

# GOOD PRACTICES IN VISUALIZATION

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# OUTLINE

- Effective Visualizations
- Use of color
- Comparison
- Copy & labels
- Ordering & aligning data

# OUTLINE

- **Effective Visualizations**
- Use of color
- Comparison
- Copy & labels
- Ordering & aligning data

# EFFECTIVE VISUALIZATIONS

- Main goal of visualization:
  - Communicate [a message/data...]
- Visualization will be **effective** if:
  - Message has been transmitted
  - Data has been properly understood
- Visualization will be **ineffective** if:
  - Visualization is too complex: user is unable to get the message
  - Visualization is misleading: user is unable to grasp the data

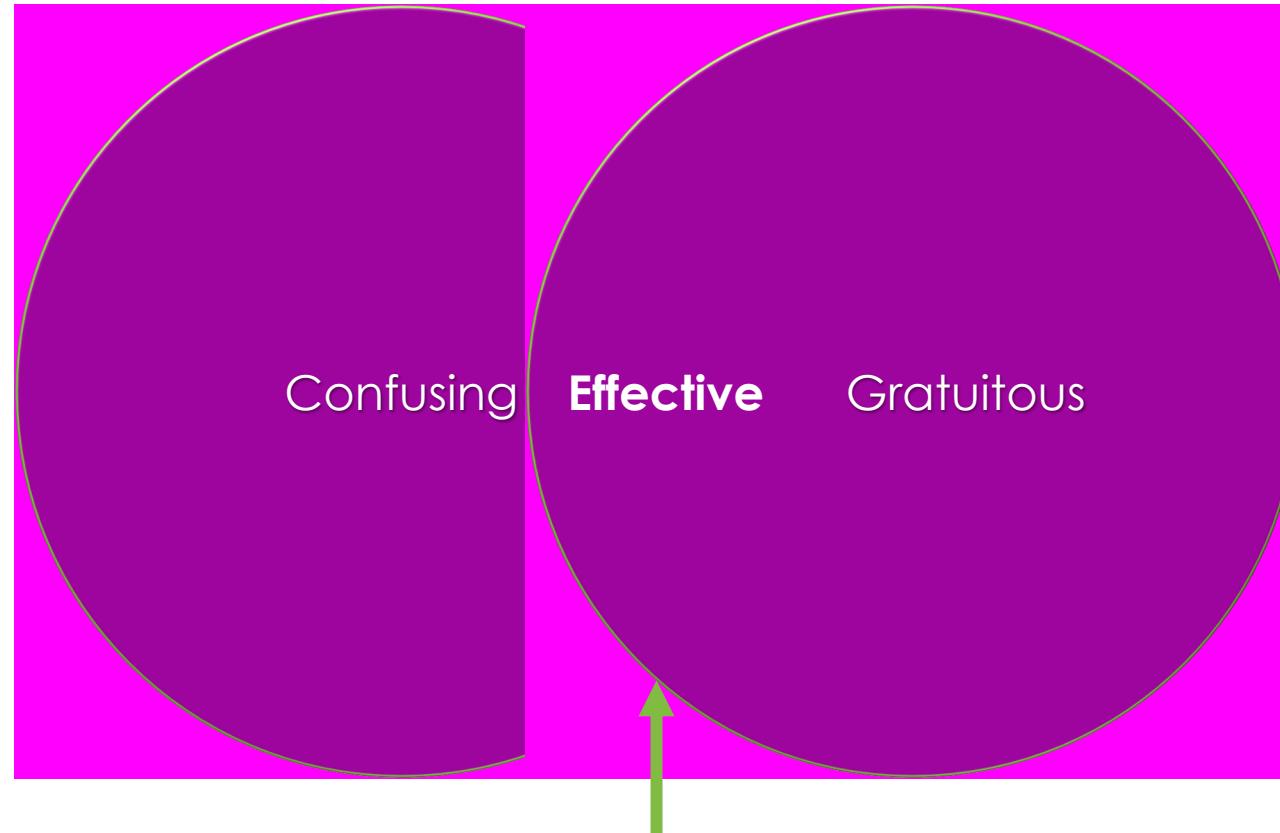
# EFFECTIVE VISUALIZATIONS

- Effective visualization. Elements to consider
  - Data density
    - We want information-rich visualizations
  - Visual mappings
    - Observers must understand the depiction without effort
  - Amount of information
    - Keys, labels [grids, legends, ticks...] help understanding the data
  - Color usage
    - Influences perception and attention

# EFFECTIVE VISUALIZATIONS

- Visualization analysis
  - Do I have a message?
    - Have I communicated it?
      - Explanatory visualization
  - Does the data contain some important insights?
    - Does the visualization allow the user to find/understand those?
      - Exploratory analysis

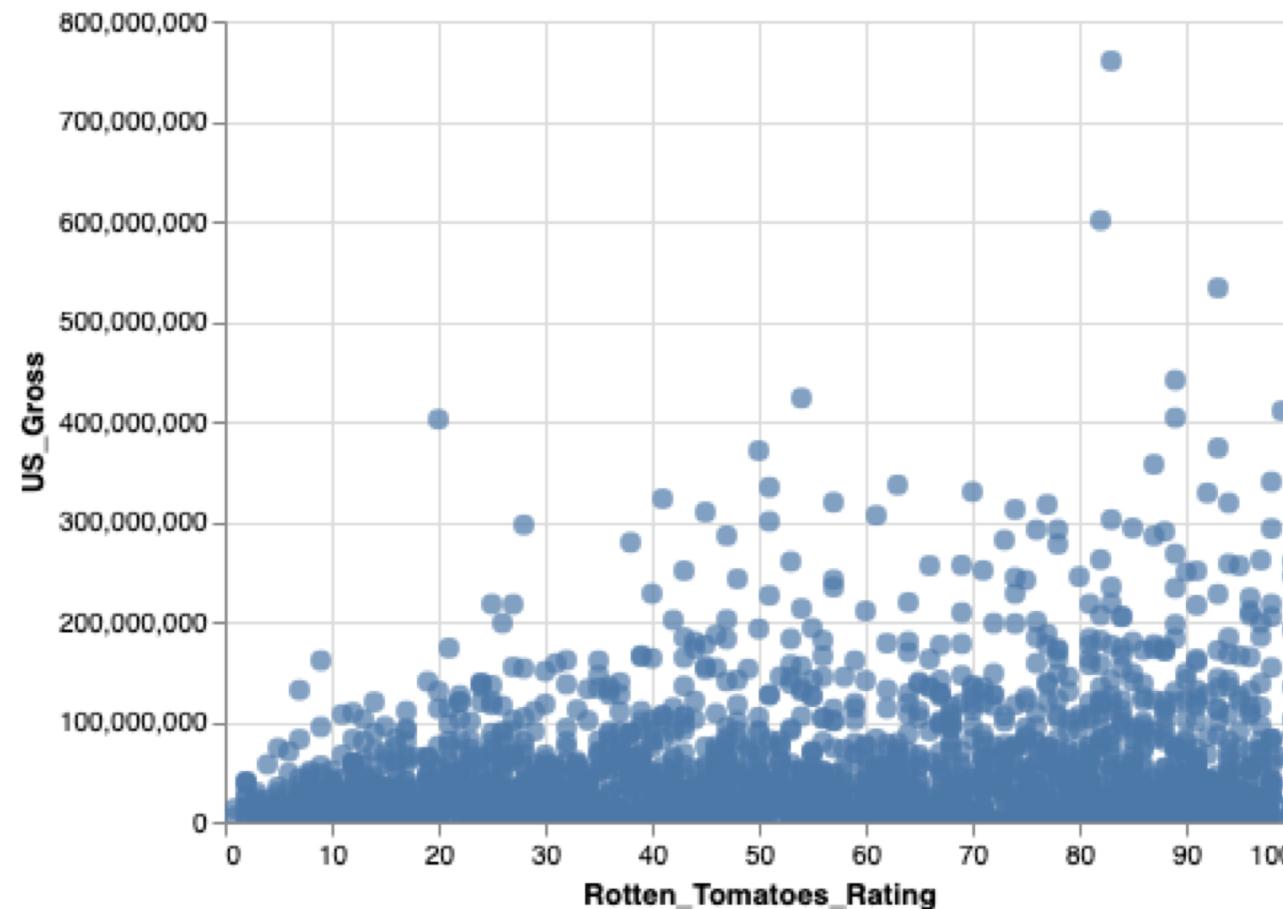
# EFFECTIVE VISUALIZATIONS



Clear message  
High data-to-ink ratio  
Accessible complexity

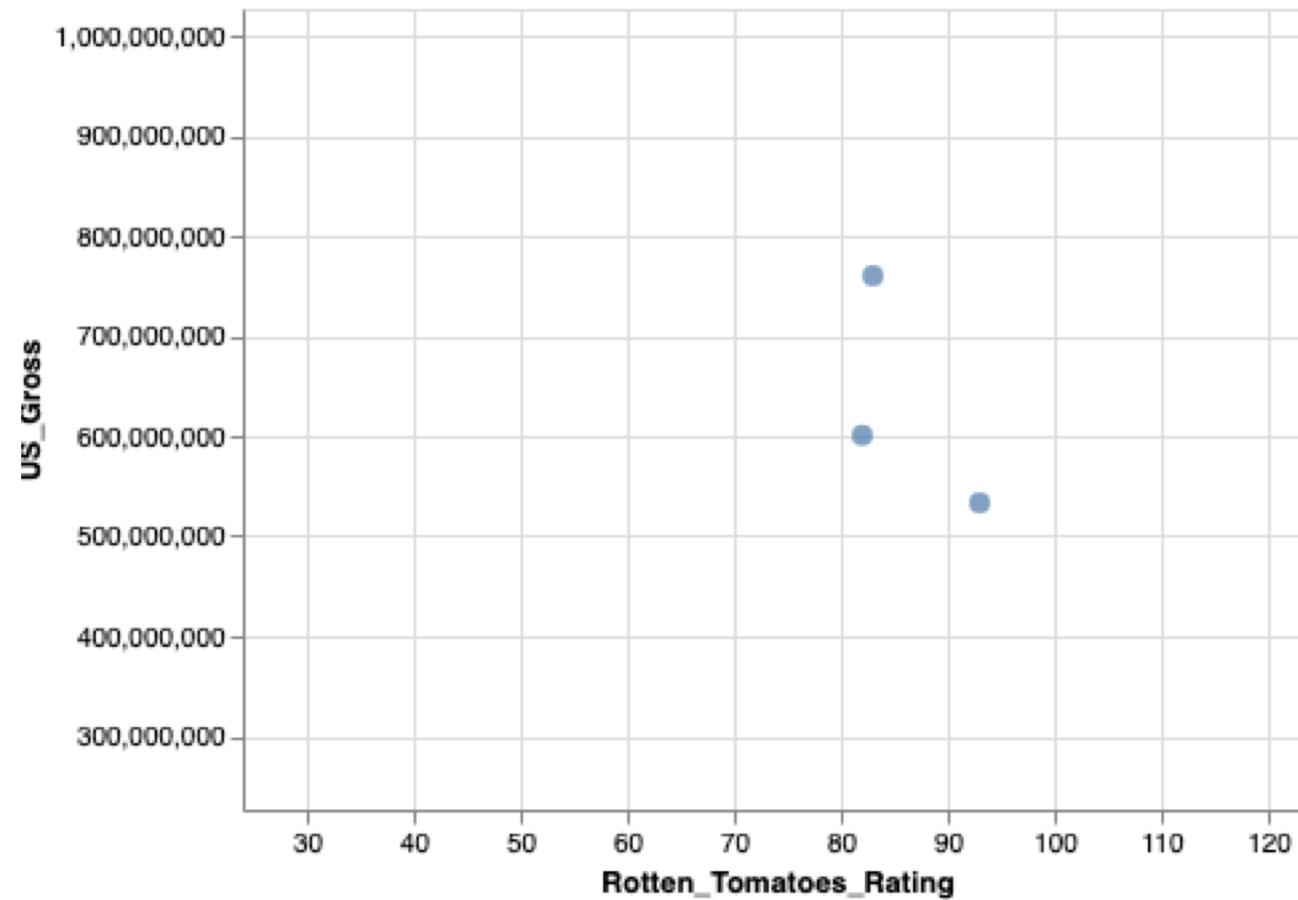
# EFFECTIVE VISUALIZATIONS

- Information rich, not informative



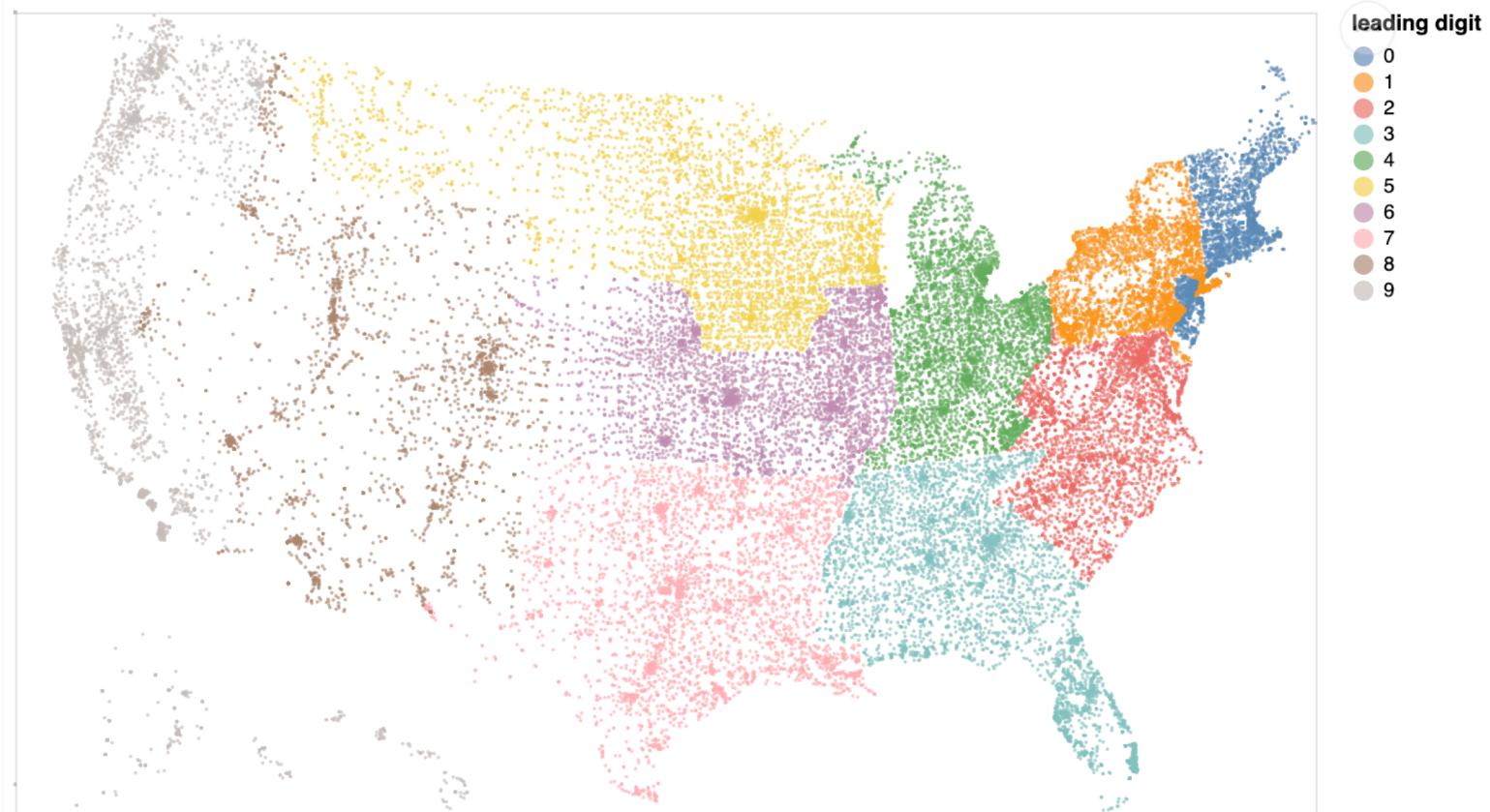
# EFFECTIVE VISUALIZATIONS

- Informative, not information-rich



# EFFECTIVE VISUALIZATIONS

- Information-rich and Informative



# EFFECTIVE VISUALIZATIONS

- Very general principle

strive to give **your viewer**  
**the greatest number of useful ideas**  
in the **shortest time**  
with the **least ink**  
in the **smallest space**

# EFFECTIVE VISUALIZATIONS

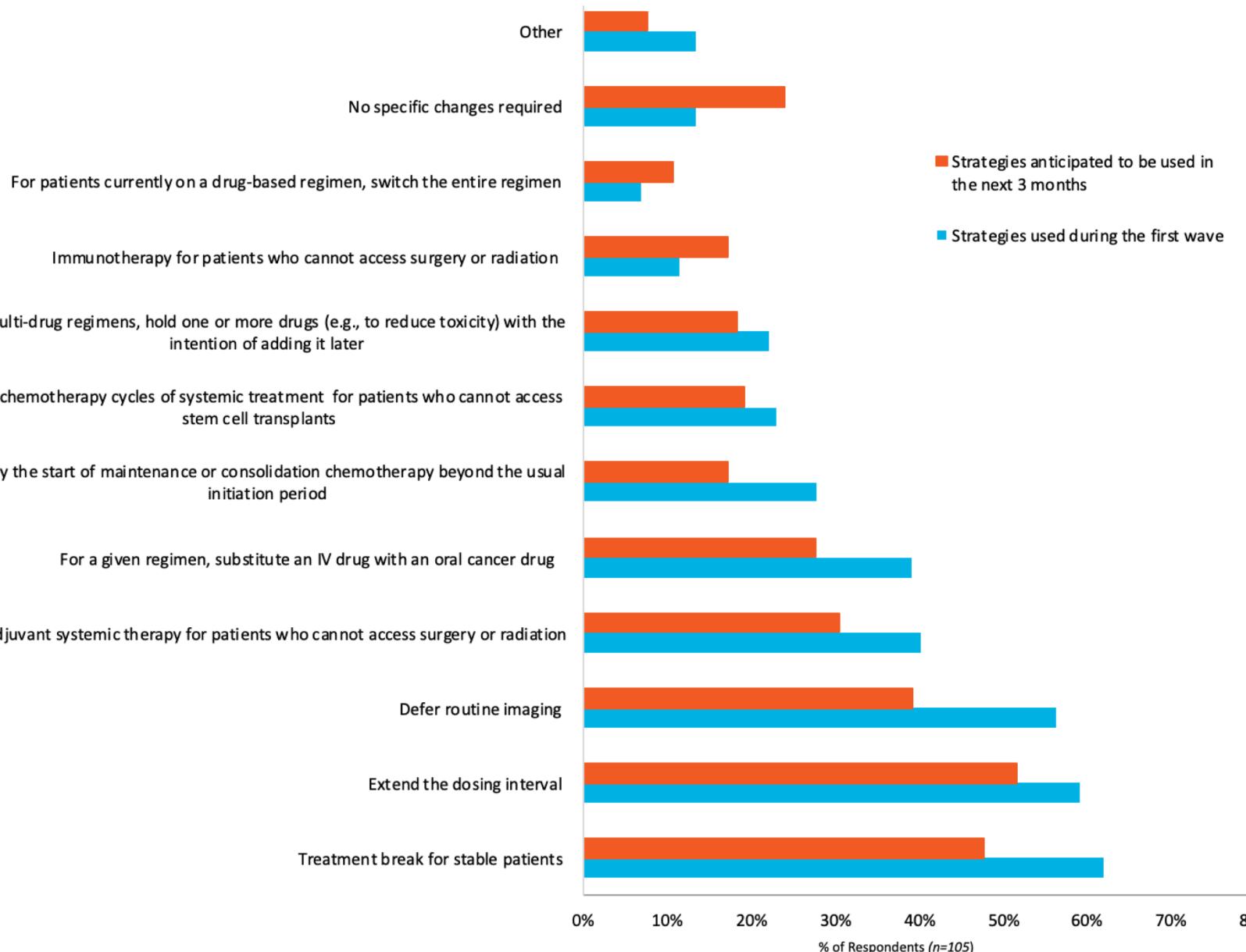
- Specific principles
  - Create visuals when necessary
  - Don't merely display data, explain it
  - Know your message
  - Strive for clear communication
  - Satisfy your audience, not yourself
  - Respect human visual limitations

# USE VISUALS ONLY WHEN NECESSARY

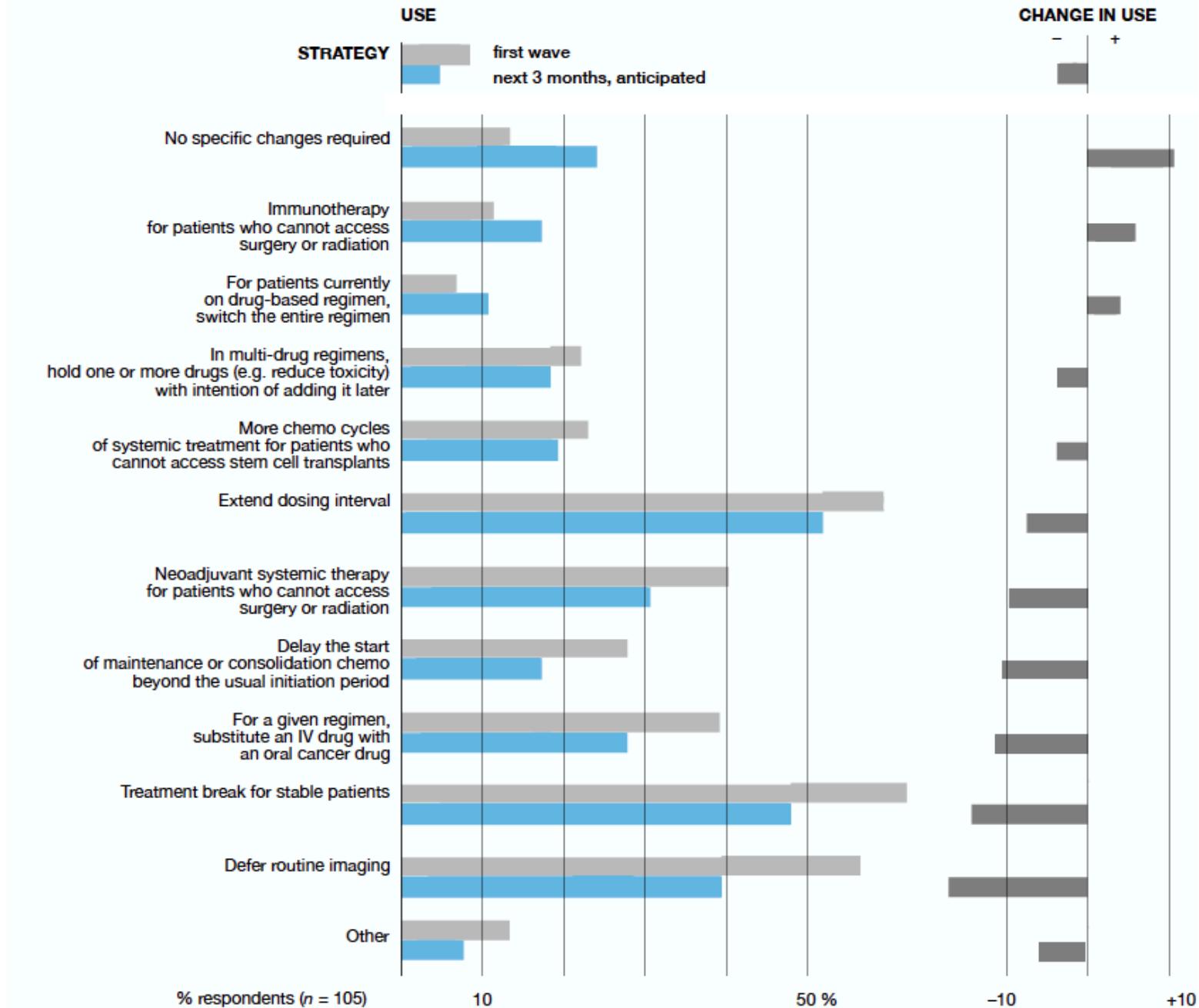
- The desire for a figure is not always proportional to its utility



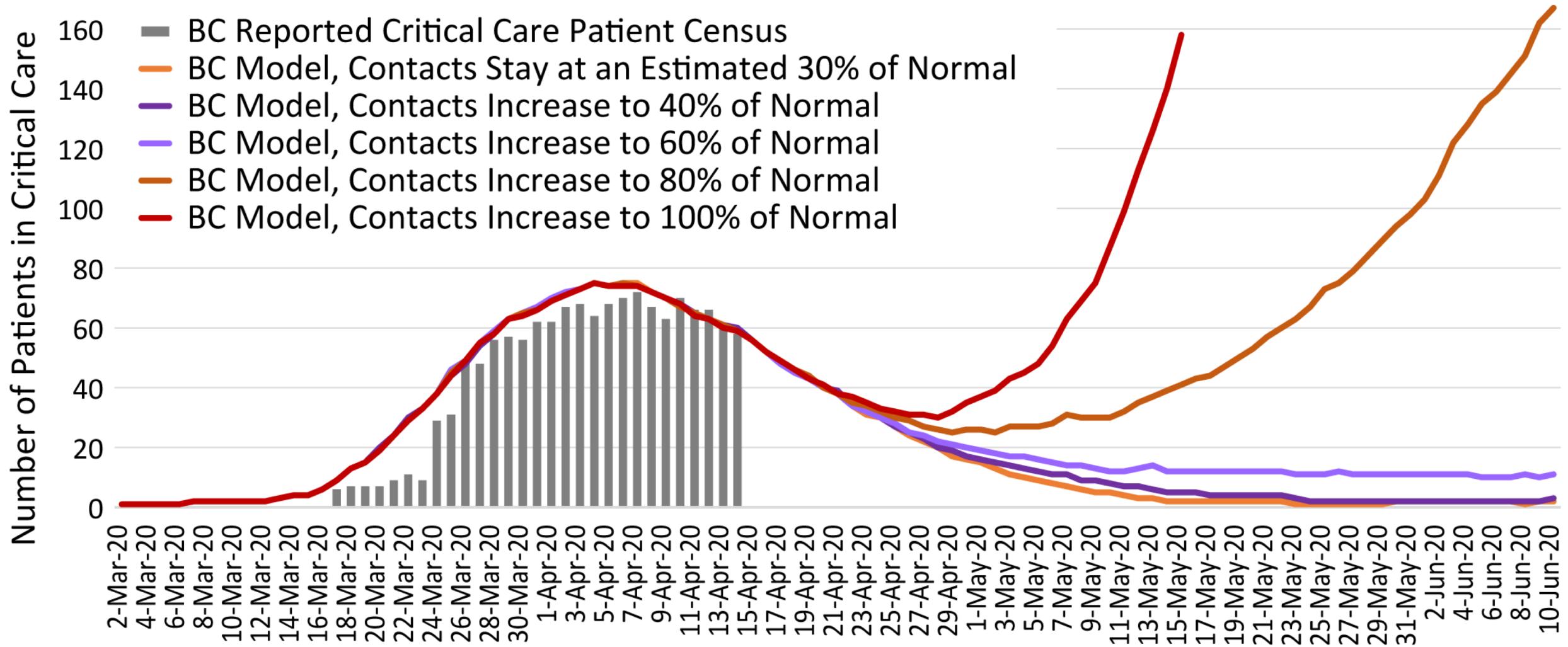
# If we want to communicate data change ...



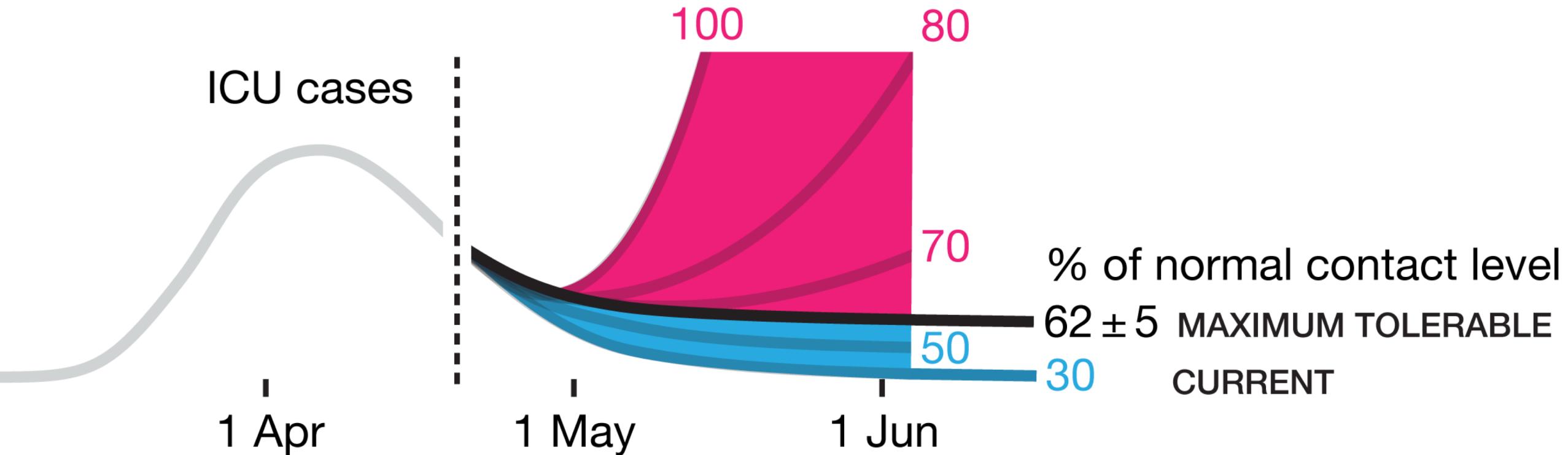
- ...we can show it



# Example: critical care implications of dynamic model in BC's context



**Critical care admission rate remains acceptable if restrictions are relaxed up to 60% of normal**



# EFFECTIVE VISUALIZATIONS. CRAFTING A MESSAGE

WHAT IS SHOWN?

RAW DATA

12 54 82 29 25 22 67 61 23 79

WHAT IS COMMUNICATED?

