Statistics at Consumer Reports

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Consumers Union

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Who Are We?

- Consumers Union, is an expert, independent nonprofit organization whose mission is to work for a fair, just, and safe marketplace for all consumers and to empower consumers to protect themselves.
  - Test Products
  - Evaluate Services
  - Analyze Economic, Health, Safety, and other Data
  - Advocate for Consumers

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Here Are Some Things We Rate …

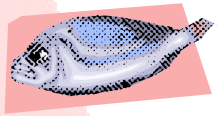
- **Automotive**
  - Cars / Tires
  - Child Safety Seats

- **Appliances**
  - Refrigerators
  - Dishwashers

- **Electronics**
  - TVs
  - Computers

- **Recreation Products**
  - Exercise Equipment
  - Toys

- **Home Improvement**
  - Tools
  - Lawn Mowers



- **Safety**
  - Mercury in Seafood
  - Lead in Toys

- **Foods**
  - Ice Cream
  - Olive Oil
  - Beer & Wine

- **Health**
  - Nursing Homes
  - Drug Prices
  - Medical Treatments
  - Hospitals
  - Physicians

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To avoid conflicts of interest we …

- Buy all products we test anonymously
- Receive no special treatment
- Accept no free samples
- Accept no ads
- Do not allow companies to use our name or findings for commercial purposes

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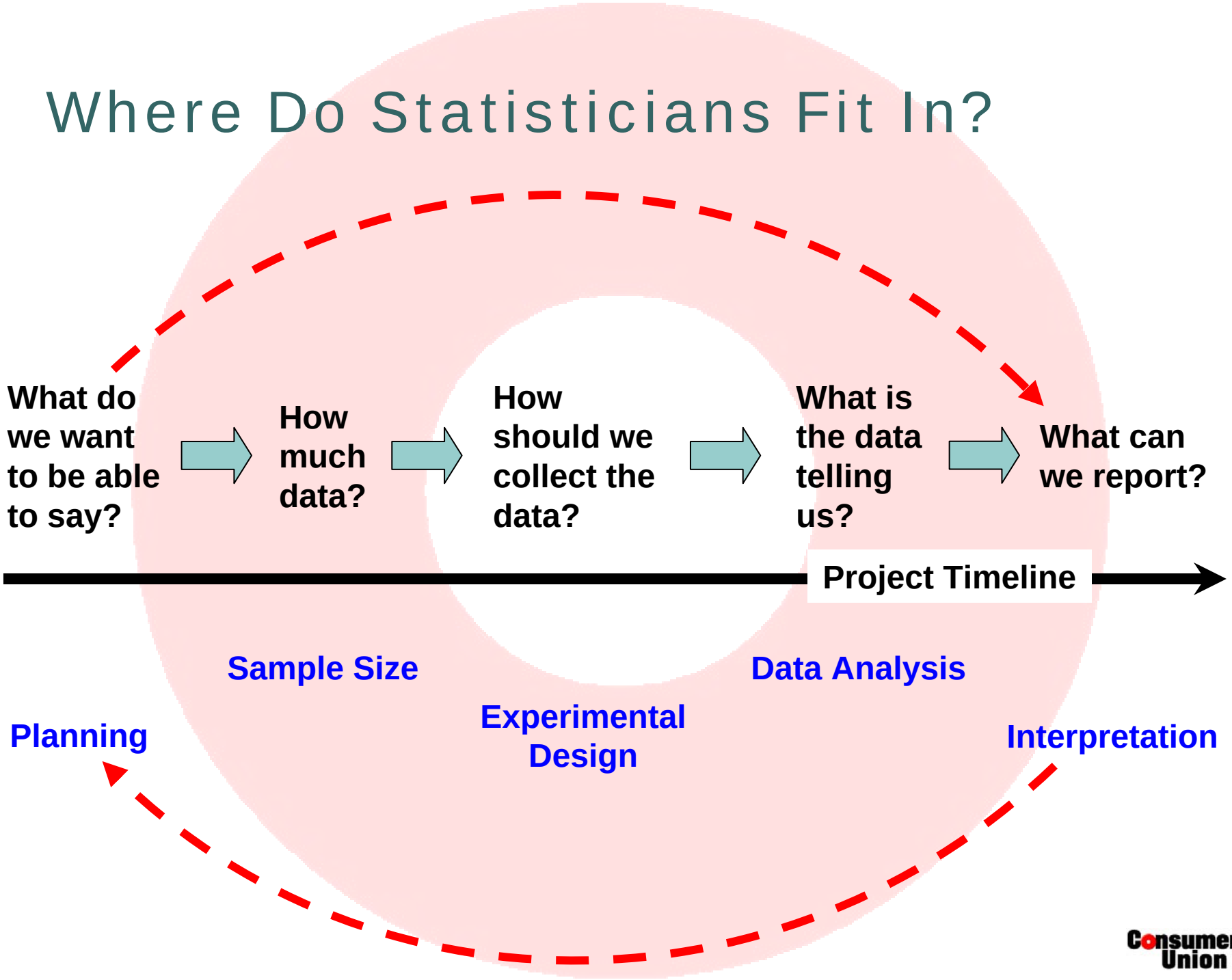
Where Do Statisticians Fit In?



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Why Include a Statistician?

- Products vary from unit to unit
  - Regional manufacturing & material
  - Storage & transportation
- Test results can vary depending on the:
  - test order
  - panelists
  - time of day
  - time of year
  - etc.

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Example 1:
Exterior Paint Testing

