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4. If the presentation classification and or Disclosure Statement below is different than those entered in the MORS Presenter Center, correct the Presenter Center entries to ensure proper labeling of the Presentation.

PART I

Author Request - The following author(s) request authority to disclose the following presentation at the MORS Event below with subsequent publication in the MORS Event Report and posting on the MORS website if applicable.

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Principal Author's Organization and complete mailing address: SAS Institute Inc. 27 Farmingdale Ln Newark, DE 19711	Principle Author Phone: 302-489-9291 Principle Author FAX: Principle Author E-mail: tom.donnelly@jmp.com
Principal Author's Signature X: Thomas A. Donnelly	Date: 3 June 2021
MORS Event: 89th MORSS	Event Date(s): 21-24 June 2021

Presentation Type ☐ Plenary ☐ Course ☒ Tutorial ☐ Special Session ☐ Poster ☐ Demonstration
☐ Working/Composite/Distributed or Focus Group List All ☐ Other

Title of Presentation: All Graphs are Wrong – Some are Useful	Presentation ID (if assigned): 56938

Classification ☐ SECRET ☐ SECRET//REL TO FVEY ☐ CONFIDENTIAL ☐ CONFIDENTIAL//REL TO FVEY
☒ UNCLASSIFIED ☐ UNCLASSIFIED W/FOUO ☐ Other

Distribution Statement ☒ A (Publicly Releasable) ☐ B ☐ C ☐ D ☐ E (see side 2 for definitions)

A.	This work was performed in connection with a government contract.	☐ YES (Complete Parts I, II & III)
B.	This presentation is based on material developed by the author as part of company/organization approved research e.g. IR&D and was NOT done under a government contract.	☐ YES (Complete Parts I, II & III)
C.	This presentation was NOT done under a government contract, contains no government information, is my own work and is approved for public release.	☒ YES (Complete Part I only)

All Graphs Are Wrong, but Some Are Useful

89th MORSS
Webcast Tutorial 56938
June 21, 2021

Tom Donnelly, PhD, CAP
Principal Systems Engineer
JMP Defense & Aerospace Team
tom.donnelly@jmp.com
302-489-9291

Xan Gregg
JMP Director R&D

Originally Presented at

2015

DISCOVERY SUMMIT

EXPLORING DATA
INSPIRING INNOVATION

View at https://community.jmp.com/docs/DOC-8270

Three Graphical Influences…

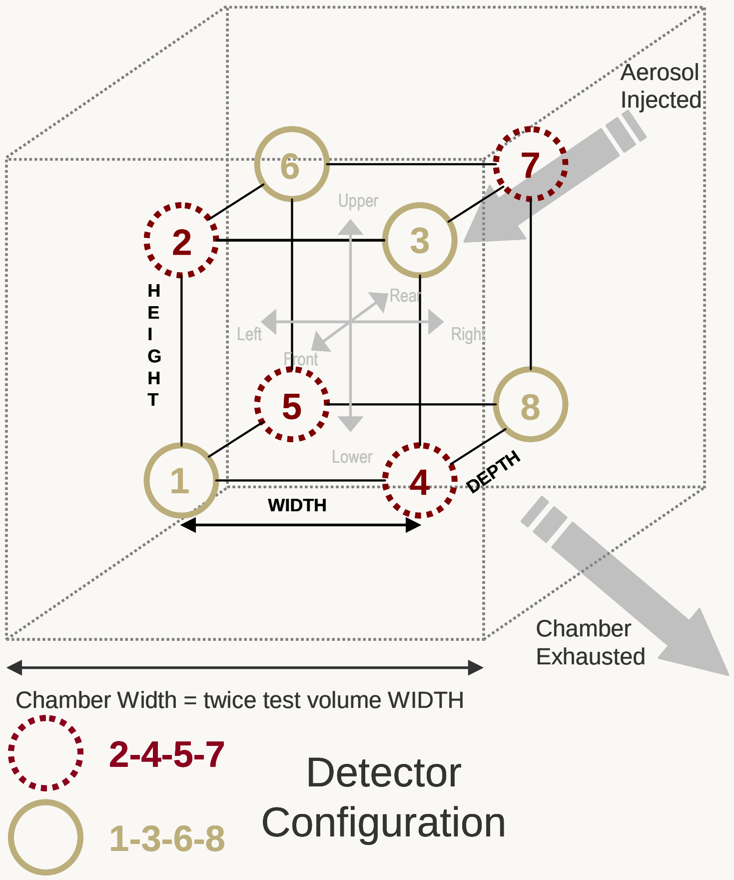
1. Edward Tufte - www.edwardtufte.com

2. Kaiser Fung - www.kaiserfung.com @junkcharts

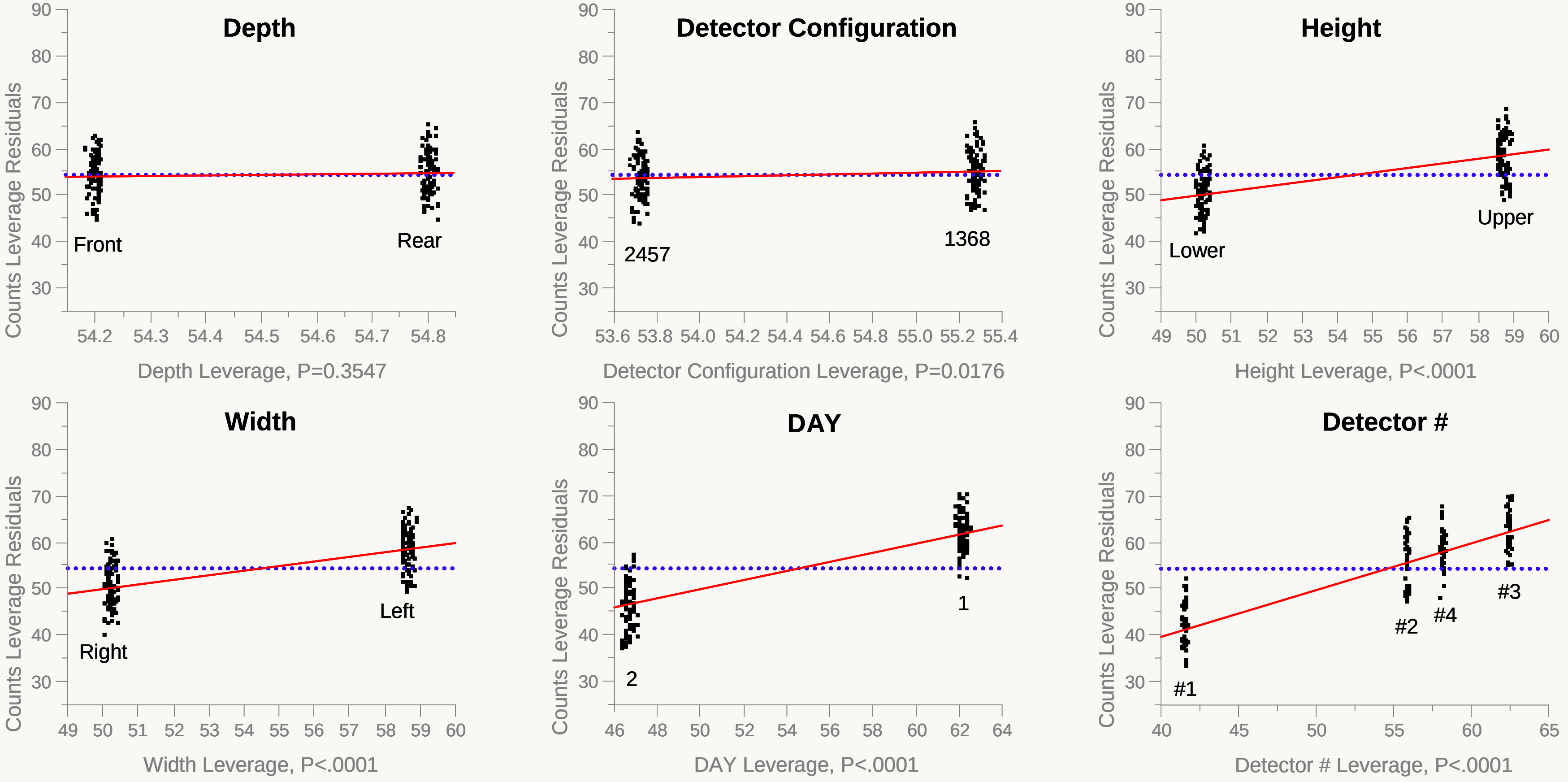
3. Xan Gregg – https://twitter.com/xangregg/media
@xangregg, #onelesspie, #GraphBuilder, #DatViz, #DataScience, #TieDye

Tufte's Big Ideas : "5 grand principles"

1. Enforce Wise Visual Comparisons
2. Show Causality
3. Show Multivariate Data
4. Integrate all visual elements (words, numbers, images)
5. Content-Driven Design



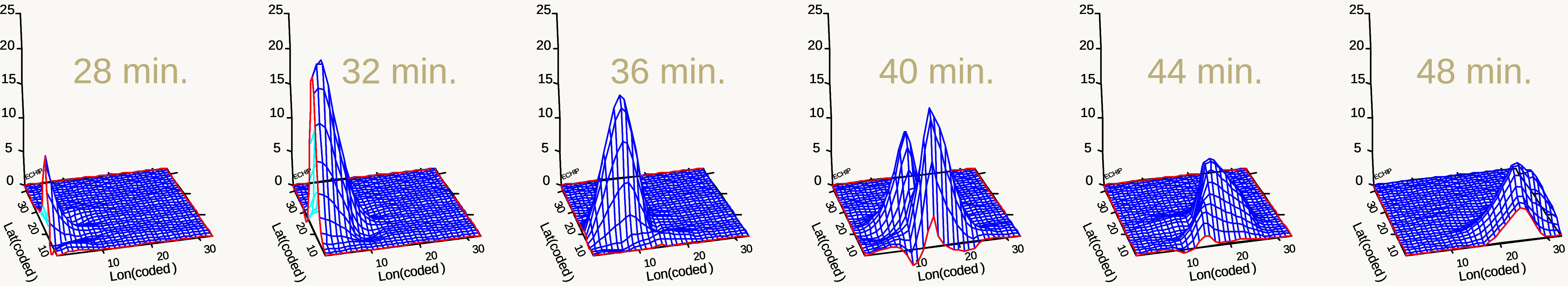
Leverage Plots for the Response Data ‘Counts” for Six Explanatory Variables



The second example shows aerosol concentration versus location variables for 6 time steps from analysis of simulation data using a Kriging or Gaussian Process regression technique that smoothly interpolates deterministic data.

<u>Tufte's Grand Principles:</u>

- Enforce wise visual comparisons
- Content counts most of all
- Show causality
- Complete integration of evidence - words, numbers, images, diagrams
- Use multivariate displays
- Use small multiples (format constancy)
- Put everything on universal grid
- Give reasons to believe
- Don't de-quantify data



Tufte's advice…

If you ever get 5 minutes with the Admiral, you don't want to be giving a PowerPoint presentation.

Instead, hand the Admiral an 11" X 17", 4-page handout that in 250 words or less describes the *problem* and it's *importance*, and in 250 words or less describes the *solution* you propose.

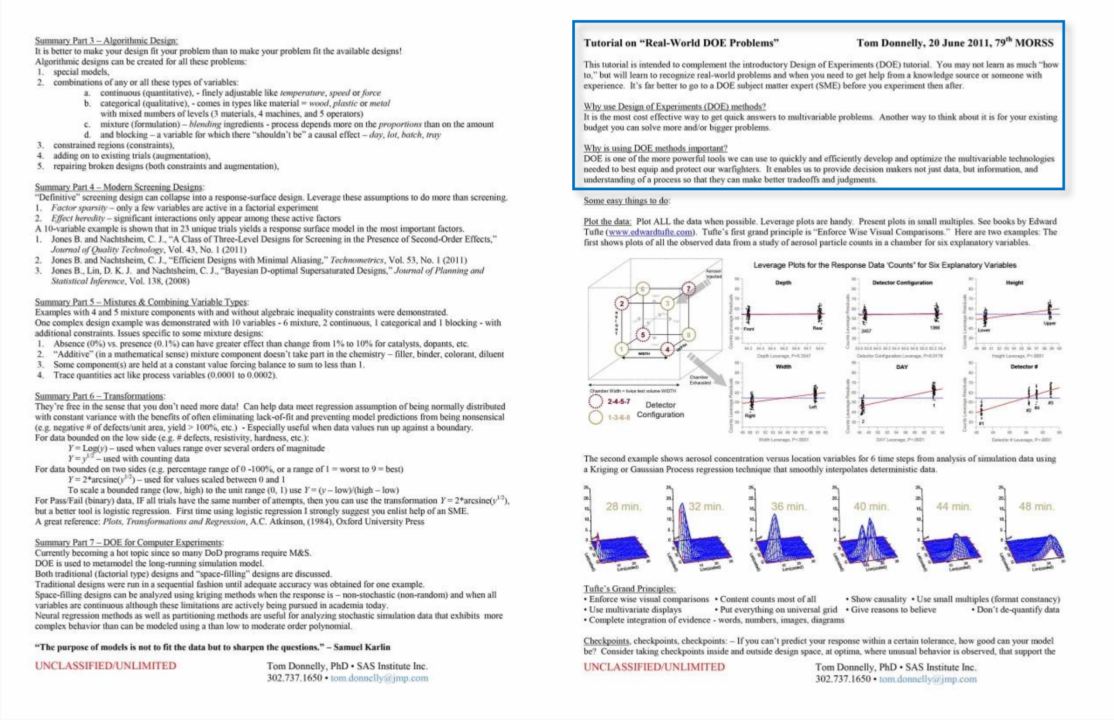
The rest of the handout *shows your credibility*…

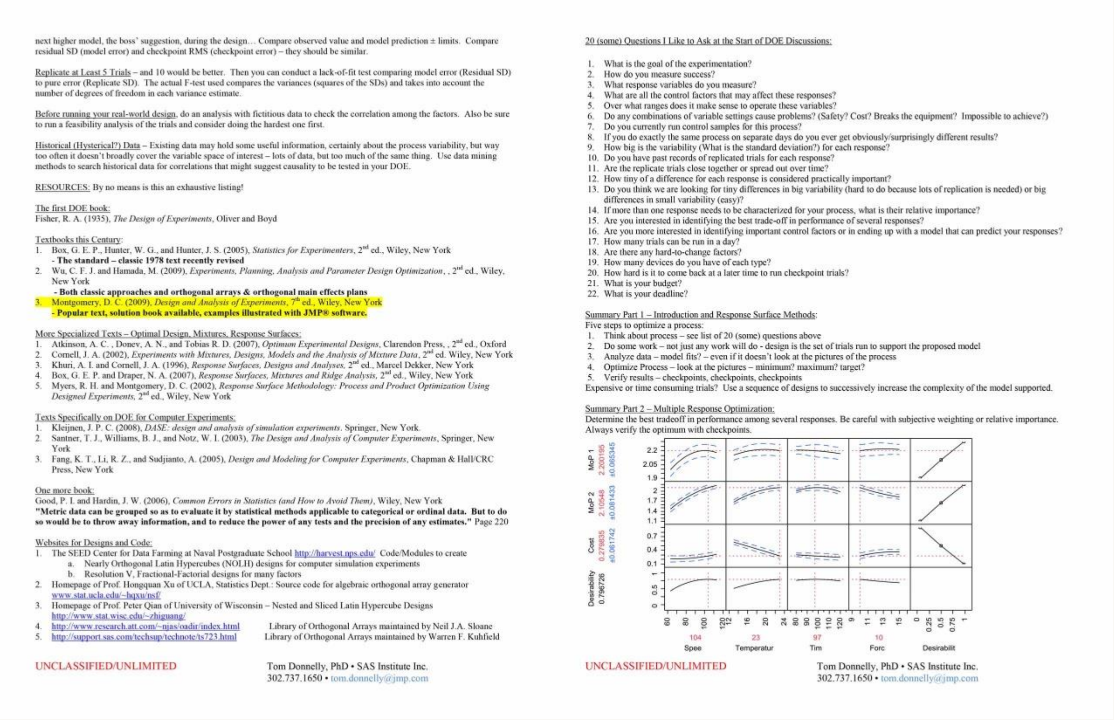
Tutorial on "Real-World DOE Problems" Tom Donnelly, 20 June 2011, 79th MORSS

This tutorial is intended to complement the introductory Design of Experiments (DOE) tutorial. You may not learn as much "how to," but will learn to recognize real-world problems and when you need to get help from a knowledge source or someone with experience. It's far better to go to a DOE subject matter expert (SME) before you experiment then after.