NO CLEAR MESSAGE.

WHAT IS INTERPRETED?

UNKNOWN. READER IS  
ON THEIR OWN.

# EFFECTIVE VISUALIZATIONS. CRAFTING A MESSAGE

WHAT IS SHOWN?

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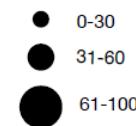
UNKNOWN. READER IS  
ON THEIR OWN.

---

DISCRETIZED



SCALE



THREE RANGES ARE IMPORTANT.  
INDIVIDUAL VALUES WITHIN A  
RANGE ARE NOT.

# EFFECTIVE VISUALIZATIONS. CRAFTING A MESSAGE

WHAT IS SHOWN?

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12 54 82 29 25 22 67 61 23 79

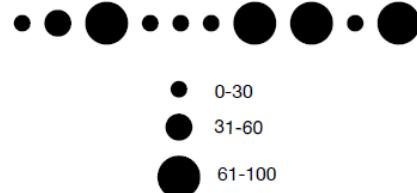
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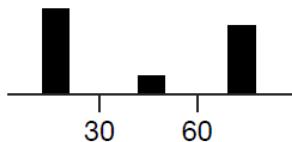
DISCRETIZED



SCALE

THREE RANGES ARE IMPORTANT.  
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RANGE ARE NOT.

BINNED



DISTRIBUTION

THERE ARE FEWER  
MEDIUM-SIZED VALUES.

# EFFECTIVE VISUALIZATIONS. CRAFTING A MESSAGE

WHAT IS SHOWN?

RAW DATA

12 54 82 29 25 22 67 61 23 79

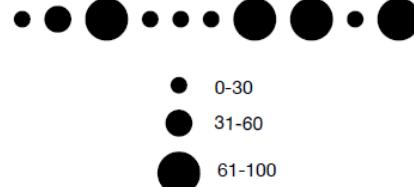
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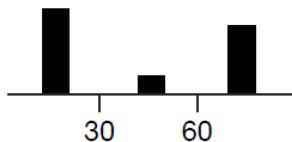
DISCRETIZED



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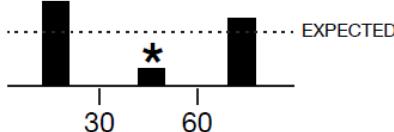
BINNED



DISTRIBUTION

THERE ARE FEWER  
MEDIUM-SIZED VALUES.

TREND

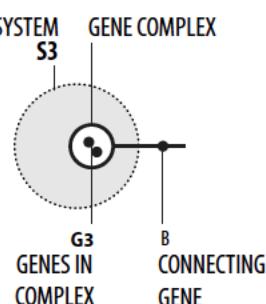
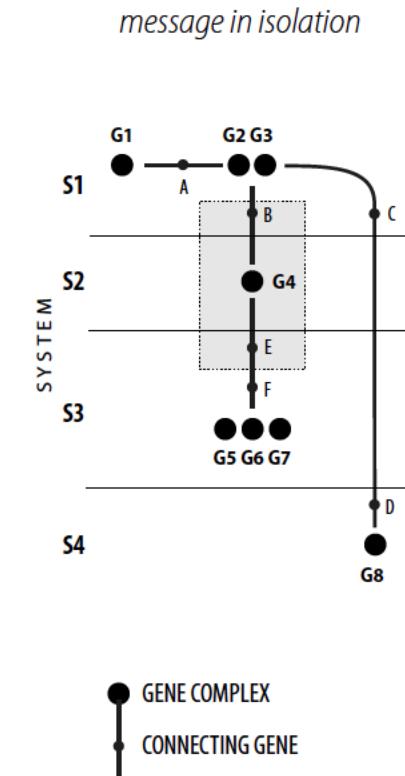
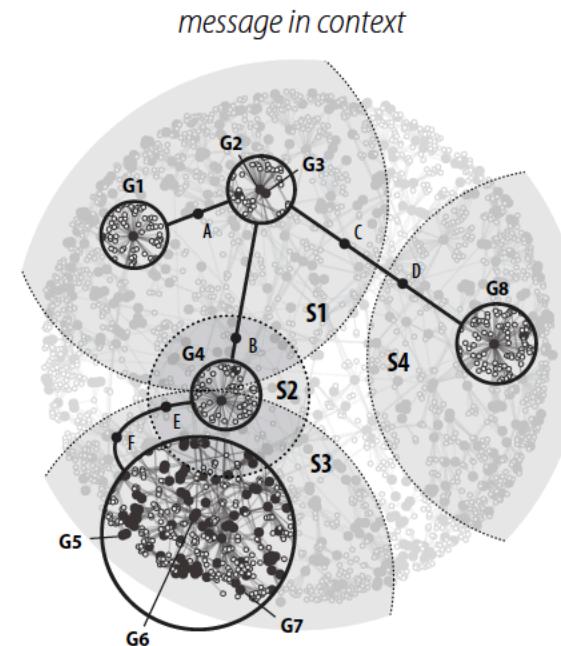
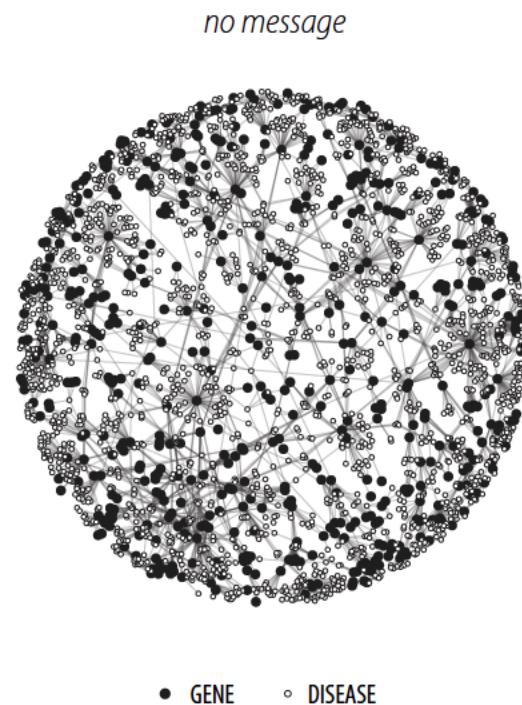


SIGNIFICANCE

THERE ARE SIGNIFICANTLY  
FEWER MEDIUM-SIZED VALUES.

# STRIVE FOR CLEAR COMMUNICATION

- Don't hide message with context

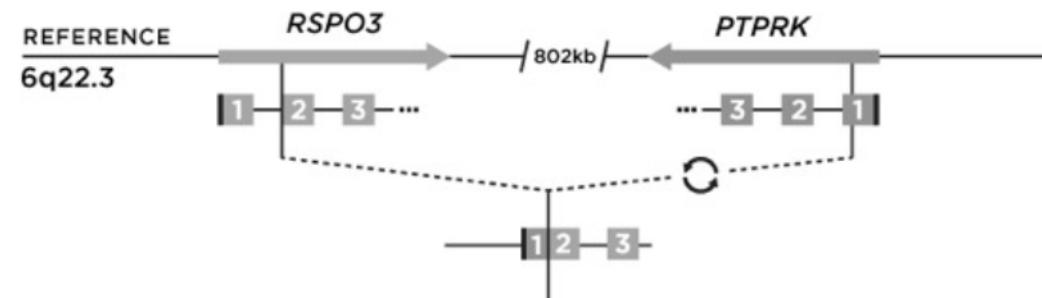


# STRIVE FOR CLEAR COMMUNICATION

- Revise and redraw
- To explore data, achieve effective encoding



- To communicate concepts, use effective design



# TAKE INTO ACCOUNT THE AUDIENCE

- Means: **Solving the problems for them**
  - Understand their problems
  - Use your knowledge to craft a visualization that solves them
- It does not mean: **Do what they tell you to do**
  - Do not ask what to show
  - Do not ask how to depict
  - Just ask about their data problem, about the message...

# SATISFY YOUR AUDIENCE, NOT YOURSELF

- Be aware of bias in evaluating effectiveness of visual forms

# SATISFY YOUR AUDIENCE, NOT YOURSELF

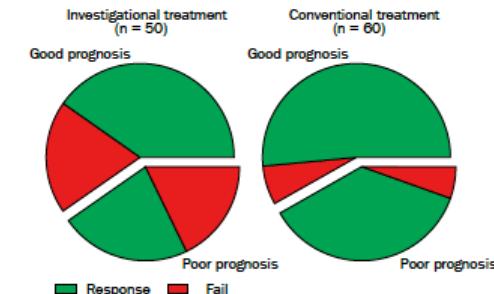
Influence of data display formats on physician investigators' decisions to stop clinical trials: prospective trial with repeated measures

Linda S Elting, Charles G Martin, Scott B Cantor, Edward B Rubenstein

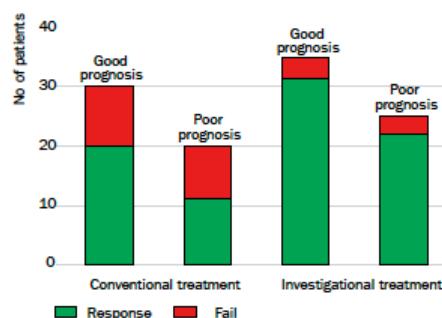
table

	Conventional treatment		Investigational treatment	
	Total no	% Fail	Total no	% Fail
Good prognosis	30	30	35	11
Poor prognosis	20	45	25	12
Total	50	38	60	12

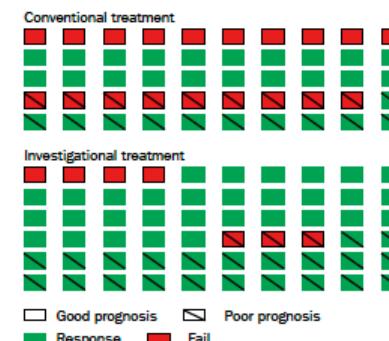
pie chart



bar graph



icon graph



# SATISFY YOUR AUDIENCE, NOT YOURSELF

Influence of data display formats on physician investigators' decisions to stop clinical trials: prospective trial with repeated measures

Linda S Elting, Charles G Martin, Scott B Cantor, Edward B Rubenstein

*“...eight voiced considerable contempt for the [icon] display.”*



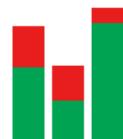
% accuracy      % preference

82      0

30 30 35 11  
20 45 25 12  
50 38 60 12

68      62

*“... icon displays were often preferred by nurses, students, ... but were considered unacceptable by physicians.”*

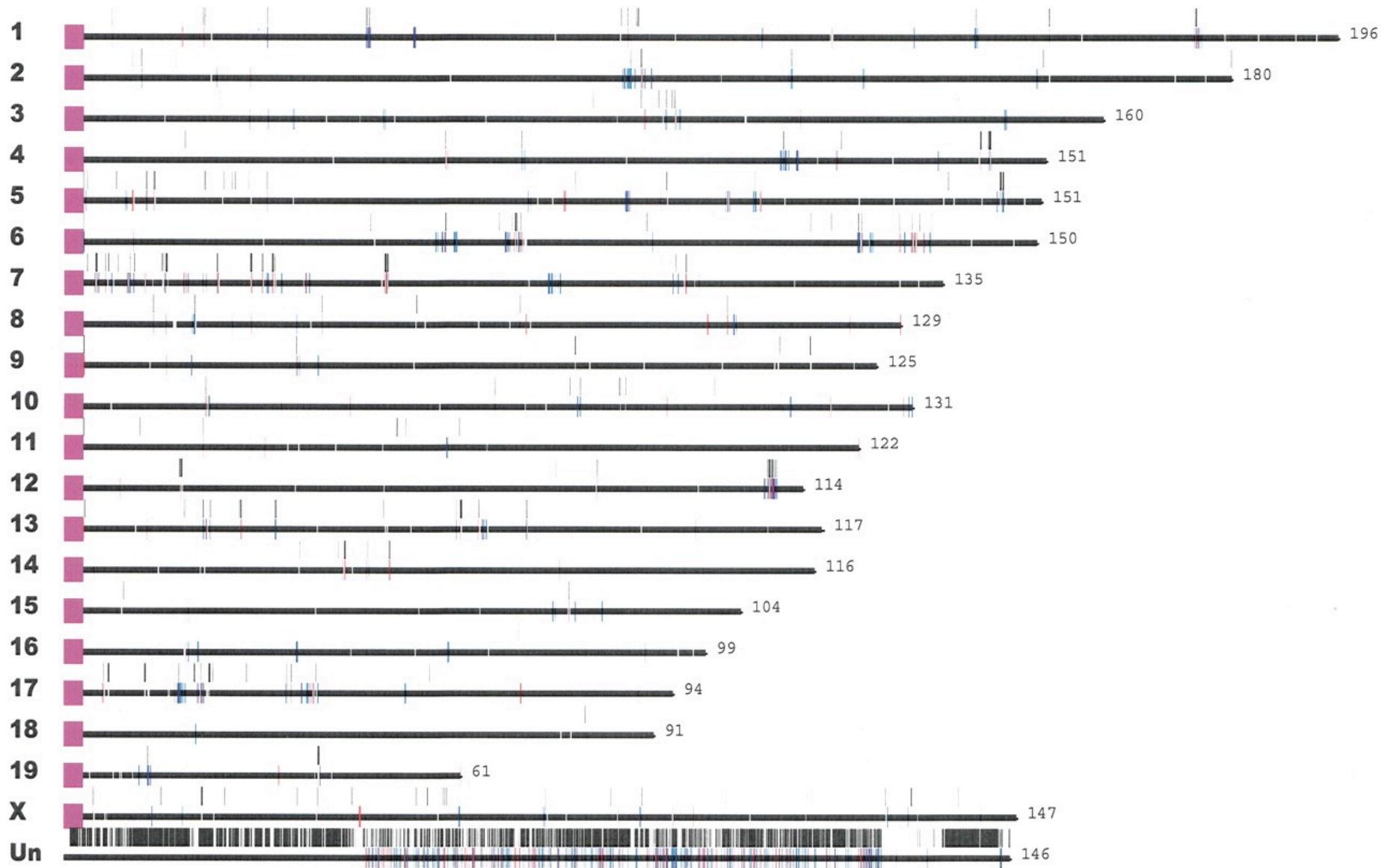


56      24



56      14

# EFFECTIVE VISUALIZATIONS. LEGIBILITY



# EFFECTIVE VISUALIZATIONS. LEGIBILITY

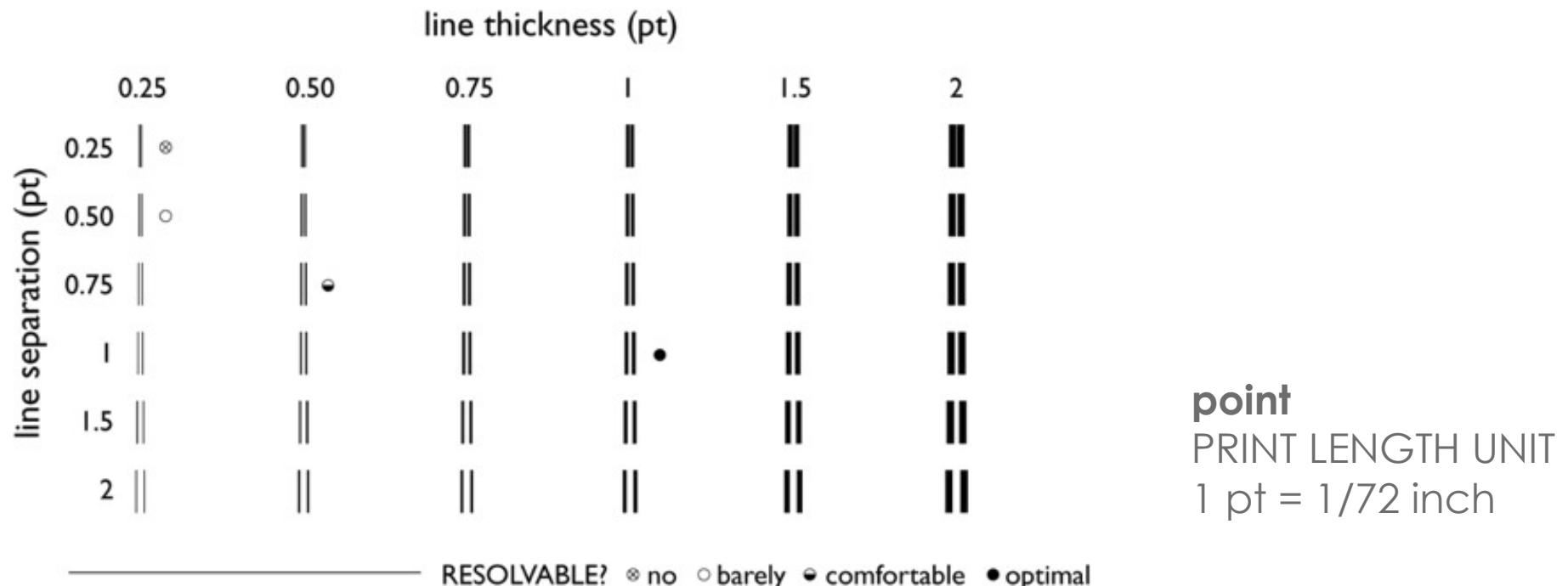
- The resolving power of the eye is approximately 50 cycles per degree (see *next slide*).
  - This limits us from distinguishing features smaller than 0.1 mm at a reading distance of 30 cm.
  - Larger features must be used to maintain legibility and comprehension. 1 point = 1/72 inch = 0.0353 cm

# EFFECTIVE VISUALIZATIONS. LEGIBILITY

- Cycles per degree (aka **acuity**):
  - Spatial resolving capacity of the visual system
  - Ability of the eye to see fine detail
  - Refers to the highest resolution we can see with the fovea
- Each cycle represents an element we can see isolated:
  - Commonly taken as a line pair: a black and white strokes together
- Other acuity limits: <https://entokey.com/visual-acuity-2/>

# EFFECTIVE VISUALIZATIONS. LEGIBILITY

## RESOLVING DETAIL



## RESOLVING COLOR DIFFERENCES

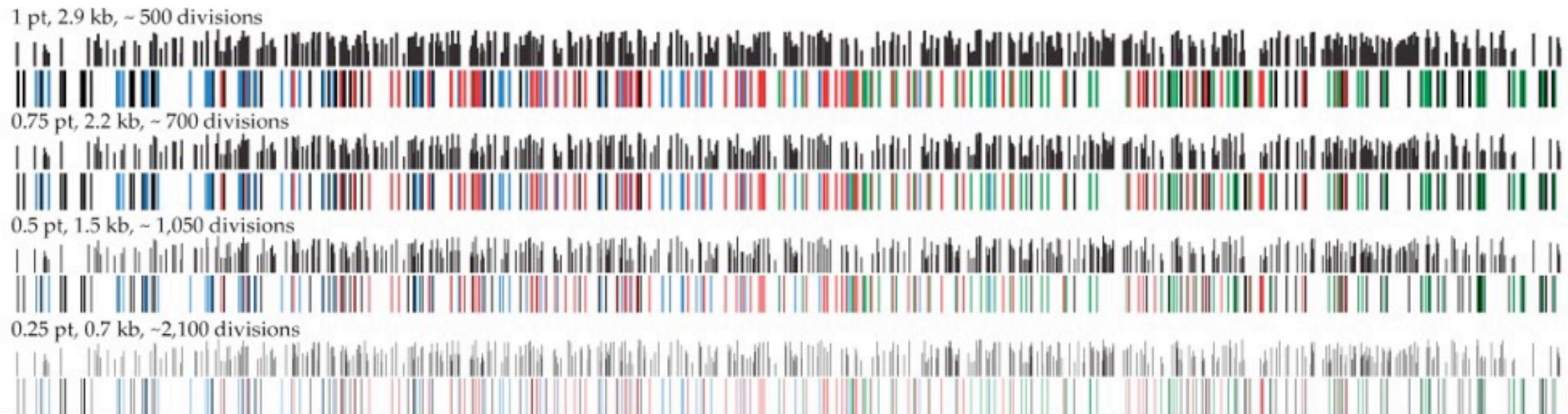


## RESOLVING COMPLEX DATA TRACKS

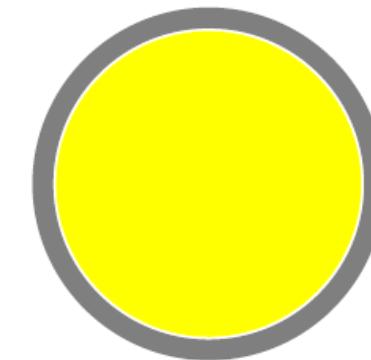
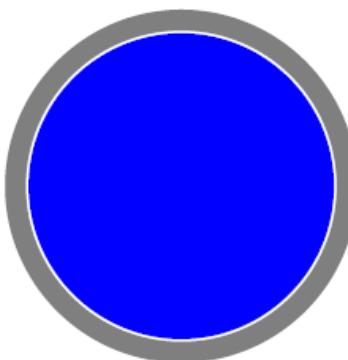


# EFFECTIVE VISUALIZATIONS. LEGIBILITY

- As a rule of thumb, do not divide scale into more than 500 intervals per 216mm (US letter size).
  - 1 pt on a 183 mm figure, 4 pixels on a 1920 horizontal resolution display, or 2 pixels on a typical LCD projector



# EFFECTIVE VISUALIZATIONS. LEGIBILITY. COLOR



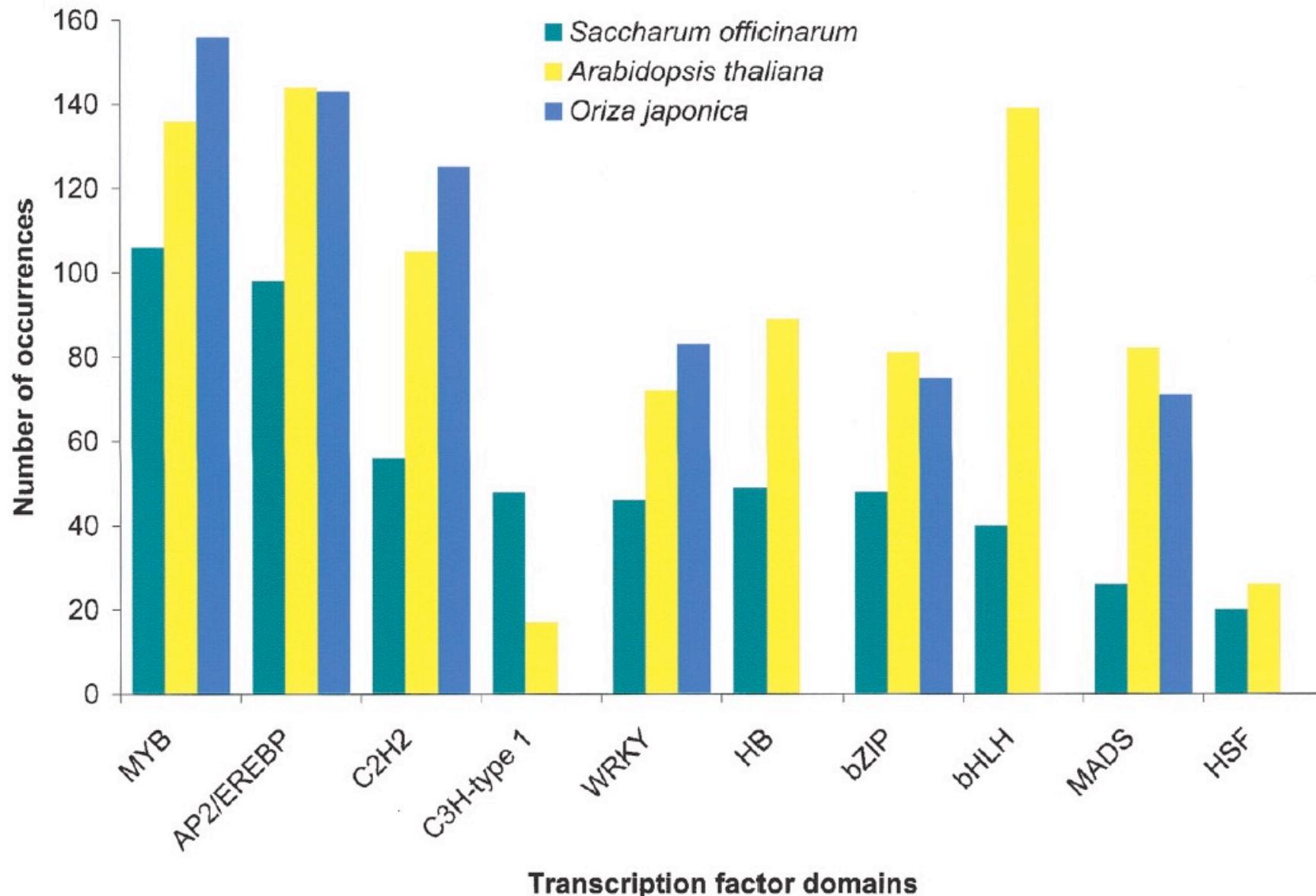
## HSB COLOR SPACE

HUE	240	60
SATURATION	1	1
BRIGHTNESS	1	1

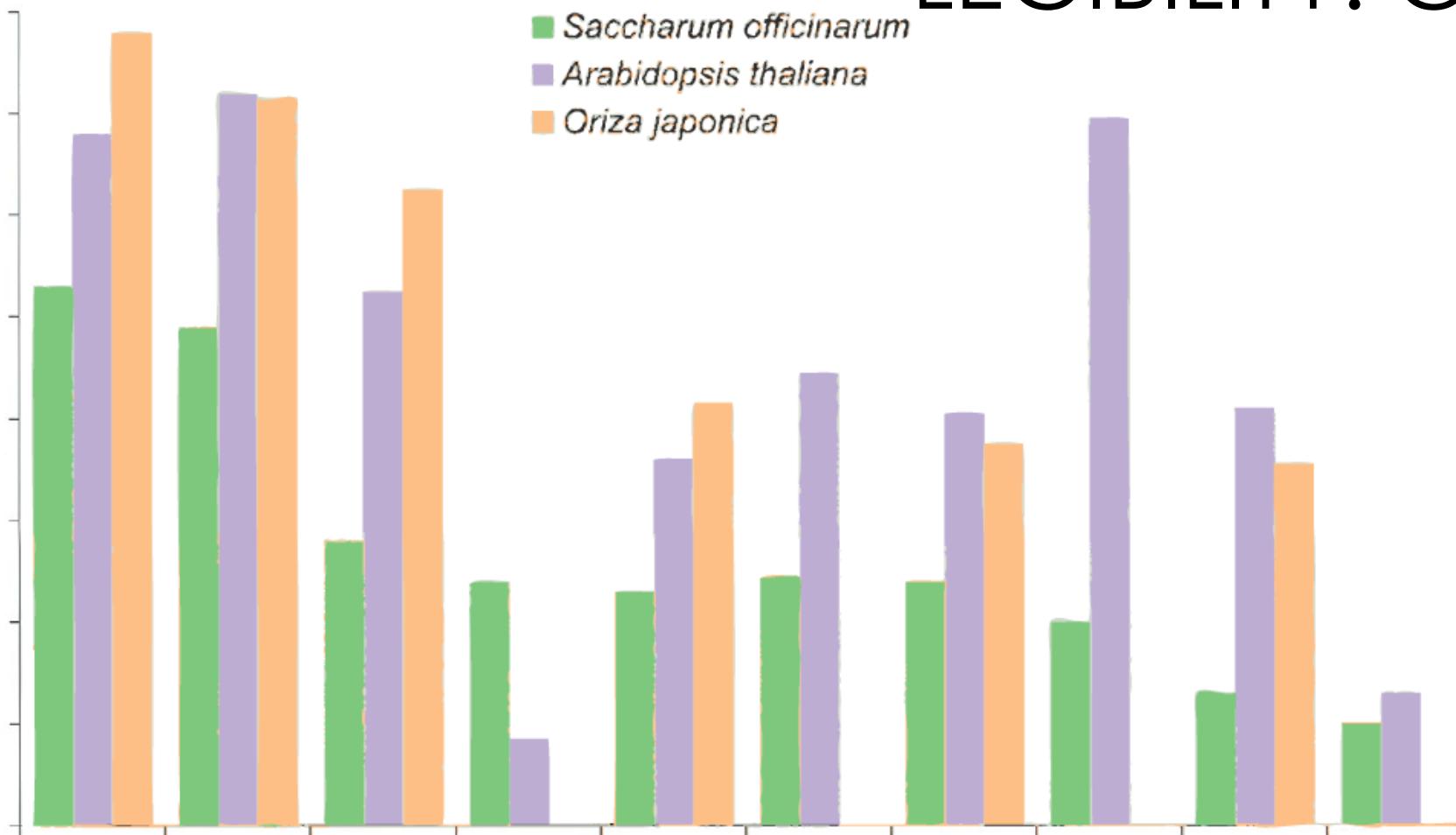
## LCH COLOR SPACE

HUE	266	86
CHROMA	130	107
LIGHTNESS	0.32	0.97

# EFFECTIVE VISUALIZATIONS. LEGIBILITY. COLOR



# EFFECTIVE VISUALIZATIONS. LEGIBILITY. COLOR



BREWER QUALITATIVE 3-COLOR PALETTES

ACCENT



PASTEL 1



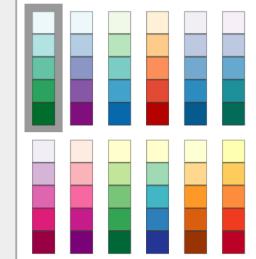
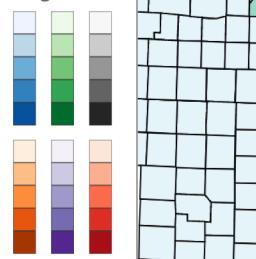
SET 2



# EFFECTIVE VISUALIZATIONS. LEGIBILITY. COLOR

Number of data classes: 3 [i](#)

Nature of your data:  
 sequential  diverging  qualitative [i](#)

Pick a color scheme:  
Multi-hue:  Single hue: 

