Toronto, Canada
International Symposium on Room Acoustics
2013 June 9-11

Why Silence?

Robert Essert (bob.essert@soundspacedesign.co.uk)
Sound Space Design
2 St George's Court
131 Putney Bridge Road
London SW15 2PA
UNITED KINGDOM

ABSTRACT

In designing performing arts buildings we design HVAC systems to be silent, or at least appropriately quiet, and we isolate performance spaces from environmental noise and vibration. Different performing arts have developed in different cultural contexts and noise environments, and background noise criteria can, and should be derived from an understanding of the acoustics of the specific performance practice. For example, how important is information transfer? Or emotional connection? This paper investigates what is "appropriately quiet" for different performance types, based on the salient aspects of the performance and audience appreciation and experience over 30 years of consulting practice.

1 INTRODUCTION

As music and theatre audiences we feel lucky to experience a rapt and appreciative silence at the end of a moving music or drama piece, letting the overall effect settle in -- the entire audience holding its breath, still; the summing up of a profound connection between the audience and performer. We relish these moments. As acousticians we attempt to give performers a setting that will allow them to take us on this journey.

Background noise criteria were developed decades ago as simple descriptors based on balanced spectra. There now are various metrics for background noise: NC, NR, PNC, NCB. They were developed for general purpose use, without specific aspects of perception in performance spaces. Today we have a more sophisticated understanding of hearing and response to sound. We understand that the influence of background noise is a function of the spectrum of the information vs that of the noise, and of the time envelope, and also of the direction of the information to the direction of the noise.

Having recently joined Artec in October 1980 we opened the 2000-seat Centre in the Square in Kitchener, Ontario. The services were designed to PNC15, and more or less achieved it. But we could still hear the HVAC noise and filament noise, and that disappointed us. PNC15 just was not quiet enough for orchestra.

In 1981 we started work on the Meyerson in Dallas and a large project in Tampa. Nick Edwards and I created the "N1" criterion because there didn't seem to be anything defined quieter than PNC15 and we wanted a way to define in dB something quiet enough. I chose the octave band

threshold of hearing for continuous noise, and we named it N1 without thinking too hard about the name. Today one can use a similar NR curve.

In this paper we review the rationale and experiences that have kept us focused on the pursuit very quiet background levels for performance spaces.

2 INFORMATION TRANSMISSION

Room acoustics is a at one level a communication channel. Information transmission is better with a low level of background noise than when there is some competing noise. When absolute level is not constrained, we may discuss this in terms of "dynamic range". We have mathematical relationships between signal and noise, and we can construct criteria to allow a certain degree of information transfer.

What is information transfer in acoustics…specifically in auditoria? Is it speech intelligibility? If so, we can use tests of individual words or complete sentences. Or we can use related signal processing measures such as Speech Transmission Index STI (understanding that STI includes the effects of reflections as well as uncorrelated noise). Increasingly, especially in teaching-learning environments, audience members may be listening to speech in a language other than their mother tongue.

How do we know what background level is quiet enough? Is it just a matter of choosing the degree of fidelity you wish to achieve and designing to dynamic range and reverberation criteria?

"Fidelity" is complex; the room acoustical communications channel is not just a single channel, as a cable. In the context of a low signal/noise ratio our sense of hearing can separate streams of information to a greater degree when the streams come from, or appear to come from, different directions. Timing and timbre can also play a part in our ability to separate streams of information.

Getting the information across in a natural acoustic becomes increasingly difficult as the room capacity increases. As the audience gets farther away, the level of the direct sound is weaker and supportive early reflections become more delayed and less helpful, and the speaker 's consonants begin to be masked by the background noise. With lower background noise natural speech can be understood at greater distance. Electronic amplification can overcome background noise and enable full information transfer, but subjectively it places another barrier between performer and audience.

3 EMOTIONAL CONNECTION

In theatre and music sound goes far beyond information transfer. Artists convey their heart and soul to the audience through emotional connection with their voices, instruments and movements, and through ensemble work with each other.

There is not a direct objective scale for impact of this sort. We can talk about "impact" as in loudness, strength, "hit you in the chest" impact. But that is only one element of impact (and a very important one). We can recognise the deep impact that can be conveyed through phrasing, timbre, vibrato, rubato and other flexibilities. And yes, silence

Speech and vocal music are especially good channels for communicating emotional content because (a) the voice has a wide range of expression and (b) we are all experienced at giving and receiving with the voice.

4 SCALE OF SILENCE

How quiet is quiet enough? Could we have a scale of silence like we have a scale of loudness? Where quieter is stronger? What would we call it? Quietude? Consider as a starter this following 6-level scale.