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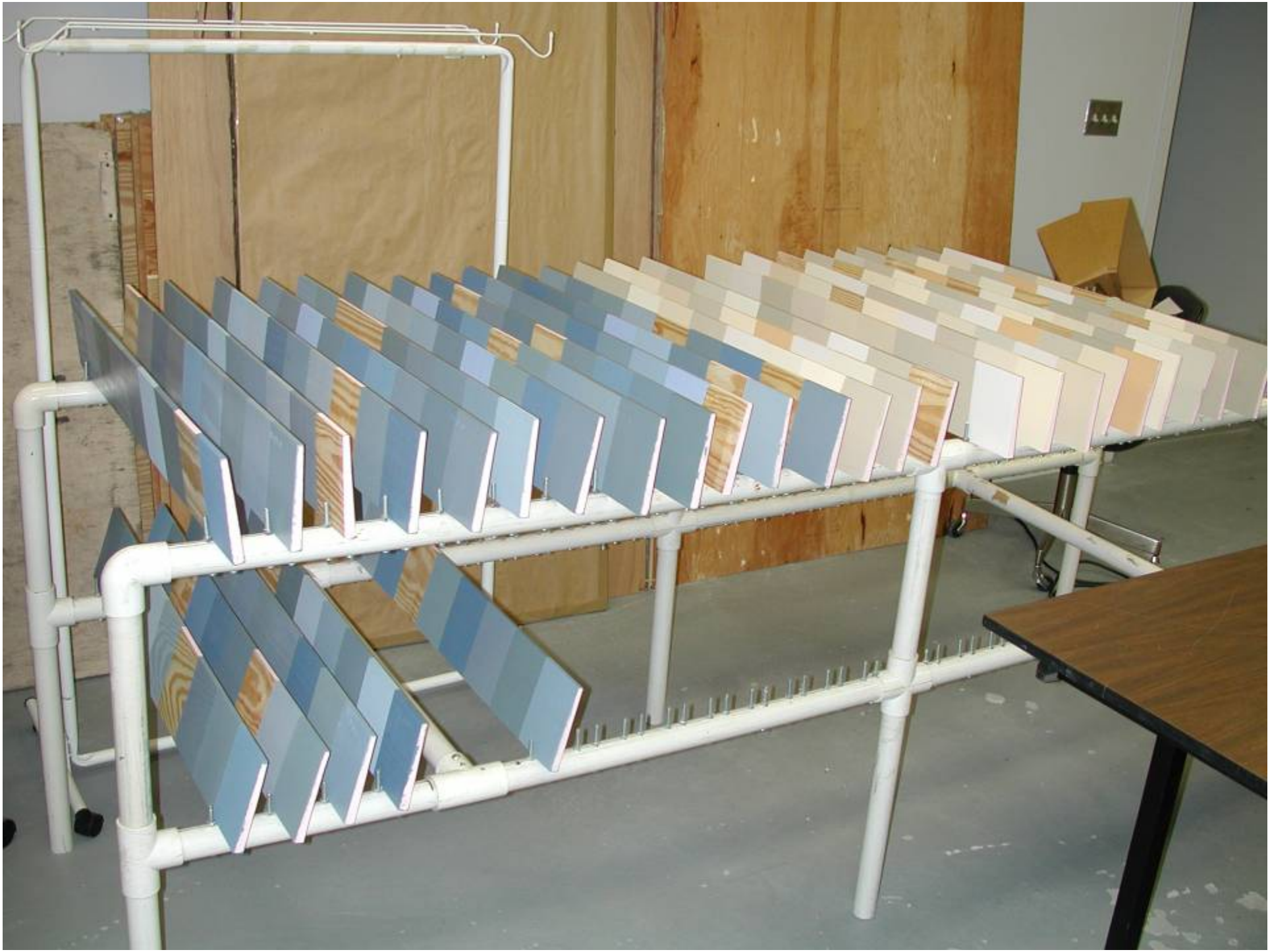

Randomized Incomplete Block Design

	Column						
Board	1	2	3	4	5	6	7
1	2054	2048	2045	3051	1021	3057	2057
2	1012	1030	1018	2051	1024	3039	1027
3	3048	2060	3054	2054	3045	2045	1030
4	2048	3060	3051	1012	3039	3054	1024
5	3057	1018	1027	2060	2057	1021	2051
6	1030	1027	1021	3060	2060	2048	2054
7	1018	1012	3057	3048	2045	1024	3045
8	3051	3054	3048	1018	3057	1030	3039
9	3060	2057	2060	3045	1027	2054	1012
10	2045	2051	2048	1024	2054	3051	3048

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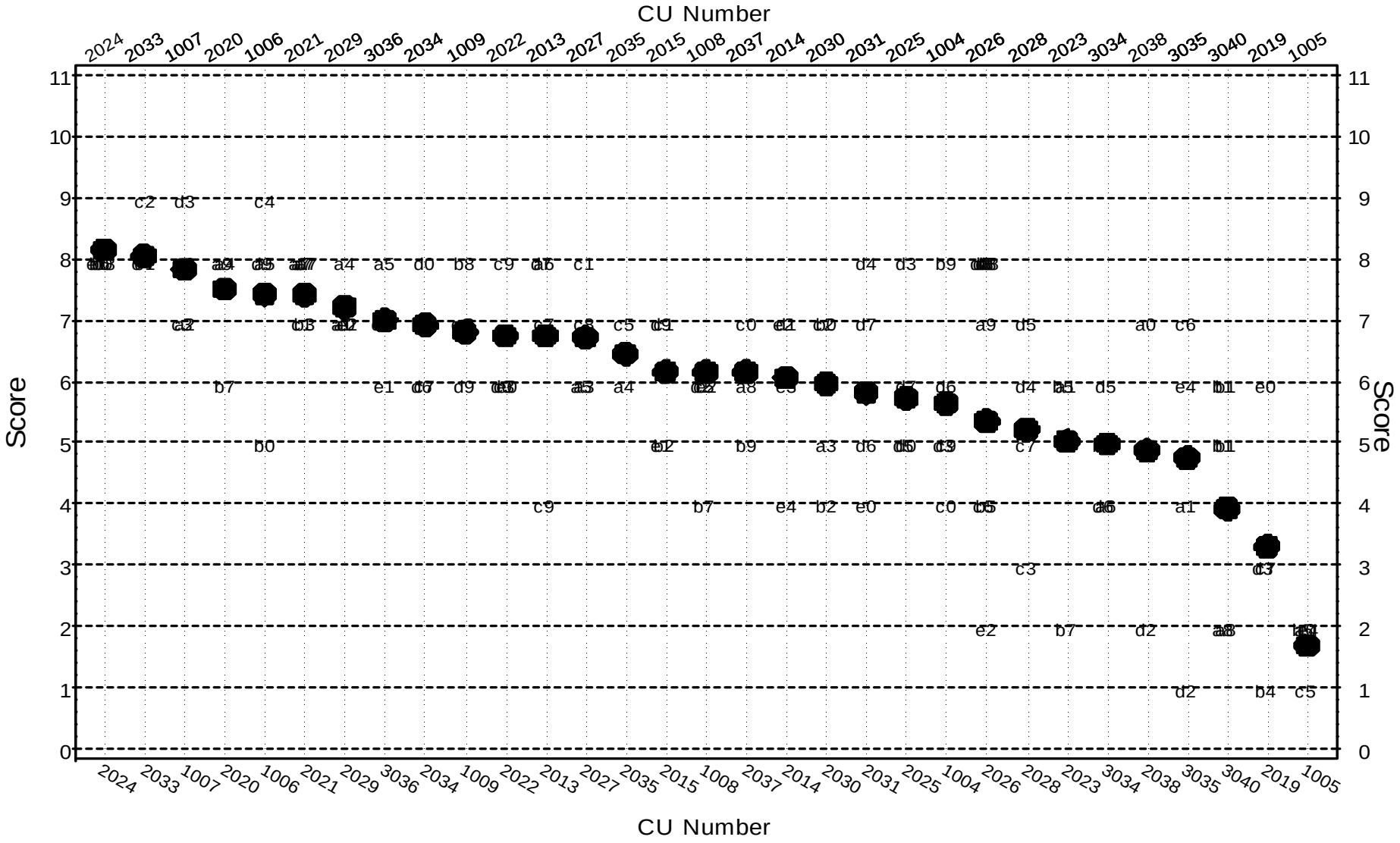
T-2896 Exterior Paint
Y21 Visual Color: Two Coats (Blue)



Filled circles represent the model least-squares mean. Data labels represent board.