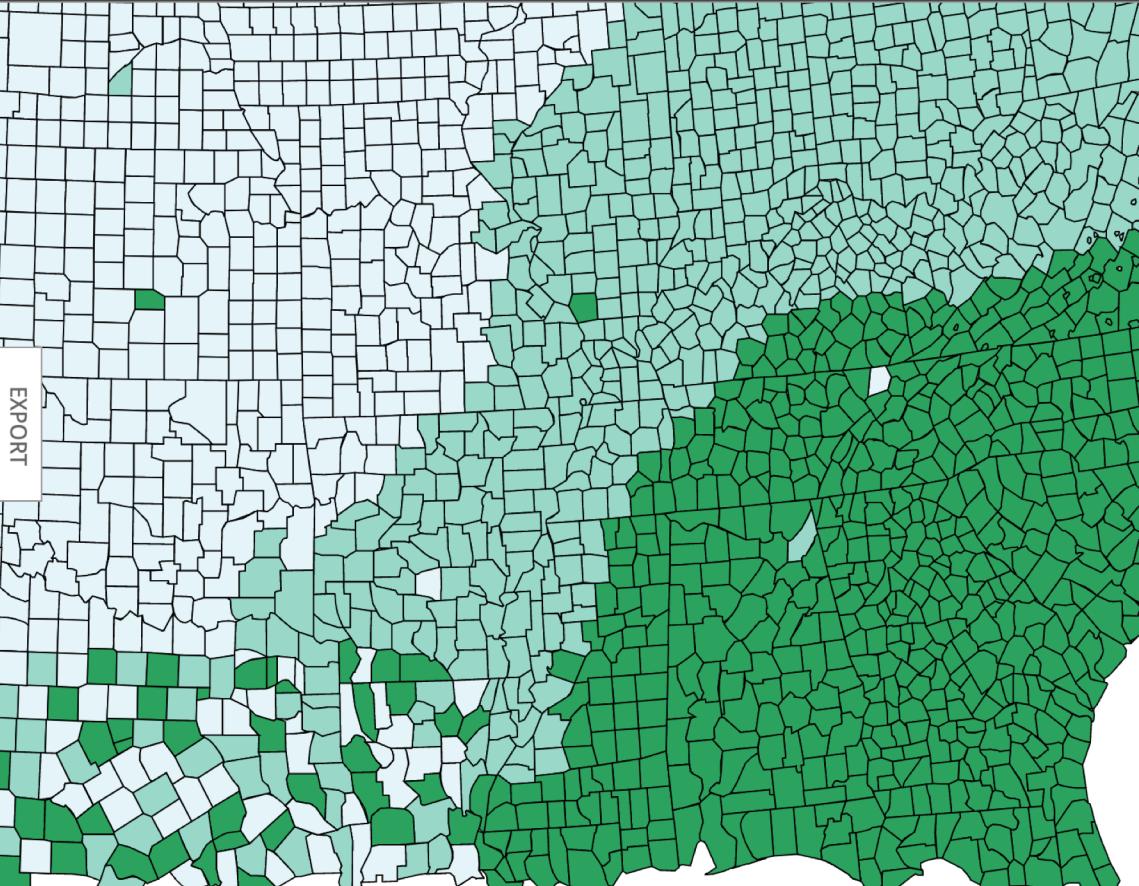
Only show:  
 colorblind safe  
 print friendly  
 photocopy safe

Context:  
 roads  
 cities  
 borders [i](#)

Background:  
 solid color  terrain  
 color transparency

how to use | updates | downloads | credits

**COLORBREWER 2.0**  
color advice for cartography



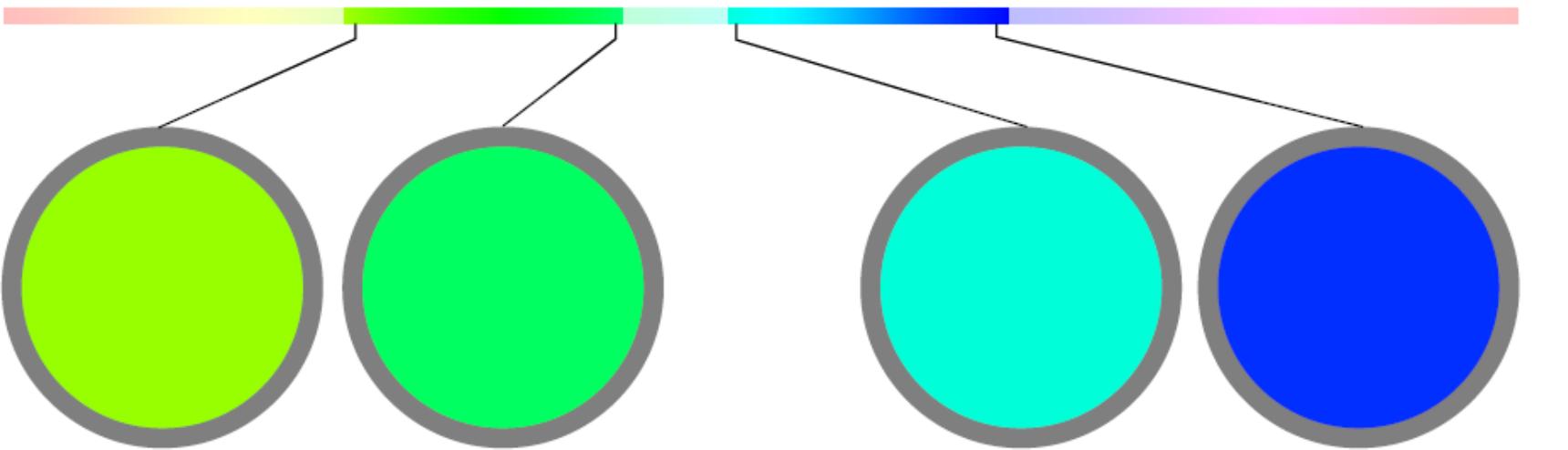
EXPORT

HEX [▼](#)

#e5f5f9  
#99d8c9  
#2ca25f

© Cynthia Brewer, Mark Harrower and The Pennsylvania State University  
[Source code and feedback](#)  
[Back to Flash version](#)  
[Back to ColorBrewer 1.0](#)

 axismaps

**HSB COLOR SPACE** $\Delta H = 60$  $\Delta H = 60$ 

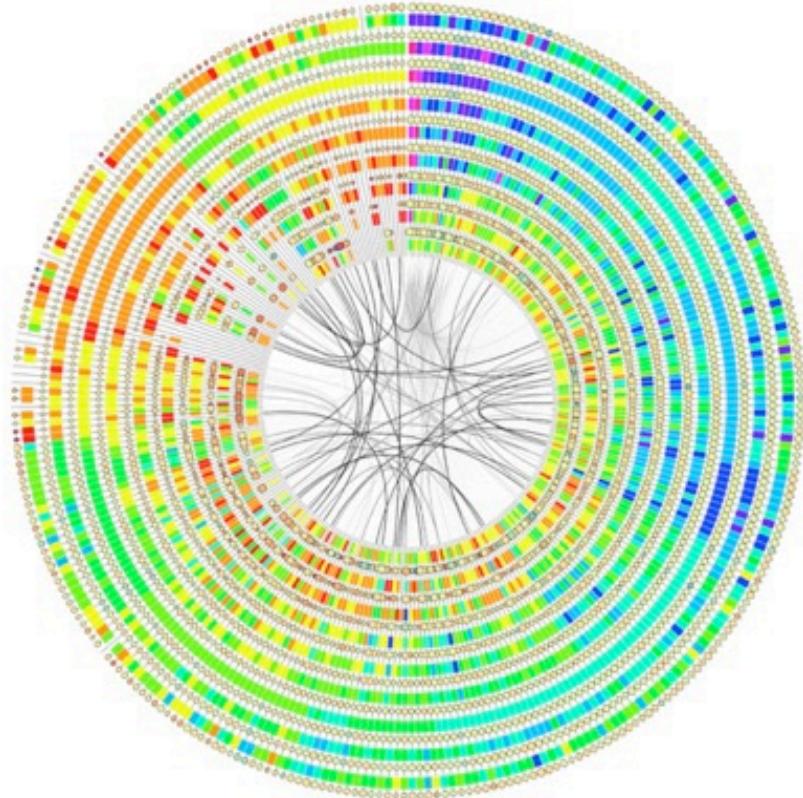
HUE	83	143	171	231
SATURATION	1	1	1	1
BRIGHTNESS	1	1	1	1

**Lab COLOR SPACE** $\Delta E_{ab} = 35$  $\Delta E_{ab} = 176$ 

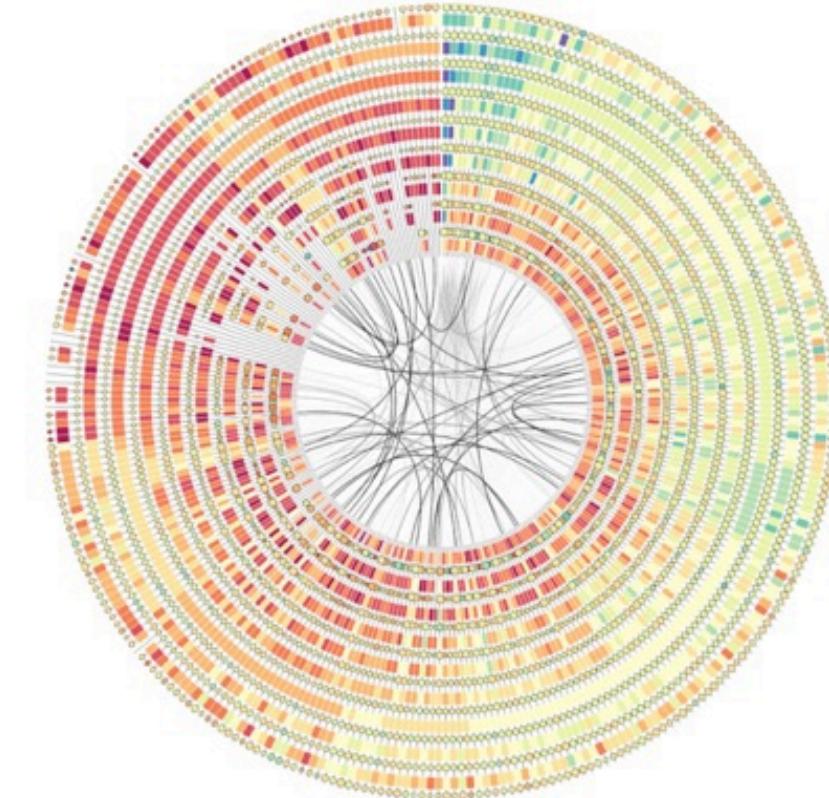
L	91	88	90	35
a	-59	-81	-58	70
b	87	60	4	-102

# EFFECTIVE VISUALIZATIONS. LEGIBILITY. COLOR

UNIFORM HSB 11 COLOR PALETTE

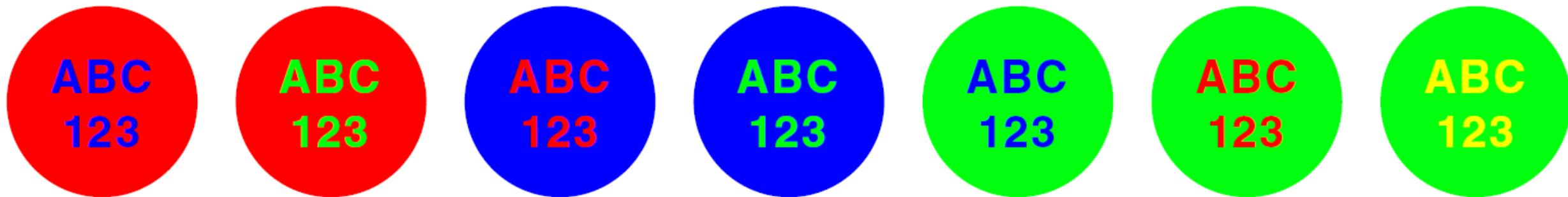


BREWER 11 COLOR SPECTRAL PALETTE



# EFFECTIVE VISUALIZATIONS. LEGIBILITY. CONTRAST

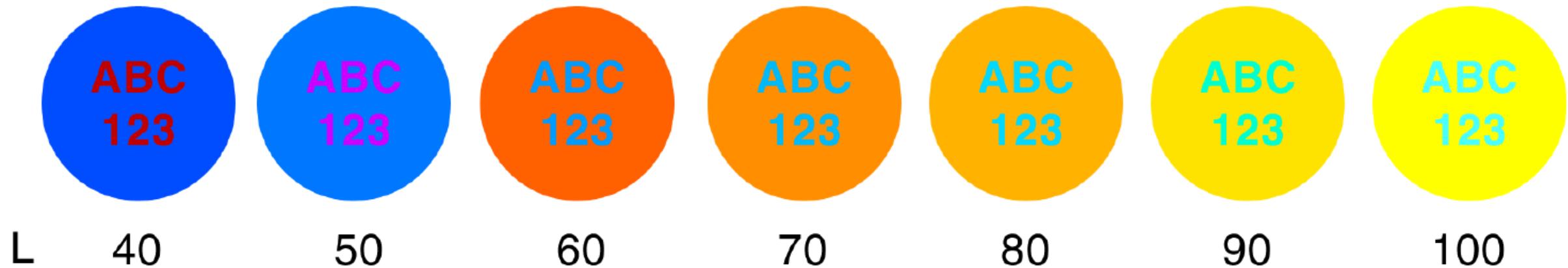
- Simultaneous contrast occurs when two pure colors are adjacent



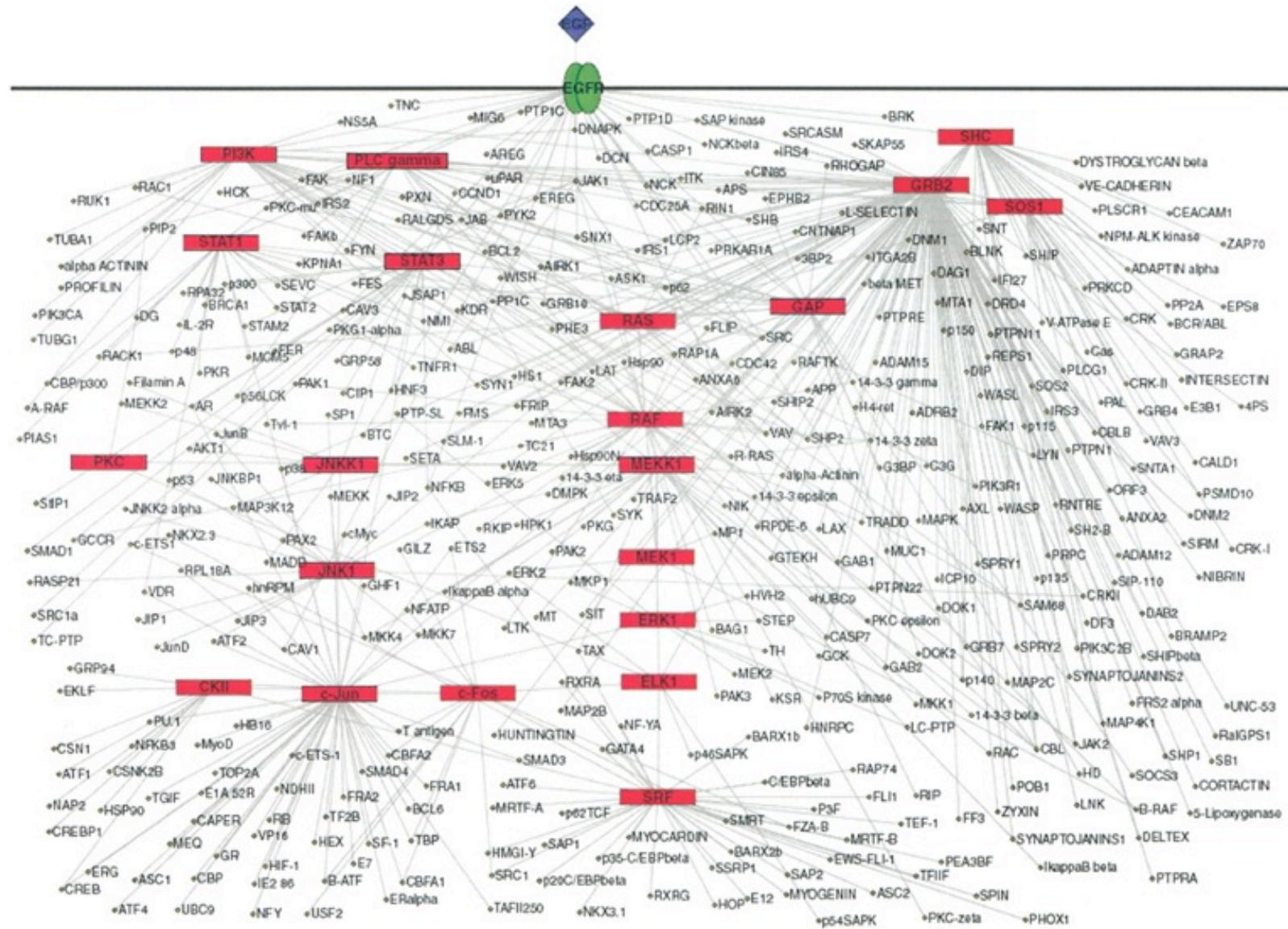
# EFFECTIVE VISUALIZATIONS. LEGIBILITY. CONTRAST

- Poor contrast occurs when two colors have similar luminance (perceived brightness)

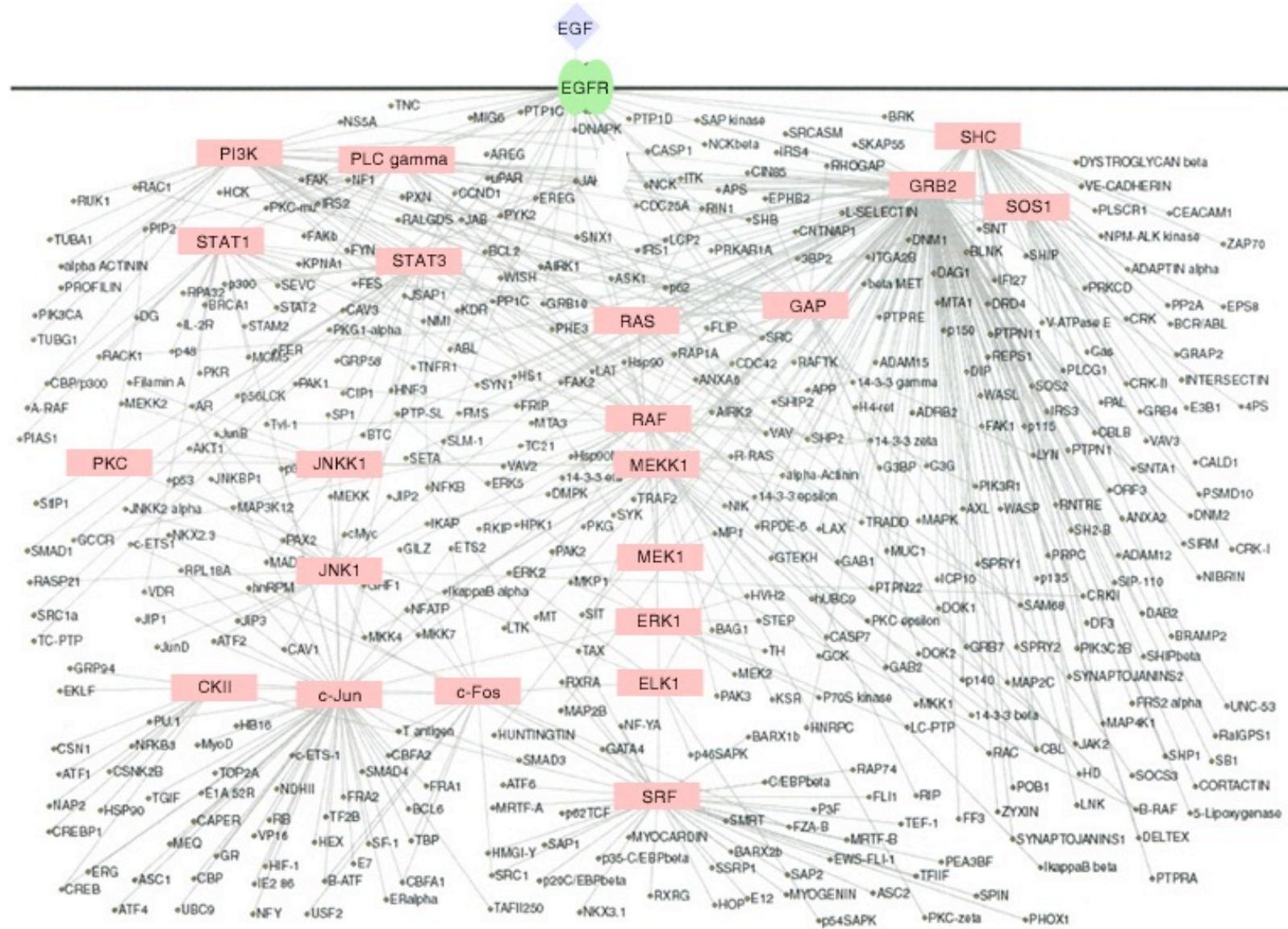
$$\Delta L = 0$$



# EFFECTIVE VISUALIZATIONS. LEGIBILITY. CONTRAST



# EFFECTIVE VISUALIZATIONS. LEGIBILITY. CONTRAST



# EFFECTIVE VISUALIZATIONS

- More specific principles
  - Data informs variation
  - Consistency
  - Avoid redundancy
  - Conciseness
  - Remove to improve
  - Focus & emphasis
  - Attractiveness

# DATA INFORMS VARIATION

#PactosdelalInfamia

## SANT VICENÇ DE CASTELLET



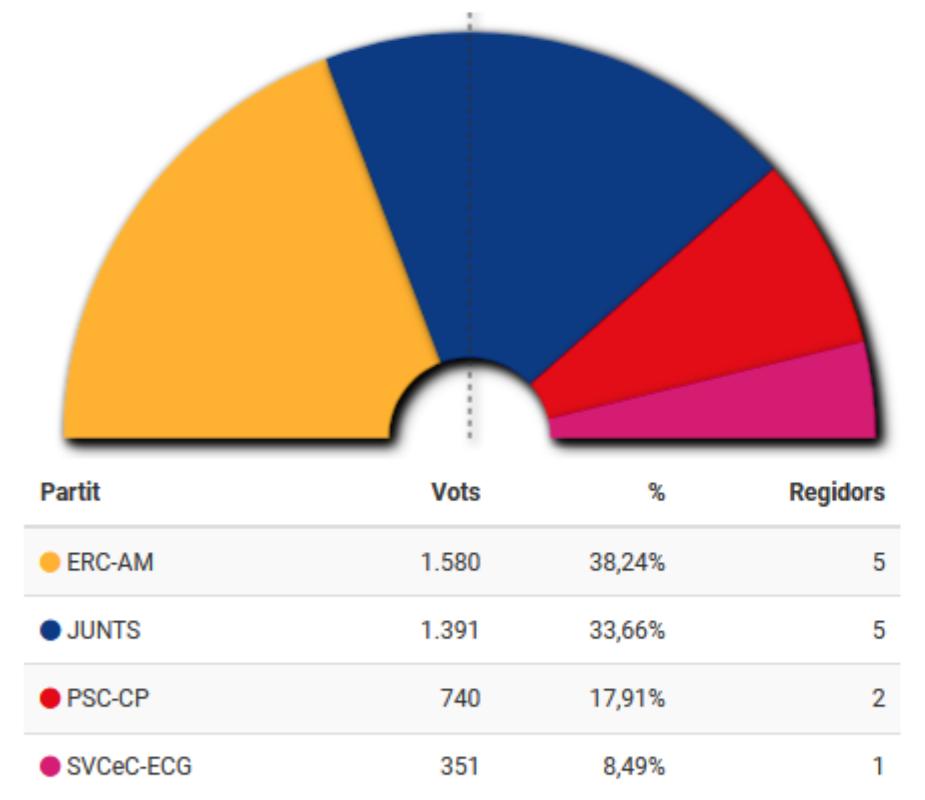
# DATA INFORMS VARIATION

#PactosdelalInfamia

## SANT VICENÇ DE CASTELLET

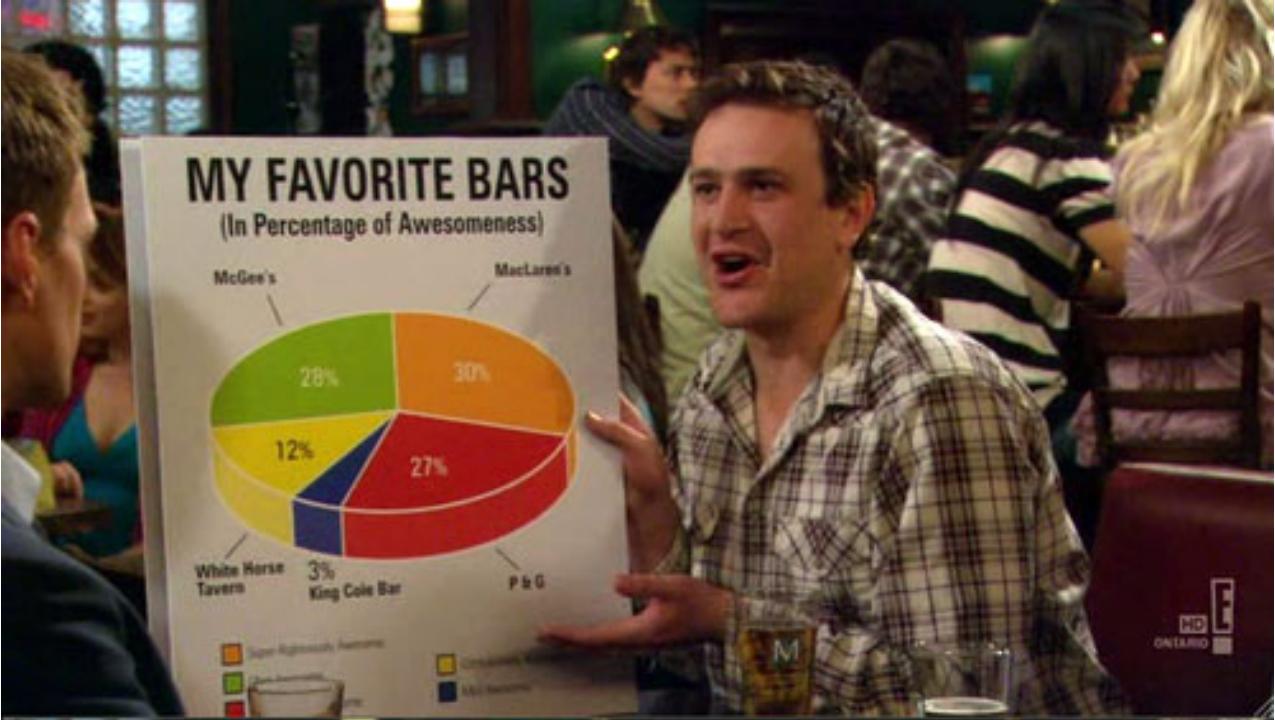


Sant Vicenç de Castellet 2019 (100,00% escrutat)



# CONSISTENCY

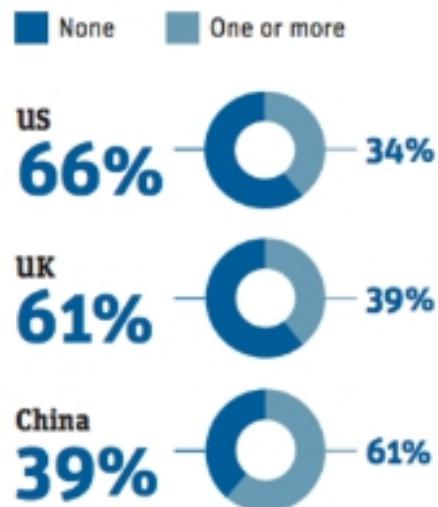
- Consistency implies color, shapes, etc.



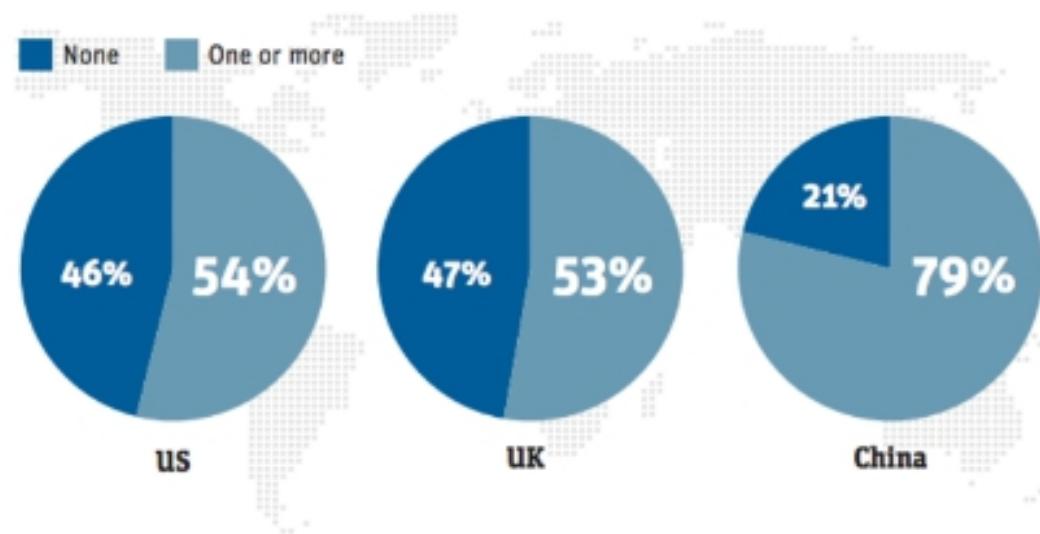
<https://www.webdevelopmentgroup.com/2015/05/data-visualization-best-practices/>

# CONSISTENCY

## How many women are on your board of directors?



## How many women are in your C-suite?



## Do you have programs in place to increase the number of women in leadership positions?



View the complete Startup Outlook 2016 report at [svb.com/ieo](http://svb.com/ieo)

<https://www.fastcompany.com/4011394/china-beats-the-u-s-when-it-comes-to-female-startup-leaders>

# CONSISTENCY

**China leads when it comes to female startup leaders with 79% of Chinese startups having one or more women in the C-Suite**

How many women directors do you have on the board?

