Acoustics in the Hospitality Industry: A Subjective and Objective Analysis

L.H. Christie & J.R.H. Bell-Booth

jamesbellbooth@marshallday.co.nz

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Abstract

Are bar, café and restaurant environments acoustically acceptable from an occupants point-of-view? Can we actually predict how satisfactory such an occupant will perceive the acoustic conditions to their communication needs? The present study attempted to address these questions by comparing physical objective measures, with subjective ratings gathered in the field.

Findings from this study were both exciting and inconclusive simultaneously. A lack of significance between subjective factors themselves and a strong difference between how people rated each of the studied establishments disproved the concept that an index could be created for use in future predictions. The results highlighted the lack of relationship between objective measures and their ability to predict a subjectively acceptable acoustic environment.

Overall it was concluded that occupants generally find the current acoustic conditions acceptable in bars, cafes and restaurants, and that perhaps it is not these environments that need improvement, but that the current standards need to be re-evaluated.

Introduction

What constitutes good acoustic conditions for the social environments of bars, restaurants and cafes? Or, more importantly, what does the general population expect and accept as desirable conditions to be in?

The present study sought to address these questions by correlating what people in these environments want and perceive the acoustic levels as, with actual physical measurements of these environments.

It was hoped that an index could be created from these variables, which could be used for future design and analysis of café, bar and restaurants relative acoustic environments.

Previous research has typically acknowledged that bars, cafes and restaurants produce less than desirable acoustic conditions for comfortable social interaction [5, 7, 9, 14, 15, 16].

That is, it has been found that the average noise level in restaurants and cafes is around 80dBA and can even reach up to 110dBA [2, 8, 9].

In comparison, the ear is most sensitive to speech for conversation purposes between 48 and 72dBA [12]. Consequently the recommended design sound level for bars, cafes and restaurants is 45-50dBA, 45-50dBA and 35-50dBA respectively [1, 11].

Acoustical comfort for the users is seen as crucial for their enjoyment and satisfaction of a space. It is defined as when activities can be undertaken without unwanted sound (noise) annoying other people.

This also has effects on both the physiological and psychological well-being of the occupants [7, 15]. The large and varied number of subjective factors however, makes it hard to quantify this perceived comfort and determine it by objective means [5].

Therefore, are bars, cafes and restaurants producing unsatisfactory objective acoustic conditions in terms of standards and ratings (that is, background sound level and speech transmission index)?

If so, how are these conditions experienced and perceived by the people subjected to them?

Overall, the aim of this research was to see if cafes, bars and restaurants provide acceptable acoustic environments for their occupants. However, can we actually and accurately predict how people will rate or perceive these acoustic environments?

Methods

The current study measured both objective and subjective parameters of the chosen acoustic environments.

This was done primarily to establish if any relationships exist, but also because past research has identified that discrepancies exist between physical and subjective acoustics [10]. That is, it appears that it is possible that measurements and criteria for noise may disregard an individual's personal reaction [11].

Environments

The premises that took part in the study were cafes, restaurants and bars in the Wellington CBD zoned

"*suburban centres*" by the district plan. This area is a busy commercial hub with influential environmental noise factors which vary widely over a 24-hour period [13].

The time that the environmental survey took place varied due to the venues management preferences and schedules, however the measurements were taken at relevant times according to the activity of the building, compliant with AS/NZ 2107:2000 (clause 6.1.4).

The establishments were defined at the discretion of the conductors of the survey into the three categories: cafes, restaurants, and bars.

Subjective Measurements

Occupant's subjective appreciation of their environment at the time was measured through a series of questions in a survey.

This survey was developed from similar previous questionnaires and was aimed to address issues relating to perceived acceptability or annoyance of the acoustic environment, relative degree of effort needed to communicate comfortably, and subjects personal level of noise sensitivity. (Refer to 7 for further information.)

General questions relating to occupants hearing capabilities, frequency to such environments, perception of dominant noise sources, and preference of listening conditions and environments were also addressed.

Objective Data Collection

Background noise was recorded at an expected occupant's position in accordance with the Australian New Zealand Standard 2107:2000 (clause 6.1.3) at an occupied time.

