



56 YEARS OF LISTENING «I found, I found!»

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The most common figure in Norwegian fairy tales is Askeladden (Eng.: *Ash-lad*), a simple kid who digs and blows into the ashes in the fireplace and looks (and probably listens!) at everything on his way, collecting what his bolder brothers find non-important. (“*I found, I found!*”) But in the end, Askeladden gets both the “*princess and half of the kingdom*». Apart from the fact that I have nice, supporting brothers, and that the princess is otherwise engaged, I find myself something like an Askeladd. I have been given the possibility to dig into all aspects of sound, since I, at the age of 13, formed a rock band in 1964. I did my Civil Service duty in Audiology and Hearing Aids, and went on to 42 years as acoustician at Statsbygg (“Norwegian State Directorate of Public Construction and Property”), mixed with positions as Assoc. Professor at the University of Oslo/Musicology and at the Norwegian Academy of Music. At night, I am a musician and a composer both for acoustic instruments/orchestras/radio-opera, theatre, jazz and contemporary electroacoustic music for concerts and exhibitions. My presentation will give some examples of “what I heard on my way”. My position as a “state client acoustician” got me involved in almost every interesting acoustic project in Norway, collecting input from the good ears and minds of all the consultants and users in theatre, opera, buildings for music education etc. Last year I finally had to decide “what to do when I grow up” and joined COWI as an acoustic consultant.

1 Introduction

This presentation was an invitation for a Young Acousticians Network session for BNAM 2020. Therefore, it will be more informal and personal than the common, more “academic” or “case” presentations at conferences. I was invited to show and play several examples of my “life in music and acoustics”. As this is a conference on acoustics, not musicology, I have put a remark “What I learned:....” about acoustics at each musical experience.

2 My life in music and acoustics

2.1 My background. Sarpsborg, Trondheim

As you might find from the CV’s on my homepage [1], I am both an acoustician and a composer/musician. I started a band when I was 13 ½ years of age, playing rock’n roll classics, Beatles and more jazzy groups like Zombies, which led us (too?) early into composing our own material, and introducing non-rock instruments like trombone and flute.



Fig. 1 Left: My first rock band (1965),
Folkets Hus/Sarpsborg Pop-Championship 1966
(unfortunately, the picture is of the winner, we were not photographed)
Right: Folkets Hus: Canopy and orchestra shell (with anonymous chamber orch.)

At the age of 17 ½ , I wrote a piece for the amateur symphonic orchestra in my hometown, Sarpsborg, which was performed at Folkets Hus, the same hall we had played rock earlier. As we see to the right in fig 1, the hall even had a canopy and orchestra shell, which was used also for my piece for Sarpsborg Symph.Orch. *What I learned:* *The need for different acoustics for different kinds of music. Orch. shell on stage. A composer (me) is too nervous to care about the acoustics of the hall. Echo from the wall behind the audience is much more annoying for rock than for symphonic music.*

Quite early I found that I would like to study “everything about sound”, and at that time, there were no other possibilities than physics at a university and electronics/acoustics at NTH (now NTNU) in Trondheim. Because the latter was more direct to the point (and shorter!), I went to Trondheim. (Actually, I spent the first 2 years of the Master studies in Oslo, where I also had the opportunity to study classical guitar at what was then called the Music Conservatory in Oslo). Trondheim was (and still is) a marvellous place to study, and Prof. Krokstad et.al. gave inspiration both in acoustics and music. The town was big enough so that “everything happened”, and so small that one could join in. Studentersamfundet gave the possibilities to play/compose/arrange for all kinds of ensembles: From traditional Folk Dance Music, through choirs (both the serious and the “stunt”- choirs), and especially jazz, (see Hansen [2]), both combos and big bands, and conducting the student-cabaret UKA. In “lack of self-criticism” I also combined Big Band and Symph. Orch. *What I learned:* *The problematic, circular shape of the hall gave problematic acoustical effect, but if a room has nice atmosphere, musicians have to adjust. Echoes, focusing etc. are more important than reverberation time!!*



Fig. 2 Trondheim: Studentersamfundet, Trøndelag Teater (old stage), Frimurerlogen