US



UK



CHINA



How many women are in your C-Suite?

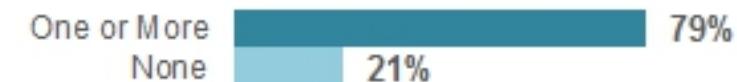
US



UK



CHINA



Do you have programs in place to increase the number of women in leadership positions?

US



UK

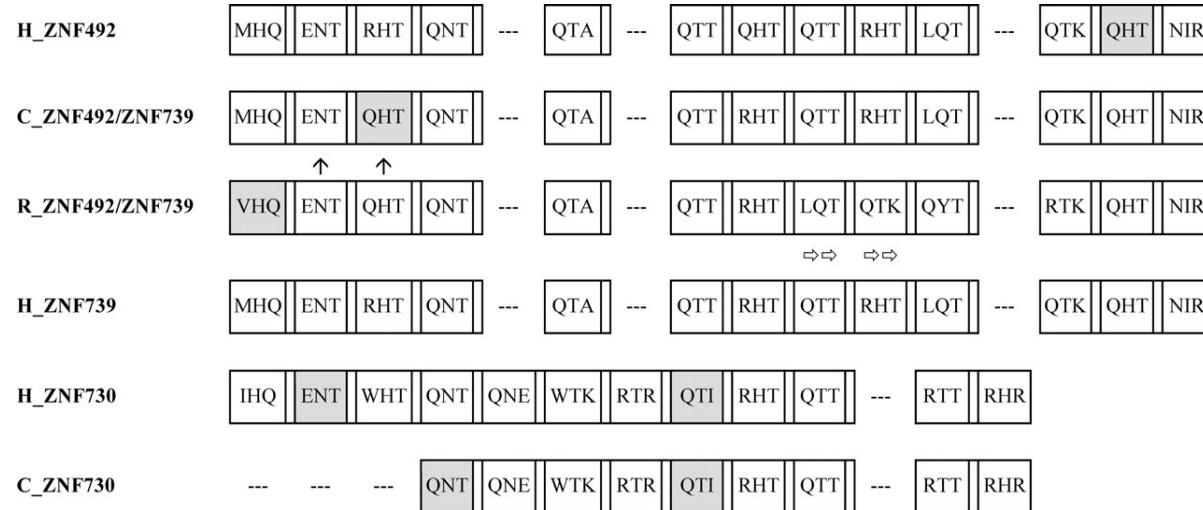


CHINA



Source: Silicon Valley Bank, Startup outlook 2016

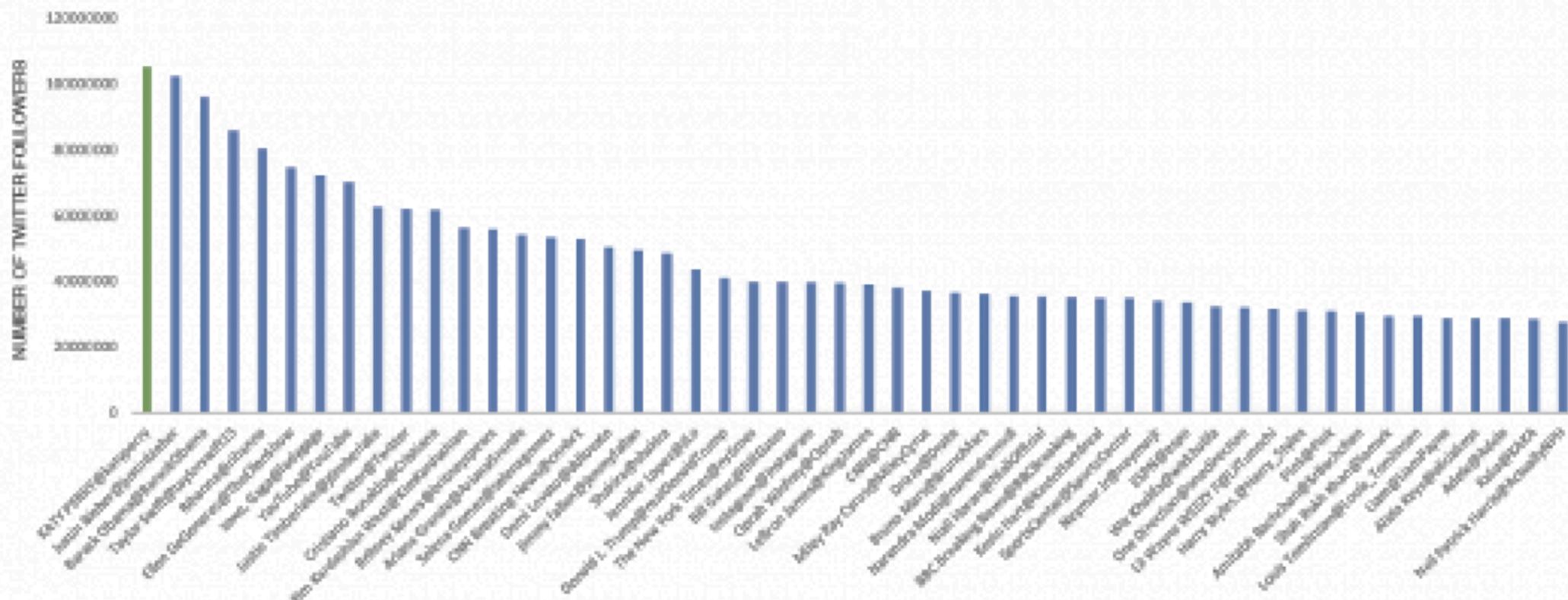
# AVOID REDUNDANCY



	MHQ	ENT	RHT	QNT	QNE	QTA	RTR	QTT	QHT	QTT	RHT	LQT	RHR	QTK	QHT	NIR
H492	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
C492/739	...	...	Q..	...	...	...	...	...	R..	...	...	...	...	...	...	...
R492/739	V..	...	Q..	...	...	...	...	R..	LQ..	QTK	QY..	...	R..	...	...	...
H739	M..	...	...	...	...	...	...	R..	...	QTK	...	...	...	...	...	...
H730	I..	...	W..	...	...	W.K	...	..I	R..	...	RT..	...				
C730			...	...	W.K	...	..I	R..	...	RT..	...					

# CONCISENESS

## HOW POPULAR IS KATY PERRY ON TWITTER?



# CONCISENESS

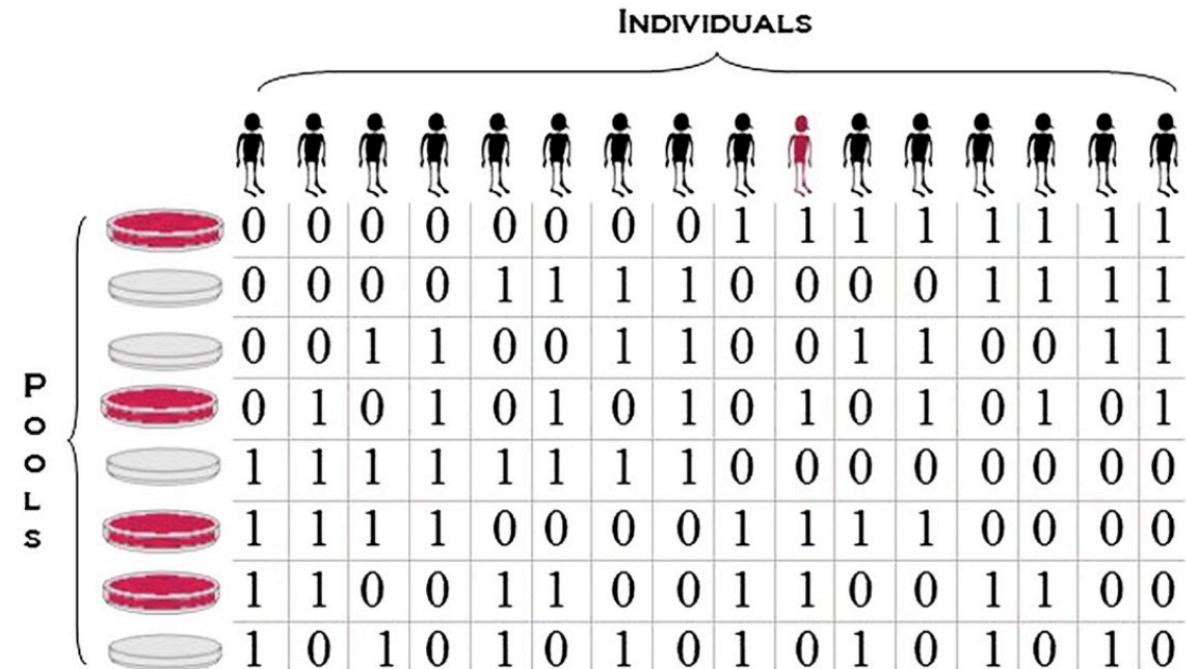
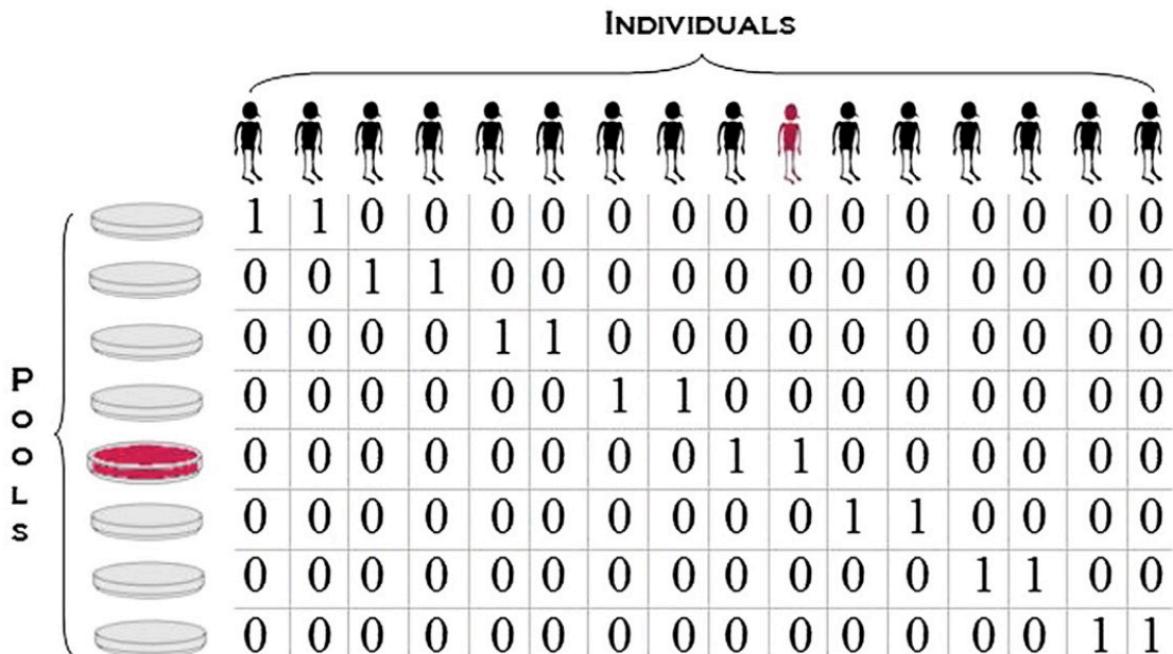
## HOW POPULAR IS KATY PERRY ON TWITTER?



Katy Perry  
@katyperry      Justin Bieber  
@justinbieber      Barack Obama  
@BarackObama      Taylor Swift  
@taylorswift13      Rihanna  
@rihanna      Ellen DeGeneres  
@TheEllenShow      Lady Gaga  
@ladygaga

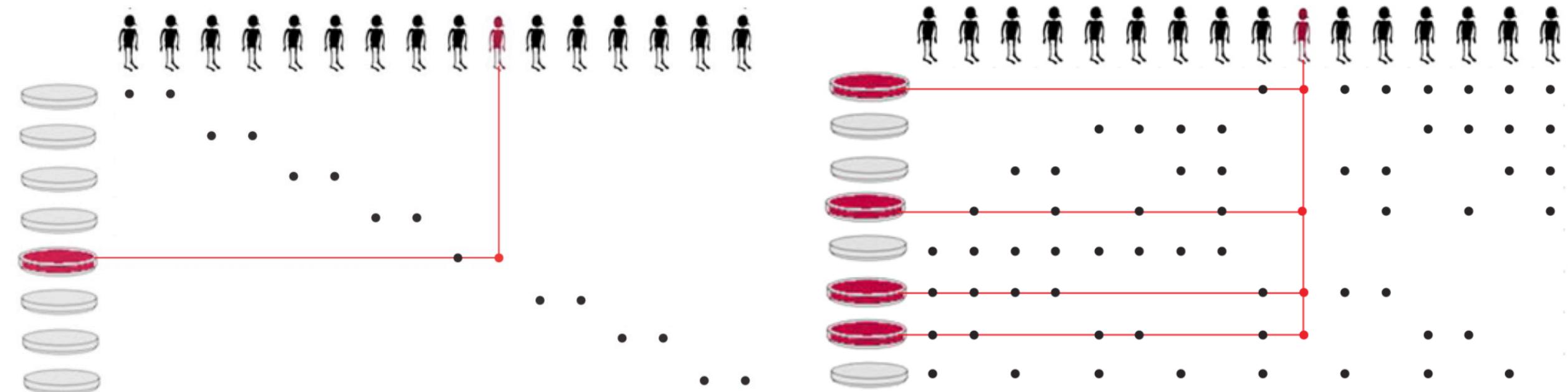
# REMOVE TO IMPROVE

- Excess ink competes with message



# REMOVE TO IMPROVE

- Excess ink competes with message

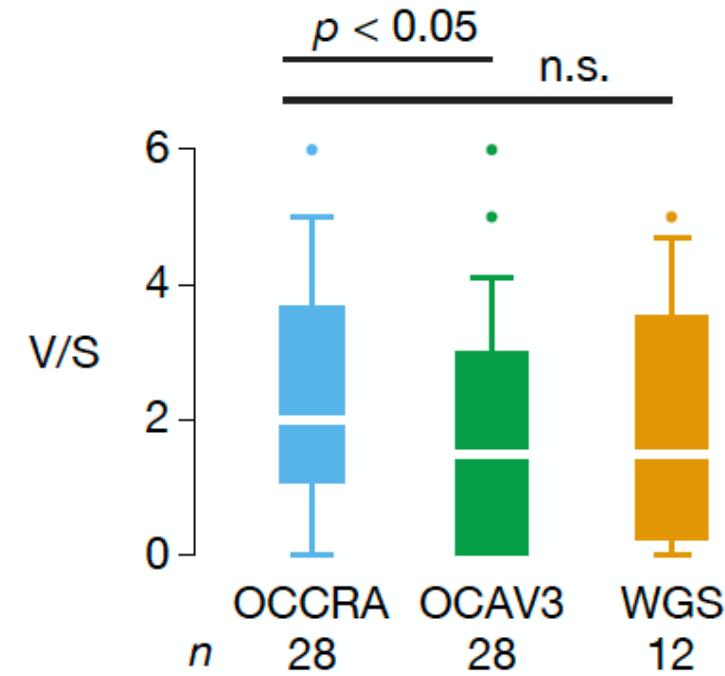
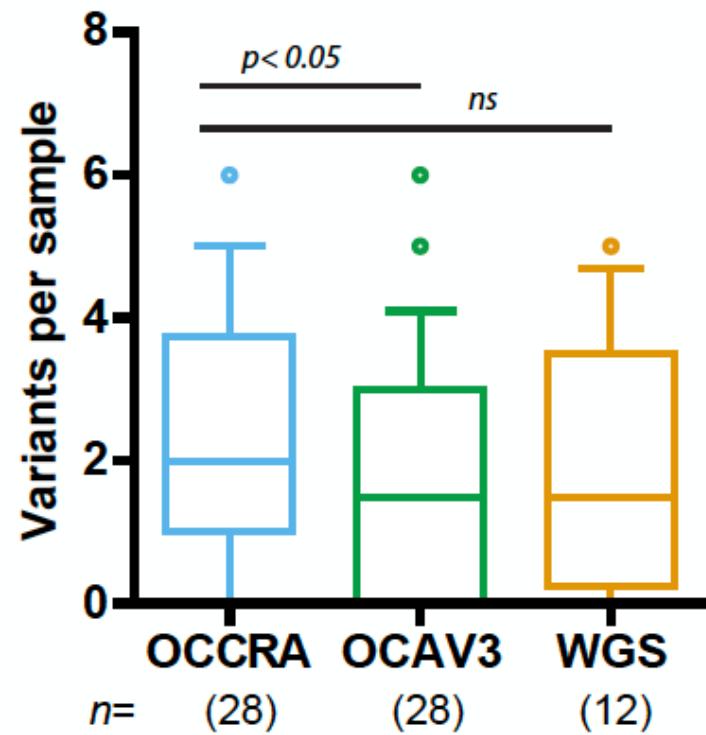


Resequencing with naïve and log pool designs. Prabhu, S. and I. Pe'er, Overlapping pools for high-throughput targeted resequencing. *Genome Res*, 2009. 19 (7): p. 1254-61.

# FOCUS AND EMPHASIS

- Match the pertinence of an object with its visual salience
  - Which also means removing salience of non-important elements
- Apply visual organization Gestalt principles

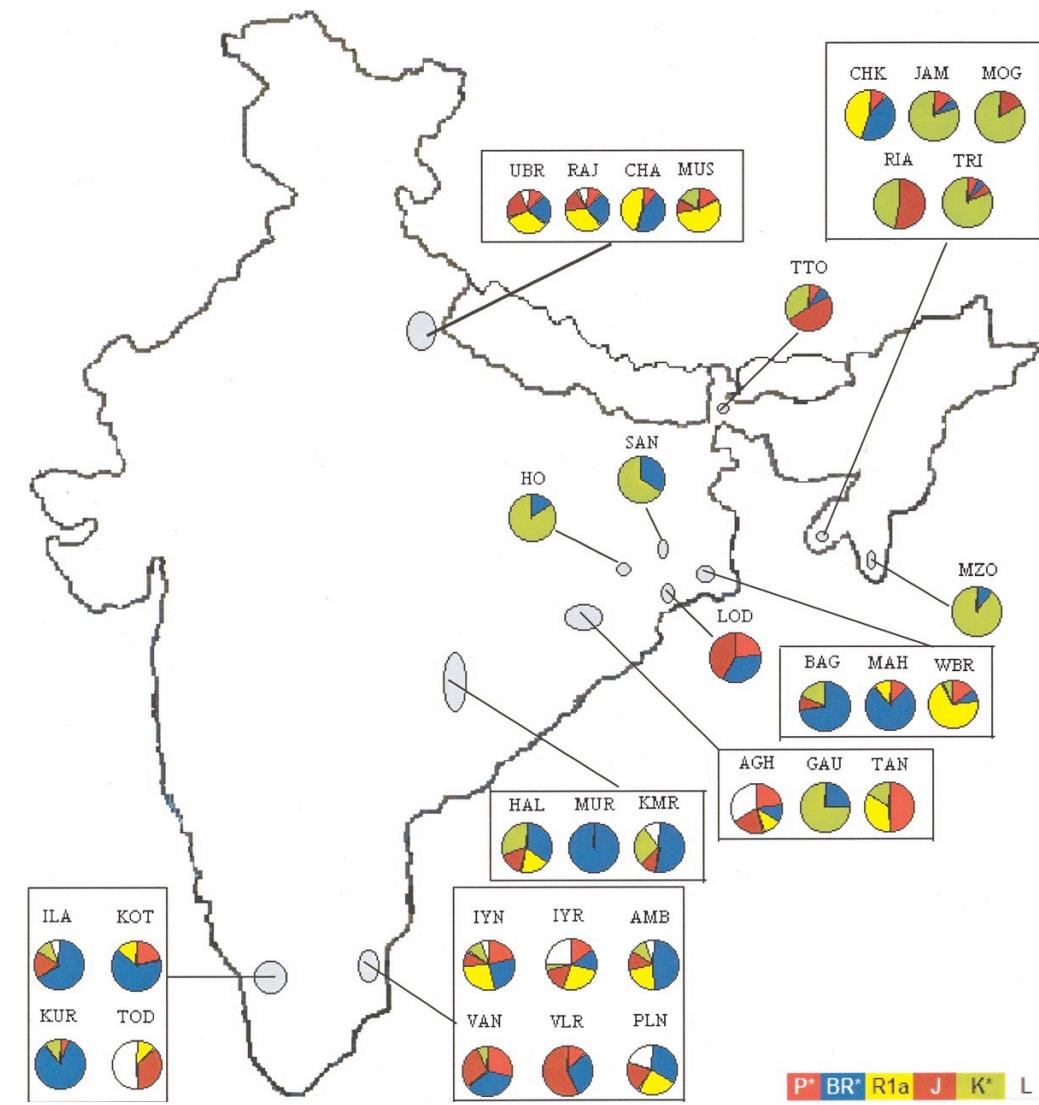
# FOCUS AND EMPHASIS



# EFFECTIVE VISUALIZATIONS. ATTRACTIVENESS

- The importance of grids

Frequencies (%) of Y-chromosomal haplogroups among ethnic populations. Basu, A., et al., Ethnic India: a genomic view, with special reference to peopling and structure. *Genome Res*, 2003. 13(10): p. 2277-90..



# EFFECTIVE VISUALIZATIONS. ATTRACTIVENESS

- The importance of grids
  - Redesign



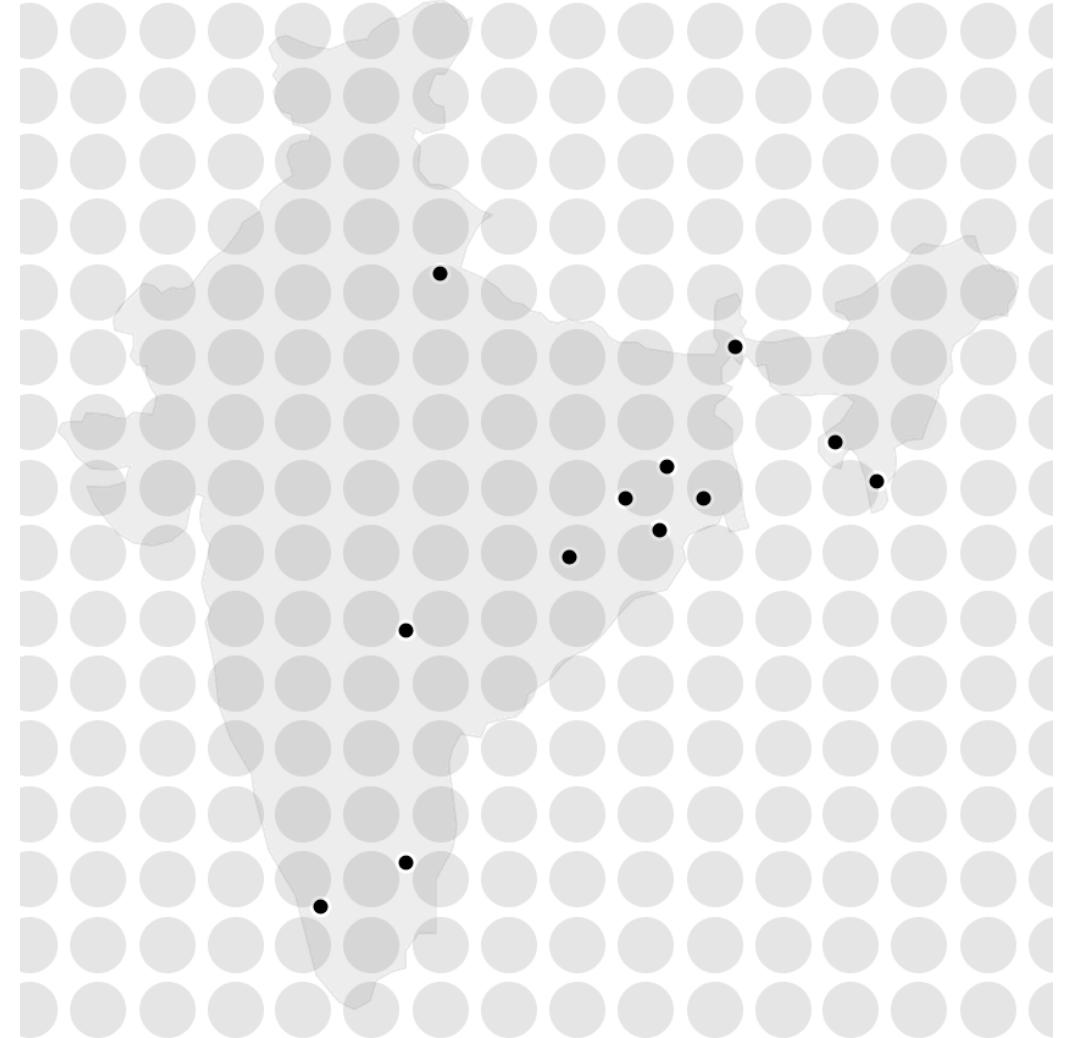
# EFFECTIVE VISUALIZATIONS. ATTRACTIVENESS

- The importance of grids
  - Redesign



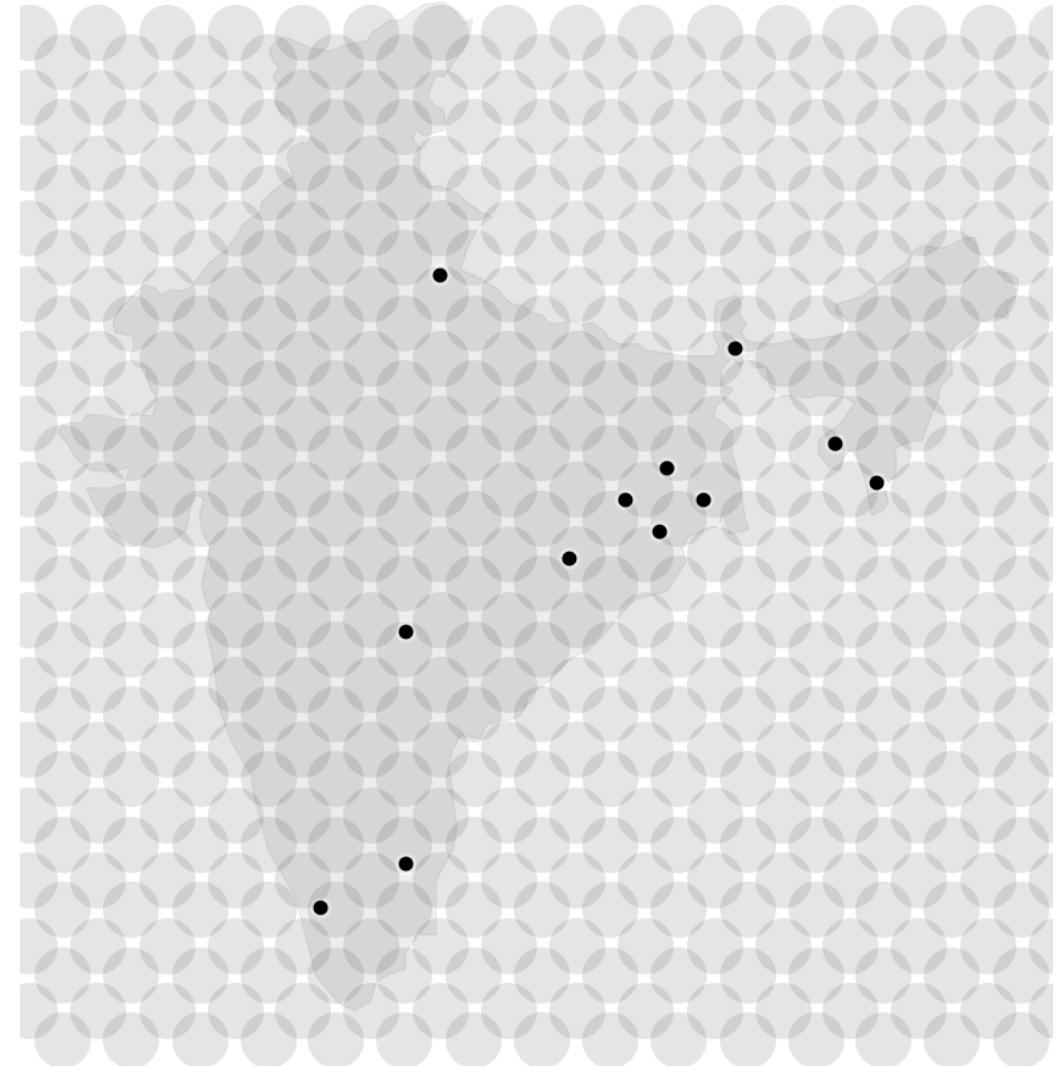
# EFFECTIVE VISUALIZATIONS. ATTRACTIVENESS

