

# Module 2A: Visualisation Excellence

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# Introduction

- Pre-Attentive Attributes
- Gestalt Principles
- Graphical Excellence
  - Well designed presentation of interesting data
  - Complex ideas communicated with clarity, precision and efficiency
  - The truth about data
- Graphical Integrity
  - Lie factor
  - Show data variation, not design variation

# Human Perception

Understanding and communicating patterns in raw data can be difficult...



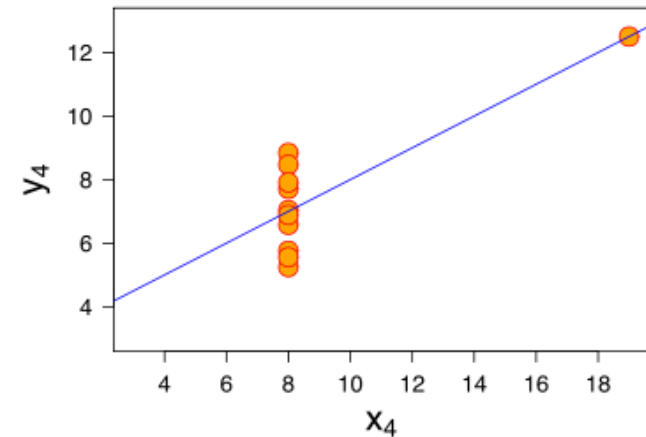
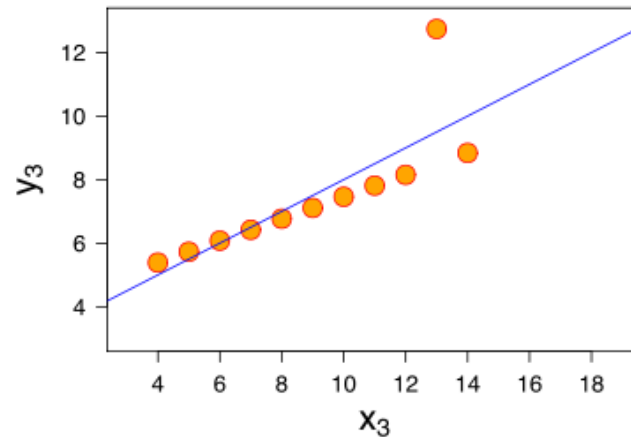
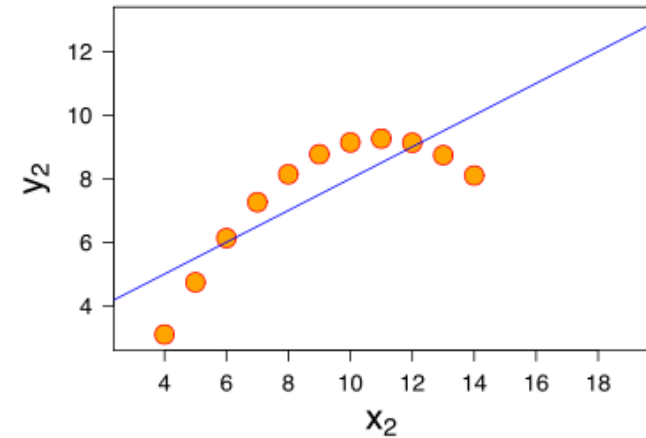
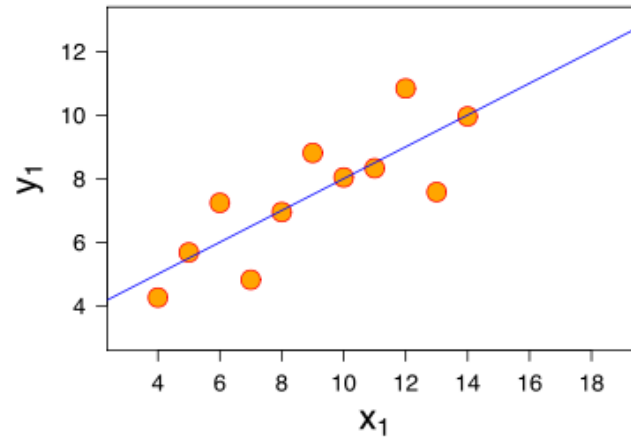
I		II		III		IV	
x	y	x	y	x	y	x	y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89



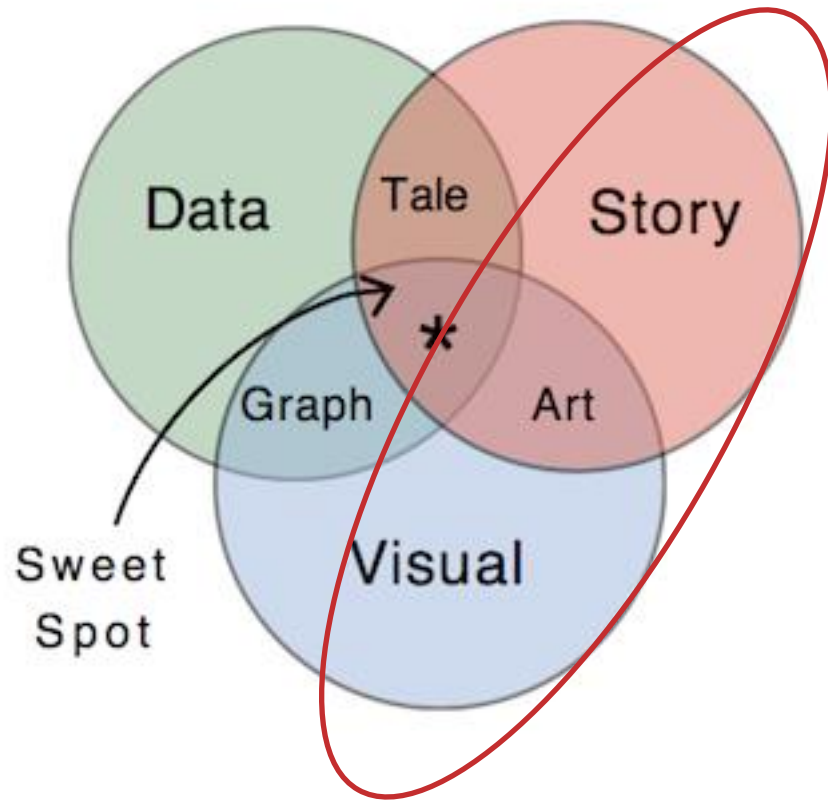
# Human Perception



**The same information  
expressed 'visually' is far  
easier to understand,  
interpret, and communicate..**



# Visual + Story = Art



- Aesthetics look and feel
- Visual art
- Psychology
- Cognitive

# Pre-Attentive Attributes



Data visualisation works because they use 'Pre-Attentive Attributes' to code the data...



Pre-Attentive Attributes are detected and processed immediately by the brain, without the need for focused attention. They are...



Perceived in less than 10 milliseconds

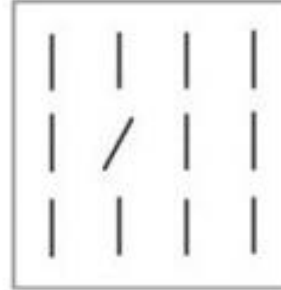


Unconsciously processed

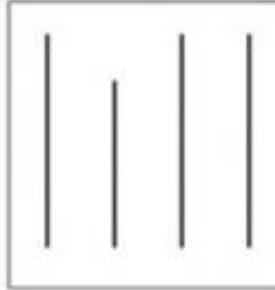
# Pre-Attentive Attributes

## Form

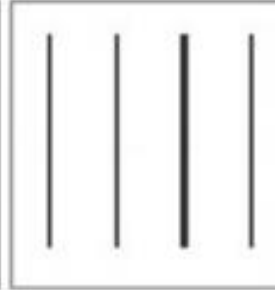
Orientation



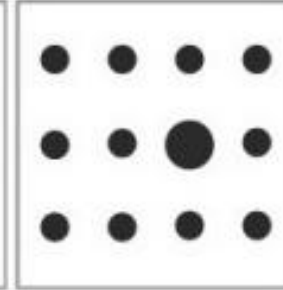
Line Length



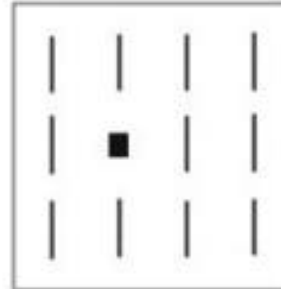
Line Width



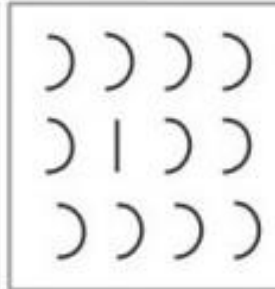
Size



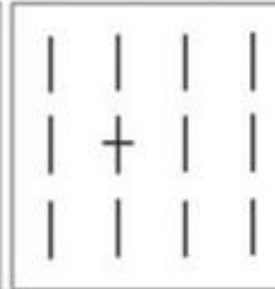
Shape



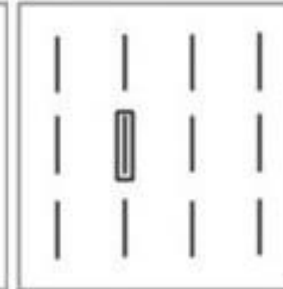
Curvature



Added Marks

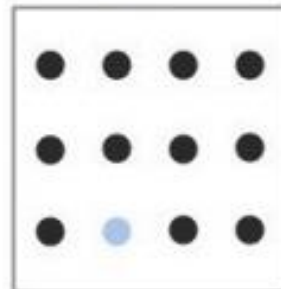


Enclosure

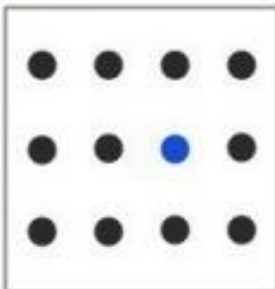


## Color

Intensity

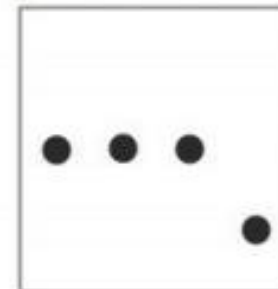


Hue






























## Spatial Position

2-D Position



# Visual Variables

	Quantitative		Ordinal		Nominal	
<div>More Accurate</div> <div>↑</div> <div>↓</div> <div>Less Accurate</div>	Position		Position		Position	
	Length		Density		Hue	
	Angle		Saturation		Density	
	Slope		Hue		Saturation	
	Area		Length		Shape	
	Density		Angle		Length	
	Saturation		Slope		Angle	
	Hue		Area		Slope	
	Shape		Shape		Area	

<http://joeparry.wordpress.com/2007/08/29/visual-variables/>



Count the 3s example with pre-attentive attributes

756395068473

658663037576

860372658602

846589107830

Count the 3s example with pre-attentive attributes

756**3**9506847**3**

65866**3**0**3**7576

860**3**72658602

8465891078**3**0

## No preattentive attributes

What are we doing well? Great Products. These products are clearly the best in their class. Replacement parts are shipped when needed. You sent me gaskets without me having to ask. Problems are resolved promptly. Bev in the billing office was quick to resolve a billing issue I had. General customer service exceeds expectations. The account manager even called to check in after normal business hours. You have a great company – keep up the good work!

## Color

What are we doing well? Great Products. **These products are clearly the best in their class.** Replacement parts are shipped when needed. You sent me gaskets without me having to ask. Problems are resolved promptly. Bev in the billing office was quick to resolve a billing issue I had. General customer service exceeds expectations. The account manager even called to check in after normal business hours. You have a great company – keep up the good work!

## Bold

**What are we doing well?** Great Products. These products are clearly the best in their class. Replacement parts are shipped when needed. You sent me gaskets without me having to ask. Problems are resolved promptly. Bev in the billing office was quick to resolve a billing issue I had. General customer service exceeds expectations. The account manager even called to check in after normal business hours. You have a great company – keep up the good work!

## Italics

What are we doing well? Great Products. These products are clearly the best in their class. *Replacement parts are shipped when needed.* You sent me gaskets without me having to ask. Problems are resolved promptly. Bev in the billing office was quick to resolve a billing issue I had. General customer service exceeds expectations. The account manager even called to check in after normal business hours. You have a great company – keep up the good work!

## Size

What are we doing well? Great Products. These products are the best in their class. Replacement parts are shipped when needed. You sent gaskets

without me having to ask.

Problems are resolved promptly. Bev in the billing office was quick to resolve a billing issue I had. General customer service exceeds expectations. The account manager even called to check in after normal business hours. You have a great company – keep up the good work!

## Outline (enclosure)

What are we doing well? Great Products. These products are clearly the best in their class. Replacement parts are shipped when needed. You sent me gaskets without me having to ask. Problems are resolved promptly. Bev in the billing office was quick to resolve a billing issue I had. General customer service exceeds expectations. The account manager even called to check in after normal business hours.