Luckily, I was invited also into the professional music life in Trondheim, playing and composing for Trøndelag Teater, and for Trondheim Symph. Orch., and in the recording studio (amongst others: for Prøysenprisen, NRK). I also studied Musicology and was part time in the instrumentation classes etc. at the Conservatory. *What I learned:* *A small horse-shoe-shape theatre has a very nice atmosphere, but some problems regarding both sightlines and acoustics. The experience of playing in an orchestra pit. For Frimurerlogen: The very nice acoustics for symp.orch. in a shoebox hall.*

At this time, I was still influenced by the Norwegian protestant moral that “one should do something useful”, so I did my Master about Hearing Aids, and my civil service at the University Hospital in Trondheim, even participating in some research papers in audiology. *What I learned:* *I am one of the very few acousticians who actually has hold human ear bones in my hand, (in order to do vibration measurements for the making of implants).*

2.2 Oslo,... and the rest of the world?

In 1978, I started working in Statens Bygge-og Eiendomsdirektorat (the Norwegian Directorate of Public Construction and Property), now: **Statsbygg**. This is a “client” institution, which does not itself do the design of the buildings, but sets criteria and run the projects. In the beginning, acoustics was not very well established as part of design teams, so luckily, I could also do calculations, measurements etc. One of the first issues was a flutter echo, and only last year I finally understood the high/middle frequency “tail” of the flutter. More about that in the next part.

Later, the number of acoustic consultants has increased enormously, so my work has more changed into setting criteria, choosing consultants, following their work, and, in the end, when the consultant is “gone”, eventually deal with minor complaints from the users. Being a client acoustician in such a big organisation as Statsbygg has brought me into almost every acoustically interesting project in Norway (and some abroad). I got see what every consultant does and could learn from all of them. Acoustics is much more about experience than parameters, or, to put it another way: **You need experience to judge the parameters!**

The increasing number of acoustic consultants over the years is of course excellent and necessary. However, I must admit that there might be a “dilemma”: Architects etc. might have lost some of the intuitive understanding of how a room will sound. I have done some teaching for students of architecture and have been somewhat surprised about the lack of overall

understanding of sound. I even suggested that the students should go blind-folded into some typical rooms; shout etc. and draw the room without having seen it. The professor was very interested,....but the next semester he was gone. Architects and project leaders rely on specialist also for designing light, but they intuitively understand if there might be way too few light sources in a room when all the surfaces are painted black. The same should go also for sound, designers should have an intuitively sense if their room will be “too loud”. Actually, I have found teachers (and students) of Interior Architecture more interested in how their room will sound, and why.

At Statsbygg I have experienced “**The Importance of Being Early**”. I have been in the position to give clear criteria regarding acoustics very early in the projects before any architect or consultant is chosen. Examples are the clearly defined (but short!) acoustical briefs for Oslo Opera and also Stavanger Concert House, several theatres etc., stating the necessary volume and room shape before the architectural competition.

At night I composed for my **jazz bands** at festivals, Norw. Broadcasting, and jazz clubs like the legendary Club7, for which I also composed theatre music (including the "dancical" Egalia). Club7 also had a shabby, but acoustically well-treated rehearsal room for bands. I also arranged for several recording session; the group Ballade (Spelemannspris/ Norw. Grammy), and was a studio musician for recordings and TV. *What I learned:* *The difficult acoustics of club scenes. The importance of the sound engineers for concerts. The nice, simple treatments for the rehearsal room with Helmholtz absorbers in Club7. Studio design: Eastlake/Westlake etc. Recording and TV-performances = waiting!*