Figure 1.2

Published Ratings Table

PRODUCT UPDATES

Exterior paints

Overall Ratings Within types, in performance order

KEY TO DURABILITY: E VG G F P

Excellent · Very good · Good · Fair · Poor

PRODUCT	PRICE	PREDICTED DURABILITY 1 YR	2 YR	3 YR	4 YR	5 YR	RESISTANCE TO FADING	DIRT	MILDEW	COMMENTS
WHITE PAINTS										
Pratt & Lambert Accolade Eggshell (flat)	$39						◒	●	◒	–
California Premium Velvet (flat)	25						◒	◒	◒	–
M.A. Bruder Sea Shore (flat)	22						●	◒	◒	–
Glidden Dulux Endurance Satin (low luster)	22						●	●	◒	–
Glidden Spred Dura Satin (low luster)	15						○	●	◒	–
Glidden Dulux Endurance (flat)	19						◒	●	◒	Excellent in adhering to chalky surface.
Glidden Dulux Endurance (semigloss)	23						●	◒	◒	–
True Value Weatherall (semigloss)	23						◒	●	◒	–
True Value Weatherall (flat)	17						◒	●	◒	–
Glidden Spred Dura (semigloss)	17						◒	◒	◒	–
Sico Supreme (flat)	C$34						●	●	○	–
Glidden Spred Dura (flat)	14						◒	●	◒	Good in adhering to chalky surface.
Sears Best Weatherbeater (flat)	18						◓	◒	◓	Tested for two years.
Sears Best Weatherbeater Satin (low luster)	19						○	◒	○	Tested for two years.
Sherwin-Williams Super Paint Satin (low luster)	26						◒	●	◒	Tested for two years. Excellent in adhering to chalky surface.
Pittsburgh Manor Hall Eggshell (low luster)	28						●	●	○	Tested for two years.
True Value Weatherall Satin (low luster)	22						◒	●	○	Tested for two years.

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DRAUGHT
GUINNESS
Budweiser
KING OF BEERS
ROLLING
ROCK
Not-For-Profit Drinking:
CU Rates Beer
FOSTER'S
Australian for Beer
Lite
Miller
Corona
SAMUEL ADAMS
THE BEST BEER IN AMERICA
COORS
LIGHT

Not-For-Profit Beer Drinking

- **71 Models**
- **Seven Categories**
  - **Domestic, Ice, Imported, Light, Non-Alcoholic, Ale, Lager**
- **Outside Panel Used**

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Panelist Selection Process

Beer Evaluation T-1665: Imported (lager)

Date: ☐☐ / ☐☐ **Session #:** ☐☐ **Panelist #:** ☐☐

		Sample 1:	Sample 2:	Sample 3:	Sample 4:	Sample 5:
01.	Carbonation	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
02.	Floral	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
03.	Overall Fruity	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
04.	OF: Citrus	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
05.	OF: Green Apple/Acetaldehyde	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
06.	OF: Artificial/Tropical Fruit/Bubble Gum	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
07.	OF: Banana	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
08.	Grainy	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
09.	Malty	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
10.	Worty	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
11.	Boiled Hop Aroma	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
12.	Alcohol Perception	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
13.	Solvent	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
14.	Diacetyl/Buttery	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
15.	Sulfury	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
16.	DMS/Vegy	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
17.	Oxidized/Cardboard	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
18.	Skunky/Lightstruck	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
19.	Soapy	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
20.	Phenolic/Medicinal	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
21.	Metallic	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
22.	Bitterness	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
23.	Dry vs. Sweet	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
24.	Astringency	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
25.	Full (Density/Viscosity) mouthfeel	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
26.	Overall Flavor Intensity	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐
27.	Quality Rating	☐☐☐	☐☐☐	☐☐☐	☐☐☐	☐☐☐

Incomplete Block Design

Session	Order				
	1	2	3	4	5
1	03	08	06	10	09
2	05	04	07	02	01
3	08	07	04	05	10
4	10	01	03	07	08
5	09	02	01	08	04
6	07	06	09	04	03
7	06	05	08	03	02
8	04	09	05	01	06
9	01	10	02	06	07
10	02	03	10	09	05

- **Shaded cells represent satisfied constraints**
- **10 sessions x 5 samples/session x 27 attributes x 17 panelists = 22,950 data points.**

