INTERNATIONAL SYMPOSIUM ON ROOM ACOUSTICS
ISRA 2013
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BREKKE STRAND

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Predicting Concert Hall Preference from Physical Quantities (Parameters)

UNCERTAINTIES RELATED TO SELECTION OF DATA

ISRA 2013, Toronto, June 9th 2013

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Concert Hall Preference

- Preference?
  - The degree to which a concert hall is preferred, statistically
- Why predict?
  - Scientifical or academical reasons
  - Curiosity
  - Basis for decisions (Building Committee)
    - RISKY BUSINESS
- Null Hypothesis:
  - Preference and Physical Quantities just covaries randomly
- We should first try to predict existing halls

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Subjective data

Beranek ranking of 58 halls:

1 Vienna Musikverein
2 Boston Symphony Hall
3 Buenos Airos, Teatro Colon
4 Berlin Konzerthaus
5 Amsterdam Concertgebouw
6 Tokyo Opera City, Concert Hall

..... Halls of rank 7 to 52 .....

53 Sydney Opera House, Concert Hall
54 San Fransisco, Davies Hall
55 Tel Aviv, Frederic Mann
56 London, Barbican
57 Buffalo Kleinhans
58 London, Royal Albert

Objective data

T_{occ} T_{unocc}	Beranek
EDT G C G_{late} G_{125}	Calculated from T_{occ} , V and R with Barron Revised Theory R = 11m + 0.67*L
L W H/W V/S_oT	Beranek geometrical data
ITDG LF 1-IACCe	Beranek data Long story, a lot to be said Long story, a lot to be said

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Uncertainty from size of parameter subset

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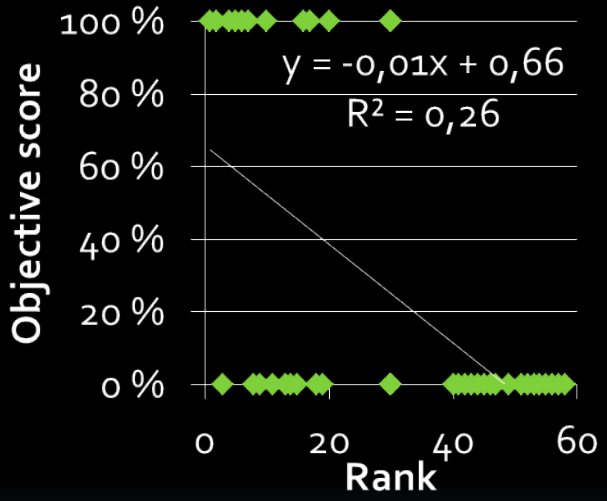
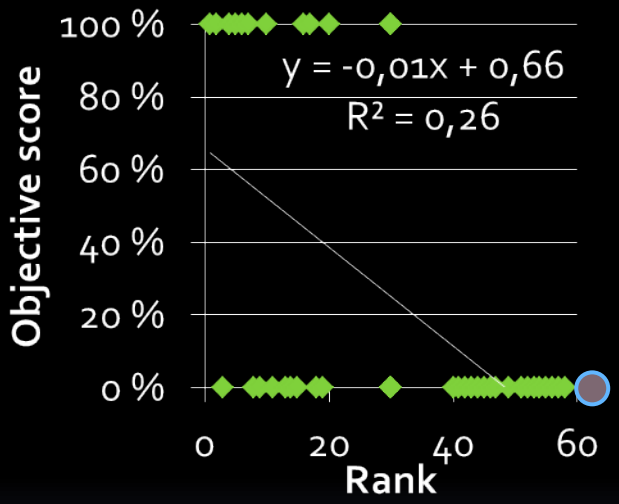
Let's start, like Sabine, with good old T



1p	T_{occ}
Max	2.14
Min	1.89

r^2=0.26 r=0.51

Let's start, like Sabine, with good old T

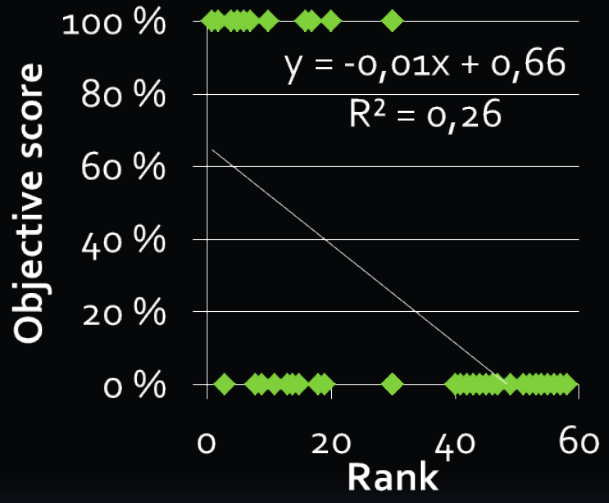


Not bad (r=0.51), but there are good halls with bad T and vice-versa. Lets ask Clarity for advice…

