

COS30045

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# DATA VISUALISATION

TOPIC 02-1: DESIGN GUIDELINES TUFTE'S INTEGRITY PRINCIPLES PART 1

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Acknowledgment: This unit is partially based on the Visualisation unit developed by Alex Lex and Hanspeter Hfister (with permission).

**Source of images used in this lecture available as links in the PDF version.**



# DESIGN GUIDELINES

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What:

- ▶ design guidelines

Why:

- ▶ maintain integrity of the data, make sure users interpret/understand the data correctly

How:

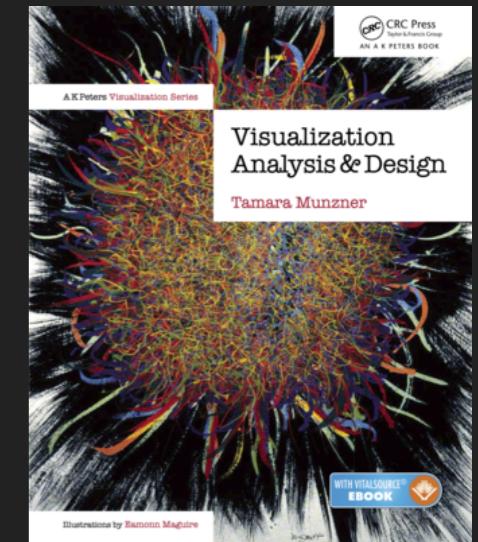
- ▶ follow Tufte's integrity principles and visualisation design principles



# DESIGN GUIDELINES

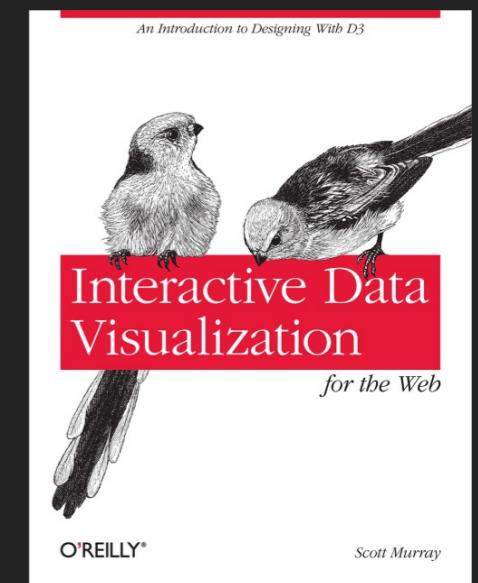
## Lecture Readings

- ▶ VAD Ch 6
- ▶ [Tufte](#) (Book Ch on graphical integrity)



## Tutorials

- ▶ IDV Ch 2 and 4



Well-designed presentations of interesting data are - a matter of *substance*, of *statistics*, and of *design*.

Edward Tufte

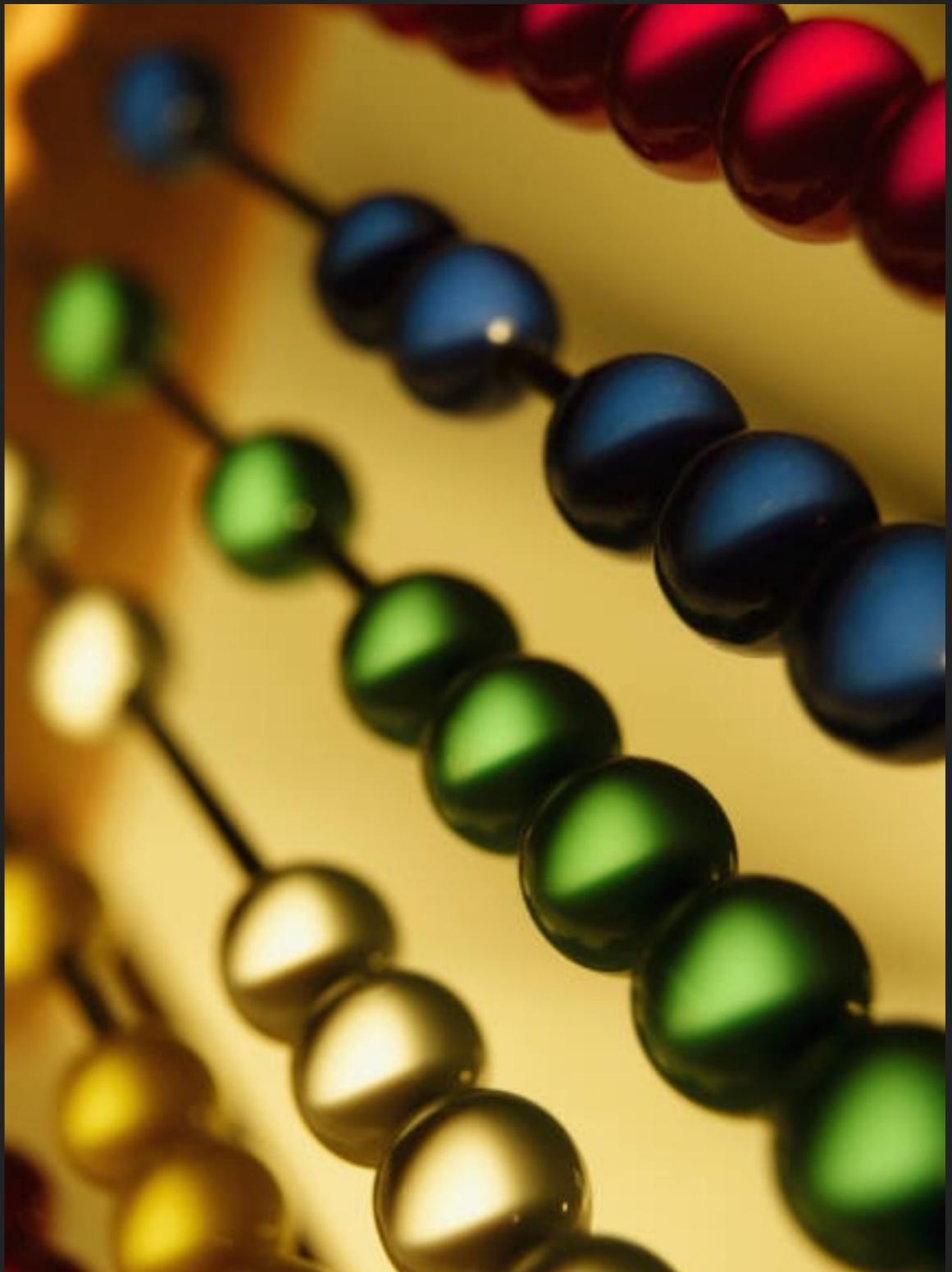
Statistician and data  
visualisation guru



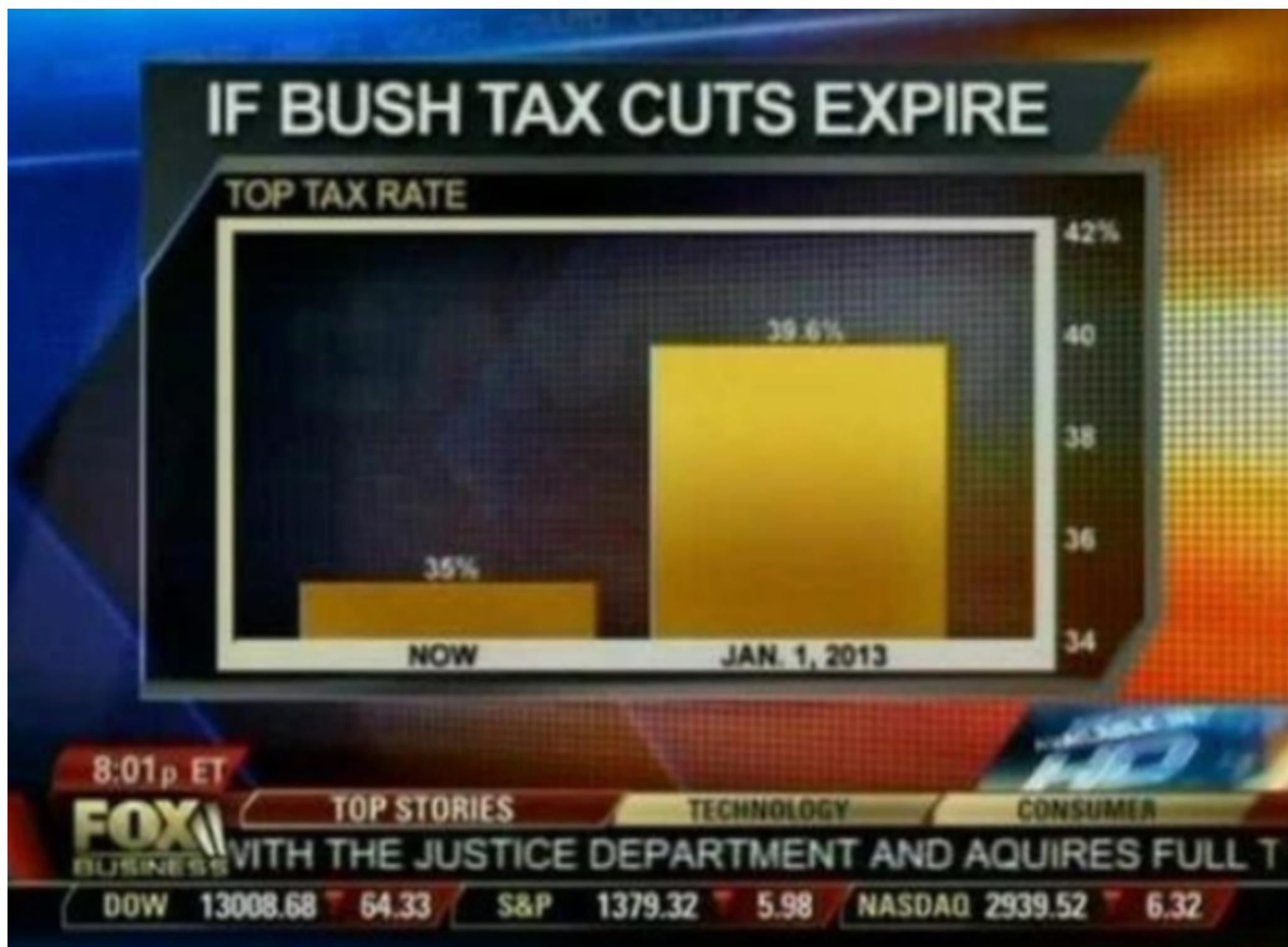
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# TUFTÉ'S INTEGRITY PRINCIPLES

- ▶ Clear, detailed, and thorough labelling to prevent graphical distortion and ambiguity
- ▶ Size of the physically measured graphic should be directly proportional to the numerical quantities ("lie factor")
- ▶ Show data variation, not design variation
- ▶ Graphics must not quote data out of context

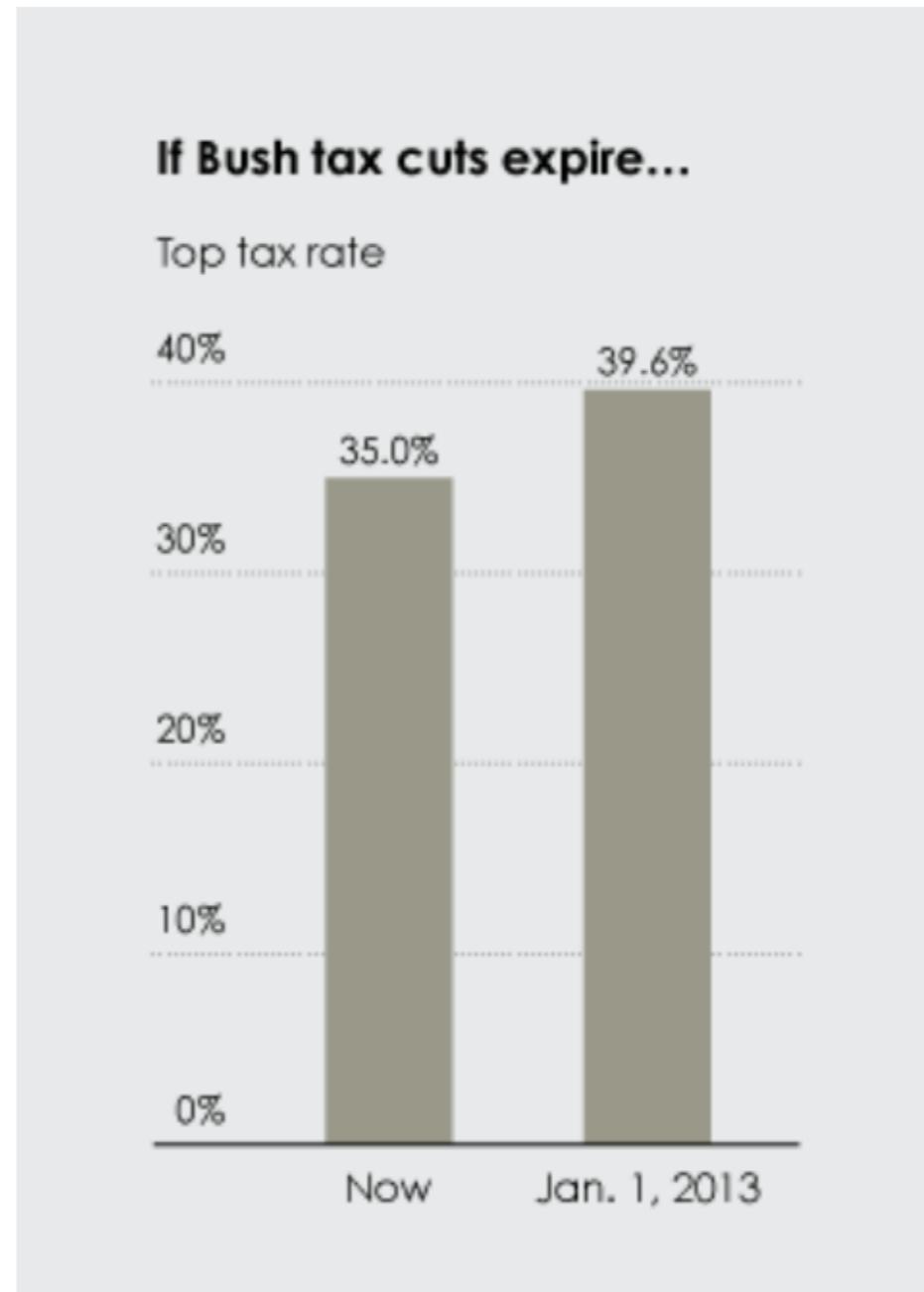


# INTEGRITY PRINCIPLE: PREVENT GRAPHICAL DISTORTION

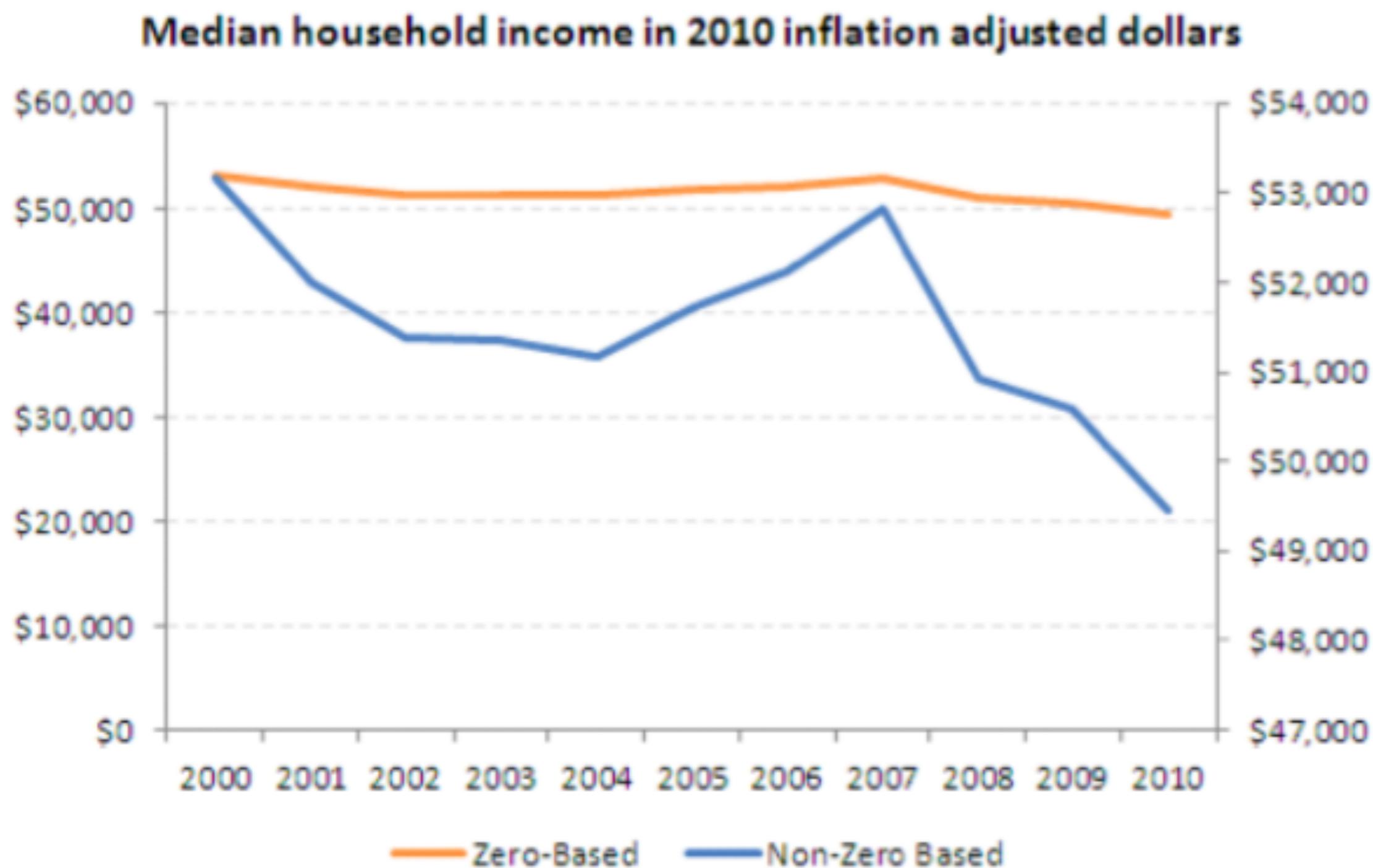


# INTEGRITY PRINCIPLE: PREVENT GRAPHICAL DISTORTION

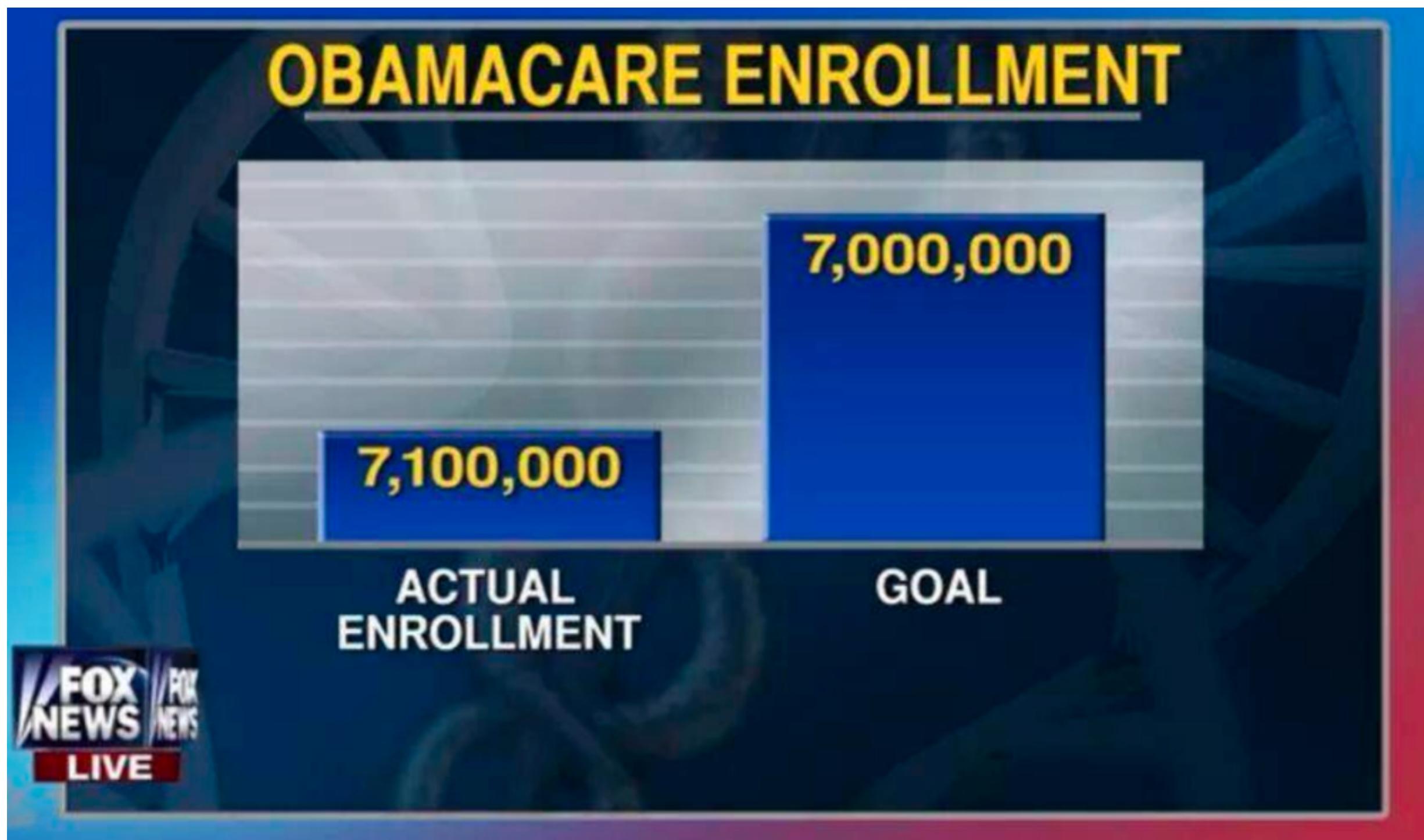
- ▶ How do we judge the size of effect in bar graph?
- ▶ difference in data must match difference in graph (see lie factor)
- ▶ relative size of bars is important
- ▶ **ALWAYS START BAR CHARTS AT 0**



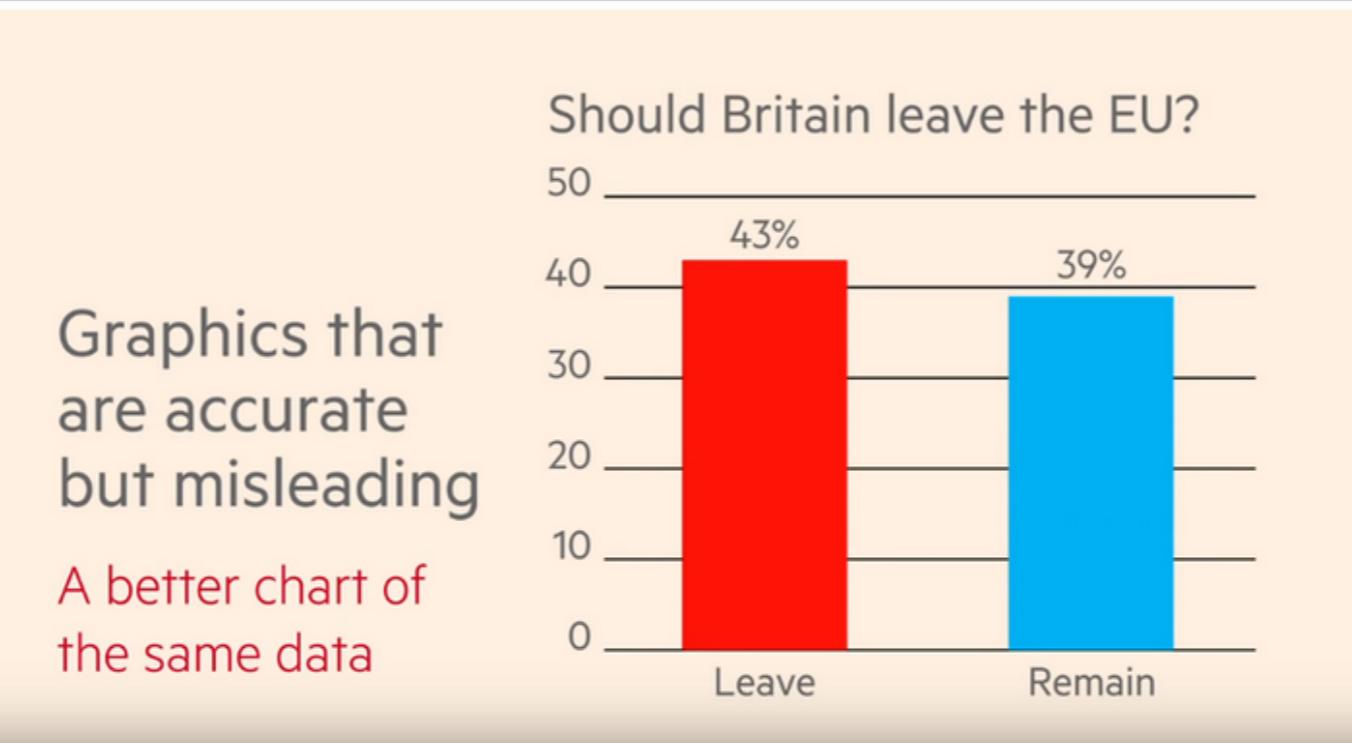
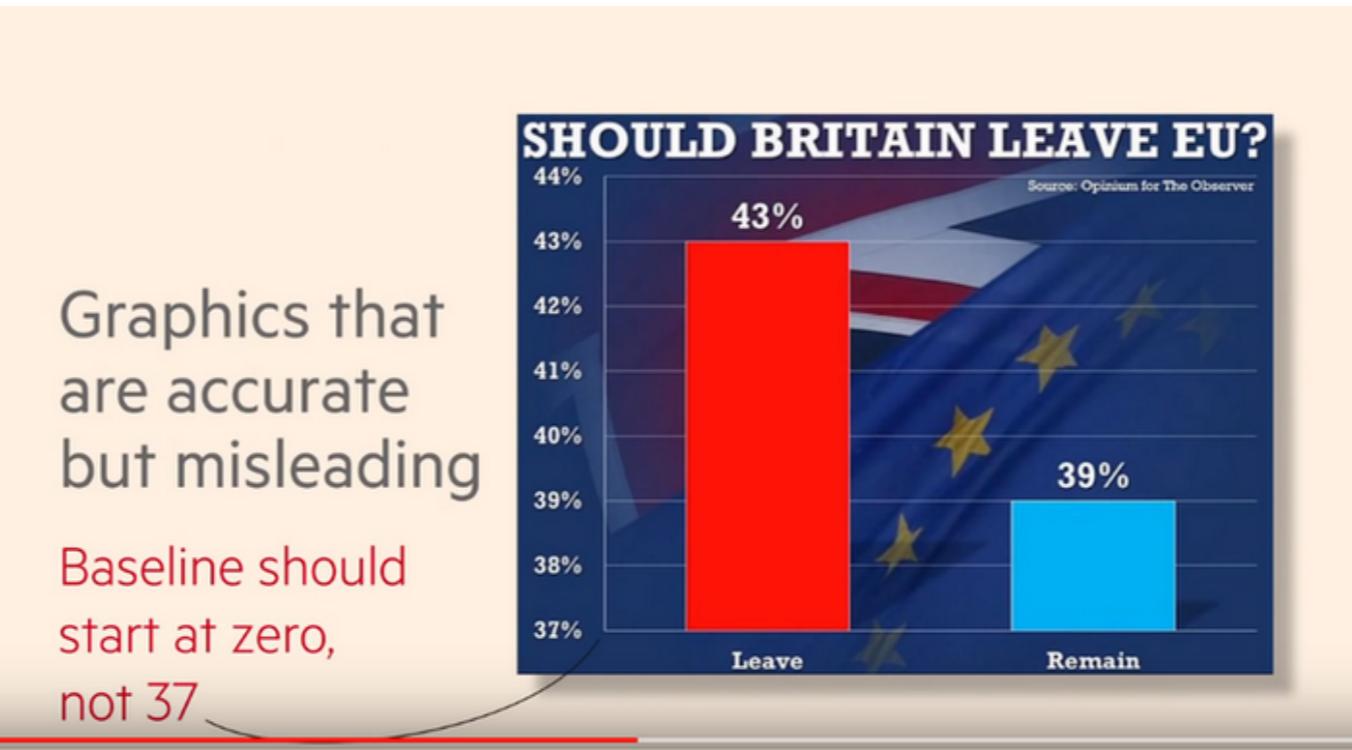
## INTEGRITY PRINCIPLE: NON-ZERO SCALE DISTORTIONS



