Satisfying Hunger, Thirst, and Acoustic Comfort in Restaurants, Diners, and Bars… Is This an Oxymoron?

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We all go to these places, but how can we ensure that the acoustic environment will be conducive to our needs?

It's Probably More Than Just Food and Drink!

All of us go to a restaurant or diner for food and drink, but unless you are going alone, you will probably wish to have a conversation with your companion(s) while enjoying a meal. Or, if you are on the way to a bar and grill, then you may also be interested in watching "the game" on the oversized TV(s) or even listening to "live music."

Once you enter the eating establishment, the issue of acoustic comfort comes into play; it is part of the interior environmental quality (IEQ) associated with an architectural space. We, as a matter of course, talk about building IEQ in offices, in health care, and in schools and especially so if designing to meet green or well building ratings. But we have not, to date, seriously focused on this aspect of architectural performance for hospitality spaces such as restaurants, but we certainly need to do so.

People have noticed that noise in restaurants seems to be ever increasing, and more recently, this issue has gotten the attention of both researchers and restaurant customers. A Special Topics Session on this subject was presented at the December 2017 Acoustical Society of America (ASA) Meeting in New Orleans. At that meeting, a paper was given by Faber and Wang (2017) that provided analyses of crowdsourced sound levels in both restaurants and bars in New York City. In total, sound level surveys were collected from 2,376 restaurants and bars using the smart-phone app SoundPrint (soundprint.co). Noise levels were categorized as "low," "moderate," and "high," with high levels being over 76 dB(A). By comparison, normal voice levels are generally taken to be about 60 dB(A) when conversing with someone at about an arm's length, so the measured noise levels in eating establishments are easily 2-4 times as loud as a normal speaking voice.

We discuss SoundPrint more fully in **SoundPrint and Crowdsourcing Sound Levels at Restaurants**, and the Faber and Wang (2017) paper has an extensive list of references for anyone who is interested in more information on this topic.

Architects Design to Meet a Mission

When an architect sets out to design/build a new building, the focus has to be on meeting the mission for that building's use. For an office building, the mission is simply to have a place to do "work." For a school building, the mission is for a place to "learn," whereas for a hospital, it is to have a place to "heal." So, following this approach, what is the mission for a restaurant, diner, or bar and grill?

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The mission for food service (hospitality) probably needs to include meeting the customers' expectations for both the food and drink and for the social aspects of a shared experience. Hospitality covers a wide range of establishments, so accordingly we can anticipate that the expectations will be rather broad, which is why this particular segment of the building market is more difficult to define and as yet not adequately addressed in terms of acoustic comfort.

Service and Expectations!

In the case of an upscale restaurant, one's expectations are for great food and a quiet acoustic environment that allows for casual conversation. After all, the diner is often there with friends and family or is trying to conduct business. However, when one heads off to a "fast food" restaurant or diner, the expectation is for good food and not too stressful communication because one is there primarily to eat and to take a break from life. But when one is at a bar, the expectation is to communicate in a loud voice at close range and maybe even communicating by "text" as opposed to "voice" because the primary expectation is usually the entertainment. But even within these examples, "a bar... is not a bar... is not a bar," means, for example, that a hotel bar at the Marriott carries different expectations than the bar at Jimmy Buffett's Margaritaville.

You have probably heard the saying that "restaurants managers want their property to sound loud and busy because it's good for business." Really? Activity noise is, of course, expected with high occupancy, but does it need to be unmanageably noisy? In fact, many people walk out of restaurants and bars on occasion because the establishments were either so loud that it was uncomfortable due to the noise level (it hurts!) or too loud because the diner wanted to have a conversation with friends across the table.

So then, what is the mission that a food service facility needs to meet, especially with reference to acoustic comfort? We know that there are noise problems because there is dissatisfaction and complaints relative to acoustic comfort, and these are being communicated by the restaurant rating services such as provided by *The Washington Post* (wapo.st/2HbjG11) or Yelp, and these now include comments on the noise environment, at least as a subjective rating such as "quiet or noisy."

And we can expect even more comments about the noise environment because simple smart-phone apps such a SoundPrint are now available and allow anyone to make a noise reading on-site and in real time (some apps are reasonably accurate) in decibel noise level. Surely, the owners do not consider losing customers due to unmet expectations on noise to be a good thing for business; now do they?

