Using Auralisation as a Tool for Subjective Evaluation

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Designing Room Acoustics for Studios

Practical experience

- …more than 50 studio designs in the last 4 years (recording, production and broadcasting facilities, including control and listening rooms)
- …90% of the studio spaces are ‘small’ in the acoustical sense (smaller than 70…100 m^3)
- …design specifications according to BBC and EBU recommendations
- …reverberation time design mainly using the Norris-Eyring theory, verified by computer simulations
- …verification measurements at installations have been proven design accuracy

Designing Room Acoustics for Studios

Design challenges

- …understanding feedback from users: “what makes a studio sounding good?”
- …going beyond reverberation times

Earlier experiments

- …subjective listening test in the Hungarian Radio:
  - single channel omni-directional measurements,
  - early-to-late energy ratios with low early-time limits (10…15 ms) correlate well with stereo accuracy, etc.
- …time-frequency display of impulse responses: decay-contour

Aim of the investigations…

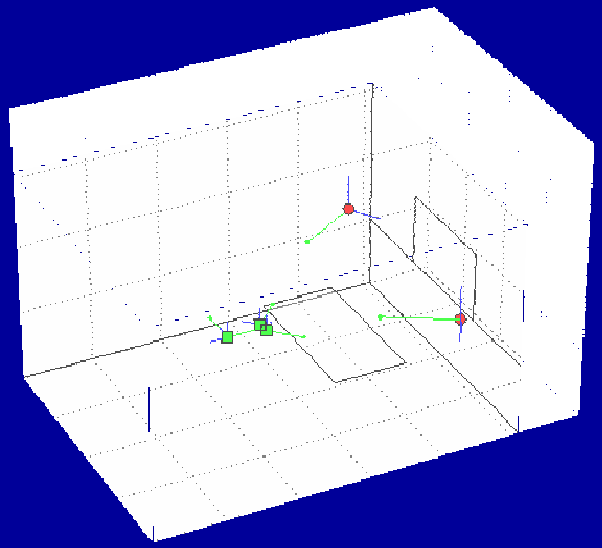
- **… to find those objective acoustical phenomena which characterize the studio spaces (some possibilities)**
  - effect of room modes
  - effect of distinct reflections
  - effect of diffusing surfaces
- **… to make the influence of the chosen parameters audible by simulation**

Aim of the investigations…

- **… to find the role of diffuse sound field in studios**
  - Diffusing surfaces are needed to make damped rooms to sound more natural
  - **but**: what diffuseness is needed, how to express and optimize diffuseness?
- **… looking for means to express diffuseness in studios**
  - Understanding the effects of diffusing surfaces in studios: subjective and objective evaluation methods
  - Using computer simulations and auralisation to evaluate different acoustical environments with different applications of diffusing surfaces.

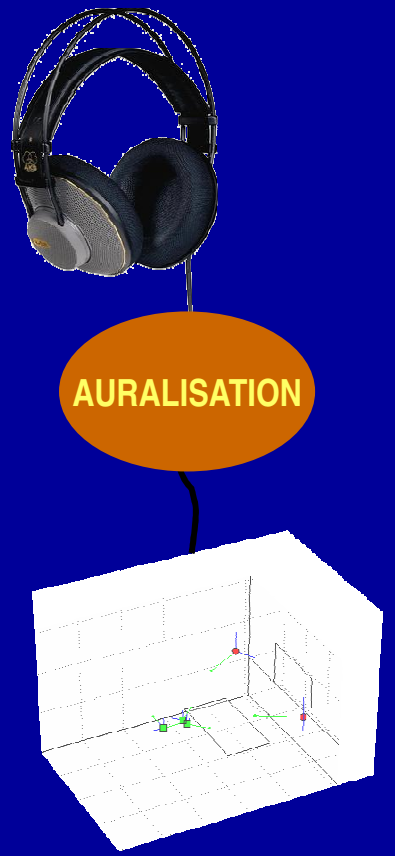
Usual and used methodologies/1

- **Subjective evaluation methods**
  - real-world experiments
  - laboratory experiments
- **Computer simulations**
  - beam-tracing method
  - simplified geometry (no structural details, simple furniture)
  - smooth specular to diffuse energy transfer
  - Matlab platform



Usual and used methodologies/2

- **Auralisation = computer simulation + subjective evaluation**
  - HRTF (2D horizontal)
  - 2 channel stereo microphone technique (ORTF-stereo)
  - simulation of a conventional two-channel stereo loudspeaker system
  - off-line convolution with two-channel recordings
  - reproduction by headphones



