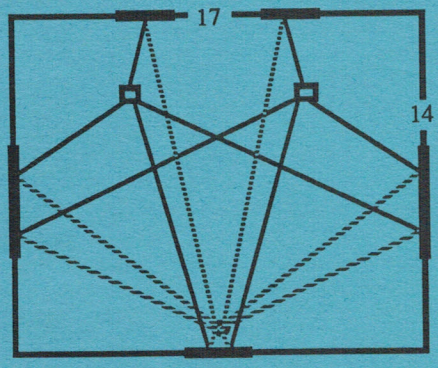
somehow, you just don't get that "you are there" kind of feeling. The sound is just too "dead." You feel like you're in outer space as opposed to any earthlike listening environment. Since the Sonex absorbs from 500 Hz up, but does nothing to the reflections and resonances below 500 Hz, the sound seems lower midrange and bass heavy. It is just not a pleasant listening experience.

Figure 3. Avoiding Early Reflections



Research has shown that people do not like to listen to music in all absorbing, dead environments. Instead, they prefer environments with a reasonable amount of diffuse, ambient reflections that allow a sound source to bounce around softly and non-coherently in the listening room. While the direct sound provides the listener with the basic musical information including imaging and soundstaging information, the ambient reflections provide the listener with a feeling of being in a real live room. While the direct signal is providing the listener with an "image" of the live instruments, the ambience provides the listener with an image of a pleasant listening environment.

The Diffuse Sound Field

Just providing lots of reflections does not a pleasant listening environment make. As mentioned earlier, "early reflections" cause interference with direct sound, so they must be avoided. Also, coherent reflections (not smeared in time) also have their problems. Non-early coherent reflections provide distinct echos. The best listening environment is one in which there is a diffuse sound field. Its like being immersed in sound from all directions. This ambient sound is significantly lower in level than the direct sound, and is so non-coherent - so smeared in time - that it loses all detail of the original instrument. All that is left is a sense of the basic tone of the instrument. Due to the fact that the ambient sound is much lower in level than the direct sound, and that it only carries the basic tone of the original instrument, it does not cover up the detail of the direct sound. However, it does provide a realistic listening experience, because people just don't exist in environments with direct sound only. Ambience is required for pleasant listening.

To provide you with a comparison, imagine the Sun as the sound source. An environment with direct sound only would be like being in outer space with nothing but the Sun. You would see (hear) the Sun, but everything else would be black (silence). Kind of stark, don't you think? An environment with diffuse sound only would be like being here on earth in a dense fog during the daytime. You would see light all around. It would be white light, following the nature of the light of the Sun, but it would be non-coherent and non-directional. It would be coming from everywhere. An environment with lots of direct sound, plus an ambient sound field would be like being outside on a sunny day. Most of the light present would be direct light from the sun, but there would also be lots of ambient light coming from reflections off everything on the earth, plus the diffraction of light coming down from the blue sky.

So, what makes up a diffuse sound field? As mentioned earlier, a diffuse sound field is one in which the ambient sound is non-coherent, and non-directional. It is made up of thousands of multiple bounce reflections. A large percentage of these reflections must be diffuse in nature; they must take a sound coming in at one angle, and break it up, sending small fractions of the original sound in many different directions. Most of these small fractions of sound don't stop after just one reflection. They bounce off of other reflectors and get spread out even more. Within about 100 mS, the room is full of reflections going in every direction. Each one has traveled a different path, with different path lengths. When the sound waves traveling by the listener are all added up, the resulting sound is non-directional due to the sound coming from all directions, and non-coherent due to the time smearing multiple path lengths.

Decay of the Sound Field

Eventually, these ambient reflections die out, because at one time or another as they bounce around the room, they hit an absorber and are absorbed. The amount of reflective surfaces and the amount of absorptive surfaces determines how long these multiple reflections remain audible. How fast the reflections die out is known as the decay rate, and most people seem to prefer a decay rate that will cause the diffuse reflections to remain audible about 1/2 second. The proper balance of diffractors and absorbers in required to achieve a pleasant diffuse sound field with a desirable decay rate.

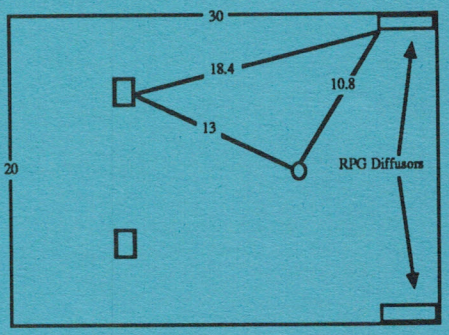
Creating a Diffuse Sound Field

Typical bare rooms do not have many diffractors or absorbers. When furniture and carpet are added, they can add a significant amount of diffraction and absorption. Still, a few pieces of furniture spread out sparsely is not significant enough to provide a good diffuse sound field. Additional diffraction and absorption are needed. One source of good diffractors that also look quite nice is large house plants. The curved leaves are angled in all different directions, causing many diffuse reflections. Heavy pleated drapes are generally diffractive and absorptive. When typical room furnishings do not provide enough diffraction and absorption for a good diffuse sound field, you must resort to products made specifically for the purpose.