Customer Wants and Needs

And what is it that we want: good food, good drink, a pleasant environment, and the appropriate level of acoustic comfort to meet the needs for a specific choice of establishment. Here is a short list of some possibilities:

- A restful environment after a day of hard concentration (low-noise annoyance, quiet music);
- The need to have casual conversation for business or personal matters (moderate noise level, good speech intelligibility, and adequate speech privacy); or
- A wish to enjoy social interactions with sports or music entertainment (significant sound level OK, limited direct conversations OK).

Acoustic factors such as noise level, reverberation, speech intelligibility, speech privacy, and sound quality are all part of the acoustic environment and relate to architectural factors including the size, shape, and surface treatments in each building space.

Architecture and Acoustics

As we have learned in the design and performance of offices, schools, and health care, architecture has a strong impact on the acoustics of any building space, and this holds for the hospitality industry as well. The architectural design (size, shape, and surfaces) of each building space determines the clarity of speech at any point within a room, and the level of background noise in conjunction with the speech clarity will determine the intelligibility of speech (think schools; see ANSI/ASA S12.60, 2010; Brill et al., 2018).

So, what do we know specifically about the relationship between architecture and acoustics in restaurants? Many times, restaurants suffer from excessive loudness and reverberation, harsh reflections, and echoes. But architectural acoustics (the science of sound as it pertains to buildings; Sabine, 1922) is a bit of an enigma because most restaurant patrons and owners don't know that there can be a way to solve their noise problems because they are not even aware that this is a field of study and that engineering solutions are available.

A starting point used to analyze the acoustic environment of restaurants is to calculate the average midfrequency absorption coefficient of the space. The midfrequency content of human