Why use Design of Experiments (DOE) methods?
It is the most cost effective way to get quick answers to multivariable problems. Another way to think about it is for your existing budget you can solve more and/or bigger problems.

Why is using DOE methods important?
DOE is one of the more powerful tools we can use to quickly and efficiently develop and optimize the multivariable technologies needed to best equip and protect our warfighters. It enables us to provide decision makers not just data, but information, and understanding of a process so that they can make better tradeoffs and judgments.

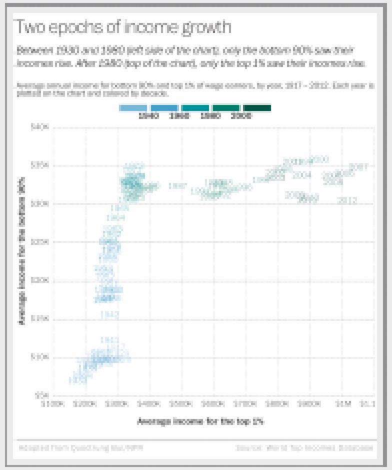


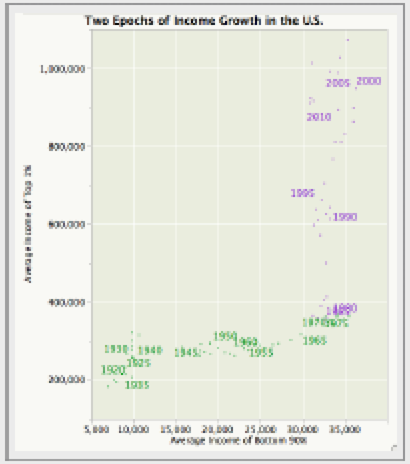


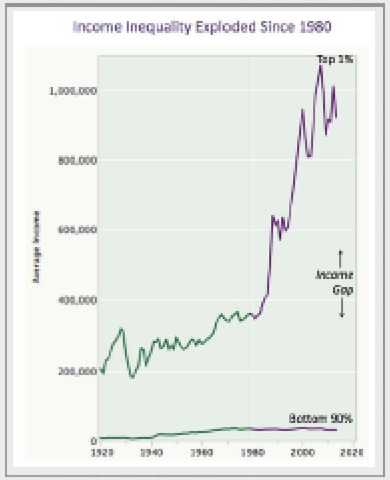
Kaiser Fung's
Language to describe what you like

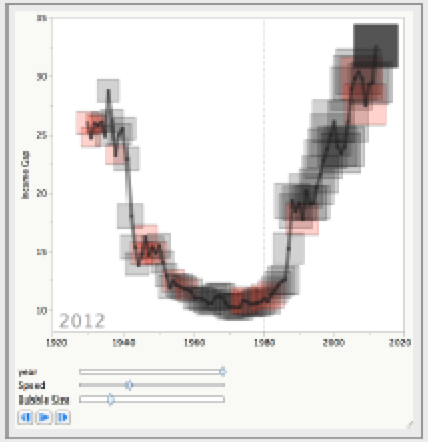
Make it Thick: data ink
Make it Sufficient
Make it Easy
Make it Scream
Speak Directly
Consider knowledge in the head
Make it Whole
Make it Interactive*

How has Income Inequality changed?









Create Color and Label indicators

Formula
Value color

Swap axes

Modulo
Value color
Background
Gridlines

Plot multiple time series

Add reference line
Add text

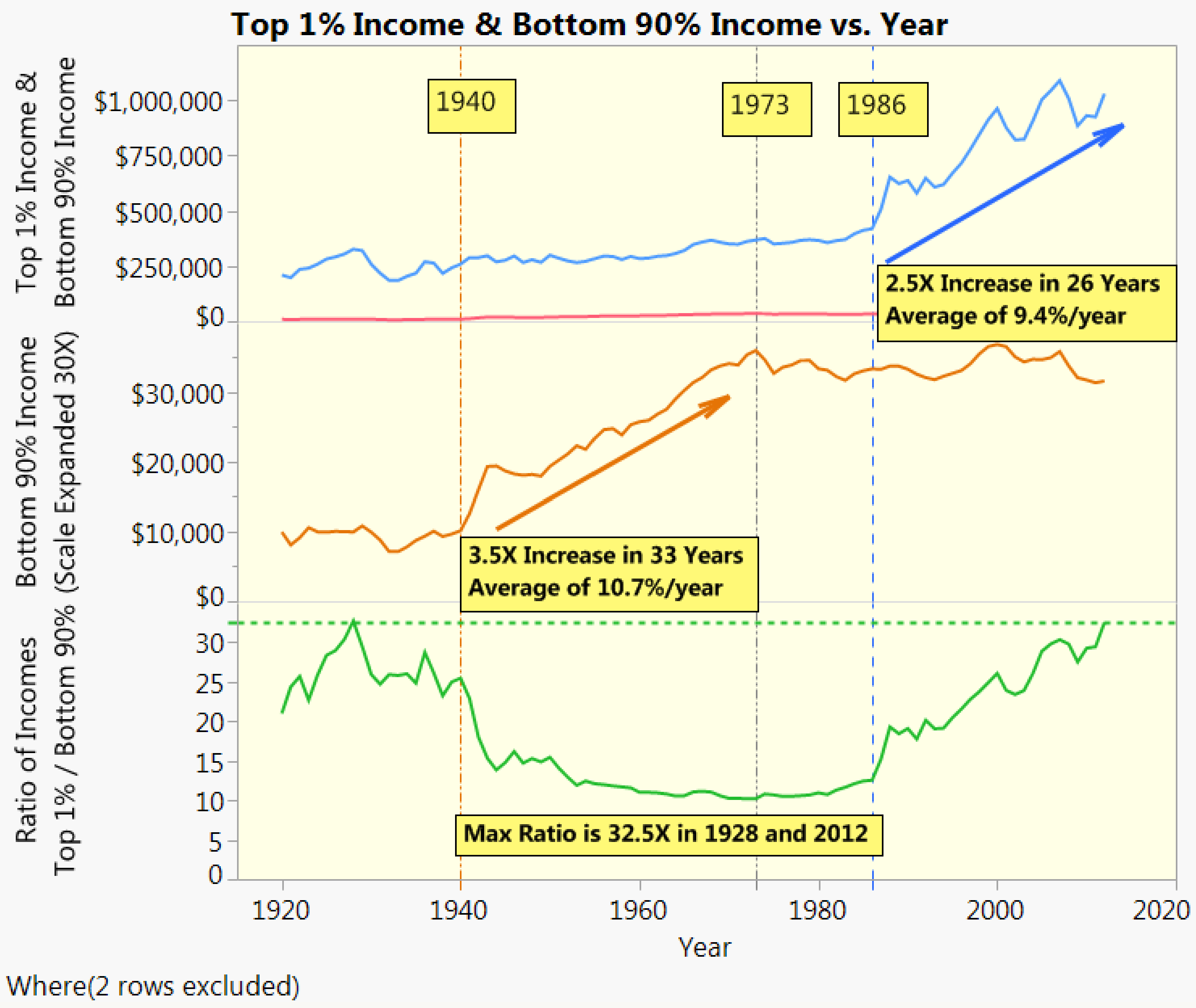
Transform data to Ratio

Formula

Merge GDP data Explore & Categorize Bubble Plot

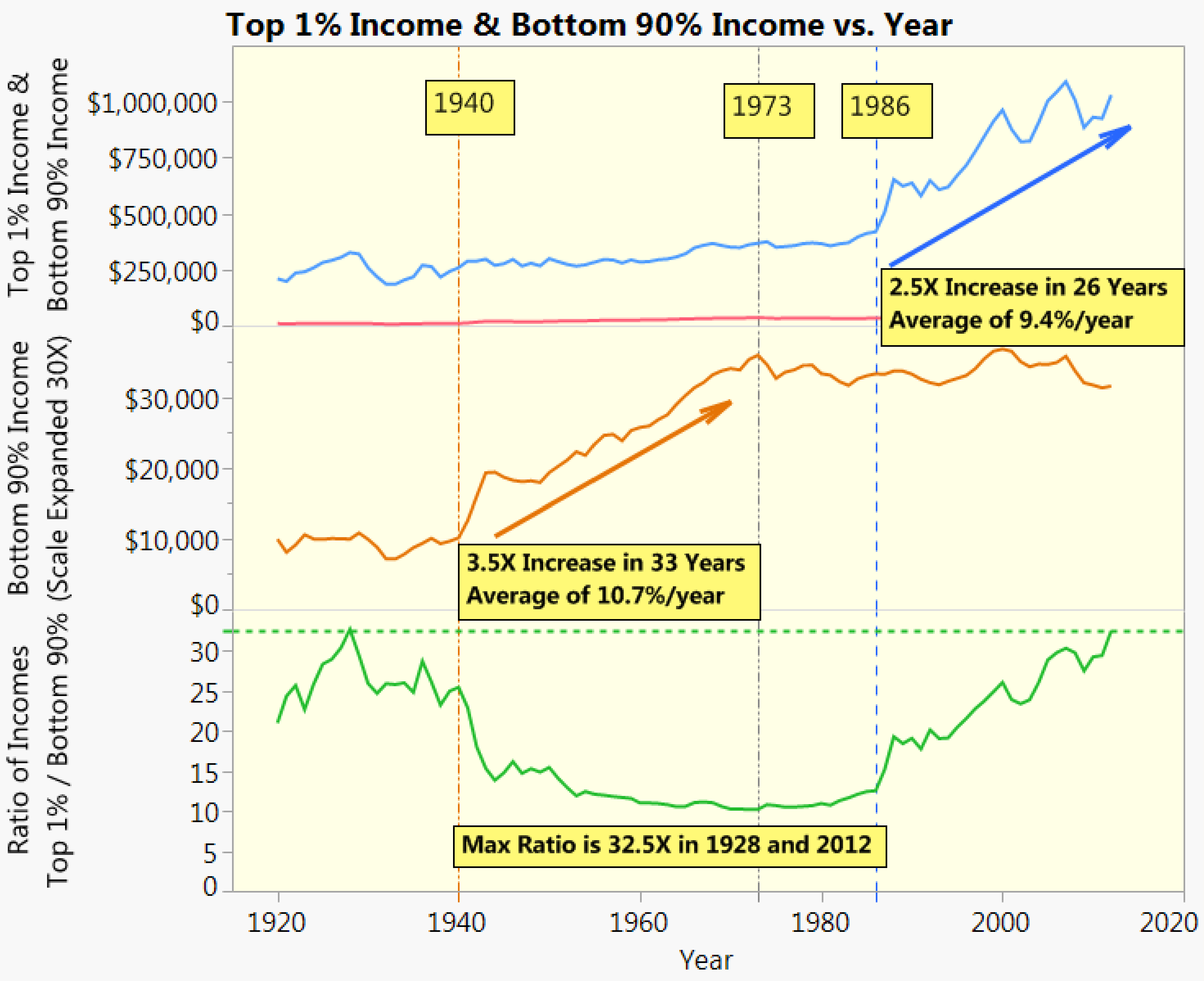
Join
Formula
Value color

Kaiser Fung @JunkCharts

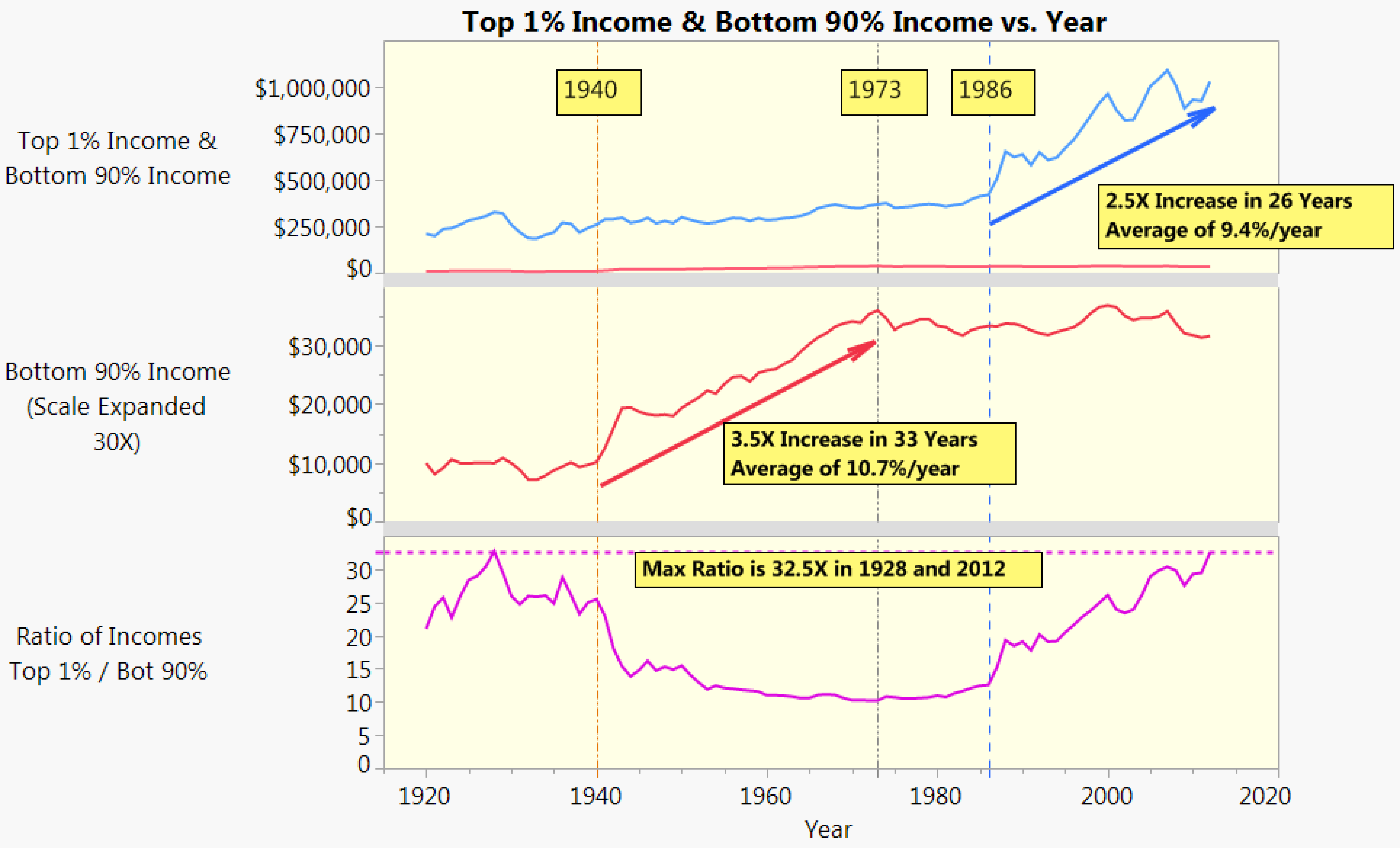


Top 1% Income & Bottom 90% Income vs. Year
Top 1% Income & Bottom 90% Income
$1,000,000
$750,000
$500,000
$250,000
$0
Bottom 90% Income (Scale Expanded 30X)
$30,000
$20,000
$10,000
$0
Ratio of Incomes Top 1% / Bottom 90%
30
25
20
15
10
5
0
1940
1973
1986
2.5X Increase in 26 Years
Average of 9.4%/year
3.5X Increase in 33 Years
Average of 10.7%/year
Max Ratio is 32.5X in 1928 and 2012
1920
1940
1960
1980
2000
2020
Year
Where(2 rows excluded)

1. Plot on same scale
2. Add gaps between plots
3. Make middle graph line color red too
4. Make bottom graph line color purple
5. Make Y-axes labels horizontal
6. Screen grid confusing
7. Plot more bins than average bottom 90% (e.g. 0-19, 20-39, 40-59, 60-79…)



Where(2 rows excluded)

