

# Will pure acoustical concerts and opera performances survive?"

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## 1 INTRODUCTION.

A discussion of the development of room acoustics in the 20<sup>th</sup> century was given in an invited lecture honouring the late Lothar Cremer at his 100<sup>th</sup> birthday, and is published in ref.1. This paper, which is a contribution to a discussion more than a scientific paper, is a continuance of the analysis of the 20<sup>th</sup> century, now trying to take a small step into the future.

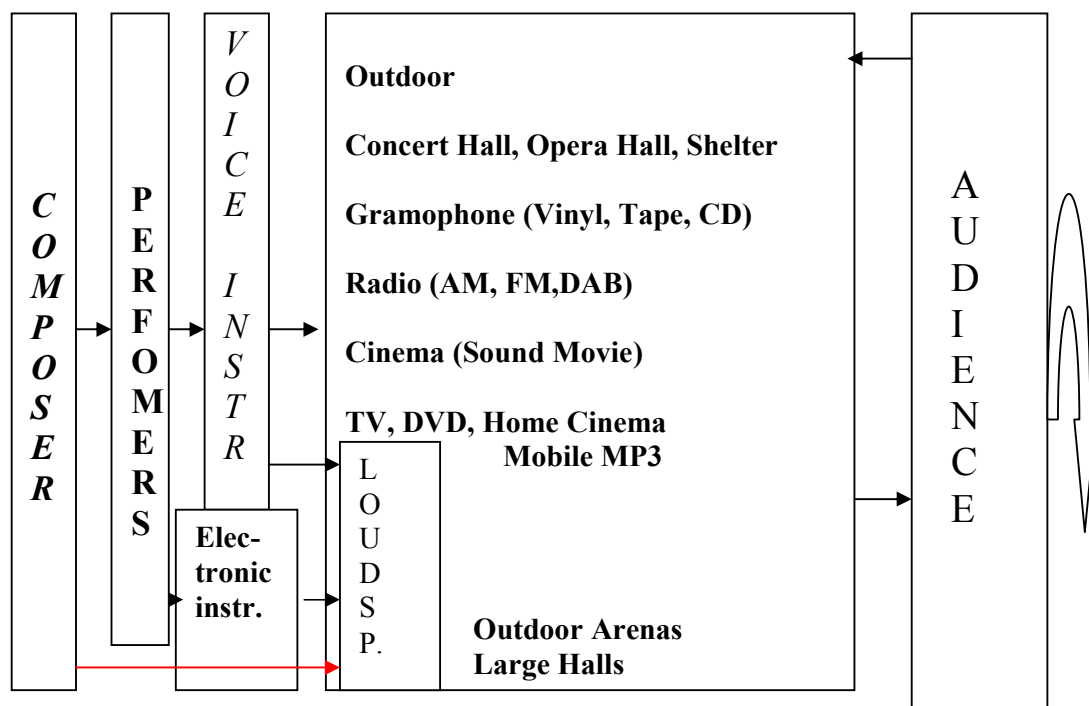
## 2 MUSIC COMMUNICATION.

We have to realise that most of the younger generations do not associate “concert” with “concert halls”, but with tons of loudspeakers and huge video screens.

A lot have seen opera parodies, only a few a real opera performance.

The 20<sup>th</sup> century was a century of innovations in communication which to a large extent changed the daily life for most of the world. Many believed traditions and culture to be like driving with the brakes on. Some attempts were tried to drastically get rid of the symphony orchestra and traditional instruments, and even greatly change basic musical traditions by introducing new principles of harmony (Schönberg 12 tone music 1920).

A self explaining overview of alternatives now in use for music communication is shown below. The red arrow indicate the great interest for the idea that the composer may address the audience directly, avoiding orchestras, by controlling electronic sound generation (K Stockhausen) or by producing tapes based on nature generated sound (Pierre Schaffer). This development, starting about 1950, is still important, but with changed goals.