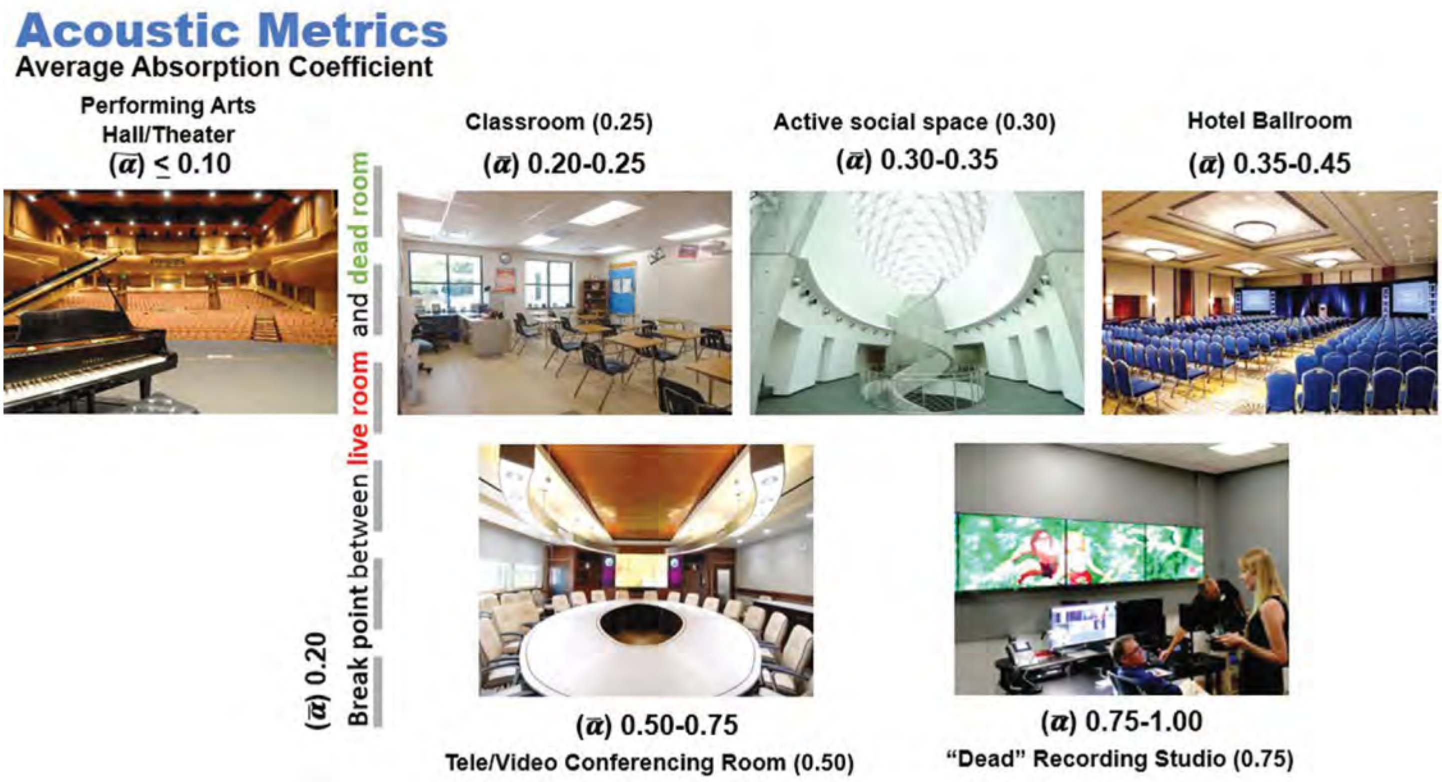

Figure 1. *Examples of various rooms and a typical average coefficient* ($\bar{\alpha}$) *associated with each of them.*

speech is what is important in determining both speech intelligibility and speech privacy, both of which will be important in restaurant acoustic comfort. Each surface in the room is either acoustically reflective or absorptive. Every material absorbs or reflects sounds to some extent across the frequency range in which people can hear.

Equation 1 is used to calculate the total sound absorption in the room. This is done by summing the surface areas of the various materials in the room multiplied by their respective absorption coefficients. The total sound absorption in the room is then divided by the total surface area in the room using **Equation 2** to get the average absorption coefficient ($\bar{\alpha}$) for that room.

The total sound absorption in a room is

$$A = S_1 \alpha_1 + S_2 \alpha_2 + .. + S_n \alpha_n = \Sigma S_i \alpha_i \qquad (1)$$

where A is the absorption of the room (in m^2 sabins), S_n is the area of the actual surface (in m^2), and α_n is the absorption coefficient of the actual surface.

The $\bar{\alpha}$ for the room is

$$\bar{\alpha} = A/S \qquad (2)$$

The $\bar{\alpha}$ in a room is a number that falls between 0 and 1. Zero means a room that is completely sound reflective, and 1 is a room that is completely sound absorbent. Most practical rooms will fall somewhere in the middle of this range, not being either too reflective or too absorptive. **Figure 1** gives examples of typical rooms and their corresponding $\bar{\alpha}$ values to show where various room types may fall within this range. For example, a concert hall (see Hochgraf, 2019 for a related article) or a music recital hall may have very little sound-absorbing material (but instead having very carefully angled reflective surfaces that direct sound to where it needs to go), therefore having an $\bar{\alpha}$ of 0.10 or thereabouts. Whereas a hotel conference room or ballroom, with carpeted flooring, acoustic ceiling tile, and acoustic wall panels, may have an $\bar{\alpha}$ of 0.35. And a specialty recording studio designed to be acoustically "dead," with almost every single surface as sound absorbent as possible, may reach $\bar{\alpha}$ values of 0.75 or so.

Analysis of over 20 dining spaces that suffered from sufficient acoustic issues to drive the owners to call in an acoustician had a variety of materials in the rooms, with some establishments having almost no sound-absorbing surfaces (meaning hard floors, walls and ceilings), whereas others had some absorbing materials, as shown in **Figure 2**.

Acoustic Design in Restaurants

The rooms that had absorbing materials but still needed interventions often had the absorbing material on the floor in the form of carpet. Some rooms had heavy carpet and drapes along the windows, yet still resulted in unsatisfactory acoustic environments. Where the absorbing material is installed matters! Certainly, adding absorbing material anywhere will cut down on the amount of reflected energy in the room (to some extent), but putting it in areas where sounds are more likely to actually interact with the material will result in a more favorable acoustic environment. As more absorbing material is added to the space, the $\bar{\alpha}$ gets higher.

It is also very important to think beyond the simple equations that we use to calculate "bulk" performance variables such as the average absorption coefficient and consider the above discussion. Once while teaching a design workshop in Mexico City, an architect asked if it was possible to solve the noise issue in one of the most famous restaurants in the city in a simple way. The architect wanted to know if putting acoustical treatment under all the tables and chairs would solve a "big" noise problem. The entire workshop group talked through this proposed solution and came to the conclusion that the likely outcome would be a 1 dB level reduction because no more than one-half of the floor area could be covered, and even if this was done, the likelihood of getting sound up under the tables and chairs was not so good.

The untreated rooms that required acoustic treatment had an $\bar{\alpha}$ of 0.12, with a range of 0.05 to 0.23, as seen in **Figure 3, *red,*** as the "untreated" option. Adding absorbing materials to 50% of the walls or ceiling resulted in an $\bar{\alpha}$ of 0.20 (which is typically considered the "break point" between an acoustically live room and a room that begins to absorb sound). This step might be considered a "first pass" in attempting to control excessive reverberation.

