Can concert hall preference be predicted and explained?

ROOM ACOUSTICAL PARAMETER VALUES AT LISTENERS’ EARS
Introduction

- Why do some halls sound better than others?
- Demand for prediction of listeners’ response
  - Planning of new concert halls
  - Amendments in existing halls
Previous work

- Subjective rank-ordering of 58 concert halls
  Beranek (2003)

- Comparison with hall-averages of measured parameters
  - => preferred values
  - => significant parameters

- However: Few listeners experience hall-average conditions (Skålevik 2008), e.g.:
  - Musikverein Vienna, 90% seats differ noticeably from hall-average conditions, 5 parameters, ISO3382
Different approach

- Listening quality not represented by hall-averages
- Instead – evaluate listening quality at listeners’ ears
  - At a given seat, let listening quality be described by a set of parameter values
- Quality of hall calculated from quality of seats
Objective Hall Rank

- Choose a set of N critical parameters
  - Let value ranges found in top-ranked halls (Vienna, Amsterdam) define “acceptable” parameter values
- Acquire data from at least 10 positions per hall
- In each position:
  - If all N values are acceptable, then Seat Rank = 1
  - If one value is not acceptable, then Seat Rank = 2
  - If k values are not acceptable, then Seat Rank = 1+k
- Objective Hall Rank = X-percentile of {Seat Rank}
  - Assuming X% “extreme” seats, generally avoided by respondents in Beranek’s rank-ordering
Parameters’ relevance test

- For a selection of halls, calculate correlation $R^2$ between Objective ranking and Beranek’s Subjective ranking
- Let $R^2$ indicate relevance of a parameter-set
  - Measured data input: $R^2$ indicates explainability
  - Predicted data input: $R^2$ indicates predictability
- Examples of testing follows....
5 aspects, 5 parameters

<table>
<thead>
<tr>
<th>Listener aspect (subjective / perceived)</th>
<th>Quantity</th>
<th>Just noticeable difference JND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound Level</td>
<td>G (dB)</td>
<td>1 dB</td>
</tr>
<tr>
<td>Reverberance</td>
<td>EDT (s)</td>
<td>5 %</td>
</tr>
<tr>
<td>Clarity</td>
<td>$C_{80}$ (dB)</td>
<td>1 dB</td>
</tr>
<tr>
<td>Apparent Source Width</td>
<td>LF</td>
<td>0.05</td>
</tr>
<tr>
<td>Envelopment</td>
<td>$G_{late}$</td>
<td>(1 dB)</td>
</tr>
<tr>
<td>Concert hall</td>
<td>Volume</td>
<td>Seats</td>
</tr>
<tr>
<td>------------------------------</td>
<td>--------</td>
<td>-------</td>
</tr>
<tr>
<td>Musikverein, Vienna</td>
<td>15000</td>
<td>1700</td>
</tr>
<tr>
<td>Concertgebouw, Amsterdam</td>
<td>19000</td>
<td>2000</td>
</tr>
<tr>
<td>St David, Cardiff</td>
<td>22000</td>
<td>2000</td>
</tr>
<tr>
<td>Gasteig, Munich</td>
<td>30000</td>
<td>2500</td>
</tr>
<tr>
<td>Konserthus, Göteborg</td>
<td>12000</td>
<td>1300</td>
</tr>
<tr>
<td>Concert hall</td>
<td>Volume</td>
<td>Seats</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>--------</td>
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</tr>
<tr>
<td>Festspielhaus, Salzburg</td>
<td>15500</td>
<td>2200</td>
</tr>
<tr>
<td>Liederhalle, Stuttgart</td>
<td>16000</td>
<td>2000</td>
</tr>
<tr>
<td>Usher Hall, Edinburg</td>
<td>16000</td>
<td>2500</td>
</tr>
<tr>
<td>Royal Festival Hall, London</td>
<td>22000</td>
<td>2900</td>
</tr>
<tr>
<td>Barbican, London</td>
<td>18000</td>
<td>2000</td>
</tr>
</tbody>
</table>
5 parameters measured

10 halls, 116 positions, X=27%

\[ R^2 = 0.68 \]

\[ y = 0.40x + 0.84 \]

\[ R^2 = 0.68 \]
EDT G C \( G_{\text{late}} \) measured

\[
y = 0.31x + 1.00 \\
R^2 = 0.71
\]

10 halls, 116 positions, \( X=27\% \)
Now imagine...

- ...only Musikverein and Concertgebouw existed
- Could the subjective ranking of the 8 next halls be predicted?
5 parameters Odeon 10

10 halls, 116 positions, X=23%

\[ y = 0.28x + 1.14 \]

\[ R^2 = 0.59 \]
EDT G C G\textsubscript{late} TVr-estimates T from Odeon

10 halls, 116 positions, X=25%

\begin{align*}
R^2 &= 0.72 \\
\text{Objective ranking} &\quad \text{Subjektive ranking} \\
0 &\quad 5 &\quad 10 \\
0 &\quad 1 &\quad 2 &\quad 3 &\quad 4 &\quad 5 \\
\end{align*}

\begin{align*}
y &= 0.33x + 0.63 \\
R^2 &= 0.72
\end{align*}
What’s new?

- New method for testing parameter sets
  - Explainability
  - Predictability
- Parameter-values at listeners’ ears
  - Instead of hall averages
- No multiple linear regression
- Inter-dependent parameters allowed
Conclusion

- The test method shows promising possibilities in evaluating suggested criteria.
- Current objective criteria needs further critical examination, examples:
  - Barbican Hall bottom-rank unexplained
  - Cardiff hall would have been designed differently, given ISO 3382 parameters at the time
- More extensive discussion given in paper
Thank you

More info?

The www center for search, research and free sharing in acoustics

www.akutek.info

magne.skalevik@brekke-strand.no