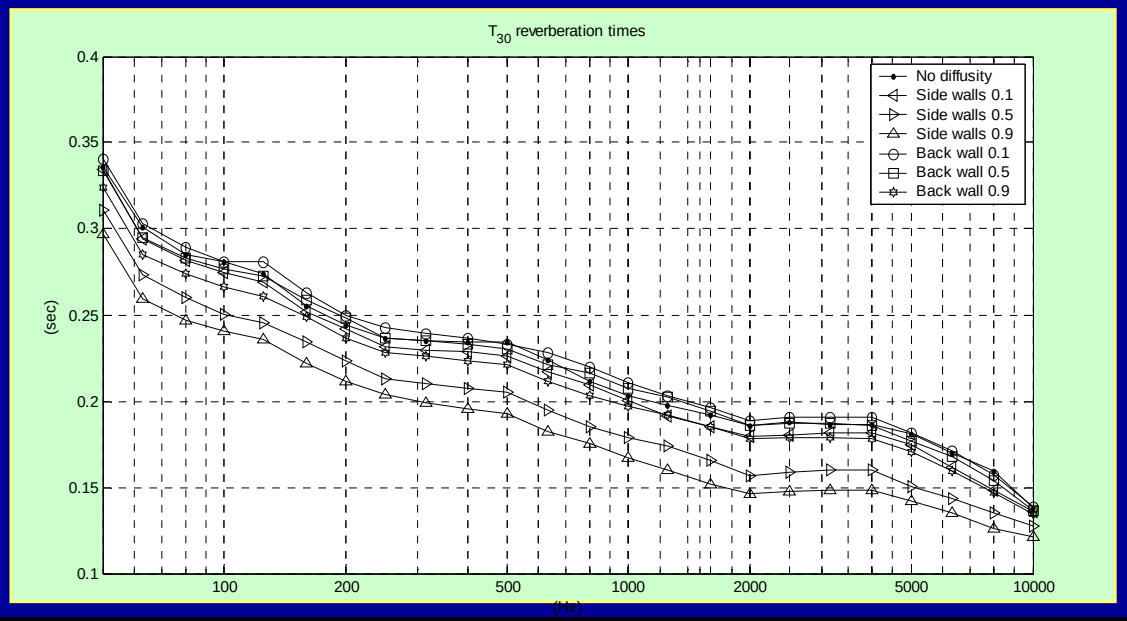
Conditions and parameters

- **Room acoustical situations**
  - shoebox-type room (5x4x3 m) with a mixing desk and a window 2-channel loudspeaker system
  - factors that change:
    - diffusion coefficient (4 combinations: from 0 to 0.9 on selected surfaces)
    - diffuse surface position (2 combination: side-walls or back-wall)
- **Evaluated features**
  - room acoustical parameters (early-to-late energy ratios, IACC, LEF)
  - auralisation: noticable differences, tendencies
  - subjects: only 4 subjects so far

Results – physical parameters

Room acoustical parameters - decay times

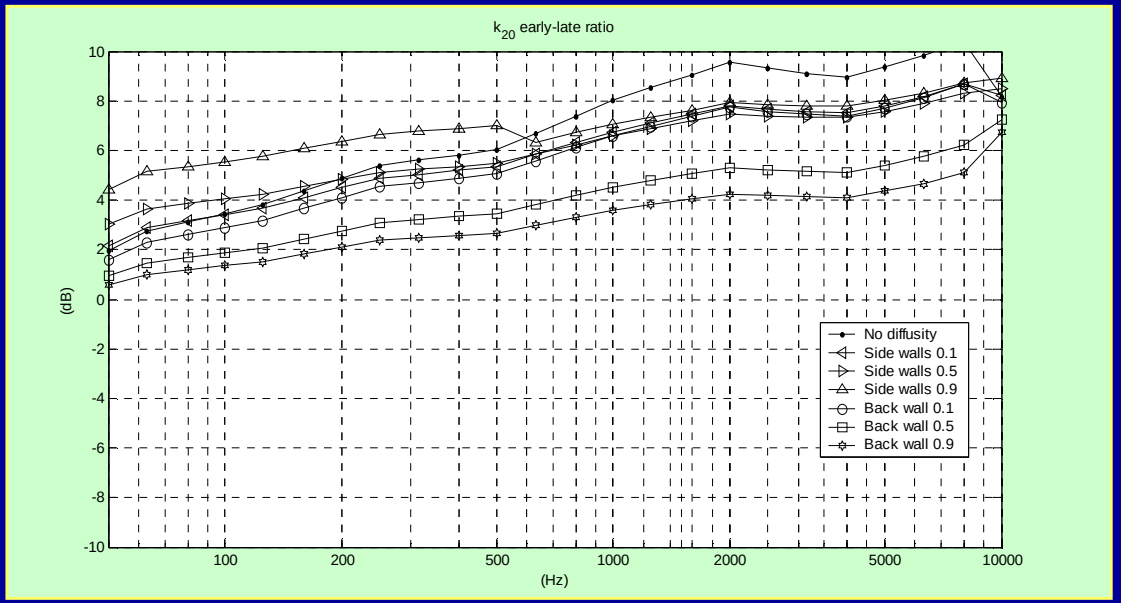
- decay times were influenced (decreased) only by higher diffuse values on the side walls



