Data Visualization

CSE 120, Winter 2020

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Lasers etch a 'perfect' solar energy absorber

"In a paper in *Light: Science & Applications*, the lab of Chunley Guo, professor of optics also affiliated with the Department of Physics and Astronomy and the Material Sciences Program, describes using powerful femto-second laser pulses to etch metal surfaces with nanoscale structures that selectively absorb light only at the solar wavelengths, but not elsewhere…

"This surface not only enhances the energy absorption from sunlight, but also reduces heat dissipation at other wavelengths, in effect, 'making a perfect metallic solar absorber for the first time,' Guo says. 'We also demonstrate solar energy harnessing with a thermal electric generator device.'"

From University of Rochester

Thanks to Jeff Heer (CSE 442) and Hunter Schafer (CSE 163) for material

What is data visualization?

- "… finding the artificial memory that best supports our natural means of perception" [Bertin 1967]

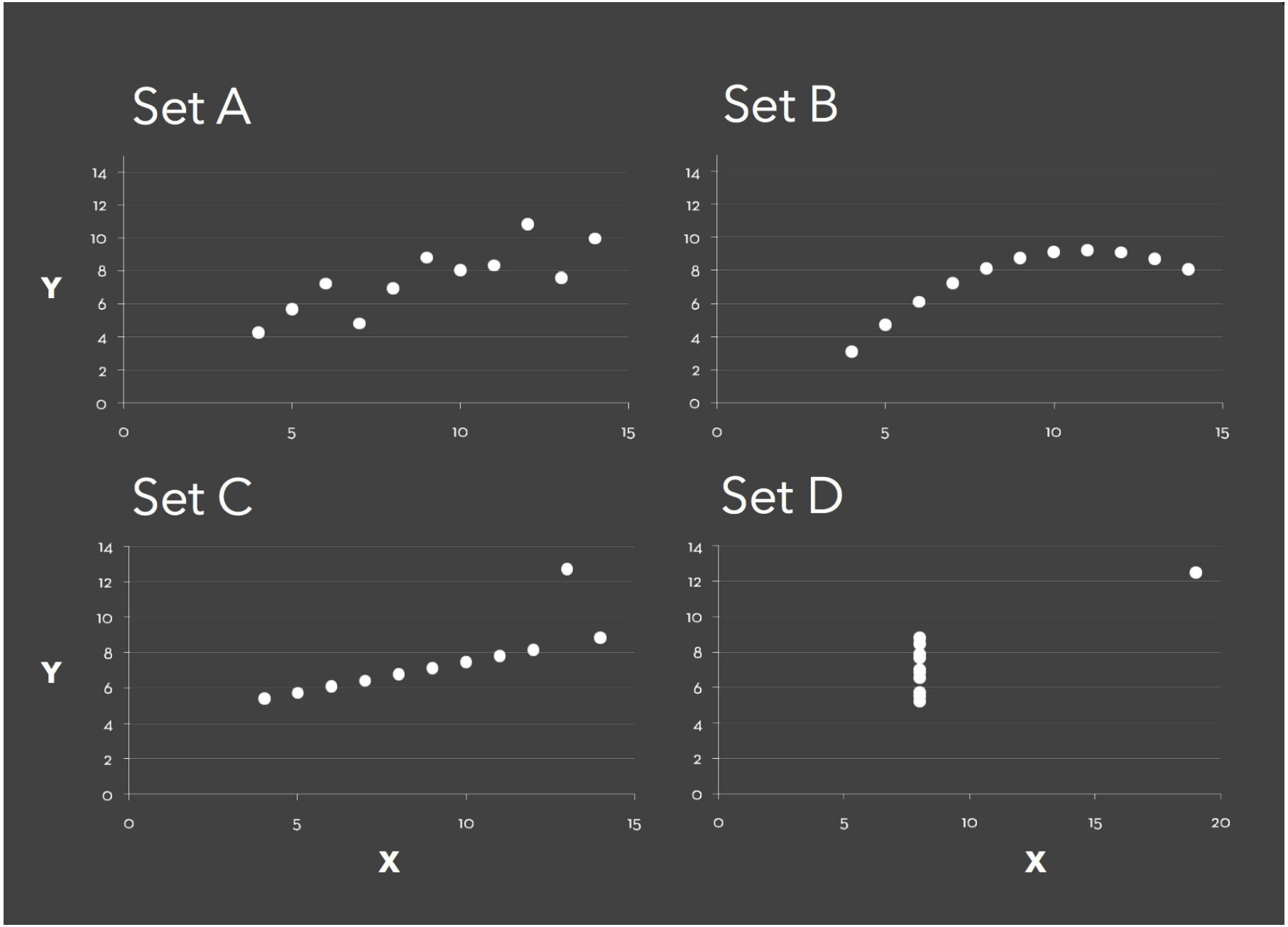
- "The use of computer-generated, interactive, visual representations of data to amplify cognition" [Card, Mackinlay, & Schneiderman 1999]

Set A		Set B		Set C		Set D	
X	Y	X	Y	X	Y	X	Y
10	8.04	10	9.14	10	7.46	8	6.58
8	6.95	8	8.14	8	6.77	8	5.76
13	7.58	13	8.74	13	12.74	8	7.71
9	8.81	9	8.77	9	7.11	8	8.84
11	8.33	11	9.26	11	7.81	8	8.47
14	9.96	14	8.1	14	8.84	8	7.04
6	7.24	6	6.13	6	6.08	8	5.25
4	4.26	4	3.1	4	5.39	19	12.5
12	10.84	12	9.11	12	8.15	8	5.56
7	4.82	7	7.26	7	6.42	8	7.91
5	5.68	5	4.74	5	5.73	8	6.89

Mean X: 9.0, Standard dev X: 3.317
Mean Y: 7.5, Standard dev Y: 2.03

Linear Regression:
$Y = 3 + 0.5X$

[Anscombe 1973]


Set A
Y
14
12
10
8
6
4
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0
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Set B
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Set C
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X
Set D
14
12
10
8
6
4
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10
15
20
X

Why make data visualizations?