Calm	Recognisable as quieter than average. May include audible, but unrecognisable talking. Birdsong and other "natural" sounds that we consider pleasant, are not loud and carry no particular information for us.
Quiet	No talking, but some movement.
Still	Not moving, still
Silence	Everyone concentrating
Focused silence	Everyone concentrating on the same thing
Intense silence	Holding your breath, listening for the quietest utterance

5 PARAMETERS AFFECTING THE IMPACT OF SILENCE

When we look at what are the main parameters of silence, our starting point might include to a limited extent the same parameters we understand to affect the perception of loudness:

Threshold of perception for continuous noise as a function of frequency

Equal loudness curves as a function of sound level and frequency

But does silence have dimensions of colour or timbre? If it does, it is probably affected by the timbre of the sound just before or after.

The time envelope is certainly important. Short, sharp silences have a different effect, different meanings, than a long, slow diminution of loudness. The characteristics of sound that frames a quiet moment is important, in part because our sensory nervous system is programmed to respond to change. Repeating silences, like repeating noise, are perceived differently than single silences.

Room reverberation overlays a natural envelope over the direct signal, so that transitions to and from silence are modified by the room. Performing artists adjust their delivery to the speed of the room — whether it is stopped chords of a symphony or a dramatic statement by an actor. In western music there are specific terms and markings for dynamics (forte, piano, pianissimo) and for rate of change of dynamics (decrescendo, subito piano), and these are interpreted by artists in the context of the room reverberation and the room background noise.

When silences are long enough and transitions slow enough for us to process cognitively, we fill in our own personal interpretations and feelings.

6 SILENCE CARRIES MEANING

Silence carries cultural, social, political and personal connotations.

In his book "The Power of Silence" Colm Kenny[1] explains how in ancient Greek society "voice" was part of the essence of humanity and silence was associated with darkness and imposed on those in an inferior position. Women were to be silent.

Silence in personal relationships can imply weakness or strength. It can be purposeless or purposeful. It can make a place for God.

So, is the essence of silence (a) the *depth* of the absence of sound (how quiet is it), or (b) *meaning* of the absence of information? The former is the more sensory, the latter more cognitive. I believe both are important.

The perceptual effects of silence are not just inversions of their sound counterparts. Silence is more like another subject than an absence. I suspect that increasing quietude turns on different neural circuits than merely decreasing amplitude.

7 SPECIFIC PERFORMANCE TYPES

7.1 Drama

We have all experienced powerful moments of silence in the theatre. At the end of Hamlet Shakespeare acknowledges the mystery of death: "the rest is silence" is often staged with a considerable pause for audience reflection in silence. Moments like this are all the more powerful in a very quiet theatre.

At first order, quiet is important to achieve intelligibility of text and clarity of the spoken word at lower loudness levels. A good actor in a good play can project his or her voice, emotion and energy to the entire audience in challenging circumstances. But the intensity of a quiet moment in the theatre does depend on the depth of the silence, and the concentration of the audience not being broken.

Drama includes silences for effect – what we call dramatic pauses. Some are for comic effect, others for tragic. Most are designed to get the audience to think beyond the current sentence to some association in the play or elsewhere in their lives. The position of the silence in relation to the sounds before and after it influences its power. This is not just about loudness envelope, but also the intensity of meaning -- which is carried by the text and the delivery; the voice and the movement.

An actor can draw the audience in closer when the background noise is absent, inviting the audience into her world, and sometimes into her soul. This can be done quickly or drawn out over an extended time. Audiences will follow the lead of a great actor into the depths of despair, the fear of the unknown, but the intensity of the result depends on both the skill of the actor and the degree of quietude.

In order to give the performers the acoustical space to do this, we need to design theatres with a silent background. HVAC systems are a primary concern, in that most performance spaces need ventilation, at least, and the equipment and mechanical engineering approaches are geared more for buildings where noise is not so critical.

In our experience continuous background noise limits the overall quality of the experience more than occasional mild intrusive noises that carry no significant information. Occasional sounds are unlikely to coincide with the most intensely quiet passages in a play, whereas continuous sounds act like a haze, limiting the clarity of perception when you're near the threshold., and it's there between most syllables. So, when the budget is very tight, we would rather reduce the protection from outside noise than increase the HVAC background noise.

Noises to be silenced for maximum quality of speech plays include: lighting noise, flying system noise; digital electronics (network switches, PCs, power supplies); control consoles and their power supplies. Of course some shows have theatrical effects, such as smoke machines, lasers, projectors and the now commonplace moving lights, and while the marketplace doesn't care to engineer very quiet equipment,

7.2 Unamplified music

Silence in music is both content and context. John Cage's 4'33" is not the same as a blank track. It depends for its effect on what might be heard in a room with musicians and audience (and perhaps also what might be seen). In 2004 I attended the BBC Symphony Orchestra concert in which they gave its first UK orchestral performance. It was very much about being there. The BBC made a point by broadcasting it live on radio.

