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The mother of all acoustical parameters

**REVERBERATION TIME**

# In the beginning...

- ...there was the Reverberation Time
- ...then came the DIRECTED sound shapes
  - Too much early energy – drowning the reverberance
- ... and the WIDE halls, the FAN shapes
  - Too little early energy – unclear sound
- The world cried for early energy control C, D, Tc, ITDG
- Then came the CANOPIES
  - Restoring early energy, but
  - Suppressing lateral energy, lack of ASW
- Measure early lateral energy by LF or 1-IACC
- EDT – perceived (running) reverberance
- G – since preference correlates with total energy
- LLG and  $G_{\text{late}}$  - listeners enveloped by late energy

# 5 listener aspects

Listener aspect (subjective / perceived)	Quantity	Just noticeable difference JND
Sound Level	G (dB)	1 dB
Reverberance	EDT (s)	5 %
Clarity	$C_{80}$ (dB)	1 dB
Apparent Source Width	LF	0.05
Envelopment	$G_{late}$	(1 dB)

What about the Reverberation Time? On a museum?  
Obsolete – like a good old fashion lady?  
JUST a GLOBAL parameter?

# RT out of time? Lets test it

- Step 1: Design a set of predictors for listeners aspects based on  $T$ ,  $V$  and  $r$  only
  - $T$  Reverberation time
  - $V$  volume
  - $r$  source-receiver distance
- Step 2: Compare 126  $TVr$ -predictions with measurements, in 11 halls, calculate JNDs
- Step 3: Compare JNDs with state-of-the-art prediction tool results
- Failure of test would falsify the hypothetical significance of RT

# From Barron's Revised Theory

Level component	Symbol	Formula (log version)
Direct energy level	Ld	$10 \cdot \log(100/r^2)$
Reflected energy level	G,refl	$10 \cdot \log(31200 \cdot T/V) - r/c \cdot 60/T$
<b>Total energy level</b>	<b>G</b>	<b><math>10 \cdot \log(10^{G,refl/10} + 100/r^2)</math></b>
<b>Late reflected energy</b>	<b>GL</b>	<b><math>G,refl - 60dB \cdot 80ms/T</math></b>
<b>Early energy level</b>	<b>Ge</b>	<b><math>10 \cdot \log(10^{G/10} - 10^{GL/10})</math></b>

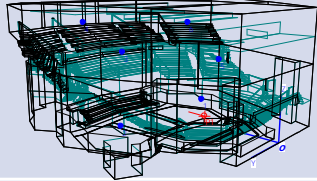
Now making use of G, Ge and GL ....

# Combining and completing

Listener aspect (subjective / perceived)	Quantity	TVr-predictors
SOUND LEVEL	G (dB)	G
REVERBERANCE	EDT (s)	$T \cdot (10\text{dB} - (G - G_{\text{refl}})) / 10$
CLARITY	C80 (dB)	$G_e - G_L$
APPARENT SOURCE WIDTH	LF (1)	$r \cdot 0.18 / 18\text{m}$ if $r \leq 18\text{m}$ $0.18$ if $r > 18\text{m}$
ENVELOPMENT	G,late (dB)	$G_L$