- Find patterns
- Answer questions and spur new ones
- Support memory
- Make a decision
- Present an argument
- Engage & inspire your audience

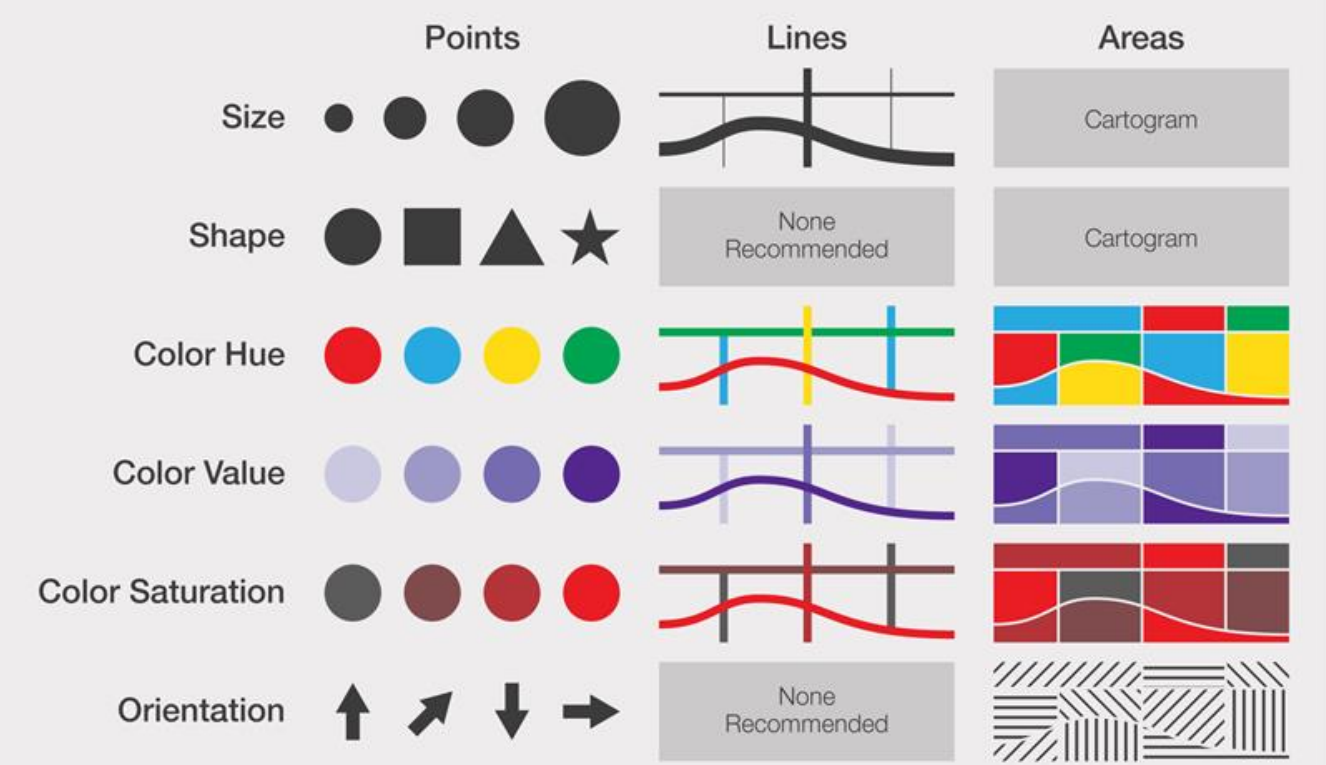
Why study data visualizations?

- The world is creating TONS of data
  - > 90% of data in the world was created in the last two years(!!!!)
  - 2.5 quintillion (2,500,000,000,000,000,000) bytes of data are created every day
- Relevant for every discipline
- Become informed consumers
- They're super cool & fun to make!

Data Types

- Nominal
  - Labels or categories
  - Fruits: apples, oranges, kiwi, …
- Ordinal
  - Ordered
  - Apples: US Utility, US No 1, US Fancy, US Extra Fancy
- Quantitative
  - Quantity, amount, or range
  - Length, temperature, location (lat/long), dates

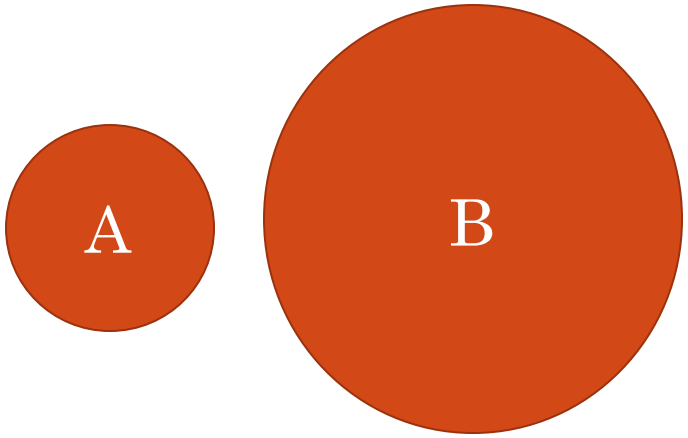
Visual Encodings



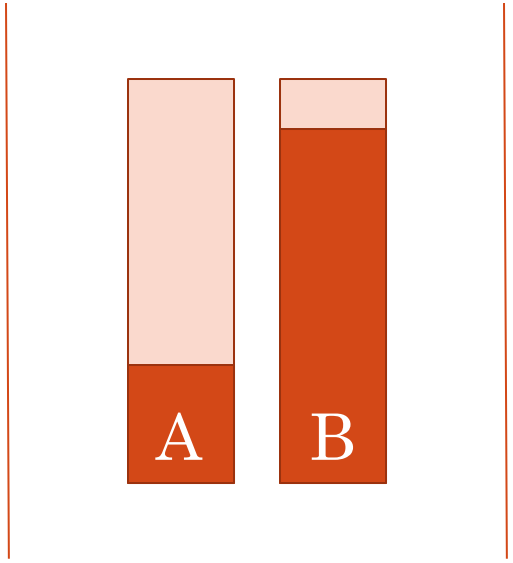
Cartograms, or value-by-area maps, distort geographic areas based on a single variable associated that area, (e.g., the size of a county is proportional to its population density).

Intuition

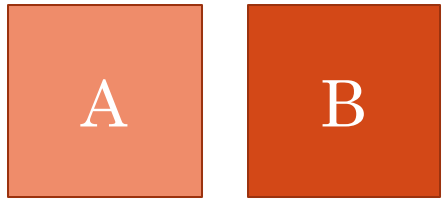
Discuss with your neighbors – How much is A compared to B?