1p	T_{occ}
Max	2.14
Min	1.89

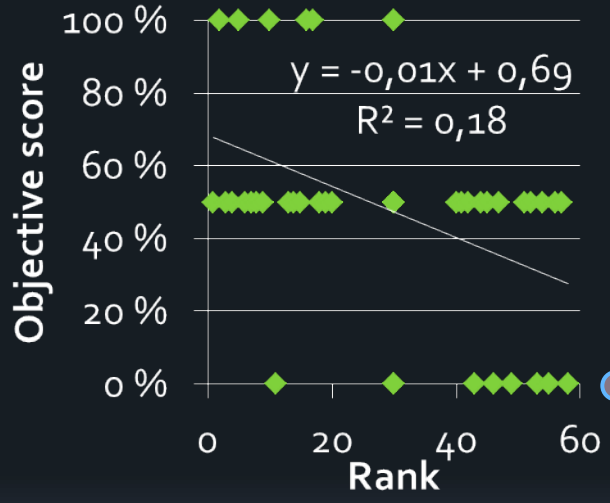
r^2=0.26 r=0.51

Uncertainty from size of parameter subset



1p	T_{occ}
Max	2.14
Min	1.89

r^2=0.26 r=0.51

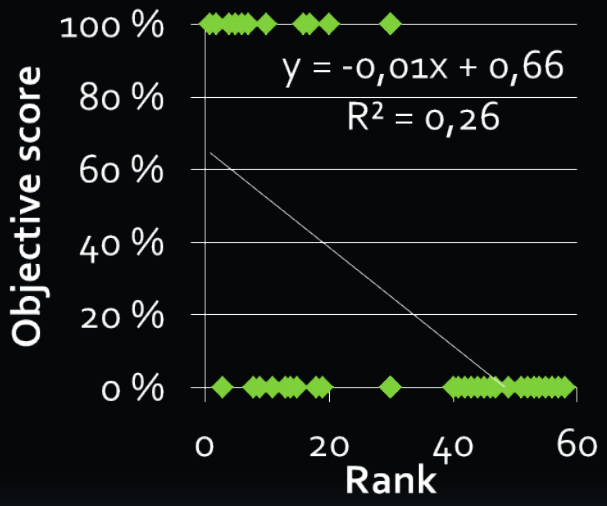


2p	T_{occ}	C
Max	2.14	1.0
Min	1.89	-0.7

r^2=0.18 r=0.42

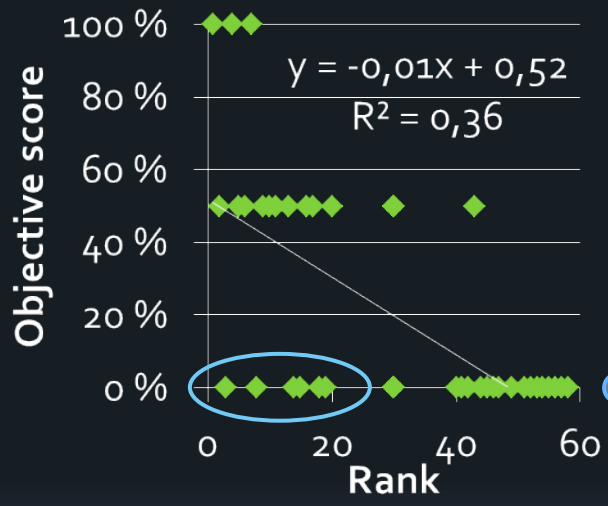
Oops, Clarity made it worse, let's ask G Strength instead…

Uncertainty from size of parameter subset



1p	T_{occ}
Max	2.14
Min	1.89

r^2=0.26 r=0.51

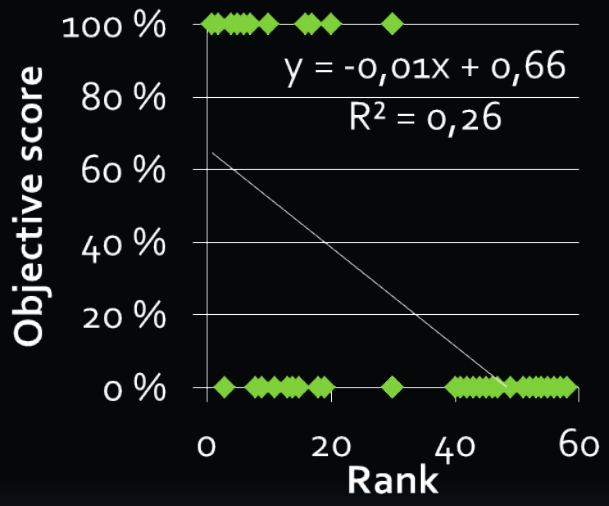


2p	T_{occ}	G
Max	2.14	5.0
Min	1.89	3.2

r^2=0.36 r=0.60

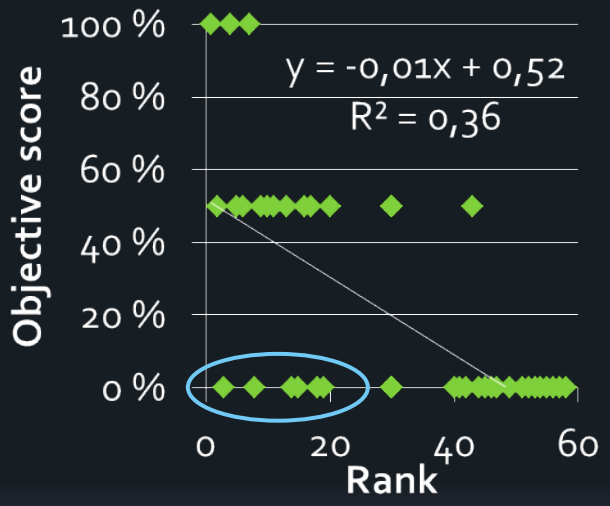
Thanks,
G Strength,
but still some
good halls
gets 0% score

Uncertainty surprises! C helped after all..



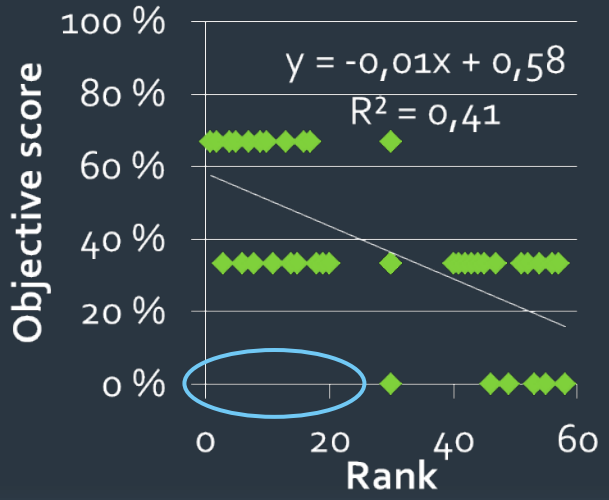
1p	T_{occ}
Max	2.14
Min	1.89

r^2=0.26 r=0.51



2p	T_{occ}	G
Max	2.14	5.0
Min	1.89	3.2

r^2=0.36 r=0.60



3p	T_{occ}	G	C
Max	2.14	5.0	1.0
Min	1.89	3.2	-0.7

r^2=0.41 r=0.64

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Uncertainty from size of parameter subset

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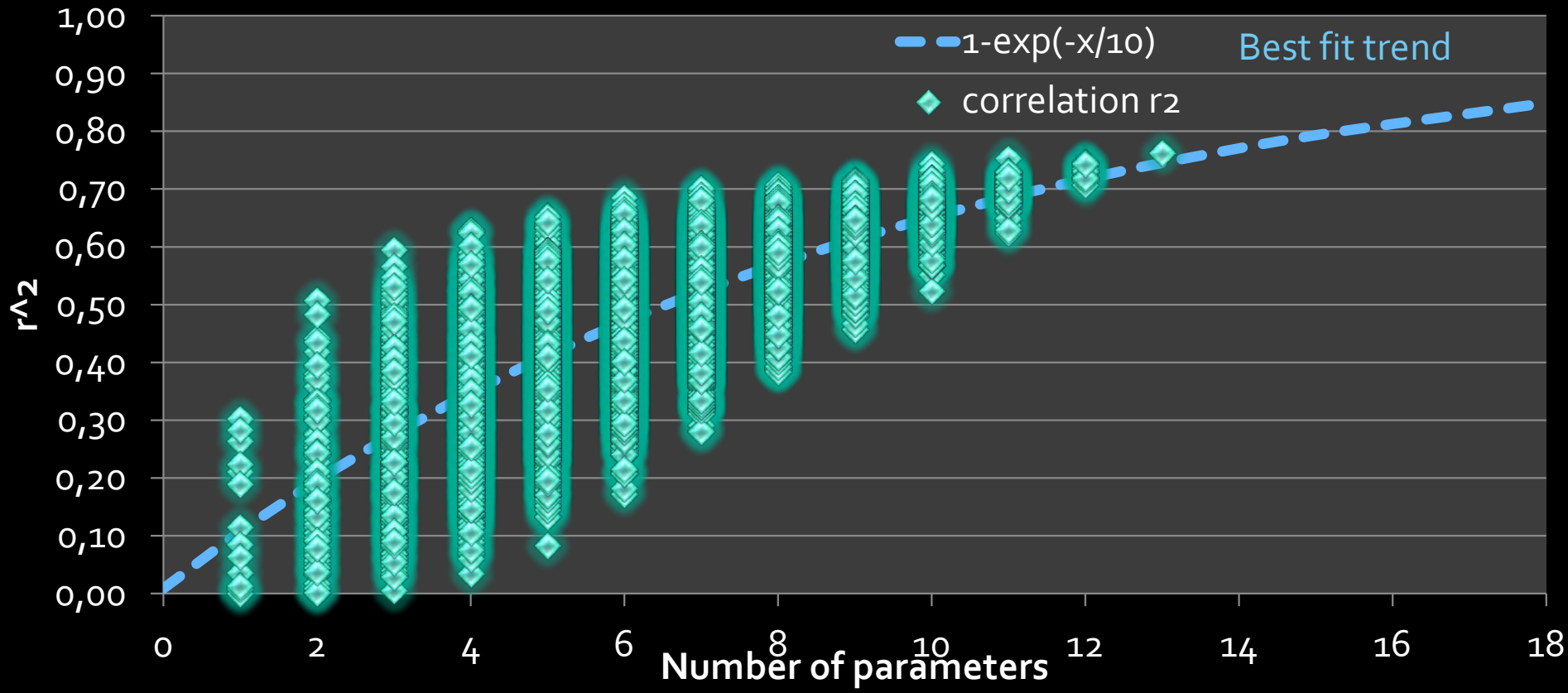
Uncertainty from size of parameter set