## INTEGRITY PRINCIPLE: PREVENT GRAPHICAL DISTORTION



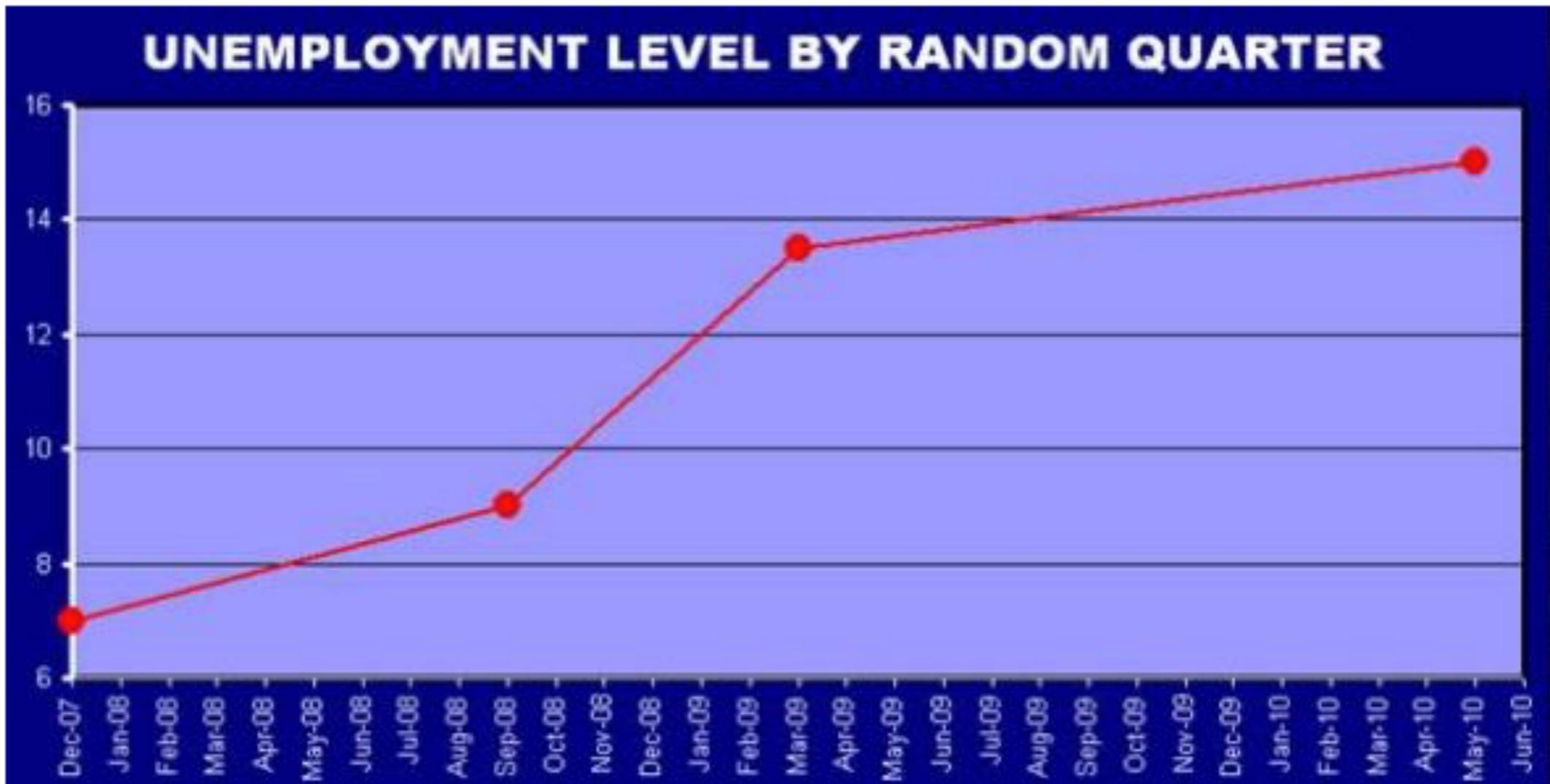
# INTEGRITY PRINCIPLE: PREVENT GRAPHICAL DISTORTION



## INTEGRITY PRINCIPLE: PREVENT GRAPHICAL DISTORTION



# INTEGRITY PRINCIPLE: PREVENT GRAPHICAL DISTORTION

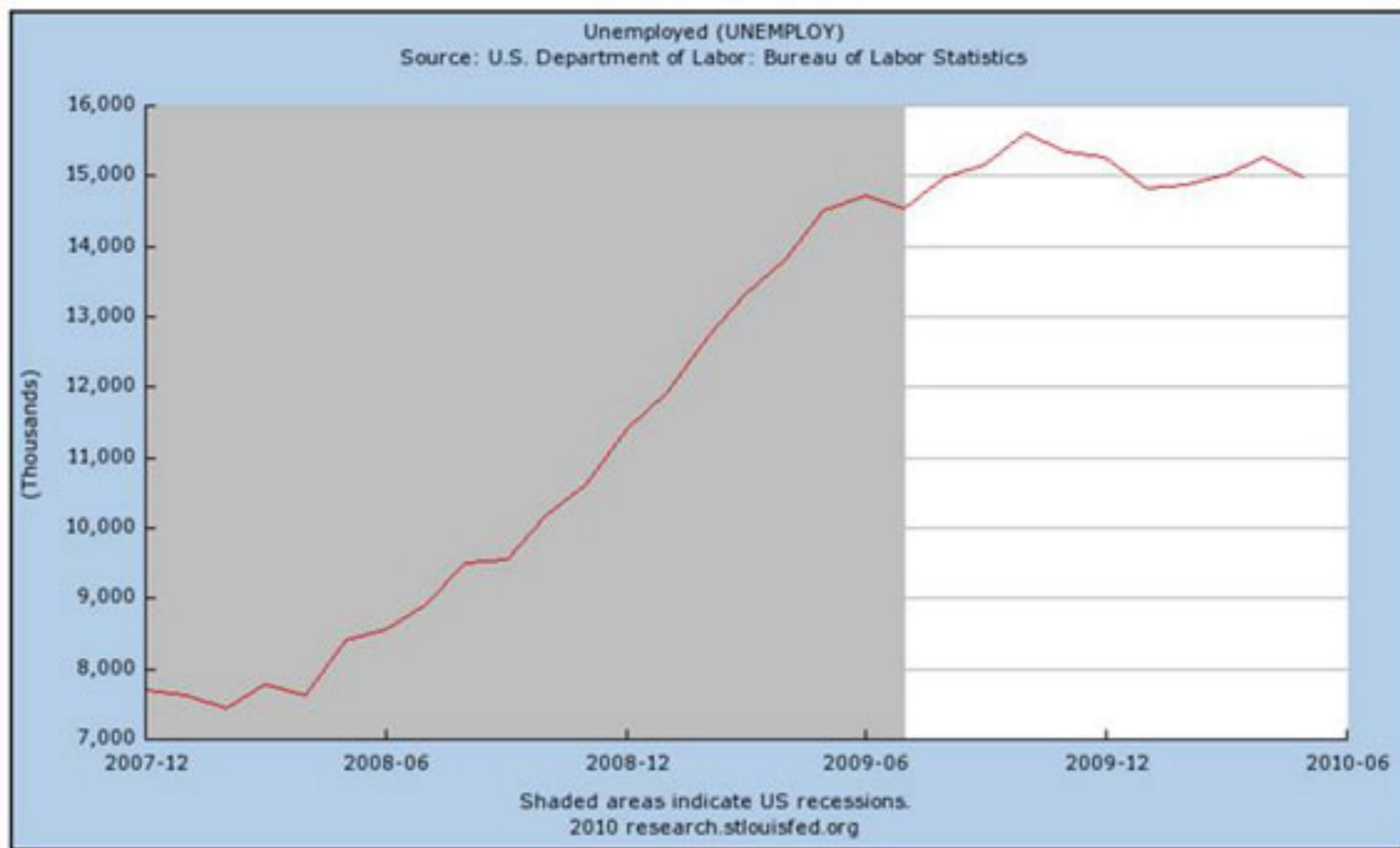


Data is for unemployment, not job losses

Data is for 'random' quarters

Manipulation of x-axis (Sep to Mar = 6 mths, Mar to Jun 15 mths)

# INTEGRITY PRINCIPLE: SCALE DISTORTIONS - OUT OF CONTEXT



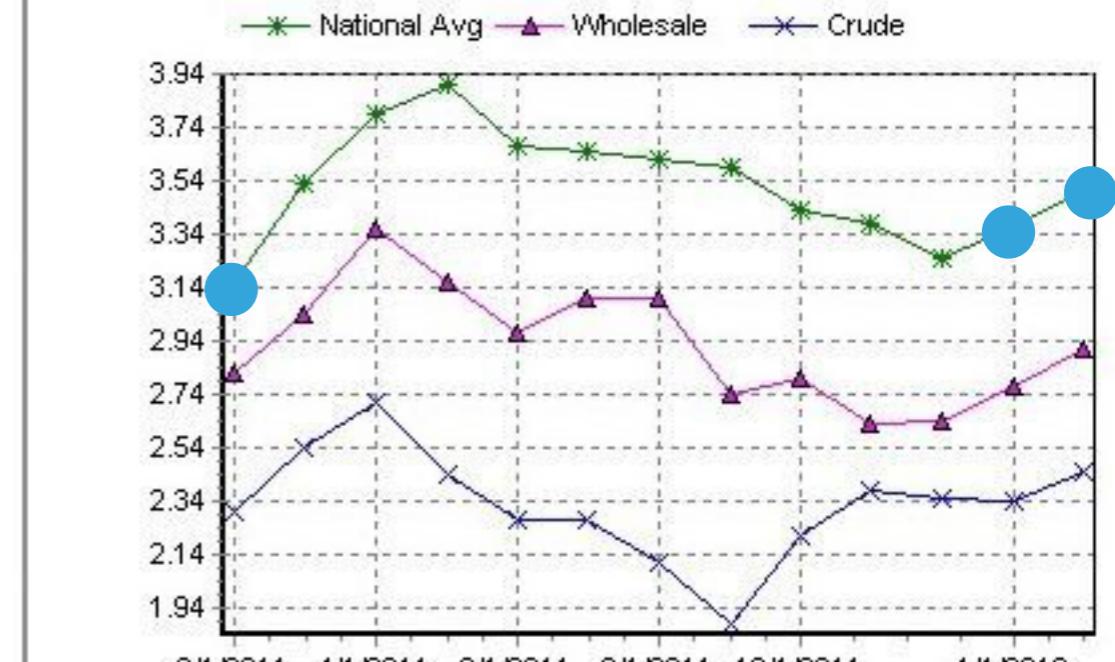
## INTEGRITY PRINCIPLE: SCALE DISTORTIONS - OUT OF CONTEXT



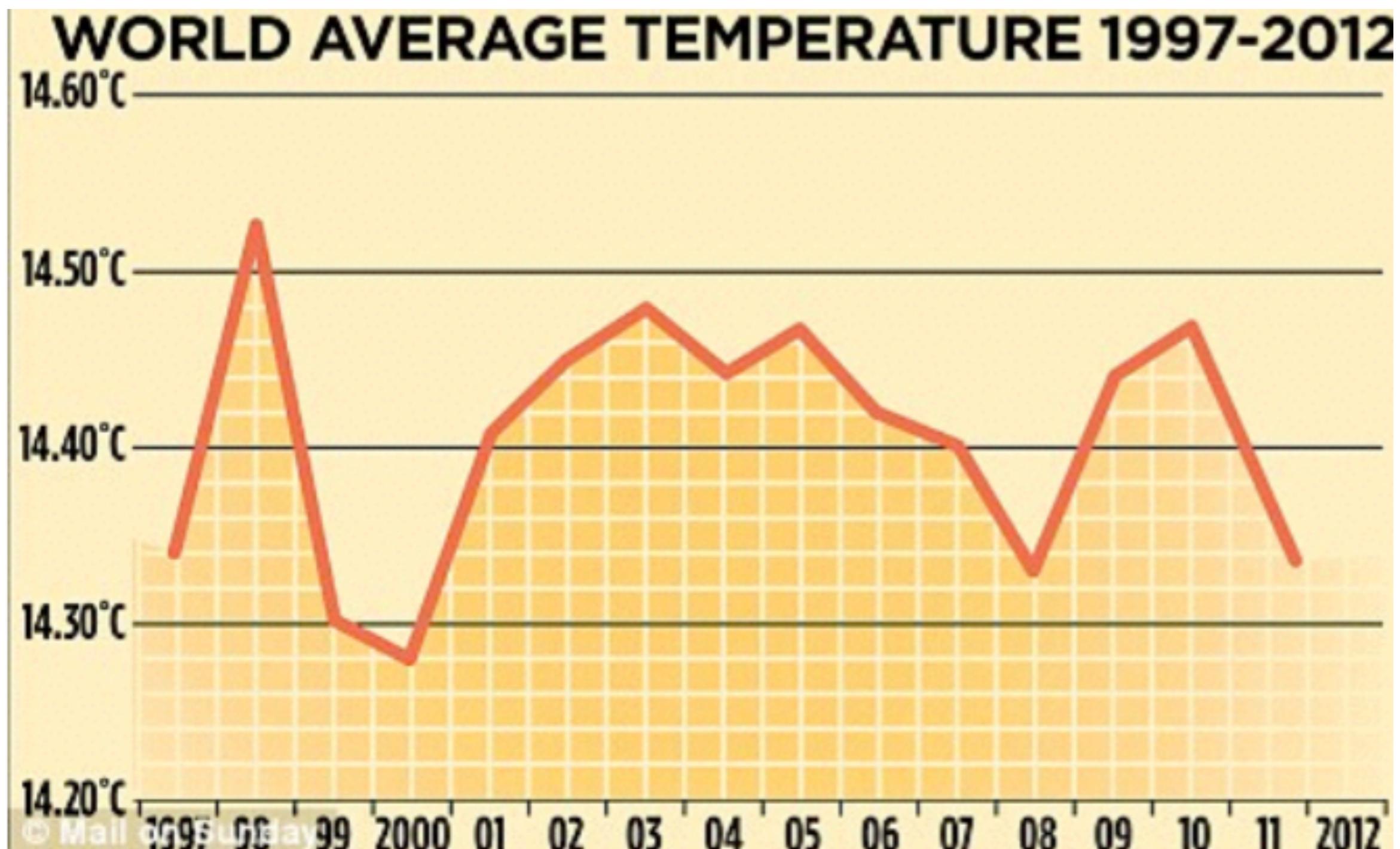
# INTEGRITY PRINCIPLE: SCALE DISTORTIONS - OUT OF CONTEXT



12 Month Average for Self-Serve Regular



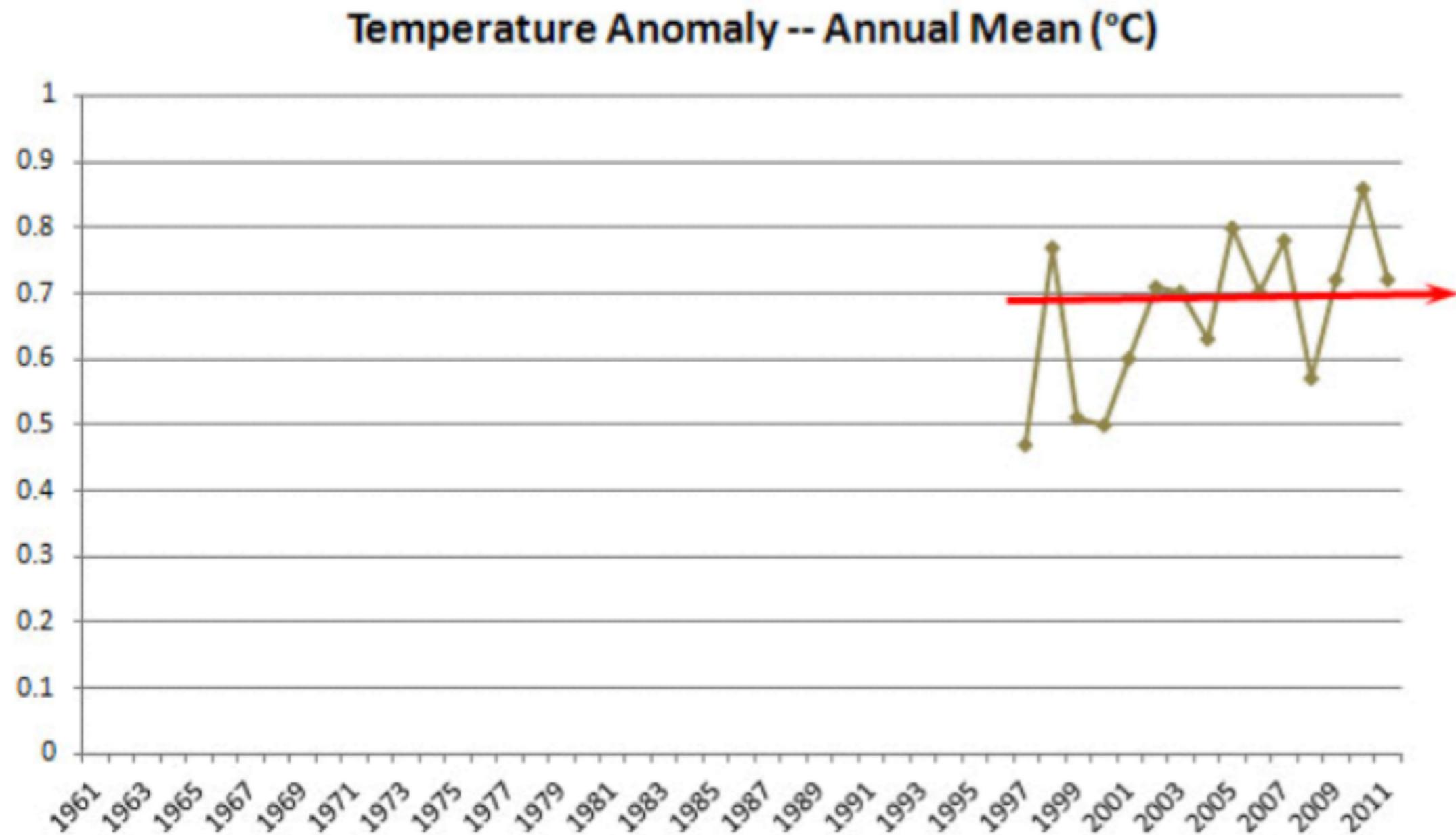
## INTEGRITY PRINCIPLE: SCALE DISTORTIONS - OUT OF CONTEXT



Does not appear to be a warming trend...

Daily Mail

# INTEGRITY PRINCIPLE: SCALE DISTORTIONS

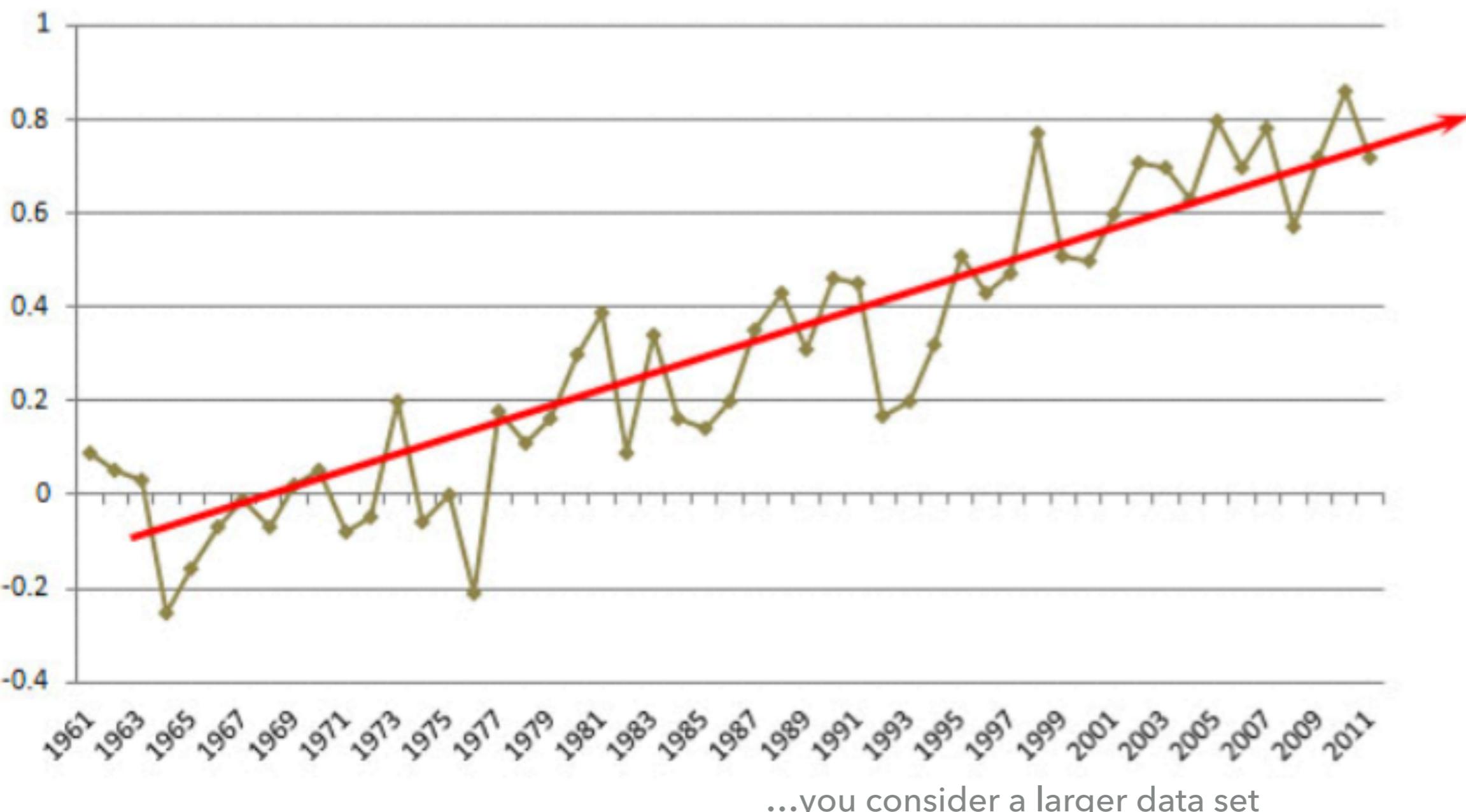


Does not appear to be a warming trend, until...

15 year data plotted by Daily Mail  
(source Mother Jones)

# INTEGRITY PRINCIPLE: SCALE DISTORTIONS

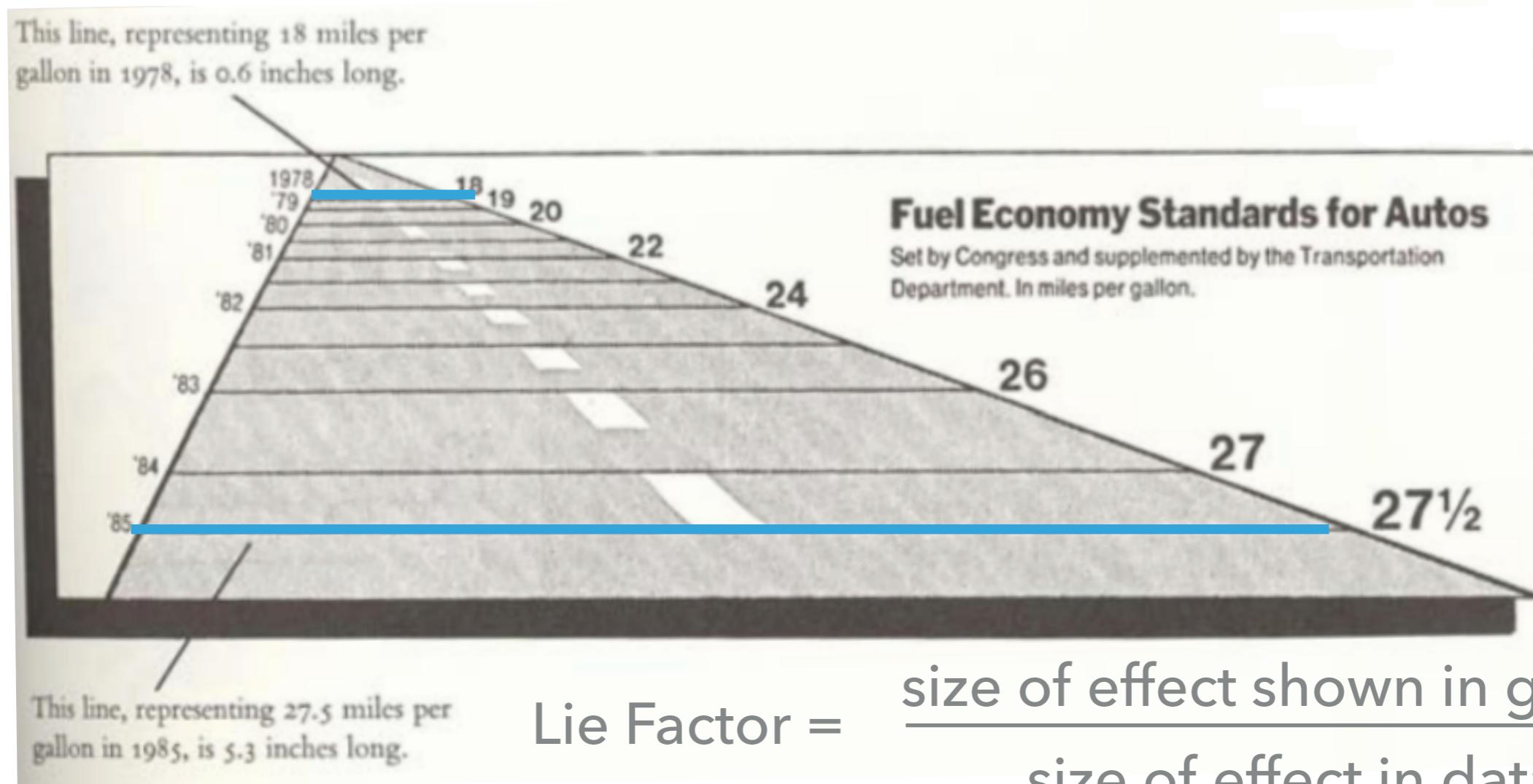
Temperature Anomaly -- Annual Mean ( $^{\circ}\text{C}$ )



...you consider a larger data set

50 year data set  
(source Mother Jones)

# INTEGRITY PRINCIPLE: SCALE DISTORTIONS - THE LIE FACTOR



1.5 cm = 29 km

13.5 cm = 44 km

2.9 cm = 29 km

4.4 cm = 44 km

# INTEGRITY PRINCIPLE: SCALE DISTORTIONS



Austrian welfare payments

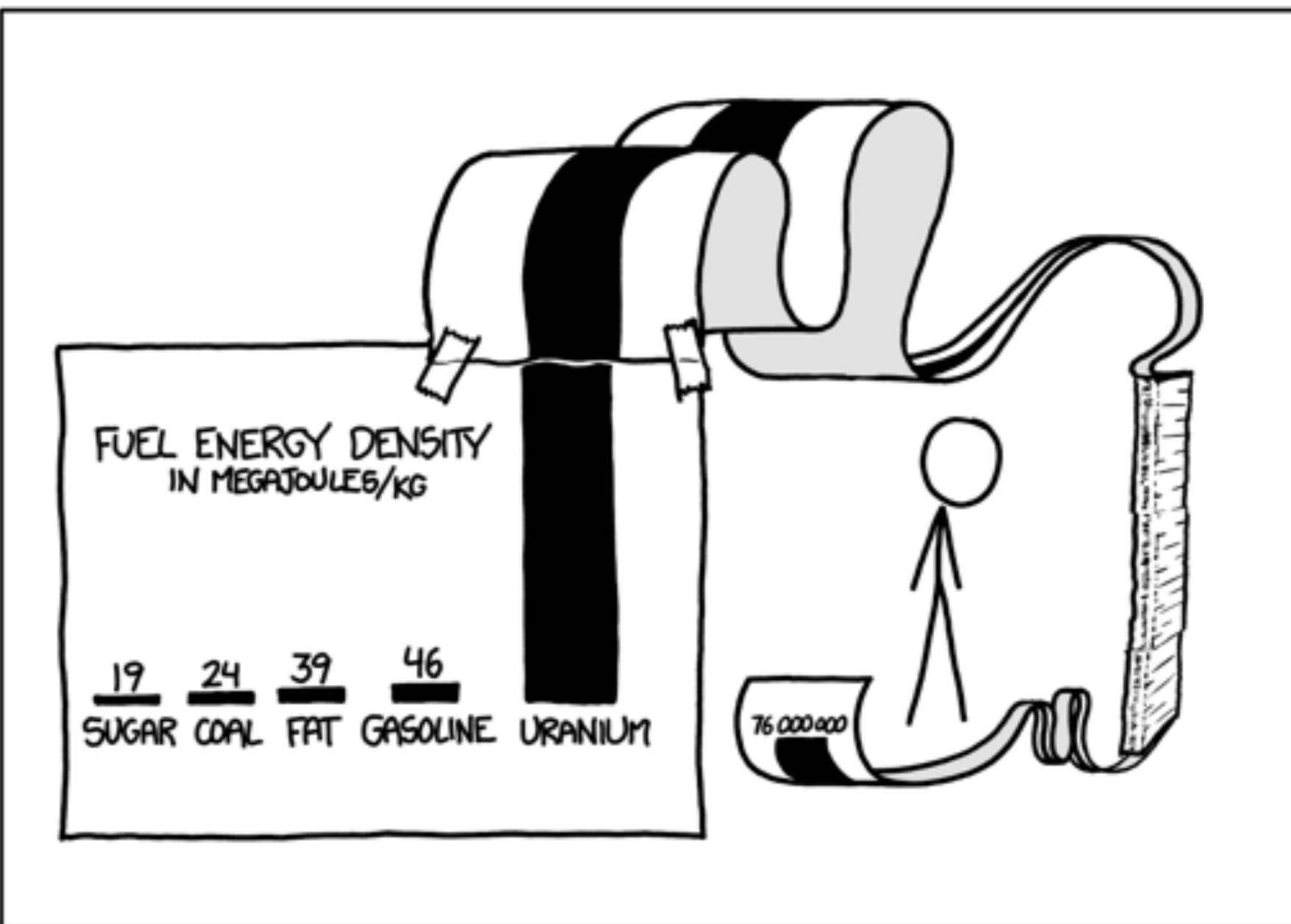
# INTEGRITY PRINCIPLE: SCALE DISTORTIONS

Grafik  
in echt

Grafik der  
Kronen-  
zeitung



Lex



SCIENCE TIP: LOG SCALES ARE FOR QUITTERS WHO CAN'T  
FIND ENOUGH PAPER TO MAKE THEIR POINT PROPERLY.

