SOLVING THE LOUDNESS VS. “SOUND” DILEMMA IN SMALL MUSIC ROOMS – CAN WE LEARN FROM RECORDING STUDIO ACOUSTICS?

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1 INTRODUCTION

The dilemma between loudness control and sound quality in small music rooms - particularly teaching and rehearsal rooms - has long bothered acousticians. In such spaces with limited volume (approx. <200 m³), the challenge is twofold: on one hand, to limit the loudness experienced by the musicians through sound absorption, and on the other, to maintain a lively and inspiring acoustic environment. In addition, the rooms should sound well balanced across the entire frequency spectrum so as not to alter the timbre of the musician’s instruments or voices.

A similar issue arises in recording studio control rooms. On one hand, the signals from the monitor loudspeakers shall reach the listening position unchanged and free from unwanted room acoustic effects, while on the other hand, a sense of “natural” acoustics must be provided for the engineers enabling them to create recordings that sound appropriate, for example, in a domestic environment, as well as providing acoustic surroundings suitable for (very) long working hours.

2 BRIEF HISTORY OF CONTROL ROOM ACOUSTICS

Up until the 1970s studio control rooms often had only basic acoustic treatment, if they had any at all. Recordings were often made in mono and therefore questions of stereo-imaging etc. did not yet exist. With the advent of more sophisticated reproduction technology and the rise of private recording studios, control room acoustics developed quite rapidly.
One seemingly obvious and acoustically “correct” solution was to create highly absorptive rooms so that no reflected sound energy from room boundaries could interfere with the direct sound from the studio monitor loudspeakers (or with the direct sound of an instrument at the microphone in the case of a recording room). However, it soon became clear that while such acoustic conditions solved many practical problems, the rooms did not provide a comfortable and inspiring environment for engineers or artists.

Consequently, acoustic concepts were sought that would allow for a certain degree of liveliness and a sense of spaciousness without producing detrimental reflections or prolonging the reverberation time too much. These concepts typically aim to create an appropriate pattern of (early) reflections at the listening position via the room surfaces, producing a spatial impression without negatively affecting the direct sound at the listening position (or at the microphone in case of a recording area). In any case, the structure of these early reflections must be designed in terms of their temporal distribution and level, so that discrete reflections do not produce audible comb-filtering effects or localization shifts.
In practice, this requires structures that provide particularly good and homogeneous sound diffusion. For this reason, highly effective “QRD” diffusers, based on the theories of Manfred Schroeder[1] quickly gained popularity in recording studio acoustics.

Earlier such concepts, such as the “Live-End/Dead-End”-principle from the early 1980s, divided studio control rooms into an absorptive area in front of the listening position (to avoid direct reflections from the studio monitors) and diffusive zone behind (to provide a dense pattern of early reflection for spaciousness). In recent decades, however, “mixed” concepts have emerged, driven in a not inconsiderable way by the many different loudspeaker-setups necessary for “immersive” sound production, in which absorptive and diffusive elements are distributed across the room surfaces in a balanced manner.

Figure 1 - Rear part of an early “Live-End/Dead-End” control room utilizing QRD diffusers, designed by the late Hellmuth Kolbe (Atmosphere Recording Studio, Schlossrued, Switzerland)

In addition to these techniques for achieving a neutral but at the same time inspiring sound, a second, perhaps less conspicuous, aspect is important: a well-balanced, ideally linear, reverberation time across the frequency spectrum – especially also in the low frequencies. This is a prerequisite in small music rooms to avoid coloration of the sound. Especially for recording studio control rooms the relevant standards and recommendations[2] define correspondingly narrow tolerances for the reverberation times over frequencies.

