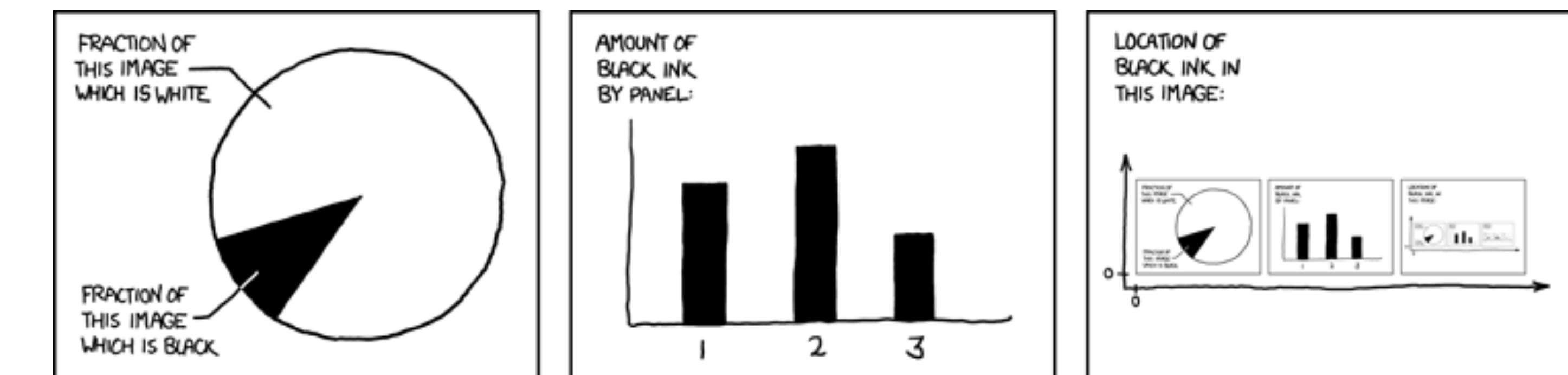


# COMP 5960

## Applied Data Visualization

### The Visualization Alphabet: Marks and Channels

Alexander Lex  
[alex@sci.utah.edu](mailto:alex@sci.utah.edu)



[xkcd]

How can I visually represent two numbers, e.g.,  
**4 and 8**

# **Marks & Channels**

**Marks:** represent items or links

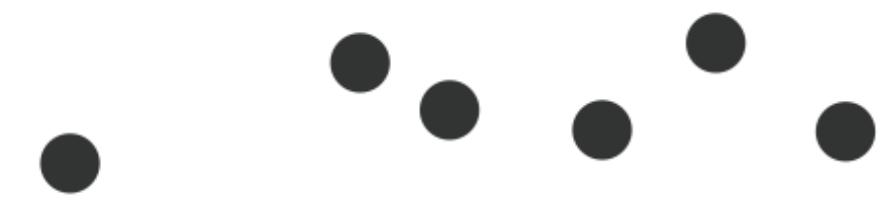
**Channels:** change appearance based on **attribute**

**Channel = Visual Variable**

# Marks for Items

Basic geometric elements

→ Points



0D

→ Lines



1D

→ Areas

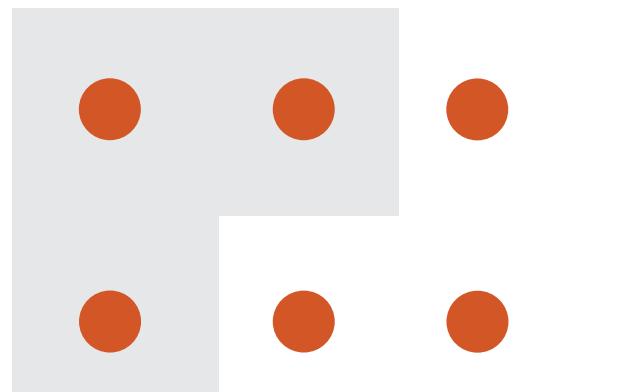


2D

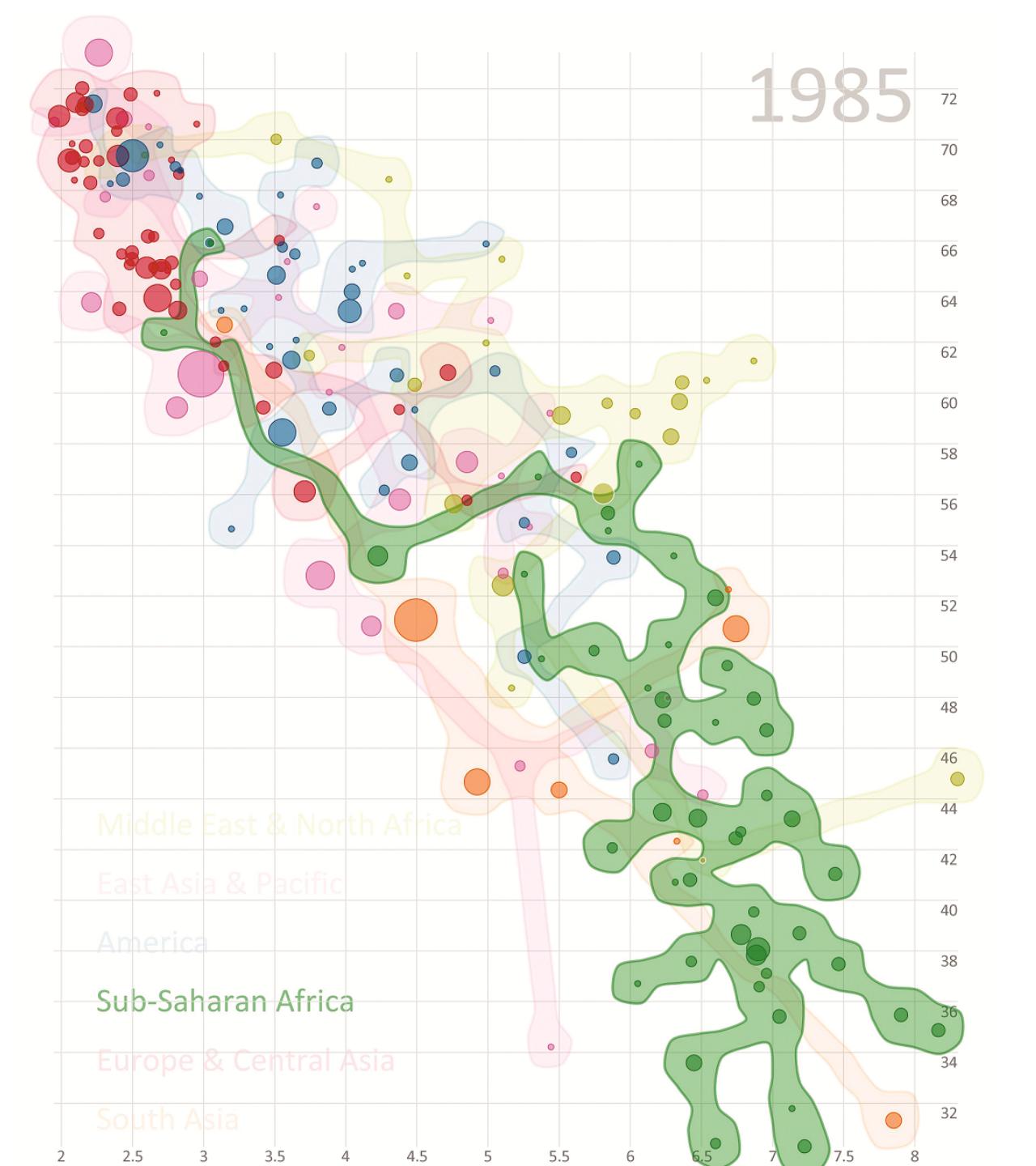
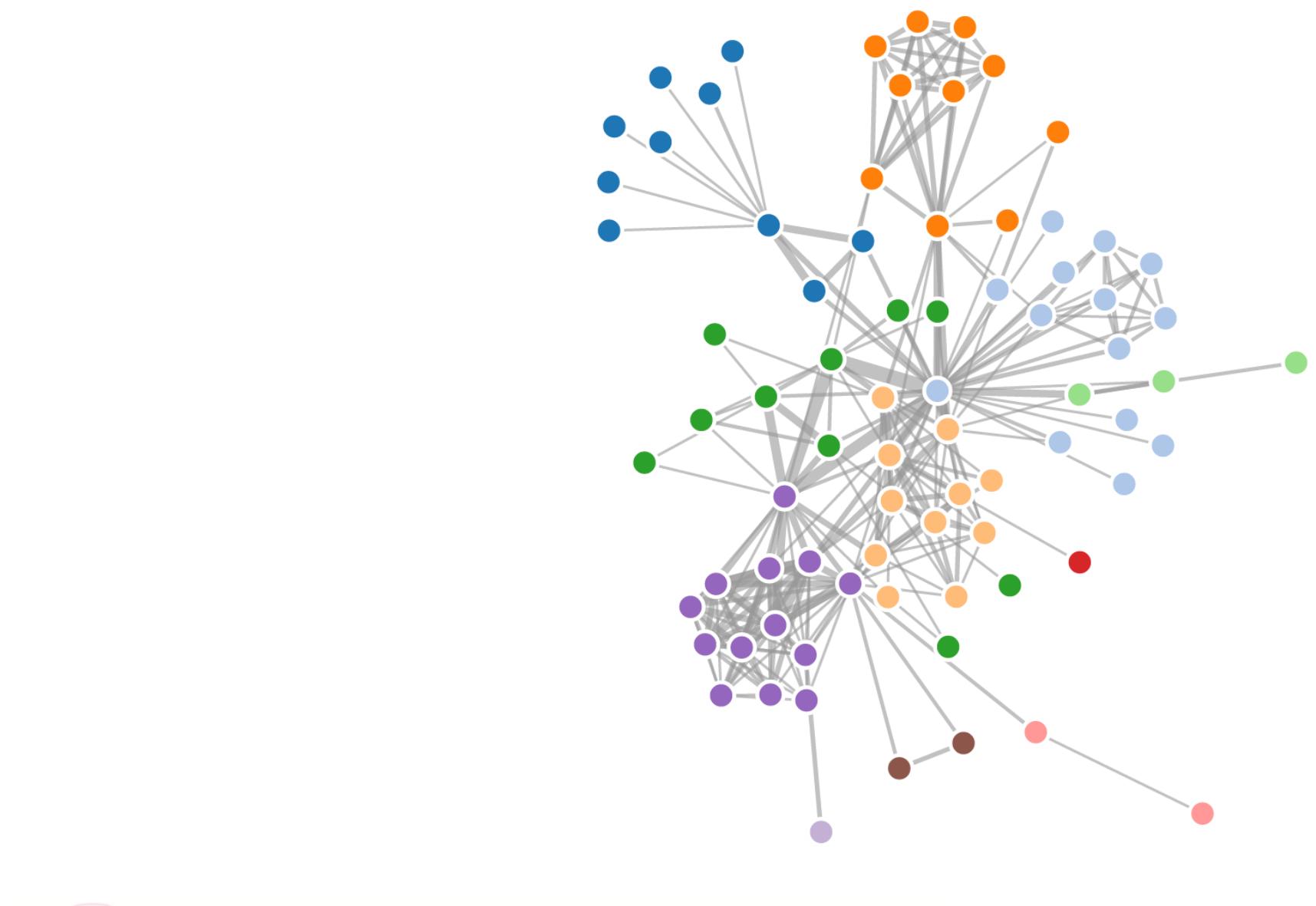
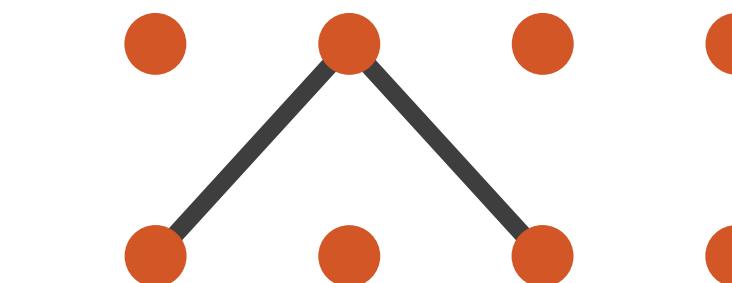
3D mark: Volume, but rarely used