ASC Tube Traps perform dual duty as absorbers and diffractors. These absorptive cylinders can absorb all frequencies from low bass to upper treble. However, they can also be used to diffract frequencies above 400 Hz. Half of the cylinder is covered with a high frequency curved reflector under the cloth exterior. If this half of the cylinder is facing into the room, sound waves from 400 Hz up will be reflected in a diffusive pattern, thus helping to produce a pleasant ambience. The amount of reflection and absorption can be balanced to your personal preference by rotating the cylinder.

Another product that has received good press as of late is the RPG Diffusor. This product is a series of different frequency resonators all connected together in a large wooden box. When the box is placed against the wall, sound waves hitting it cause the resonators to resonate in such a way that sound emanates from the RPG diffusor in all directions. The sound is made even more non-time aligned and non-phase aligned than the sound coming off of a curved surface diffusor. This is great for producing a very diffuse field very fast, but caution should be observed. Placing these diffusors near the speakers can cause too much diffuse sound to be produced too soon, with too much amplitude. Even though the RPG diffusor spreads the sound around, enough of the sound can be heard as an early reflection, thus ruining the imaging and soundstaging capabilities of the system. The early reflection path length rule should be used here as well. The path difference from direct sound to the sound heard that "reflects" off of the RPG diffusor should be at least 15 feet. This limits their use in most listening rooms. An example of a good use of RPG diffusors is shown in Figure 4. Two diffusors are placed across from each other on the side walls a few feet behind the listener. They add a good diffuse sound field behind the listener which gives more of a sense of listening in a much larger environment. However, they do not cause early reflections, because the direct to reflected path length differences are all greater than 15 feet.

Figure 4. RPG Diffusors



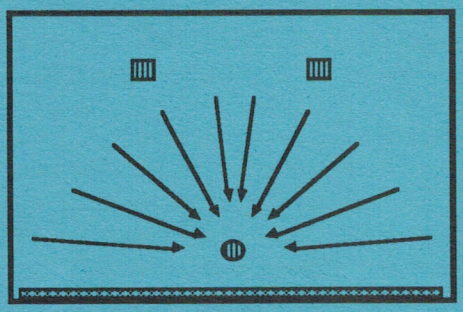
Direct Path = 13 Ft
Reflected Path = 29.2 Ft
Path Difference = 16.2 Ft

Reflections from the Rear

In order to sound right, a diffuse sound field must be truly diffuse. Having sound coming from all directions in front of you without having any sound coming from behind you produces a strange feeling. This is what can easily happen in many small room listening environments. Figure 5 shows a small listening room with the listener seated with his head 1 foot in front of the wall behind him. In order to avoid the early reflections that most certainly would be heard from the back wall, he covers the wall in Sonex. This solves the early reflection problem, but it also cuts out any ambient reflections that would be coming from the rear wall. The diffuse ambient sound field has been cut in half. Sound is coming from all directions in the front hemisphere, but no sound is coming from the rear. The ear can hear this

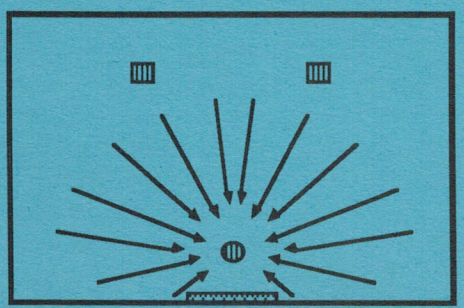
difference, and it sounds very strange. Its kind of like imagining the front half of your body in a pleasant listening environment while the back half of your body is in completely silent outer space. Instead of being amongst the music, you are detached and isolated. Many people who have tried this didn't like it and took all of the Sonex down. Still, there's a better way.

Figure 5. No Rear Reflections



A solution for this problem requires that early reflections be eliminated, but other ambient reflections from the diffuse sound field be allowed to continue. If early reflections from the side walls have been eliminated, the only "early" sound headed for the general listening area will be the direct sound. Fortunately, all of the direct sound that the listener might hear as an early reflection will be headed for the wall behind the listener's head at a relatively shallow angle of incidence; typically, 30 degrees or less. Thus an absorber that is only wide enough to catch the direct sound that would cause early reflections can be placed behind the listener's head, thus eliminating the early reflection problem. Figure 6 shows an example of this. Sound from the diffuse sound field that is moving in all directions throughout the room (except away from absorbers) is allowed to reflect off the wall area around the absorber towards the listener's head from the rear. The result: Lots of diffuse sound from the rear without any early reflections. In the typical situation, a 2' wide absorber will be sufficient for listeners seated within a foot of the wall. A 3' wide absorber will be needed if the listener is seated 2' from the wall. Just add 1 foot to the distance from the wall for the width of the absorber.