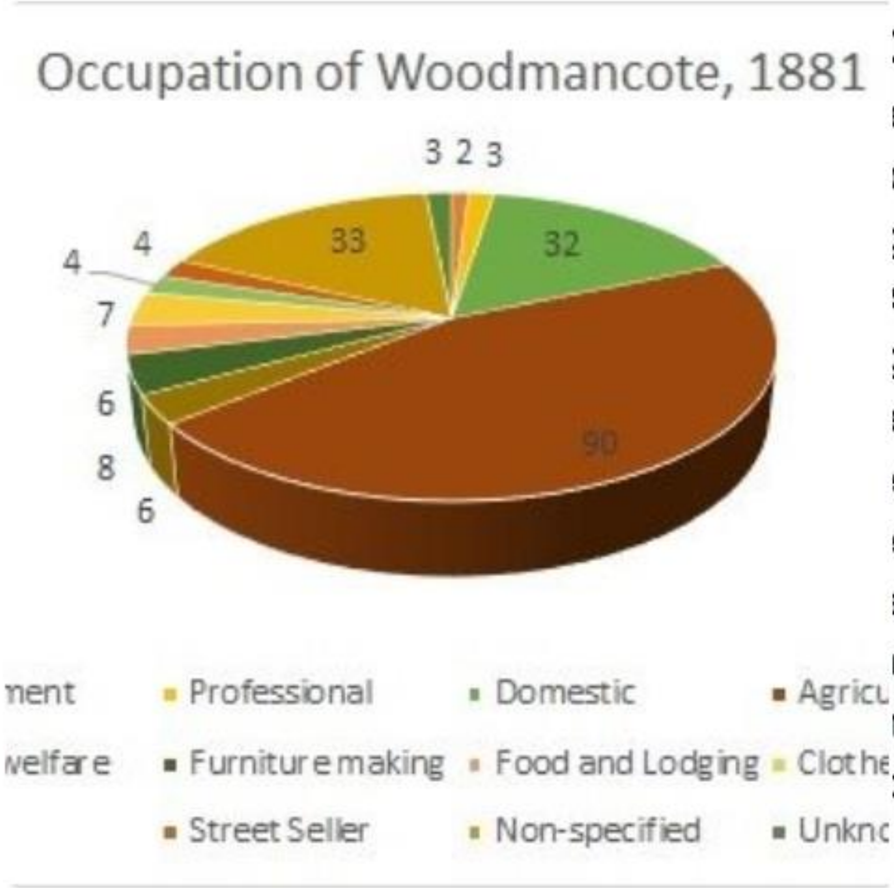


Top 1% Income & Bottom 90% Income vs. Year
Top 1% Income & Bottom 90% Income
Bottom 90% Income (Scale Expanded 30X)
Ratio of Incomes Top 1% / Bot 90%
$1,000,000
$750,000
$500,000
$250,000
$0
$30,000
$20,000
$10,000
$0
30
25
20
15
10
5
0
1940
1973
1986
2.5X Increase in 26 Years
Average of 9.4%/year
3.5X Increase in 33 Years
Average of 10.7%/year
Max Ratio is 32.5X in 1928 and 2012
1920
1940
1960
1980
2000
2020
Year

Xan Gregg @xangregg · Mar 28

Remaking a 3D pie chart on Wikipedia for Pi Day, two weeks late. @junkcharts #onelesspie

community.jmp.com/t5/JMP-Blog/Be...



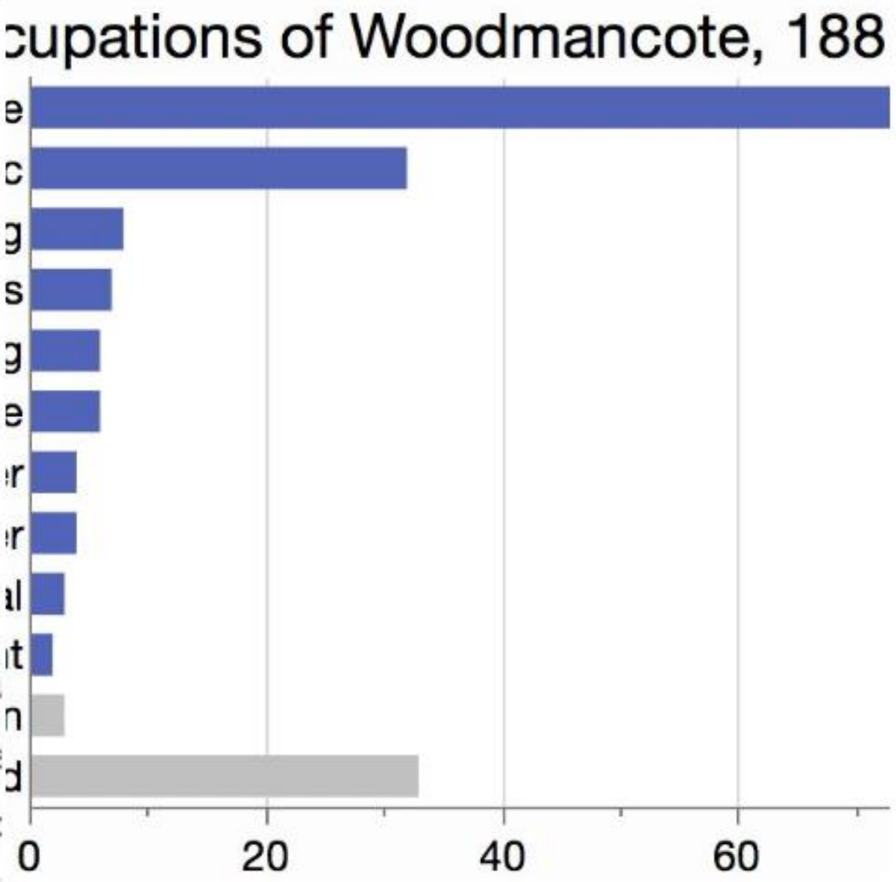


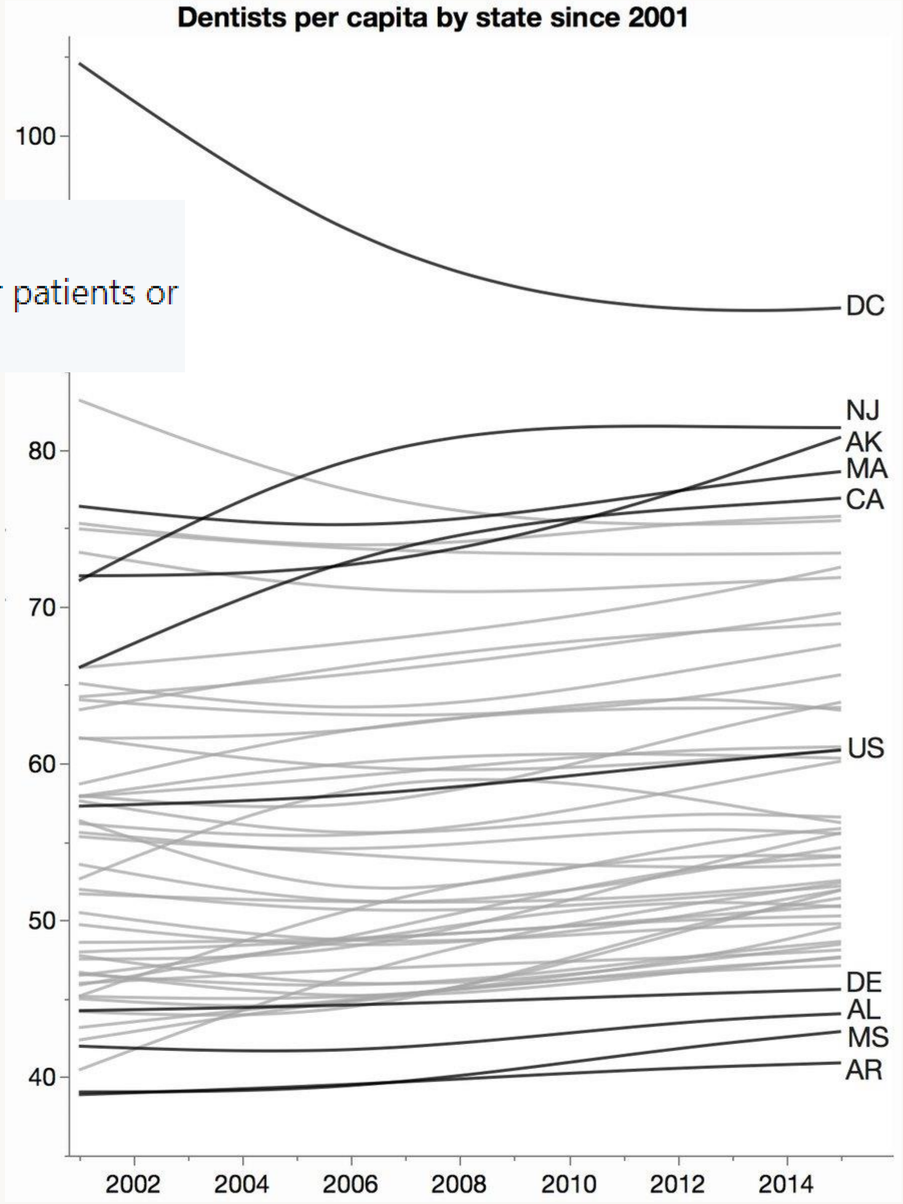
Table 86. Active dentists, by state: United States, selected years 2001–2015

[Data are based on reporting by dentists]

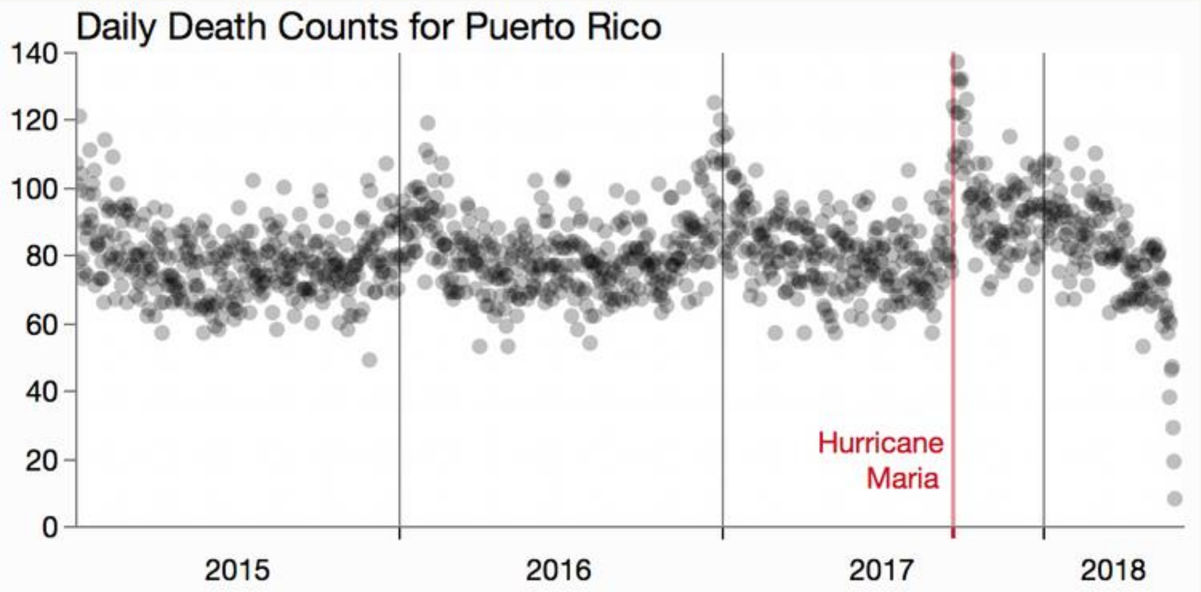
State	2001	2006	2013	2014	2015	2001	2006	2013	2014	2015
	Number of dentists					Number of dentists per 100,000 civilian population				
United States	163,345	172,603	191,347	192,313	195,722	57.32	57.85	60.47	60.30	60.89
Alabama	1,880	1,921	2,128	2,125	2,130	42.08	41.50	44.05	43.85	43.84
Alaska	457	489	577	588	597	72.11	72.41	78.24	79.78	80.85
Arizona										
Arkansas										
California										
Colorado										
Connecticut										
Delaware										
District of Columbia										
Florida										
Georgia	3,614	4,115	4,701	4,731	4,805	43.14	44.94	47.05	46.85	47.04
Hawaii	1,022	1,009	1,060	1,069	1,083	83.36	77.04	75.24	75.27	75.65
Idaho	690	864	932	907	939	52.27	58.83	57.79	55.48	56.74
Illinois	8,154	7,994	8,599	8,593	8,697	65.29	63.22	66.71	66.70	67.63
Indiana	2,870	2,842	3,116	3,104	3,157	46.84	44.88	47.42	47.05	47.69
Iowa	1,516	1,526	1,604	1,611	1,652	51.71	51.16	51.87	51.81	52.88
Kansas	1,314	1,347	1,461	1,471	1,482	48.63	48.75	50.47	50.68	50.90
Kentucky	2,256	2,287	2,488	2,441	2,445	55.46	54.20	56.56	55.32	55.25
Louisiana	2,058	2,017	2,221	2,199	2,262	45.96	46.88	48.00	47.30	48.43
Maine	598	642	693	669	674	46.51	48.50	52.15	50.29	50.70
Maryland	3,955	3,989	4,268	4,260	4,322	73.59	70.89	71.90	71.29	71.96
Massachusetts	4,898	4,797	5,232	5,303	5,319	76.56	74.84	77.99	78.50	78.28
Michigan	5,783	5,928	6,075	6,010	6,056	57.88	59.07	61.36	60.61	61.03
Minnesota	2,880	3,105	3,284	3,288	3,312	57.80	60.13	60.58	60.25	60.33
Mississippi	1,117	1,140	1,275	1,264	1,284	39.15	39.24	42.63	42.23	42.91
Missouri	2,634	2,666	2,900	2,952	2,943	46.69	45.63	47.98	48.68	48.38
Montana	511	525	598	612	619	56.34	55.11	58.95	59.81	59.93
Nebraska	1,103	1,117	1,203	1,223	1,250	64.13	63.01	64.36	64.95	65.92
Nevada	846	1,177	1,448	1,446	1,525	40.32	46.66	51.89	50.95	52.75
New Hampshire	735	815	847	830	851	58.54	62.29	64.04	62.50	63.96
New Jersey	6,054	6,922	7,238	7,256	7,303	71.28	79.92	81.26	81.17	81.52
New Mexico	814	861	1,062	1,065	1,060	44.44	43.88	50.89	51.07	50.84
New York	14,309	14,062	14,468	14,428	14,560	74.98	73.61	73.48	73.06	73.55
North Carolina	3,474	4,016	4,719	4,791	5,038	42.31	45.04	47.93	48.20	50.17
North Dakota	305	311	394	405	419	47.73	47.89	54.45	54.73	55.36
Ohio	5,929	5,797	6,003	5,978	6,078	52.07	50.49	51.87	51.55	52.34
Oklahoma	1,664	1,749	1,943	1,937	1,966	47.99	48.66	50.42	49.93	50.26
Oregon	2,197	2,431	2,708	2,700	2,785	63.35	66.22	68.94	67.99	69.12
Pennsylvania	7,595	7,454	7,698	7,783	7,774	61.75	59.58	60.22	60.83	60.72
Rhode Island	588	576	566	553	572	55.62	54.18	53.76	52.42	54.15
South Carolina	1,839	1,958	2,288	2,229	2,350	45.24	44.93	47.98	46.16	48.00
South Dakota	348	382	457	460	460	45.91	48.78	54.07	53.91	53.58
Tennessee	2,912	2,947	3,246	3,252	3,273	50.64	48.40	49.97	49.67	49.59
Texas	9,642	10,365	13,391	13,692	14,268	45.23	44.37	50.53	50.75	51.94
Utah	1,409	1,559	1,892	1,864	1,885	61.70	61.73	65.16	63.30	62.92
Vermont	354	343	365	347	355	57.82	55.07	58.20	55.36	56.71
Virginia	4,189	4,367	5,194	5,277	5,329	58.19	56.91	62.82	63.36	63.57
Washington	3,957	4,312	4,951	5,050	5,219	66.11	67.68	71.00	71.50	72.79
West Virginia	863	835	890	881	897	47.91	45.68	48.03	47.65	48.64
Wisconsin	3,069	2,860	3,215	3,202	3,193	56.76	51.28	55.97	55.60	55.33
Wyoming	266	266	309	323	317	53.77	50.89	52.99	55.28	54.09

