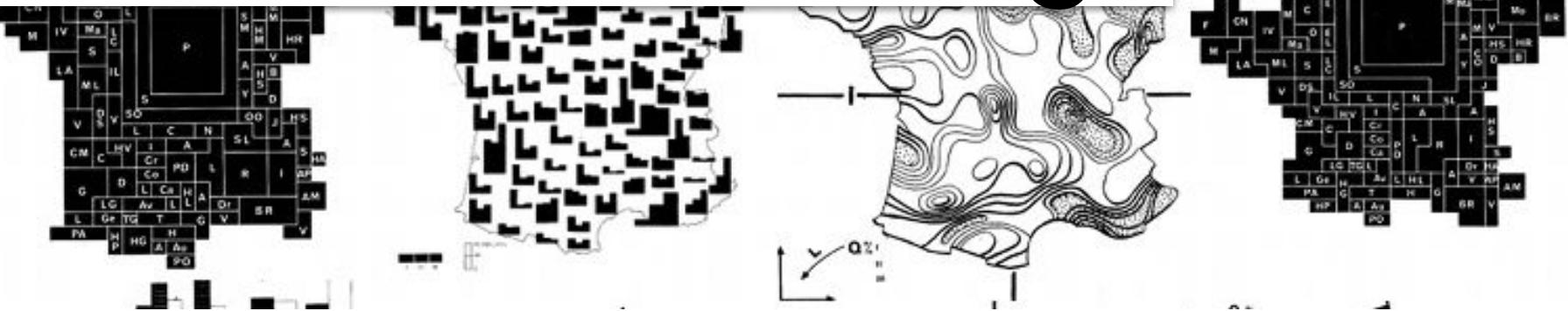


## Session 2

# Visualization Design



Online Course  
**Data Visualization  
for Professionals**



THE UNIVERSITY  
of EDINBURGH

**Benjamin Bach**

May 2022

<http://benjbach.me>  
<https://datavis-online.github.io>

-- Not for external use --

# Encoding: designer

## 1 Data

**What is my data?**

Which data type?

Ordinal / numerical / categorical?

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**What is my visual representation?**

Which visual variables am I using?

How am I encoding my data?

## 3 Rendering

**What is my medium?**

monoscopic/stereoscopic?

Tangibility?

Print / digital?

**View**

# Decoding: user

6

## Comprehending

**What does it mean for me?**

What shall I do now?

Is this all true?

What do I learn?

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## Interpreting

**What does it mean?**

What does color mean?

What does 'up' mean?

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## Perceiving

**What does it show?**

Where is big, medium, small?

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*What are the building blocks for effective visualizations and visualization designs?*

1. Visual perception
2. Gestalt Laws
3. Data types
4. Visual Variables
5. Color (extra)
6. Visualization Guidelines (extra)

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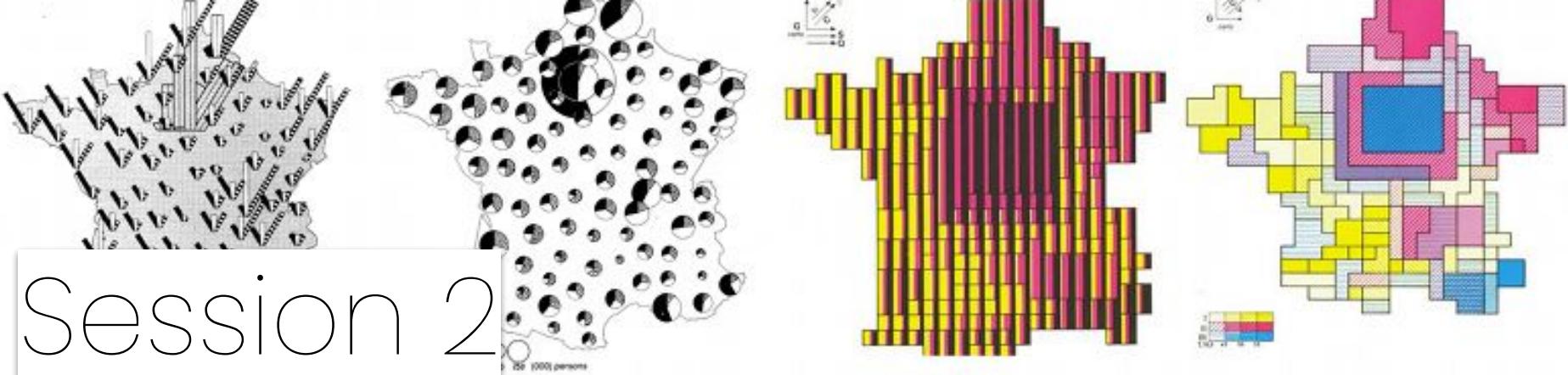
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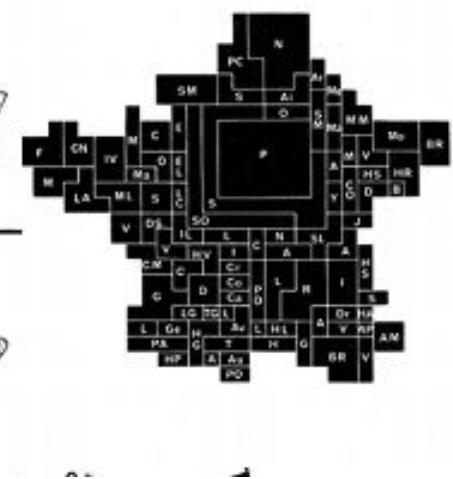
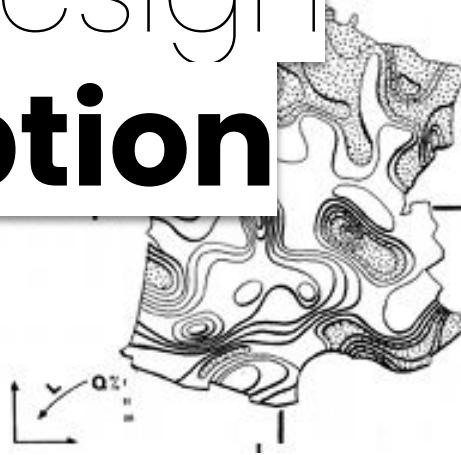
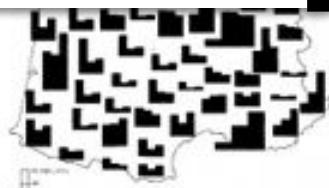
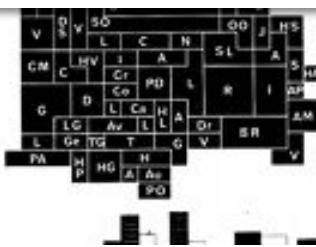
1. Visual perception
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## Session 2

# Visualization Design

# Visual Perception



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## Find every '5'

9176867991960386255930486551443  
9353652502752141394912668766013  
5095444663473545993604636448078  
6425620171155906710121069218701  
0584448205561385902503573068845  
1172102391879794238892669764599  
6987227951015948926017759166604  
8436204036527029291707742717051  
3280506428553158863136868380421  
4055135906770329783671748392874

## Find every '5'

9176867991960386255930486551443  
9353652502752141394912668766013  
5095444663473545993604636448078  
6425620171155906710121069218701  
0584448205561385902503573068845  
1172102391879794238892669764599  
6987227951015948926017759166604  
8436204036527029291707742717051  
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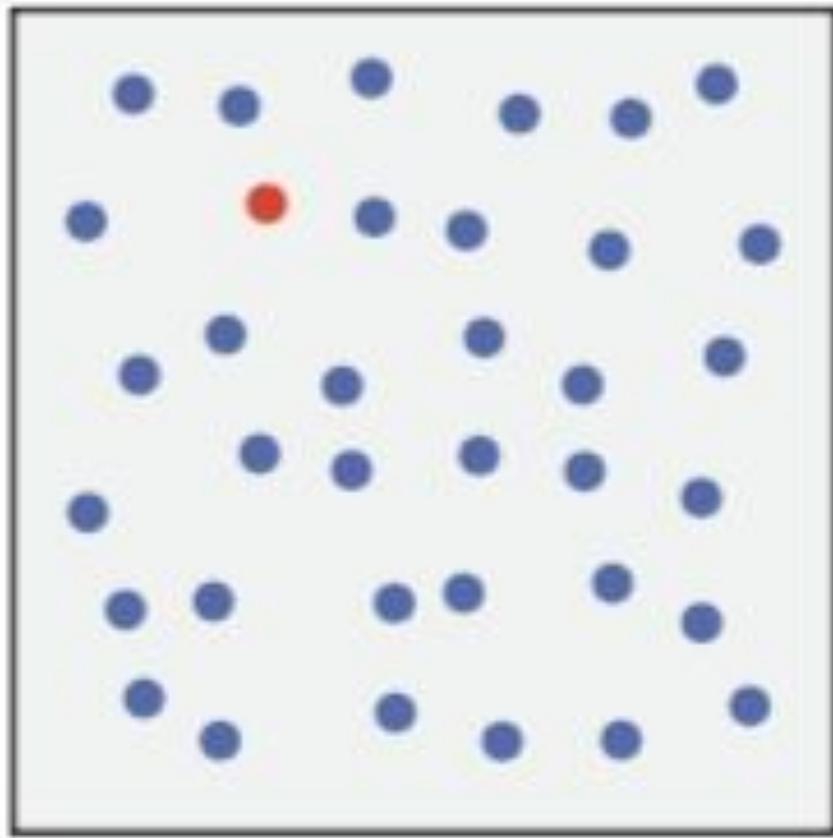
## Pre-attentiveness:

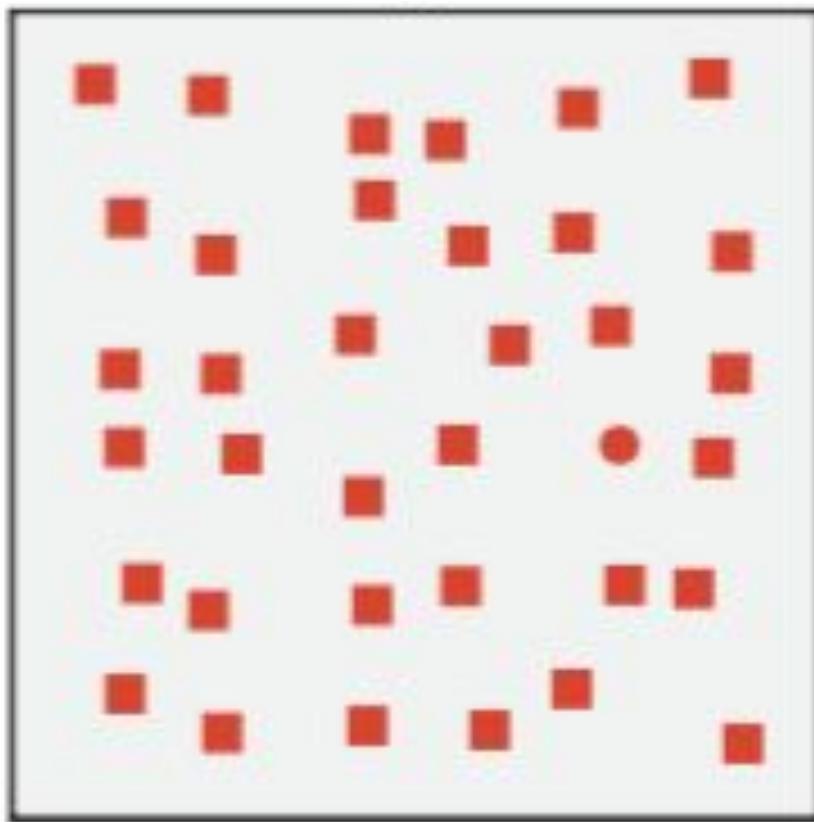
- "is the subconscious accumulation of information from the environment"
- realizing something before you think

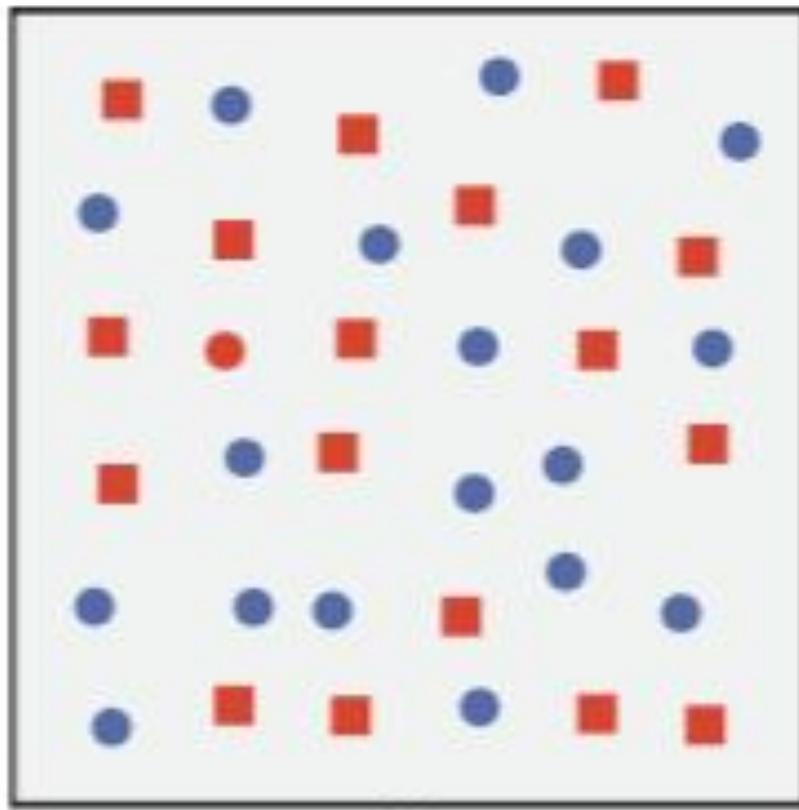
## Parallelity:

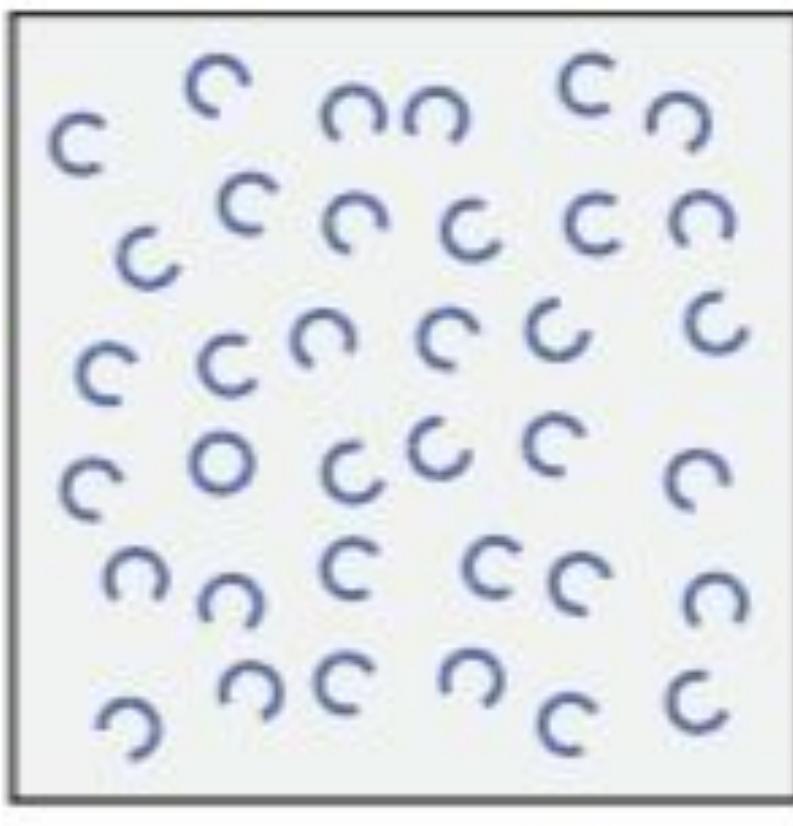
- Perceiving stimuli in parallel











# Preattentiveness



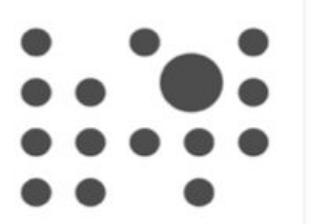
Length



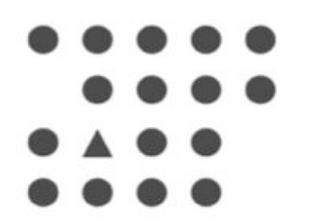
Width



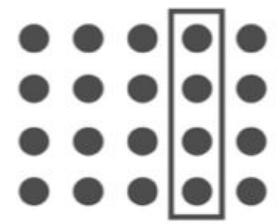
Orientation



Size



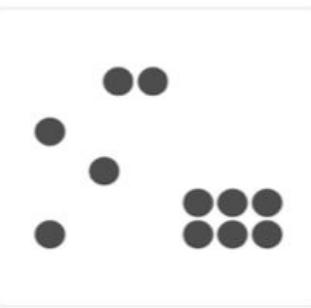
Shape



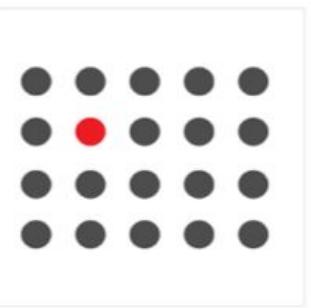
Enclosure



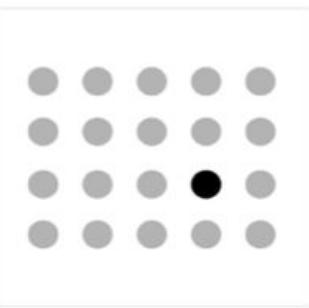
Position



Grouping

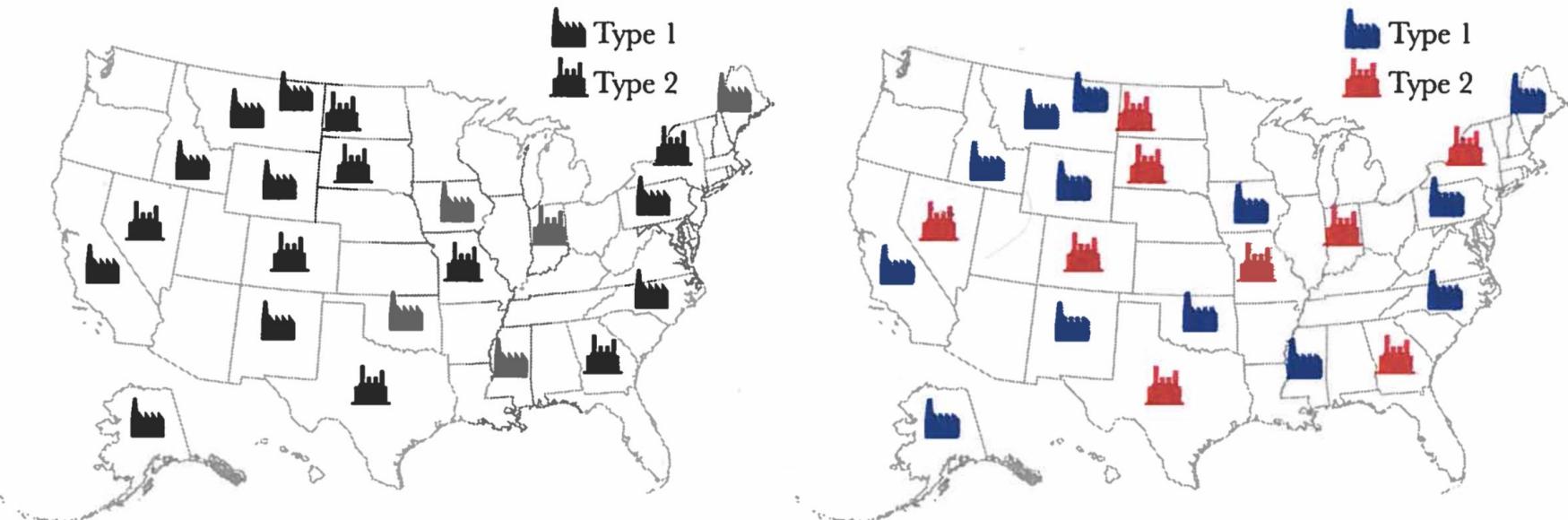


Color Hue

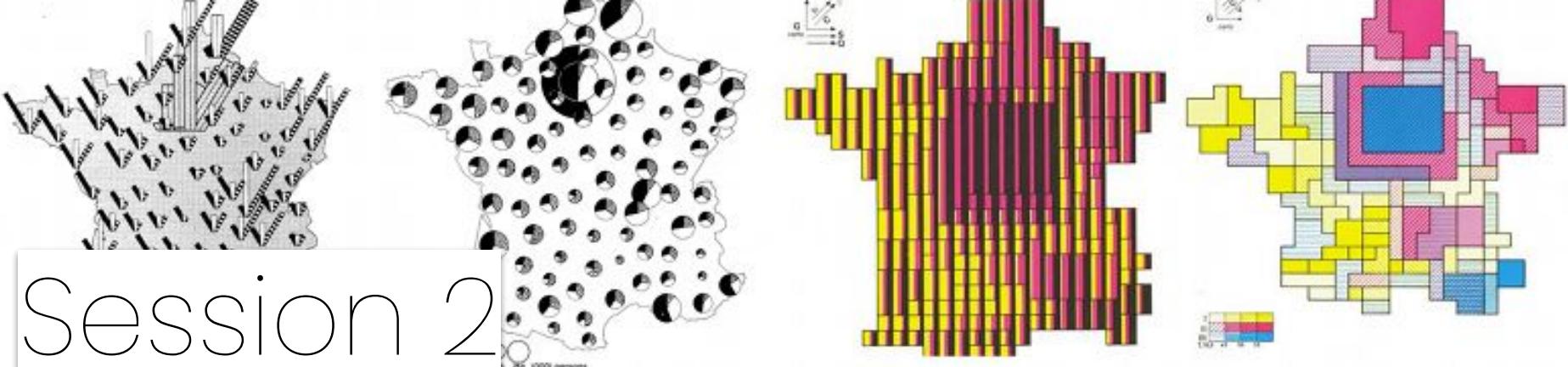


Color  
Intensity

# Example:



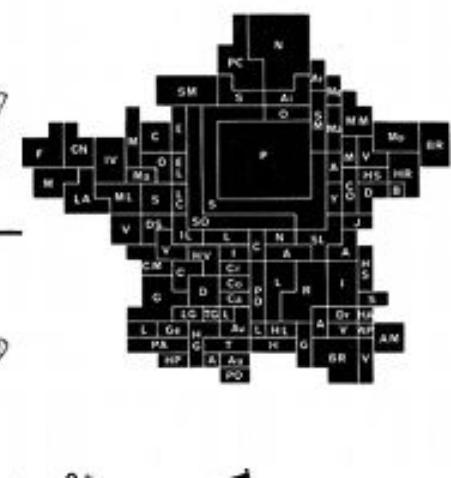
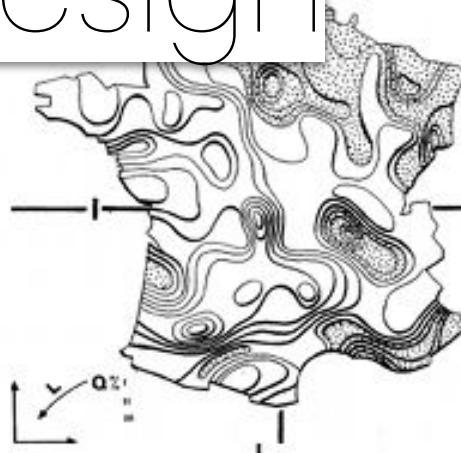
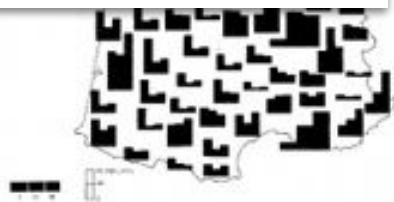
**Figure 6.3** On which of these maps is it easier to identify the number of factories of each kind?



## Session 2

# Visualization Design

## Gestalt Laws



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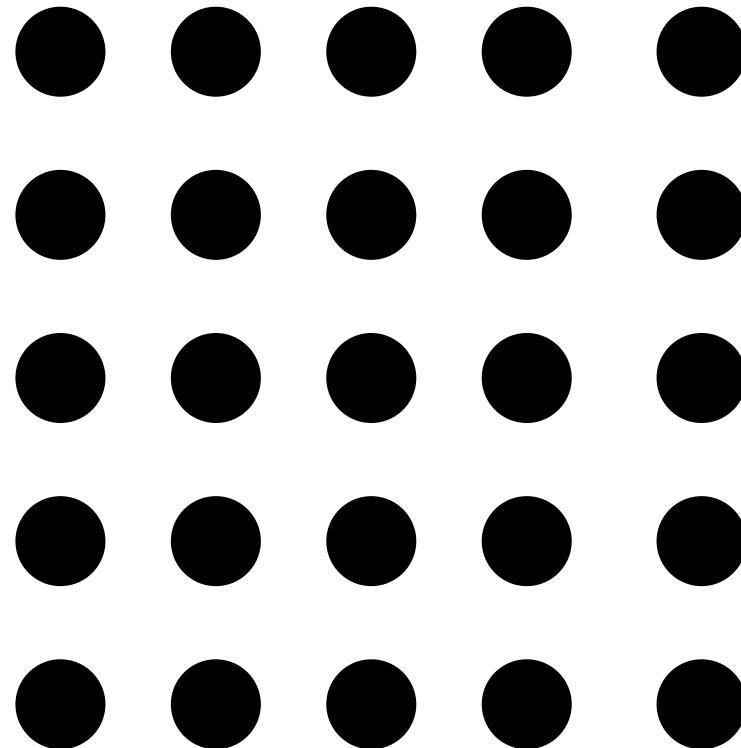
**Benjamin Bach**

May 2022

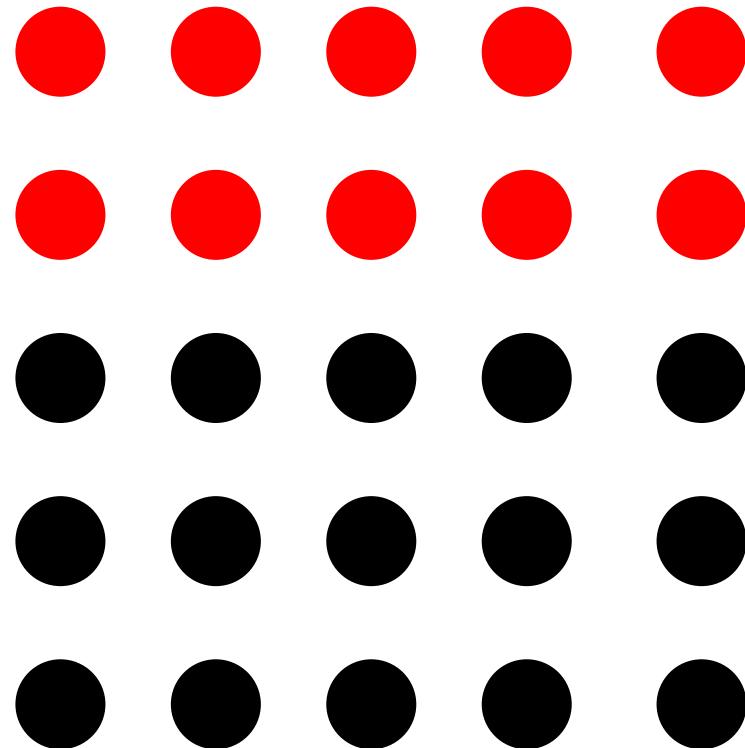
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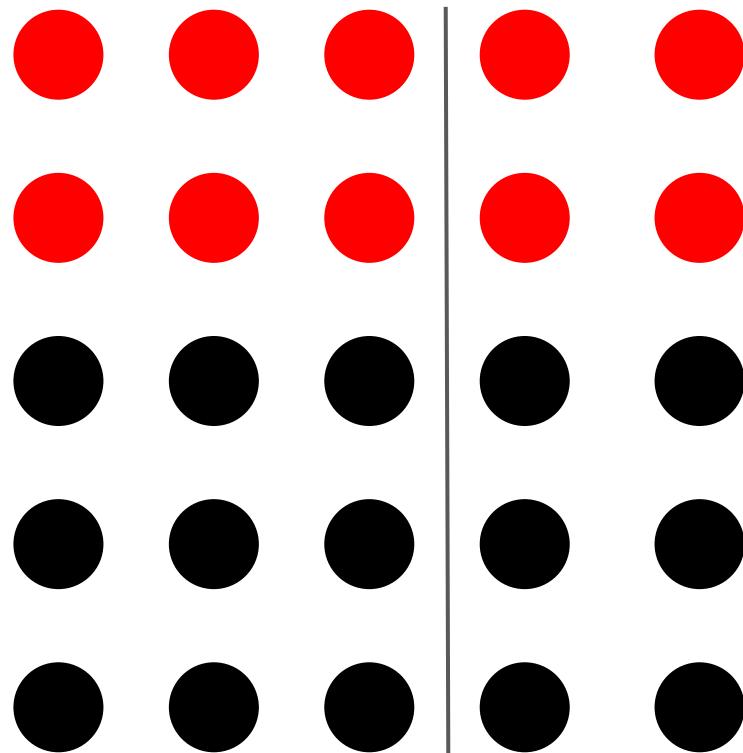
# Gestalt Laws



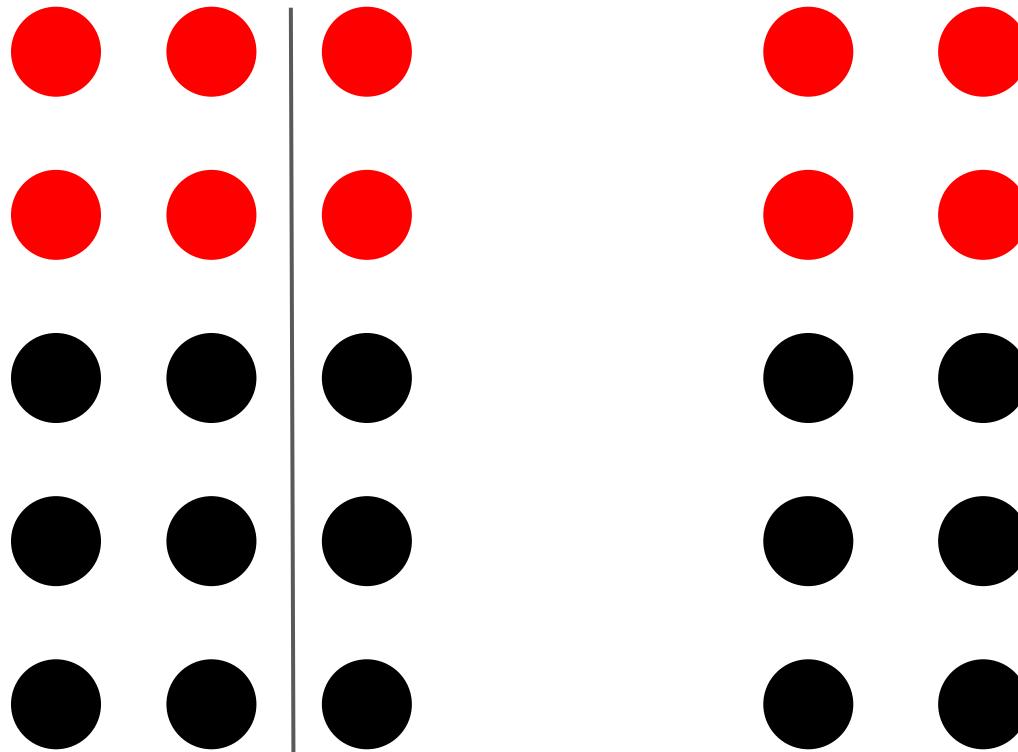
# Law of Similarity



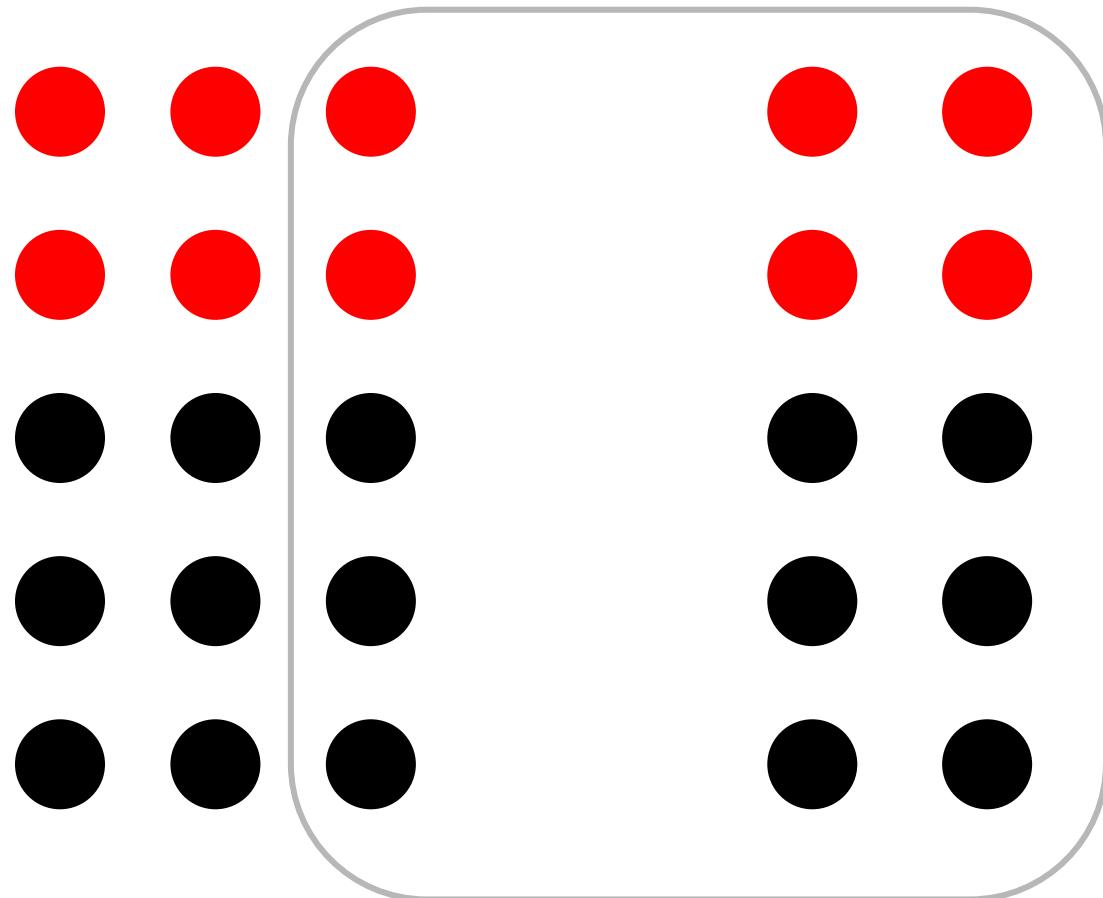
# Law of Closure



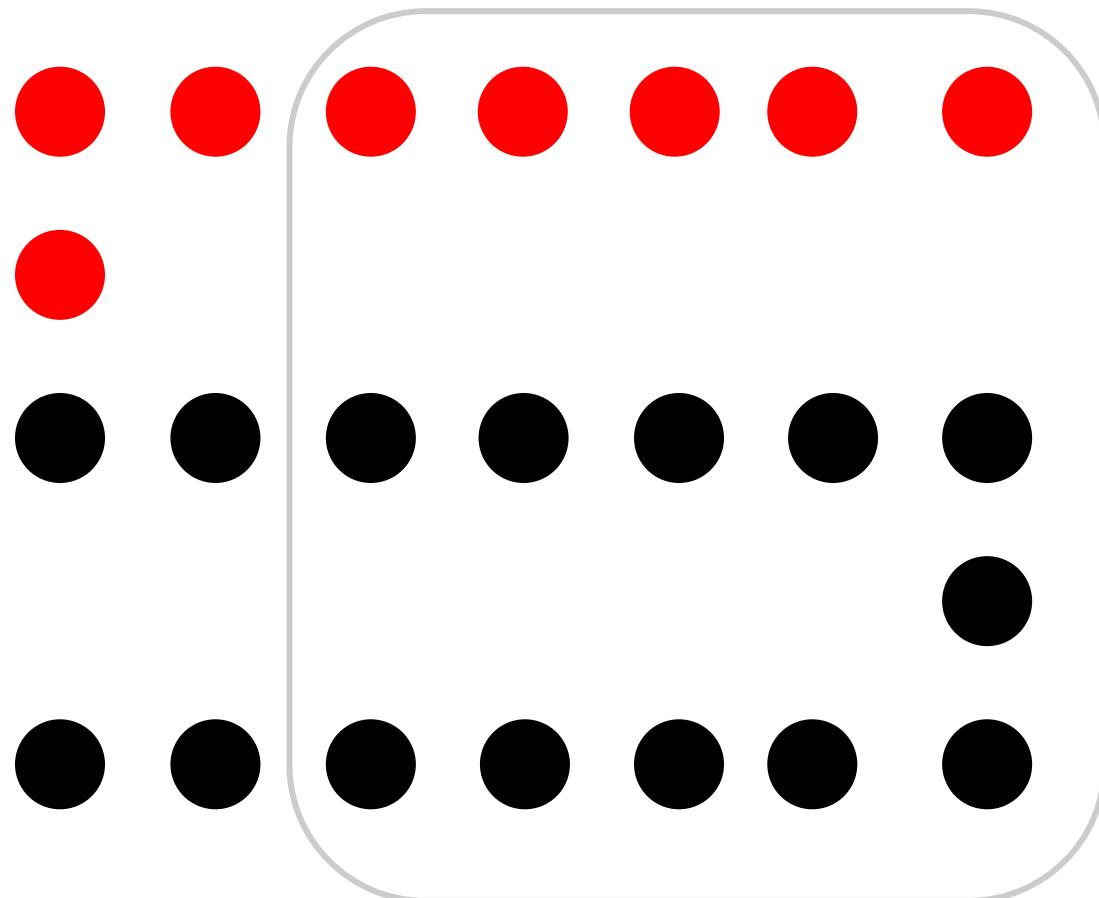
# Law of Proximity



# Law of Enclosure

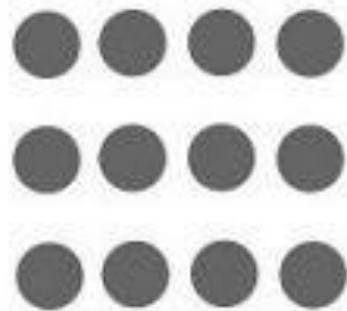


# Law of Continuity

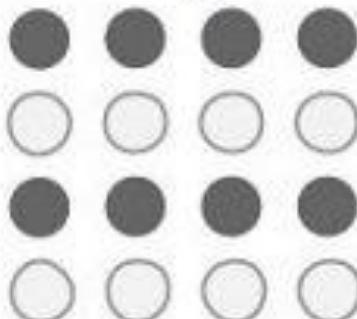


# Gestalt Laws

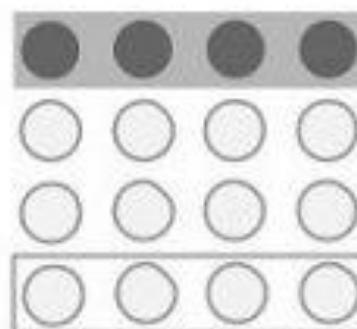
Proximity



Similarity



Enclosure



Symmetry



Closure



Continuity

Connection

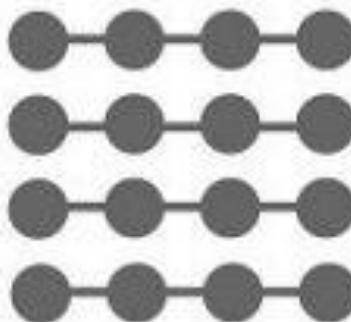


Figure & ground



# Gestalt Laws

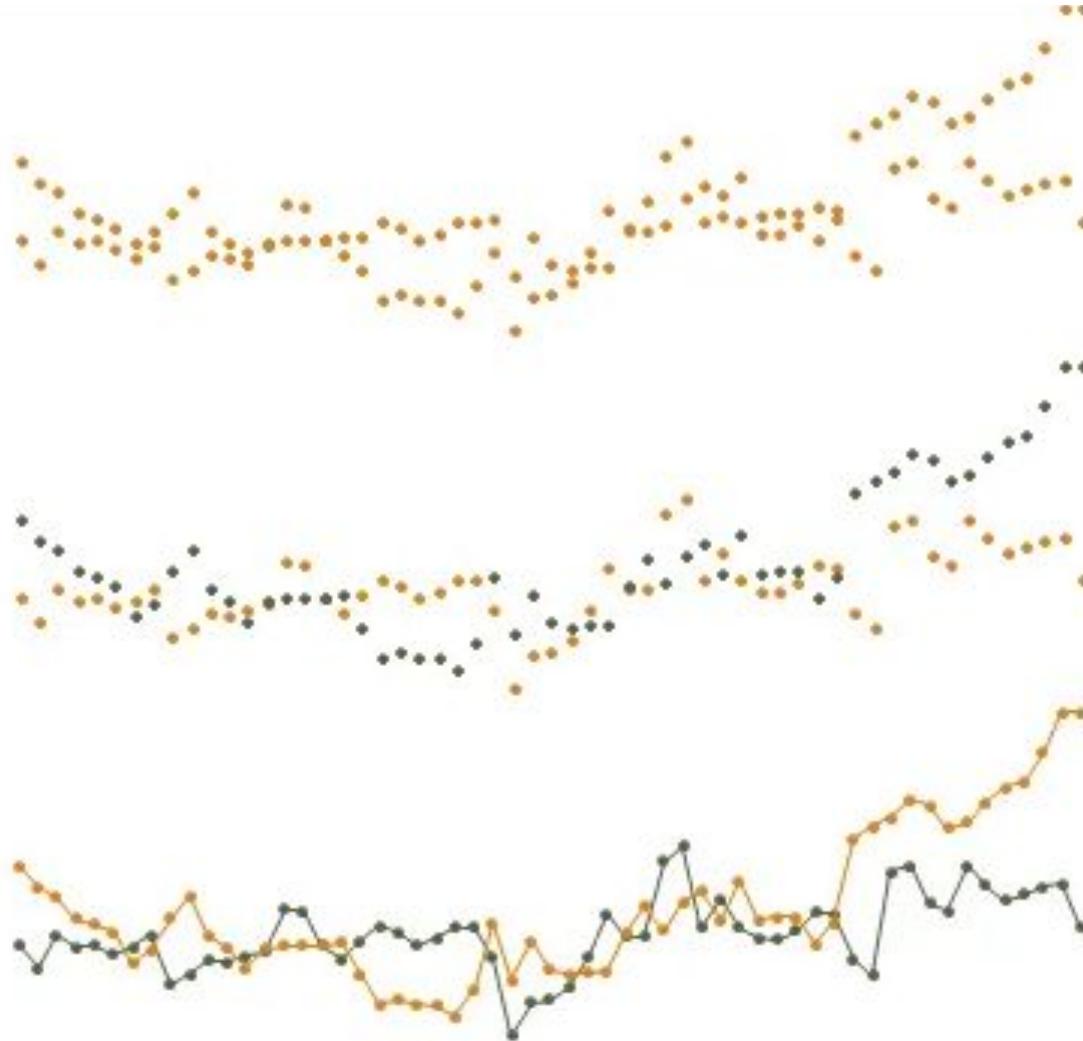


# Gestalt Laws



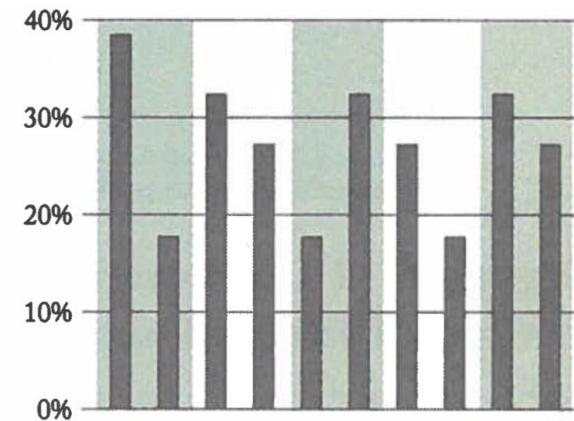
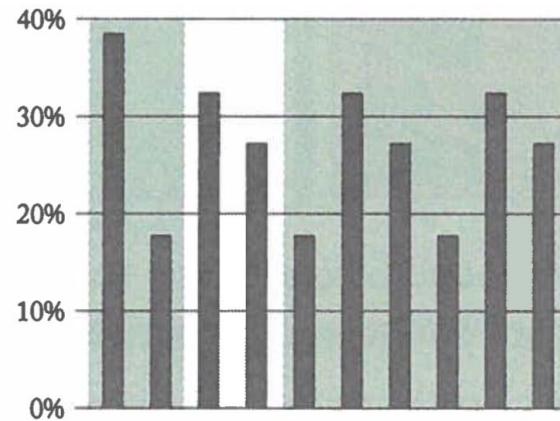
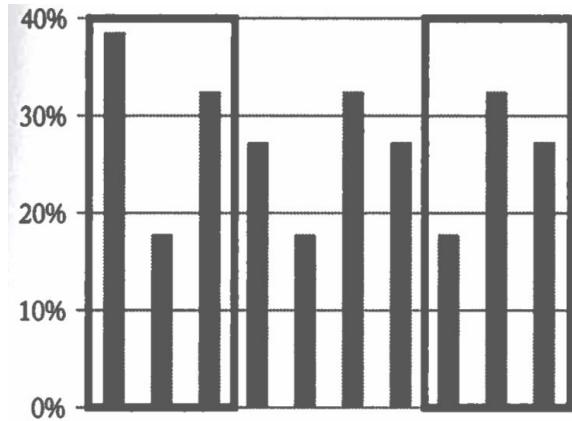
Law of  
Similarity

