Acoustics vs. Emotion

Norman Varney

Acoustics is much more important to home theatre than most people realize. It makes or breaks the experience. It is the difference between belief and disbelief.

Have you ever known music to move you to tears? Ever held your breath during a movie in anticipation of a frightening event? Did you jump watching the "Dark Lake" scene from *Harry Potter And The Half-Blood Prince*? My mom shushed my daughter from disturbing "the audience" while we were watching the DVD of Tchaikovsky's *Swan Lake* performed by the American Ballet Theatre in our home theatre. These are moments of willing suspension of disbelief. They are difficult to achieve when there is too much interference, missing information, and distortion. Having an acoustically controlled environment insures you will receive the maximum experience.

What Is The Experience?

When we listen to music or watch a movie, we are often taken on a journey. The journey ebbs and flows as it travels up hills and down valleys. Of course, I'm talking metaphorically about how, as we sit there, unable to control the scene, it has control over us. The whole reason why we are sitting there in the first place is to be entertained. We can be selective regarding how we want to be entertained, meaning, we may choose sad music to feel melancholy or watch a comedy to get happy. We may even find music or movies that take us through many emotions: scared, thrilled, caring, angry, nostalgic, relaxed, excited, etc. These are subjective conscious and subconscious reactions to aural stimuli. They are brought on by our collective imagination, memory, intelligence, and desires. They are responses. More specifically, they are feelings.

Some people are more sensitive than others. Some characteristics of sensitivity, whether physical or mental, we are born with, while others are developed through our personal experiences. For example, when talking about artists, who are inspired and desire to create beauty, some are more sensitive visually to colors and imagery, while others are more sensitive audibly to harmony, rhythm, loudness, etc. There are those who are more dominantly conscious of the visual world and others of the auditory. It is said that effective situations and tendencies towards effective responses lead to an increase of intensity that is driven by the individual's talents. Even within subcategories, you find that artists with particular fortes develop more power of discrimination, a larger, richer storehouse of experience in that area of interest. They have more neural traces for stronger memory in their area of interest and hence become experts. In general, artists are conscious of form and beauty. This consciousness often spills over into other personality traits, like how they dress, irritability, whether they are extreme introverts or extroverts, and their overall sensitivity to the world around them. I'll bet you can easily think of several quirky artists, right?

At its most basic level, experience is either good or bad. When talking about the experience of a movie or piece of music, it either moves us positively or negatively. Rarely do we think nothing of it. We always have opinions and it is human nature to want to share them with others.

Willing Suspension Of Disbelief

The poet/philosopher Samuel Taylor Coleridge coined the term in 1817. He suggested that when writers capture and infuse "human interest and a semblance of truth" into an imaginary tale, the reader would suspend judgment concerning its improbability. Suspension of disbelief often applies to fictional works of the action, comedy, fantasy, and horror genres. Cognitive estrangement in fiction often involves using an individual's ignorance to support suspension of disbelief. Often it involves using the individual's imagination to fill in the missing information.

Sometimes the artists ask too much from the audience to achieve willing suspension of disbelief. I had trouble with all the Germans having English accents in the movie *Valkyrie* with Tom Cruise.

Poetry is often full of representations and imagery that cannot be taken literally—as well, the antics in cartoons, or the time intervals for events within an episode that would normally take weeks or months to occur, or incredible physical stunts and enormous destruction. Even simple two-dimensional, black-and-white movies, smaller than life, can take you to another world, at another time. When not very realistic, we require our minds to fill in the blanks and ignore the impossible in order to be entertained, rather than frustrated.

Silent Movies

When silent movies first appeared, the reception was rather perplexing. Without any audible cues, the audience frequently did not know whether to laugh or cry when the villain was hit over the head with a chair. Straight away, music was incorporated to set the mood and guide the audience. It began in 1895 in Paris with piano accompaniment. In the 1910s, movie houses in large cities had organs that included sound effects like sirens, thunder, and horse gallops, while some theatres had small musical ensembles. The first designated film score was composed by Camille Saint-Saëns, for *The Assassination Of The Duke Of Guise* in 1908. At their peak, silent movies were the single largest source of employment for instrumental musicians in America. Silent movies were our first clue as to how important audio is to storytelling.