The background noise was recorded to hard disk using ProTools LE 6.1.1, the Digidesign peripheral MBox USB sound card, and an AKG C108 omni directional microphone. The level (dB L_{eq}) was measured over a five minute period of the recording using the Bruel & Kjaer 2231 sound level meter, shown to comply with AS 1259.2. The recording was calibrated with a known tone with known SPL recorded at the beginning of each measurement.

The unoccupied reverberation time (RT30) was measured using winMLS software version 1.2 and the recommended calibrated Digigram V2 VX pocket sound card [17].

In accordance with the RASTI method [4] the loudspeaker used had a directivity pattern that reflected that of a person talking.

The Speech Transmission Index (STI) was calculated using the same winMLS software. Inputs of the STI calculation were the measured reverberation time and background noise levels (dB Leq), and the standard speech levels for normal, raised, loud and shouting as prescribed in the American National Standards Institute (ANSI) S3.5: 1997 standard.

Assumptions

It was assumed that STI was the best method of measuring speech intelligibility for the purposes of this research [3]. The reverberation time, an influential input to the STI calculation, was measured at an approximate distance of 800mm from the speaker.

For simplicity, reverberation measurements were made under unoccupied conditions, thus absorption provided by the occupants is negated.

It was also assumed that a representative sample of the general population would be attained through the random selection of places and people.

Descriptive Results

Social Characteristics of Sample

The age and sex of the occupants in all the venues combined for each category of bars, restaurants and cafes is shown in tables 1, 2, and 3.

It can be seen that the majority of people who frequent bars are in the younger age groups, particularly ≤25 (47%). People in the 25 -35 years category represented the largest population to visit both cafés (42%) and restaurants (53%).

However, a comparison of the means, shows that there is really no significant age difference between people who frequent each environment.

That is, the mean ages are situated around the late 20's or early 30's, being 28, 34, and 27 for bars, cafes and restaurants respectively.

No significant differences in sex were found between each of the three environments.

It should be noted that the results only reflect trends of the population surveyed at the time and not those of the general population, thus an index or predictive method built upon the results only caters for those who already willingly use these spaces.

However this does not negate their value as it gives an indication of the existing patronages preferences and tendencies.

Internal Finishes of Venues

The general finishes of all the premises were acoustically reflective; polished timber or tiled floors, plasterboard or concrete walls; and partitions of plasterboard, timber or concrete ceilings.

This will have a negative effect on the acoustic qualities of the space by increasing the reverberation times considerably. It is presumed that these materials are a consideration of design for the space to be durable and easily maintained.

Table 1. Bars Overall

Age	Male		Female		Total	
	No.	%	No.	%	No.	%
≤25	8	22	26	70	34	47
25-35	14	39	7	19	21	29
36-45	12	33	2	5	14	19
46-60	2	6	2	5	4	5
≥60	0	0	0	0	0	0
Total	36	49	37	51	73	100
Average: 28						

Table 2. Cafes Overall

Age	Male		Female		Total	
	No.	%	No.	%	No.	%
≤25	6	17	13	30	19	24
25-35	15	42	18	42	33	42
36-45	6	17	9	21	15	19
46-60	6	17	2	5	8	10
≥60	3	8	1	2	4	5
Total	36	46	43	54	79	100
Average: 34						

Table 3. Restaurants Overall

Age	Male		Female		Total	
	No.	%	No.	%	No.	%
≤25	7	24	8	29	15	26
25-35	16	55	14	50	30	53
36-45	6	21	6	21	12	21
46-60	0	0	0	0	0	0
≥60	0	0	0	0	0	0
Total	29	51	28	49	57	100
Average: 27						