# Marks for Links

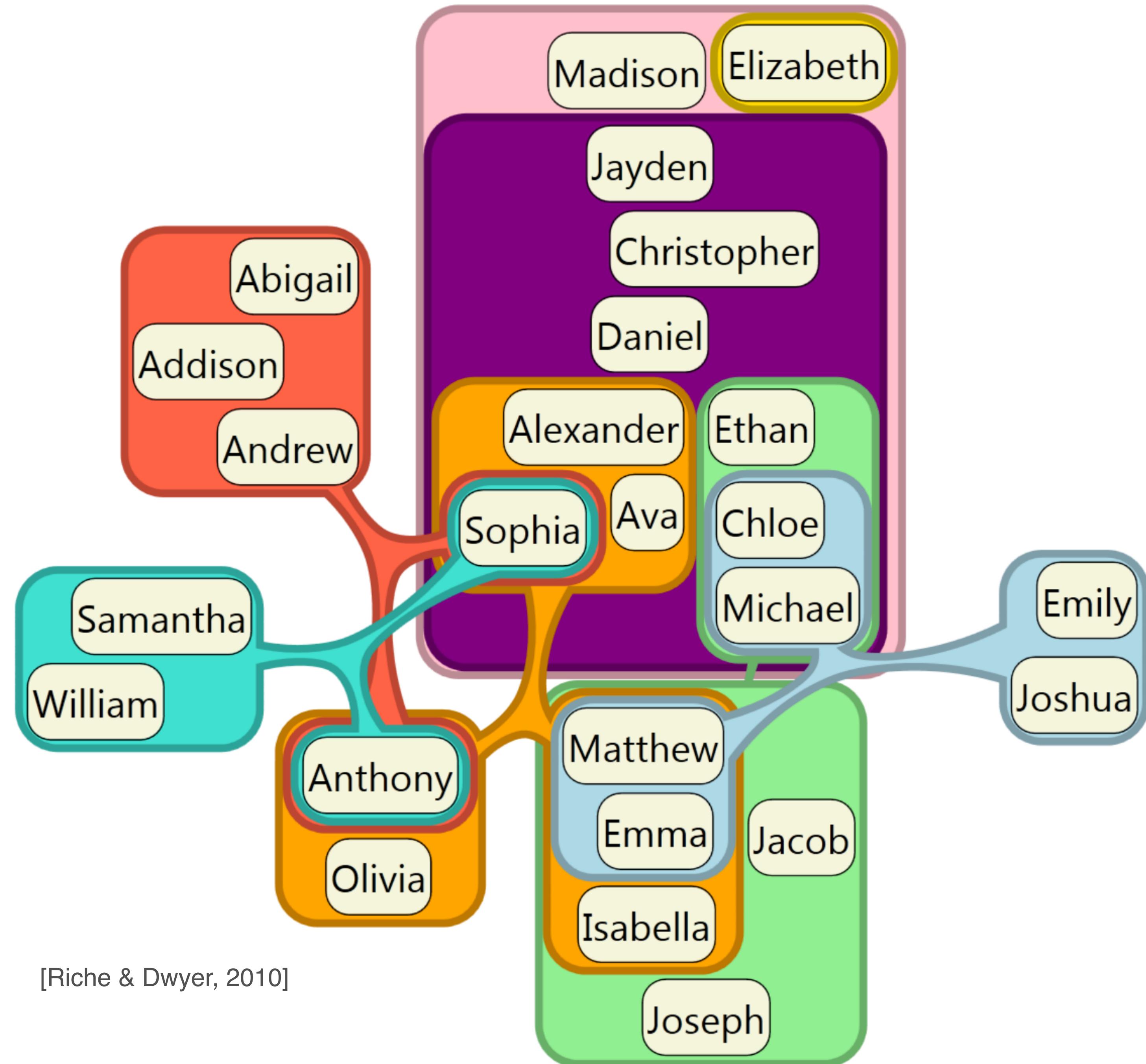
→ Containment



→ Connection



# Containment can be nested



# Channels (aka Visual Variables)

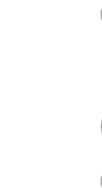
Control appearance  
proportional to or  
based on attributes

## → Position

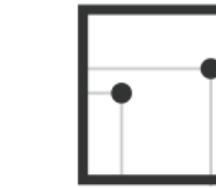
→ Horizontal



→ Vertical



→ Both



## → Color



## → Shape



## → Tilt



## → Size

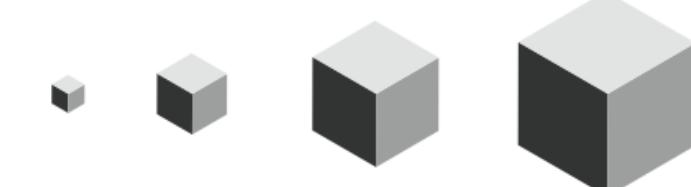
→ Length



→ Area



→ Volume

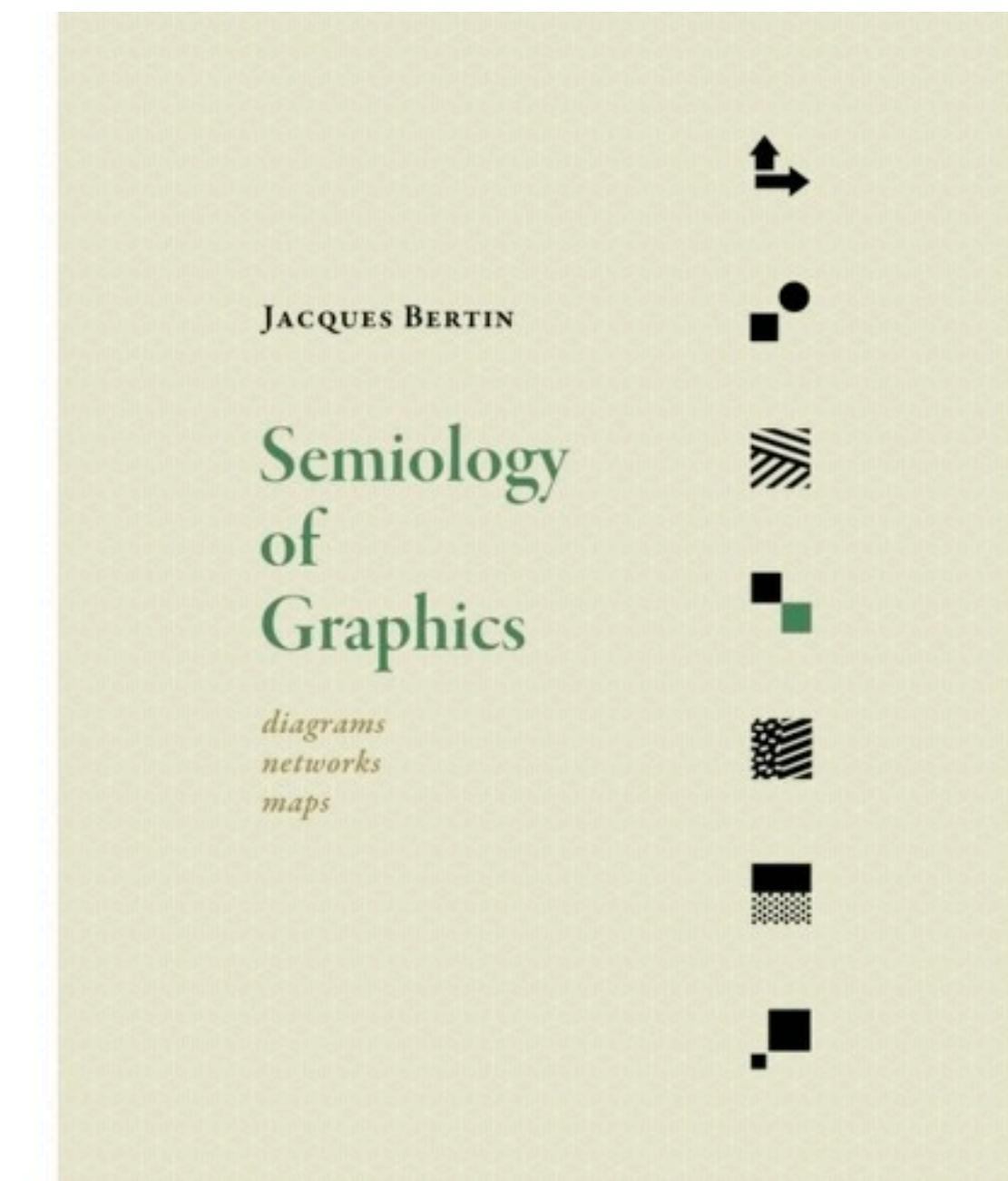


# Jacques Bertin

French cartographer  
[1918-2010]

Semiology of Graphics [1967]