# Gestalt Laws



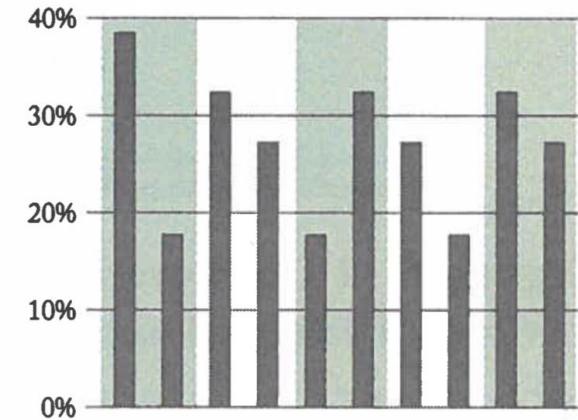
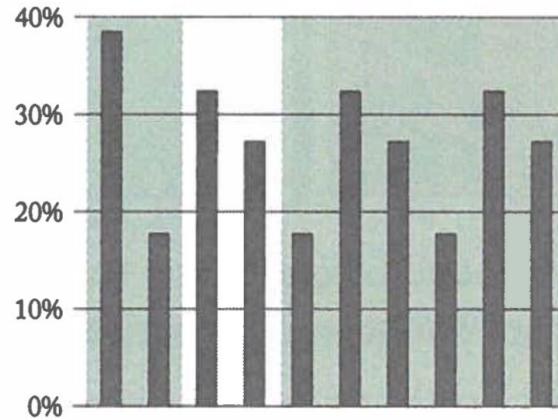
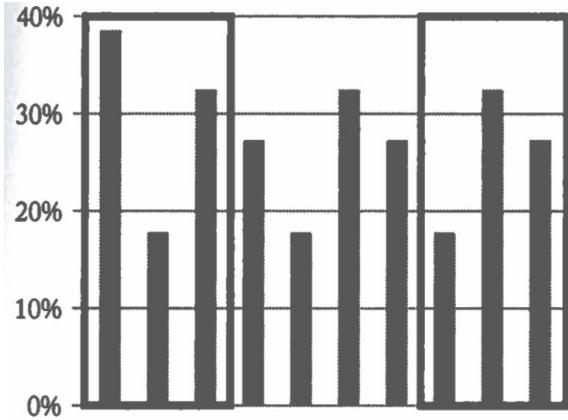
Law of  
Connection

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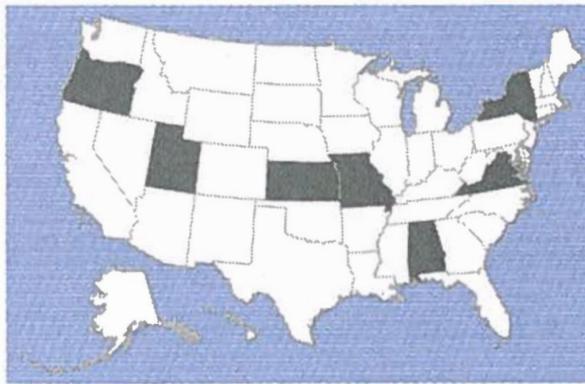
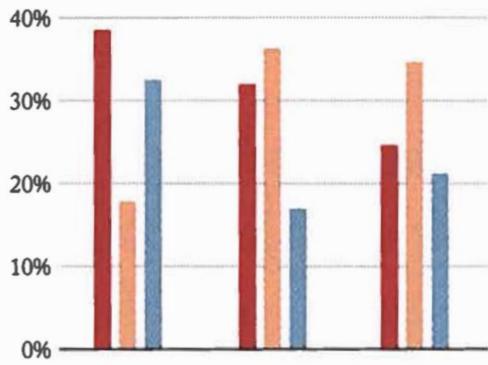


**Figure 6.10** Boxing bars helps readers identify groups.

# Gestalt Laws

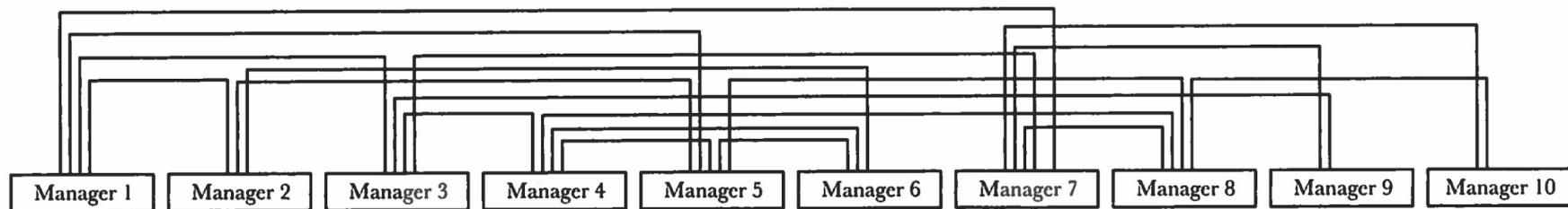
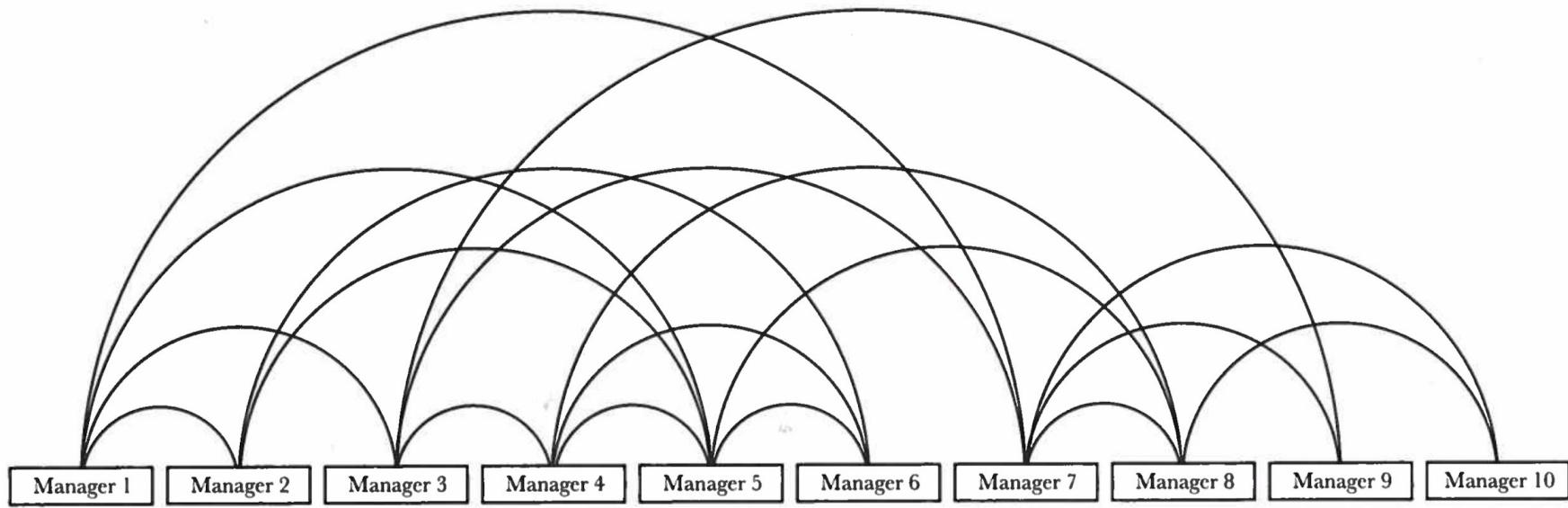


**Figure 6.10** Boxing bars helps readers identify groups.



**Figure 6.7** Objects that look alike will be identified as parts of a group.

# Continuity for line following

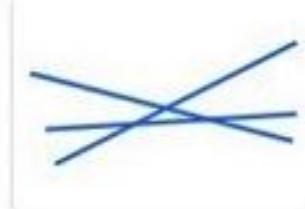


# Visual Patterns

High, low and in between



Going up, going down and remaining flat

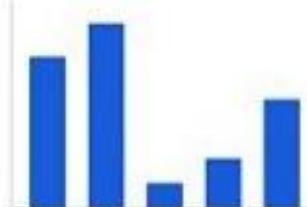


Steep and gradual

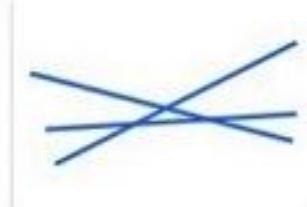


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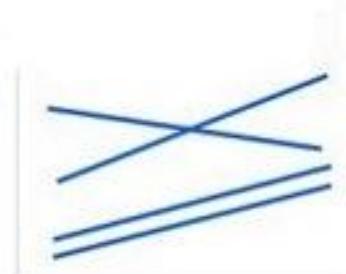
Going up, going down and remaining flat



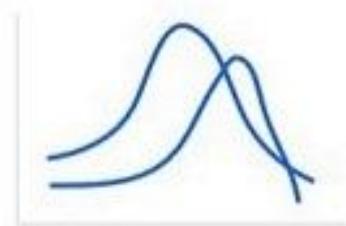
Steep and gradual



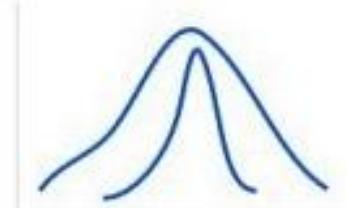
Non-intersecting and intersecting



Symmetrical and skewed

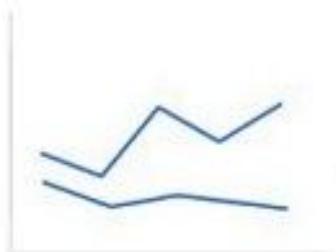


Wide and narrow

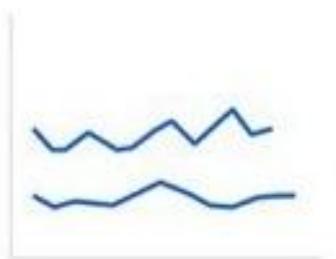


# Visual Patterns

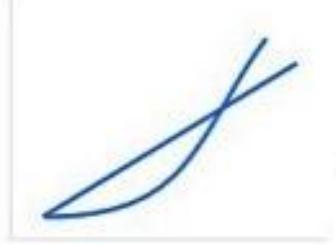
Steady and fluctuating



Random and repeating



Straight and curved

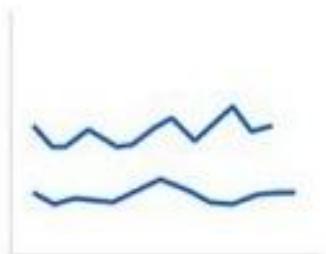


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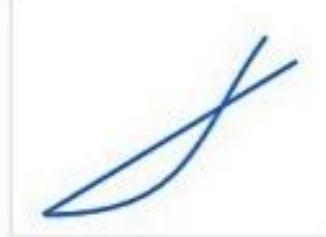
Steady and fluctuating



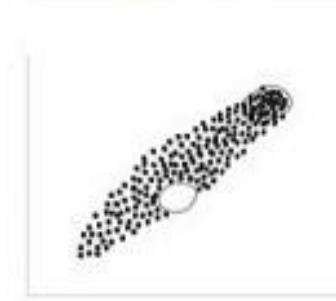
Random and repeating



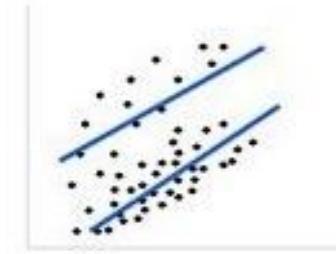
Straight and curved



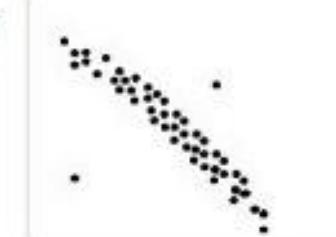
Clusters and gaps

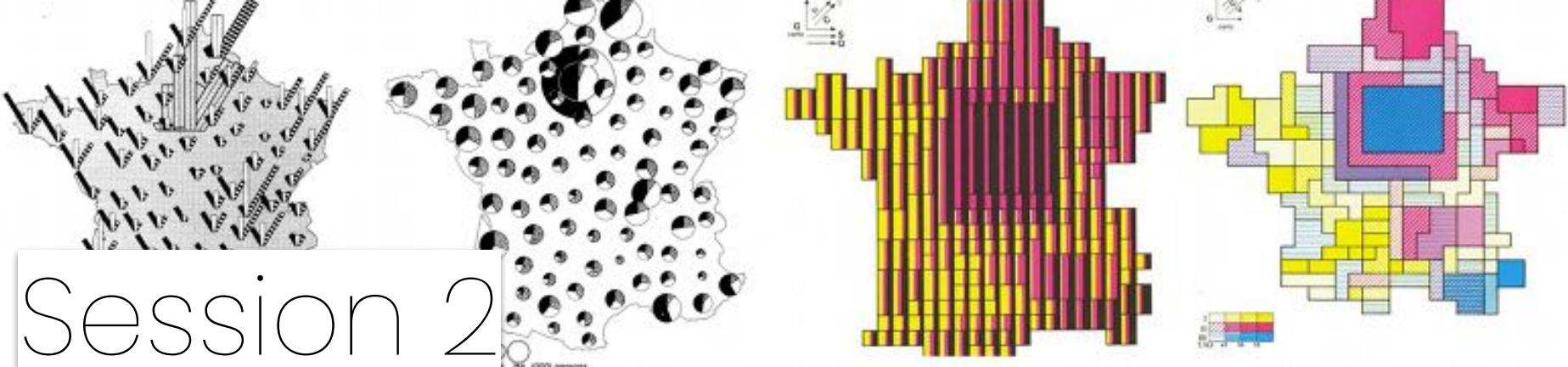


Tightly and loosely distributed



Normal and abnormal

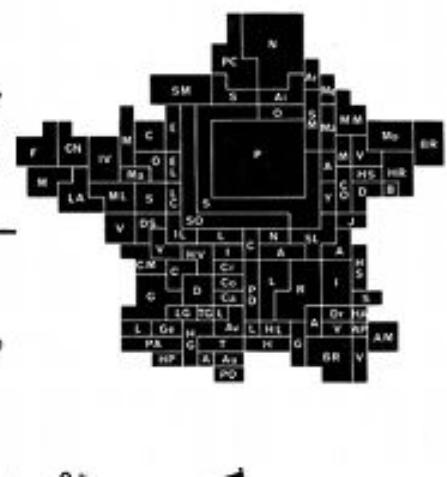
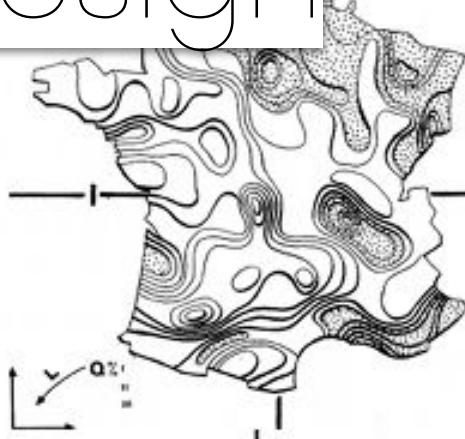
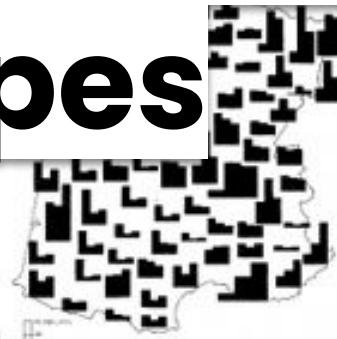




## Session 2

# Visualization Design

## Data types



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What does 'up' mean?

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4

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**What does it show?**

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View

# Data Types

Categorical  
(Qualitative)



Ordered

Numerical  
(Quantitative)



# Data Types

Categorical  
(Qualitative)



Ordered



Numerical  
(Quantitative)



# Data Types

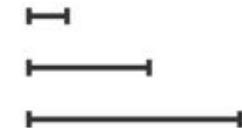
Categorical  
(Qualitative)



Ordered



Numerical  
(Quantitative)



A	B	C	S	T	U
Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
3	10/14/06	5-Low	Large Box	0.8	10/21/06
6	2/21/08	4-Not Specified	Small Pack	0.55	2/22/08
32	7/16/07	2-High	Small Pack	0.79	7/17/07
32	7/16/07	2-High	Jumbo Box		7/17/07
32	7/16/07	2-High	Medium Box		7/18/07
32	7/16/07	2-High	Medium Box	0.65	7/18/07
35	10/23/07	4-Not Specified	Wrap Bag	0.52	10/24/07
35	10/23/07	4-Not Specified	Small Box	0.58	10/25/07
36	11/3/07	1-Urgent	Small Box	0.55	11/3/07
65	3/18/07	1-Urgent	Small Pack	0.49	3/19/07
66	1/20/05	5-Low	Wrap Bag	0.56	1/20/05
69	item	5 4-Not Specified	Small Pack	0.44	6/6/05
69		5 4-Not Specified	Wrap Bag	0.6	6/6/05
70	12/18/06	5-Low	Small Box	0.59	12/23/06
70	12/18/06	5-Low	Wrap Bag	0.82	12/23/06
96	4/17/05	2-High	Small Box	0.55	4/19/05
97	1/29/06	3-Medium	Small Box	0.38	1/30/06
129	11/19/08	5-Low	Small Box	0.37	11/28/08
130	5/8/08	2-High	Small Box	0.37	5/9/08
130	5/8/08	2-High	Medium Box	0.38	5/10/08
130	5/8/08	2-High	Small Box	0.6	5/11/08
132	6/11/06	3-Medium	Medium Box	0.6	6/12/06

attribute

item

cell

Cat.

A	B	C	S	T	U
Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
3	10/14/06	5-Low	Large Box	0.8	10/21/06
6	2/21/08	4-Not Specified	Small Pack	0.55	2/22/08
32	7/16/07	2-High	Small Pack	0.79	7/17/07
32	7/16/07	2-High	Jumbo Box		7/17/07
32	7/16/07	2-High	Medium Box		7/18/07
32	7/16/07	2-High	Medium Box	0.65	7/18/07
35	10/23/07	4-Not Specified	Wrap Bag	0.52	10/24/07
35	10/23/07	4-Not Specified	Small Box	0.58	10/25/07
36	11/3/07	1-Urgent	Small Box	0.55	11/3/07
65	3/18/07	1-Urgent	Small Pack	0.49	3/19/07
66	1/20/05	5-Low	Wrap Bag	0.56	1/20/05
69	item	5 4-Not Specified	Small Pack	0.44	6/6/05
69		5 4-Not Specified	Wrap Bag	0.6	6/6/05
70	12/18/06	5-Low	Small Box	0.59	12/23/06
70	12/18/06	5-Low	Wrap Bag	0.82	12/23/06
96	4/17/05	2-High	Small Box	0.55	4/19/05
97	1/29/06	3-Medium	Small Box	0.38	1/30/06
129	11/19/08	5-Low	Small Box	0.37	11/28/08
130	5/8/08	2-High	Small Box	0.37	5/9/08
130	5/8/08	2-High	Medium Box	0.38	5/10/08
130	5/8/08	2-High	Small Box	0.6	5/11/08
132	6/11/06	3-Medium	Medium Box	0.6	6/12/06

attribute

item

cell

Cat. Num.

A	B	C	S	T	U
Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
3	10/14/06	5-Low	Large Box	0.8	10/21/06
6	2/21/08	4-Not Specified	Small Pack	0.55	2/22/08
32	7/16/07	2-High	Small Pack	0.79	7/17/07
32	7/16/07	2-High	Jumbo Box		7/17/07
32	7/16/07	2-High	Medium Box		7/18/07
32	7/16/07	2-High	Medium Box	0.65	7/18/07
35	10/23/07	4-Not Specified	Wrap Bag	0.52	10/24/07
35	10/23/07	4-Not Specified	Small Box	0.58	10/25/07
36	11/3/07	1-Urgent	Small Box	0.55	11/3/07
65	3/18/07	1-Urgent	Small Pack	0.49	3/19/07
66	1/20/05	5-Low	Wrap Bag	0.56	1/20/05
69	item	5 4-Not Specified	Small Pack	0.44	6/6/05
69		5 4-Not Specified	Wrap Bag	0.6	6/6/05
70	12/18/06	5-Low	Small Box	0.59	12/23/06
70	12/18/06	5-Low	Wrap Bag	0.82	12/23/06
96	4/17/05	2-High	Small Box	0.55	4/19/05
97	1/29/06	3-Medium	Small Box	0.38	1/30/06
129	11/19/08	5-Low	Small Box	0.37	11/28/08
130	5/8/08	2-High	Small Box	0.37	5/9/08
130	5/8/08	2-High	Medium Box	0.38	5/10/08
130	5/8/08	2-High	Small Box	0.6	5/11/08
132	6/11/06	3-Medium	Medium Box	0.6	6/12/06

attribute

item

cell

Cat.      Num.      Ord. /  
                          Cat.

A	B	C	S	T	U
Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
3	10/14/06	5-Low	Large Box	0.8	10/21/06
6	2/21/08	4-Not Specified	Small Pack	0.55	2/22/08
32	7/16/07	2-High	Small Pack	0.79	7/17/07
32	7/16/07	2-High	Jumbo Box		7/17/07
32	7/16/07	2-High	Medium Box		7/18/07
32	7/16/07	2-High	Medium Box	0.65	7/18/07
35	10/23/07	4-Not Specified	Wrap Bag	0.52	10/24/07
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66	1/20/05	5-Low	Wrap Bag	0.56	1/20/05
69	item	5 4-Not Specified	Small Pack	0.44	6/6/05
69		5 4-Not Specified	Wrap Bag	0.6	6/6/05
70	12/18/06	5-Low	Small Box	0.59	12/23/06
70	12/18/06	5-Low	Wrap Bag	0.82	12/23/06
96	4/17/05	2-High	Small Box	0.55	4/19/05
97	1/29/06	3-Medium	Small Box	0.38	1/30/06
129	11/19/08	5-Low	Small Box	0.37	11/28/08
130	5/8/08	2-High	Small Box	0.37	5/9/08
130	5/8/08	2-High	Medium Box	0.38	5/10/08
130	5/8/08	2-High	Small Box	0.6	5/11/08
132	6/11/06	3-Medium	Medium Box	0.6	6/12/06

attribute

item

cell

Cat.      Num.      Ord. /  
                Cat.

Ord. /  
Cat.

A	B	C	S	T	U
Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
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35	10/23/07	4-Not Specified	Small Box	0.58	10/25/07
36	11/3/07	1-Urgent	Small Box	0.55	11/3/07
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69	item	5 4-Not Specified	Small Pack	0.44	6/6/05
69		5 4-Not Specified	Wrap Bag	0.6	6/6/05
70	12/18/06	5-Low	Small Box	0.59	12/23/06
70	12/18/06	5-Low	Wrap Bag	0.82	12/23/06
96	4/17/05	2-High	Small Box	0.55	4/19/05
97	1/29/06	3-Medium	Small Box	0.38	1/30/06
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130	5/8/08	2-High	Medium Box	0.38	5/10/08
130	5/8/08	2-High	Small Box	0.6	5/11/08
132	6/11/06	3-Medium	Medium Box	0.6	6/12/06

attribute

item

cell

Cat.	Num.	Ord. / Cat.	Ord. / Cat.	Num.
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A	B	C	S	T	U
Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
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6	2/21/08	4-Not Specified	Small Pack	0.55	2/22/08
32	7/16/07	2-High	Small Pack	0.79	7/17/07
32	7/16/07	2-High	Jumbo Box		7/17/07
32	7/16/07	2-High	Medium Box		7/18/07
32	7/16/07	2-High	Medium Box	0.65	7/18/07
35	10/23/07	4-Not Specified	Wrap Bag	0.52	10/24/07
35	10/23/07	4-Not Specified	Small Box	0.58	10/25/07
36	11/3/07	1-Urgent	Small Box	0.55	11/3/07
65	3/18/07	1-Urgent	Small Pack	0.49	3/19/07
66	1/20/05	5-Low	Wrap Bag	0.56	1/20/05
69	<b>item</b>		Small Pack	0.44	6/6/05
69	5 4-Not Specified		Wrap Bag	0.6	6/6/05
70	12/18/06	5-Low	Small Box	0.59	12/23/06
70	12/18/06	5-Low	Wrap Bag	0.82	12/23/06
96	4/17/05	2-High	Small Box	0.55	4/19/05
97	1/29/06	3-Medium	Small Box	0.38	1/30/06
129	11/19/08	5-Low	Small Box	0.37	11/28/08
130	5/8/08	2-High	Small Box	0.37	5/9/08
130	5/8/08	2-High	Medium Box	0.38	5/10/08
130	5/8/08	2-High	Small Box	0.6	5/11/08
132	6/11/06	3-Medium	Medium Box	0.6	6/12/06

**attribute**

**cell**

Cat.	Num.	Ord. / Cat.	Ord. / Cat.	Num.	Num.
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A	B	C	S	T	U
Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
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32	7/16/07	2-High	Small Pack	0.79	7/17/07
32	7/16/07	2-High	Jumbo Box		7/17/07
32	7/16/07	2-High	Medium Box		7/18/07
32	7/16/07	2-High	Medium Box	0.65	7/18/07
35	10/23/07	4-Not Specified	Wrap Bag	0.52	10/24/07
35	10/23/07	4-Not Specified	Small Box	0.58	10/25/07
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65	3/18/07	1-Urgent	Small Pack	0.49	3/19/07
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69		5 4-Not Specified	Wrap Bag	0.6	6/6/05
70	12/18/06	5-Low	Small Box	0.59	12/23/06
70	12/18/06	5-Low	Wrap Bag	0.82	12/23/06
96	4/17/05	2-High	Small Box	0.55	4/19/05
97	1/29/06	3-Medium	Small Box	0.38	1/30/06
129	11/19/08	5-Low	Small Box	0.37	11/28/08
130	5/8/08	2-High	Small Box	0.37	5/9/08
130	5/8/08	2-High	Medium Box	0.38	5/10/08
130	5/8/08	2-High	Small Box	0.6	5/11/08
132	6/11/06	3-Medium	Medium Box	0.6	6/12/06

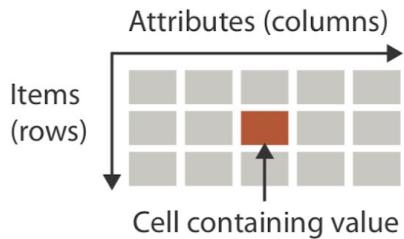
attribute

cell

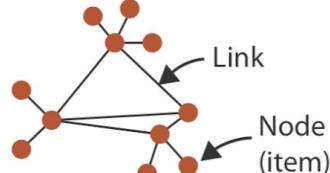
# More data types

## Dataset Types

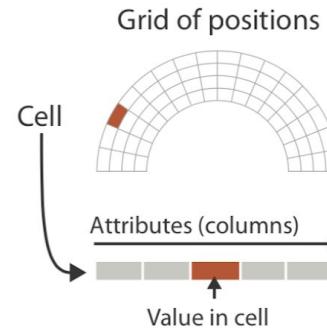
→ Tables



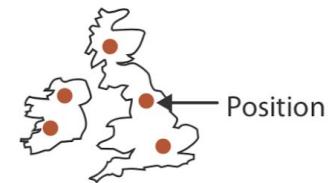
→ Networks



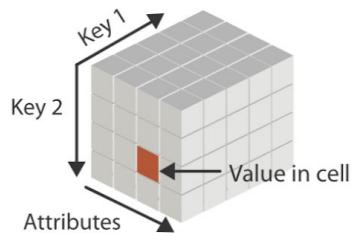
→ Fields (Continuous)



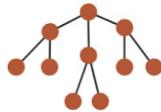
→ Geometry (Spatial)



→ Multidimensional Table



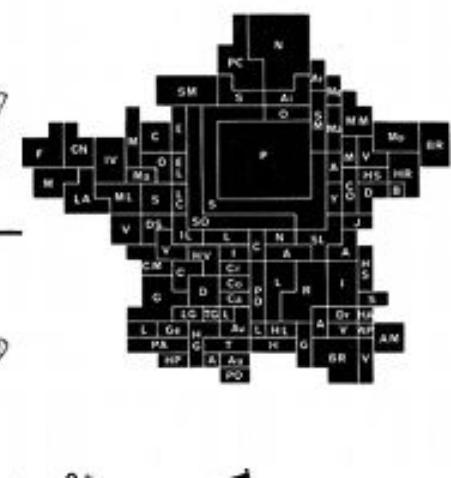
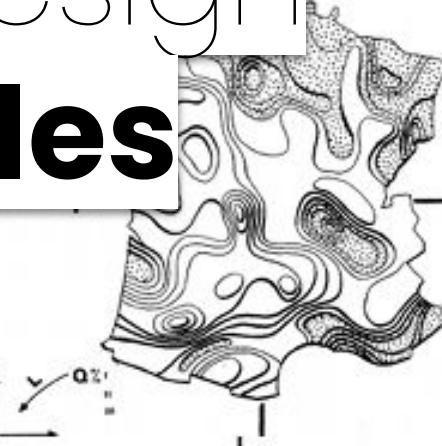
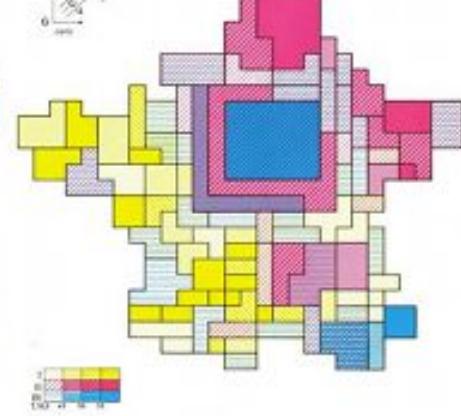
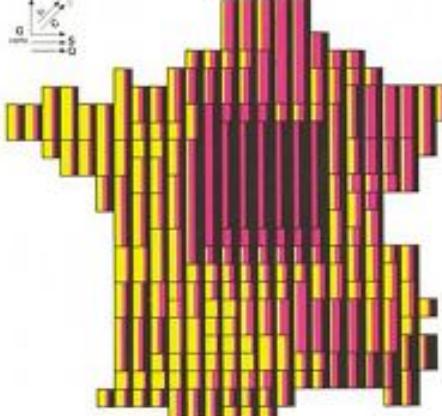
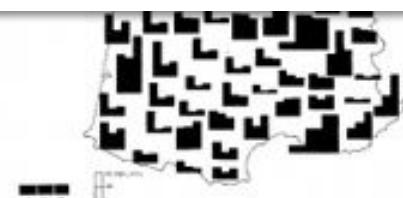
→ Trees



# Session 2

# Visualization Design

# Visual Variables



# Online Course

## **Data Visualization for Professionals**



THE UNIVERSITY  
of EDINBURGH

# Benjamin Bach

May 2022

<http://benjbach.me>

<https://datavis-online.github.io>

-- Not for external use --

# Encoding: designer

## 1 Data

**What is my data?**

Which data type?

Ordinal / numerical / categorical?

## 2 Visual Mapping

**What is my visual representation?**

Which visual variables am I using?

How am I encoding my data?

## 3 Rendering

**What is my medium?**

monoscopic/stereoscopic?

Tangibility?

Print / digital?

**View**

# Decoding: user

6

## Comprehending

**What does it mean for me?**

What shall I do now?

Is this all true?

What do I learn?

5

## Interpreting

**What does it mean?**

What does color mean?

What does 'up' mean?

What do these patterns show?

4

## Perceiving

**What does it show?**

Where is big, medium, small?

How do things compare?

What relationships exist?

# Visual Marks



Points



Lines

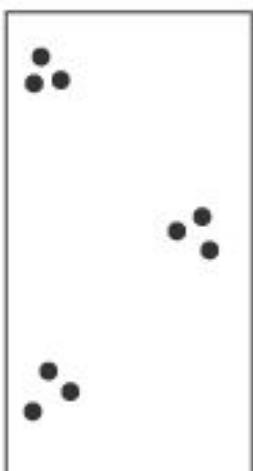


Areas

# Visual Variables

## Bertin's Visual Variables

POSITION

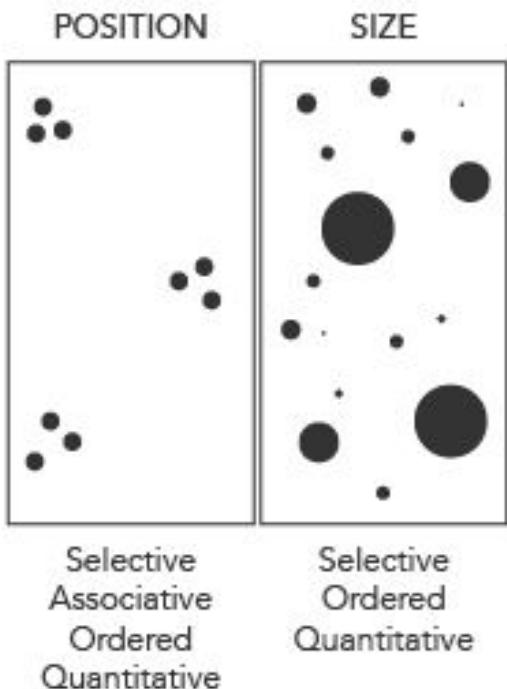


Selective  
Associative  
Ordered  
Quantitative

Bertin, Jacques. "Semiology of Graphics: Diagrams." *Networks, Maps* 10.00690805.1987 (1983): 10438353.

# Visual Variables

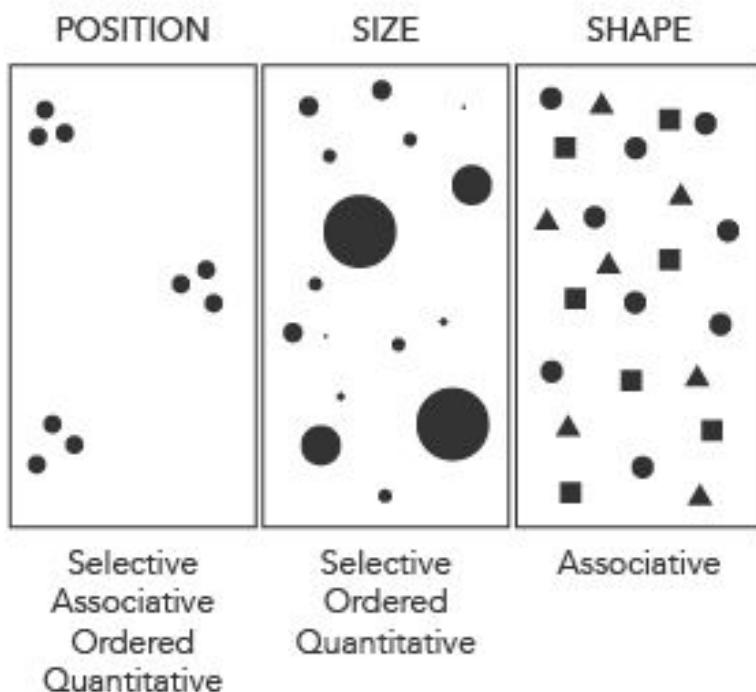
## Bertin's Visual Variables



Bertin, Jacques. "Semiology of Graphics: Diagrams." *Networks, Maps* 10.00690805.1987 (1983): 10438353.

# Visual Variables

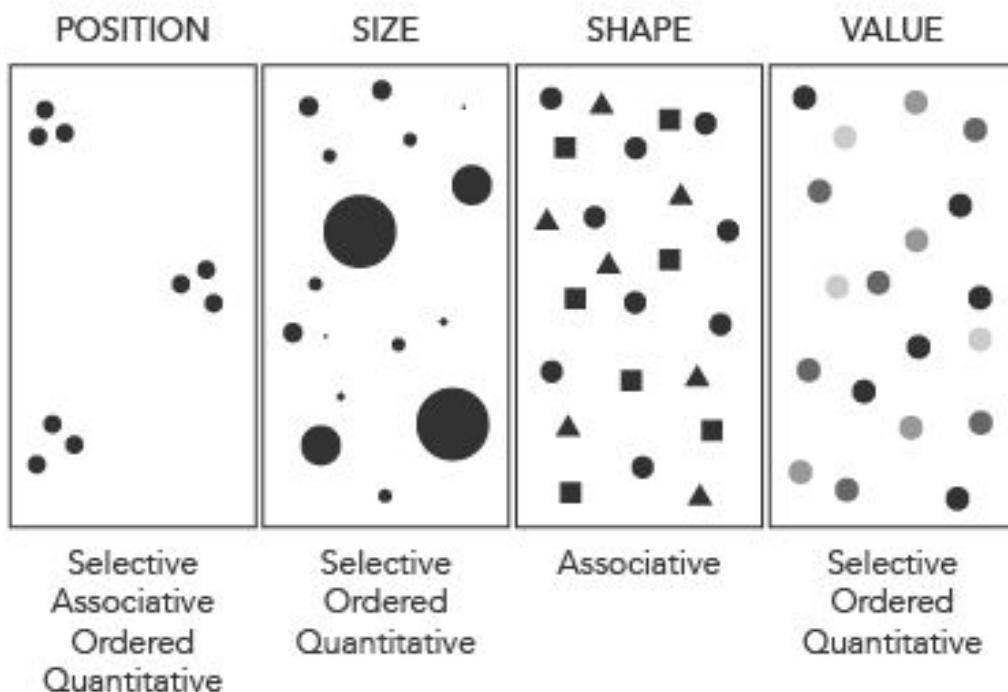
Bertin's Visual Variables



Bertin, Jacques. "Semiology of Graphics: Diagrams." *Networks, Maps* 10.00690805.1987 (1983): 10438353.

# Visual Variables

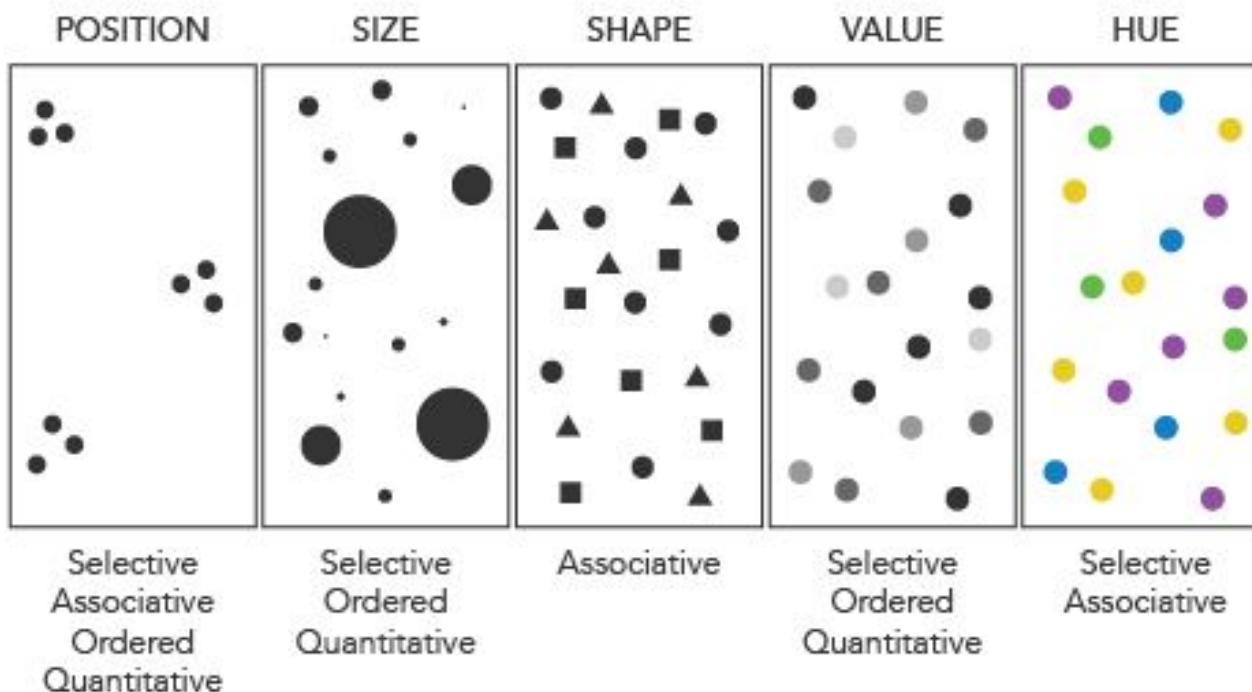
Bertin's Visual Variables



Bertin, Jacques. "Semiology of Graphics: Diagrams." *Networks, Maps* 10.00690805.1987 (1983): 10438353.