A = 25% B



A = 33% B

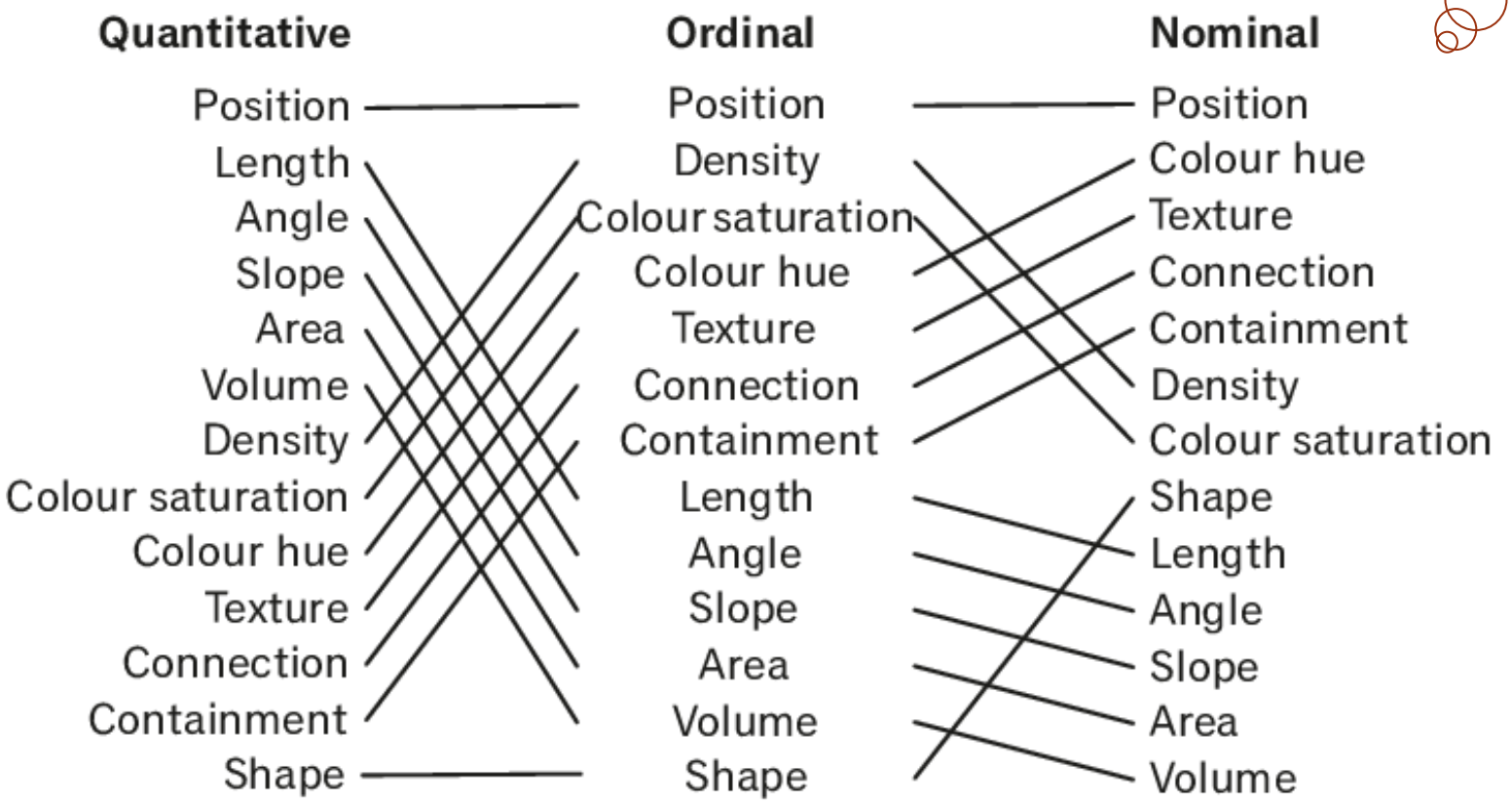


A = 60% B

Mackinlay's ranking

Conjectured effectiveness of encodings by data type.

Remember!
Quantitative = amount
Ordinal = ordered
Nominal = label

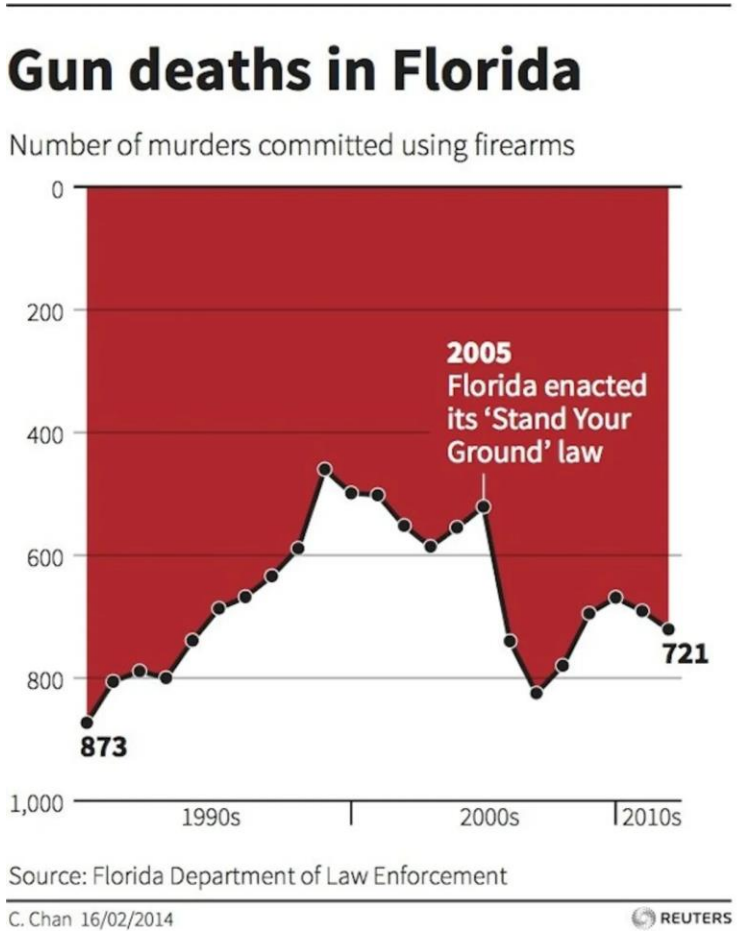


[Mackinlay 1986]

