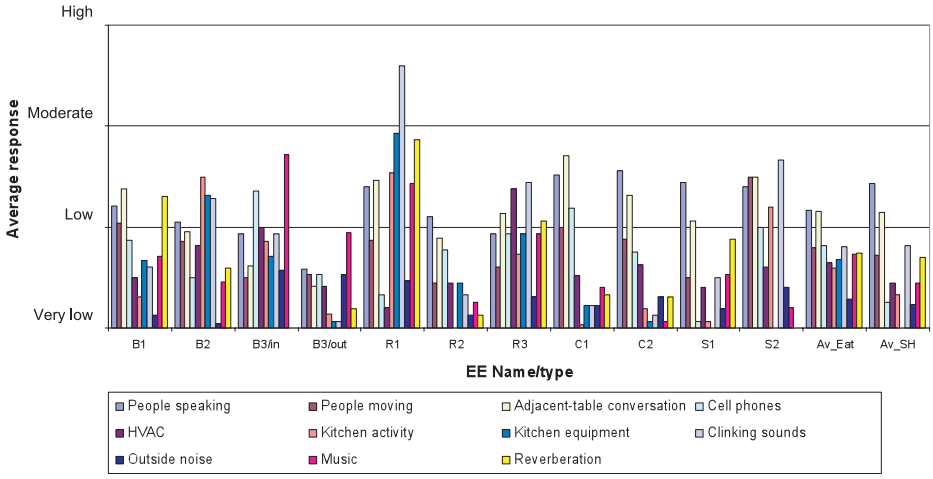

Figure 2. Extent that customers are bothered by different sources of noise in EEs.

at all' in R2, C1 and S1) and by *kitchen equipment* (more in B2 and R1, almost 'not at all' in B3/out, C2, S1 and S2), and least bothered by *outside noise* (on average, a bit more than 'not at all', but more in B3, much less in B2). Customers in eateries were less bothered than in seniors' homes by *people speaking*, equally bothered by *adjacent-table conversation* and *clinking sounds*, and more bothered by the other noise sources (especially *cell phones*).

Customers were asked about the incidence and extent of problems experienced in EEs due to noise while they were dining out. The problems can be divided into three categories: 'psychological' (*reduced enjoyment* and *broken concentration*), 'linguistic' (*difficulty talking with waiter* and *difficulty hearing at the table*), and 'health-related' (*fatigue*, *headache*, *tired voice*). On average, about 90% of the customers in the eateries (except in R3, with only 79-84%) experienced all of the problems; *difficulty hearing at the table* was reported most (94%), *headache* the least (88%). In seniors' homes, *difficulty hearing at the table* was the most reported (64%) problem, followed by *reduced enjoyment* (55%), and *difficulty talking with waiter* and *broken concentration* (both 36%); *headache* was reported least (5%). How much customers experienced problems is shown in Figure 3. The problems experienced to the greatest extent (on average, a bit more than 'a little') were *difficulty hearing at the table* (much less in B3/out, much more in C1 and C2) and *broken concentration* ('not at all' in R2, 'some' in C1). *Reduced enjoyment* was experienced, on average, a bit less than 'a little' (much less in B3/out, much more in B3/in and R1). Experienced on average between 'not at all' and 'a little' were *difficulty talking with waiter* (least in B1, R3, C1, most in B3/in, R1), *tired voice* (less in R2, R3, more in B3/in), *fatigue* ('not at all' in R3, most in B3/in), and *headache*, experienced to the least extent ('not at all' in R2, S1, S2, most in B3/in). On average, customers in eateries experienced *broken concentration*, *difficulty talking with waiter*, *headache* and *fatigue* to a greater extent than in seniors' homes; *tired voices* and *difficulty hearing at the table* were experienced to the same extent, and *reduced enjoyment* less. On average, 'psychological' problems were experienced to a greater extent than 'linguistic' problems, with 'health' problems experienced the least; all types of problems were experienced to a somewhat greater extent in eateries than in senior's homes.

