

Visualization in HCI

05-499/05-899 Section C



The Visualization Alphabet: Marks and Channels

February 22, 2017

Marks & Channels

Marks: represent items or links

Channels: change appearance based on **attribute**

Channel = Visual Variable

Marks for Items

Basic geometric elements

→ Points



0D

→ Lines



1D

→ Areas

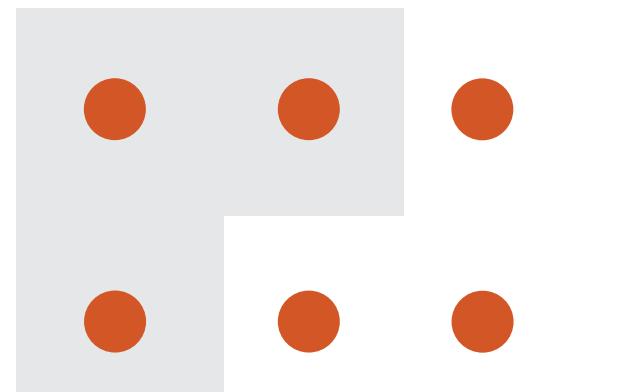


2D

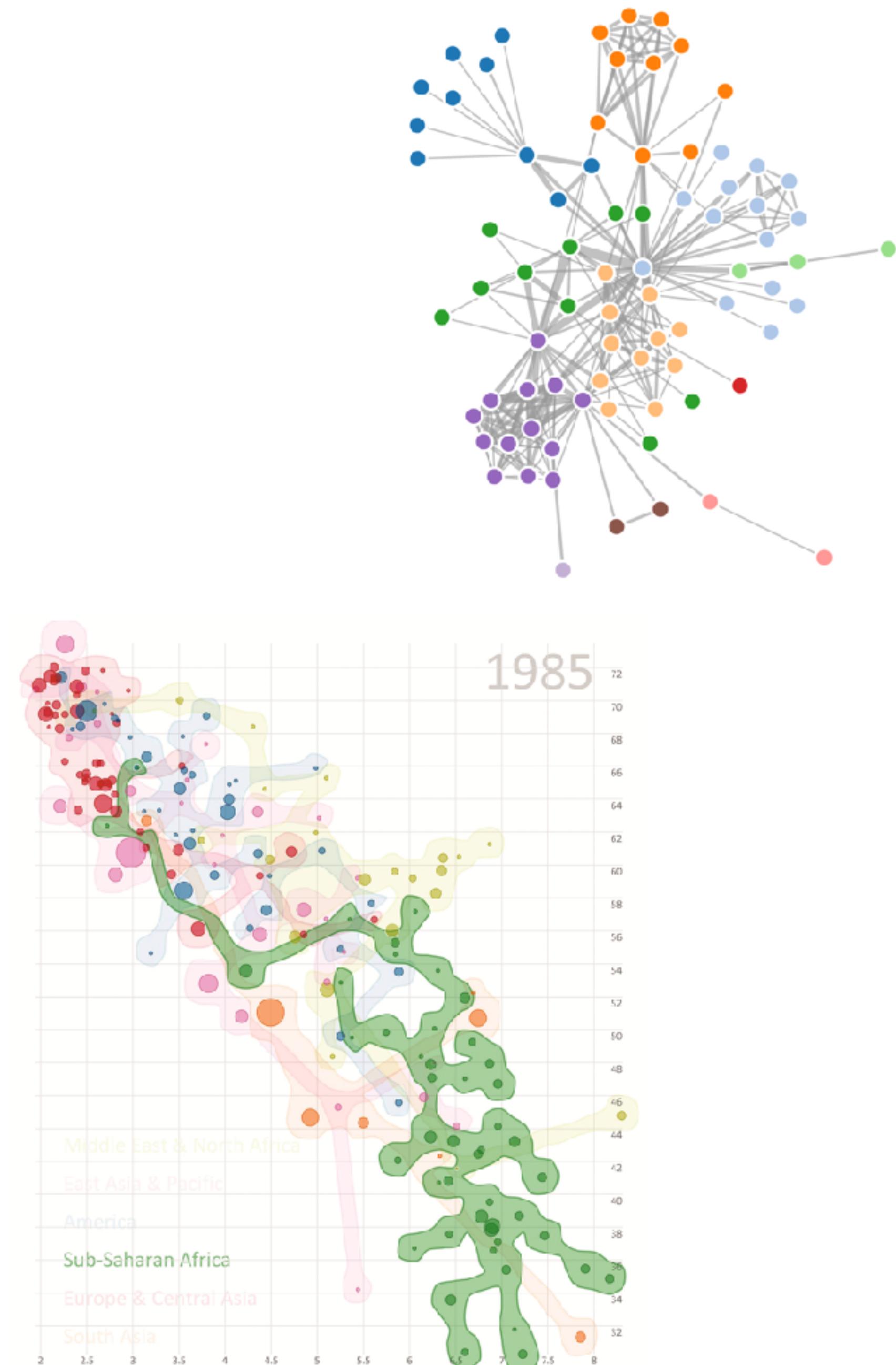
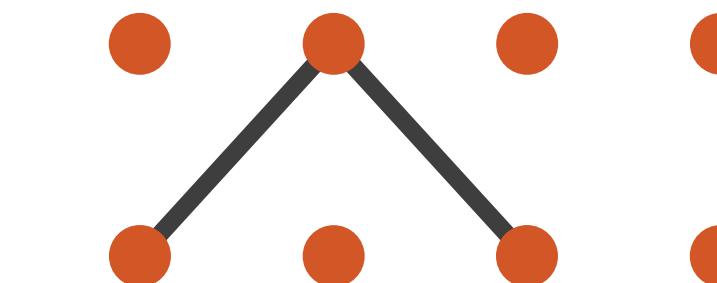
3D mark: Volume, but rarely used

Marks for Links

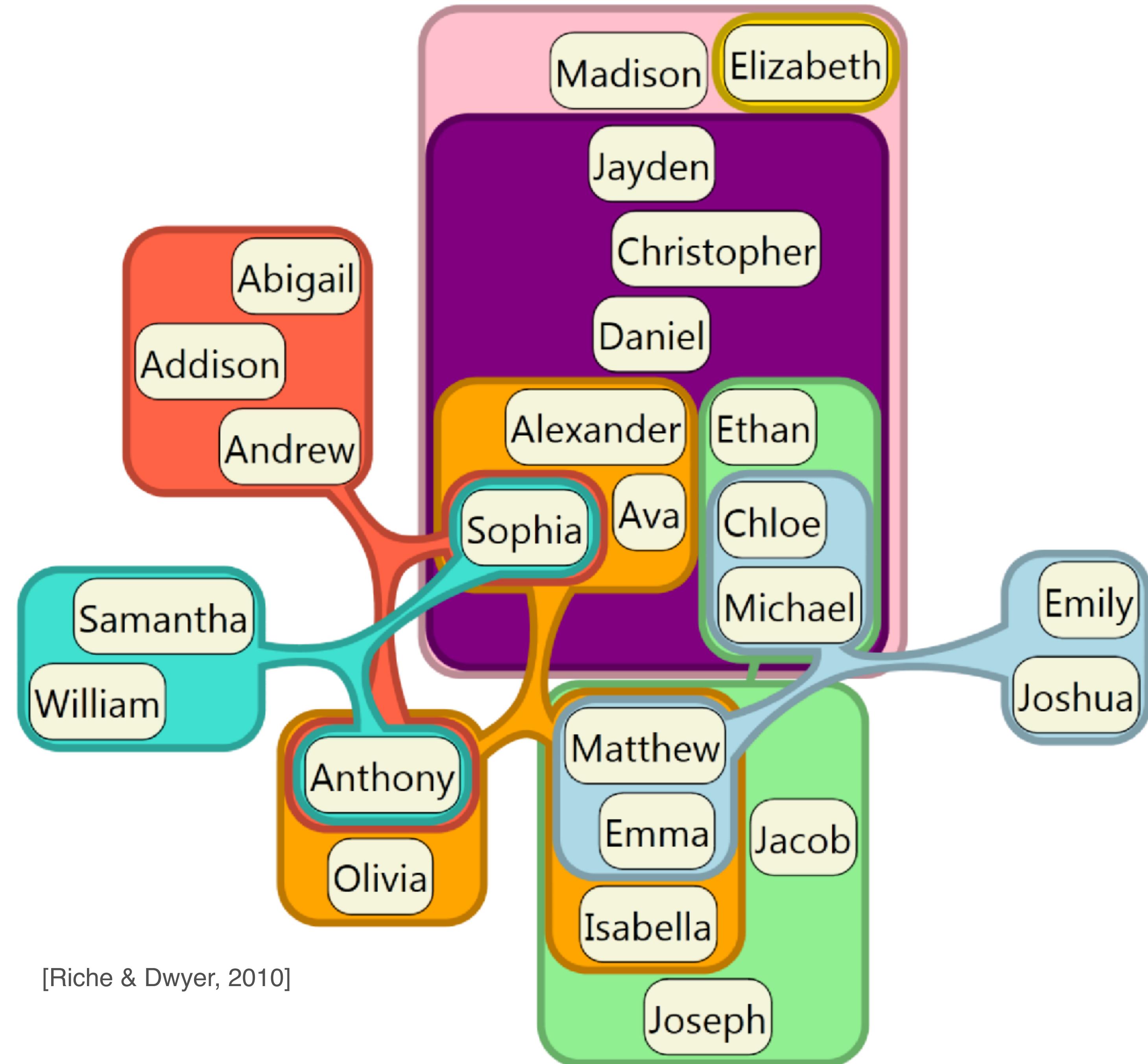
→ Containment



→ Connection



Containment can be nested



Channels (aka Visual Variables)

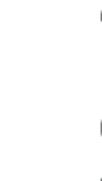
Control appearance
proportional to or
based on attributes

→ Position

→ Horizontal



→ Vertical



→ Both



→ Color



→ Shape



→ Tilt



→ Size

→ Length



→ Area



→ Volume



Jacques Bertin

French cartographer
[1918-2010]

Semiology of Graphics [1967]