# Visual Variables

Bertin's Visual Variables



Bertin, Jacques. "Semiology of Graphics: Diagrams." *Networks, Maps* 10.00690805.1987 (1983): 10438353.

# Visual Variables

## Bertin's Visual Variables

The figure consists of six panels arranged in a row, each demonstrating a different Gestalt principle:

- POSITION:** Shows three clusters of small black dots.
- SIZE:** Shows two large black circles and several smaller black dots.
- SHAPE:** Shows a mix of solid black shapes (triangles, squares, circles) and outlines of these shapes.
- VALUE:** Shows a mix of gray shades (black, white, gray).
- HUE:** Shows a mix of colored dots (purple, green, yellow, blue).
- ORIENTATION:** Shows various line segments (solid and dashed) at different angles.

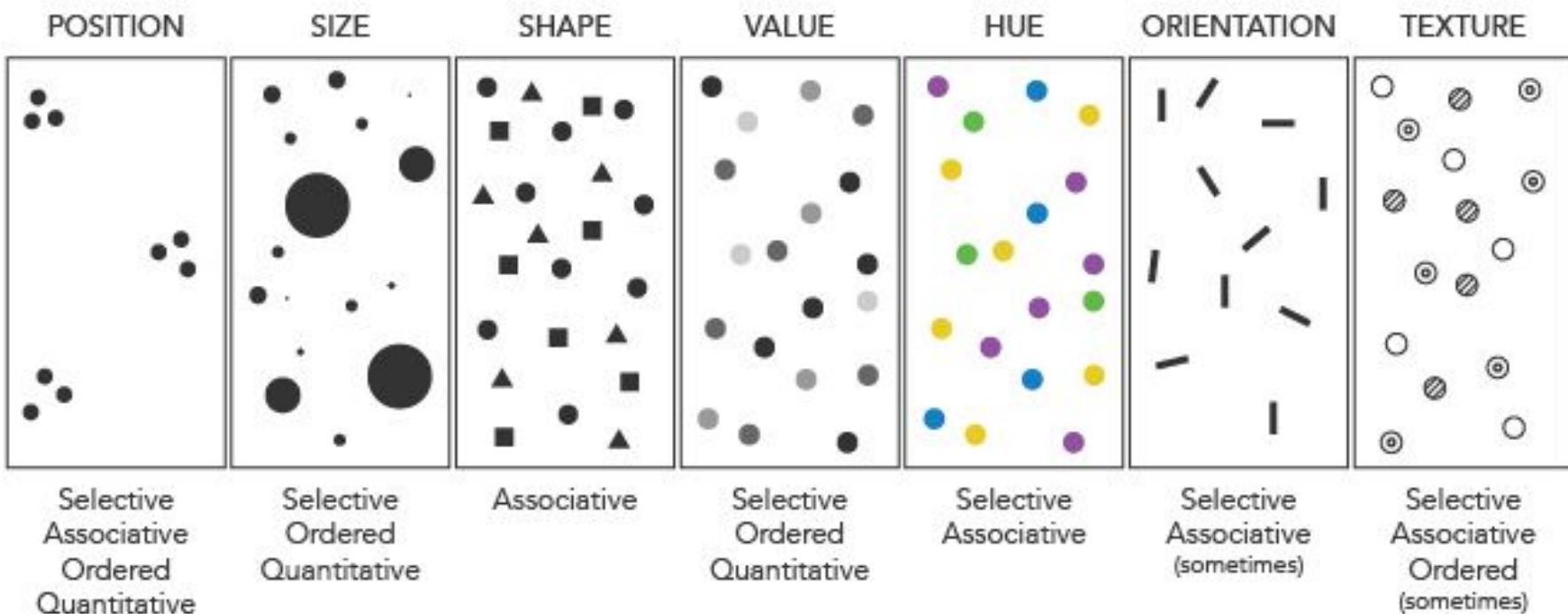
Below each panel is a label indicating the type of perceptual organization it illustrates:

Panel	Type of Perceptual Organization
Position	Selective Associative Ordered Quantitative
Size	Selective Ordered Quantitative
Shape	Associative
Value	Selective Ordered Quantitative
Hue	Selective Associative
Orientation	Selective Associative (sometimes)

Bertin, Jacques. "Semiology of Graphics: Diagrams." *Networks, Maps* 10.00690805.1987 (1983): 10438353.

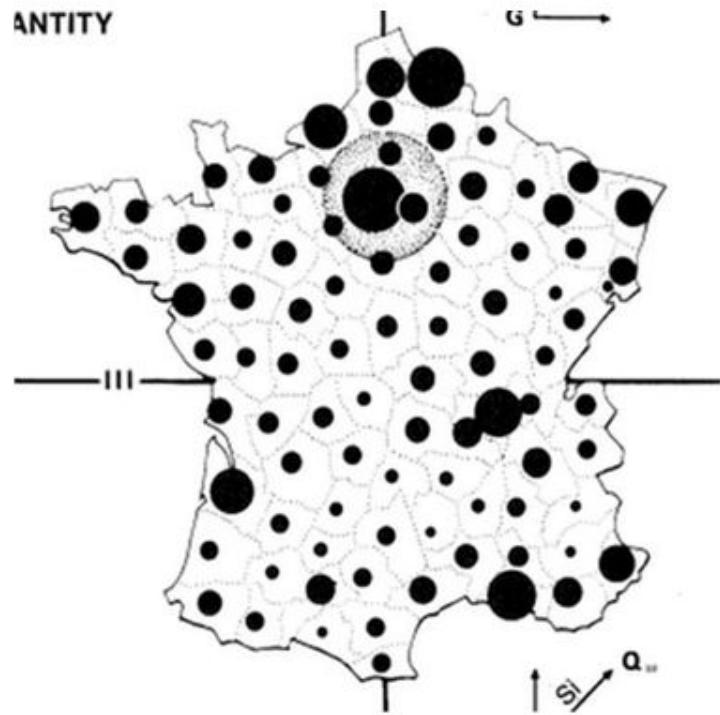
# Visual Variables

Bertin's Visual Variables



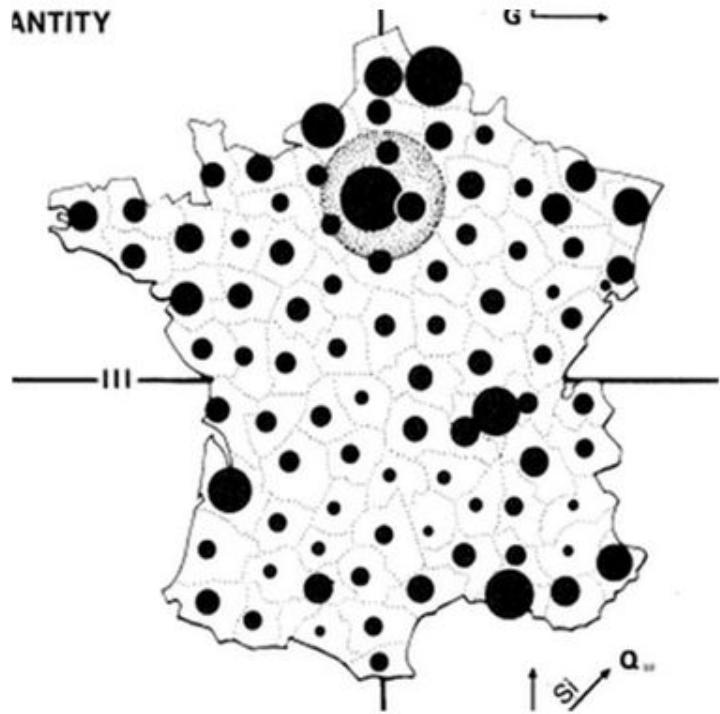
Bertin, Jacques. "Semiology of Graphics: Diagrams." *Networks, Maps* 10.00690805.1987 (1983): 10438353.

# Visual Variables

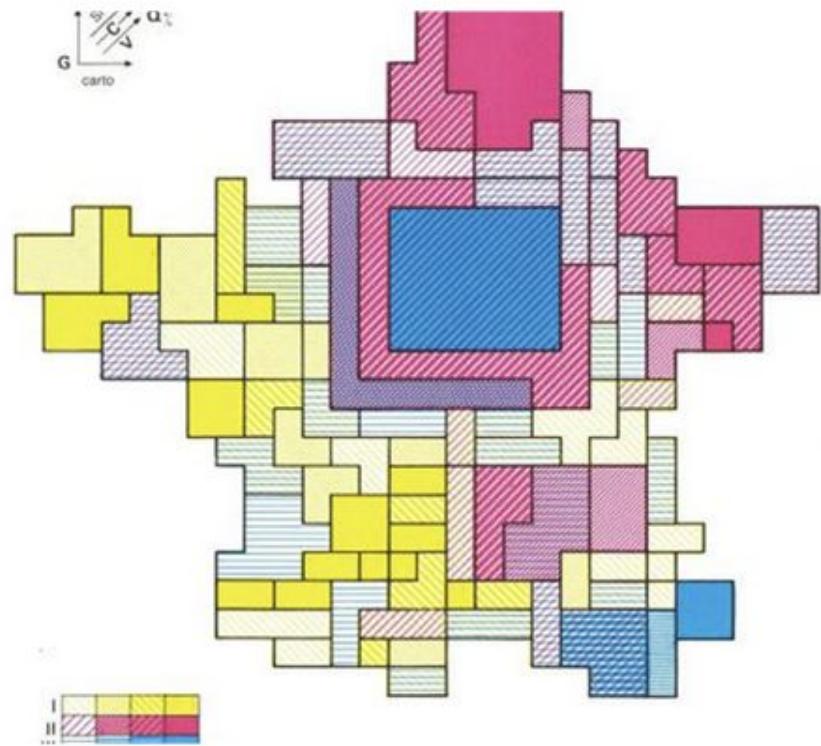


- Points
- Size

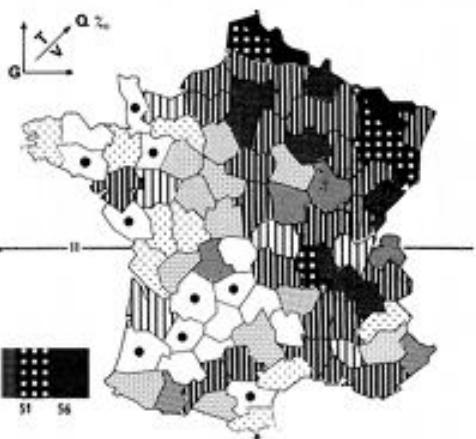
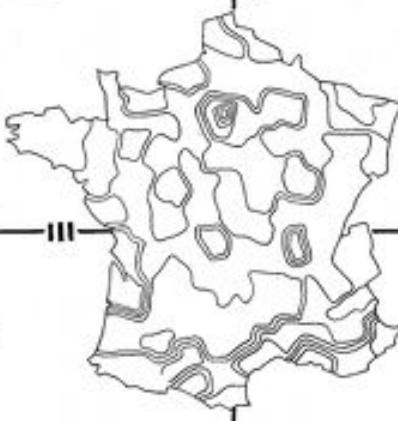
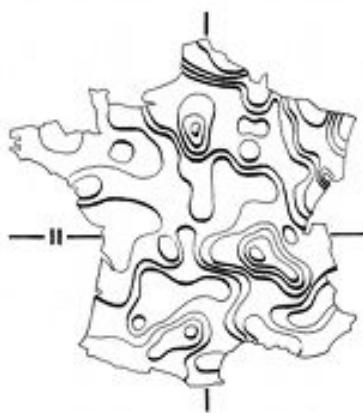
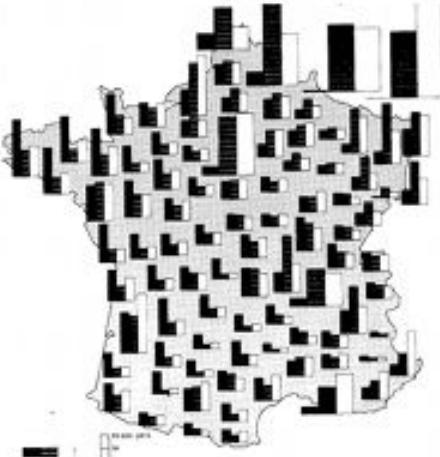
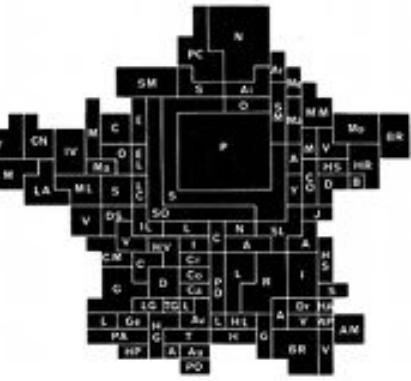
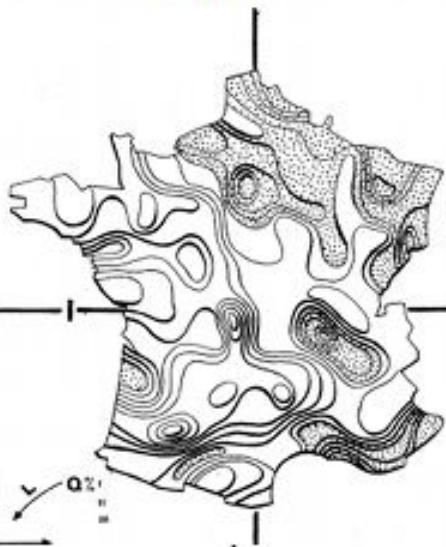
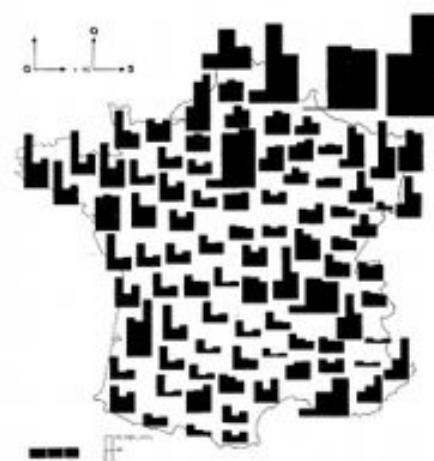
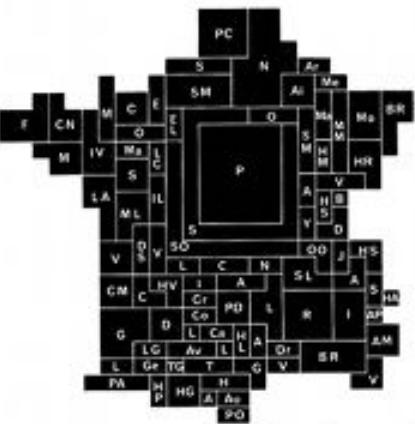
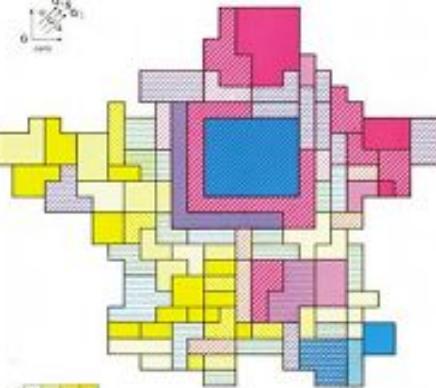
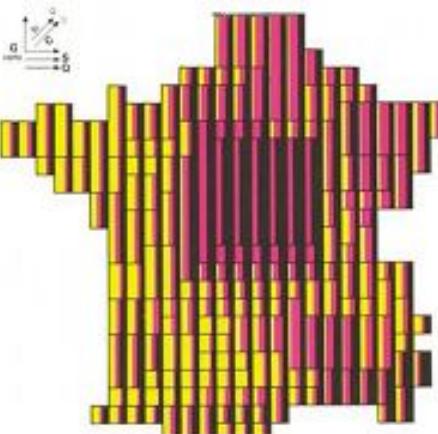
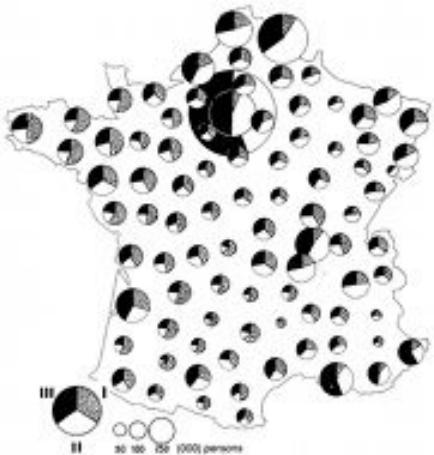
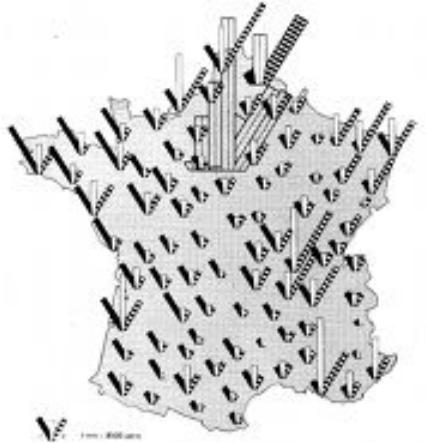
# Visual Variables



- Points
- Size



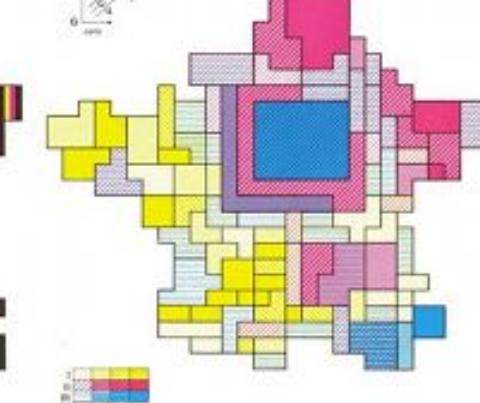
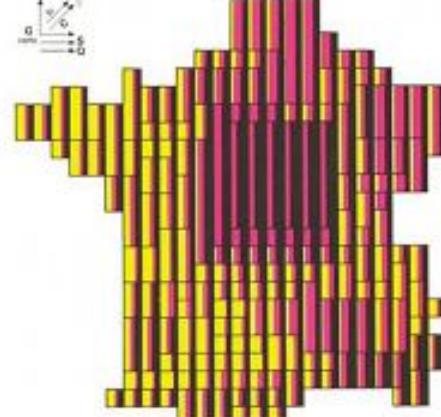
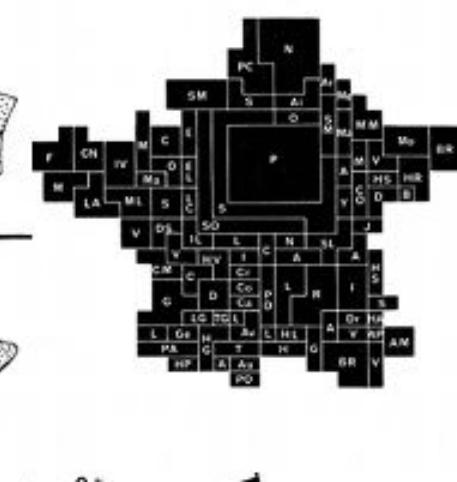
- Areas
- Size
- Hue
- Texture



# Session 2

# Visualization Design

# Characteristics of Visual Variables



# Online Course

# **Data Visualization for Professionals**



THE UNIVERSITY  
of EDINBURGH

# Benjamin Bach

May 2022

<http://benjbach.me>

<https://datavis-online.github.io>

-- Not for external use --

# Characteristics of Visual Variables

**Selective:** Does it make a mark distinguishable?

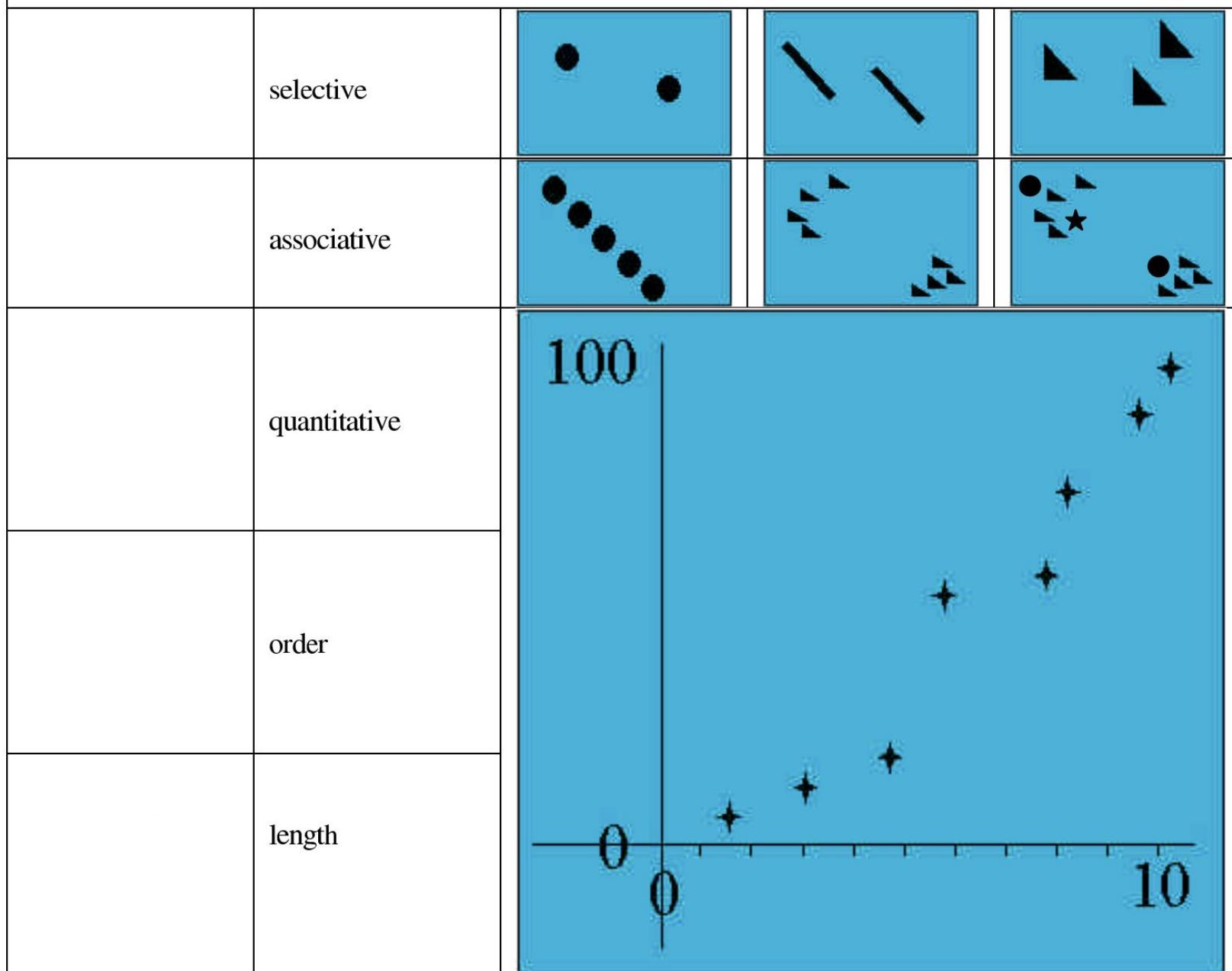
**Associative:** Can I group marks?

**Quantitative:** Can I do maths with it?

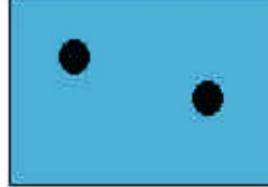
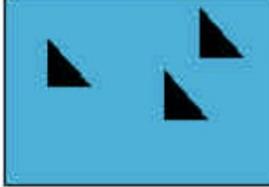
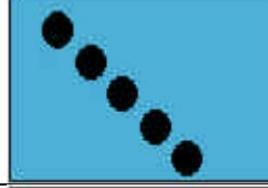
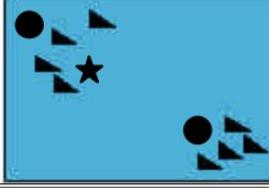
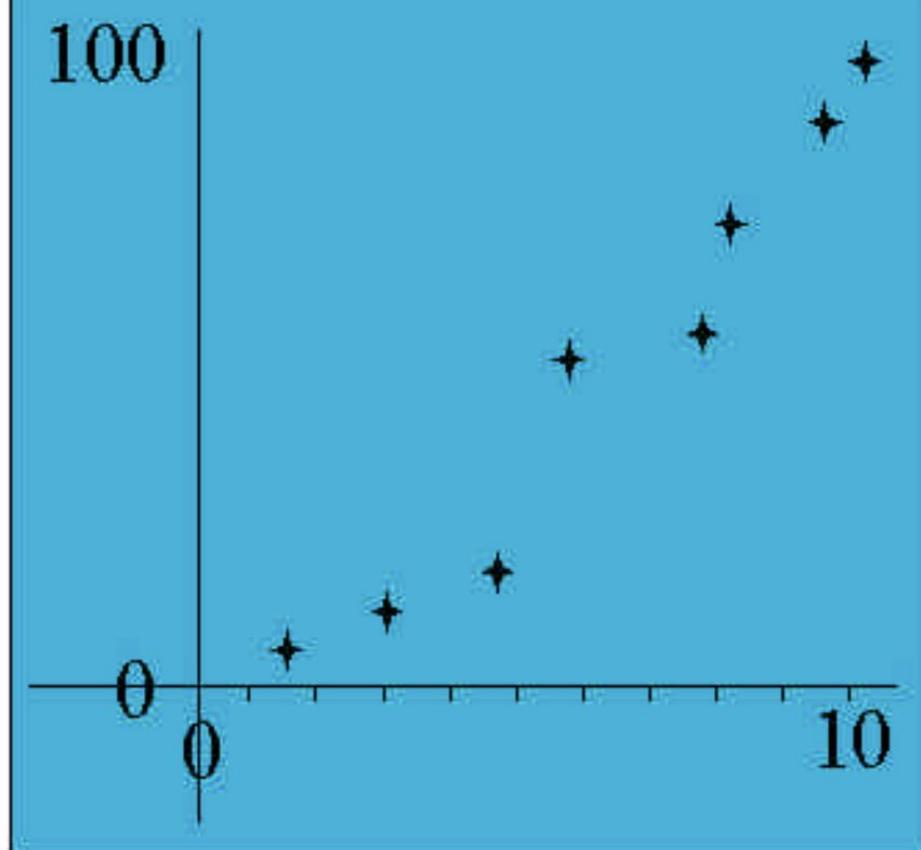
**Order:** Does it imply an order on the marks?

**Length:** How many values does the variable has?

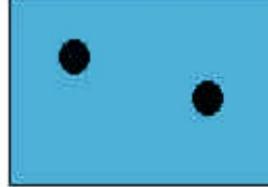
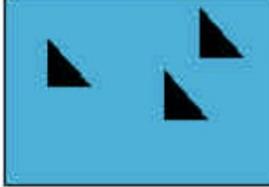
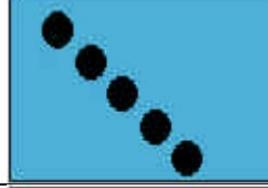
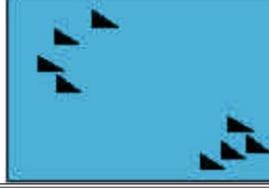
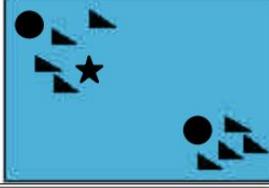
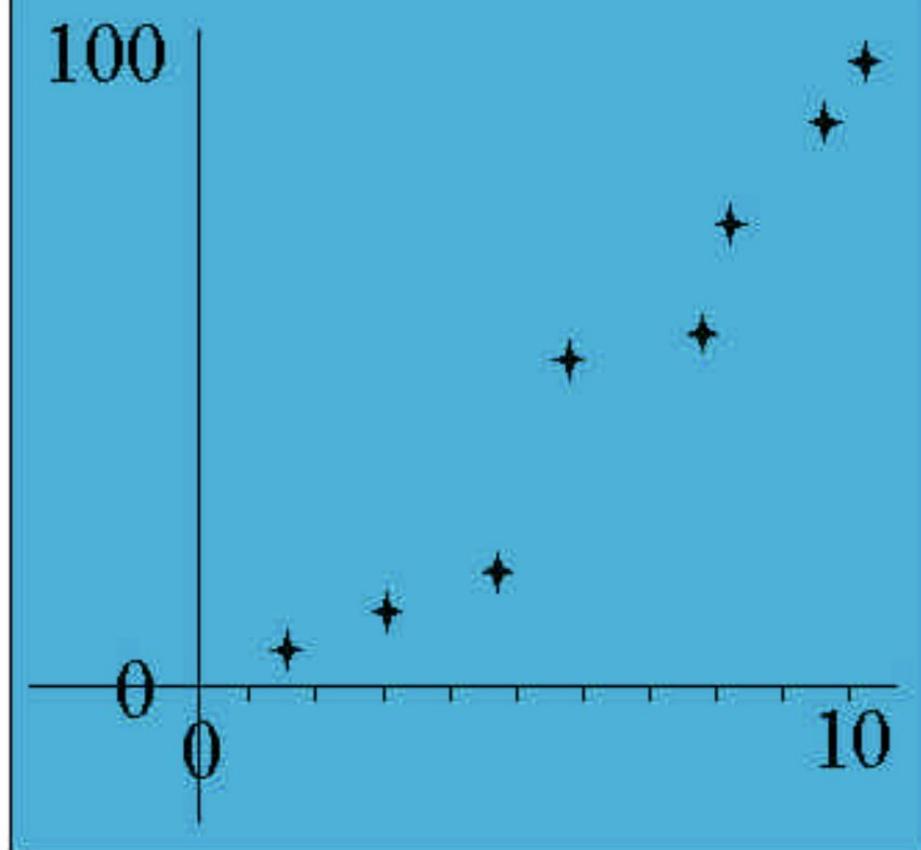
## Visual Variable: Position



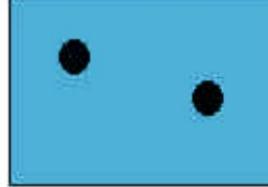
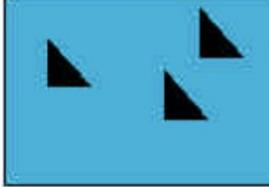
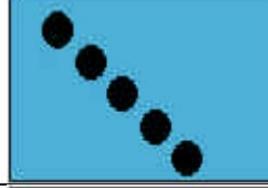
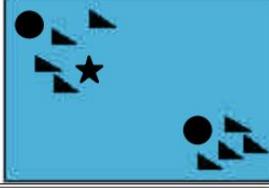
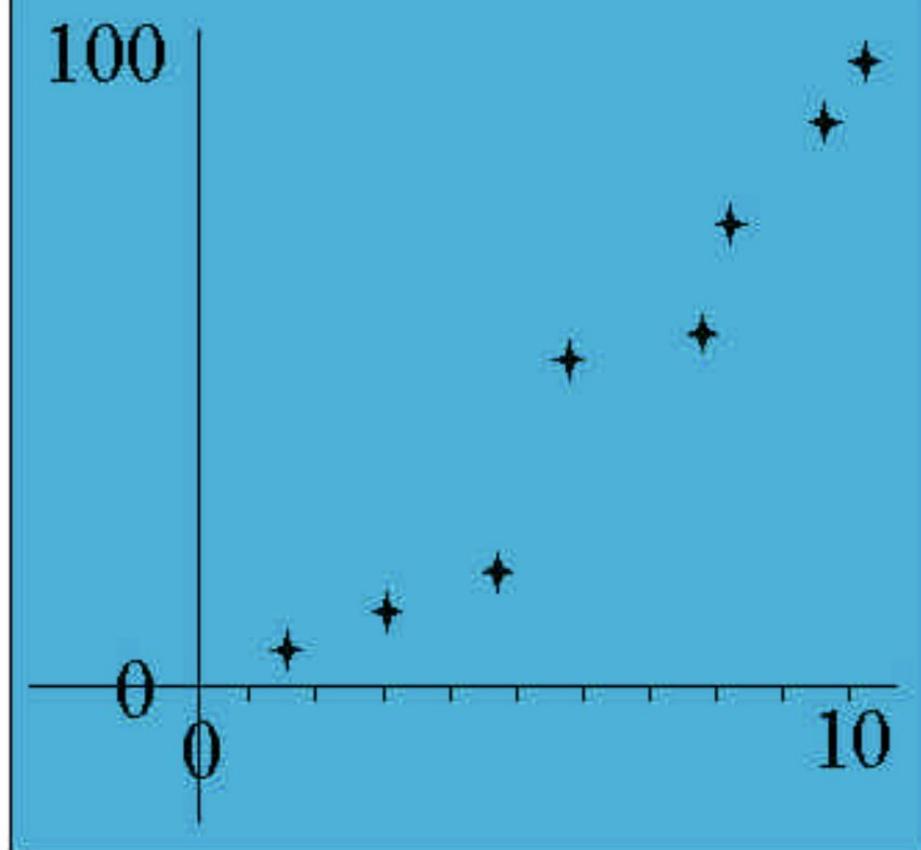
## Visual Variable: Position

✓	selective			
	associative			
	quantitative			
	order			
	length			

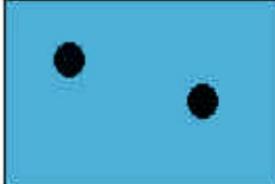
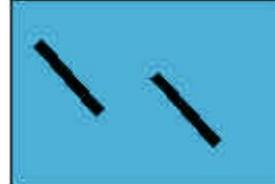
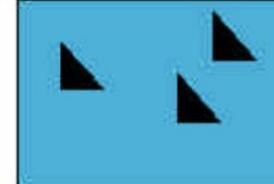
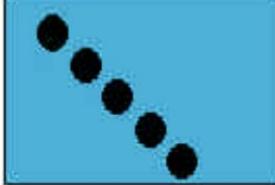
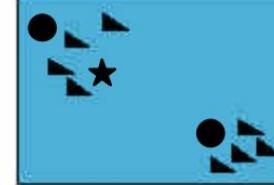
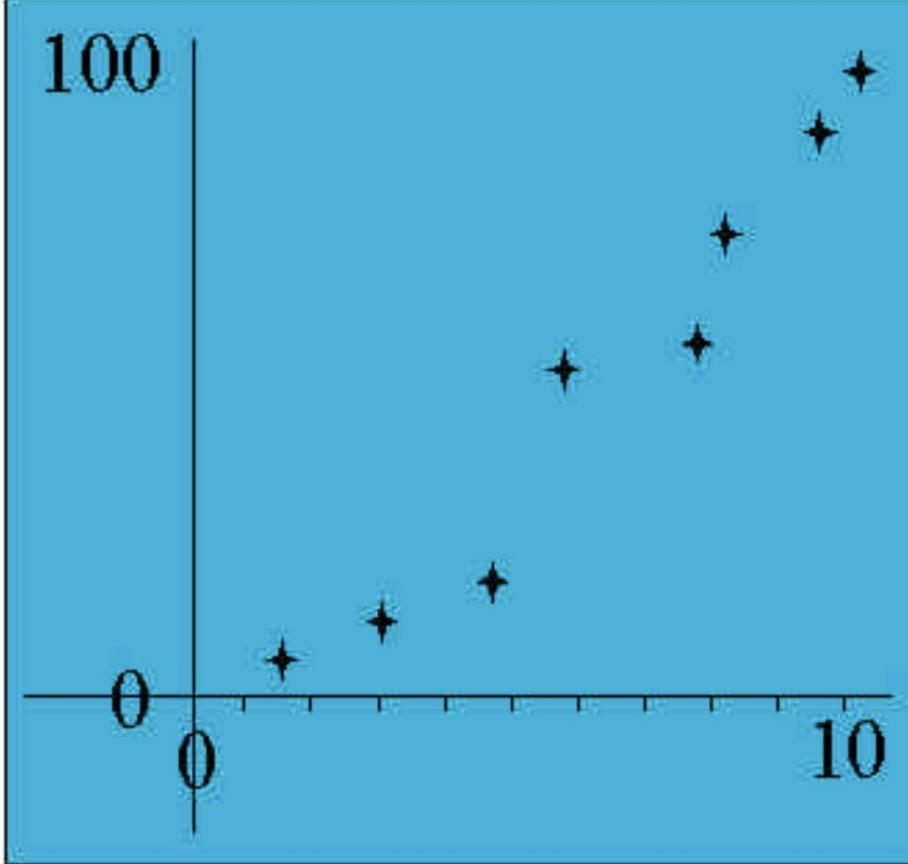
## Visual Variable: Position

✓	selective																										
✓	associative																										
	quantitative	 <p>A scatter plot illustrating a quantitative relationship. The horizontal axis (x-axis) is labeled with 0, 10, and 100, with a break between 0 and 10. The vertical axis (y-axis) has one labeled tick at 100. Data points, represented by asterisks (*), show a clear positive correlation, starting near (1, 10) and ending near (9, 100).</p> <table border="1"><thead><tr><th>x</th><th>y</th></tr></thead><tbody><tr><td>1</td><td>10</td></tr><tr><td>2</td><td>20</td></tr><tr><td>3</td><td>30</td></tr><tr><td>4</td><td>40</td></tr><tr><td>5</td><td>50</td></tr><tr><td>6</td><td>60</td></tr><tr><td>7</td><td>70</td></tr><tr><td>8</td><td>80</td></tr><tr><td>9</td><td>90</td></tr><tr><td>10</td><td>100</td></tr></tbody></table>				x	y	1	10	2	20	3	30	4	40	5	50	6	60	7	70	8	80	9	90	10	100
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8	80																										
9	90																										
10	100																										
	order																										
	length																										

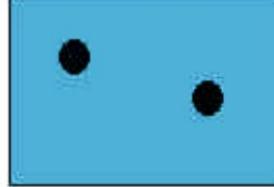
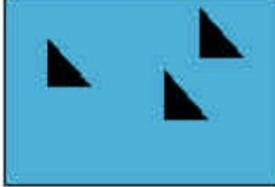
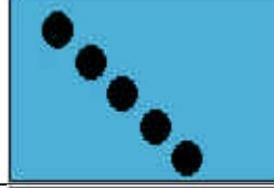
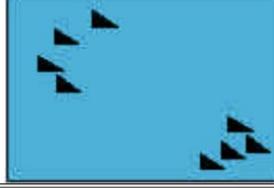
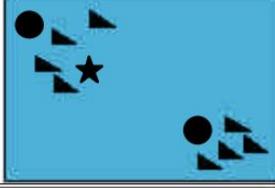
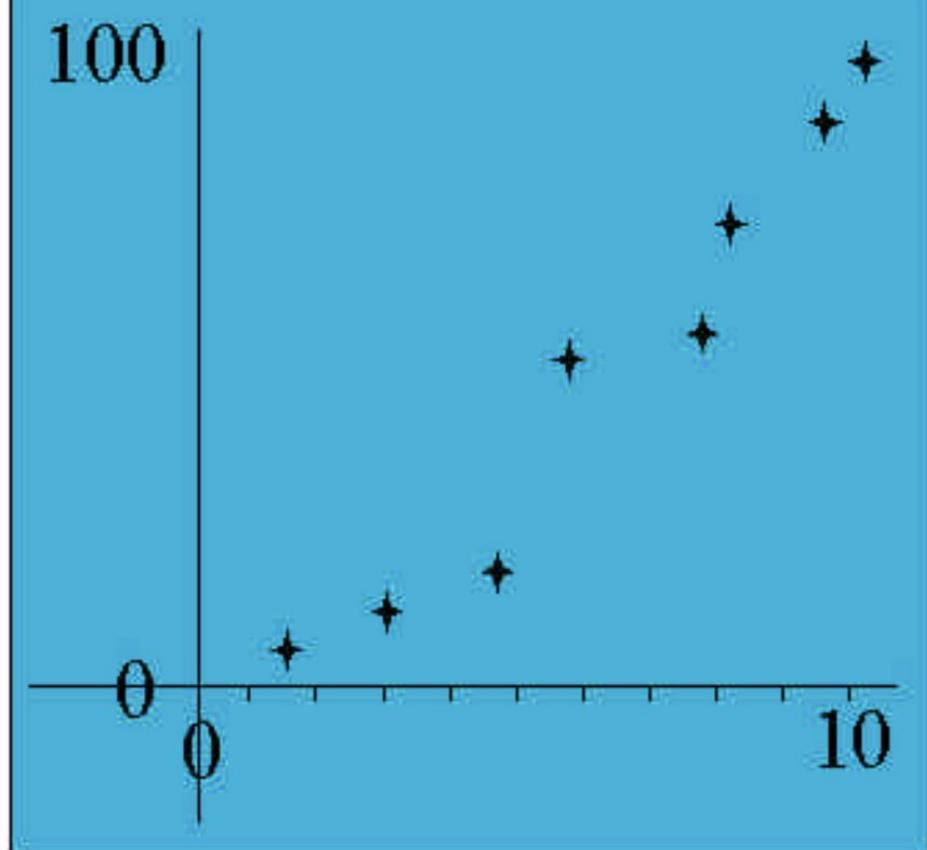
## Visual Variable: Position