Customers were asked whether, and to what extent, they could overhear adjacent-table conversation, or felt they could be overheard. On average, 98% reported overhearing (least in R3 and

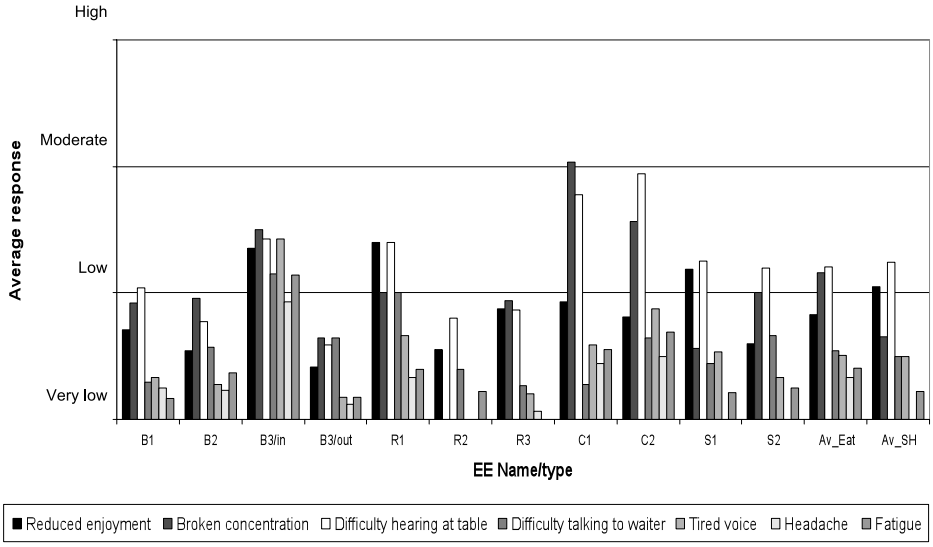

Figure 3. Extent of problems experienced by customers due to EE noise.

S1) and 88% being overheard (least in B3/out and S1, most in C1, S2). On average, overhearing was experienced 'some' (least in B3/out, most in B3/in), being overheard between 'a little' and 'some' (least in S1, most in B3/in). Both were experienced to a greater extent in eateries than in seniors' homes.

5.2.2 Employee questionnaire

A total of 27 completed questionnaires from employees—21 females and 6 males—were analyzed. The number of completed employee questionnaires varied from only 1 in B1 to 6 in R2, with an average of 3, so the statistical significant of the results is low. The job titles of the employees who participated included a manager, supervisor, cashier, waiter/waitress, bartender and cook. Employee ages varied from 21 to 55, with an average of 35 years. The duration of their working experience varied from 0.3 to 19 years. Employees on average worked for 27 hours per week in eateries, and 34 hours per week in seniors' homes. Twenty-six percent of the employees reported that English was not their first language. About 26% of them reported being aware of having a hearing impairment; 14% reported that this was 'moderate', the rest 'mild'. Three of four employees in B2 reported experiencing a hearing problem since they were hired.

Employees were asked about bothersome sources of noise. On average, *kitchen equipment* and *kitchen activities* were the most bothersome sources of noise for employees. *Customer's moving*, *colleagues talking* and *colleagues moving*, *kitchen activities* and *kitchen equipment* bothered about 70% of the employees in the seniors' homes. Since there was no music in the two seniors' homes, and cell phones were not allowed in the dining rooms, there were no complaints about those sources of noise. However, *cell phones* were one of the most bothersome sources of noise for employees in eateries.

Employees were asked to indicate to what extent sources of noise bothered them in the work-place. Employees in seniors' homes were bothered more than in eateries by *customers moving*, and by *colleagues talking* and *colleagues moving*. In general, employees in seniors' homes were more conscious of others and the noise they generate than in eateries. However, in eateries employees were bothered more by *kitchen activities* and *kitchen equipment*.

Employees were asked about problems that they experienced due to the noise in their working area. At least 70% of the employees in eateries had *difficulty talking with colleagues*, and the *need to raise their voices to be heard*. However, in seniors' homes, about 60%

of employees experienced 'health-related' problems such as *tinnitus*, *fatigue* and *headache*, as well as *broken concentration* due to the noise. Because of the noise in the seniors' homes, almost 50% of workers had *difficulty talking with colleagues* and *difficulty talking with customers*. All of these problems were experienced not more than 'some'.

Employees were asked to indicate to what extent they could hear conversations at the tables, and between their colleagues, when they were not part of those conversations. About 83% of the workers in EEs reported that they could overhear conversation at the tables. However, 89% of employees in eateries reported that they could overhear their colleagues' conversations; the proportion in seniors' homes was 83%—however, not more than 'some'.