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  - Redesign



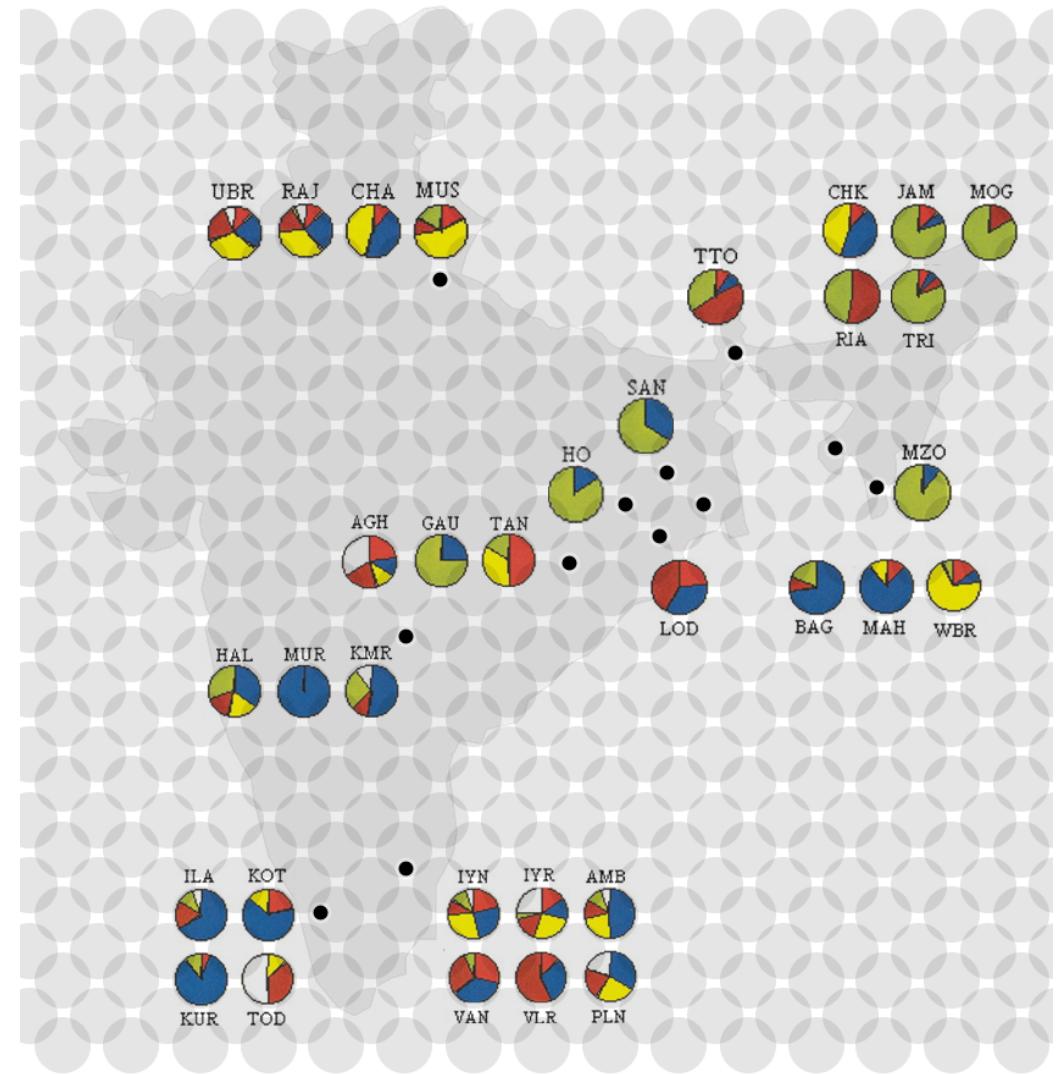
# EFFECTIVE VISUALIZATIONS. ATTRACTIVENESS

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  - Redesign



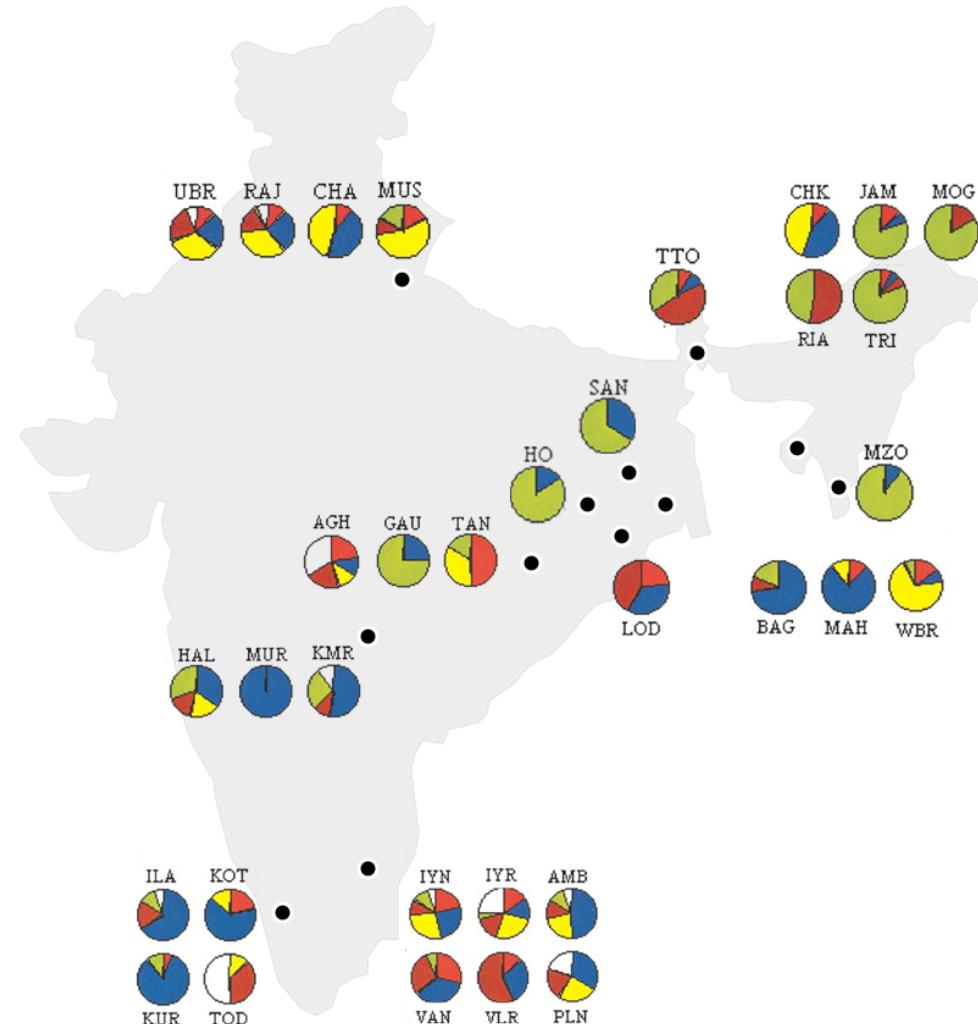
# EFFECTIVE VISUALIZATIONS. ATTRACTIVENESS

- The importance of grids
  - Redesign



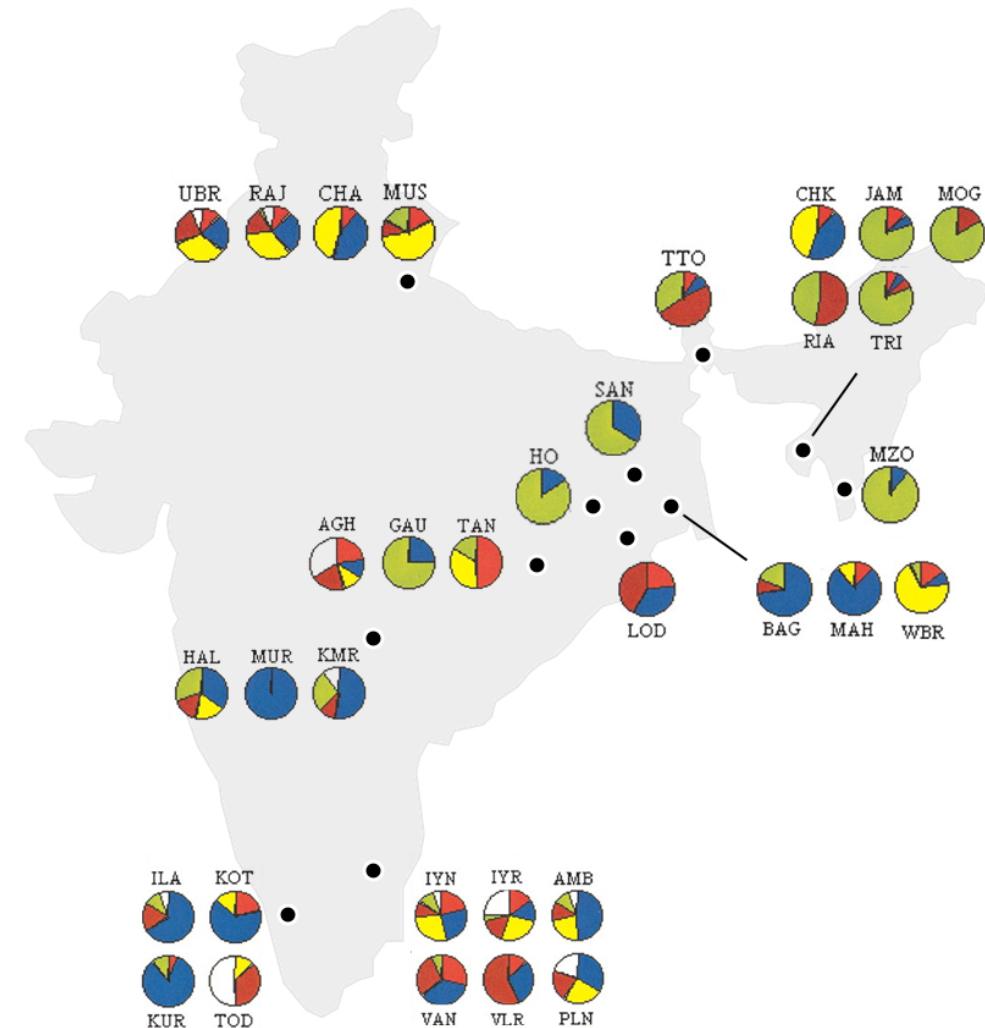
# EFFECTIVE VISUALIZATIONS. ATTRACTIVENESS

- The importance of grids
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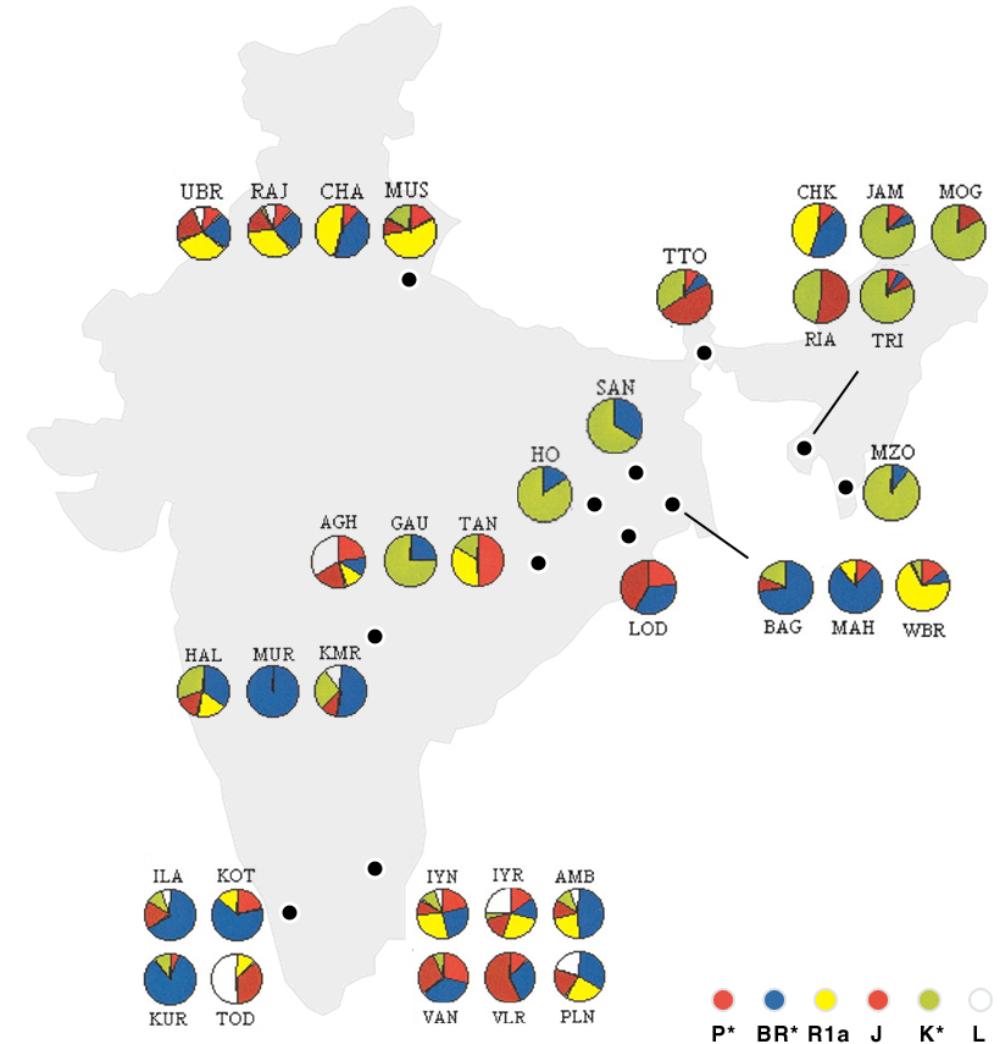
# EFFECTIVE VISUALIZATIONS. ATTRACTIVENESS

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  - Redesign

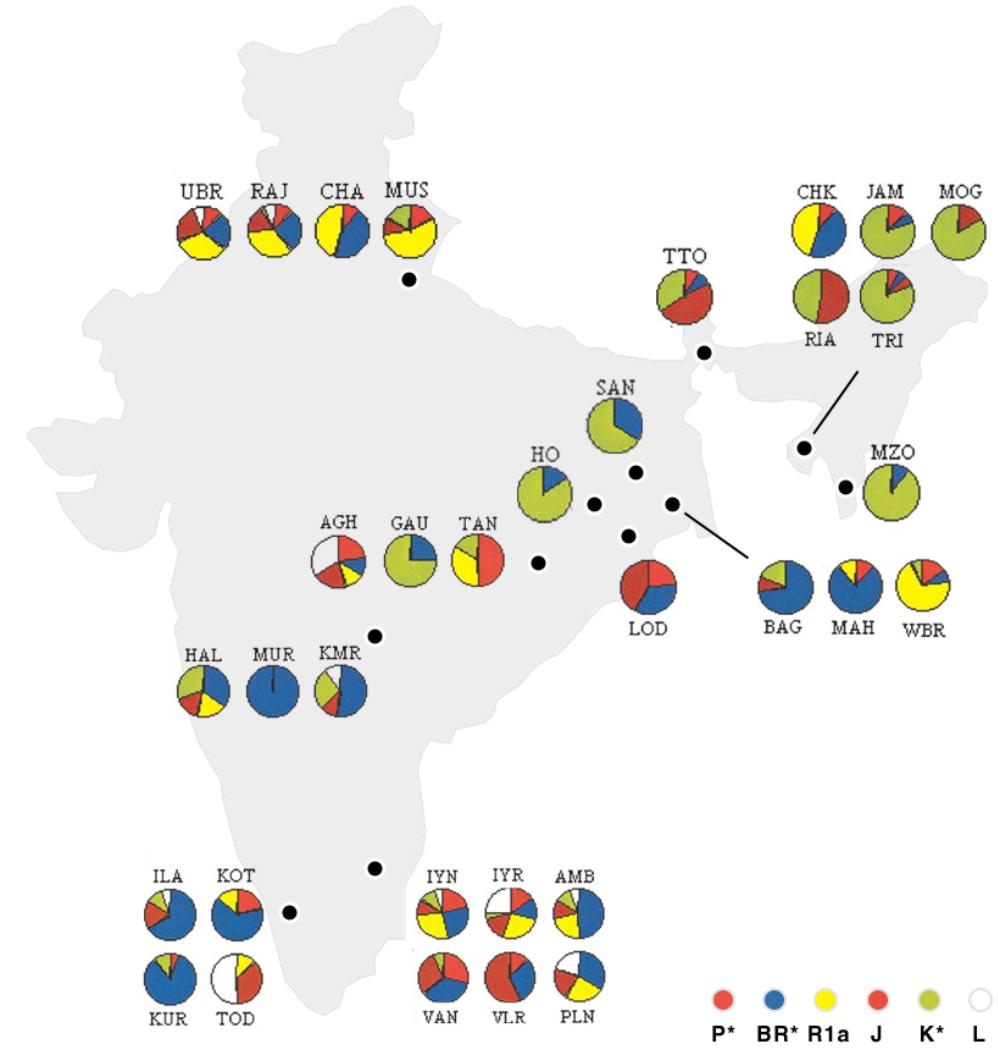
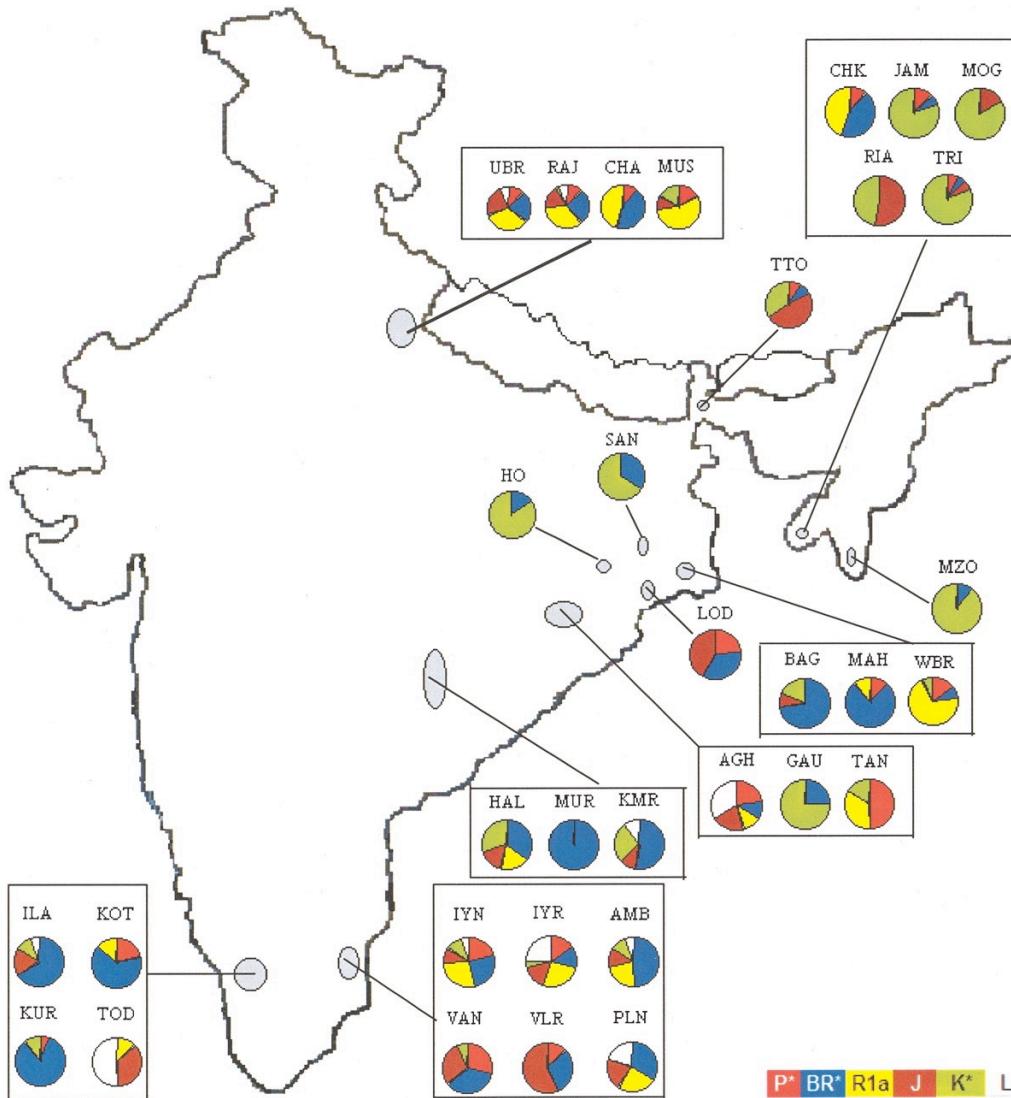


# EFFECTIVE VISUALIZATIONS. ATTRACTIVENESS

- The importance of grids
  - Redesign



# EFFECTIVE VISUALIZATIONS. ATTRACTIVENESS



# OUTLINE

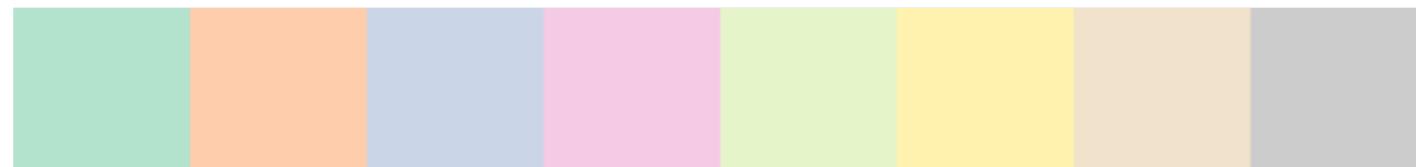
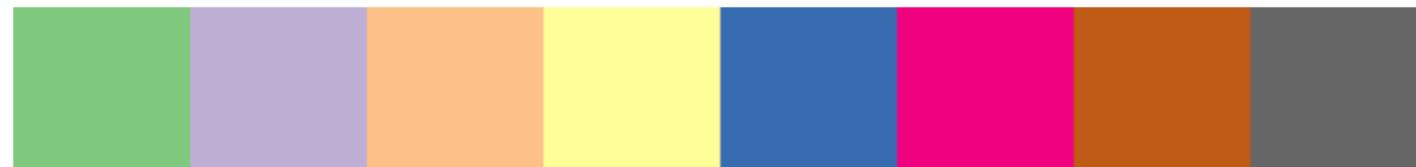
- Effective Visualizations
- **Use of color**
- Comparison
- Copy & labels
- Ordering & aligning data

# USE OF COLOR. BACKGROUND

- Four types of use of color in vis:
  - To distinguish
  - To encode values
  - To highlight

# USE OF COLOR. BACKGROUND

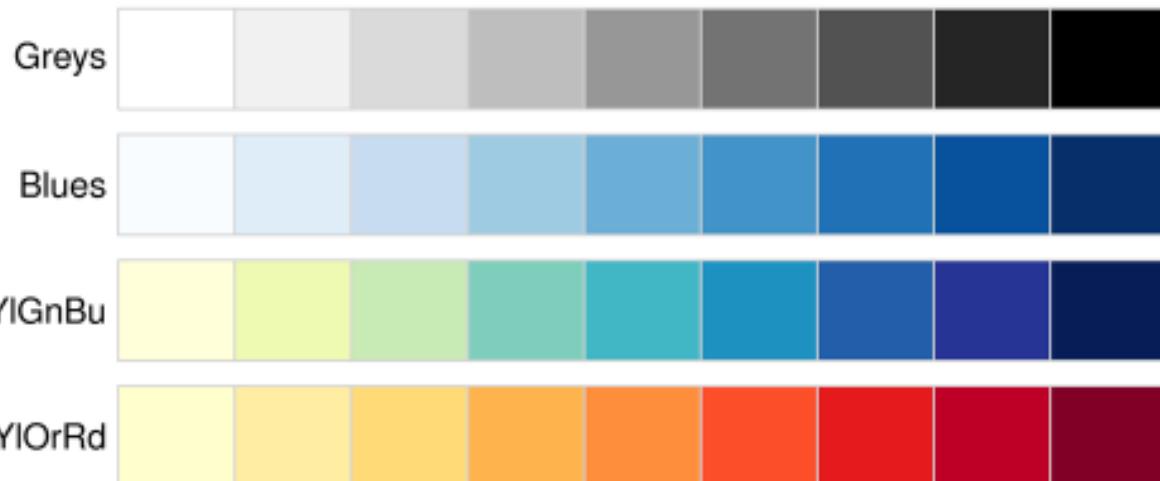
- Four types of use of color in vis:
  - To distinguish: categorical data



# USE OF COLOR. BACKGROUND

- Four types of use of color in vis:
  - To encode values. Quantitative data

**Sequential palettes**



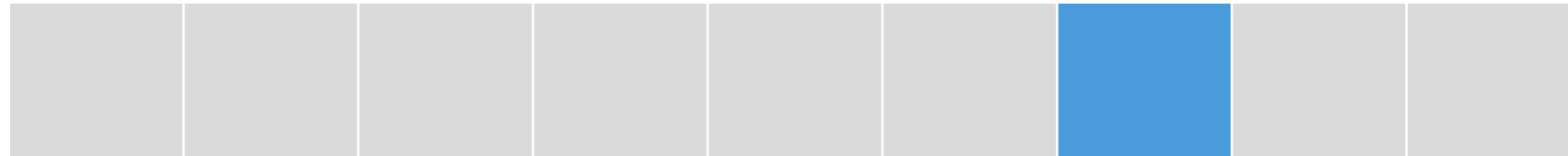
**Diverging palettes**



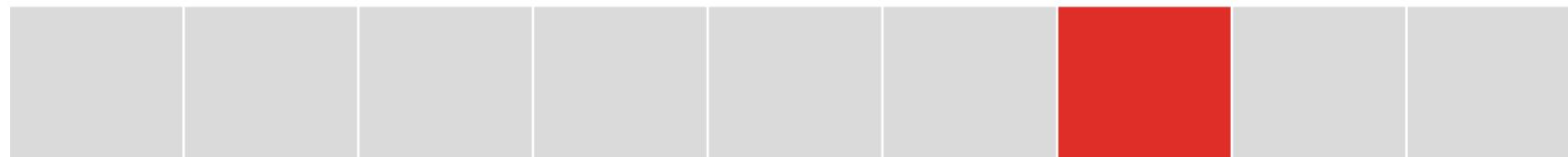
# USE OF COLOR. BACKGROUND

- Four types of use of color in vis:
  - To highlight elements/values

highlight



alert

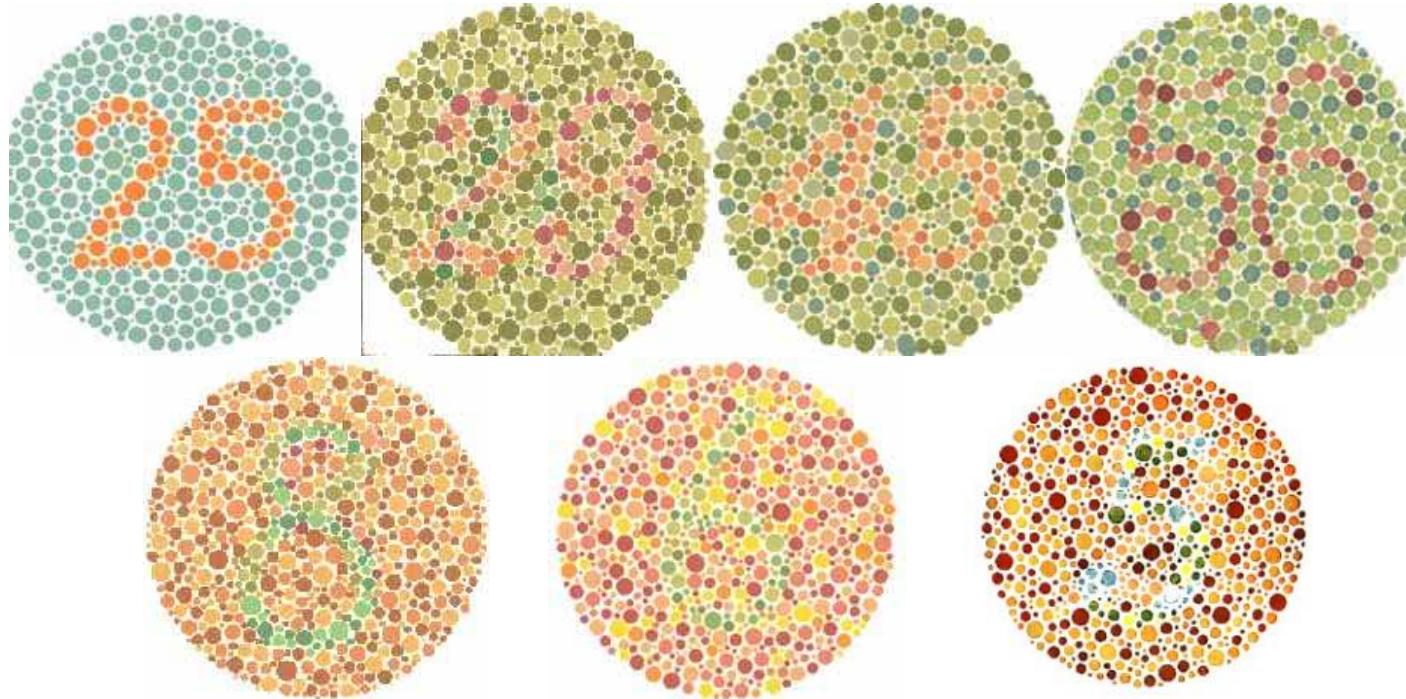


# USE OF COLOR. BACKGROUND

- Color blindness:
  - Inability to distinguish the colors the same way than non-color impaired people
    - 5-10% of men
    - 1-2% of women
  - Relatively easy to detect
    - Ishihara tests

# USE OF COLOR. BACKGROUND

Ishihara test images



# USE OF COLOR. BACKGROUND

- Other vision problems:
  - About 4% of the population have low vision (0.6% are blind)
  - Low-vision conditions increase with age
    - Half of people over 50 have some degree of low-vision condition
  - Worldwide, the fastest-growing population is 60+ years
    - Over 40, almost everyone needs corrected vision to clearly see small objects or text
    - Age-related vision problems include macular degeneration, diabetic retinopathy, cataracts, and retinitis pigmentosa

# USE OF COLOR. BACKGROUND

- Supporting packages and webpages:
  - **Colorblindor:** Color-blindness simulator.
    - <http://www.color-blindness.com/coblis-color-blindness-simulator/>
  - **Chromatic Vision Simulator:** Simulates three forms of colour deficiencies: Protanopia, Deuteranopia and Tritanopia.
    - Available for Android and iOS
  - **VisionSim:** Developed by the Braille Institute. It simulates a variety of low-vision conditions.
    - Available for Android and iOS

# USE OF COLOR. TIPS FOR COLOR SELECTION

- Color design rules:
  - Use color only when needed to serve a particular communication goal.

# USE OF COLOR. TIPS FOR COLOR SELECTION

- Selecting color palettes

- Use <http://colorbrewer2.org> or well-known dependable sources (Adobe, Tableau...)