You have a great company – keep up the good work!

## Separate spatially

What are we doing well? Great Products. These products are clearly the best in their class. Replacement parts are shipped when needed. You sent me gaskets without me having to ask.

Problems are resolved promptly.

Bev in the billing office was quick to resolve a billing issue I had. General customer service exceeds expectations. The account manager even called to check in after normal business hours. You have a great company – keep up the good work!

## Underline (added marks)

What are we doing well? Great Products. These products are clearly the best in their class. Replacement parts are shipped when needed. You sent me gaskets without me having to ask. Problems are resolved promptly. Bev in the billing office was quick to resolve a billing issue I had. General customer service exceeds expectations. The account manager even called to check in after normal business hours.

You have a great company – keep up the good work!



Aoccdrnig to a rscheearch at an Elingsh uinervtisy, it deosn't mttar in waht oredr the ltteers in a wrod are, the olny iprmoetnt tihng is taht frist and lsat ltteer is at the rghit pclae. The rset can be a toatl mses and you can sitll raed it wouthit porbelm. Tihs is bcuseae we do not raed ervey lteter by itslef but the wrod as a wlohe.





YELLOW	BLUE	ORANGE
BLACK	RED	GREEN
PURPLE	YELLOW	RED
ORANGE	GREEN	BLACK
BLUE	RED	PURPLE
GREEN	BLUE	ORANGE

# Special Effect vs Noise

- **Bold**

- *Italics*

- Underline

- CAPITAL CASE

- Typeface

- Color

- **Inversing Elements**

- Size

- Blinking & Flashing

## Typefaces for Dyslexia

- Microsoft Office Typefaces.

**Arial. Comic Sans. Century Gothic.  
Verdana. Trebuchet. Calibri.**

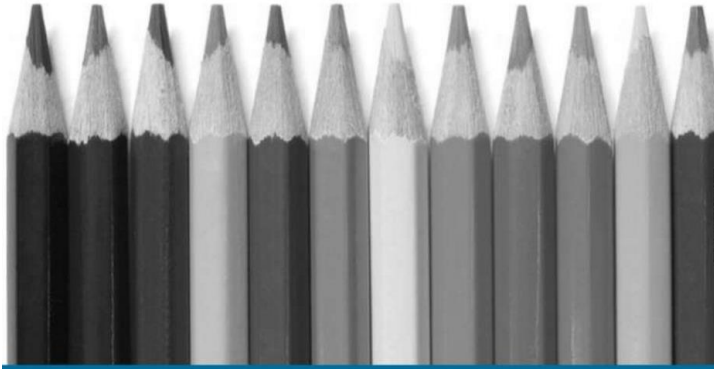
- 2. Free fonts designed for dyslexia:

**Lexia Readable. Dyslexie  
Open Dyslexic, Open-Dyslexic, OpenDyslexic.**

<https://bdanewtechnologies.files.wordpress.com/2011/03/typefaces6.pdf>

<http://opendyslexic.org/>





**TOTAL COLOR BLINDNESS**

Only able to differentiate  
**black/dark** vs **white/ bright**



**DEUTERANOMALIA**

Not able to differentiate  
**green**, **dark red**, **purple**



**PROTANOPIA**

Not able to differentiate between  
**red**, **dark green**, **blue**,  
**purplish-red** colours



**TRITANOPIA**

Not able to differentiate **blue**  
and **yellow**

## Colour Blindness



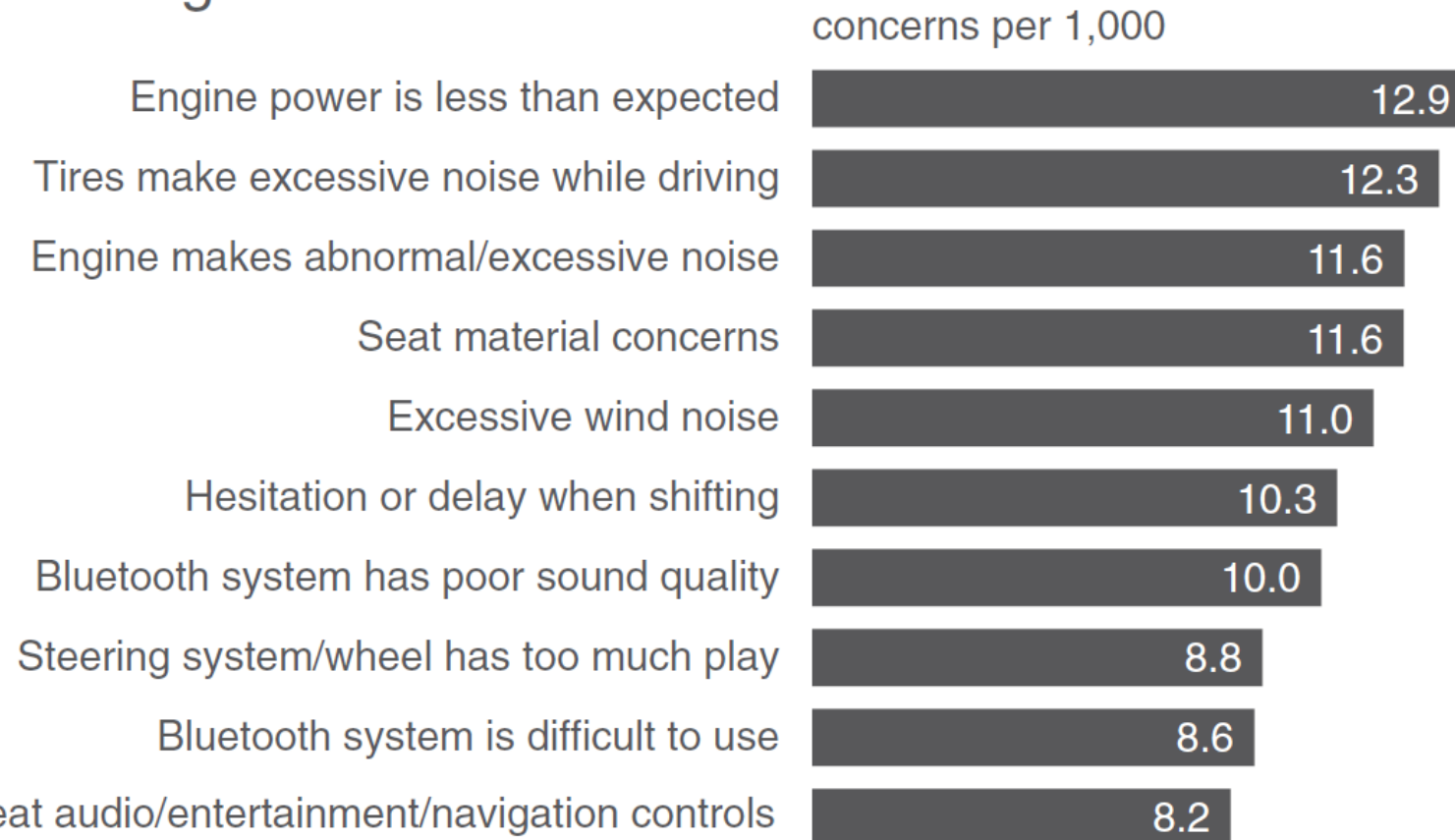
**NORMAL VISION**

# Example of Pre-attentive Attributes in Graphs

## Original graph, no pre-attentive attributes



### Top 10 design concerns



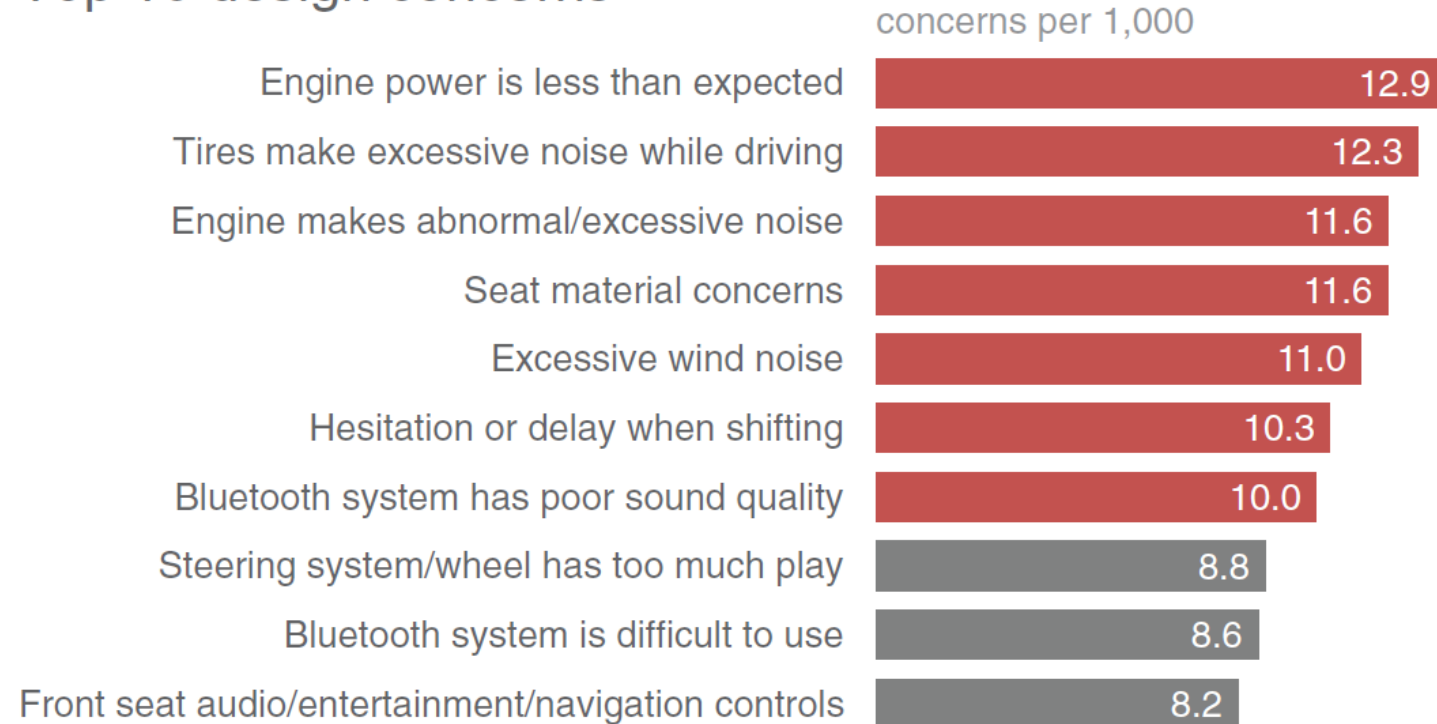
# Leverage color to draw attention



**7 of the top 10 design concerns have 10 or more concerns per 1,000.**

Discussion: is this an acceptable default rate?