3 STANDARDS FOR SMALL MUSIC REHEARSAL ROOMS

The ISO Standard 23591:2021[3], largely based on the earlier Norwegian Standard NS 8178[4] published in 2014, provides clear guidance on volume- and usage-dependent reverberation times for music rehearsal rooms and qualitatively addresses other aspects of their acoustic design.
Based on these standards, many rooms have already been built in numerous countries, and it can be assumed that the recommended values have generally proven effective in practice. The author, however, is of the opinion – based on experience from various completed projects - that the recommended reverb times in these two standards are slightly on the high side. Musicians seem to generally prefer shorter reverb times, providing the sound fields are sufficiently diffuse.

4 WHAT CAN WE LEARN FROM STUDIO ACOUSTICS WHEN DESIGNING SMALL MUSIC ROOMS?

Which insights from studio acoustics can help develop good acoustics in small music rehearsal rooms and resolve the “loudness vs. sound dilemma”?

4.1 Targeted Use of Diffusion

As mentioned earlier, studio acoustics have long successfully employed diffusive elements to achieve spaciousness in otherwise highly damped rooms. When designing music rehearsal rooms, it should be remembered that the acoustically perceived sense of space is not simply a function of reverberation time (RT) but is significantly influenced by the structure and intensity of early reflections.

Although ISO 23591 as well as NS 8178 mention “diffusion” and “sound diffusing elements” as important for room acoustics, this is mostly in a functional context—for instance, to avoid flutter echoes. While this is correct, this neglects the point that diffusion can also be used as a tool to enhance spaciousness and liveliness of the sound by creating a suitable pattern of early reflections.

4.2 Balanced Reverberation Time

A balanced reverberation time across frequencies is another important aspect that can be adopted from studio acoustics. A uniform RT ensures a neutral, low-coloration sound, making a rehearsal room suitable for a broad range of instruments and voices. Again ISO 23591 and NS8178 provide guidance on reverberation times for all three categories of musical use (“quiet,” “loud,” and “amplified”) across the 63Hz – 4kHz frequency range. These tolerances should especially be maintained in the low-frequency range. Many rehearsal rooms neglect this aspect, resulting in an unwanted, “boomy” sound. Unfortunately, outside the world of recording studio acoustics, incorporating targeted low-frequency absorption is still often regarded as something “exotic” or at least extravagant.

It seems appropriate to mention here that the intentional “shaping” of the reverb time across frequencies can be used as a subtle tool to achieve the desired tonal balance in a room. The late Gerhard Steinke[5], for example, promoted the use of a “S”-shaped curve, which intentionally suppresses RT in the low-mid frequency range to achieve a more transparent and less “boxy” sound in recording and rehearsal spaces.

4.3 Practical Advantages

For economic and organizational reasons, most larger institutions, such as music universities, require rehearsal rooms that are suitable for a broad range of instruments, singers, and ensembles, thus minimizing the need for individually tailored rooms.
To meet the diverse requirements of musicians, it is common practice to provide variable acoustic measures to adjust reverberation time. The desired variability suggested by the ISO and NS standards is relatively large, ranging approximately from the shortest to the longest values in a 1:2 ratio (for example, according to ISO 23591, for a 100 m³ rehearsal room, the average RT is ~0.8 s for “quiet music” and ~0.4 s for “amplified music”).

Unfortunately, variable acoustic treatment that provides frequency-linear absorption is complex and costly. Simpler, cheaper solutions (such as acoustic curtains) usually have uneven sound absorption across frequencies, which can affect the tonal balance of a room. In addition, musicians do not always use variable acoustic measures correctly – intentionally or not - which is perhaps understandable, since they enter these rooms to make music, not to conduct experiments in room acoustics.

Generating spaciousness through targeted diffusion rather than just longer reverberation, can reduce the range of reverb times required. Consequently, rooms can be designed to accommodate a wider range of musical uses a priori.

It may even be possible to omit one of the ISO 23591/NS 8178 categories—for example, by designing rooms that are sufficiently damped for “amplified music” but still lively enough for “loud music”. However, to achieve this goal, the amount of diffusion (i.e. the size of surfaces with sound-diffusing characteristics) must be significant. A lonely “token” QRD-diffusor in a music room is not sufficient.