Uncertainty from size of parameter subset

	L	LF	1-IACCe	ITDG	T_{occ}	T_{unocc}	EDT	G	C	G_{125}-G	H/W	W	GL	V/S_0T
rsq single-parameter	0.00	0.01	0.30	0.06	0.26	0.10	0.14	0.13	0.00	0.06	0.26	0.22	0.23	0.01
rsq-difference when removed from set of 14	-0.03	-0.05	-0.04	-0.05	-0.04	-0.01	-0.01	-0.04	-0.07	-0.04	-0.05	-0.05	-0.03	-0.02

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Uncertainty from size of parameter subset

	L	LF	1-IACCe	ITDG	T_{occ}	T_{unocc}	EDT	G	C	G_{125}-G	H/W	W	GL	V/S_0T
rsq single-parameter	0.00	0.01	0.30	0.06	0.26	0.10	0.14	0.13	0.00	0.06	0.26	0.22	0.23	0.01
rsq-difference when removed from set of 14	-0.03	-0.05	-0.04	-0.05	-0.04	-0.01	-0.01	-0.04	**-0.07**	-0.04	-0.05	-0.05	-0.03	-0.02

Apologies, Clarity for jumping to conclusions. You really make a difference ☺

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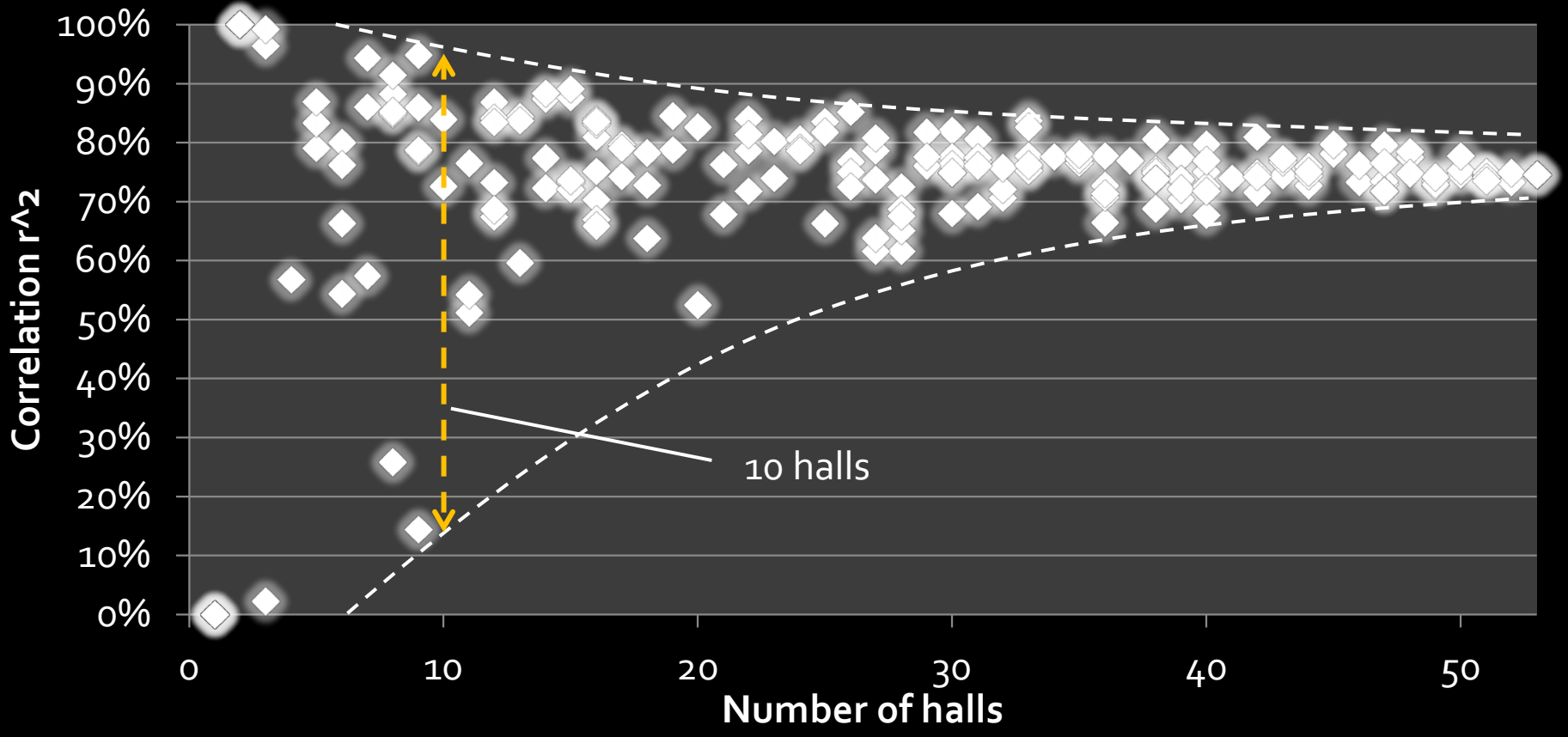
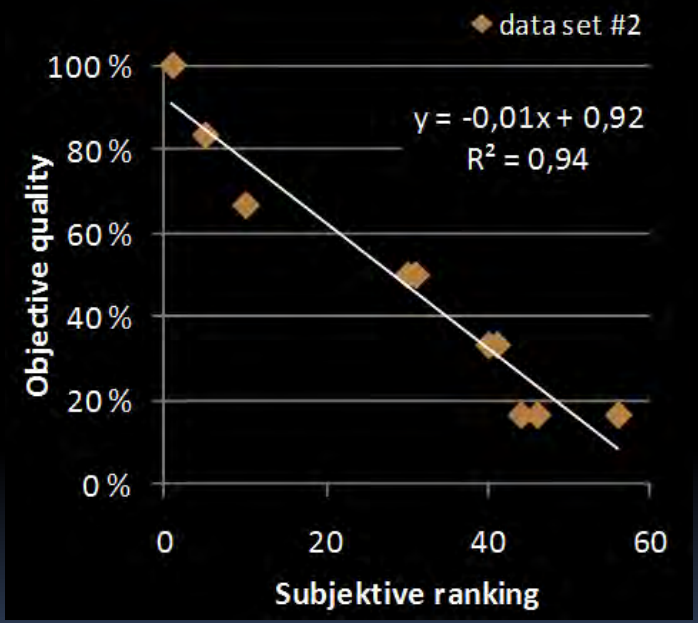
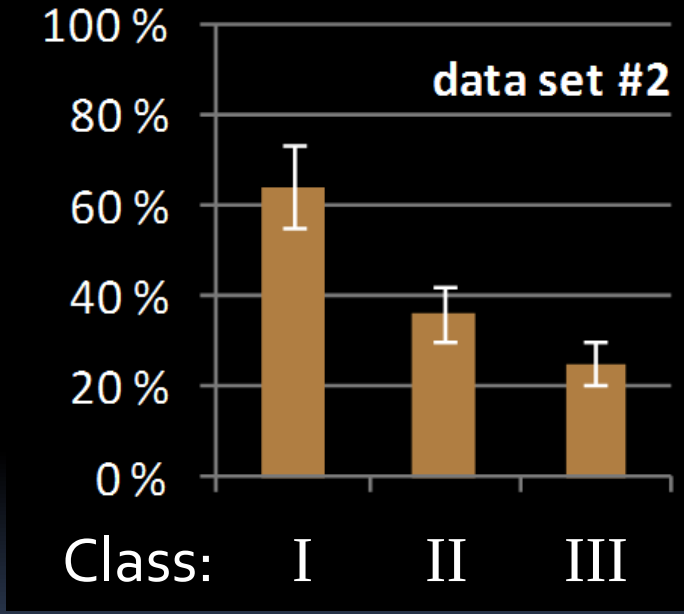
Uncertainty from size of concert hall subset