Theoretical principles for visual  
encodings

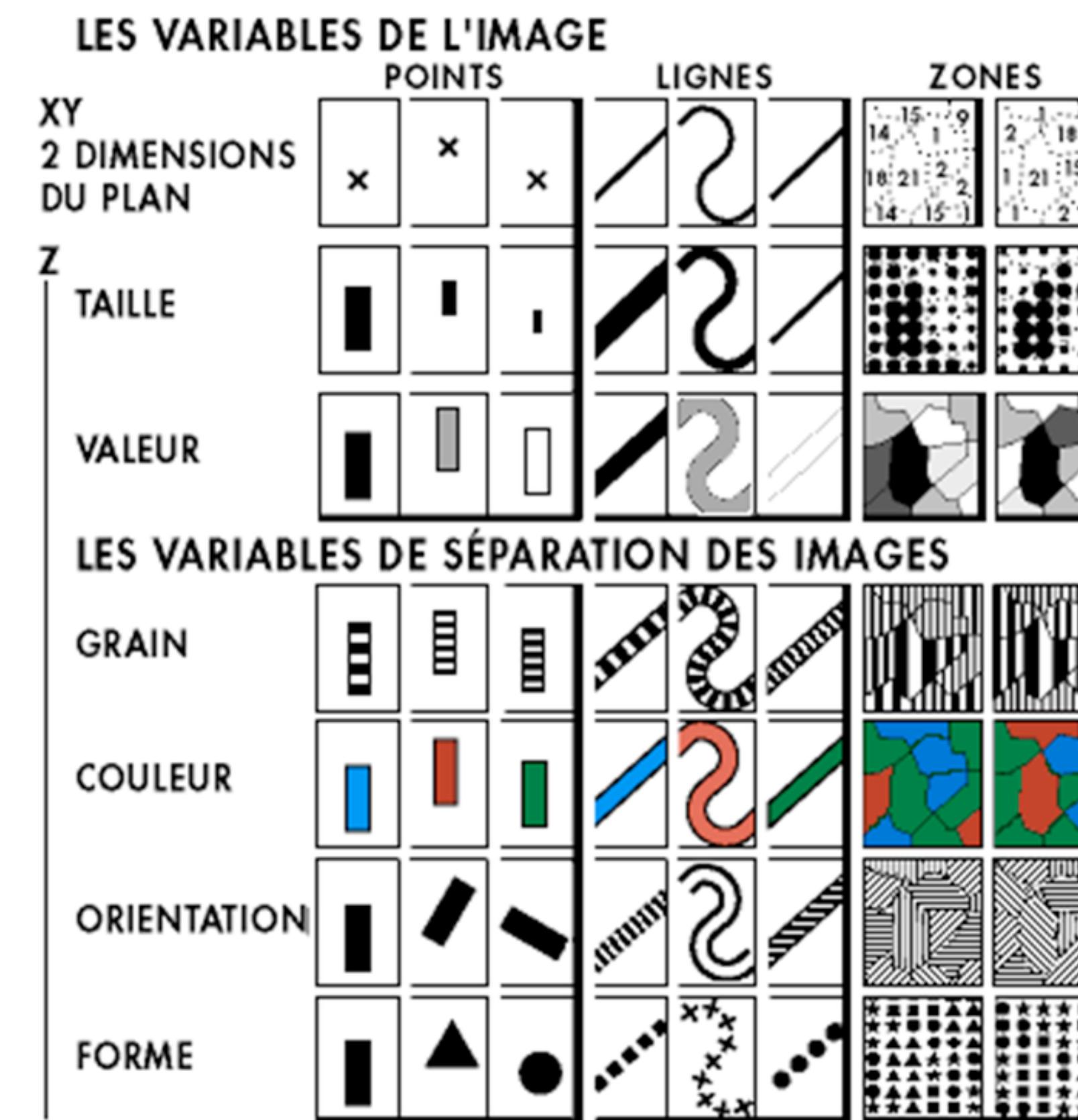


# Bertin's Visual Variables

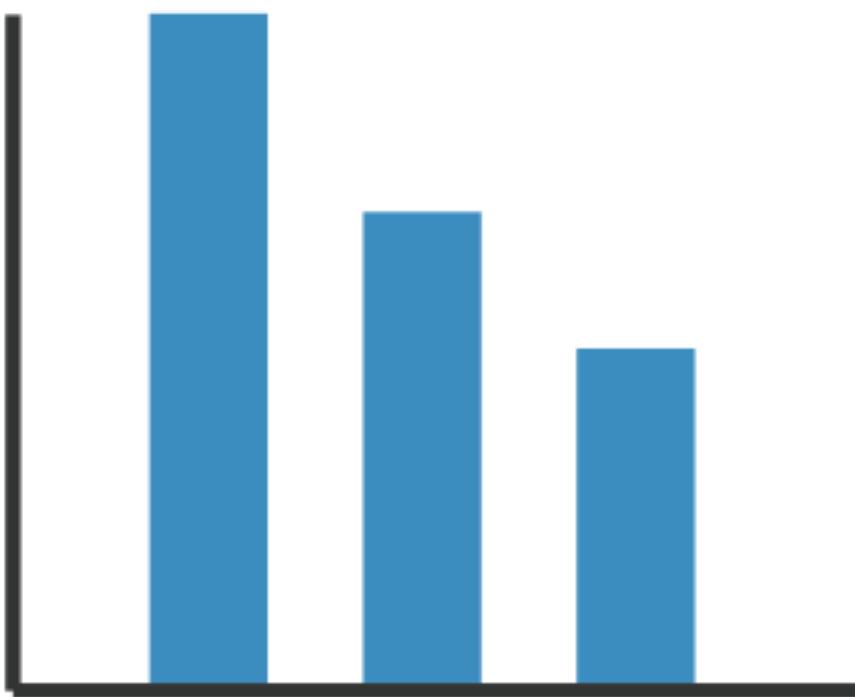
Position  
Size  
(Grey)Value

Texture  
Color  
Orientation  
Shape

Marks: Points Lines Areas



# Using Marks and Channels



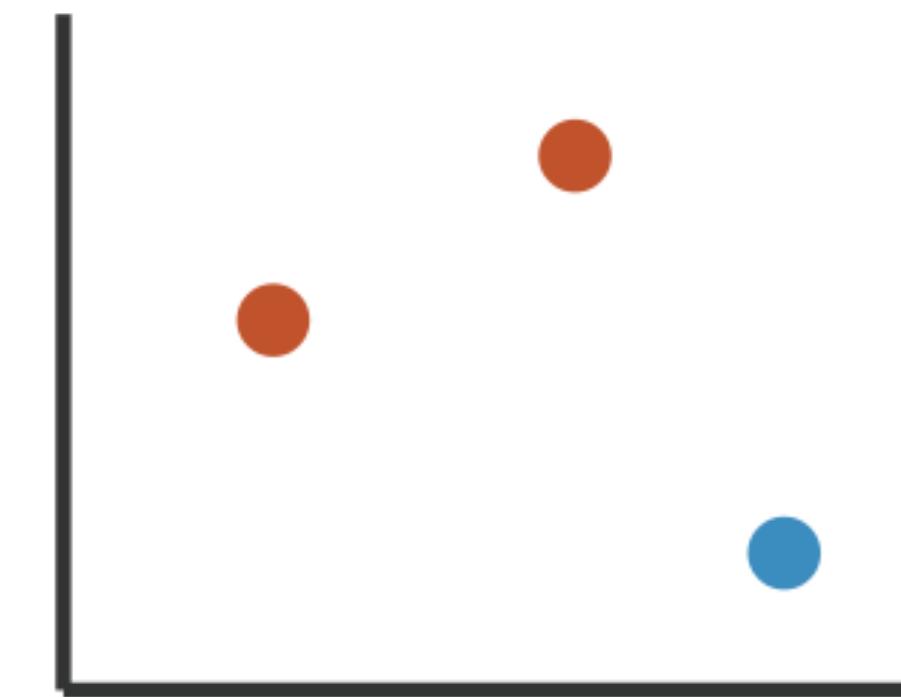
Mark: Line

Channel: Length, Position  
1 quantitative attribute



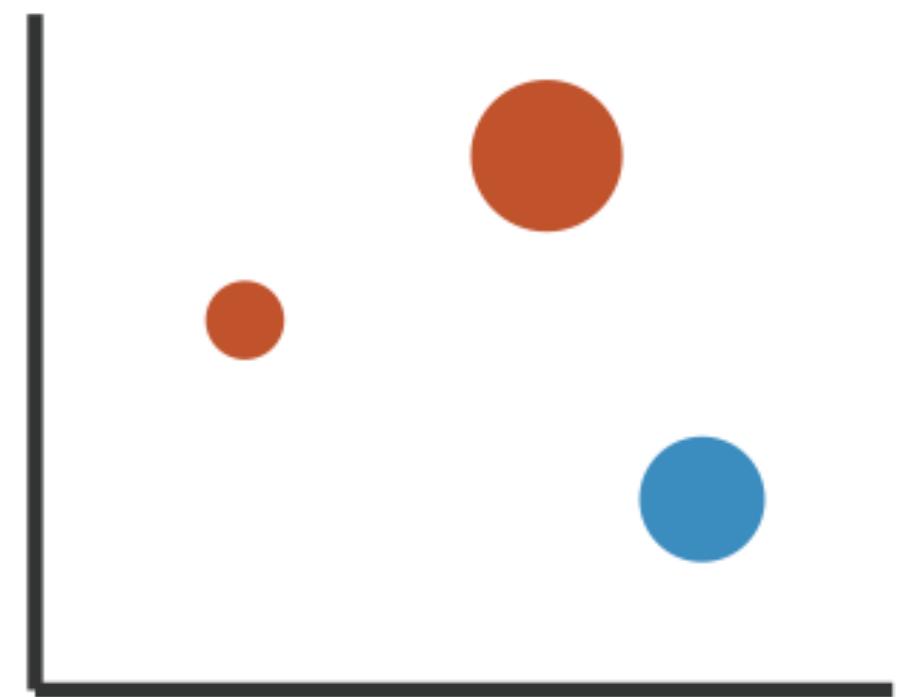
Mark: Point

Channel: Position  
2 quantitative attr.



Adding Hue

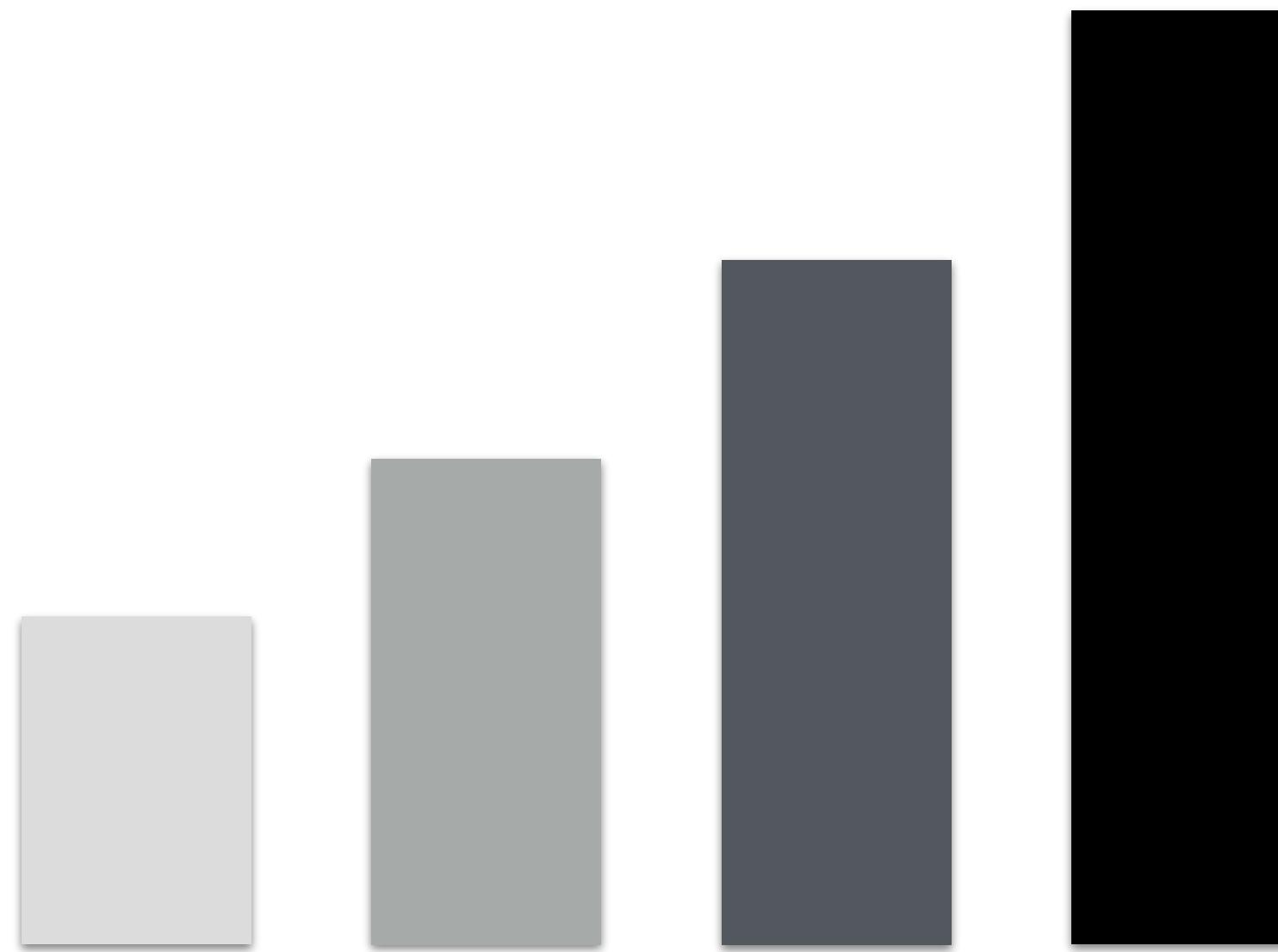
+1 categorical attr.