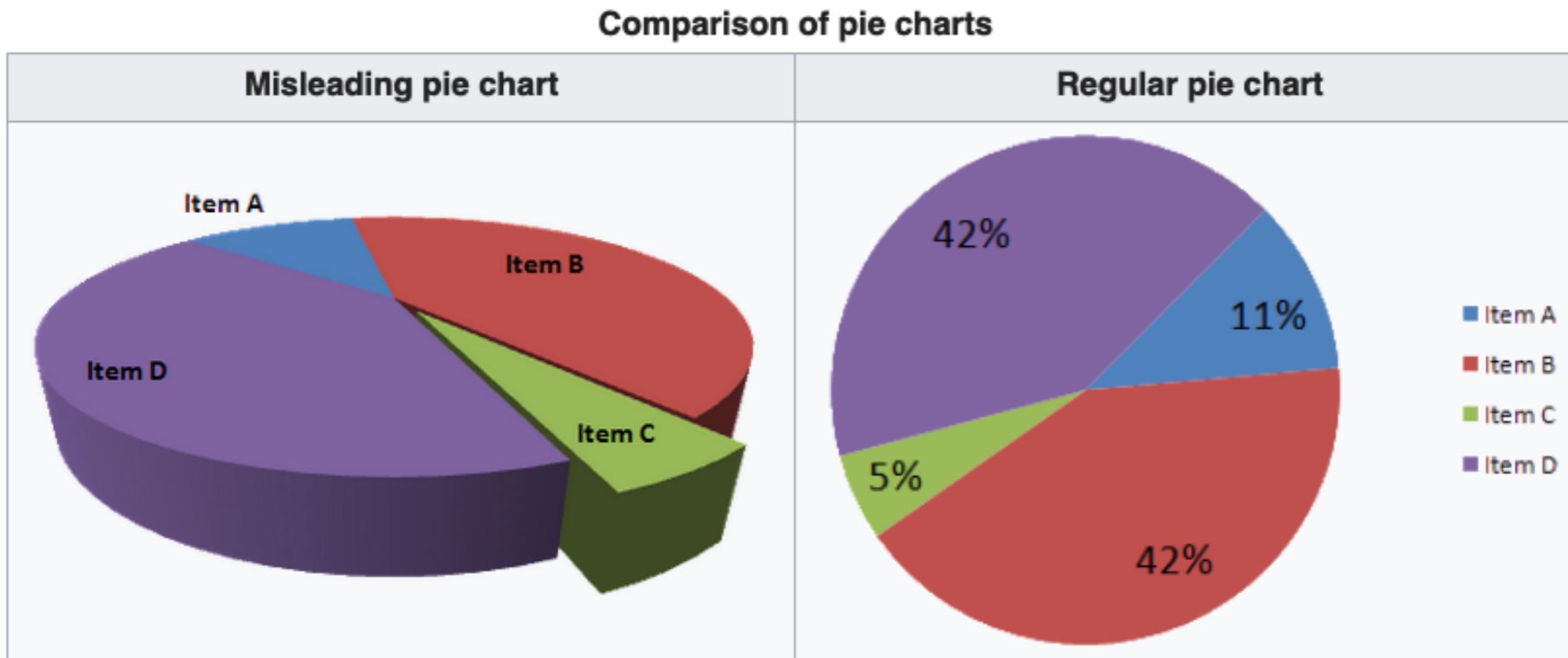
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# DATA VISUALISATION

TOPIC 02-2: DESIGN GUIDELINES TUFTE'S INTEGRITY PRINCIPLES PART 2

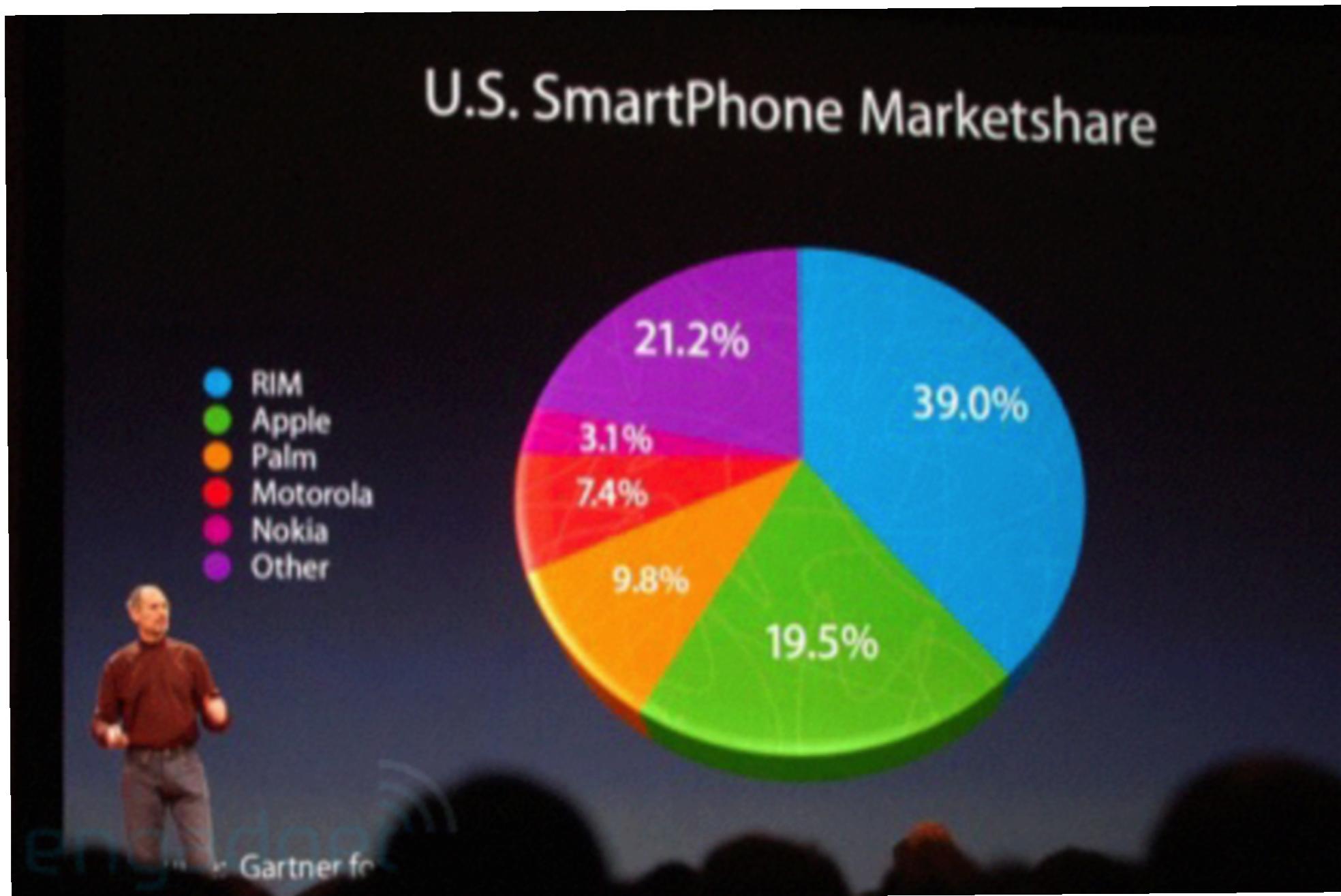
# INTEGRITY PRINCIPLE: SCALE DISTORTIONS IN 3D



## 3D Pie Chart

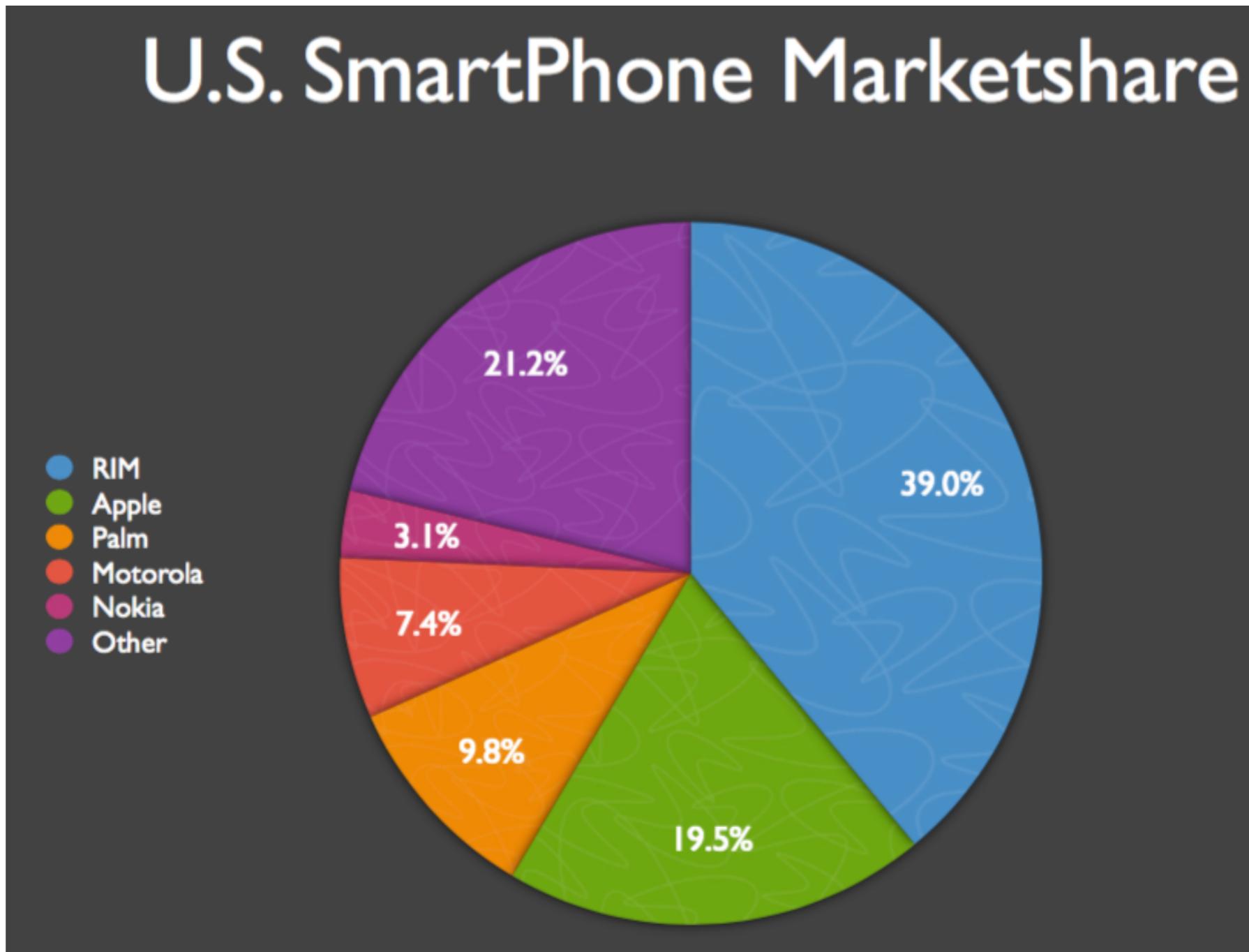
- ▶ perspective - things at front look bigger than those at the back
- ▶ difficult to judge the relative magnitude

# INTEGRITY PRINCIPLE: SCALE DISTORTIONS IN 3D



How far behind RIM is Apple?

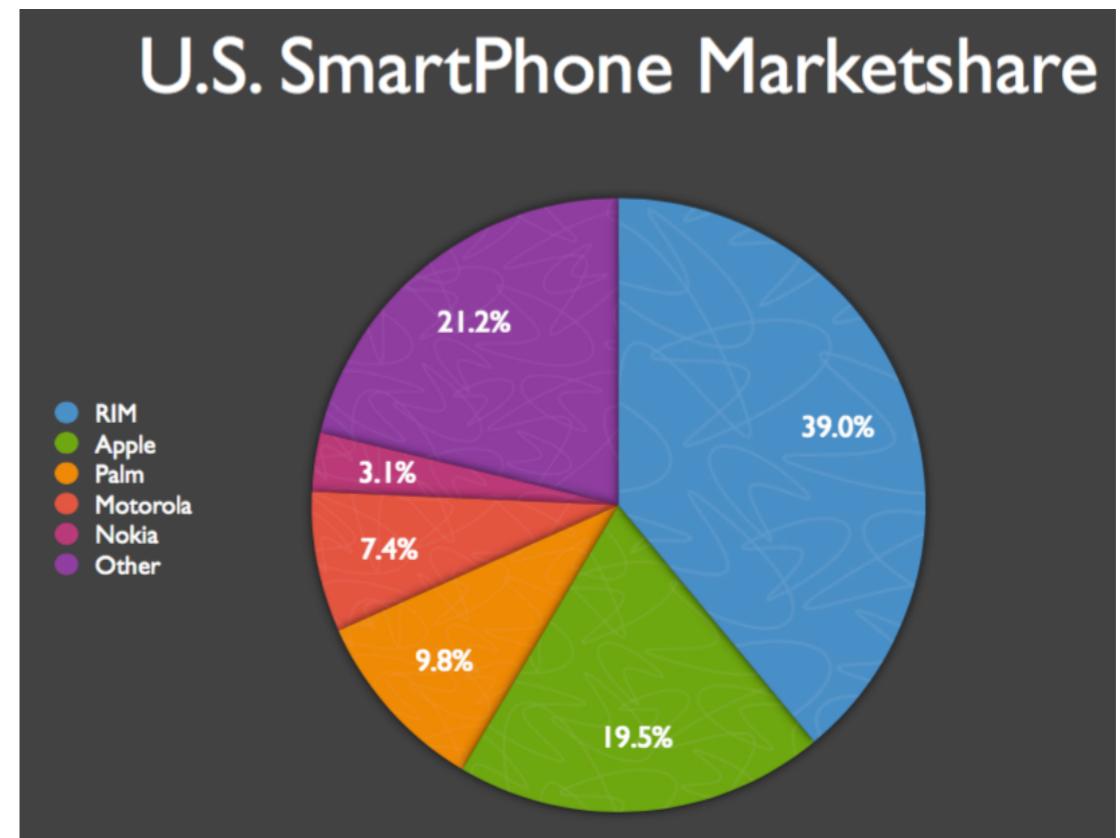
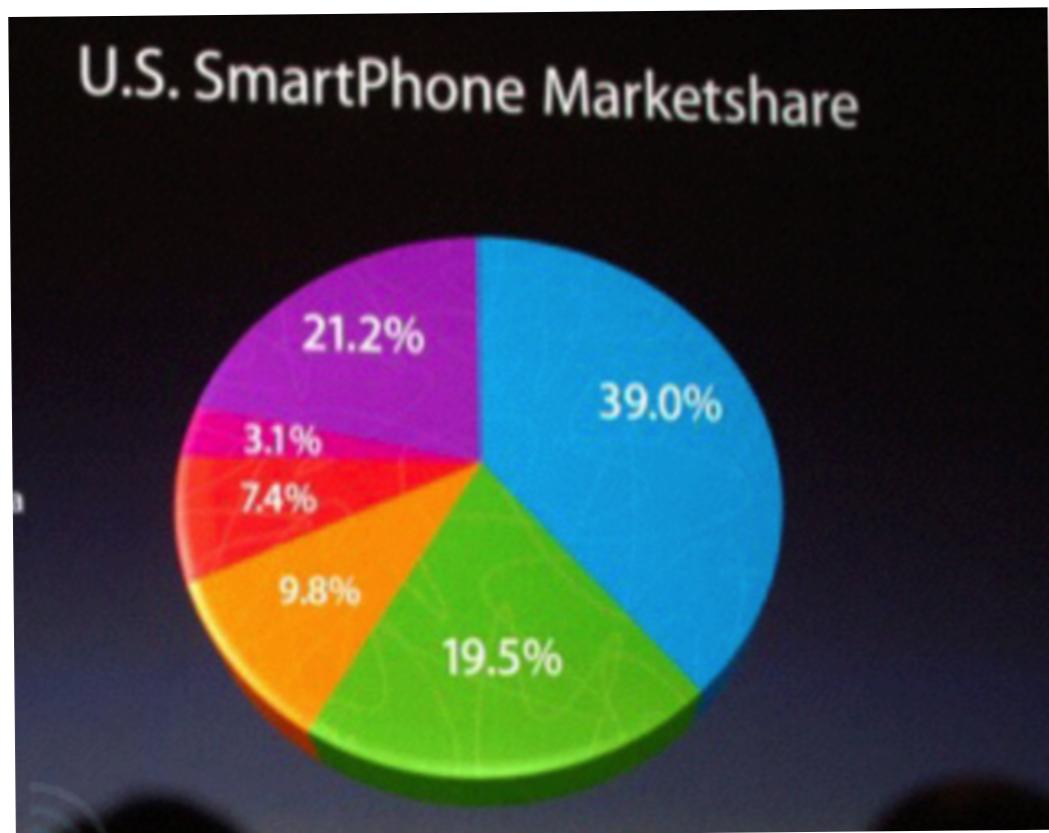
# INTEGRITY PRINCIPLE: SCALE DISTORTIONS IN 3D



How far behind RIM is Apple?

HP/AL

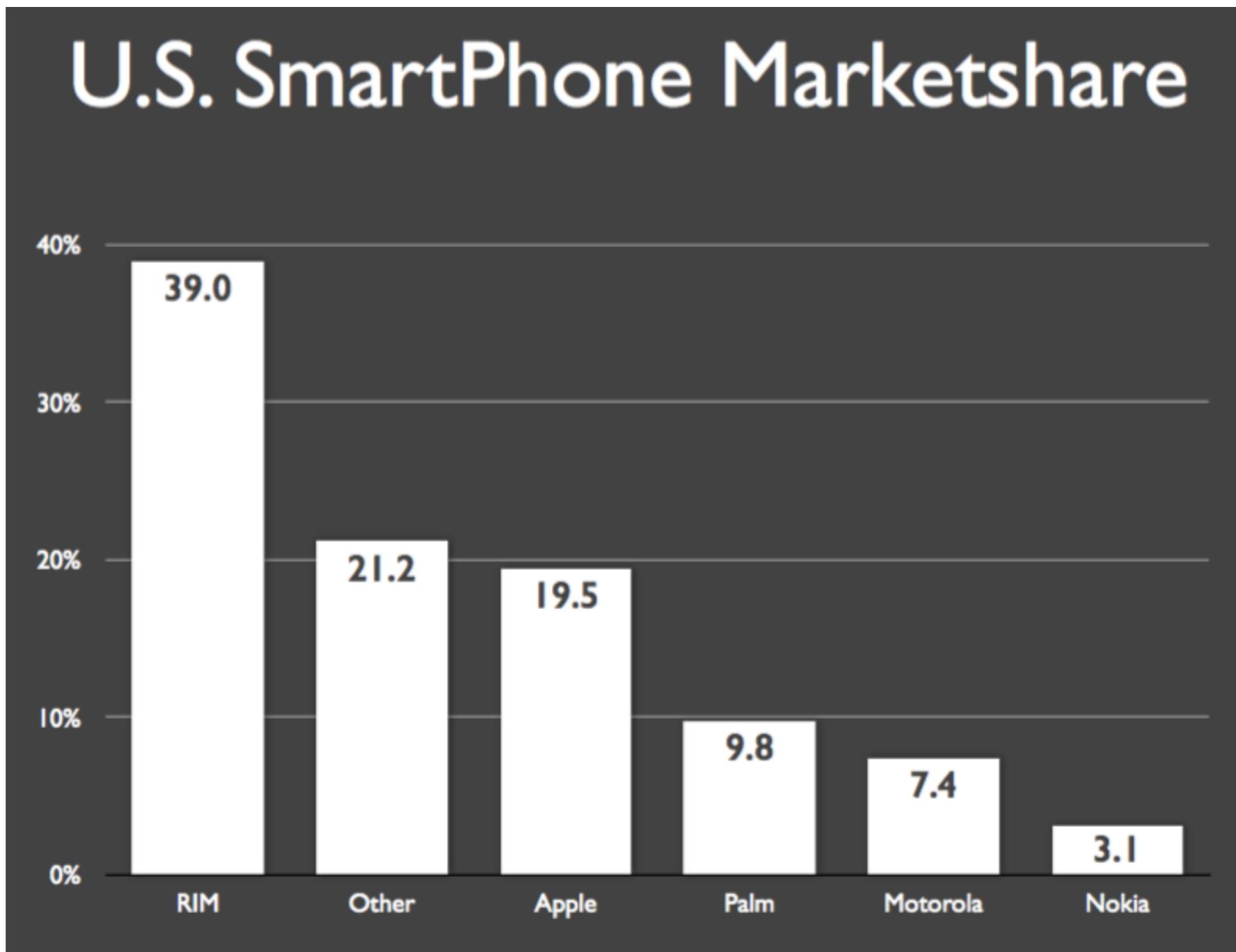
# INTEGRITY PRINCIPLE: SCALE DISTORTIONS IN 3D



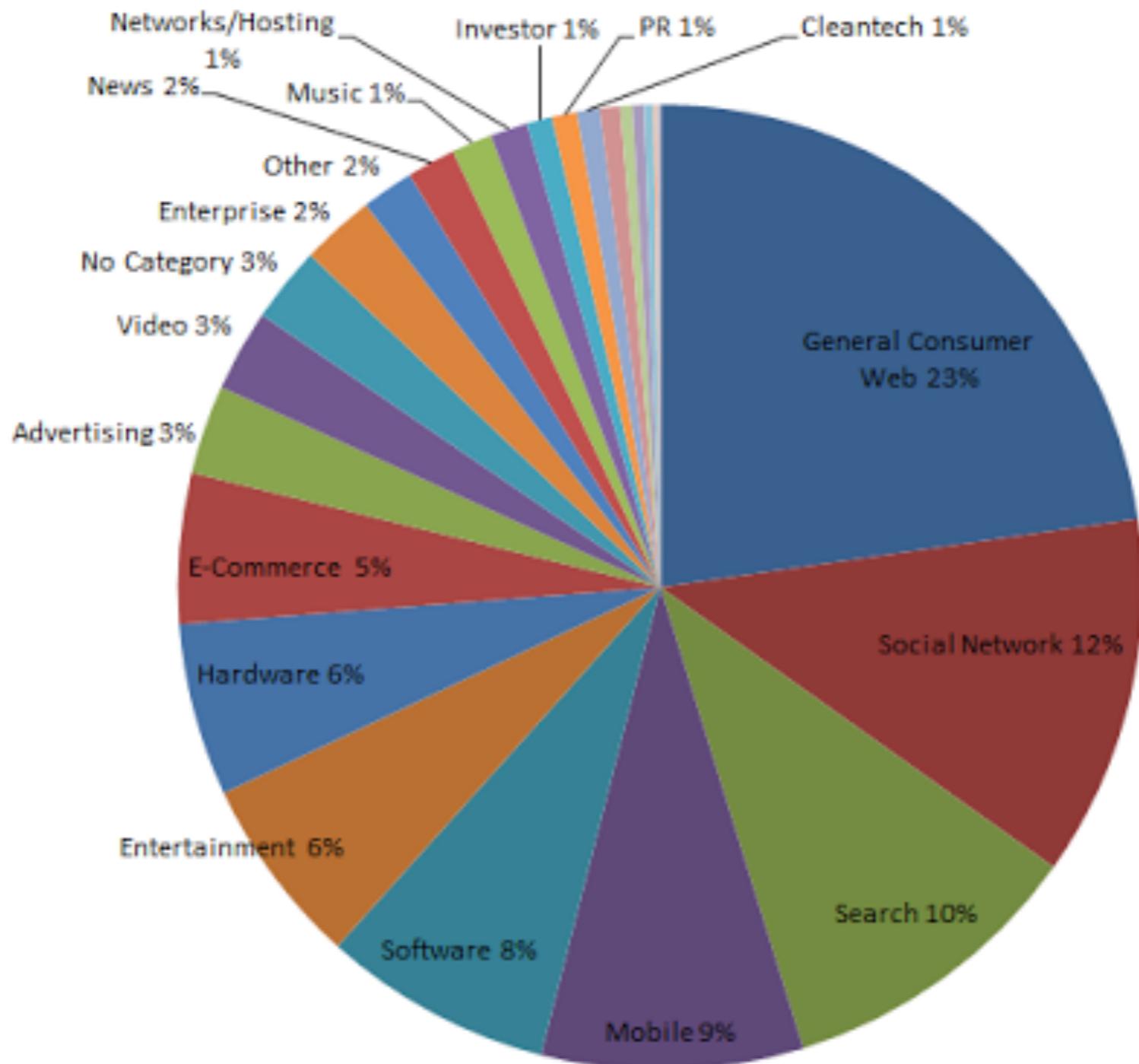
Slice at the front of the pie appears larger than it is

Slice in the back appears smaller than it is

# BAR GRAPH

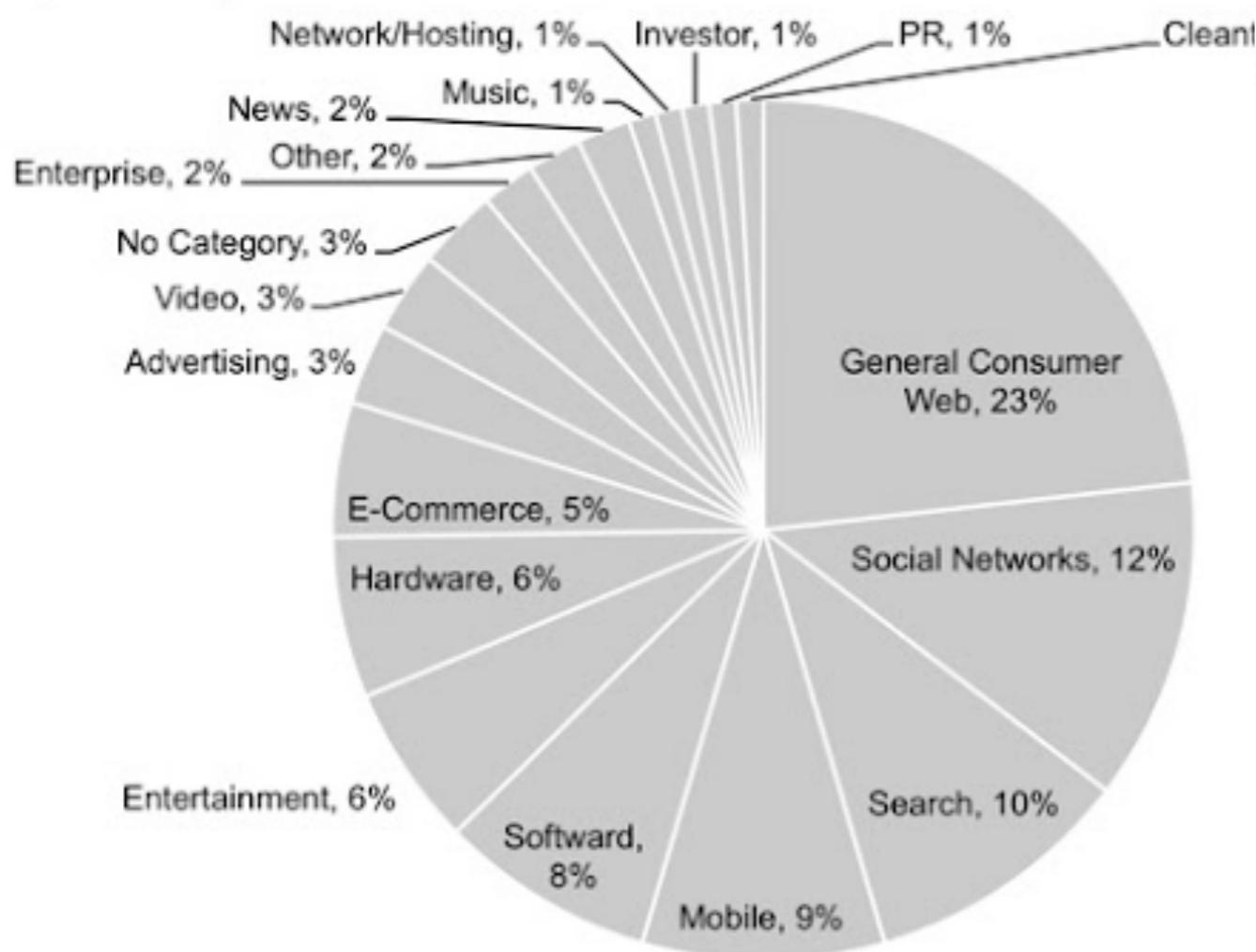


# PIE CHART PROBLEMS



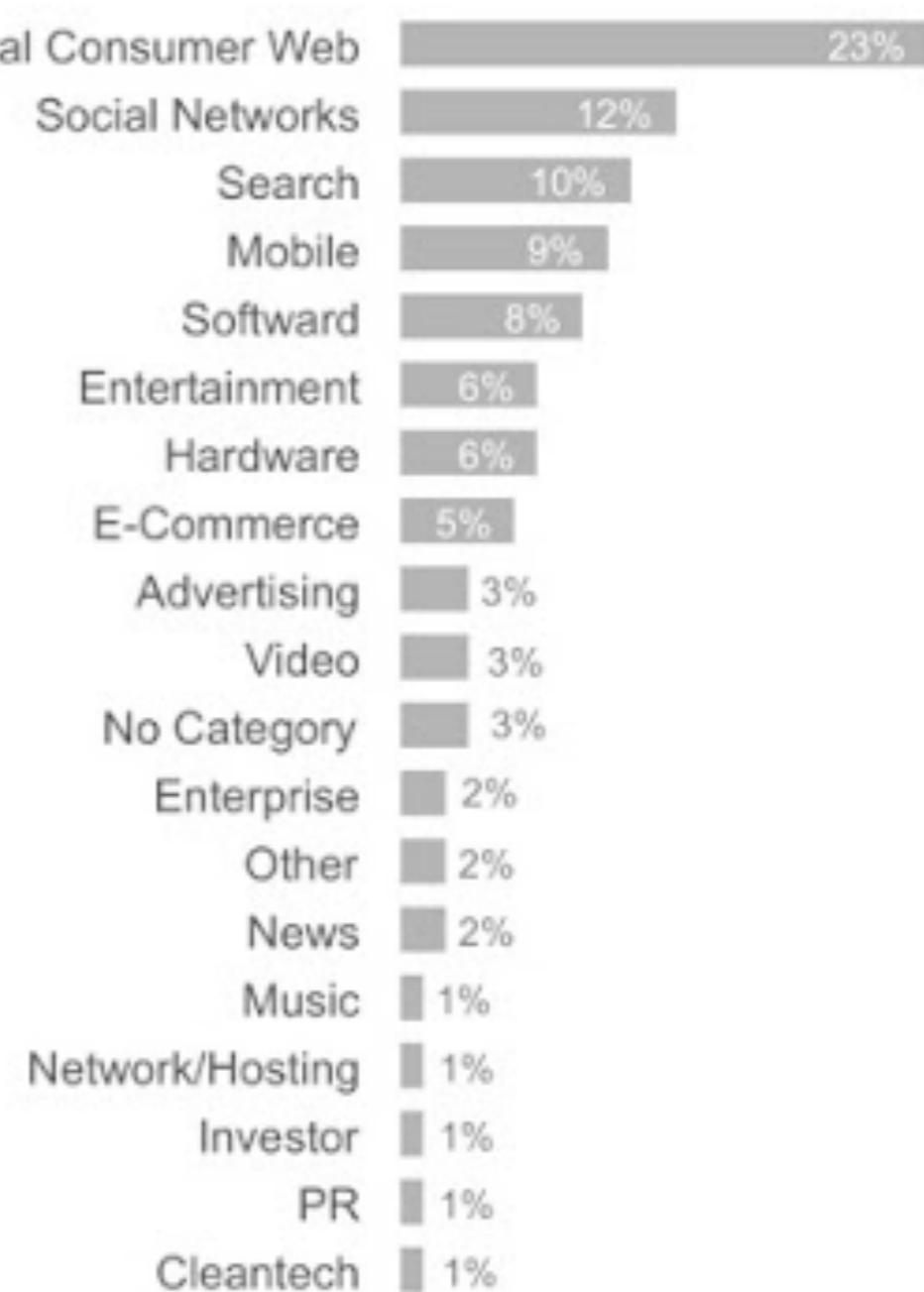
## TechCrunch Coverage: 2005 - 2011

A slightly better pie?