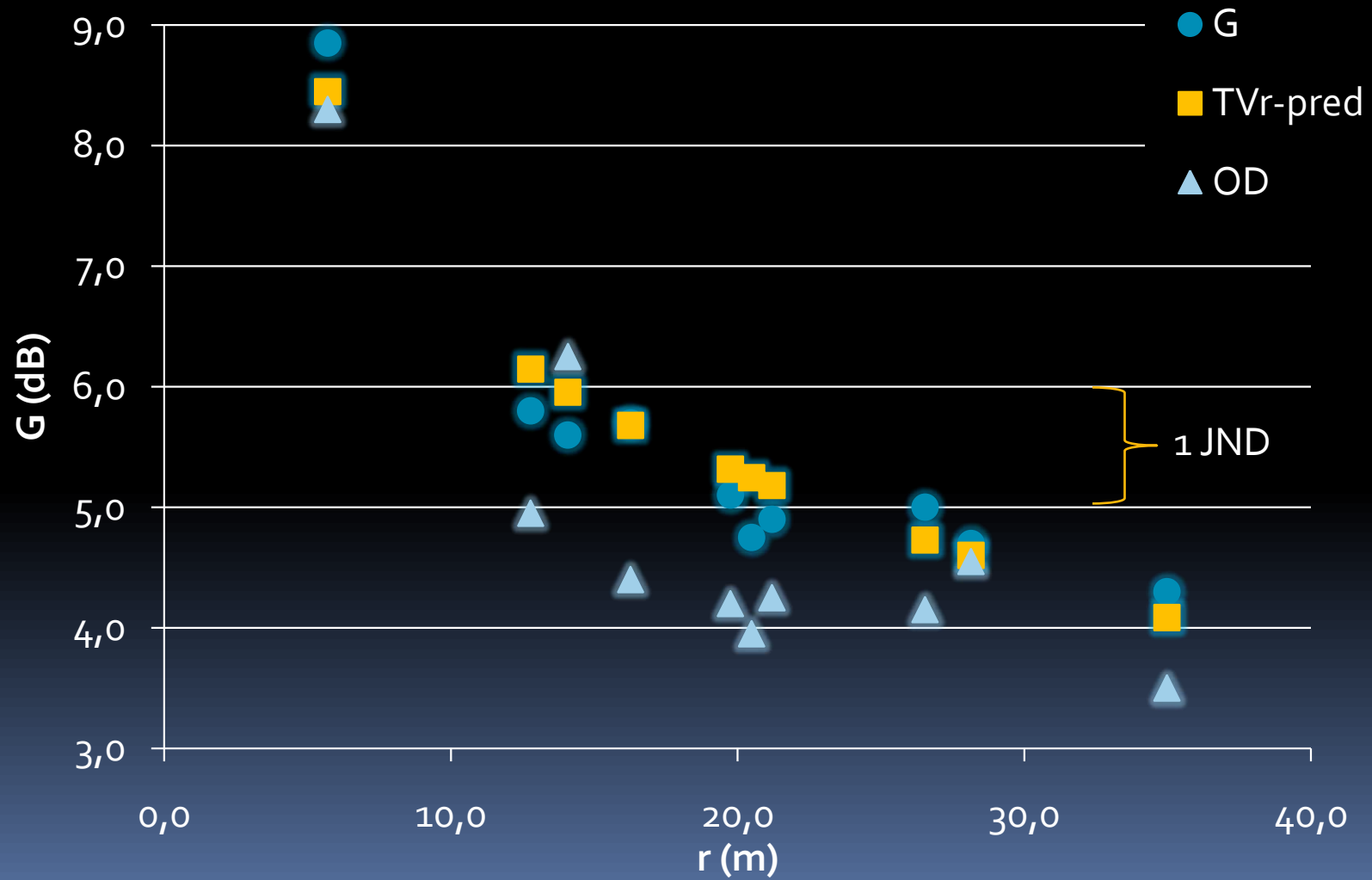
LF is here a simple empirical estimate from  $r$

Concert hall	Volume	Seats	RT (unocc)	
Barbican, London	18000	2000	2,0	
Concertgebouw, Amsterdam	19000	2000	2,5	
Derngate, Northampton	13500	1300	2,1	
Festspielhaus, Salzburg	15500	2200	1,9	
Gasteig, Munich	30000	2500	2,2	

Concert hall	Volume	Seats	RT (unocc)	
Konserthus, Gøteborg	12000	1300	1,7	
Liederhalle, Stuttgart	16000	2000	2,1	
Musikverein, Vienna	15000	1700	3,2	
Royal Festival Hall, London	22000	2900	1,6	
St David, Cardiff	22000	2000	2,2	
Usher Hall, Edinburg	16000	2500	2,0	