✓	selective																								
✓	associative																								
✓	quantitative	 <p>A scatter plot illustrating a quantitative relationship. The horizontal axis (x) is labeled with 0 and 10, and has tick marks every 1 unit. The vertical axis (y) is labeled with 0 and 100, and has tick marks every 10 units. The data points, represented by asterisks (*), show a clear positive linear trend starting near (1, 10) and ending near (9, 90).</p> <table border="1"><thead><tr><th>x</th><th>y</th></tr></thead><tbody><tr><td>1</td><td>10</td></tr><tr><td>2</td><td>20</td></tr><tr><td>3</td><td>30</td></tr><tr><td>4</td><td>40</td></tr><tr><td>5</td><td>50</td></tr><tr><td>6</td><td>60</td></tr><tr><td>7</td><td>70</td></tr><tr><td>8</td><td>80</td></tr><tr><td>9</td><td>90</td></tr></tbody></table>				x	y	1	10	2	20	3	30	4	40	5	50	6	60	7	70	8	80	9	90
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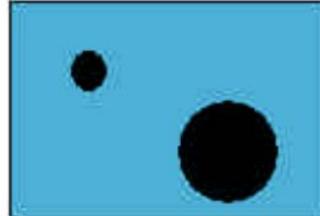
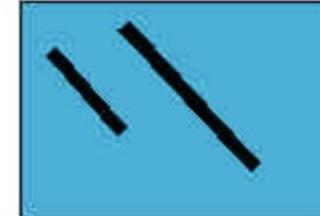
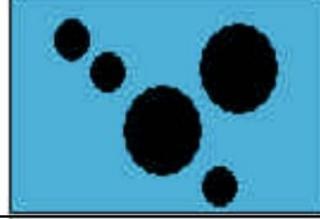
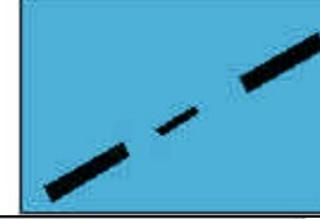
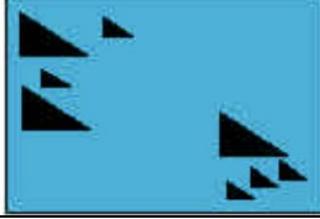
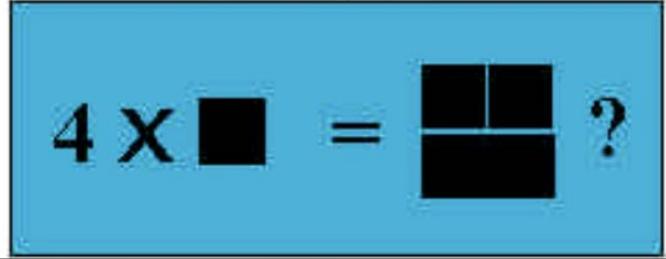
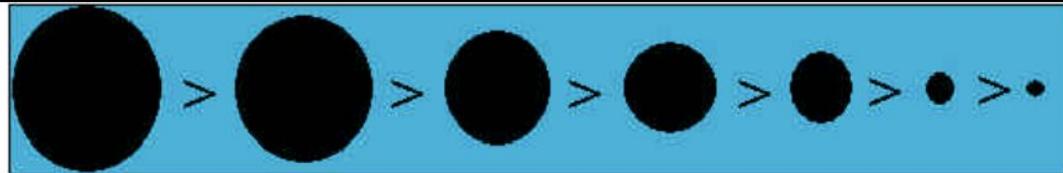
## Visual Variable: Position

✓	selective				
✓	associative				
✓	quantitative				
✓	order				
	length				

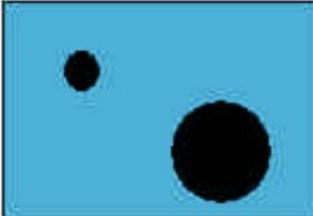
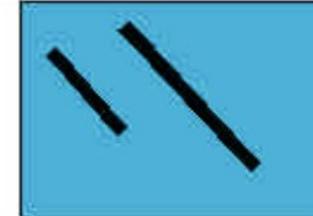
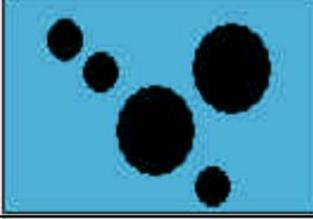
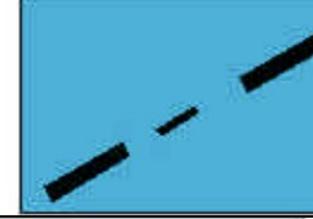
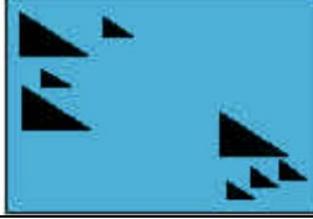
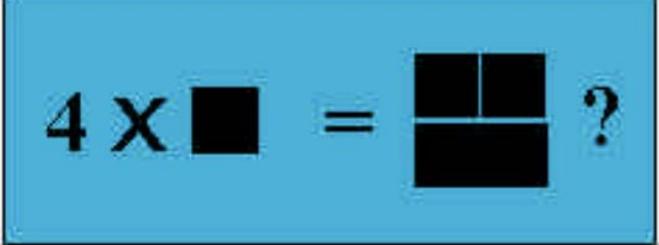
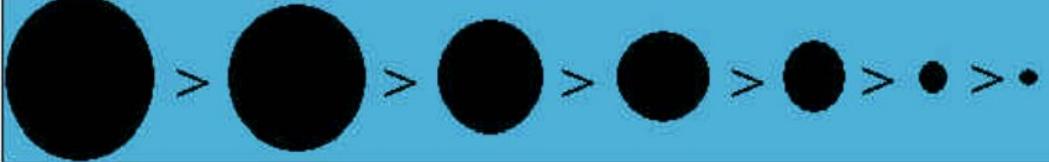
## Visual Variable: Position

✓	selective																								
✓	associative																								
✓	quantitative	 <p>A scatter plot illustrating a quantitative relationship. The horizontal axis (x) ranges from 0 to 10, with major tick marks at 0, 10, and several unlabeled intermediate tick marks. The vertical axis (y) has one labeled tick mark at 100. Data points, represented by black asterisks (*), show a clear positive linear trend, starting near (1, 10) and ending near (9, 90).</p> <table border="1"><thead><tr><th>x</th><th>y</th></tr></thead><tbody><tr><td>1</td><td>10</td></tr><tr><td>2</td><td>20</td></tr><tr><td>3</td><td>30</td></tr><tr><td>4</td><td>40</td></tr><tr><td>5</td><td>50</td></tr><tr><td>6</td><td>60</td></tr><tr><td>7</td><td>70</td></tr><tr><td>8</td><td>80</td></tr><tr><td>9</td><td>90</td></tr></tbody></table>				x	y	1	10	2	20	3	30	4	40	5	50	6	60	7	70	8	80	9	90
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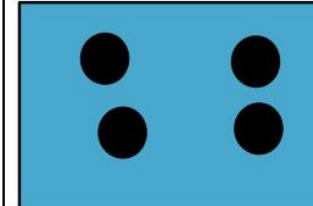
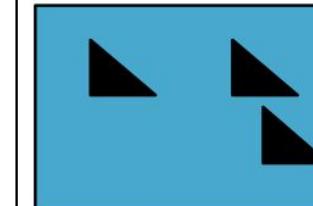
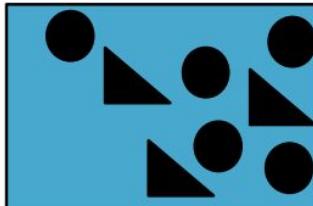
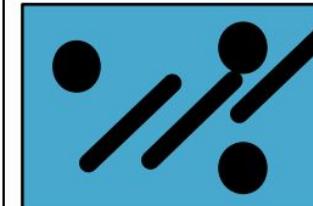
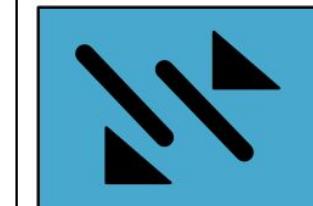
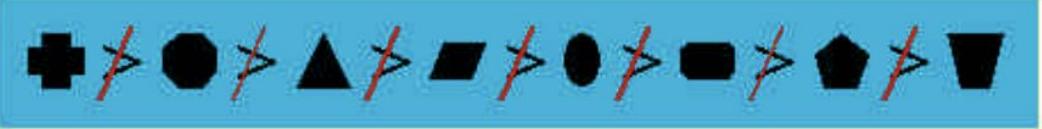
## Visual Variable: Size

	selective			
	associative			
	quantitative			
	order			
	Length		<ul style="list-style-type: none"> <li>• theoretically infinite but practically limited</li> <li>• association and selection ~ 5 and distinction ~ 20</li> </ul>	

## Visual Variable: Size

✓	selective			
✓	associative			
≈	quantitative			
✓	order			
✓	Length		<ul style="list-style-type: none"><li>• theoretically infinite but practically limited</li><li>• association and selection ~ 5 and distinction ~ 20</li></ul>	

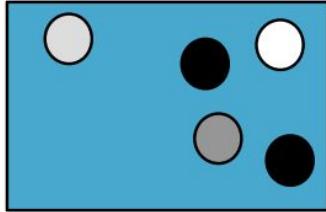
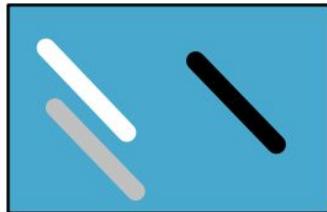
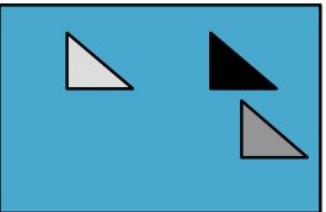
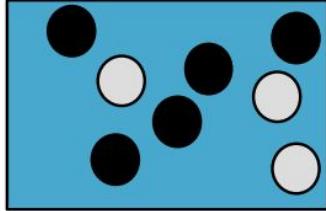
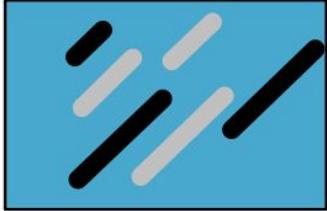
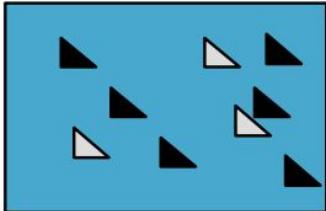
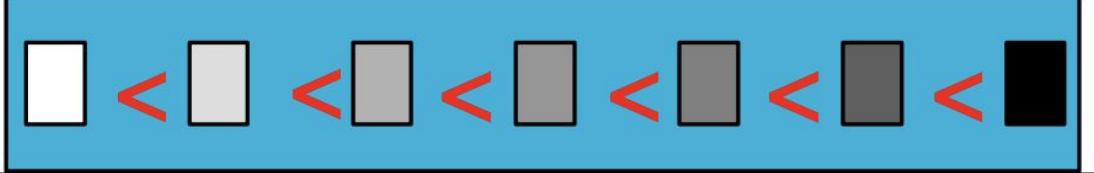
## Visual Variable: Shape

	selective			
	associative			
	quantitative			
	order			
	length		theoretically infinite	

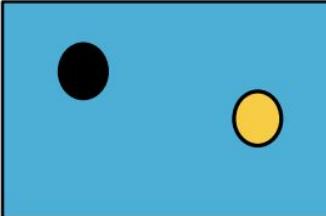
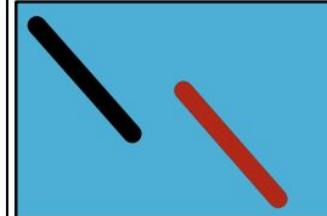
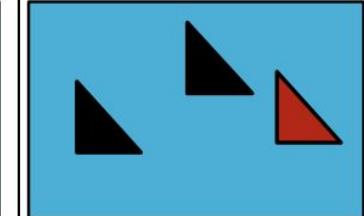
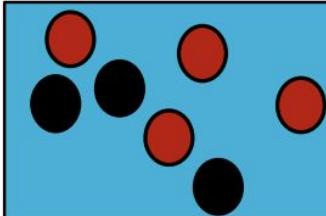
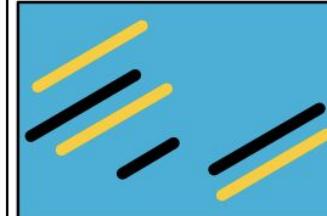
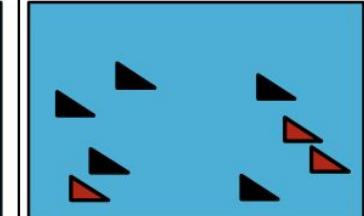
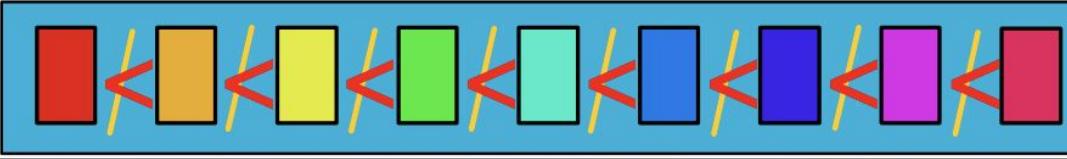
## Visual Variable: Shape

	selective			
	associative			
	quantitative			
	order			
	length		theoretically infinite	

## Visual Variable: Value

✓	selective			
✓	associative			
✗	quantitative			
✓	order			
✓	length	<ul style="list-style-type: none"><li>• theoretically infinite but practically limited</li><li>• association and selection ~ &lt; 7 and distinction ~ 10</li></ul>		

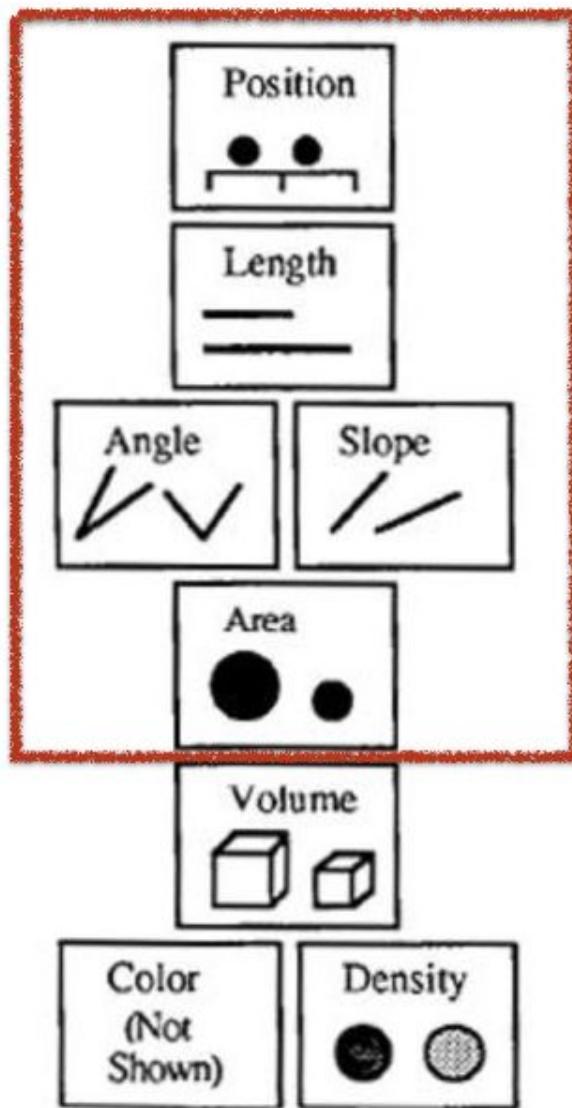
## Visual Variable: Colour

	selective			
	associative			
	quantitative			
	order			
	length	 <ul style="list-style-type: none"> <li>• theoretically infinite but practically limited</li> <li>• association and selection ~ &lt; 7 and distinction ~ 10</li> </ul>		

More accurate



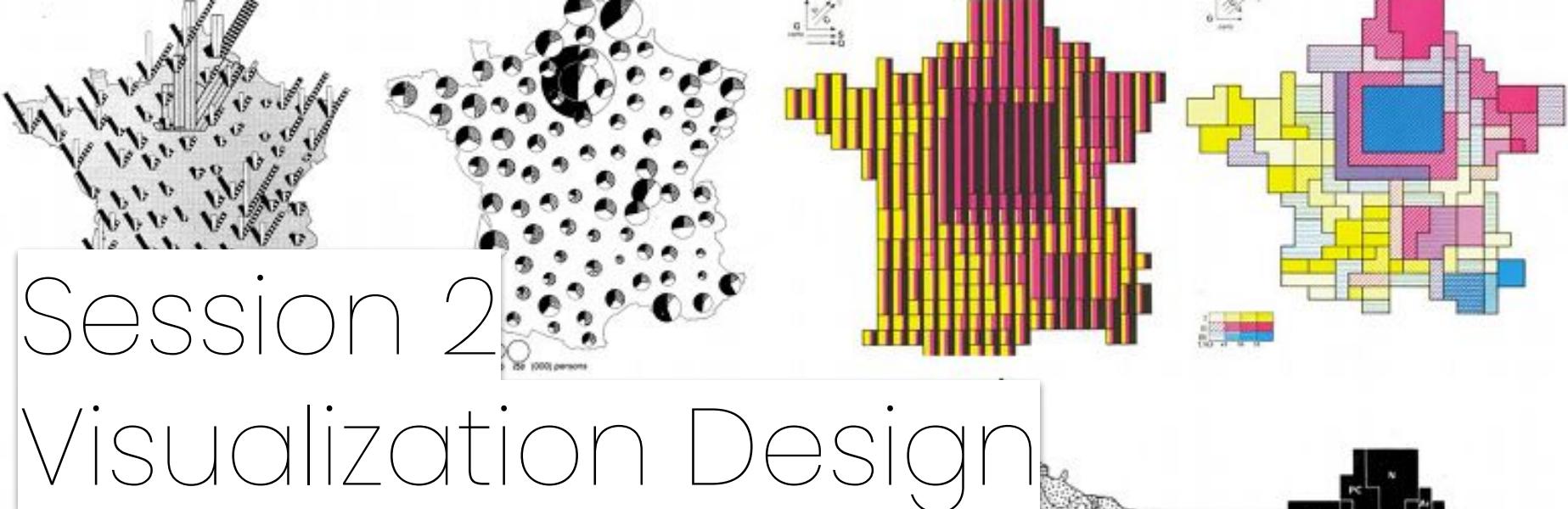
Less accurate



Mackinlay, APT (A Presentation Tool), 1986

# Recommended Reading

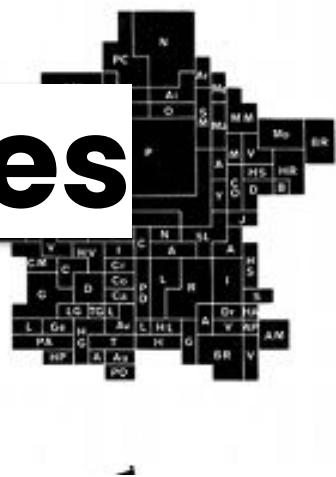
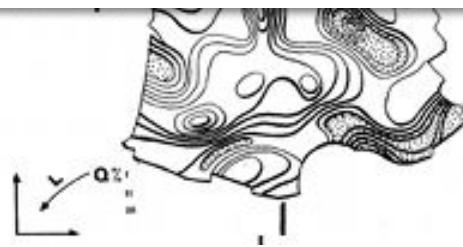
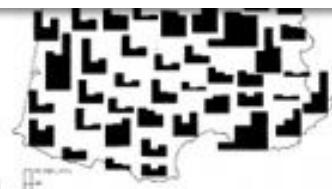
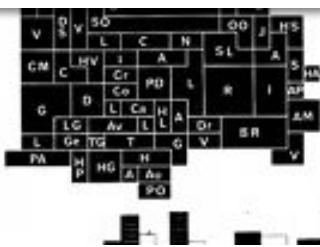
- Tamara Munzner: **Visualization Analysis and Design**
  - Chapter 2. What: Data Abstraction
  - Chapter 5. Marks and Channels
- Alberto Cairo: **The Functional Art**
  - Chapter 1: Why Visualize: From Information to Wisdom
  - Chapter 2: Forms and Functions: Visualization as Technology
- Andy Kirk: **Data Visualization**
  - Chapter 1: Defining Data Visualization
- Jaques Bertin: **Semiology of Graphics**
  - II.C: The retinal variables
- Cleveland & MacGill: **Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods, 1984**



## Session 2

# Visualization Design

# Visualization Guidelines



Online Course  
**Data Visualization  
for Professionals**



THE UNIVERSITY  
of EDINBURGH

**Benjamin Bach**

May 2022

<http://benjbach.me>  
<https://datavis-online.github.io>

-- Not for external use --

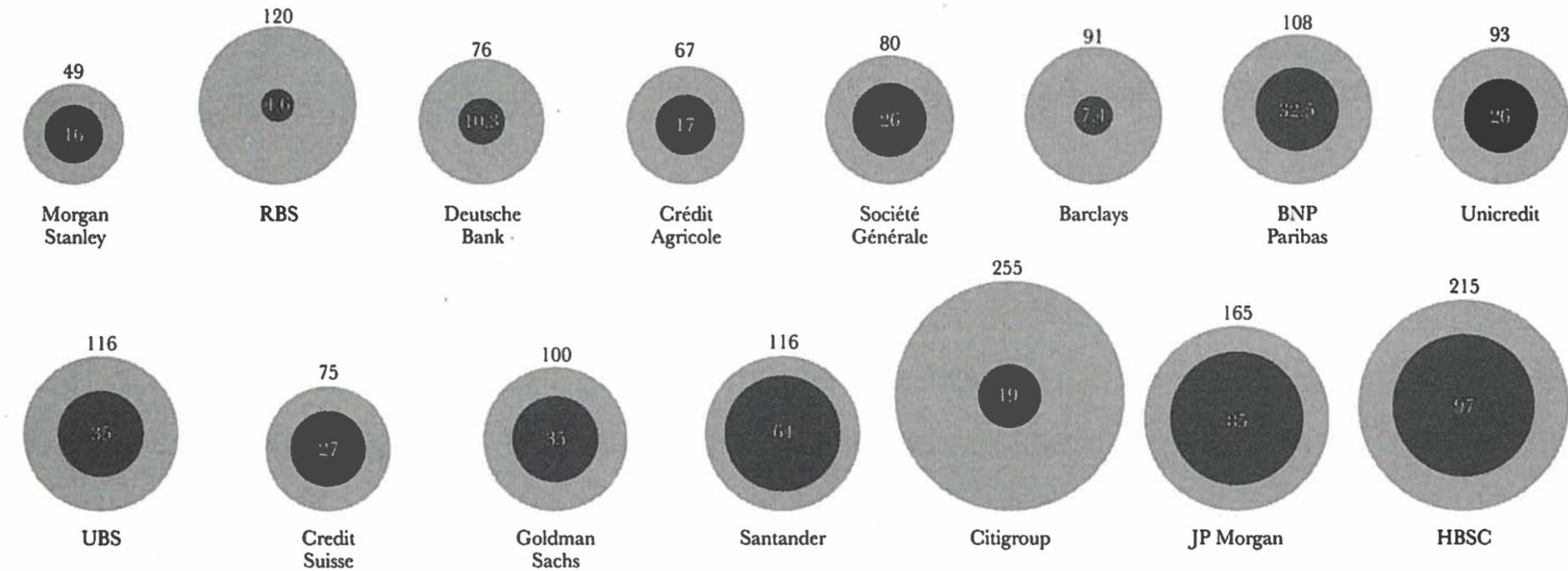
## Market Capitalization of the World's Biggest Banks

In billions of dollars

January 2007

January 2009

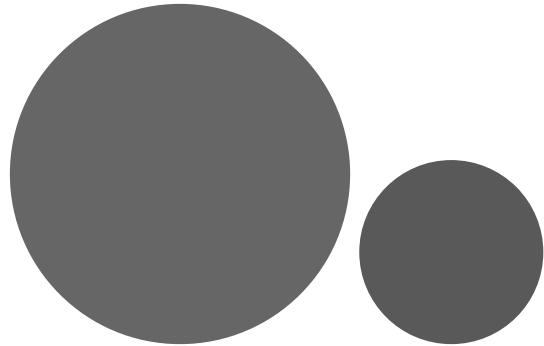
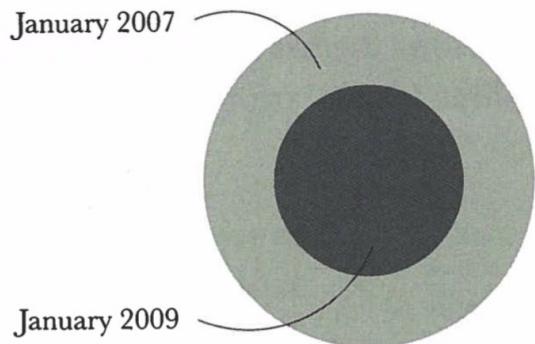
Source: Bloomberg



# How to decode bubbles?

*Billions of dollars*

Source: Bloomberg



a)



b)



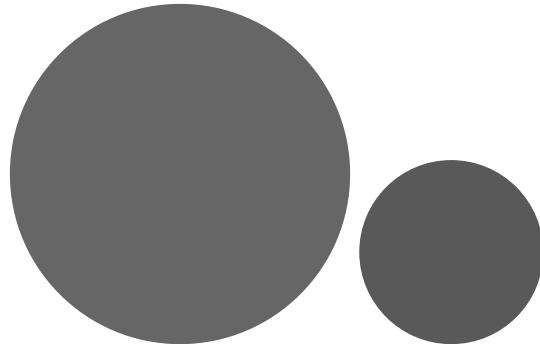
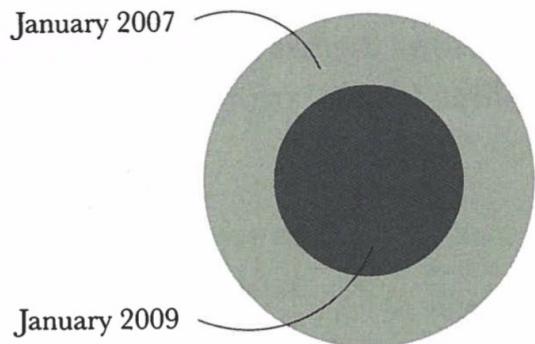
c)



# How to decode bubbles?

*Billions of dollars*

Source: Bloomberg



a)



b)



c)

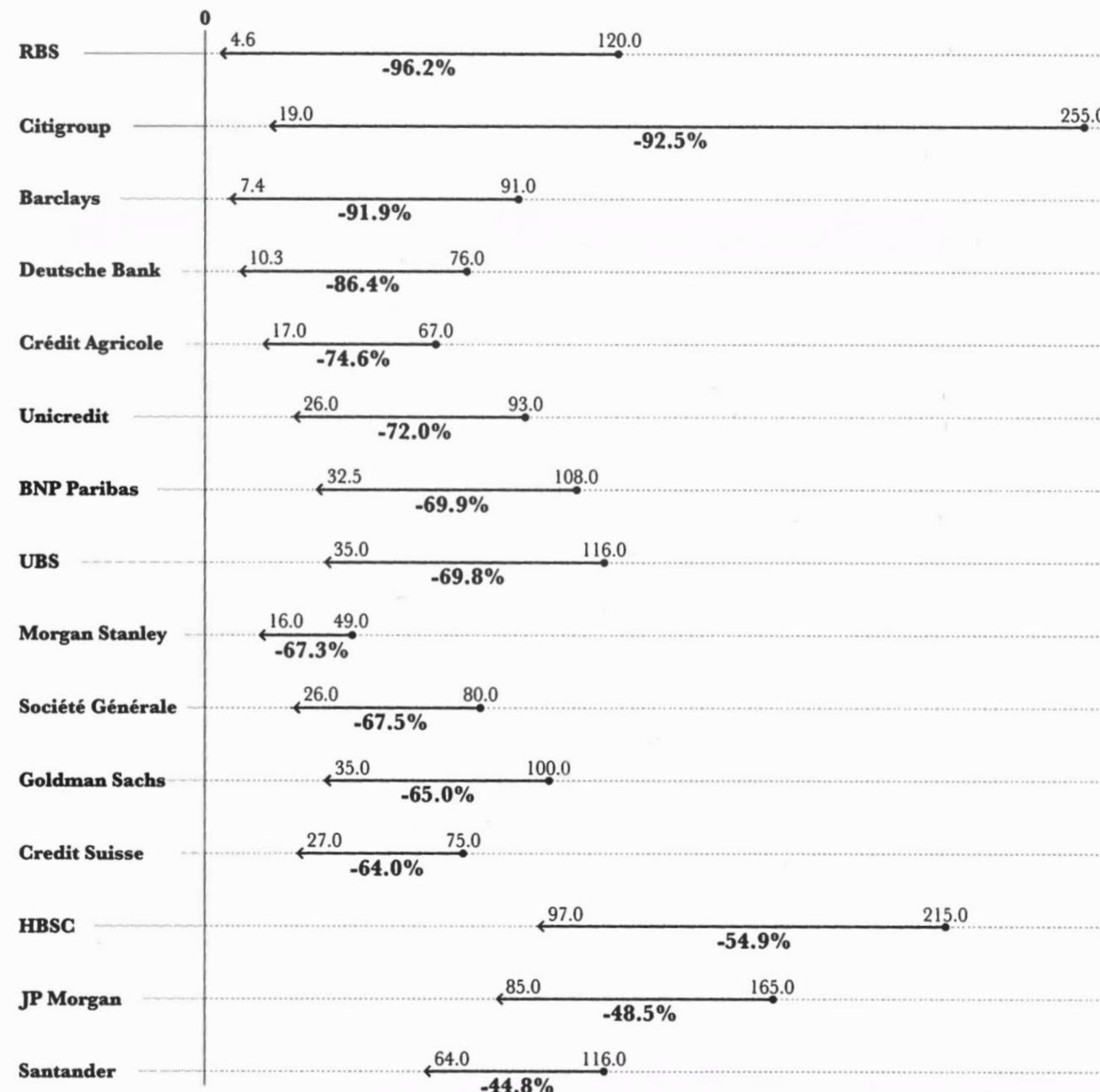


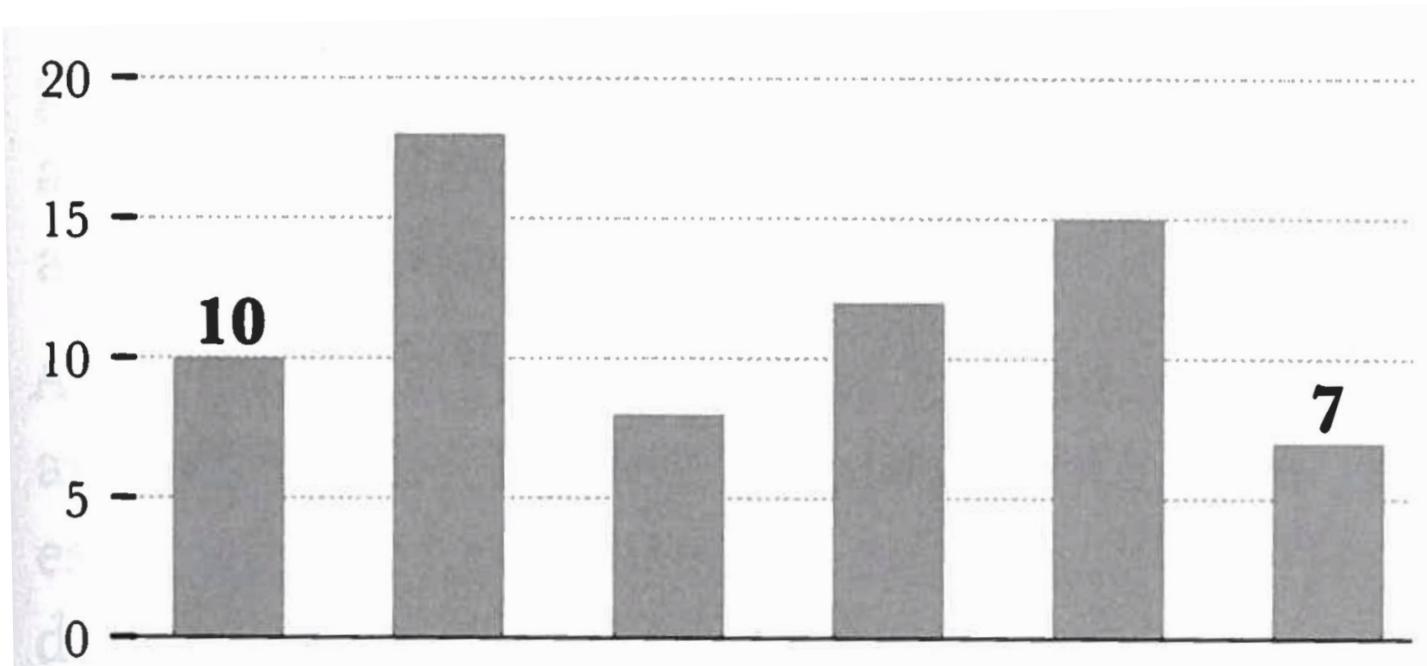
## Market Capitalization of the World's Biggest Banks

Billions of dollars

January 2009 ← → January 2007

Source: Bloomberg





10



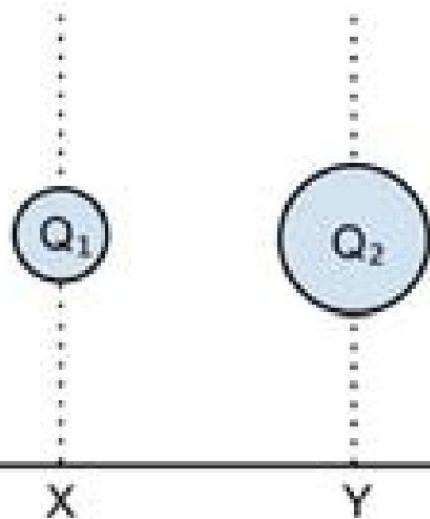
7



10

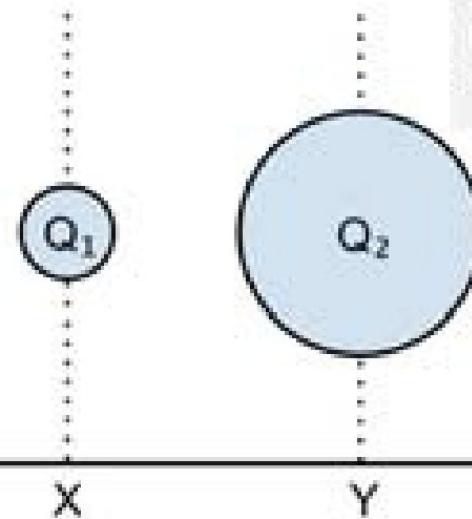


# Wrong sizes

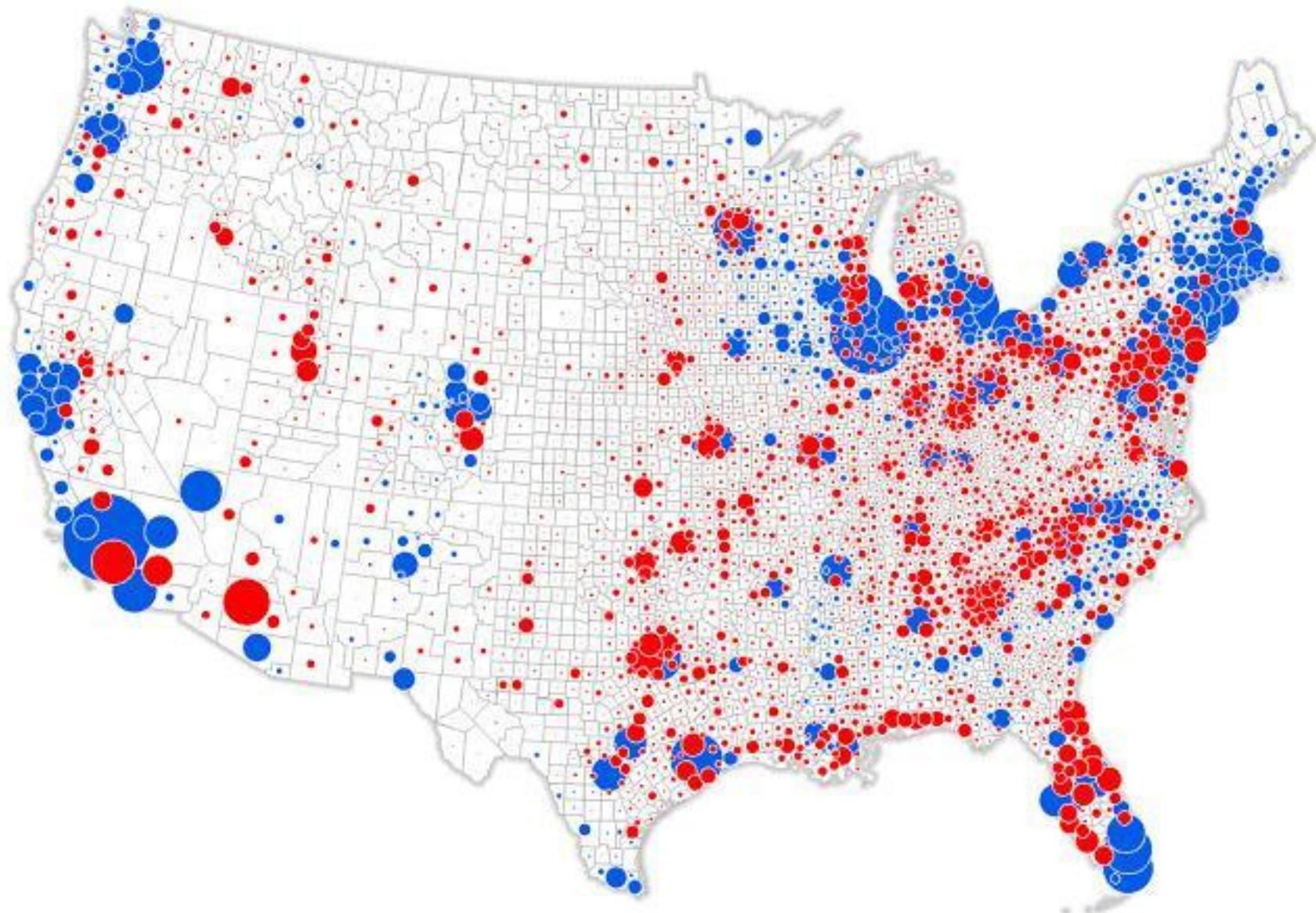


Control

vs.



Deceptive

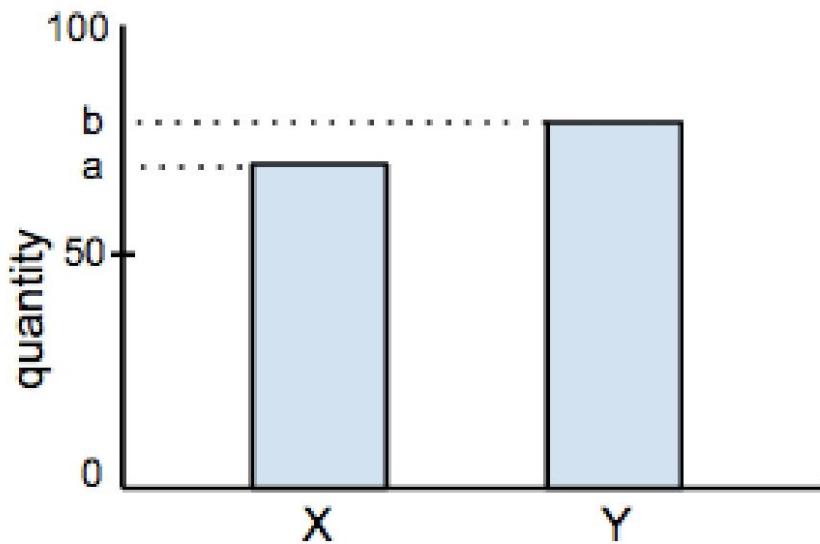


# Guideline #1

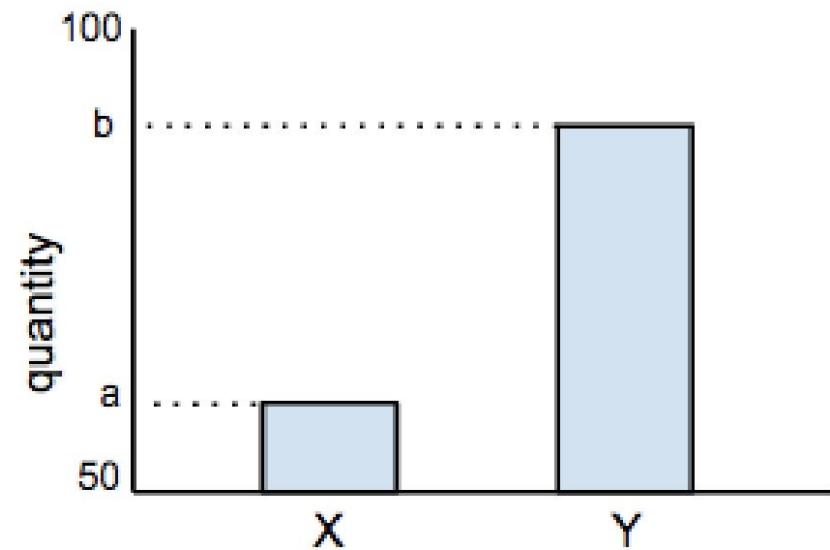
*"Don't use area size to compare quantities."*

**Exception:** *It can work on maps.*

# Truncated Axes



vs.