Kenny outlines how in vocal music absence of voice or other solo part can have meaning. God is beyond words in many places in music. In his Moses und Aron Shoenberg's Moses lacks the ability to vocalise what he is thinking, what he has heard from God. John Tavener uses silences in his religious music to express a "longing for God".

Some music is compressed into a narrow dynamic range. Other music has its greatest impact when there is a wide dynamic range, where loud is very loud and quiet is very, very quiet.

In unamplified music the instruments and voices have limited power, and so the strength of sound is limited by the audience capacity, among other things. Our goal is to maximise the sonic dynamic range in order to allow the performers to maximise the dramatic impact of the music. Many musicians do "play the room", and one part of that is to strive for a super-quiet pianissimo. The range of this expression is limited by the continuous background noise

Musicians also want to communicate the *quality* of sound at very quiet dynamics, to know that the timbre and phrasing of the sound on which they work so hard could be appreciated by the audience in the last row.

In opera we have the combination of music, acting and technical theatre. Equipment noise sources operated during the music include flying systems, smoke machines, huge elevators, large rolling wagons, motorised turntables and moving lights.

But there are times when the audience is drawn into the stage world. When the conductor and director collaborate to achieve a magic pianissimo of shimmering strings or a whispered

utterance from a singer, audiences do get quiet. It does take teamwork – the machinery stilled, potentially noisy lights turned off.

In a large part of the opera repertoire recitatives are declaimed with gaps between phrases and just a small accompanying continuo group of instruments playing. In a large auditorium the text can come through more clearly if the background is very quiet. Both the Four Seasons Centre and the Winspear Opera House were designed to the so-called "N1" criteria. It is clear that some part of the vocal presence and overall acoustical quality in these halls is due to the low background noise.

7.3 Dance

Footfall noise can be a concern to dance companies. Some dance companies have built up an argument that the room should not be too quiet because the movement then becomes "noisy" with the noise of point shoes on the floor, whereas they envision the movement in silence.

The NYC Ballet made a case – then imported to the Miami City Ballet -- that the room acoustics should not project the sound efficiently from the stage. This is, of course, the antithesis of the goal for opera. This may have had a negative impact on the acoustics for opera in the original design of the NY State Theatre (Now the Koch Theatre) and was certainly in the air in later renovations. I think this fear is somewhat of a red herring.

This argument entered our project for the Four Seasons Centre, but only mildly. The Canadian Opera Company was the Client, and the opera acoustic was the higher priority. We guided the design of the stage floor to damp the radiation (for both opera and ballet), but did our best to project stage sound for opera, and achieve a very quiet background noise level. The National Ballet of Canada and the COC are both quite happy with the results.

7.4 Amplified musicals

It may seem that quiet background noise is not important in today's highly amplified musicals, but I submit that it the audience experience is better when the ventilation and performance equipment are not audible. All too often the background noise is quite distracting. Sometimes the sound reinforcement is compressed, even in live theatre, to overcome background noise. It comes back to focusing on information transfer, and losing the performance subtlety. It's too bad, because the people in charge are theatre people, and have experienced the amazing impact of quiet moments.

7.5 Chinese Opera

We are working on a project in Hong Kong to create a new theatre specifically for Chinese Opera. There are many styles, not just one, and as a group they are called Xiqu. The variously comprise speech, singing, an orchestra, movement, dance, acrobatics, martial arts, and involve elaborate costumes and makeup, and simple staging and lighting.

The Cantonese culture is noisy, Hong Kong is a noisy city. The outdoor performance tradition has moved indoors, except for the temporary bamboo theatres. Performances include a very loud percussion section, with the other instruments and voices amplified. There has been considerable discussion and incentive to accept the noisy cultural context and amplified performance practice and not to design for silent services noise. We are working with NR15

and not higher because the Client wishes to showcase the older, subtler forms of Xiqu from Beijing and Shanghai, where the quality of sound without amplification is still appreciated. We aim to allow the singing gestures and speech to come through clearly with little or no amplification.

8 CONCLUSION

Silence plays an integral role in acoustical quality. It is not an add-on or an option. The key is to integrate the discussion about silence and background noise into a discussion about the art form and to make decisions on criteria to guide the M&E services design in support of the performance.

REFERENCES

1 Colm Kenny, *The Power of Silence,* Karnak Books, London (2011)