Categorical



No order required

Sequential



Order required but no neutral value

Diverging



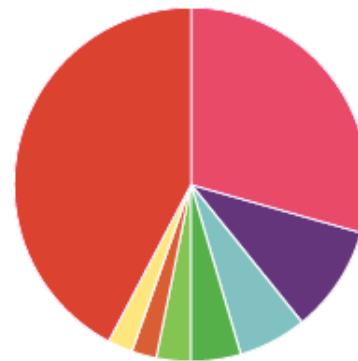
Order required **and** neutral value

PTION

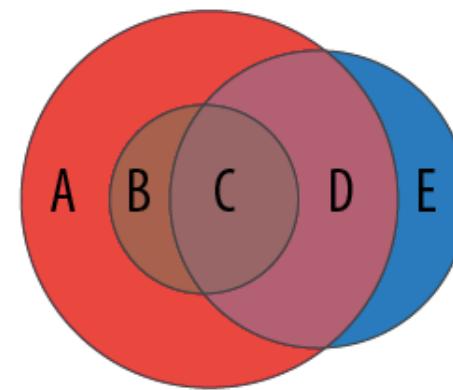
one color  
dominates



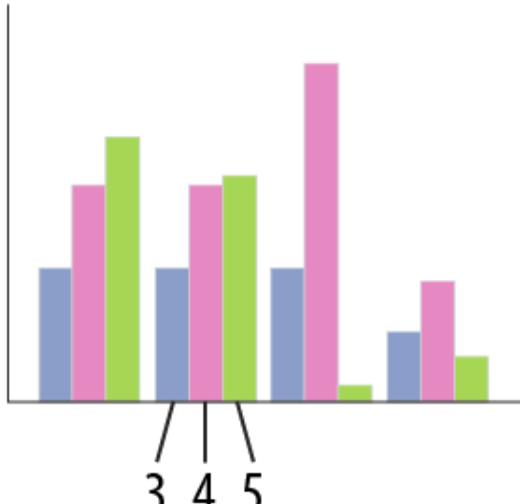
difficult to  
distinguish



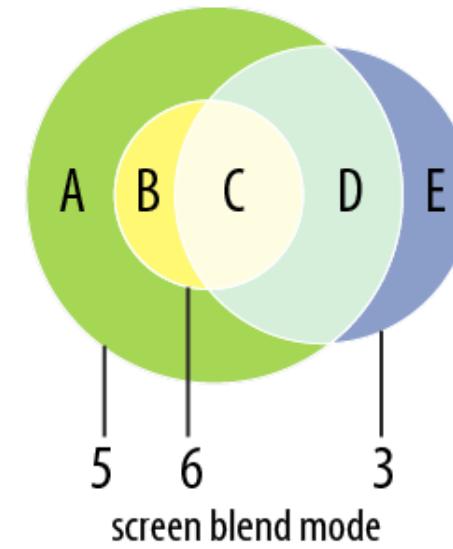
murky



recolored with Brewer palettes



set2

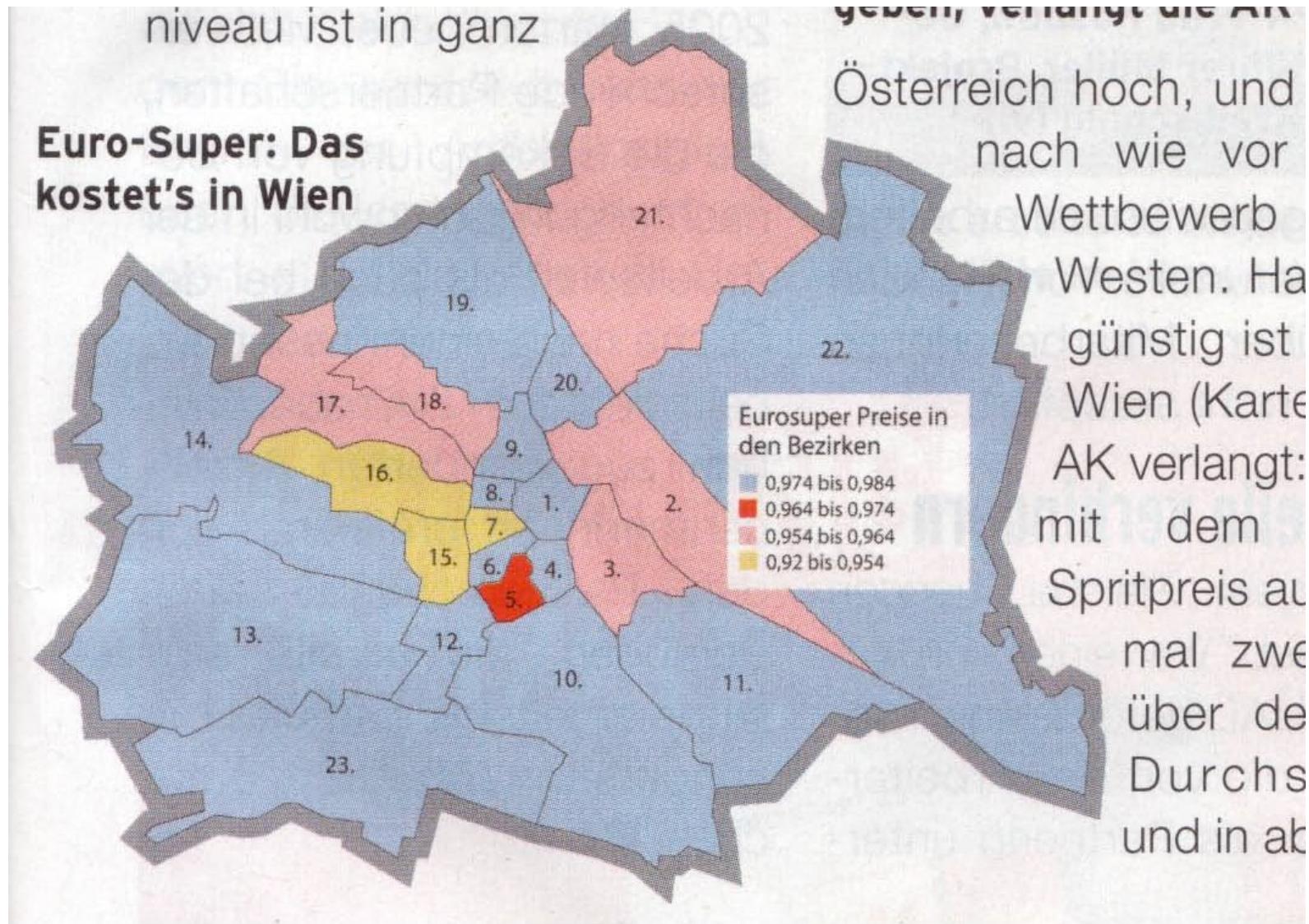


screen blend mode

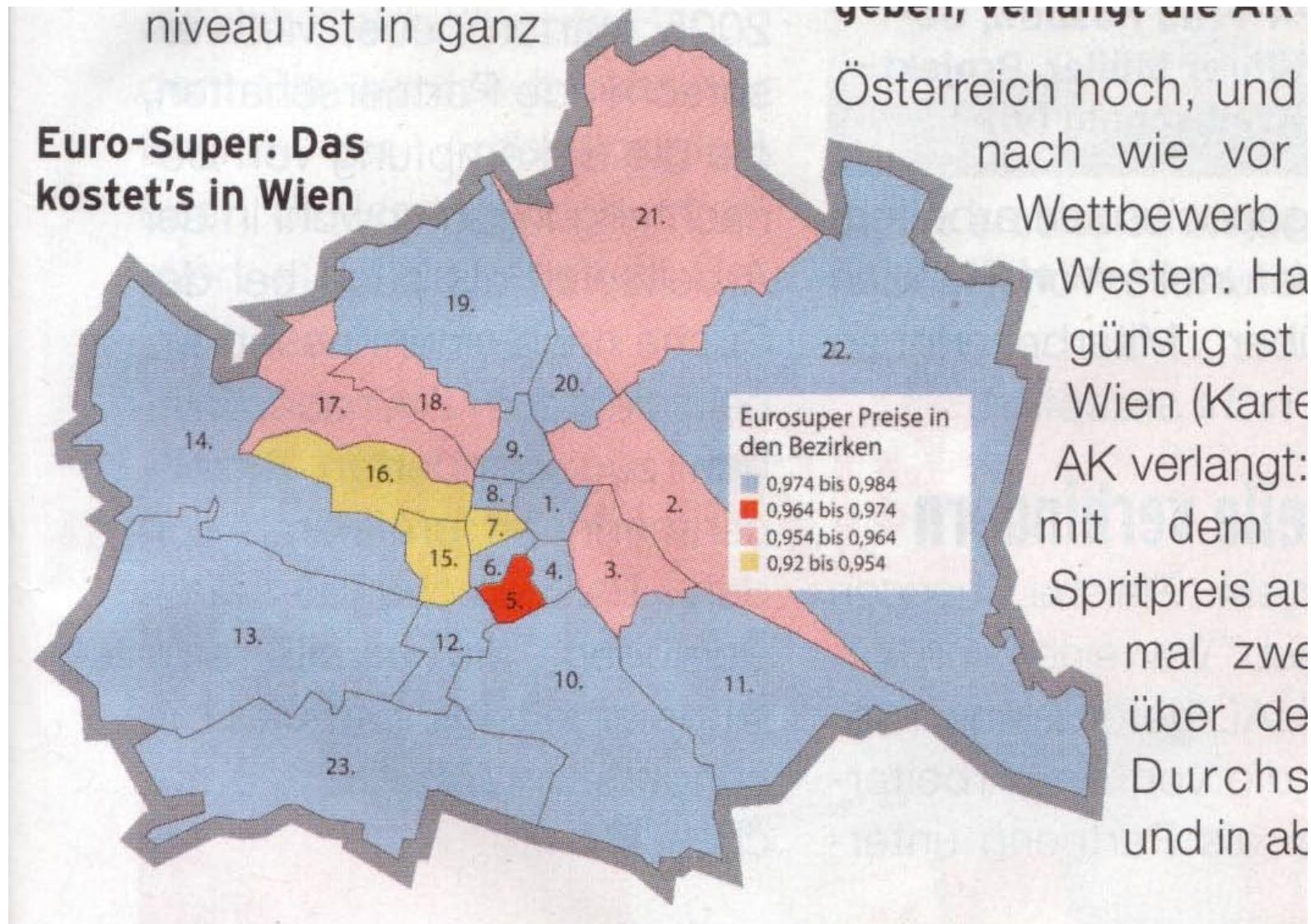
# USE OF COLOR. COLOR FOR TABLES OR CHARTS

- Non-data components should be displayed just visibly enough to perform their role (e.g., light grey)
  - Excessive salience could cause them to gather attention
- Good strategy:
  - Start with greys or blacks
    - Only
  - Use another accent to highlight relevant data
  - That's it, you are done

# USE OF COLOR. SALIENCE

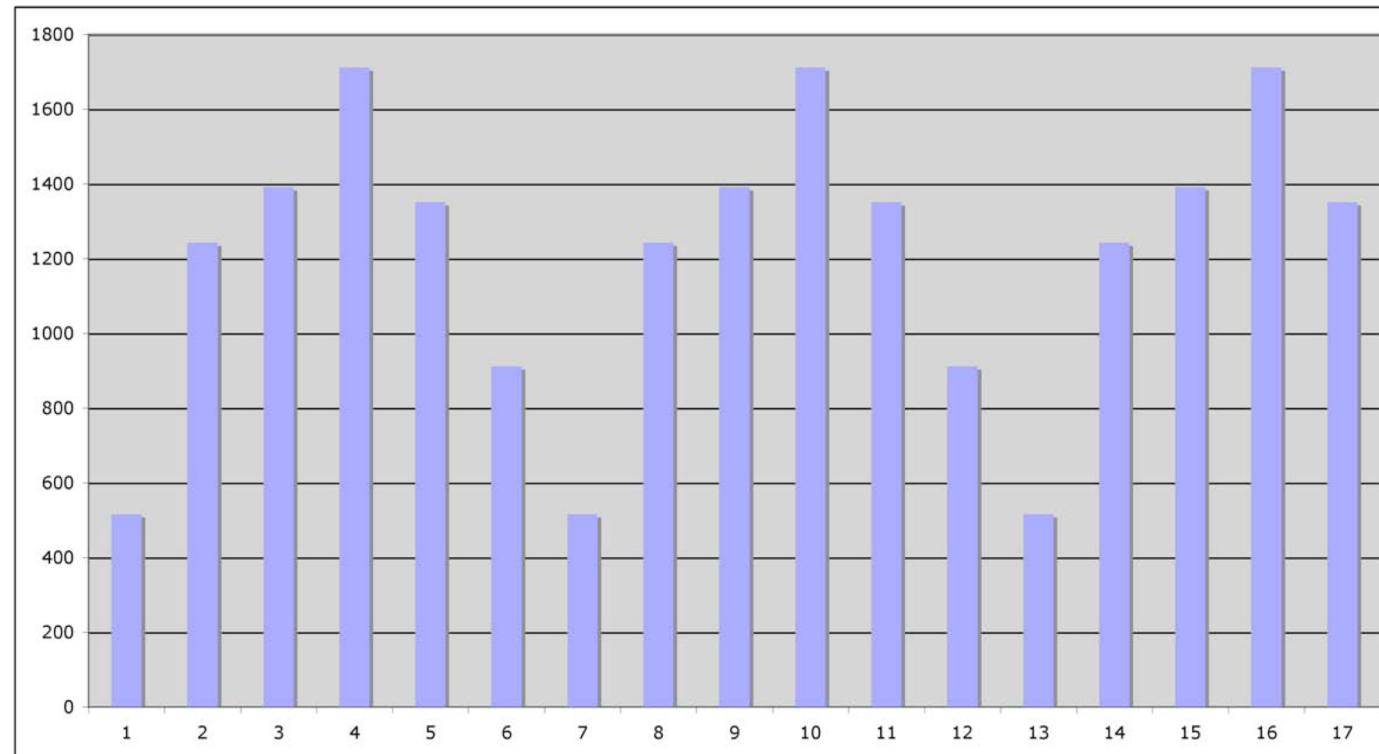


# USE OF COLOR. SALIENCE



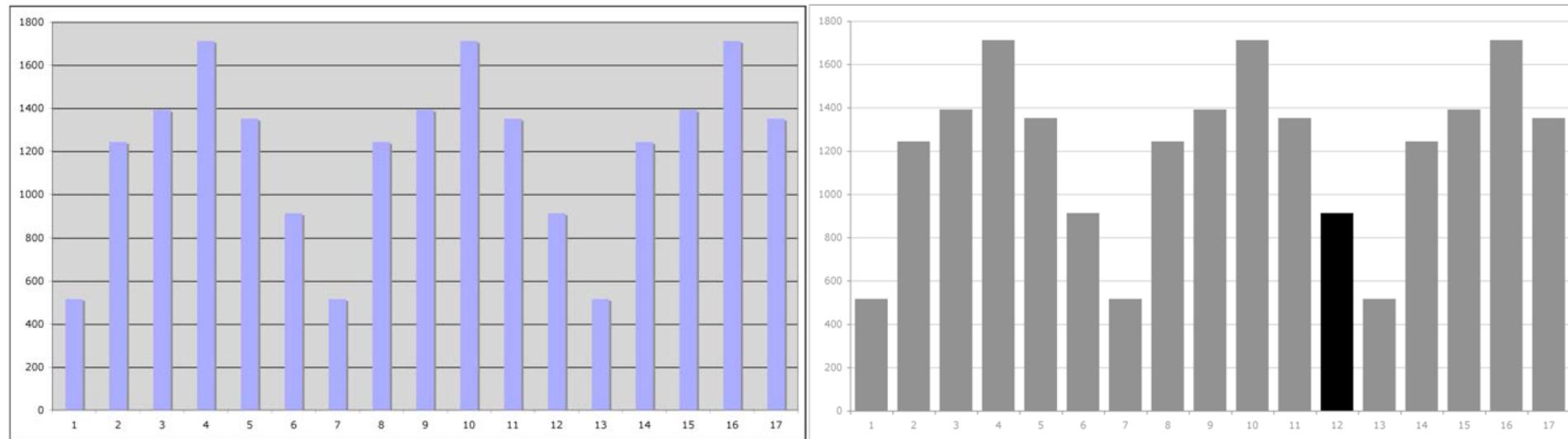
# USE OF COLOR. REDESIGNING A CHART

- De-emphasizing...



# USE OF COLOR. REDESIGNING A CHART

- De-emphasizing...



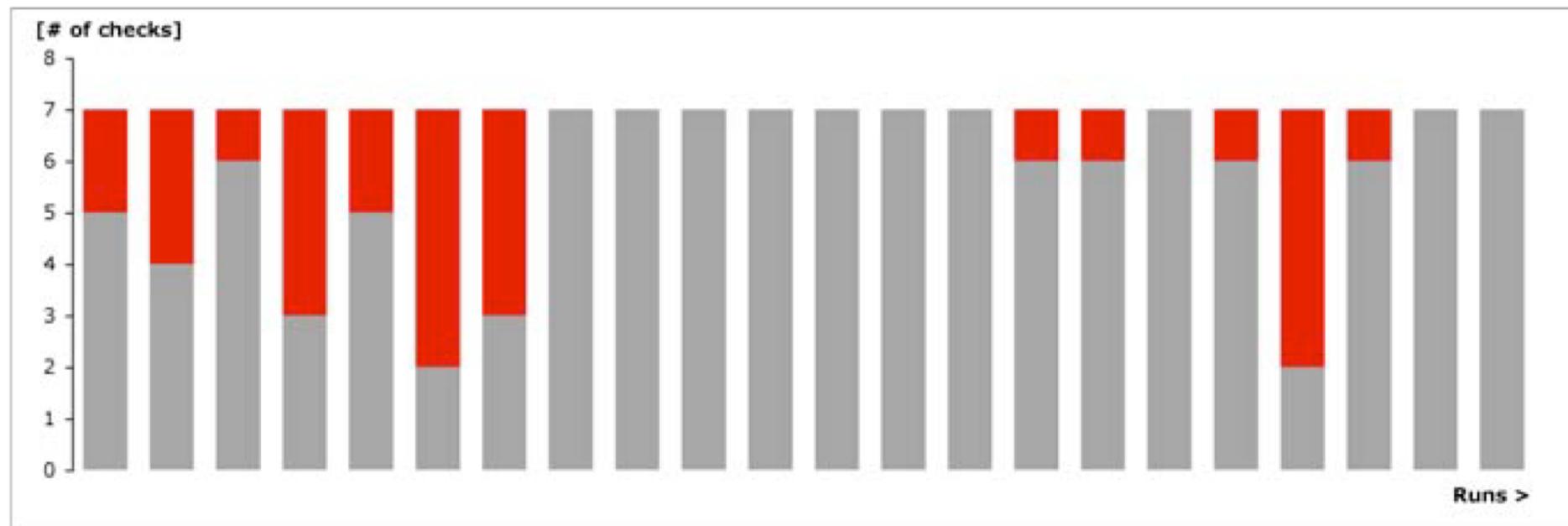
# USE OF COLOR. COLOR DESIGN RULES

- Avoid using a combination of red and green



# USE OF COLOR. COLOR DESIGN RULES

- Avoid using a combination of red and green



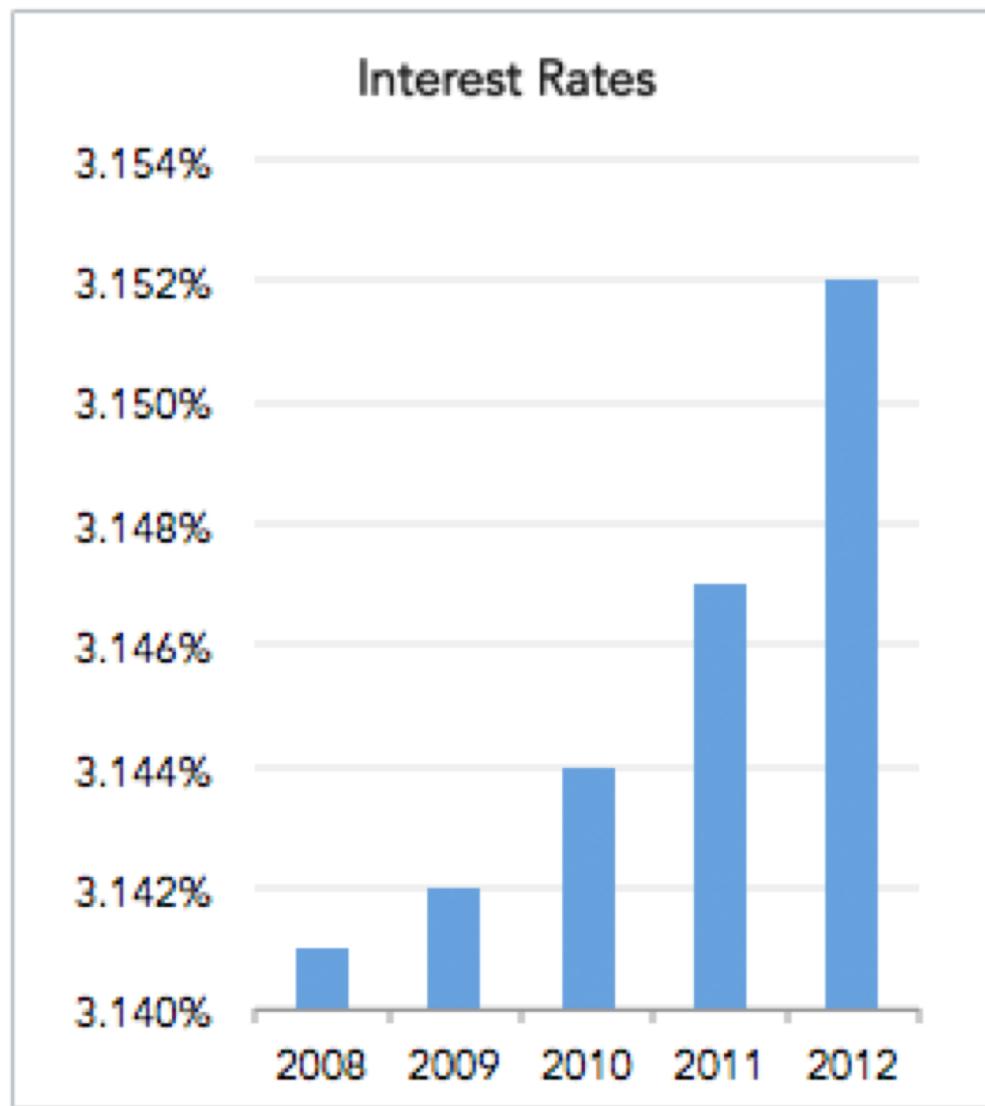
# OUTLINE

- Effective Visualizations
- Use of color
- **Comparison**
- Copy & labels
- Ordering & aligning data

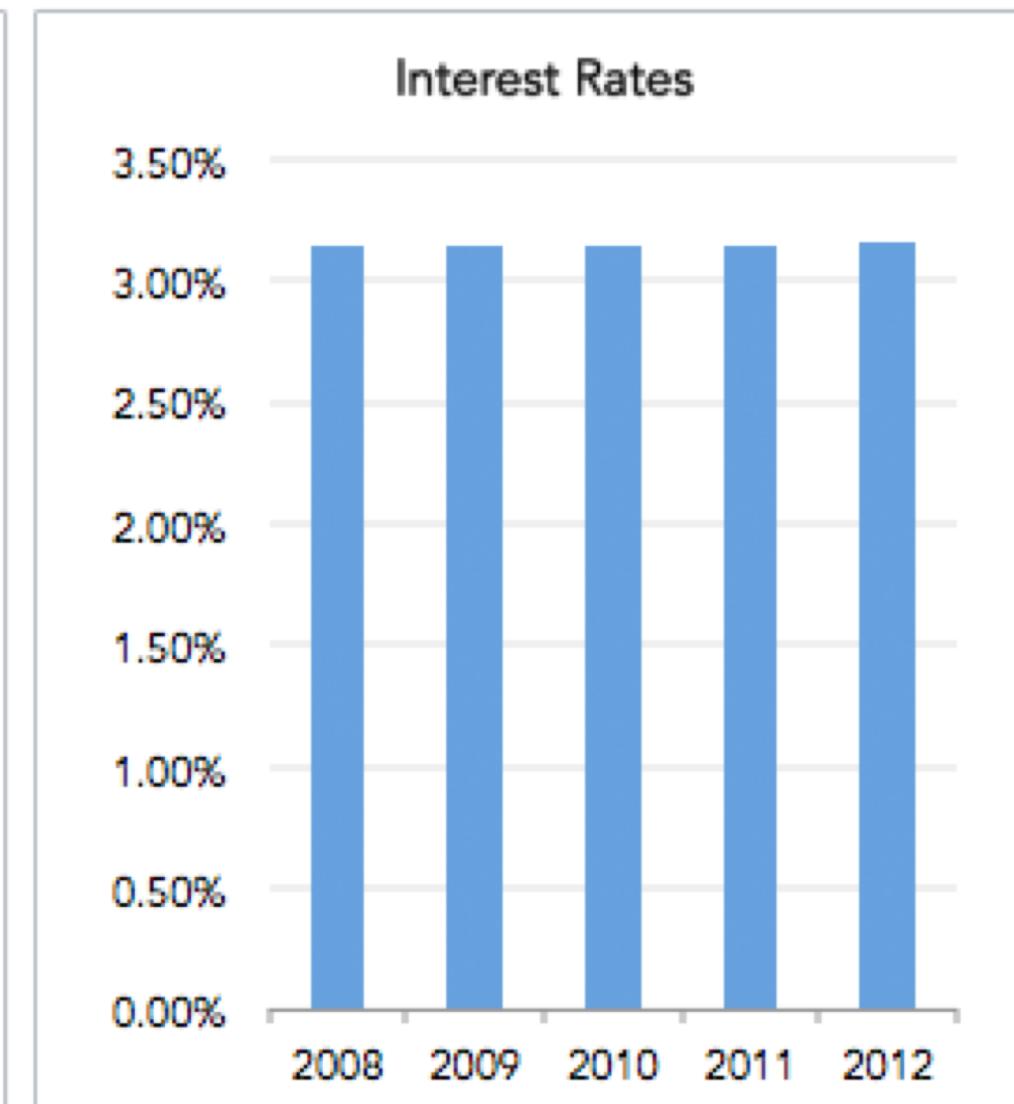
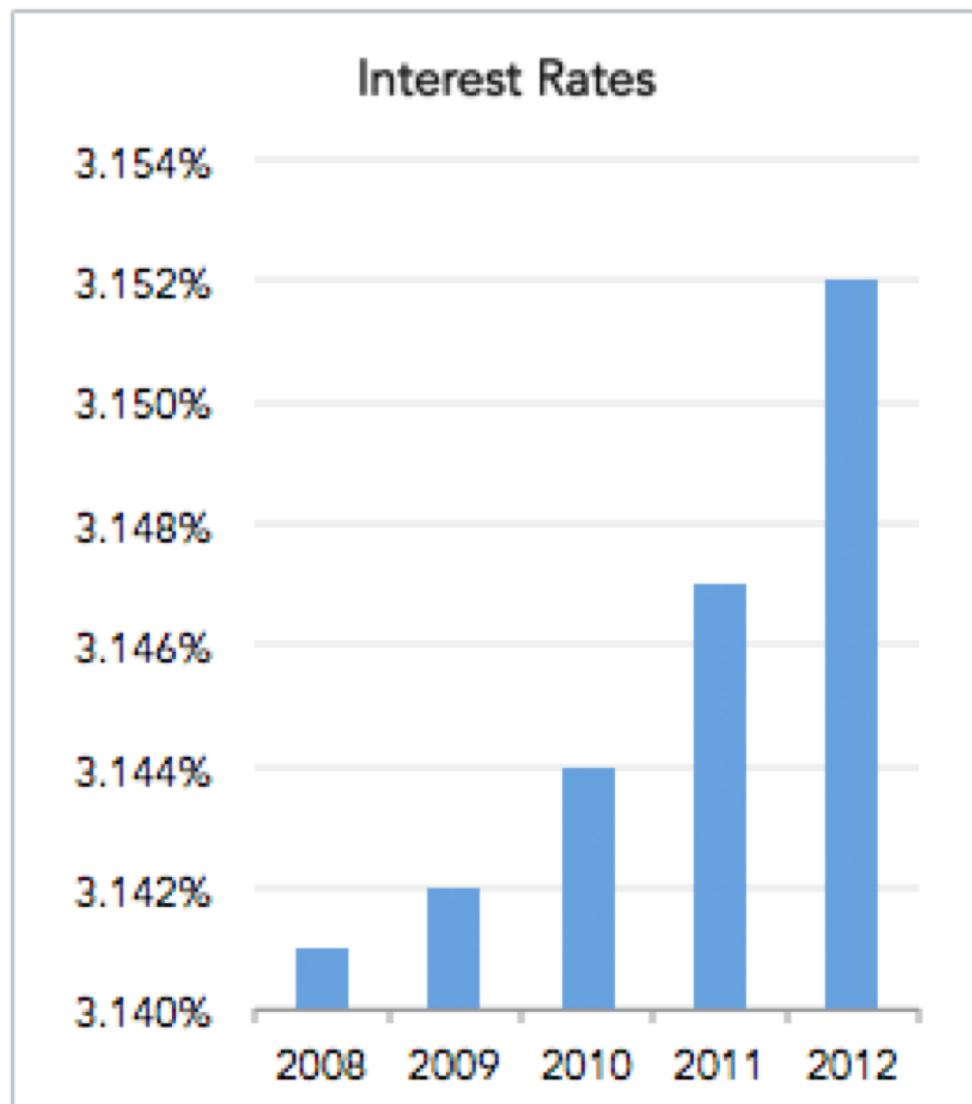
# COMPARISON

- Visual comparison one of most common tasks
- Tips to take into account
  - Zero baseline if possible
  - Choose the most effective visualization
  - Place elements to facilitate comparison
    - Distances, positions matter
  - Tell the whole story

