



Magne Skålevik
Brekke & Strand, Oslo
www.akutek.info

Room Acoustical Parameters

CAN CONCERT HALL PREFERENCE BE PREDICTED?

AIA-DAGA meeting, Merano, 19-21 March 2013



What concert hall preference?

- Which halls are more preferred, or less preferred, by the average concert-goer?
- Why predict preference?
 - Scientific or academical reasons
 - Curiosity
 - **Basis for decisions** (Building Committee)
 - RISKY BUSINESS
- Null Hypothesis: Preference is purely random



5 aspects 5 parameters

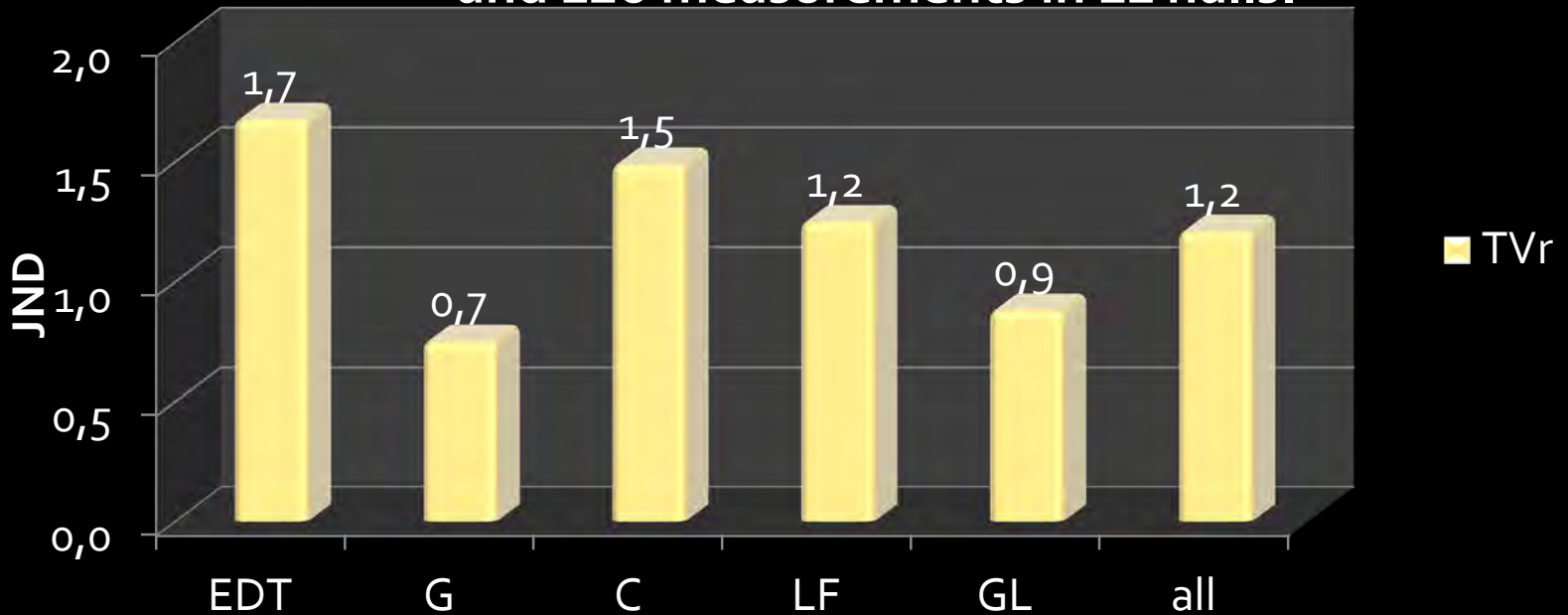
ISO-3382*

Subjective listener aspect	Physical quantity (Parameter) notation and unit	
Subjective level of sound	Sound Strength	G (dB)
Perceived reverberance	Early Decay Time	EDT (s)
Perceived clarity of sound	Clarity	C80 (dB)
Apparent Source Width	Early Lateral Energy Fraction	LF (1)
Listeners Envelopment	Late (*Lateral) Sound Level	GL (dB)



TVr-predictors (Barron Revised Theory)

Difference (in JND units) between TVr-prediction and 126 measurements in 11 halls.