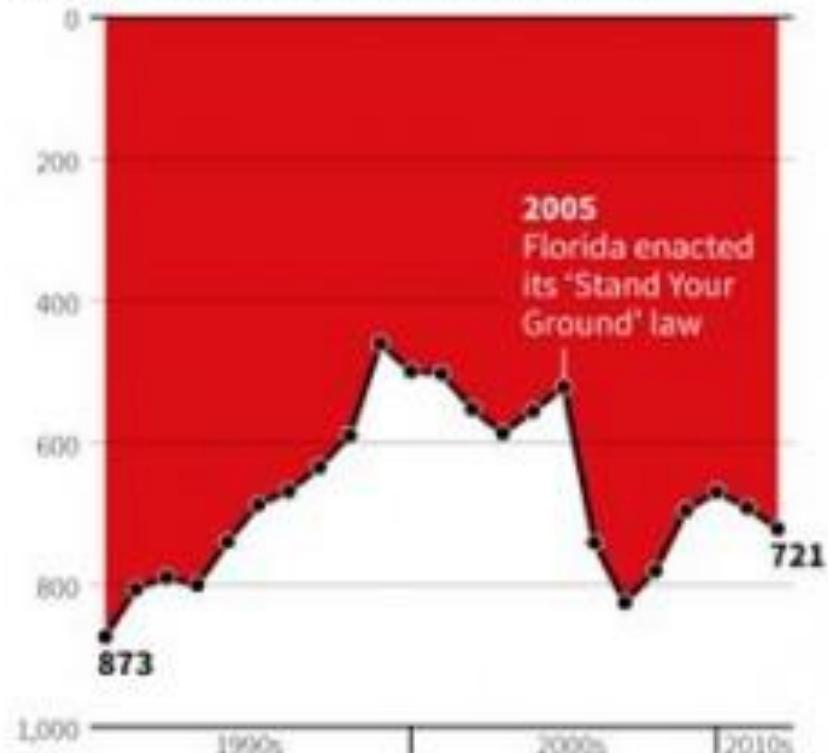
## Guideline #2

*"Don't truncate chart axes."*

**Exception:** Except you tell the reader.

## Gun deaths in Florida

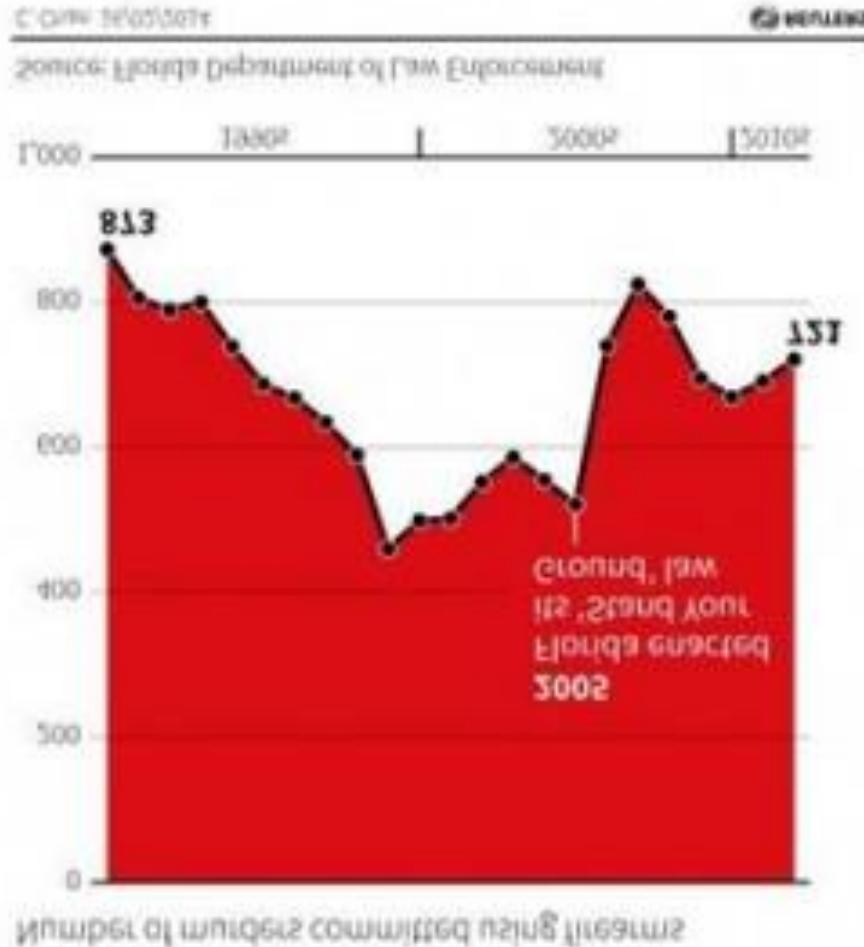
Number of murders committed using firearms



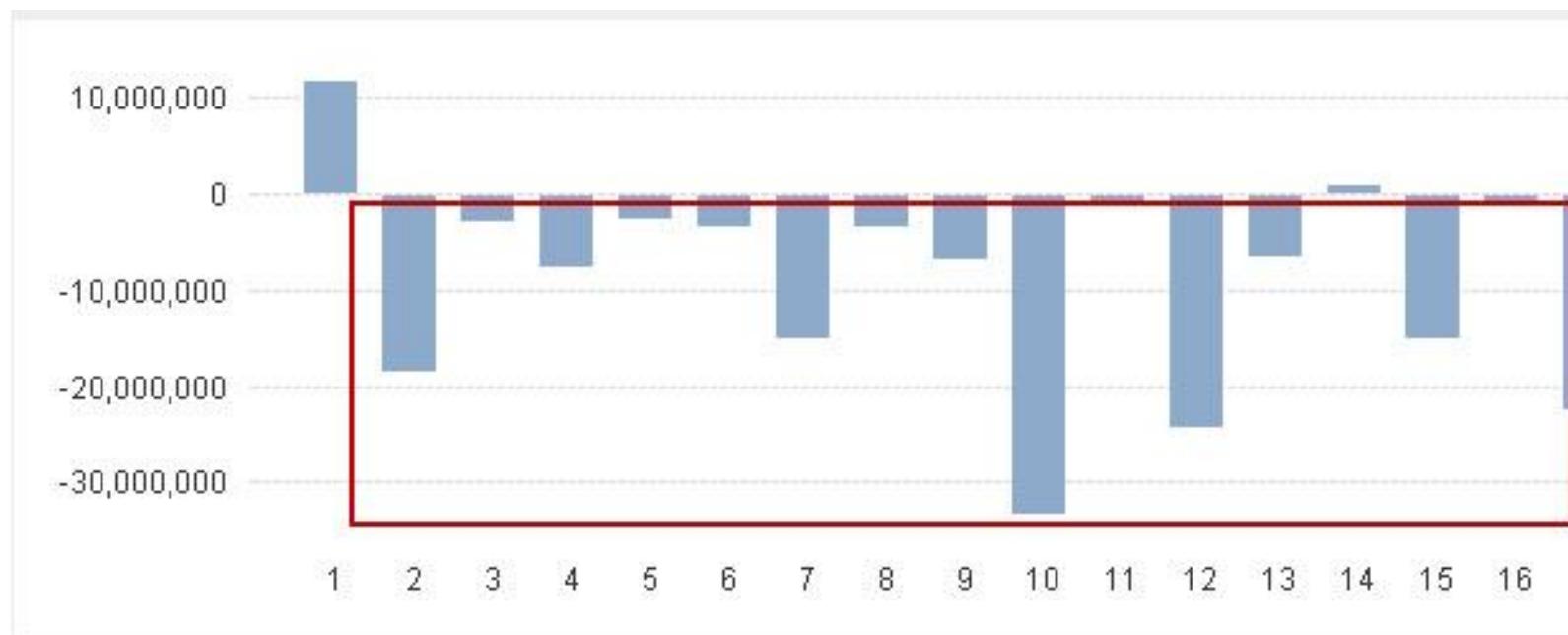
Source: Florida Department of Law Enforcement

C. Chan 16/02/2014

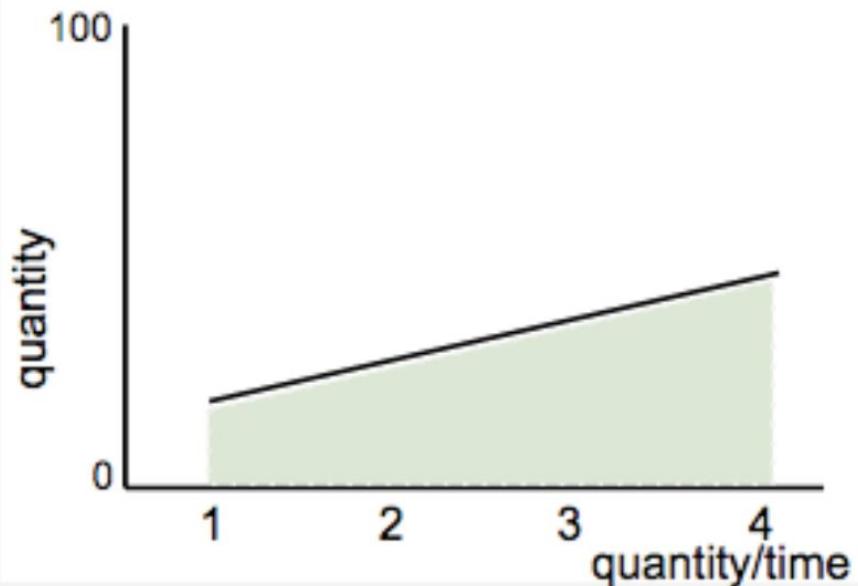
REUTERS



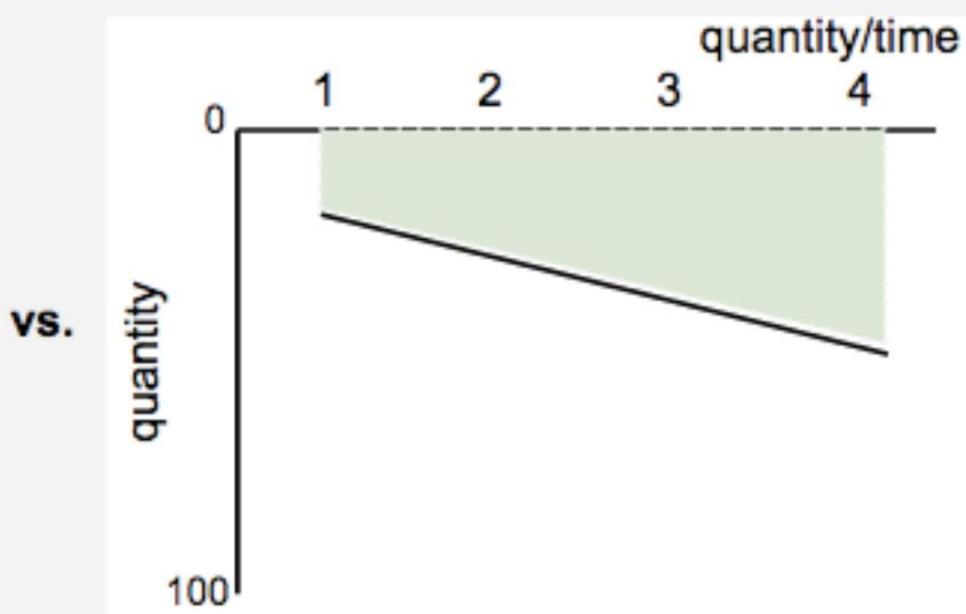
REUTERS



# Inverse charts



Control



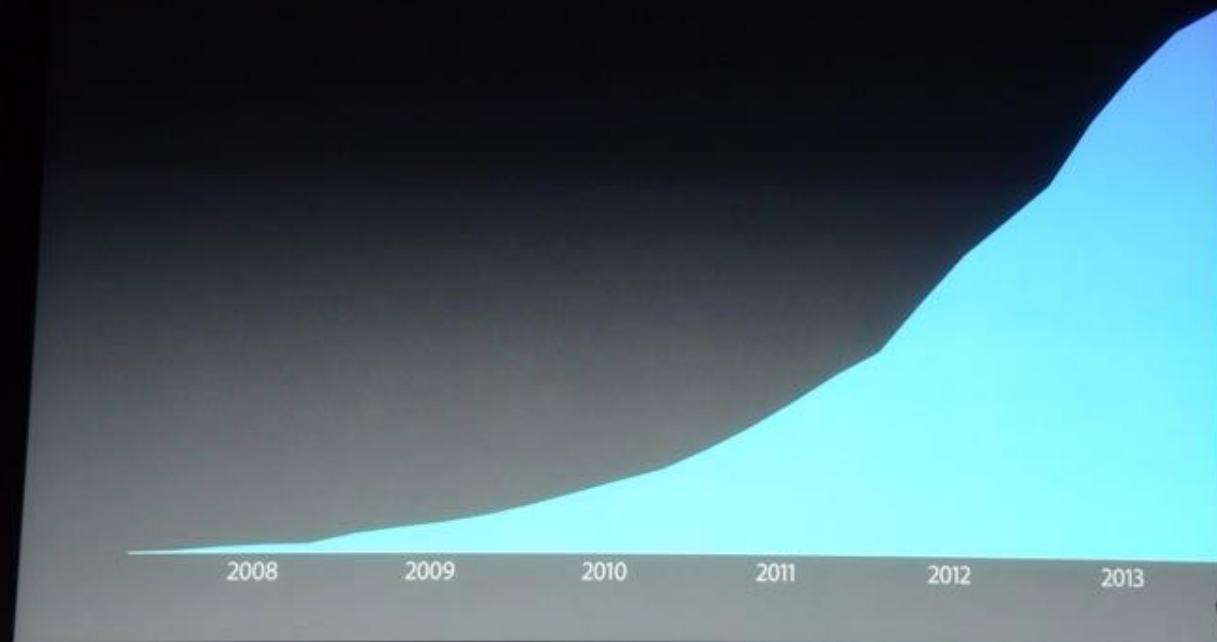
Deceptive

## Guideline #3

*"Don't inverse charts—it is deceiving."*

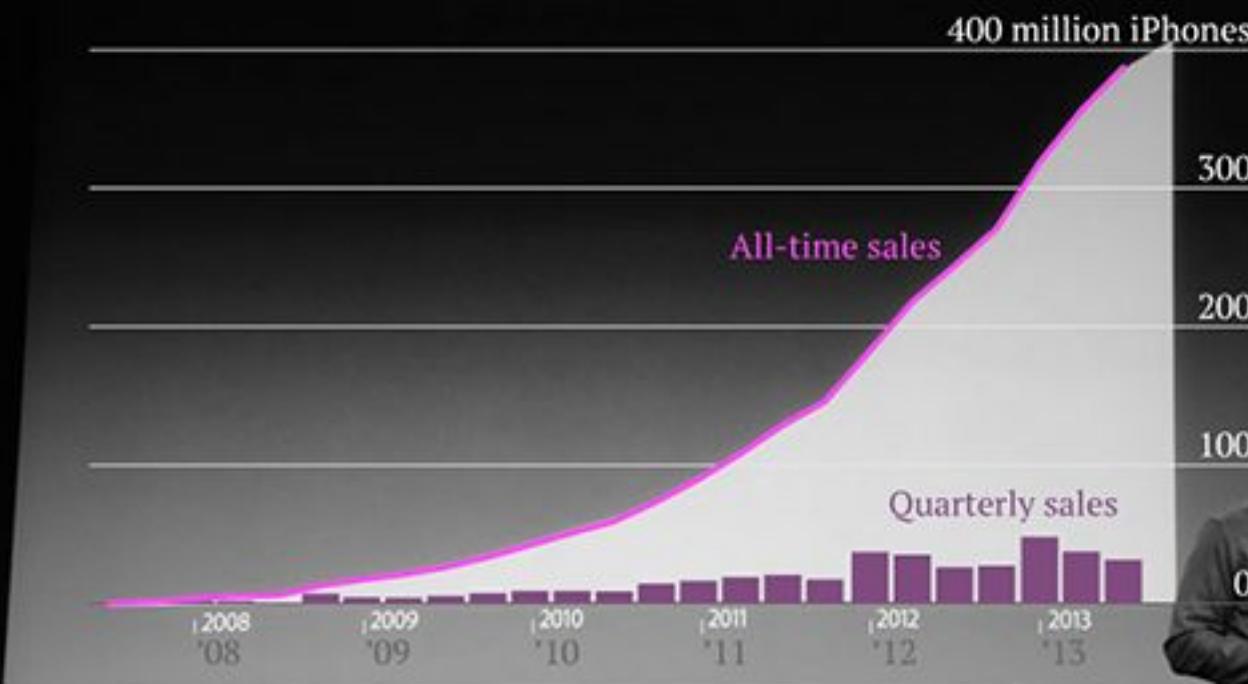
**Exception:** Except you tell the reader and it serves your purpose.

## Cumulative iPhone sales



THE VERGE

## Cumulative iPhone sales



Quartz | qz.com

Data: Apple

Photo: The Verge

THE VERGE

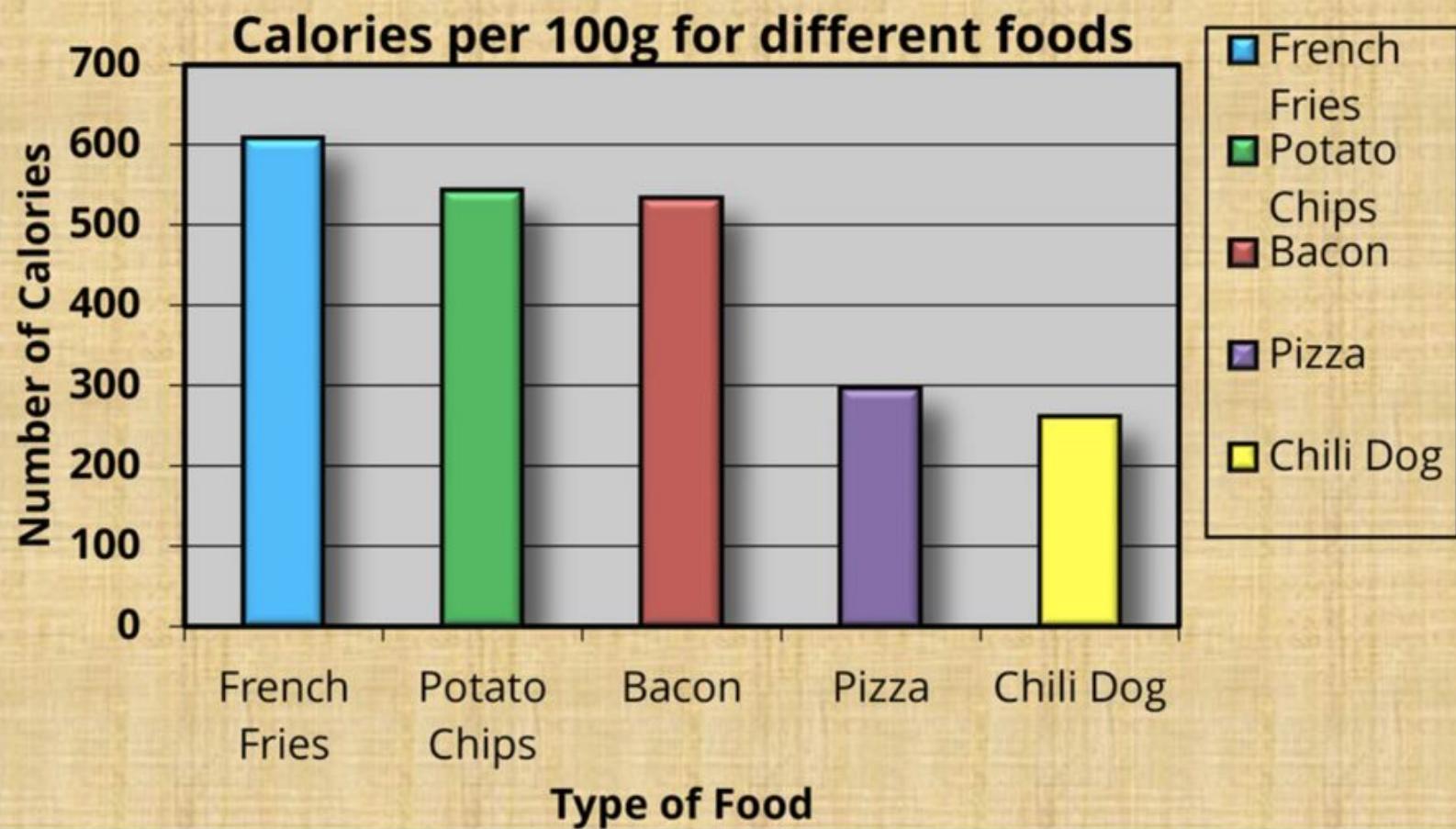
## Guideline #4

*"Be true about your intention."*

**Exception:** none

# Common flaws (from 8 graphics only..)

- 1. Missing **scales**
- 2. **3D** distortion
- 3. **3D** occlusion
- 4. Missing **color** contrast
- 5. **Colors** are too similar
- 6. Not B/W safe
- 7. overuse of **texture**
- 8. **Volume** as visual variable
- 9. Un-proportional **mappings**
- 10. Truncated **axes**
- 11. Missing **titles**
- 12. Missing axis **labels**
- 13. Unnecessary shapes/**ink**
- 14. Incomplete **data**
- 1. Wrong **legends**
- 2. Bad visual **mappings**
- 3. **Uncommon** / unknown design choices
- 4. Too much **clutter**
- 5. **Misplaced** data points
- 6. Long lines, which are hard to follow
- 7. Missing **legends**
- 8. **Too much** information in one graphic
- 9. **Missing** descriptions
- 10. **Overlapping** graphical elements
- 11. **Too many** charts in one