Example: 10 halls, 6 paramameters, r^2=0.94

Vienna
Amsterdam
Cardiff
Munich
Gothenburg
Salzburg
Stuttgart
Edinburg
London, Festival
London, Barbican





	EDT	G	C	LF	G_{late}	G_{125}
Upper limit	2.2	5.3	0.7	0.25	2.5	5.7
Lower limit	1.8	3.3	-1.3	0.15	0.5	3.7

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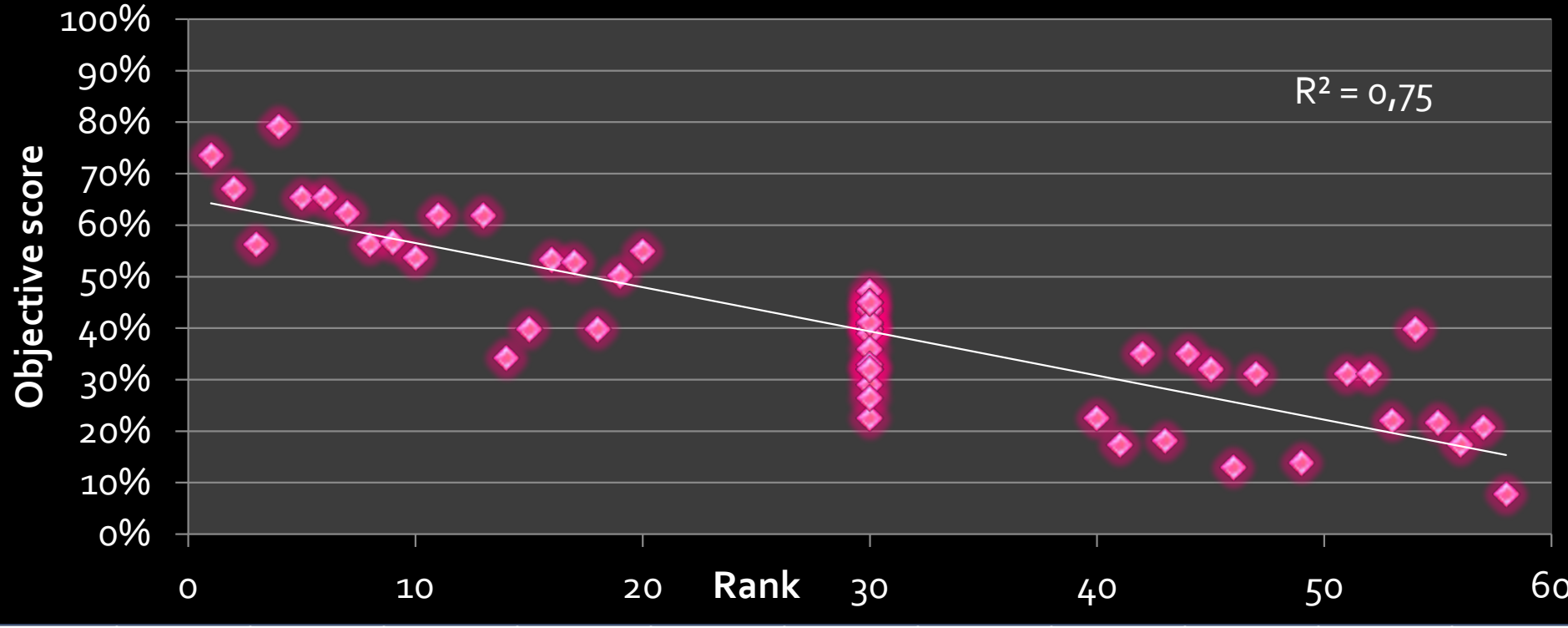
53 halls, 12 parameters, $r=0.86$, $r^2=0.75$