Design criteria

- Tell the whole truth & nothing but the truth
  - Consider the impact of your visualization
- Use encodings that people decode better
  - Better = faster and/or more accurately
  - Think about accessibility!
- Encode the most important information using the most effective encodings

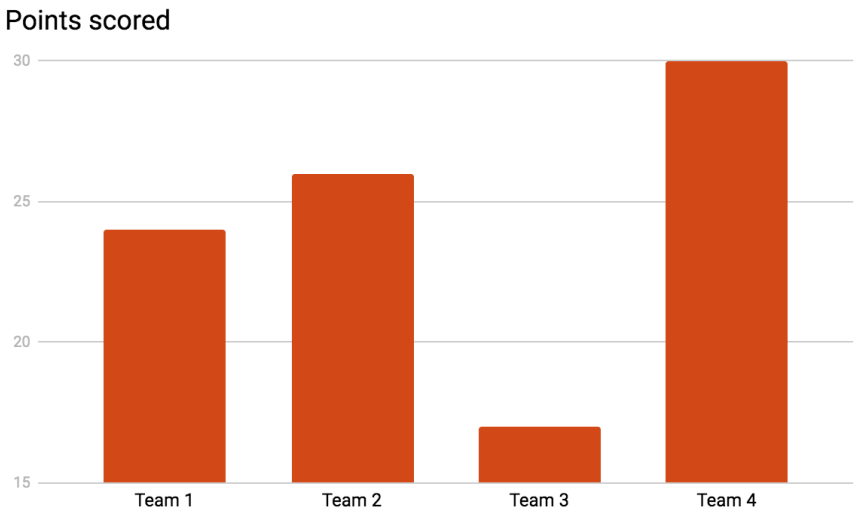
Misleading Visualization Practices

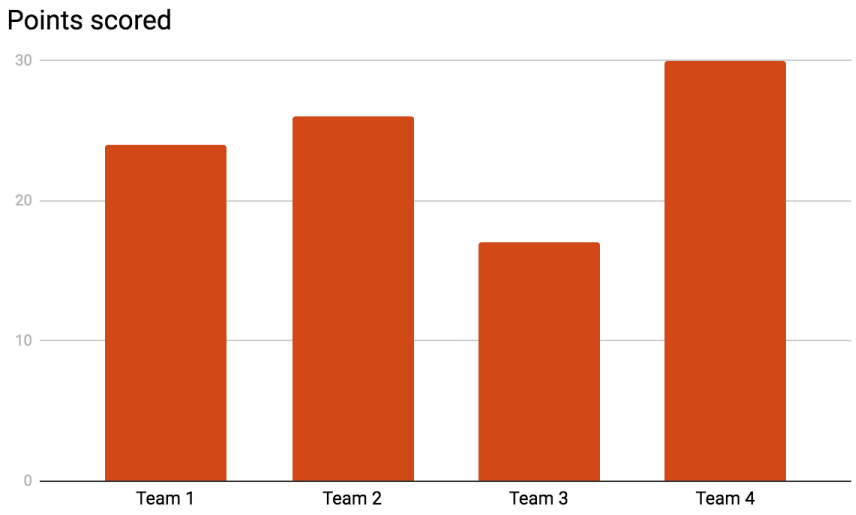


After 2005, did gun deaths in Florida increase or decrease?

Misleading Visualization Practices

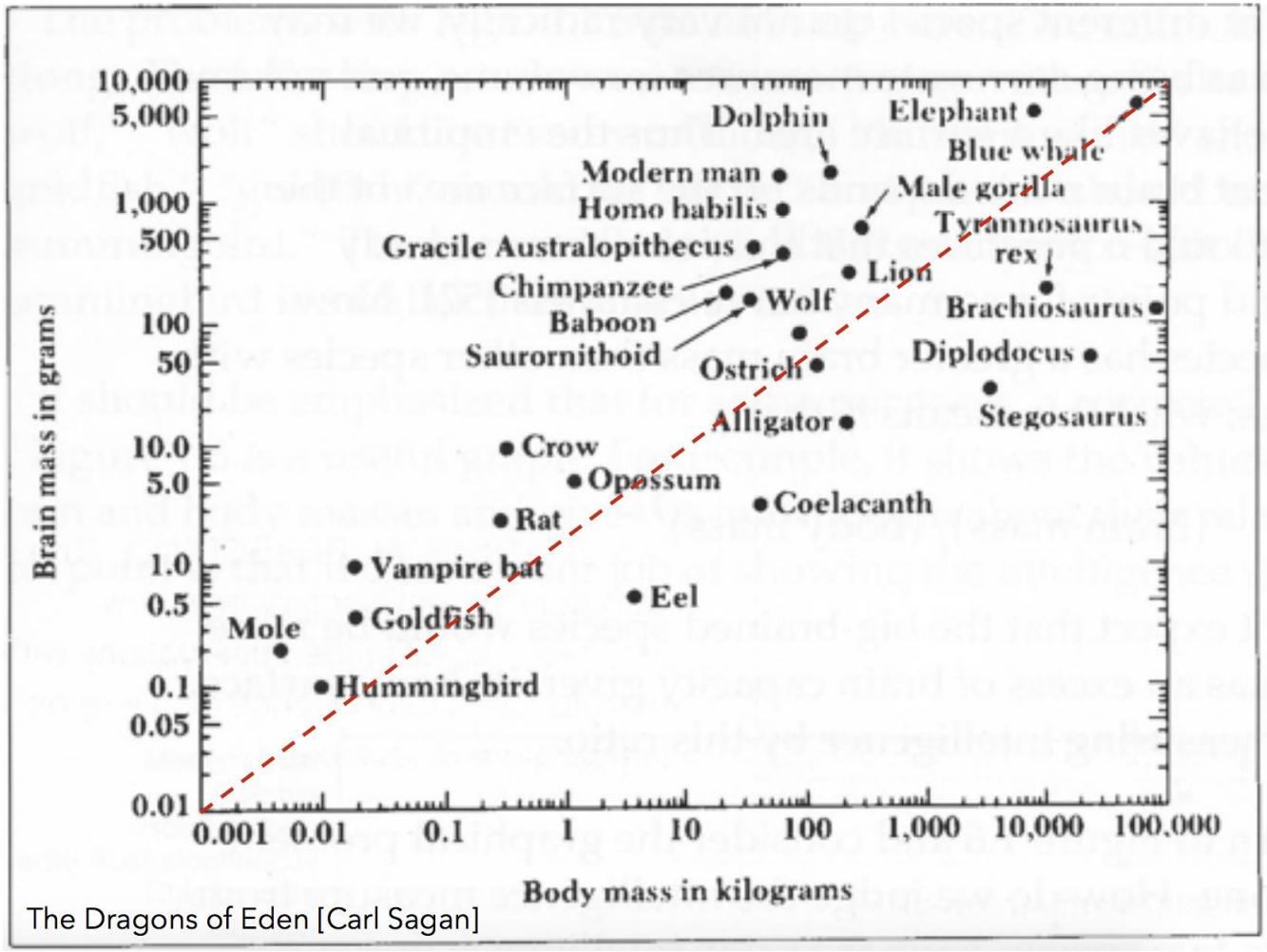
This is the same data!