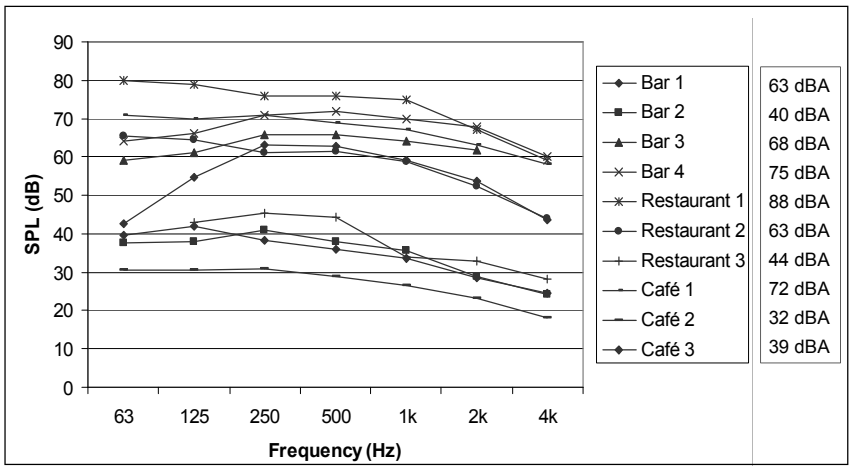

Figure 1: Noise Spectra of each Venue.

Objective Results

Figure 1 shows the distribution of background noise levels in the surveyed venues and their frequency distributions. The range of the measured levels is broad, between 34 dBA (L_{eq}) and 81 dBA (L_{eq}).

While it is concerning that 60% of the establishments exceed the recommended maximum level of 50 dBA in AS/NZ 2107:2000, this recommended value is for **background noise** in unoccupied buildings, ready for occupancy.

While the standard states that noise will rise above this recommended unoccupied level on occupancy [1], the levels that were recorded were up to 25dB above the allowable occupied margin. The extreme rises observed could be explained by the "café effect"[1] in relation to the reverberation times.

Despite the noise levels being high, none are above the recommended OSH safety limit of 85 dBA (L_{eq}) [1].

The maximum level recorded was 81dBA at restaurant 1 (80dBA is also seen as the critical point at which after this level acoustical comfort deteriorates in a 'noise-breeds-noise' effect [7, 14].), while conversely the lowest background noise level was 34dBA in café 2. This could also be seen as a less desirable environment, as a low noise floor can be unsupportive to conversation and quite psychologically disturbing.

Namely, people will often feel uncomfortable and without sufficient speech privacy. Two of the bars also had very low background noise levels which is quite unexpected, as bars generally in the past have been considered to be 'noisy' environments.

This perception is also often cited as a critical factor to their atmosphere and success. Overall, it is illustrated that restaurants are producing the highest background noise levels in our surveyed sample.

If these standards (AS/NZ 2107:2000) are taken as guidelines for acoustically supportive environments, then only one out of the sample meets these requirements (restaurant 3) providing direct evidence and support for the statement that bars, cafes and restaurants in objective terms are producing less than desirable inter-communicative conditions.

Reverberation Times

Figure 2 shows the reverberation times measured in the locations surveyed. It appears the reverberation time is much lower than 1.0 seconds, sitting comfortably in the recommended AS/NZ 2107:2000 time of <1.0 second.

However it should be mentioned that to comply with the method of measuring reverberation time to satisfy the STI method, reverberation times were measured using a loud speaker with the directivity of a natural speaker or human head as apposed to an omni directional speaker to satisfy the AS 2460 procedure and thus the AS/NZ 2107:2000 [1].

Furthermore the distance between the microphone and speaker is approximately only 800mm to simulate the conditions of natural speaker and listener in café bar and

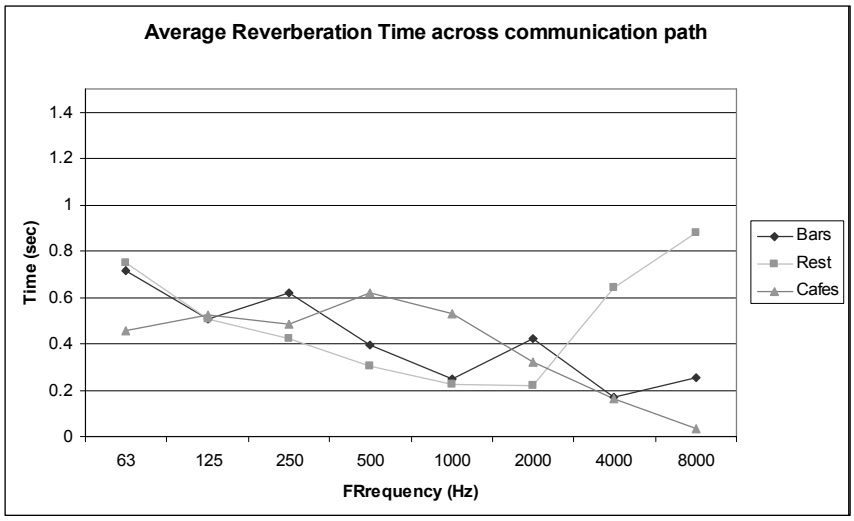

Figure 2: One-third Octave Band Reverberation Times.