People thinking economically will have problems arguing in favour of symphony orchestras of the size which became normal from about 1850 (100-110 players). Using a 1.violin group of 16 highly skilled players (instruments costing more than 100 000 \$) is not easily defended even to acousticians. Especially difficult is the expansion from 8 to 16 players, giving only 3 dB increase in power level. (The last of the 16 players is contributing only 0.3 dB to power, ordinary impossible to hear. Balance in an orchestra is a problem of mutual masking, and even small changes in level may bring new musical lines over the threshold of hearing (Jürgen Meyer in ref.1).

But all attempts to dramatically make the symphony orchestra obsolete, have failed. 12-tone music may occasionally be heard, but is barely known even by the most enthusiastic part of the audience. But even if the basic goal failed, the efforts have been of great value.

*The results were supplements to music traditions rather than substitutes.*

The pipe organ is not a cheap orchestra, but an instrument by its self. Saint-Saens magnificent "Organ Symphony" demonstrates that. .

Electronic and computer sound production are used to a large extent in sound scaping, "illuminating"

("soundluminating")sculptures, rooms or landscapes to stimulate both visual and auditive senses.

Electrical and electroacoustical instruments, such as electric guitars and synths(synthesizers), are really the basis for pop and rock as developed from nineteen fifties. "Shadows" was the first and last group completely relying on el guitars. Rock and pop groups normally compensate the rather boring sound of

el guitars by singing and stage shows.

**Sound reinforcement** is now a must by all types of popular music; musicals, dance music and shows.

Even the most famous symphony orchestras in Europe, such as Berlin and Wiener Philharmonic, are now following an American tradition presenting reinforced outdoor classical concerts. (In Oslo each summer at Holmenkollen with Oslo Philharmonic Orchestra, using a tent for shelter). Outdoor opera performances in the old Greek and Roman theatres (Verona, Rom and others) have become very popular and are certainly sharpening the appetite of the audience even for indoor performances.

The "newest" instrument which has become standard in a symphony orchestra is the clarinet, which Mozart introduced in his Symphony nr.39 in 1788.

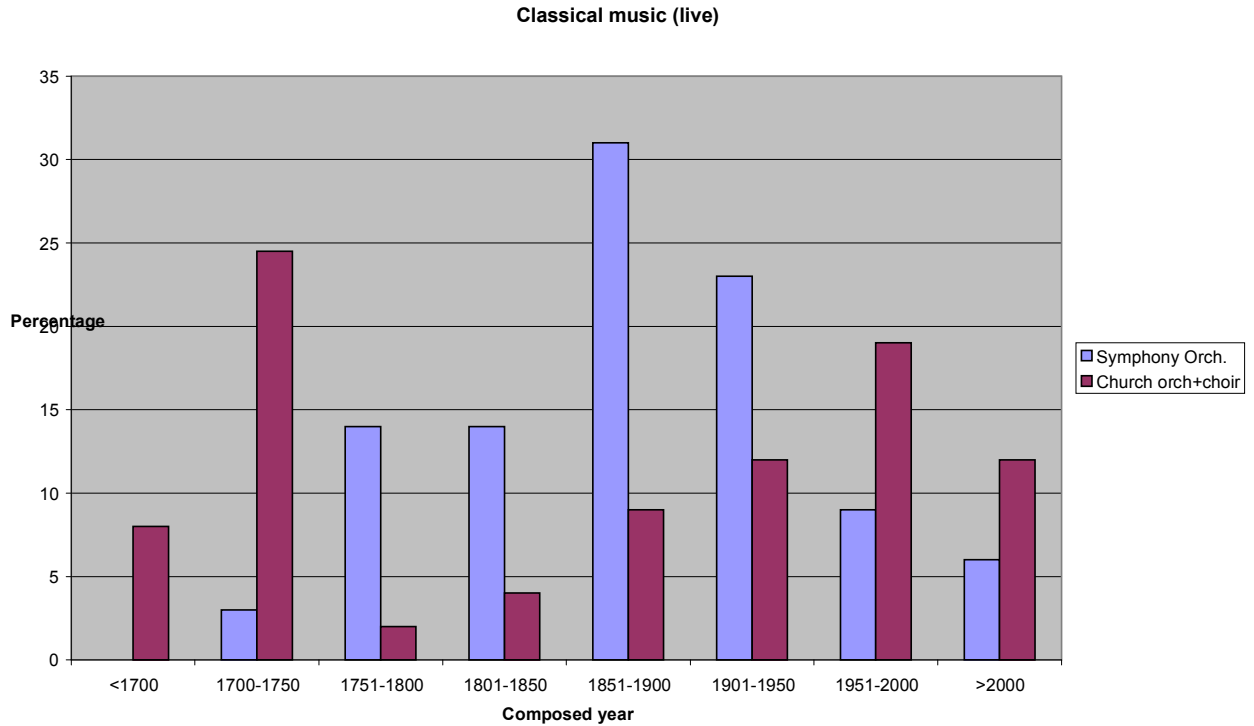
## 2 WHAT KIND OF MUSIC ARE ORCHESTRAS AND CHOIRS OFFERING PUBLIC TODAY?