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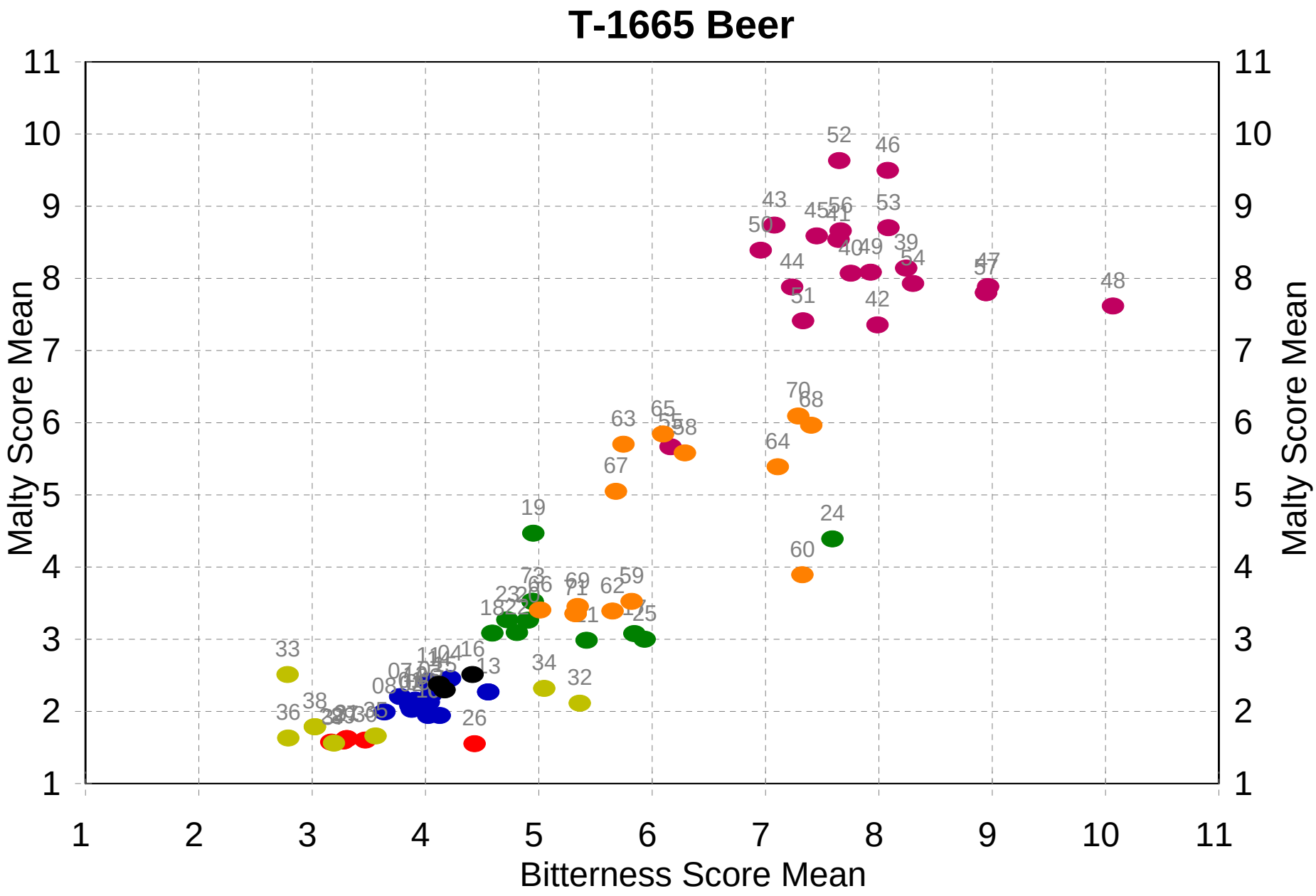
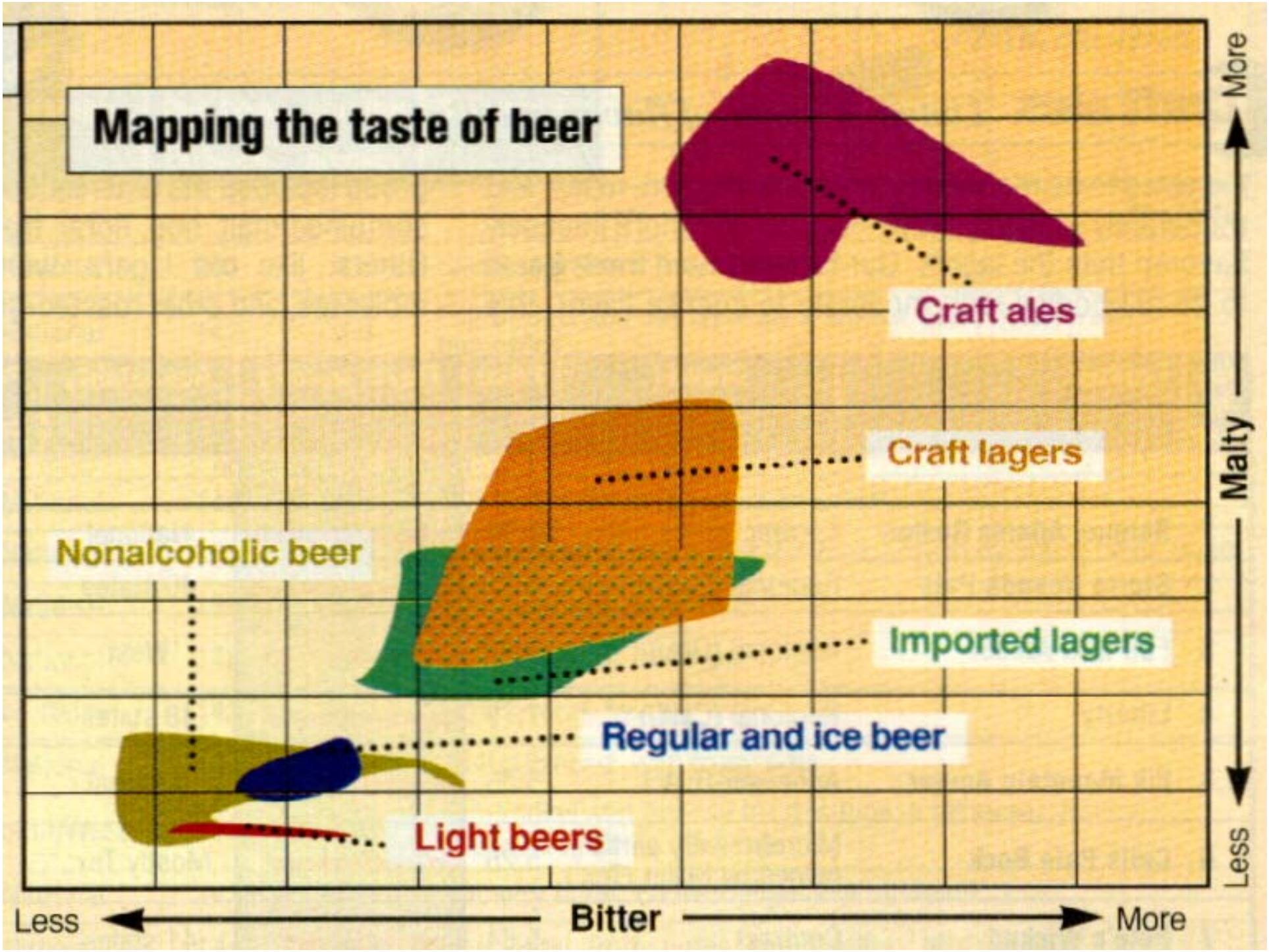
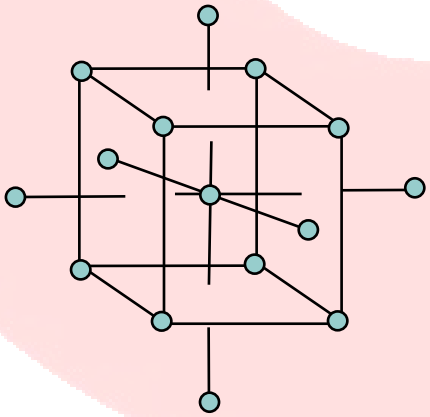


Data labels represent CU numbers. Colors represent categories:

Domestic Regular, Ice, Imported, Light, Non-Alcoholic, Microbrew Ales, Microbrew Lagers.


Mapping the taste of beer
Craft ales
Craft lagers
Nonalcoholic beer
Imported lagers
Regular and ice beer
Light beers
More
Malty
Less
Less
Bitter
More

So, How Do We Generate Statistical Designs?



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Using Computer Software to Design Your Experiments

- There are a lot of software packages available for generating experimental designs.
  - *DesignEase*, *DesignExpert*, *RS/Discover*, *Minitab*, *SAS/Jmp*, etc.
- Unfortunately, these packages are designed to produce the kinds of designs used in a manufacturing environment, not for product comparison.

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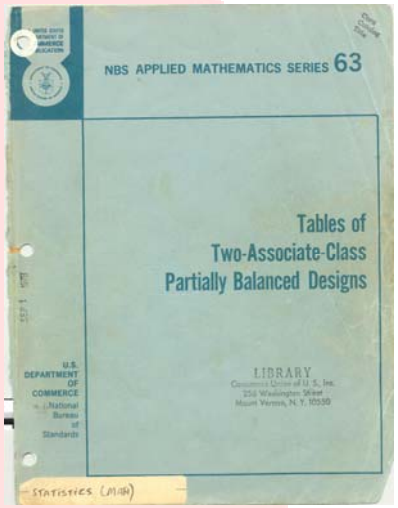
Where Do You Turn?

