4. The Room Where Music is Recorded

Recording takes place in an enclosed space, which could be a bedroom, a classroom, a recording studio, a concert hall, or a cathedral. (Recording can be done outdoors under ideal conditions, and it has a unique sound, but it is not often practical to do so.)

The space where music is performed has a large impact on how it sounds. A poor room may makes us feel uncomfortable about the recording. This can be entirely unconscious.

So what makes a good space for recording? Well, the size of the space is very important. We get auditory cues about the size of the room, based on the time it takes for the sound to be followed by a reflection or echo. Humans are very good at this, which can sometimes be unfortunate, because bad-sounding rooms are very obvious to us. A bad room could sound “boxy,” or claustrophobic – or it might have many unpleasant echoes that make it difficult to understand the lyrics or make sense of the notes being played.

The reverberation time of a room is the time it takes for the echoes of the initial sound to decay to inaudibility. (It’s actually more scientific than that, but this will do for our purposes.) A small room might have a reverberation time measured in milliseconds (thousandths of a second), while a large cathedral can echo for many seconds. Neither extreme is good for most music. It’s also possible to record in a room with no echoes whatsoever – an anechoic chamber, which sounds very unnatural to our ears.

Most of the great recording studios in the world have a reverberation time of one to two seconds. If the nature of the reverberation sounds natural to us, those echoes compliment the music and make us feel like we are in a comfortable space.

A concert hall might have a reverberation time of several seconds. Classical composers create music that is meant to be heard in a concert hall, and the conductor, musicians, and recording engineer also take this into account and can use the reverberation to add excitement and drama. Controlling the ratio between the direct sound from the instrument and the reverberation requires good microphone placement for the effect desired. Too close, and the reverberation is mostly lost. With a microphone too far away, the reverberation dominates our impression of the sound. The instrument or voice sounds distant.

The ideal reverberation time depends largely on the music. Chamber music was meant for a space smaller that a concert hall, perhaps more like home-sized room. Folk-style acoustic music sounds best in a smaller room with little reverberation. A room that has almost no reverberation may contribute to the intimacy of very personal music.

The music should drive the choice of the recording environment. Many recording studios have to accommodate a wide range of musical styles, and that requires skilled engineers to make it sound appropriate for the performance. Some studios have methods to adjusting the acoustics to a limited extent.

In this discussion, a small room would be a typical household room. A medium room could be 35 feet or more in most dimensions. Obliviously a concert hall is much larger than that. It could be hundreds of feet in width and depth, with a very high ceiling.

The reverberation time is affected not only by the size of the room, but also by the surfaces in the room. A room made out of stone, like a cathedral, is going to have much more reverberation than a space with drapery all around. An inappropriate reverberation time can ruin the music, so the natural characteristics of the room are important.

Many recordings utilize artificial reverberation to provide the illusion of the proper space for the music. Artificial reverb can conflict with the natural reverberation time of the room and degrade the sound, so many recording studios are purposely designed to have a short decay time. Or perhaps there is no discernable reverberation at all -- the room is considered "dead." This is one solution, because a dead room can be modified with artificial reverb to make it sound like any sized space you want. That makes the engineer's job easier, but is it the best solution? I would say no, but there are many hit records made in very dead rooms, so it is not impossible. Dead rooms are not comfortable for musicians to play in either.

Another requirement for a recording studio is isolation from the outside world. There is a lot of misunderstanding, even among some audio professionals, about how to stop outside sound from intruding into the studio. Absorptive materials, like household thermal insulation, or drapery, do very little to stop sound intrusion. The only thing that works is mass -- big, heavy walls that are tightly sealed. Even a tiny gap in an otherwise solid and massive wall can seriously degrade the sound isolation, so great care must be taken in the design and construction of a soundproof studio. Any doors or windows need to be specially designed to stop noise transmission. Heating and air conditioning ducts need to be properly designed and constructed to operate silently, and prevent sound transmission between rooms. Needless to say, a proper recording studio requires very expensive construction techniques. No one wants to hear trucks passing by, people talking, or airplanes flying overhead on their recording.