## TechCrunch Coverage: 2005 - 2011

Bars are best!



# PIE CHART INTERPRETATION – BIGGEST TO SMALLEST?

**A**



**B**



**C**

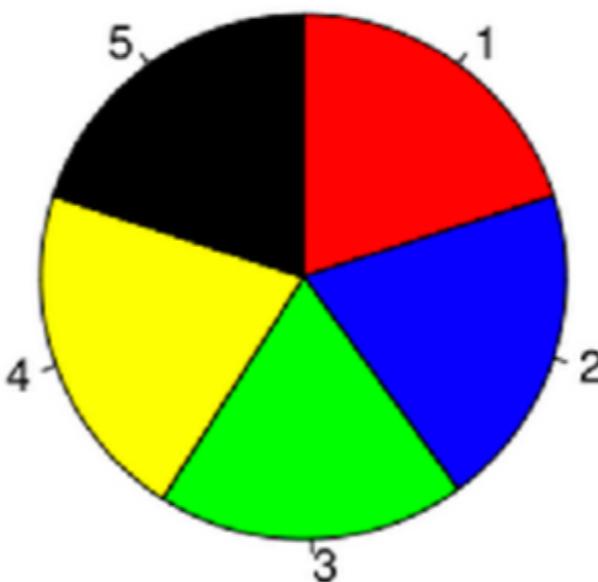


# PIE CHART INTERPRETATION – BIGGEST TO SMALLEST?

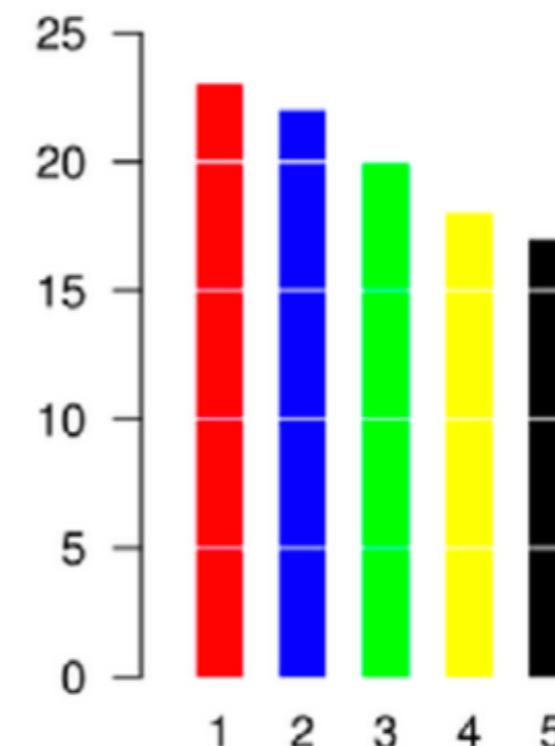
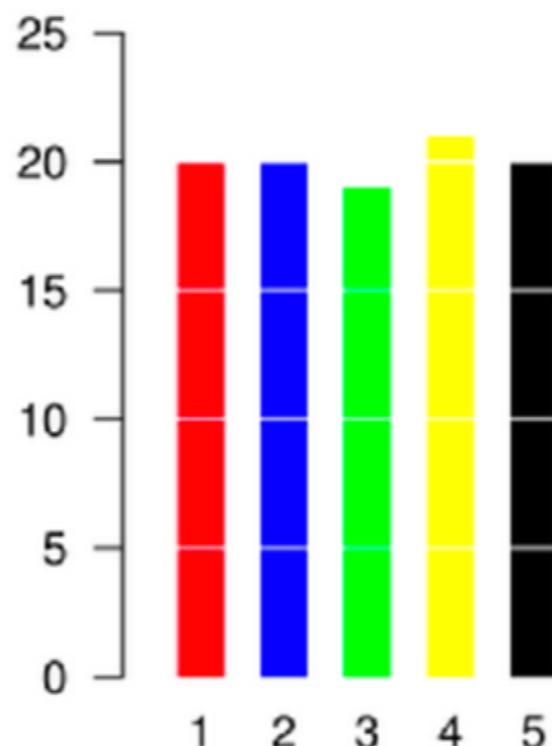
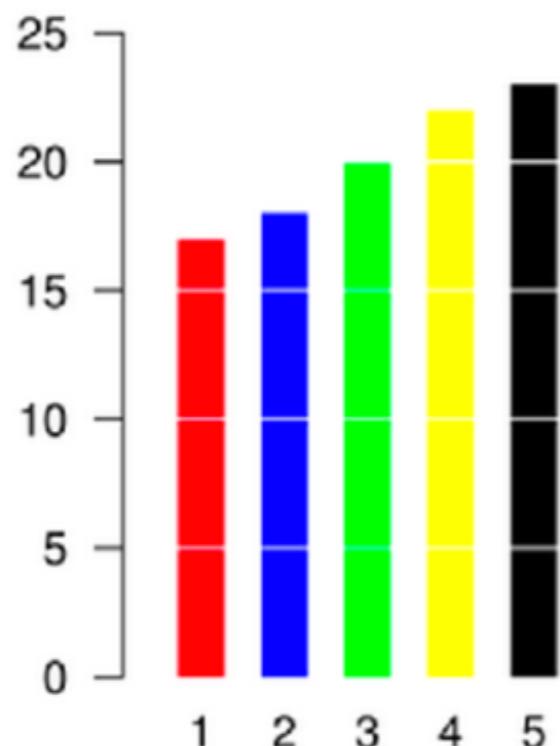
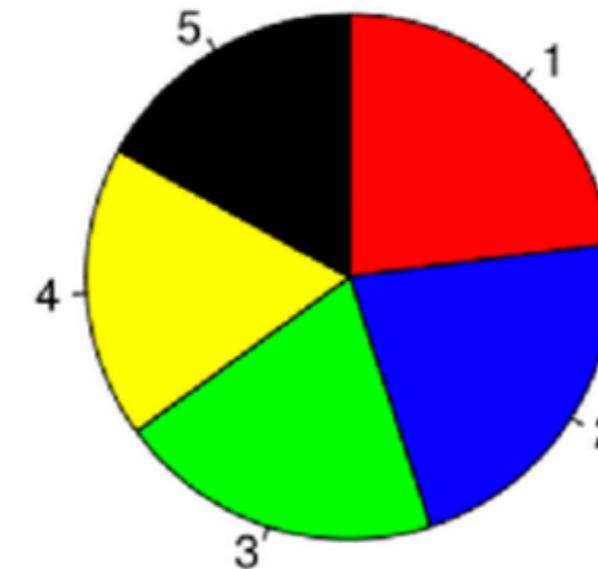
A



B

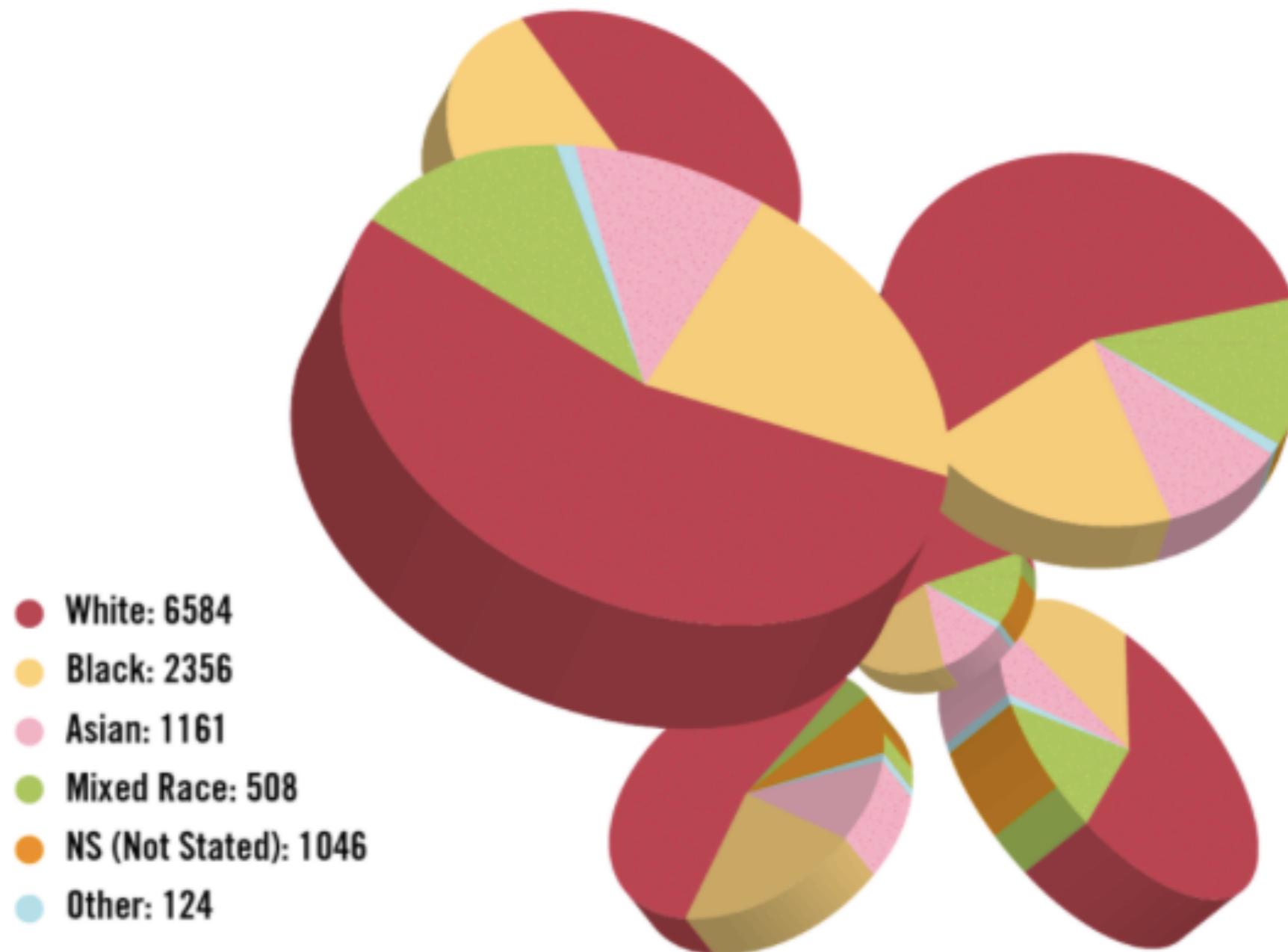


C

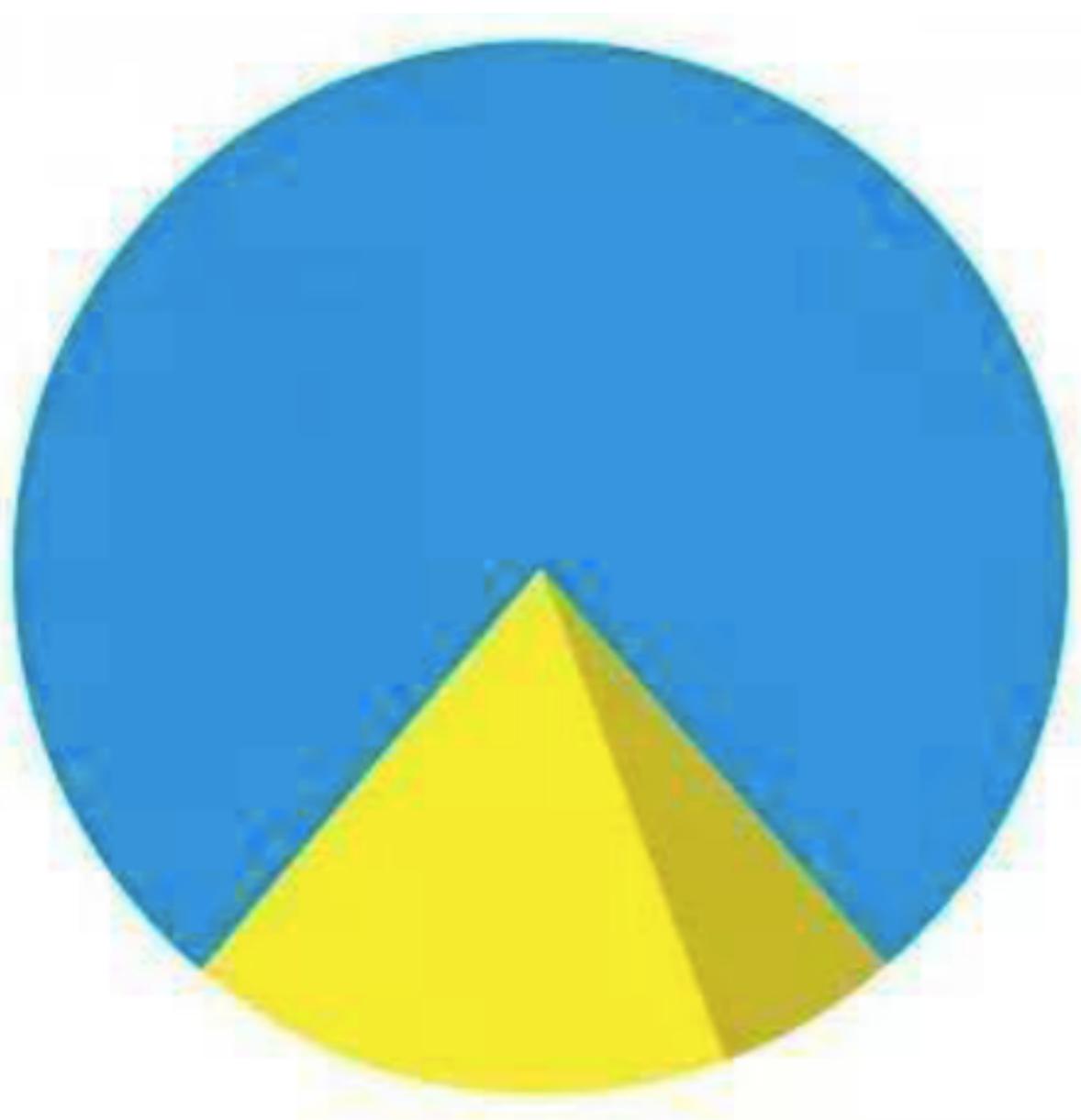


# PIE PROBLEMS

Convictions in England and Wales for class A drug supply.



# THE DATA VIS FAVOURITE PIE CHART



- Sky
- Sunny side of pyramid
- Shady side of pyramid

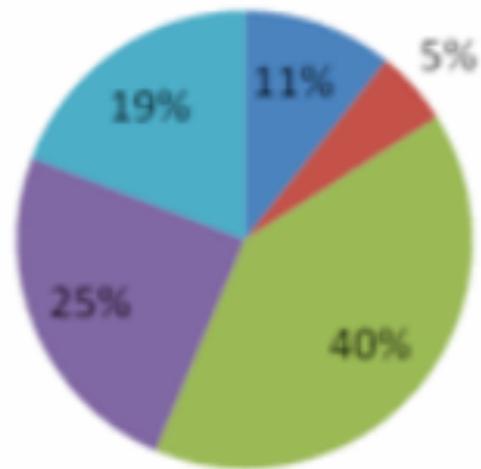
# THE DATA VIS SECOND FAVOURITE PIE CHART



# COMMUNICATION – WHAT IS THE IMPORTANT BIT OF INFORMATION?

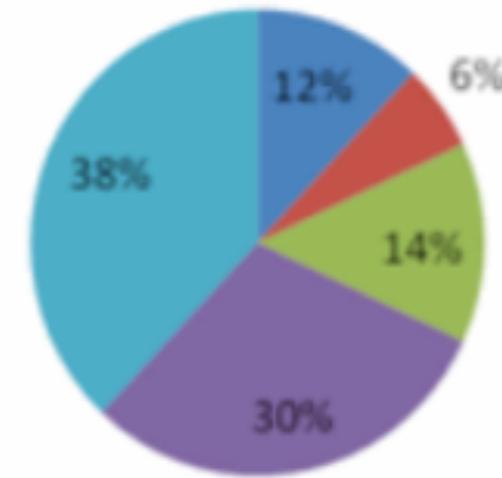
**PRE: How do you feel about doing science?**

■ Bored ■ Not great ■ OK ■ Kind of interested ■ Excited



**POST: How do you feel about doing science?**

■ Bored ■ Not great ■ OK ■ Kind of interested ■ Excited



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## REPORT THE IMPORTANT NUMBER

After the pilot program,

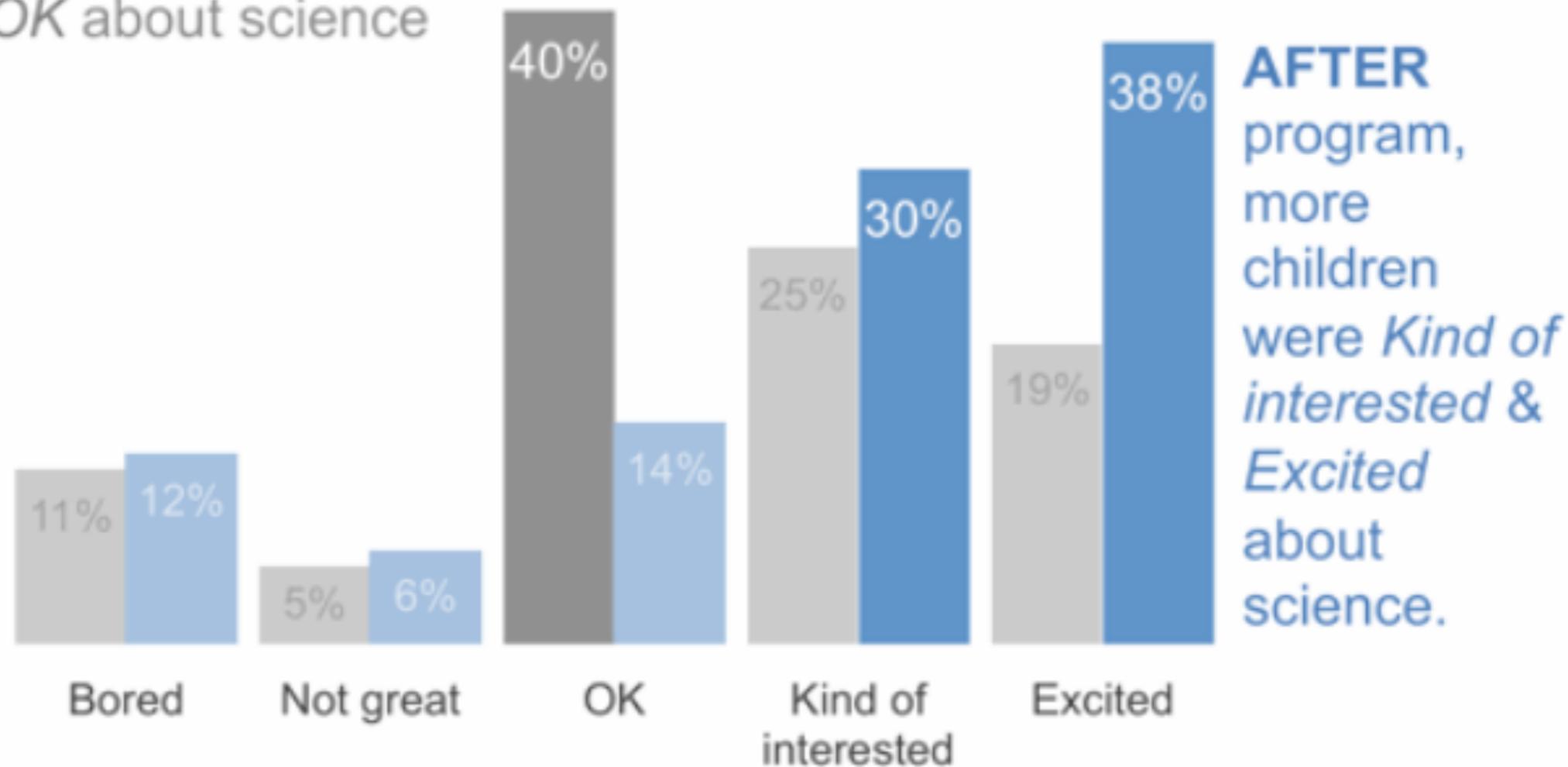
**68%**

of kids expressed interest towards science,  
compared to 44% going into the program.

# BAR GRAPH

How do you feel about science?

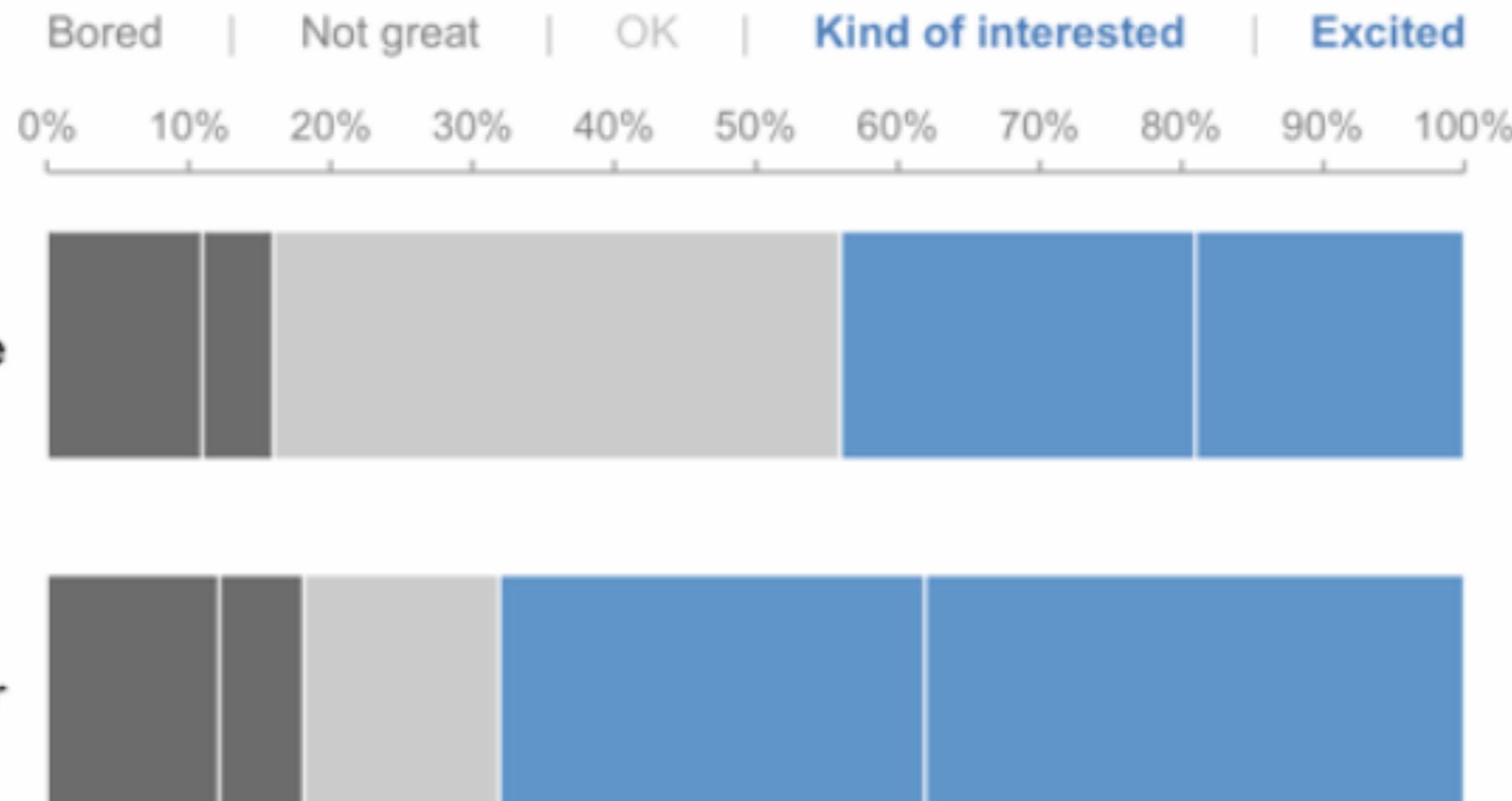
**BEFORE** program, the majority of children felt just OK about science



**AFTER** program,  
more  
children  
were *Kind of  
interested &  
Excited*  
about  
science.

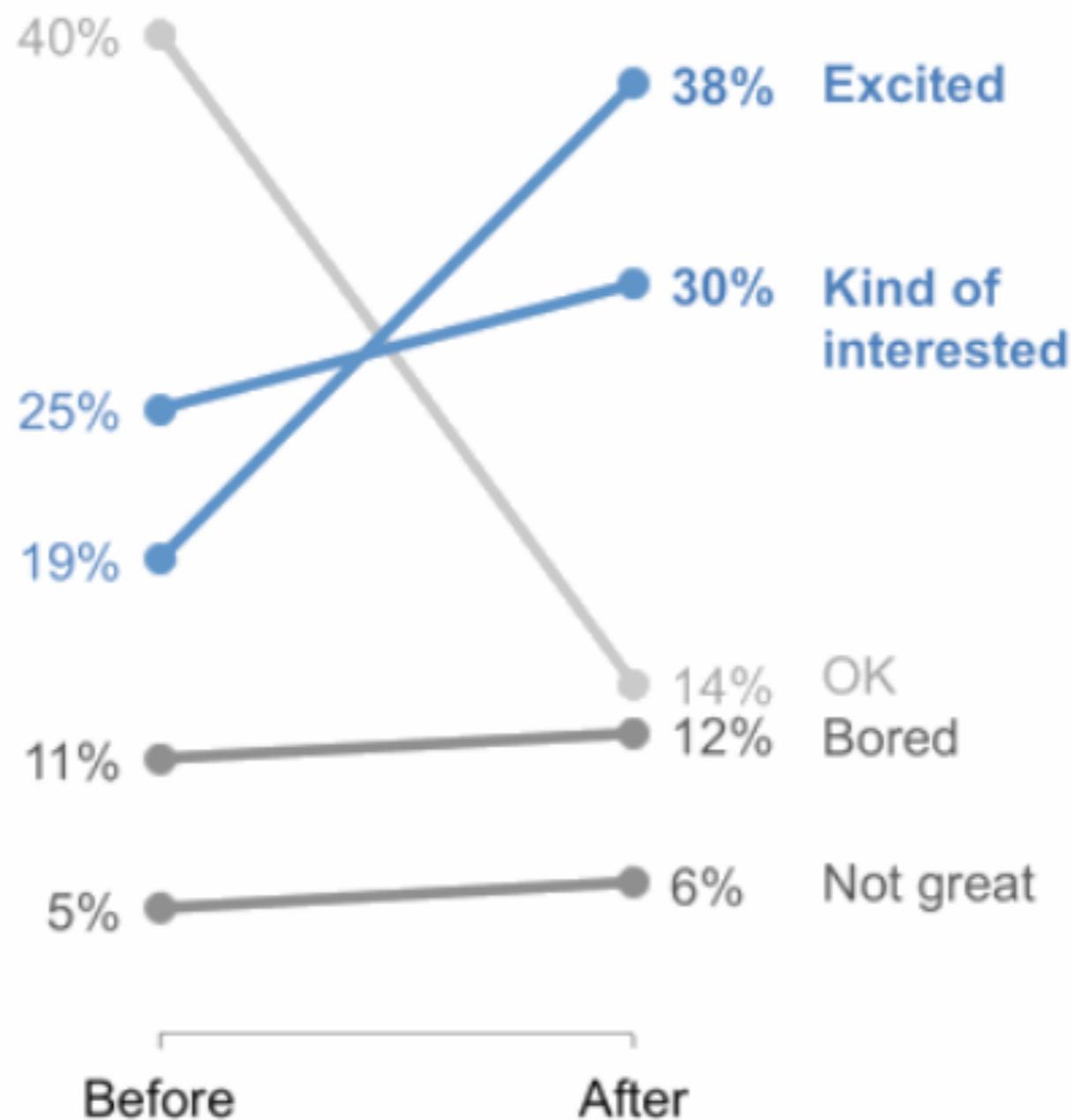
# STACKED HORIZONTAL BAR GRAPH

How do you feel about science?