Team 2 got 26 points – how many points did Team 3 get?

Misleading Visualization Practices

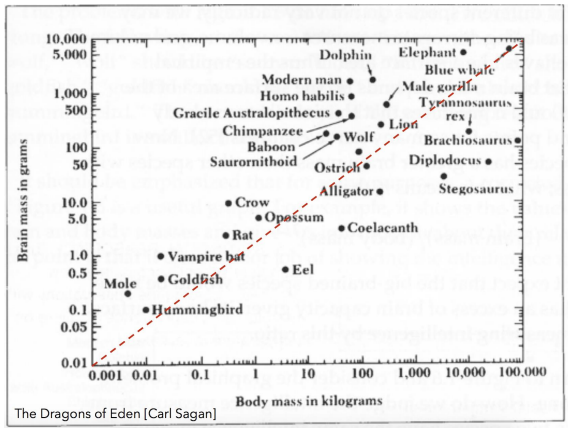


The Dragons of Eden [Carl Sagan]

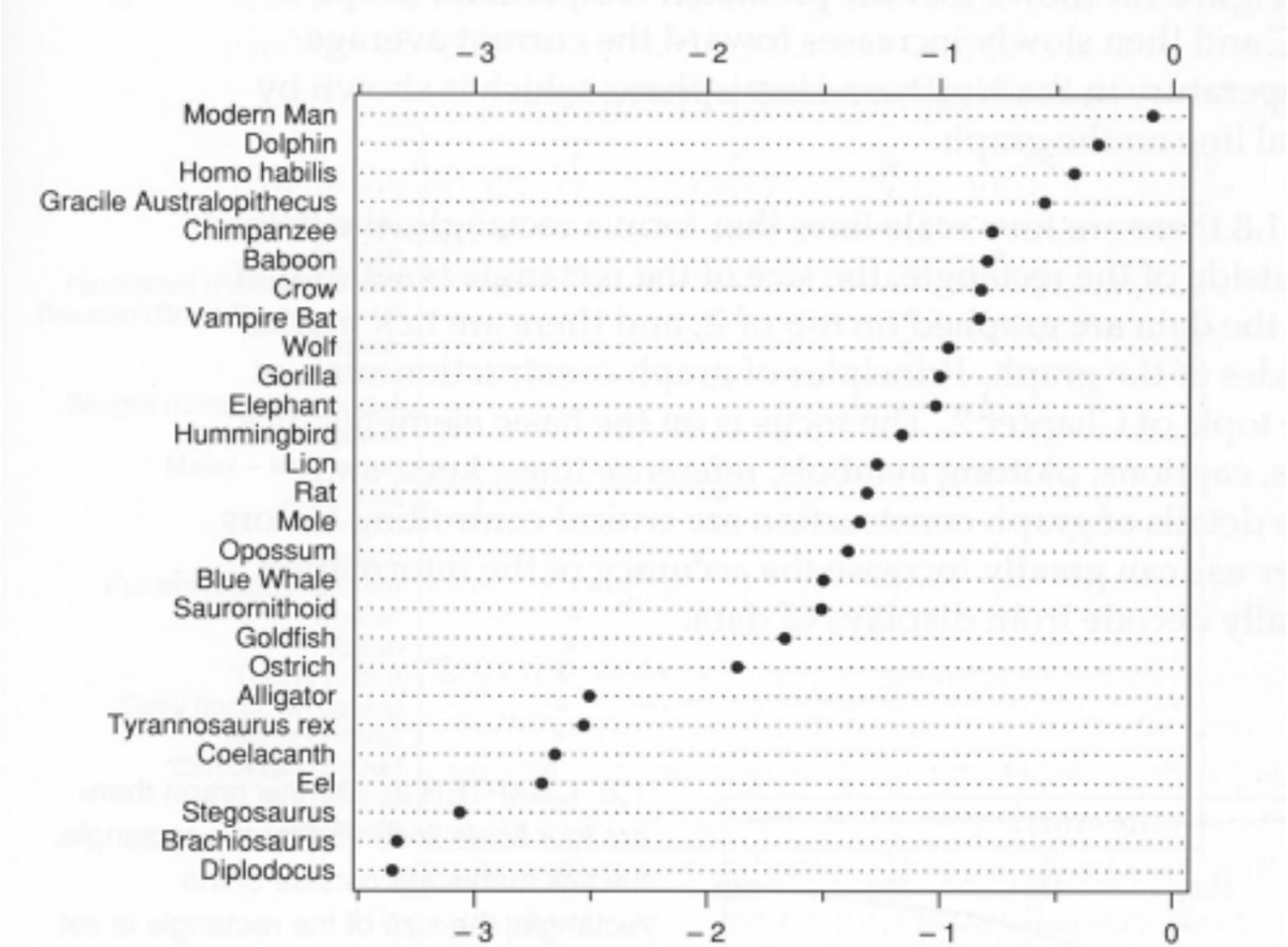
Which two animals have the highest brain mass to body mass ratio?

Misleading Visualization Practices

This is the same data!