With the advent of low-cost, high-quality recording equipment in the 1990s, it became possible to outfit a studio at much lower cost than it took in the past, when a single tape machine could cost as much as a house. This has opened up recording to anyone with a few thousand dollars to spend, and experienced people have made great records in their living room, bedroom, or basement. But the laws of physics still apply to the home recording studio, and eliminating outside noise (or bothering the neighbors), and designing the space to have a good "sound" can be challenging. It’s especially difficult because most homes do not have a room large enough to permit pleasant reverberation.

Not only does the recording space affect the sound of the recording, but it can also affect the performance itself. Musicians often unconsciously tailor their playing style to fit the room in which they are performing.

Small recording spaces cannot duplicate the natural reverberation time of a large room and require artificial reverb (or none at all, which can also be effective for some types of music). And recording at home allows a performer to re-record a performance if a dog barks or a truck goes by, an option that would not be acceptable in a professional studio. And, as we will see in a future installment, many of the problems of a small, acoustically uninteresting space can be mediated by the recording technique: performing all the instruments and voices one at a time, layered one on top of another to achieve the final product.

Let's look at how we can modify our recording space to get the best sound out of it. First we have isolate our recording space from the outside world. The next step is to optimize the room for recording. We have three basic tools for doing that: room proportions, absorption, and diffusion.

As a general rule, the larger the space, the easier it is to make it sound good. Small rooms are much more challenging.

The proportions of the room may seem like it would only affect the visual aesthetics of the space, but the ratio between the height, width, and depth of the studio can have a profound impact on how it sounds. This applies to all rooms where acoustics are important, including the recording control room, a listening room, a classroom, a church, or a concert hall.

Maybe it is because I have designed quite a few recording studios that I find that a room that sounds good also has proportions that are visually pleasing.

All enclosed spaces, no matter how large or small, will have certain audio frequencies that are emphasized, and other frequencies diminished, depending on the spacing between any two boundaries of the room. That is physics and cannot be substantially changed. However, if any of the three dimensions is an integral multiple of another room dimension, you can have certain frequencies "build up" disproportionally, and that is very audible. The worst case is a cube, which will have a characteristic sound that is very uneven in frequency response, perhaps 10-30dB of variation over the audible range. It will sound unnatural and unpleasant.

This is particularly a problem in small rooms because the frequencies that are often the most problematic, 300 to 700Hz, will fall in the mid-range of the audio spectrum. This makes the sound "muddy" and indistinct.

Also, many homes built in the last 70 years or so utilize standardized building materials, usually in multiples of four or eight feet. A room might be 12 by 16 feet, with an 8-foot ceiling. That room is not going to sound good.

Acoustical designers mitigate this problem by using non-related dimensions as the fundamental overall dimensions of the room. You can find on-line references, formulas, and calculators for determining what should be "good" proportions for a room. That's a lot easier than in the pre-computer days when you had to calculate the room's audio peaks and nulls by hand on a piece of paper.

Even a room with perfect proportions for audio is still going to sound bad with just bare walls. The walls might be made of drywall in residential or commercial construction, but studio walls are usually made of concrete block or equivalent. This type of wall is much more sound-isolating ("soundproof") than drywall. Almost all the sound in the space is going to echo around until it dies out. This room will be highly reverberant, which might be great if it is very large and designed for classical music recording. A smaller room will sound more like a garage – not appropriate for sound recording, or listening.

To reduce the amount of reverberation, we can add sound-absorbing materials to the space. Most people think of things like thick carpeting, acoustic tiles on the ceiling, heavy drapery, or household insulation (fiberglass or mineral wool) to absorb sound. Remember, these do little to "soundproof" a room.

These materials absorb frequencies very unevenly. The examples above are good at absorbing high frequencies (above about 2kHz), but are almost totally ineffective at lower frequencies. The lower the frequency, the less the absorption. Those mid-range frequencies so often emphasized in smaller rooms with less-than-ideal proportions are hardly absorbed at all. The result is a sound that can still be “boomy” or “muddy,” and yet also sound very dull and “dead” due to all the high-frequency absorption.