Employees were asked about the acoustical environment of their working areas and how well their expectations for an ideal work environment were met. On average, employees in EEs found the acoustical environment to be 'average'. However, employees working in the kitchen areas in B2 and R2 found their workplace to be 'very poor' and 'poor', respectively.

Finally, employees were asked to comment on any important issues that may have been missed by the questionnaire. Cooks and prep cooks complained about noisy ventilation that contributed the most to difficulty in conversation, and that masked sound coming from the main eating area. In B3, because of the noisy ventilation, and in spite of the already loud music, the cook commented that she wished the music was played louder!

5.2.3 Customer-questionnaire correlations

To investigate possible relationships between customer responses to different questions, correlation analysis was done. Pearson's correlation coefficients P were calculated between pairs of responses to questions on the customer questionnaires and/or the measured physical and acoustical data, and the apparent implications of correlations inferred, to answer relevant research questions. The objective here was to highlight interesting apparent relationships, not to identify causation. Following are the apparent interpretations of the stronger (generally, $|P|>0.5$) correlations for each research question (see below). Note that nothing was significantly correlated with customer *sex* or *English first language*.

i. *What affects customer enjoyment of the dining experience?*

- Customer enjoyment of the dining experience increases the more expectations are met for *eating/drinking*, *talking* and *relaxing*, as the amount of bother from *people speaking*, *adjacent-table conversation*, *music* and *reverberation* decreases, as the amount of *difficulty talking at the table* and of *difficulty talking with waiters*, of *broken concentration*, *tired voice* and *fatigue* decrease, and with the *wearing of a hearing aid*.

ii. *How do the EE physical and acoustical characteristics affect customers?*

- The higher is the unoccupied noise level, the lower is the number of customers; the higher is the occupied noise level, the lower are the average age of the customers, the number of seniors in the dining party, the incidence of all sources of bother and the incidence of all problems caused by noise; customer responses are not significantly correlated with reverberation time;
- As the EE size and sound absorption increase, and as the seating density decreases, the incidence of bother from *cell phones*, *kitchen equipment*, *kitchen activity* and *outside noise* and, to a lesser extent,

HVAC noise, *clinking sounds* and *music*, and of all problems (especially *headache* and *fatigue*) decrease.

iii. *What is correlated with customer age?*

- Older customers dine with more seniors, and dine in EEs with lower occupied noise levels; older customers report lower incidences of all sources of noise, but the amounts of bother caused by all sources of noise do not vary with customer age;
- Older customers make fewer reports of all problems caused by noise, but the amounts of problems caused by noise do not vary with customer age;
- The incidence and amount of *overhearing* or *being overheard* do not vary with age;
- Older customers report more hearing impairment and more wearing of hearing aids.

iv. *What is related to customer hearing impairment and wearing of hearing aids?*

- Customers with hearing impairment or that wear hearing aids dine with more seniors;
- Customers with more severe hearing impairment prefer quieter music;
- Customers with more severe hearing impairment or that wear hearing aids are more likely to visit EEs for *business meetings* and *celebration*;
- Customers wearing hearing aids are more likely to visit EEs for *celebration*;
- Customer's wearing hearing aids have their expectations met better for *eating/drinking*, *talking* and *celebration*;
- Customers wearing hearing aids more often have a preferred seating location and prefer a seating location because of noise;
- Customers wearing hearing aids report a higher incidence of bother from *outside noise*; customers with more severe hearing loss report more bother from *reverberation*;
- Customers wearing hearing aids report a higher incidence of bother from *adjacent-table conversation* and *clinking sounds*;
- Increased severity of hearing impairment increases the incidence of *difficulty hearing at the table*;
- Wearing a hearing aid increases the incidence of *difficulty hearing at the table* and of *difficulty talking with waiters*;
- Wearing a hearing aid increases the amount of *reduced enjoyment*, *difficulty hearing at the table* and *difficulty talking with waiters*.

v. *How are reasons for visiting EEs related?*

- *Celebration* is associated with *business* and *studying/working* as reasons to visit an EE;
- How much expectations are met for *eating/drinking*, *talking* and *relaxing* are correlated;
- How much expectations are met for *business* and for *studying/working* are correlated;
- How much expectations are met for *studying/working* and for *relaxing* are correlated.