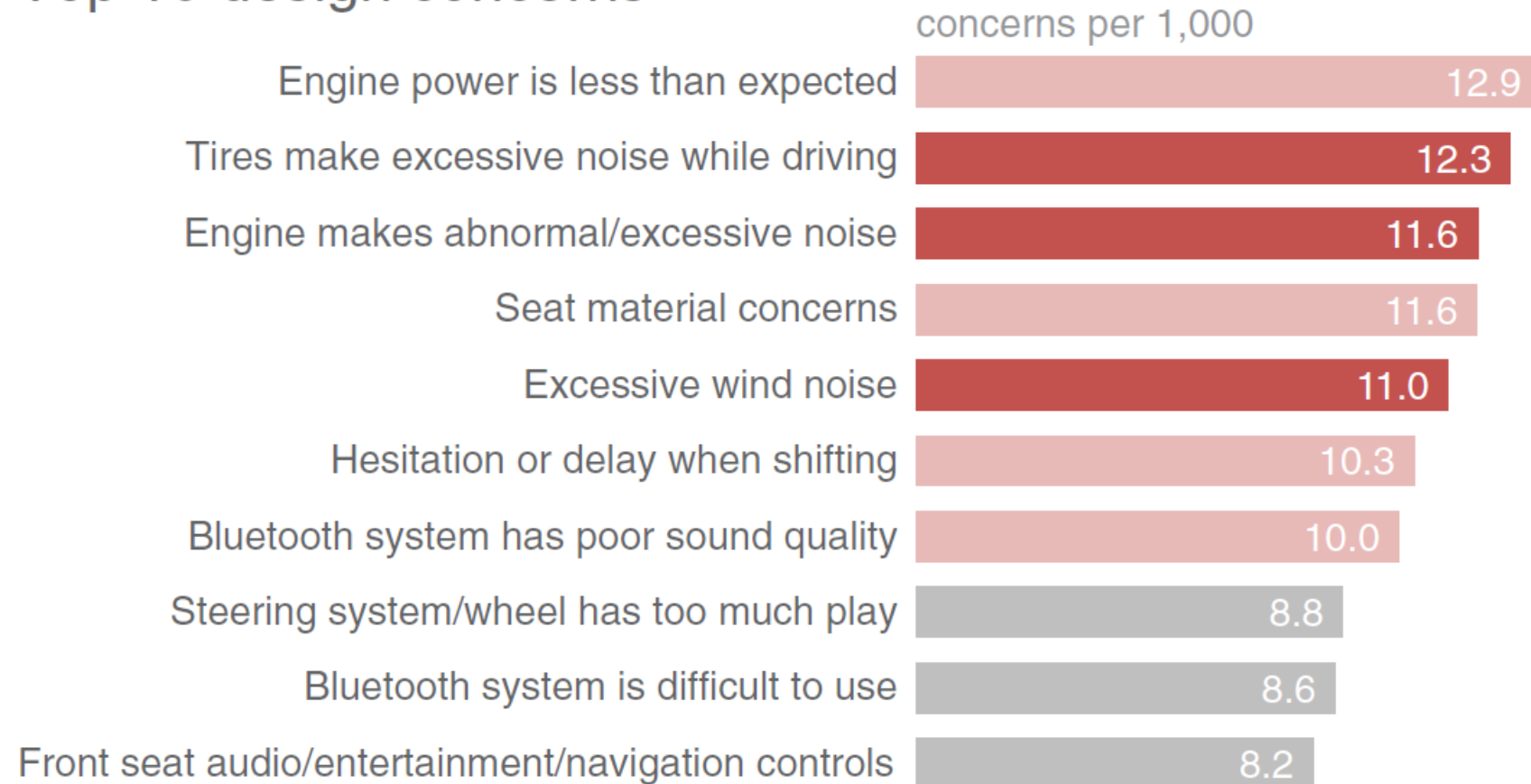
## Top 10 design concerns



# Create a visual hierarchy of information



## Top 10 design concerns

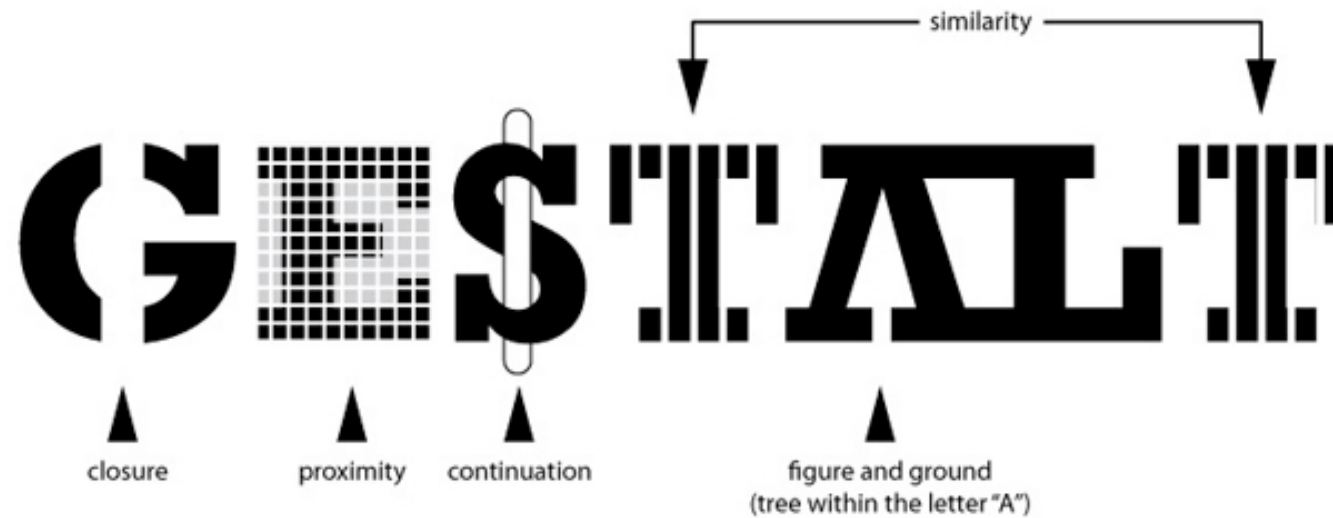


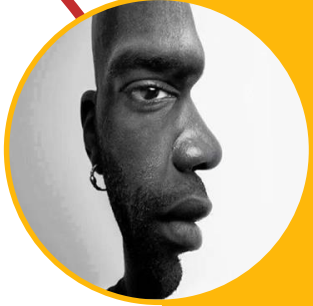
Comments indicate that **noisy tire issues** are most apparent **in the rain**.

Complaints about **engine noise** commonly cited **after the car had not been driven for a while**.

Excessive **wind noise** is noted primarily in **freeway driving at high speeds**.

# Gestalt Principles





# Gestalt Principles



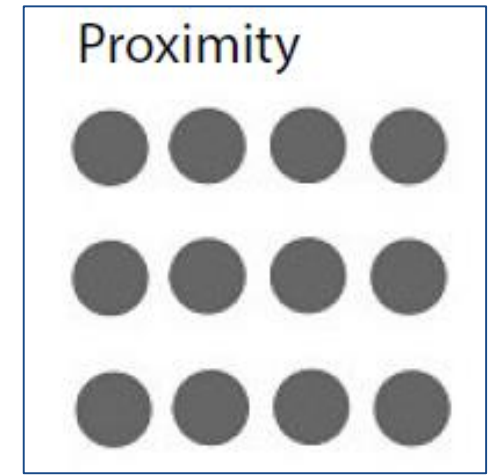
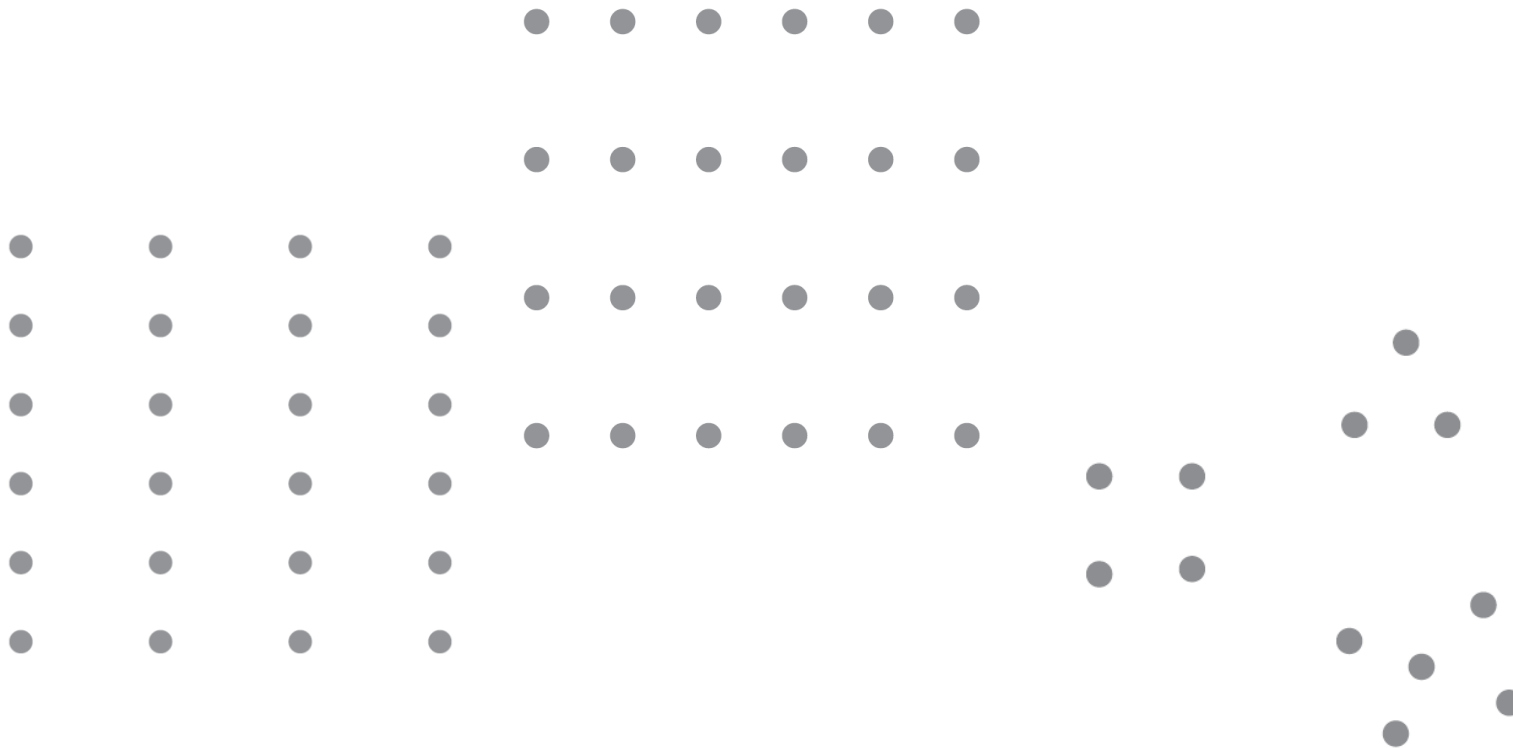
Our brains organize and group visual elements into groups or unified wholes when certain principles are applied...



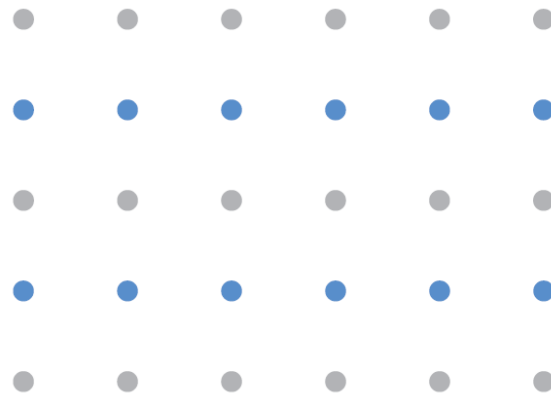
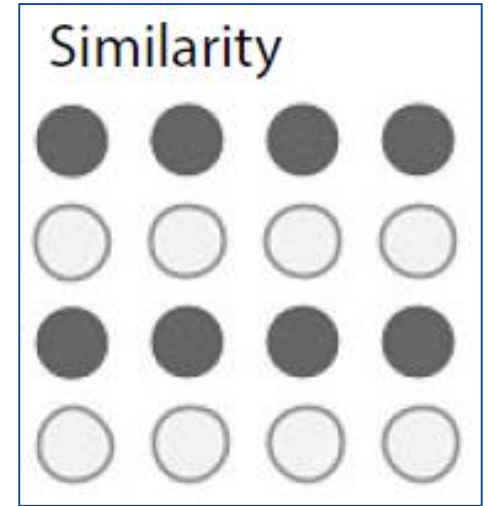
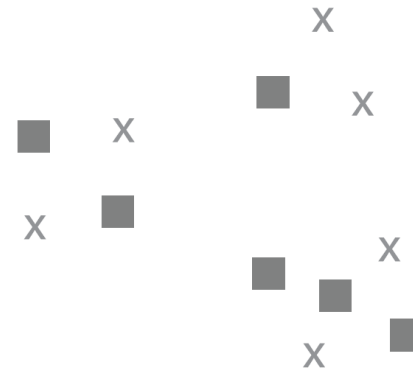
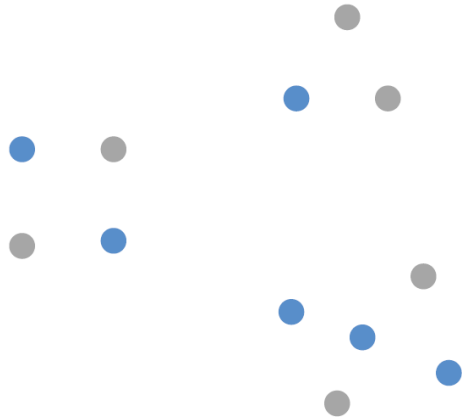
We can use these principles to **highlight patterns** that are important, and **downplay** other **patterns**.



- We see three rows of dots instead of four columns of dots because they are closer horizontally than vertically.