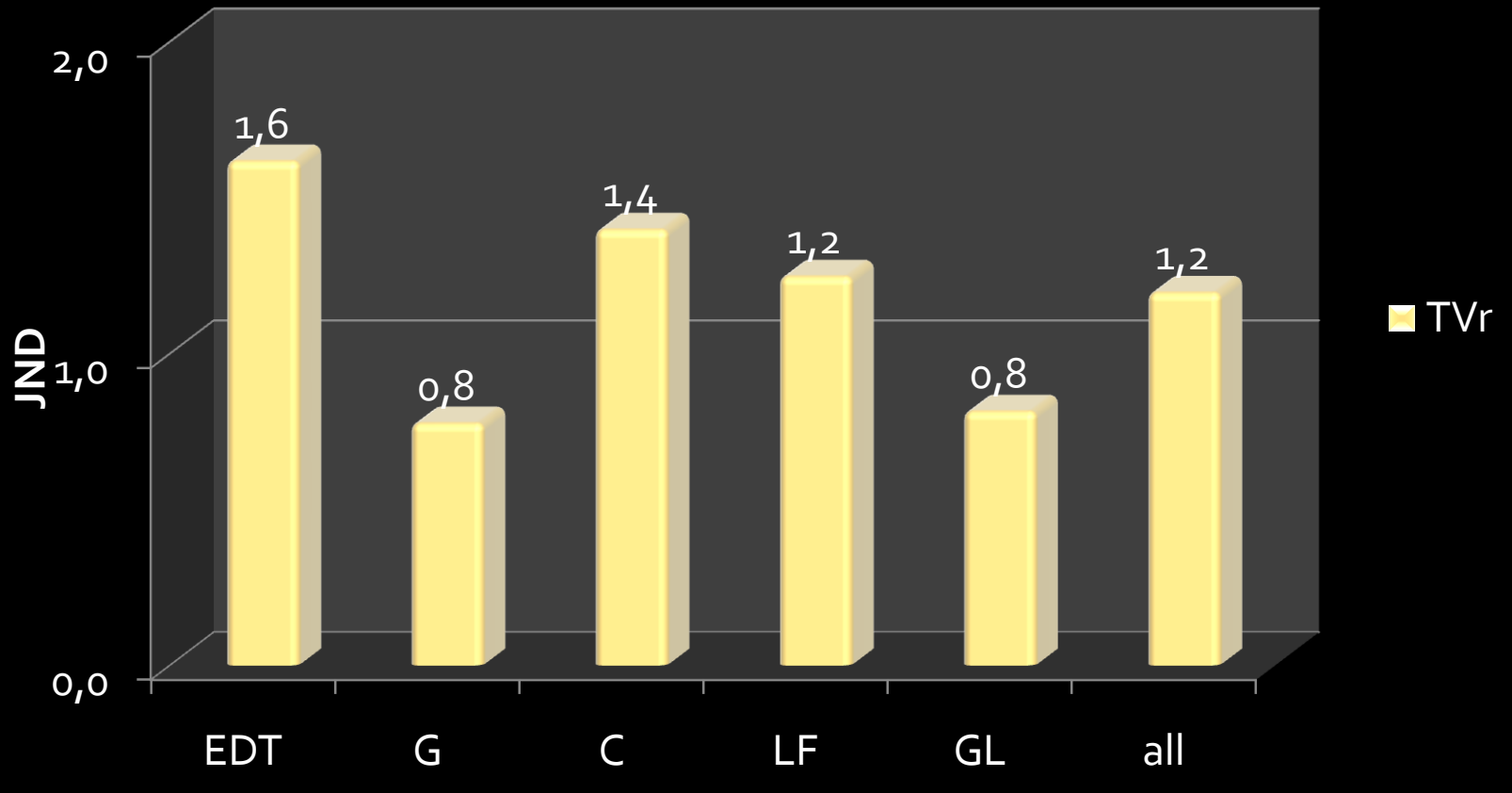


# Example: Concertgebouw G



# Comparison with measurements

Difference (in JND units) between TVr-prediction and measurement. Average 1.2 JND



# Test result

Prediction method	Success (< 1JND)	Average JND
<b>TVr</b> (measured T)	<b>52%</b>	<b>1.20</b>
Odeon 10	42%	1.57
TVr (Odeon T)	50%	1.23

Odeon T =hall average RT from Odeon 10

Odeon T differs from measured T by 0.28 JND on average

## Conclusion:

RT significance not rejected by the test

Sabine Still Stands

# 3 independent variables

- $r$       local spatial parameter
- $V$       global geometrical parameter
- $T$       global acoustical parameter

T

r

v

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# Thank you

More info?

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

**[www.akutek.info](http://www.akutek.info)**

Follow link to full paper version:

[Reverberation Time—the mother of all room acoustical parameters](#)