1. The café effect describes the phenomenon whereby the background noise in a room rises as a result of the occupants raising their speaking level to compete with the ever increasing background level (Whitlock, J.A.T., "Acoustical Mechanisms influencing Speech Intelligibility for Primary School Children", Masters' Thesis (University of Auckland), 2003.)

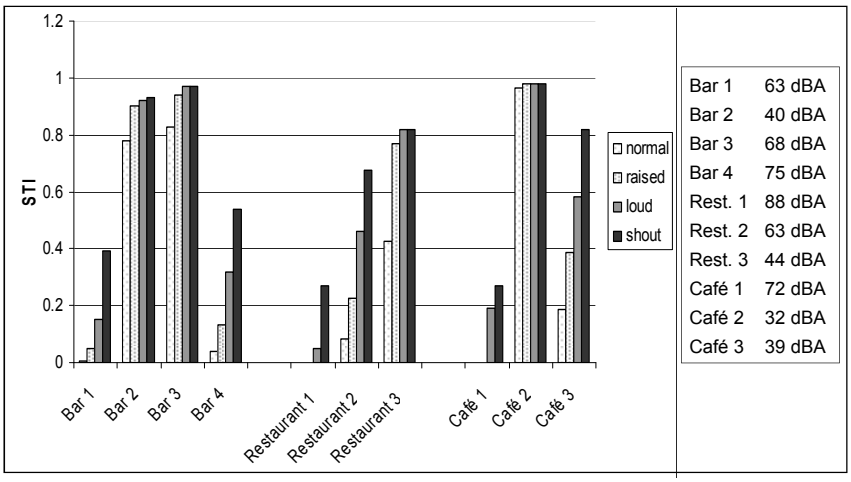

Figure 3: STI Ratings for each Speech Level and Venue.

restaurant environments.

The reverberation times of the surveyed venues showed little correlation to the background noise and hence the higher levels in some establishments cannot be explained by the "cafe effect".

This may not be the case if reverberation times were measured in accordance with AS 2460. If this were true, it would imply groups of people communicating behaved as omni directional sources.

STI ratings

Speech Transmission Indices (STI's) for each venue at each speech level are presented in Figure 3 below. An STI close to 1.0 is considered excellent intelligibility, and closer to 0.0 is seen as bad or poor speech intelligibility conditions.

The graph also highlights that with higher background noise levels, communication appears to improve exponentially with effort, whereas it appears to improve logarithmically in less noisy environments.

Both these points illustrate how dependant upon background noise level STI is in these measurements.

Predominant Sources of Sound

Further information was collected from occupants as to what they perceived as the dominant source of sound. This is illustrated in figure 4.

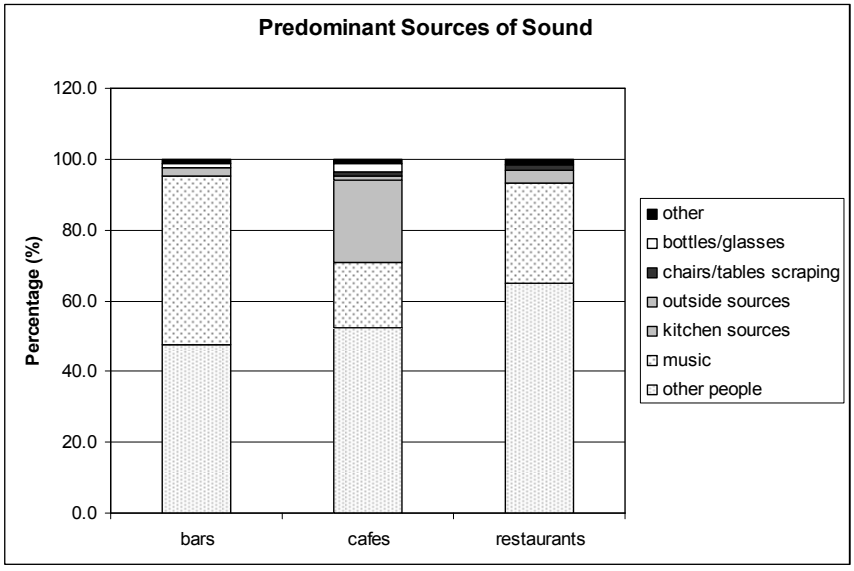

Figure 4: Distribution of Sound Sources in Each of the Environments.