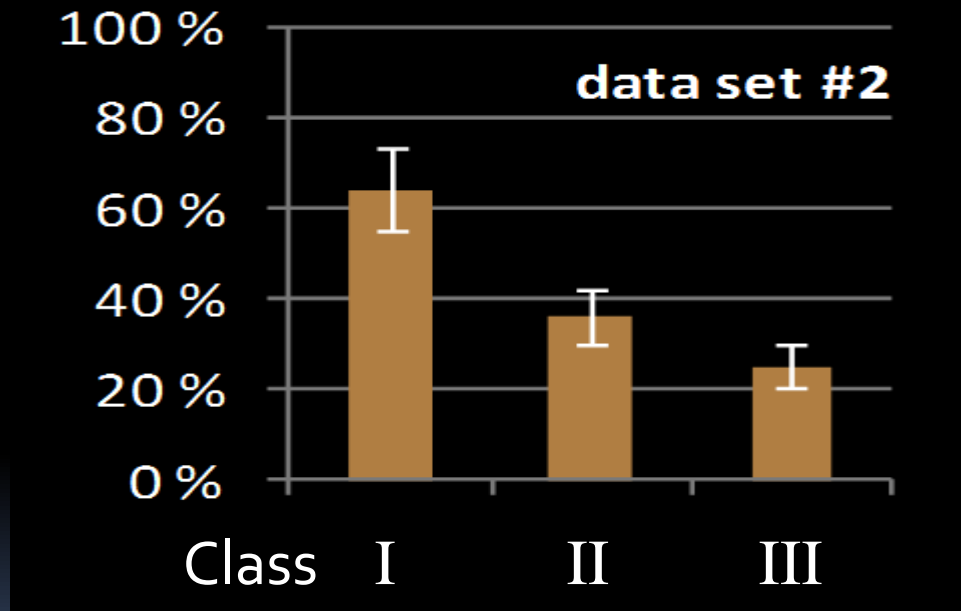
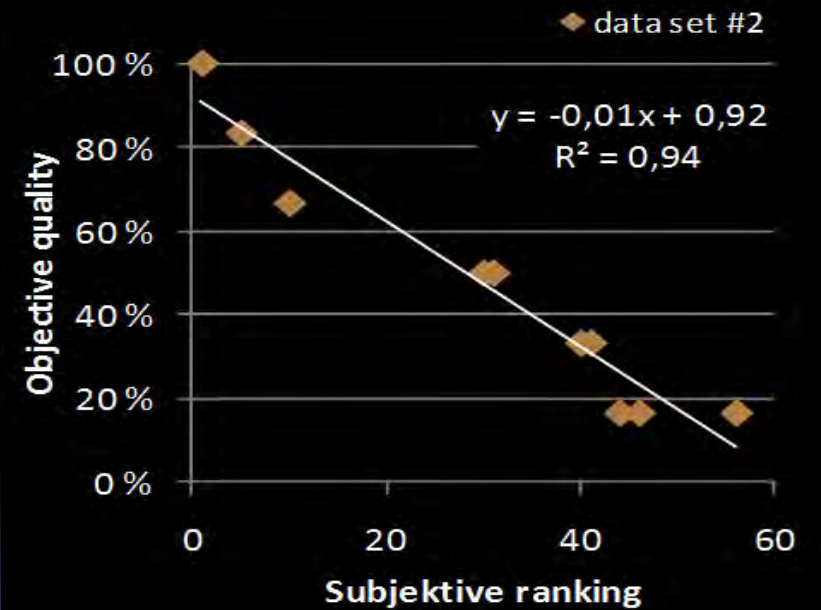


Does parameter data correlate with subjective preference data?

- Let's take parameter data for 10 of the halls included in Beraneks rank ordering of 58 halls
- The 10 halls
 - Musikverein, Vienna
 - Concertgebouw, Amsterdam
 - St David, Cardiff
 - Gasteig, Munich
 - Konserthus, Gøteborg
 - Festspielhaus, Salzburg
 - Liederhalle, Stuttgart
 - Usher, Edinburg
 - Royal Festival Hall, London
 - Barbican, London



10 halls: Objective vs Subjective



	EDT	G	C	LF	G _{late}	G ₁₂₅
Criterion	2.0	4.3	-0.3	0.20	1.5	4.7
Tolerance ±	1.1	1.0	0.7	1.1	1.0	1.0



10 halls too few? Now take 53 halls

- Beranek subjective ranking of 58 concert halls
- T_{occupied} and geometrical data in 53 of 58 halls
- Using TVr-predictors (Barron Revised Theory)
- Our set of physical data:

T

EDT

G

C

G_{Late}

G_{125}

W

H/W



53 halls out of Beranek's 58

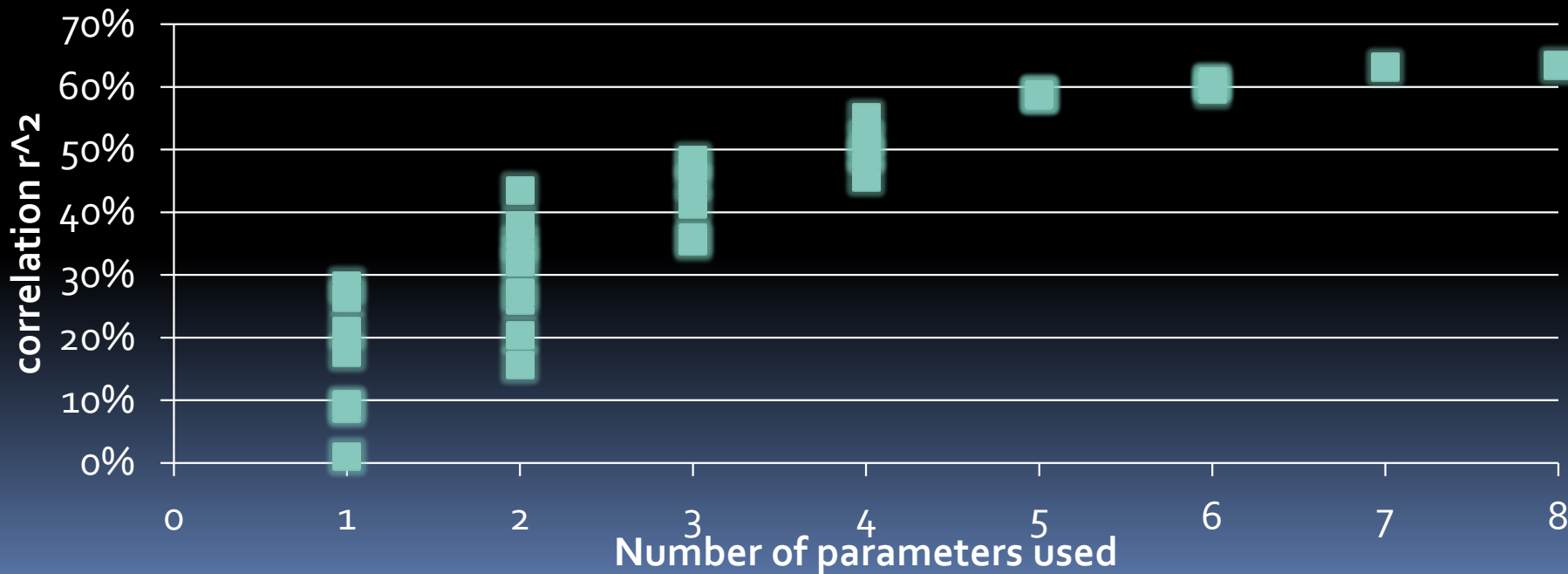
	Rank
Vienna Grosser Musikverinsaal	1
Boston Symphony Hall	2
Buenos Aires, Teatro Colon	3
Berlin Konzerthaus (Shauspielhaus)	4
Amsterdam Concertgebouw	5
Tokyo Opera City, Concert Hall	6
Zurich Grosser Tonhalsaal	7
New York Carnegie Hall	8
Basel Stadt Casino	9
Cardiff, St David Hall	10
Dallas, Meyerson Symphony Center	11
Lenox, MA, Seiji Ozawa Hall	13
Costa Mesa, Segerstrøm Hall	14
Salt Lake City, Symphony Hall	15
Berlin Philharmonie	16
Tokyo, Suntory Hall	17
Tokyo, Bunka Kaikan	18
Brussels, Palais des Beaux-Arts	19
Baltimore, Meyerhoff Symphony Hall	20
Bonn Beethovenhalle	30
Chicago, Orchestra Hall	30
Christchurch, Town Hall	30
Cleveland, Severance Hall	30
Gothenburg Concert House	30
Jerusalem, Binyanei Ha'Onnoh	30
Kyoto Concert Hall	30
Leipzig, Gewandhaus	30

	Rank
Lenox, Tanglewood Music Shed	30
Munich, Philharmonie Am Gasteig	30
Osaka, Symphony Hall	30
Rotterdam De Doelen	30
Tokyo, Metropolitan Art Space	30
Tokyo, Orchard Hall	30
Toronto, Roy Thompson Hall	30
Vienna Konzerthaus	30
Washington, DC, JFK Concert Hall	30
Salzburg, Festspielhaus	40
Stuttgart, Liederhalle Grosser Saal	41
New York, Avery Fisher Hall	42
Copenhagen Radiohuset Studio 1	43
Edinburgh, Usher Hall	44
Glasgow, Royal Concert Hall	45
London Royal Festival Hall	46
Liverpool, Philharmonic Hall	47
Paris, Salle Pleyel	49
Montreal, Salle Wilifrid-Pelletier	51
Tokyo, NHK Hall	52
Sydney Opera House Concert Hall	53
San Fransisco, Davies Hall	54
Tel Aviv, Frederic Mann Auditorium	55
London, Barbican Concert Hall	56
Buffalo Kleinhans Music Hall	57
London, Royal Albert Hall	58



