Diffusivity of Performance Spaces
– it’s significance to perceived sound quality from directional sources

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# Diffusivity - optical analogy:

<table>
<thead>
<tr>
<th>Domain</th>
<th>Diffuse</th>
<th>Non-diffuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room lighting</td>
<td>Indirect lighting, matt white surfaces, insensitive to source directivity</td>
<td>Direct lighting, mirrors, high contrast shiny surfaces, sensitive to light beam directions</td>
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</tbody>
</table>
## Diffuse and non-diffuse conditions

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<tr>
<td>Time</td>
<td>Even energy density; Smooth exponential decay</td>
<td>Prominent reflections - short delays or echoes, time-energy gaps</td>
</tr>
<tr>
<td>Freq</td>
<td>Even frequency response</td>
<td>Peaks, dips, modes, comb-filters</td>
</tr>
<tr>
<td>Space</td>
<td>Even intensity distribution, no sound shadows; <em>Multitude of transmission paths</em></td>
<td>Hot spots, dead spots, beaming, acoustic glare, interference patterns; <em>Few effective transmission paths</em></td>
</tr>
</tbody>
</table>
Dynamic Diffusivity

Number of transmission paths

An-echoic  Non-diffuse  Diffuse

Volume dependent

1. arrival  Transition time  Diffusivity onset

D

1
J. Meyer 1972: Violin radiation
Transmission quality

Number of transmission paths

1. arrival

1. arrival

Transition time, dependent on source D

An-echoic
Non-diffuse
Diffuse

Poor
Rich

D

D
Perceived transmission quality

Merged early sound

0 ms  50 ms
Sufficiently early transition

rich early sound

0 ms 50 ms

time
Too late transition

Poor early sound

0 ms  50 ms
Multi-channel transmission
Multi-channel transmission

1. Direct component via channel 1
2. Reflected component via channel 6
3. Receiver
Multi-channel transmission

Elmia Hall, standard room in ODEON
Multi-channel transmission

The 100dB channel separator created in ODEON 7.0

N = 6 channels sufficient for analyzing up to D = 6

Polar diagram for 1 of 6 channels
Elmia 10,000m³

6 channel energy-time (dB-ms)
Vienna 15,000 m³

6 channel energy-time (dB-ms)
Oslo 19.000m³
6 channel energy-time (dB-ms)
Rehearsal room 60m³

6 channel energy-time (dB-ms)
Channel separation

Average separation between 6 room acoustical channels, in 4 different performance spaces

![Graph showing channel separation over time re Direct (ms) with dB levels for Rehearsal, Elmia, Wien, and OKH.]
Early-late channel separation

Average separation between 6 room acoustical channels, in 4 different performance spaces

0 2 4 6 8 10 12

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200

- Rehearsal
- Elmia
- Wien
- OKH

10ms 30ms 70ms 95ms

3dB
Early energy E50 study

- E50 = energy received 0-50ms
- E50’s predicted via 6 channels in ODEON 7.0
- Channel inputs from simulated directive source
- Varying directionality D < 6
Sum of 6 channel transmission with input from directional source, Event 1:

Ch1 = direct path
4 events (e.g. musical notes): source outputs

Vertical

Event 1

Event 2

Event 3

Event 4

Horizontal

Event 1

Event 2

Event 3

Event 4

Event # 1 2 3 4
91 random events: E50 correlates better with produced energy than does energy via direct path (Ch 1)
Room condition sensitivity

• Early sound quality responds positively to
  – Smaller volumes
  – Less absorption

• Early sound quality is insensitive to surface diffusion (scattering) for $D < 6$
Conclusions

• If its onset is sufficiently early, the DIFFUSIVITY of a performance space provides for transmission of an instrument’s FULL SOUND to receivers, independent of angle or positions relative to the instrument, or any obstruction of sightline between source and receiver.

• For instrument directivities up to D=6 (at least), diffusivity onset is determined by the size of the performance space.
Further work

• The significance of surface diffusion will be investigated for $D > 6$
• This requires more than 6 channel analysis
Thank you for your time!

• Free download of this presentation, and
• More room acoustics and music acoustics, on

www.akutek.info