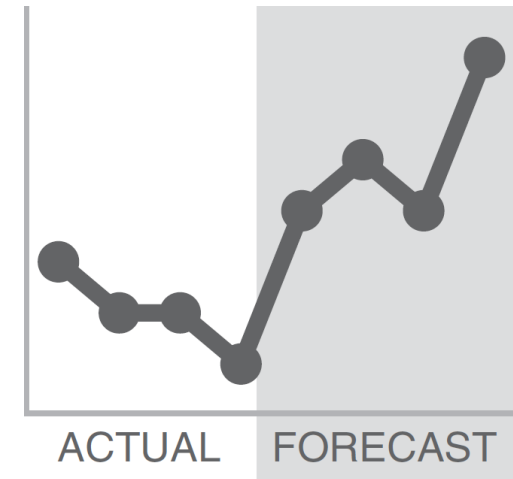
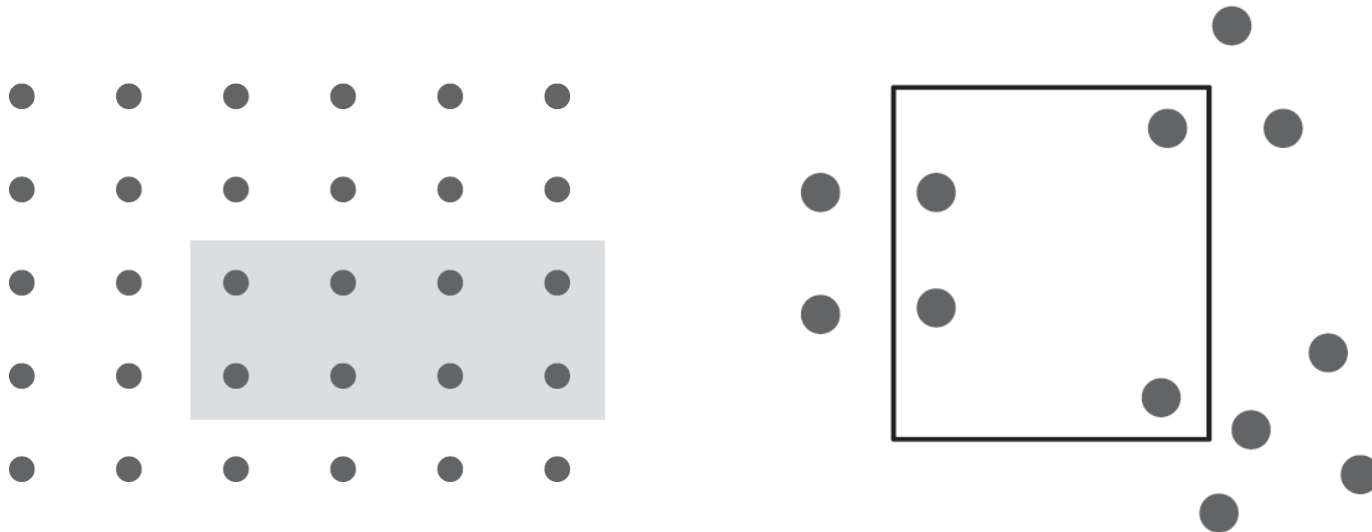
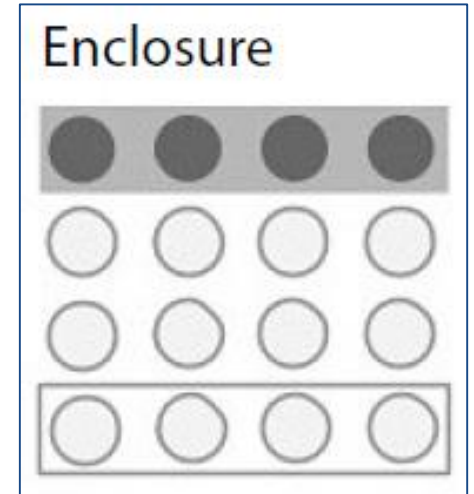


- We see similar looking objects as part of the same group.

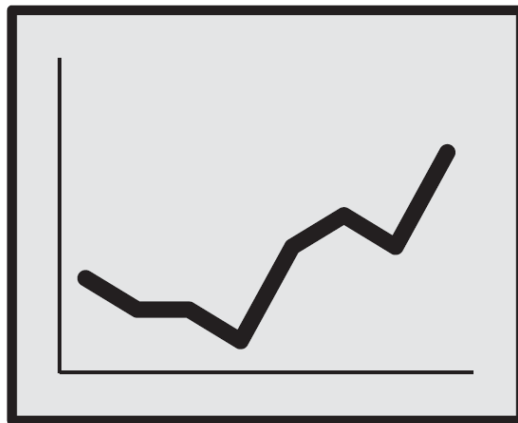
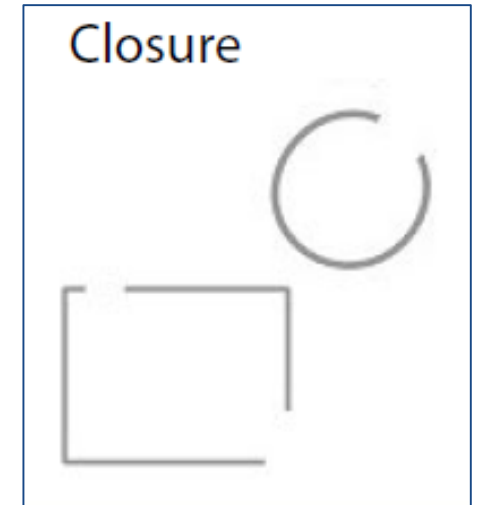




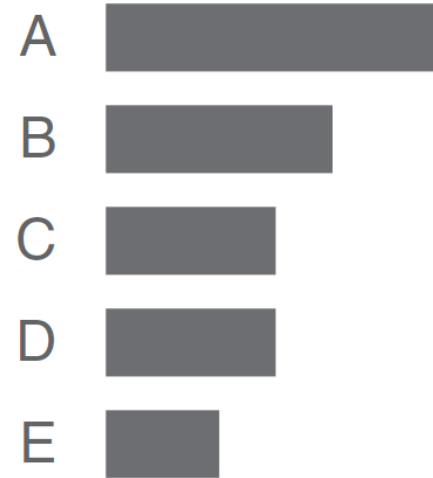
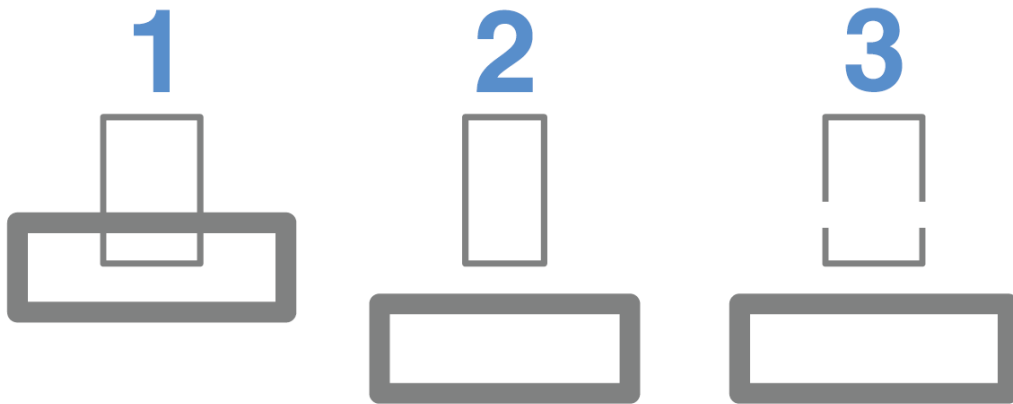
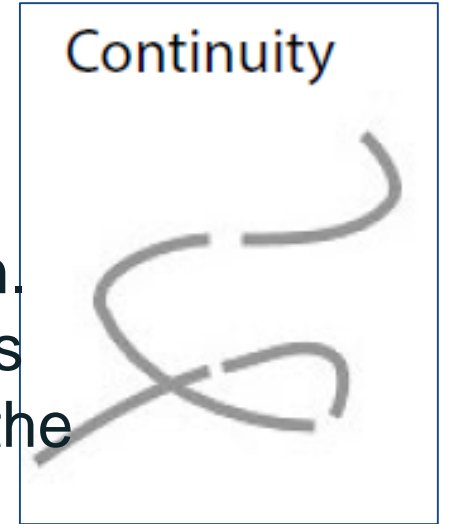
- We group the first four and last four dots as two rows instead of eight dots.



- Closure is the concept that our minds fill in gaps to complete objects and shapes.
- We automatically close the square and circle instead of seeing three disconnected paths.
- We complete the shape made by the hand and combine it with the bottom of a light bulb to make the shape of a full light bulb even though nothing is there.



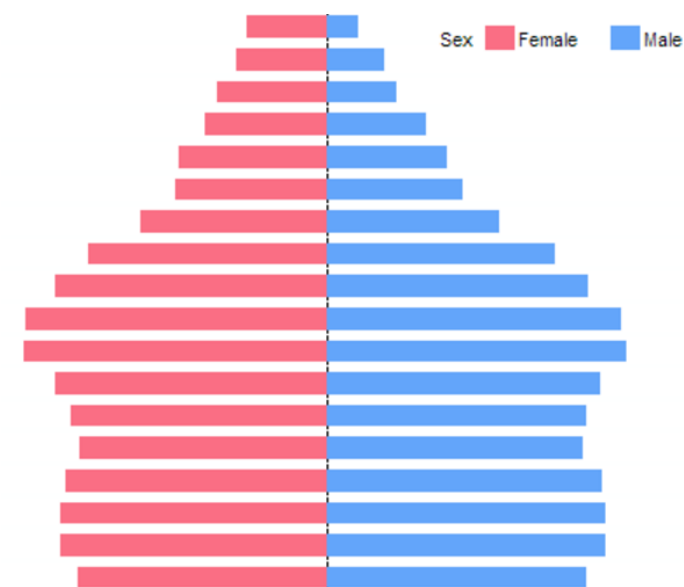
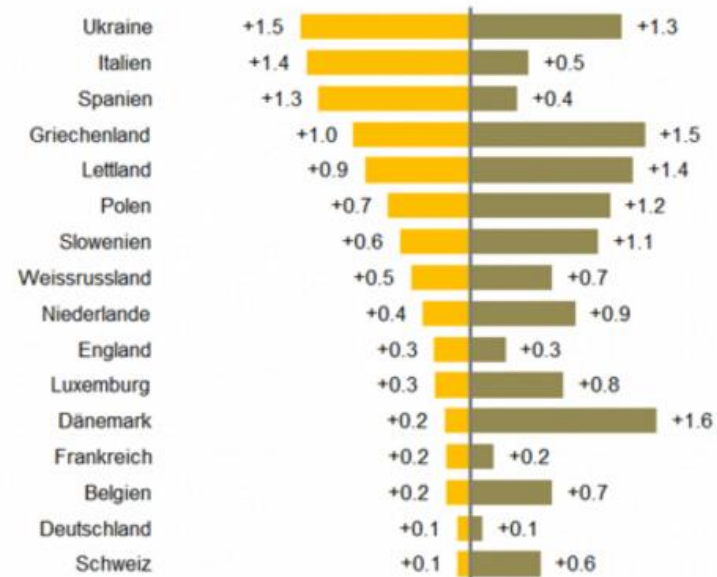
- We see one continuous path instead of three arbitrary ones.
- Continuity is the concept that rather than seeing many discontinuous patterns, we tend to see one continuous pattern. Here rather than seeing the tips of the shoes as individual parts of an ellipse, we see a large circle made with all of the tips of the shoes combined.



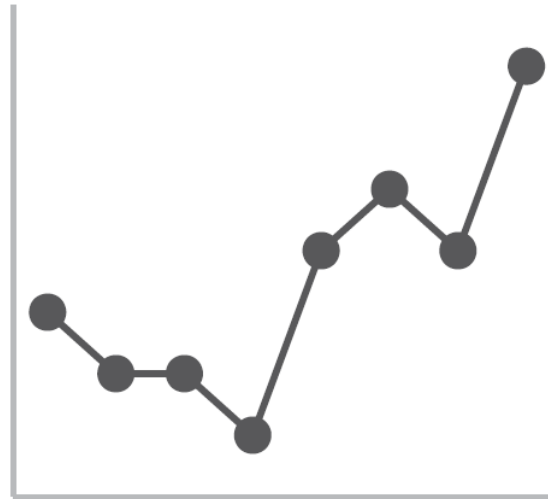
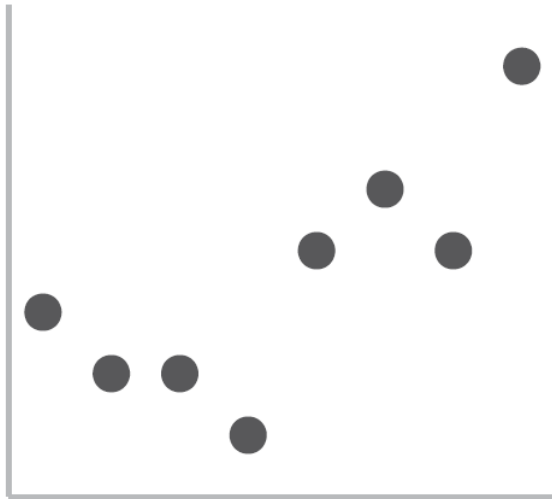
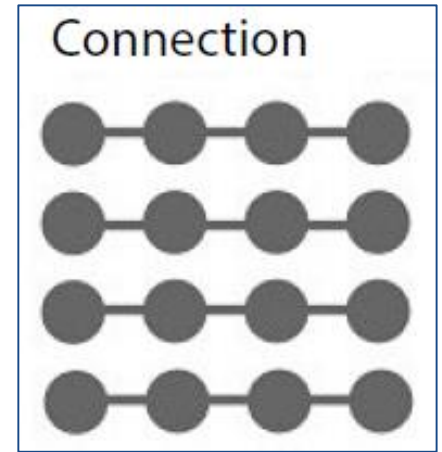
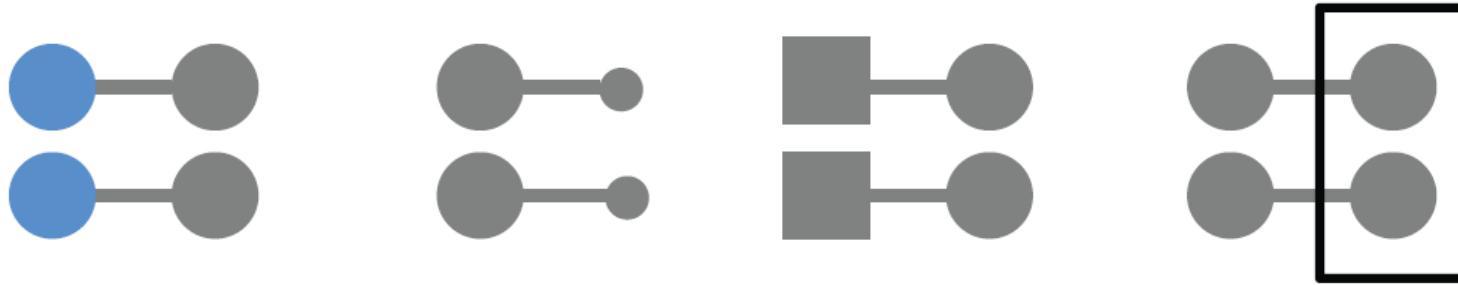
- We see three pairs of symmetrical brackets rather than six individual brackets.