Overall, sounds from other occupants were rated as the dominant noise sources in all three environments. This suggests that a major source of annoyance to social interaction, is in fact others conversations. Therefore, how is this problem overcome when speech is both the aim and the cause of the problem?

Preferred Environment for Communication

When asked about the preferred environment to support inter-personal communication, it was found that restaurants were the space where patrons most desired supportive conditions for communication.

This is reasonable allowing for the fact that people go to these environments to hold conversations with one another. This is illustrated in Figure 5.

Subjective Results

Pearson Product Moment Correlations (r) were calculated between various parameters and scales for inferential statistics. A significance level of 5% was used for all statistical analyses.

Great variation was found not only between these three hospitality environments, but also within each of them.

That is, people have different needs and preferences depending on what type of environment they are in.

Restaurants

- Restaurants provided the least desirable conditions in terms of background noise levels and STI ratings.
- Privacy was the most influencing variable in restaurants.
- Occupants rated speech intelligibility low in restaurants.
- People in restaurants typically find it more difficult to be heard (as compared to hearing).

Bars

- The patrons of bars rated their space more acceptable than any other group.
- Degree of effort was found to be the largest predictor of acceptability in bars.
- Patrons of bars required the most amount of effort to communicate
- The type of people frequenting bars, were the most comfortable relaxing in a noisy environment.

Cafes

- People who frequented cafés required the least amount of effort to communicate.
- Speech intelligibility was rated as more of an important factor than the patrons of the other environments. However, they did not rate them as the preferred place for communication.
- Cafes were also rated as the least acceptable environment.

Objective to Subjective Comparison

Results of linear regressions performed between the main subjective factors collected via a survey, showed that **there was not enough strength in the correlations to create a reliable method of prediction or index.**

A regression of variable 13 ("Does noise impair your conversations at all?") against the STI at the ANSI S3.5:1997 speech levels, revealed a weak correlation.

This implies that occupants of cafes, bars and restaurants may

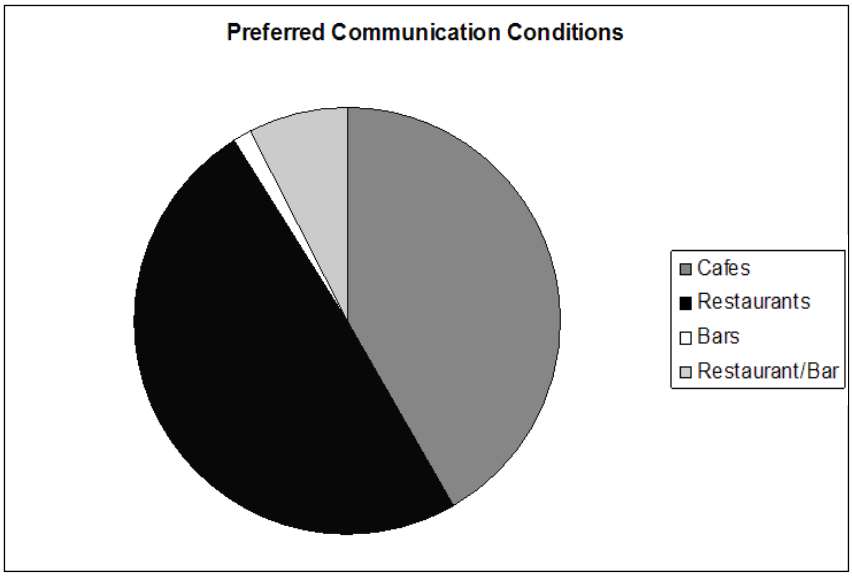

Figure 5: Preference ratings for communication.

be adapting to the acoustic environment by raising their level of speech above what is currently considered standard.

This finding also suggests that the ANSI speech levels are not in fact representative of normal, raised, loud and shouting levels of speech in these environments.

