HALLS WITHOUT QUALITIES – OR THE EFFECT OF ACOUSTIC DIFFUSION

E Kahle Kahle Acoustics, Brussels, Belgium ekahle@kahle.be

1 INTRODUCTION

Surface texture and acoustic diffusion is believed by many to be an integral and necessary ingredient for good concert hall acoustics. Beranek writes in his 1992 summary article that "a diffuse sound field created by an adequate number of reflections from all angles plus irregularities and ornamentation to eliminate acoustical 'glare'…" must be provided as one of the acoustical features required to achieve for good acoustics[1] and Haan and Fricke[2] indicate that surface diffusivity is, according to their findings, the acoustical feature most strongly correlated to acoustic quality in concert halls.

It should be noted that the surface diffusivity was established by Haan by looking at architectural plans or images of concert halls. Furthermore, it should be borne in mind that most of the research was undertaken during the last decades of the 20th century, often in an attempt to find objective parameters differentiating between the successful historic halls and the halls built in the decades after WWII, a period when ornamentation and curved surfaces were considered inacceptable by many architects who preferred plain flat surfaces in parallel with novel, untried geometries.

During more recent decades, many concert halls have been built exhibiting extensive surface texture, to a degree that surface irregularities are, for some, synonymous with "acoustic surfaces". Furthermore, both amongst architects and acousticians there seems to be a tendency of "the more the better", supposing that surface texture and acoustic diffusion are by definition always beneficial and do not have any negative side effects. Is this correct? As more concert halls with extensive surface texture have been completed, perhaps now is the right moment to stop, step back and ask the question whether surface texture is indeed always acoustically beneficial or whether there is "a price to pay".

2 DISCUSSION

2.1 Conclusions from previous research

Reflections from textured surfaces at least partly follow Lambert's law of reflecting acoustic energy to all directions irrespective of angle of incidence. They therefore tend to "hold" acoustic energy close to the stage, as surfaces closer to the stage are more strongly irradiated than surfaces further away from the stage (the latter often closer to most audience members)[3,4]. Measurements in real halls as well as in scale models show decreased variation of RT with increased diffusion but, on the contrary, an increased variation of G, as a function of source-receiver distance, when surface texture is increased[5,6].

Recent research by the group at Aalto University in Helsinki found that subjective preference in listening tests with recordings of the loudspeaker orchestra at equal distance in different concert halls was linked to the perceptual factor of proximity[7], that engaging concert hall acoustics is made up of temporal envelope preserving reflections[8] and that rooms can be recognized and identified by their early room response[9], so by the early acoustic signature of the room, rather than the reverberant sound field.

The acoustic signature of a room is created by sufficiently strong early reflections that must be noticeable and identifiable by our auditory system[10,11], which seems to indicate that these reflections must be specular reflections rather than strongly diffuse reflections as created by surface texture.

Are the reflections created by the architectural style of the 19th and early 20th century concert halls perhaps stronger and less diffuse than we think they are, as research indicates that they do preserve/create a discernable signature of those halls? Several practicing acousticians have noted that even historic concert halls (including the Musikvereinssaal in Vienna, the Concertgebouw in Amsterdam or Carnegie Hall New York) have astonishingly extensive flat surfaces. The strong, coherent reflections from those surfaces can indeed create a clear acoustic signature of the rooms and therefore explain the findings from Lokki's group. In private correspondence, Harold Marshall, talking about the Musikvereinssaal, indicated to the author that "inspection shows that there is far more plane surface than you would think" and that "even the ceiling is flatter than it looks".