# SLOPE GRAPH

How do you feel about science?



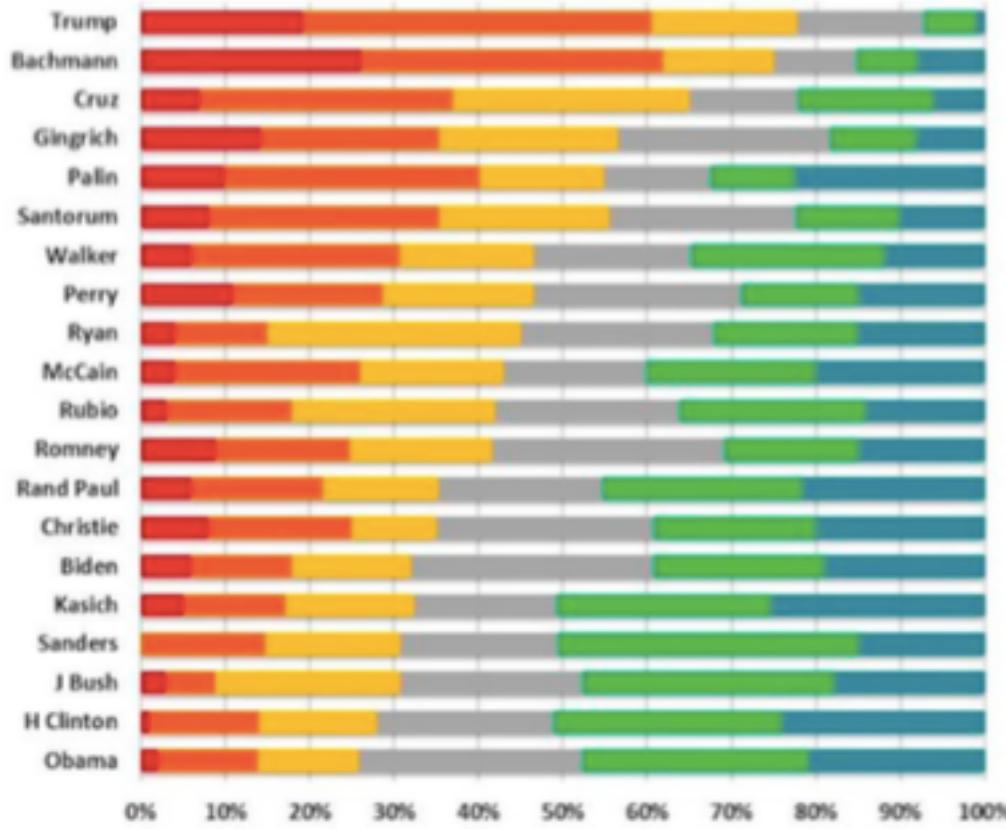
# ALIGNMENT

## ▶ Stacked horizontal bar graph

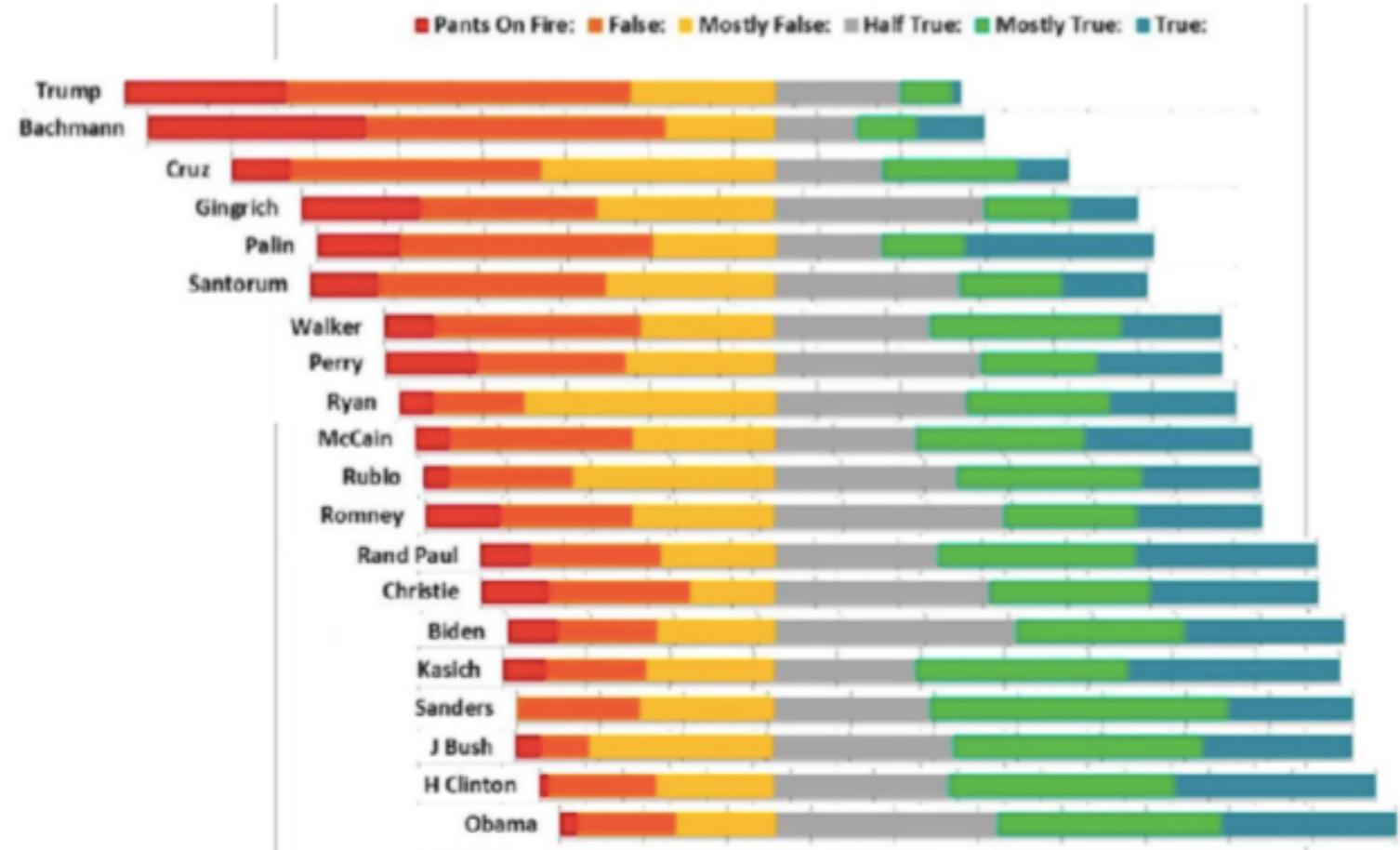
### Who Lies More: A Comparison

PolitiFact, an independent fact-checking website, has graded more than 50 statements since 2007 from each of these candidates. Here is how they rank.

■ Pants On Fire: ■ False: ■ Mostly False: ■ Half True: ■ Mostly True: ■ True:



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used in this presentation:

mostly from Microsoft Clipart circa 2009  
(unless otherwise specified)  
Note references are linked to images in PDF  
version of this presentation.

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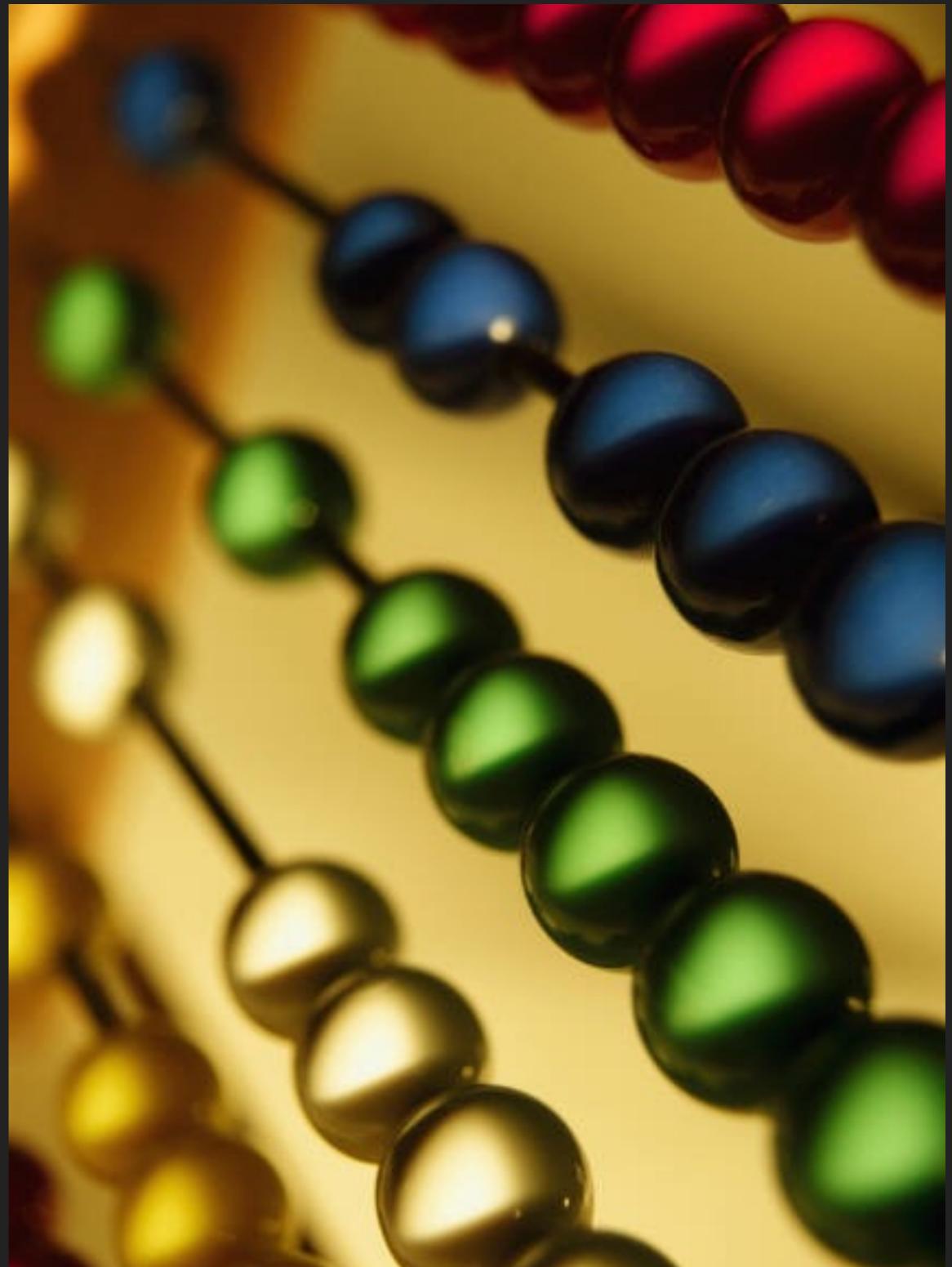
# DATA VISUALISATION

TOPIC 02-3: DESIGN GUIDELINES TUFTE'S DESIGN PRINCIPLES PART 1

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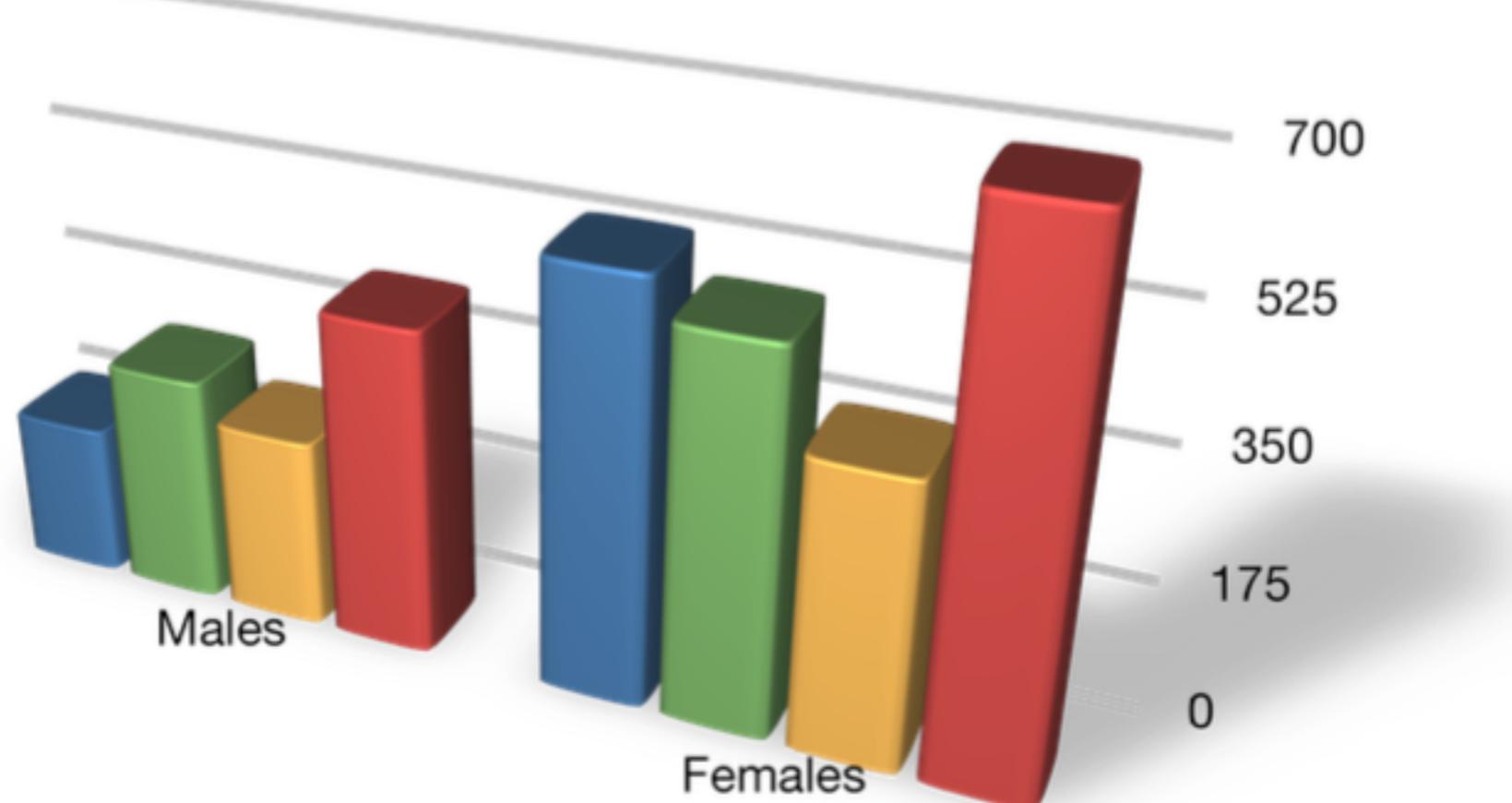
# TUFTÉ'S DESIGN PRINCIPLES

- ▶ Maximise data-ink ratio
- ▶ Avoid chart junk
- ▶ Aim for high data density
- ▶ Layering and separation of information



# DESIGN PRINCIPLE: MAXIMIZE DATA-INK RATIO

Data-Ink Ratio =  $\frac{\text{data-ink}}{\text{total ink used in graphic}}$



■ 0-\$24,999

■ \$25,000+

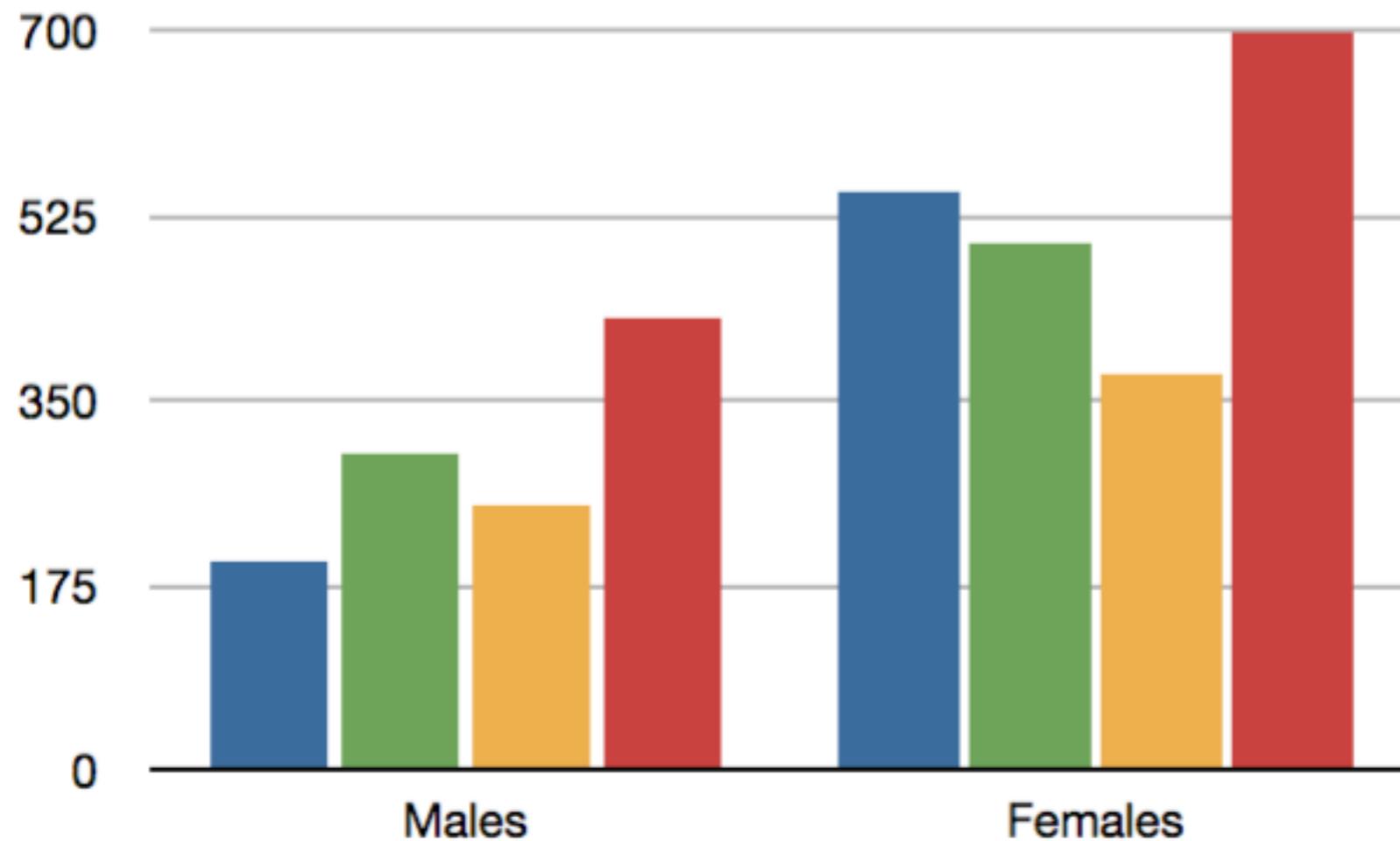
■ 0-\$24,999

■ \$25,000+

HP/AL Reference

# DESIGN PRINCIPLE: MAXIMIZE DATA-INK RATIO

Data-Ink Ratio =  $\frac{\text{data-ink}}{\text{total ink used in graphic}}$



■ 0-\$24,999

■ \$25,000+

■ 0-\$24,999

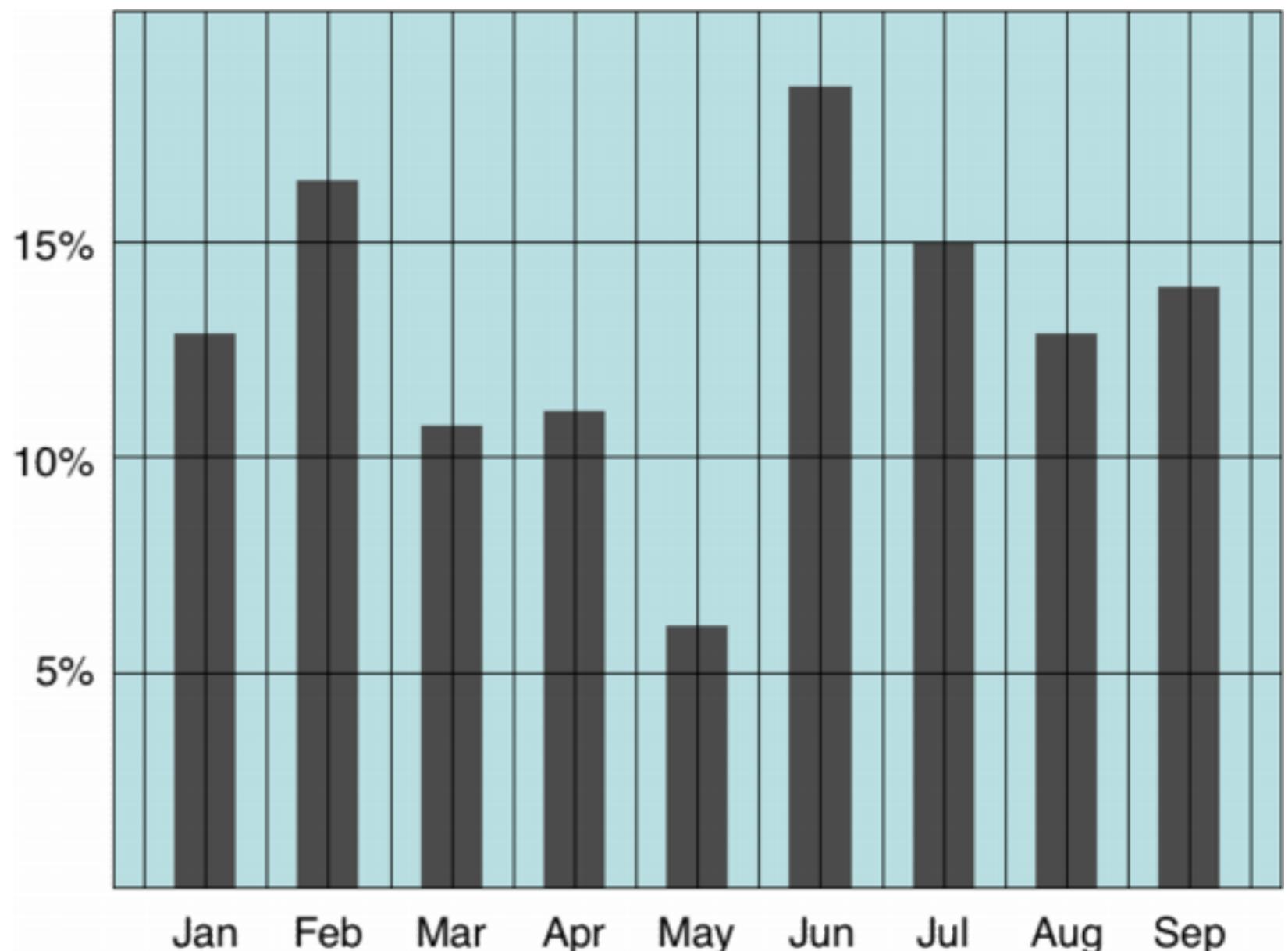
■ \$25,000+

HP/AL Reference

# DESIGN PRINCIPLE: MAXIMIZE DATA-INK RATIO

- ▶ Avoid 'Chart Junk':

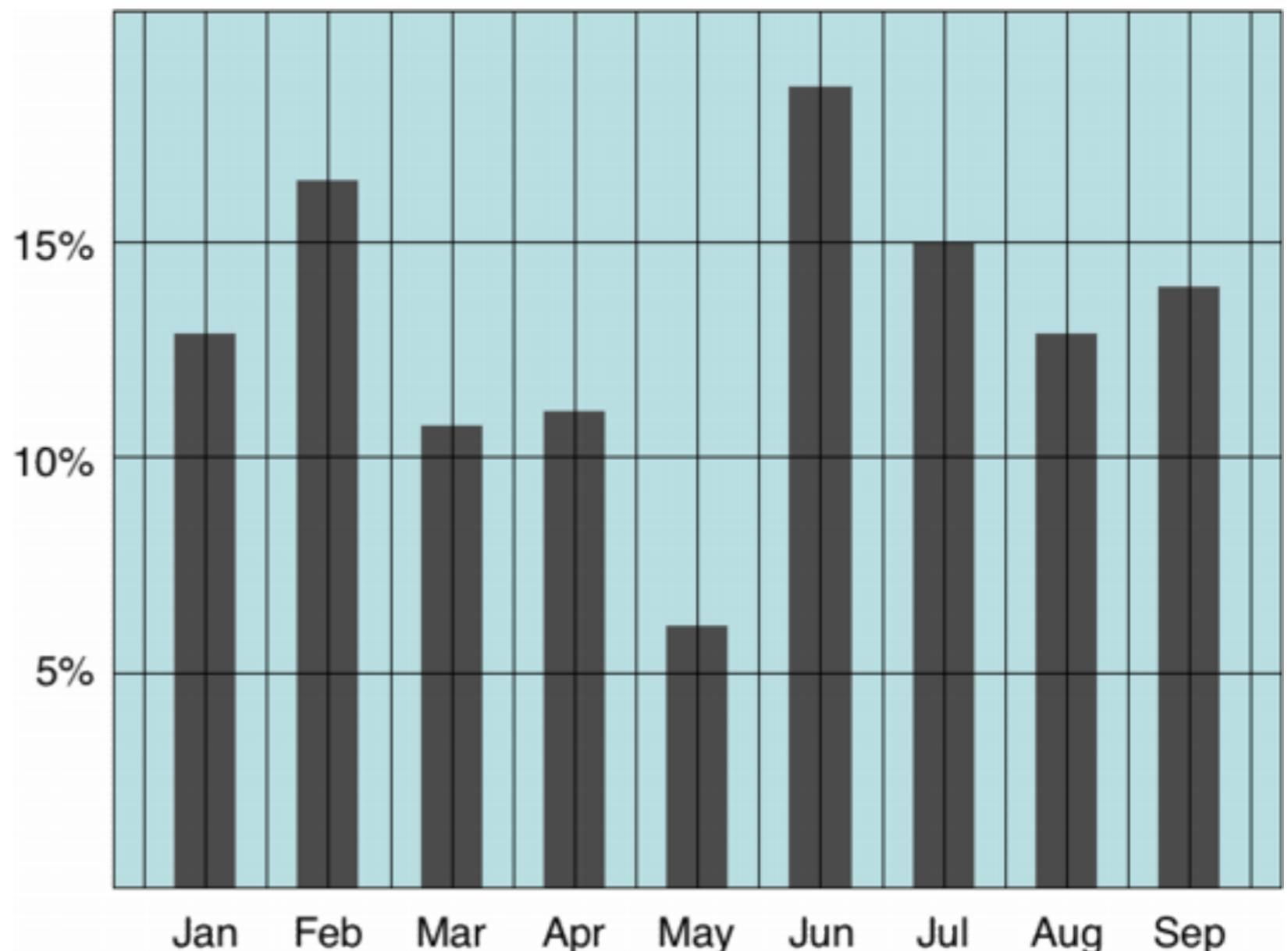
- ▶ Chart Junk:  
extraneous visual  
elements the  
district from the  
message