Symmetry

[    ] {    } [    ]

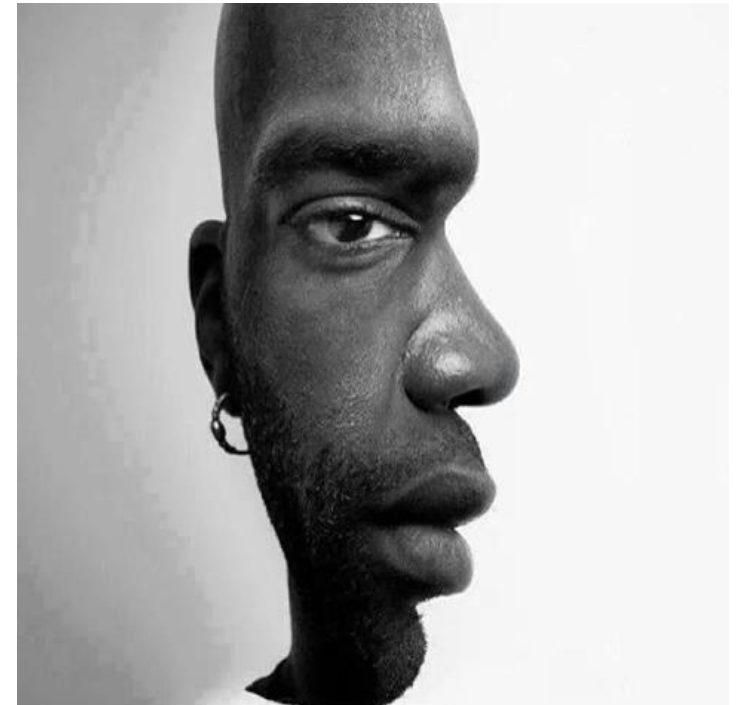


- We group the connected dots as belonging to the same group.



- We either notice the two faces, or the vase.  
Whichever we notice becomes the figure, and the other the ground
- Reversible Figures are optical illusions that uses graphical similarity between objects and shapes to cause us to be able to see two or more images. This image is an example that has half of a man's face but it can look as if you are looking at the side of the man's face or half of the front of his face.

Figure & ground



# Graphical Excellence



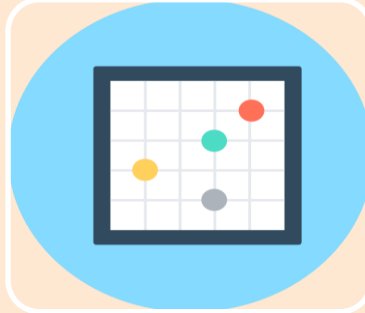
# Graphical Excellence



the  
greatest  
number  
of ideas



in the  
shortest  
time



with  
the  
least  
ink



in the  
smallest  
space










Edward Tufte, The Visual Display of Quantitative Information



# Data Visualisation

that have achieved 'Graphical Excellence' ...

-  Show the data and help the audience think about the important messages
-  Avoid distorting the data or its message
-  Present many numbers in a small space
-  Emphasise the important numbers
-  Make large data sets coherent
-  Encourage the audience to compare different pieces of data
-  Reveal the data at several levels of detail (overview to fine detail)

Adapted from: Tufte, Edward. (2001). The Visual Display of Quantitative Information, 2nd Edition. Graphics)

# Graphical Excellence

Three key aspects...



Data:Ink & Chartjunk



Graphical Integrity

- Lie Factor



Data Density

# Graphical Excellence

## Data:Ink & Chartjunk



Graphical Excellence is high when the **Data:Ink** is high and **Chartjunk** is low



**Data:Ink** = ink used to represent data / total ink used to print the graphic

To **maximise** the Data:Ink

- we must erase 'non-data-ink' and 'redundant data-ink'



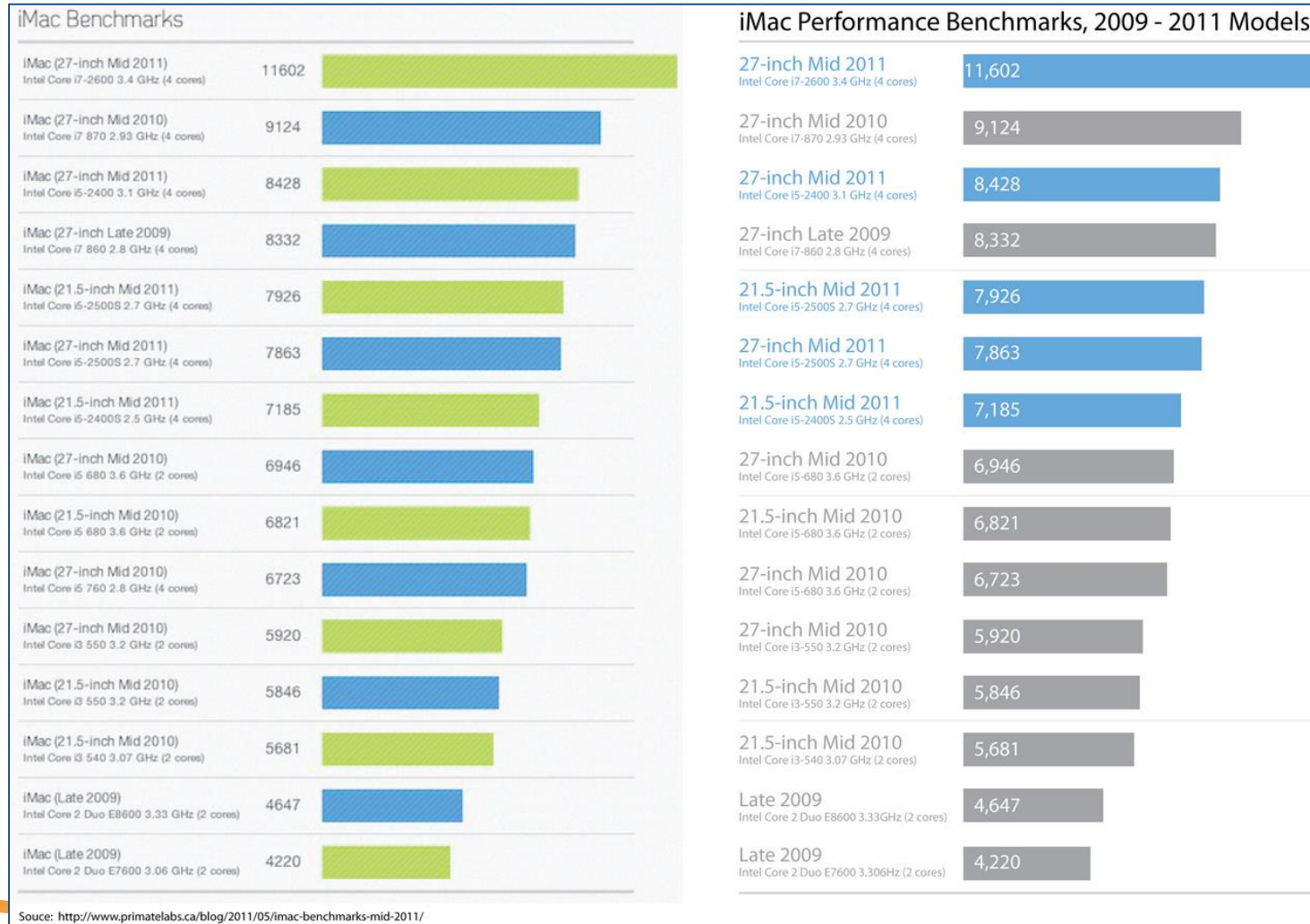
**Chartjunk** = superfluous, decorative, or diverting ink

To **minimize** Chartjunk

- we must remove '**moiré vibration**', **grids**, and '**the duck**'

# Data:Ink & Chartjunk

## Moiré Vibration



# Data:Ink & Chartjunk

## Grid

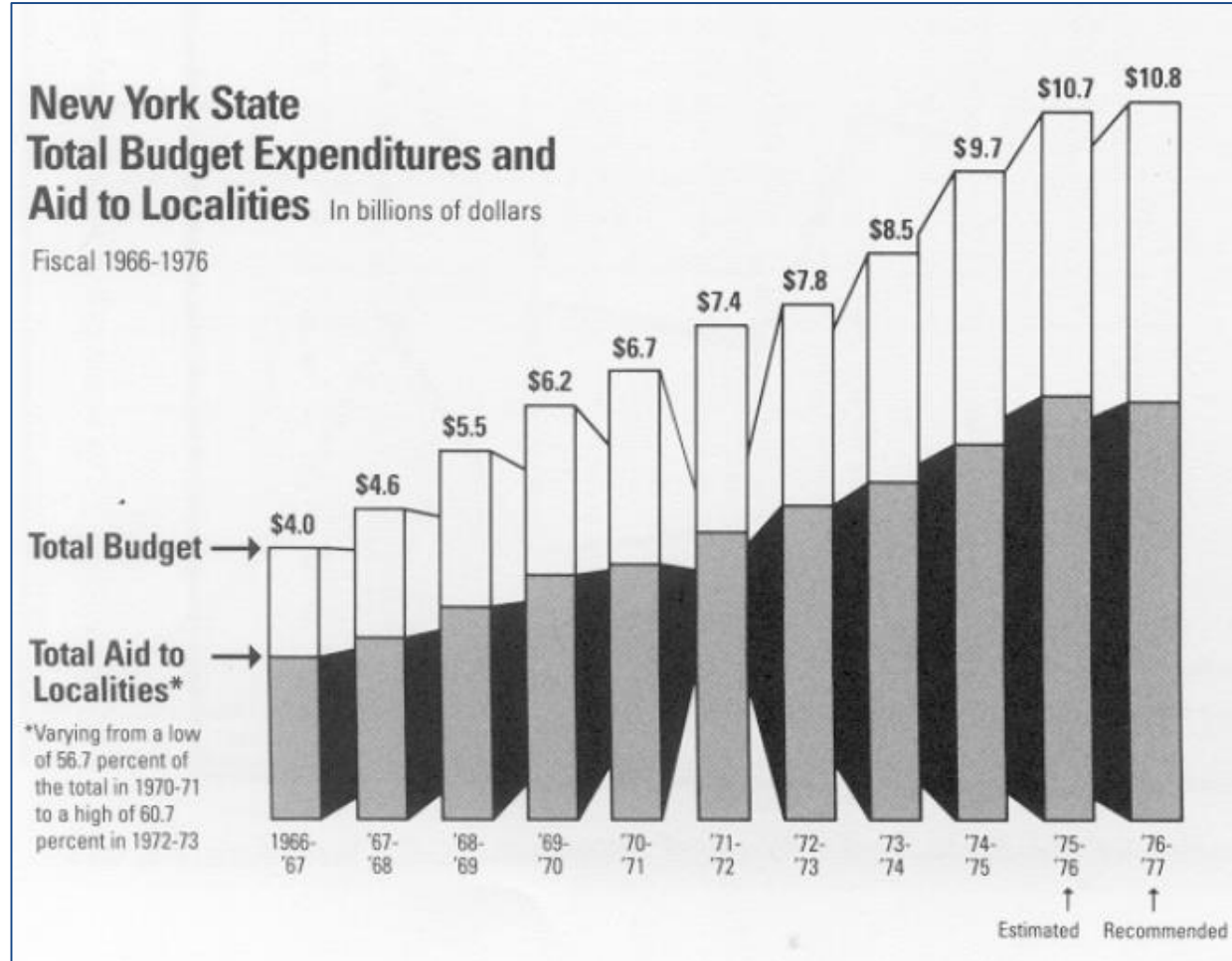
Group	Metric A	Metric B	Metric C
Group 1	\$X.X	Y%	Z,ZZZ
Group 2	\$X.X	Y%	Z,ZZZ
Group 3	\$X.X	Y%	Z,ZZZ
Group 4	\$X.X	Y%	Z,ZZZ
Group 5	\$X.X	Y%	Z,ZZZ