L	ITDG	T_{occ}	T_{unocc}	EDT	G	C	G_{125}-G	H/W	W	GL	V/S_0T

ISRA 2013

53 halls, 12 parameters, $r=0.86$, $r^2=0.75$



L	ITDG	T_{occ}	T_{unocc}	EDT	G	C	G_{125}-G	H/W	W	GL	V/S_0T

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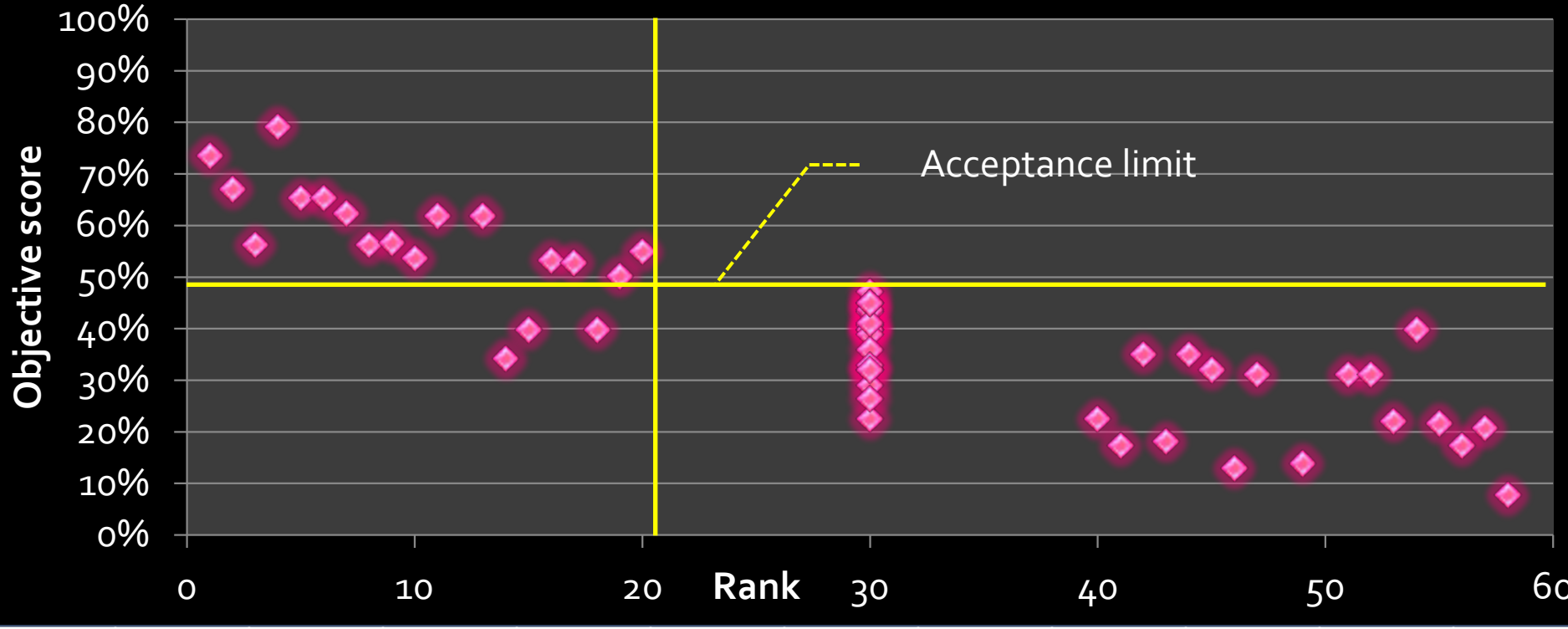
Assuming Rank >20 is not acceptable



L	ITDG	T_{occ}	T_{unocc}	EDT	G	C	G_{125}-G	H/W	W	GL	V/S_0T

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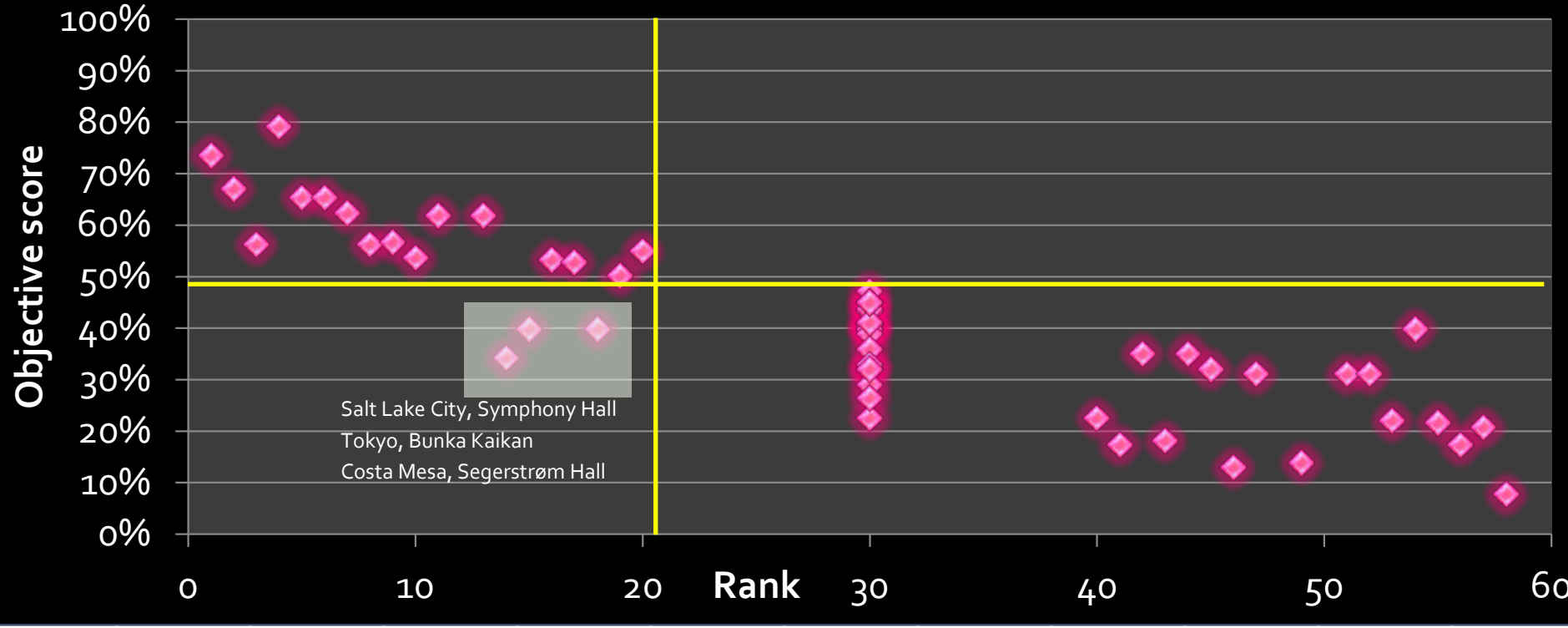
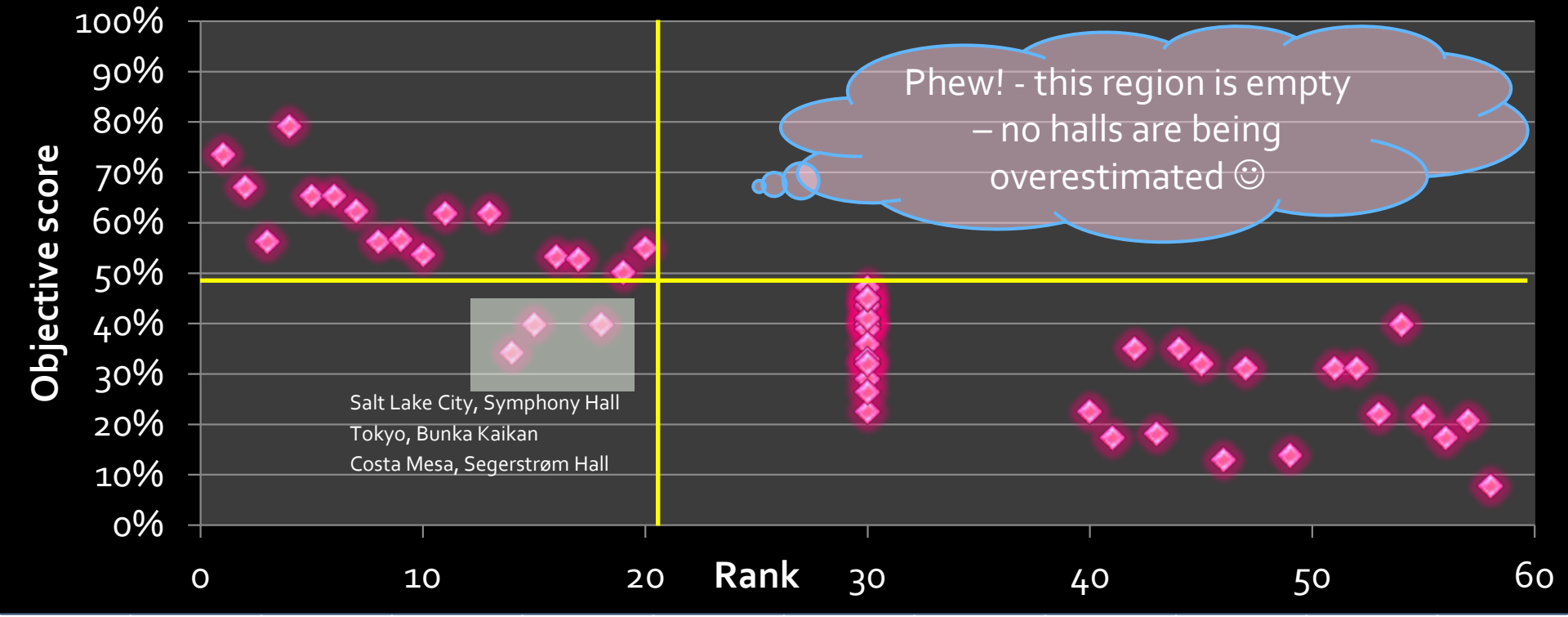
Uncertainty effect: 15% of Top20 rejected