The diagram next page show a distribution of age of music presented the two last years by a professional symphony orchestra (Trondheim Symphony Orchestra) and separately a similar distribution for church concerts in Trondheim.

The diagram shows the percent of the total time of music which are composed within each 50 years interval.

The distribution is of course only for one Norwegian city, but it may be expected similar trends for most orchestras.

Younger persons reaction to "old" and very "traditional" classical music was clearly expressed by my nephew and wife, both professional and well known rock and musical artists, after hearing Mozart's Requiem in Smetana Hall Praha. They were both impressed by the high levels obtained, and the great dynamic range. And enormously impressed by the richness of details, the ease of following several melodic lines, and the beautiful overall impression. The importance of listening directly to the musicians without manipulations by sound engineers and producers was also commented.



*The mean age of music played by the Symphony Orchestra is about 100 year. The symphony orchestra thus survive due to the fact that music written for the orchestra retains its popularity both among artists and audience. Jazz, pop and rock are using the same melodic and harmonic fundament.*

Concentrated and undisturbed listening at a live concert is very important, especially by classical music. The duration of a symphony or concerto is typically 10 times the duration of tunes in pop and rock (40 min. to 4 min.). The private life today seldom allows 1 1/2 hour listening without any disturbances.

**A live concert or performance is of course interactive. The audience is inspiring the people on stage and each other. Recordings of live performances with audience are preferred to studio recordings even if some imperfections must be accepted.**

One may conclude that the competition from technical communications seems not to represent a threat to traditional orchestras, choirs, soloists and halls.

***But one trend is clear; the quality demand is increasing.***

**Only the best soloists, conductors, orchestras, choirs and halls may be sure of surviving.**

### 3 Copying without succeeding completely.

Musikverein Wien Grosse Saal (GMV)(ref. 3 pp173 )and Semperopera Dresden are used as models for most halls built during the last 20 years; "shoebox" shaped concert halls, and "horseshoe" shaped opera halls.

Most are acoustically successful.

*I personally have visited quite a few, and find the step up to the quality of the old models is larger than expected.*

The differences are obvious by just looking at the pictures of Grosse Saal and Olavshallen, Trondheim(ref.3 pp437);

- quite different materials and surface treatments
- lack of the magnificent artistic decorations of Musikverein in Olavshallen.

Building materials used:

*GMV: Stone, plaster on wood or brick, glass.*

*A multitude of materials prevent concentrated contributions to resonant absorption.*  
*Important detail: The large windows are subdivided in several small framed rectangular glasses.*  
*The framework increases the total mass, prevent propagation of bending waves, and the joints introduce losses which are of importance for reducing transmission loss at the coincidence frequency.*

OH: Ceiling (over the free hanging reflectors) of light pre produced concrete elements. Part of the walls are gypsum plates on studs in varying distances. The rest is casted gypsum, about 20 mm thickness, and formed as skew elements to introduce diffusion. The original plan was to cover all walls with small ceramic tiles glued to the gypsum plates. The great cost stopped that excellent solution, against the recommendations of the acoustic consultants. The orchestra enclosure consists of elements of wood. Over the reflectors of reinforced plastics, hanging carpets may be drawn across the hall to increase absorption.

#### **Surface treatments:**

*GMV: Walls and ceiling are either painted using oil based paint, or gilt, closing effectively all micro pores in the surface of materials, thus reducing the absorption given by thermal and viscous losses to an absolute minimum*

*The smooth and hard surfaces of glass certainly are of importance for the great reverberation times at high frequencies.*

OH: Walls and ceiling are painted using water based paint.