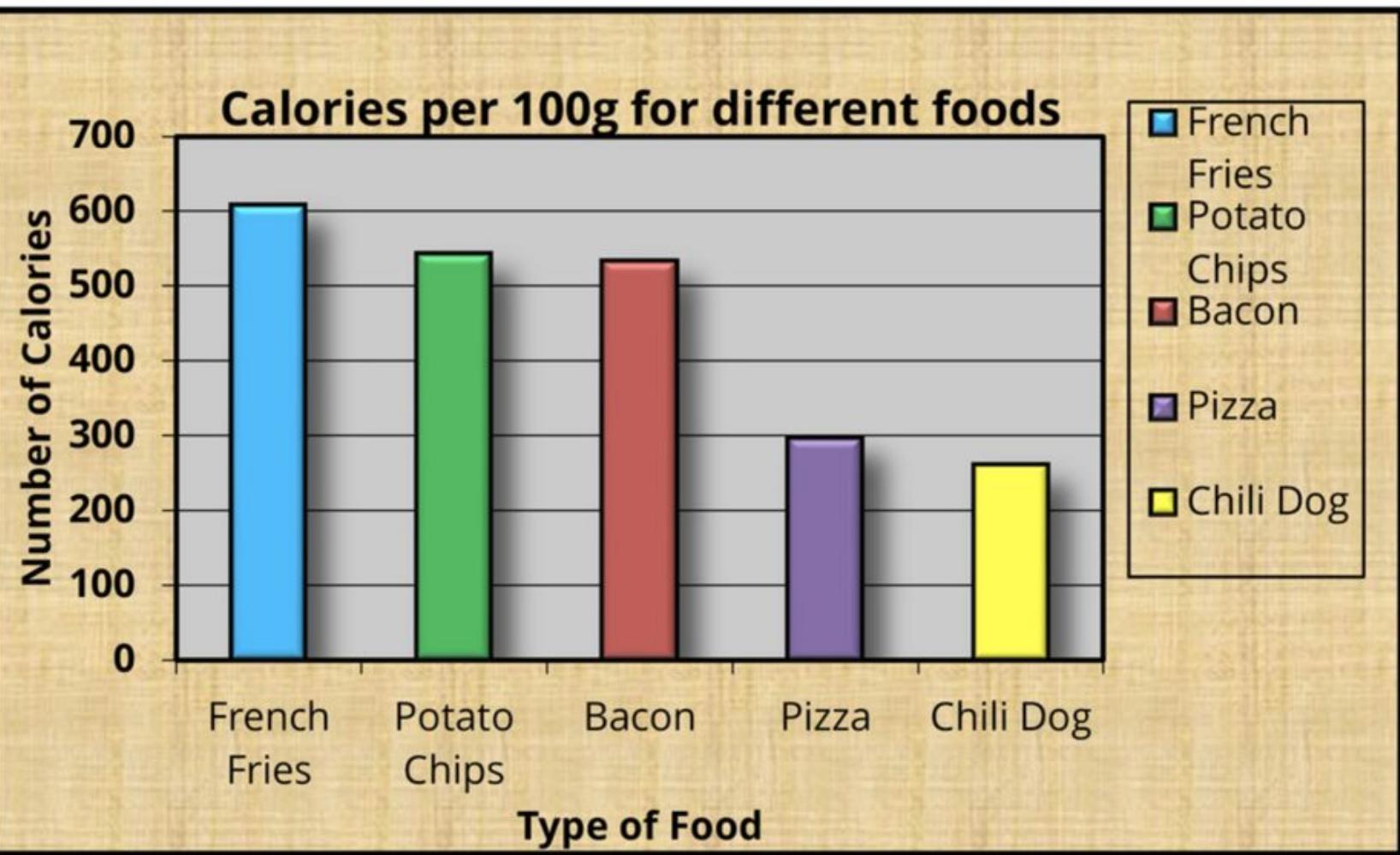
Data-Ink Ratio =

Data-Ink

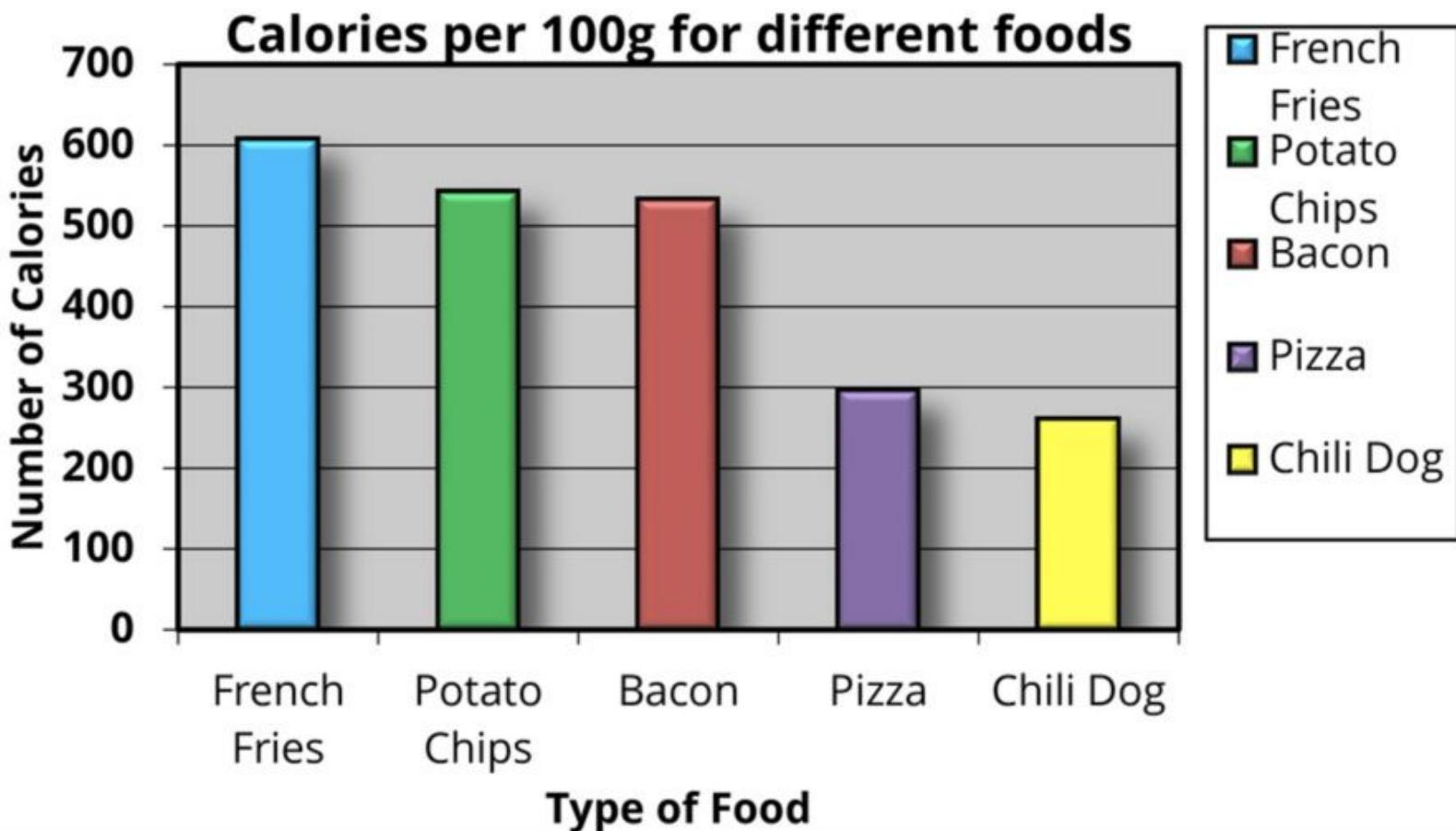
---

Total Ink used to represent  
the graphic

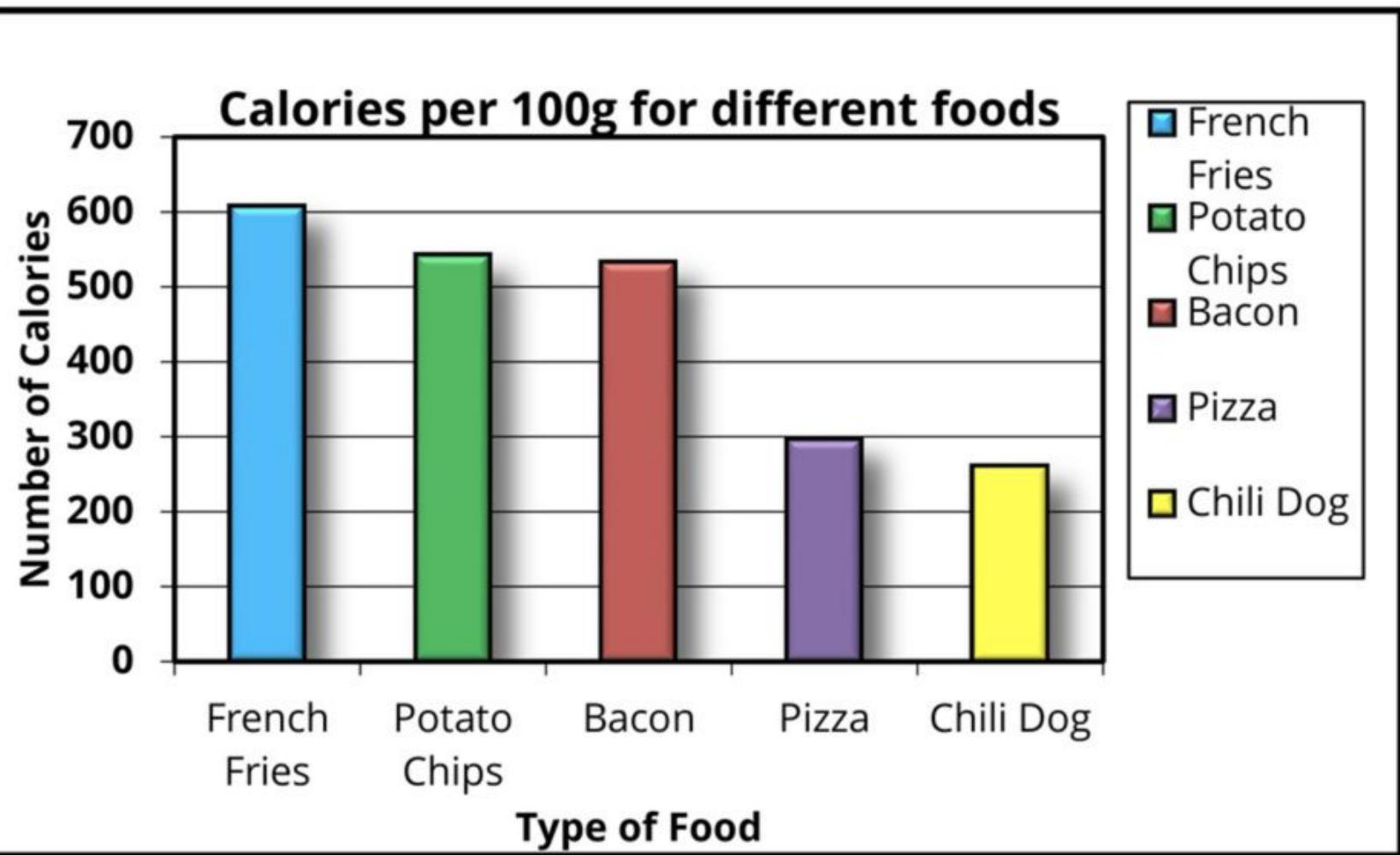
# Remove backgrounds



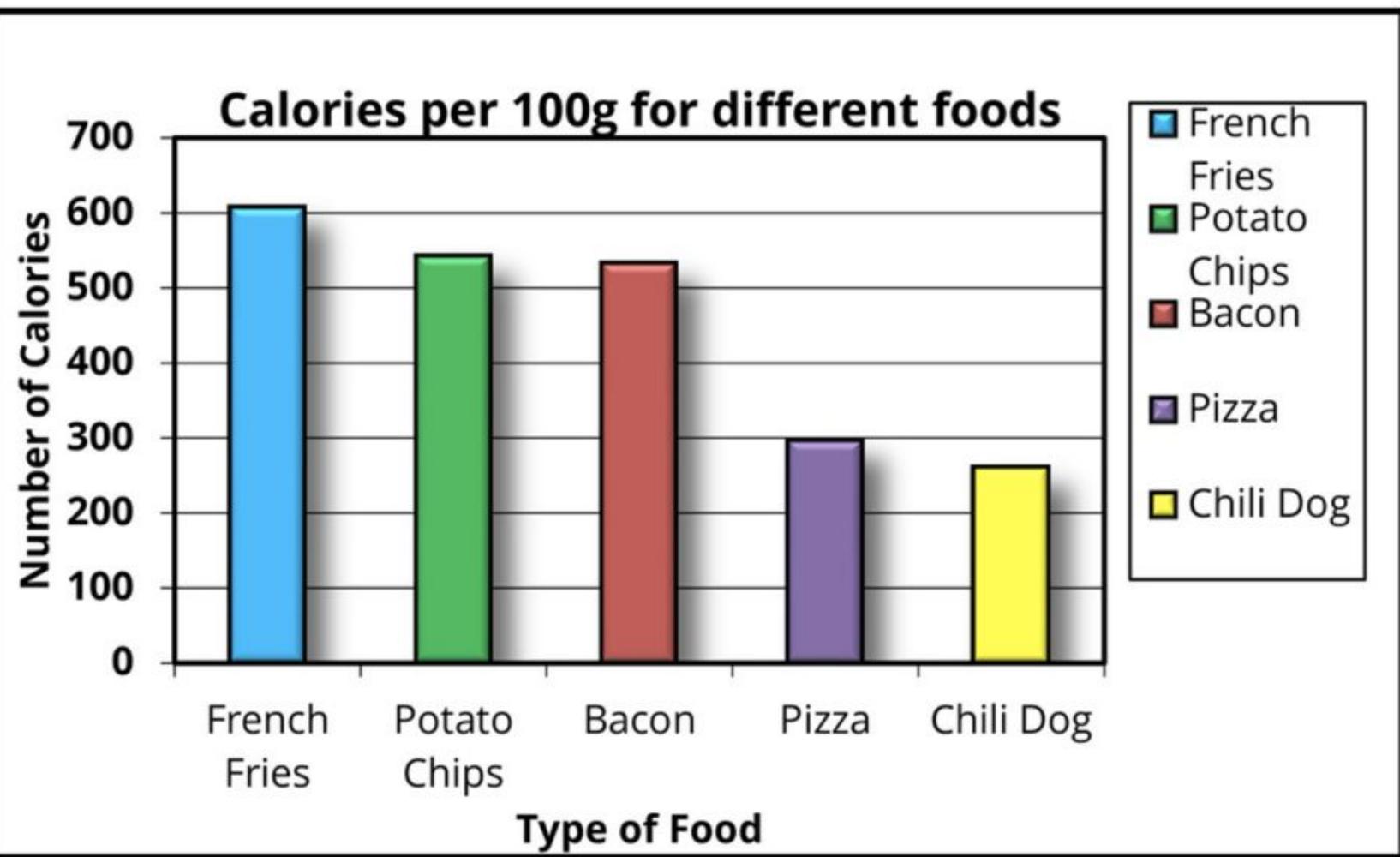
# Remove backgrounds



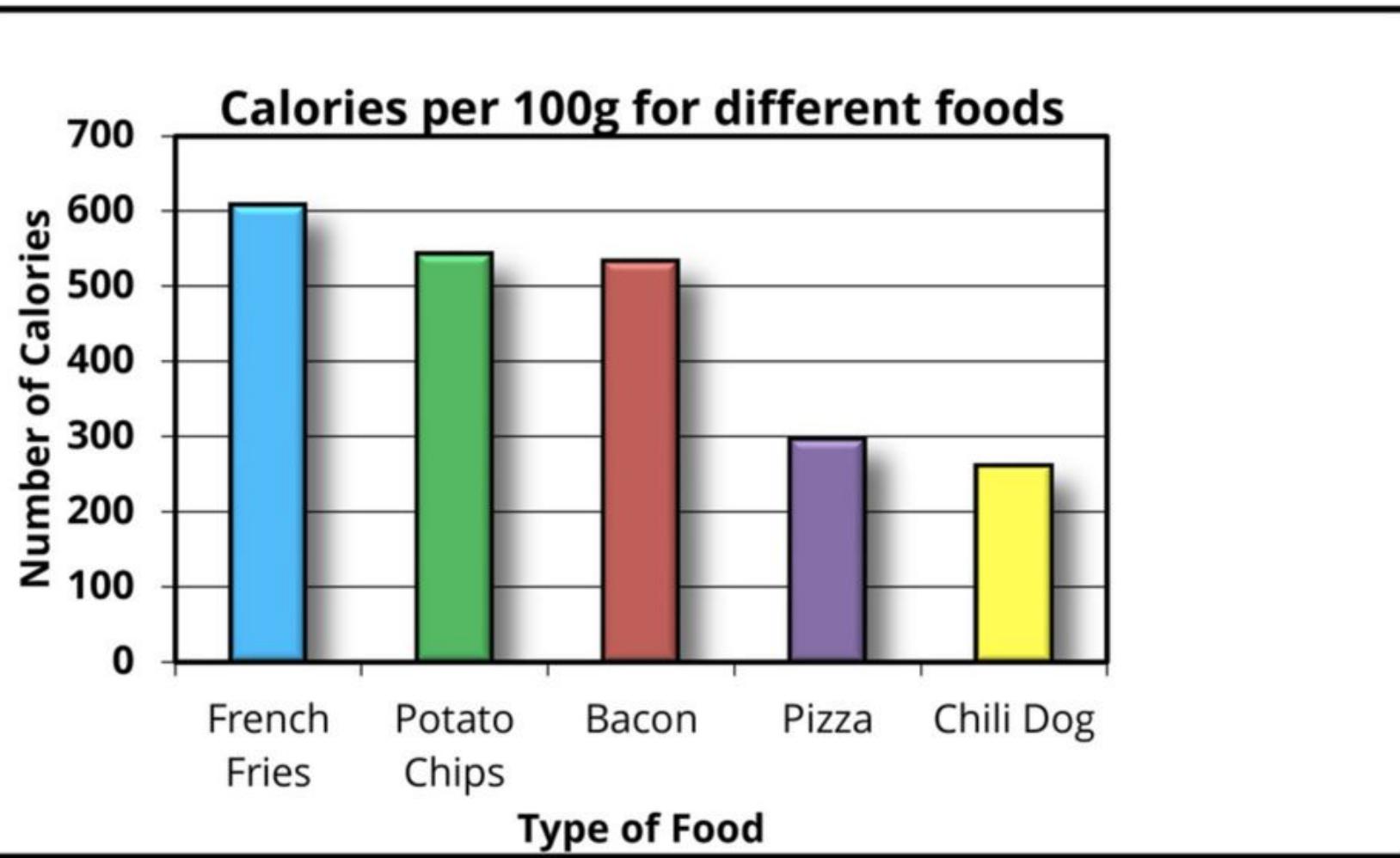
# Remove backgrounds



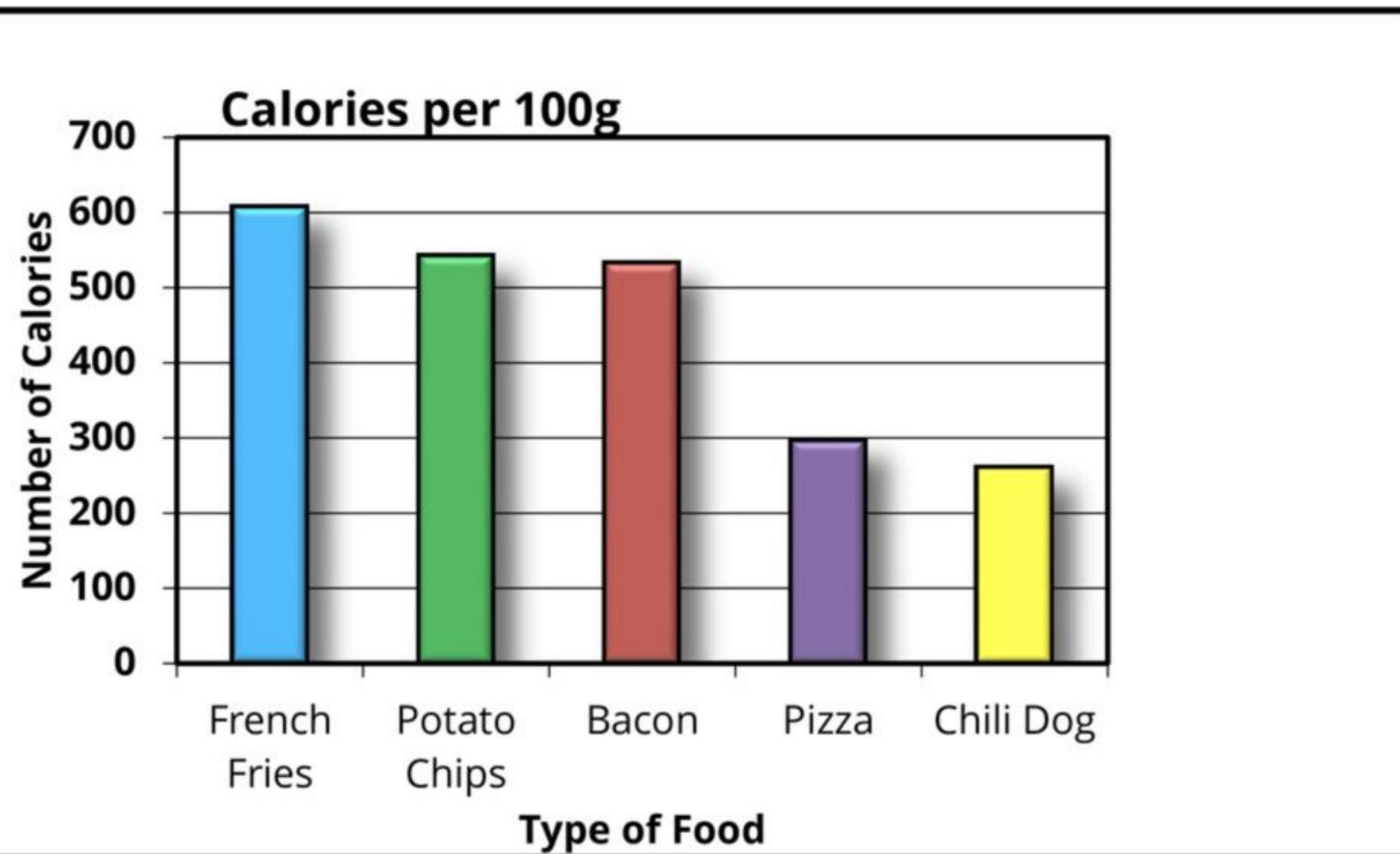
# Remove redundant labels



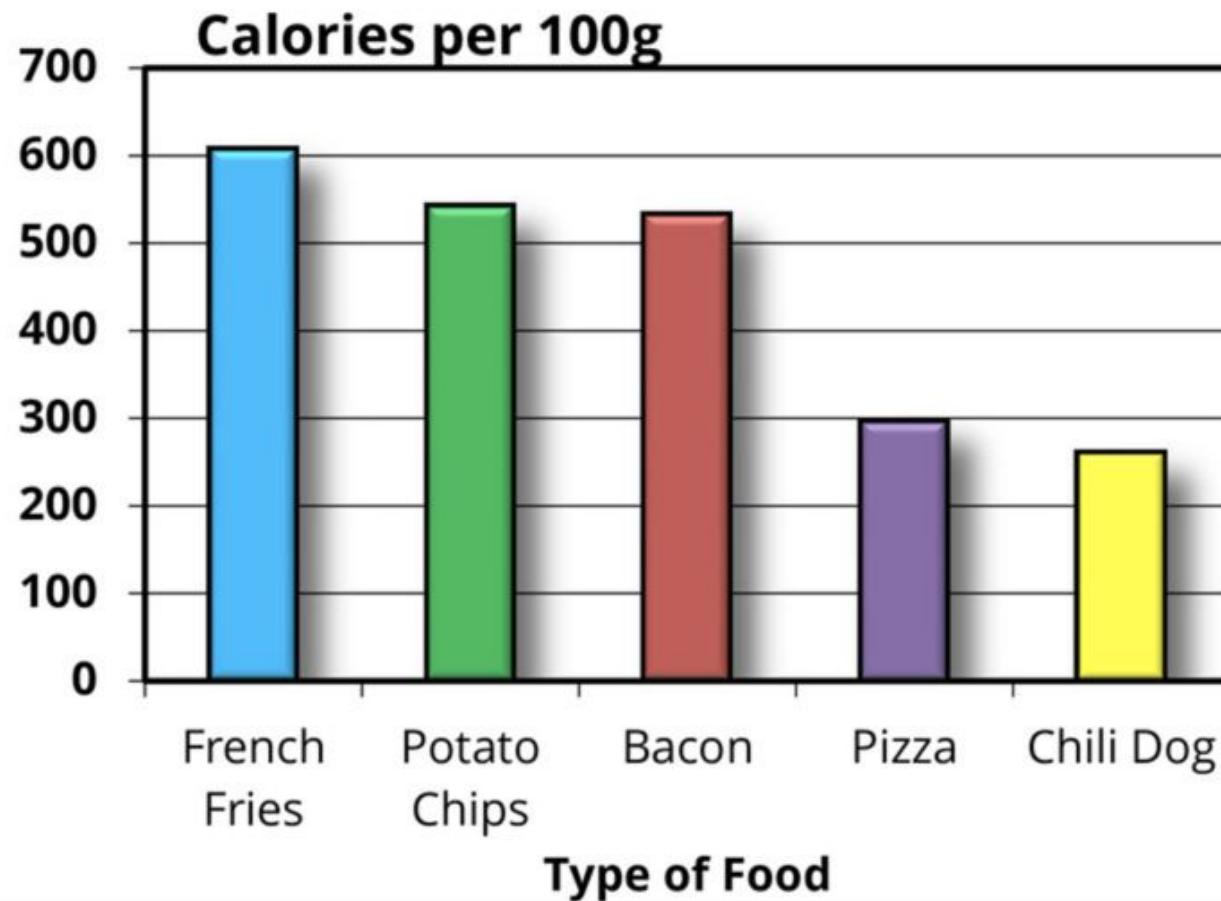
# Remove redundant labels



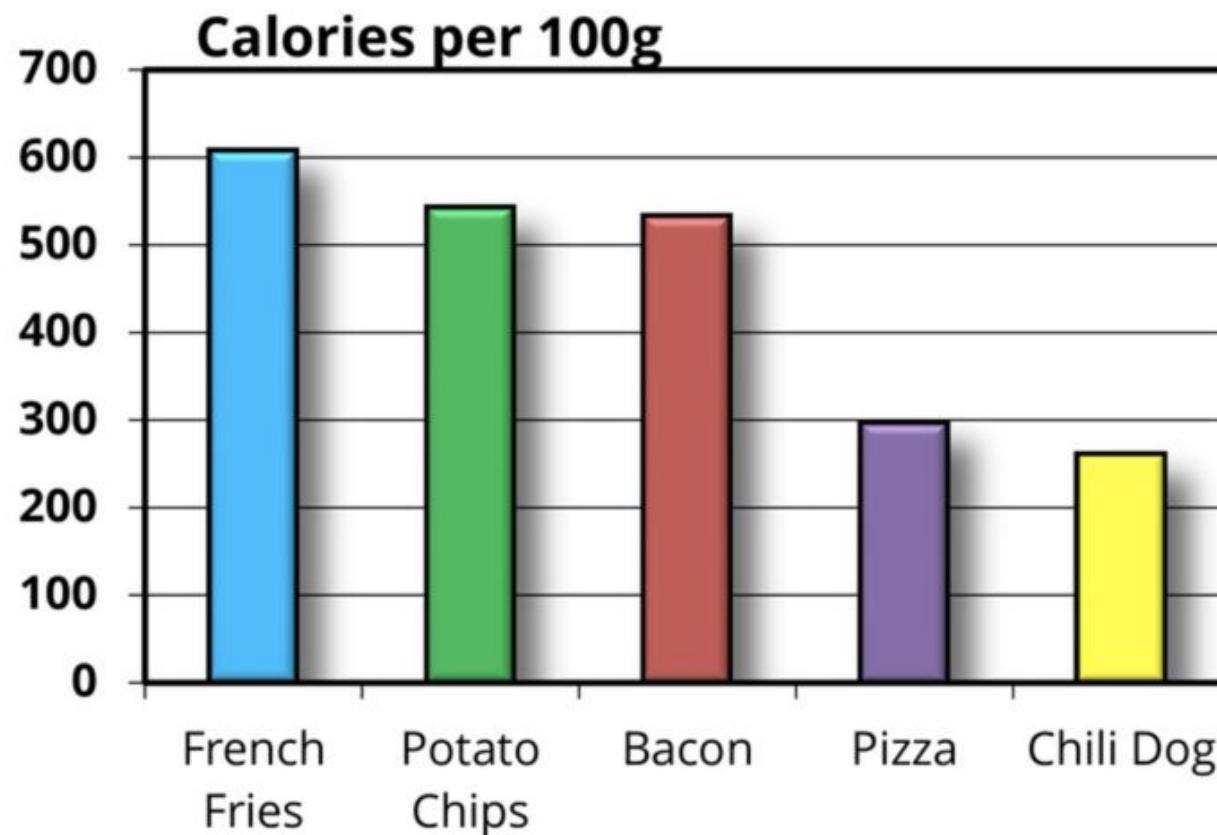
# Remove redundant labels



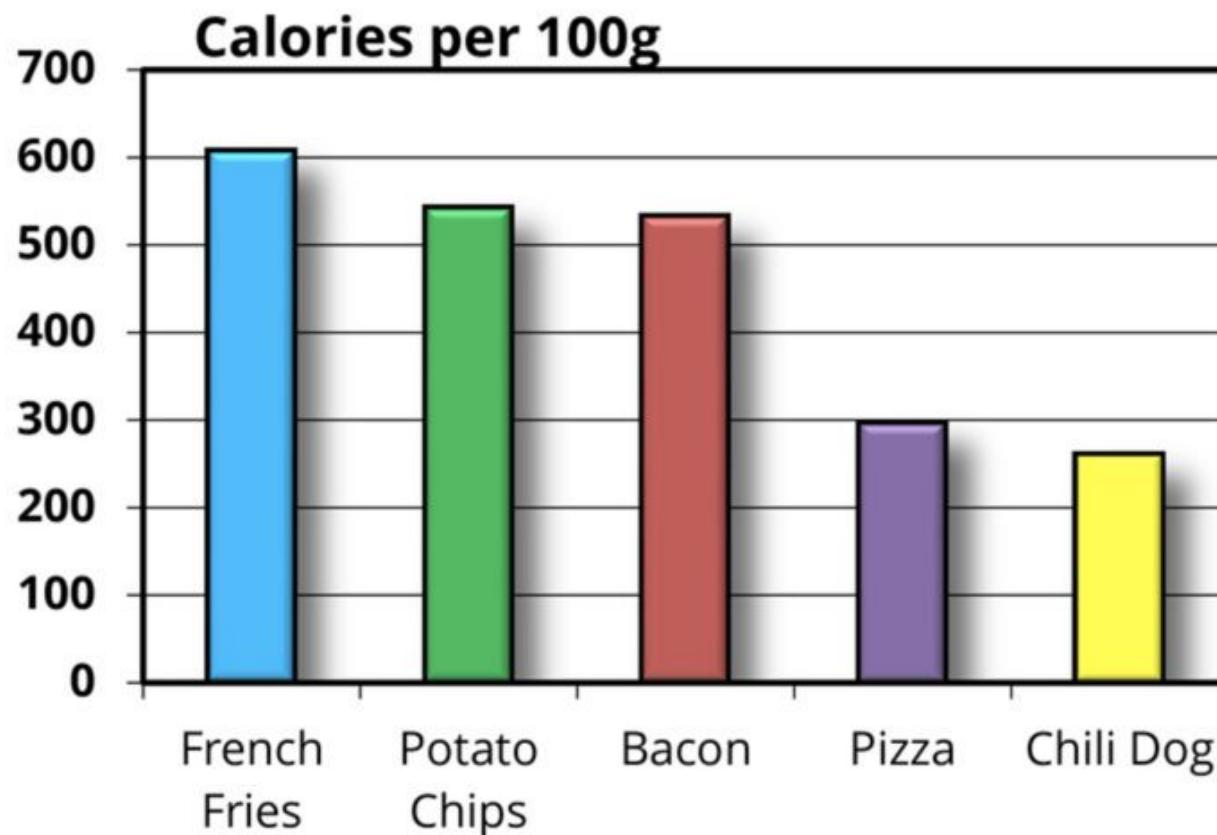
# Remove redundant labels



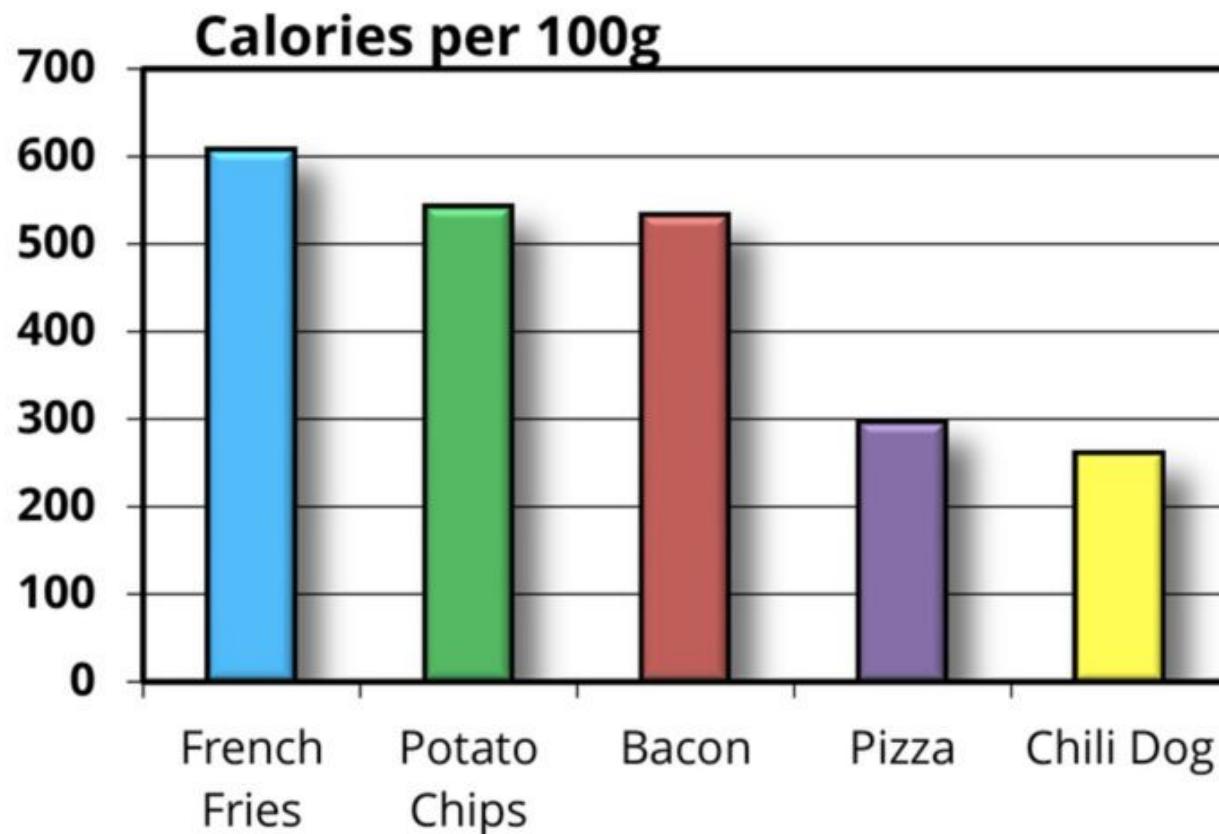
# Remove redundant labels



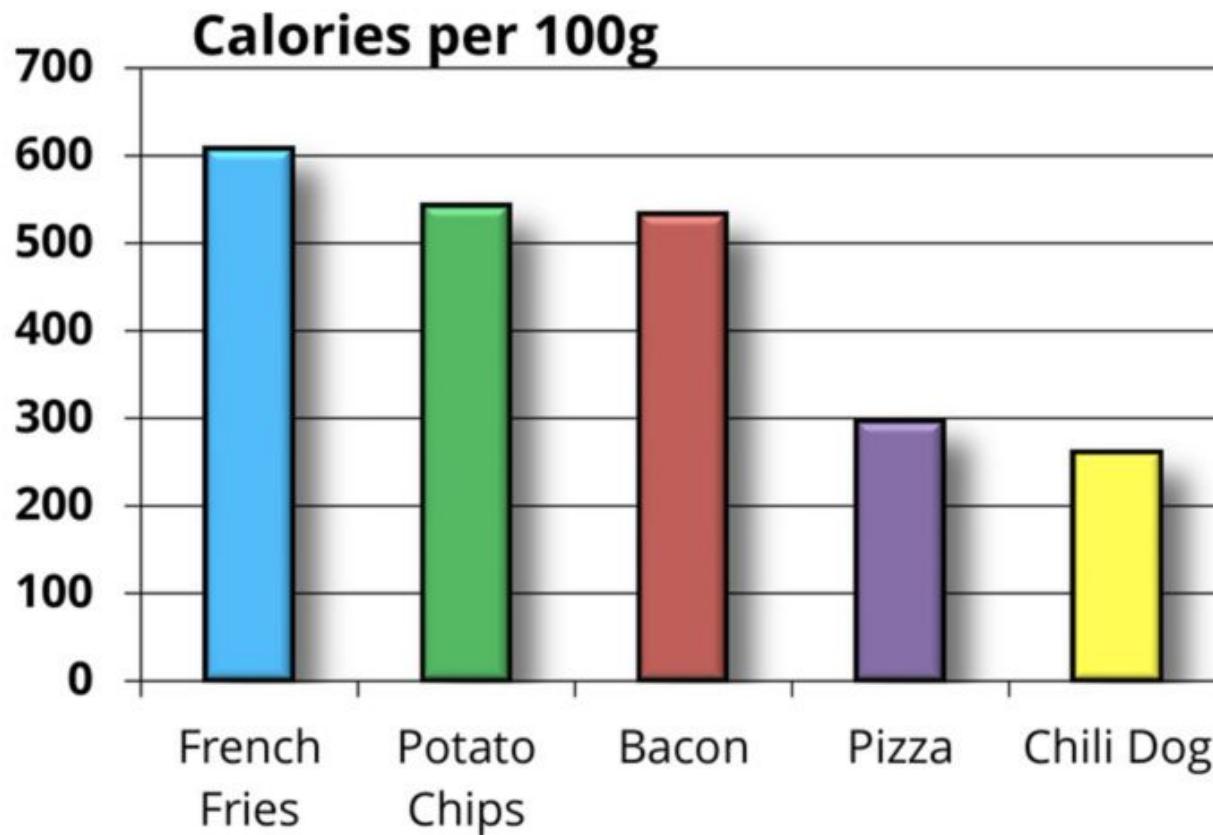
# Remove borders



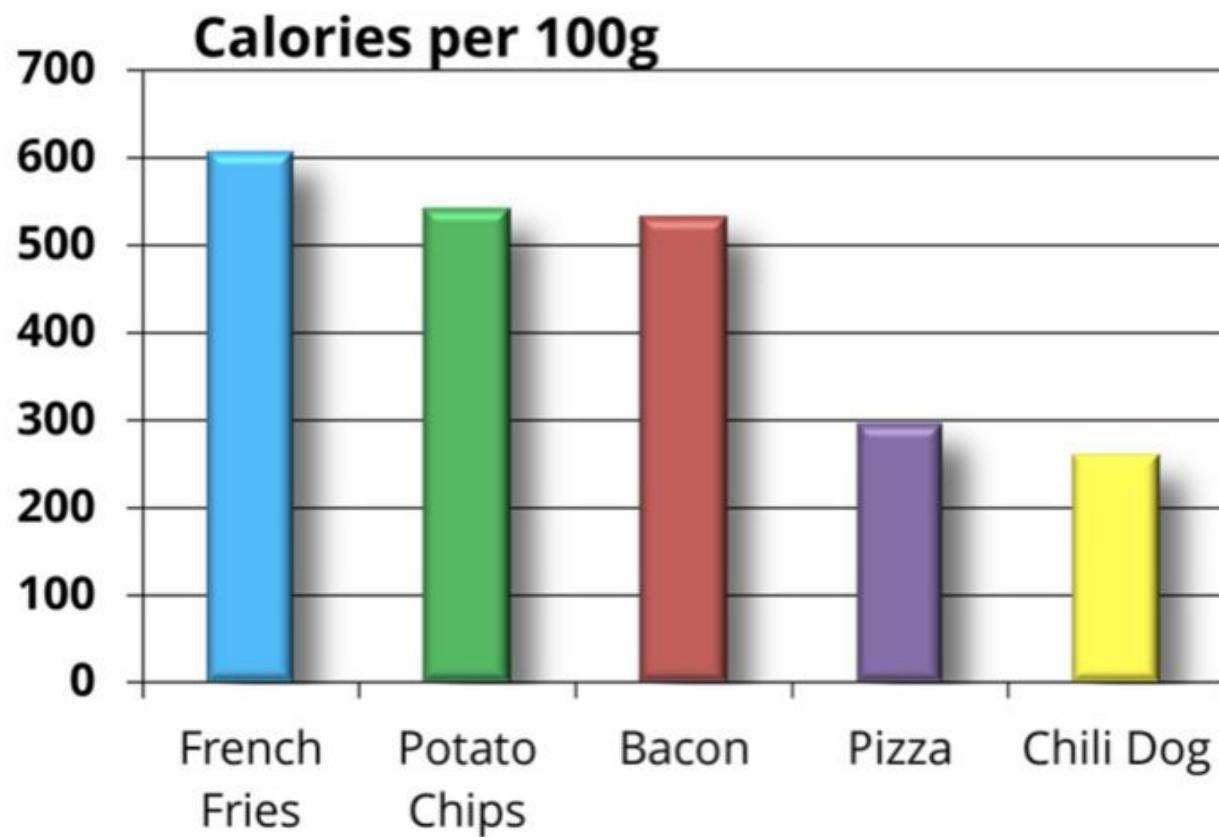
# Remove borders



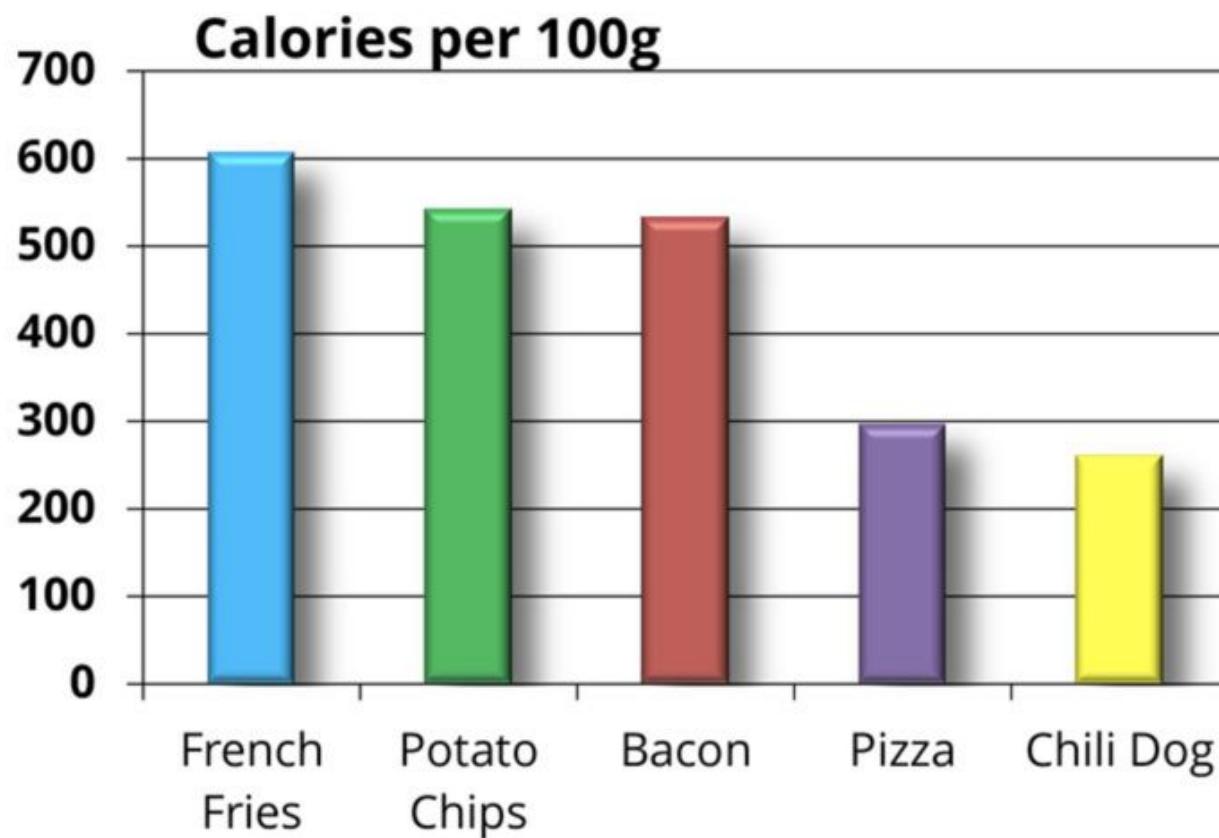
# Remove borders



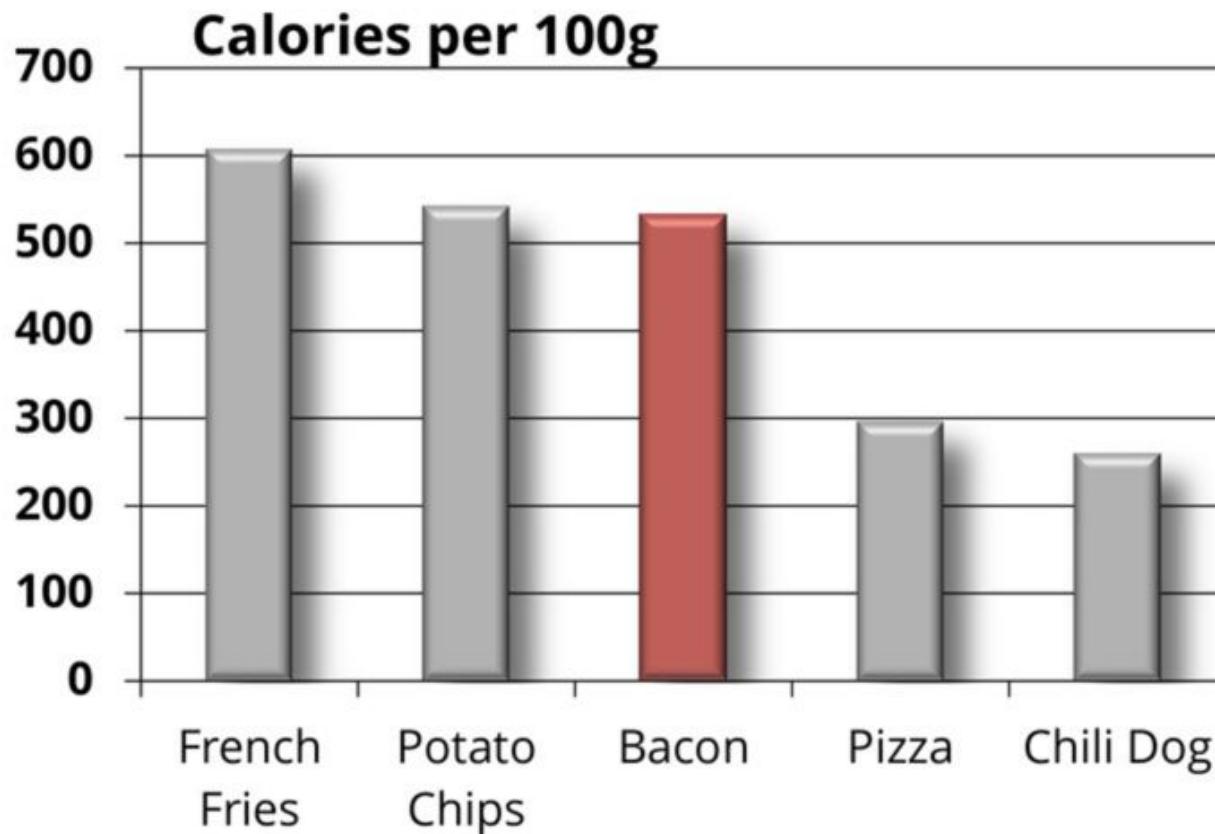
# Remove borders



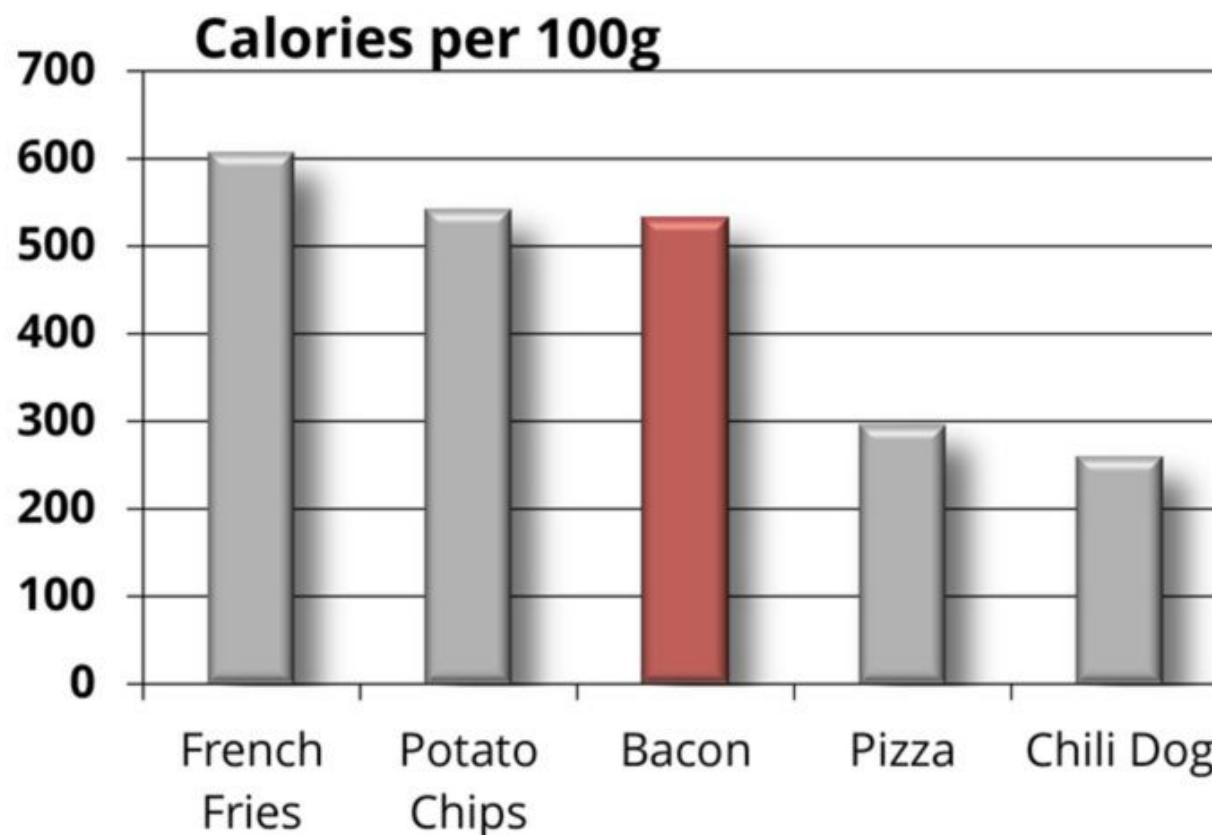
# Reduce colors



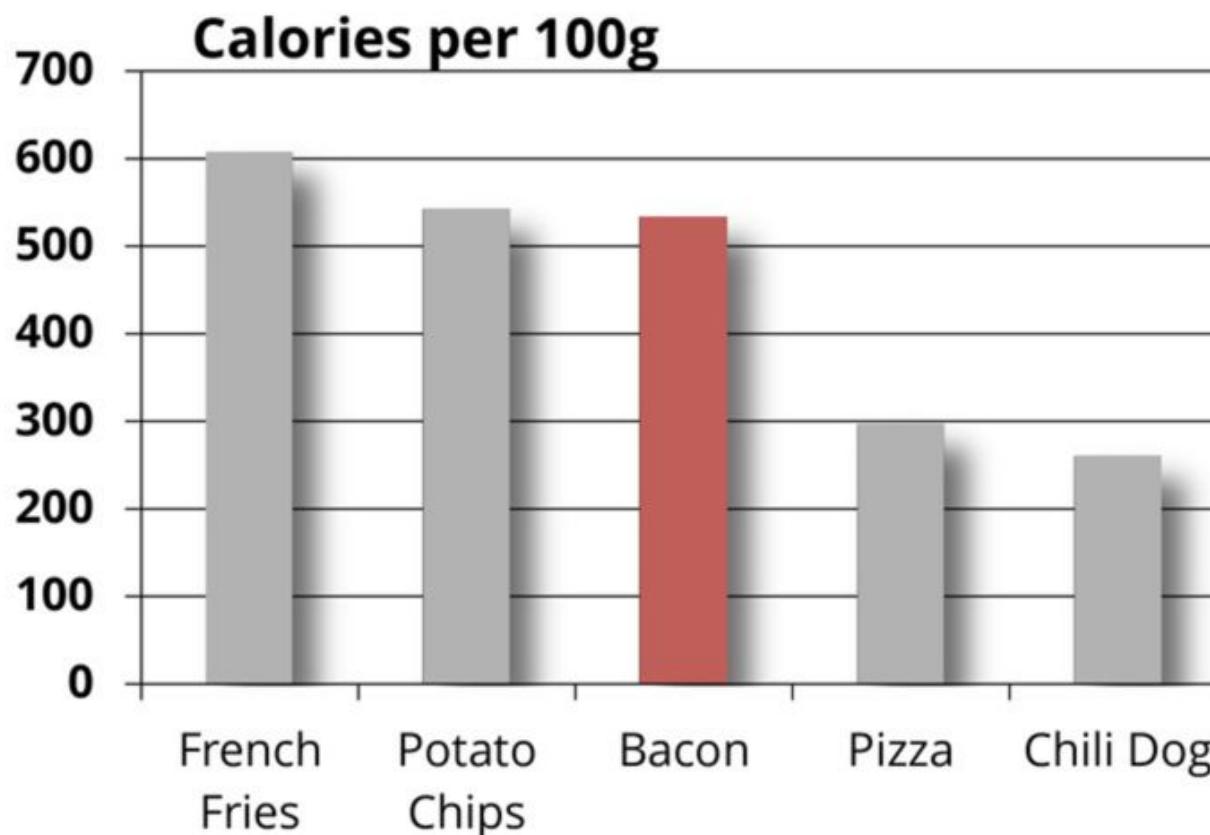
# Reduce colors



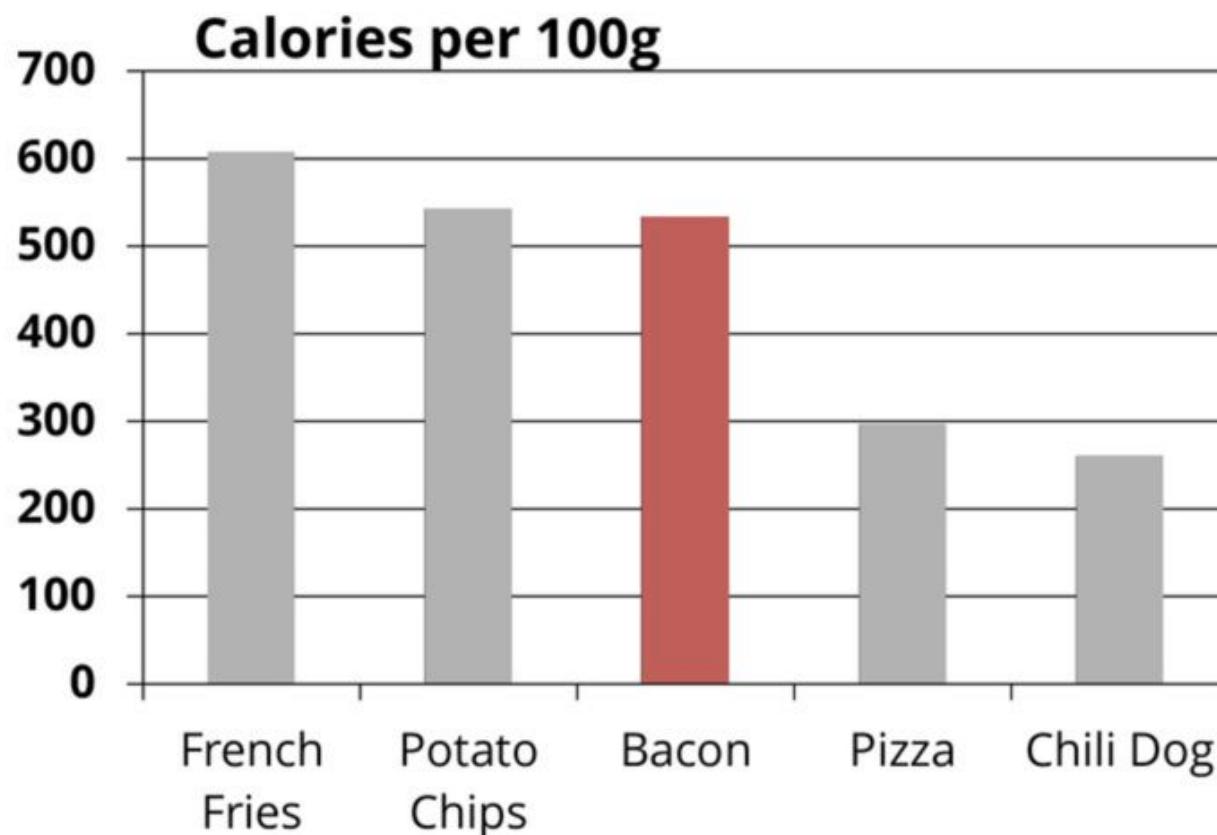
# Remove special effects



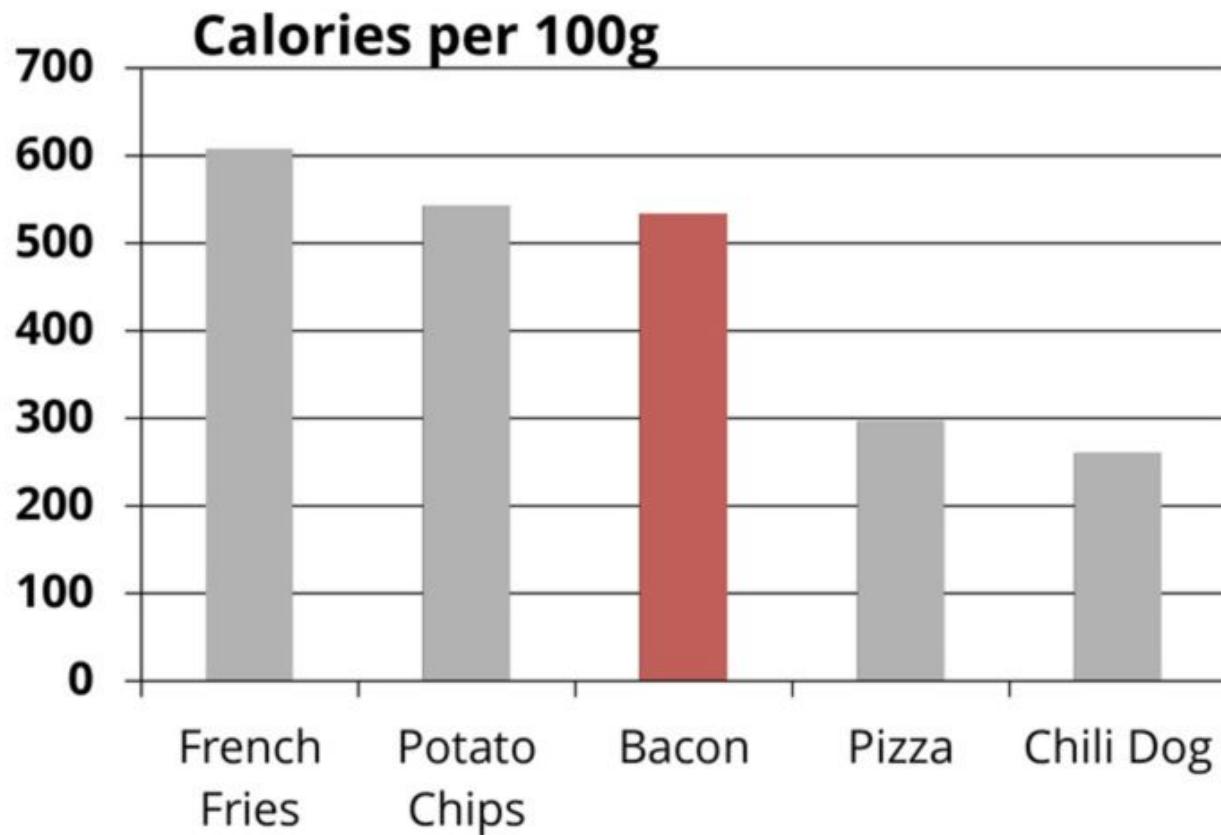
# Remove special effects



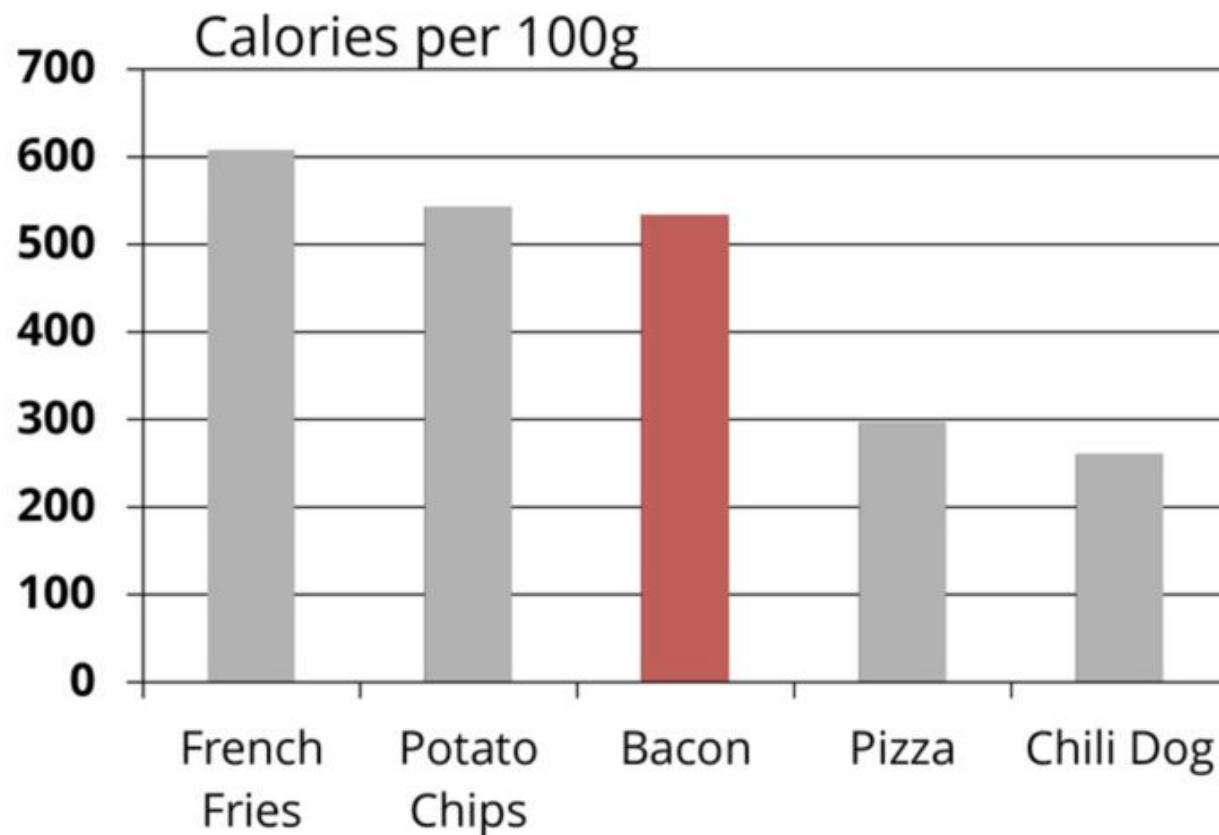
# Remove special effects



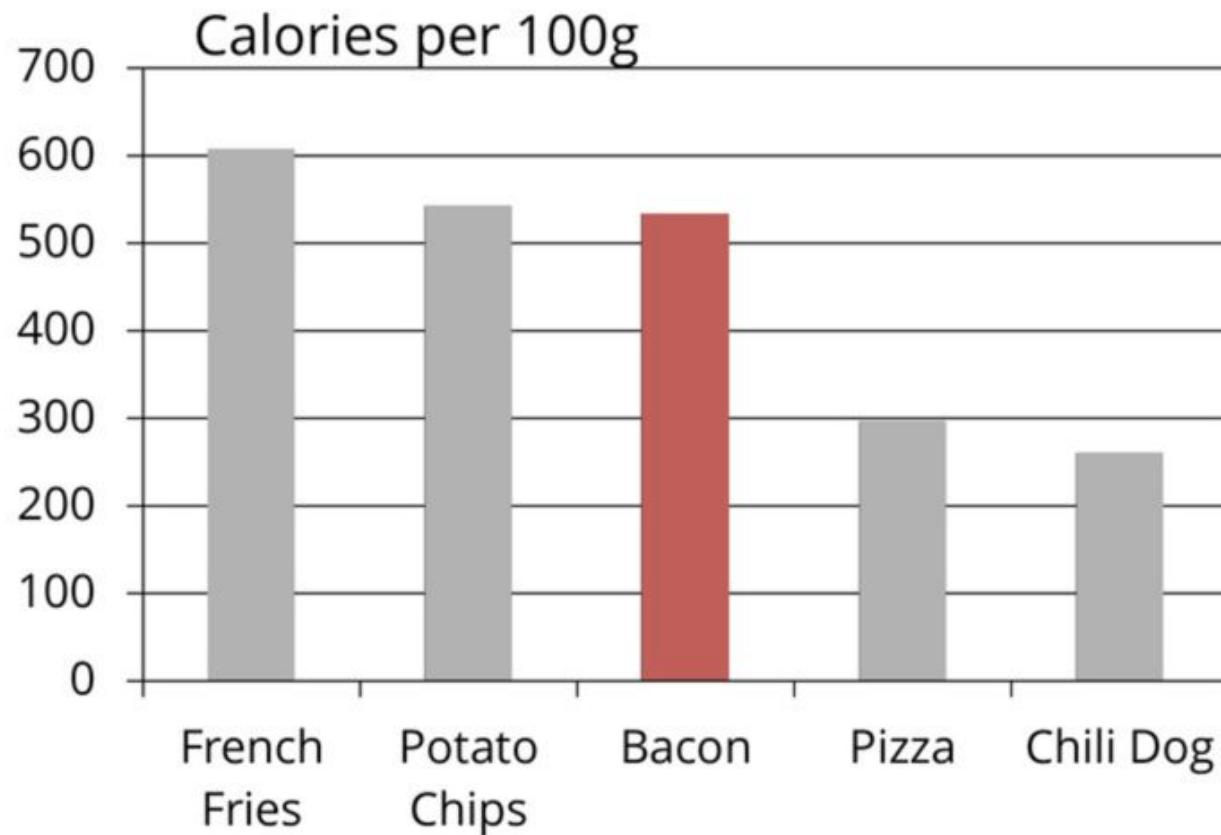
# Remove bolding



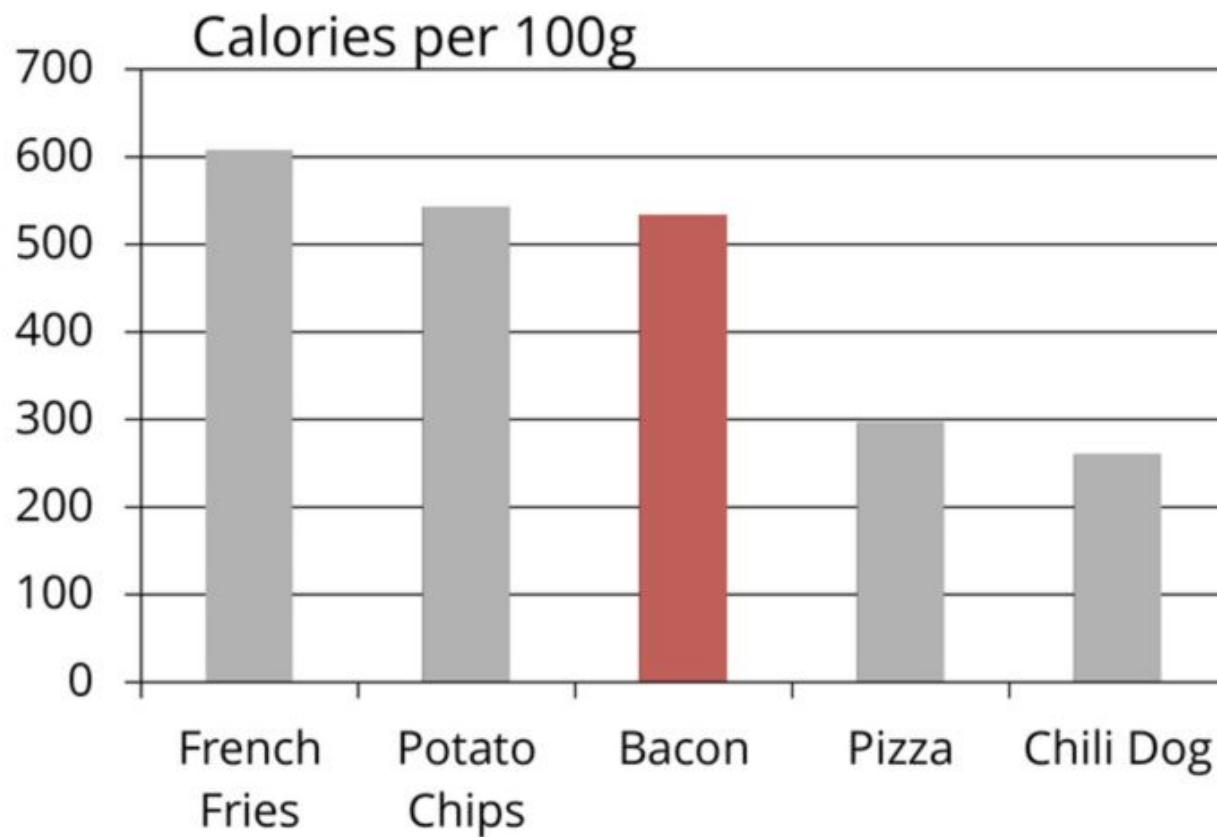
# Remove bolding



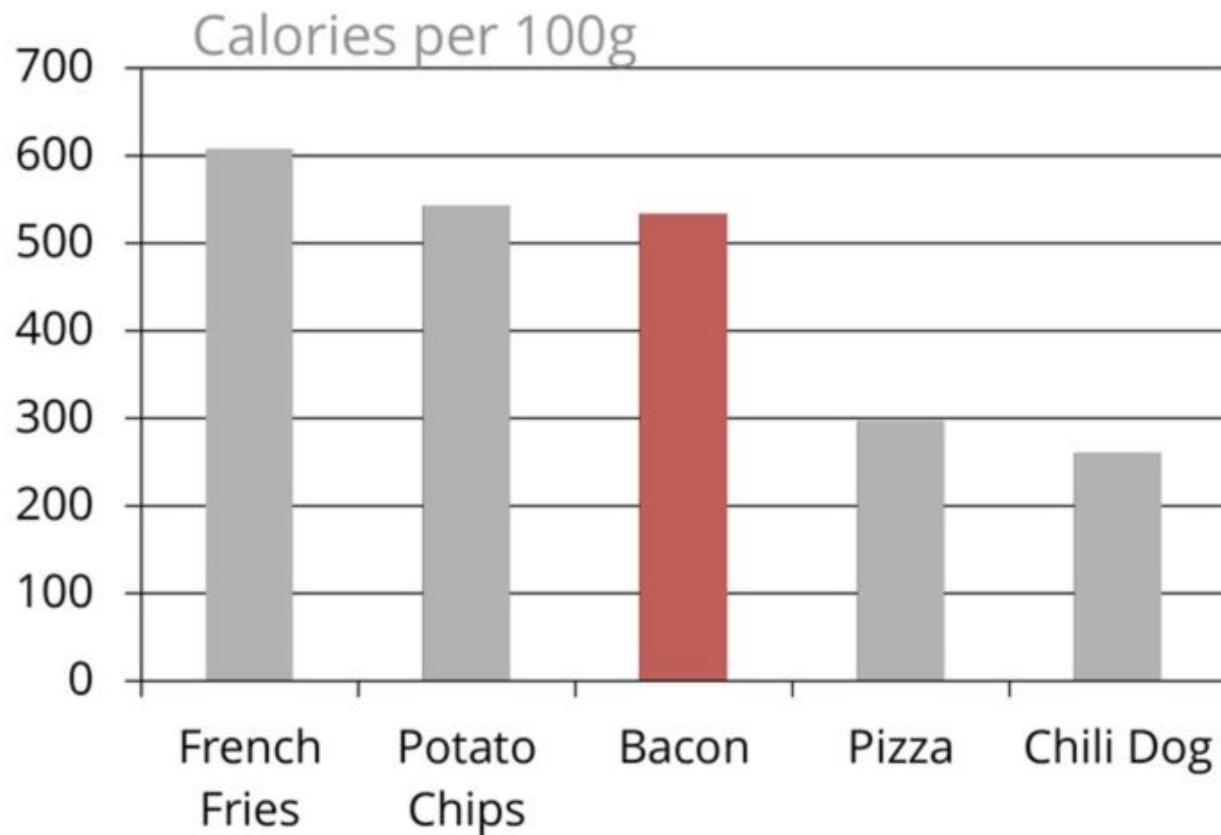