However, if a more subdued environment is desired, adding sound-absorbing material to more than 50% of the wall or ceiling surfaces will result in the next tier of treatment, which has an $\bar{\alpha}$ of 0.27. Treating 80% or more of the ceiling surface,

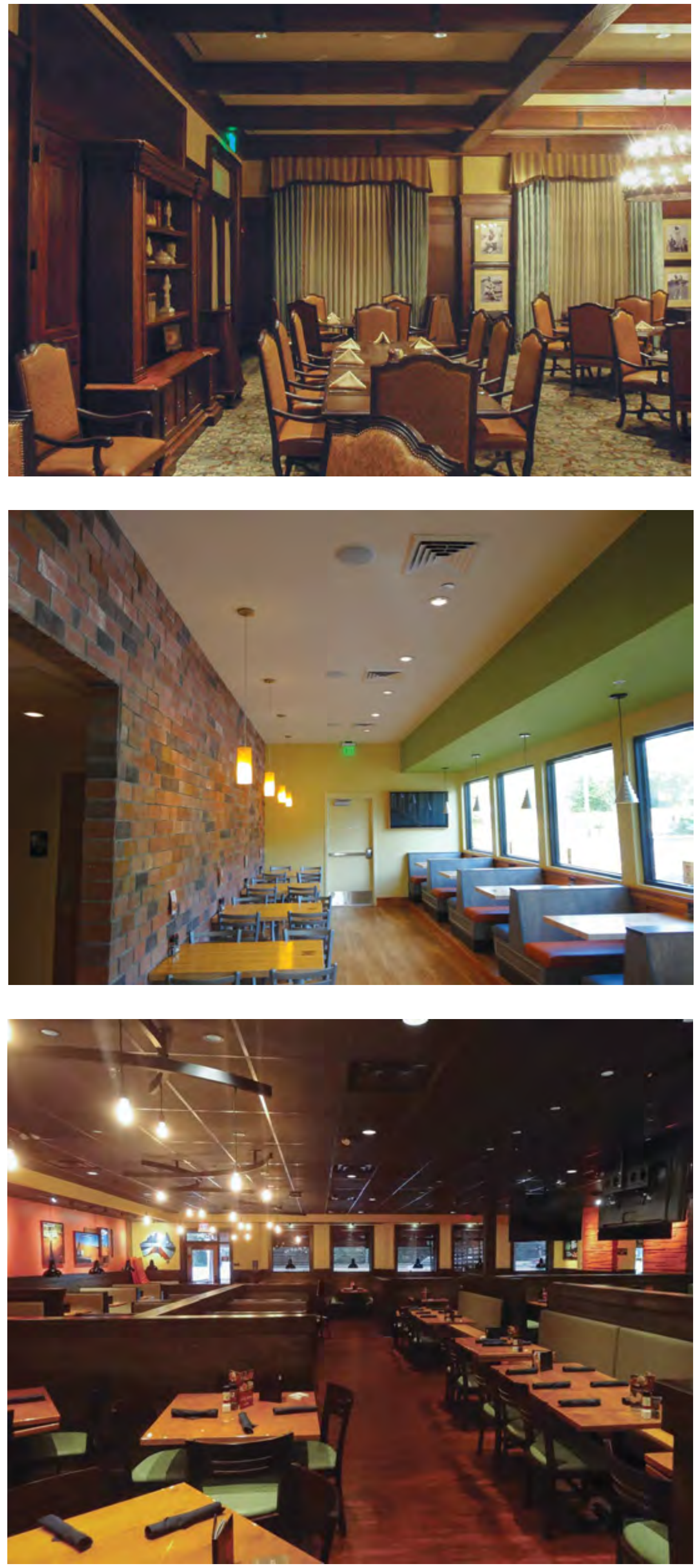

__Figure 2.__ All of these restaurants suffered from acoustic defects and all having a varying amount of absorbing material. __Top:__ Heavy carpet, drapery, and upholstered seating. __Center:__ Mainly reflective materials. __Bottom:__ Acoustic ceiling tile (in grid).