Group	Metric A	Metric B	Metric C
Group 1	\$X.X	Y%	Z,ZZZ
Group 2	\$X.X	Y%	Z,ZZZ
Group 3	\$X.X	Y%	Z,ZZZ
Group 4	\$X.X	Y%	Z,ZZZ
Group 5	\$X.X	Y%	Z,ZZZ

Group	Metric A	Metric B	Metric C
Group 1	\$X.X	Y%	Z,ZZZ
Group 2	\$X.X	Y%	Z,ZZZ
Group 3	\$X.X	Y%	Z,ZZZ
Group 4	\$X.X	Y%	Z,ZZZ
Group 5	\$X.X	Y%	Z,ZZZ

# Data:Ink & Chartjunk

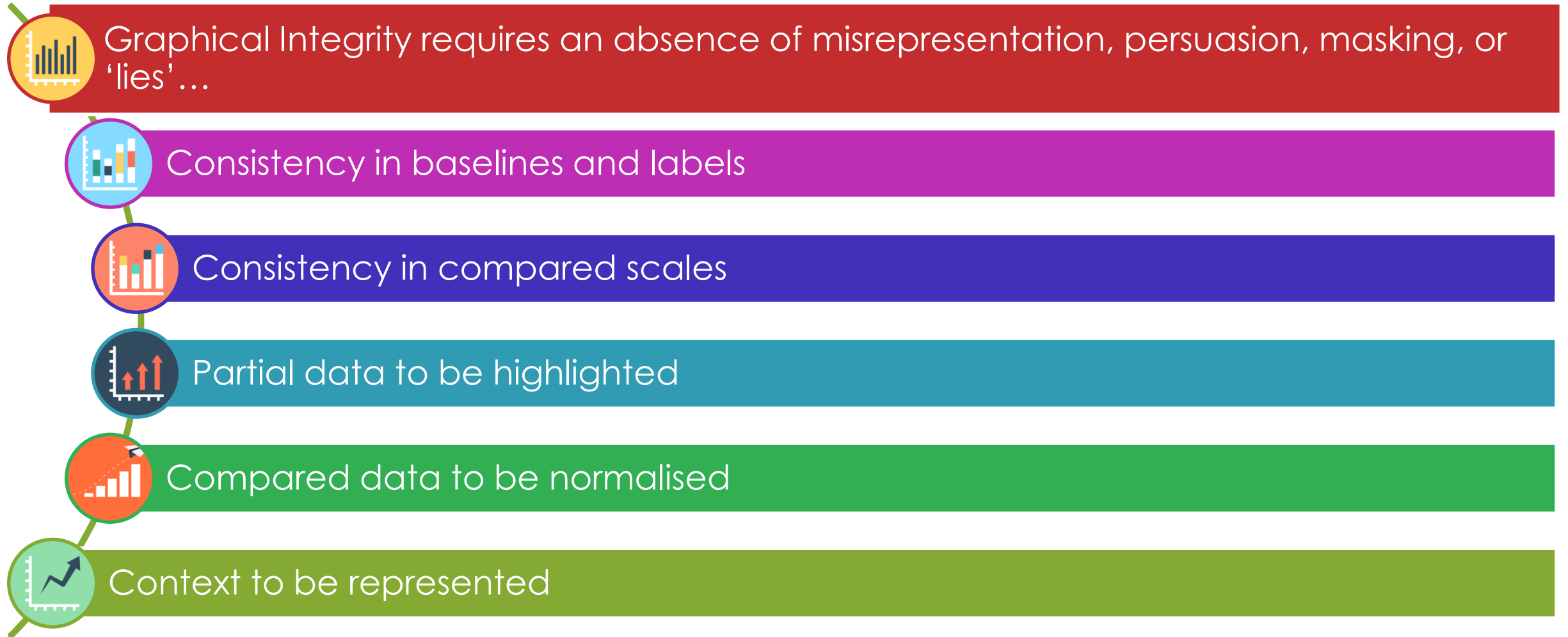
## the Duck



# Graphical Integrity

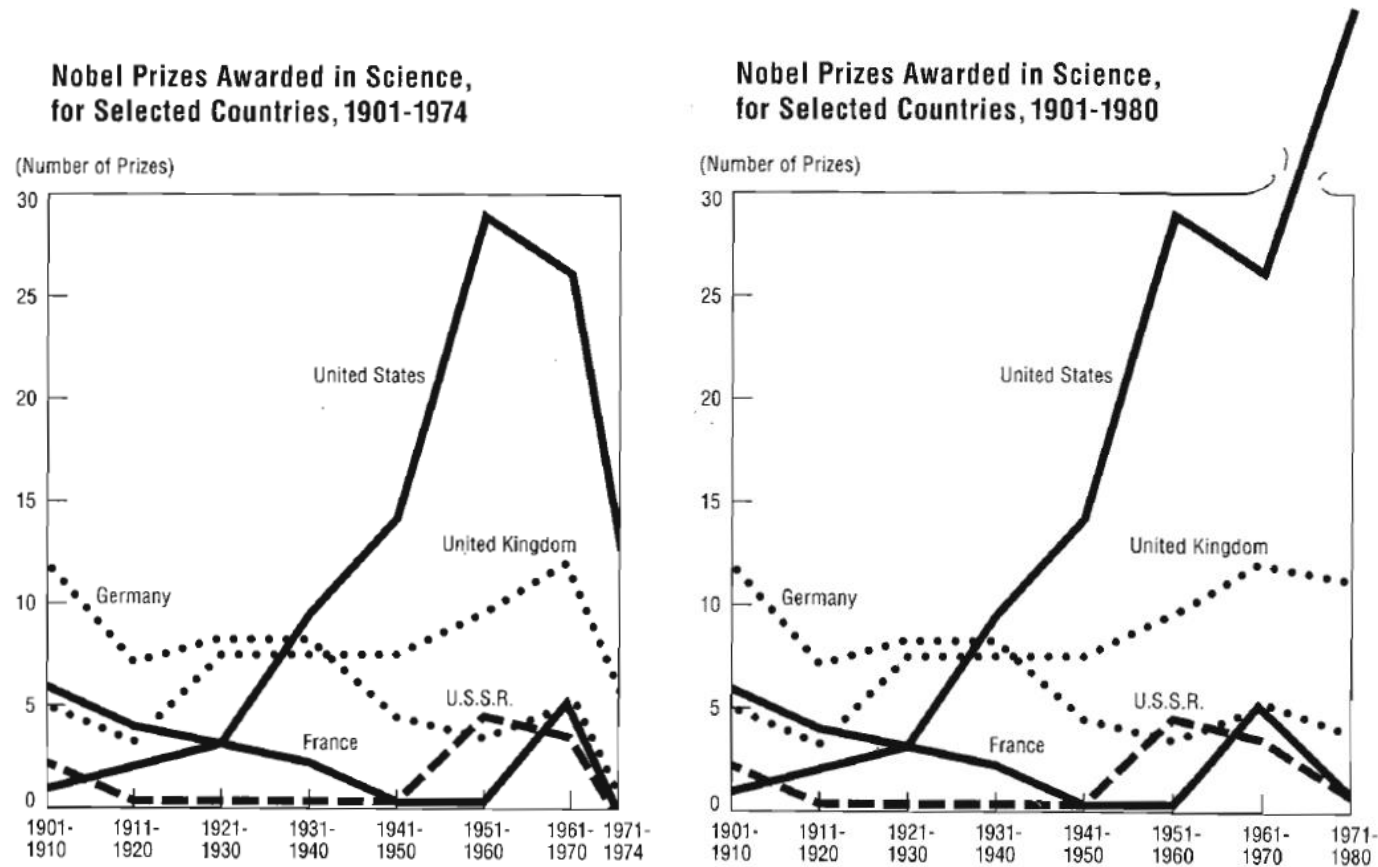


# Graphical Excellence is high when the **Graphical Integrity** is high...





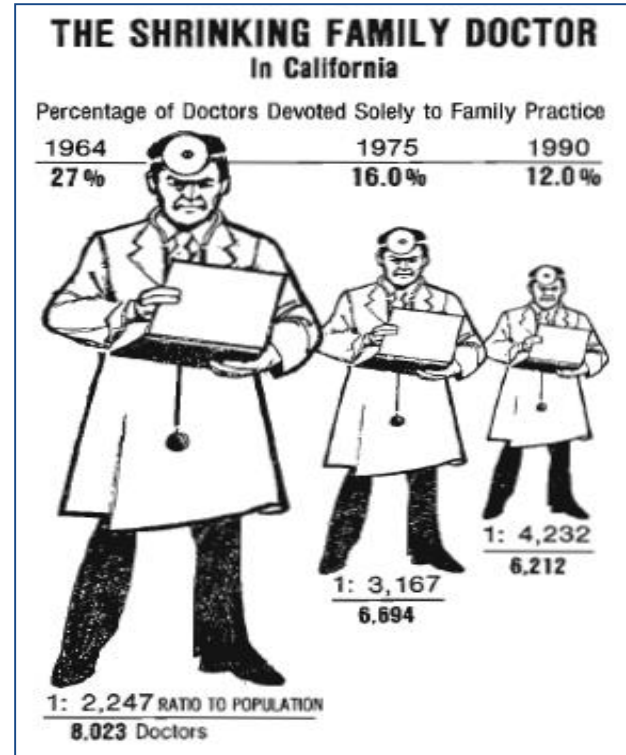
# Graphical Integrity



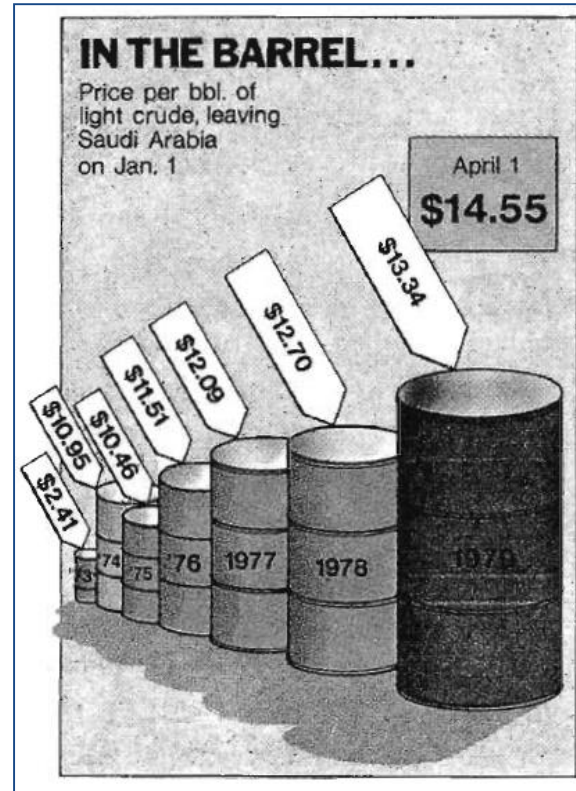
<http://innovis.cpsc.ucalgary.ca/innovis/uploads/Courses/InformationVisualizationDetails/Tufte-partII.pdf>

$$\text{Lie Factor} = \frac{\text{size of effect shown in graphic}}{\text{size of effect in data}}$$

Lie Factor = c.3 (area)