- The U.S. National Bureau of Standards (now NIST) published tables of "Partially Balanced Designs" (1973).
  - May not be available for your specific number of models, block size, and number of reps.
  - Don't easily allow for constraints.
  - Currently out of print.



- Cyclic Designs - an incomplete block design obtained from a cyclic development of an initial block.
  - Their construction is relatively simple.
  - They are very efficient.
  - Don't easily allow for constraints.
  - They tend to have patterns in the run order.

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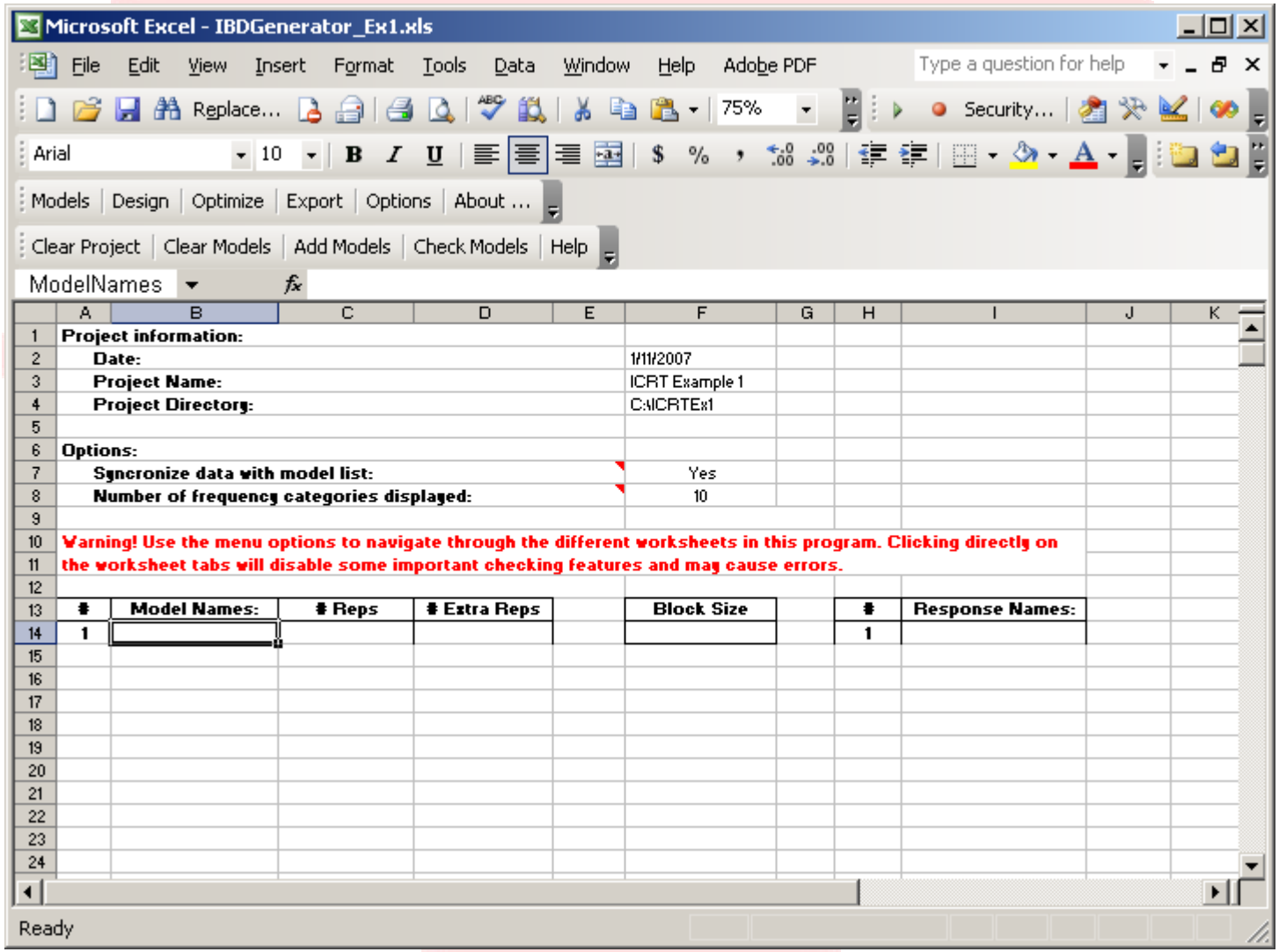
IBDGenerator

IBDGenerator.xls



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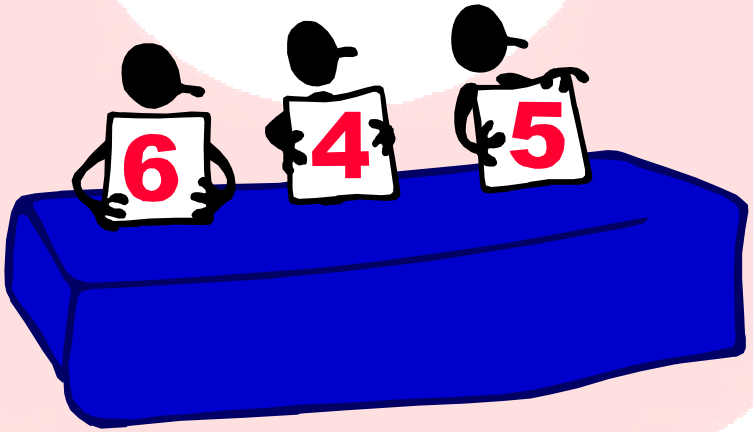
How Do We Rate Products?



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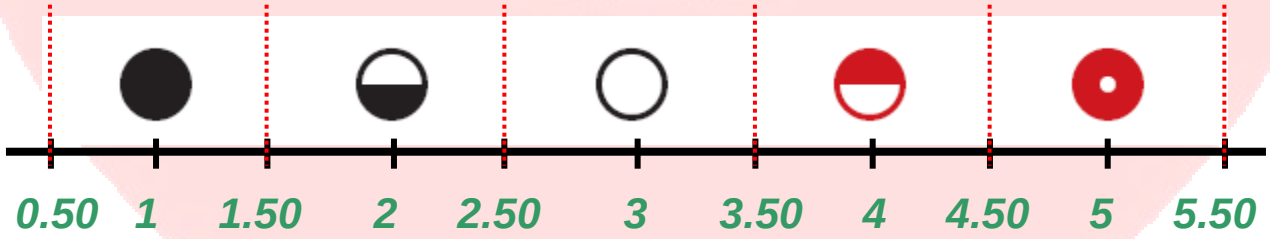
Rating Products

- We try to follow the KISS principle
  - Keep It Simple Statistically
- First, the individual attribute scores are transformed to a common scale which ranges from a low of 0.50 to a high of 5.49.
  - Known internally as a Fractional Blob scale.