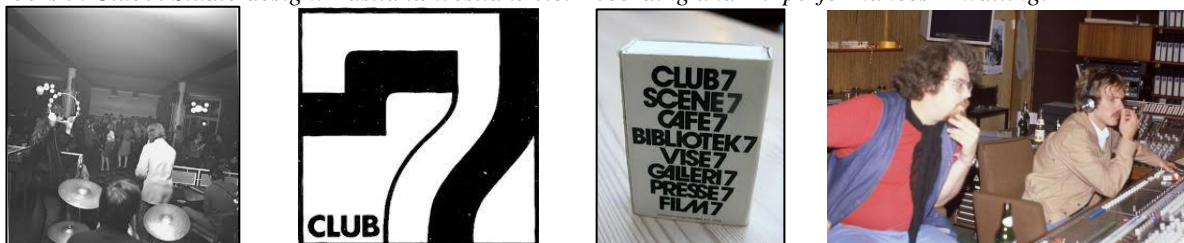


Fig. 4 Club7, Oslo, and Talent Studios, Oslo

In 1991-1992 I had a one-year leave from Statsbygg, as **Landsdelskomponist** (“Composer in Residence” for Northern Norway, at the Music Conservatory in Tromsø). Based in a building I had earlier been involved with the acoustical design of, I wrote music for ensembles all over Northern Norway. In 1992 I was Festival Composer at Festspillene in Nord Norge with performances of my music during the whole festival, including a church performance and a big event in Harstad Harbour including several choirs, marching bands, rock musicians from the roofs of buildings, a stereo loudspeaker setup with 300 m between left and right, water cannons and even a “diver’s ballet!”. *What I learned:* *The time delay between musicians placed far away from each other.*

I love writing **music for unorthodox venues** that are totally “wrong” compared to common acoustic criteria. One example is **Sildetanken, Melbu**, a big “steel tank” earlier used for storing herring, 22m in diameter and 22 m high, with a so long reverberation time that it cracked the measurement system I had at that time (app. 15+ s). In 1992, I wrote the music for the **sound installation for the Norwegian Pavilion at the World’s Fair** in Seville, Spain, [3] which actually won the price for best sound/installation. At that time there was no HD available to play 32 channels, so a special system that synchronised the start of 16 CD players was invented. I can make a joke about me and Wagner being the only composers who have designed our own building for our music (Wagner: Beyreuth, Me: The tube-shaped room in Seville). *What I learned:* *Music in unorthodox places: For Sildetanken, the long reverberation demanded that I had to stay in one key/tonality, and text was extremely difficult. But: As will be discussed later: Extreme short sounding notes (xylomarimba) is fantastically clear even in extreme reverb!! From the Seville project: Lots of experience with multichannel compositions. Absorbers on all surfaces (serve as screen for multivision), but resonance of about 20 Hz for the sub-bass! Later I used more modern multichannel playback for my Music For Ice-sculptures (Olympic Games 1994) etc.*



Fig. 5 Left: Sildetanken, Melbu. Middle: CD-cover, Right: Norw. Pavilion, World’s Fair, Seville, Spain

In 1996 I wrote a **RadiOpera** ([4], see Vollsnes [5]), for NRK (Norw. Broadcasting Co), for soloists, the radio orchestra and electroacoustics, which won the European Broadcasting Union Prix Italy. *What I learned:* The radio format made it possible to change the acoustics, and to keep the perception of text to a degree not possible on an opera stage, as the mixing of a direct voice with reverberation does not steal the attack in the same way as a natural reverberation in a hall does. Close mic'-ing of a symphony orch. Detailed work regarding synchronisation the singers later.

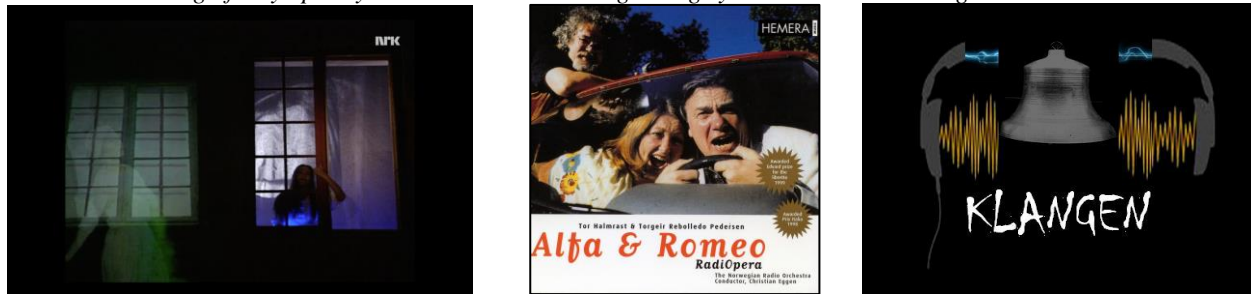


Fig. 5 “En Façade” Multimedia Ultima Festival, CD-cover «Alfa og Romeo» RadiOpera., Cover of KLANGEN (free download)