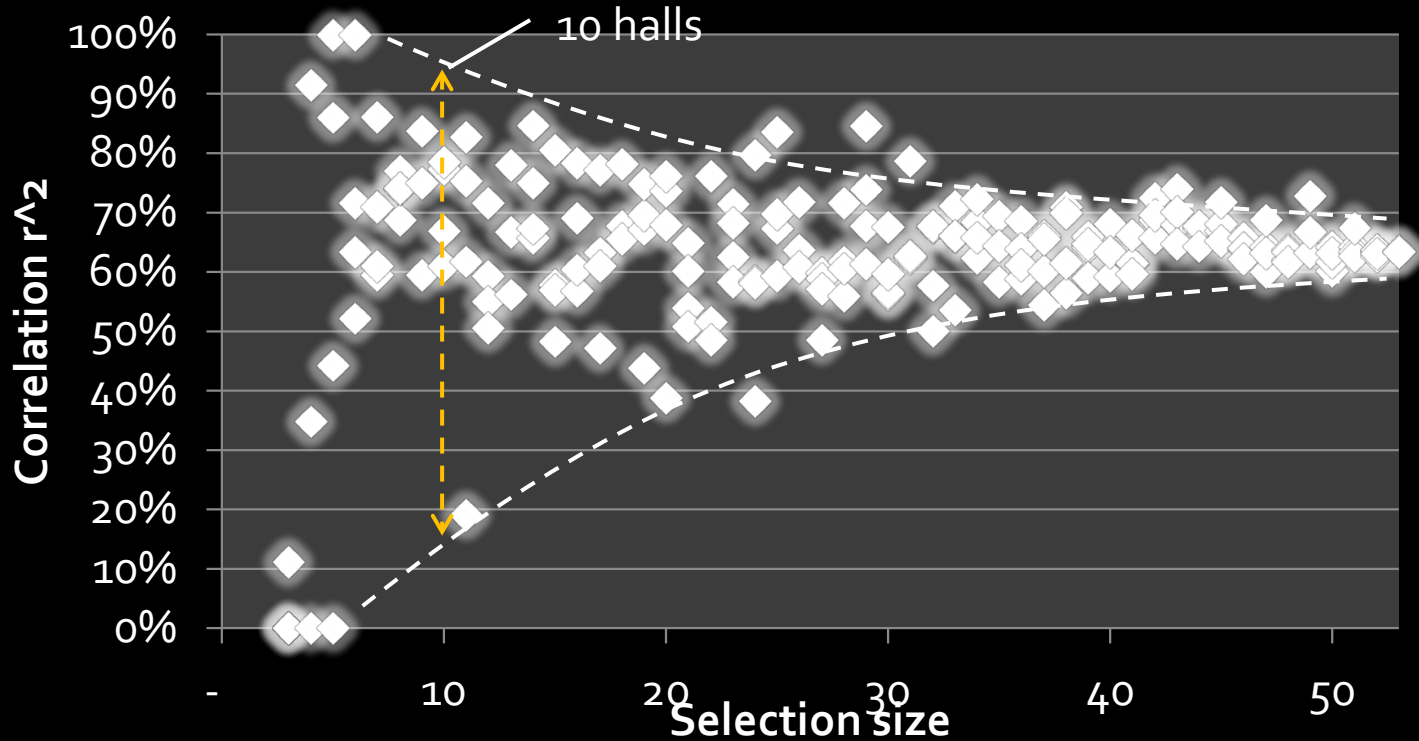
Subjective-Objective correlation converge with more data, 53 halls