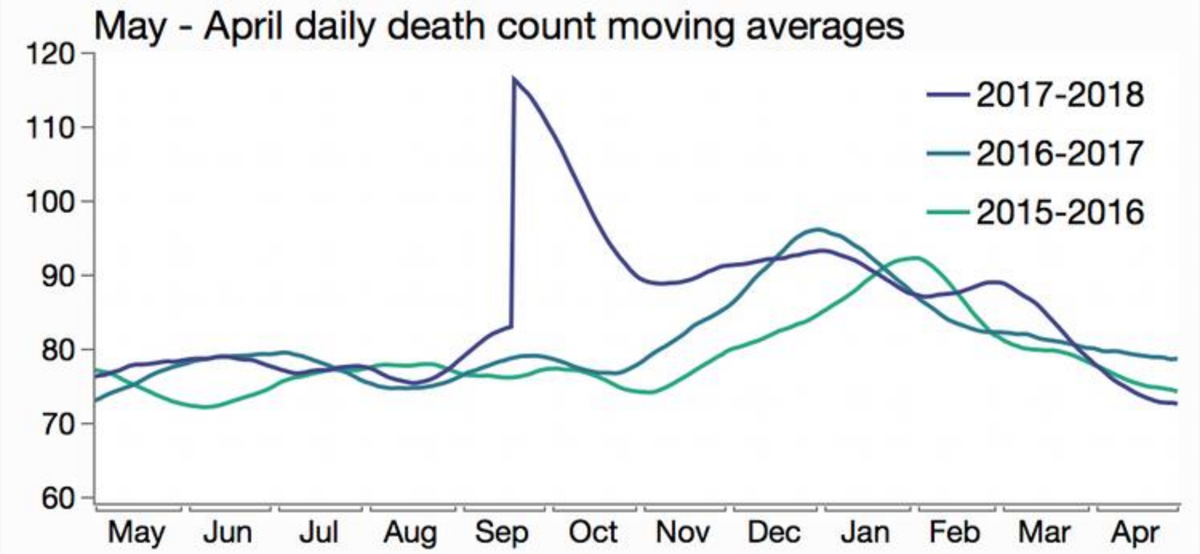
Xan Gregg @xangregg · May 27

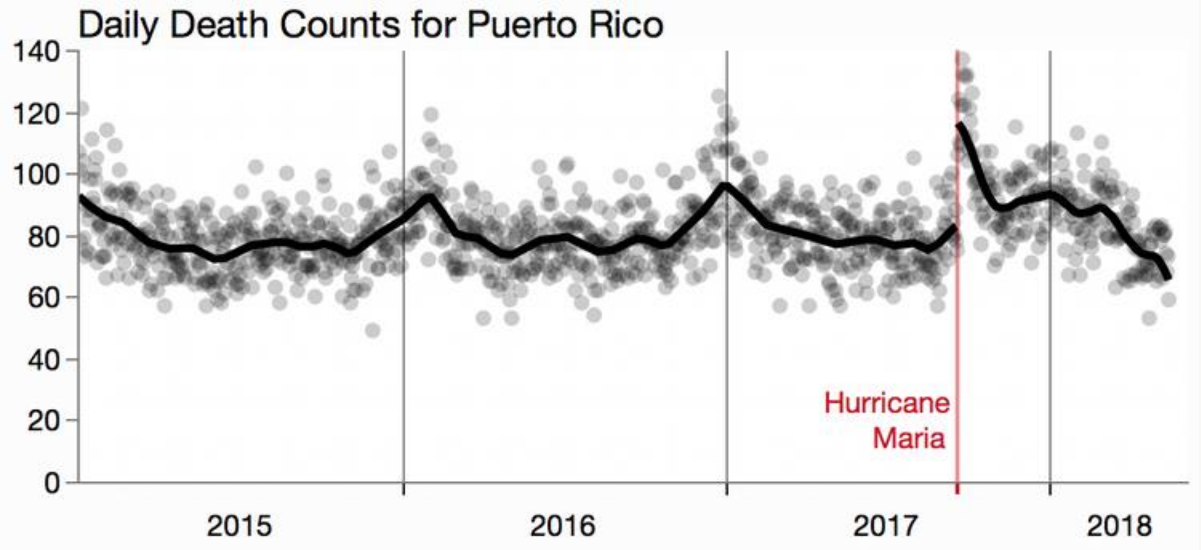
Dentists per capita in US states. What going on with DC? Commuter patients or extra teeth grinding...?

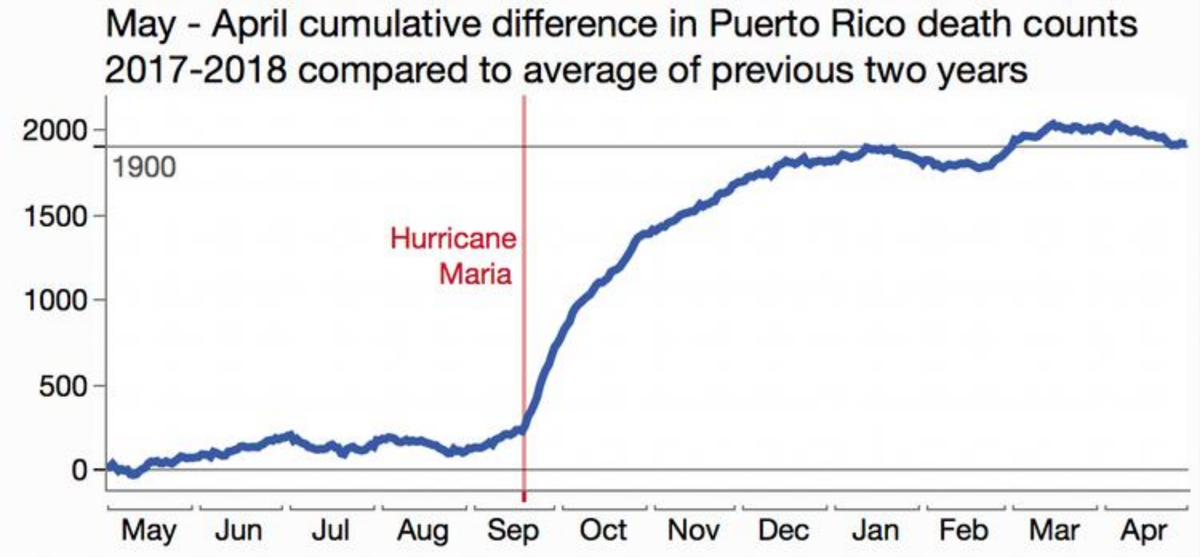


https://www.cdc.gov/nchs/data/hus/2016/086.pdf









https://community.jmp.com/t5/JMP-Blog/Visualizing-Puerto-Rico-s-Hurricane-Maria-daily-mortality/ba-p/60243

All Graphs Are Wrong, but Some Are Useful

Back to Xan's Talk…

View Xan's Original Presentation at https://community.jmp.com/docs/DOC-8270

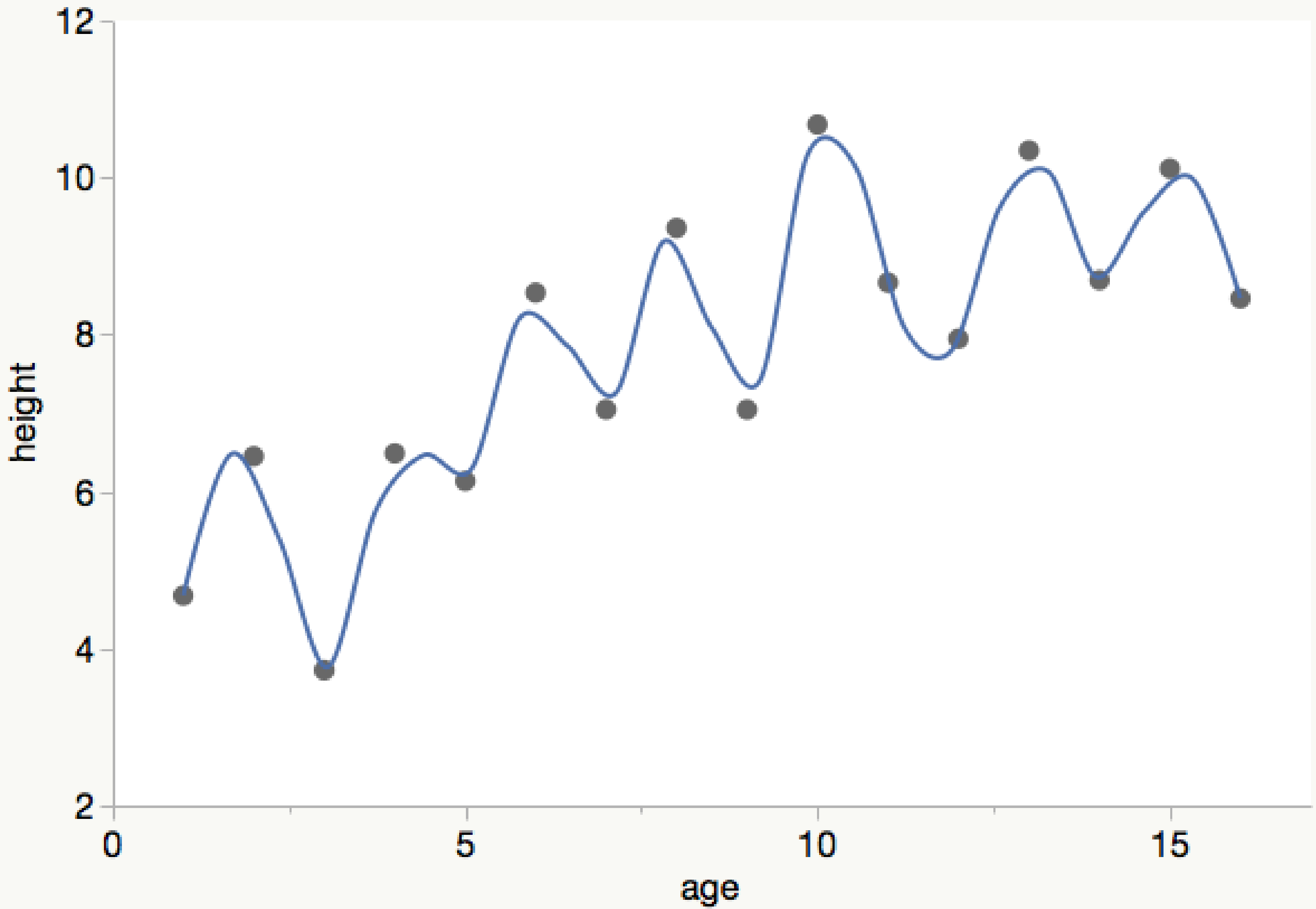
All models are wrong, but some are useful.

George E. P. Box (1979)

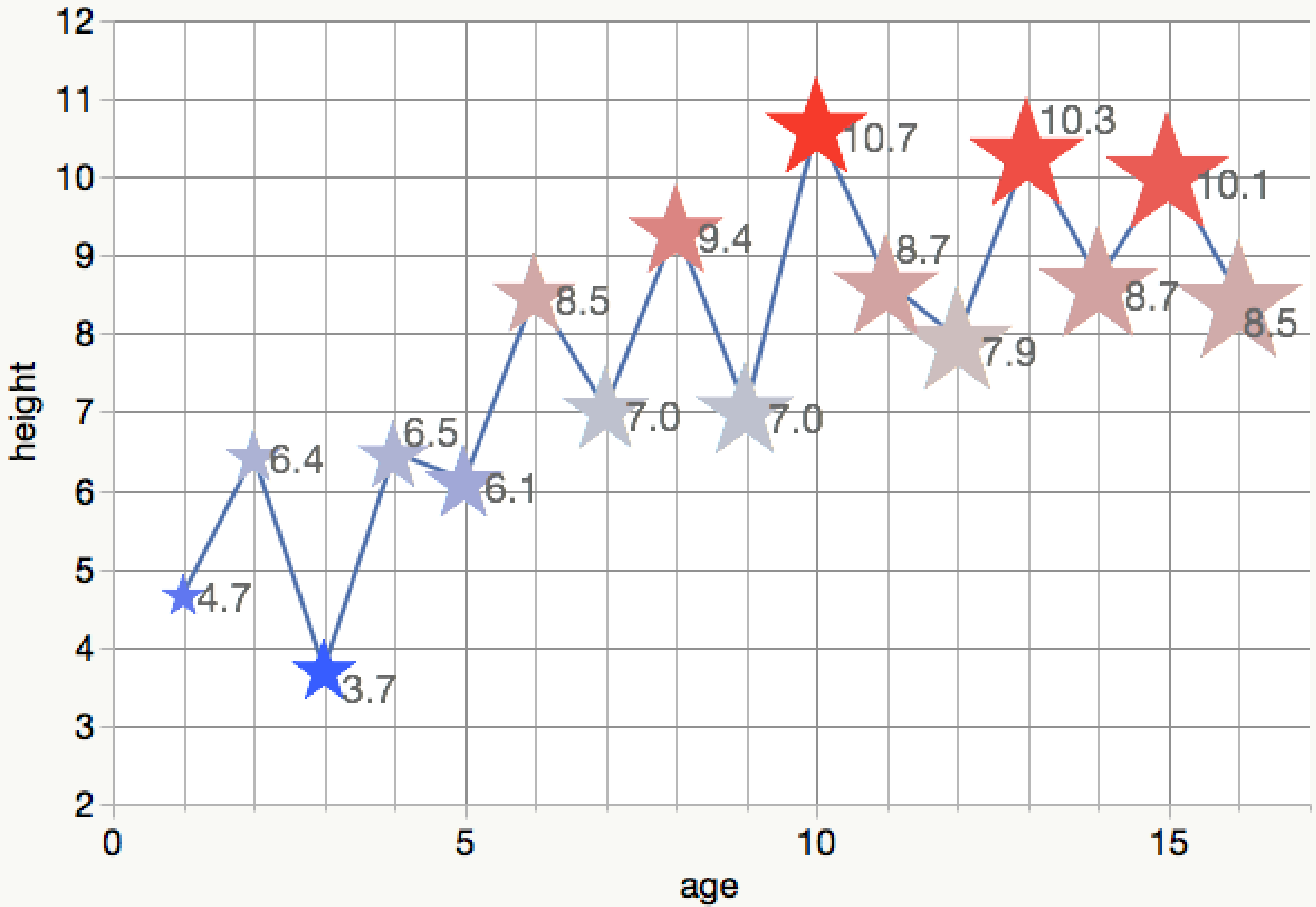
Since all models are wrong the scientist cannot obtain a "correct" one by excessive elaboration. … overelaboration and overparameterization is often the mark of mediocrity.