vi. *Are there correlations between the EE activity and the problems customers experience?*

- The more customers expectations are met for *eating/drinking*, the less they suffer *reduced enjoyment*;
- The more customers expectations are met for *talking*, the less they suffer *reduced enjoyment* and *difficulty hearing at the table*;
- Customers who report that they are bothered by *people speaking*, *people moving*, *adjacent-table conversation*, *cell phones*, *kitchen equipment, kitchen activity*, *clinking sounds*, *outside noise* and *music* suffer more *broken concentration*, *tired voice*, *headache* and *fatigue*;

- Customers who are bothered by *music* report more *reduced enjoyment*.

vii. *Are there relations between the sources of noise in EEs?*

- Reports by customers that they are bothered by *people speaking*, *people moving*, *adjacent-table conversation*, *cell phones*, *kitchen equipment*, *kitchen activity*, *clinking sounds*, *outside noise* and *music* are strongly correlated;
- Bother associated with *people speaking*, *people moving* and *adjacent-table conversation* are positively correlated;
- Bother associated with *kitchen equipment*, *kitchen activity* and *clinking sounds* are directly correlated.

viii. *Are there relations between the various consequences of noise (not reduced enjoyment)?*

- The incidences of all problems are directly related;
- The following amounts of problems experienced are positively correlated: *difficulty hearing at the table*, *difficulty talking with waiters*, *broken concentration*, *tired voice* and *fatigue*.

5.2.4 Employee-questionnaire correlations

As was done for the customer questionnaires, correlation analysis was done between the responses to questions on the employee questionnaires and the measured physical and acoustical data, and the apparent implications of stronger (generally, $|P|>0.5$) correlations were inferred, to answer relevant research questions (see below). Following is the discussion for each research question; again, nothing was significantly correlated with employee *sex* or *English first language*.

i. *What affects the perceived quality of the EE as the ideal workplace for employees?*

- The perceived overall quality of EEs for employees decreases with increased *outside noise* and employee *noise exposure*, and increases with *years of hearing impairment*.

ii. *How do the EE physical and acoustical characteristics affect employees?*

- Increased EE size and reverberation time increase the incidence and amount of *difficulty talking with customers* and of *difficulty talking with colleagues*; increased *average occupancy* increases employee *noise exposure*.

iii. *What is correlated with employee age?*

- Older employees report a higher incidence and amount of bother from *cell phones*, and a higher amount of *overhearing of colleagues*.

iv. *What is correlated with employee hearing impairment?*

- Increased *severity of hearing impairment* decreases the incidence and amount of bother from *customer talking*, and decreases the incidence and amount of *difficulty talking with colleagues* and of *difficulty talking with customers*;
- An increased number of *years with hearing impairment* increases the incidence of bother from *customer movement* and *kitchen activity*, the amount of bother from *customer movement*, the incidence of *broken concentration*, the amount of *need to raise voice*, and the perceived quality of the EE as a workplace;
- An increased number of *years with hearing impairment* decreases the amount of *overhearing of customers* and employee *noise exposure*.

v. *How are the sources that bother employees related?*

- The incidence and amount of bother from the following noise sources are positively correlated: *colleague talking* and *colleague movement*, *customer movement*,

colleague movement and *outside noise*, *kitchen activity*, *kitchen equipment* and *HVAC noise*.

vi. *How are the problems employees experience because of sources of noise correlated?*

- The incidence and amount of problems from the following sources are positively correlated: *difficulty talking with colleagues*, *difficulty talking with customers*, *fatigue*, *tinnitus*, *broken concentration*, *frustration*, *need to raise voice* and *headache*.

vii. *Are there correlations between the sources of bother and the problems they cause employees to experience?*

- The following combinations of sources of bother and of problems caused are positively correlated:
  - *customer talking* and *difficulty talking to customers;*
  - *customer movement,* and *headache* and *fatigue;*
  - *colleagues talking* and *broken concentration* and *frustration;*
  - *outside noise* and *headache;*
  - *kitchen activity* and *kitchen equipment*, and *broken concentration*, *frustration* and *tinnitus*.