Theoretical principles for visual
encodings

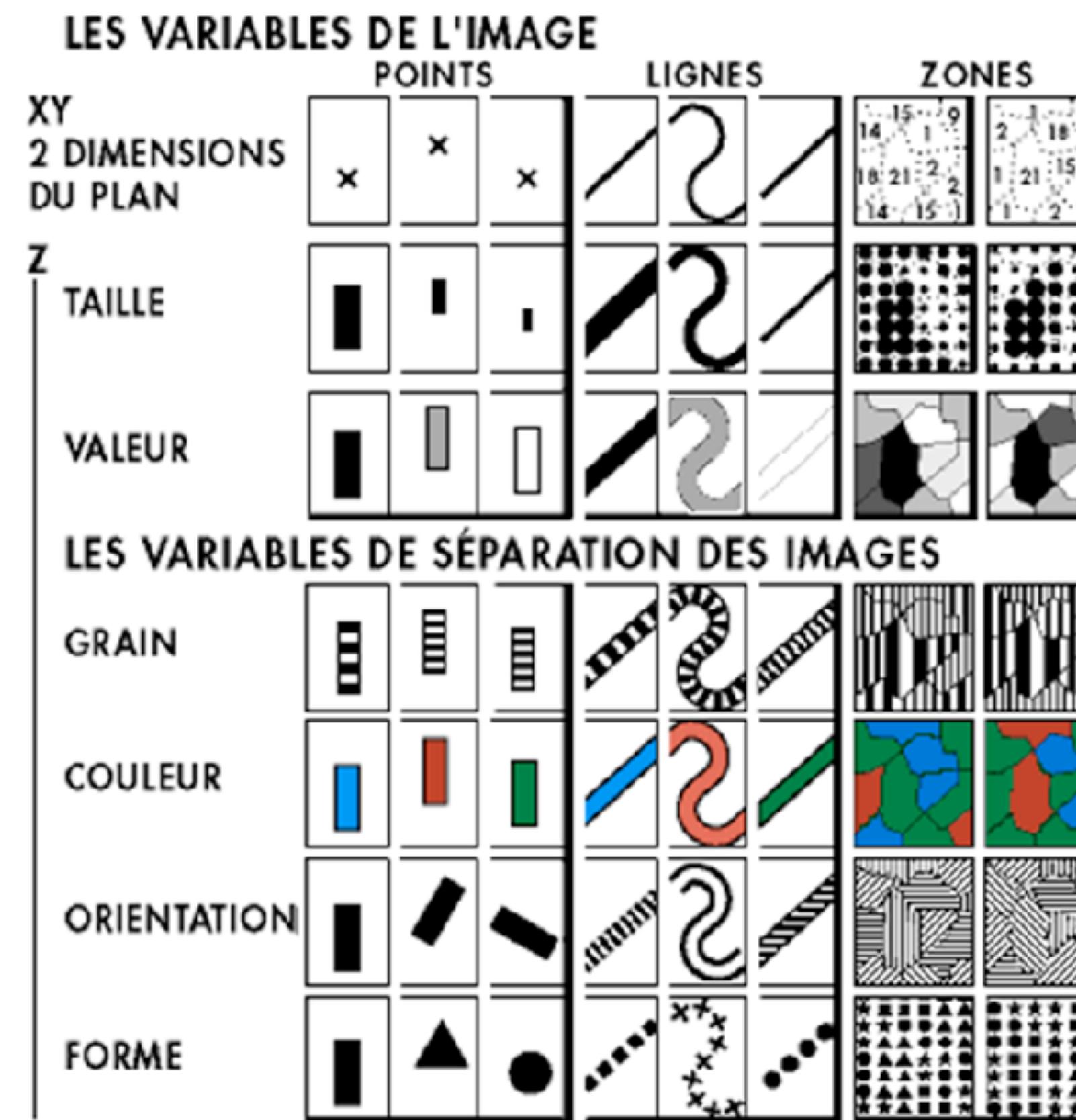


Bertin's Visual Variables

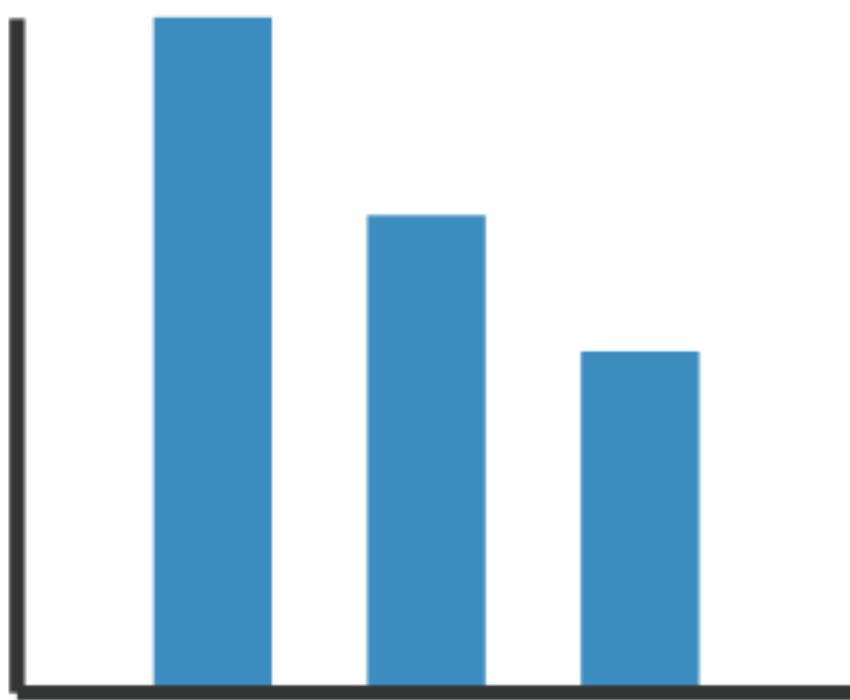
Position
Size
(Grey)Value

Texture
Color
Orientation
Shape

Marks: Points Lines Areas



Using Marks and Channels



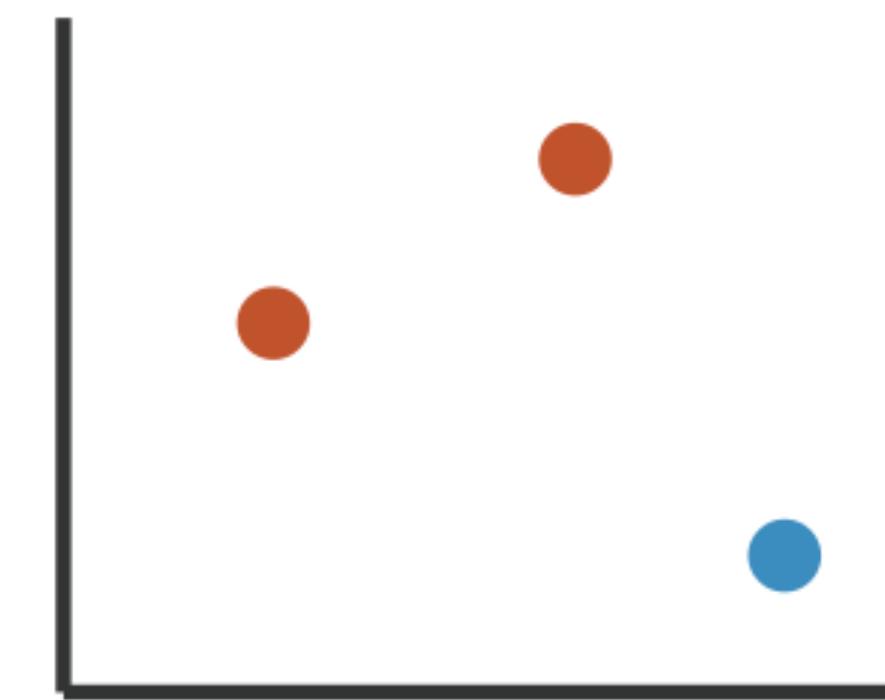
Mark: Line

Channel: Length/Position
1 quantitative attribute
1 categorical attribute

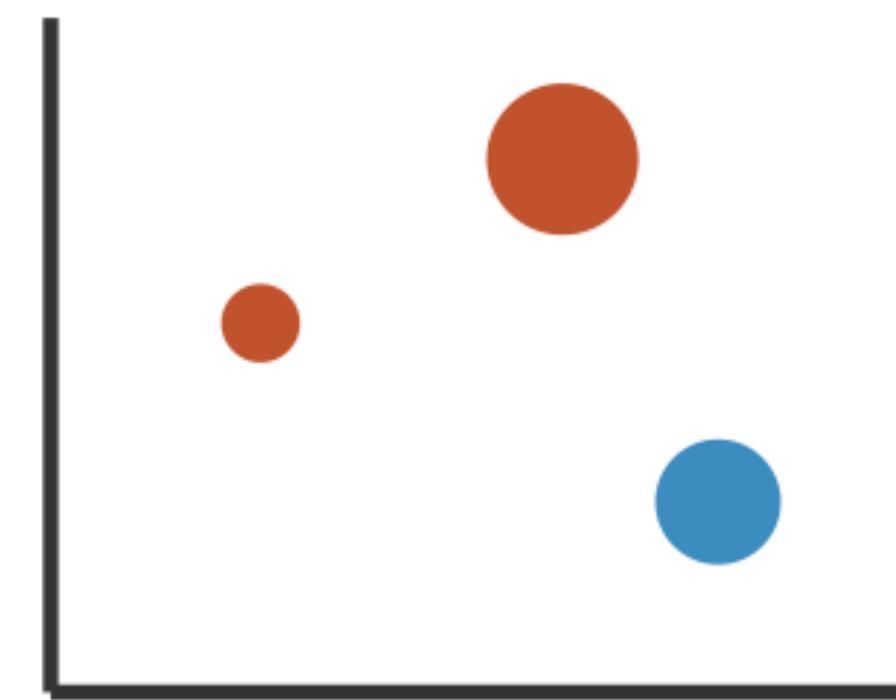


Mark: Point

Channel: Position
2 quantitative attr.

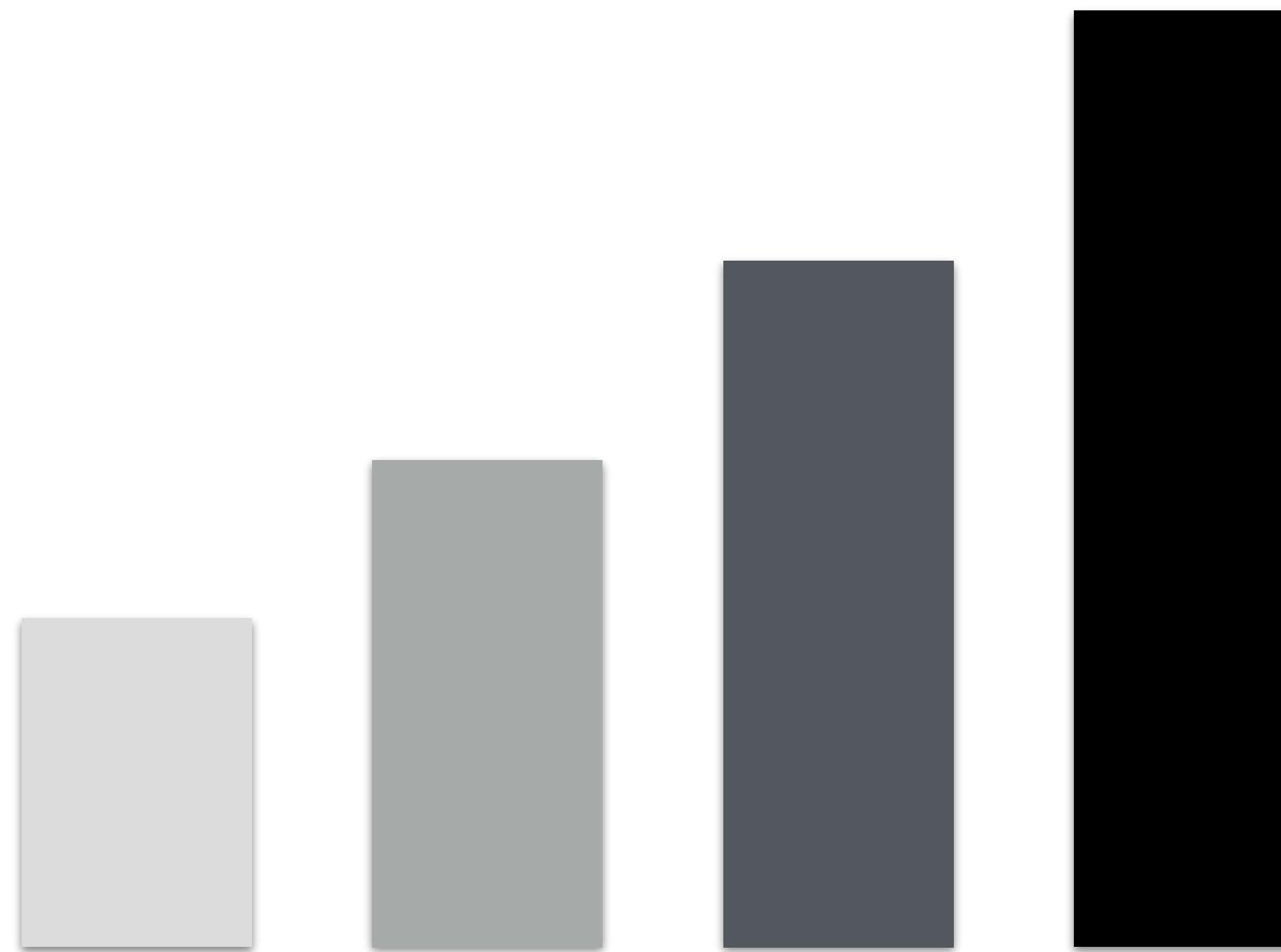


Adding Hue
+1 categorical attr.



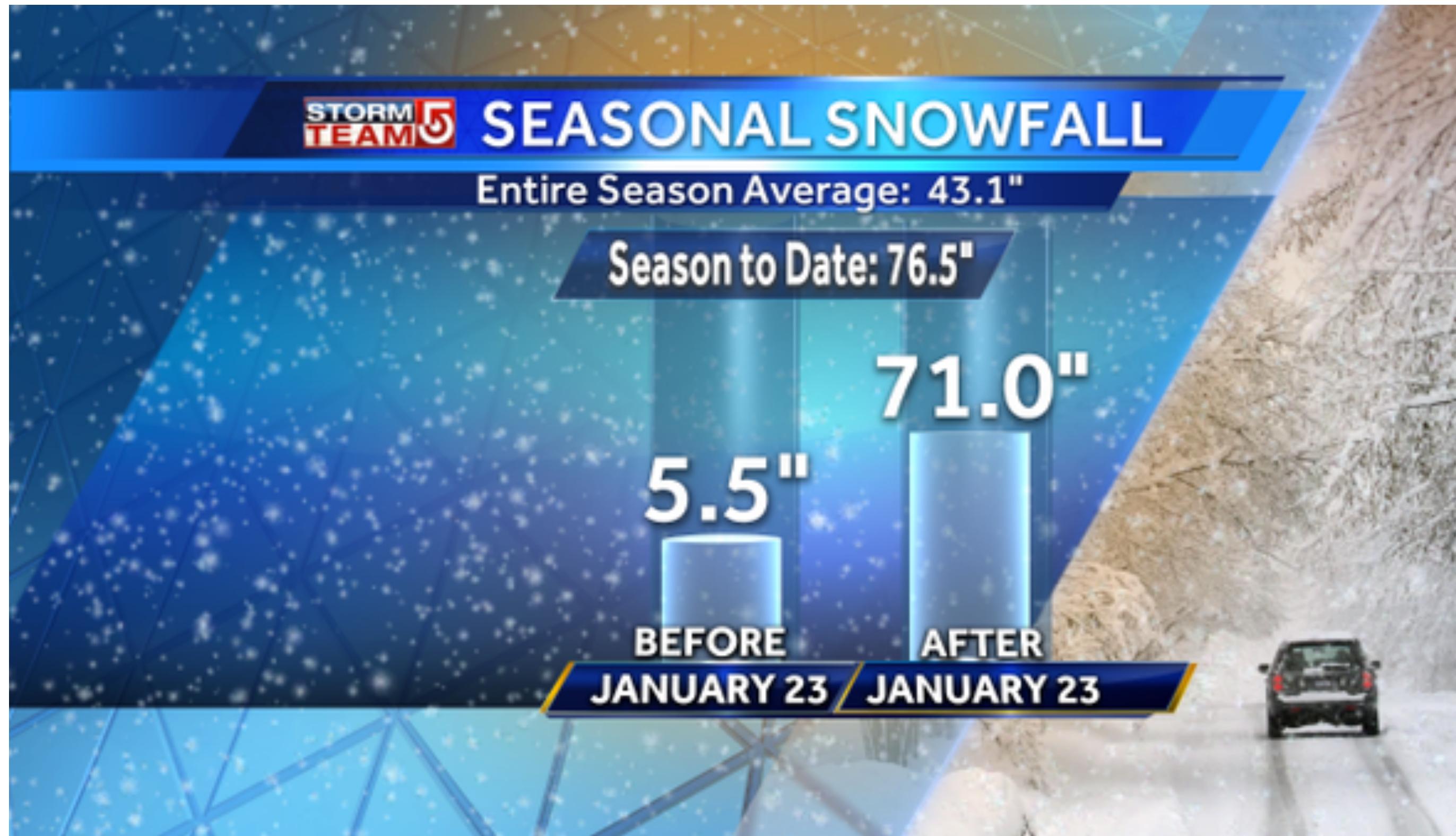
Adding Size
+1 quantitative attr.

Redundant encoding



Length, Position and Value

Good bar chart?



Rule: Use channel proportional to data!

Types of Channels

Magnitude Channels

How much?

Position

Length

Saturation ...

Identity Channels

What? Where?

Shape

Color (hue)

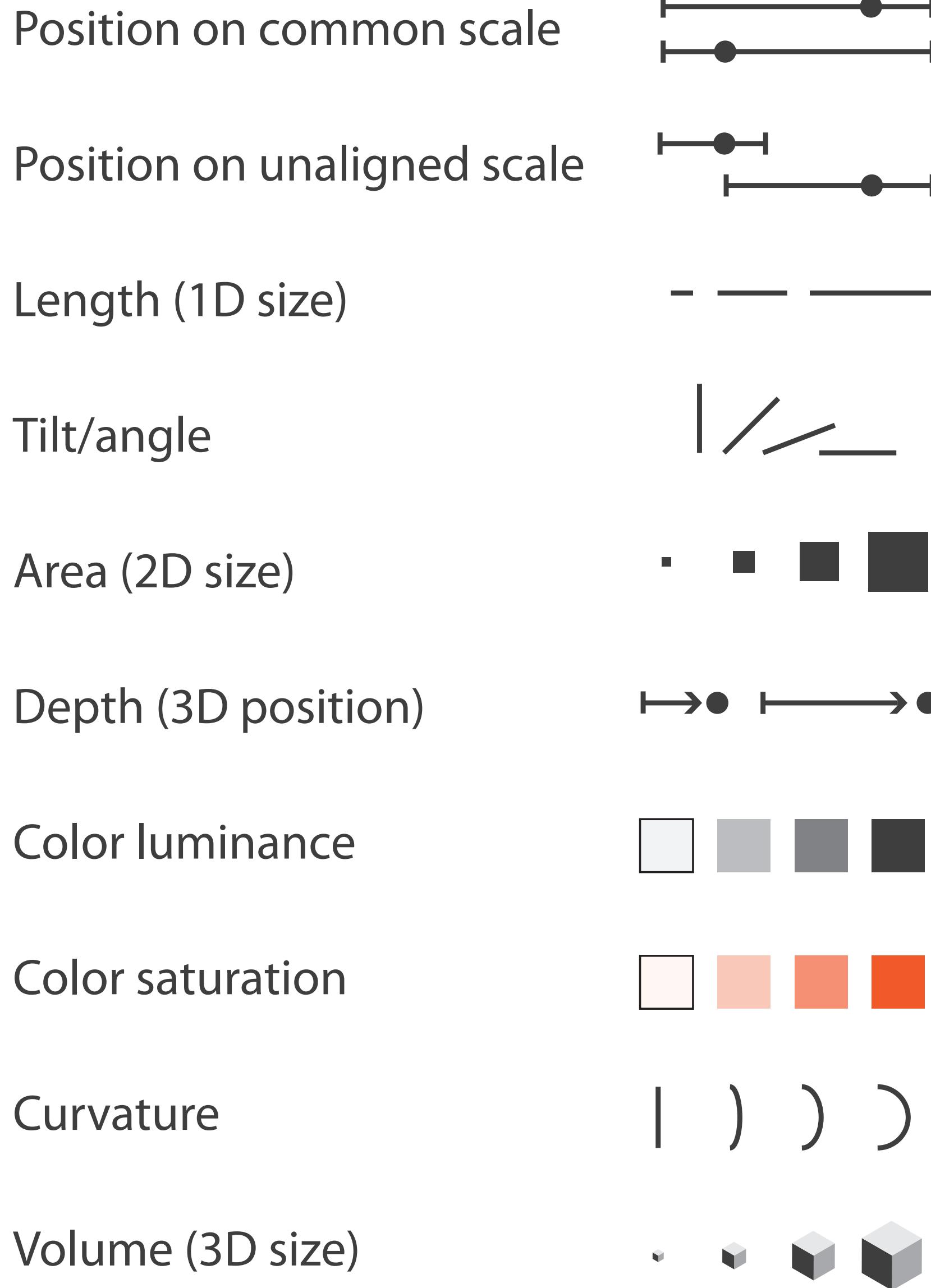
Spatial region ...