George E. P. Box (1976)

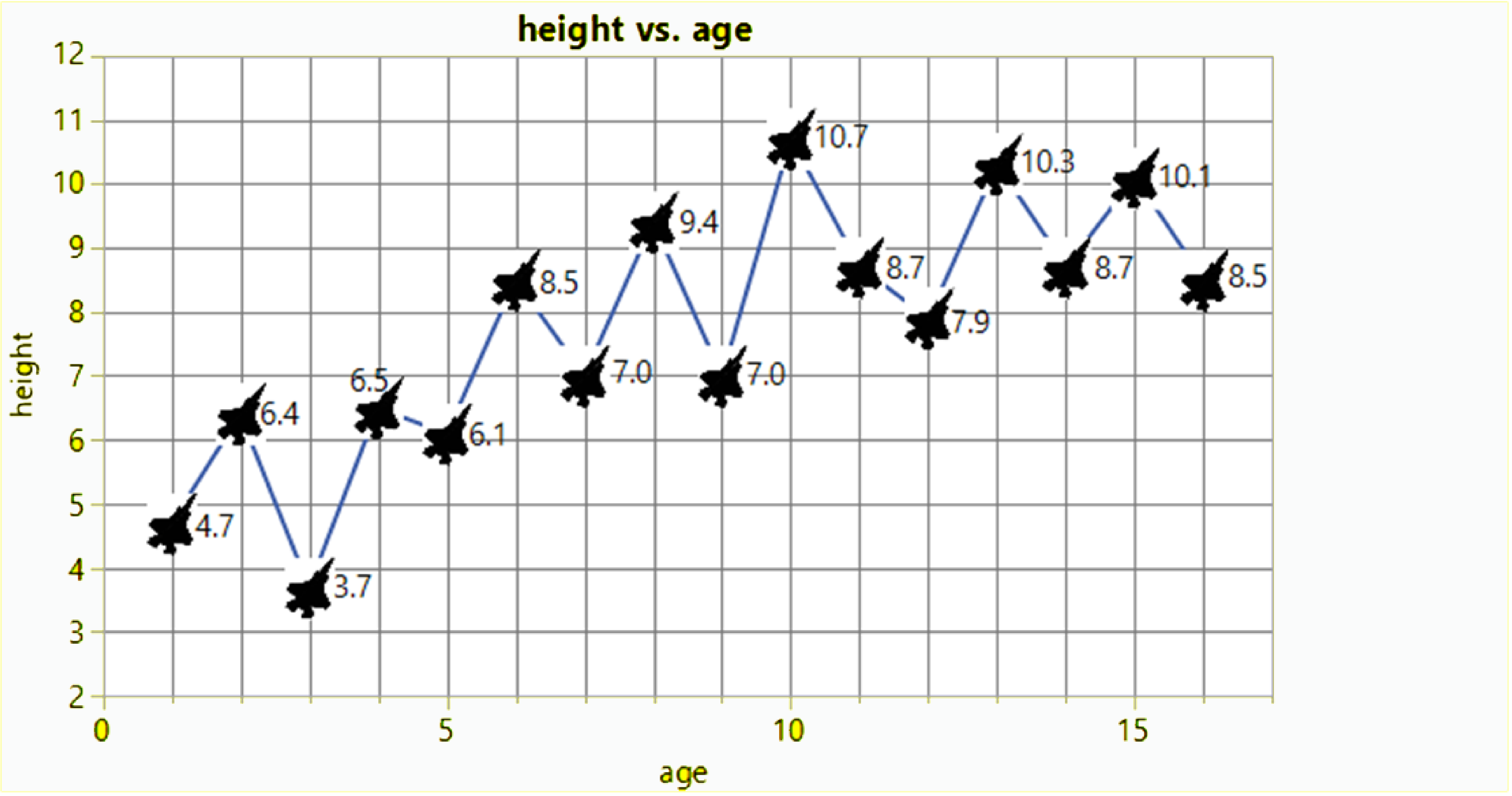
Overelaboration in Modeling



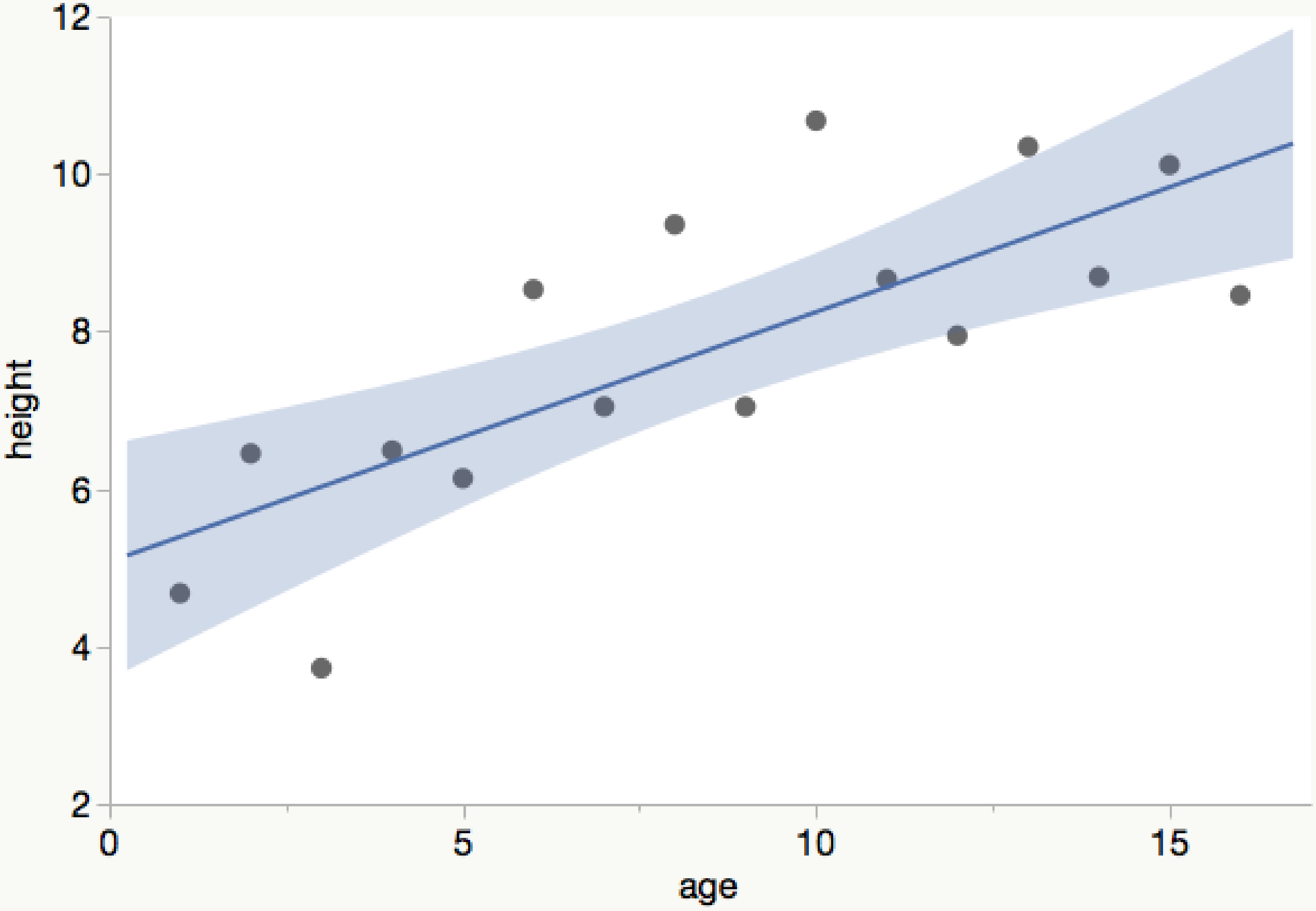
Overelaboration in Graphing



Overelaboration in Graphing



Information rather than Data



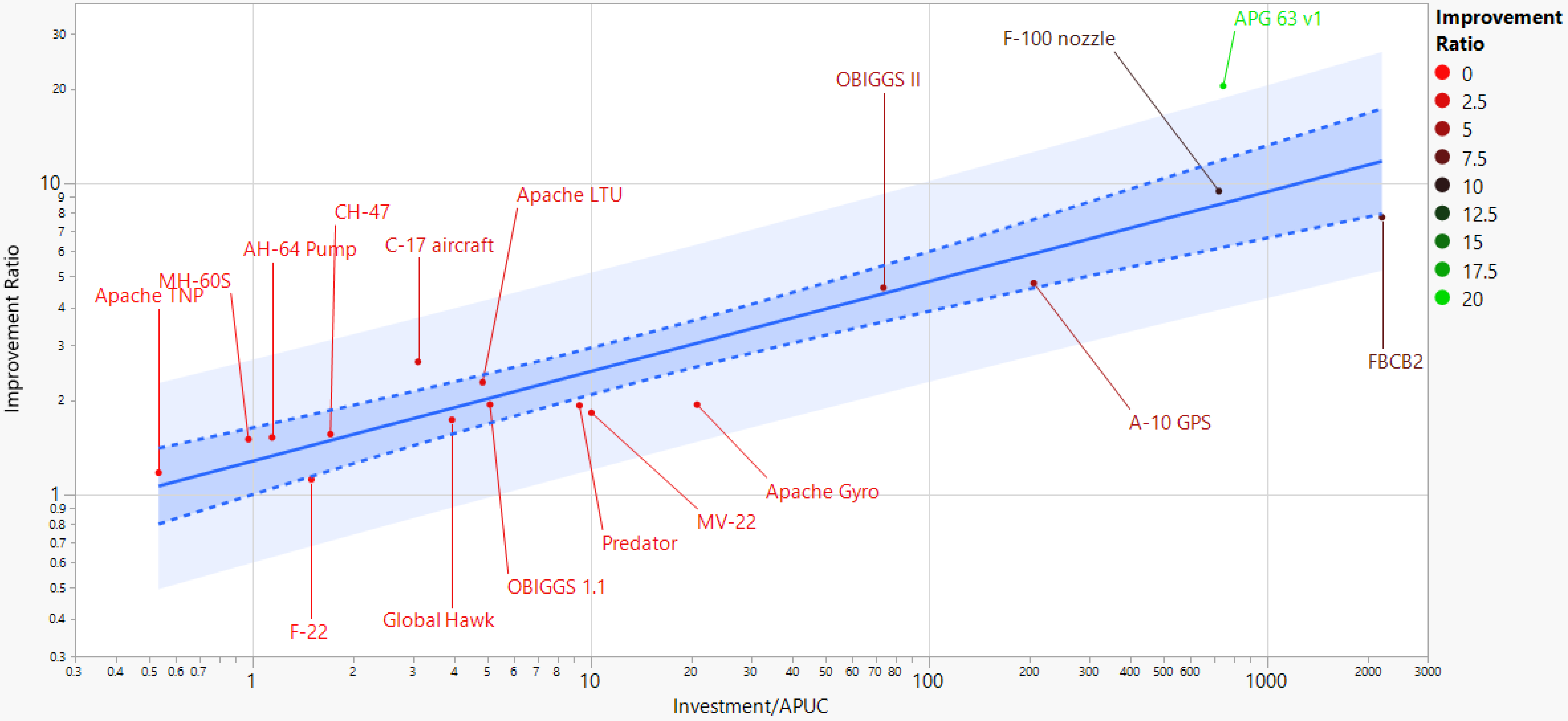
Admiral James “Sandy” Winnefeld Jr.

Vice Chairman of the Joint Chiefs of Staff (2011-2015)

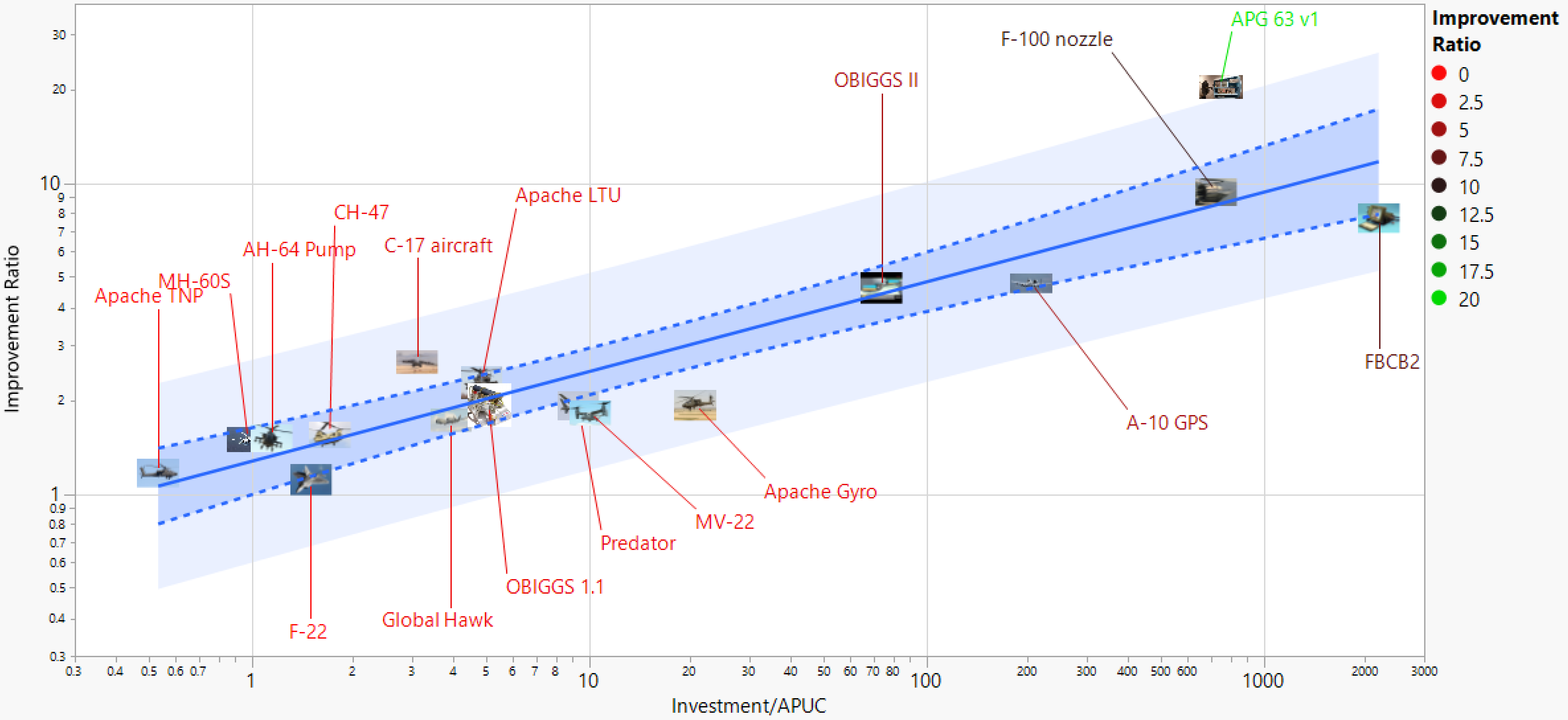
May 2011, MORS MDA Workshop, Point Loma, CA

Admiral James "Sandy" Winnefeld Jr.
Vice Chairman of the Joint Chiefs of Staff (2011-2015)
May 2011, MORS MDA Workshop, Point Loma, CA

"I've got data.
What I need is information.
More than that I need knowledge.
And, more than that I need understanding.
So, I can take action."



Improvement Ratio
0
2.5
5
7.5
10
12.5
15
17.5
20
APG 63 v1
F-100 nozzle
OBIGGS II
Apache LTU
CH-47
C-17 aircraft
AH-64 Pump
MH-60S
Apache TNP
FBCB2
A-10 GPS
Apache Gyro
MV-22
Predator
OBIGGS 1.1
Global Hawk
F-22
Improvement Ratio
Investment/APUC