Figure 6. Rear Yes; Early No

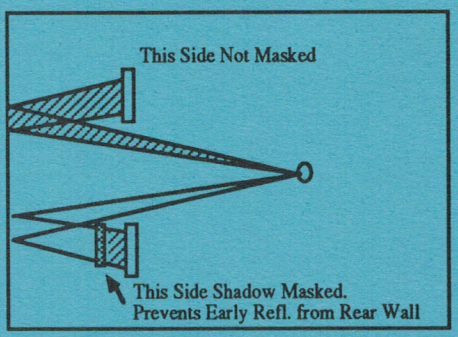


Other Acoustic Solutions

There are many methods of producing good listening environments that have been promoted throughout the years. One is the Live End Dead End (LEDE) room, where the part of the room from the listener forward is completely absorptive, and the part from the listener backward is very live and ambient. This solves most early reflection problems, and provides a good amount of ambience, but all of the ambience is from the rear. Once again, it is a somewhat strange sound.

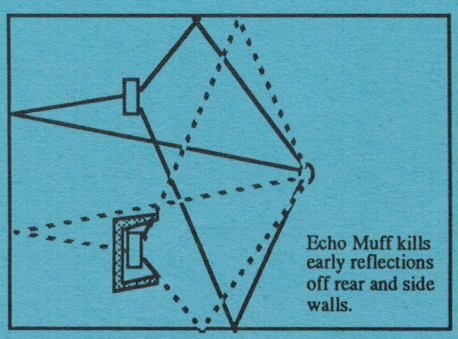
As an alternative to placing absorbers on the walls, shadow masking can be used to eliminate many early reflections. Instead of absorbing the sound where the offending reflection occurs on the wall, that section of the wall is "shadowed" by an absorber that is much closer to the speakers. An example of this is shown in Figure 7. Shadow masking is commonly used with dipolar speakers that have a lot of sound energy coming out the back of the speaker. The wall area between the speakers will have two significant early reflections coming off them, one from each speaker. Absorbers can be placed behind the speakers so that the path from the speaker to the wall is blocked, thus eliminating the early reflections. Other areas of the rear wall will still receive the sound energy from the speakers, thus adding to the diffuse sound field in the room.

Figure 7. Shadow Masking



A more intense version of shadow masking can be found in the product known as Echo Muffs. These U-shaped absorbers go around the sides and back of the speakers, thus preventing the upper frequency sound from going anywhere except in the general direction of the listener. Most early reflections (except from the wall behind the listener) are eliminated, but so are many of the diffuse reflections that produce a pleasant ambience. If the Echo Muffs aren't restricted to too narrow of a propagation pattern, a lot of the sound headed for the listener's side of the room can be reflected off the back wall, and thus provide a reasonable amount of ambience in the room. Figure 8 shows an example of using Echo Muffs to avoid early reflections.

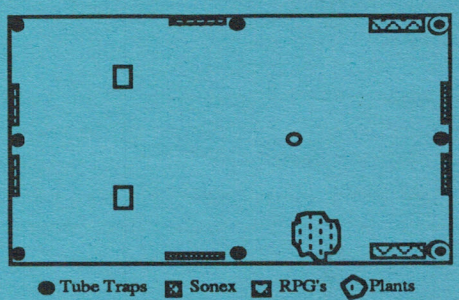
Figure 8. Echo Muffs



Conclusions

If you've read this far, you now know that reflections can have a significant effect on the sound of a music system. Until recently, few people have looked at the effects of reflections on sound in the listening room. Everyone's been working hard on improving turntables, electronics, wires, and speakers, but they have ignored the listening room: the last and weakest link in the audio chain. Now, the listening room is finally getting some attention. More people are understanding what is going on in the listening room. They are learning about good and bad reflections, about resonances and sound decay rates. They are learning how to create optimum articulation within a pleasant ambient environment. They are building effective acoustic environments by looking at the problem scientifically, and producing solutions to those problems. Figure 9 shows an example of good acoustical treatment for a large listening room. Sonex is used for absorption to remove early reflections and speed up the decay rate. Large house plants and RPG diffusors help to provide large areas of diffusion to help produce a pleasing ambient sound field. Tube Traps provide diffraction of upper frequencies, as well as absorption all the way down into the bass to clean up the muddiness and poor articulation.

Figure 9. Example



People who ignore their listening room and the tools that can be used to improve it are not getting the most for their money. They're getting 90% performance out of their stereo system, but only 50% performance from their listening room, with a result of about 45% performance. Buying a new preamp may get them 94% performance from their system, thus raising the result to 47%. However, they could spend the same money plus some time working on their listening room, and improve its performance to 80%. Their net performance would then be 72%, a much larger improvement than the new preamp solution.

The bottom line is this: Don't ignore your room acoustics. There are a lot of things you can do to improve the sound at little cost: House plants for diffusion, and Sonex for absorption of early reflections. More elegant solutions exist for those that want premium performance. ASC Tube Traps provide broadband absorption to get rid of muddy bass, increase articulation, and speed up room decay rates. They also provide diffusion to create a pleasant ambience in the room. RPG diffusors have their place in large listening rooms where they can create a larger sense of ambience such as might be found in large listening halls. Echo Muffs can help deaden really live rooms while eliminating early reflections. All of these are useful tools, and should be considered by any audiophile who wants to have truly great sound.