Architectural Acoustics: Diffusion, Blend and Clarity.

Problem (I a): Can acoustical 'transparency' be experienced in reverberant spaces, or (I b): can the feature 'blend of sources' occur in rooms of low reverberant energy?

My hypothesis: The answer to both (I a) and (I b) is sound scattering.

Problem (II): How can architects be explained the acoustical advantages of surface diffusivity?

Thoughts about acoustical clarity:

Clarity is indeed a desirable acoustical feature, so is blend of sources, but does there exist a complementarity between those two qualities, or are there ways in acoustical design that both might be aimed for?

In my view the integral-defined objective parameters C80 and D50 relate to **perceived** clarity in a manner which is not always linear.
This means that, in auditoria, certain seating areas in which measured clarity show high values, the sound field does still not feel transparent. Oppositely, in other cases, measured low D50 can be encountered in places that subjectively are judged as clear.
I assume that the reason for this is the fact that soundfields in auditoria rarely are highly diffuse.
The more the room geometry favours certain sound-directions at the expense of others, probably the less correlation is found between perceived clarity and measured parameters.

In this way classical ornamented halls (of high surface diffusivity) may show a kind of pleasant acoustical clarity, that is not merely a result of low reverberant energy.
And smoothly surfaced rooms, on the other hand, may show a muddy quality of sound because their room geometrical features are not sufficiently complex.

The two aspects of Acoustical Clarity:

In order to widen the understanding of this, I find it helpful to distinguish between two different aspects of clarity, the one being a vertical and the other a horizontal one.

Leo Beranek, in the 2004 edition of his book, touches this quite enlightening distinction:

His description is as follows (page 24) :

<"Horizontal definition" refers to the degree to which sounds that follow each other stand apart> On the other hand;
<"Vertical definition" refers to the degree to which notes sounded simultaneously are heard separately.>

In this manner I see the concept "clarity" as actually hiding two aspects; (I) horizontal 'definition', and (II) what I should prefer to call vertical 'transparency'.
Only the first of those should be expected to relate to the early- to late energy parameters.

With 'definition' here is meant the perceived 'resolution' of rhythmical details appearing successively, and with 'transparency' more the conditions for identifying partial voices within sustained chords or harmonic progressions.
In rehearsals of orchestral music this feature 'transparency' is quite much praised when appearing, though *this is not frequently the case in halls of typical modern architectural finishes*.
This 'transparency' has the feeling of "airiness", and since it enables the ear to detect voices within an orchestral texture, it will help conductors in cleaning up intonation difficulties or in their work with sound colours.

I assume that the conditions for such airiness depend on hall-size and the absence of distortions like echoes, comb filter colouration (see Halmrast) etc.

My impression when comparing halls where I play regularly is that this 'transparency' or 'vertical definition' not necessarily is promoted by close reflecting surfaces.
It rather seems dependent on IR energy-decays being approximately exponential, as seen from reflectograms, -and of evenness in the room's frequency response.

For this reason it seems to me that SDI (Surface Diffusivity Index) should be expected to be well correlated with 'transparency' in the above meaning.

In accordance with this I would state that high SDI halls (coffered and ornamented) in most cases sound more 'transparent' than modern halls.
In the latter the sources may seem amplified by suspended reflectors, and in this way 'clear'.
However, the quality of this kind of clarity tend to feel musically less attractive, hence acoustic designers see a need for attenuating the density of reflector arrays, which originally were employed in order to enhance ensemble contact, text intelligibility etc.
It is puzzling to notice that in the ornamented halls, *text intelligibility often seem excellent*, despite the fact that there are surprisingly few surfaces able to aim reflections at the listeners.
Generally good directional diffuseness, as well as shorter reverberation times, probably causes this striking effect.

About "Source Blend":

Is 'blended sound' caused by reverberance or by diffusivity?

Blend is explained in the way, that sound from each source is reflected off a multitude of different reflection points, not merely off one discrete high-energy acoustical mirror.
Scattering creates a lot of small mirror- sources, or at best, walls might act as smoothly "illuminated" surfaces. This may result in a rich and mellow quality of sound.
Oppositely, unscattered reflections may cause an unpleasant and "glary" sound character.

In more reverberant rooms, sound of various reflection-orders mix, and in this way a state of diffuseness is assured in the soundfield. Especially if first order reflections are not excessively directed towards the listeners, a feel of 'source blend' then can be enjoyed.
In the work of Lothar Cremer, I see this as one of his 'secrets'.

Why there is a need for diffusivity when playing early music like Mozart.

Transparency of the sound field is needed when playing Mozart, but no less crucial is 'blend of sources'! And some kind of voice-broadening is required, in order to avoid a lifeless sound impression!
A Mozart score contains passages, or patterns of notes, which neither could nor should be played with a vibrato in the romantic way. Besides, a Mozart orchestra consists of instrumental groups too small in numbers to blend in a desirable way, if not helped by the room.
Music by Mozart therefore seems 'vulnerable' when performed in typical low surface diffusity, 20th century halls, especially if the reverberation times are short.

In such conditions the performers will be unable to achieve the liveliness of expression which is intended by this music!

In contrast to this, music of the *romantic era* is composed in such a way that a blend of sound components comes easily. The style itself allows an extensive use of vibrato, and larger instrumental groups cause a broadened picture of reflections. Melodic lines are embedded in a more "fat" orchestral texture.
Consequently it is permissible (although not optimal) to perform romantic music in halls which do not by themselves support 'blend'

Improved degree of 'blend' may be achieved either (1) -by increased reverberation,
or (2) -by introduction of significant diffusivity to the room.
For Mozart's music, alternative (2) should be the more preferable in my view!

Today there is a tendency that the need for blend is met by seeking more reverberant conditions.
This may be a consequence of the fact that modern architects are trained to seek visual simplicity, and to detest any kind of surface ornamentation, so the acoustical diffusivity strategy in many cases is "blocked".

Some observations:

I was listening to orchestra of existing Oslo Opera. The auditorium is a typical 1935 functionalist design, with smooth, unscattered side walls.
On this occasion my listening position was the seats of lowest orchestral clarity (in terms of measured D50), in the mid stalls.
Seats here have been measured to have D50(pit) of as low as 20%, like similar situation in the Gothenburg Opera

The 'horizontal' definition seemed good. Rapid violin passages were perceived distinctly.

I was able to follow a conversation in low voice between conductor and concertmaster, though the pit rail was shading both.

Vertical transparency, however, was less satisfactory: It was impossible to distinguish for instance individual voices of the woodwinds within sustained chords.

The sound of 1st violins had a "glary" edge in upper register.
It sounded, as if, -to compensate for the discouraging lack of blend,- there would be a need for sixteen first violins, whereas the usually recommended number for the style, is eight.

Some conclusive remarks:

1. Even with longer RT, the virtue of transparency may be achievable if adequate diffusion is implemented in the designs.

2. Diffusity as well as reverberance may create the attribute "blend".

3. In this respect reverberance and diffusion can substitute each other mutually. "Blend" can hide a lack of reverberation, and reverberation to some degree is able to conceal a lack of diffusion.

4. In cases of low RT, diffusion becomes more decisive for the musical result.

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