Improvement Ratio
Investment/APUC
APG 63 v1
F-100 nozzle
OBIGGS II
FBCB2
A-10 GPS
Apache Gyro
MV-22
Predator
OBIGGS 1.1
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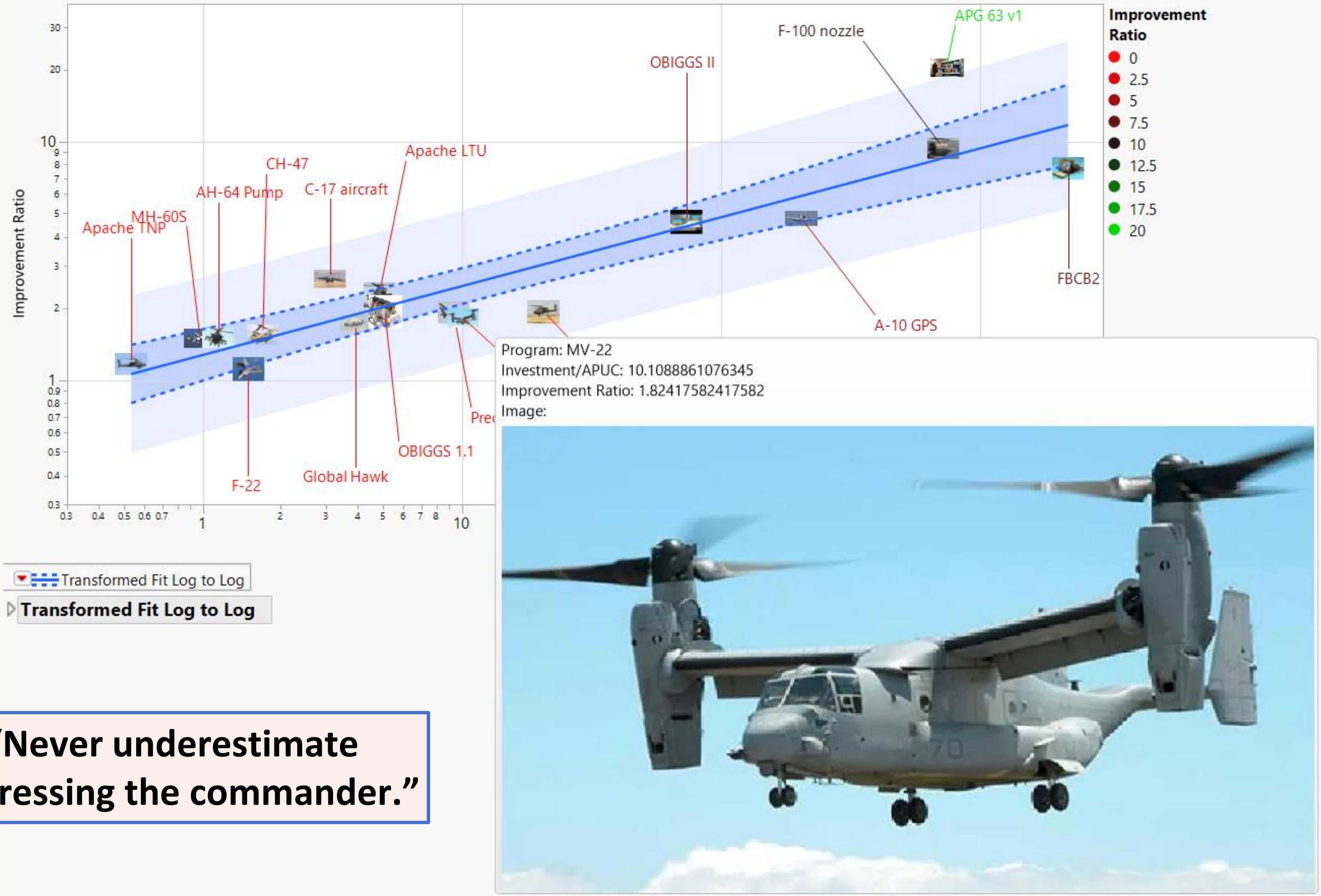
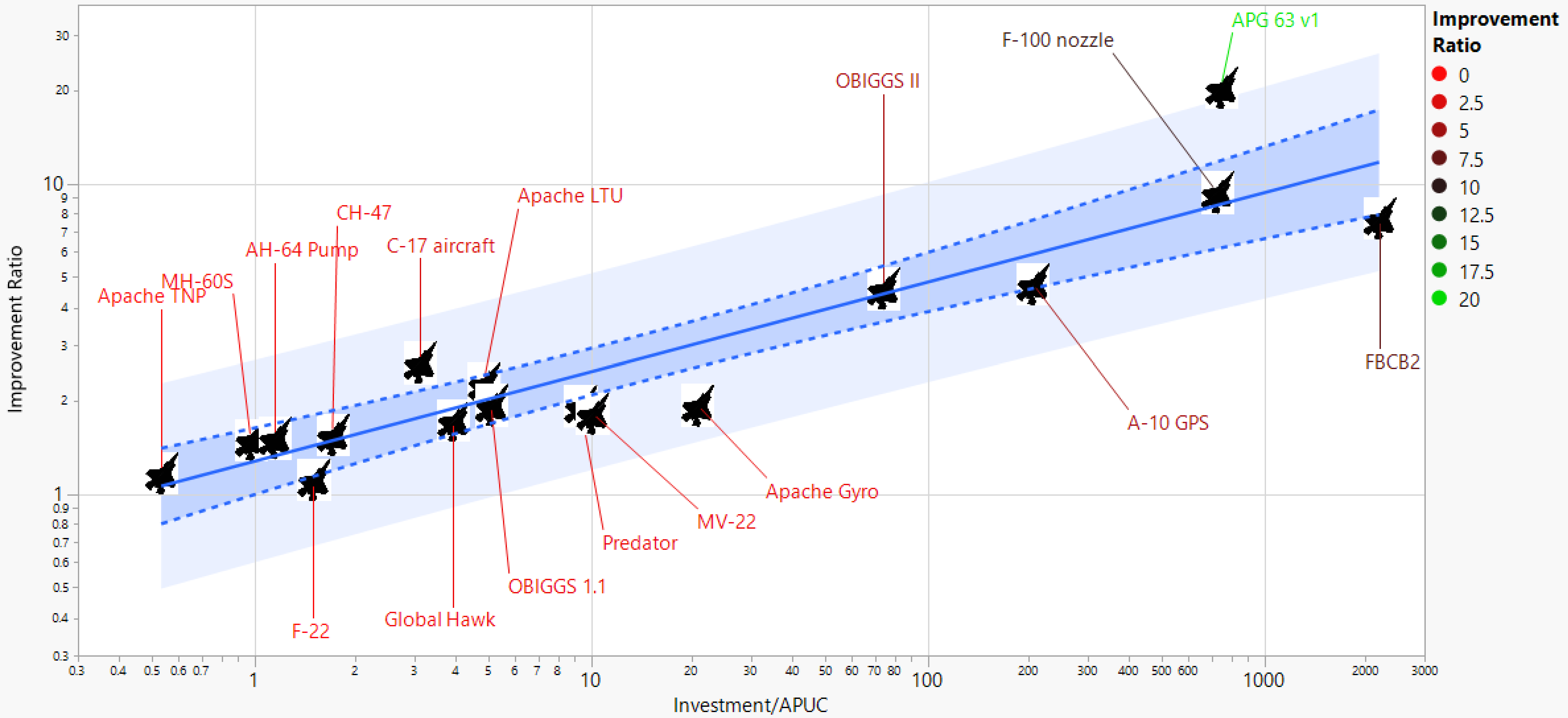
CH-47
AH-64 Pump
MH-60S
Apache TNP
Improvement Ratio
0
2.5
5
7.5
10
12.5
15
17.5
20



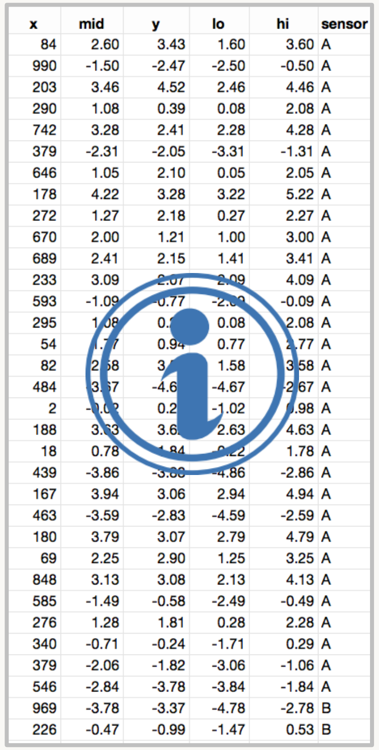
"Never underestimate impressing the commander."



"Never underestimate impressing the commander."

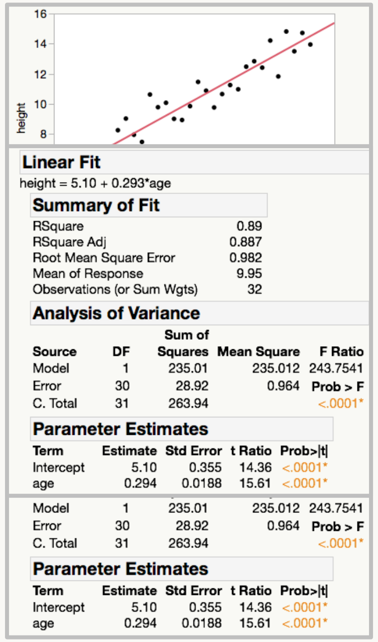
Statistical Discovery

Collect



x	mid	y	lo	hi	sensor
84	2.60	3.43	1.60	3.60	A
990	-1.50	-2.47	-2.50	-0.50	A
203	3.46	4.52	2.46	4.46	A
290	1.08	0.39	0.08	2.08	A
742	3.28	2.41	2.28	4.28	A
379	-2.31	-2.05	-3.31	-1.31	A
646	1.05	2.10	0.05	2.05	A
178	4.22	3.28	3.22	5.22	A
272	1.27	2.18	0.27	2.27	A
670	2.00	1.21	1.00	3.00	A
689	2.41	2.15	1.41	3.41	A
233	3.09	2.07	2.09	4.09	A
593	-1.09	-0.77	[illegible]	-0.09	A
295	[illegible]	[illegible]	0.08	2.08	A
54	[illegible]	0.94	0.77	[illegible]	A
82	[illegible]	[illegible]	1.58	[illegible]	A
484	[illegible]	[illegible]	-4.67	[illegible]	A
2	[illegible]	[illegible]	-1.02	[illegible]	A
188	[illegible]	[illegible]	2.63	4.63	A
18	0.78	[illegible]	[illegible]	1.78	A
439	-3.86	[illegible]	-4.86	-2.86	A
167	3.94	3.06	2.94	4.94	A
463	-3.59	-2.83	-4.59	-2.59	A
180	3.79	3.07	2.79	4.79	A
69	2.25	2.90	1.25	3.25	A
848	3.13	3.08	2.13	4.13	A
585	-1.49	-0.58	-2.49	-0.49	A
276	1.28	1.81	0.28	2.28	A
340	-0.71	-0.24	-1.71	0.29	A
379	-2.06	-1.82	-3.06	-1.06	A
546	-2.84	-3.78	-3.84	-1.84	A
969	-3.78	-3.37	-4.78	-2.78	B
226	-0.47	-0.99	-1.47	0.53	B

Analyze



Linear Fit

height = 5.10 + 0.293*age

Summary of Fit

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RSquare Adj	0.887
Root Mean Square Error	0.982
Mean of Response	9.95
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Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	235.01	235.012	243.7541
Error	30	28.92	0.964	Prob > F
C. Total	31	263.94		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	5.10	0.355	14.36	<.0001*
age	0.294	0.0188	15.61	<.0001*

Model	1	235.01	235.012	243.7541
Error	30	28.92	0.964	Prob > F
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Term	Estimate	Std Error	t Ratio	Prob>|t|
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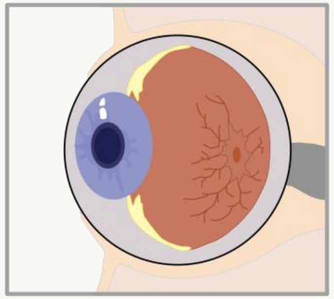
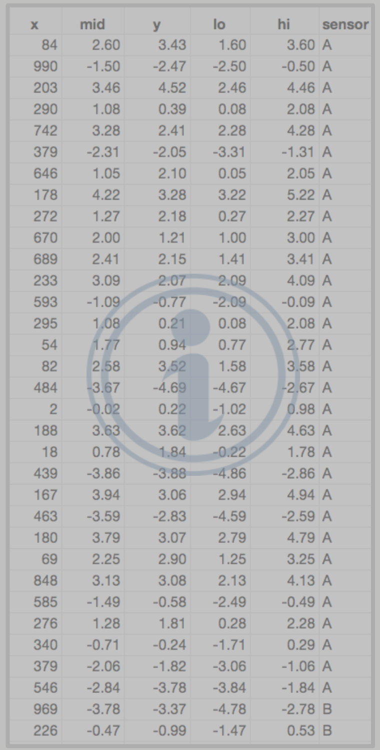
See



Understand

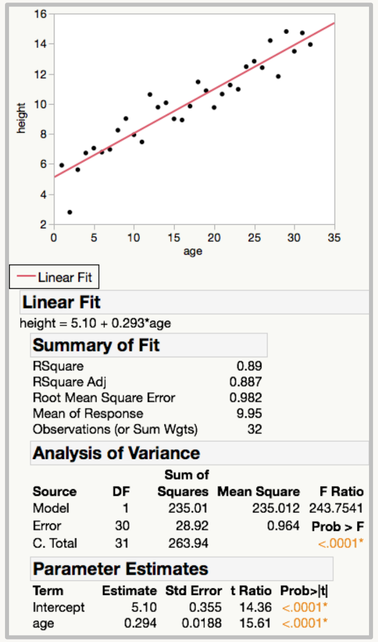
Statistical Discovery

Collect



x	mid	y	lo	hi	sensor
84	2.60	3.43	1.60	3.60	A
990	-1.50	-2.47	-2.50	-0.50	A
203	3.46	4.52	2.46	4.46	A
290	1.08	0.39	0.08	2.08	A
742	3.28	2.41	2.28	4.28	A
379	-2.31	-2.05	-3.31	-1.31	A
646	1.05	2.10	0.05	2.05	A
178	4.22	3.28	3.22	5.22	A
272	1.27	2.18	0.27	2.27	A
670	2.00	1.21	1.00	3.00	A
689	2.41	2.15	1.41	3.41	A
233	3.09	2.07	2.09	4.09	A
593	-1.09	-0.77	-2.09	-0.09	A
295	1.08	0.21	0.08	2.08	A
54	1.77	0.94	0.77	2.77	A
82	2.58	3.52	1.58	3.58	A
484	-3.67	-4.69	-4.67	-2.67	A
2	-0.02	0.22	-1.02	0.98	A
188	3.63	3.62	2.63	4.63	A
18	0.78	1.84	-0.22	1.78	A
439	-3.86	-3.88	-4.86	-2.86	A
167	3.94	3.06	2.94	4.94	A
463	-3.59	-2.83	-4.59	-2.59	A
180	3.79	3.07	2.79	4.79	A
69	2.25	2.90	1.25	3.25	A
848	3.13	3.08	2.13	4.13	A
585	-1.49	-0.58	-2.49	-0.49	A
276	1.28	1.81	0.28	2.28	A
340	-0.71	-0.24	-1.71	0.29	A
379	-2.06	-1.82	-3.06	-1.06	A
546	-2.84	-3.78	-3.84	-1.84	A
969	-3.78	-3.37	-4.78	-2.78	B
226	-0.47	-0.99	-1.47	0.53	B

Analyze



Linear Fit

height = 5.10 + 0.293*age

Summary of Fit

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Term	Estimate	Std Error	t Ratio	Prob>|t|
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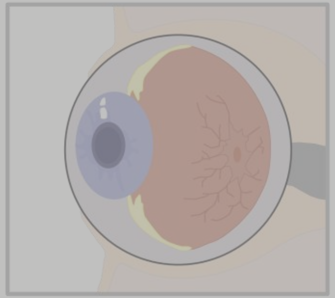
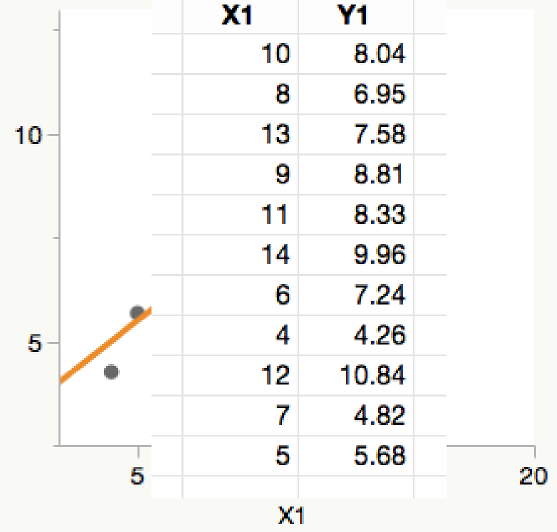
See



Understand

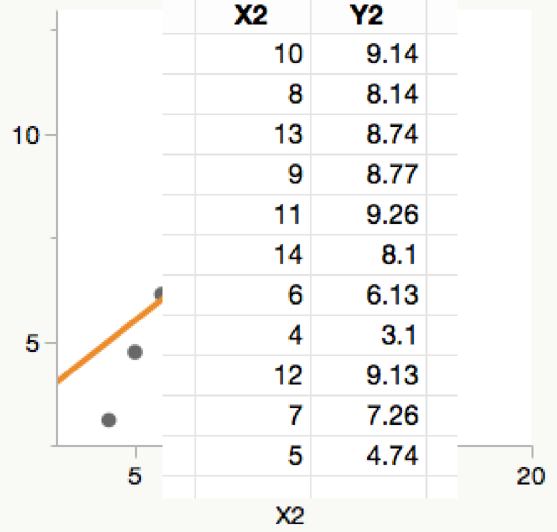
Why graph? Anscombe's Quartet



X1	Y1
10	8.04
8	6.95
13	7.58
9	8.81
11	8.33
14	9.96
6	7.24
4	4.26
12	10.84
7	4.82
5	5.68

RSquare	0.67
RSquare Adj	0.63
Root Mean Square Error	1.2
Mean of Response	7.5
Observations (or Sum Wgts)	11