L	ITDG	T_{occ}	T_{unocc}	EDT	G	C	G_{125}-G	H/W	W	GL	V/S_0T

Uncertainty effect is one-sided, good news



L	ITDG	T_{occ}	T_{unocc}	EDT	G	C	G_{125}-G	H/W	W	GL	V/S_0T

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Testing predictions on unranked halls

Score≥50% Replication supported
Valencia, Paleu de la Musica
*Lucerne, Cultural Ctr. Concert Hall
*Manchester Bridgewater Hall
*Fort Worth, Bass Performance Hall
Taipei Cultural Centre, Concert Hall
Mexico City, Salla Nezahualcoyotl
Philadelphia, Verizon Hall
Baden-Baden Festspielhaus
Lahti, Sibelius/Talo
Birmingham Symphony Hall
*Munich, Herkulessalle
Odense, Koncerthus Nielsen Hall

Score<50% Replication NOT supported
Seattle, Benaroya Hall
Sao Paolo, Sala Sao Paulo
Minneapolis, Minn. Orchestra Hall
Kuala Lumpur, DewanFil. Petronas
Budapest, Patricia Hall
Denver Boettcher Hall
*Olavshallen, Trondheim
Sapporo Concert Hall
Athens, Megaron Concert Hall
Belfast, Waterfront Hall
Rochester, NY, Eastman Theatre
Caracas, Aula Magna

Agree or disagree? Take the www.akutek.info Survey

*Verified by survey

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Best fit criteria, 12 parameters, r^2=0.75, r=0.86

Par	L	ITDG	T_{occ}	T_{unocc}	EDT	G	C	G_{125}-G	H/W	W	GL	V/SoT
max	38	31	2.14	3.00	(2.29)	(5.0)	1.0	3.1	(1.3)	32	(2.5)	65
min	28	13	1.89	2.20	1.79	3.2	-0.7	1.0	0.77	(20)	0.3	57
weight	0.6	0.9	1.6	0.4	0.9	1.2	1.1	1.0	1.2	1.0	1.0	0.7

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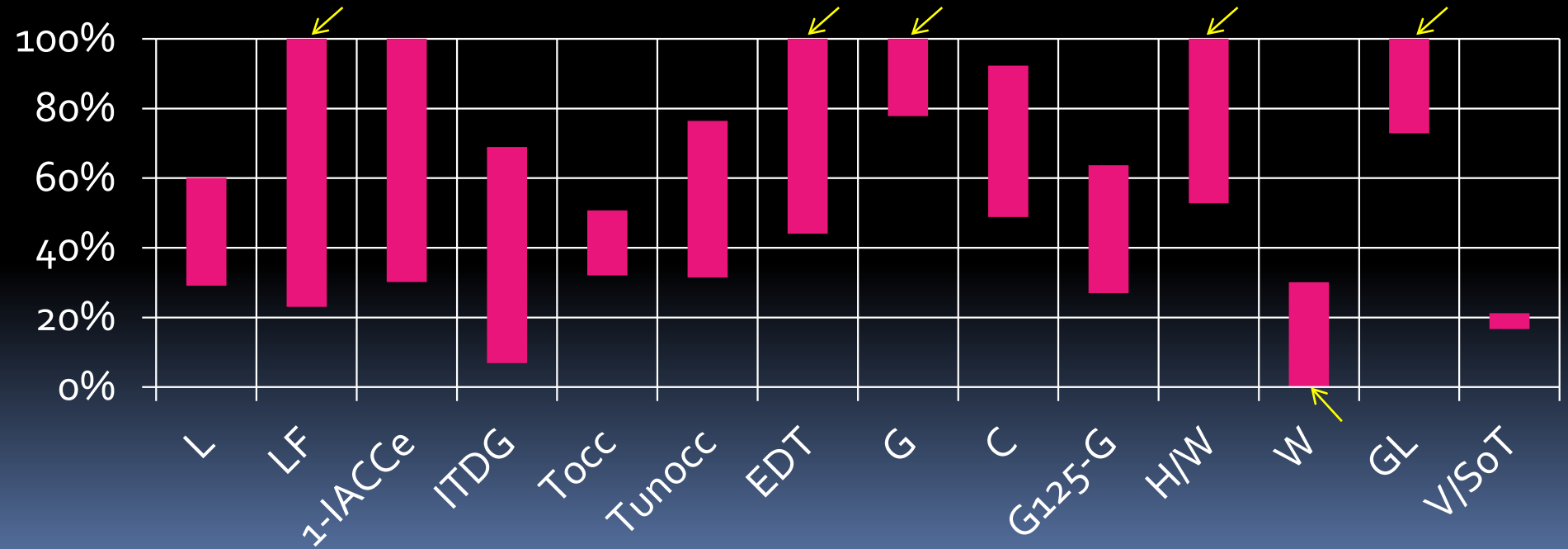
Uncertainty from limited value-range in data selection