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? Which Rank?

Position

Length

Saturation ...

## Identity Channels

What?

Shape

Color (hue)

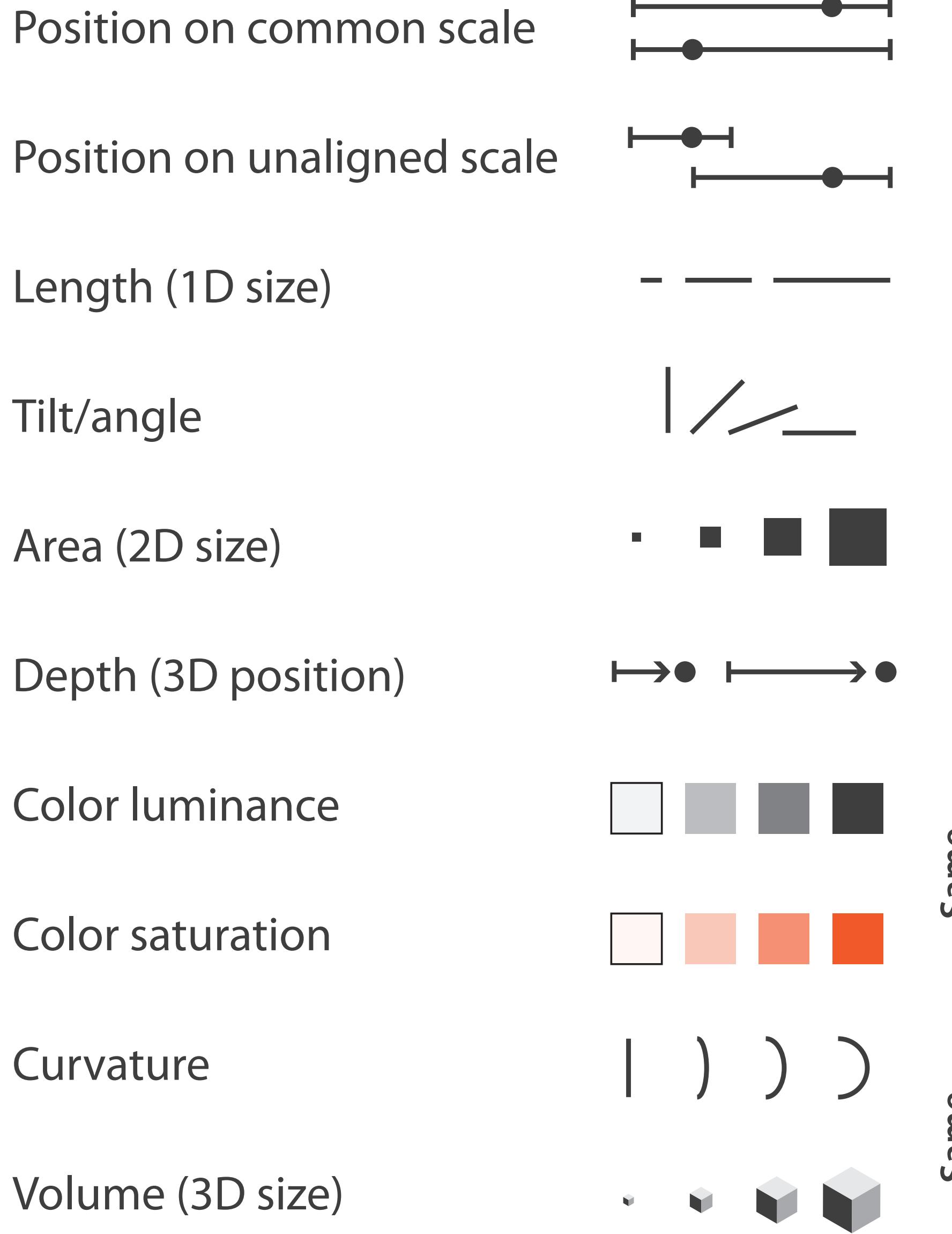
Spatial region ...

Ordinal & Quantitative Data

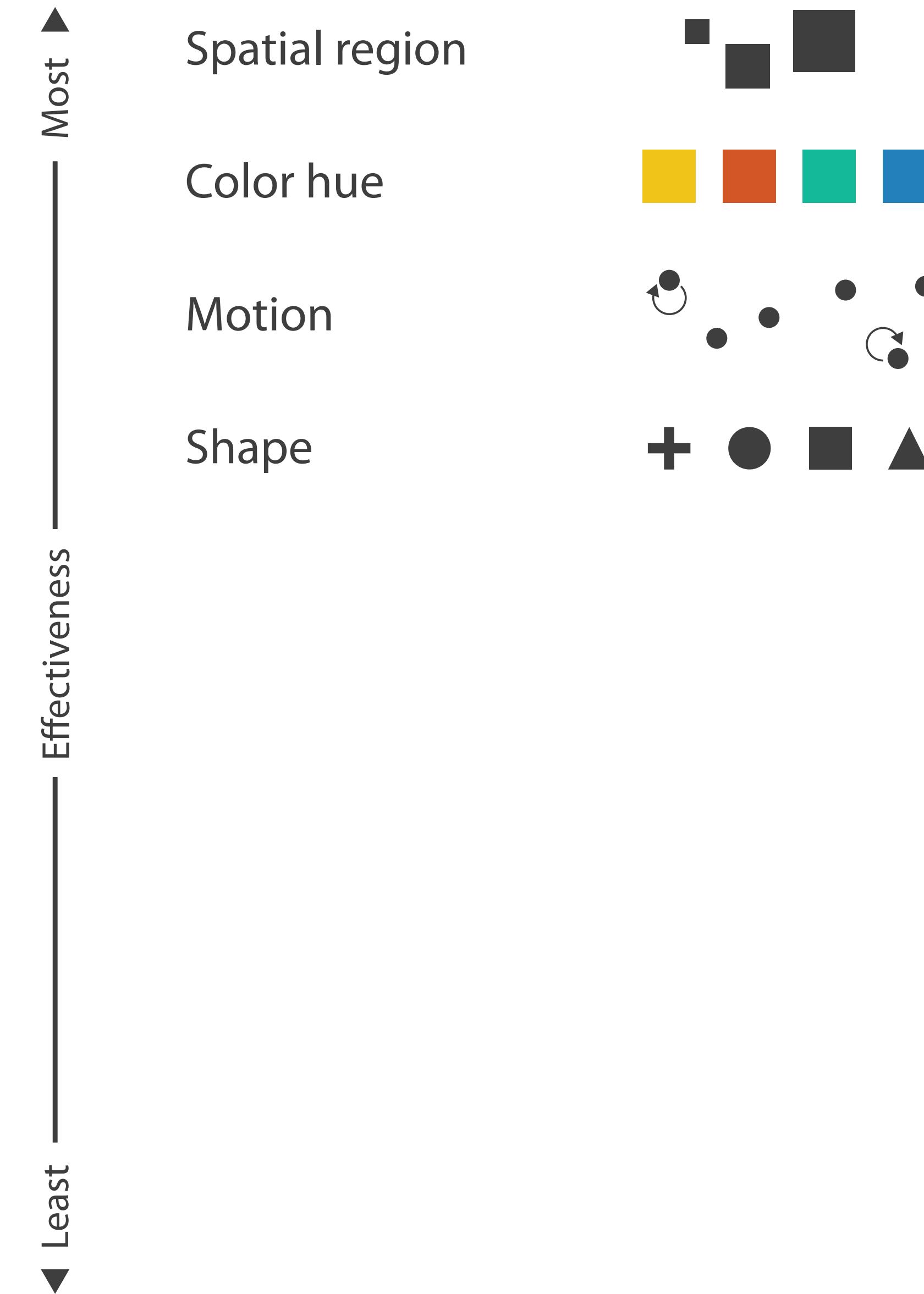
Categorical Data

## Channels: Expressiveness Types and Effectiveness Ranks

### → Magnitude Channels: Ordered Attributes



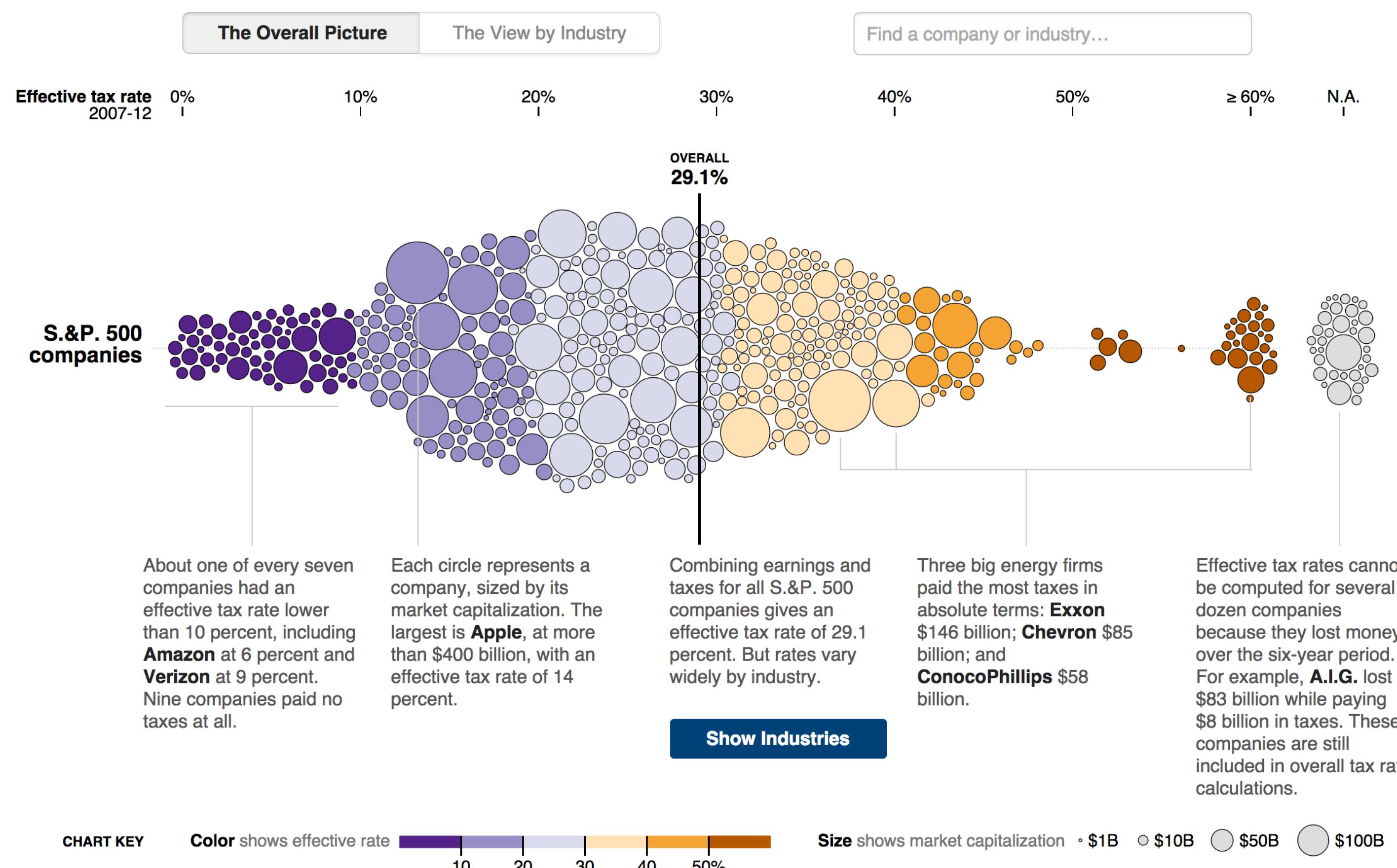
### → Identity Channels: Categorical Attributes



# 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 »](#)



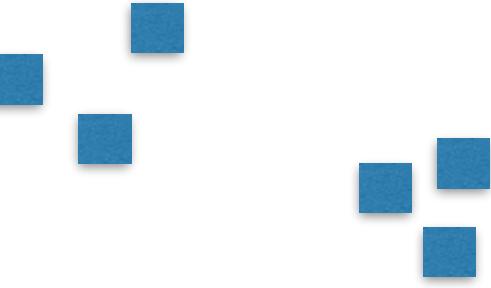
# Characteristics of Channels

## Selective



Is a mark distinct from other marks?