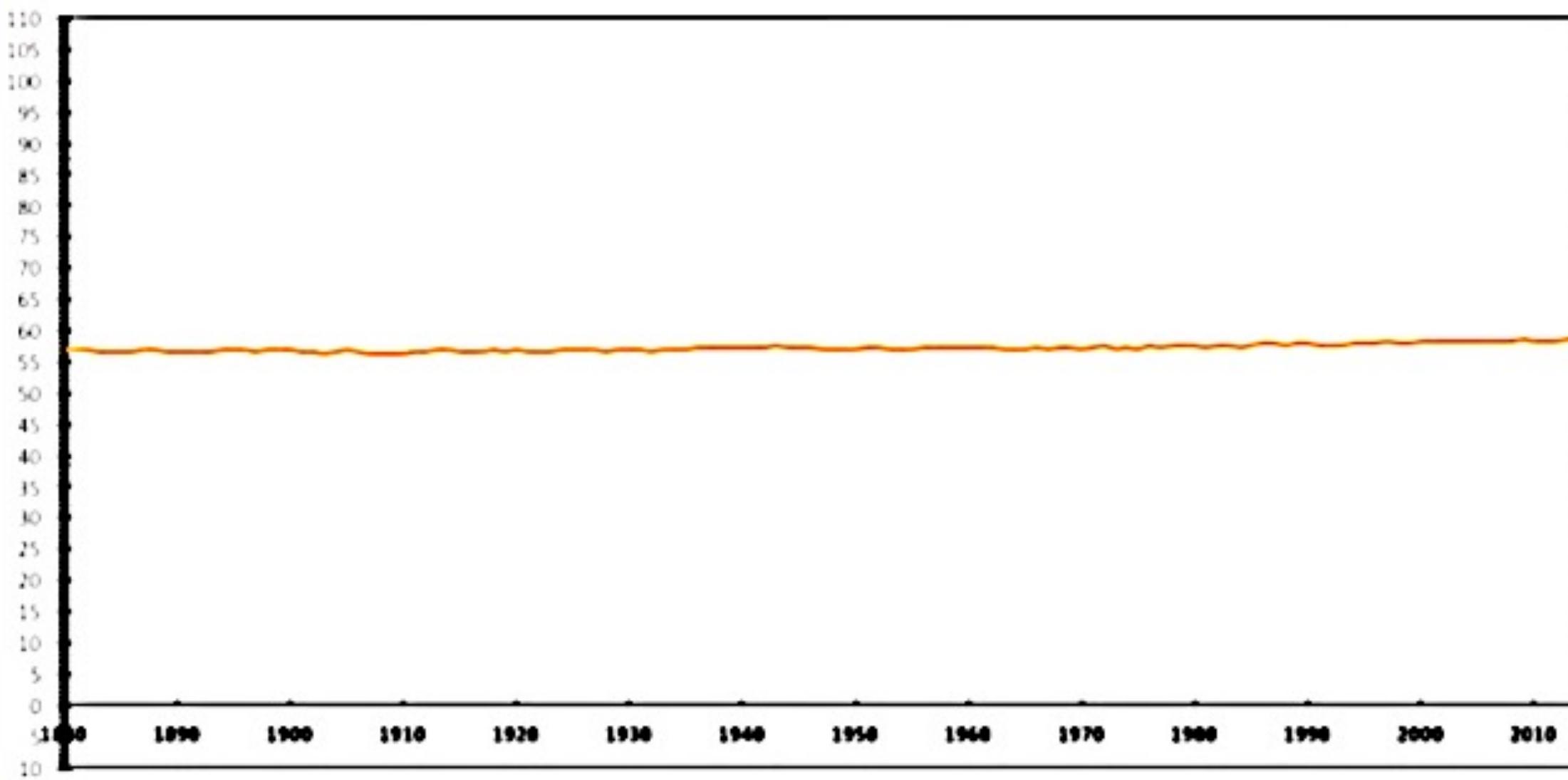
# COMPARISON. ZERO BASELINE

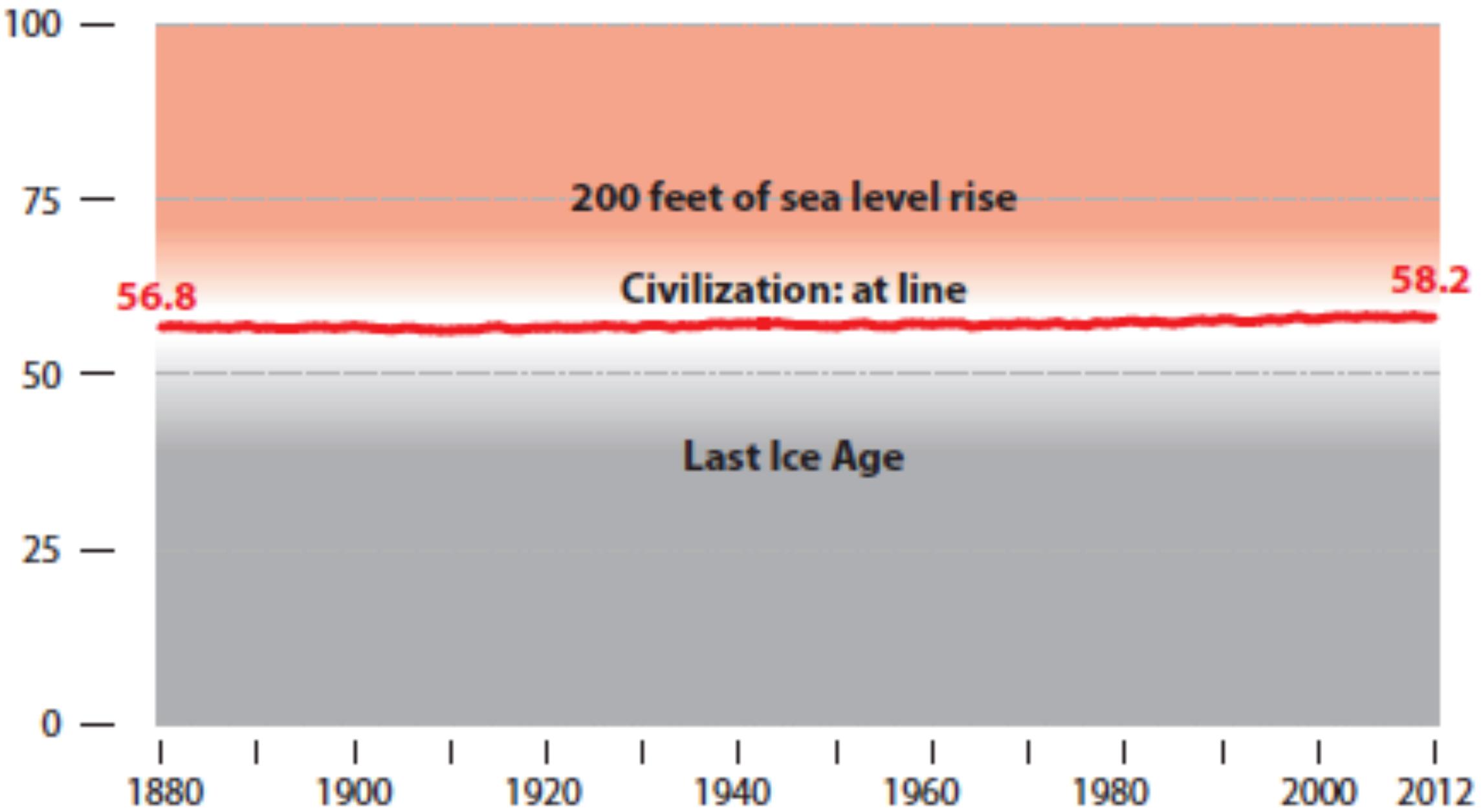


# COMPARISON. ZERO BASELINE

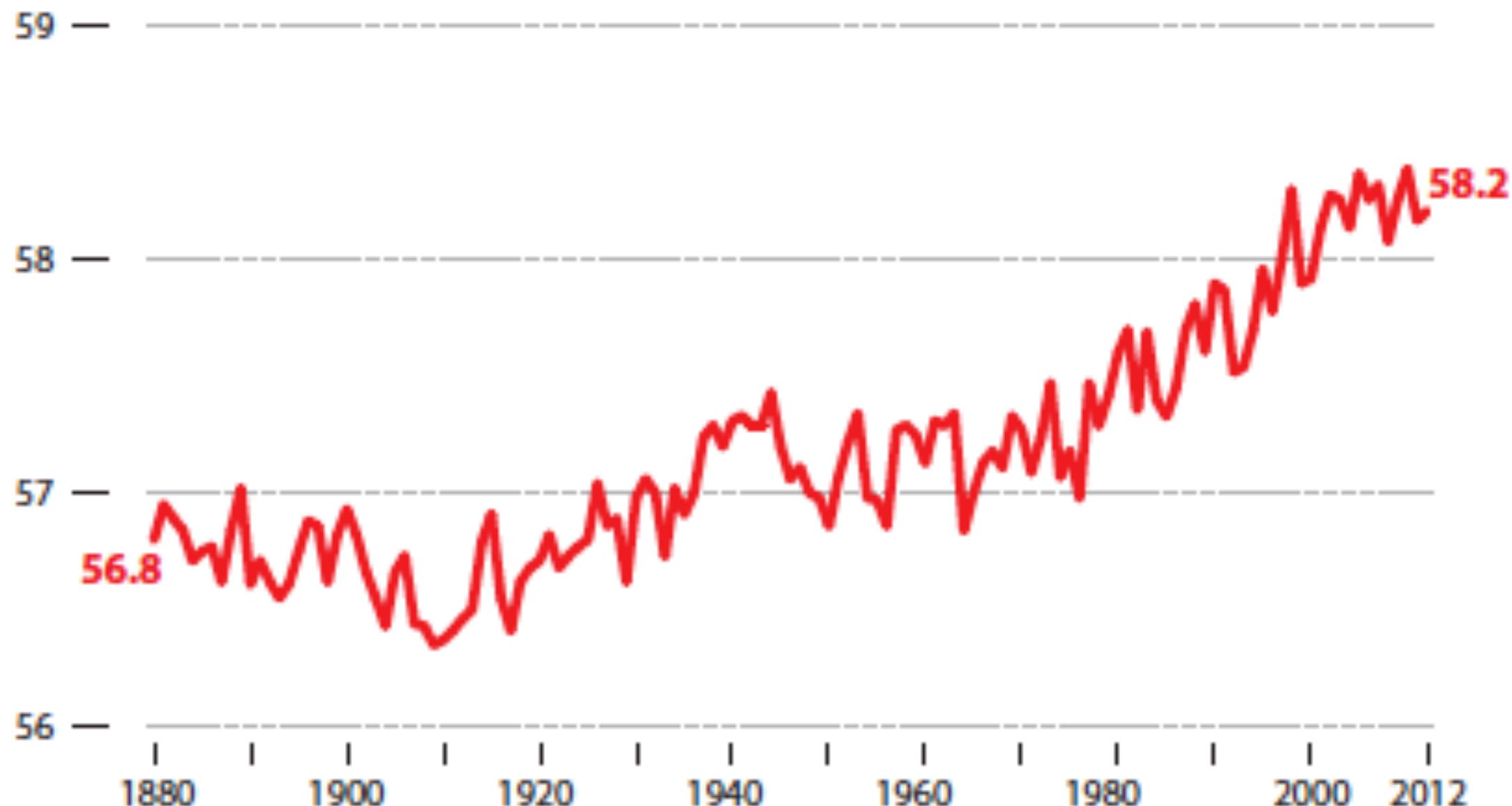


Average Annual Global Temperature in Fahrenheit  
1880-2015

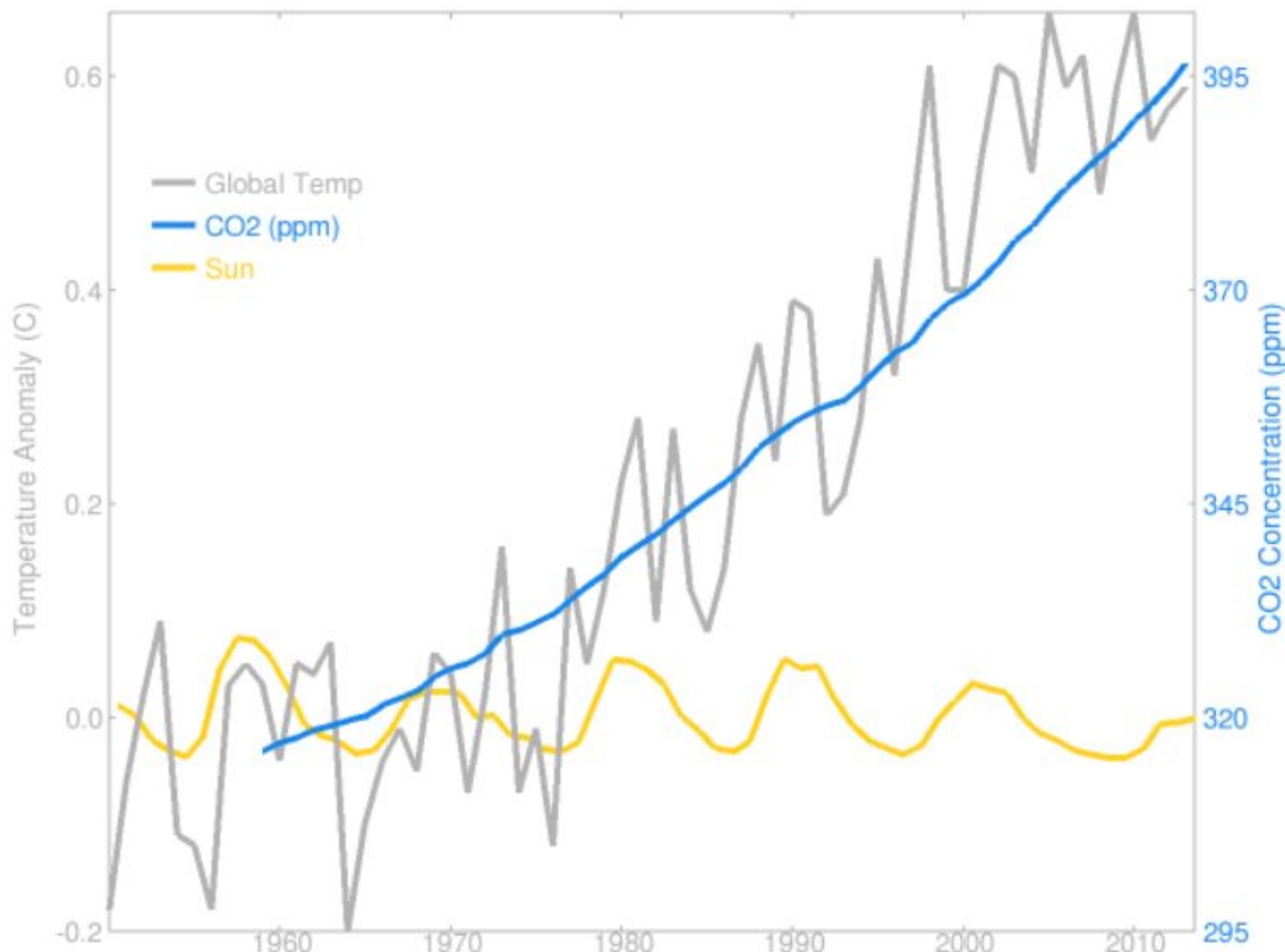




## Average annual global temperature in degrees Fahrenheit



### World climate Widget

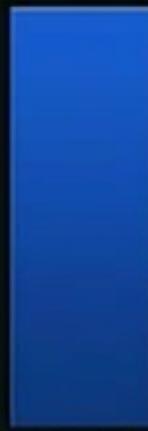




## KNUCKLEBALL VELOCITY

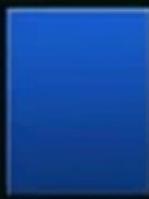
R.A. DICKEY

77.3 MPH



2012

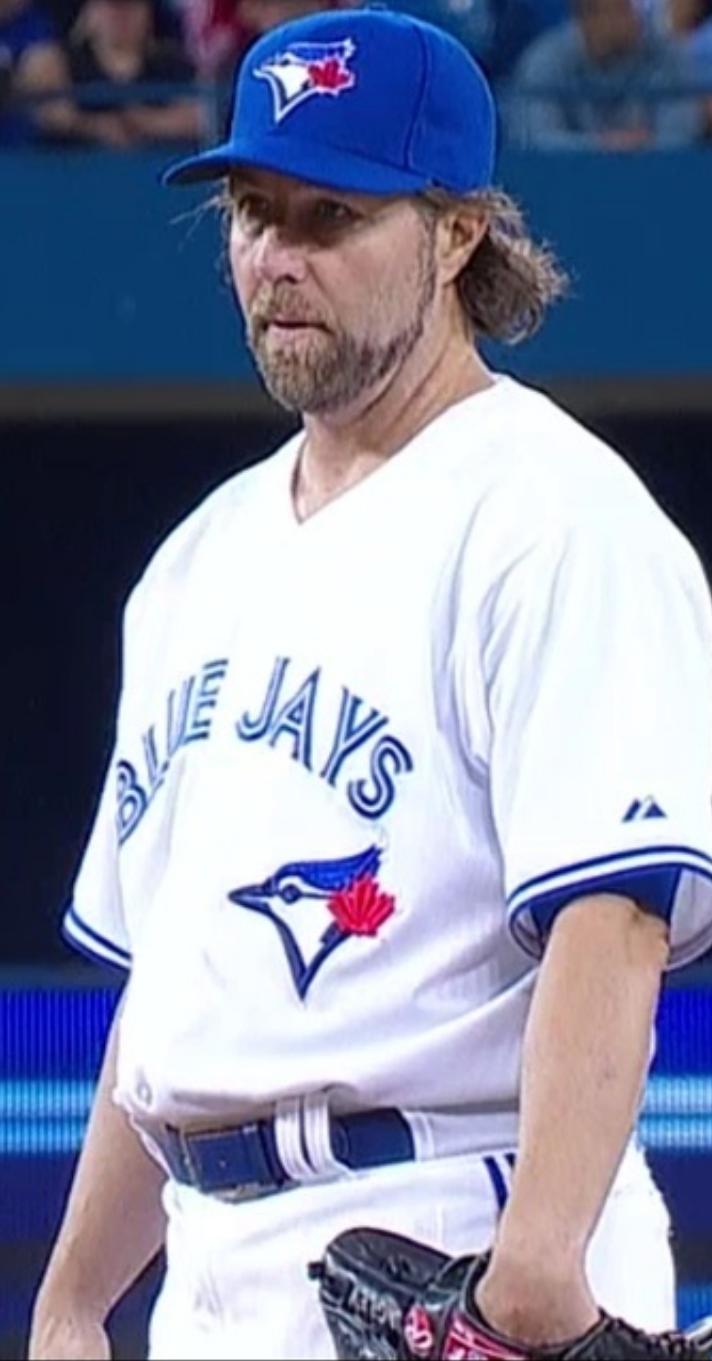
75.3 MPH



2013

BlackBerry

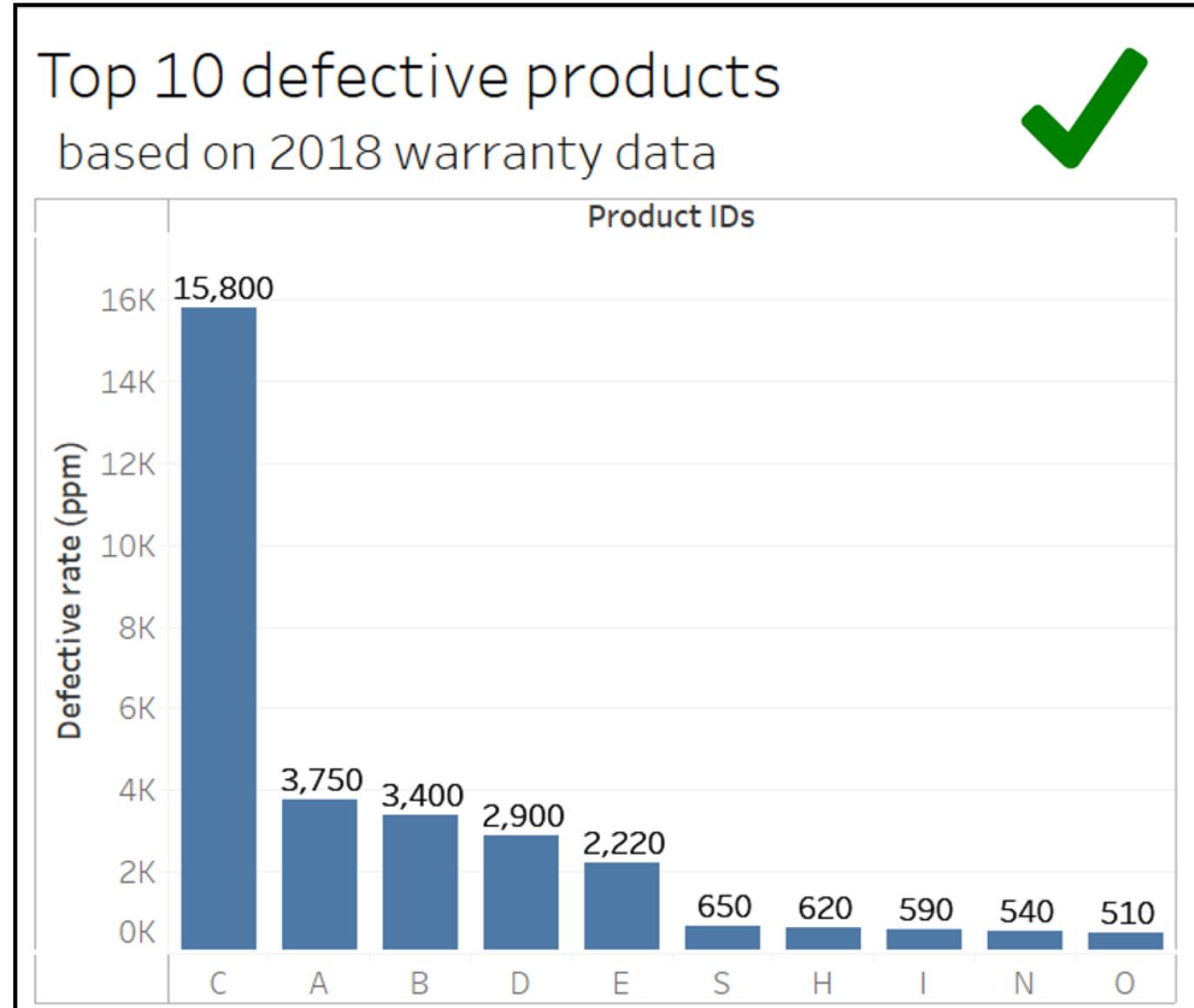
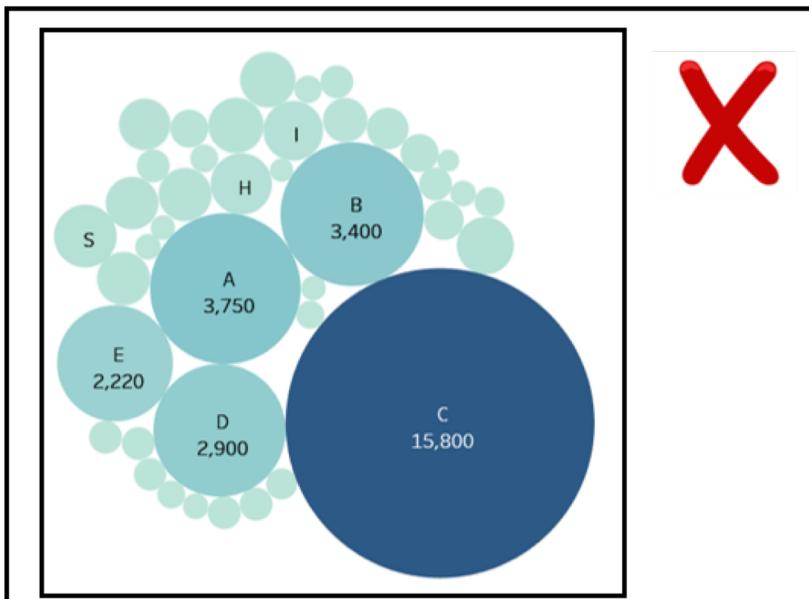
Keep Moving



# COMPARISON. MOST EFFECTIVE VISUALIZATION

- Many visual depictions may communicate the same data correctly
  - But some are more difficult to understand than others
    - Need more time/cognitive effort
- Always select the most effective ones
  - In terms of time, space, cognitive effort...

# COMPARISON. MOST EFFECTIVE VISUALIZATION



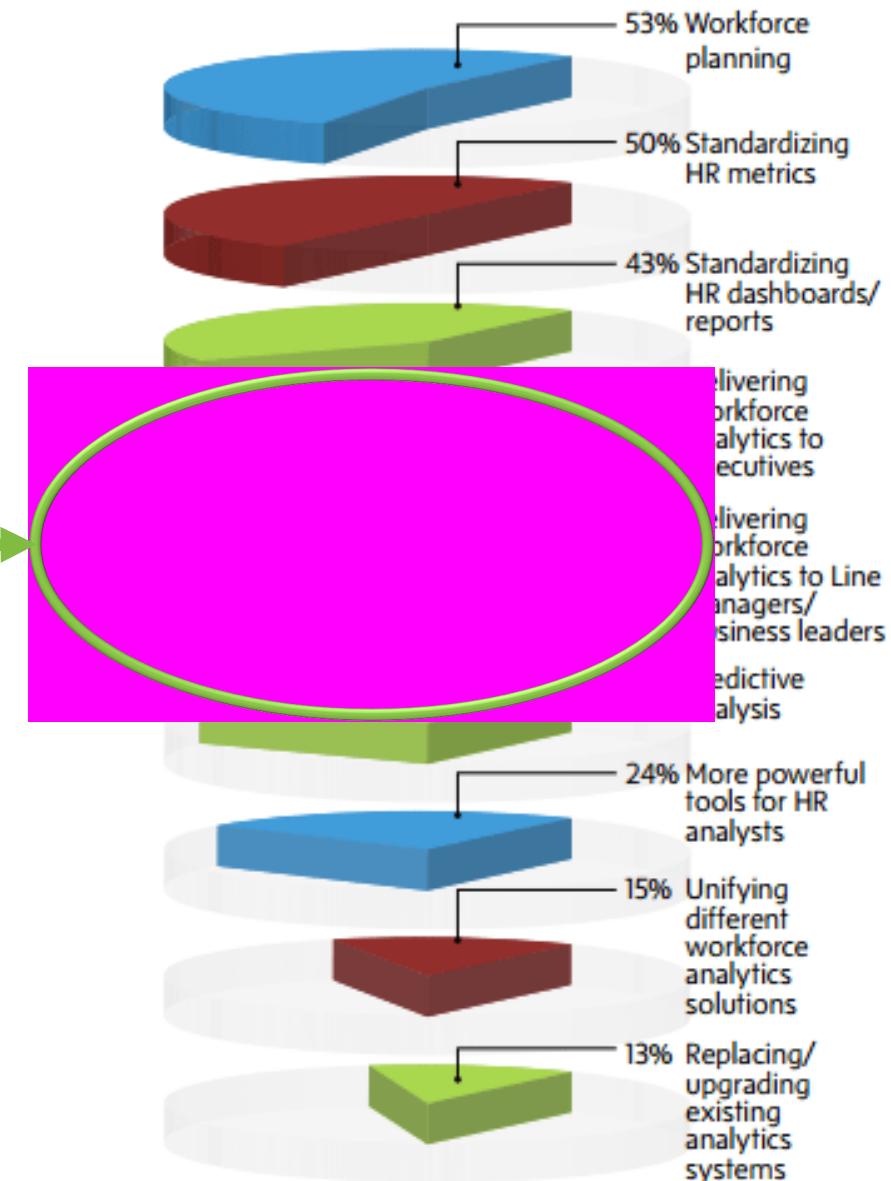
# COMPARISON. PLACEMENT

- Place elements to facilitate comparison
  - Distances, positions...

# COMPARISON. PLACEMENT

- Place elements to facilitate comparison
  - Distances, positions...

Relative sizes?