Par	L	ITDG	T_{occ}	T_{unocc}	EDT	G	C	G_{125}-G	H/W	W	GL	V/SoT
max	38	31	2.14	3.00	(2.29)	(5.0)	1.0	3.1	(1.3)	32	(2.5)	65
min	28	13	1.89	2.20	1.79	3.2	-0.7	1.0	0.77	(20)	0.3	57
weight	0.6	0.9	1.6	0.4	0.9	1.2	1.1	1.0	1.2	1.0	1.0	0.7

Selection-related Uncertainty: Values in (paranthesis) are equal to limits in the data selection

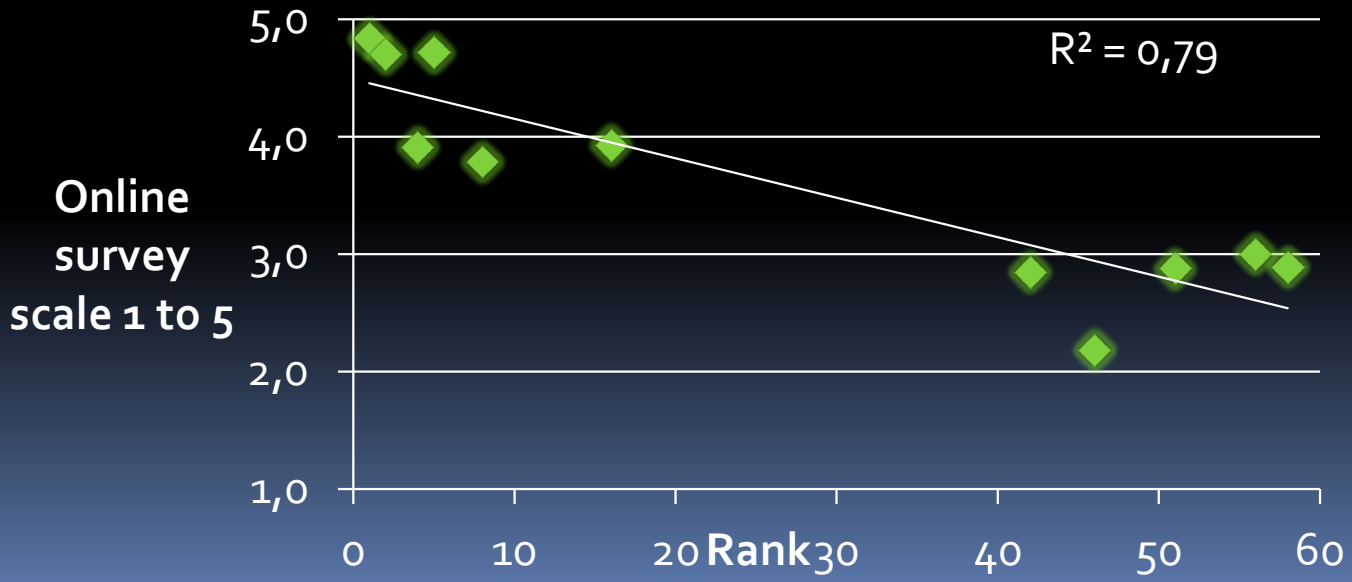
Uncertainty from limited value-range in data selection

Bars indicate the acceptable value ranges; 0-100% is the total range of data values



Online survey

- Status: 343 votes from 36 respondents, total 77 halls;
- 13 Halls with 7 votes or more: Correlation between Survey results and Beranek Ranking is promising



We need more data!
Survey is still open on
www.akutek.info

Link to survey
https://www.surveymonkey.com/s/MMFMZ5W

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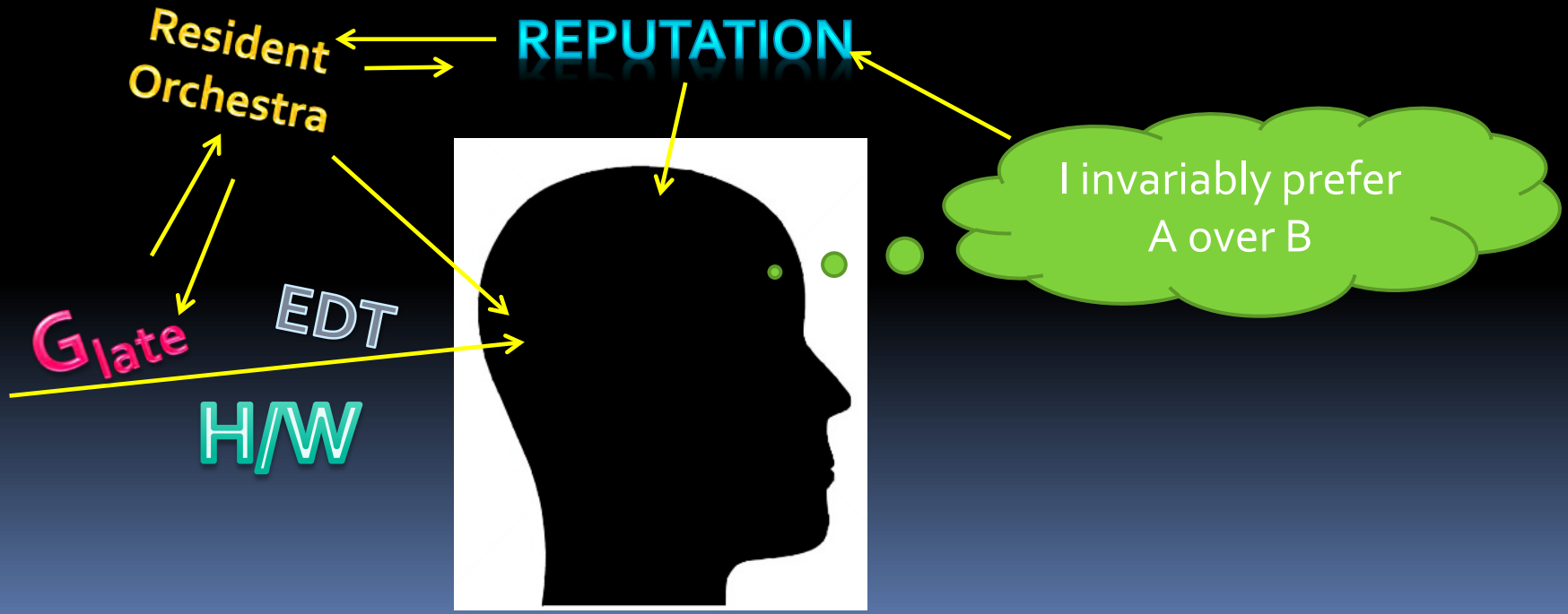
Black Box explanation

- Predicting response from a Black Box
- Insight is desired
- However, prediction cannot wait for insight