5.2.5 Stratification analysis

One way to obtain information about the factors explaining customer-questionnaire responses is stratification analysis. EE customer-questionnaire responses were stratified by different factors of interest, then tested statistically to investigate the apparent implications of significant relationships. Responses were stratified by *EE name*, *EE type*, *number in party*, *preference for noise/quiet*, *preference for music*, *how much overhearing*, *how much overheard*, *sex*, *age*, *English first language* and *hearing impairment*, in each case in appropriate categories (see below). For each factor, statistical tests were done to determine which, if any, of the average responses in the various categories were different. First, analysis of variables (ANOVA) was used to determine if *any* of the average responses in the different categories were different. If not, no further tests were done, and it was concluded that the average responses in the different categories are not different. If, however, the responses for at least two of the factor categories were different, Tukey's multiple-comparison test was used to determine for which categories the responses were significantly different. The apparent implications of the significantly different results were then inferred.

For example, it is of interest to see how customer responses vary with customer age. Thus the data were stratified into three *age* categories: ≤ 29, 30-59 and ≥ 60 years. Preliminary analysis showed that at least one pair of average responses was different, so Tukey's test was performed. It showed that, with statistical significance, and for all sources of bother, the least number (35-75%) of customers aged ≤ 29 yr, more (80-92%) of those aged 30-59 yr, and the most (90-100%) of those aged ≥ 60 yr, reported being bothered. Apparently, reports of being bothered by all sources of bother increase with age.

The following discussion, organized by stratification factor, questionnaire topic and individual question, summarizes the main implications of the result of stratifying the customer-questionnaire responses, organized by stratification category. Only results which were statistically significant at $p<0.05$ are discussed. Note that no results were significant for *preference for music*, *how much overhearing*, *how much overheard*, *sex*, *English first language* or *hearing impairment*:

i. *EE name* [categories: B1/ B2/ B3/ R1/ R2/ R3/ C1/ C2/ S1/ S2]

- Reason for visit:
  - *eating/drinking*: customers

report they visit for *eating/drinking* less (40%) in R3 than in the other EEs (75-100%)
- *studying/working*: customers report they visit for *studying/working* 'some' (20-30%) in B1 and B3/in, most (60%) in B2 and C2, and least (0-10%) in the other EEs
- *relaxing*: customers report they visit for *relaxing* the least (20%) in B2 and R3, more (40-60%) in the other EEs, more (80%) in R3, and most (100%) in C2;

- Sources of bother:
  - customers report all sources of bother except *reverberation* the least (0-55%) in S1, much more (65-90%) in R2 and R3, and the most (90-100%) in the other EEs; *reverberation* is reported the least in B3/in;
- How much bother:
  - *kitchen equipment*: customers report they are bothered by *kitchen equipment* 'slightly' in R2, less than 'a little' in B1, B3/in and R3, more than 'a little' in B2, 'some' in R1, and almost 'not at all' in the other EEs
  - *kitchen activity*: customers report they are bothered by *kitchen activity* 'a little' in B3/in, between 'a little' and 'some' in B2 and R1, and 'not at all' in the other EEs
  - *clinking sounds*: customers report they are bothered by *clinking sounds* between 'not at all' and 'a little' in B2, B3/in and R3, 'a lot' in R1 and almost 'not at all' in the other EEs;
- Type of problems:
  - all: customers report all problems the least (0-62%) in S1 (with the least reports for *headache*, *fatigue*, *difficulty talking with waiters*, *tired voice* and *broken concentration*, and the most reports of *reduced enjoyment* and *difficulty hearing at the table*), more (70-90%) in R2 and R3, and most (90-100%) in the other EEs;
- How much are problems experienced:
  - *broken concentration*: customers report no *broken concentration* in R2, almost 'not at all' in S1, between 'not at all' and 'a little' in the other EEs, and 'some' in B3/in and C2.

ii. *EE type* [categories: bistro/ restaurant/ cafeteria/ senior's home]