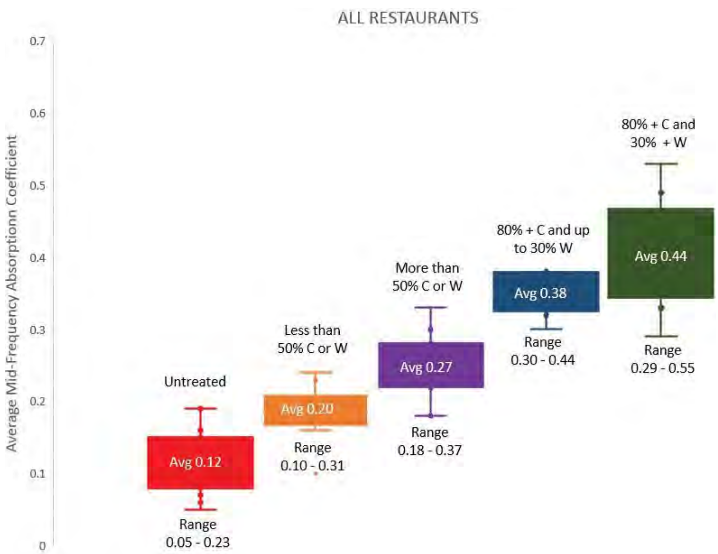

Figure 3. *Average absorption coefficients associated with various amounts of absorbing materials in restaurants. C, ceiling; W, wall;* ***color blocks****, average absorption coefficient of the actual surface ($\bar{\alpha}$); vertical bars, ranges of measured α values. Averages for $\bar{\alpha}$ are 0.12, 0.20, 0.27, 0.38, and 0.44, respectively.*

in conjunction with up to 30% of the wall surfaces, will result in an $\bar{\alpha}$ of 0.38. And treating 80% or more of the ceiling surface and over 30% of the walls will result in an $\bar{\alpha}$ of 0.44. In most restaurants, it is difficult to treat more surfaces than this due to the number and locations of windows, lighting fixtures, mechanical ducts, etc. Accordingly, the $\bar{\alpha}$ of a restaurant typically tops out around 0.44.

The higher the average absorption coefficient, the more sound will be absorbed by the room surfaces. So, if a restaurant is to offer a quiet, subdued environment, where people can talk quietly, it is important to use larger amounts of sound-absorbing material on the available ceiling and wall areas. If a venue is to have a more "energetic" feel, less sound-absorbing material should be used but that material should be used in strategically placed areas that have the potential to get louder than others.

Using no absorbing material in a restaurant, however, often results in acoustic environments that are uncomfortable and become excessively loud, even in places that want a more "energetic feel." This is typically why noise is considered one of the chief complaints of patrons of restaurants. Many restaurants have no acoustic material; they have hard floors, with painted gypsum board walls and ceilings. Some restaurants have acoustic ceiling tiles, but older establishments may have "refreshed" the space with a new coat of paint, so the ceiling tiles are often old and painted. Unless the tiles were spray painted with nonbridging paint, the paint seals up the surface of the tiles and essentially reflects sound back into the room, making the tiles that would previously absorb sound actually reflect it.

Technical Analysis of Intelligibility in Restaurants

The speech transmission index (STI) is "an objective measure used to predict the intelligibility of speech transmitted from talker to listener" (British Standards Institution 2011, BS EN 60268-16) or how well speech is heard and understood from one person to another. The STI was calculated in 13 untreated restaurants that suffered from poor acoustic environments (Siebein and Siebein, 2017). The STI values for the untreated restaurants ranged from 0.49 to 0.75 when unoccupied. To give context, according to BS EN 60268-16, an STI of 0.50 is considered the target value for voice alarm systems (a life safety system designed to provide spoken emergency alerts in a building but may also include background music or other nonemergency signals); a STI of 0.58 is considered a "high-quality public address (PA) system"; an STI of 0.70 is considered "high speech intelligibility"; and an STI of 0.76 or greater is considered "excellent intelligibility but is rarely achievable in most environments." This may be why in these 13 restaurants, one could clearly hear conversations from other diners at other tables when the restaurant was minimally occupied.

The STI for patrons sitting at the same table should be maintained as high as possible in all situations to optimize the ease of communication among those diners. Assuming no other patrons are in the area and the background noise is quiet, the STI value here will be higher, meaning that speech will be more likely to be understood. It is desirable to maintain high STI values for this situation under all conditions. The STI from locations across the room should be minimized under all conditions to limit the buildup of noise that would reduce the STI across the table. Generally, the more sound absorption present in the room, the higher the STI value.