I started **teaching Sound Theory at University of Oslo**, Dept. of Musicology in 2009, and from 2016 I have also been teaching at the **Norw. Academy of Music**, for students in electroacoustic composition and piano tuning. *What I learned:* It is often said that a teacher learns from his students. This might also be the case, but most important: teaching presses the teacher to look into everything with new eyes, and there are no stupid questions! The teaching made me look into several basic issues, for instance that the first tonal scale we find when looking at the harmonic overtones includes 9, not 8 notes! I have used this for several micro-tonal compositions. Also: The fact that a piano is a very strange instrument: Inharmonicity etc. The teaching also made me collect «a short list» (650 p.) KLANGEN [6] of «everything important about (musical) sound”.

2.3 Some Acoustic Projects

Concert Halls/Operas: Oslo Opera, Stavanger Konserthus, Kilden, Kristiansand (early part only), Musikkens Hus, Aalborg (early part only), Oslo Concert Hall (podium acoustics for Mariss Jansons). **Theatres:** Trøndelag Teater (new building), Hålogaland Teater, Riksteateret. **Musical Education:** Conservatories and Music Departments in: Oslo, Bergen, Trondheim, Tromsø, Alta, Nesna, Volda, Stavanger, Kristiansand. **All other kinds of state-owned buildings:** Offices, jails, court houses, schools, universities, airports (earlier), hospitals (earlier). **Private projects:** Nes Kulturhus, Rehearsal Spaces for Ny Musikk etc., Recording Studios/Sound Control Rooms, Grønnåsen kirke (Tromsø), Victoria (National Jazz-scene, Oslo), Acoustic Report, Olavshallen, Trondheim.

3 Timbre, Reflections, Flutter, Echolocation, Resonances, Ambisonics

My job in Statsbygg and at the Univ. of Oslo has no or little time for actual research, so most of my **research** is done in the evenings etc. and is based on “what I found on my way”. Mostly I have been interested in all aspects of **Timbre**. The word Timbre is badly defined, or one could say that the definition tells us what Timbre is NOT. I have looked closely into how close reflections influences the timbre, **coloration, both for orchestra podiums and in sound control rooms**. (see Halmrast [7] quoted in Kleiner [8]) and how the reverberation is perceived by the musician him/herself [9]. This led to an investigation about **echolocation** («How the blind «sees» with the ears”, a combination of time domain and frequency domain) [10], and also the special **mid/high frequency tail of flutter echoes** [11], quoted in Cox [12], (due to diffraction from the edges of the surfaces which are not of infinite size, giving a transformation from spherical to plane wave). So, at last, I found answer to the first question I asked when I started out in acoustics!

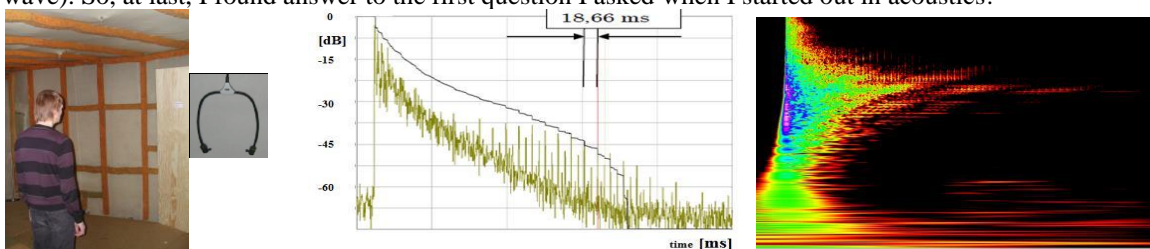


Fig. 6. Left: Echolocation test in «almost anechoic room». Middle and Right: Time and Frequency of Flutter Echo

