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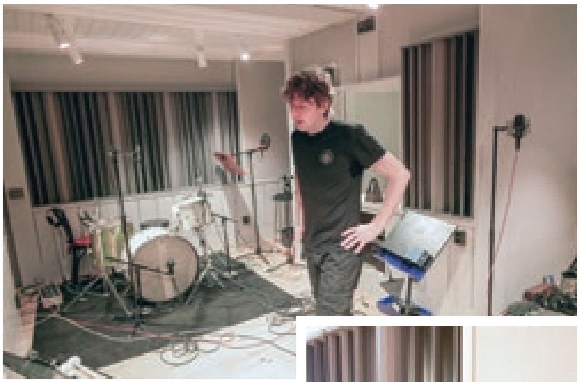
TECHNOLOGY



Forest acoustics – diffusor design

On a recent visit to Sweden, *Resolution* was impressed with the acoustics of two studios, both of which incorporated innovative diffusors in their Lennart Nilsson-designed rooms. In particular, a diffusor-equipped recording room sounded open and pleasingly ambient despite its small size. MATTS ODEMALM, creator of the Svanå Miljöteknik diffusor, explains his theories

The goal was to design a concept that mimics forest acoustics, and exploits the way the human ear/brain combination actually works, when it decodes whatever is fed into it.

The result was the "Wing" family, using unequal length acoustical delay lines, open at both ends, to shape important early reflections.

The resulting acoustics now work with the way our body handles these signals, not against it!

Background — In ancient times, it was understood that if discrete early reflections were delayed too much, this created an echo that made it harder to understand speech. By trial and error, a proscenium of a correct size was shaped in amphitheatres in the Greek and Roman civilizations. The shape and size of this proscenium was designed to create a reflecting sound field, at the same time ensuring this was kept within a suitably short integration time window.

This was needed to create an acoustic environment that could support the voices and instruments of the time, ensuring chants and music would reach out to the audience, adding up to a beautiful musical experience.

This was executed without any echoes which would have interfered with the artistic performance!

The acoustic knowledge developed at that time was an empirical approach of testing, and learning from mistakes. During the Baroque, Classical, Romantic and Impressionist periods, the acoustic music spaces were developed as music genres changed.

One quite famous example of concert halls from these later years (built 1870), is the "shoe box" shaped Wiener Musikvereinssaal, in Vienna. This has an internationally acknowledged reputation as a good acoustic setting, well adapted to the needs of the music composed during that period. As it happens, it also has many wall and ceiling ornaments, helping to create a suitable diffusing effect, without causing any "echoes".

In the early 19th century, an electro-acoustic revolution occurred, which completely changed the demands on acoustic spaces.

The invention of the loudspeaker created a strong acoustic reflecting field that reduced the definition of speech and music: discreet reflections gave a strong echo, which reduced the clarity of voice and music. Acoustic treatment was introduced in the form of sound absorbing material, as the key method of reducing the strong reflections experienced. When radio and recording spaces were introduced in the early 1920s, the acoustic problem was accentuated. Many scientific studies were performed during this period, but little success in practical acoustic treatment was developed. The first serious attempt at systematic acoustic treatment in Europe took place in the large radio studios, for example as shown by the BBC. In the 1960s the electric bass guitar became widely used, and this highlighted the problem of standing waves in studio spaces. The recognition of wave and geometric acoustics was defined by Manfred Schroeder.

In recent years a correction of the timeline in the electrical domain has dramatically improved wave acoustics. In the geometric acoustic domain, important theory and invention has taken steps towards improving the situation. The introduction of the Schroeder theory on diffusors and the TDS theory introduced by Dr. Richard Heyser, facilitated a giant step in the understanding of studio acoustics.

In more recent times, the path of development included the studio acoustics from Westlake design.

The next step was the development of LeDe design. This used diffusors to reduce discrete reflections from the rear of the room, and a non-environmental acoustic in the front of the room. Steering discrete reflections around the listening area, the so-called Reflexion-Free Zone (RFZ), reduces comb filtering. This also made an improvement in control room acoustics.

Development of the Wing concept — Observing how our hearing has adapted to the most critical of our tasks as humans (i.e. staying alive!), has recently led to some fresh understanding on how to shape a well-functioning control/recording room acoustic. An examination of our hearing quickly shows this phenomenal human auditory system has so many properties. One interesting property is the Precedence effect. Its a "second chance", that adds to the direct sound, is normally 30-50 ms long. This property is shaped to help humans to better hear predators stalking them, for example where vision is limited, as in a forest. The dense broadband low reflection sound field found in a common forest helps our Ear/Brain combination to minimize masking effects and extend the Precedence effect in time.

One example of how this works, is a so called "Forest Acoustics Test". This is the audible effects of how the arrangement of tree trunks in a random pattern, allows our Ear/Brain to hear a transient — even several hundred meters away — with a clearly discernible decay time. This would definitely have increased our chance of survival, when we were chased by predators!