Objective data available: T EDT G C G_{Late} G_{125} W H/W



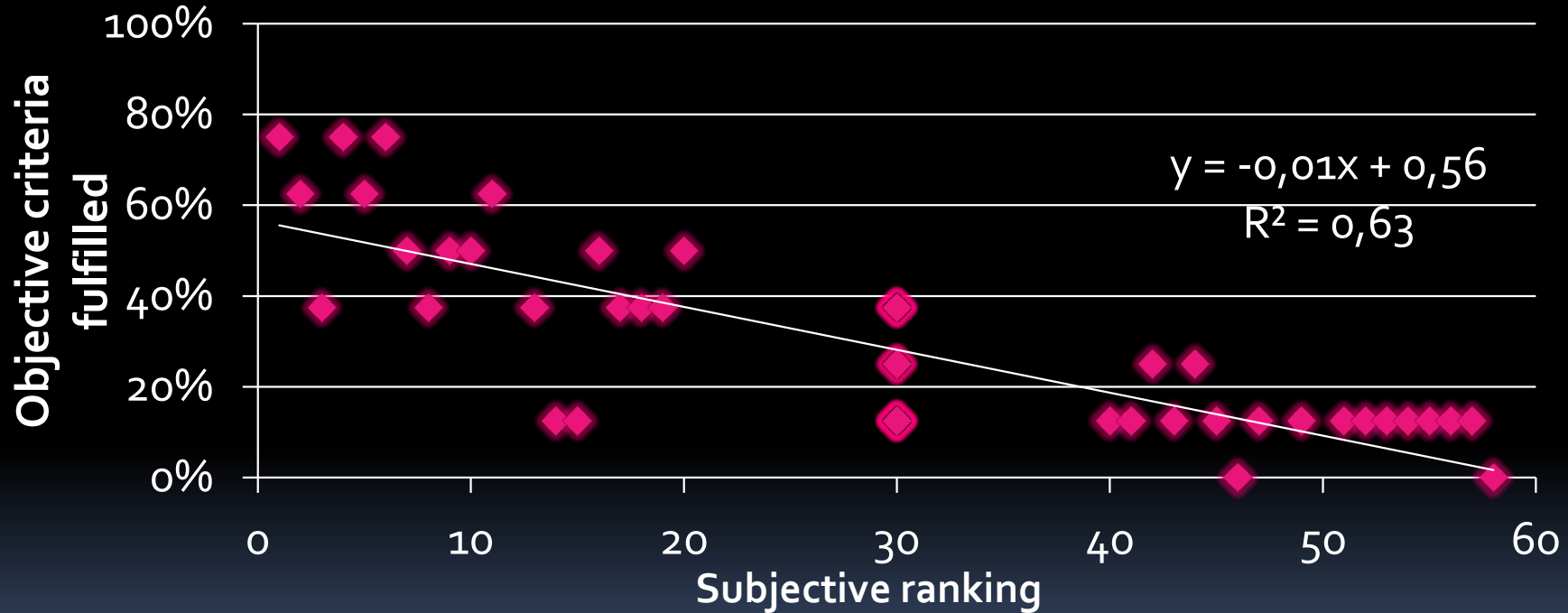


How does size of random subset affect correlation uncertainty?





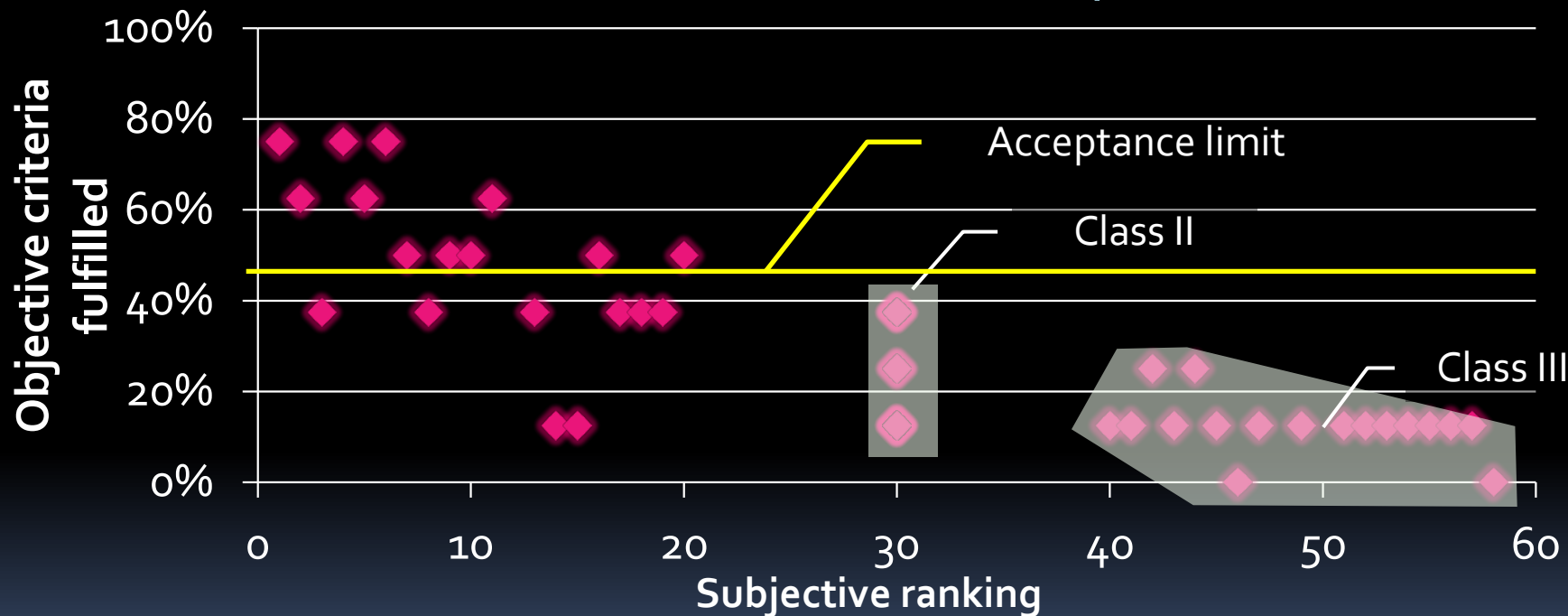
Curious scientists ask for correlation, $r^2=0.??$