Ordinal & Quantitative Data

Categorical Data

Channels: Expressiveness Types and Effectiveness Ranks

→ Magnitude Channels: Ordered Attributes



→ Identity Channels: Categorical Attributes



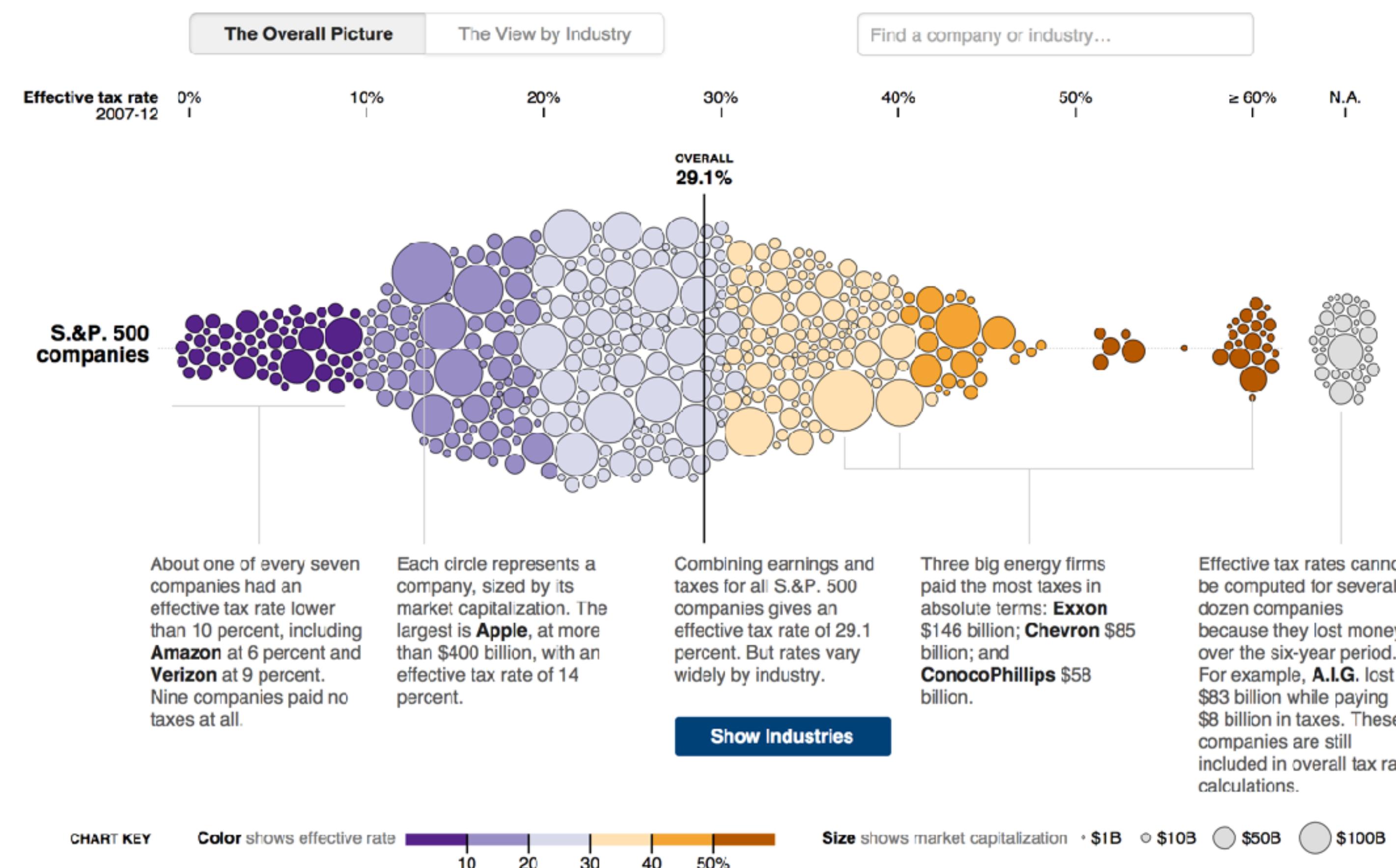
▲ Most
Effectiveness
Least ▼

[Same]

What visual variables are used?

Across U.S. Companies, Tax Rates Vary Greatly

Last week, in a Congressional hearing, Apple got grilled for its low-tax strategy. But not every business can copy that approach. Here is a look at what S&P 500 companies paid in corporate income taxes — federal, state, local and foreign — from 2007 to 2012, according to S&P Capital IQ. [Related Article »](#)



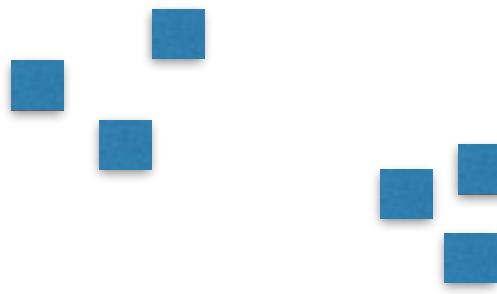
Characteristics of Channels

Selective



Is a mark distinct from other marks?

Can we make out the difference between two marks?

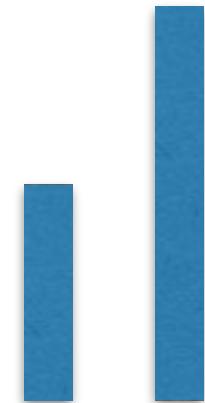


Associative

Does it support grouping?

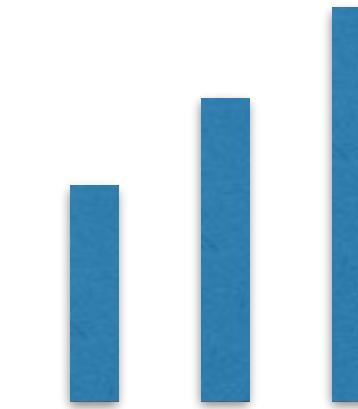
Quantitative (Magnitude vs Identity Channels)

Can we quantify the difference between two marks?



Characteristics of Channels

Order (Magnitude vs Identity)



Can we see a change in order?

Length

How many unique marks can we make?

Position

Strongest visual variable

Suitable for all data types

Problems:

Sometimes not available
(spatial data)

Cluttering

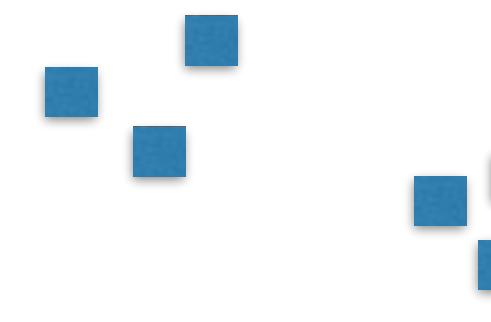
Selective: yes

Associative: yes

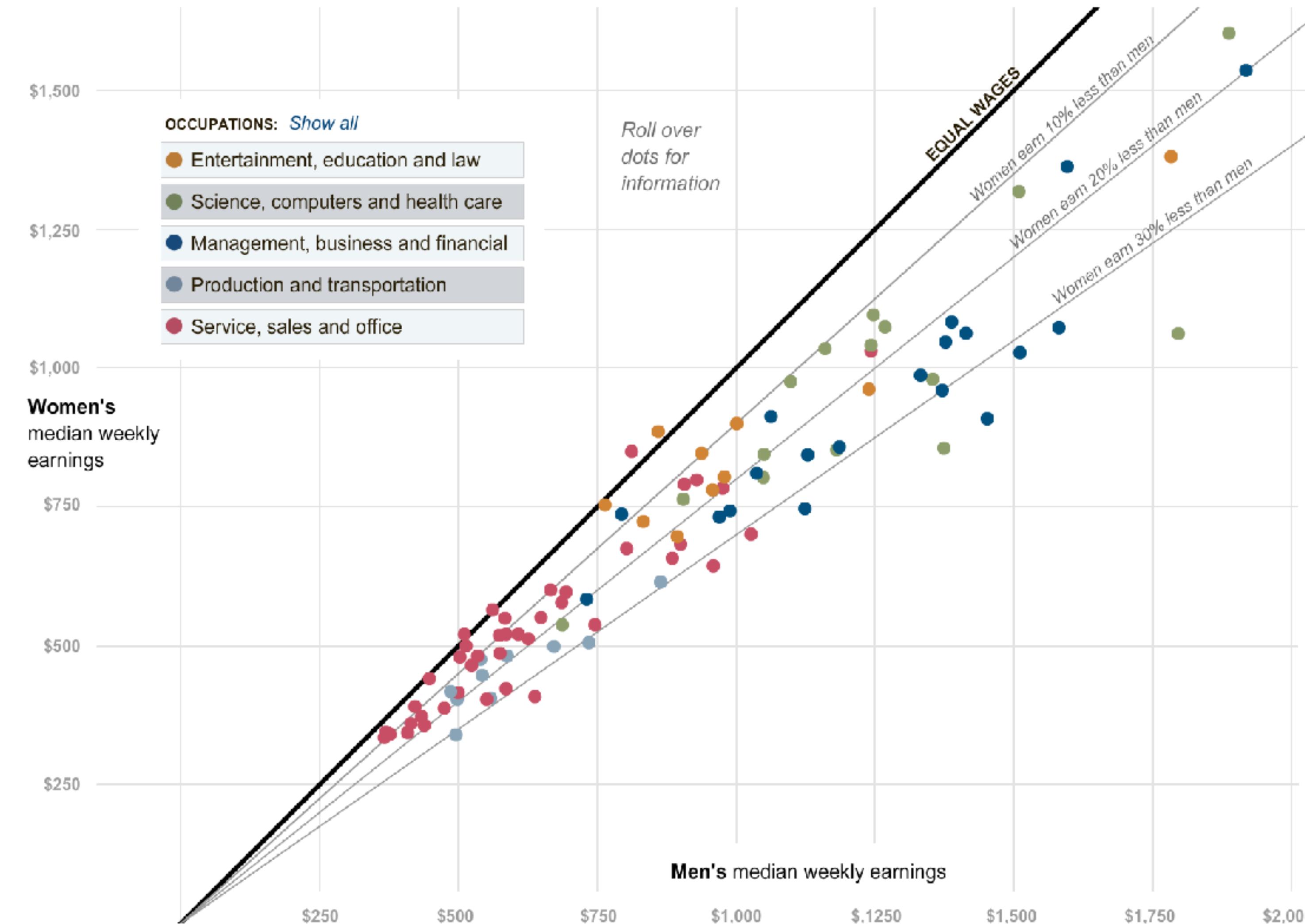
Quantitative: yes

Order: yes

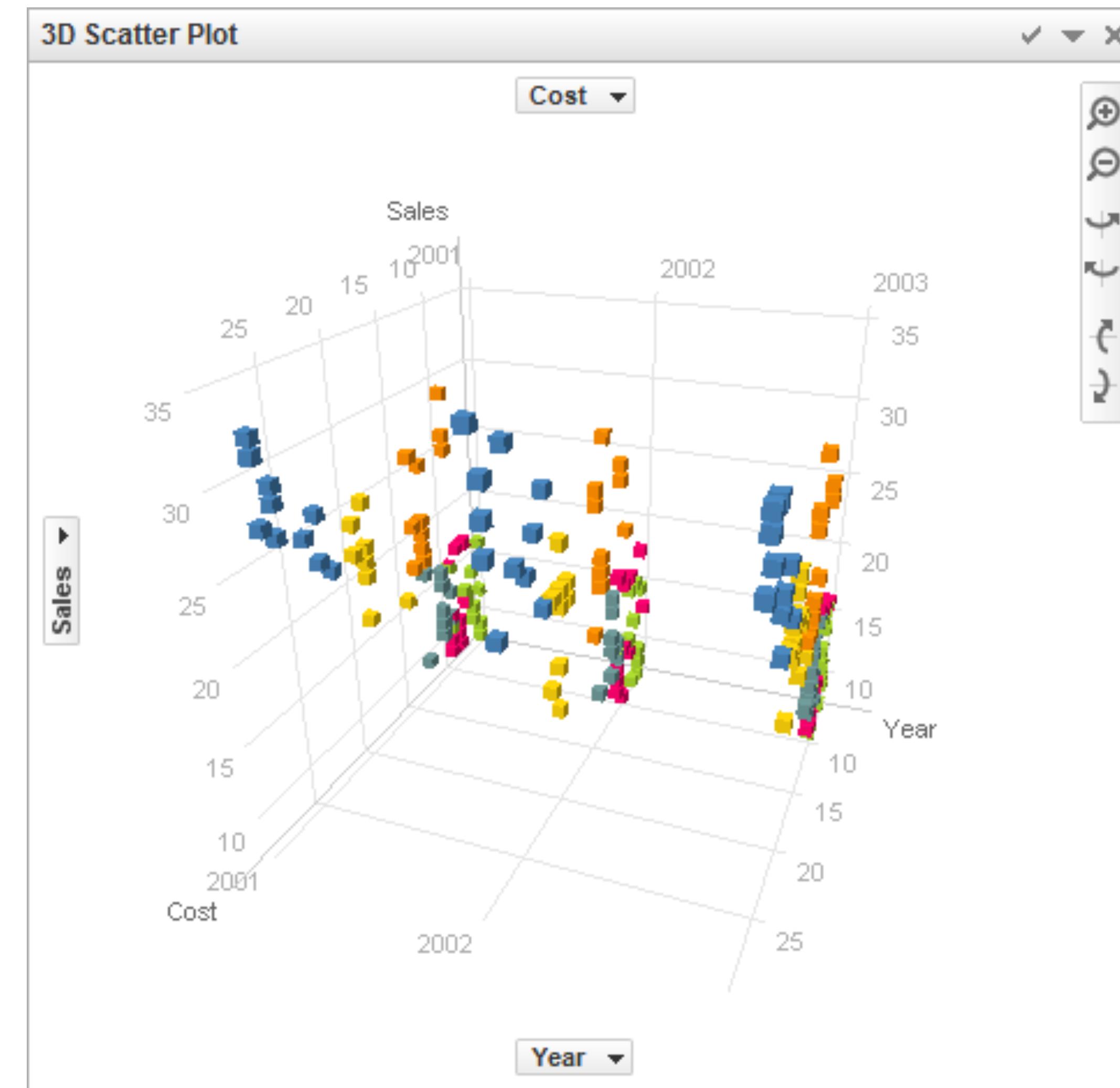
Length: fairly big



Example: Scatterplot



Position in 3D?



Length & Size

Good for 1D, OK for 2D, Bad for 3D

Easy to see whether one is bigger

Aligned bars use position redundantly

For 1D length:

Selective: yes

Associative: yes

Quantitative: yes

Order: yes

Length: high



Example 2D Size: Bubbles

Four Ways to Slice Obama's 2013 Budget Proposal

Explore every nook and cranny of President Obama's federal budget proposal.

All Spending

Types of Spending

Changes

Department Totals

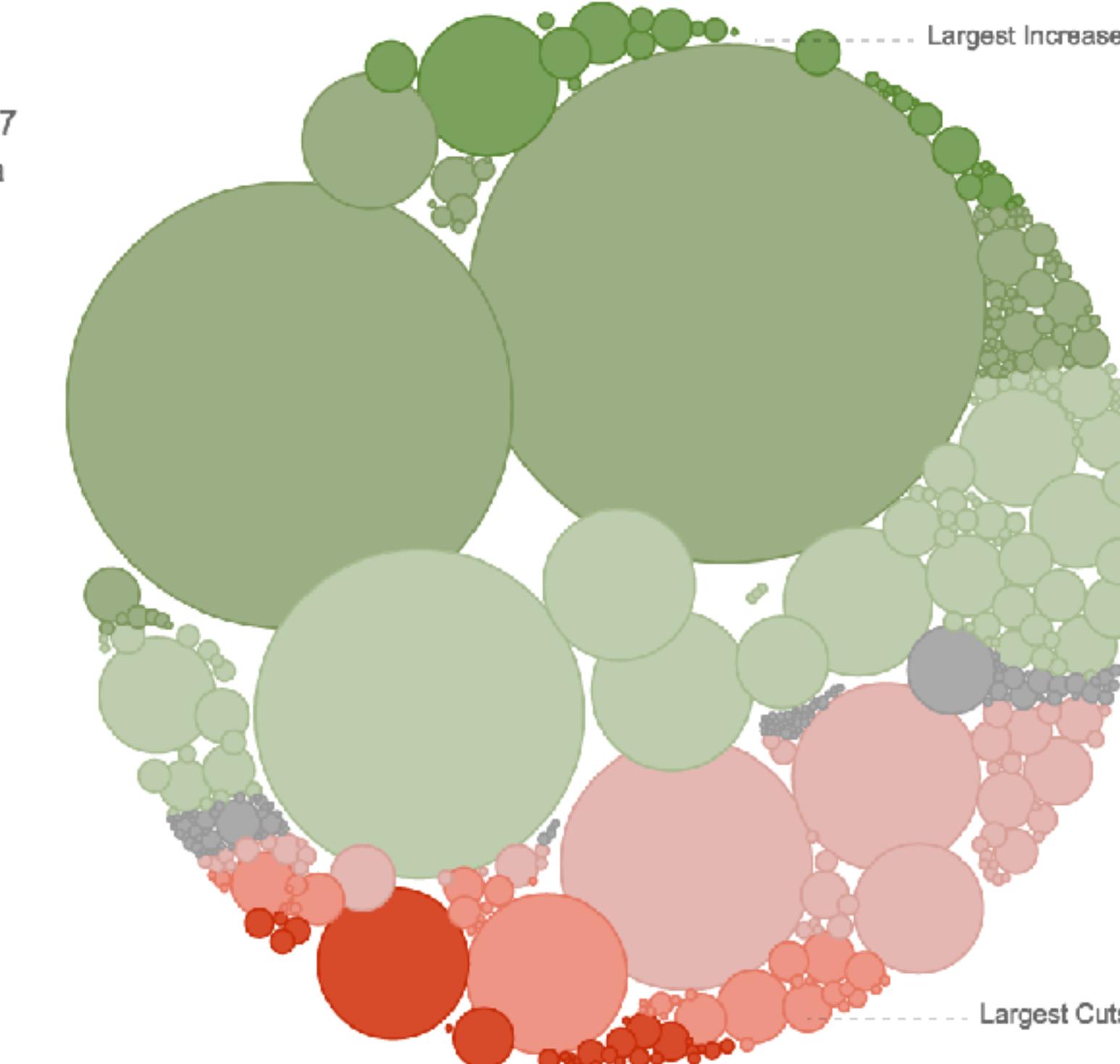
How \$3.7 Trillion Is Spent

Mr. Obama's budget proposal includes \$3.7 trillion in spending in 2013, and forecasts a \$901 billion deficit.