#### **Diffusion:**

Diffuse reflecting objects give frequency dependent reflections and may give *geometrical dispersion*; that different parts of the spectrum of a sound event reach the listener over different paths, and thus with different delays (or phase).

Diffusion is "smoothing" the sound distribution, and directs sound energy to all absorbing areas. *Several types of diffusing objects are found in GMS. Reliefs in the ceiling and on fronts of balconies in combination with visible barks and rafters are effective scatters at high frequencies.*

Sculptures under the balconies are broadband scatters; the body volume functions at low frequencies, head and arms at medium, and details as fingers and nose at high frequencies. Ten large chandeliers are excellent scatters. Each bulb and its glass holder are effective at high frequencies. The whole volume of each chandelier act as a scatter which, due to the size, is effective even at low frequencies.

The great pipe organ at the back of the stage is an effective broadband diffuser.

Pipes tuned to the frequency of incident sound will be excited. Some of the captured energy is lost in the pipe, but most is re-radiated as spherical waves from pipe openings.

The cylinder formed pipes are even scattering sound incident to the whole area of the organ.

All objects increases the area of solid surfaces in the hall, so thermal and viscous losses increases. Some care must be used for not introducing so much scattering objects that the reverberation times at high frequencies suffer.

In OH electrical lamp holders and 100 spotlights al over the hall are scattering objects, but not broad band.

Diffusing objects of glass were proposed for the orchestra enclosure, and even a "passive" organ consisting of only pipes. The proposals were not accepted due to problems when demounting the stage enclosure for a different use of the hall.

In a multi use hall upholstered chairs are important for speech intelligibility.

In a concert hall an increase in reverberation times gives small problems, so only moderate upholstering are necessary.

#### **Why are the copies inferior?**

- cost. What will Grosse Musikverein cost today?
- architects wants to make a hall in a style representative for our time, and they of course don't to clone a hall.
- a very close cooperation between architect and acoustical consultant is needed to find realistic combinations of materials and surface treatments giving a minimum of absorption.
- painters and sculptors should be parts of the team to make scattering decorations
- avoid integrating different functions in the same hall.

## 4 The Future?

Lack of *intimacy* is the most severe negative aspects of the shoebox concert hall

The distance from the last row of seats to the podium in Grosse Musikverein is about 42 m.

The audibility is quite acceptable, but the visibility not.

This was realized by the architect Hans Scharoun and acoustical consultant Lothard Cremer when Berlin Philharmonie Grosse Saal and Kammermusiksaal were planned (completed 1967).

The stage surrounded by the audience area (360° hall) will of course reduce the distances to back rows.

I heard a concert in the large hall for the first time in 2007 sitting rather far from the orchestra, but in front. I was completely impressed; a hall perhaps not of the quality of Grosse Musikverein, but certainly among the best I have visited.

I also heard a concert in Kammermusiksaal. The program consisted of movements from the most popular concertos for violin, cello, clarinet and piano, and a 50 piece orchestra was playing.

Sitting behind the orchestra, near the timpani, and on opposite side of the soloists, I really experienced the problems by 360° halls. The whole program was heard as “concertos for timpani and orchestra”.

*360° seems not a promising concept for orchestras; perhaps better for chamber music.*

*But may be 180° is a better choice; using balconies to keep distances small.*

This leads really to a traditional opera or theatre hall. Teatro Colon, Buenos Aires, is highly praised as a concert hall, and we have the last years experienced several symphony concerts recorded for Television from opera halls. Why not?

## 5 Design tools.

Computer simulations has been in use by room acoustic design for more than 40 years.

In early times hardware limitations made it necessary to simplify the digital model of most halls.

Using super computers it is today possible to make more realistic models and even including scattering and diffraction in the simulation. But it is still necessary to make simplifications, and digital simulations are trustworthy tools only for users who understand possible effect of these simplifications.

Auralisation, a concept and technology to a large extent developed at Teknisk Akustik Göteborg, makes it possible to listen to music in different seat positions in a design model nearly as it will sound in the real hall.