Criteria	T	EDT	G	C	G _{Late}	H/W	G ₁₂₅	W
Hall average	2.0 s	2.0 s	4 dB	0 dB	3 dB	1.0	4 dB	23 m
Tolerance \pm	0.1 s	0.2 s	1 dB	1 dB	1 dB	0.2	1 dB	5 m



Building committee says: «Halls in Beranek Class II and III are unacceptable»

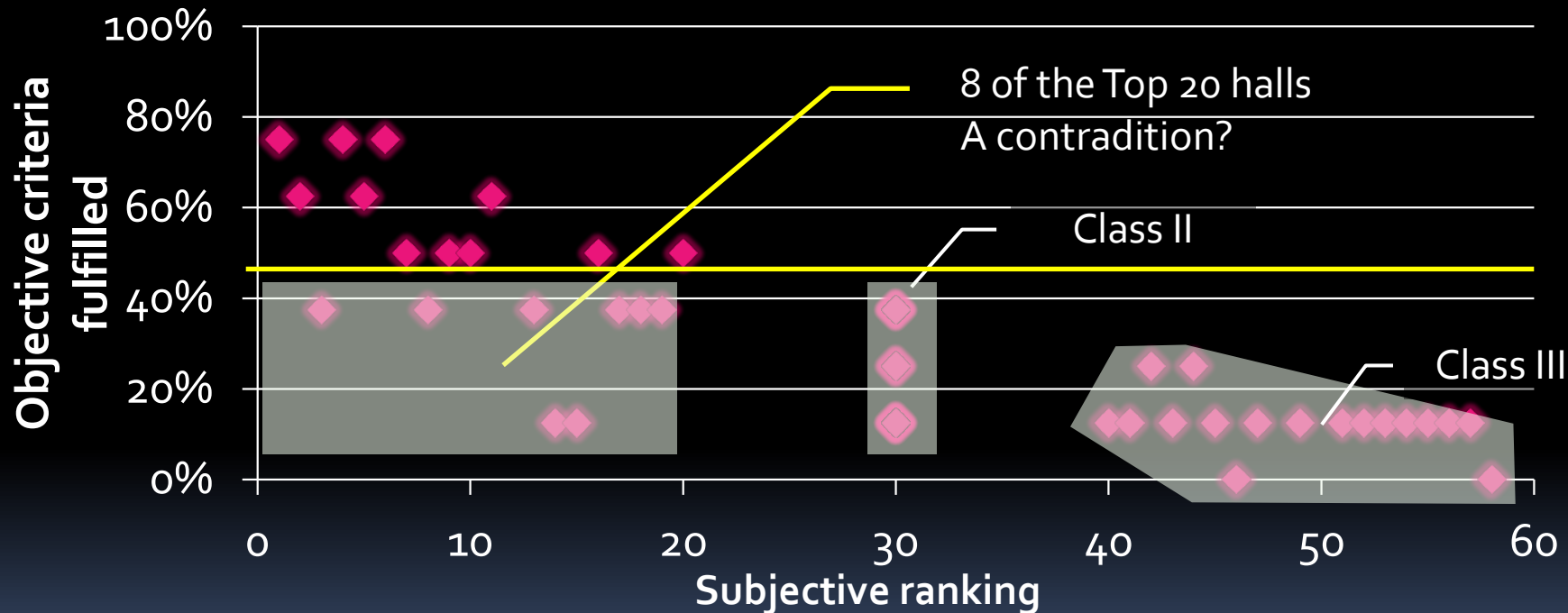


Criteria	T	EDT	G	C	G _{Late}	H/W	G ₁₂₅	W
Hall average	2.0 s	2.0 s	4 dB	0 dB	3 dB	1.0	4 dB	23 m
Tolerance ±	0.1 s	0.2 s	1 dB	1 dB	1 dB	0.2	1 dB	5 m



Consequence of acceptance limit:

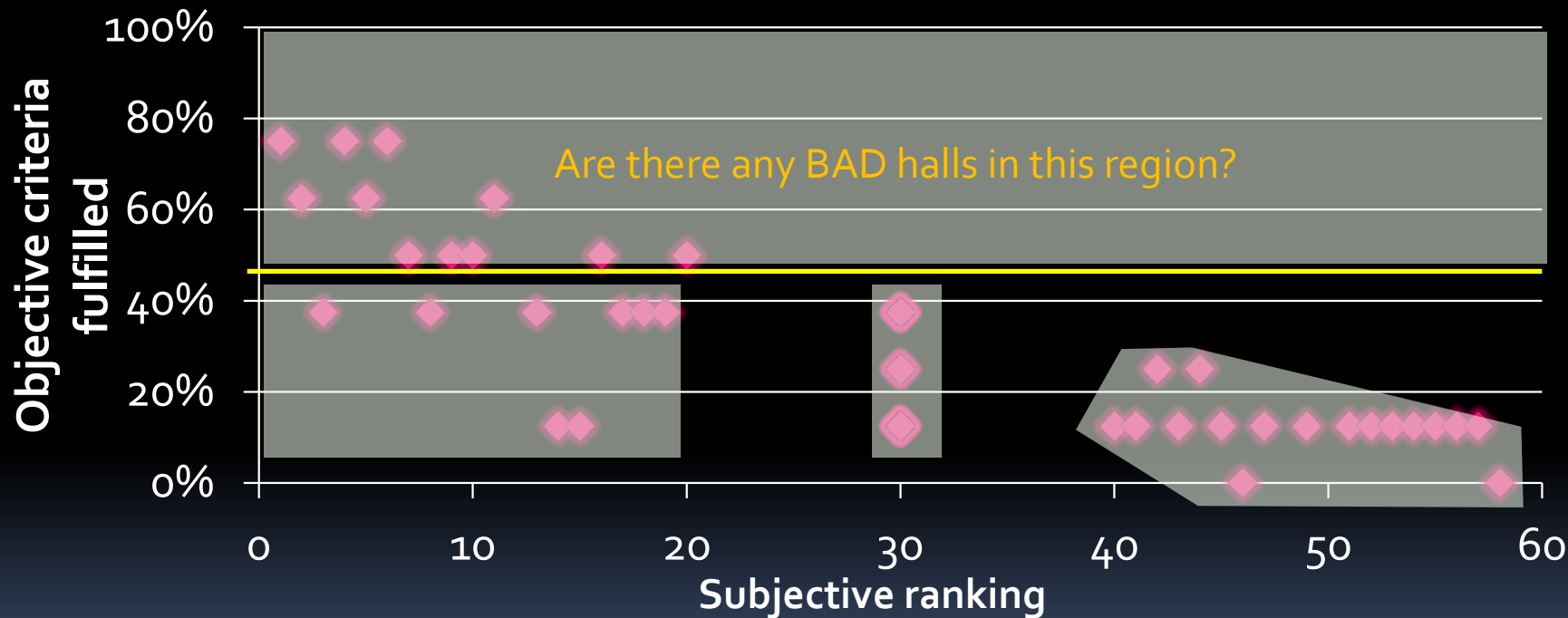
8 of 20 Class I halls not good for replication



Criteria	T	EDT	G	C	G _{Late}	H/W	G ₁₂₅	W
Hall average	2.0 s	2.0 s	4 dB	0 dB	3 dB	1.0	4 dB	23 m
Tolerance ±	0.1 s	0.2 s	1 dB	1 dB	1 dB	0.2	1 dB	5 m



Risk: Newer halls (1990+) not included in ranking



Criteria	T	EDT	G	C	G _{Late}	H/W	G ₁₂₅	W
Hall average	2.0 s	2.0 s	4 dB	0 dB	3 dB	1.0	4 dB	23 m
Tolerance ±	0.1 s	0.2 s	1 dB	1 dB	1 dB	0.2	1 dB	5 m



Consequences of criteria: These 11 halls among the Top Twenty could be replicated.

	Rank	V	N	r avr	T	EDT	G	C	GL	H/W	W	score
Vienna Grosser Musikverinsaal	1	15000	1680	29	2,0	2,0	4	-1	1	0,9	20	75 %
Berlin Konzerthaus (Shauspielhaus)	4	15000	1575	25	2,0	1,9	4	-1	2	0,9	21	75 %
Tokyo Opera City, Concert Hall	6	15300	1636	30	2,0	1,9	4	-1	1	1,1	20	75 %
Boston Symphony Hall	2	18750	2625	32	1,9	1,9	2	0	-1	0,8	23	63 %
Amsterdam Concertgebouw	5	18780	2037	29	2,0	1,9	3	-1	0	0,6	28	63 %
Dallas, Meyerson Symphony Center	11	23900	2065	30	2,8	1,9	4	-3	2	1,0	26	63 %
Zurich Grosser Tonhalsaal	7	11400	1546	28	2,1	2,0	5	-1	3	0,7	20	50 %
Basel Stadt Casino	9	10500	1448	25	1,8	1,7	5	0	2	0,7	21	50 %
Cardiff, St Davis Hall	10	22000	1952	29	2,0	1,9	2	0	-1	0,7	27	50 %
Berlin Philharmonie	16	21000	2218	34	1,9	1,8	2	0	-1	0,3	43	50 %
Baltimore, Meyerhoff Symphony Hall	20	21530	2467	34	2,0	2,0	2	-1	-1	0,6	29	50 %

Criteria	T	EDT	G	C	G _{Late}	H/W	G ₁₂₅	W
Hall average	2.0 s	2.0 s	4 dB	0 dB	3 dB	1.0	4 dB	23 m
Tolerance ±	0.1 s	0.2 s	1 dB	1 dB	1 dB	0.2	1 dB	5 m



Consequences of criteria: These 8 Top Twenty halls would NOT be replicated. At what cost?