However, the background noise level also has a significant relationship to the STI. In a dining or social space, average background noise levels of 77 dB(A) (Scott, 2018) are often found. The "background noise" is the voices of all the other diners speaking at their tables reflecting across the room

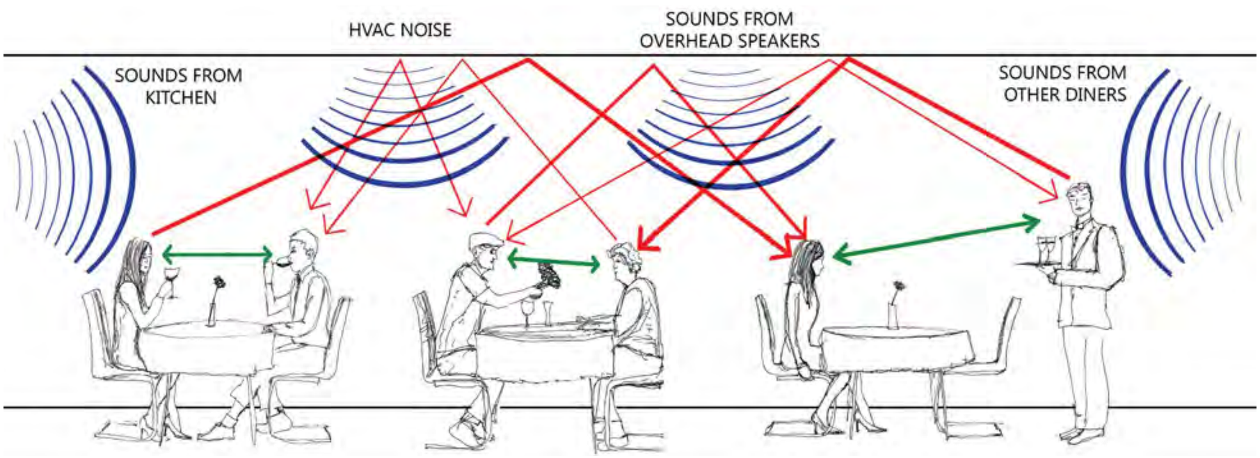

Figure 4. *Diagram showing communication paths between multiple people seated in a restaurant. Assuming that the seating area is full and the background noise is high, the speech transmission index (STI) value here will be lower, meaning that speech will not be understood very well.* ***Green lines****, direct speech;* ***thick and thin red lines****, reflected speech;* ***blue curves****, other noises such as the air diffusers.*

to other seating locations as well as the sounds of dining including the clanking of dishes, preparation of food, bussing tables, and cleaning.

An analysis was also performed of the same 13 restaurants where an "occupied" environment was simulated. When the same rooms were simulated to be occupied with more patrons, the STI levels decreased to a range of 0.21 to 0.31. These STI values are considered "bad or poor" according to BS EN 60268-16 and perhaps provide some confirmation of users' experience that they are unable to understand conversations clearly at their own table, especially when the restaurants are more fully occupied. **Figure 4** shows conceptually what happens when many sound sources are present in a restaurant, making it more difficult to carry on conversations.

SoundPrint and Crowdsourcing Sound Levels at Restaurants

The SoundPrint app has the potential to make restaurant owners and operators aware of whether the sound levels at their venue are acceptable to patrons or not, with the idea of hopefully inspiring them to change their acoustic environment when needed. The app combines basic sound level meter technology with crowdsourcing functions that essentially allows restaurantgoers to measure sound levels in an establishment and report them to the SoundPrint database, where they can be stored and viewed by other members. The restaurants that receive data are ranked into four categories: quiet [70 dB(A) or lower], moderate [71-75 dB(A)], loud [76-80 dB(A)], and very loud [81+ dB(A)]. The founder of SoundPrint, Greg Scott, initially created the app as a way to find a quiet spot to take a date in New York City. The idea springboarded, and users all over the United States have begun measuring and submitting their sound levels to the database. According to Scott, the SoundPrint app has, to date, received data of over 60,000 sound samples in 30,000 venues around the world, the majority within the United States. The database will be expanded to countries abroad soon.

This kind of app gives restaurantgoers the power to report venues that are too loud, make management aware that noise issues exist, and hopefully open a dialog for the owners/operators to engage in and determine how they can tone down the space to make it more acceptable to patrons. The app is being used not only in restaurants but in bars and coffee shops and recently in retail stores, movie theaters, libraries, and arenas! In a sense, it is a way of educating the public about building acoustics and the importance of good acoustic design in buildings.

What Can or Should Be Done About Acoustic Comfort in Restaurants?

The concept of "proper acoustics" in places of public accommodations including restaurants, diners, and bars has been an ongoing issue for quite some time. ASTM International (formerly the American Society for Testing and Materials) considered writing a standard 20 years ago for the measurement/performance of such spaces, but it died an uncertain death during development because no consensus could be found on specific acoustic requirements that would be acceptable to all the interested parties (owners, workers, and users). Then, in 2017, the ASA was requested to look at the possibility of writing such a standard, and, to that end, a special session on "Restaurant Acoustics" was sponsored by the ASA Panel on Public Policy[1] at the Boston meeting. Since then, additional special sessions have been offered and more test data have been collected, but what to do next?