- Reason for visit:
  - *talking* - customers visit for *talking* least (48%) in restaurants, more (60%) in bistros and seniors' homes, and most (93%) in cafeterias
  - *studying/working* - customers visit for *studying/working* never in seniors' homes, 10% in restaurants, 30% in bistros and much more (60%) in cafeterias
  - *relaxing* - customers visit for *relaxing* least (20%) in seniors' homes, more (50%) in bistros and restaurants, and most (80%) in cafeterias;
- Sources of bother:
  - all: customers report all sources of bother the least (0-55%) in senior's homes, much more (80-90%) in restaurants, and the most (90-100%) in bistros and cafeterias;
- How much bother:
  - *clinking sounds*: customers report negligible bother by *clinking sounds* in cafeterias, between 'none' and 'a little' in bistros and seniors' homes, and between 'a little' and 'some' in restaurants;
- Type of problems:
  - all: customers report all

problems least (0-60%) in seniors' homes, more (85-90%) in restaurants, and most (100%) in bistros and cafeterias;

- How much problems:
  - *broken concentration*: customers report almost no *broken concentration* in seniors' homes, between 'none' and 'a little' in restaurants, 'a little' in bistros, and 'some' in cafeterias.

iii. *Number in party* [categories: 1/ 2/ 3/ 4/ 5/ ≥ 6]

- Reason for visit:
  - *talking*: customers who visit EEs alone report they visit for *talking* much less (30%) than those who visit in groups (70-85%);
  - *business meeting*: customers who visit EEs alone or in a party of four visit least (10%) for *business meeting*; those in parties of two, three or five visit more (20%), and those in parties ≥ 6 visit the most (65%).

iv. *Preference for noise/quiet* [categories: prefer noise/ prefer quiet]

- How much bother:
  - *people speaking*: Customers who prefer noise report less than 'a little' bother; those who prefer quiet report between 'a little' and 'some' bother;
  - *clinking sounds*: Customers who prefer noise report less than 'a little' bother; those who prefer quiet report more than 'a little' bother.

iv. *Age* [categories: ≤ 29/ 30-59/ ≥ 60]

- Reason for visit:
  - *studying/working* - customers aged ≥ 60 yr report they visit EEs for *studying/working* least (8%), those 30-59 yr more (18%), and those ≤ 29 yr most (41%);
- Sources of bother:
  - all - customers aged ≤ 29 report all sources of bother least (35-75%), more (80-92%) if aged 30-59 and most (90-100%) if aged ≥ 60;
- Type of problems:
  - all - customers aged ≥ 60 report all problems the least (45-78%), those 30-59 more (90-92%) and those ≤ 29 most (92-100%).

5.3 REDUCED-ENJOYMENT REGRESSION MODEL

It is clearly of interest to develop models for predicting acoustical quality from the data, as this could potentially be used in EE design. While there is, in principle, considerable potential for developing various prediction models using multivariable regression analysis, highly significant results cannot be expected with such a small amount of data. Thus only one model was developed—for the amount of customer reduced enjoyment of the dining experience, considered as the best overall measure of perceived EE quality by customers.

Based on the customer-questionnaire correlation results, an optimal multivariable, linear-regression model for amount of *reduced enjoyment* was developed from the questionnaire responses and physical-acoustical measurement data. The model was considered optimal when it was realistic and had the minimum number of predictor parameters, all of which were statistically significant ($p<0.05$). Eq. (1) presents this model, which explained 90% of the variance:

amount of reduced enjoyment = - 0.264 (*how well expectations met for talking*)
- 0.136 (*music loudness preference*)
+ 0.102 (*amount of bother from clinking sounds*)

+ 0.245 (*amount of bother from music*)
+ 0.278 (*amount of difficulty talking with waiters*)
+ 0.293 (*amount of difficulty hearing at the table*) (1)

The value of *music loudness preference* in Eq. (1) varies from 0 (very low) to 5 (very high). The values of the other variables vary from 0 (no effect) to 5 (maximum effect).

According to this model, customer enjoyment of an EE visit is increased by improving the acoustical conditions for verbal communication, reducing bother from clinking sounds and music, and is higher for customers who prefer louder music.

5.4 DISCUSSION

This study was not planned with rigorous statistical analysis in mind. Thus the study design is far from optimal, and the statistical significance of the results is low. The ranges of customer and employee demographics, and of EE physical and acoustical characteristics, are not uniformly intermixed. For example, the customers in the bistros and cafeterias tended to be young, female university students with normal hearing, often with English not their first language, and who prefer a noisier environment, visiting the EE with the objective of studying/working. Customers in restaurants and seniors' homes tend to be older, more likely professionals, with English first language, more hearing impairment, and who prefer a quieter environment. A key factor is customer age.