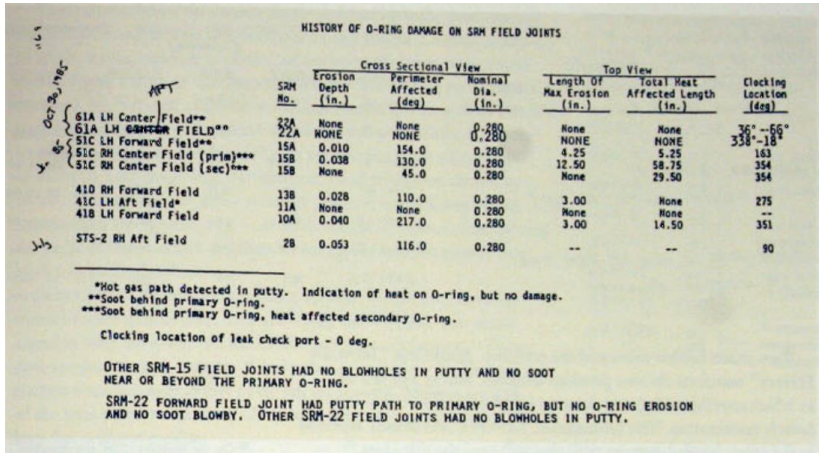
The Dragons of Eden [Carl Sagan]



The Elements of Graphing Data [Cleveland]

Challenger Explosion

- Launched January 28, 1986
- Broke apart 73 seconds after launching
- Caused by cold temperatures affecting the O-rings which held together the rockets



HISTORY OF O-RING DAMAGE ON SRM FIELD JOINTS

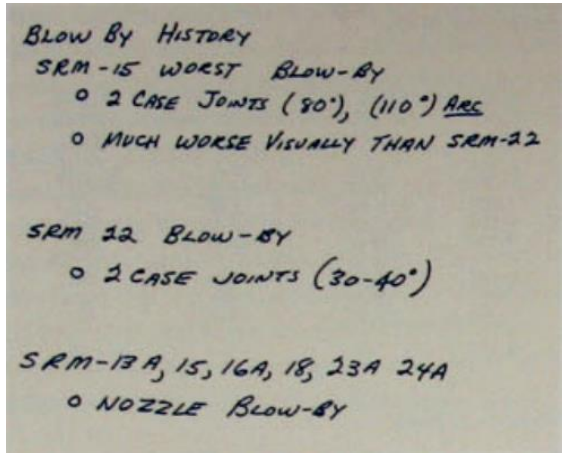
Motor	SRM No.	Cross Sectional View: Erosion Depth (in.)	Cross Sectional View: Perimeter Affected (deg)	Cross Sectional View: Nominal Dia. (in.)	Top View: Length Of Max Erosion (in.)	Top View: Total Heat Affected Length (in.)	Clocking Location (deg)
61A LH Center Field**	22A	None	None	0.280	None	None	36° -66°
61A LH CENTER FIELD**	22A	NONE	NONE	0.280	NONE	NONE	338°-18°
51C LH Forward Field**	15A	0.010	154.0	0.280	4.25	5.25	163
51C RH Center Field (prim)***	15B	0.038	130.0	0.280	12.50	58.75	354
51C RH Center Field (sec)***	15B	None	45.0	0.280	None	29.50	354
41D RH Forward Field	13B	0.028	110.0	0.280	3.00	None	275
41C LH Aft Field*	11A	None	None	0.280	None	None	--
41B LH Forward Field	10A	0.040	217.0	0.280	3.00	14.50	351
STS-2 RH Aft Field	2B	0.053	116.0	0.280	--	--	90

*Hot gas path detected in putty. Indication of heat on O-ring, but no damage.
**Soot behind primary O-ring.
***Soot behind primary O-ring, heat affected secondary O-ring.

Clocking location of leak check port - 0 deg.

OTHER SRM-15 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY AND NO SOOT NEAR OR BEYOND THE PRIMARY O-RING.

SRM-22 FORWARD FIELD JOINT HAD PUTTY PATH TO PRIMARY O-RING, BUT NO O-RING EROSION AND NO SOOT BLOWBY. OTHER SRM-22 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY.

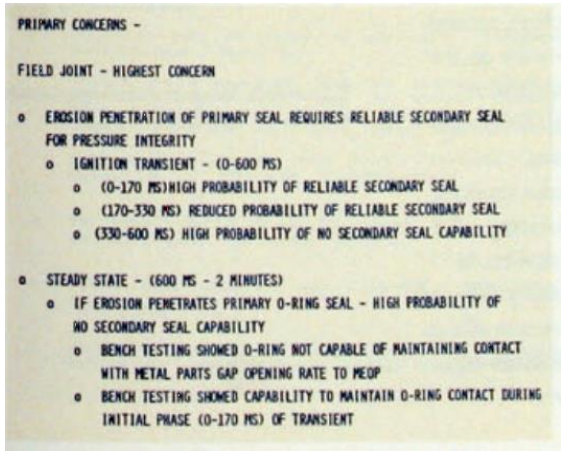


BLOW BY HISTORY

SRM-15 WORST BLOW-BY
- 2 CASE JOINTS (80°), (110°) ARC
- MUCH WORSE VISUALLY THAN SRM-22

SRM 22 BLOW-BY
- 2 CASE JOINTS (30-40°)

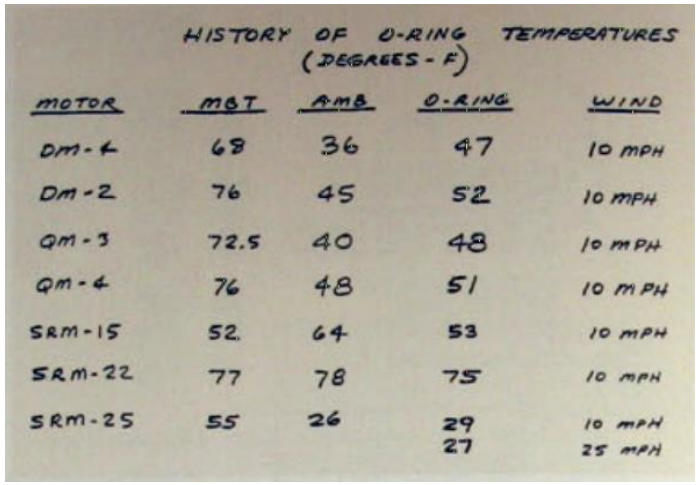
SRM-13A, 15, 16A, 18, 23A 24A
- NOZZLE BLOW-BY