The normal practice for the development of acoustic standards generally follows a defined path that starts with design practice and ends with building codes and regulations. To date, design knowledge for the acoustics of these spaces is generally available to architects, engineers, designers, and consultants, often based on research into the design practice and performance as previously discussed. Design guidelines for restaurants tend to be internally held by the owners. For instance, chain "fast food" restaurants such as McDonalds and Burger King usually have model design standards for their buildings. However, despite all the talk about "noisy is good for turnaround," the fast food industry has certain model building specifications that include acoustic ceiling tiles, usually in the form of 2-foot × 2-foot suspended ceilings. Although their first consideration is likely to be installation costs, accessibility, and esthetics, acoustics is being provided in the suspended ceilings despite the contention that noisy is good. Really?

Can We Quantify or Qualify Acoustic Comfort?

One can choose to address acoustic comfort in restaurants in either of two ways. The most obvious approach is to address the need for acoustic comfort in hospitality using the same methods and metrics currently used in other building segments, which would be a quantitative mode using measurement and performance standards. A second but more qualitative mode would be to develop a classification standard.

We certainly know how to go about accomplishing the first option, and the tools for doing so are shown in **Figure 5**.

ASTM International is well-known for its portfolio of acoustic measurement standards, and these are referenced in the ANSI/ASA S12.60 standard for acoustics in classrooms, for example, where both measurement and performance standards are applied. This is not difficult to specify for schools

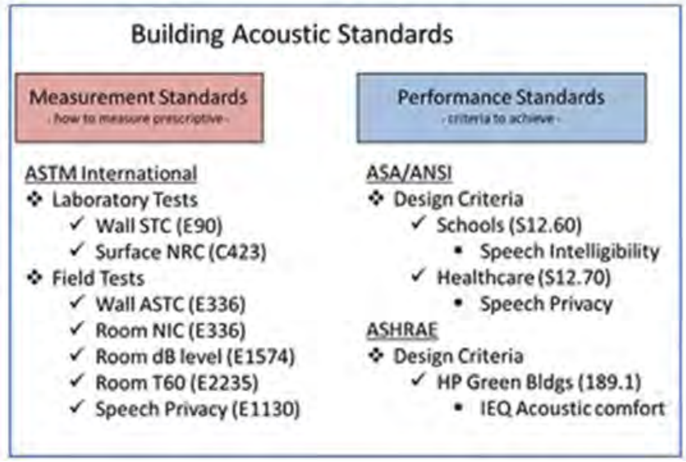

Figure 5. *Measurement and performance standards for quantitative approach. ASA/ANSI, Acoustical Society of America/American National Standards Institute; IEQ, indoor environmental quality. STC, sound transmission class rating; ASTC, field-measured apparent STC; NRC, noise reduction coefficient rating; NIC, noise isolation class rating; HP, high performance; T60, reverberation time; ASHRAE, American Society of Heating, Refrigeration, and Air-Conditioning Engineers; terms in parentheses, actual test standard designation by ASTM International, ASA, or ASHRAE.*

because all classrooms need a good listening environment for students to learn from the teachers (Brill et al., 2018; Leibold et al., 2019), and so the focus is on speech intelligibility. Additionally, many classrooms are architecturally very similar in size and shape, making the acoustic needs relatively easy to define.

Restaurants, diners, and bars, on the other hand, have a list of requirements including speech intelligibility, speech privacy, annoyance, and entertainment, and within these, there is a range of conditions for each acoustic factor depending on the type of establishment, time of day, or day of the week. So, treating a restaurant in the same way as a school does not make a whole lot of sense without addressing a very complex set of requirements. Although it may be possible to develop a range of performance requirements for acoustic comfort in the hospitality building segment, this may take a significant level of research and "buy-in" from all the interested parties (owners, customers, and employees). This is why a previous attempt by ASTM International to take this approach was not successful. Accordingly, we may wish to take a more simplistic approach just to get started, and then see where this may lead.

[1] *See Sound Perspectives essay on this panel by Walsh in this issue of* Acoustics Today.