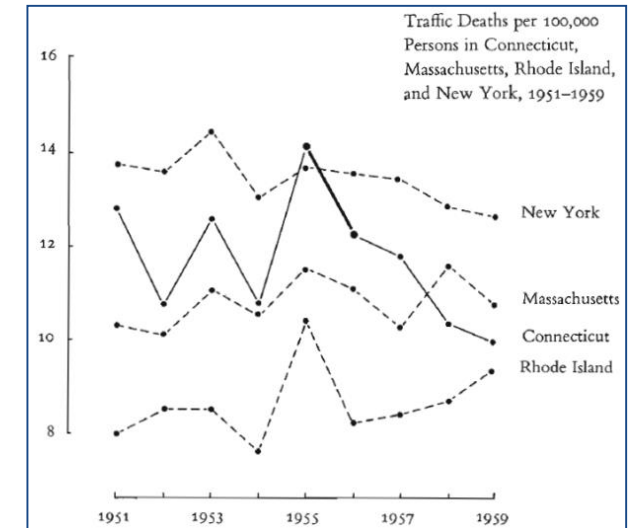
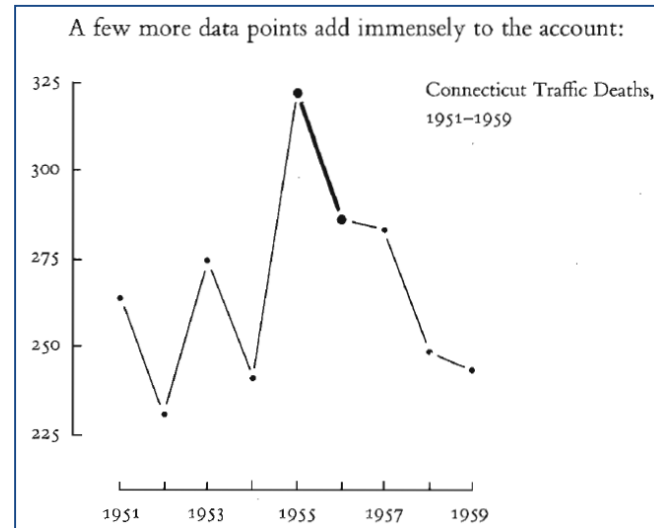
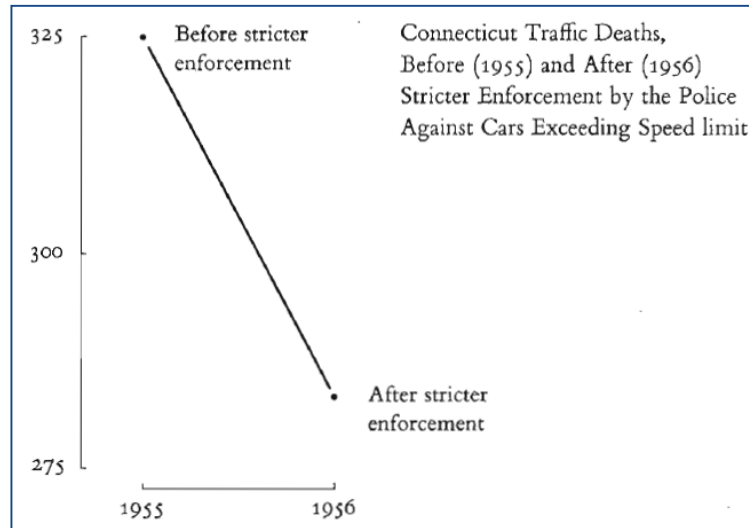
*Los Angeles Times, August 5, 1979, p. 3.*



*Time, April 9, 1979, p. 57.*

Lie Factor: 59.4  
(volume)

# Graphical Integrity



The message evolves as the context increases...

# Six principles to ensure 'Graphical Integrity'...



Make the representation of numbers proportional to quantities



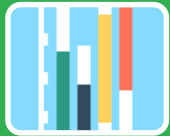
Use clear, detailed, and thorough labeling



Show data variation, not design variation



Use standardized units, not nominal values



Depict 'n' data dimensions with less than or equal to 'n' variable dimensions



Quote data in full context

# Graphical Integrity



Graphical Excellence is high when the Data Density is high...



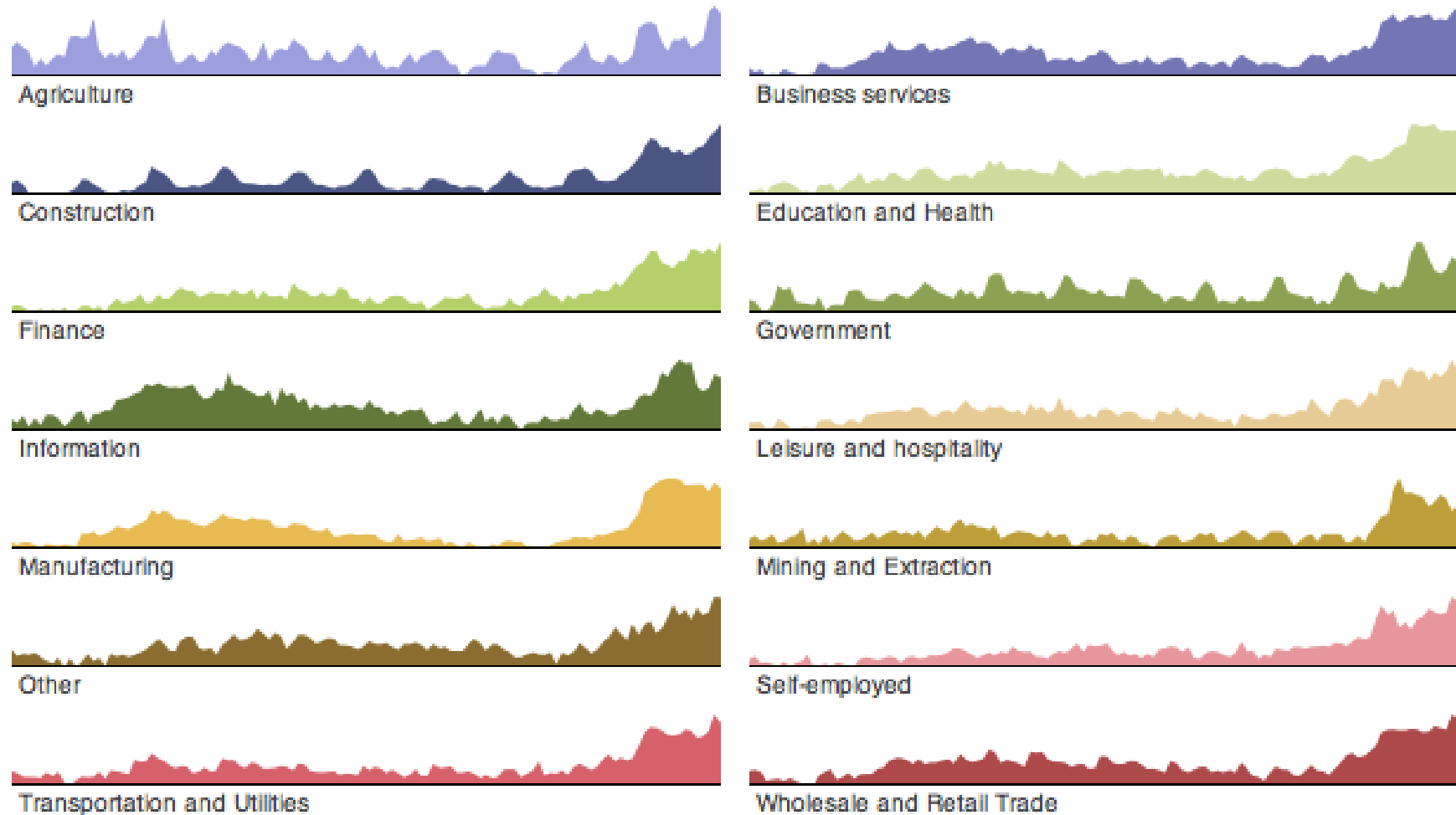
Data Density = number of data entries in graphic / area of graphic



To maximise Data Density we should...

- Consider the use of 'small multiples'
- Maximise space by removing unnecessary 'ink'

# Small Multiples

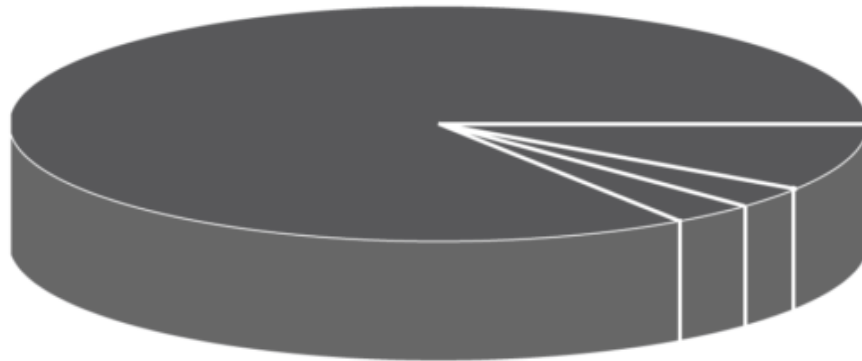


# How to Spot Visualization Lies

Keep your eyes open

## EXTRA DIMENSION JUST BECAUSE

*Just say no.*



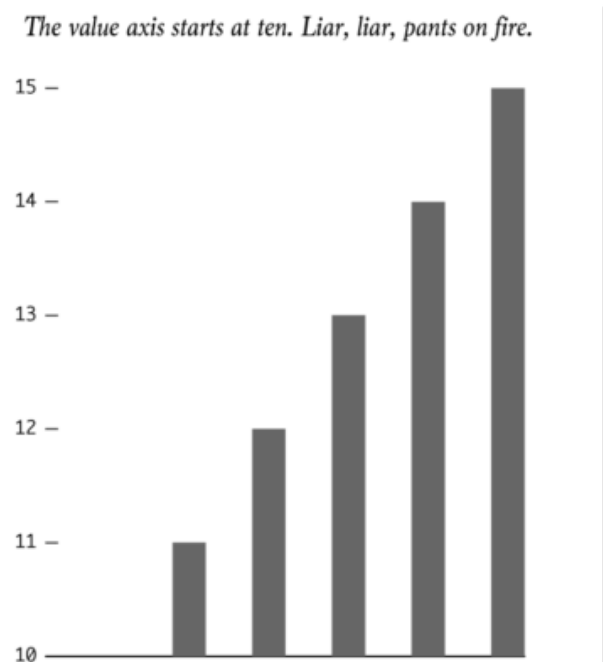
## PUTZING AROUND WITH AREA DIMENSIONS

*These fill the same amount of area, but they look very different.*

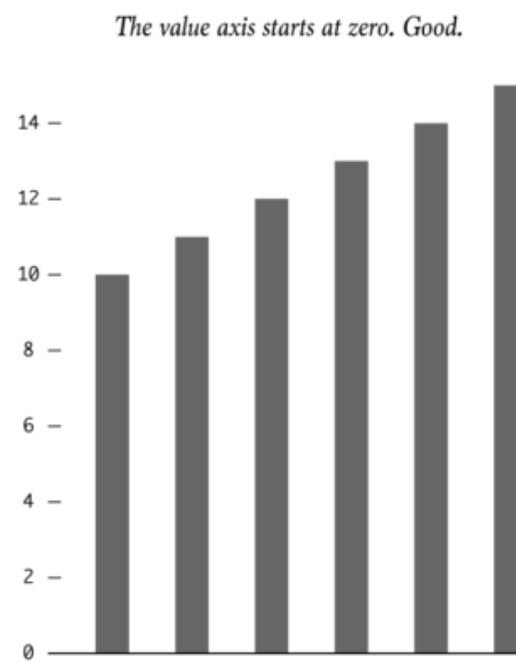


## TRUNCATED AXIS

The value axis starts at ten. Liar, liar, pants on fire.

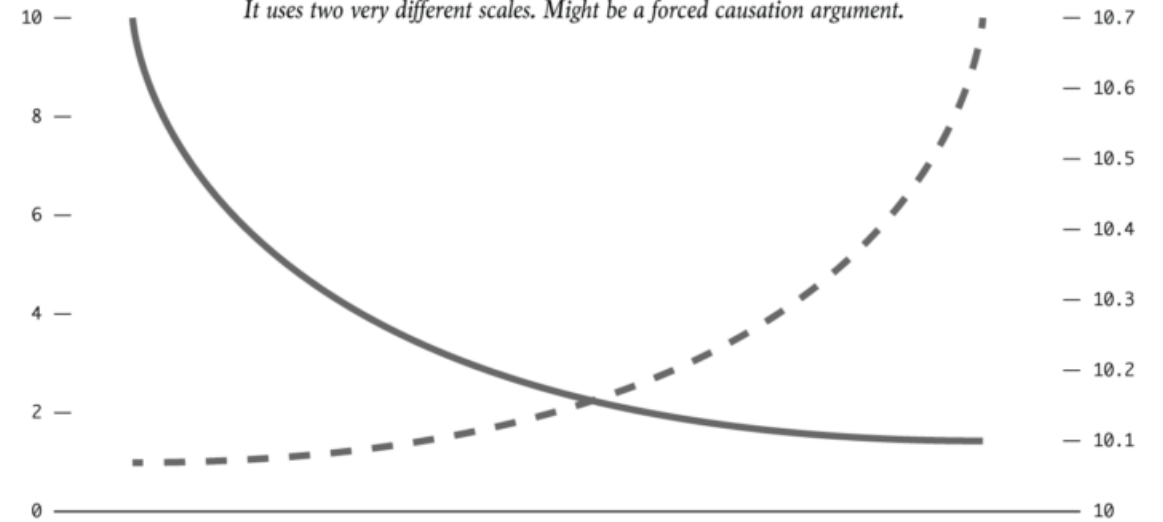


The value axis starts at zero. Good.