	Rank	V	N	r avr	T	EDT	G	C	GL	H/W	W	score
Buenos Aires, Teatro Colon	3	21524	2487	31	1,6	1,6	1	1	-3	1,1	24	38 %
New York Carnegie Hall	8	24270	2804	31	1,8	1,7	1	0	-2	0,9	26	38 %
Lenox, MA, Seiji Ozawa Hall	13	11610	1180	28	1,7	1,6	4	0	1	0,7	21	38 %
Tokyo, Suntory Hall	17	21000	2006	31	2,0	1,9	2	-1	-1	0,5	31	38 %
Tokyo, Bunka Kaikan (Ueno)	18	17300	2327	31	1,5	1,5	1	1	-2	0,7	27	38 %
Brussels, Palais des Beaux-Arts	19	12520	2150	29	1,6	1,6	3	0	0	1,3	23	38 %
Costa Mesa, Segerstrøm Hall	14	27800	2903	37	1,6	1,5	-1	1	-5	0,6	42	13 %
Salt Lake City, Symphony Hall	15	19500	2812	34	1,7	1,6	1	0	-2	0,6	30	13 %

One cost may be **Loss of Freedom**. The question is left for discussion

Criteria	T	EDT	G	C	G _{Late}	H/W	G ₁₂₅	W
Hall average	2.0 s	2.0 s	4 dB	0 dB	3 dB	1.0	4 dB	23 m
Tolerance ±	0.1 s	0.2 s	1 dB	1 dB	1 dB	0.2	1 dB	5 m



Consequences of criteria: These UNRANKED halls could be replicated. **Subjective verification required.**

	Rank	V	N	r avr	T	EDT	G	C	GL	H/W	W	score
Manchester Bridgewater Hall	-	25000	2357	25	2,0	1,9	2	0	-1	0,9	26	75 %
Lucerne, Cultural Ctr. Concert Hall	-	18000	1892	23	2,1	2,0	4	-1	1	1,1	22	75 %
Valencia, Paleu de la Musica	-	15400	1790	18	2,1	2,0	5	-1	2	0,8	21	75 %
Taipei Cultural Centre, Concert Hall	-	16700	2074	26	2,0	2,0	4	-1	1	0,7	27	63 %
Fort Worth, Bass Performance Hall	-	27300	2072	26	2,0	1,9	2	0	-1	1,2	22	63 %
Hong Kong, Cul. Ctr. Concert Hall	-	21250	2019	21	2,0	1,9	3	0	0	0,6	33	63 %
Sao Paulo, Sala Sao Paulo	-	20000	1610	24	2,1	2,0	3	-1	1	0,8	23	63 %
Philadelphia, Verizon Hall	-	23520	2519	23	1,9	1,7	2	0	-1	0,9	26	50 %
Seattle, Benaroya Hall	-	19263	2500	27	2,0	1,9	3	-1	0	0,7	26	50 %
Worcester Mechanics Hall	-	10760	1343	22	1,6	1,5	4	1	1	0,5	25	50 %
Lahti, Sibelius/Talo	-	15500	1250	29	2,2	2,2	4	-1	2	0,8	23	50 %

We need fresh data! On-line concert hall rating survey on www.akutek.info

Criteria	T	EDT	G	C	G _{Late}	H/W	G ₁₂₅	W
Hall average	2.0 s	2.0 s	4 dB	0 dB	3 dB	1.0	4 dB	23 m
Tolerance ±	0.1 s	0.2 s	1 dB	1 dB	1 dB	0.2	1 dB	5 m



Explanation?

- Two important parts of scientific explanation
 - Prediction
 - Insight (in underlying mechanisms)
- Black box: Predictable outcome, no insight
- Average overall preference in concert-goers
 - underlying mechanism is hidden
- Resident orchestra – how can its effect be separated from the effect of the concert hall?



Conclusions

- Conservative use of parameter prediction in concert hall planning can **reduce risk** of overestimating a hall
- However, some could-have-been-good halls may not be built
 - The cost may be **loss of freedom** in design
- Predictors should be tested for consequences
 - **not only the subjective-objective correlation**
- Relationship between Parameter and Preference is **Non-Linear**
- Use of more parameters, **if available**, provide more certainty
- Correlation seen in a smaller data selection (fewer halls) is more uncertain (r^2 between 0.15 and 0.95)
- **Prediction without Insight** in underlying mechanisms - unsettling
- We need more subjective data, [give your on-line rating](http://www.akutek.info) on www.akutek.info



Thank you

More info?

The www center for search, research and open sources in acoustics

www.akutek.info

On-line listening tests – check it out:

http://www.akutek.info/demo_files/listening_tests

magne.skalevik@brekkestrand.no