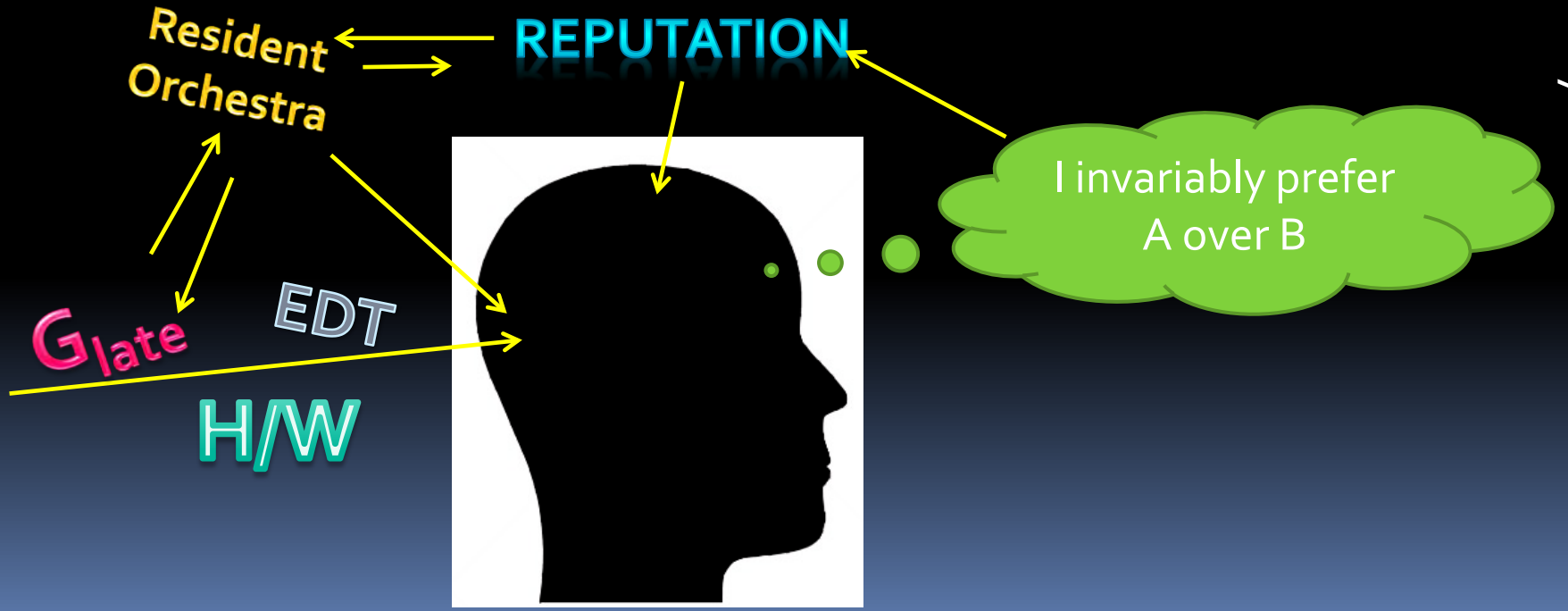
Black Box explanation

- Is the brain alone the Black-Box?
- Or one box in a network of black boxes?



Black Box Evolution

For discussion: Preference evolved together with Music, Orchestras, Architecture, Technology, Population, Musical Instruments. The fittest survives. Who's the species? Who's the environment? Suggestion:



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Conclusions

- Uncertainties in Preference-Predictors should be tested on existing halls
- Increased number of halls reduces uncertainty in r^2
- Parameter size and combinations influence on the maximum achevivable r^2
- Data should include values of «too much» and «too little»
  - Relationship between Parameter and Preference is Non-Linear
- Uncertainty in building-desicions can be reduced by «safety-first» policy
  - However, some could-have-been-good halls may not be built
  - The cost of certainty may be loss of freedom in design
- Black-box prediction without Insight in underlying mechanisms – unsettling, but necessary
- We need more subjective data, give your on-line rating on www.akutek.info
- Further work:
  - Computer-models of at least 50 halls with preference data
  - LF and 1-IACCe must wait for this

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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

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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)

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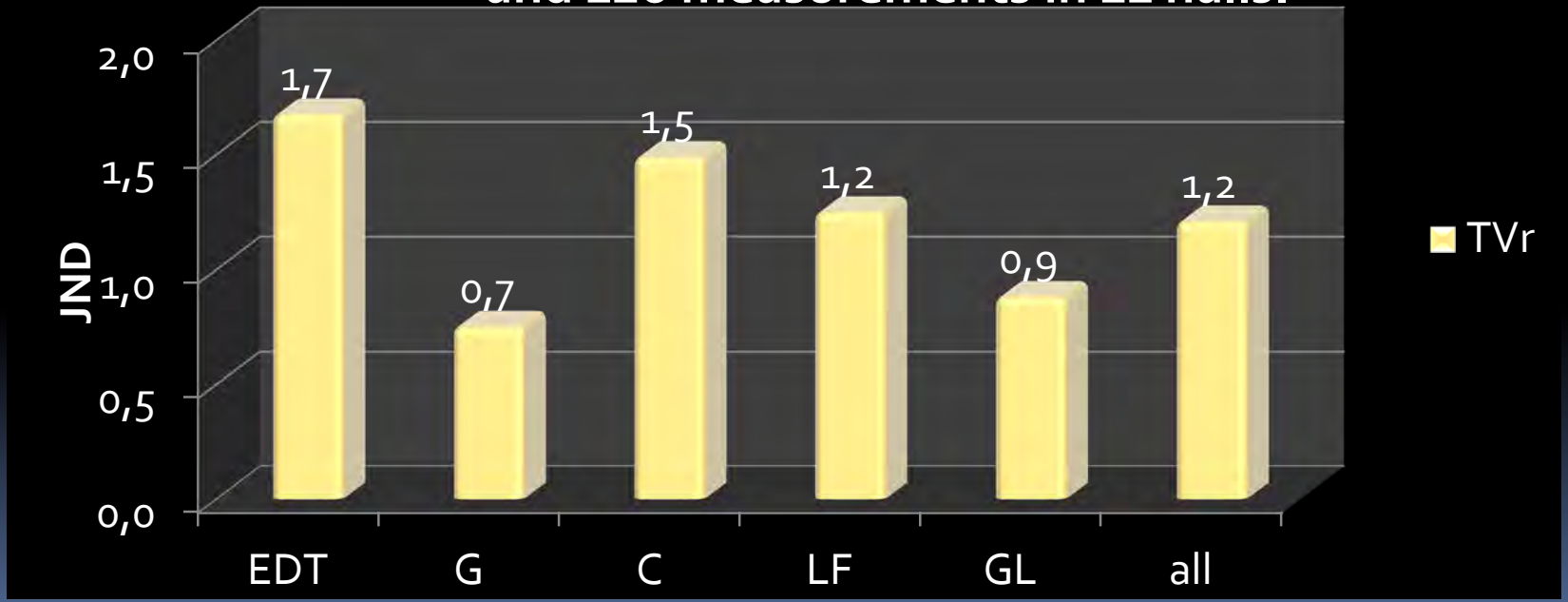
TVr-predictors (Barron Revised Theory)

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



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53 halls out of Beranek's 58

	Rank
Vienna Grosser Musikverinsaal	1
Boston Symphony Hall	2
Buenos Airos, 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 Davis 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