Can we make out the difference between two marks?

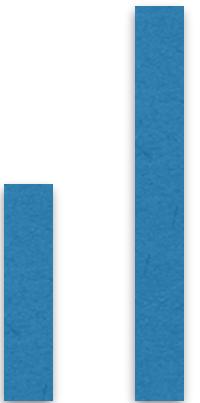


## Associative

Does it support grouping?

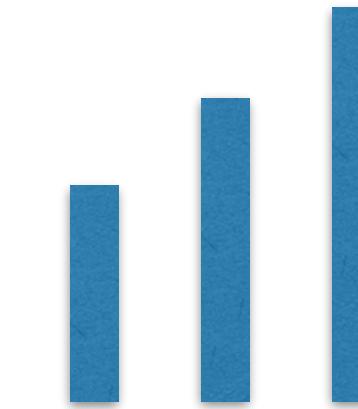
## Quantitative (Magnitude vs Identity Channels)

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

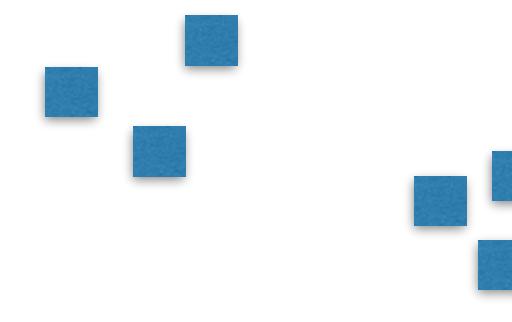
Strongest visual variable

Suitable for all data types

Problems:

Sometimes not available  
(spatial data)