A study on the acoustic situations in **(too) small rehearsal rooms** showed that “shrill” for high frequencies (for clarinet etc.) and room resonances in the bass (for trombone and tuba etc.) might be more important than the common reverberation time criteria. For bigger halls, reverberation is often considered to be just something that comes after the original sound. I have investigated how long **reverberation actually prolongs/smoothens the attack** [13], (as I experienced in Sildtanken), and how early reflections might be beneficial in order to minimise this effect. In a recording studio one can mix any amount of direct sound with a (too) long reverberation, and thus preserve the attack, but in a concert hall we must use early reflections (which on the other side might give coloration). The influence depends on the type of musical signal and the difference in time delays for the early reflections. This led to Cepstrum analysis of reflections/coloration/echoes and rhythm, [14] and [15], and questions like if “all pass filters” might be used too early in common algorithms for electronic reverb/electronic enchantment systems, giving a too smooth attack.

In my early days of **electroacoustic music** (see Rudi [16]), I had the opportunity to be played at festivals like Bourges in France, and my later pieces have been performed for instance at GRM/Ina in Paris [17], on their big «Loudspeaker Orchestra», and also presented at Computer Music Conf, NY 2019. *What I learned: My early electroacoustic compositions and especially my last electroacoustic piece, FLUTR [18] for 24 channels has been important for the understanding of sound in rooms, and the acoustic design (if any) of the highest ranked venues for electroacoustic music, including the «pro and contras» of Ambisonics etc. Such knowledge is useful also for room acoustic measurements, as extensions of IRIS measurements etc.*

4 Criteria(?)

“Not everything that counts can be counted, and not everything that can be counted counts” (A. Einstein).

Acousticians (and all kinds of Engineers) are very concerned about the refinement of their criteria. Reproducibility of the measurements might be important legally, but there might be other issues that are more important. For instance: It is a big achievement that we in Norway have the “acoustic bible”, NS 8175, but: When we have very detailed criteria for some issues, issues that are not covered will be even less visible. This problem of relying too much on the criteria that are easily measured also goes when designing or evaluating a concert hall than exact numbers for the ISO-standardised parameters. Some issues that should be included are:

- **Directivity of the source** (Very important for vineyard etc.)
- **Direction of perceived reverberation**
- **Difference between Very Early and Early reflections:**
- **Coloration on stage** (Comb-filters from «single», distinct reflection(s)?)
- Coloration due to **Flutter Echoes** (between sidewalls on stage or ceiling/floor)
- **Direction of early reflections to the audience**
(LF etc. does not clearly indicate if all lateral reflections arrive from just one side-(wall), giving no actual «envelopment»)
- **Envelopment** from the rear of the hall (not just from the side/lateral)
- **What is an echo?**
(Dietsch does not detect a cluster of perhaps rather weak reflections over a period of time from the rear part of a hall, which often is perceived as “almost echo” due to lack of reflections before these reflections arrive)
- **Room Acoustic Attack** (Integrated Cumulative Imp. Resp.)
Long RT without close reflections often smoothens instruments attack so they sound less brilliant.
(Compromise regarding coloration from these early reflections)
- **Frequency Response/Resonances**
(simple measures like “bass ratio” or 1/1, 1/3 octave is not accurate: Waterfall?)
(Listen to IR convolved with noise, perhaps several times)
- Response **back to the musician** (Recordings of Imp Resp. of “musician’s” own clap with in-ear mic)
- **Critical Distance in detail:** How far from the source is the sound field actually correlated/coherent? (and for which freq.-band?)
- And of course: **Empty/Occupied**
Measurements (and loudspeaker orchestra tests) should not be done on empty stages (and in empty halls).
(We should perhaps try to develop/standardise «dummy screens/absorbers» in order to simulate «none-empty» conditions, both for computer simulations and actual measurements?)

Almost all these issues can be counted, but we need to learn which of these parameters that counts most! Acoustic design is like cooking a good meal or composing music: We know how each ingrediencies tastes and how each note sounds, but the problem is to choose the amount of each of them.

5 Summary

Listen! (perhaps also to too old acousticians?).

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