Pictureless Talkies

You are probably too young, as I am, to know of the days when people would sit close to a big wireless wooden box from which programs of adventure, comedy,

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drama, horror, mystery, romance, thrillers, and musical variety emerged. This was known as the Golden Age of Radio. When such programs were broadcasted, listeners were required to use their imagination to fill in the blank screen. For those with great imagination (most of us), the storytelling and sound effects were enough to trigger our imagination to create images in our minds that were more persuasive than by any other means, sans actually being there. This was a very real experience for many. In 1947, 82 out of 100 Americans were frequent radio listeners. The audio grabbed your attention and got your heart racing far greater than silent movies or reading books because there were more human elements involved. Radio proved to us the importance of audio over picture.

Picture And Sound

Fast forward through television, 3D movies, and Smell-O-Vision to our current state-of-the-art dedicated home movie theatres. When done right, the room visually and sonically disappears and all that remains is what the artists worked so hard to deliver. No walls, ceiling, or floor lit up by the screen or reflected from the loudspeakers; no HVAC rumbling or hissing in the background; and no outside noises to distract. You're sitting in the space where all the sound converges in time and energy so that it sounds holographic and is cohesive with the picture. This is the point where organized data triggers emotional responses to the highest degree. This is when the investment of time and money pays back.

Primary Purposes For Hearing

Helen Keller said, "I am just as deaf as I am blind. The problems of deafness are deeper and more complex, if not more important than those of blindness. Deafness is a much worse misfortune. For it means the loss of the most vital stimulus—the sound of the voice that brings language, sets thoughts astir, and keeps us in the intellectual company of man."

Though many lower forms of life on our planet do not have an auditory mechanism to which you could associate the sense of hearing with, they can feel vibrations. This haptic sensory system helps such organisms find food and avoid becoming food. Is this listening? Certainly.

Listening means to react to vibration. Sound is of the brain, and vibration is of nature. The brain detects vibration and instantly tries to identify and label it. The mind then takes the interpretation and formulates a response. This is perception.

Our hearing mechanism converts acoustical energy to electrical energy for processing, to chemical for responding. Hearing can tell you more about the environment around you than any of our other senses. It can tell you about things happening in the dark, behind you, or even miles away, like an approaching thunderstorm. A low growl behind you will quickly get your undivided attention. Your brain categorizes the sound and estimates its size and distance in less than 50 milliseconds (many times faster than we can process vision). Based on the information collected, the brain then concludes, via experience and intelligence, the type and level of threat the sound is, and then determines whether to fight, flee, or freeze.

Though we capture sound binaurally, we hear three-dimensionally. This is due to the shape of the pinna, the exterior sound funnel and first filter part of the ear, and our ear locations on our either side of our head. The pinna is unique to each individual, and during our growth we have learned and adapted to how it collects sound. Each curve of cartilage reflects and alters the sound that is sent to the ear canal. We all hear the same sounds uniquely as well. Try changing the shape of your ear by pushing on different parts of it and notice how sound changes tonality, and perceptions of space, size, and location. Typically, humans can detect spatial differences in the front horizontal plane of 1 degree for frequencies around 1 kHz. We locate and map sounds by deciphering the difference of time arrivals (mostly below 700 Hz.) and differences in intensities (mostly above 700 Hz.) between our ears. These disparities work best for sounds that are in front of us. Because of the orientation of the pinna, we collect sound best when we face it. Locations of sounds below, above, and behind us are difficult to solve unless we move and direct our heads toward them.