PRIMARY CONCERNS -

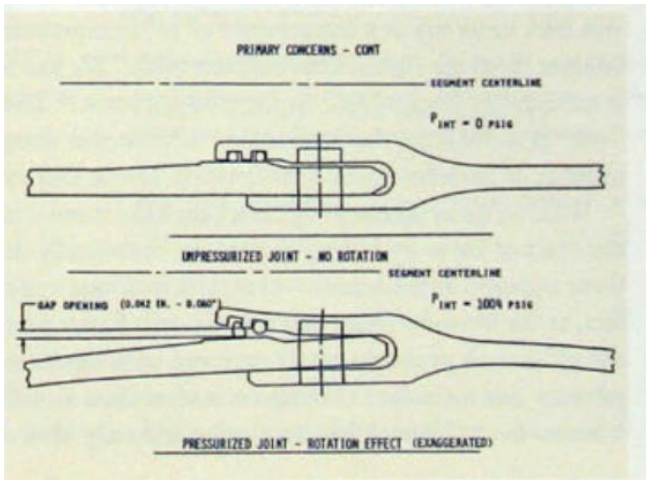
FIELD JOINT - HIGHEST CONCERN

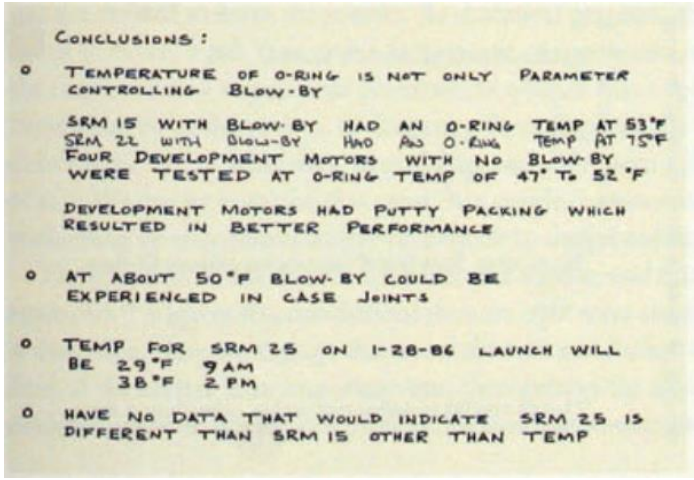
- EROSION PENETRATION OF PRIMARY SEAL REQUIRES RELIABLE SECONDARY SEAL FOR PRESSURE INTEGRITY
  - IGNITION TRANSIENT - (0-600 MS)
    - (0-170 MS) HIGH PROBABILITY OF RELIABLE SECONDARY SEAL
    - (170-330 MS) REDUCED PROBABILITY OF RELIABLE SECONDARY SEAL
    - (330-600 MS) HIGH PROBABILITY OF NO SECONDARY SEAL CAPABILITY
- STEADY STATE - (600 MS - 2 MINUTES)
  - IF EROSION PENETRATES PRIMARY O-RING SEAL - HIGH PROBABILITY OF NO SECONDARY SEAL CAPABILITY
    - BENCH TESTING SHOWED O-RING NOT CAPABLE OF MAINTAINING CONTACT WITH METAL PARTS GAP OPENING RATE TO MEOP
    - BENCH TESTING SHOWED CAPABILITY TO MAINTAIN O-RING CONTACT DURING INITIAL PHASE (0-170 MS) OF TRANSIENT



HISTORY OF O-RING TEMPERATURES (DEGREES - F)

MOTOR	MBT	AMB	O-RING	WIND
DM-1	68	36	47	10 MPH
DM-2	76	45	52	10 MPH
QM-3	72.5	40	48	10 MPH
QM-1	76	48	51	10 MPH
SRM-15	52	64	53	10 MPH
SRM-22	77	78	75	10 MPH
SRM-25	55	26	29 27	10 MPH 25 MPH





CONCLUSIONS:

- TEMPERATURE OF O-RING IS NOT ONLY PARAMETER CONTROLLING BLOW-BY

  SRM 15 WITH BLOW-BY HAD AN O-RING TEMP AT 53°F
  SRM 22 WITH BLOW-BY HAD AN O-RING TEMP AT 75°F
  FOUR DEVELOPMENT MOTORS WITH NO BLOW-BY WERE TESTED AT O-RING TEMP OF 47° TO 52°F