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Calculating an Overall Score

- Although there are multiple ways to combine the individual attribute scores, the most common way is with a weighted average.

$$\text{Composite Score} = \frac{w_1 A_1 + w_2 A_2 + \ldots + w_k A_k}{w_1 + w_2 + \ldots + w_k}$$

- The composite score is then transformed to a 1 to 100 scale.

$$\text{Overall Score} = -9.5 + 20 \times \text{Composite Score}$$

Score	Overall Score	Blob
5.49	100	
5.00	91	
4.50	81	
4.49	80	
4.00	71	
3.50	61	
3.49	60	
3.00	51	
2.50	41	
2.49	40	
2.00	31	
1.50	21	
1.49	20	
1.00	11	
0.50	1	

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Limiting Factors

- However, there may be a critical component to a product's performance that we want to limit its overall score, e.g., no matter how convenient or easy to use, you would not rate a child's car seat excellent if it performed poorly for safety.
- A limiting factor prevents the overall score from going beyond a specified value if the score for this attribute falls below a certain value.

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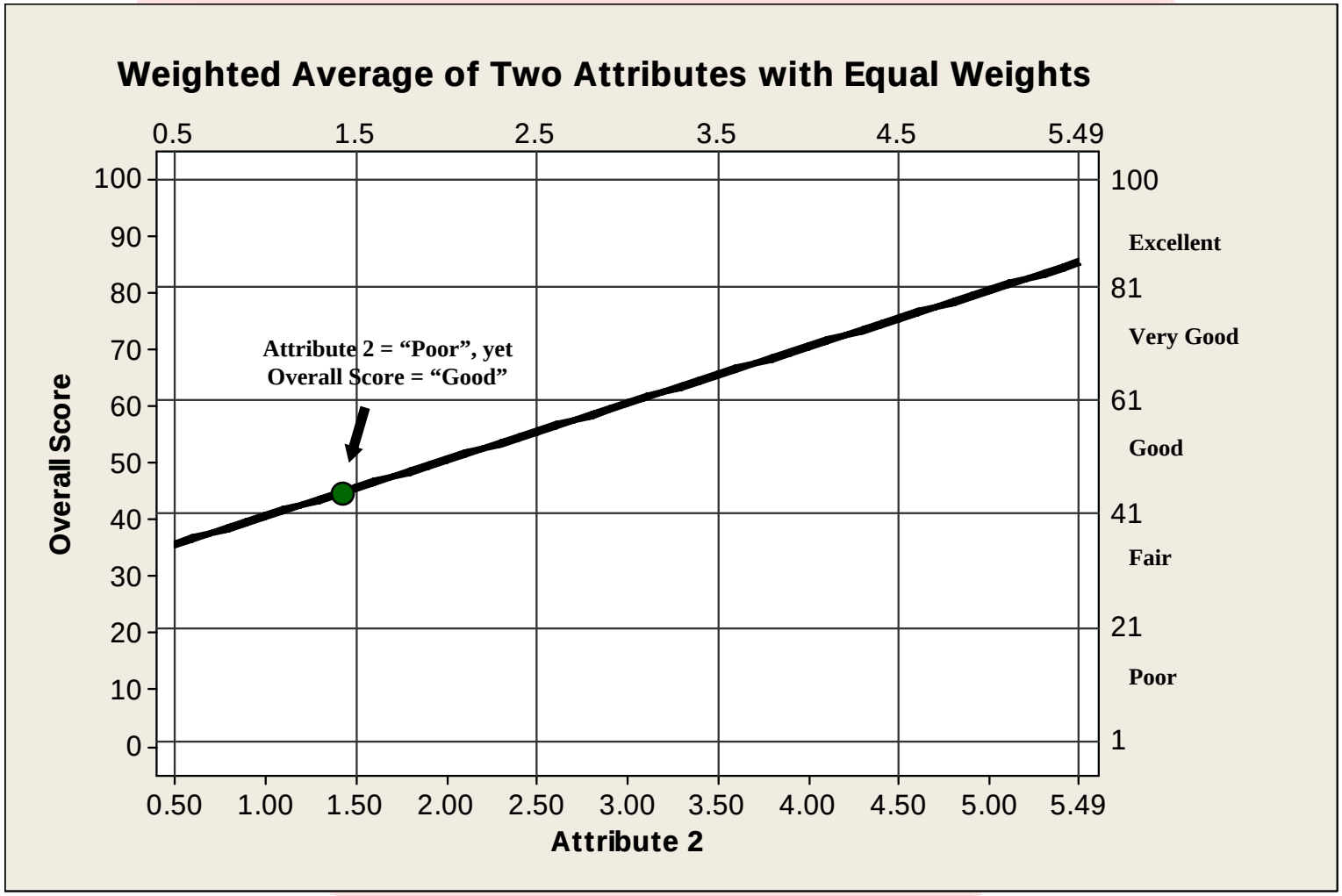
Good But Rancid Problem



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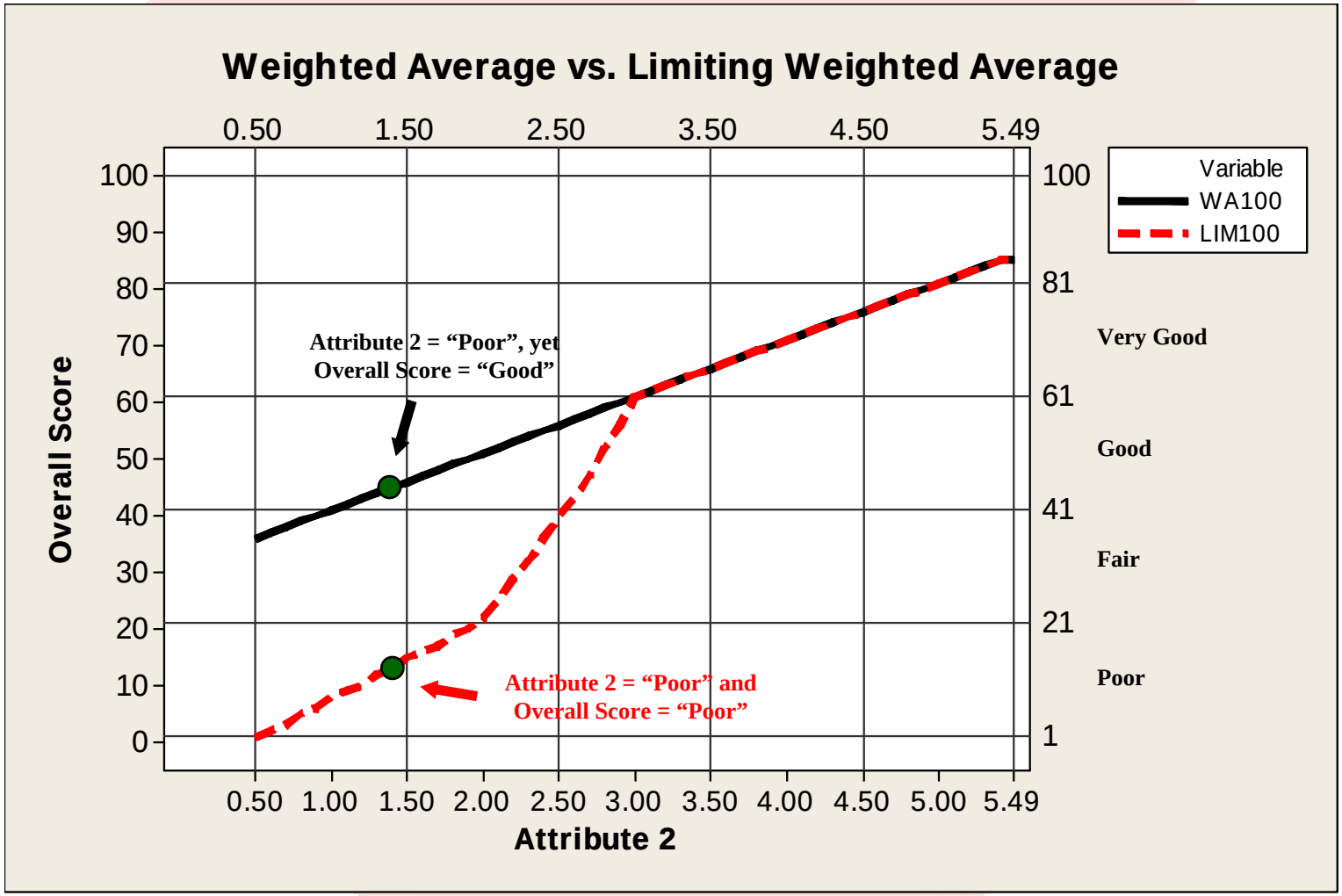
Possible Solution