In addition to time and intensity disparities, we include experience to determine distance. We analyze what happens to the sound as it travels to us. Think of how sound interacts with the environment when someone calls your name from down the street, versus in your home, versus next to your ear. Your eyes are not needed for confirmation. The information assembled from changes in frequency response and reflections help to calculate how far away the sound is. This form of mapping is not as instinctive and requires experience to be learned.

Feelings can be associated with sound and even the sound of the environment interacting with it. Imagine a childhood friend calling your name from within a cave—it might conjure up feelings of fright, or from a barn, which may invoke joy, or for some it might be the other way around. In any case, the combination of the external data, processed along with our internal memory data, causes biochemical events, resulting in our emotional reactions. Neurotransmitters of dopamine, serotonin, serum cortisol, oxytocin, adrenalin, etc. are regulated by our memory bank.

Hearing informs our brain more about the world around us than by any of our other senses. It alerts us of dangers, categorizes, locates, evaluates, and reminds and teaches us quicker and more completely so that we can better appraise our surroundings.

Let's look at several important attributes required for achieving a maximum experience:

Loudness/Intensity

Our threshold of audibility begins at less than one billionth of a change to atmospheric pressure. Sound-pressure level can be measured in the logarithmic scale called decibels. From 0 dB, just audible (eardrum displacement is less than the diameter of a hydrogen atom), to 150 dB, sound no longer audible is an energy difference ratio of one to one quadrillion. Often, much of the soundtrack depends on loudness to tell the story well. Differences in intensities tell you about where a sound is located, where your attention is supposed to be, and builds the scene character. Prosodic features in dialog, such as accent and rhythm, deliver meaning and emotion. When equipment is not calibrated optimally and/or the acoustics are poor, much of the information is lost in translation.

Space/Reverberation

Acoustically, reverberation is the time it takes a sound-energized space to decay to one-millionth of its original intensity after the sound is stopped. It is typically analyzed in third-octave bands across the audible bandwidth. Artificial reverberation is used to give particular character to the scene and help define the acoustic space of its size, construction, and mood. As previously mentioned,

it can also offer relative distance. Reverb information is usually very low-level detail, and much of it gets buried in poor acoustical playback environments. The existing room reverberation can overpower, or at least combine with the recorded reverberation, skewing the intended message.

This is the case in all but carefully engineered acoustic spaces. The average media room has reverberation times that often fluctuate beyond one second, depending on the frequency. Nice and neutral, they are not. Try a hand-clap in your playback room. If you hear it linger for more than half a second, you can be sure that intelligibility is being seriously compromised.

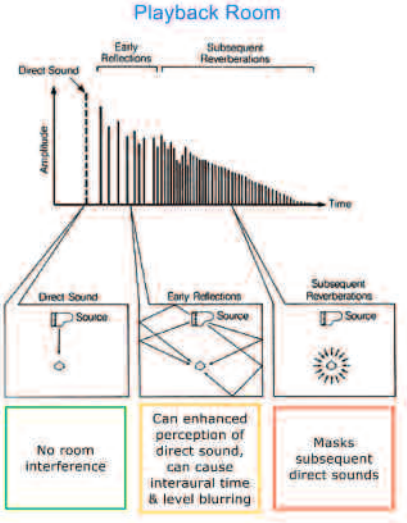
Each room has unique shape, construction, and furnishings, which absorb, reflect, and diffuse different frequencies at different amounts. Some frequencies dominate others, attacks and decays are obscured, spatial cues are imprecise, harmonics are diminished, dynamics are lost, and fine resolution concealed. For most listeners, much of what makes a soundtrack interesting is never conveyed. Rooms with linear reverberation times between about 0.25 seconds and 0.4 seconds sound defined, natural, and comfortable.

Noise Floor/Dynamics

The average residential noise floor is about 40 dBA SPL. This ambient noise is caused by mechanical equipment, appliances, outside noise, other residence, etc. A high noise floor limits the dynamic range and masks low-level details in the soundtrack. Small clues have to be filled in by the brain. Many are missed all together, such as details regarding the recorded space, special effects, the silence sometimes used to create suspense, dynamic expression in music, tonalities that give texture and character, etc. In addition, noises can distract our focus and remove us from our willing suspension of disbelief.