# DESIGN PRINCIPLE: MAXIMIZE DATA-INK RATIO

## Bar Graph

- ▶ 9 data points
- ▶ Very poor data-ink ratio

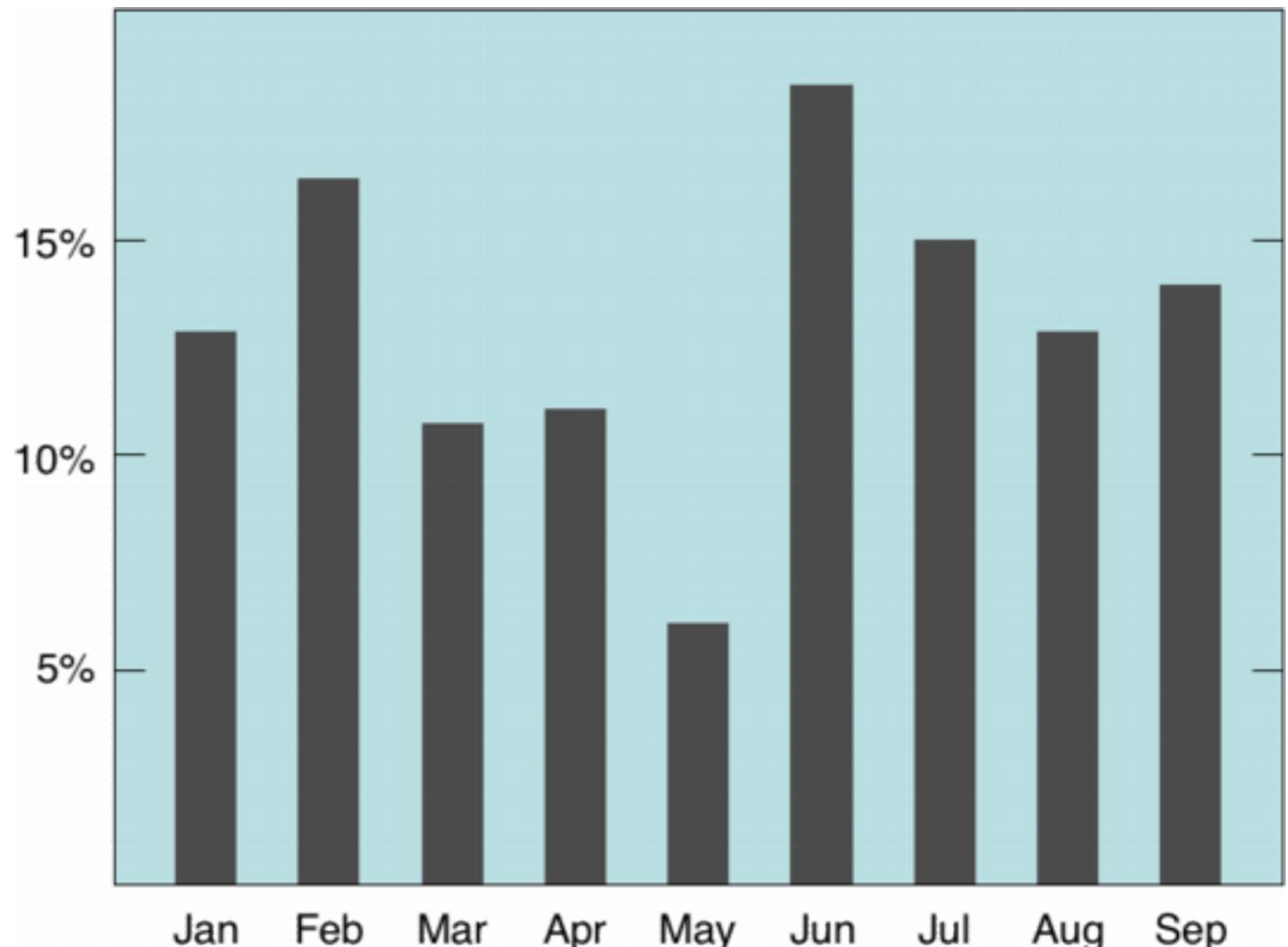


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# DESIGN PRINCIPLE: MAXIMIZE DATA-INK RATIO

## Bar Graph

- ▶ remove the grid

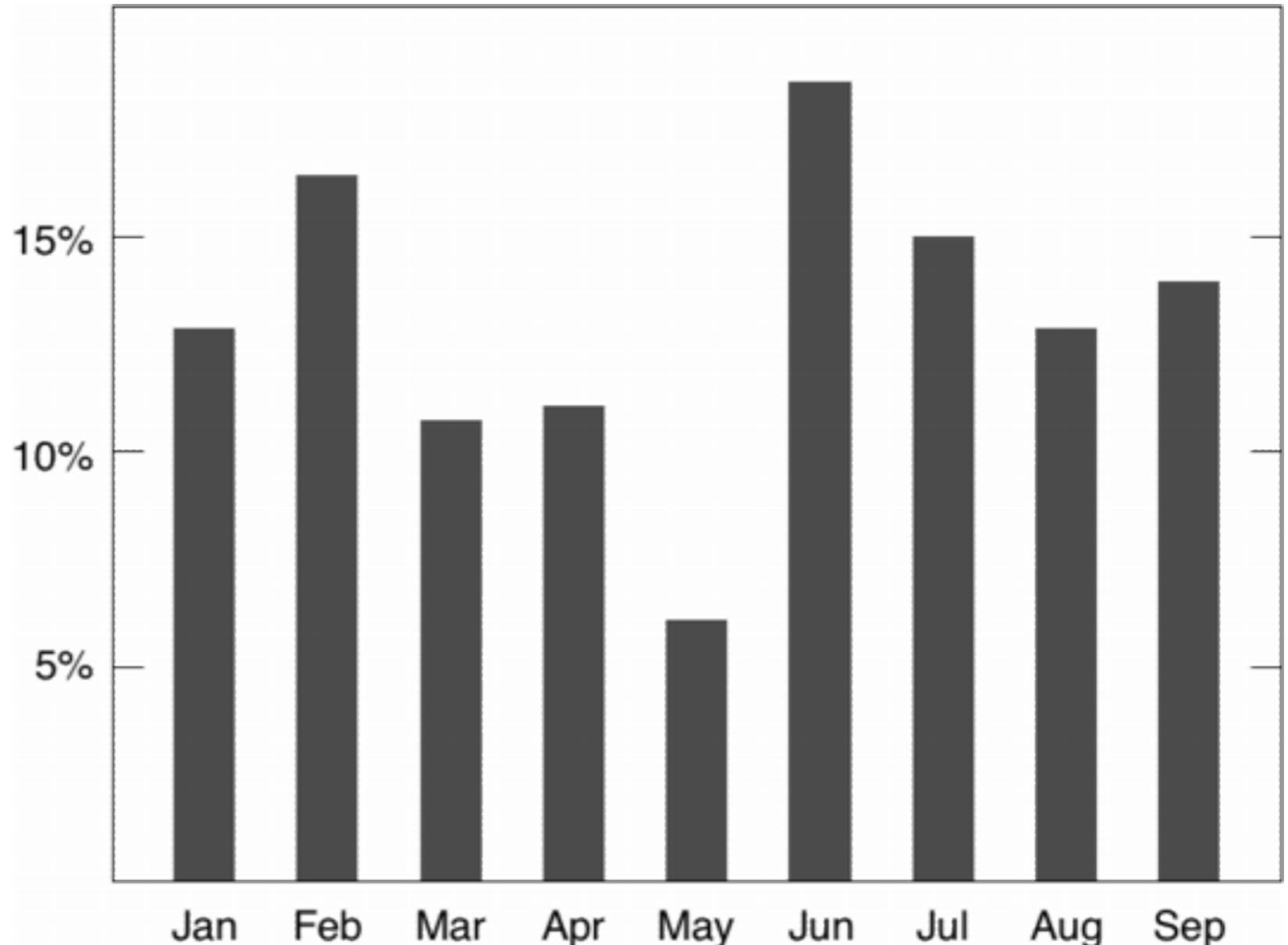


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# DESIGN PRINCIPLE: MAXIMIZE DATA-INK RATIO

## Bar Graph

- ▶ remove the background

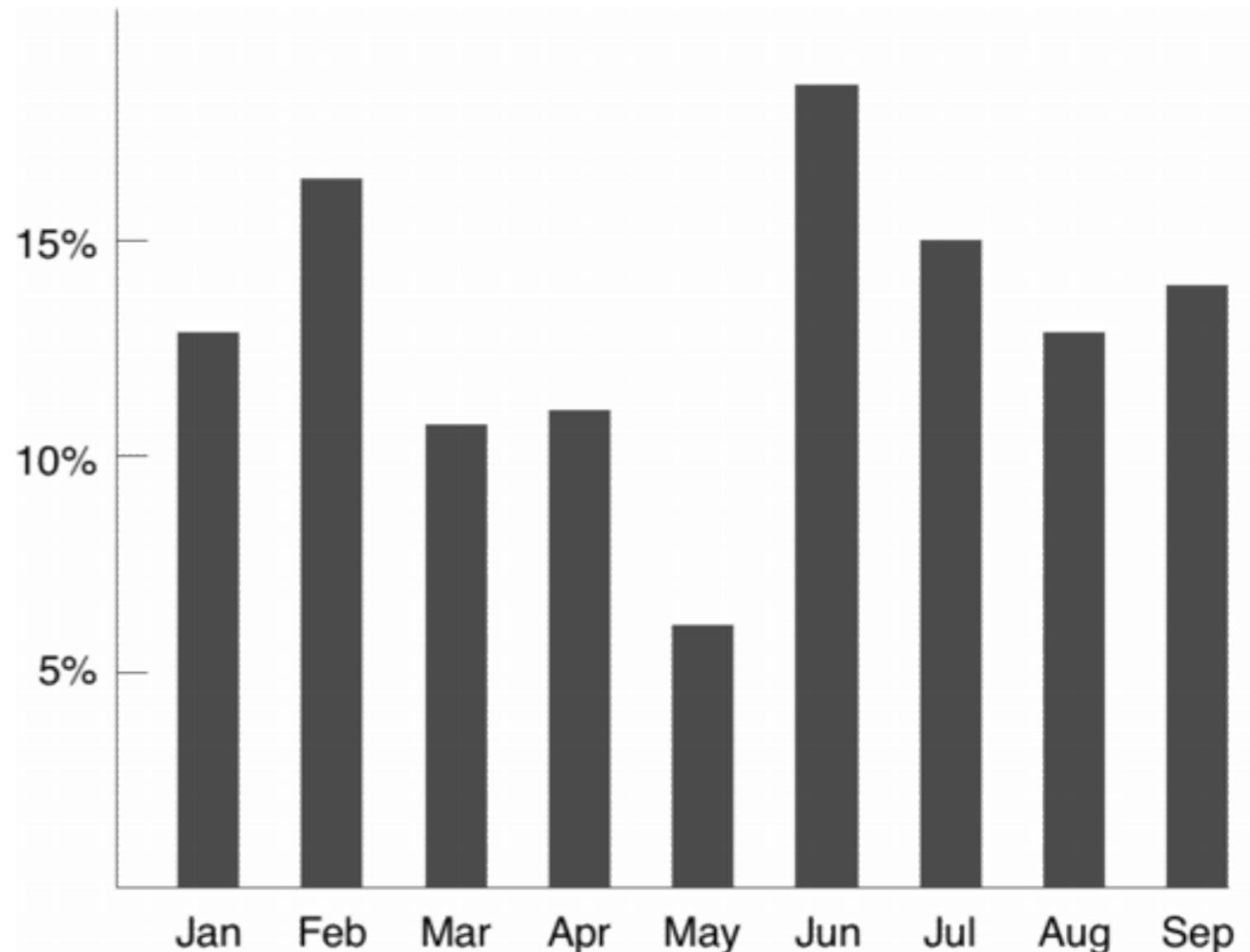


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# DESIGN PRINCIPLE: MAXIMIZE DATA-INK RATIO

## Bar Graph

- ▶ remove the box

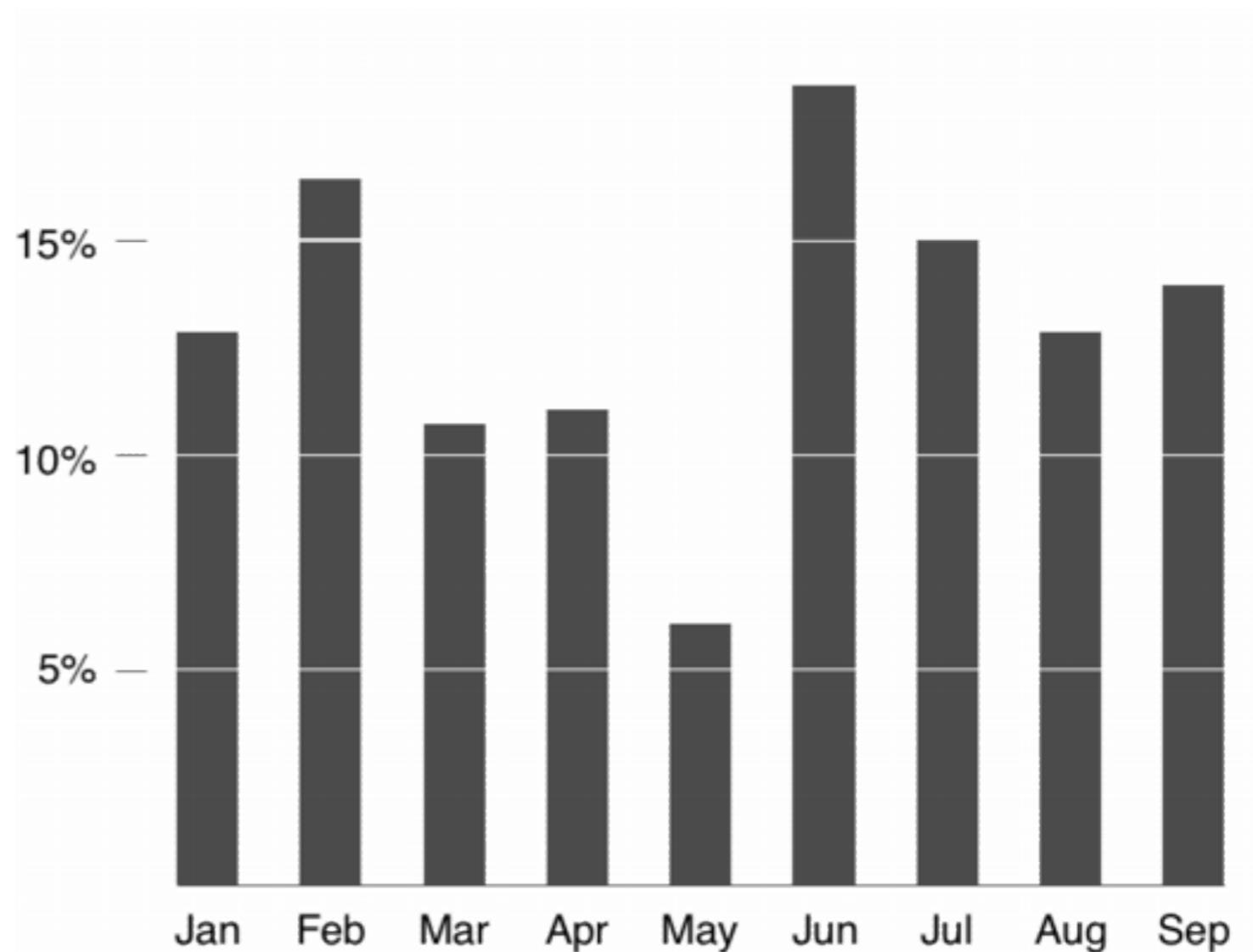


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# DESIGN PRINCIPLE: MAXIMIZE DATA-INK RATIO

## Bar Graph

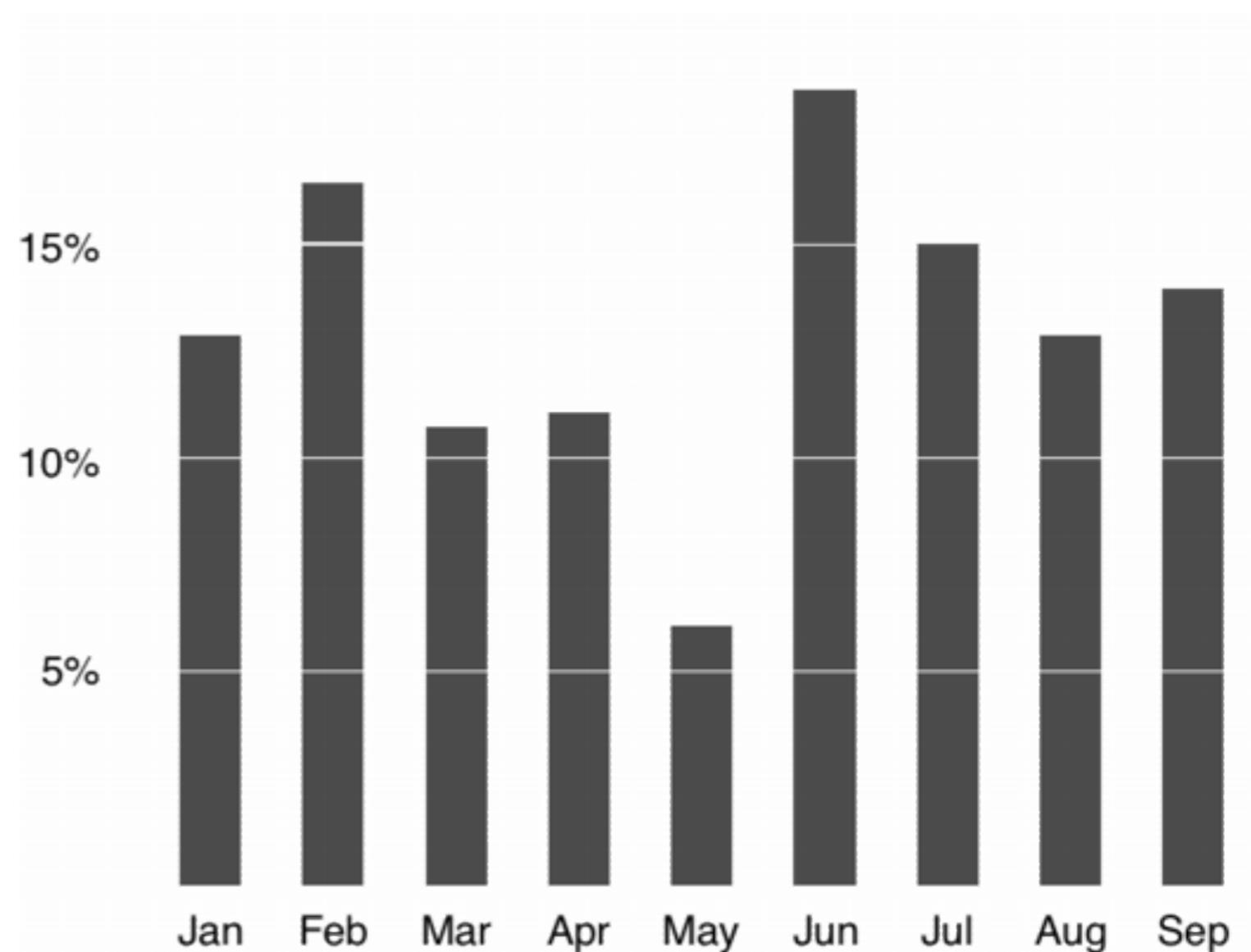
- ▶ subtract ink to make horizontal scale



# DESIGN PRINCIPLE: MAXIMIZE DATA-INK RATIO

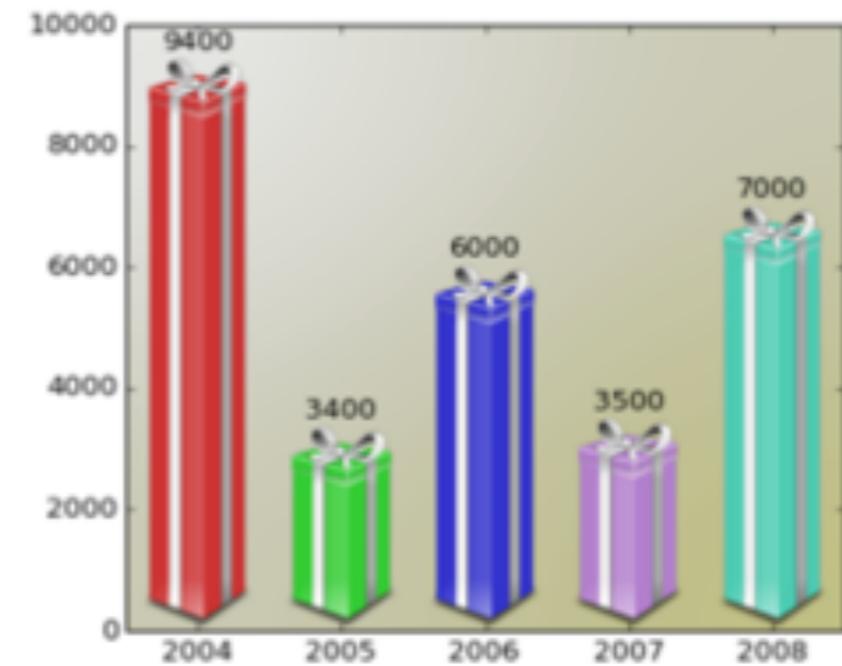
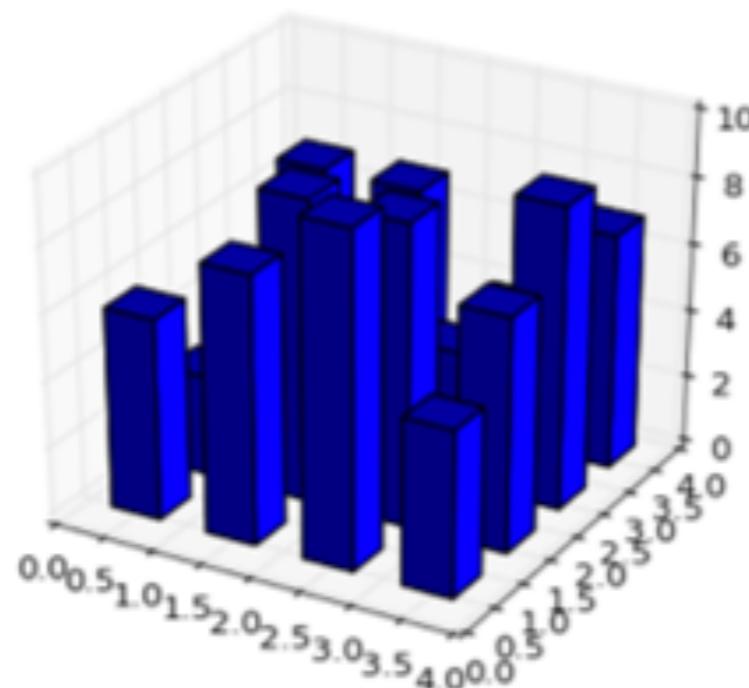
## Bar Graph

- ▶ take out base line and horizontal ticks
- ▶ every pixel communicates information about the data

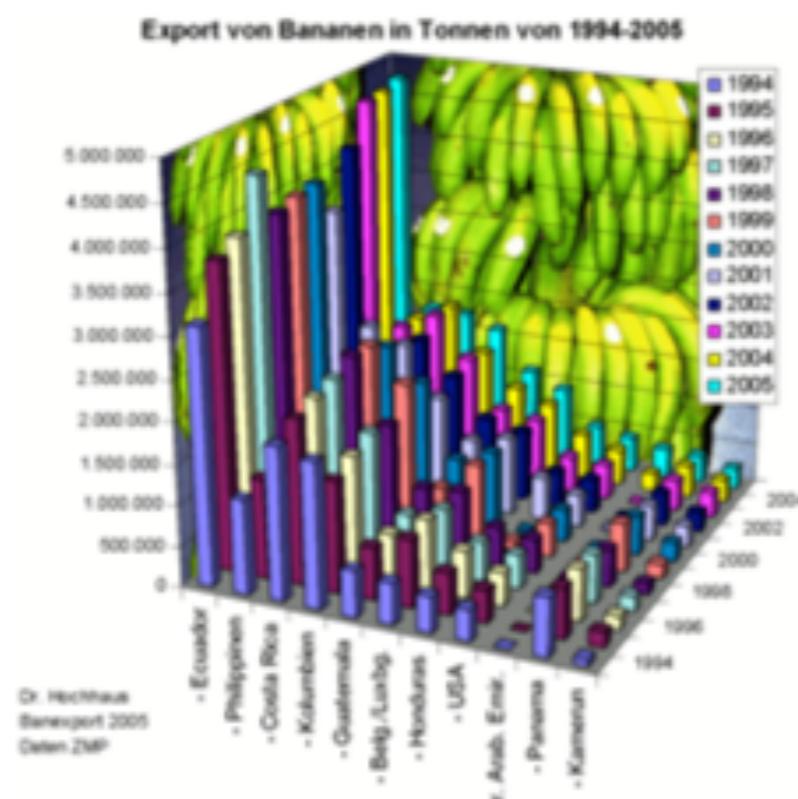


# DESIGN PRINCIPLE: MAXIMIZE DATA-INK RATIO

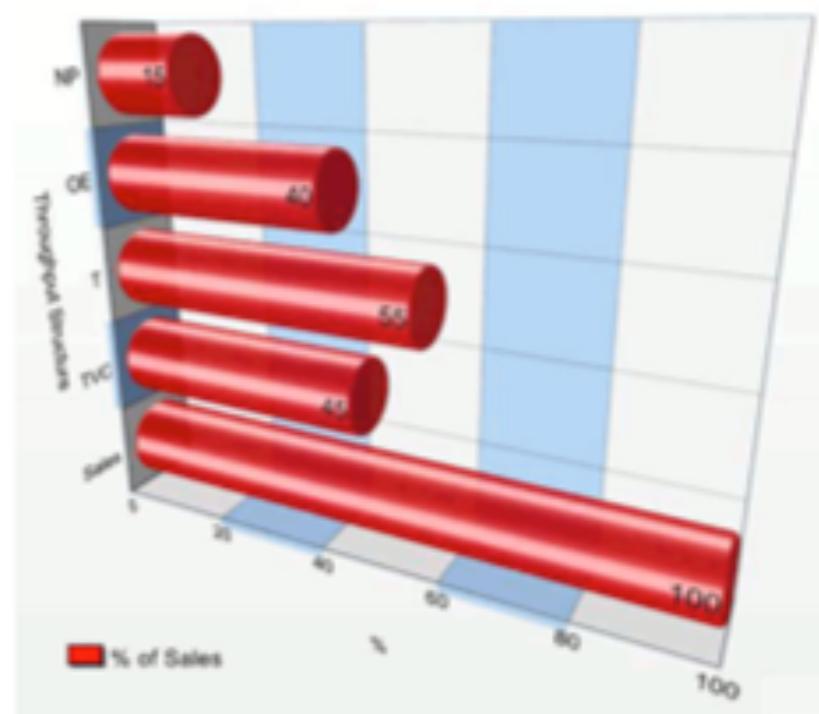
Too much  
'ink'!!