Customers visit EEs for more reasons than just eating/drinking and talking. Many visit for business meetings, studying/working, celebration and relaxing. Customers' reasons for visiting EEs tend to fall into two sets, one of which is eating/drinking, talking and relaxing, the other studying/working, business meetings, celebration and relaxing. How much their expectations are met for the different reasons within each of these two categories are correlated. This suggests that different EE characteristics (and their acoustical environments) are best for the two sets of activities. These two objectives correspond to quieter and noisier activities, respectively, and affect how the acoustical environment affects customers.

Generally EE customers don't enjoy their visit if there is inadequate speech intelligibility between people at their table, and inadequate speech privacy between tables. Lack of speech intelligibility at the table causes customers to suffer broken concentration and tired voices. The likely reason for the tired voices is the need to raise the voice to be heard over the noise (Lombard effect). Customers who reported overhearing, also reported being overheard more. However, people with more hearing impairment reported less overhearing and being overheard.

Customers prefer to dine in a quiet environment with an appropriately low level of music. In EEs with loud sources of noise (kitchen equipment, HVAC, loudspeakers playing music), customers more often choose their seats to avoid them.

Customers preference for a particular seating location apparently indicates a need/desire for better acoustical conditions, and the ability to achieve them (that is, to control the environment), and is associated with greater satisfaction with the EE visit.

Customers suffer various problems due to noise, including reduced enjoyment, difficulty talking and hearing, broken concentration, tired voices, headaches and fatigue. However, they experience these problems not more than 'some'. The most bothersome sources of noise are other people talking, kitchen activities and equipment, and cell phones. Although these sources of noise are bothersome, and impair conversation, they are

usually not experienced more than 'some'. Excessive reverberation is also a problem.

The expectations of hearing-impaired seniors who visit EEs for socializing and relaxing are generally better met than for the normal-hearing. This could be explained as follows: they don't experience sources of noise such as cell phones, kitchen activities and equipment, outside noise and music as much as the normal-hearing customers, and their expectations are for EEs to be somewhat noisy. On the other hand, since they prefer to dine in a quieter place with lower background-noise level, smaller volume and surface area, and with lower average occupancy, they perceived less noise.

For employees, people talking and moving, and kitchen activity and equipment, are the most bothersome sources of noise. These sources of noise cause them to suffer from fatigue, tinnitus and headaches. Cell phones are more bothersome with increasing background-noise level. However, cell phones (ringing or talking) are not a problem for employees that are older and more hearing-impaired. Significant relationships are found between working hours, being more concerned about perceived noise levels in the workplace, and experiencing health problems. The greater is the number of working hours per week, the more employees experienced fatigue, headaches and difficulty talking with colleagues and, consequently, frustration. Hearing-impaired employees report less difficulty talking with colleagues and customers. However, the longer they have been hearing-impaired and the more severe it is, the more they need to raise their voices to be heard, and the more they suffer broken concentration. The severity of hearing impairment can result from a longer period of exposure to the noise. The greater is the background-noise level in the occupied EE, the more employees need to raise their voices to converse.

It is of interest, but not easy, to identify the best and worst EEs in the study. All EEs had some positive and negative attributes (physical or acoustical characteristics, how much expectations were met, bothersome noise sources, problems caused by the acoustical environment, etc.) associated with them. As for the worst EE, all of the EEs had some negative characteristics. B3/in had the most negative characteristics: lowest average surface absorption coefficient, highest unoccupied and occupied noise levels and employee noise exposure, the most customer experience of bother by cell phones, music and outside noise, and the most customer reduced enjoyment, difficulty talking with the waiter, tired voice, fatigue, headache, overhearing and being overheard. However, it also had some positive characteristics: highest expectation met for eating/drinking and relaxing, least bother by people moving, least headache. As for the best EE, all of the EEs had positive characteristics; no one in particular stands out.

In any case, it is clear that the good acoustical design of an EE usually includes the following characteristics: EE not too big or reverberant, not too crowded, quiet or low music, low noise levels, conducive to verbal communication.