How to Qualify Acoustic Comfort

A simple way to qualify acoustic comfort would be to develop a classification standard such as that which is currently being developed at ASTM International for the classification of electronic sound masking systems for use in architectural spaces. This rating approach for electronic sound masking is intended to give the designers and users a method to choose wisely in providing the degree of performance needed when a consistent level of speech privacy is necessary, for instance, in offices and health care facilities. So, what kind of subjective classification might work in the hospitality market? One approach is to model the system of classifications in a similar way as was done on ski slopes (see **Figure 6,** ***left***).

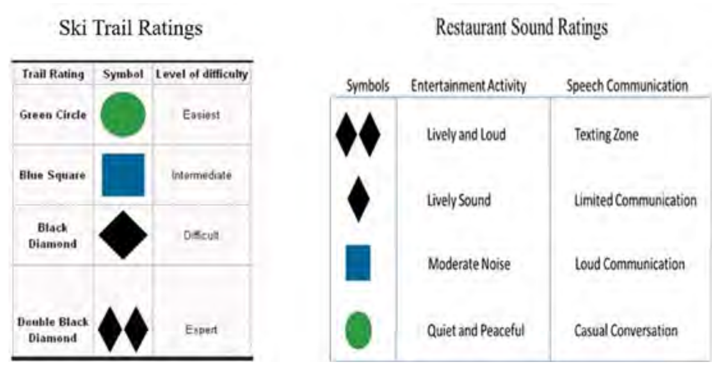

Figure 6. Left: *classification system used in downhill skiing.* ***Right:*** *proposed classification system for use in restaurants.*

When standing at the top of a ski slope, we see visual indicators that grow increasingly ominous as the degree of difficulty increases, starting with a green circle (bunny slope) and ending with a restrictive-looking black double diamond (dare devil, i.e., cliff). This is a rating scheme that could also be implemented in the hospitality building segment by adapting the descriptive columns to reflect the pertinent factors related to "acoustic comfort." We know from the previous discussion that some customers will be expecting a quiet space for casual conversations, whereas others will be looking for a lively and loud space for music entertainment. We are trying to address customer satisfaction that is based on their expectations, So how to proceed?

Why not give the customer a "heads-up" on what to expect in different areas of a restaurant or bar? We could ask the owner to label the various areas within the hospitality space according to customer expectations. This might look like what is shown in **Figure 6,** ***right***. It should be noted that the entire purpose of this system of classifications is to satisfy the expectations of the customers who have chosen to go to this establishment relative to the acoustic environment that they will find when there. If the customer is satisfied, then the owners will be delighted. In any case, the issue of noise as relates to the employees will be covered under the US Occupational Safety and Health Administration (OSHA) occupational noise regulations.

And How Might This Work?

The business owner may wish to post a sign (as seen in **Figure 6,** ***right***) at the entry of the establishment to alert the customers that acoustic comfort has been rated by room or space within the building and that each space will have a visual notification at the entry to the space. A placard with the appropriate symbol can be affixed to the wall or ceiling on entry to that specific space such as the formal dining area, informal snacking area, or bar.

The rating system applied to a specific establishment has to be determined by the establishment owner, and this could be accomplished in a number of ways. The owner may wish to actually hand out customer satisfaction surveys on-site, use electronic customer surveys on their website, or review on-line satisfaction surveys from the local newspaper or restaurant rating services such as SoundPrint, TripAdvisor, and Yelp. In any case, it is to the advantage of the facility owner to help the customers choose wisely to meet their acoustic comfort needs. Happy customers mean return business.

What Does the Future Bring?

If we wish to move this classification system to a more analytical form as time goes on, then we need to look next to our "smart phone" because we now have many available apps that can be used to measure in real time and on-site the sound environment in any space. This will take additional longer term research into how to make the measurements. Currently, the SoundPrint app, for example, has a sound level meter feature, but the details and accuracy are not specifically discussed, other than that a minimum 15-second measurement period is recommended. Those of us who have conducted SoundScape measurements (sound-level time history survey at either an outdoor or indoor site) would likely believe that the measurement period needs to be related to the type of noise being measured, and 15 seconds is not sufficient as a general recommendation.

How to conduct these measurements would be a nice academic exercise. The classification categories could be based on an integrated sound level such as the A-weighted equivalent continuous sound level (L_{eqA}) over 15 minutes, with a value not exceeding something like 95 dB(A) for the highest noise spaces, and down to an L_{eqA} over 30 minutes, with a value not exceeding perhaps 50 dB(A) for the more casual dining spaces. Again, it would be dependent on the owner or other interested parties, maybe the National Restaurant Association, to conduct this type of research to identify the actual decibel-level ranges and how best to measure them.

Good luck and happy eating!

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BioSketches

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