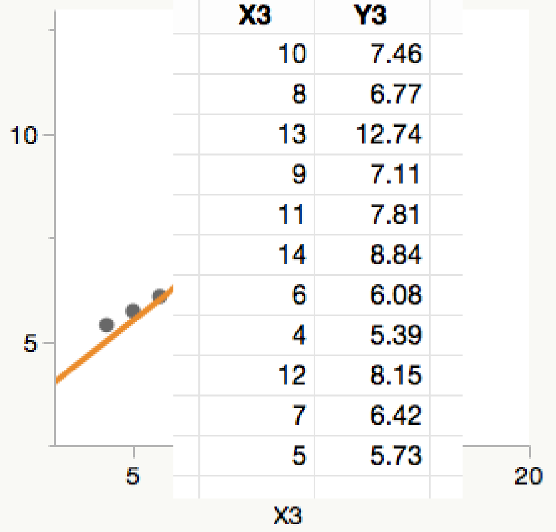
Term	Estimate	Std Error	Prob>|t|
Intercept	3.00	1.125	0.0257*
X1	0.50	0.118	0.0022*



X2	Y2
10	9.14
8	8.14
13	8.74
9	8.77
11	9.26
14	8.1
6	6.13
4	3.1
12	9.13
7	7.26
5	4.74

RSquare	0.67
RSquare Adj	0.63
Root Mean Square Error	1.2
Mean of Response	7.5
Observations (or Sum Wgts)	11

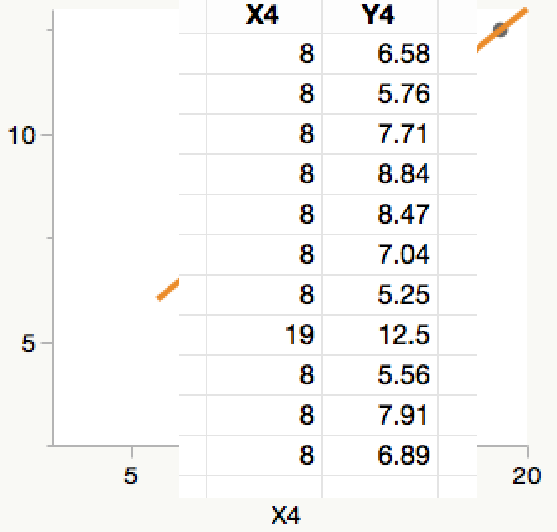
Term	Estimate	Std Error	Prob>|t|
Intercept	3.00	1.125	0.0258*
X2	0.50	0.118	0.0022*



X3	Y3
10	7.46
8	6.77
13	12.74
9	7.11
11	7.81
14	8.84
6	6.08
4	5.39
12	8.15
7	6.42
5	5.73

RSquare	0.67
RSquare Adj	0.63
Root Mean Square Error	1.2
Mean of Response	7.5
Observations (or Sum Wgts)	11

Term	Estimate	Std Error	Prob>|t|
Intercept	3.00	1.124	0.0256*
X3	0.50	0.118	0.0022*



X4	Y4
8	6.58
8	5.76
8	7.71
8	8.84
8	8.47
8	7.04
8	5.25
19	12.5
8	5.56
8	7.91
8	6.89

RSquare	0.67
RSquare Adj	0.63
Root Mean Square Error	1.2
Mean of Response	7.5
Observations (or Sum Wgts)	11

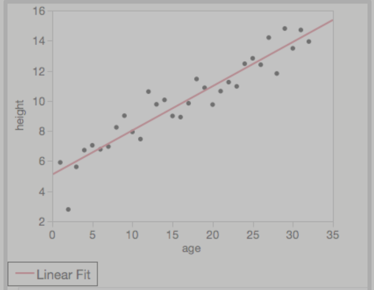
Term	Estimate	Std Error	Prob>|t|
Intercept	3.00	1.124	0.0256*
X4	0.50	0.118	0.0022*

Statistical Discovery

Collect

x	mid	y	lo	hi	sensor
84	2.60	3.43	1.60	3.60	A
990	-1.50	-2.47	-2.50	-0.50	A
203	3.46	4.52	2.46	4.46	A
290	1.08	0.39	0.08	2.08	A
742	3.28	2.41	2.28	4.28	A
379	-2.31	-2.05	-3.31	-1.31	A
646	1.05	2.10	0.05	2.05	A
178	4.22	3.28	3.22	5.22	A
272	1.27	2.18	0.27	2.27	A
670	2.00	1.21	1.00	3.00	A
689	2.41	2.15	1.41	3.41	A
233	3.09	2.07	2.09	4.09	A
593	-1.09	-0.77	-2.09	-0.09	A
295	1.08	0.21	0.08	2.08	A
54	1.77	0.94	0.77	2.77	A
82	2.58	3.52	1.58	3.58	A
484	-3.67	-4.69	-4.67	-2.67	A
2	-0.02	0.22	-1.02	0.98	A
188	3.63	3.62	2.63	4.63	A
18	0.78	1.84	-0.22	1.78	A
439	-3.86	-3.88	-4.86	-2.86	A
167	3.94	3.06	2.94	4.94	A
463	-3.59	-2.83	-4.59	-2.59	A
180	3.79	3.07	2.79	4.79	A
69	2.25	2.90	1.25	3.25	A
848	3.13	3.08	2.13	4.13	A
585	-1.49	-0.58	-2.49	-0.49	A
276	1.28	1.81	0.28	2.28	A
340	-0.71	-0.24	-1.71	0.29	A
379	-2.06	-1.82	-3.06	-1.06	A
546	-2.84	-3.78	-3.84	-1.84	A
969	-3.78	-3.37	-4.78	-2.78	B
226	-0.47	-0.99	-1.47	0.53	B

Analyze



Linear Fit

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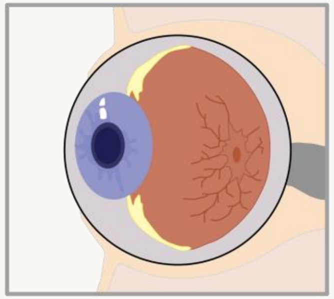
age	0.294	0.0188	15.61	<.0001*

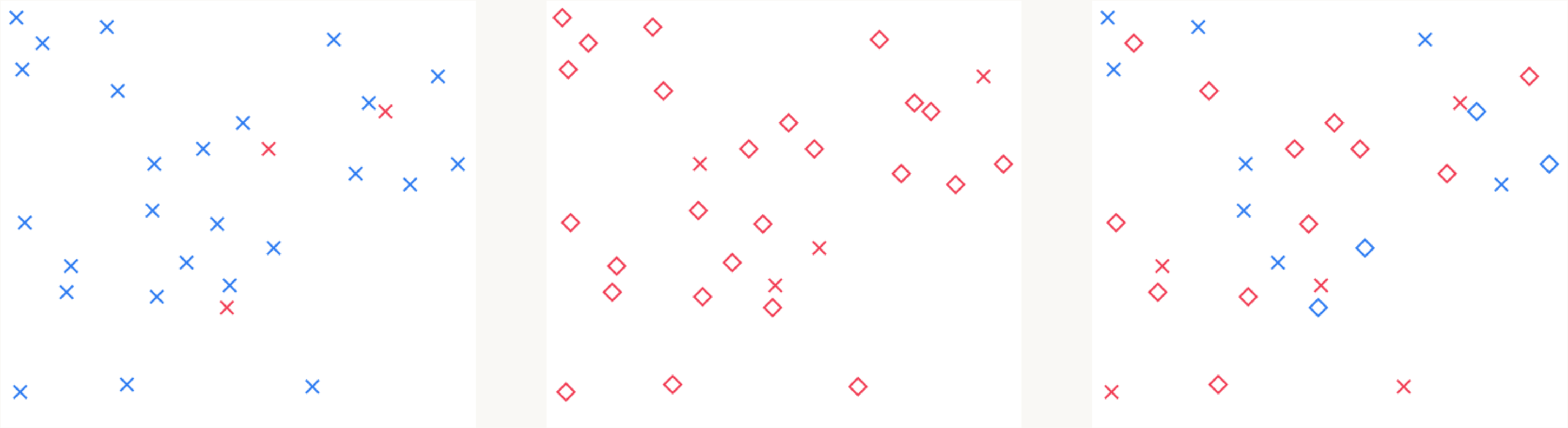
See



Understand

Pre-attentive Processing

Pre-attentive Processing



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290	1.08	0.39	0.08	2.08	A
742	3.28	2.41	2.28	4.28	A
379	-2.31	-2.05	-3.31	-1.31	A
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593	-1.09	-0.77	-2.09	-0.09	A
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484	-3.67	-4.69	-4.67	-2.67	A
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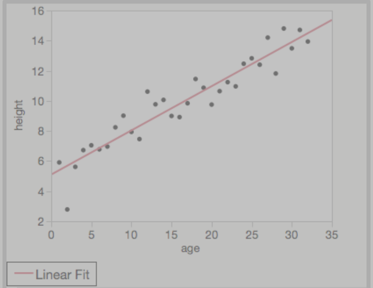
463	-3.59	-2.83	-4.59	-2.59	A
180	3.79	3.07	2.79	4.79	A
69	2.25	2.90	1.25	3.25	A
848	3.13	3.08	2.13	4.13	A
585	-1.49	-0.58	-2.49	-0.49	A
276	1.28	1.81	0.28	2.28	A
340	-0.71	-0.24	-1.71	0.29	A
379	-2.06	-1.82	-3.06	-1.06	A
546	-2.84	-3.78	-3.84	-1.84	A
969	-3.78	-3.37	-4.78	-2.78	B
226	-0.47	-0.99	-1.47	0.53	B

Analyze



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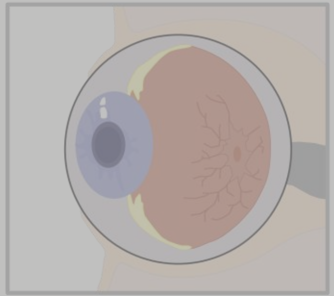
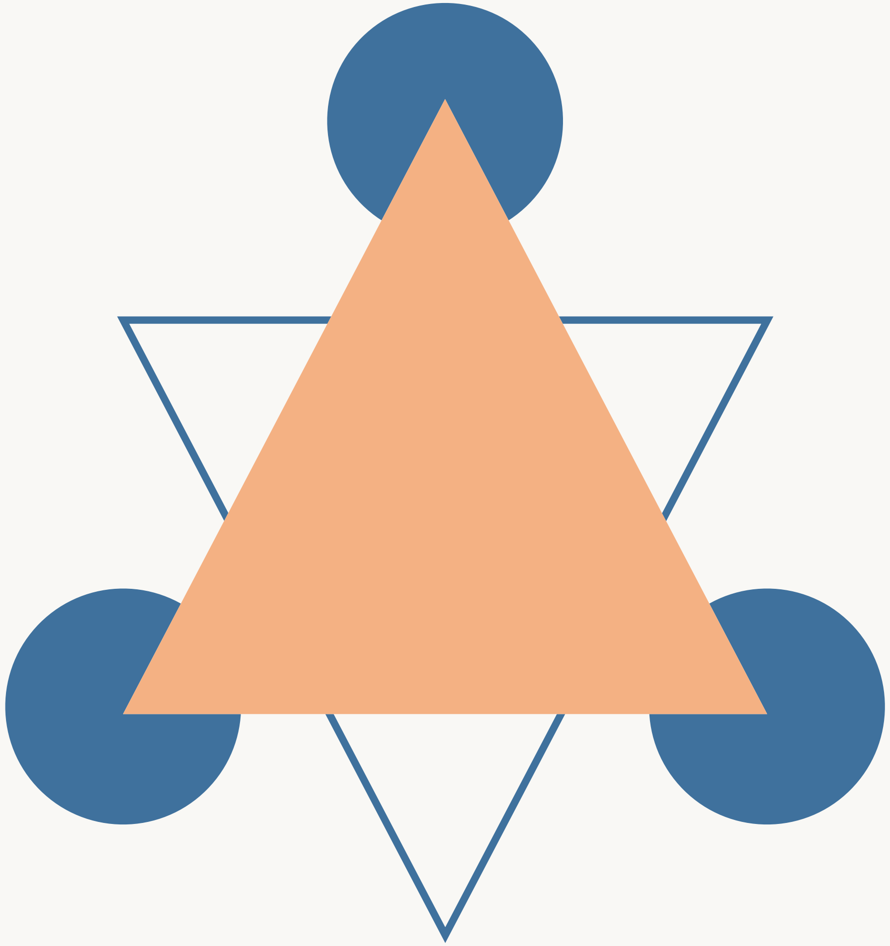
See