5 CASE STUDY

A practical example illustrates how adding diffusive elements and linearizing the RT in a 130 m³ rehearsal room significantly improved the perceived acoustic quality

The room was initially constructed as a test room to evaluate architectural and acoustic concepts for the newly built music university. Students and their professors were encouraged to use the room for solo practice and ensemble work, and to complete questionnaires about various aspects of the perceived sound quality afterwards. Musical genres included classical music, jazz and folk music.
The original, simple acoustic treatment (“V1.0”) consisted mainly of cement-bonded wood wool panels with backing insulation, along with some low-frequency membrane absorbers. Acoustic curtains provided variability (see Figure 2).

Figure 2 – The test room with “V1.0” acoustic treatment.

This resulted in a relatively short RT with irregular frequency response (see Figure 3, blue lines).
Despite the short RT, the sound was often described as “harsh”, “bright” and even “loud”. The author is of the opinion that these judgements are largely a result of the insufficiently diffuse sound field in the room. Pronounced discrete early reflections colour the sound and also make the plain surfaces and the limited room size quite noticeable to the ear. On top of this, the visual impression of a relatively “cold” room has a significant influence on psychoacoustic perception and is not to be underestimated. Therefore, the results from the questionnaires were not satisfactory overall (see Figure 4, blue columns).

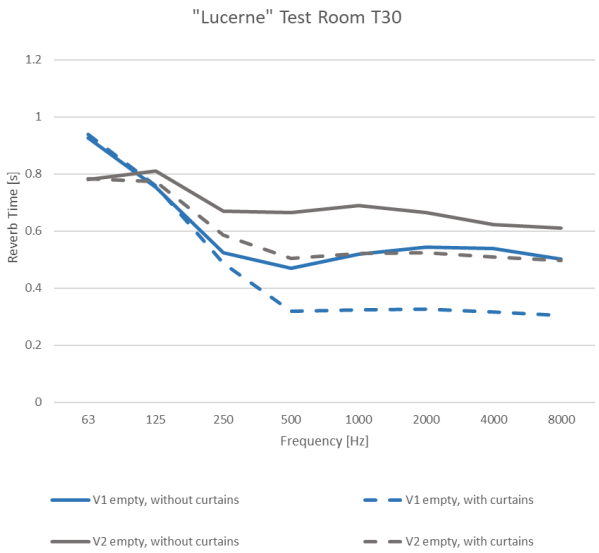

Figure 3 – Measured Reverb Times (T_{30}) in the test room

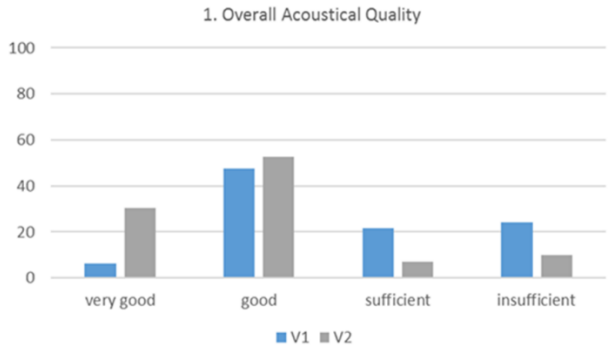

Figure 4 – Ratings on "Overall Acoustical Quality" of the test room

In an improved version of the room ("V2.0"), acoustic modules with a pronounced pattern of absorptive and reflective surfaces were installed on walls and ceiling, while the overall surface covered by acoustic treatment remained almost the same (Figure 5). The RT was slightly increased and linearized (see Figure 3, dark grey lines). Subjective ratings on overall sound quality did now show a marked shift towards acceptable results (see Figure 4, grey columns).