Cluttering



Selective: yes

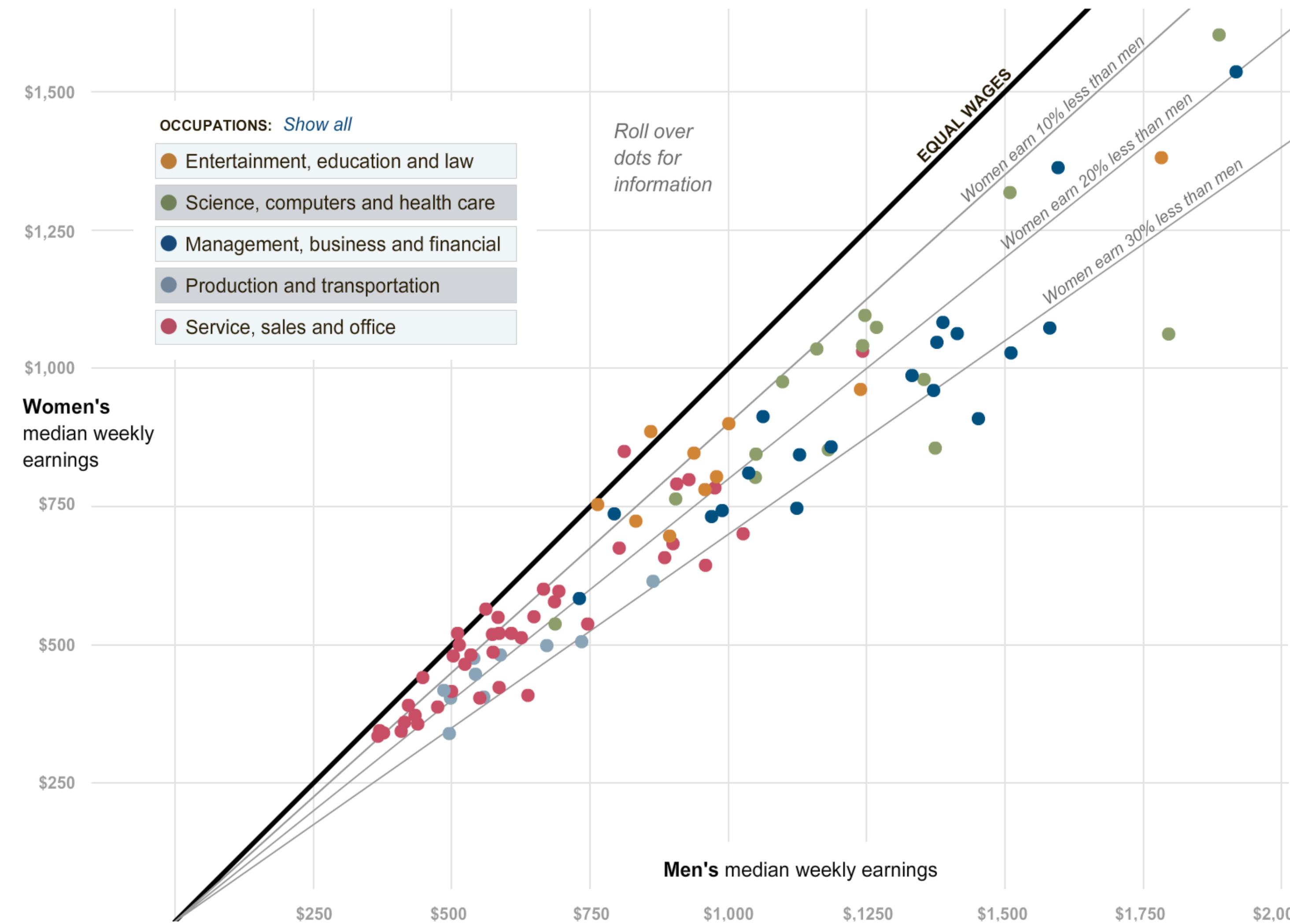
Associative: yes

Quantitative: yes

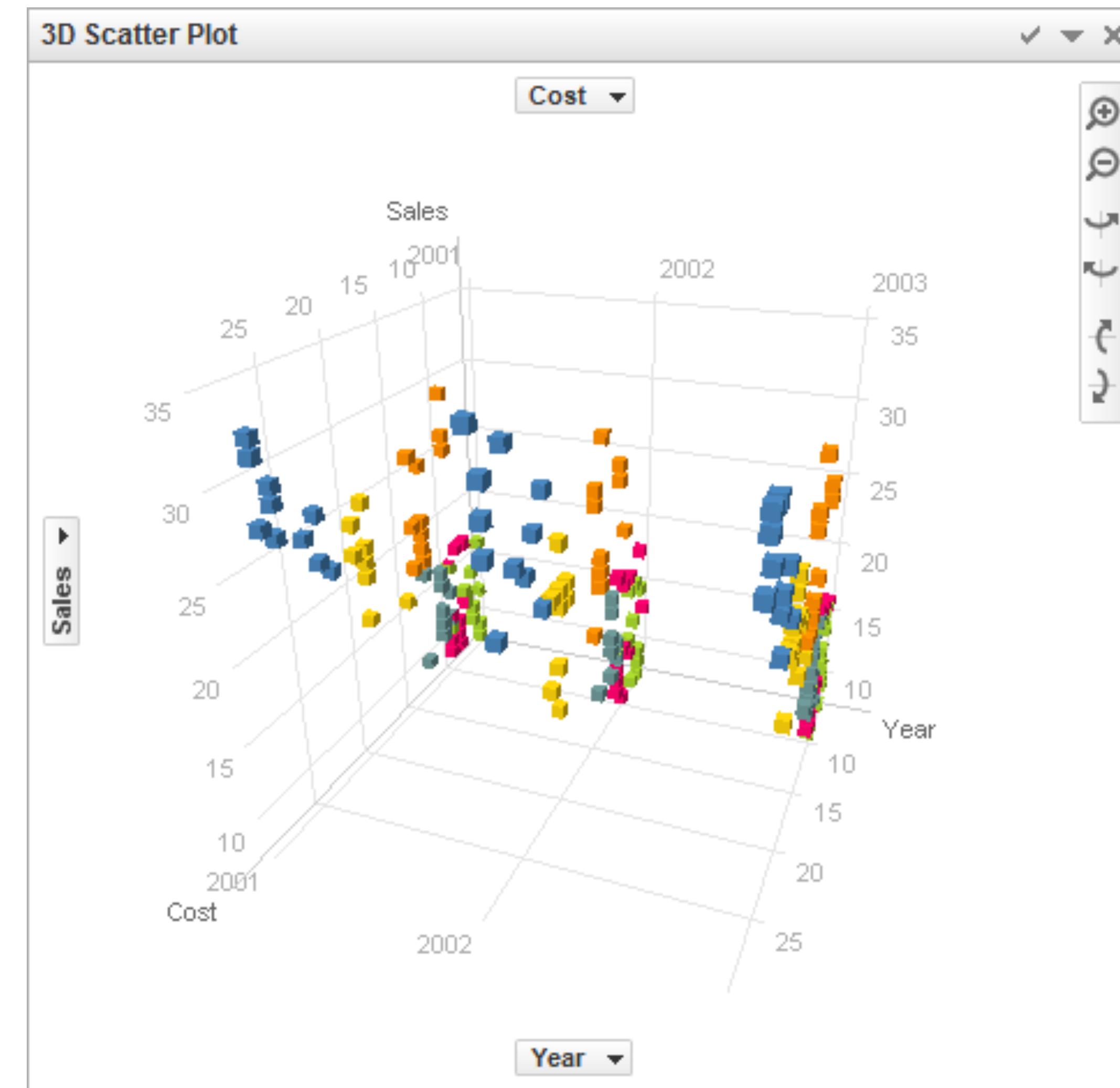
Order: yes

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

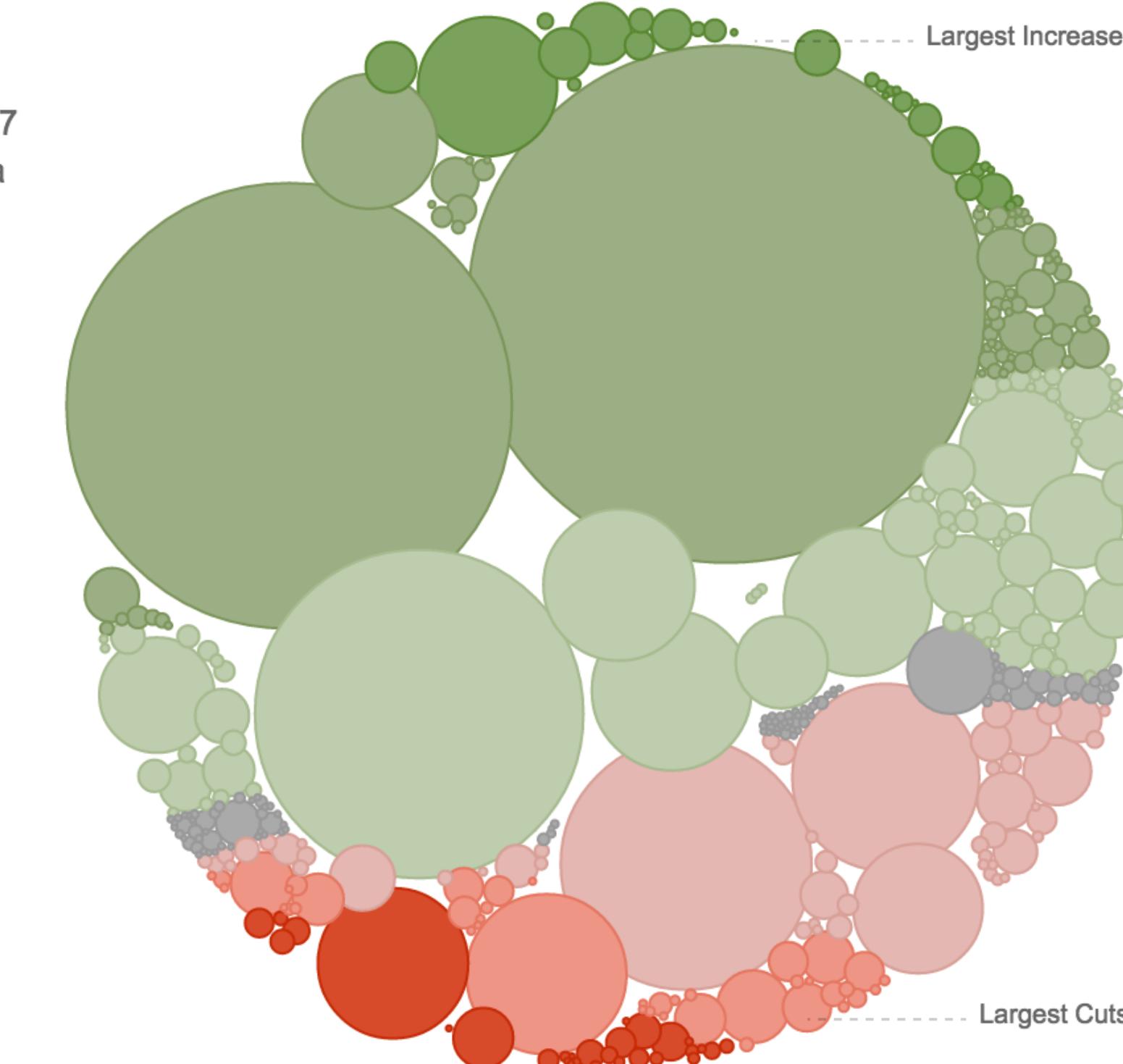
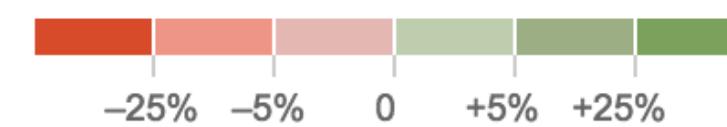
### How \$3.7 Trillion Is Spent

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

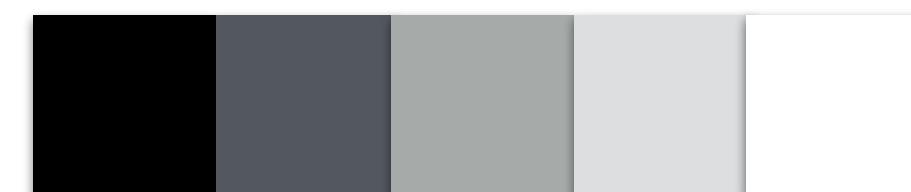
Selective: yes

Associative: yes

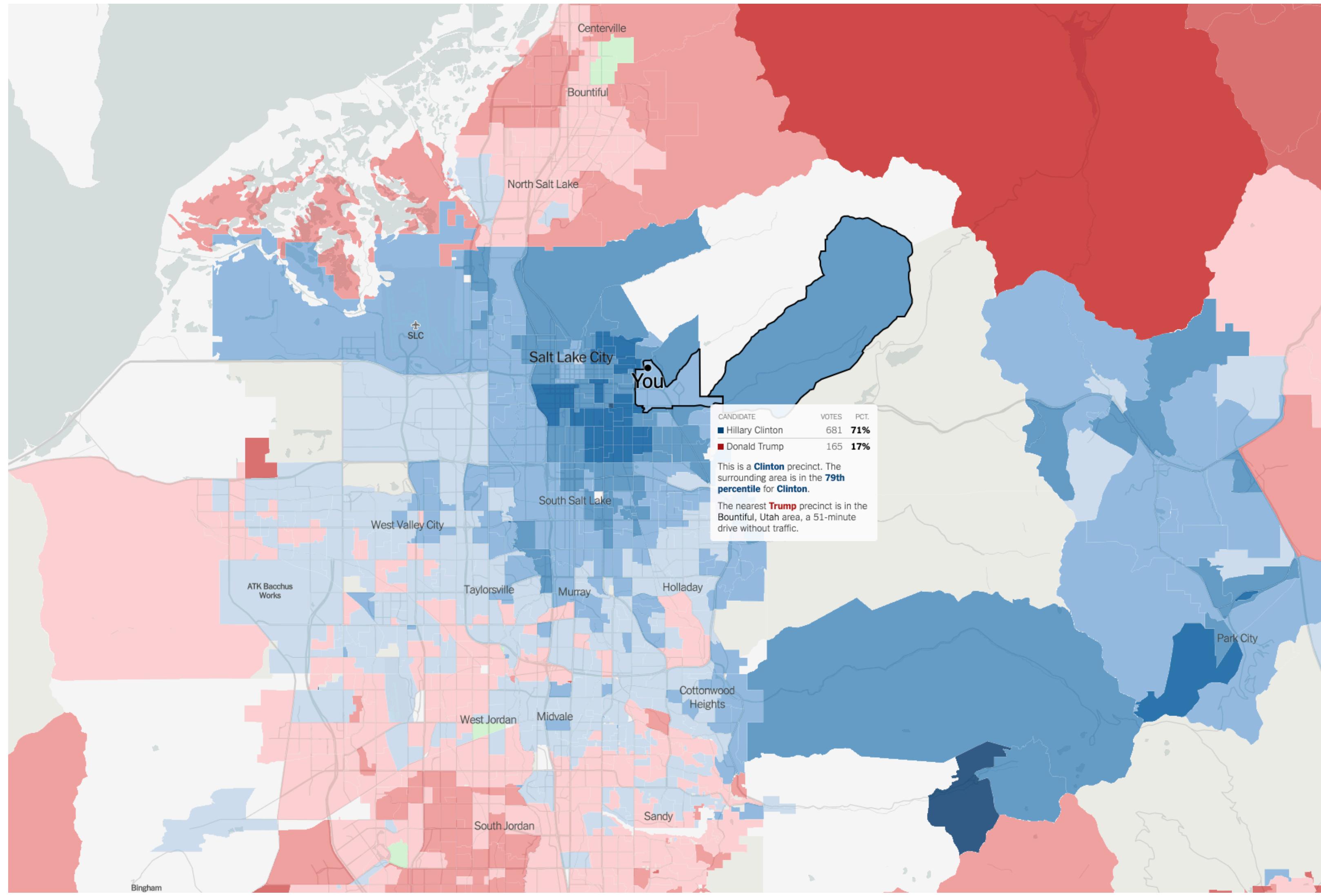
Quantitative: somewhat (with problems)

Order: yes

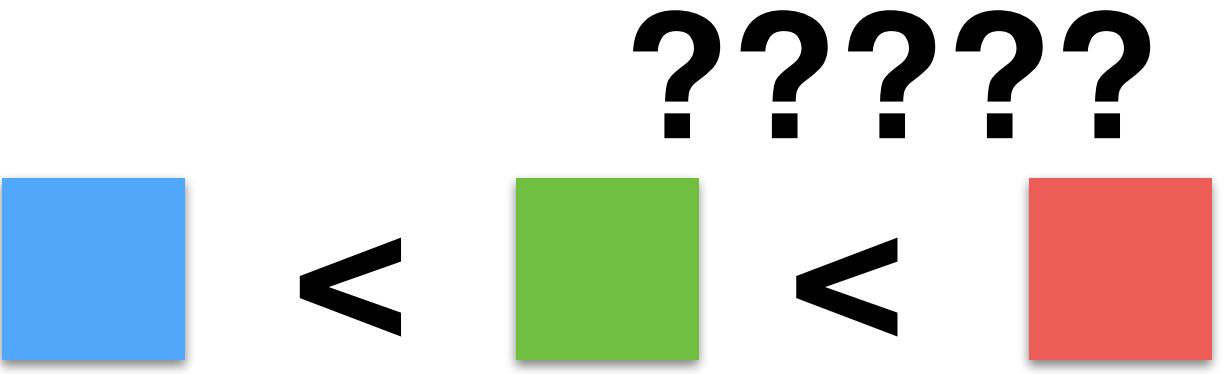
Length: limited



# Example: Diverging Value-Scale



# Color



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

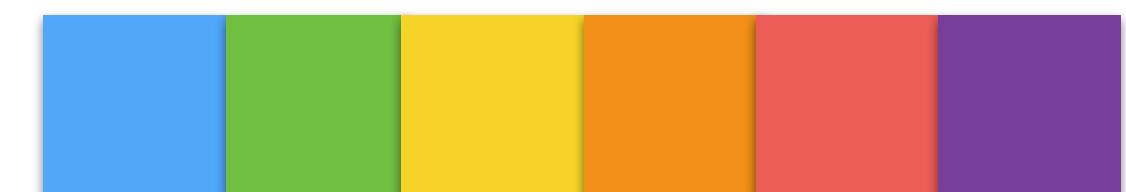
Lots of pitfalls! Be careful!

Order: no

My rule:

Length: limited

minimize color use for encoding data



use for brushing

# Color: Bad Example

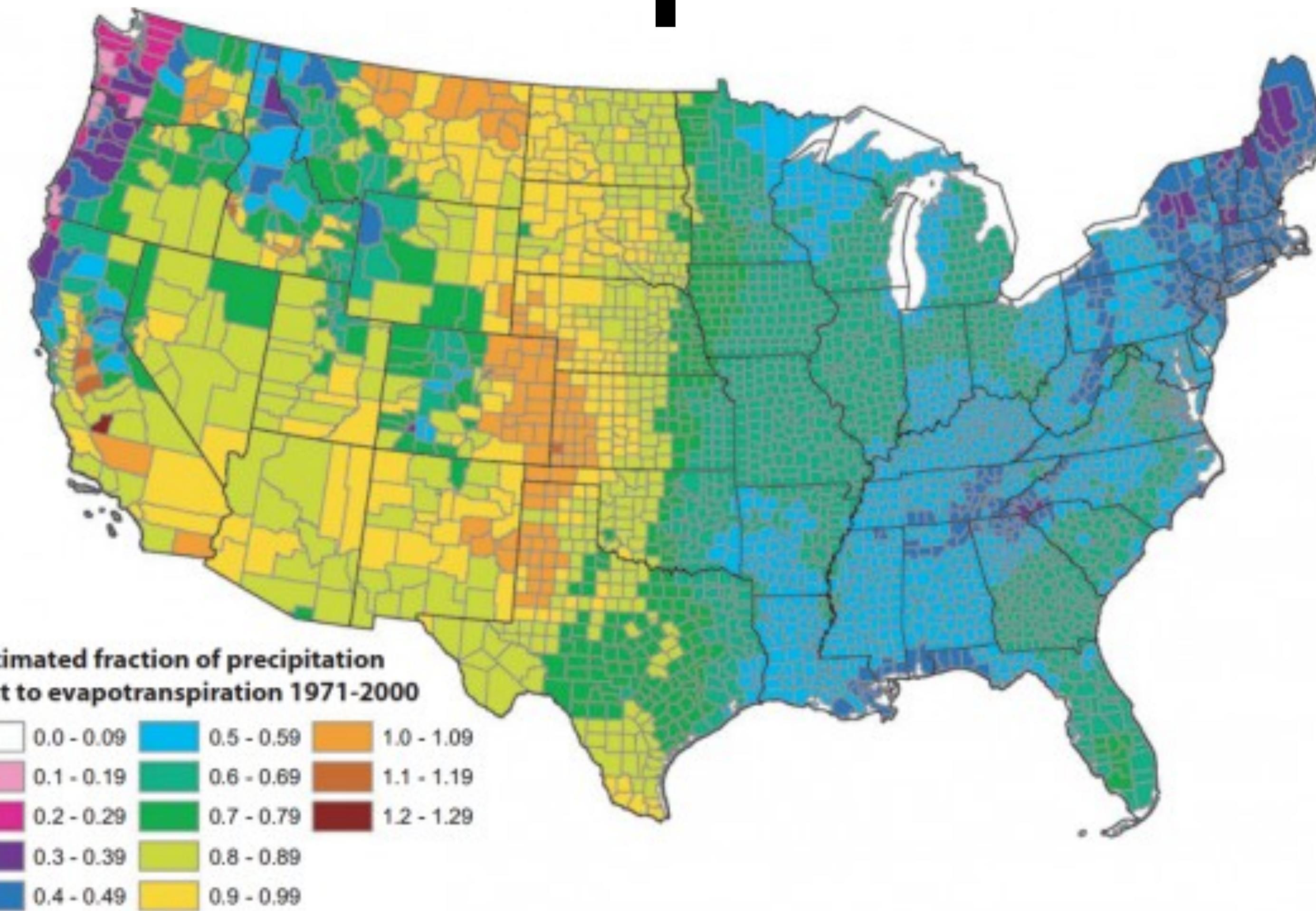


FIGURE 13. Estimated Mean Annual Ratio of Actual Evapotranspiration (ET) to Precipitation ( $P$ ) for the Conterminous U.S. for the Period 1971-2000. Estimates are based on the regression equation in Table 1 that includes land cover. Calculations of  $ET/P$  were made first at the 800-m resolution of 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.

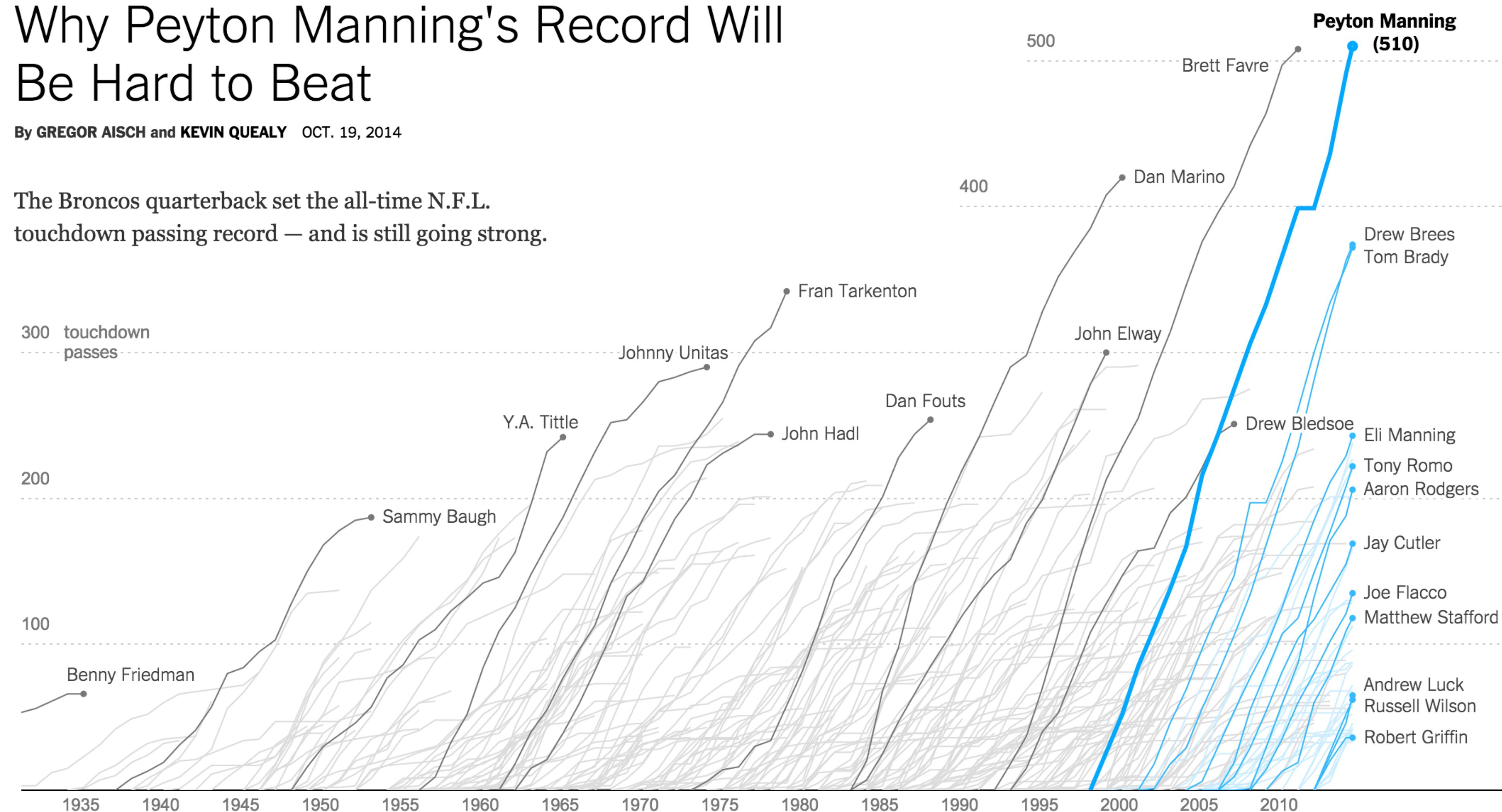
Cliff Mass

# 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.

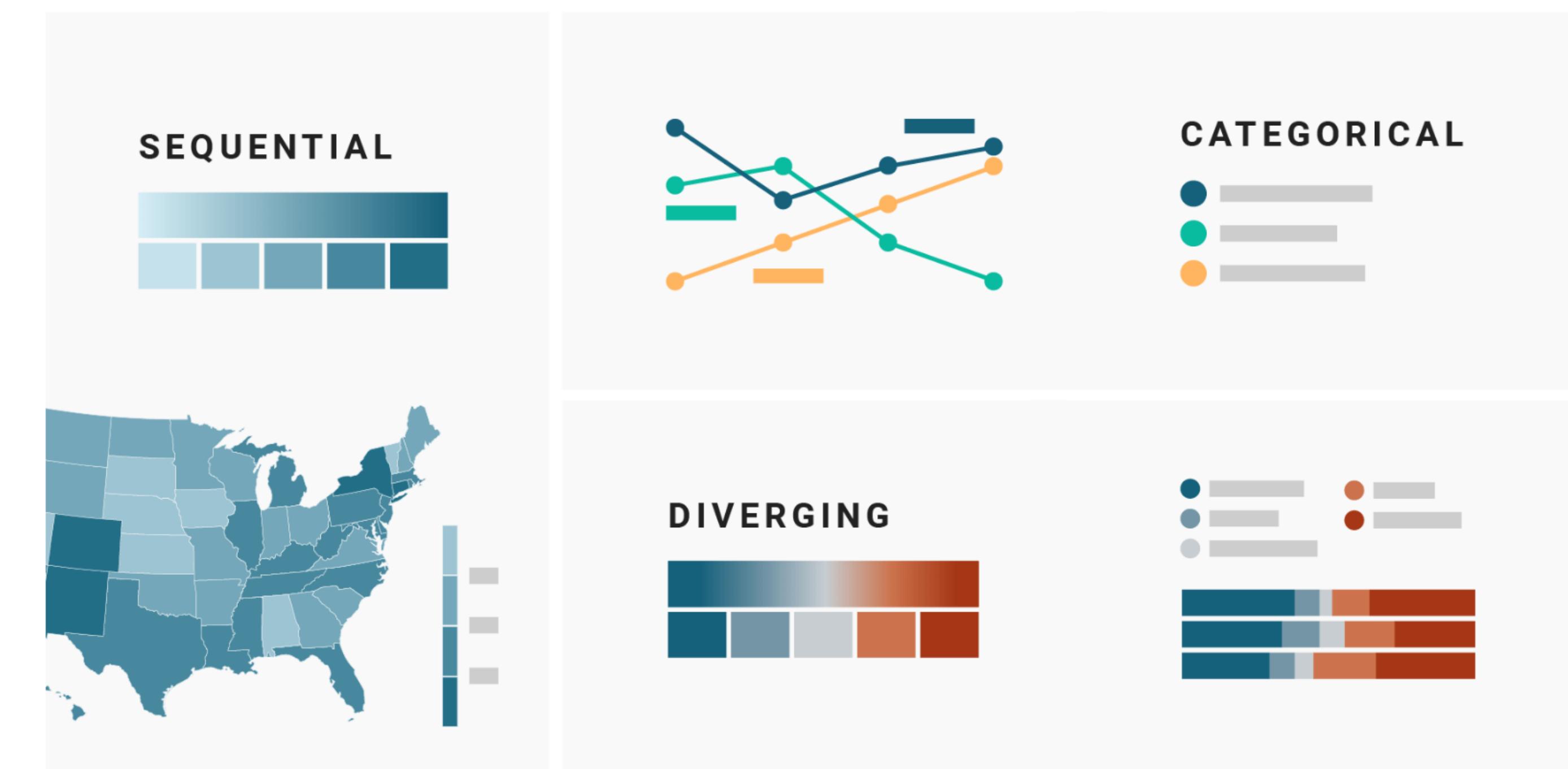


# Reading

## Which color scale to use when visualizing data



Lisa Charlotte Muth



<https://blog.datawrapper.de/which-color-scale-to-use-in-data-vis/>

# Shape

Great to recognize many classes.

No grouping, ordering.