Circles are sized according to the proposed spending.



Color shows amount of cut or increase from 2012.



Value/Luminance/Saturation

OK for quantitative data when length & size are used.

Not very many shades recognizable

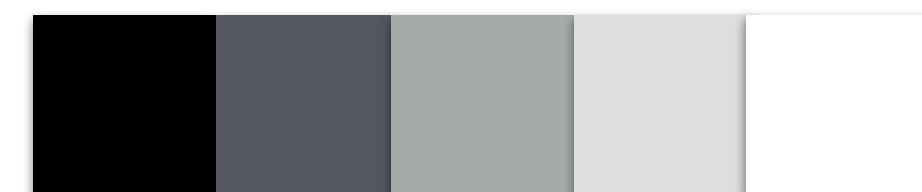
Selective: yes

Associative: yes

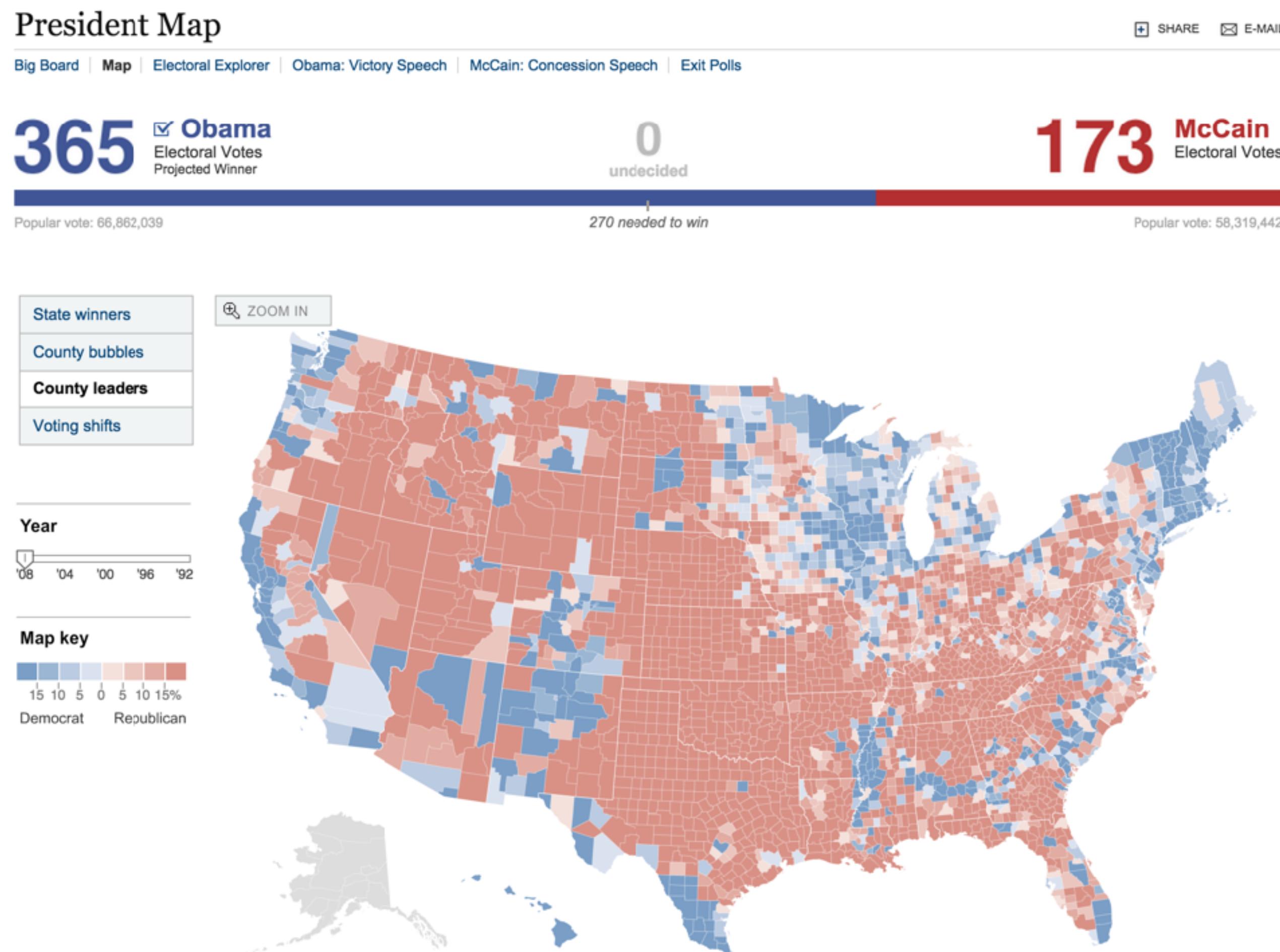
Quantitative: somewhat (with problems)

Order: yes

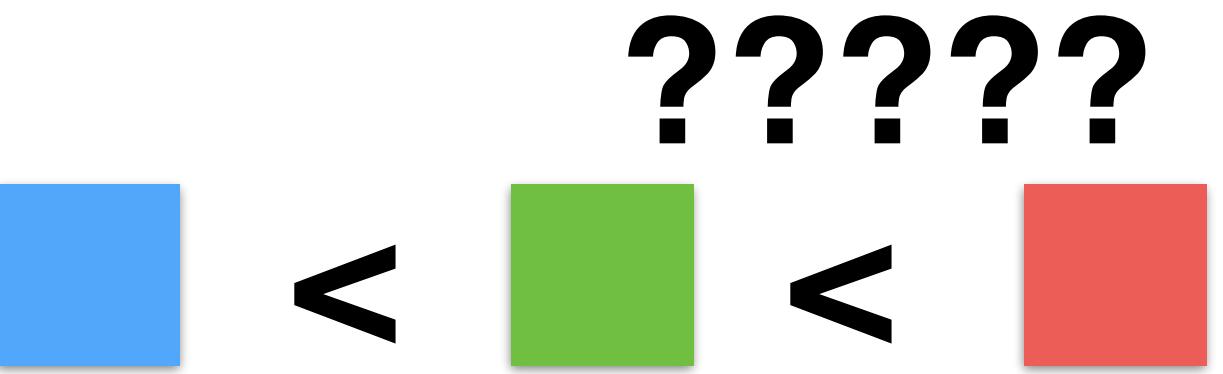
Length: limited



Example: Diverging Value-Scale



Color (Hue)



Good for qualitative data (identity channel)

Selective: yes

Limited number of classes/length (~7-10!)

Associative: yes

Does not work for quantitative data!

Quantitative: no

Lots of pitfalls! Be careful!

Order: no

A common rule among vis designers:

Length: limited

minimize color use for encoding data



use for brushing

Color: Bad Example

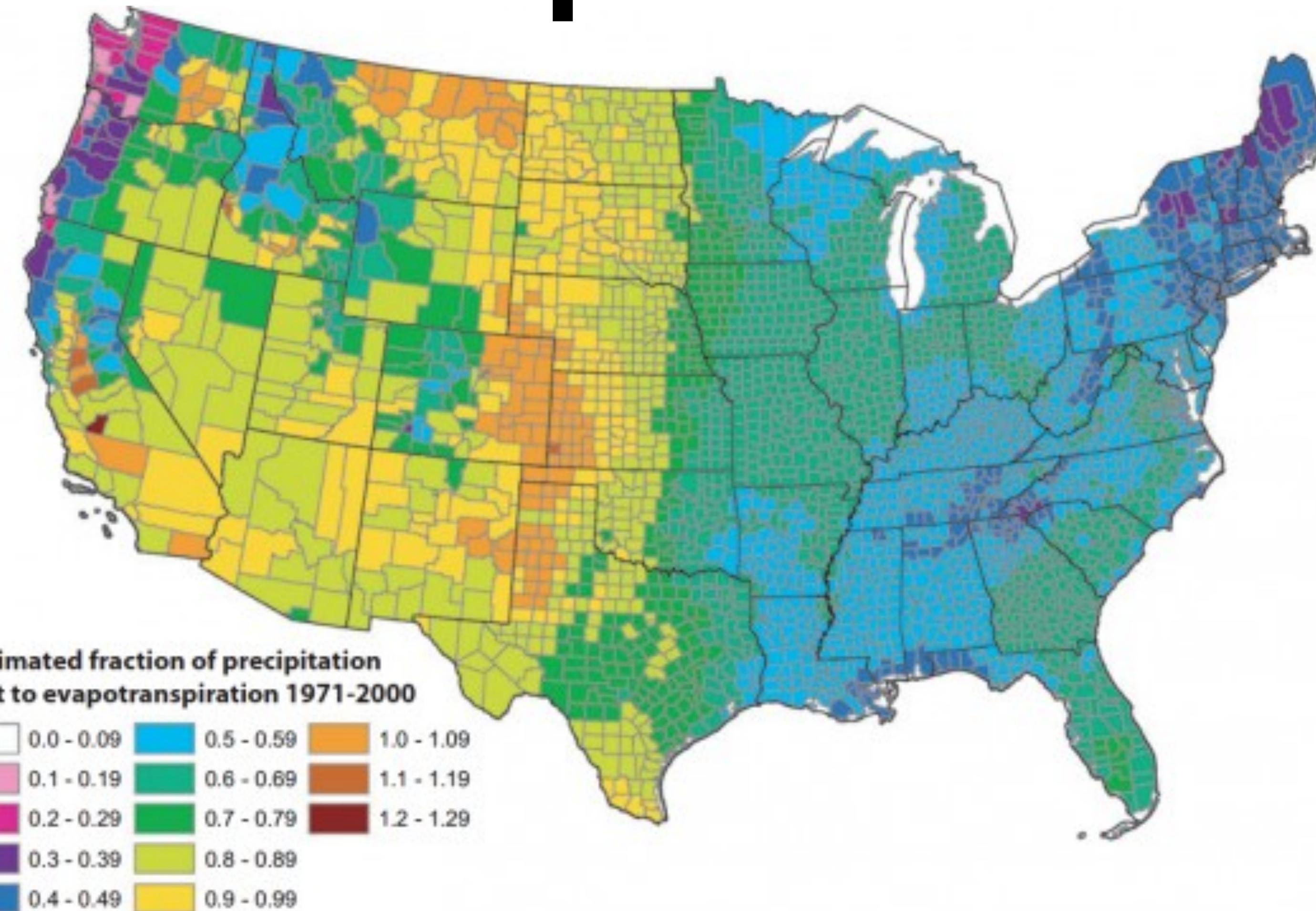


FIGURE 13. Estimated Mean Annual Ratio of Actual Evapotranspiration (ET) to Precipitation (P) for the Conterminous U.S. for the Period 1971-2000. Estimates are based on the regression equation in Table 1 that includes land cover. Calculations of ET/P were made first at the 800-m resolution of the PRISM climate data. The mean values for the counties (shown) were then calculated by averaging the 800-m values within each county. Areas with fractions >1 are agricultural counties that either import surface water or mine deep groundwater.

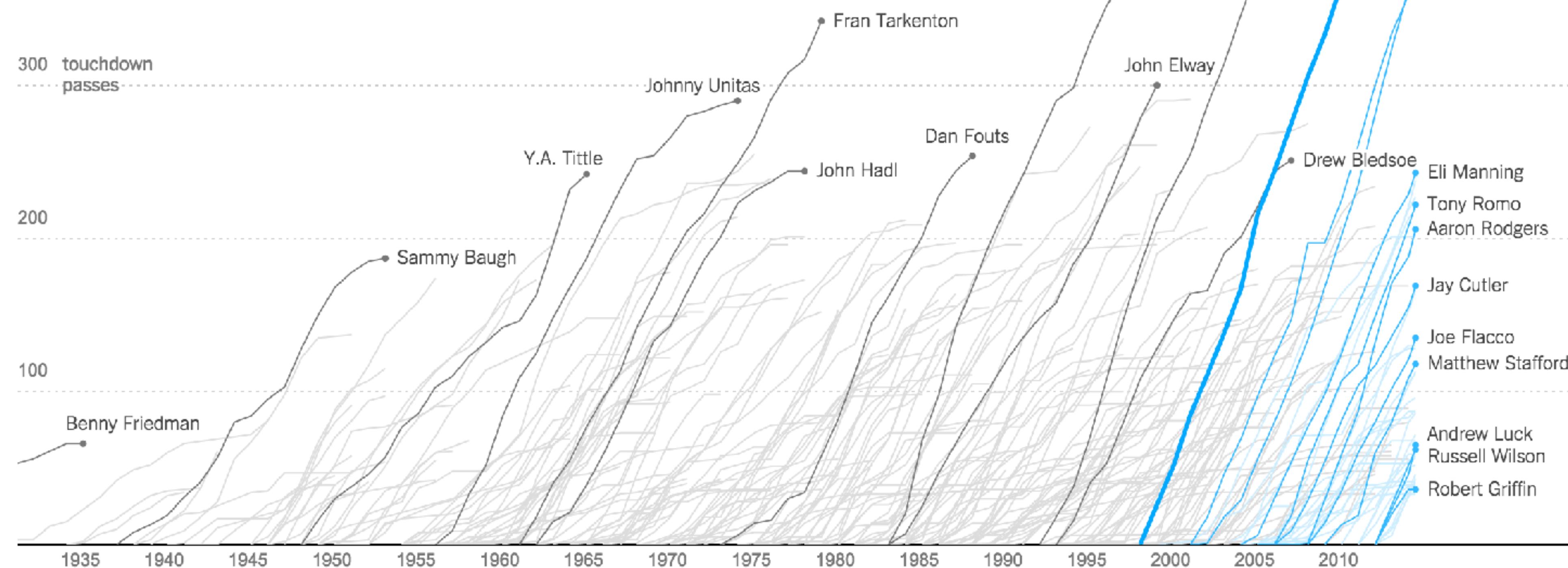
Cliff Mass

Color: Good Example

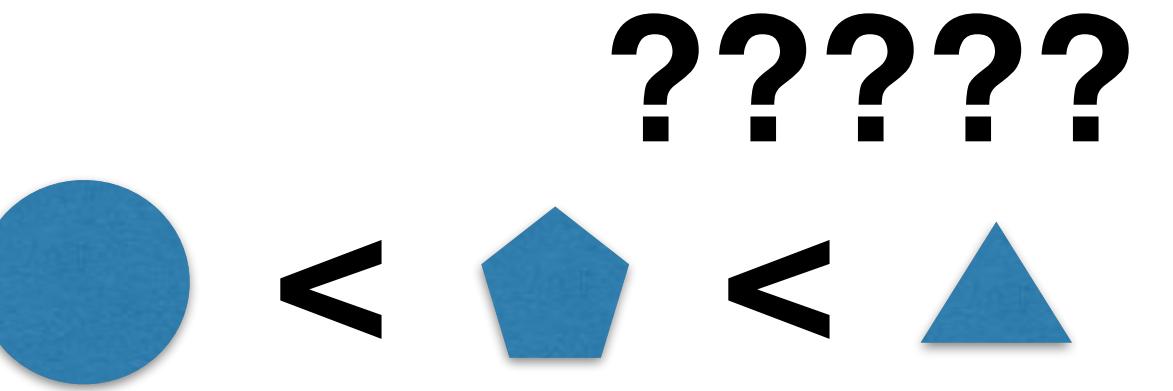
Why Peyton Manning's Record Will Be Hard to Beat

By GREGOR AISCH and KEVIN QUEALY OCT. 19, 2014

The Broncos quarterback set the all-time N.F.L. touchdown passing record — and is still going strong.