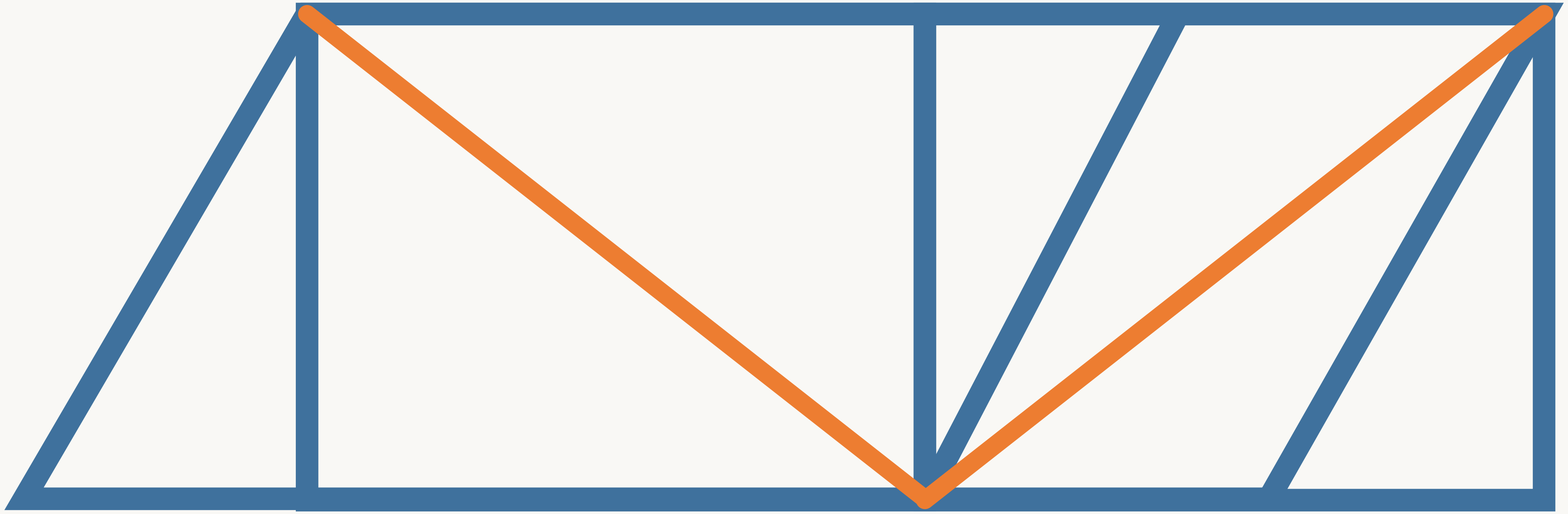


Understand

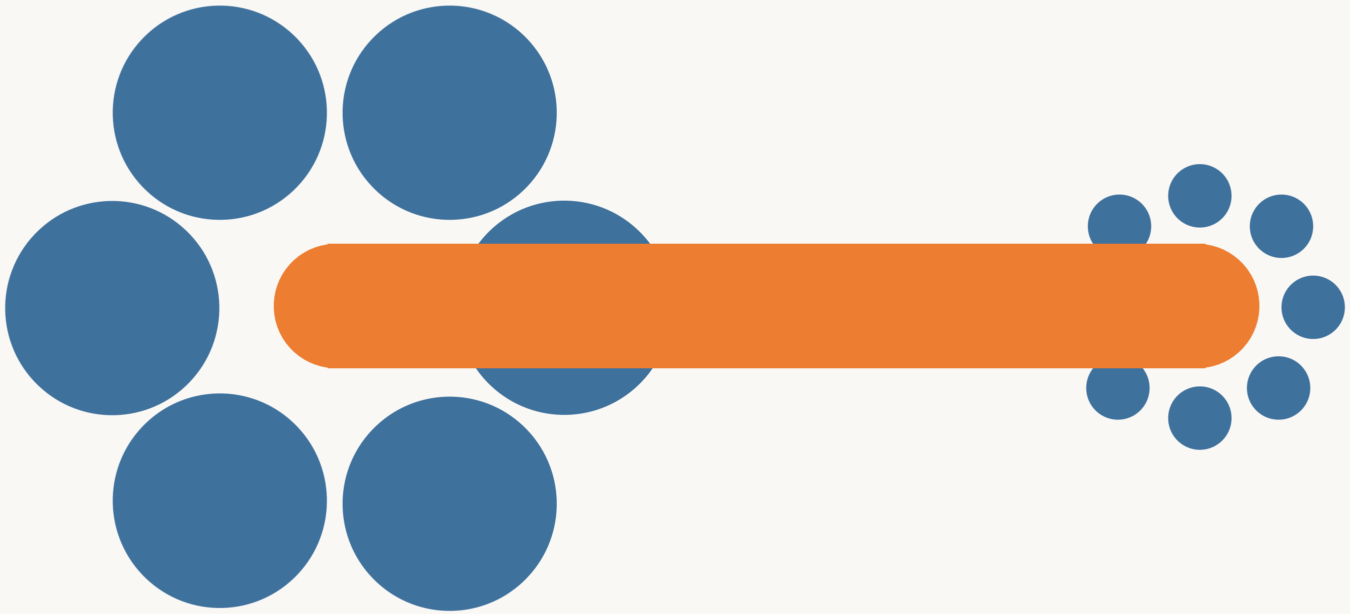
Kanizsa Triangle



Sander’s Parallelogram

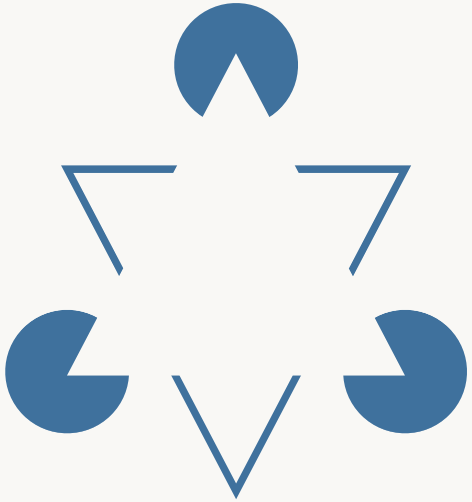


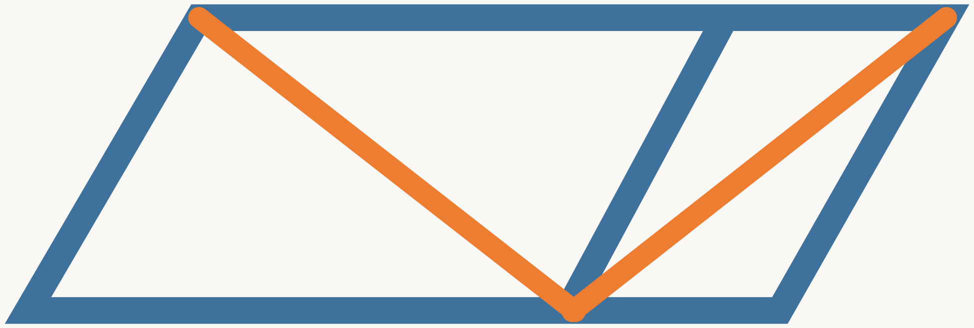
Ebbinghaus Illusion

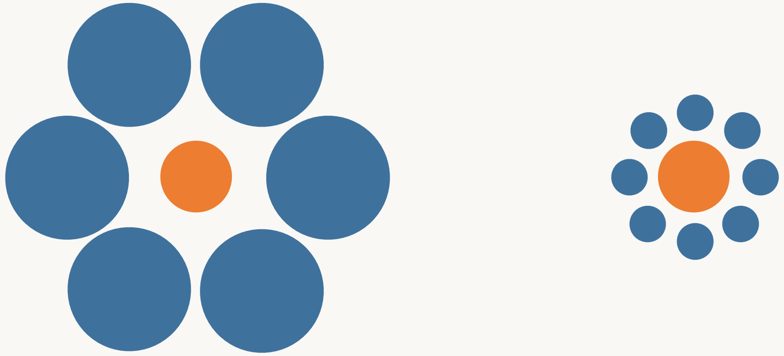


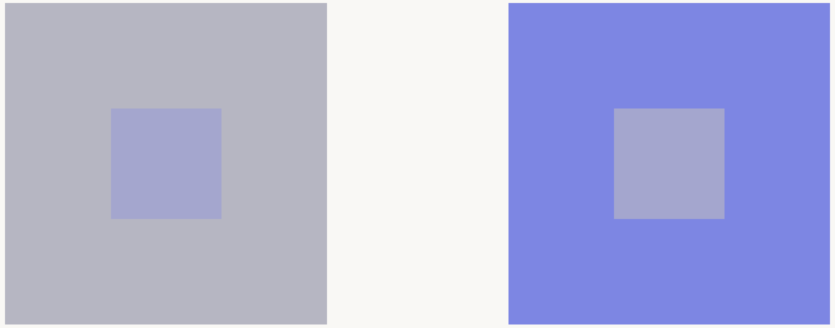
Chubb Illusion

Features, not Flaws

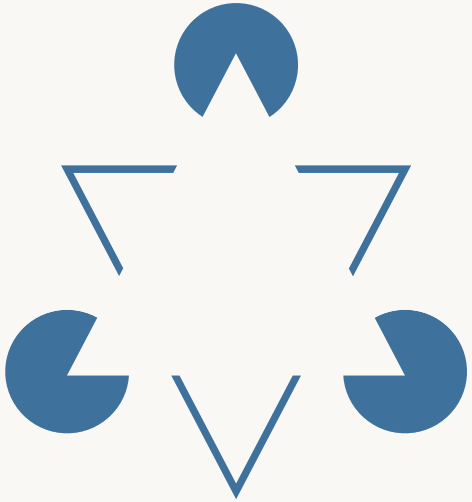


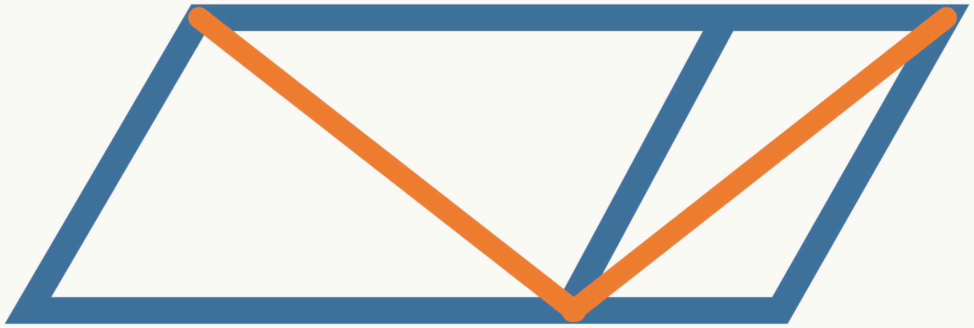


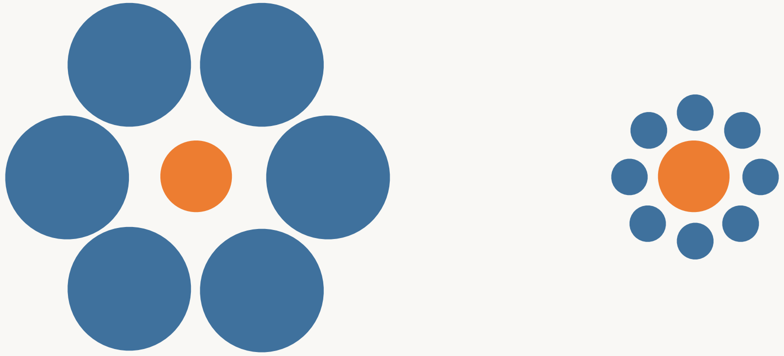


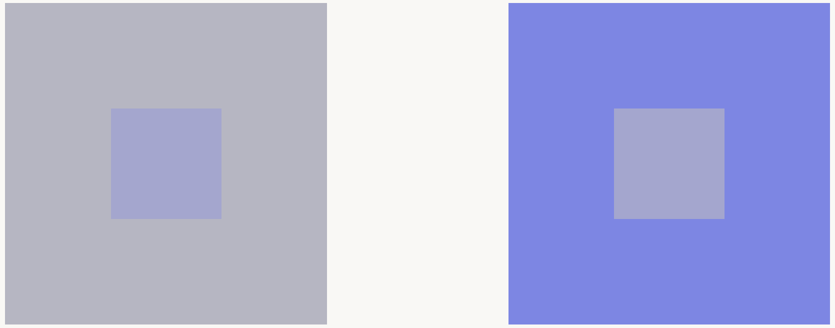


Resistance to Alternative Denotation

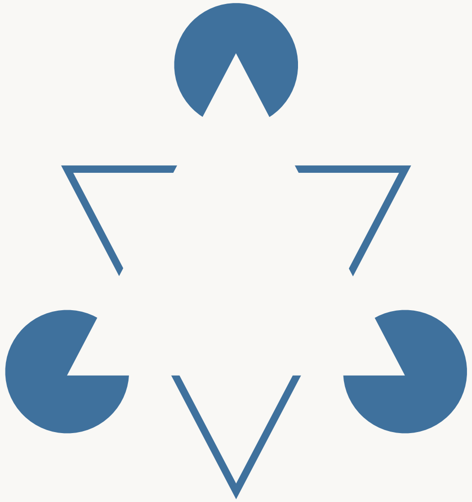




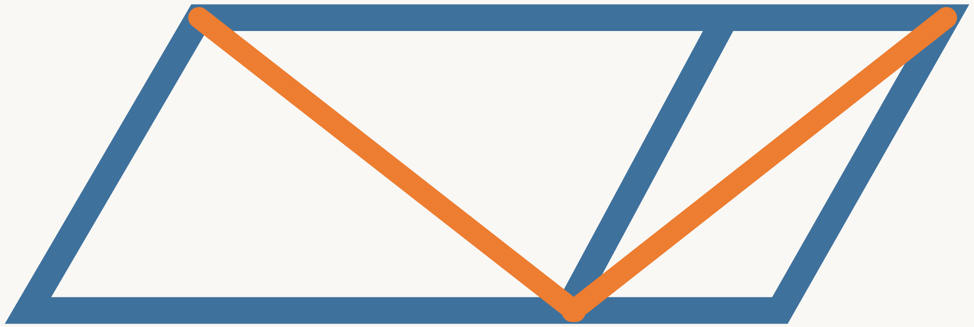




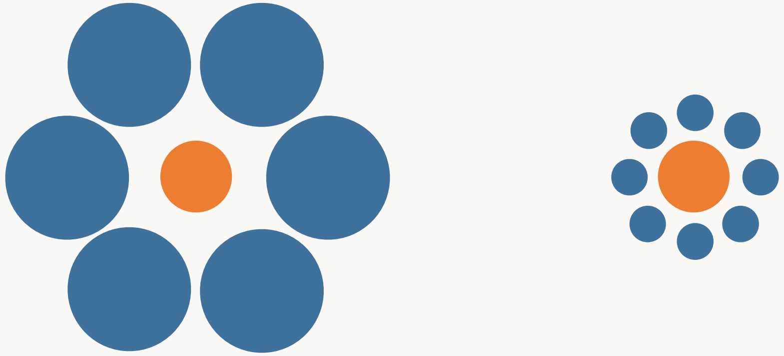
Shape



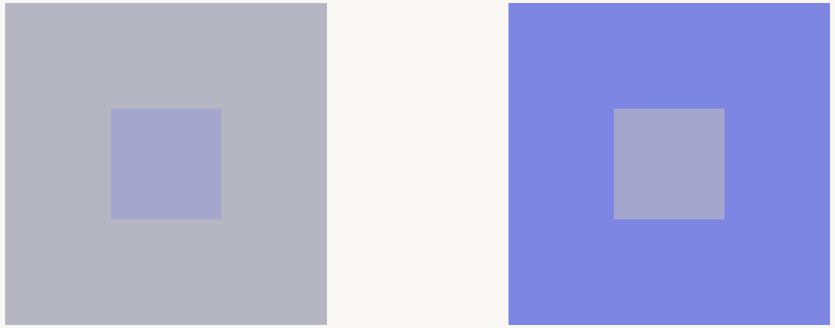
Length



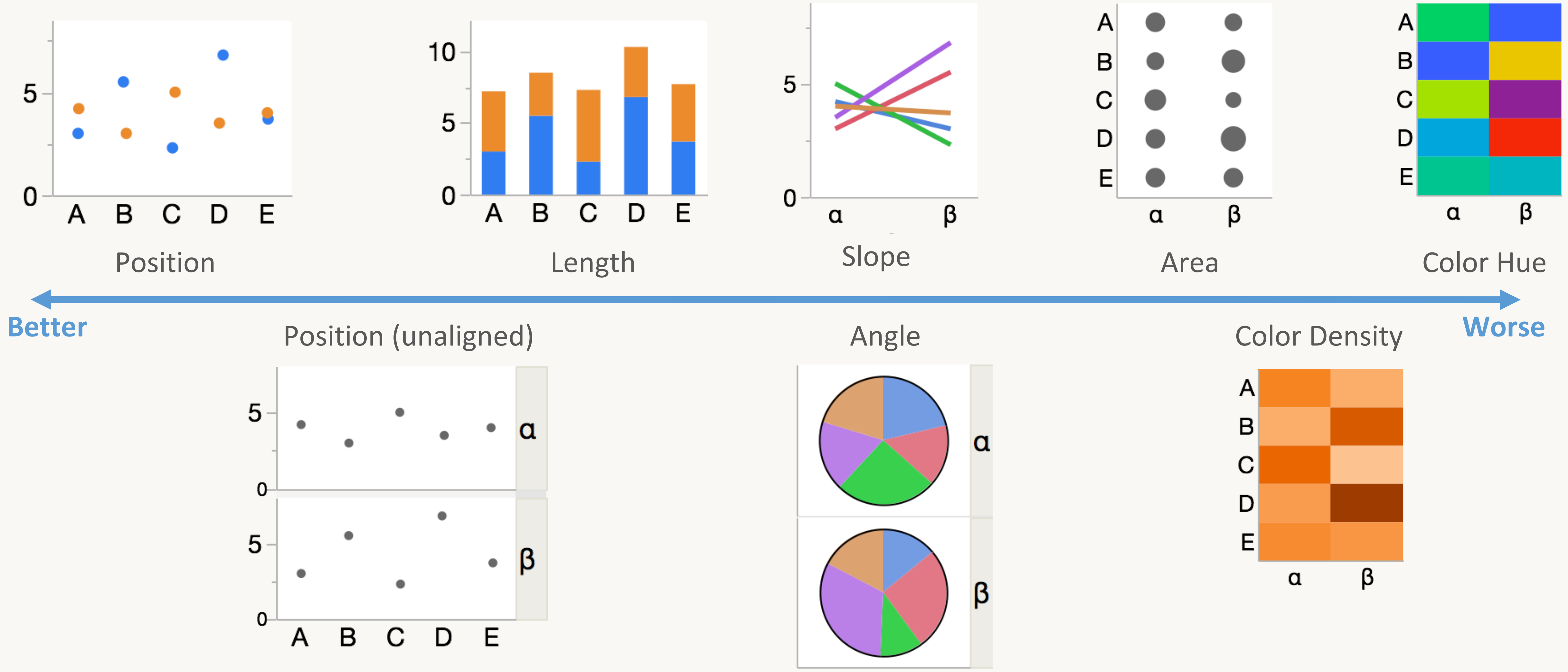
Size



Color



Graphic Attributes: Quantitative Scales



Based on “Graphical Perception: Theory, Experimentation, and Application …” by William Cleveland and Robert McGill, JASA, Sept. 1984

Putting Theory Into Practice

- Information vs. Data
- Distance perception
- Color perception

- Graph the information
- Use (don’t abuse) pre-attentive processing
- Choose appropriate color scales
- Less is more

All Graphs Are Wrong, but *Yours* Can Be Useful

JMP Defense & Aerospace Team

… AND HOW TO CONTACT US

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