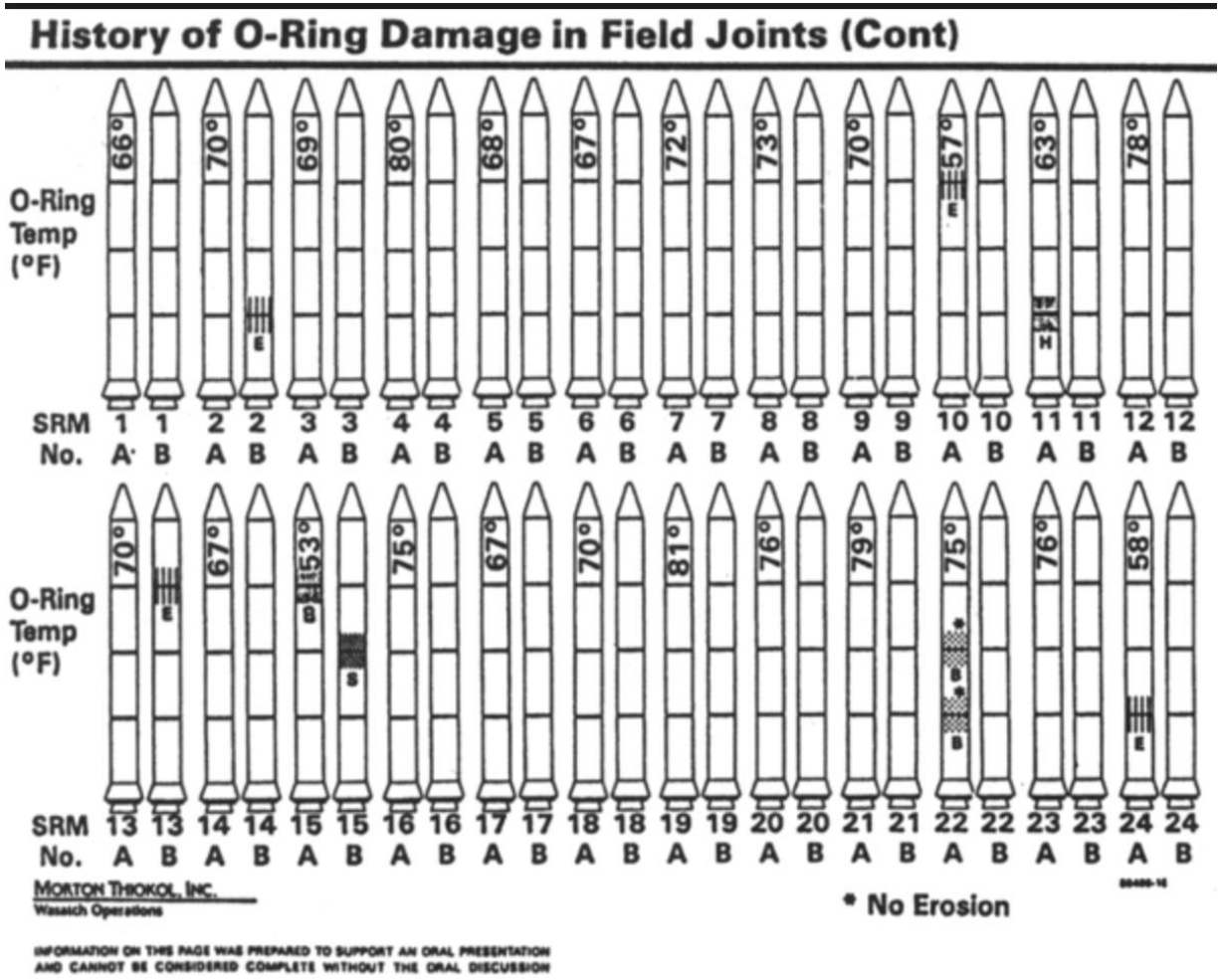
  DEVELOPMENT MOTORS HAD PUTTY PACKING WHICH RESULTED IN BETTER PERFORMANCE

- AT ABOUT 50°F BLOW-BY COULD BE EXPERIENCED IN CASE JOINTS

- TEMP FOR SRM 25 ON 1-28-86 LAUNCH WILL BE 29°F 9 AM
  38°F 2 PM

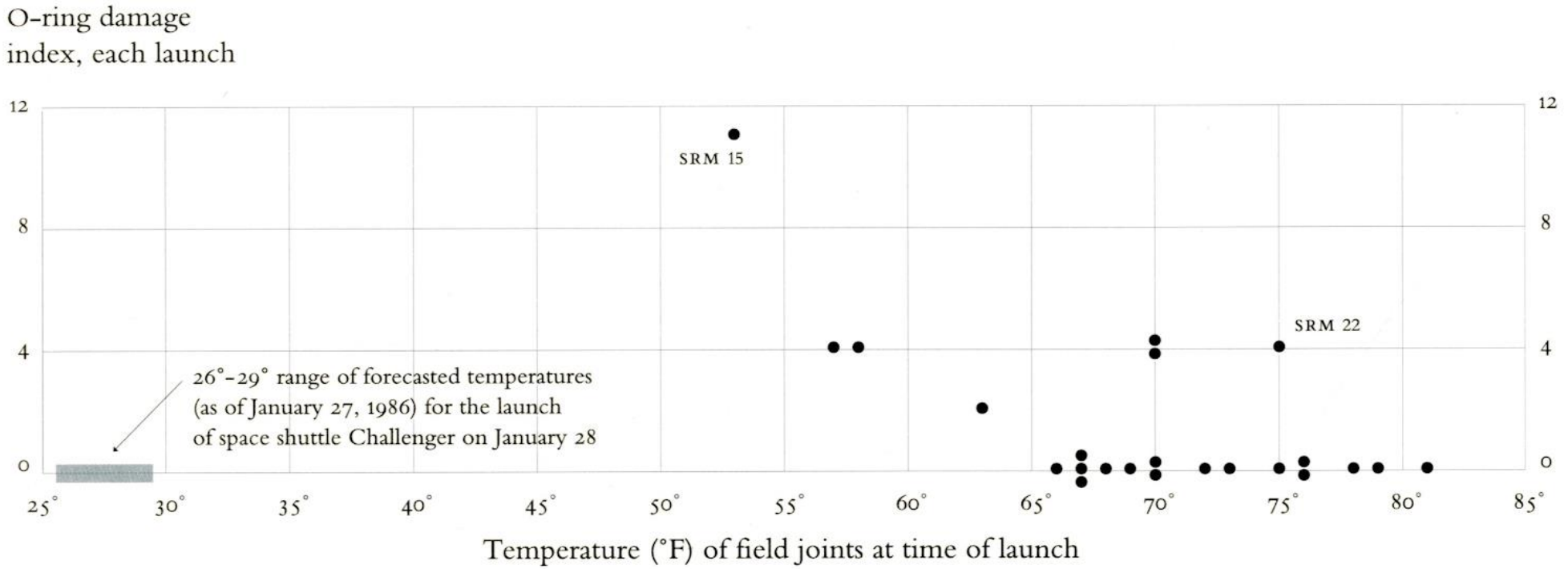
- HAVE NO DATA THAT WOULD INDICATE SRM 25 IS DIFFERENT THAN SRM 15 OTHER THAN TEMP

Pre-launch visualizations



Post-launch visualizations

[Rogers Commission Report, 1986]



Redesign

[Tufte, 1997]

Reflections on Challenger

- Remember the context when viewing redesigns
  - The original authors do not know the outcome
- Other factors beyond data visualization!
  - Scientists did raise concern about the temperature
  - Internal & external pressure? Groupthink?

This was cool. What now?

- Check out some of Erika's favorite visualizations 😎
  - Wind map of the US
  - Bus bunching vis
  - Visual intro to machine learning
- Build your own visualizations!
  - D3 for the web
  - Python + seaborn for other applications
- Read about accessibility and data vis
- Consume content from the data vis community
  - Twitter & Medium!
- Think carefully about visualizations you see in the wild

References

- https://www.forbes.com/sites/bernardmarr/2018/05/21/how-much-data-do-we-create-every-day-the-mind-blowing-stats-everyone-should-read/#26a89fdd60ba
- https://gistbok.ucgis.org/bok-topics/symbolization-and-visual-variables
- https://www.google.com/search?q=visual+and+statistical+thinking&oq=visual+and+statisti&aqs=chrome.0.0j69i57j0l6.2137j1j1&sourceid=chrome&ie=UTF-8