Shape



Great to recognize many classes.

No grouping, ordering.

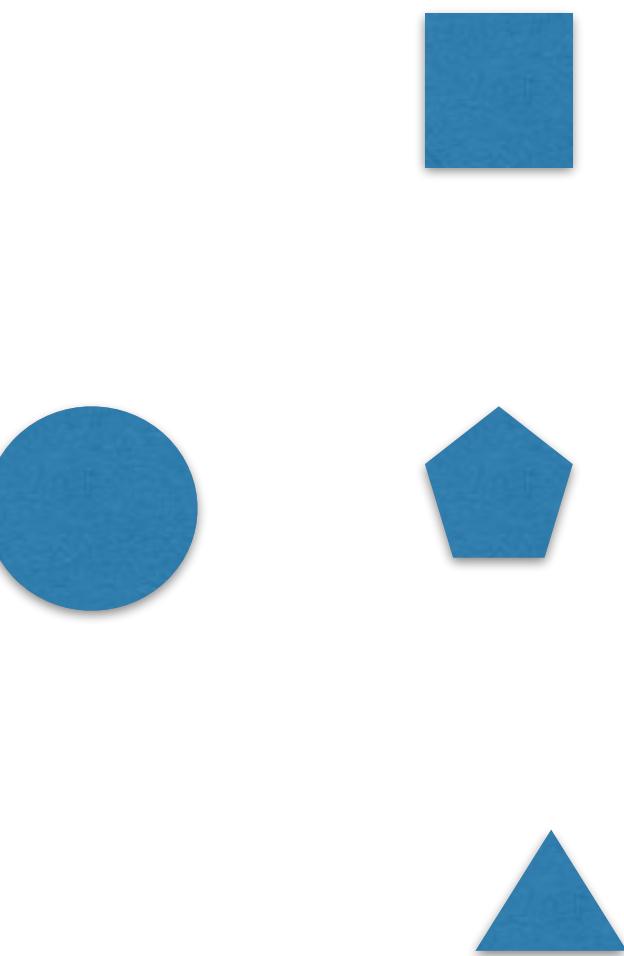
Selective: yes

Associative: limited

Quantitative: no

Order: no

Length: vast





ASTON MARTIN



Audi

MITSUBISHI
MOTORS

BENTLEY

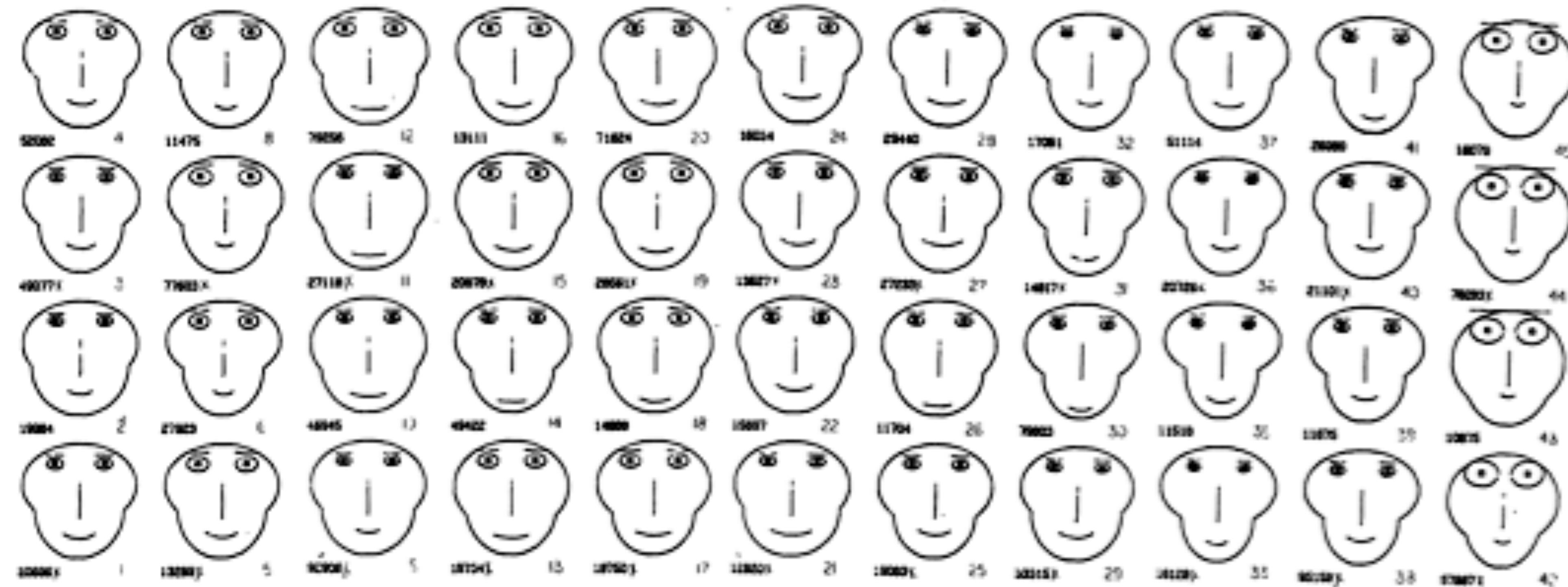


FOR SAFETY You must know German trafficsigns																



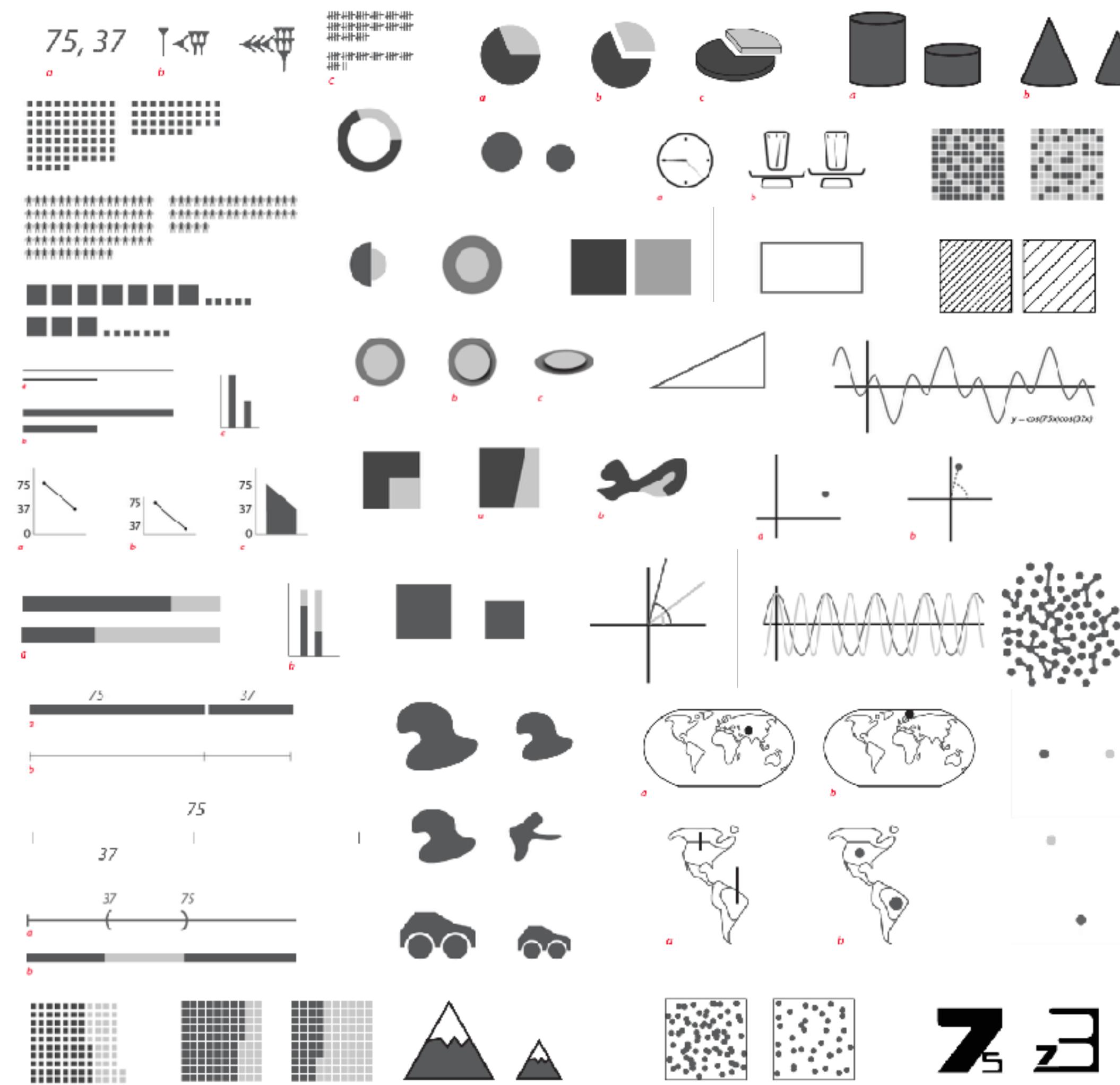
Chernoff Faces

Idea: use facial parameters to map quantitative data



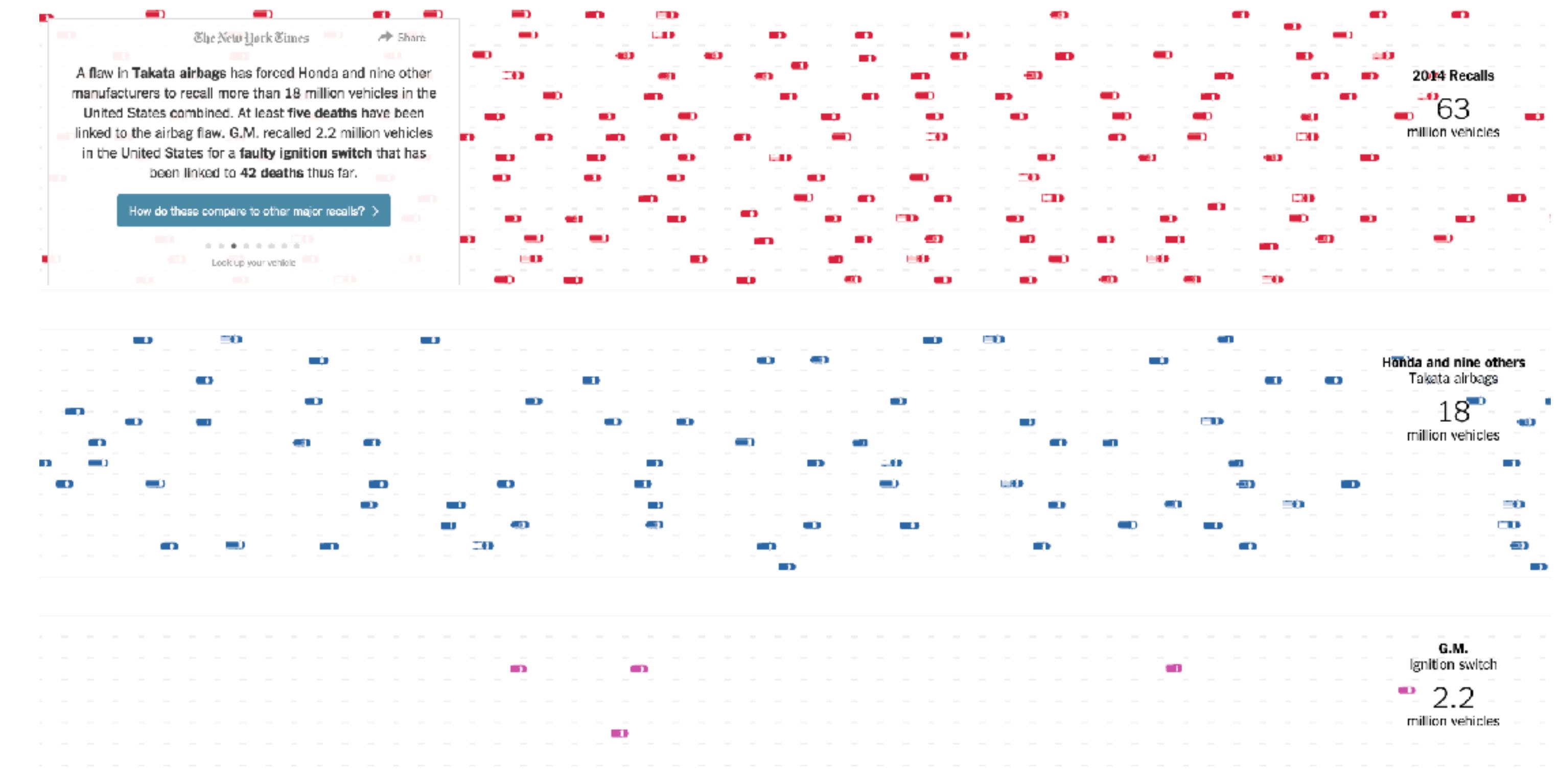
Critique: <https://eagereyes.org/criticism/chernoff-faces>

More Channels



Design Critique

A Record Year for Auto Recalls

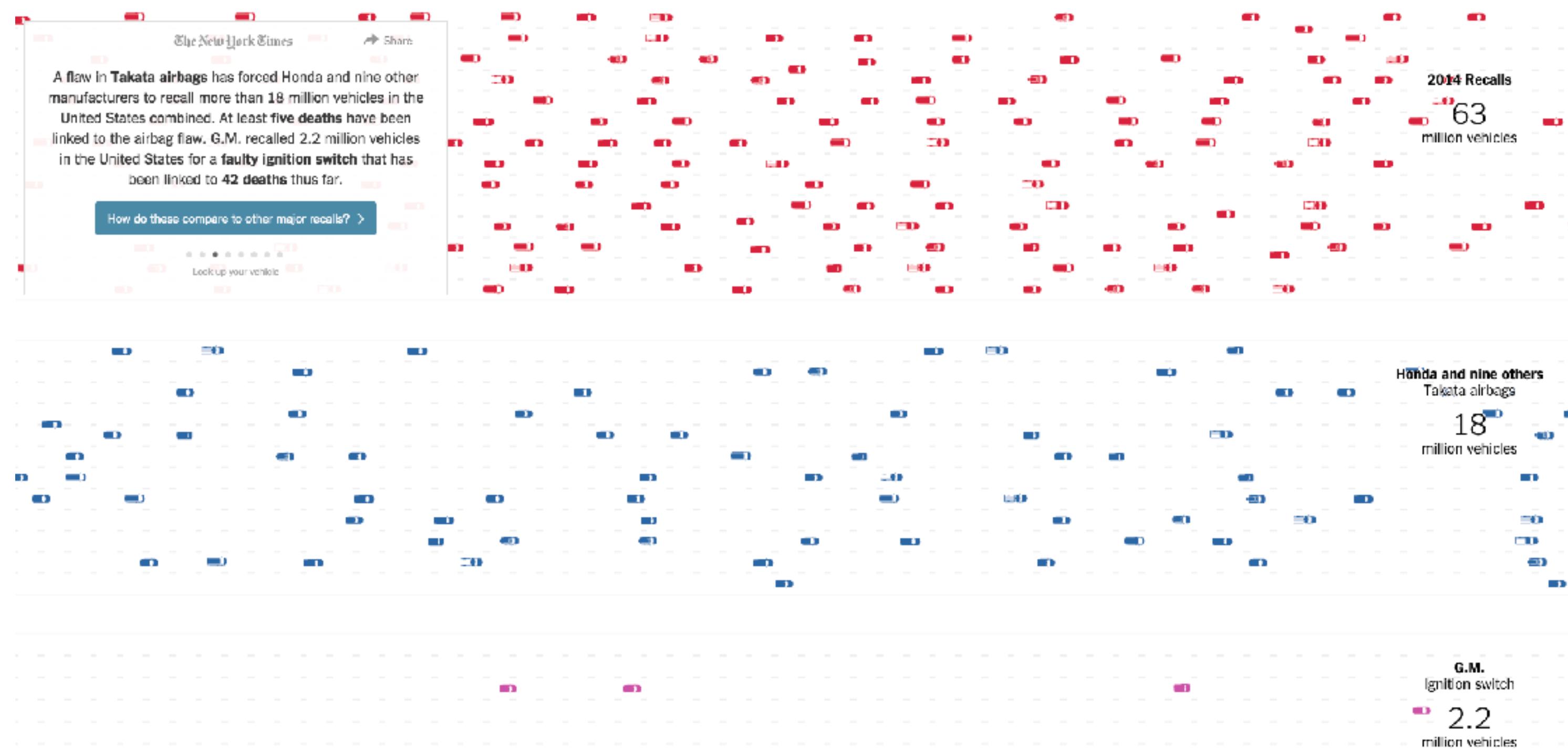


NY Times: <http://bit.ly/auto-recall>

A Record Year for Auto Recalls

In your discussion group please answer the following questions:

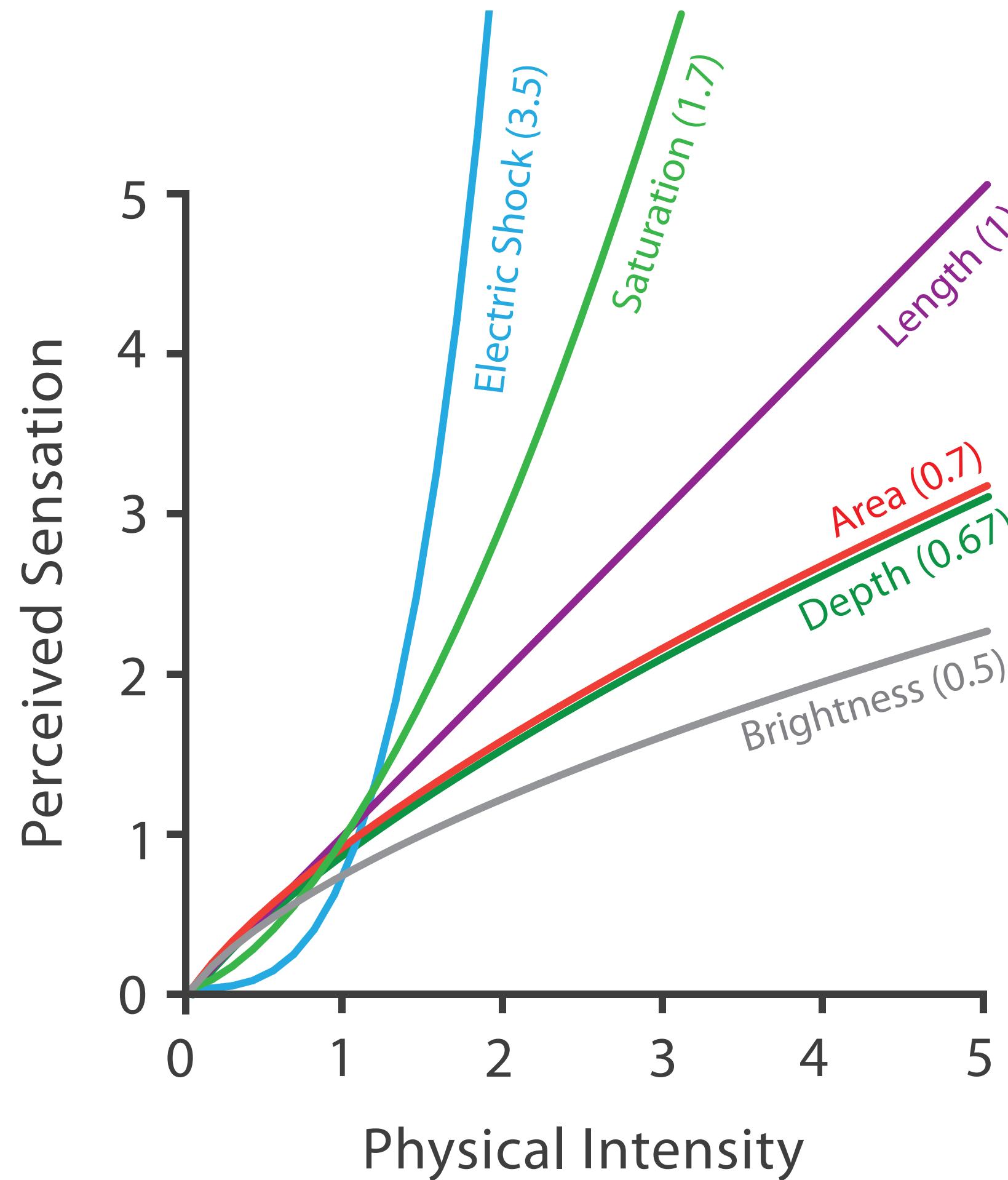
- What is the data shown in this visualization?
- What are the marks, what are the channels?
- What questions does this visualization answer?
- What do you think about the use of animation?
- Is the visualization easy to understand?
- Can you read the data from the visualization?
- Why do you like / dislike this visualization?
- Can you suggest any improvements? How would you redesign it?



**Can we quantify
channel effectiveness?**

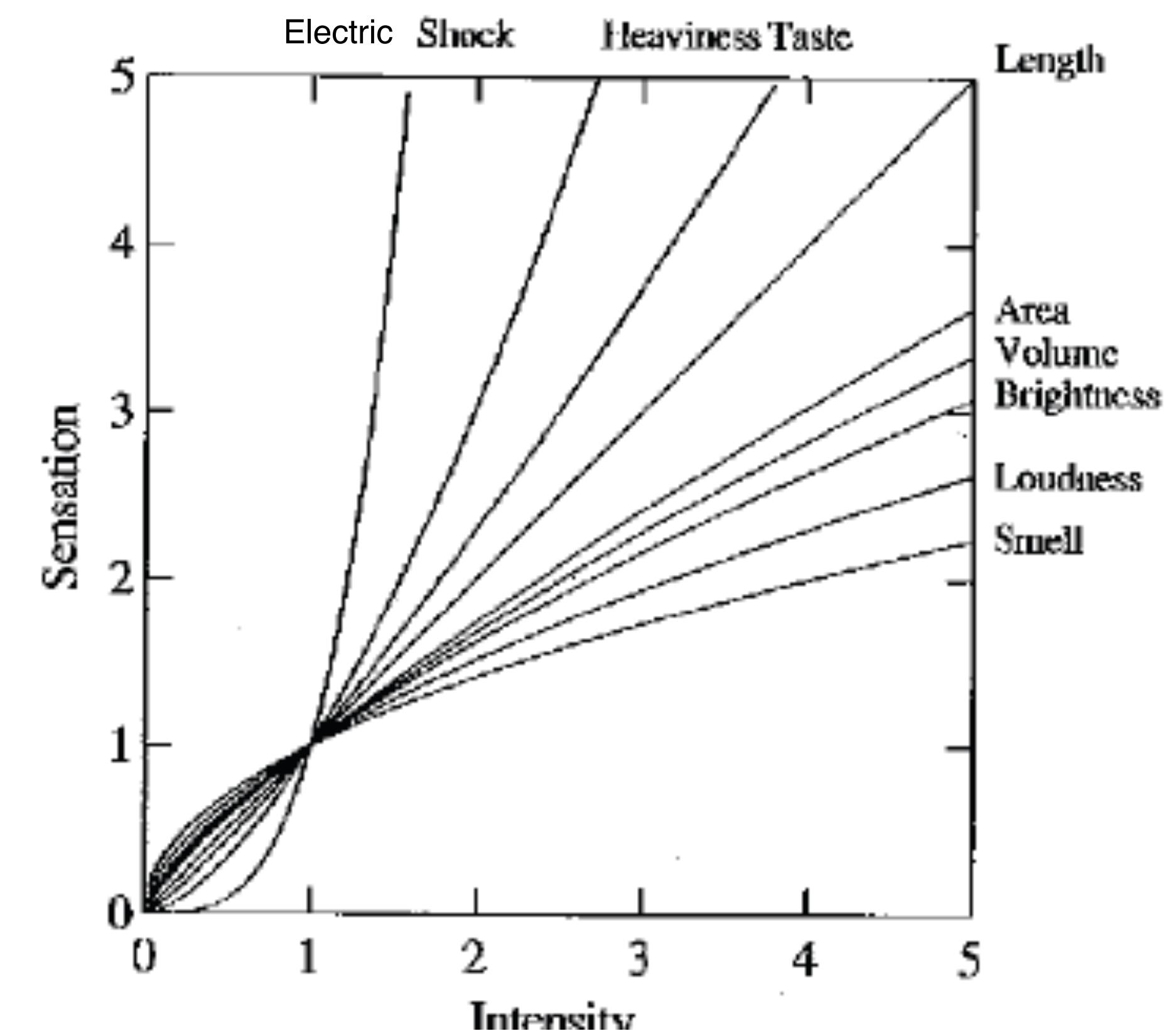
Why are quantitative channels different?

Steven's Psychophysical Power Law: $S = I^N$

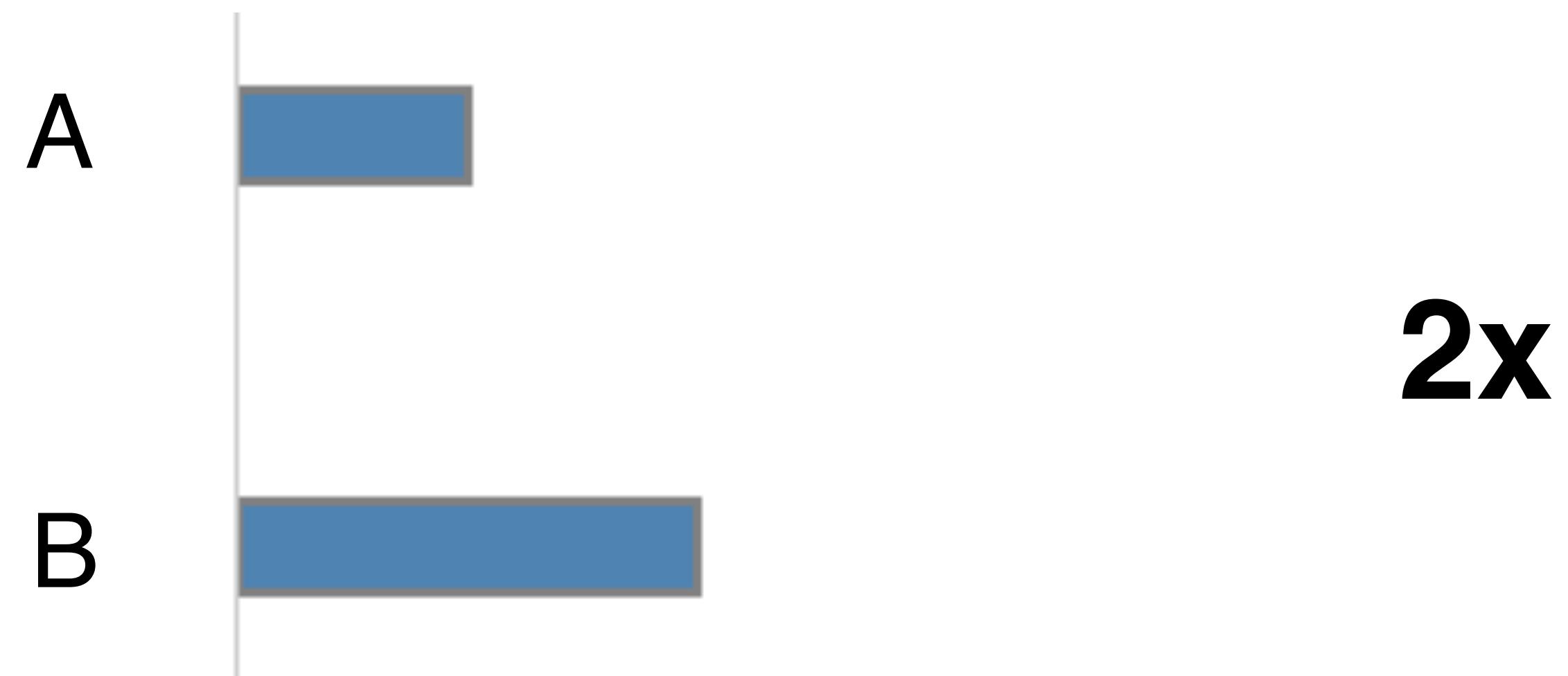


S = sensation
 I = intensity

Steven's Power Law, 1961



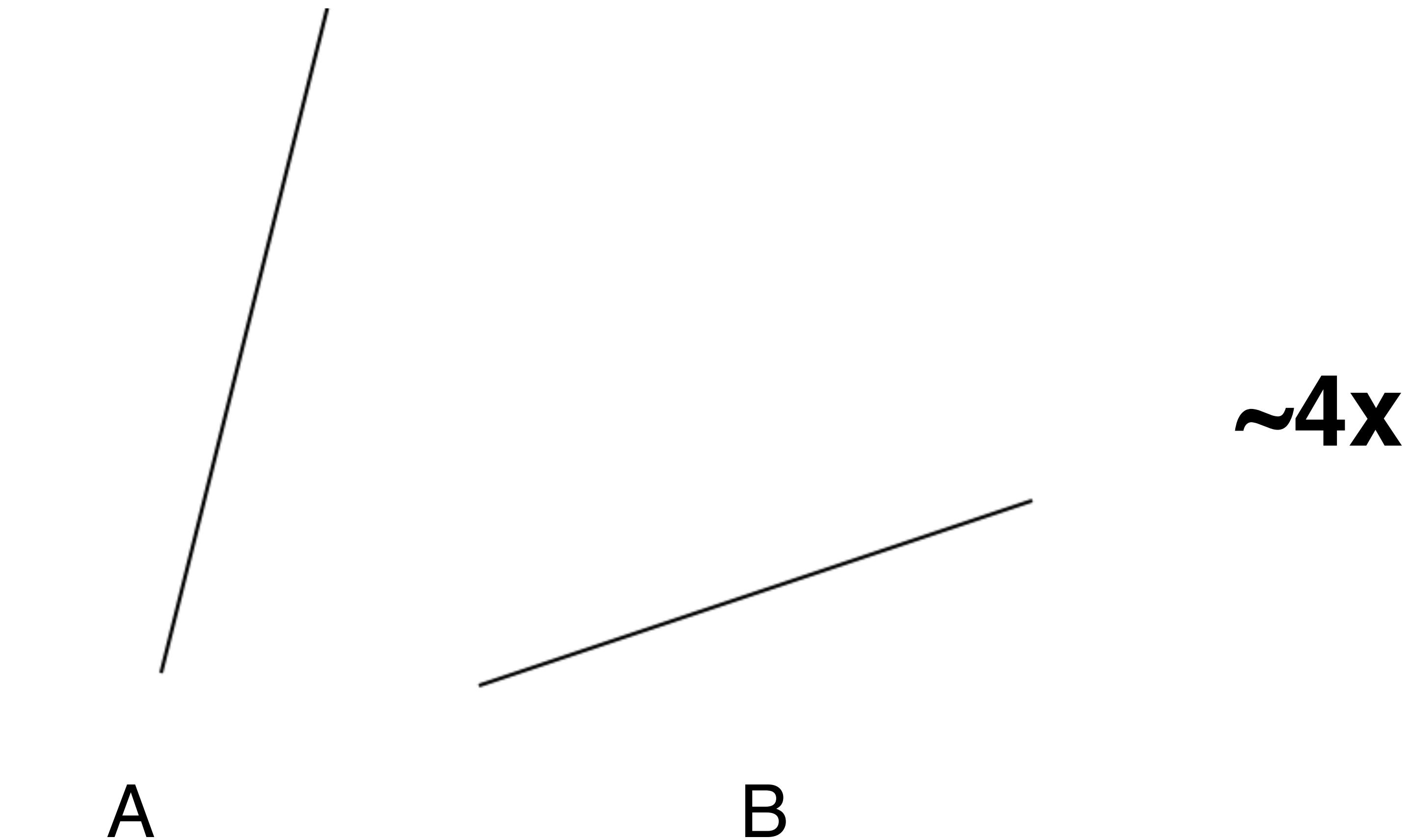
How much longer?