Combined with the possibilities for the detailed visual simulations available for architects, it should be possible to design halls deviating greatly in form from the halls from 1900<sup>th</sup> century, being more intimate and hopefully acoustically superior.

## 6 Room Acoustical Criteria.

Research contributions from several of the most innovative researchers in room acoustics have given us a set of *room acoustic parameters* objectively describing aspects of the acoustics relevant for describing functions of halls by speech and by music. Most parameters have been in use for more than 20 years, and measured data from several halls makes it possible numerically to compare halls under design with existing halls.

My experience is that existing set of parameters may give a fully acceptable description of a hall to evaluate speech intelligibility, and even to secure acceptable conditions for music performances.

But not precise enough to separate the halls with the highest subjective ranking from those being just acceptable.

Simplifications made 30 years ago are no longer necessary in a time using PC for calculations, and even for measurements.

### **A few critical comments to commonly used parameters:**

The attributes most in use for subjective characterisation of a hall are:

- definition (“deutlichkeit”) (four parameters are compared)

- envelopment ("raumlichkeit")
- loudness or level

Reverberation, described by the parameter "reverberation time" may perhaps be treated as a separate attribute.

**Definition**

$$\text{"Deutlichkeit" after Thiele (1953): } D = \frac{\int_0^{50(80)ms} p^2 dt}{\int_0^{\infty} p^2 dt}$$

**Problems:**

- The abrupt integration limit results in great variations of D from position to position.
- Definition, ability to discriminate in time, is subjectively highly directional dependent.
- Direct sound (the first wave front) is not given precedence to early reflections.

$$\text{"Signal to Noise Ration" (Lochner & Burger 1958): } SNR = 10 \lg \frac{\int_0^{\infty} p^2 \cdot \psi_s(t) \cdot dt}{\int_0^{\infty} p^2 \cdot \psi_n(t) \cdot dt}$$

$\psi$  is a window functions; for signal (s) continuously reduced from 50 to 90 ms and the window for noise (n) is 1 from 90 ms.

**Problems:**

The chosen window functions are not optimal due to the fact that reflections in the delay range 60-90 ms have nearly no influence on the parameter.

$$\text{Centre time (Kürer 1972): } t_s = \frac{\int_0^{\infty} t \cdot p^2 dt}{\int_0^{\infty} p^2 dt}$$

**Problem:**

Direct sound, which is the basis of the time scale, will have no influence on the Centre time.

*Speech Transmission Index (STI)* (Steenecken and Houtgast 1980 ref.4) is based on the modulation transfer function (MTF). (M.R. Schroeder ref.5) showed that MTF is the Fourier transform of the element quadratic impulse response (echogram). A convenient expression for STI is:

$$STI(f) = \frac{\int_0^{\infty} h^2(t) \cdot e^{-j\omega t} dt}{\int_0^{\infty} h^2(t) dt} \cdot \frac{\bar{p}_s^2}{\bar{p}_s^2 + \bar{p}_n^2} = STI_{imp}(f) \cdot \frac{1}{1 + 10^{\frac{L_n - L_s}{10}}}$$

The integrals are the normalised Fourier transform ( $STI_{imp}(f)$ ) of the impulse transfer response, which afterwards is modified by the signal to noise ratio.

STI(f) are calculated or measured in 7 octave bands, weighted to a single parameter, which thus includes the influence of both direct and reflected sound, and noise. The reverberation time is recognised in the modulation spectrum as a low pass corner frequency for a 6 dB/octave roll off. Calculation of STI is standardized in IEC IS 268 Part 16.

In fluent speech the phonemes make a string of spectra. The STI is very well fitted to describe the risk of phonemes being corrupted by reverberation or noise. Variations in fundamental frequency,

which is important for intonation, seldom results in change of octave, and therefore not indicated by STI.

STI is superior to all alternative parameters for measuring and predicting speech intelligibility. A binaural version is missing.

In music information is partly spectrum modulations, such as a rhythmical strings, or frequency modulation, as a melody.

Neither STI, nor any of the parameters used for characterisation of "definition", are specially suited for describing the influence of room acoustics on music experience.