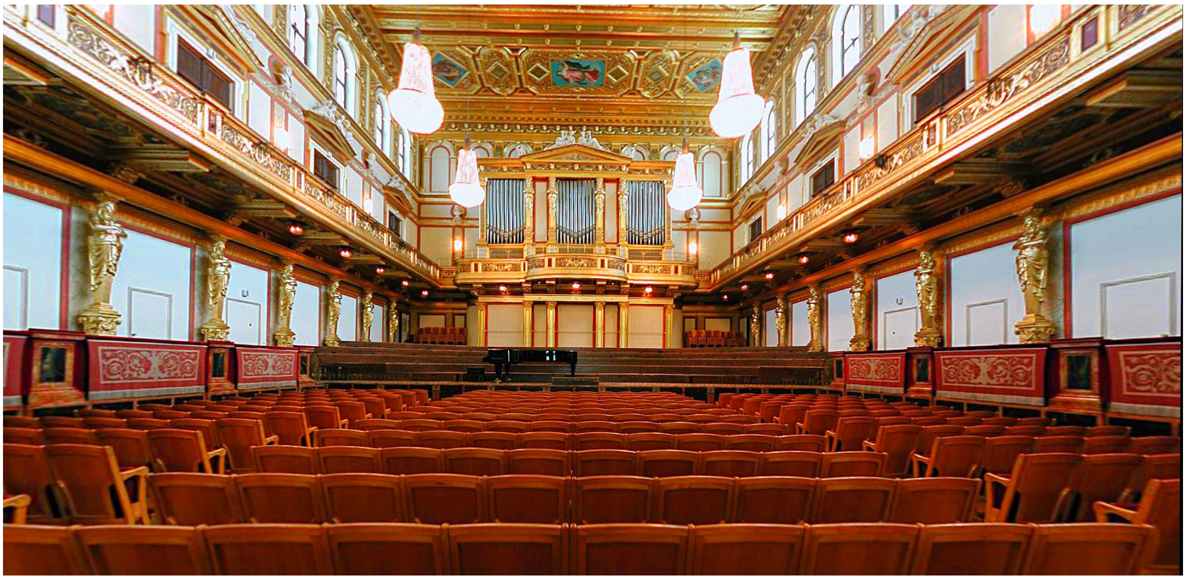

Figure 1: Musikvereinssaal Vienna

2.2 The author's exposure to diffusion

The author's first encounter with acoustic diffusion (in terms of surface texture) was at Artec Consultants Inc, for the Concert Hall at the KKL Lucerne: the famous plaster reliefs on the side walls, also called "bumps". The discussion there was whether the acoustical effects of "positive bumps" (proposed by Russell Johnson) or "negative bumps" (proposed by Jean Nouvel) would be the same, similar or at least both acceptable – finally, both Jean Nouvel and Russell Johnson approved the final design for negative bumps with their signature. It should be noted that surface texture at the time was a deviation from Russell Johnson's previous designs that deliberately avoided fine-scale diffusion (for example Dallas Meyerson Concert Hall or Birmingham Symphony Hall). Listening to the finished hall in Lucerne it soon became clear that the hall is excellent, and the author's first conclusion concerning fine-scale surface texture was that "no negative effects could be heard off any diffusing surface" while "the only possible problems come from non-diffusing surfaces like the undersides of the balconies". At the same time, the author remarked that string projection in Lucerne was less good than for example in Symphony Hall Birmingham where late reflections can often be noticed and localised. In Lucerne, the reverberation chamber door settings were used to compensate for the relatively weak string projection, the angle in plan of the doors closest to the musicians was optimized to improve/increase string projection while limiting brass projection.

A highly relevant experience in the context of this paper occurred during the ISRA 2010 congress in Melbourne, Australia, when listening to the Elizabeth Murdoch Recital Hall, a hall that exhibits an abundance of relatively deep surface texture. During playing and listening tests (amongst others together with Tapio Lokki) it was observed that, already in the middle of the parterre, sources on stage (whether spoken word or musical instruments) sounded relatively distant and with a relatively weak source presence. This observation aligned with Lokki's earlier findings that subjective preference was correlated with subjective proximity in listening tests with the loudspeaker orchestra, for listening positions at identical distance. Might subjective distance be increased when using strong surface texture on early reflection-generating surfaces, therefore reducing source presence as well as overall preference? And is this fully explained by the more rapid decrease in G with distance due to back-scattering of early energy to the stage[6], or rather by the reduction of coherence[8] leading to the absence of an identifiable auditory event[11]?

Listening tests at the Elbphilharmonie in Hamburg, but equally in other rooms with extensive use of surface texture, indicate a beautiful singing tone of the instruments on stage, but a localization of this bloom on stage and a relatively weak room presence (or rather a weak room personality or room physicality).

Several acousticians recommend fine scale diffusion around the stage, on most or all of the surfaces around the stage, in order to avoid excessively strong reflections but maintaining overall reflected energy. In the author's experience this not a good idea acoustically either, neither for musicians on stage nor for audience members, as it tends to hold loudness (and loudness of reverberation) on stage while not providing useful and useable information about other instruments to the musicians: in those cases musicians tend to complain about excessive loudness on stage and that they feel there is a “veil” on stage that makes hearing other instruments more difficult.

2.3 Perception and Acoustic Criteria

For concert hall listening, we prefer halls that have a personality, that are identifiable and recognizable and that exhibit a strong acoustic signature; we want the source to be *present* and we want the room to be *recognizable* and *identifiable*. The discussions in this paper seem to strongly corroborate the concept of stream segregation in concert hall listening into a *source stream* and a *room stream*, but seem to equally indicate that there is no clear cut-off time for reflections to be allocated to each stream, as even early reflections can be part of the acoustical signature of a room.