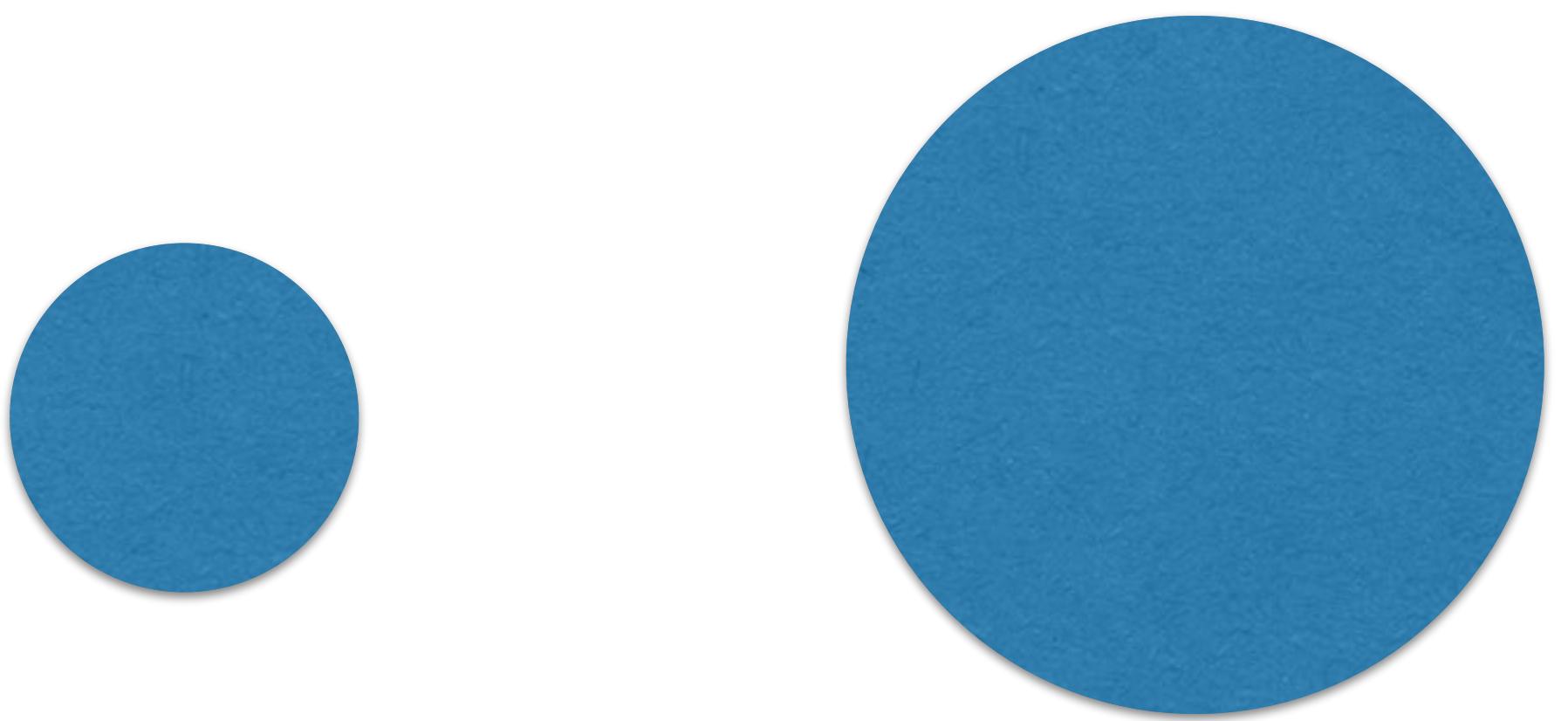
How much longer?



How much steeper?



How much larger?



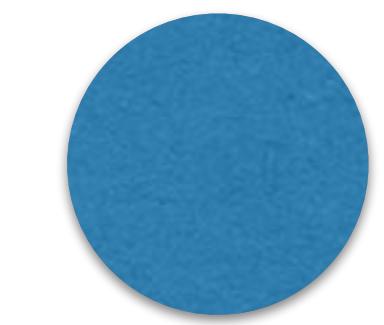
A

B

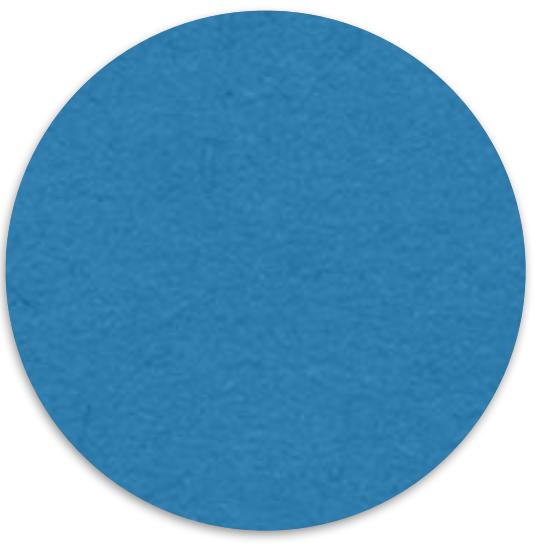
**2x
diameter
4x area**

area is proportional to
diameter squared

How much larger (area)?



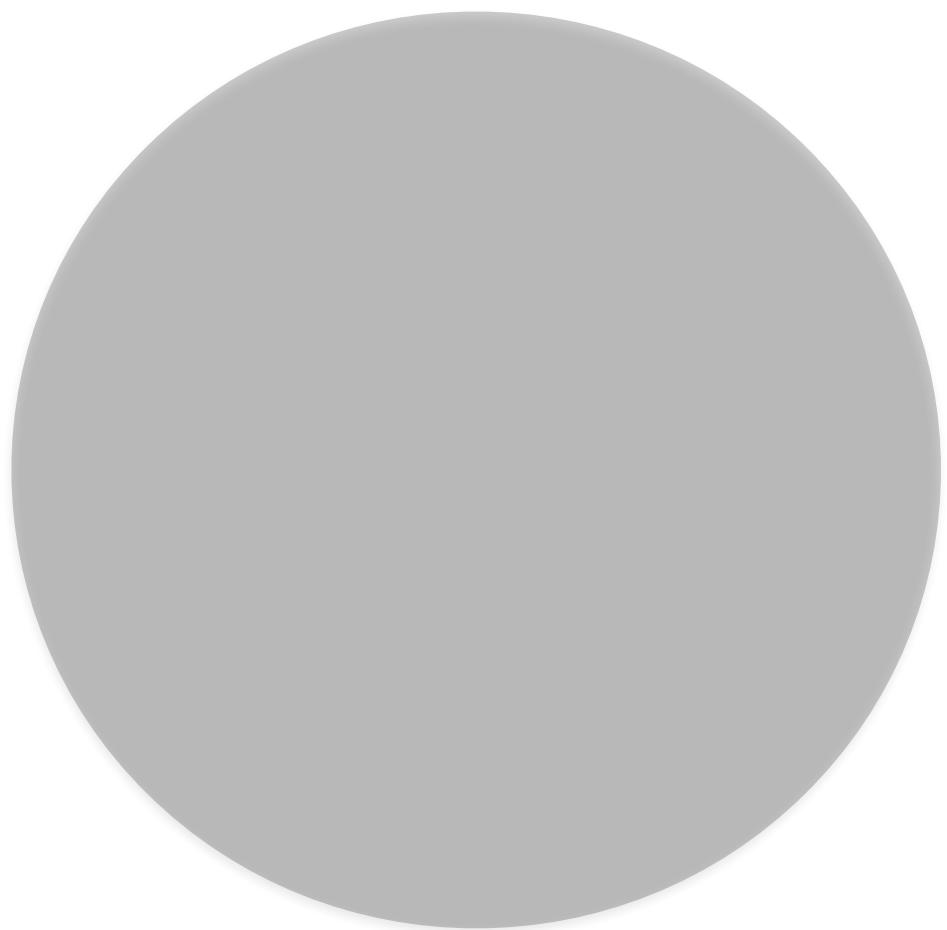
A



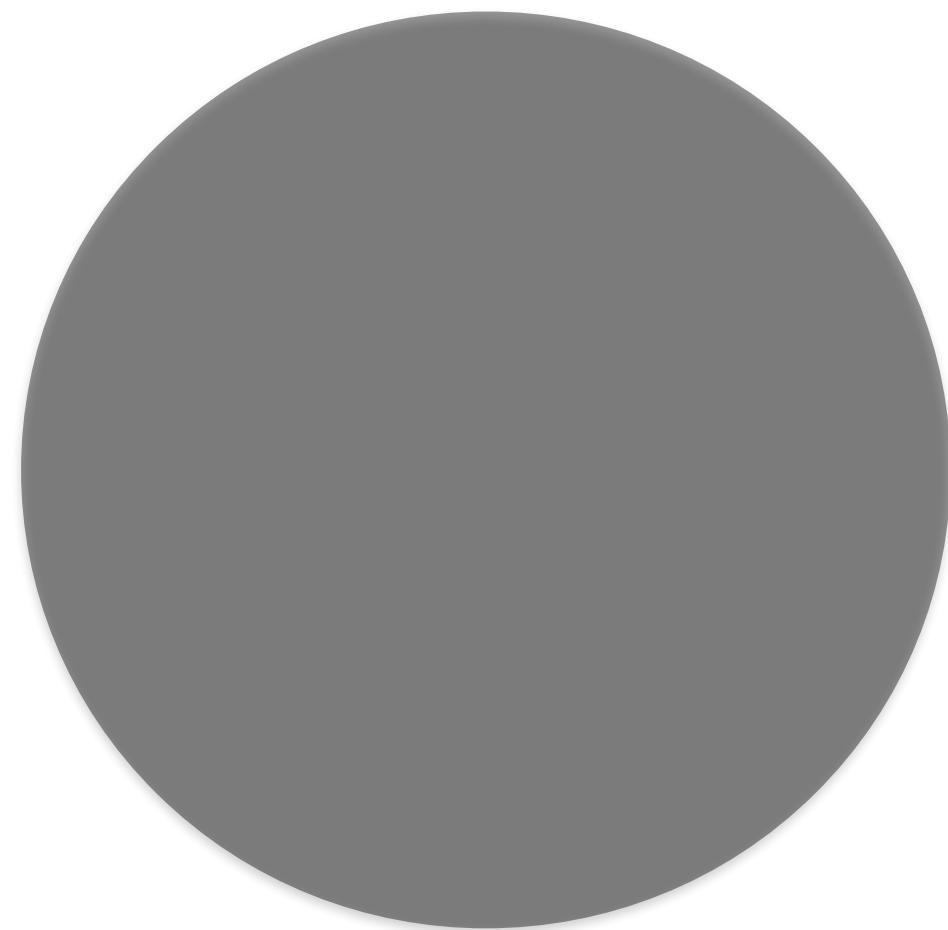
B

3x

How much darker?



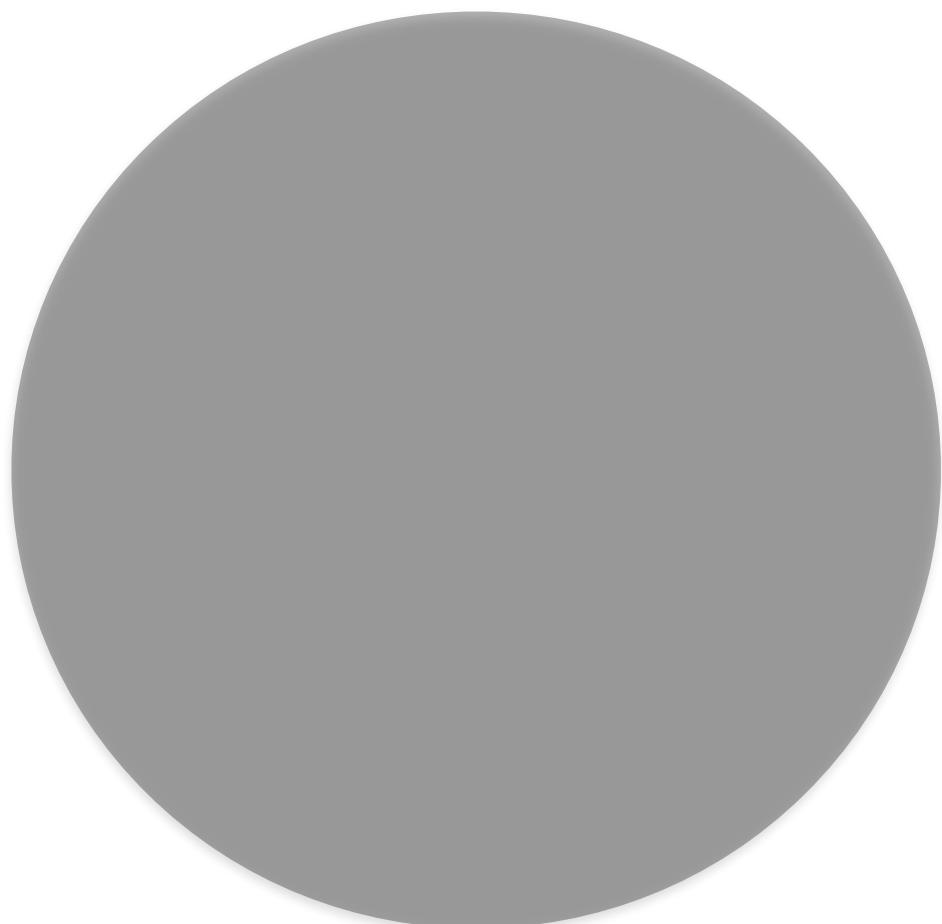
A



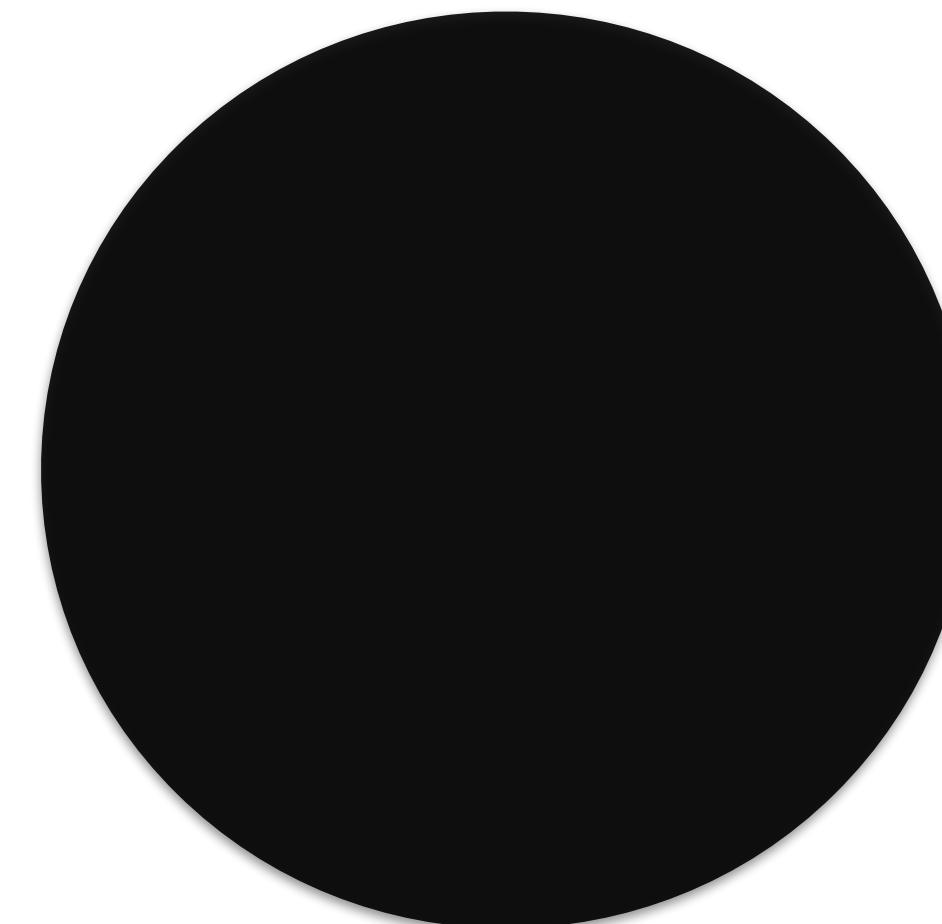
B

2x

How much darker?