Absorbing low- and mid-frequencies is challenging in small rooms. The absorptive material must be quite thick, feet instead of inches, to have any effect on those lower frequencies. The larger the room, the easier it is to make it sound good, and the space available makes it practical to use large structures to absorb low and mid frequencies.

The low frequency absorption problem might actually be easier to solve in a typical home because of some characteristics of the drywall-on-wooden studs construction allow a lot of bass energy to pass right through the walls. I’m sure you can think of examples of this in your own experience. What passes through the wall is essentially gone and does not contribute to low frequency reverberation time in the room. Of course, it doesn’t help your relationship with your neighbors, nor block out the sound of a passing truck.

The same rules apply to the ceiling and floor. It’s easy to forget their contribution, positive or negative.

In most well-designed recording studios, the ceiling is at least 15 feet high and absorptive, since the ceiling is usually the easiest place to add a lot of deep absorptive material. And this is more comfortable for the performers, because our ears do not like reflections from above (hundreds of thousands of years of humans living mostly with nothing above them but sky probably has an impact on what seems natural to us). In a studio, floors are usually wood or other hard surface, although rugs can be deployed to control the floor reflections somewhat.

Abbey Road studios have walls made of a double layer of bricks, which are set end-on as you look at them. It is a highly reflective surface for sound. These rooms, built around 1930, are among the finest sounding recording studios in the world, due to their large size and excellent proportions. They employ some sound absorbing material in sections of the walls, and more so on the ceiling. They rely on a pleasant and carefully controlled reverberation time to achieve the core of their sound.

The last tool we will discuss on this topic is diffusion. This is simply the scattering of the sound as it hits a surface. If a painted concrete wall is the sound equivalent of a mirror, a wall with diffusion could be thought of as one with a very uneven surface, perhaps a room that has a lot of connected smaller rooms, or massive columns, like you would find in a cathedral.

The key principle is that the sound is reflected off of many surfaces that are varying distances away from the sound source. That breaks up the reflections in time, which we find much more pleasing than a hard, distinct echo.

That’s the principle used by devices called diffusors: they present an uneven surface with random high and low spots, spreading out the reflections in time.

One way to do this is with random-sized blocks made of fairly reflective material like wood, mounted over a section of a wall. Another technique combines absorption and diffusion in one unit, using random-sized wooden slats, perhaps set at random angles, and backed by highly absorbent material. A third technique uses a cylinder, or a section of a cylinder, to reflect the sound at different times depending on the diameter of the diffusor.

But to be effective, the diffusion surface has to be large, and the depth of the “holes” and the height of the “peaks” has to be significant. Differences measured in feet is better than a difference measured in inches. This can take up a lot of space in a small room.

But diffusion does not have to be purpose-built. Abbey Road Studio 2, where the Beatles and many others recorded, has no dedicated diffusion at all. However, the room is big, roughly 60 by 27, with a 28-foot ceiling, and it is filled with a lot of stuff: several pianos, organs; racks of headphones; carts full of folding chairs; many microphone stands, etc. All these things in the room provide a lot of diffusion.

When I started doing some informal recording in our manufacturing area, the rows of metal shelving holding hundreds of cardboard bins full of parts provided a very pleasant diffusion for the “studio.”

Studio designers often incorporate diffusion into the design, with uneven walls, often made of wood, and sometimes specifying a non-rectangular room. Large cylindrical diffusors can be designed into the structure, which scatter the sound in all directions. (Note that these wood walls are inside the primary heavy sound-isolating walls.)

Optimizing the sound of a recording space is often a trial-and-error process, as the problems are identified and a solution determined.

Using the tools of absorption and diffusion, along with optimal proportions, results in a recording space that sounds good for the purpose.

This is My Take on Music Recording. I’m Doug Fearn. See you next time.