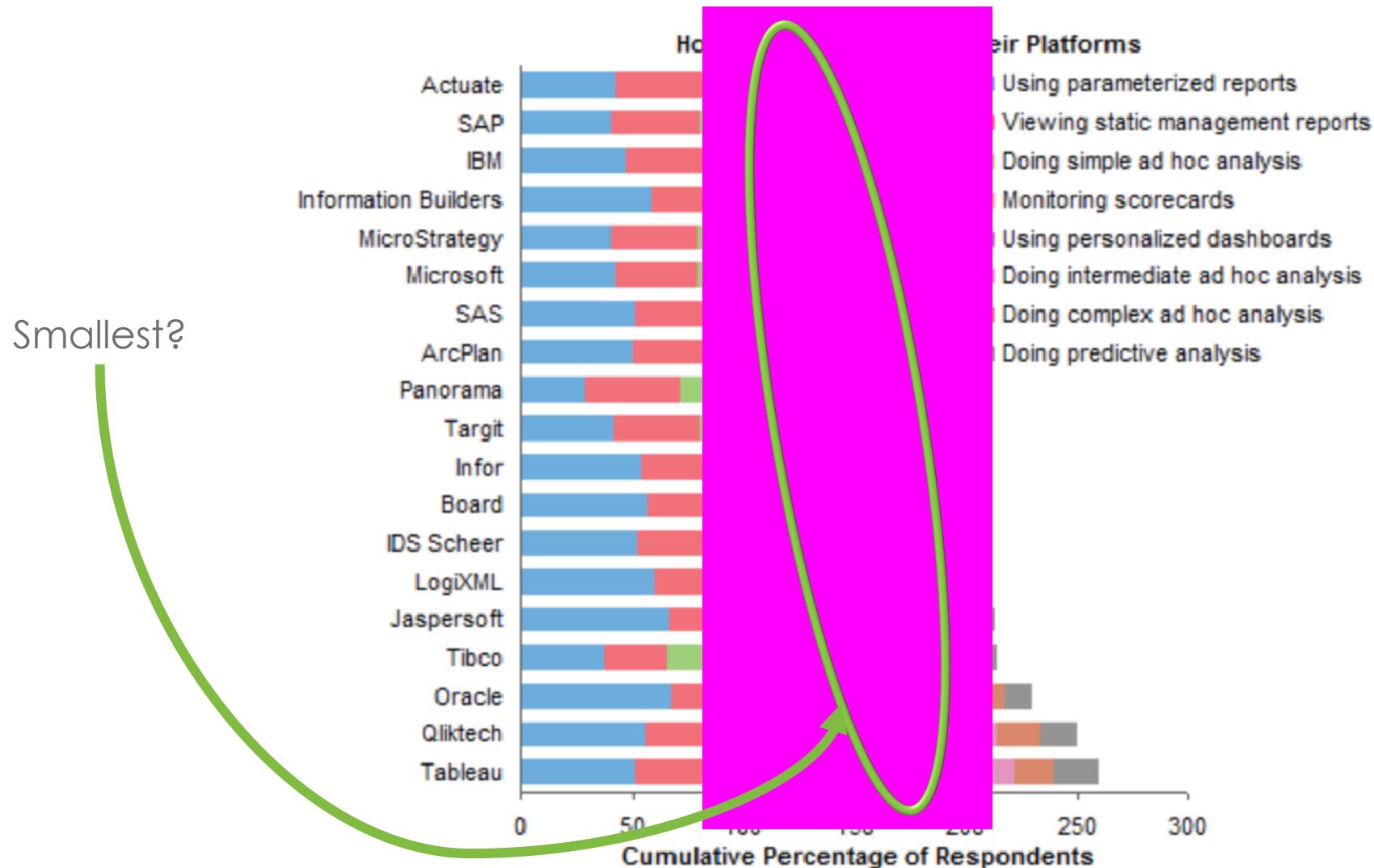
<https://flowingdata.com/2013/08/07/piemaster/>

# COMPARISON. PLACEMENT

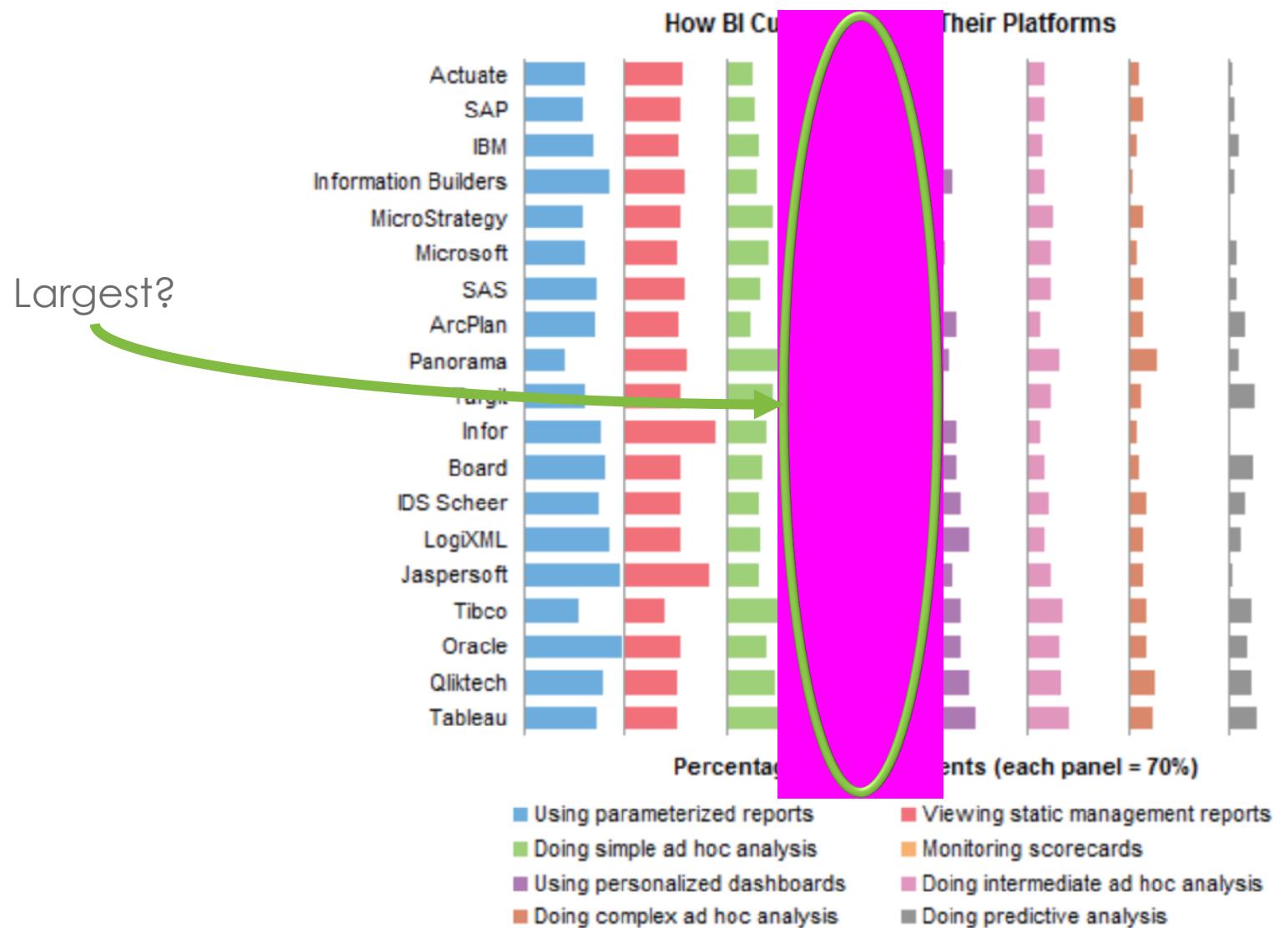
Smallest?



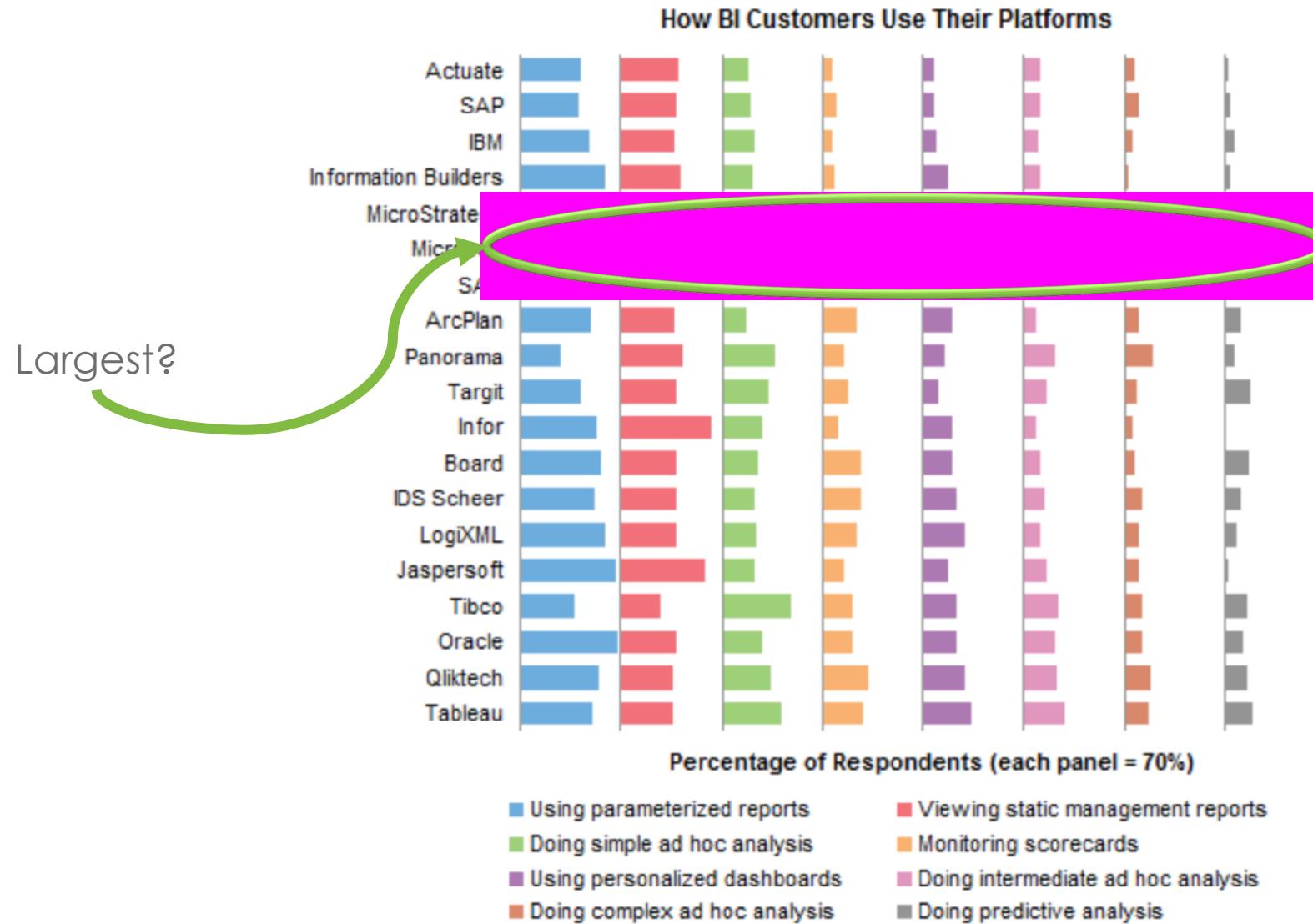
# COMPARISON. PLACEMENT



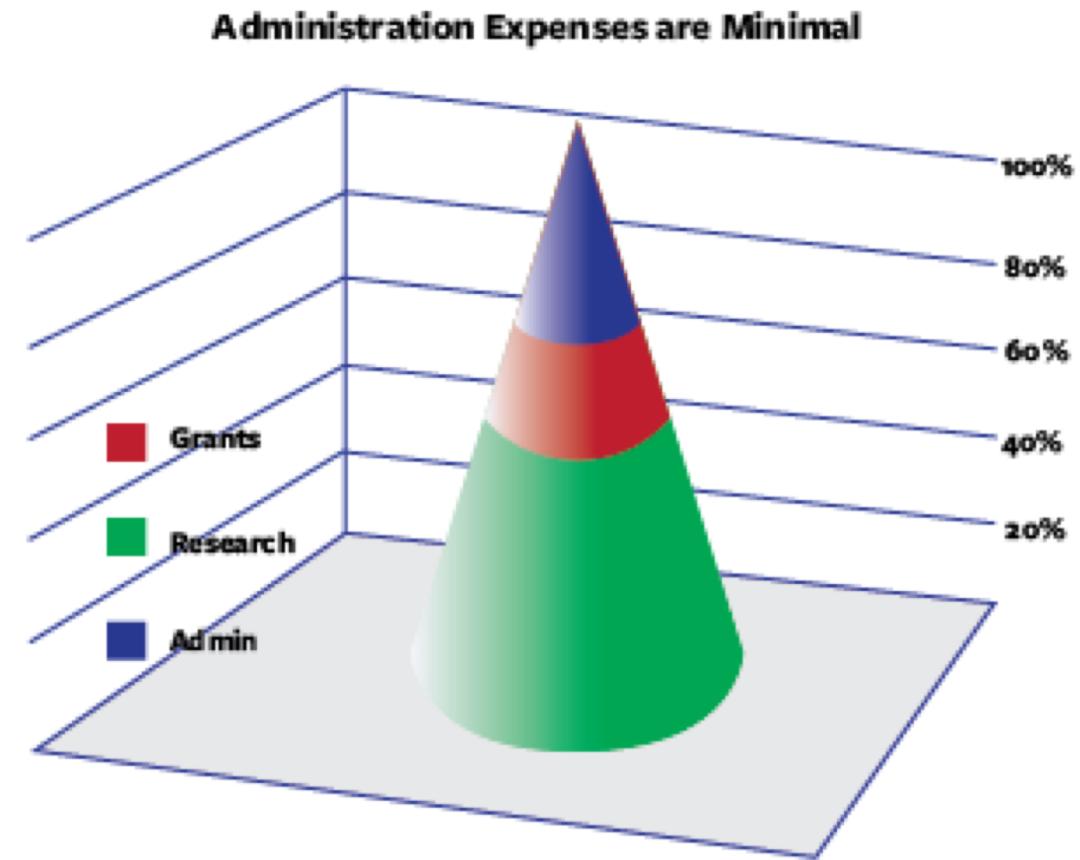
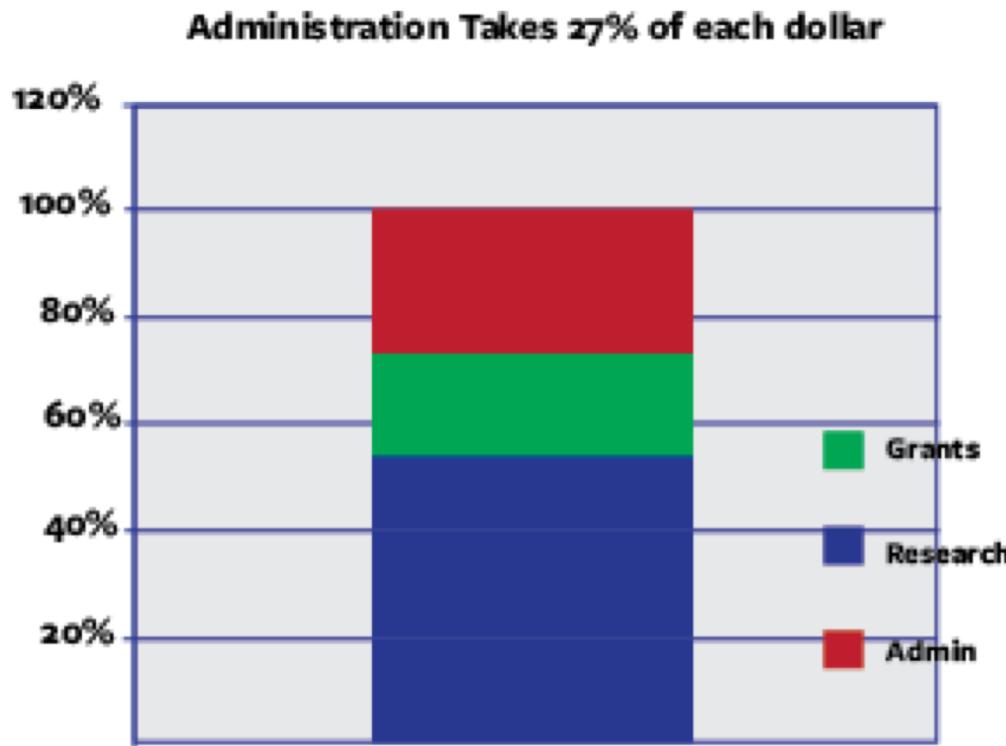
# COMPARISON. PLACEMENT



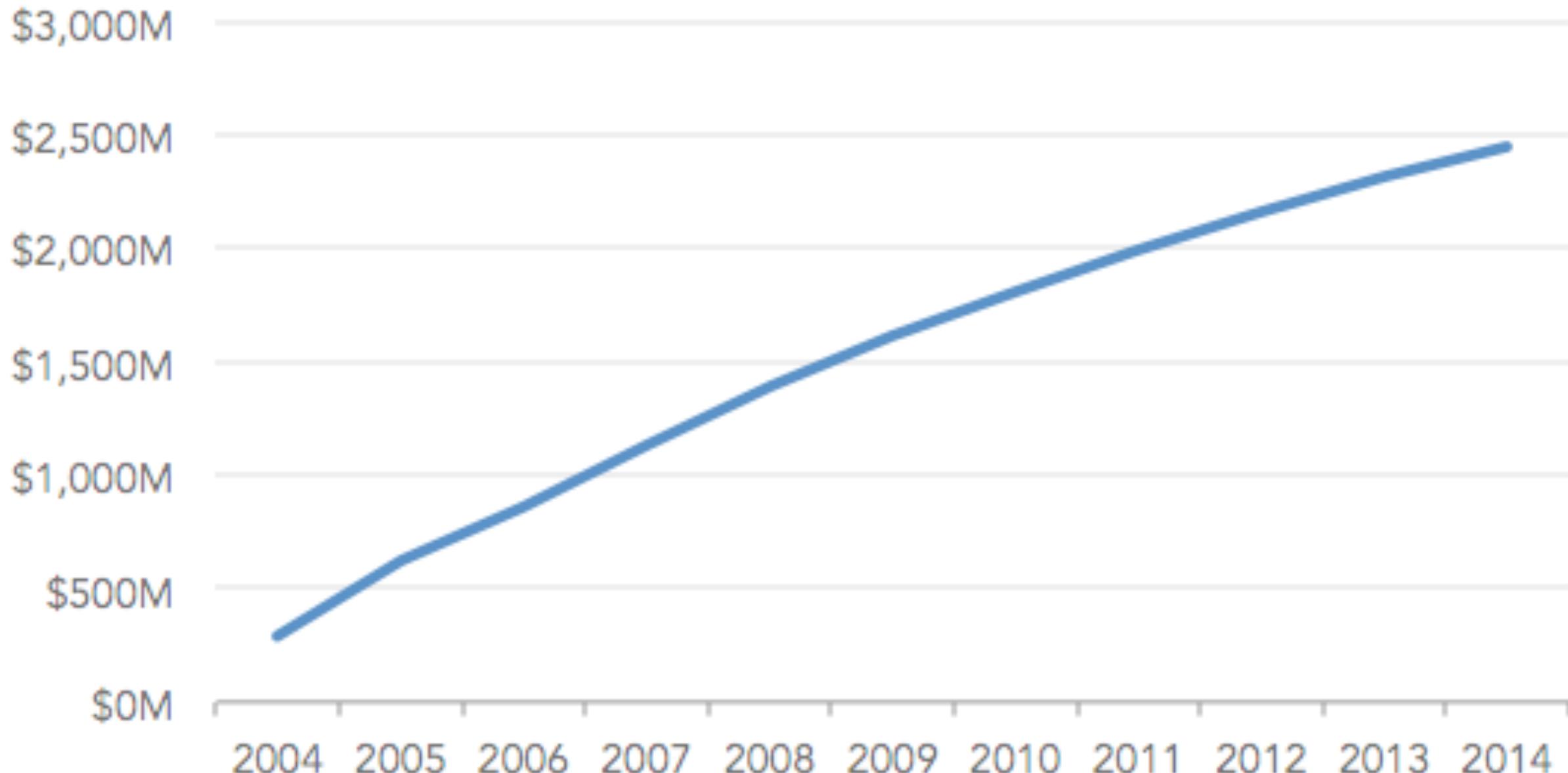
# COMPARISON. PLACEMENT



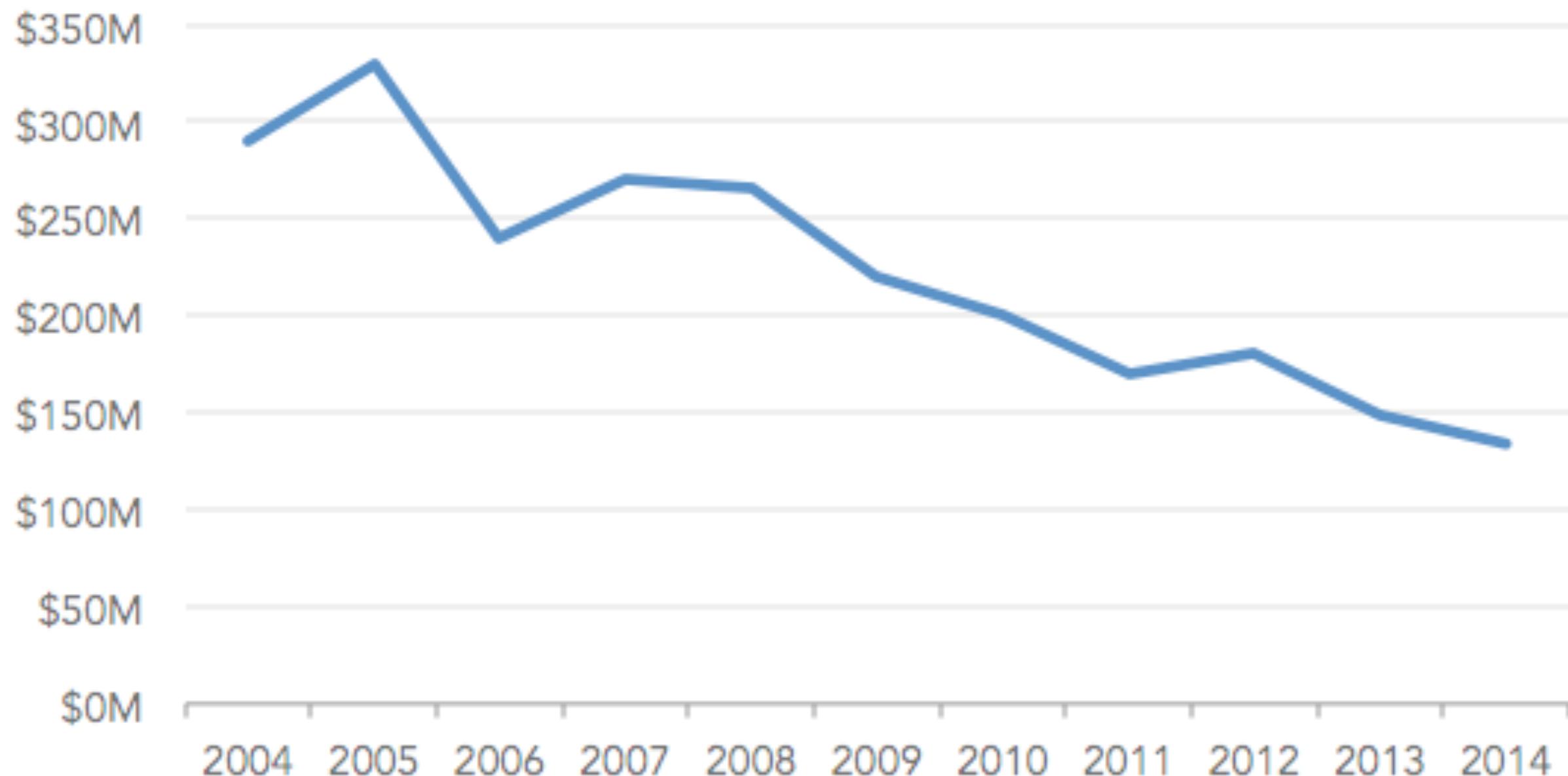
# COMPARISON. PLACEMENT



## Cumulative Annual Revenue



## Annual Revenue

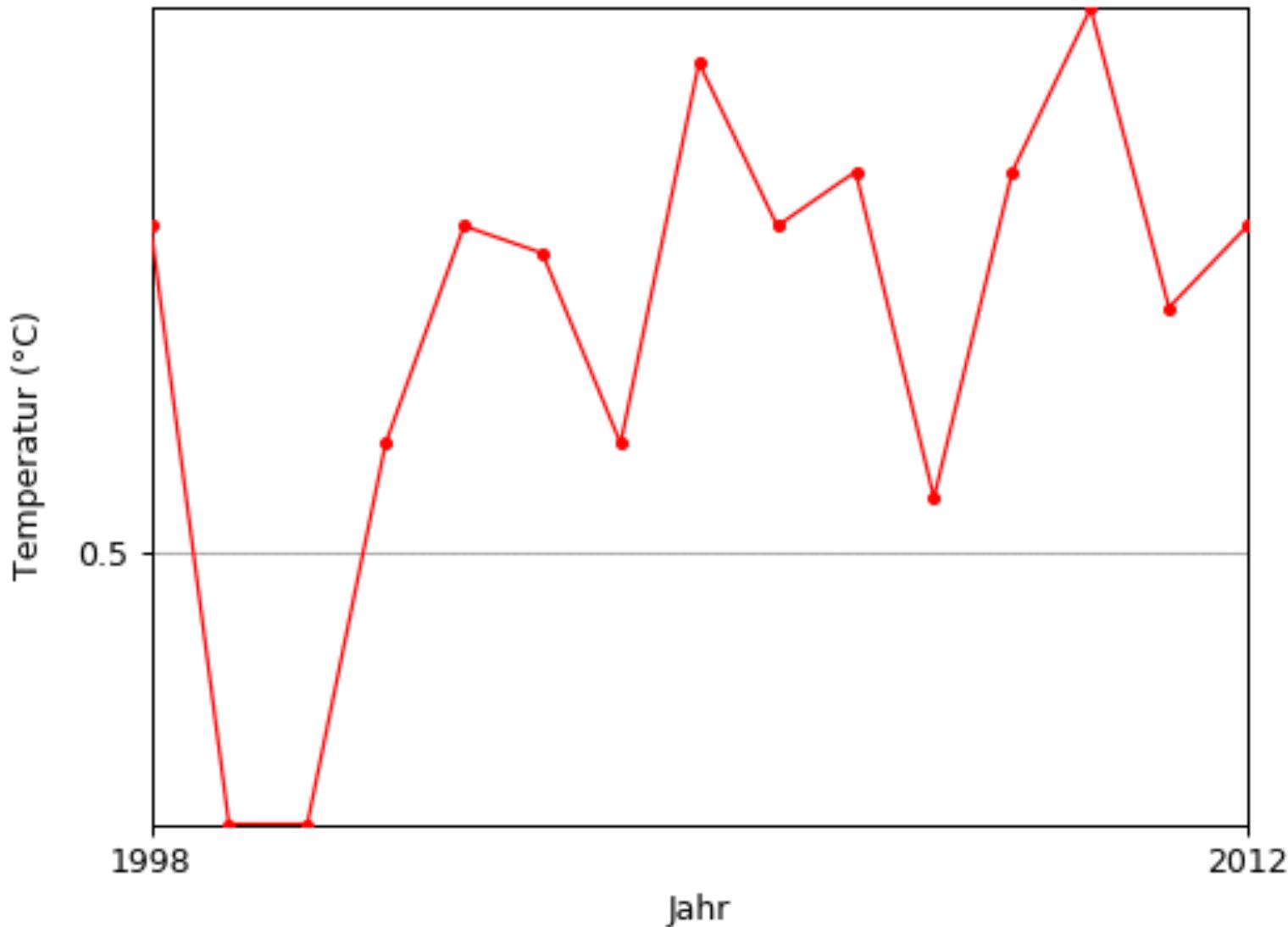


# COMPARISON. WHOLE STORY

- Tell the whole story
  - Omitting data may be misleading
  - But extra data can also be misleading

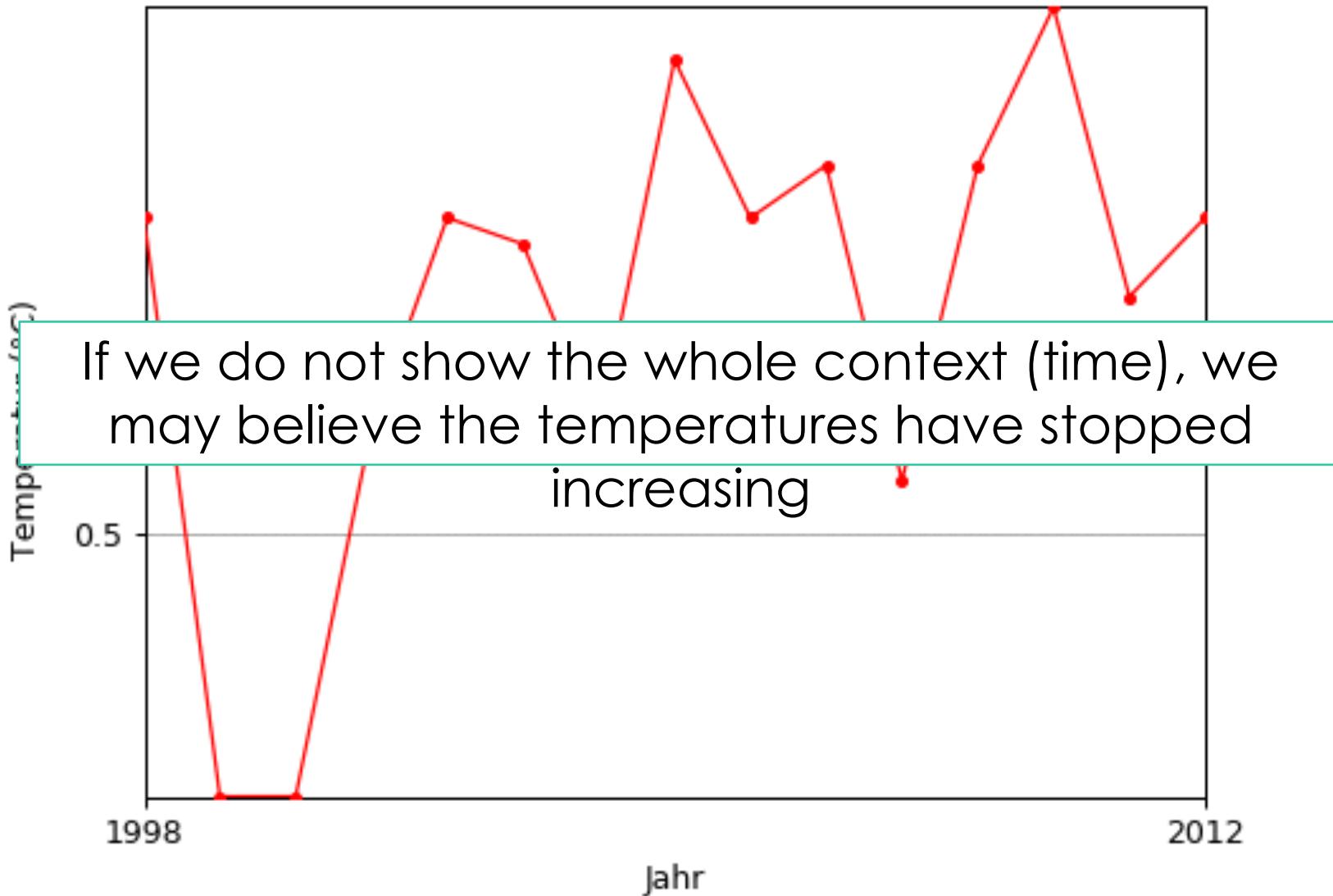
# COMPARISON. WHOLE STORY

Vermeintlicher Stillstand der Erwärmung  
der Erdoberfläche (1998 - 2012)



# COMPARISON. WHOLE STORY

Vermeintlicher Stillstand der Erwärmung  
der Erdoberfläche (1998 - 2012)



# OUTLINE

- Effective Visualizations
- Use of color
- Comparison
- **Copy & labels**
- Ordering & aligning data

# GOOD PRACTICES IN VISUALIZATION

Pere-Pau Vázquez – Dept. Computer Science – UPC