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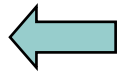
Limiting Factors Example

- Consider an example with 3 attributes, one of which is a limiting factor:

Model	Weights			Weighted Average w/o Limiting Factors	Weighted Average with Limiting Factors
	Limiting				
	0.50	0.25	0.25		
	Safety	Convenience	Ease of Installation		
A	5.49	5.49	5.49	5.49	5.49
B	3.00	5.49	5.49	4.25	4.25
C	2.75	5.49	5.49	4.12	3.65
D	2.00	5.49	5.49	3.75	2.00
E	2.00	5.00	5.00	3.50	1.85
F	1.00	5.49	5.49	3.25	1.00



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How Do We Select CR Best Buys™?

CR Best Buy

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Ratings Table

- One of the trademarks of Consumer Reports™ is the Ratings Table.

ID	Brand/Model	Price	Overall Score	Picture Quality	Weight (oz)	Flash Range (ft)	Battery Life (shots)	Shutter Lag
1	Canon PowerShot A620	220	81	●	12	14	520	○
2	Hewlett-Packard PhotoSmart R817	220	79	●	7	13	260	◓
3	Olympus Stylus 800	330	79	●	7	21	400	○
4	Kodak EasyShare Z700	250	75	●	10	13	200	○
5	Canon PowerShot A520	160	72	●	8	12	300	◒
6	Kodak EasyShare One	210	69	●	9	11	150	○
7	Canon PowerShot A530	180	67	◓	7	12	360	◒
8	Hewlett-Packard PhotoSmart R927	400	67	◓	7	16	200	◓
9	Samsung Digimax L85	380	67	◓	8	10	260	◒
10	HP Photosmart R717	260	66	●	7	16	80	◒
11	Nikon Coolpix P4	360	66	◓	7	13	200	◒
12	Olympus FE-140	200	64	◓	6	11	260	◒
13	Fujifilm FinePix A500	150	60	◓	6	10	400	◒
14	Kodak EasyShare C643	180	59	○	7	12	260	○
15	HP Photosmart M527	190	53	○	7	13	200	◒

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Ratings Table

- But which product offers the best value to a consumer?

ID	Brand/Model	Price	Overall Score	Picture Quality	Weight (oz)	Flash Range (ft)	Battery Life (shots)	Shutter Lag
1	Canon PowerShot A620	$220	81	●	12	14	520	○
2	Hewlett-Packard PhotoSmart R817	220	79	●	7	13	260	◓
3	Olympus Stylus 800	330	79	●	7	21	400	○
4	Kodak EasyShare Z700	250	75	●	10	13	200	○
5	Canon PowerShot A520	160	72	●	8	12	300	◒
6	Kodak EasyShare One	210	69	●	9	11	150	○
7	Canon PowerShot A530	180	67	◓	7	12	360	◒
8	Hewlett-Packard PhotoSmart R927	400	67	◓	7	16	200	◓
9	Samsung Digimax L85	380	67	◓	8	10	260	◒
10	HP Photosmart R717	260	66	●	7	16	80	◒
11	Nikon Coolpix P4	360	66	◓	7	13	200	◒
12	Olympus FE-140	200	64	◓	6	11	260	◒
13	Fujifilm FinePix A500	150	60	◓	6	10	400	◒
14	Kodak EasyShare C643	180	59	○	7	12	260	○
15	HP Photosmart M527	190	53	○	7	13	200	◒