Construction For Good Acoustics

The room's shell should be constructed with dimensions that offer good distribution of room modes. Hopefully, the room is large enough to accommodate the number of desired seats without placing people too close to boundaries or loudspeakers. The wall, floor, and ceiling systems should be designed to keep noise from penetrating, offer enough mass to support bass frequencies, but not too much to completely contain them.



Reflection/Absorption/Diffusion

These are the tools available to control sound quality in the space. As a general rule, we want to absorb the first order reflections of the LCR loudspeakers, and diffuse the surrounds, then see what remains regarding reverberation times. It's a matter of understanding what treatment type, location, and quantity is needed to control the room so that it is neutral and comfortable. When this is accomplished, the room does not interfere or compete with the loudspeakers, and the room sonically disappears.

A/B Rooms

While working for Owens Corning at their Science and Technology center, we built two identical rooms for the purpose of characterizing acoustical treatments. They were designed so that room-mode problems and noise issues were minimized. Other than that, they were sized and furnished as a typical U.S. residential media room would be. Decent 5.1 systems were precisely set up and calibrated so that both rooms were identical in construction, furnishings, and electronics. We then installed engineered acoustic treatments to the interior of the A (after treatment) room. While doing our research, I often had to give little presentations to VIPs regarding our work in these rooms. The reactions in the A room were always the same, "I want this at my house." It was after several of these incidences I realized that I, as someone who understood and appreciated good sound, was not the only one moved by it.

I decided to investigate. We had our own medical facility onsite, which included an audiology booth. The approximately 600 employees had hearing tests annually. This allowed me to set a hearing criteria and ask for volunteers from those who met the criteria. The volunteers were a great mix of various PhDs, nationalities, age, and sex—none of whom understood or cared much about audio.

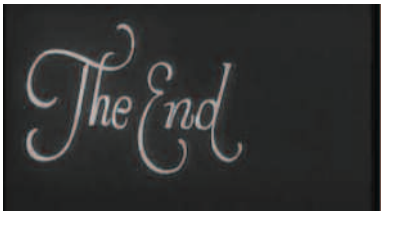
We performed bio-feedback tests in the A/B rooms while playing a seven-minute clip from *Das Boot*, where the submarine dives below its designed limit in order to elude the enemy. As it descends towards an eventual crush depth, pressure builds on the crew and their U-boat. The hull begins to moan with fatigue. Before long bolts start popping, injuring the crew, and soon water begins to fill the tiny compartment. It didn't matter whether our test subjects experienced the A room first or the B room, their blood pressure, heart rate, and respiration measurably increased in the acoustically treated room. By reading the plotted graph, we could even see how some individuals were more affected by the blood, while others by the flooding.

The difference between the two rooms and why the A room delivered such a higher degree of experience is twofold:

1) The subjects' brains received additional and more accurate information to process.

2) The subjects' brains did not have to work as hard at deciphering the information.

Our brains can connect the dots sooner and decode the picture with more detail, when there are more dots. Their relationships make more sense, just like the difference between low- and high-resolution digital audio or video. With less information, we are forced to fill in data on the fly. This can cause errors and distortions when we fail to detect relationships. The result of the A/B room experiment was a very clear, acoustics-controlled emotional response. **WSR**



Norman Varney is the Acoustical Product Development Manager for Kinetics Noise Control in Dublin, Ohio. Having been in the noise control and sound quality industries for decades he has earned many awards for acoustical products, room designs, etc. while working for A/V RoomService, Owens Corning Science & Technology Center and MIT. Mr. Varney has written many articles on acoustics for numerous publications over the years, as well as participated in seminars and panel discussions. He blames it all on The Beatles.