Figure 5 – The test room with "V2.0" acoustic treatment

Despite longer RT, the room was rarely rated as "harsh" or "loud" in the questionnaires. This is likely due to the improvement in density and structure of the early reflections resulting from increased diffusion. Broadband ETCs show, for identical source–receiver positions, the reflection patterns of the original (V1.0) and revised (V2.0) acoustics (Figure 6).

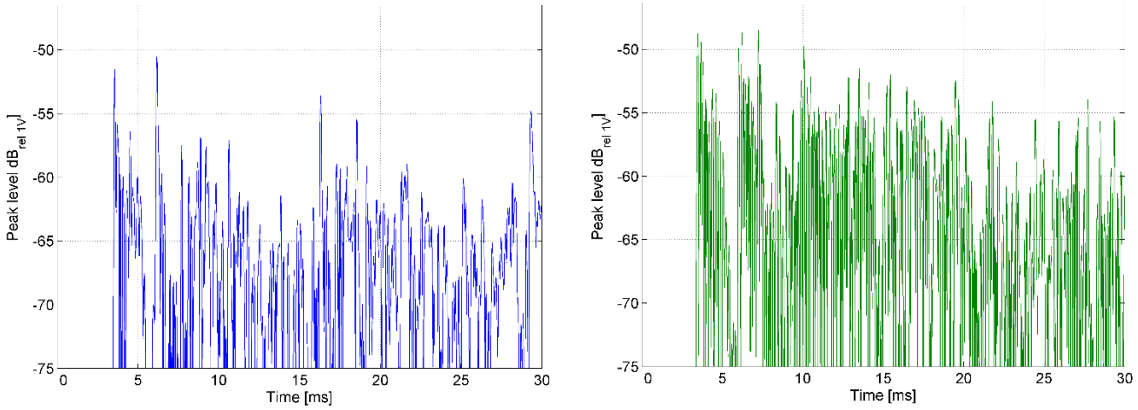

Figure 6 – Comparison of ETCs from the test room, left: original "V1.0" acoustic treatment, right: revised "V2.0" acoustic treatment

6 PRACTICAL IMPLEMENTATION OF SOUND DIFFUSING SURFACES

Besides the use of QRD diffusers, which are unfortunately inherently costly to buy or labour-intensive to build, it should not be forgotten that many structures exist that can provide substantial diffusion while at the same time being simpler to construct.

Ranging from the effective and relatively easy-to-construct "Binary Amplitude Diffusers"[6], through "classic" convex-shaped surfaces, down to decidedly simple structures such as wedge-shaped panels and irregular wooden slatting, the range of possibilities is wide and limited only by the imagination and knowledge of the acoustic designer.

Figure 7 – Diffusion provided by wooden slats (in front of LF and MF absorbers) on walls and a "Binary Amplitude Diffuser"-structure on the ceiling ("Jazzcampus", Basel, Switzerland; Buol & Zünd Architects; acoustic design by the author)

Figure 8 – Basic music rehearsal room, diffusion provided by purpose-built wedge-shaped acoustic modules, also providing LF absorption ("Weinlager" rehearsal rooms, Basel, Switzerland; Esch-Sintzel Architects; acoustic design by the author)

7 SUMMARY

Due to the similarity of the acoustic challenges between recording studios and small music rehearsal rooms, long-established strategies in studio acoustics can be applied to small music rooms.
Linearizing the reverb time over frequency, combined with markedly increased diffusion can provide a suitable acoustic environment for a wide range of instruments and voices. Early reflections enhance spatial impression even at low RTs, in many cases effectively resolving the loudness vs. sound dilemma.

8 REFERENCES

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2. EBU Tech. 3276 “Listening conditions for the assessment of sound programme material: monophonic and two-channel stereophonic”. (1998)
3. International Standard ISO 25391 “Acoustic quality criteria for music rehearsal rooms and spaces”. (2021).
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6. J.A.S. Angus and P. D’Antonio., “Two Dimensional Binary Amplitude Diffusers”, Paper presented at the 107th AES Convention. New York (1999)

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