As a result, the STI value obtained for these premises using the ANSI levels could be assumed to also not be a true representation of speech intelligibility. An argument could therefore be presented suggesting that the **current standards and speech levels are not appropriate guides to these particular environments?**

When comparing the subjective descriptive means to the objective noise levels, it can be seen that the louder these levels are, the more aware occupants are likely to be of their current surrounding acoustic environment.

Hence, they are more inclined to realise that they would prefer 'less noisy' or more intelligible environments. The inverse is also apparent. Both these findings are presented below. However, are these results because subjects were provoked to become aware of their acoustic surroundings?

Would they still think the same thoughts anyway and notice their communication needs as much if they were not explicitly asked or stimulated to do so?

In another light, environmental awareness was a predominant factor in bars. Could this be because the occupants are more emotionally charged and thus reactive to noise [7]?

That is, it has been suggested that people who are having a social occasion are more likely to be emotional and engaging than they normally would be. The strong relationships found between noise sensitivity and environmental

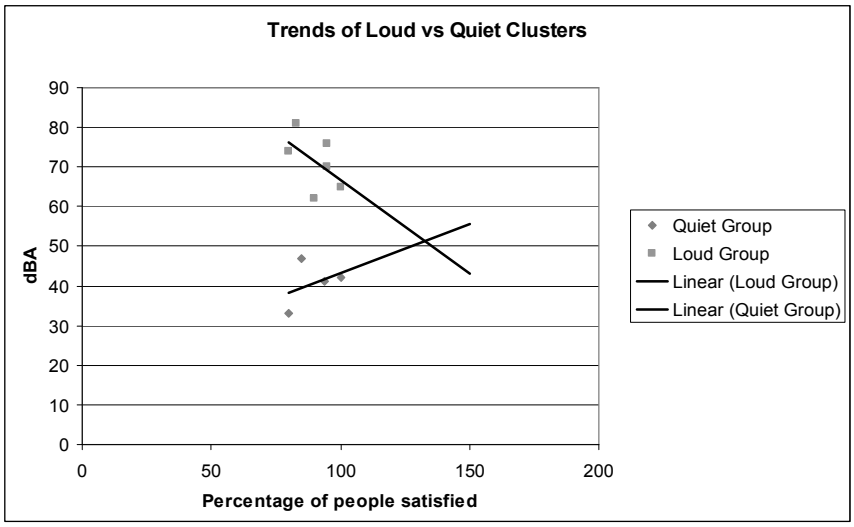

Figure 7: Preferred Trends of the Two Clusters.

awareness support these views additionally.

Of the environments surveyed, it is apparent that two clusters appear; acceptability in louder environments, and acceptability in quieter environments. Figures 6 and 7 highlight these findings.

Figure 6 suggests that those surveyed in louder environments predominantly accepted the level but tended to prefer a little less noise. The majority of those surveyed in a quieter setting on the other hand, also accepted the level but tended to prefer a little more background noise.

Although both groups rate acceptability highly, the intersection of their trend lines suggests an equilibrium point just above 50 dBA which is coincidentally just above the maximum recommended unoccupied background noise level for bars, restaurants and cafes (AS/NZ2107:2000).

This suggests the **standard is conservatively low**, understandably as the recommended level is for unoccupied spaces. However the range of surveyed establishments is not broad enough to draw any firm results.

Furthermore it is apparent that study into the cause of the elevated background (occupied) noise levels is relevant. It has been suggested that the "cafe effect" and the "noise