6. CONCLUSION

While this study only involved ten EEs, and only a total of 180 questionnaires were analyzed, the results allow interesting insights into the acoustical conditions to which customers and employees are exposed in eating establishments, the effects they have and the factors that affect them. It is clear that many EEs have poor acoustical environments—they are crowded, noisy and not conducive to verbal communication—but may suit

certain reasons for visiting. There is evidence that EEs should be designed for two somewhat different sets of customers and activities, and with two sets of acoustical conditions. EE-employee noise exposures were not found to approach regulated exposure limits. Future work should aim to refine the questionnaires, involve a more rigorous study design, and increase the number of EEs, customers and employees involved.

APPENDIX. QUESTIONNAIRE QUESTIONS

CUSTOMER QUESTIONNAIRE

1a. What were your reason(s) for visiting this eating establishment today: *eating/drinking; talking; business meeting; studying/working; celebration; relaxing*.

1b. With respect to those reasons you have checked, indicate how well the sound environment in this eating establishment met your expectations for an ideal environment? [very well; well; average; poorly; very poorly]

2. How frequently do you come to this eating establishment? [for the first time; less than once a month; more than once a month; almost every day]

3a. Do you prefer any specific seating location in this eating establishment? [yes; no]

3b. If yes, is this because of noise concerns in this eating establishment? [yes; no]

4a. How many people (including you) were having this meal together? Please specify the number of people in each of the following groups: children; adults; seniors.

4b. How many customers were in the restaurant during your visit?

5. Please indicate how much each of the following sources of noise in this eating establishment bothers you during this visit: *people speaking; people moving; adjacent-table conversation; cell phones*; heating/ventilation/air-conditioning (*HVAC*); *kitchen activities; kitchen equipment; clinking sounds; outside noise; music; reverberation* [not at all; a little; some; a lot; very much].

6. Please indicate to what extent noise in this eating establishment contributes to your experiencing the following problems during this visit: *reduced enjoyment; difficulty hearing at the table; difficulty talking with waiter; broken concentration; tired voice; headache; fatigue* [not at all; a little; some; a lot; very much].

7a. Please indicate to what extent you can easily hear conversations from: adjacent tables; cashier counter; kitchen [not at all; a little; some; a lot; very much]

7b. Please indicate to what extent you feel others can overhear conversations at your table [not at all; a little; some; a lot; very much]

8a. Sex [female; male]

8b. Age

9a. Is English your first language? [yes; no]

9b. Is English the main language spoken in this eating establishment? [yes; no]

10a. During this visit, would you prefer to have your meal in a noisy or quiet setting? [noisy; quiet; doesn't matter]

10b. During this visit, would you prefer to have music with your meal? [yes; no; doesn't matter]

10c. If yes, what level of music would you prefer? [very high; high; moderate; low; very low]

11a. Are you aware of having a hearing impairment? [yes; no]

11b. If yes, how severe? [mild; moderate; moderately severe; severe; profound]

EMPLOYEE QUESTIONNAIRE

1. What is your job title?
2. Please indicate to what extent each of the following sources of noise bothers you while you are working in this eating establishment: *customer talking; customer movement; colleague talking; colleagues movement; cell phones; kitchen activities; kitchen equipment*; heating/ventilation/air conditioning (*HVAC*); outside noise; music [not at all; a little; some; a lot; very much].
3. Please indicate to what extent the noise in this eating establishment contributes to your experiencing the following problems: *difficulty talking with colleagues; difficulty talking with customers; broken concentration; frustration; need to raise your voice to be heard; headache; fatigue; tinnitus* [not at all; a little; some; a lot; very much].
4. Please indicate how well the acoustical environment in this eating establishment today met your expectations for an ideal work environment. [very well; well; average; poorly; very poorly]
5. Please indicate to what extent you can easily hear the following conversations while you work and are not a part of the conversations: conversations at the tables; conversations between your coworkers [not at all; a little; some; a lot; very much].

6a. Sex [female; male]

6b. Age

7a. Is English your first language? [yes; no]

7b. Is English the main language spoken in this eating establishment? [yes; no]

8a. Are you aware of having a hearing impairment? [yes; no]

8b. If yes, how severe? [mild; moderate; moderately severe; severe; profound]

9a. For how many years or months have you had this hearing problem?

9b. For how many years have you been working in this eating establishment?

10c For how many hours per week do you work in this eating establishment?

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