# Remove bolding



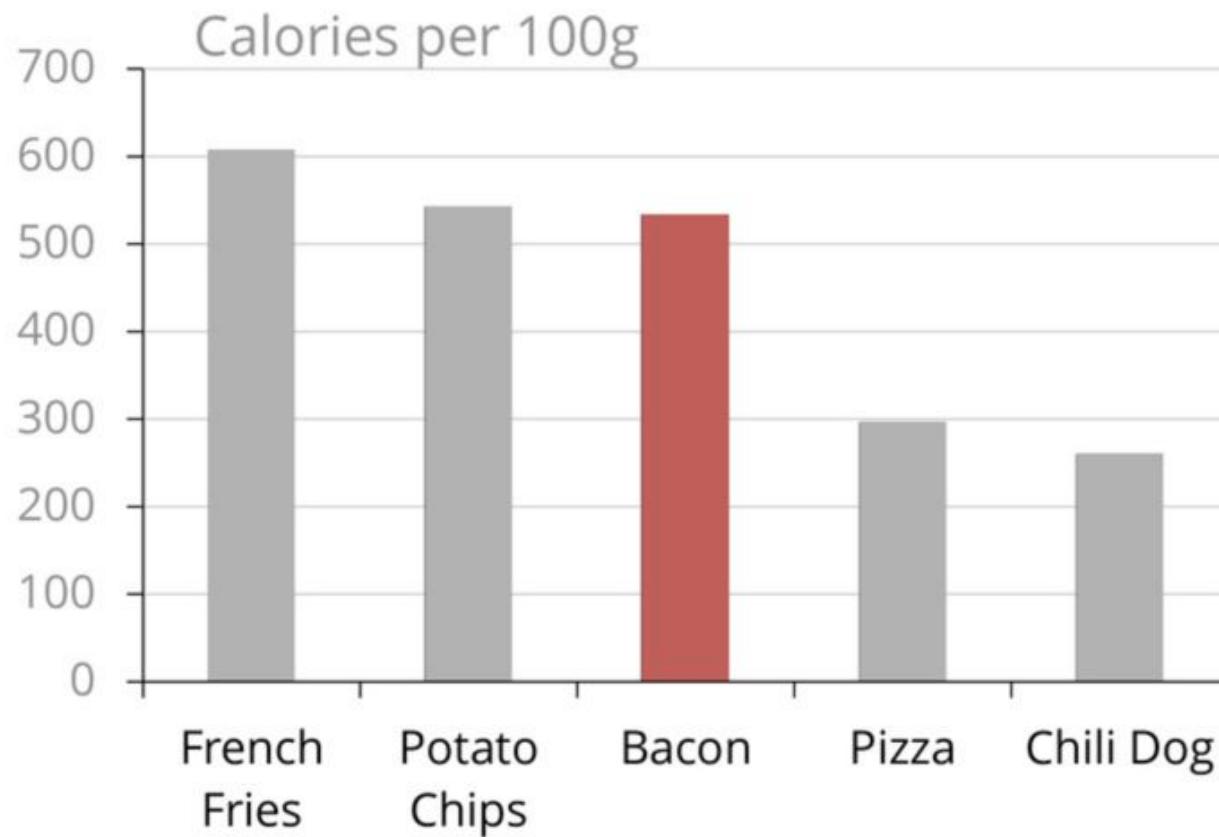
# Lighten labels



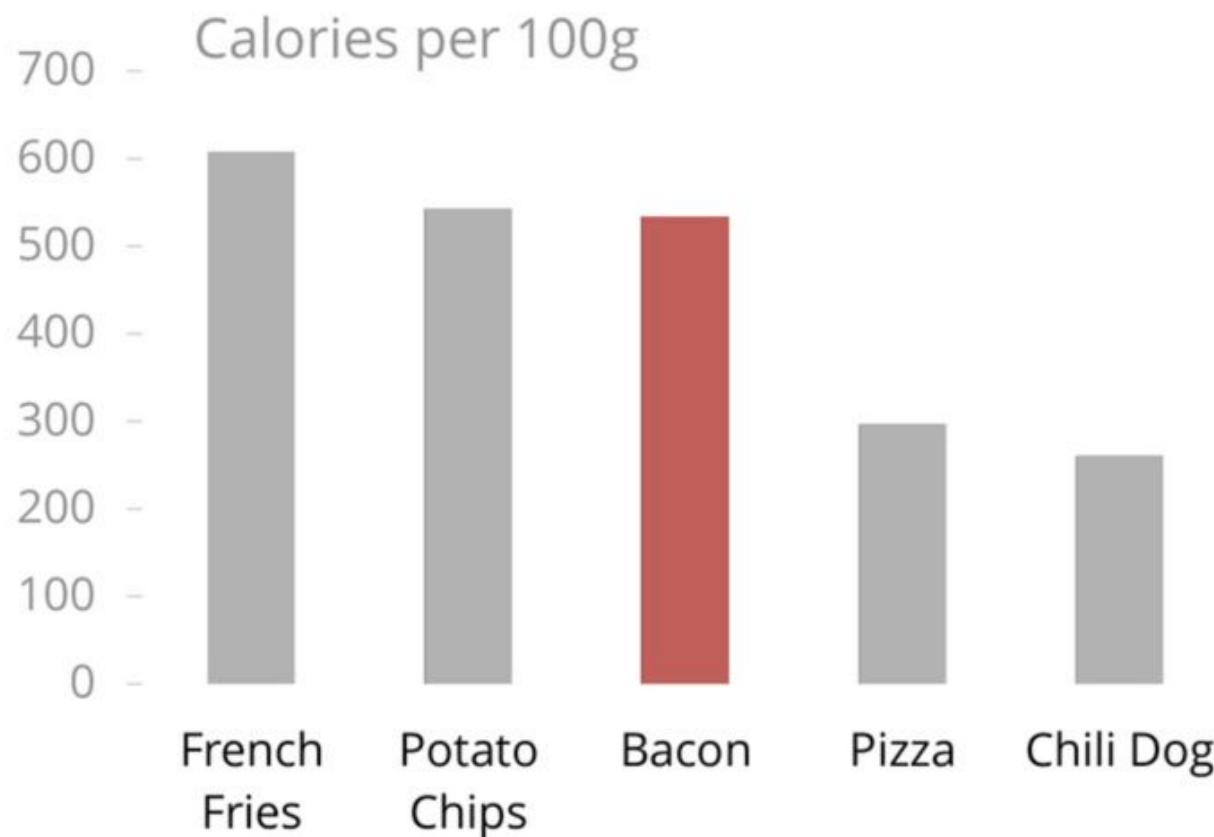
# Lighten labels



# Lighten lines

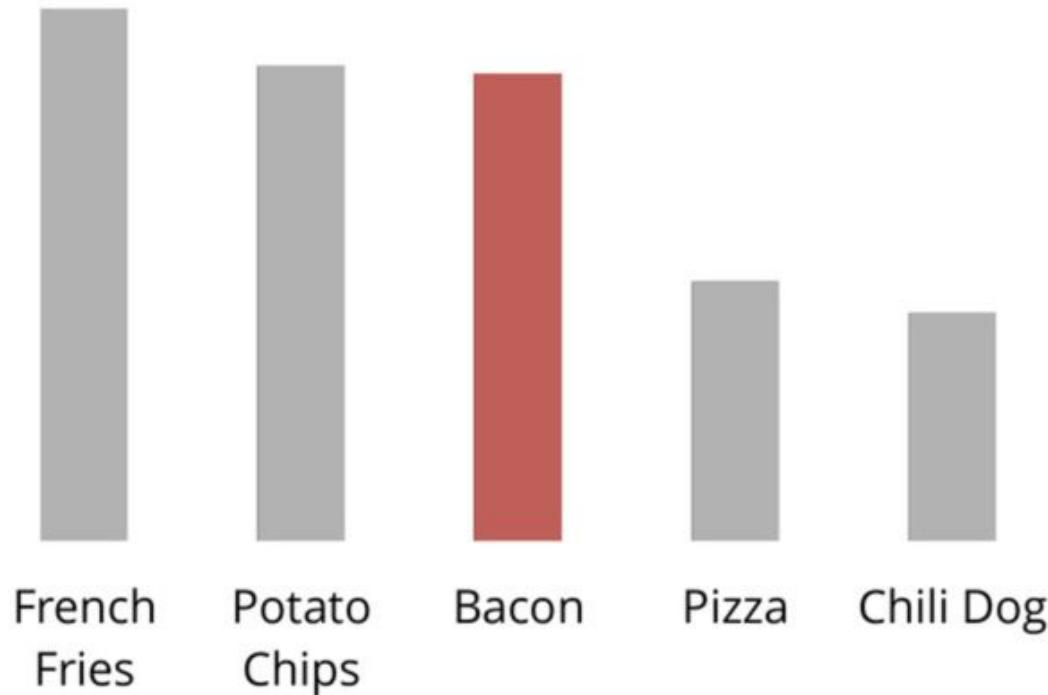


# Direct label

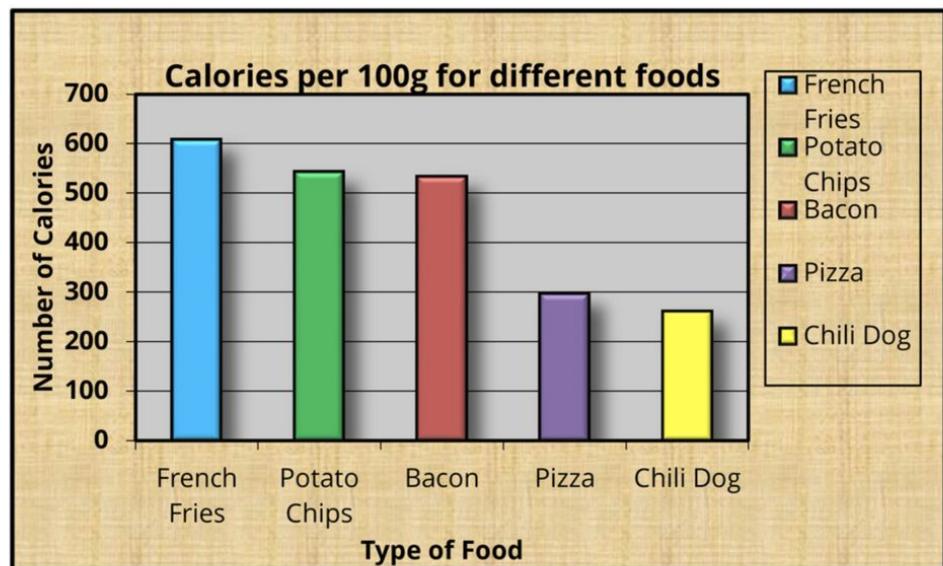


# Direct label

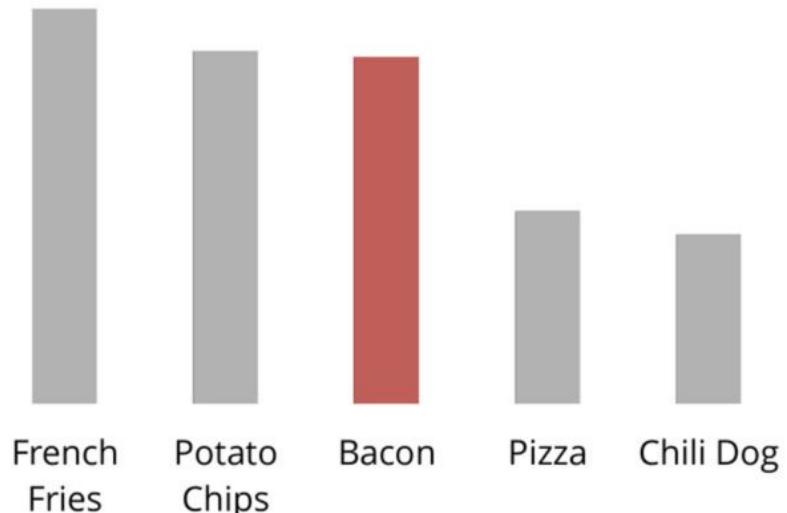
Calories per 100g



# Data-ink ratio



Calories per 100g

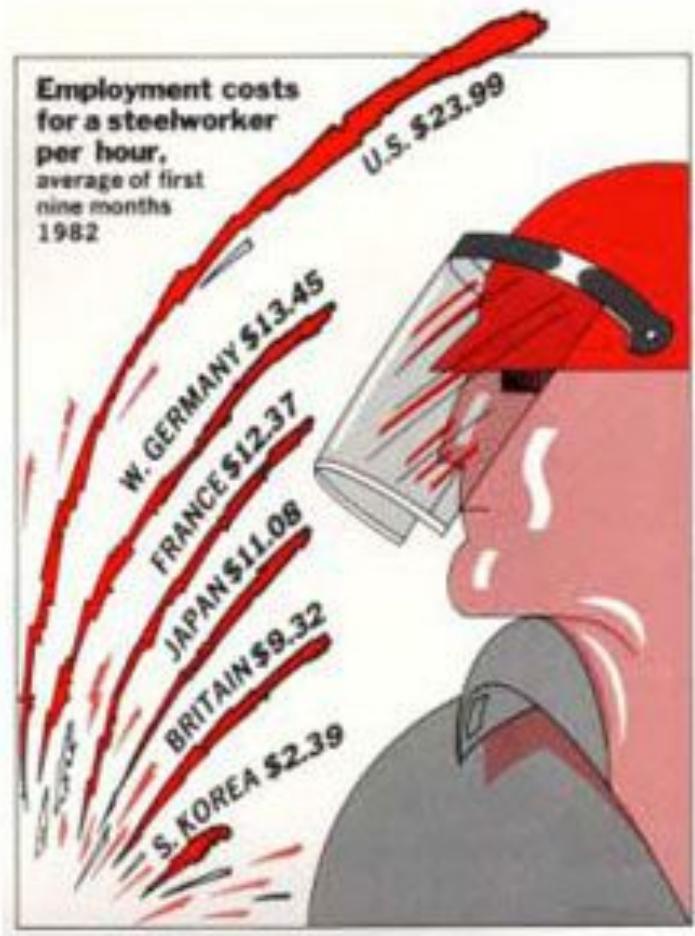


## **Guideline #5**

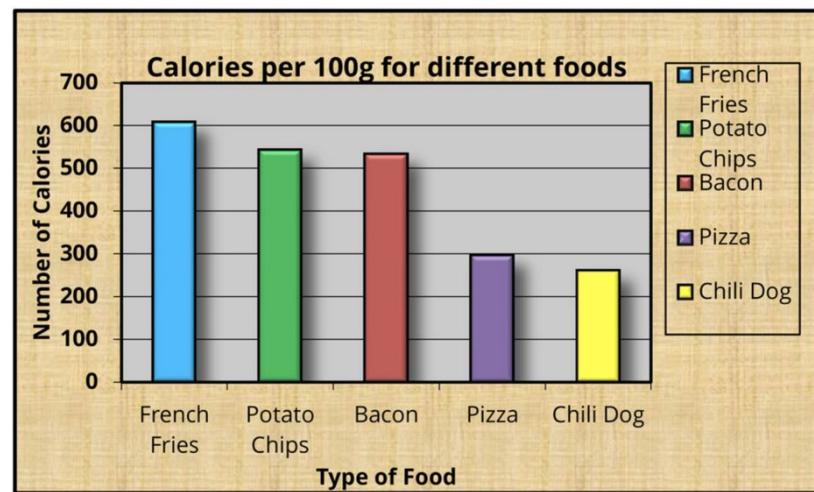
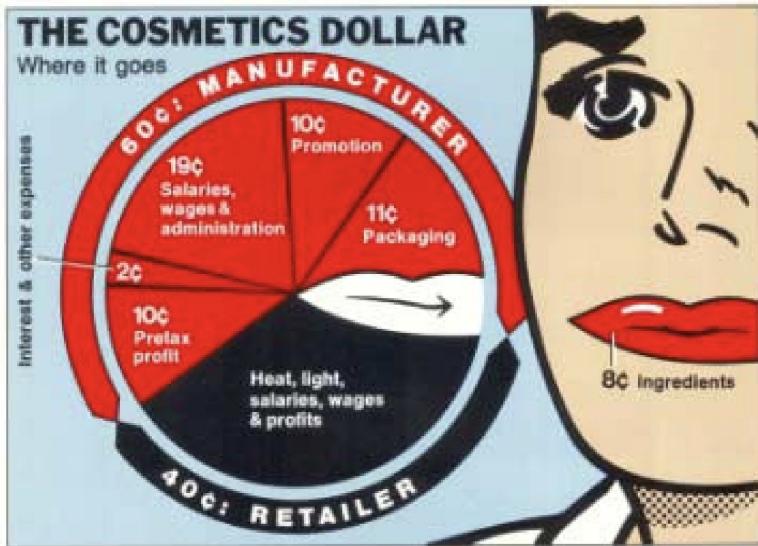
*"Try to optimize your data-ink ratio"*

**Exception:** ...

# Embellishment: Metaphors



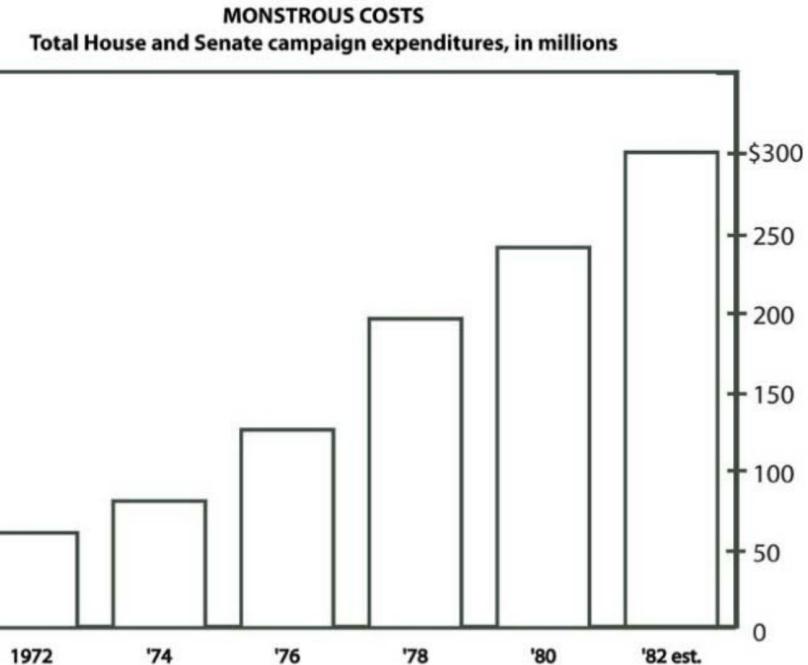
# Embellishment



Metaphor

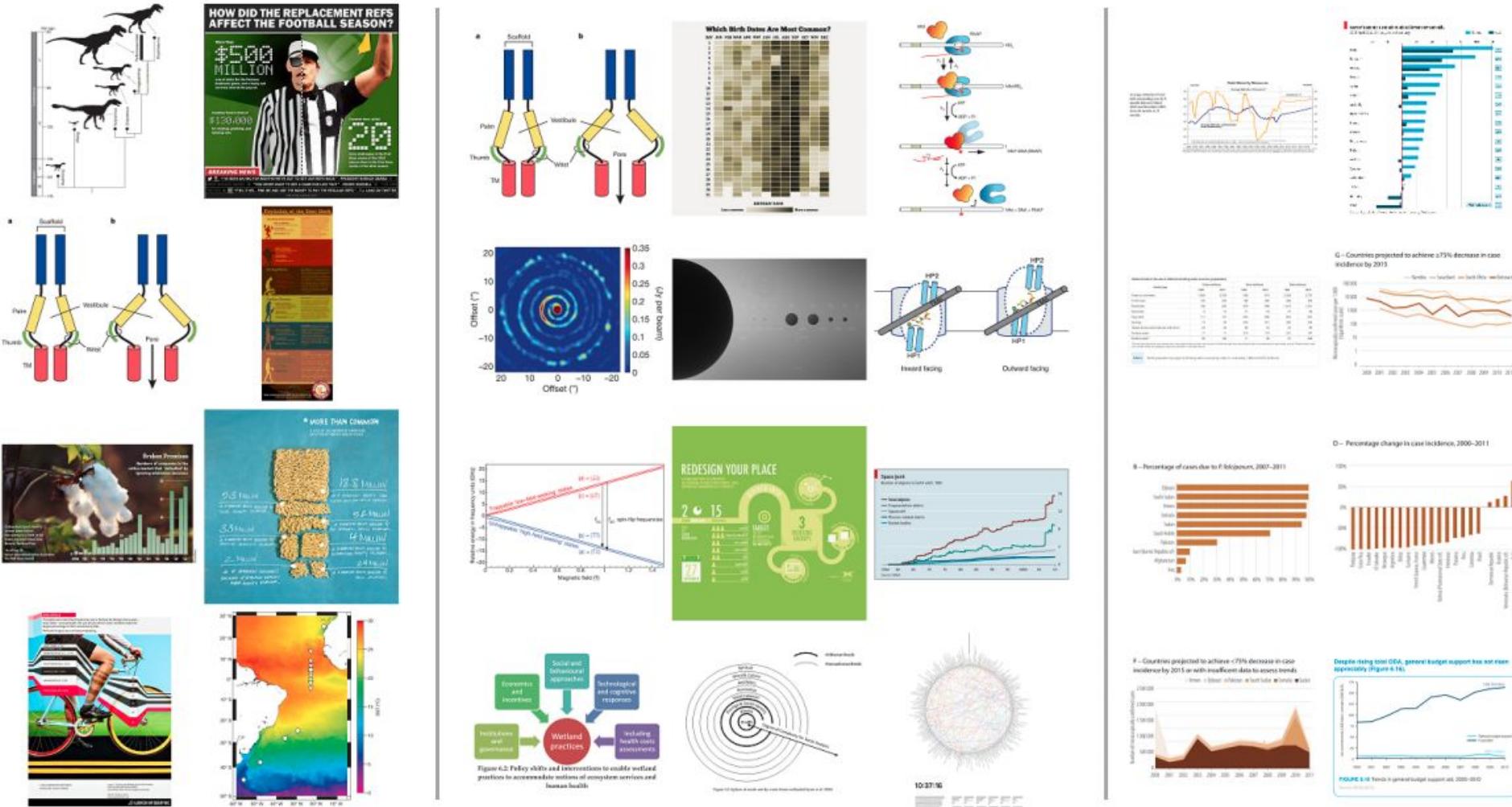
Distractors

# Embellishment



Understanding of embellished charts not worse, but recall after some weeks, much higher.

# What makes a chart memorable?



# What makes a chart memorable?



Top 10 most memorable: top-left to bottom right for each category.

# What makes a chart memorable?

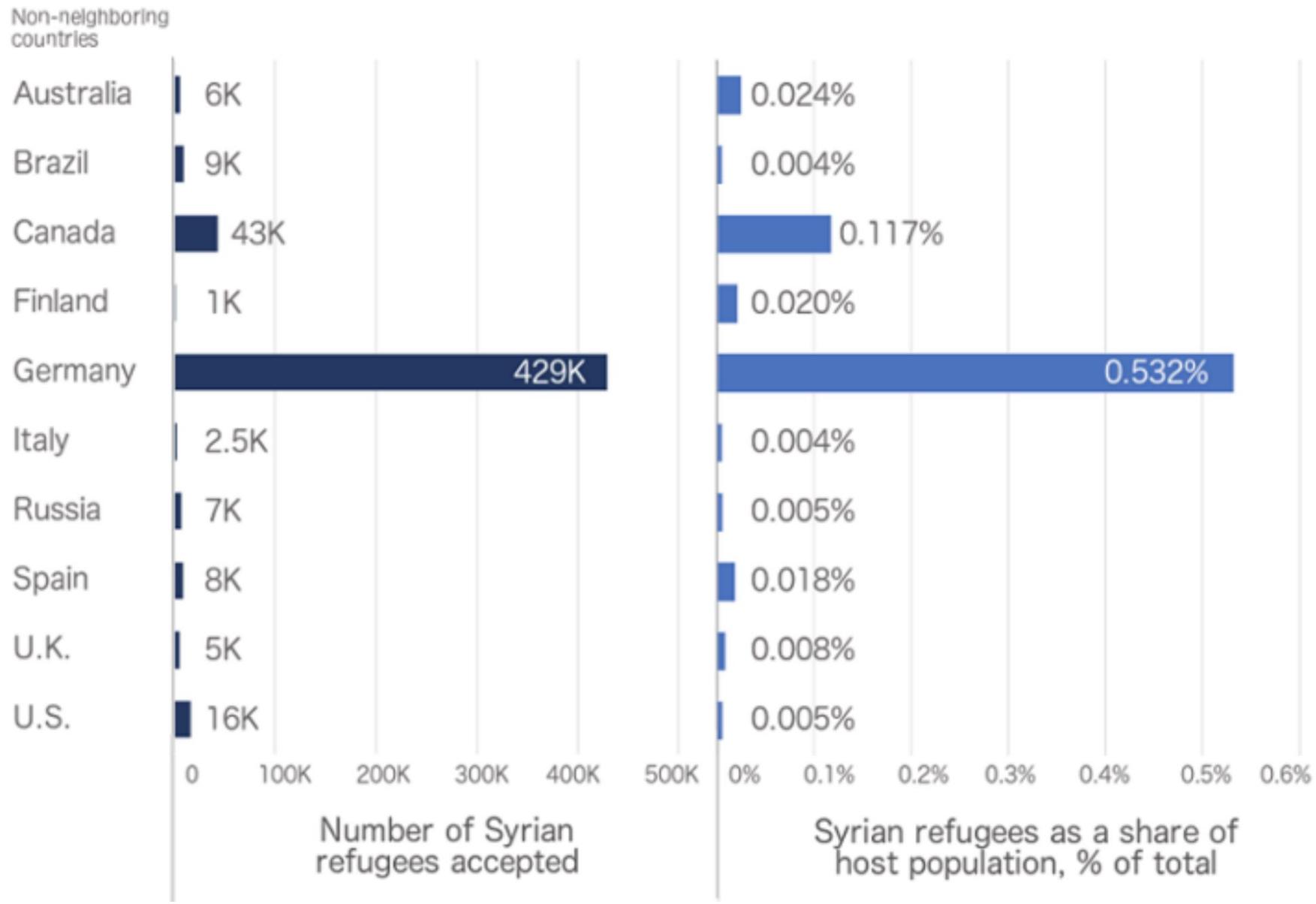
- Color
- Human recognizable objects
- Low data-ink ratio
- Unique visualization types < common graphs

## Guideline #6

*"Add embellishment carefully to make your graphic memorable and enjoyable"*

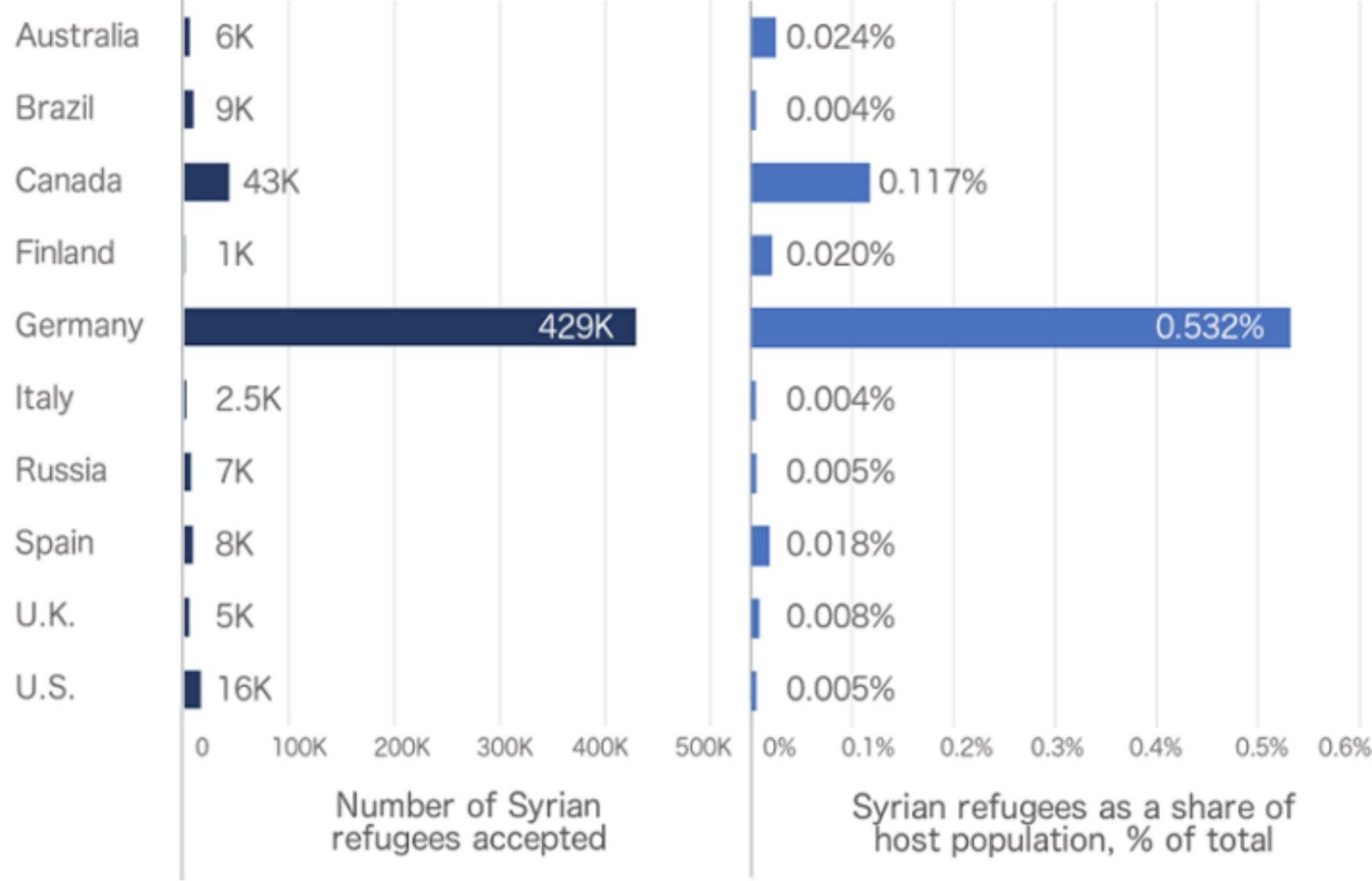
**Exceptions:** Unless it clutters your visualization and obstructs the message.

# Letting in Potential Killers?



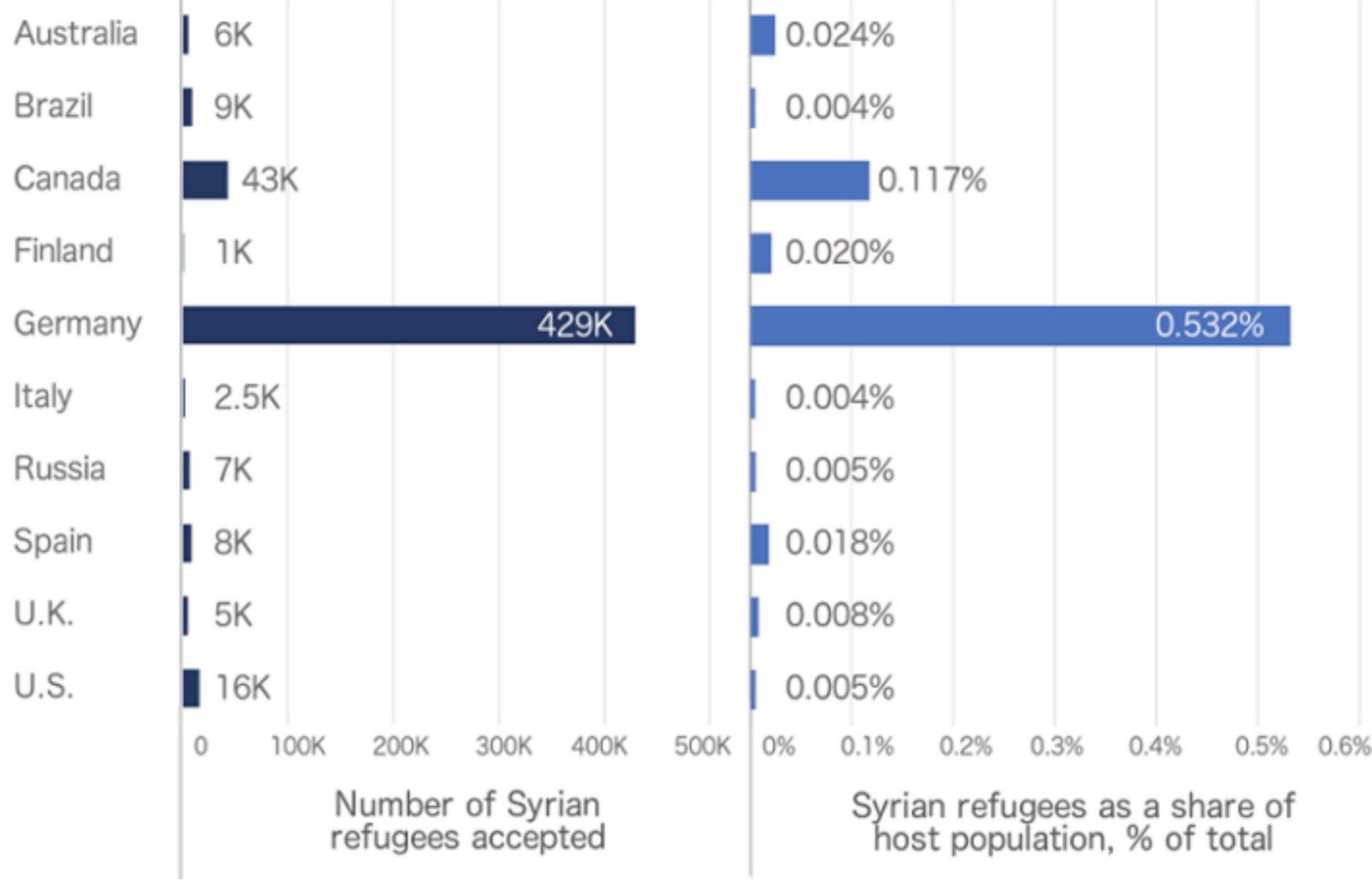
# We must do our share!