A



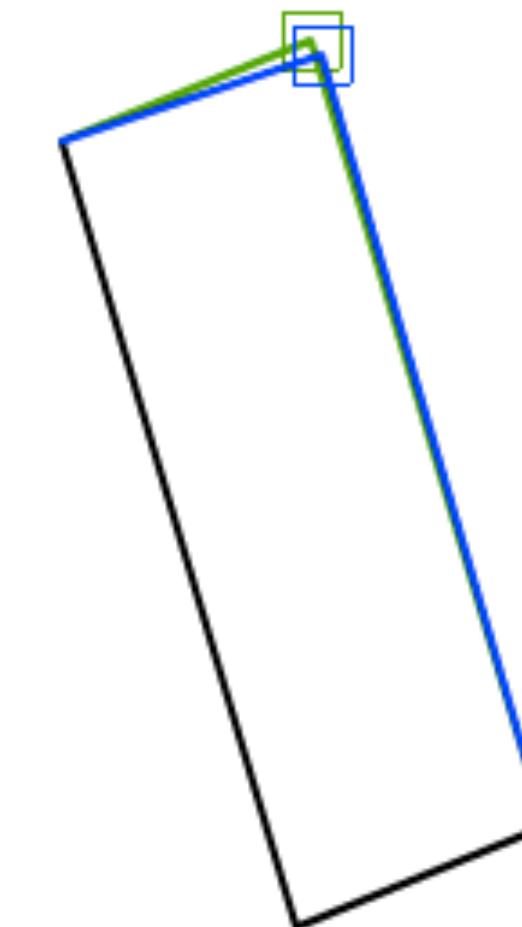
B

3x

Position, Length & Angle

The eyeballing game

Adjust to make a parallelogram



Accurate to 5.0 units

Next

Your inaccuracy by category:

Parallelogram	5.0	---	---
Midpoint	---	---	---
Bisect angle	---	---	---
Triangle center	---	---	---
Circle center	---	---	---
Right angle	---	---	---
Convergence	---	---	---

Average error: 5.00 (lower is better)

Time taken: 3.3

Best of last 500 score and time: [\(more\)](#)

- 1.32 250 s Harabubakken sparkakar kl
- 1.36 81 s ± rides saddle horn
- 1.39 110 s have both-can f myself±
- 1.46 93 s ± is one kinky dude
- 1.50 95 s no NT...sample my taco? ±
- 1.55 114 s
- 1.57 113 s
- 1.65 85 s ± "come on funny feeling"
- 1.70 71 s JSA
- 1.75 89 s JSA

Best on this computer score and time:

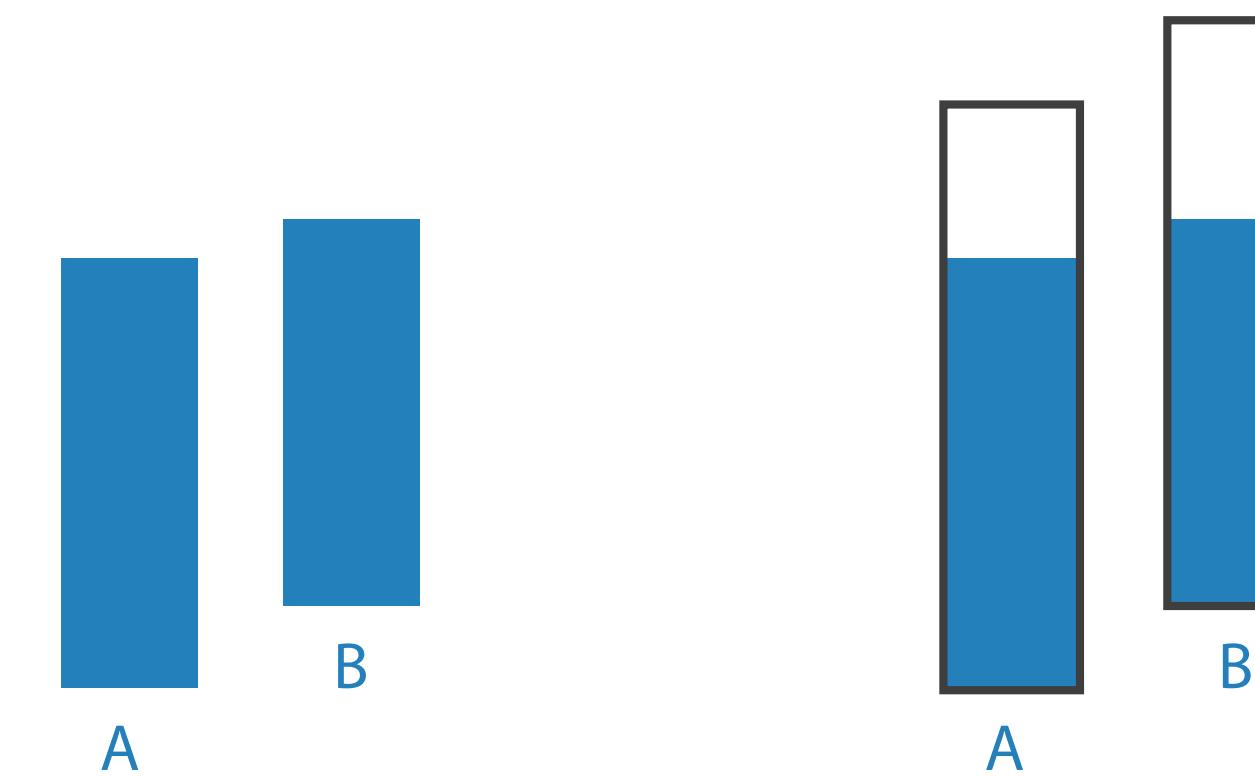
<http://woodgears.ca/eyeball/index.html>

Other Factors Affecting Accuracy

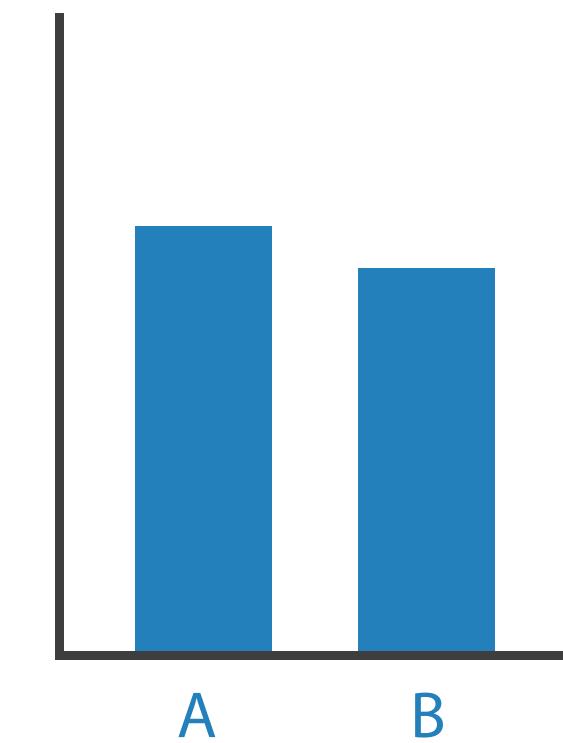


Other Factors Affecting Accuracy

Alignment



Distractors



Distance

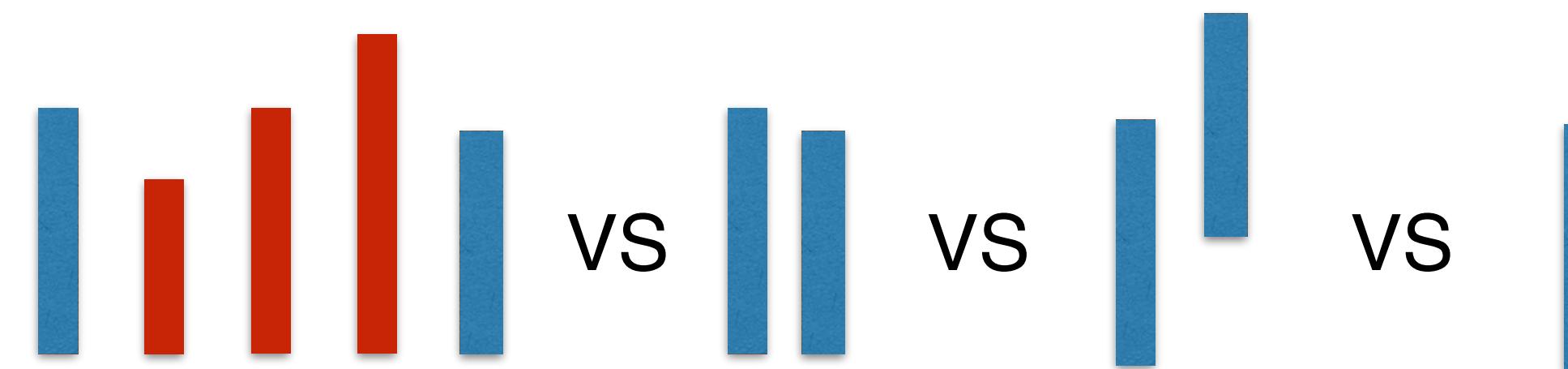
Common scale

Unframed
Unaligned

Framed
Unaligned

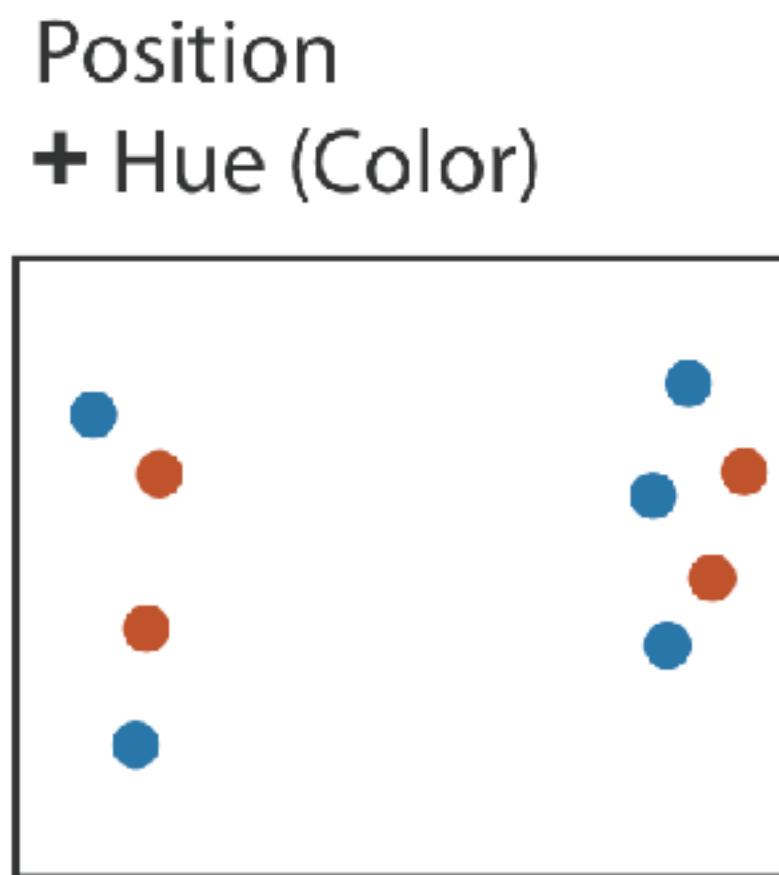
Unframed
Aligned

...



Separability of Attributes

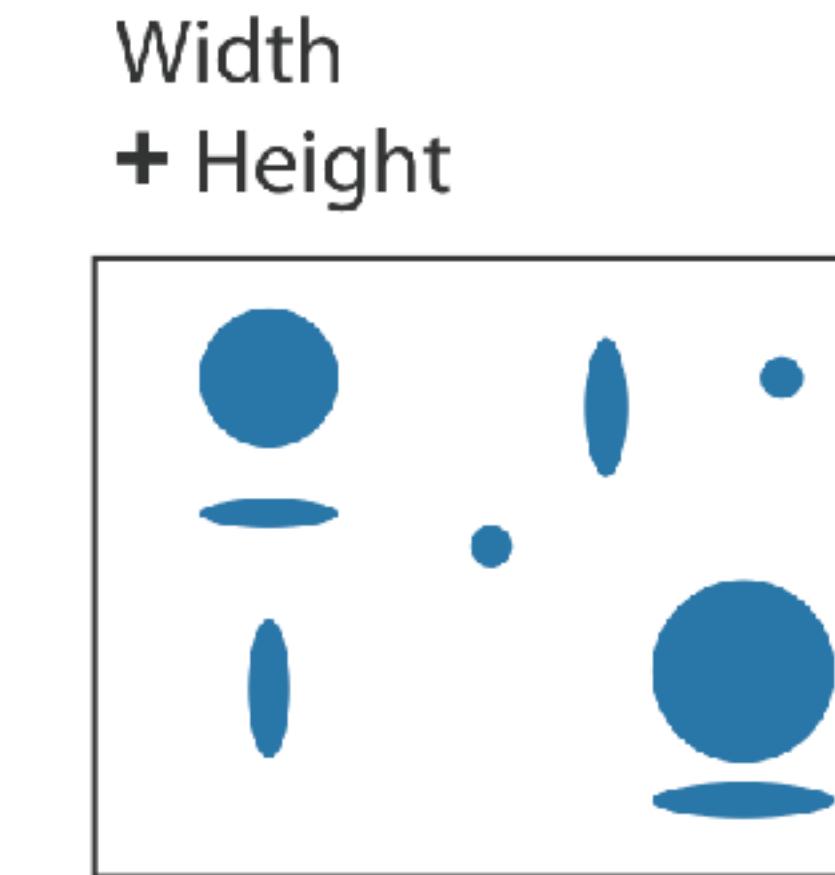
Can we combine multiple visual variables?



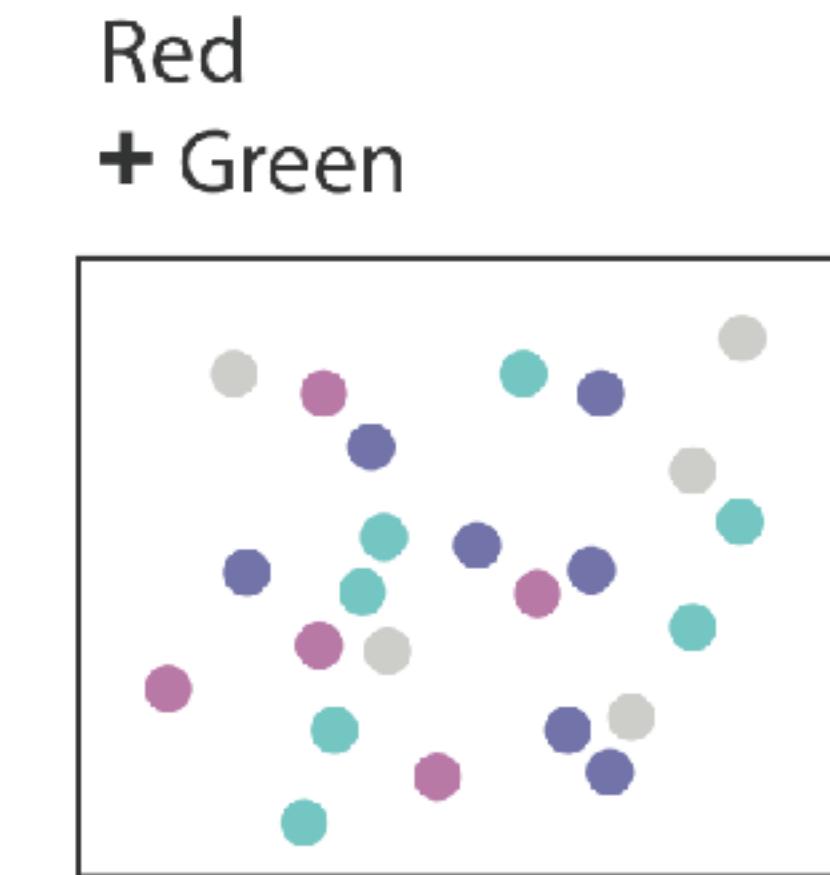
Fully separable



Some interference



Some/significant
interference



Major interference