**"Envelopment, bathing in sound".**

$$\text{Lateral factor (efficiency) (Barron \& Marshall 1981): } le = \frac{\int_{-80ms}^{80ms} (p \cdot \sin \theta)^2 dt}{25 \int_0^{80ms} p^2 dt}$$

( $\theta = 0$  in the direction of the source)

Problem:

Great values of lateral factor may be obtained even in very small room (bathroom), while the subjective

impressions of a large and small room of same reverberation time are very different.

**"Level" or loudness.**

Level at listeners ear re level of direct sound 10 m from source.

Problem: Loudness from a source covering 200 m<sup>2</sup> is different from a loudspeaker.

**Parameters normally missing:**

*Direct sound and details of the first reflections.*

Direct sound is of course the only bringing localisation information. Details of the initial part of the impulse response is even important due to the possibility of coloration and comb-filter effects which may be clearly heard (Halmrast ref. 6)

**Stage parameters** introduced by Gade seems to function well.

All parameters are frequency dependent, but a scientific based method of weighting different frequency ranges are only defined by STI. Octave levels are mostly used, even if it is well known that the frequency discrimination of the hearing is close to 1/3 octave.

Correlation between the reverberation time and most of these parameters is high (Gade & Rindel ref. 7).

This may depend on the shape of the halls measured, not only on the parameters and their definition.

## 7 Concluding.

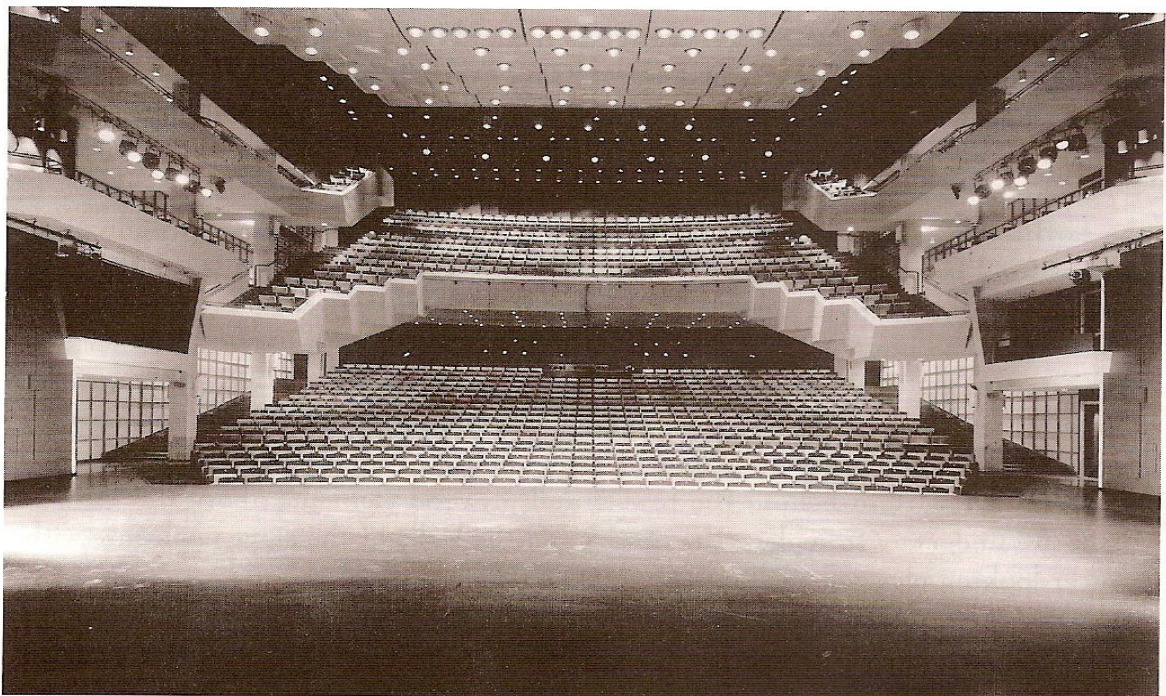
Room acoustical criteria and parameters have become obsolete both due to greatly improved possibilities of measurements and calculations; and due to the need for improved criteria by building intimate halls with individual architecture and room acoustics which may be even better than the best known today.

References:

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Musikverein Wien Grosse Saal



Olavshallen Trondheim