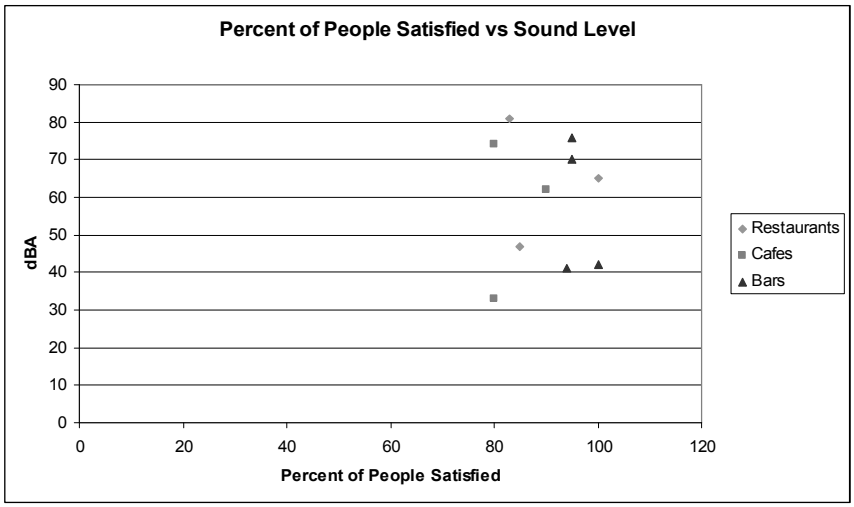

Figure 6: Percentage of Occupants Satisfied as Compared to the Current Sound Level.

breeds noise" scenario are related to reverberation. The results in this study show no such conclusion. This could be because of the method of measurement of reverberation being based on a natural speaker communicating to a natural receiver and demonstrates that it is possible groups of people behave more like an omni-directional source and should be simulated as one.

Summary

Restaurants

The fact that restaurants provided the least communicative environment is concerning as people preferred restaurants as the most likely of the three environments to have good acoustic conditions to support communication.

Occupants are generally more conscious of other diners and the noises they are generating than with bars and cafes.

This is also supported by previous findings that the most predominant and annoying source of sound is other people A possible reason for this could be due to the different emphasis or importance people put on being heard and hearing in different environments.

For example, in restaurants it could be considered more of a necessity to be heard by the waiter and the person(s) communicating to.

It can be assumed that in restaurants people want and expect more private and intimate environments, particularly so that a reasonable conversation can be carried out comfortably. However, is this due to people adapting to what they want from these particular environments, or is this due to a heightened awareness from the particular type of people who frequent restaurants?

It could also be that people in restaurants are more sensitive to noise and perhaps not as likely to frequent bars. This could also be supported by responses to the question "When you choose a venue, are you concerned that there will be loud music?"

A possible explanation for dissatisfaction using the found relationships, could be that as speech intelligibility becomes more important, the degree of effort required increases, making the patron feel like they are breaching their privacy and thus reducing their rating of acceptability of the space.

This implies that restaurants should provide privacy by means of isolation rather than masking to reduce the degree of effort required to communicate.

Bars

Degree of effort is required significantly more in bars than in restaurants and cafes and occurs predominantly in hearing other people rather than being heard.

This is illustrated in the percent of variance from the group mean for questions 10, 11 and 13 which ask; "how much effort does conversation require?"; "Do you find it difficult to hear?"; and "Does noise impair your conversations at all?".

This also coincides with the fact that those surveyed in bars rated their environment with a greater level of acceptability, with people in bars being generally less concerned about noise and speech conditions than people in cafes and restaurants.

The higher perceived level of tolerance could be explained by patrons expecting a higher level of noise in these bar environments which would require a higher level of speech effort. This tolerance could also however be influenced by the effect on mood which alcohol consumed at the time may have.

Cafes

The observed relationship between degree of effort and environmental awareness and the findings that speech intelligibility is considered most important to people in café environments may suggest that cafes produce the least communicative conditions of the three, which in turn would make people more aware of their need for better conditions and hence subconsciously affect their rating of intelligibility.

However overall, cafes were not the worst performing in terms of background sound level and STI's. It is possible that as background noise in cafes increase the degree of effort increases and thus acceptability falls.

A large proportion of noise sources contributing to background noises were those associated with kitchen areas, especially coffee machines and grinders.

These sources may contribute a great deal to the overall acceptability of a space.

In conclusion, bars, cafes and restaurants are considered too loud or undesirable acoustically for occupants from an objective point-of-view. No conclusions can be made as to whether they are subjectively too loud or undesirable from an individual's personal experience.

Correlations between the measured subjective factors and acceptability for each venue were not conclusive enough to find a robust method or arrangement to predict an occupant's acceptance and satisfaction of the acoustic environment.

A greater sample size of venues would help overcome this issue in future study.

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The pilot once turned a plane in to the shop with a complaint that read "Unfamiliar noise from engine." The next day, the plane was ready for him. The engineer's logbook entry read "Ran engine continuously for four hours. Noise now familiar."