Non-neighboring countries



# Syrian Refugee Distribution:

Non-neighboring countries



## **Guideline #7**

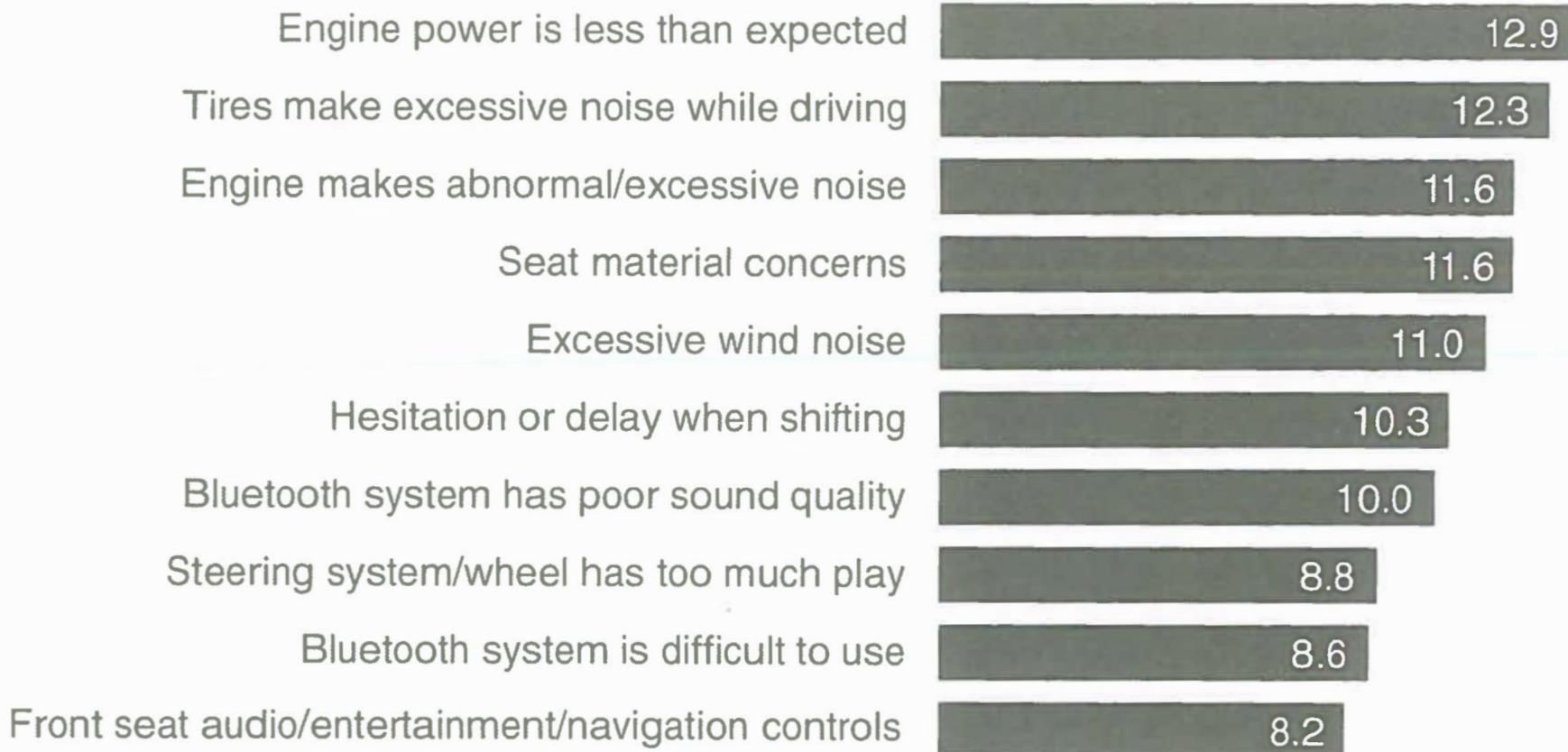
*"Choose a title appropriate to your message or data – it will prime your reader. "*

**Exceptions:** none

# Highlight

## Top 10 design concerns

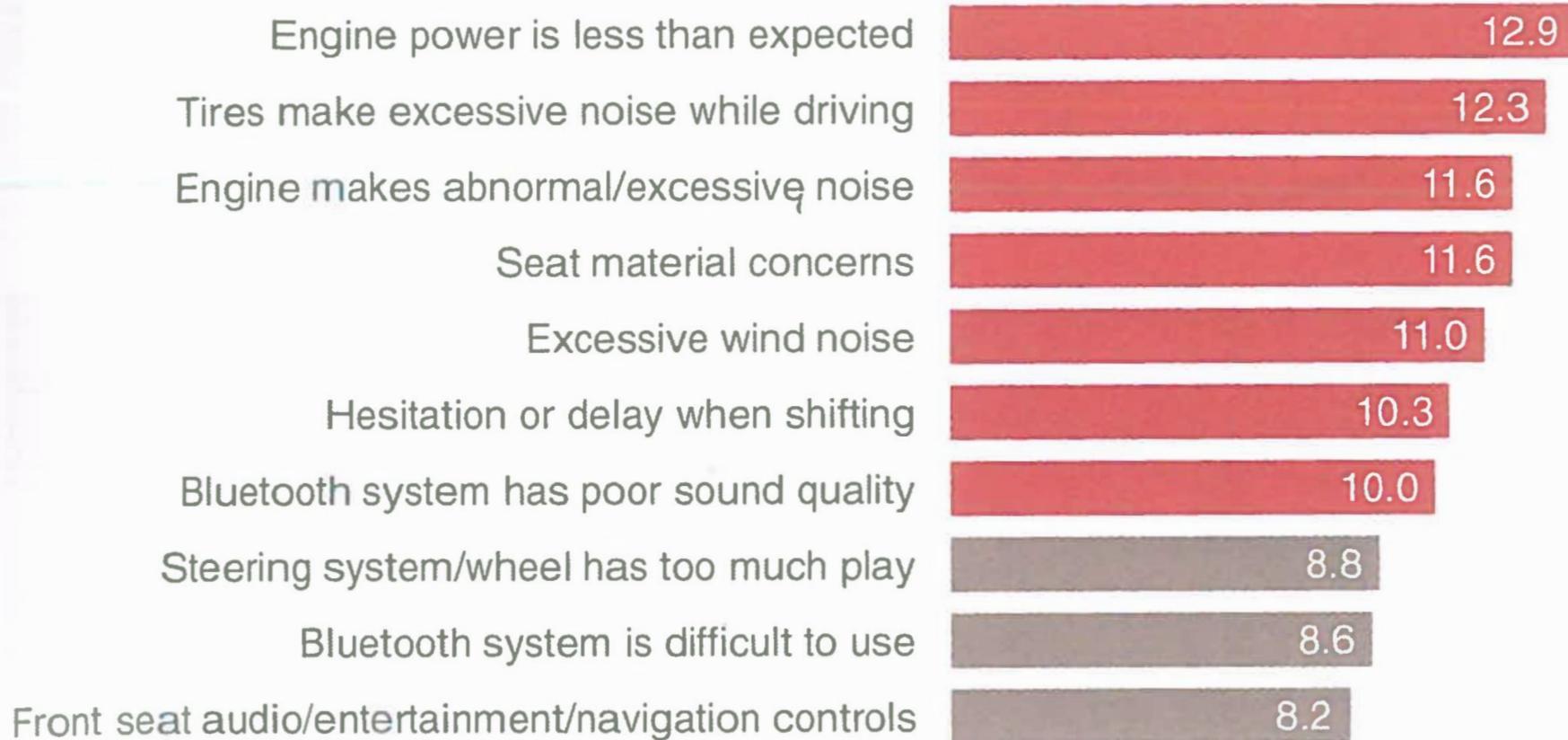
concerns per 1,000



# Highlight

## Top 10 design concerns

concerns per 1,000



# Highlight

## Top 10 design concerns

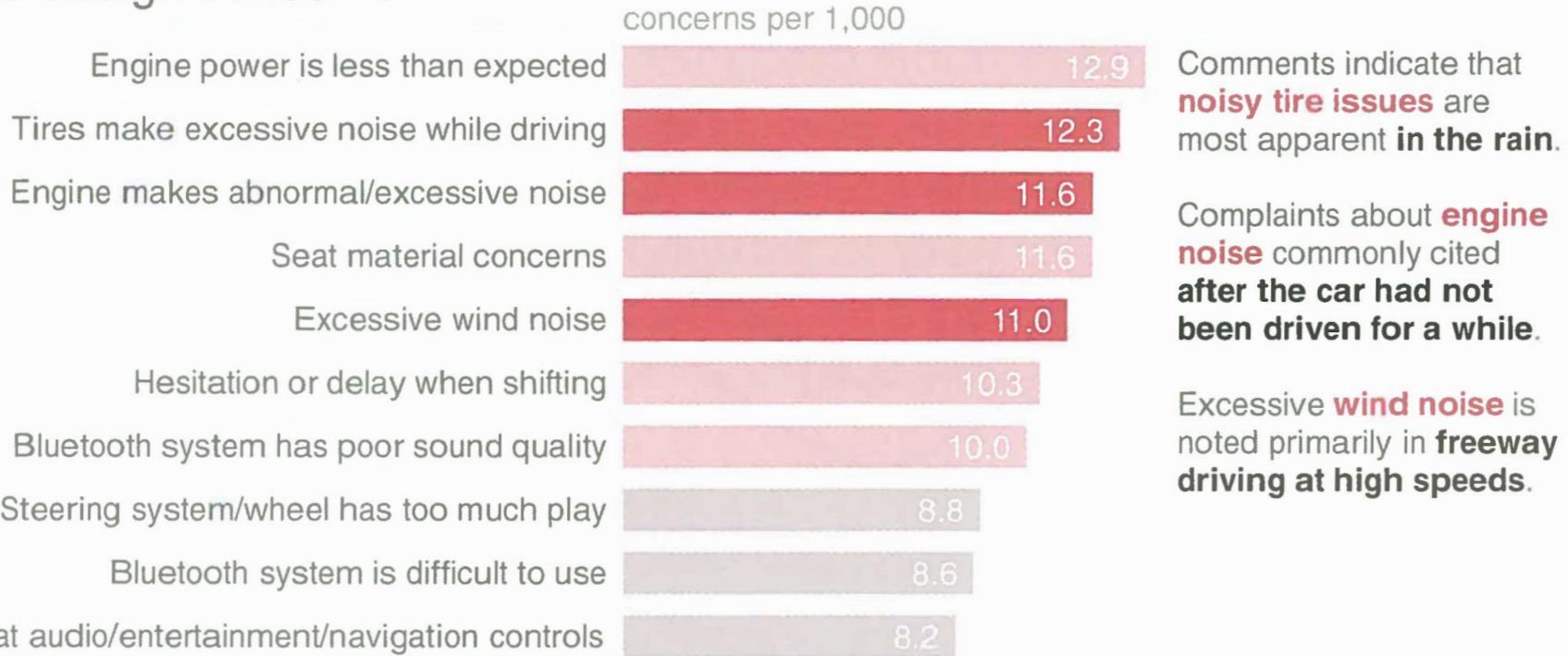
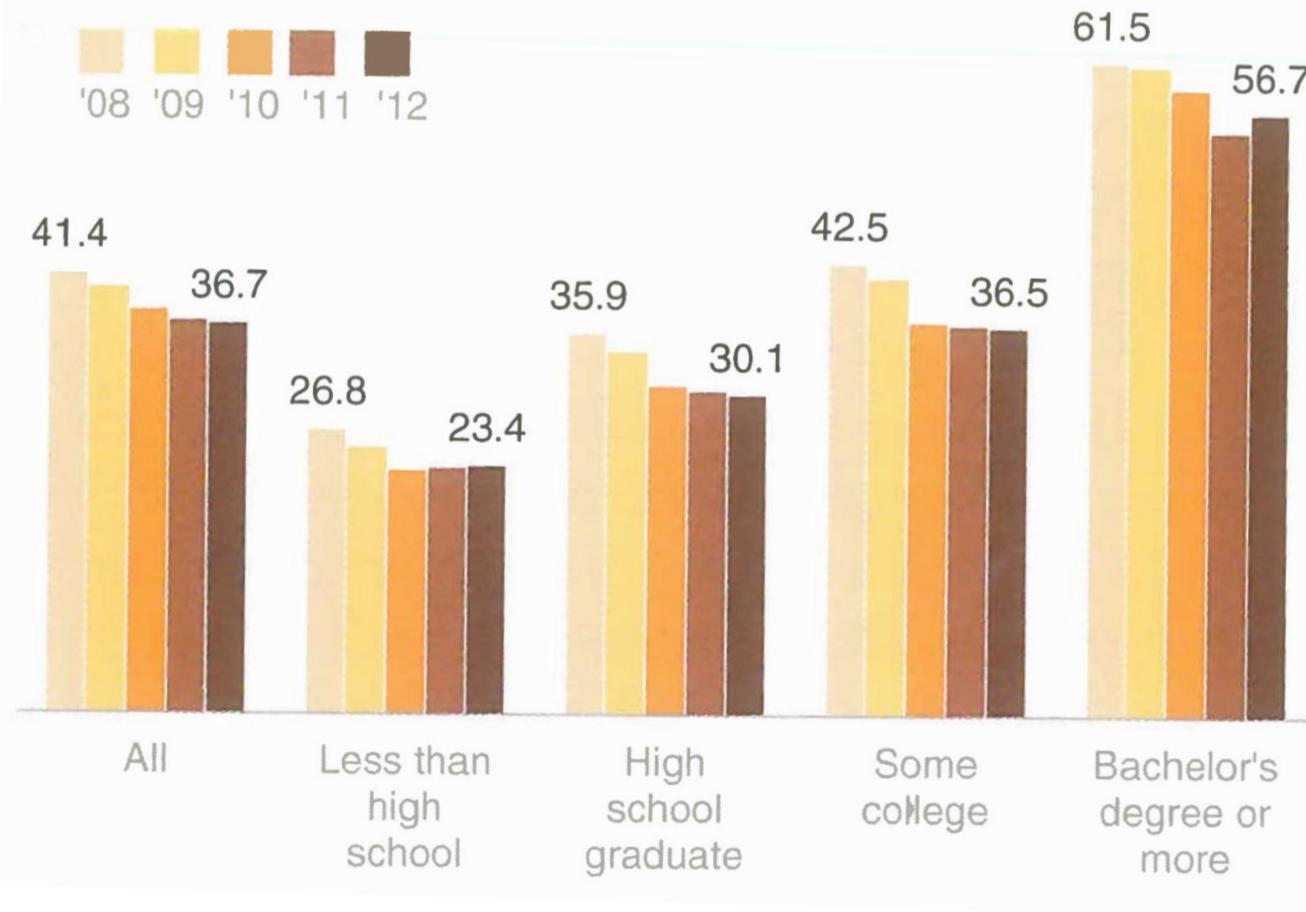


FIGURE 4.9 Create a visual hierarchy of information

# Message

## New Marriage Rate by Education

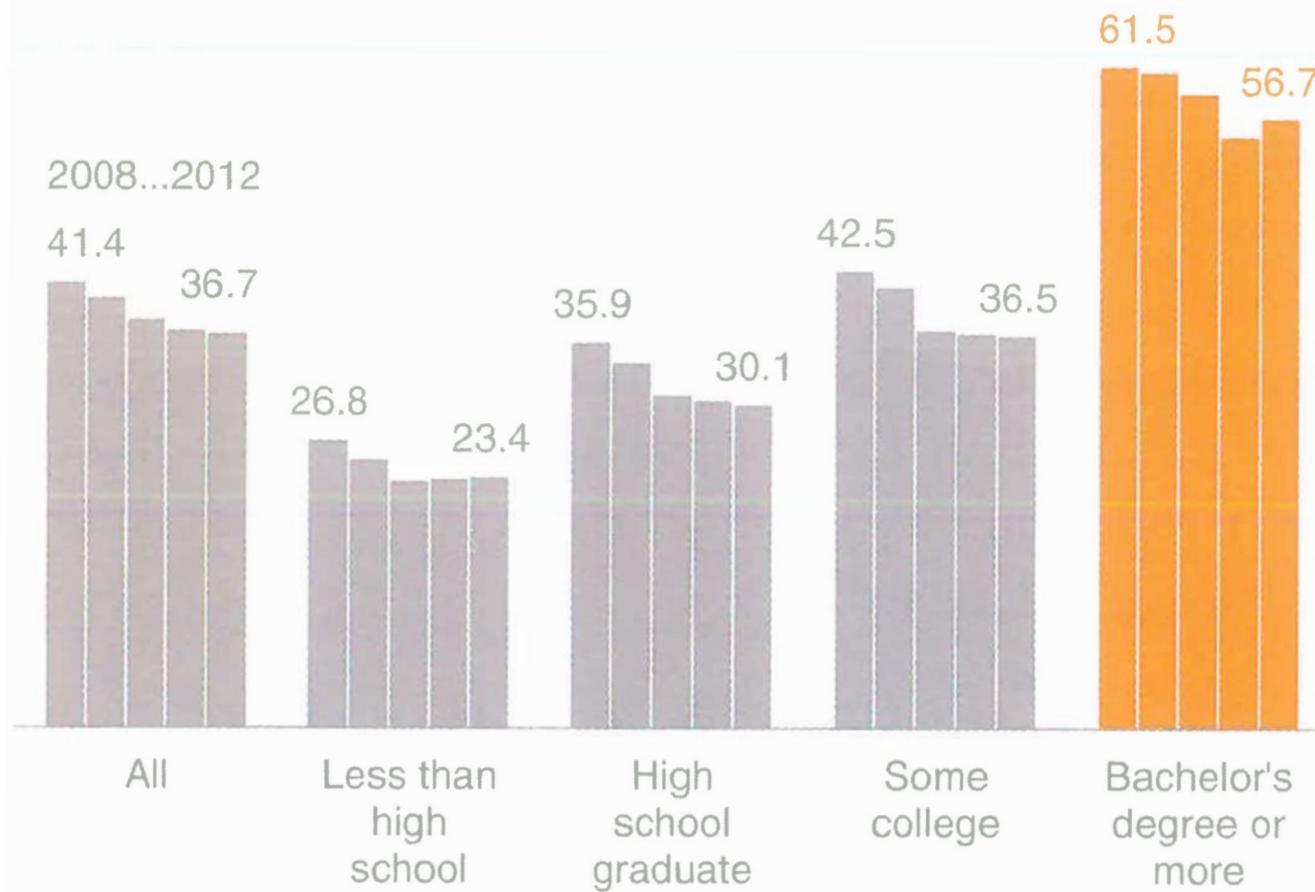
*Number of newly married adults per 1,000 marriage eligible adults*



# Message

## New Marriage Rate by Education

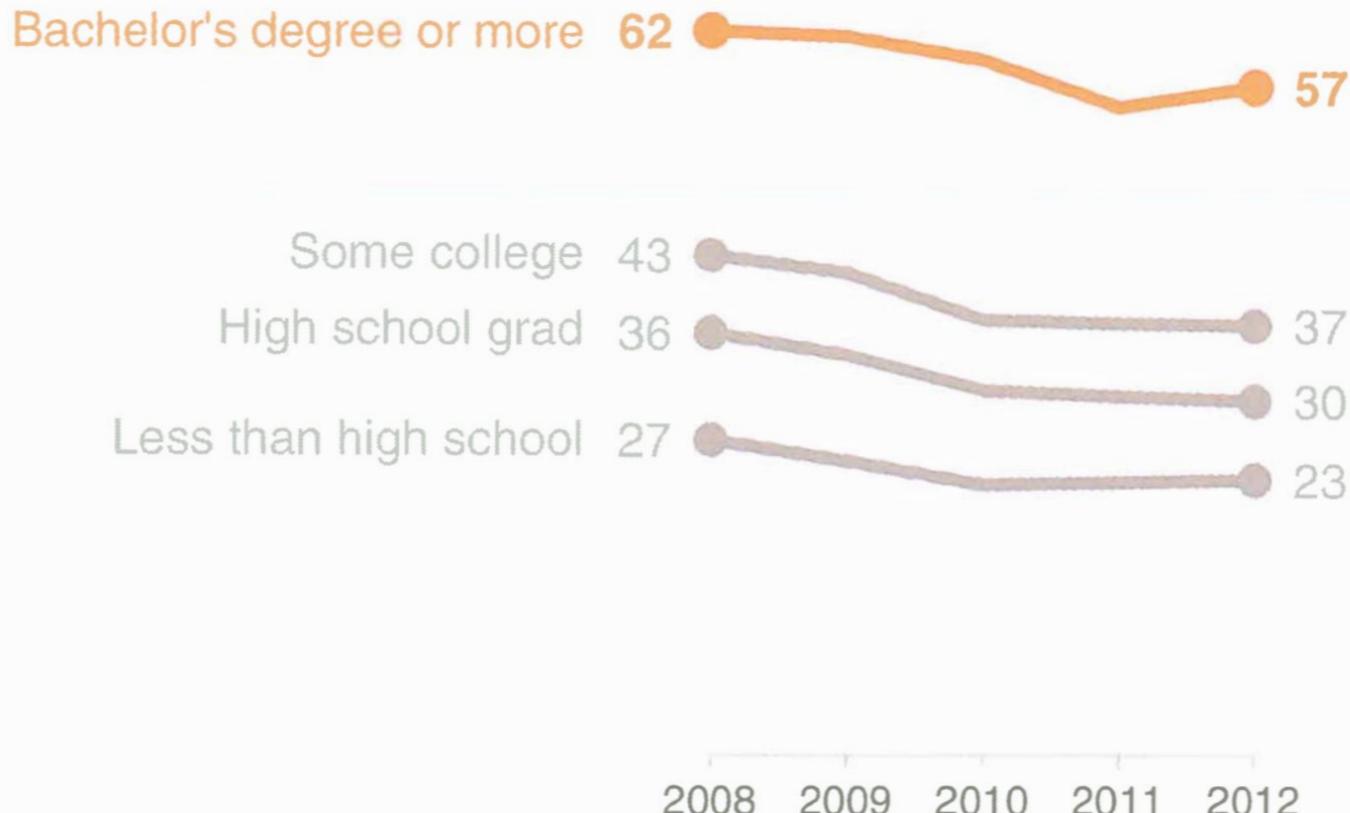
*Number of newly married adults per 1,000 marriage eligible adults*



# Message

## New marriage rate by education

Number of newly married adults per 1,000 marriage eligible adults



## Guideline #8

*"Highlight what is important "*

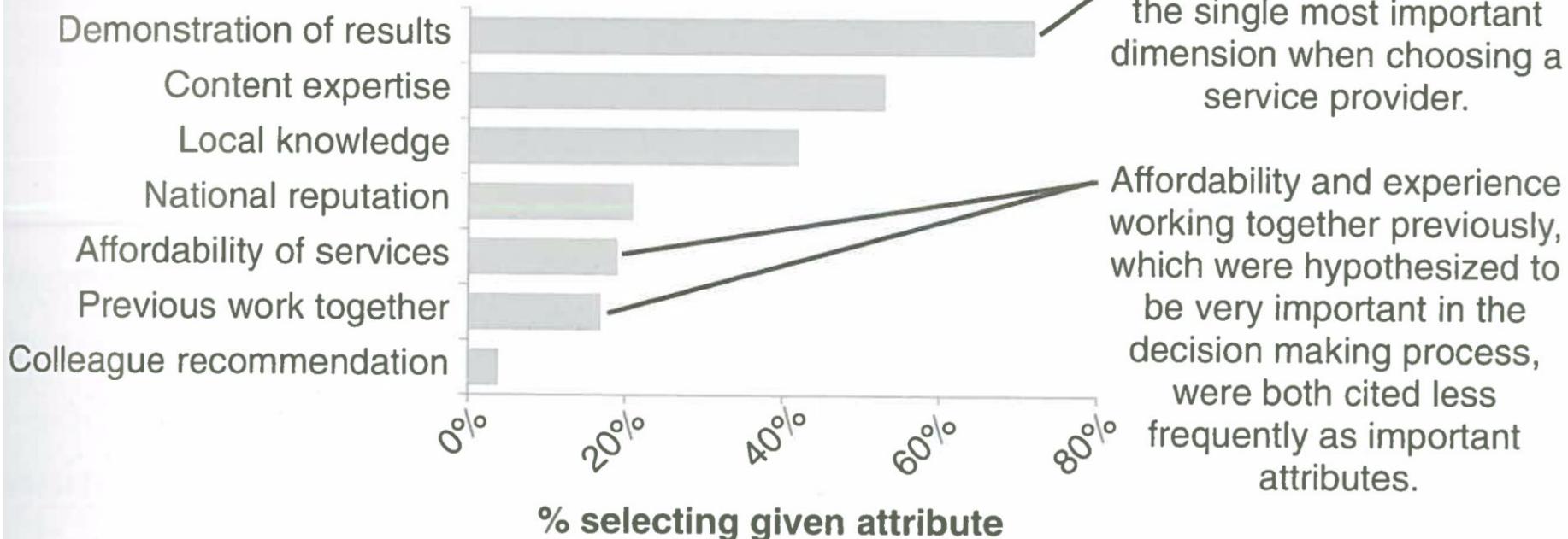
**Exceptions:** except you have too many important things to say:

**Solution:** show another chart (can be the same)

# Layout

## Demonstrating effectiveness is most important consideration when selecting a provider

In general, what attributes are the most important to you in selecting a service provider?  
(Choose up to 3)



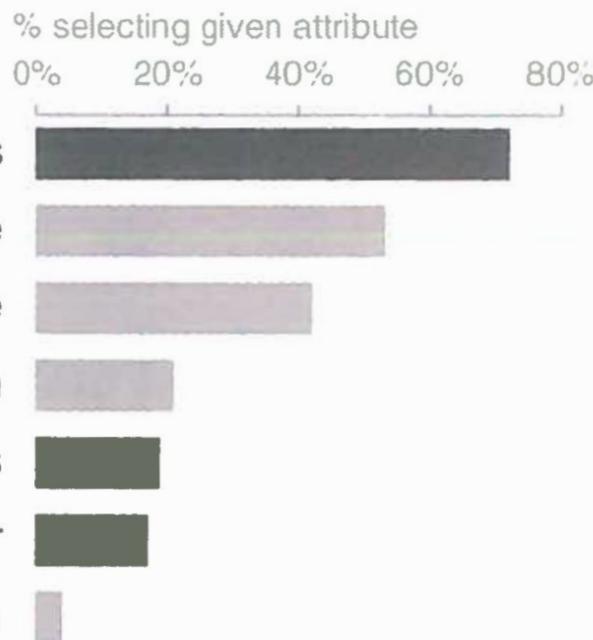
Data source: xyz; includes N number of survey respondents. Note that respondents were able to choose up to 3 options.

# Layout

**Demonstrating effectiveness** is most important consideration when selecting a provider

In general, **what attributes are the most important** to you in selecting a service provider?

(Choose up to 3)



Survey shows that **demonstration of results** is the single most important dimension when choosing a service provider.

**Affordability** and **experience working together previously**, which were hypothesized to be very important in the decision making process, were both cited less frequently as important attributes.

Data source: xyz; includes N number of survey respondents.  
Note that respondents were able to choose up to 3 options.

# **Guideline #9**

*"Annotate what is important "*

**Exceptions:** ?

# Hurricane **CAIRO** (category 5)



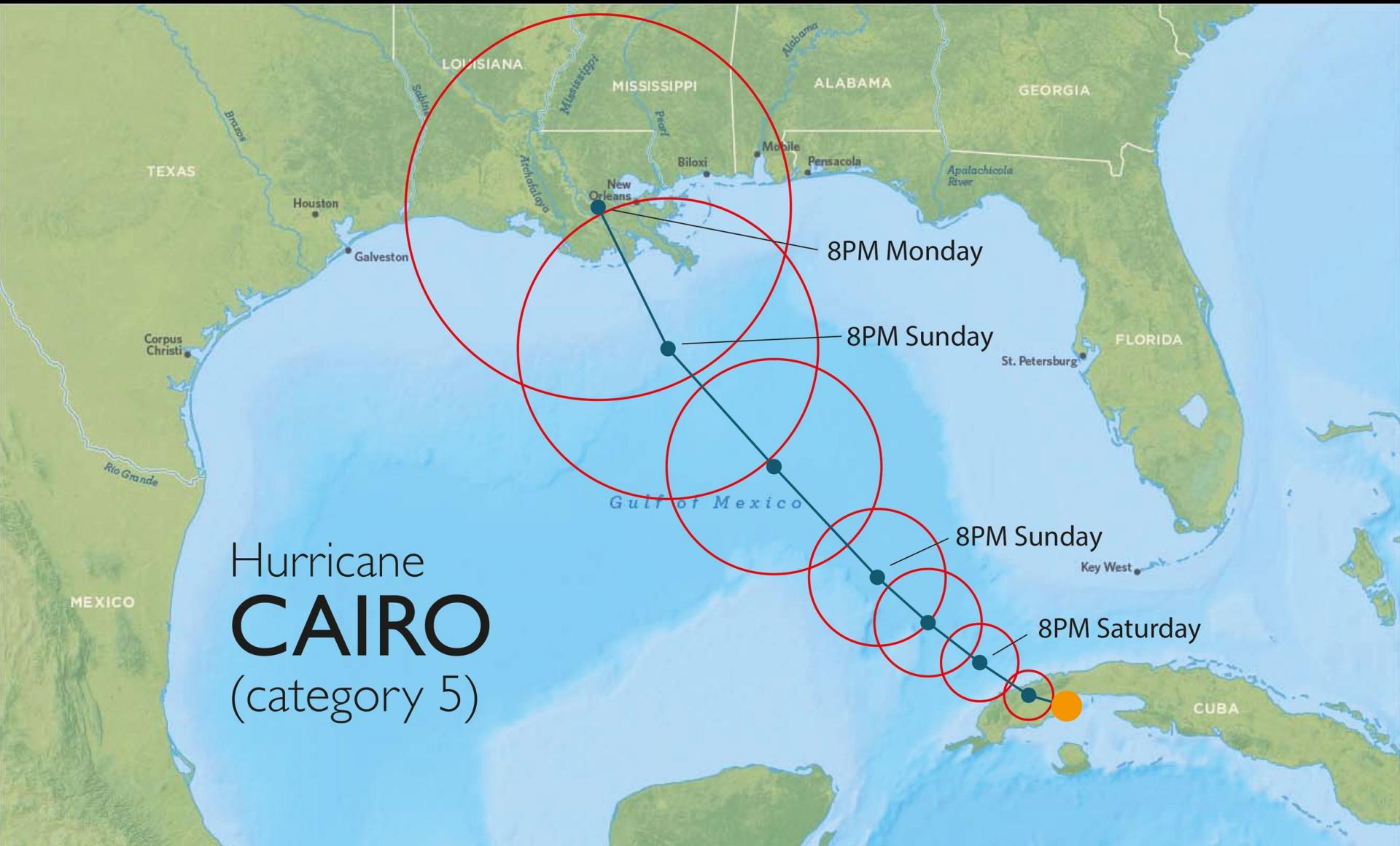
What you show

# Hurricane **CAIRO** (category 5)



What I think some people see

# Hurricane **CAIRO** (category 5)



What the cone is based on



What non-scientists are not aware of (cone is just 66% probability)

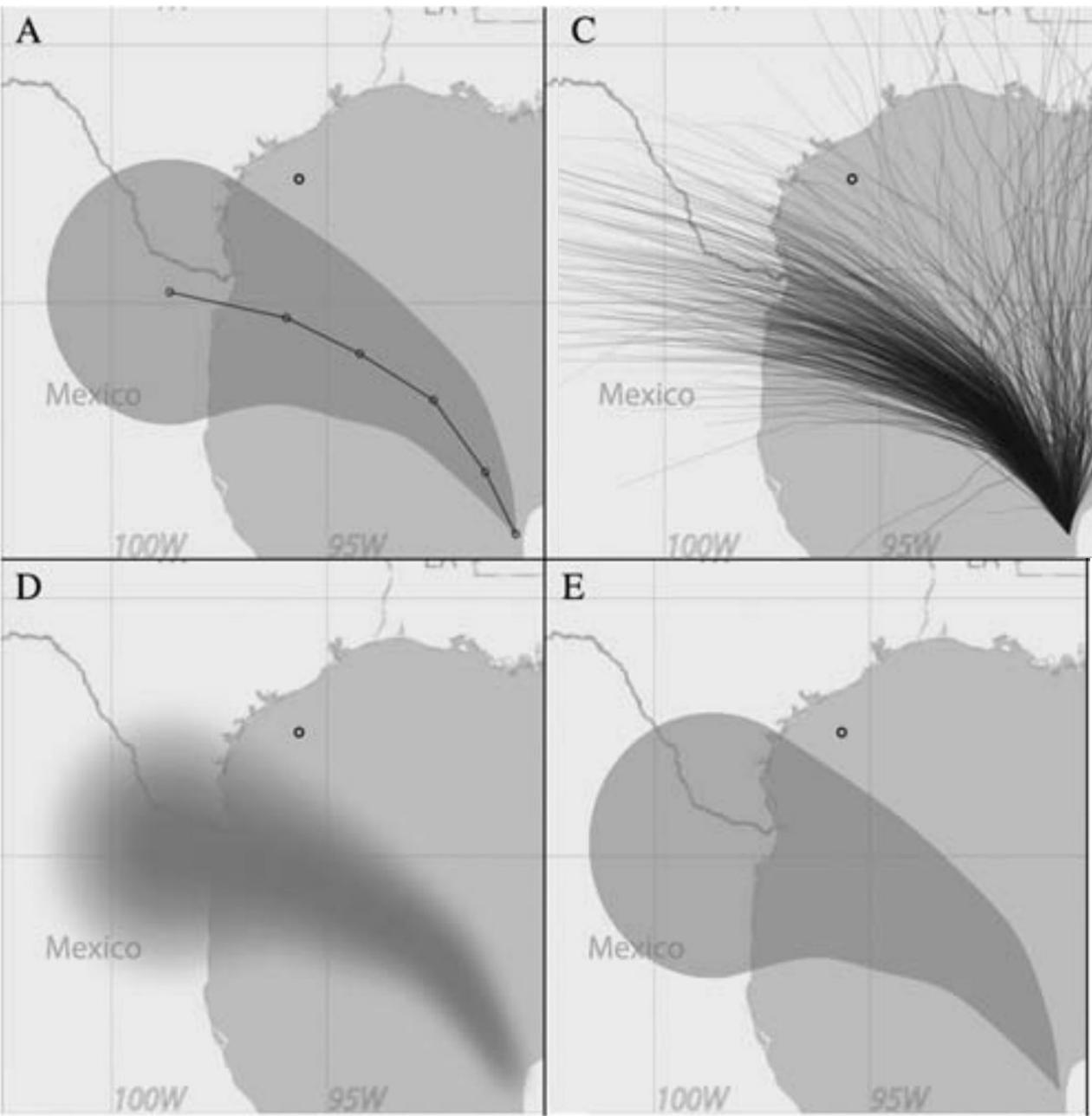


What we could be showing instead

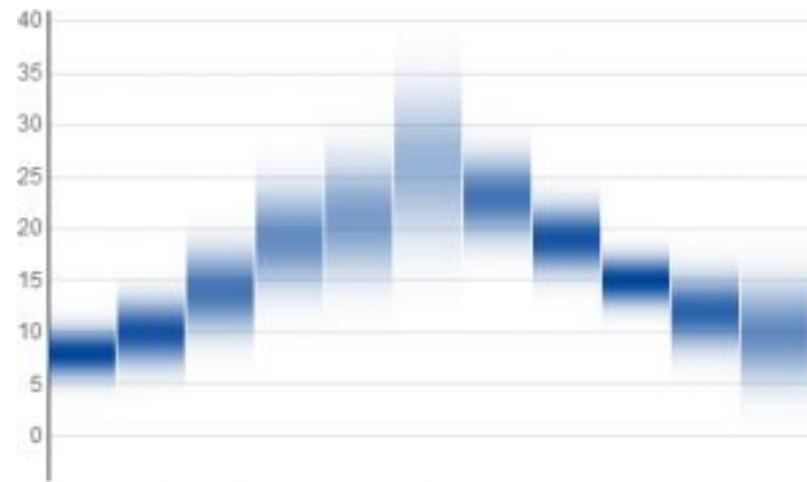
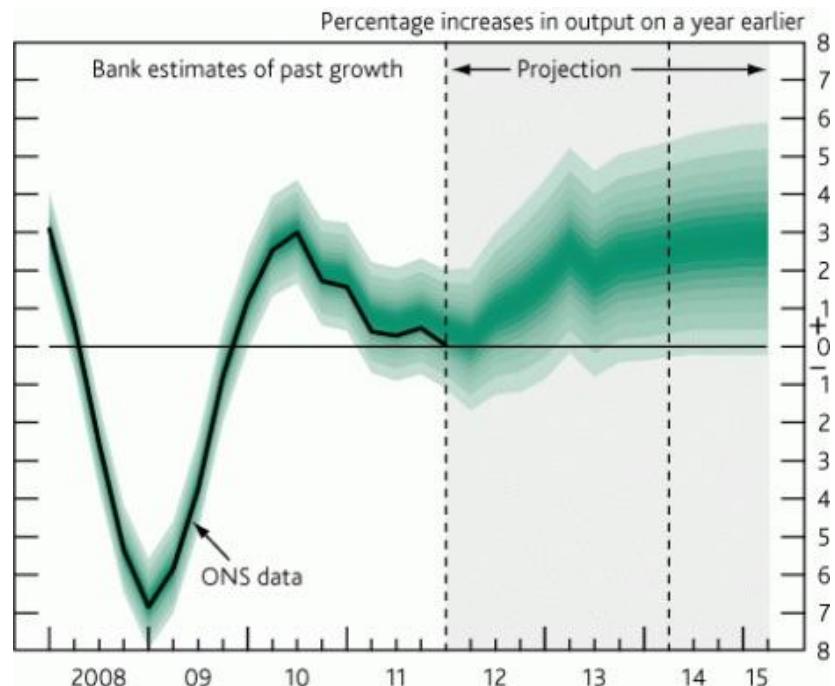
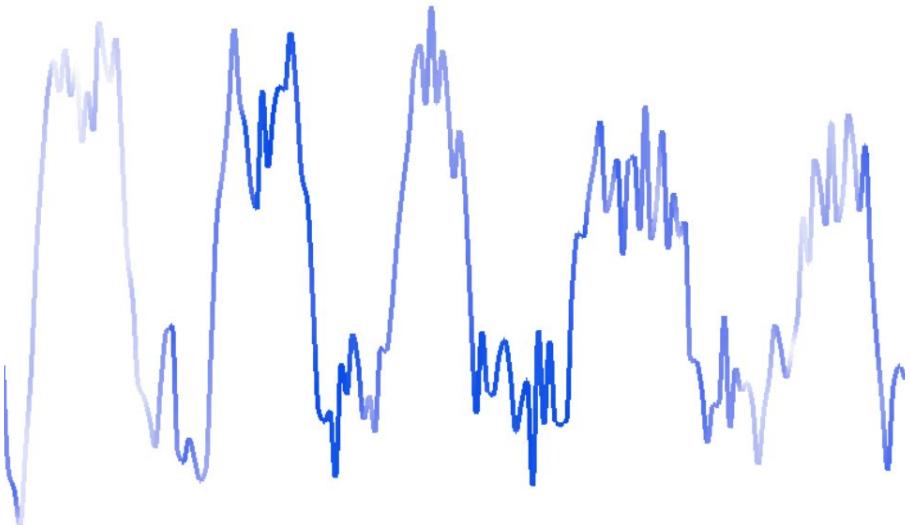
# Hurricane **CAIRO** (category 5)

What all this may mean!

# Uncertainty



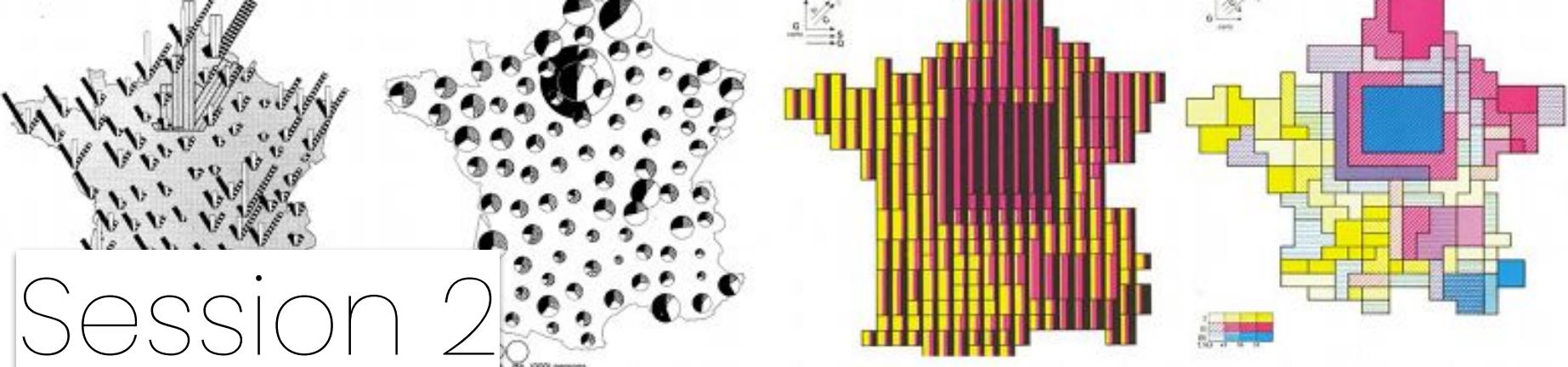
# Uncertainty



# Guideline #10

*"Be clear about uncertainty "*

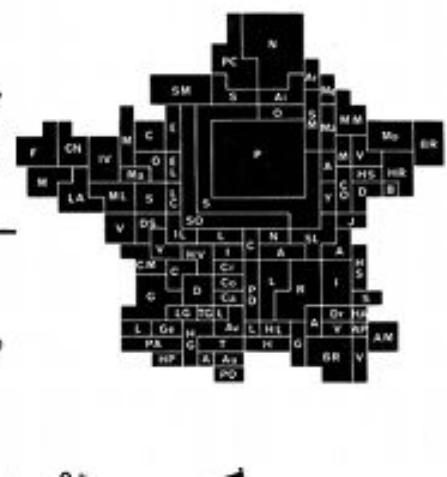
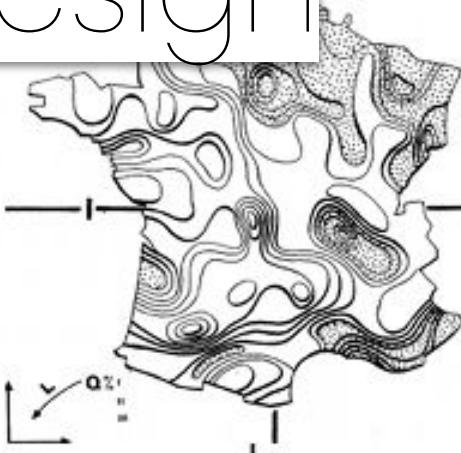
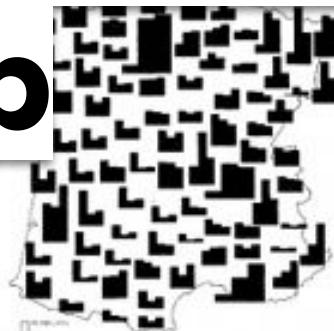
**Exceptions:** you are sure about it.



## Session 2

# Visualization Design

## Wrap up



Online Course  
**Data Visualization  
for Professionals**



THE UNIVERSITY  
of EDINBURGH

**Benjamin Bach**

May 2022

<http://benjbach.me>  
<https://datavis-online.github.io>

-- Not for external use --

# Wrap up

- (Good) visualizations are perceived pre-attentively and in parallel
- Gestalt laws explain how we perceive higher level patterns in graphical representations
- 3 data types: categorical, ordered, numerical
- 3 visual marks: points, lines, areas
- 7 visual variables: position, size, shape, orientation value, hue, texture
- Color scales: sequential, diverging, categorical
- Guidelines: area-size, data-ink ratio, embellishment, titles, etc.

# Wrap up

- (Good) visualizations are perceived pre-attentively and in parallel
- Gestalt laws explain how we perceive higher level patterns in graphical representations
- 3 data types: categorical, ordered, numerical
- 3 visual marks: points, lines, areas
- 7 visual variables: position, size, shape, orientation value, hue, texture
- Color scales: sequential, diverging, categorical
- Guidelines: area-size, data-ink ratio, embellishment, titles, etc.

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