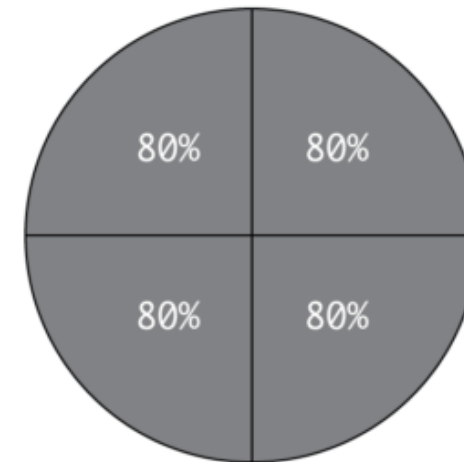
## DUAL AXES

It uses two very different scales. Might be a forced causation argument.



## IT DOES NOT ADD UP

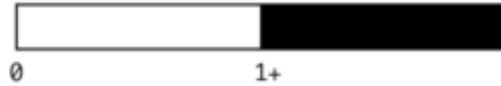
The parts add up to more than the whole, which is 100%.  
For my next trick, I will turn this rabbit into a big bag of money.





## ODD CHOICE OF BINNING

Two bins. What's really in the 1+ category?  
*Might be hiding something.*

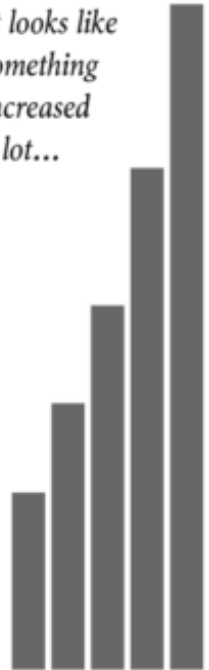


*That's better. It can show more variation.*

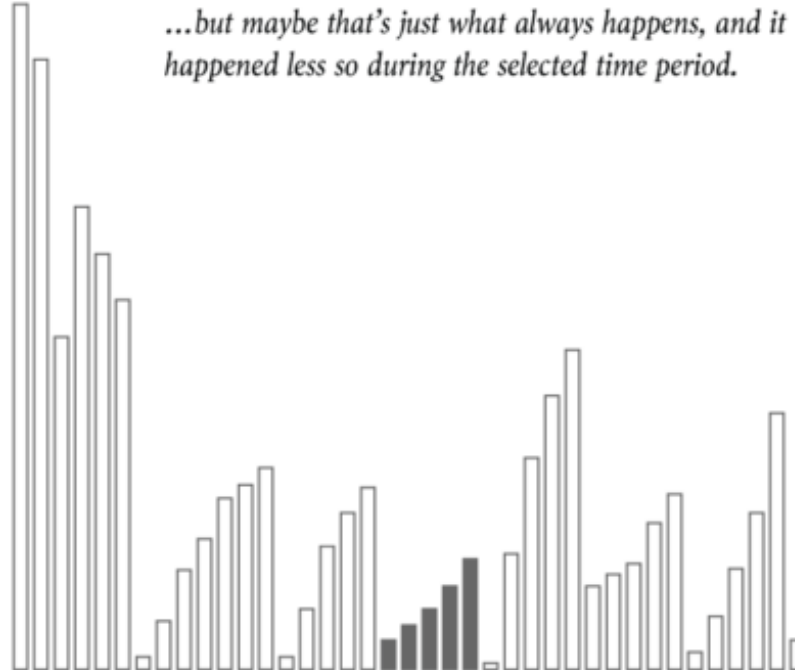


## LIMITED SCOPE

*It looks like something increased a lot...*

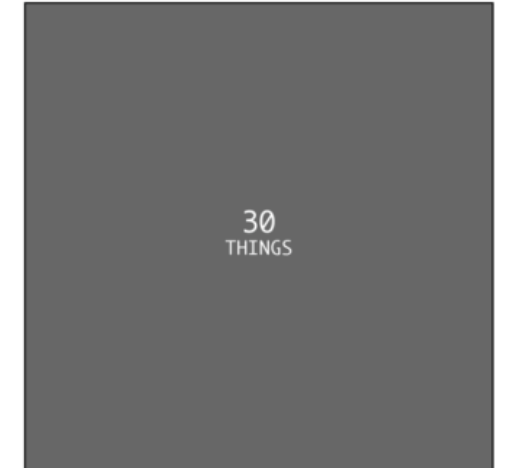


*...but maybe that's just what always happens, and it happened less so during the selected time period.*



## AREA SIZED BY SINGLE DIMENSION

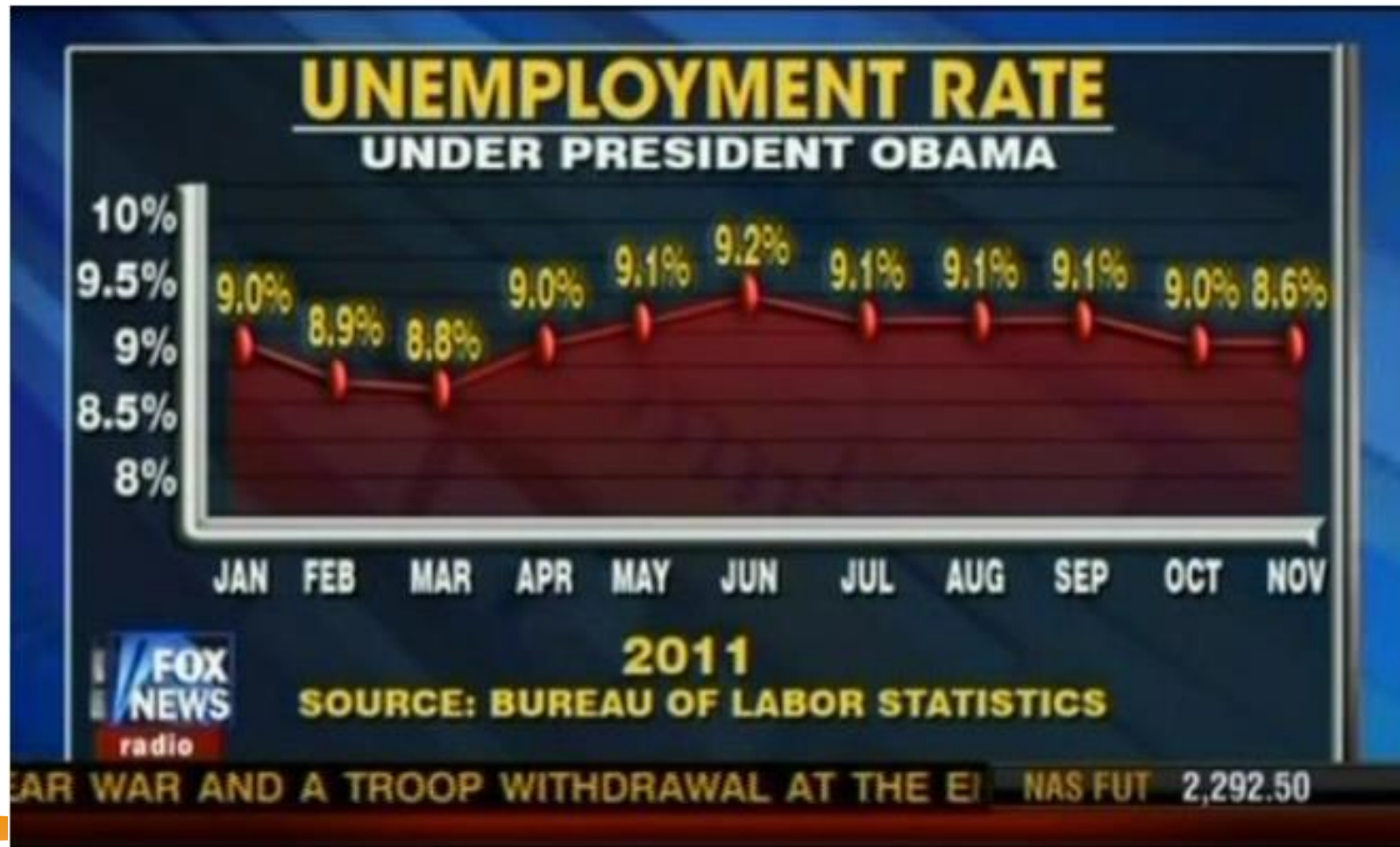
*Thirty is three times ten, but that third rectangle looks a lot bigger than the first.  
*Might be trying to inflate significance.**



$$\text{Lie Factor} = \frac{\text{size of effect shown in graphic}}{\text{size of effect in data}}$$

# Misleading Graphics

Poor Graphical Integrity & Graphical Excellence



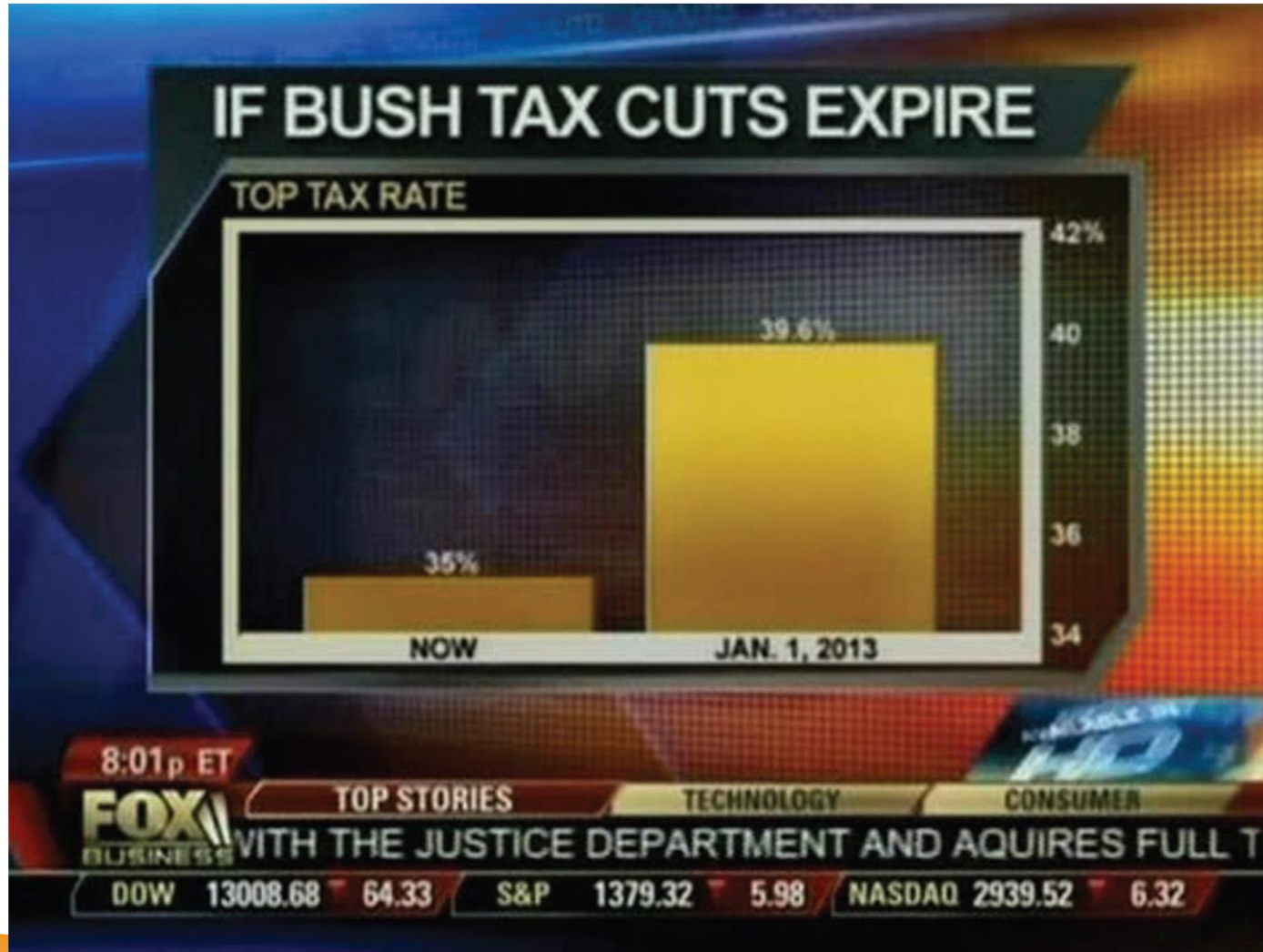
High Chartjunk

Low Data:Ink ratio

# How to Improve the Graph?



# Poor Graphical Integrity & Graphical Excellence



High Chartjunk

Low Data:Ink ratio

# How to Improve the Graph?



# Summary

- Pre-Attentive Attributes
- Gestalt Principles
- Visualisation Excellence
  - Graphical Excellence
  - Graphical Integrity
- Three key aspects of Graphical Excellence
- Six principles to ensure Graphical Integrity
- Graphical Excellence is high when the Graphical Integrity is high...