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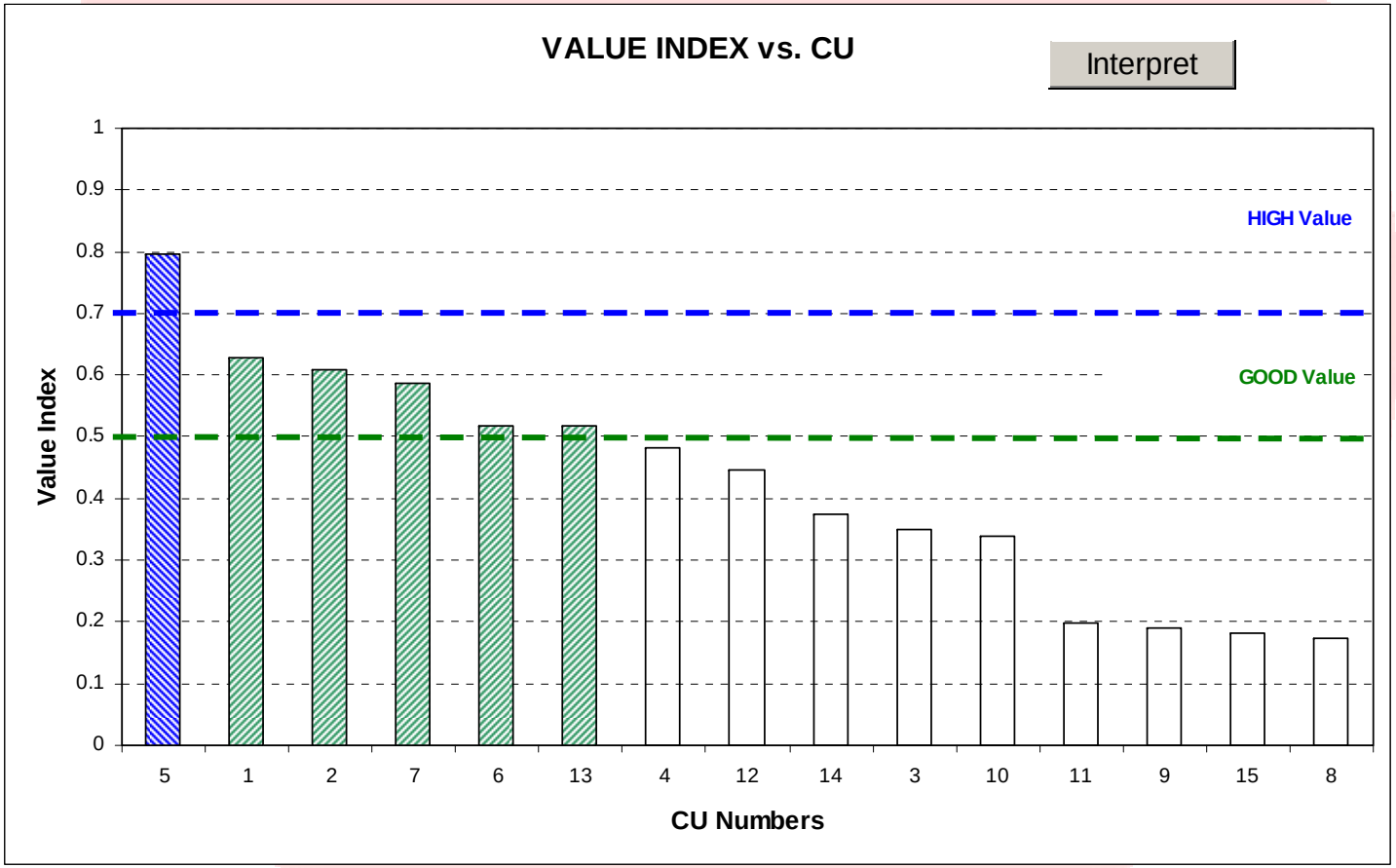
The Value Index



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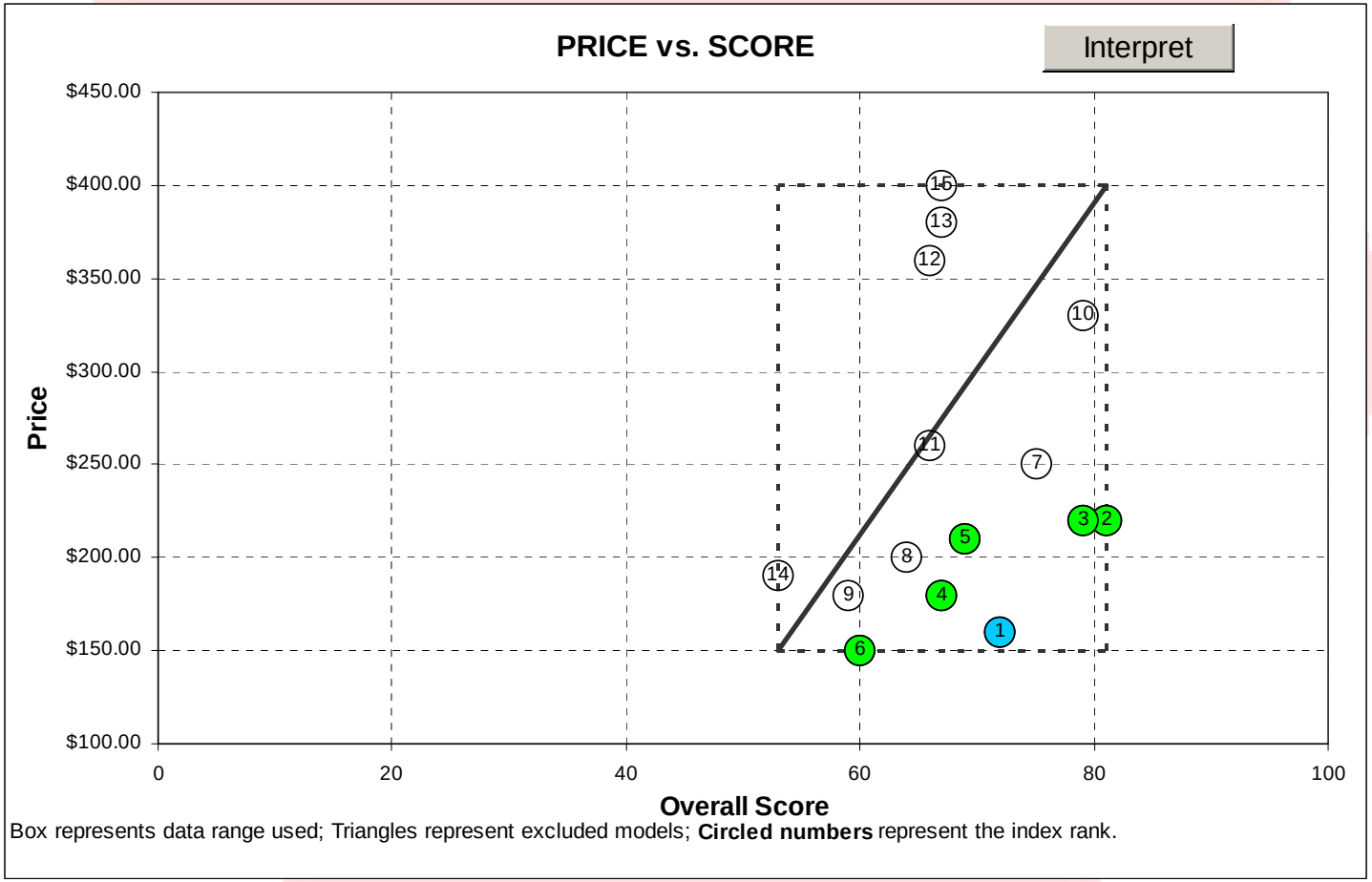
Value Zones



Box represents data range used; Triangles represent excluded models; **Circled numbers** represent the index rank.

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Which Products Offer the Best Value?

- Currently, the Value Index is used to identify potential CR Best Buys©.

ID	Model	Category	Price	Score	Recommendation
5	Canon PowerShot A520	Compact models	160	72	HIGH Value
1	Canon PowerShot A620	Compact models	220	81	GOOD Value
2	Hewlett-Packard PhotoSmart R817	Compact models	220	79	GOOD Value
7	Canon PowerShot A530	Compact models	180	67	GOOD Value
6	Kodak EasyShare One	Compact models	210	69	GOOD Value
13	Fujifilm FinePix A500	Compact models	150	60	GOOD Value
4	Kodak EasyShare Z700	Compact models	250	75	
12	Olympus FE-140	Compact models	200	64	
14	Kodak EasyShare C643	Compact models	180	59	
3	Olympus Stylus 800	Compact models	330	79	

- But we are exploring other possible uses.

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It's a Tough Job, but Somebody Has to Do It ...

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