matplotlib gallery



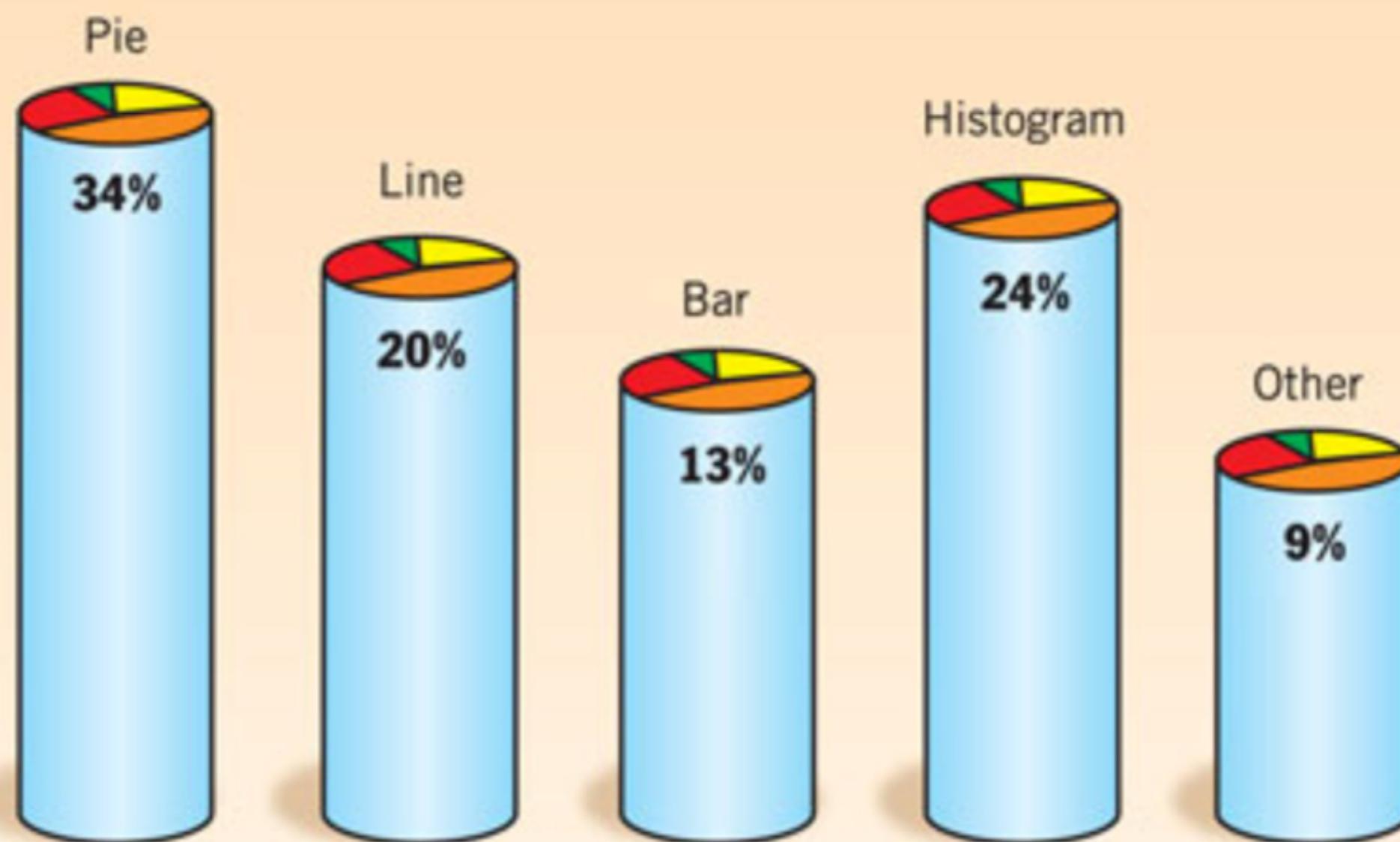
Dr. Hochhaus  
Banenport 2005  
Daten ZMP



% of Sales

Excel Charts Blog

# America's Most Popular Charts



# DESIGN PRINCIPLE: DATA DENSITY

Data Density = 

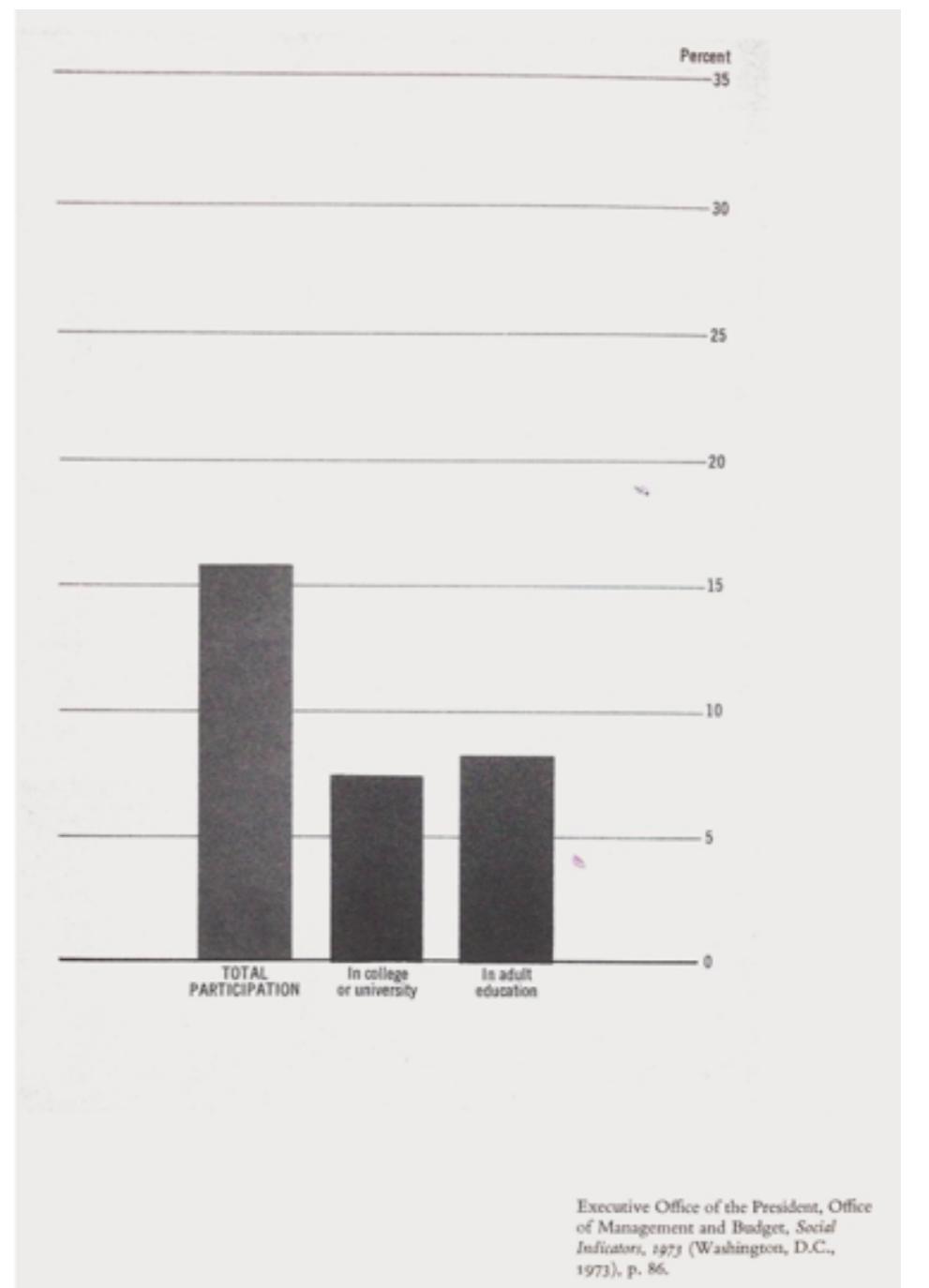
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 area of data in graphic

- ## ▶ aim for high data density

<b>4-POINT</b>	<b>BELL GOTHIC</b>	<b>BELL CENTENNIAL-1</b>
Vaughn Donald L 542 39th St Short Wylam	--- 780-6608	
Vaughn Ernest		
65 Merriment Rd Hertseyton	--- 491-6244	
Vaughn J 625 Barclay Ln	836-2436	
Vaughn Joe Jr Stert	672-2919	
Vaughn John 2109 44th Pl F'ntl Park	978-4227	
Vaughn Susan A 2109 44th Pl F'ntl Park	787-4227	
Vaultz Eva 1543 Denison Av SW	925-1752	
Vause F 603 Huckleberry Ln	979-5289	
Vause Stephen 445 1/2 Cres Crest Rd	926-2642	
Vause Harold G 445 1/2 Cres Spring Rd	853-2642	
Vautrot Ruby L Mpls 1015 10th Av S	933-2865	
<b>Vauquel Norberto</b>		
Old Jaisan Hwy Adamsville	674-3370	
Vawter 1000 28th St Wm Dr	352-6102	
Veach Leonie Adrienne	665-1831	
Vead Al 251 21st Av S	251-9049	
Vead Al 21st 1711 Pinson	841-7380	
Vead Al 21st 1711 Pinson	841-2789	
Vean Clarence E Gandy	631-3836	
<b>VEAL CONVENTION SERVICES—</b>		
1711 Pinson	841-2789	
2109 10th Av N	352-6102	
Veezey Wilbur E 1541 53rd St Easley	923-1960	
Veezey Wilbur William A 287—A Chastain Cir	942-4137	
Veezey Willie J 3048 Whipping Pines Cir	823-5795	
Vebco Corp 1900 28th Av S Homewood	956-1661	
Vebco Corp 1900 28th Av S Homewood	879-2259	
Vedel Dental Technicians Inc lab		
1116 5th Av N	322-5475	
Vedel George E 304 Columbia Dr	967-2832	
Vedel George E 7474 Saurier Ln	974-2832	
Res/34744 Saurier Ln	870-7478	
Vedel Murray B 121 Oakmoor Dr	942-3639	
Vedel Collier J Daily City	674-7772	
Veechoneth & Co 1000 28th Av Hill Dr	251-3567	
Veechoneth & Co Encls ags 2930 7th Av S	251-3567	
Veenchoten L A 1919—D Tree Top Ln	822-7109	
Veenchoten W 3205 Pine Ridge Rd	871-8883	
Vega Abraham 1516 16th St N	933-7619	
Vega Debra S 4 Waterman Cir	839-2000	
Vegan Edwin 216 Rockland Dr Bluff Park	823-0403	
Vegetable Patch Number 1 The		
Highway 31 S Alabst	663-7618	
Vegetable Patch Number 2 Dogwood	663-7718	
Vegetable Patch The Number 2 Dogwood	665-4179	
Vegil Patrick B Pawnee	841-1238	
Veitch Beulah 1172 7 Ave Mile Rd	853-3361	
Vest 1000 28th Av Wm Dr	841-7402	
Vest W 7 1/2 37 N Adams	836-6371	
Vesta Villa Exeon Self Seve		
1500 Hwy 31 S	823-5008	
<b>VESTAVIA CEMETERY SERVICE</b>		
1454 Main St Vestavia	822-1213	
<b>VESTAVIA BARBECUE &amp; LOUNGE</b>		
610 Montgomery Hwy Vestavia	822-9904	
Vestavia Barber Shop		
1421 1/2 37th N Adams Hwy	823-1974	
<b>VESTAVIA BEAUTY SALON</b>		
710 Montgomery Hwy	823-1893	
<b>Vestavia Beverage Co</b>	674-Montgomery Hwy	822-9847
<b>VESTAVIA</b>		
Montgomery Hwy S Vestavia	979-4420	
Vestavia Church Of Christ	2325 Columbiana Rd	822-0018
<b>VESTAVIA CHURCH OF GOD</b>		
2325 Columbiana Rd	823-1895	
Vestavia Church Of God Day Care day	nursery 2535 Columbiana Rd	823-1895
<b>VESTAVIA CITY OF—See Vestavia</b>		
Hills City Of		
<b>VESTAVIA COIFFEURS</b>		
617 Montgomery Hwy-Vestava	823-1104	
Vestavia Country Club		
Shades Mountain	823-2451	
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Golf Shop Shades Mountain	822	

Telephone book:  
very high data  
density

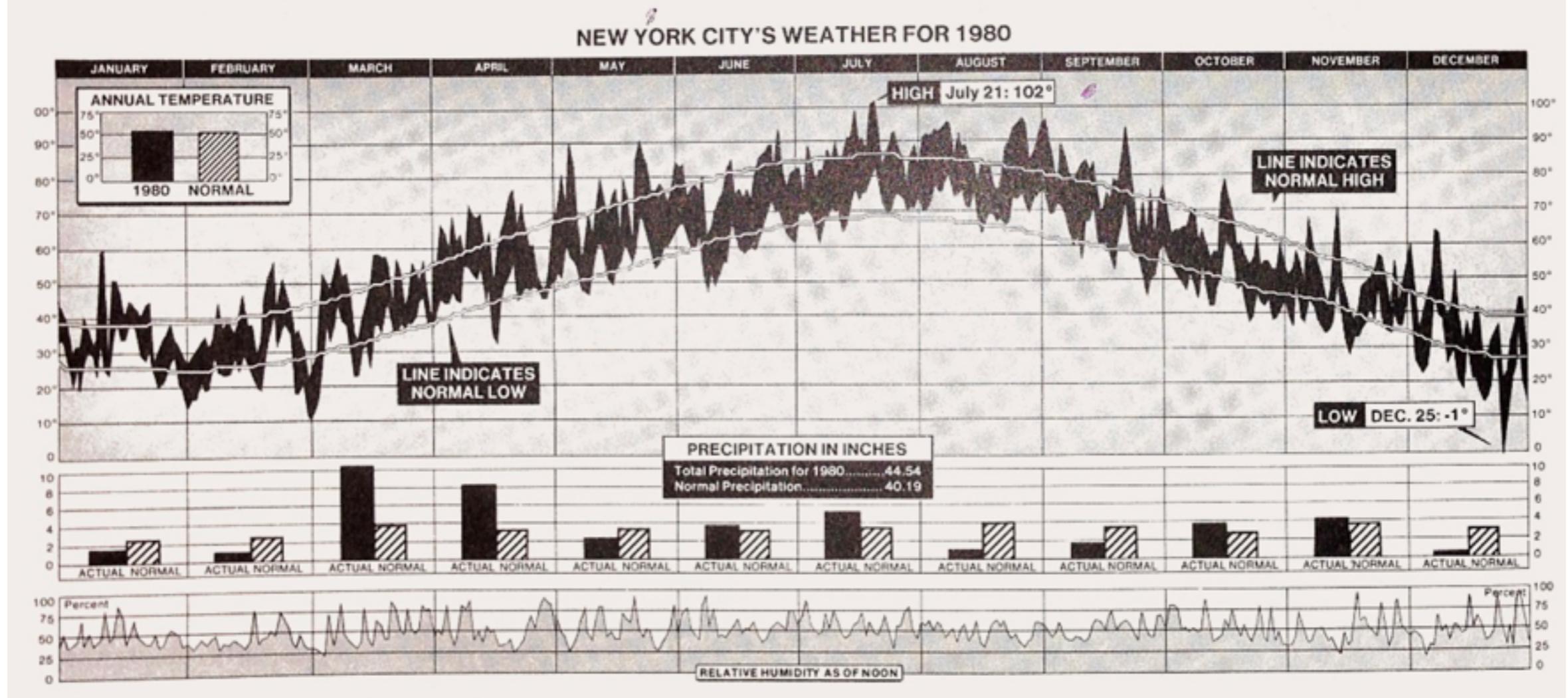


Tuft

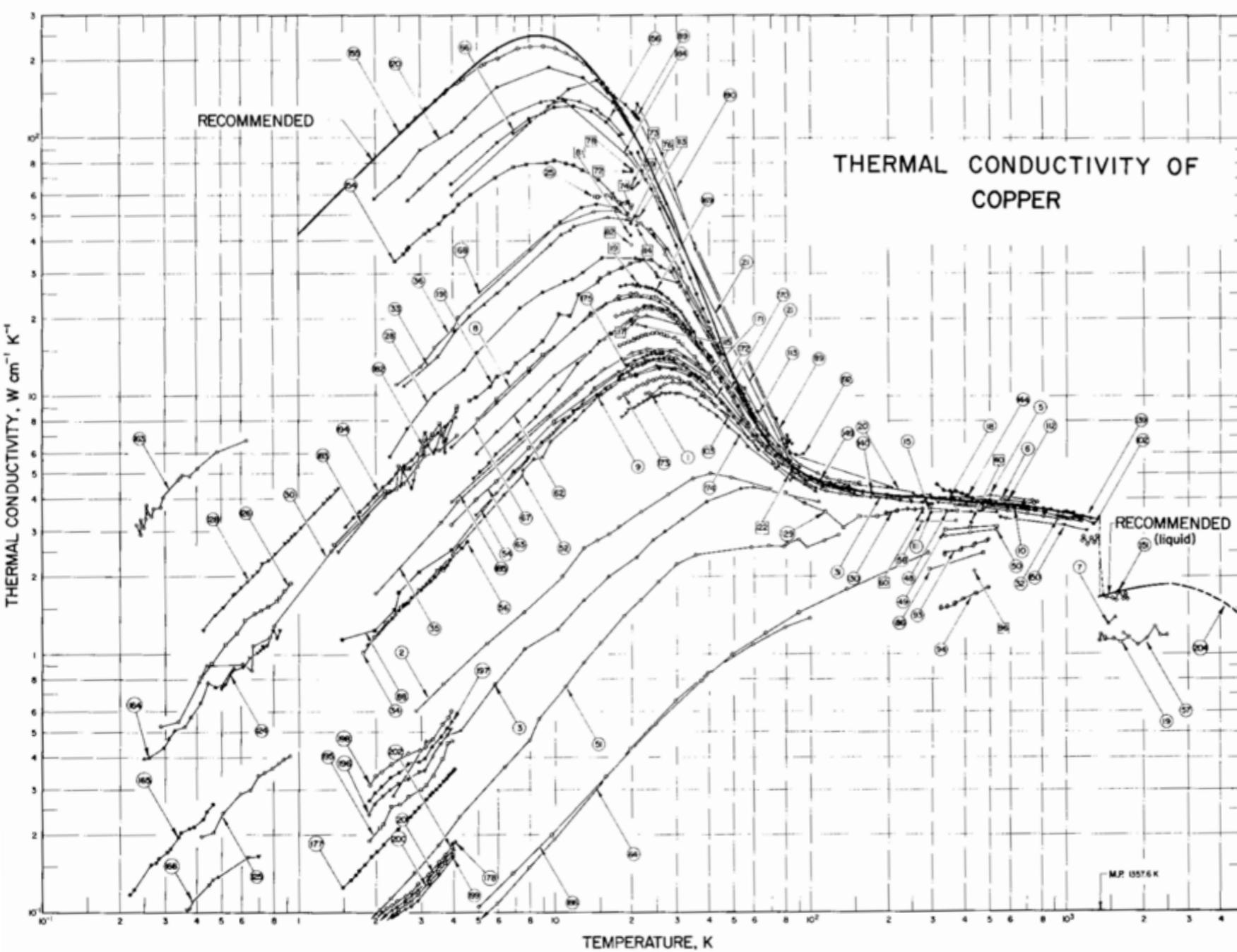
"Data matrix of 4 entries, the names and the numbers of the two bars on the right. The left bar is merely the total of the two. The graph covers 26.5 square inches, resulting in a data density of .15 numbers per square inch, which is thin indeed."

# DESIGN PRINCIPLE: HIGH DATA DENSITY

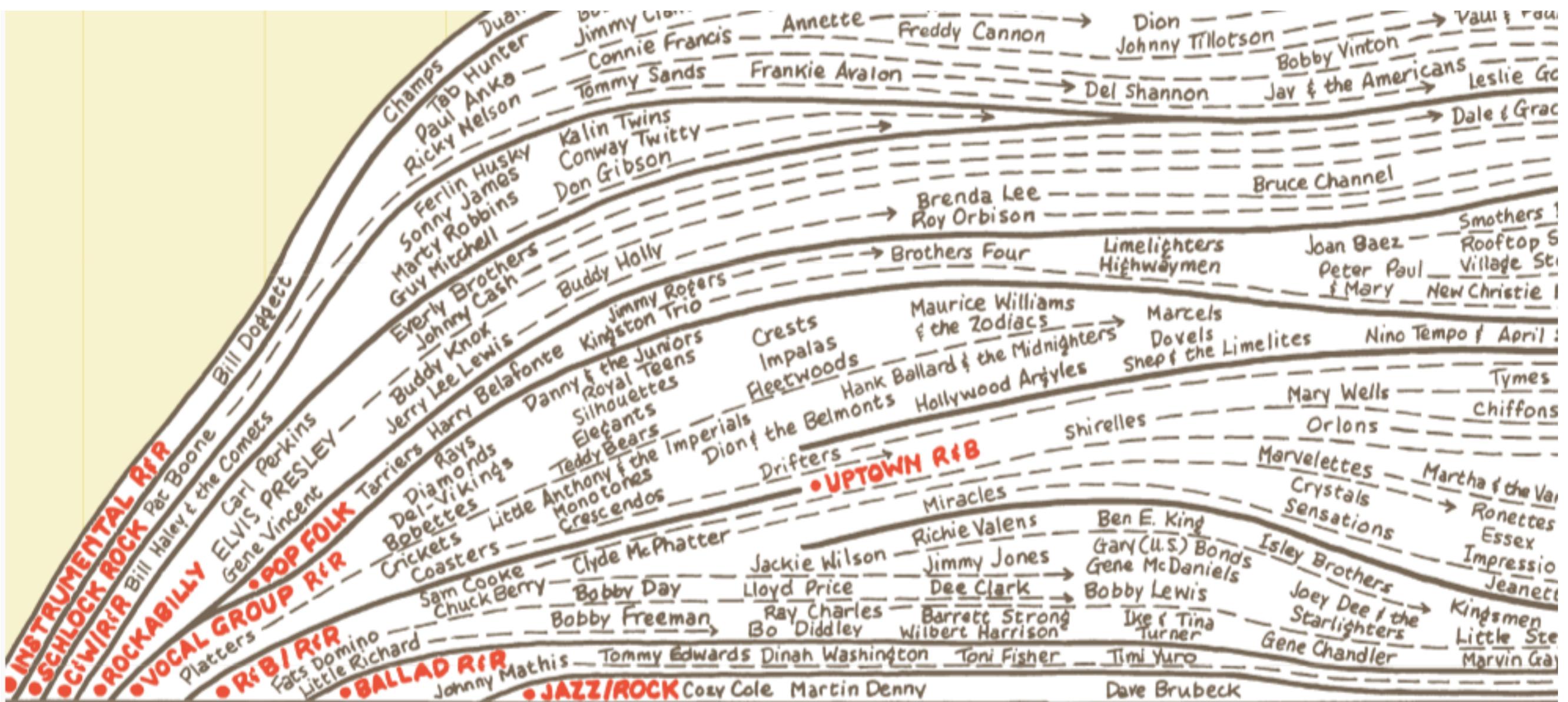
In contrast, the New York weather history, in this reduced version, does very well at 181 numbers per square inch (28 per square centimeter):



# DESIGN PRINCIPLE: DATA DENSITY



# GENEALOGY OF POP/ROCK MUSIC

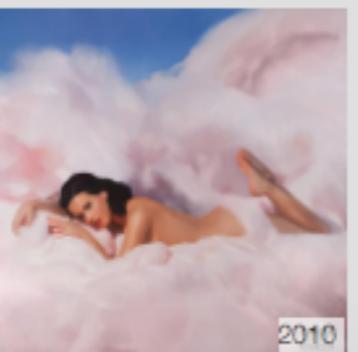
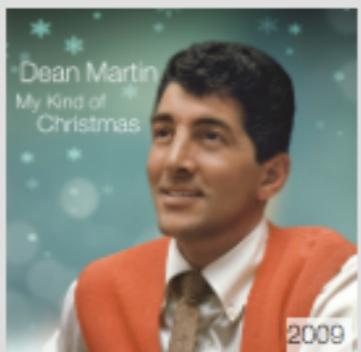
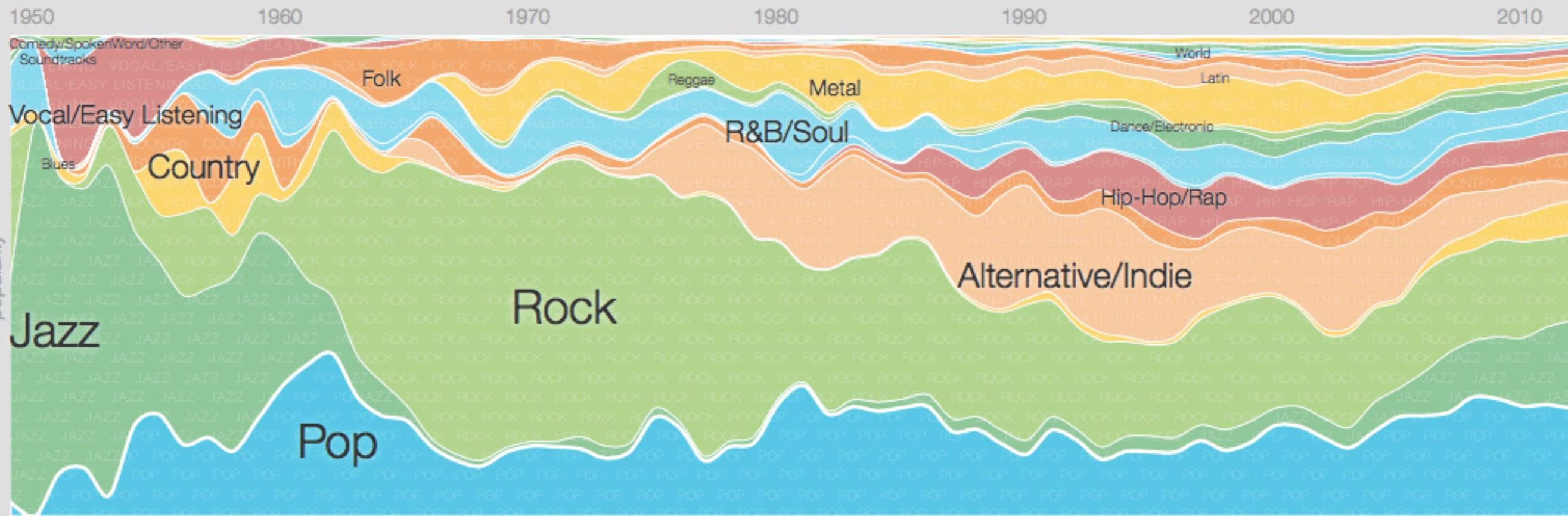


R Garofalo

# Music Timeline

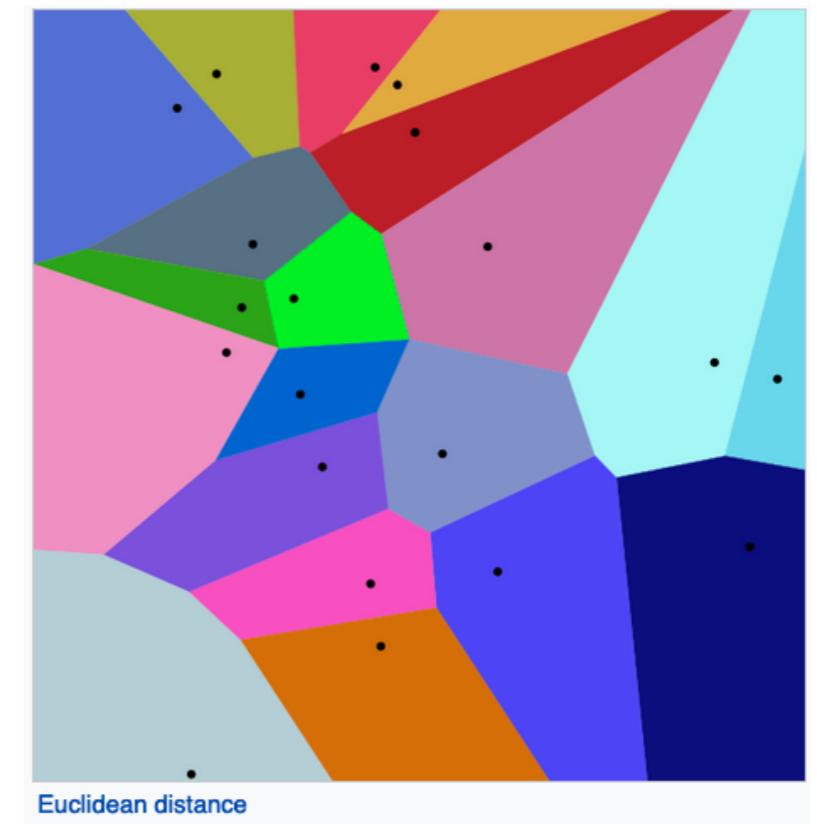
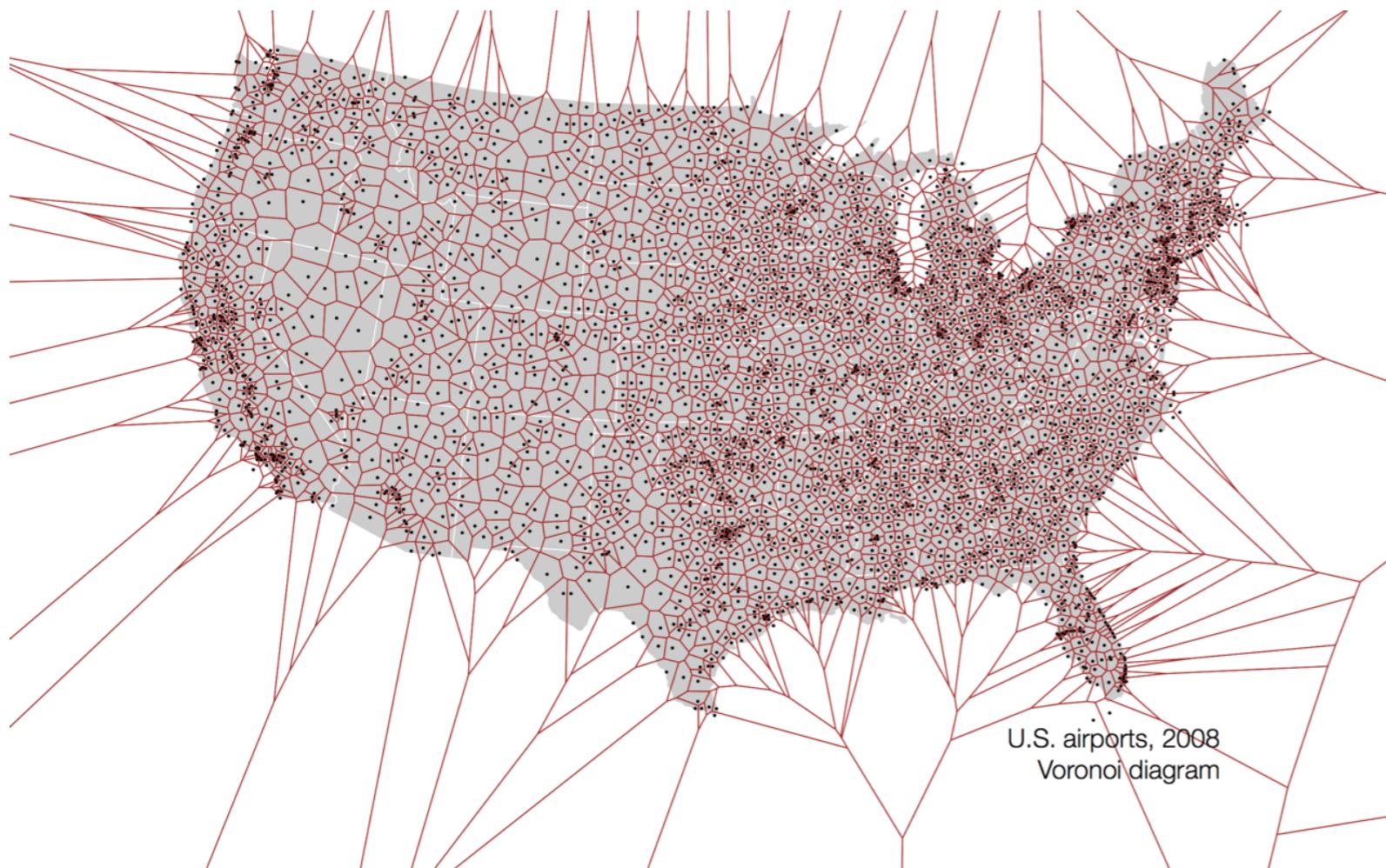
Album or artist:

## FAQ



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# DESIGN PRINCIPLE: DATA DENSITY

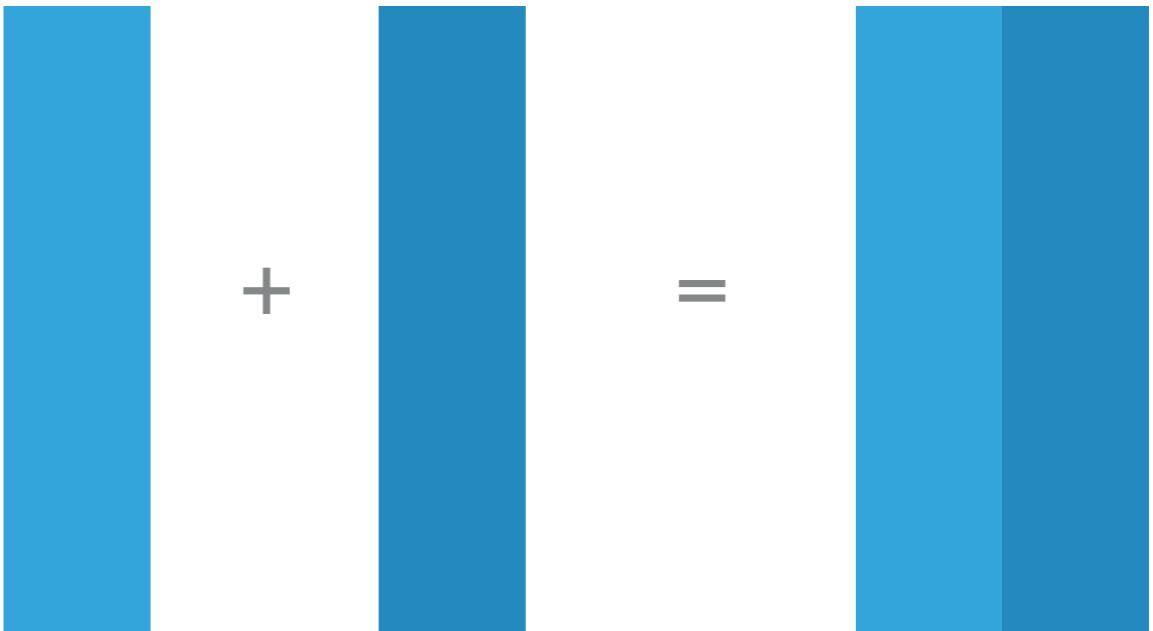


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# DESIGN PRINCIPLE: LAYERING AND SEPARATION

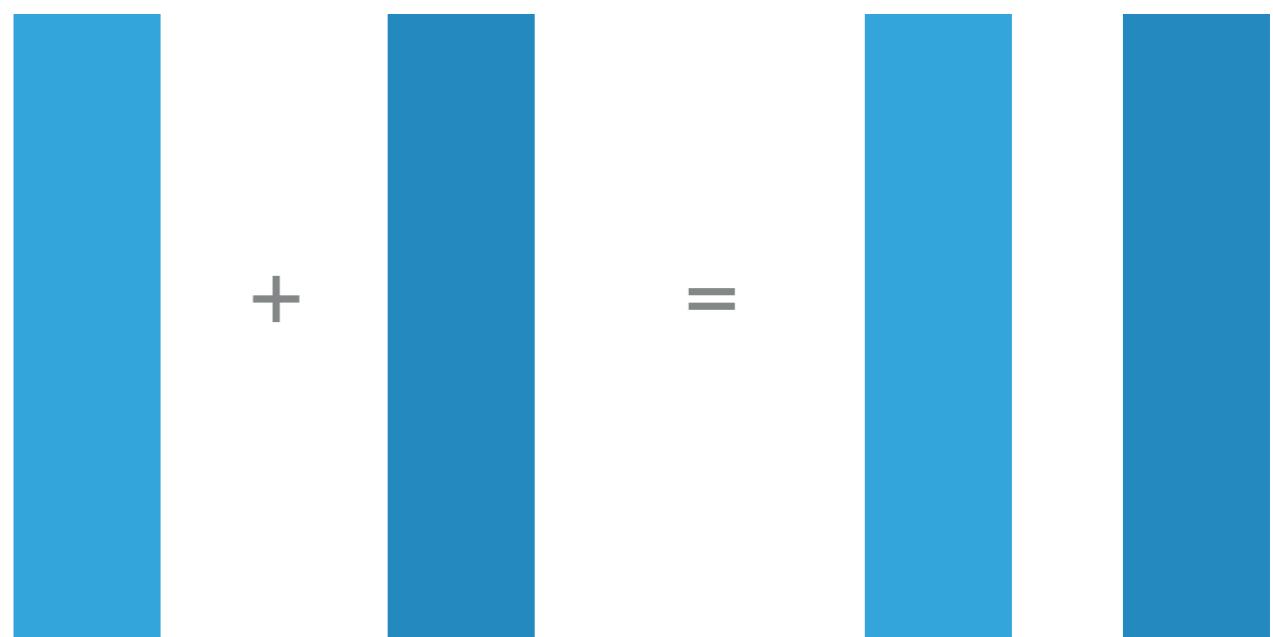
- ▶ Separate and layer information

$$1+1=2$$



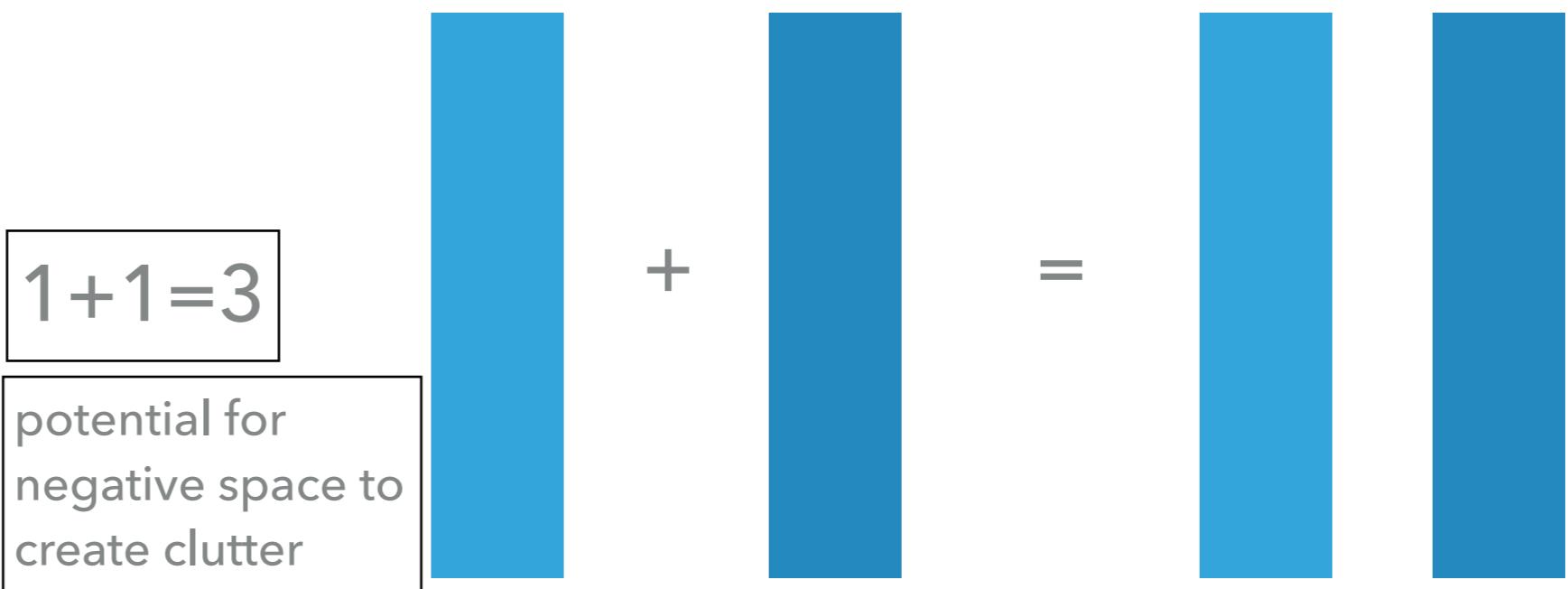
$$1+1=3$$

potential for  
negative space to  
create clutter



# DESIGN PRINCIPLE: LAYERING AND SEPARATION

- ▶ Separate and layer information

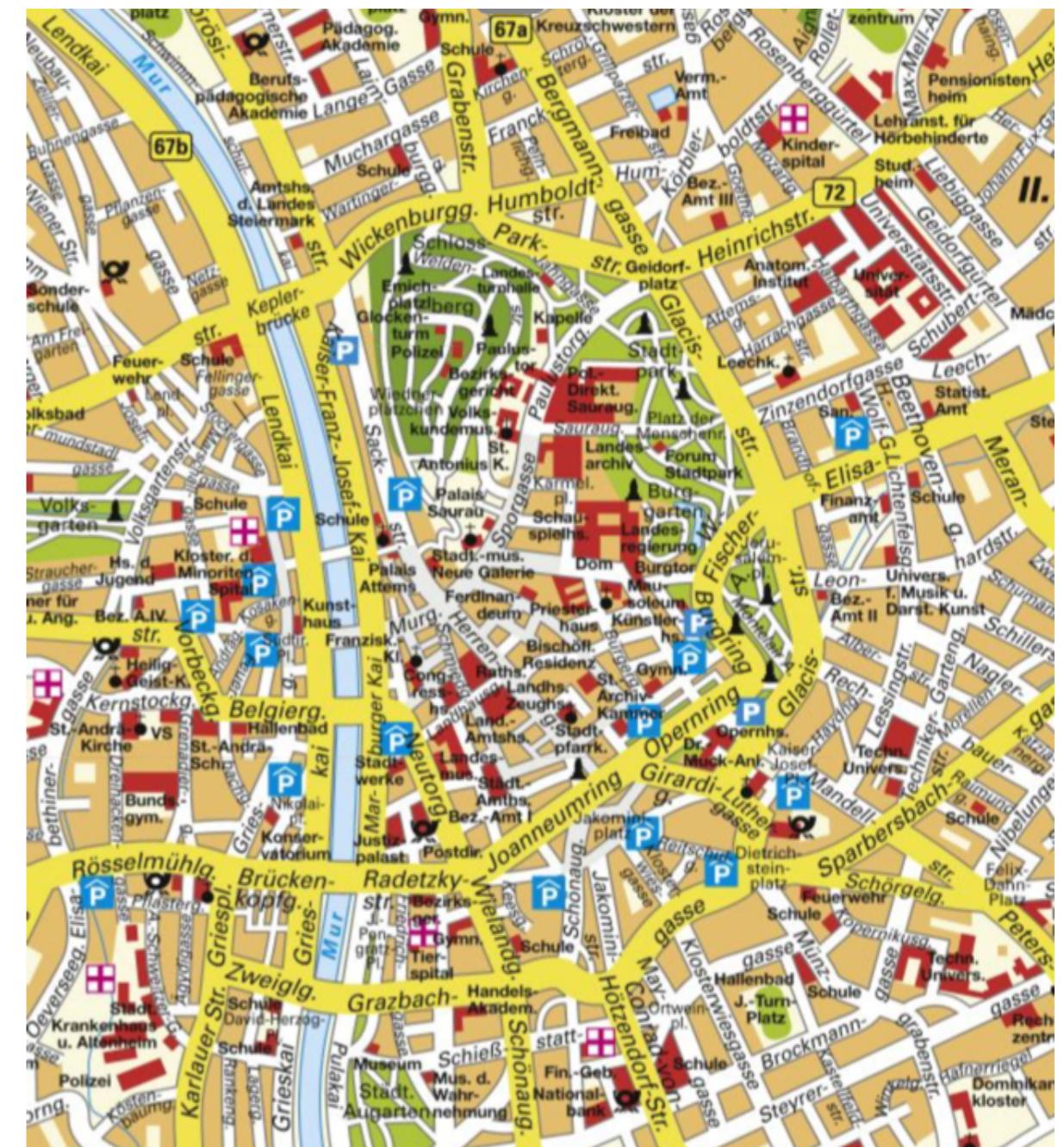
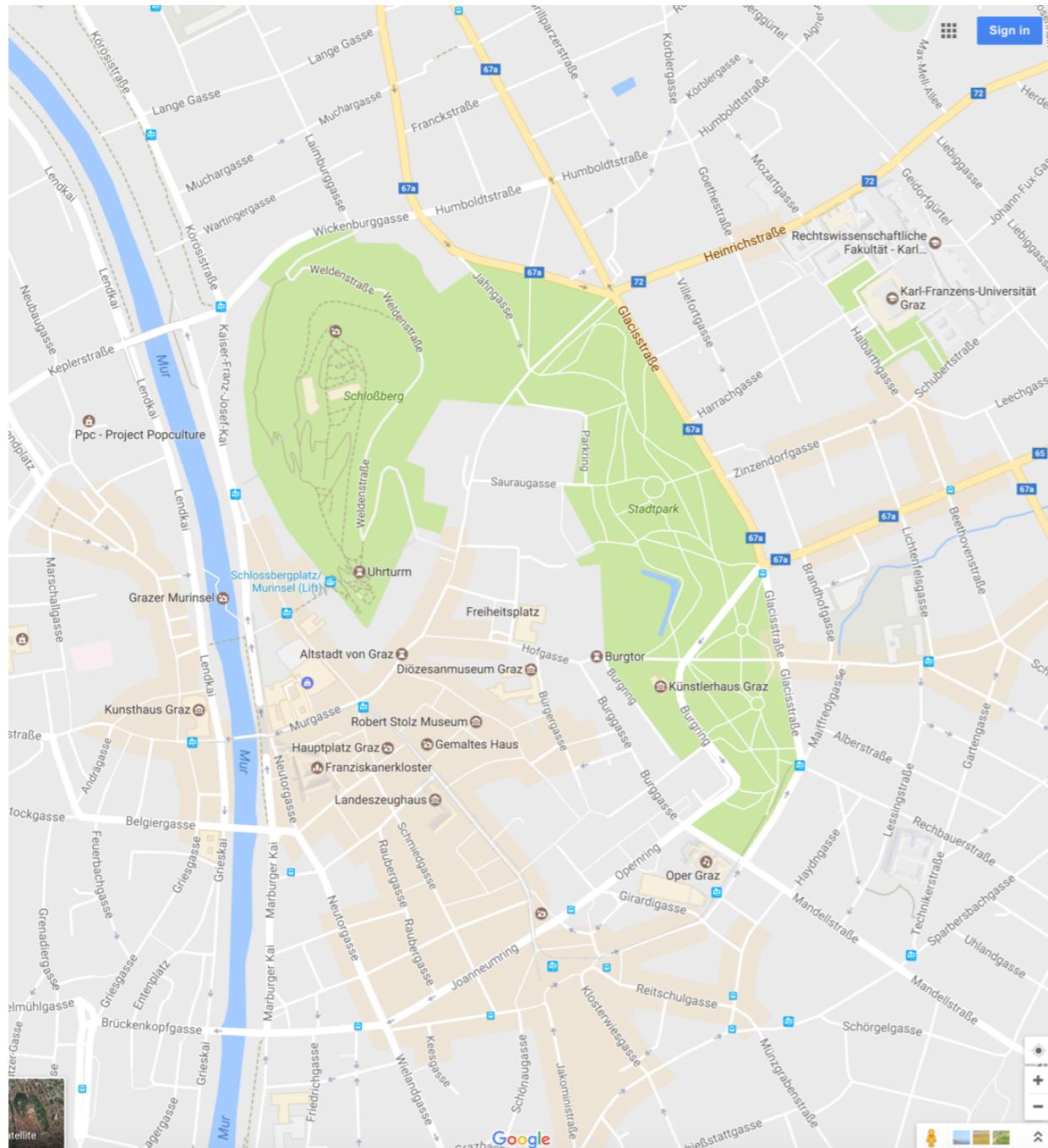


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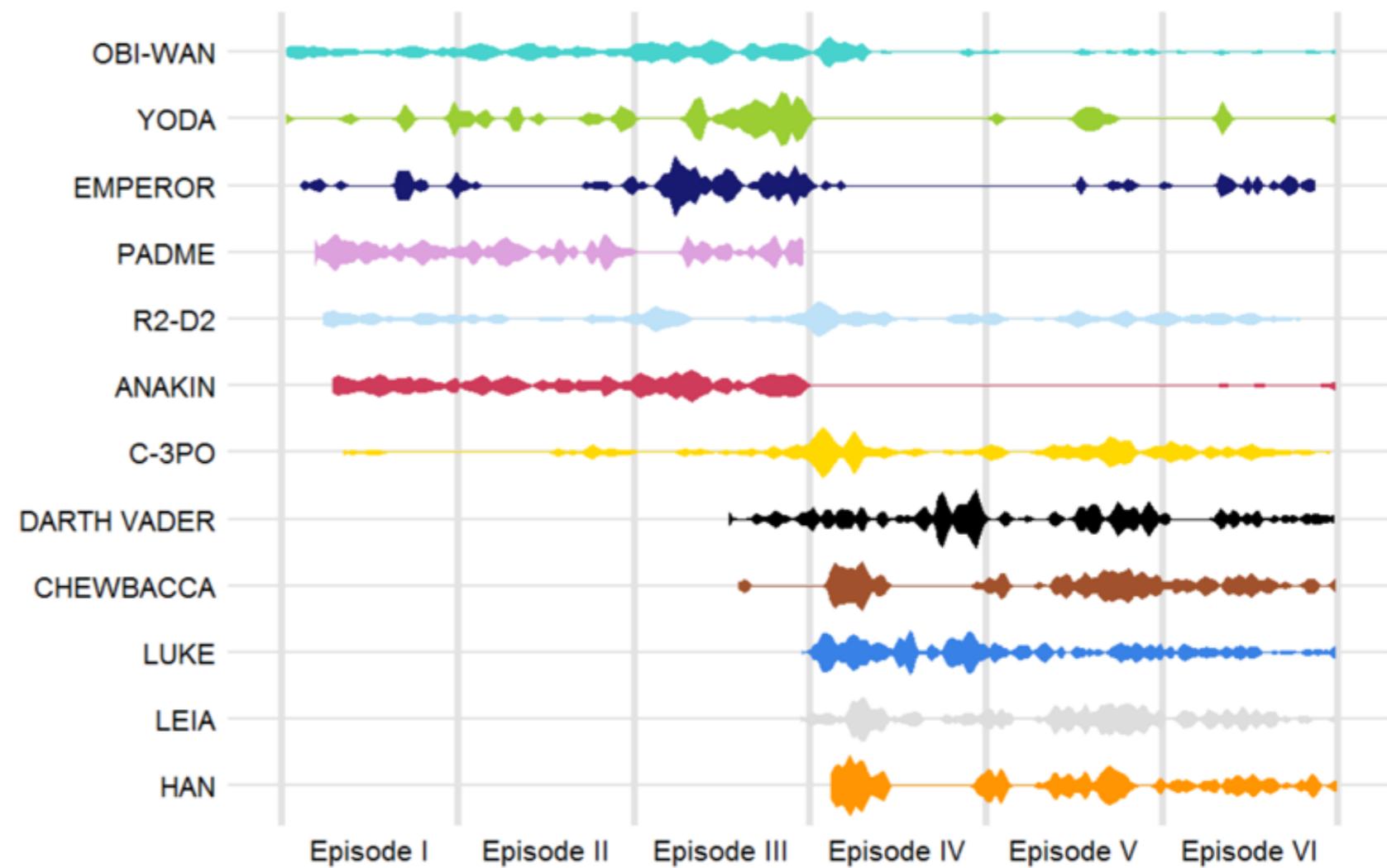
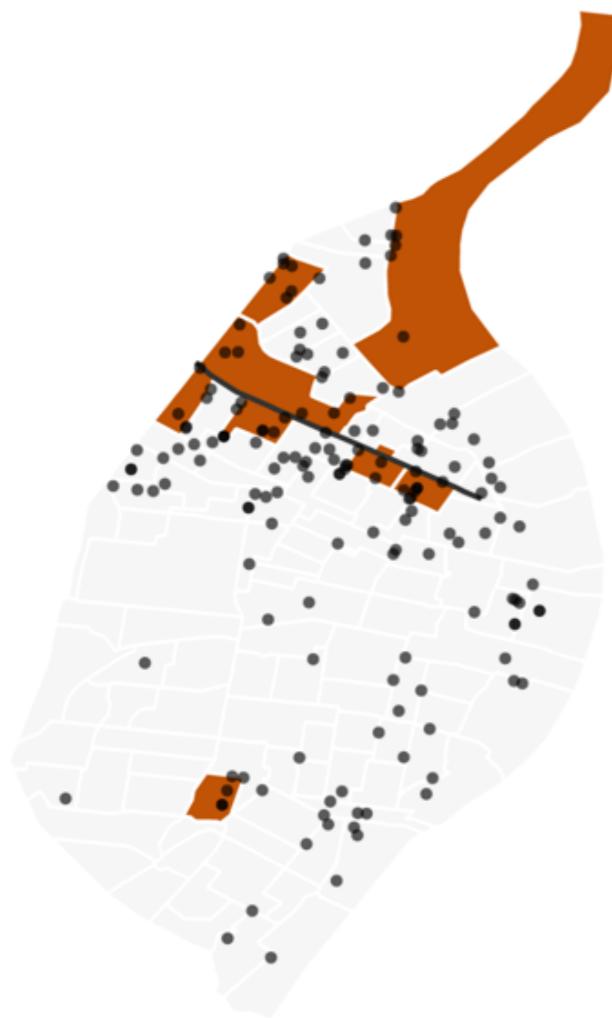
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	A.M.	A.M.	A.M.	A.M.	A.M.
<b>New York</b>	12:10	12:40	1:30	3:52	4:50
<b>Newark N.J.</b>	12:24	12:55	1:44	4:07	5:04
North Elizabeth	.....	.....	.....	.....	.....
<b>Elizabeth</b>	12:33	1:03	1:51	.....	5:11
Linden	12:36	.....	1:56	.....	5:16
North Railway	.....	.....	.....	.....	.....
<b>Rahway</b>	12:40	1:11	2:00	.....	5:20

	am				
<b>New York</b> .....	12:10	12:40	1:30	3:52	4:50
<b>Newark N.J.</b> .....	12:24	12:55	1:44	4:07	5:04
North Elizabeth.....	.....	.....	.....	.....	.....
<b>Elizabeth</b> .....	12:33	1:03	1:51	.....	5:11
Linden.....	12:36	.....	1:56	.....	5:16
North Railway.....	.....	.....	.....	.....	.....
<b>Rahway</b> .....	12:40	1:11	2:00	.....	5:20

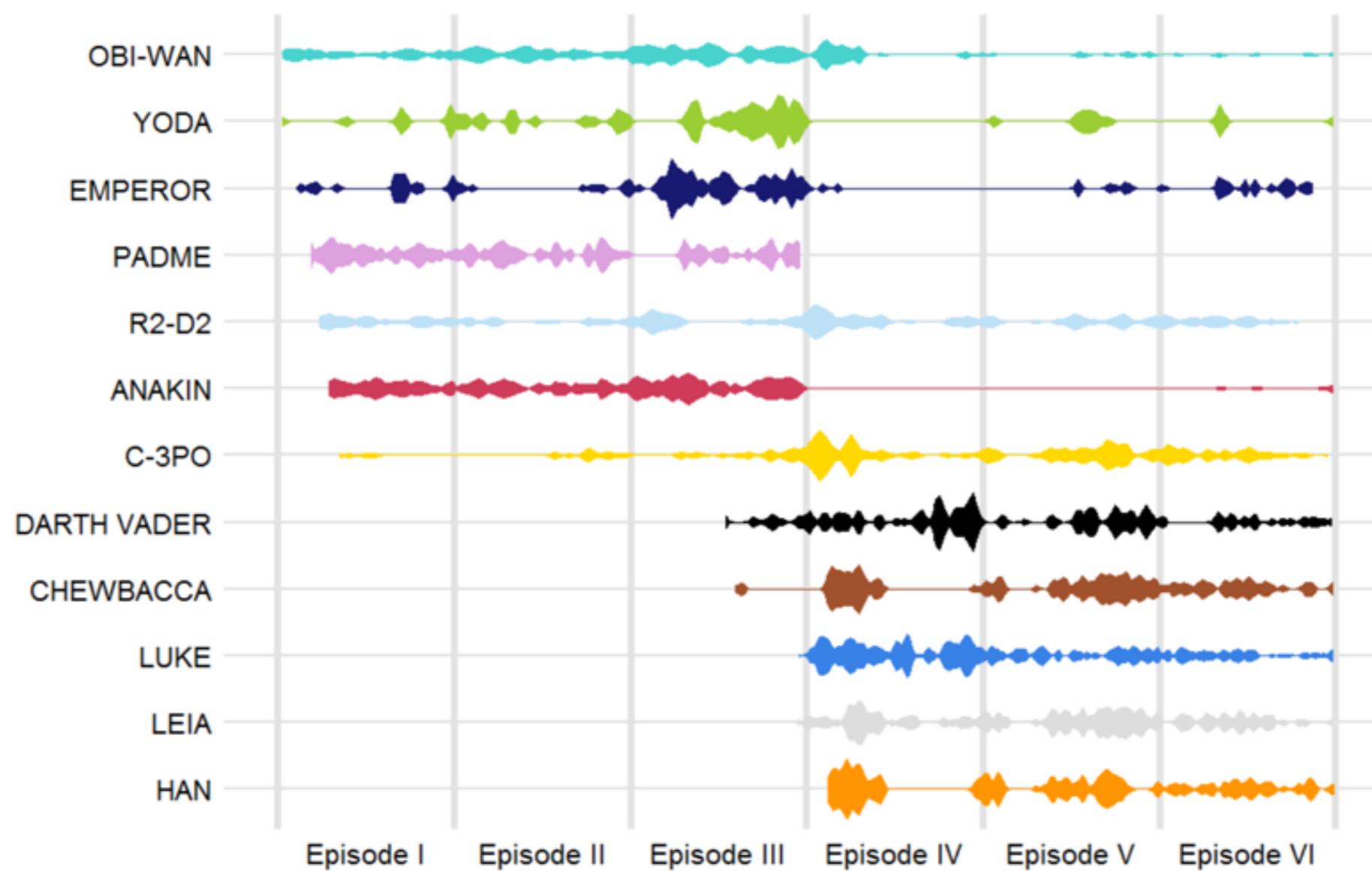
# DESIGN PRINCIPLE: LAYERING AND SEPARATION



# DESIGN PRINCIPLE: LAYERING AND SEPARATION



E. Gabasova





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Note references are linked to images in PDF  
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