There is indication that early reflections need to be coherent as well as discernable and identifiable for our cognitive processing, in order to maximize integration of those reflections into source stream to enhance *source presence* and proximity to the sources. In parallel, there is indication that the room should be cognitively discernable and identifiable in order to allow our auditory system to extract a maximum of information out of this secondary stream. *Room presence* is to be maximized not only in terms of acoustic energy, but in terms of acoustic signature and information content about the space we are in. Simplistically: we want and need to hear where the rear wall behind us is located, how high the ceiling is and how far away from a wall we are seated. Concentrated listeners in concert halls can give an answer to these questions, whether they are blind or sighted, but only when this auditory information is cognitively present and discernable. When this information is missing, there is a lack of physicality of the room, which the author believes to be negative in concert halls, as we no longer feel that we share the same space with the musicians. It should be noted that this is contrary to the situation in Mixing Rooms in Recording Studios, Audio Control Rooms and generally listening rooms for loudspeaker listening: here the listening room is supposed to be neutral and absent in order to avoid interference with the acoustic signature of the recording. It can be conjectured from this comparison that the acoustic needs are significantly different between rooms for classical non-amplified music and rooms for amplified music.

The discussion above leads to the conclusion that an audible, identifiable acoustic signature of a concert hall is acoustically beneficial and required for a successful high-quality concert hall: if the best concert halls are recognizable by their “acoustic signature”, do we not want such an identifiable, unique signature for every hall?

Both the notions of “identifiable elements of the acoustic signature” and of direction of arrival and identification of room surfaces are absent from the definition of current acoustic criteria including all ISO 3382 criteria. Further research into the definition and preference ranges for those new parameters that are yet to be defined is required in the future. Is a paradigm shift perhaps necessary, determining and defining what the “preferred acoustic signature of a hall” is or should be – and then, in a second step, how this signature can be obtained through room shaping and adapted acoustic finishes?

3 CONCLUSION AND OUTLOOK

There clearly is no final conclusion to this paper since it is intended to initiate discussion on this topic. The author is concerned that the generally accepted idea of surface texture being beneficial with “no price to pay” is erroneous. In the author’s recent design work, surface texture has been limited to the absolute minimum, sometimes due to budget constraints and sometimes as an esthetic and acoustical choice. After critical listening to those and other projects, the author believes that curved surfaces are preferable to fine-scale surface texture. Concerning historic halls, research has shown that the architectural language of those halls not only preserves but creates a specific acoustic signature for every room, indicating that large-scale diffusing elements and “objects” (balconies, columns, alcoves, etc.) may be more important to the explanation of the acoustical quality of the historic halls than fine-scale ornamentation.

It should be clear that significant further research is required into objective acoustic criteria, if they are supposed to predict subjective impressions and correlate with perceptual factors. Research results indicate that identifiable reflections have strong subjective effects (positive and/or negative), while in the definition of current acoustic criteria the spatial and temporal integration of energy does not differentiate between identifiable acoustic reflections and incoherent sound energy, or shall we say between “auditory events” and “noise”.

4 REFERENCES

1. L. Beranek, ‘Concert Hall Acoustics–1992’, J. Acoust. Soc. Am. 92(1) 1-39. (July 1992).
2. C.H. Haan, F.R. Fricke, ‘An evaluation of the importance of surface diffusivity in concert halls’, Appl. Acoust. 51, 53–69 (1997).
3. M. Barron, ‘Theory and measurement of early, late and total sound levels in concert spaces’, J. Acoust. Soc. Am. 137, 3087–3098 (2015).
4. E. Kahle, C. Mulder and T. Wulfrank, ‘Perceptual Relevance of Location of Reverberation in a Concert Hall’, Psychomusicology - Music, Mind and Brain: Special Issue: Honoring Leo Beranek, 3, (September 2015)
5. J.Y. Jeon, H.S. Jang, Y.H. Kim and M. Vorländer, ‘Subjective and objective evaluations of scattered sounds in concert halls’, Proc. ISRA 2013, P077. Toronto (2013).
6. E. Green, ‘Systematic spatial variations of objective measures in a 1:25 scale model rectangular concert Hall with variable scattering’, Proc. ISRA 2013, P013. Toronto (2013).
7. T. Lokki, H. Vertanen, A. Kuusinen, J. Pätynen and S. Tervo, ‘Auditorium acoustics assessment with sensory evaluation methods’. Proc. ISRA, August 29-31, Melbourne, Australia (2010).
8. T. Lokki, J. Pätynen, S. Tervo, S. Siltanen and Lauri Savioja, ‘Engaging concert hall acoustics is made up of temporal envelope preserving reflections’, J. Acoust. Soc. Am. 129 (6), EL223-EL228 (2011).
9. A. Haapaniemia, T. Lokki, ‘Identifying concert halls from source presence vs room presence’, J. Acoust. Soc. Am. 135, EL311 (2014).

10. R. Wettschurek, 'Über die Abhängigkeit raumakustischer Wahrnehmungen von der Lautstärke', PhD thesis, TU Berlin (1976).
11. E. Green, E. Kahle, 'Dynamic spatial responsiveness in concert halls', Proc. IoA 2018, Hamburg (2018).