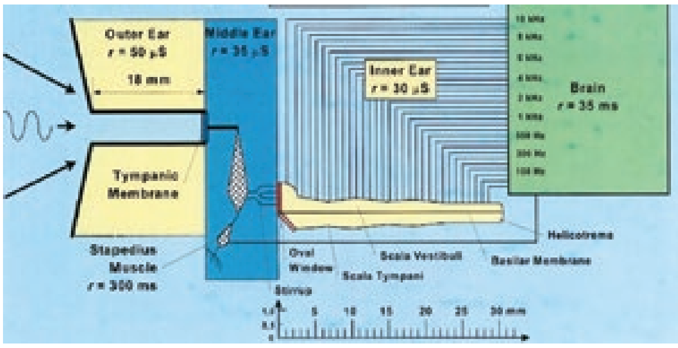
To explore the Forest Decay Effect, I designed a "Wood Clap" device. This was made of two wooden planks, connected with a steel hinge. When I used the "Wood Clap" close to a forest glade of random trunks, I could first hear the short smack, from the direct sound (a strong transient can mask sound up to 100ms). After this, I could then experience the amazing dynamic broadband diffuse "answer from the forest". I was convinced!

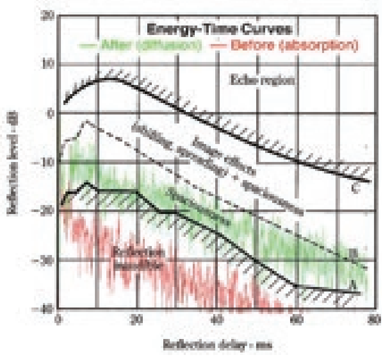
The masking effect (created by the transient sound from the Wood Clap), cannot on its own explain the strong dynamic reflected sound field from the forest. The true explanation lies in one of the keystones in psychoacoustics. This is the approximate — 1000 times time constant difference, between the ears and the brain.

A sound with a 1ms duration, sounds much lower in level than one that is 100ms long, despite the fact that the amplitude is the same. The difference in estimated subjective sound level, is around 10dB. Lengthening the "short" sound in time (without affecting the amplitude), increases the resolution, and the subjective sound level. It also reduces several different kinds of masking effects relative to other frequencies and sounds.

All this explains why we must measure peak level (0,05ms rise time) to keep track on hearing harmful levels, levels the brain doesn't perceive.

A powerful example is a gunshot in an open field. This will reach a peak level





of over 150dB (in a fraction of a second!), still it just sounds to humans like a "pop". However, if you try to listen to a rock concert at the same level, this is a very poor idea!

All kinds of different masking effects is also the key to why humans may still enjoy listening to music, even when substantial components of the information is removed (as in MP3 playback).

Testing — To minimize the auditory systems shortcomings I tried to mimic the acoustics of the forest by focusing only on optimizing a single module in the time domain (temporal diffusion). The idea was to force the incoming sound to go sideways (max 0,85 cm). This was used as an alternative to different kinds of Schröder diffusors, as this would require sound to bounce out of a closed cavity, thereby require a listening distance of 2-3 times the wavelength of the lowest diffused frequency. After a year of intensive testing, this module ended up with several different length delay lines, open at both ends. The depth of the module was 25cm, delaying the incoming sound approximately 5ms. Normally when you place identical diffusor modules side by side this creates lobing effects. A very welcome "free lunch" was that the identical Wing modules "connect" to each other when placed side by side. This keeps energy relatively constant, when used in different size rooms.

In addition they become psycho-acoustically invisible in the near field. Measurements and critical listening tests confirmed the theory of an even broadband redistribution of low intensity in the near field. The dense broadband low level (<-20dB) diffuse field, created in a room fully treated with Wing modules, reflects "psycho-acoustically correctly" into this transparent, neutral, high resolution spacious sound field. The explanation is the psychoacoustic effect of this simple formula — 10logX — where X is number of reflections (Enter ex 1000 reflexes and the psychoacoustic level is raised 30 dB).

Installation of diffusors — So far we have fully treated rooms of between 25-250m3: industrial laboratories, performance spaces, music recording control rooms, and class rooms for children with cochlear implants. All have reported experiencing the same "psycho-acoustic foot print". The primary reason is that the very important EDT (early decay time) is even, and similar in level. An interesting and important result is that the S-field listening room reflections mirror the recording rooms' acoustic — even if the recording is made outside in a field.

From Jamie Angus' (Professor of Audio Technology in the School of Computing, Science, and Engineering at the University of Salford) and David M. Howard's (Founding Head of a new Department of Electronics at Royal Holloway, University of London) book Acoustics and Psychoacoustics: The diffuse reflection room — 'Although there are many reflection paths to the listening point they are all of different lengths, and hence time delay. The extra paths are also all of a greater length than the specular path. Furthermore the phase reflection diffusion structure will add an additional temporal spread to the reflections. As a consequence the initial time delay gap will be filled with a dense set of low-level early reflections instead of a sparse set of higher level ones. Of particular note is that, even with no added absorption, the diffuse reflection levels are low enough in amplitude to have no effect on the stereo image.'

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