Results – physical parameters

Room acoustical parameters - early-to-late energy ratios

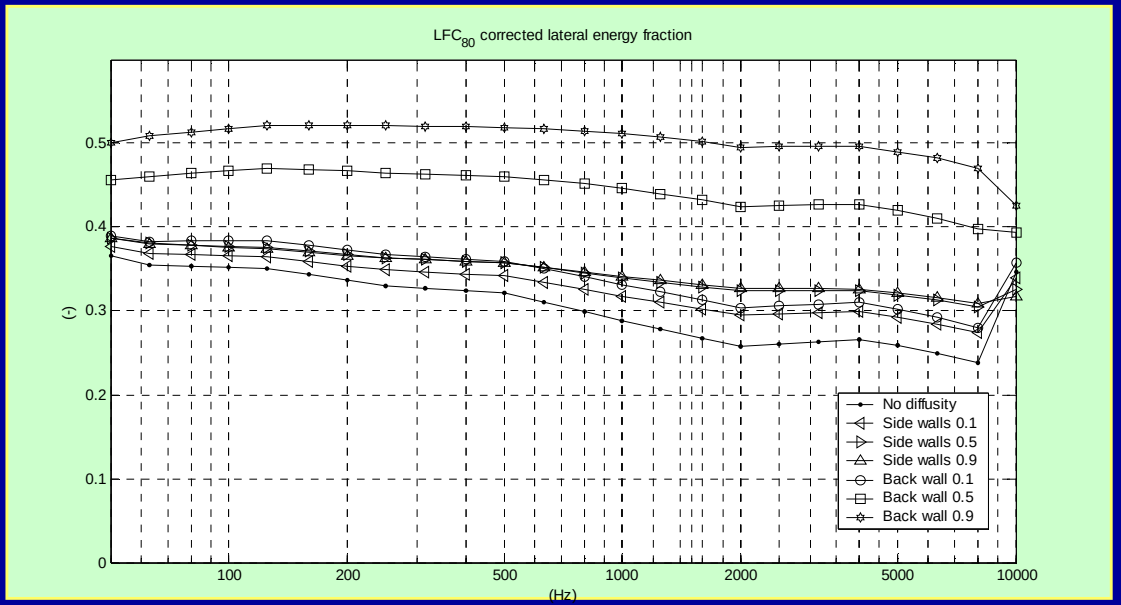
- only energy ratios with 15…20 ms time limits showed significant differences



Results – physical parameters

Room acoustical parameters - two-channel parameters

- Lateral energy fractions showed significant difference, no consistent results with IACC



Results – subjective evaluation

- **Auralisation**
  - significant correlation of preferences among subjects, even with the simple ORTF microphone simulation technique
  - diffusing surfaces on the side walls are not preferred: image becomes blurred, coloration occures.
  - the more diffusion on the back wall, the clearer and steadier the image.

Conclusions

- **Room acoustical parameters**
  - correlating parameters:
    - early-to-late energy ratios with 15…20 ms time-limits (lower was better)
    - lateral energy ratios with 80 ms time limits (higher was better)
  - other parameters (including IACC) gave no consistent or correlating results
- **Auralisation**
  - It is possible to express and track changes even with simple methods.

Future work …

- Other room geometries and sizes
- Organizing subjective experiments on more subjects
- Speeding up calculations
- Verification by measurements…