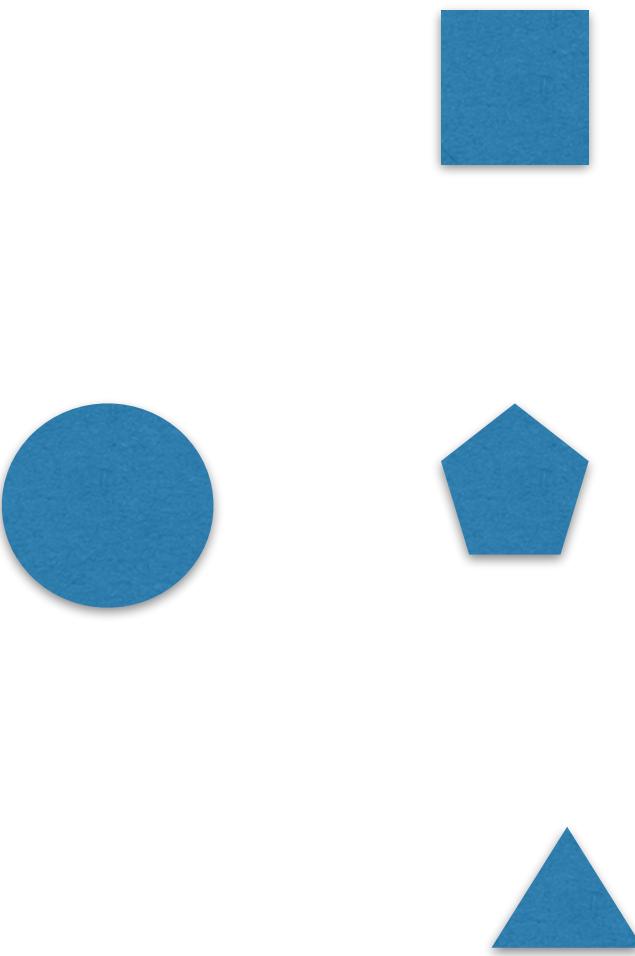
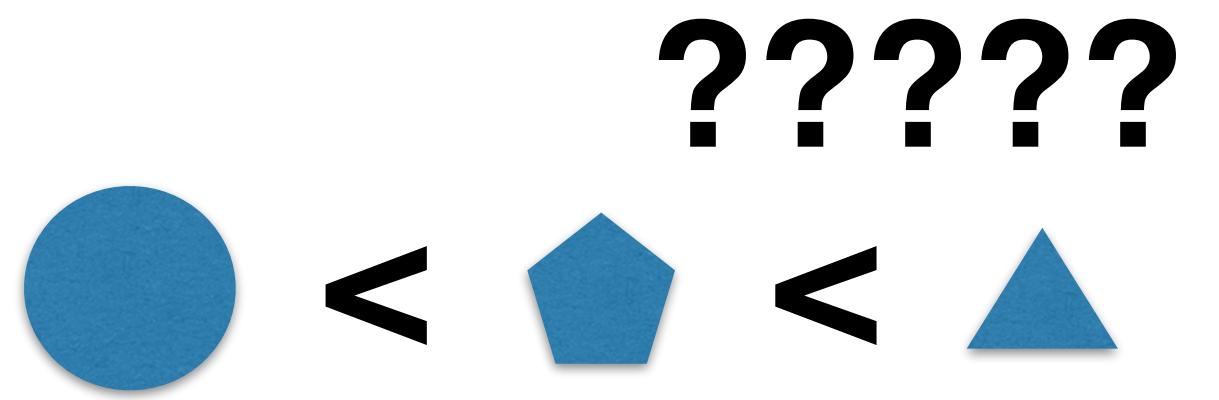
Selective: yes

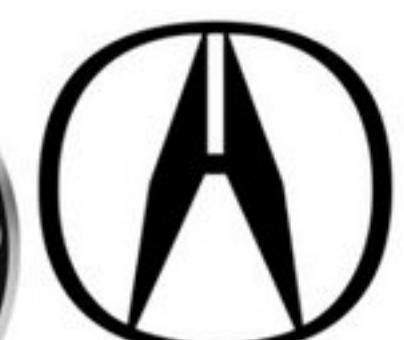
Associative: limited

Quantitative: no

Order: no

Length: vast





ASTON MARTIN



BENTLEY

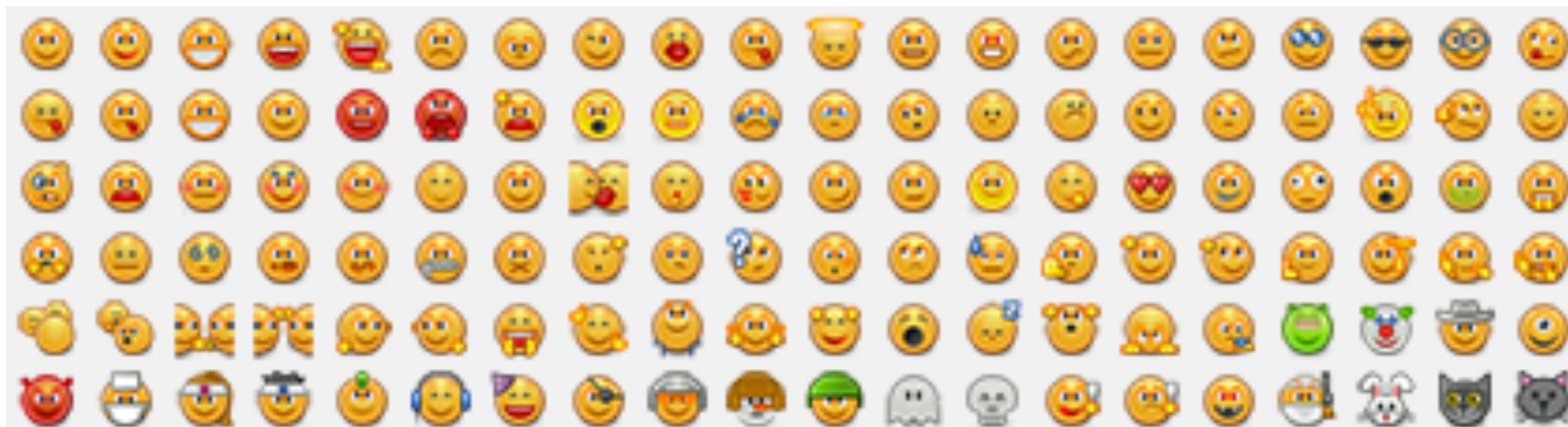


Audi

MITSUBISHI  
MOTORS

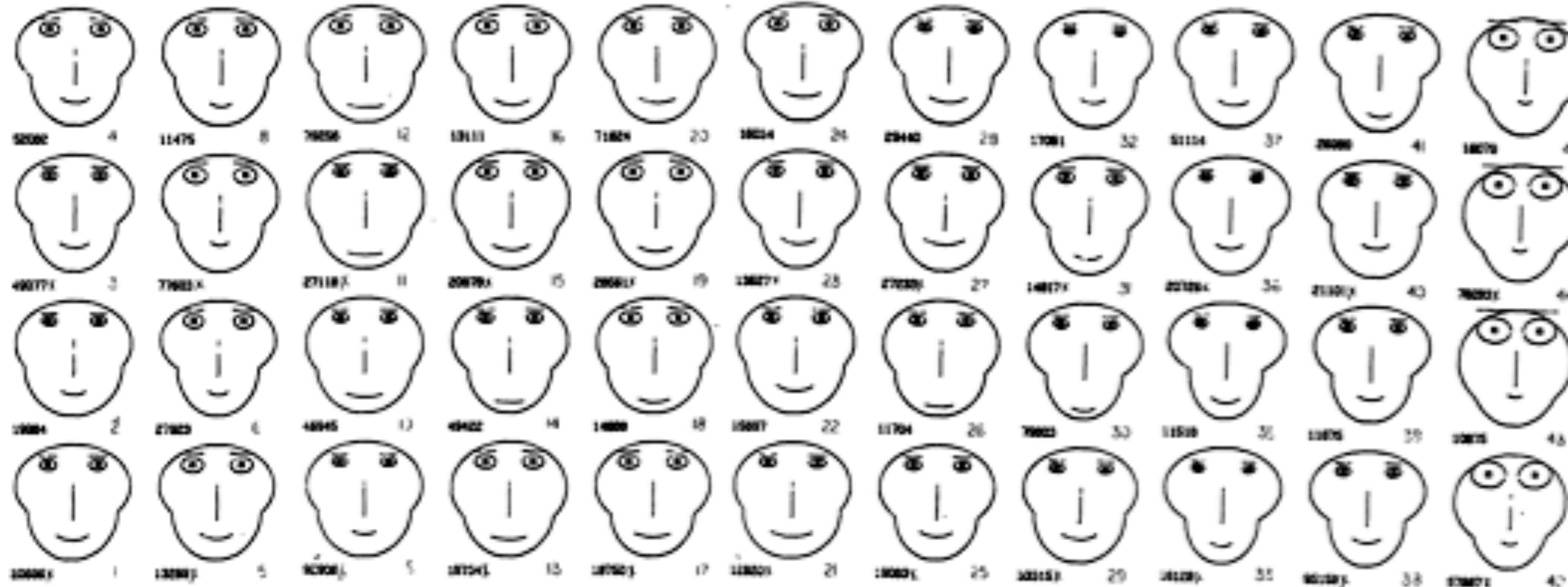
ferrari

Photoshop plugins

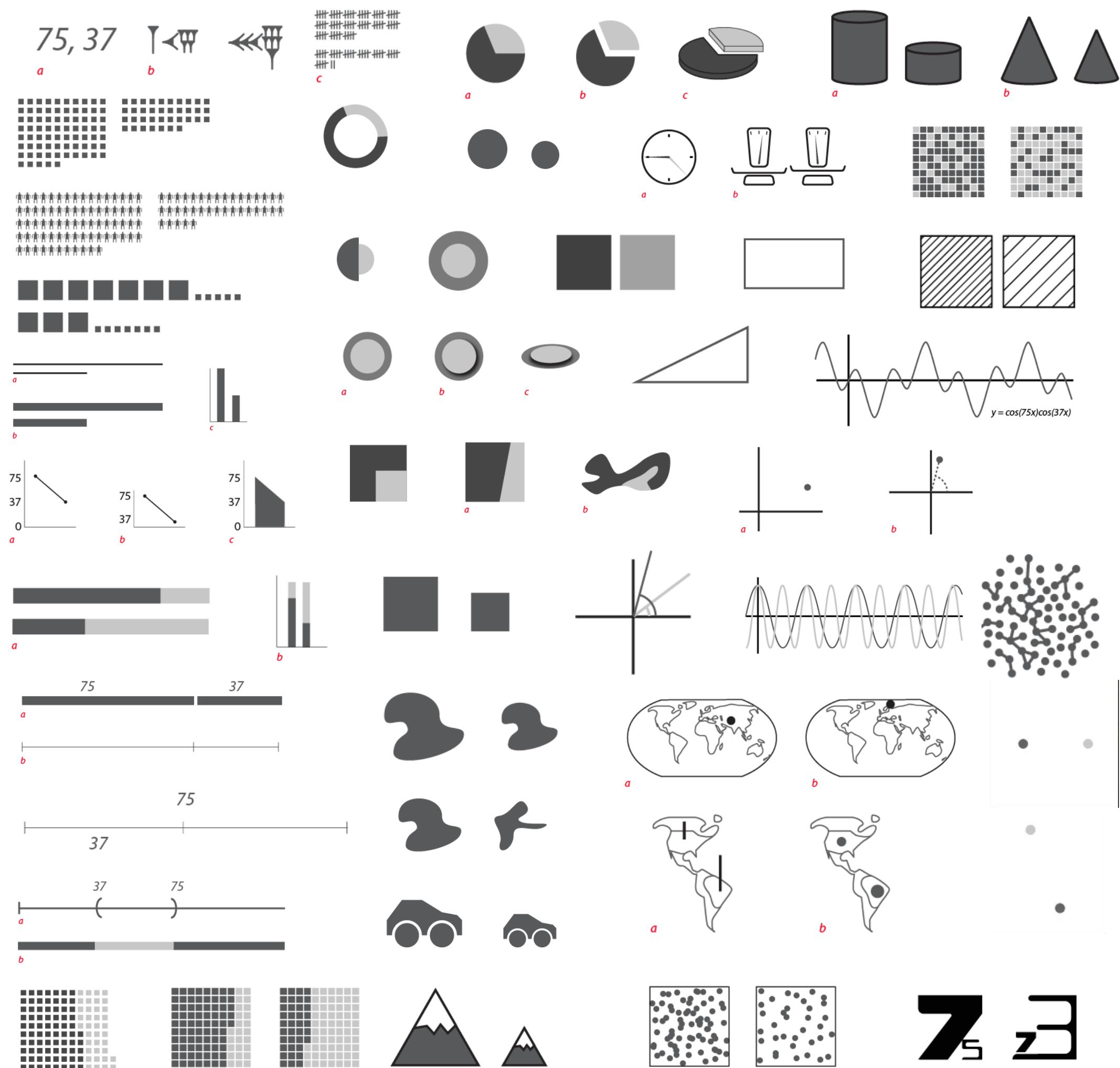
# Chernoff Faces

Idea: use facial parameters to map quantitative data



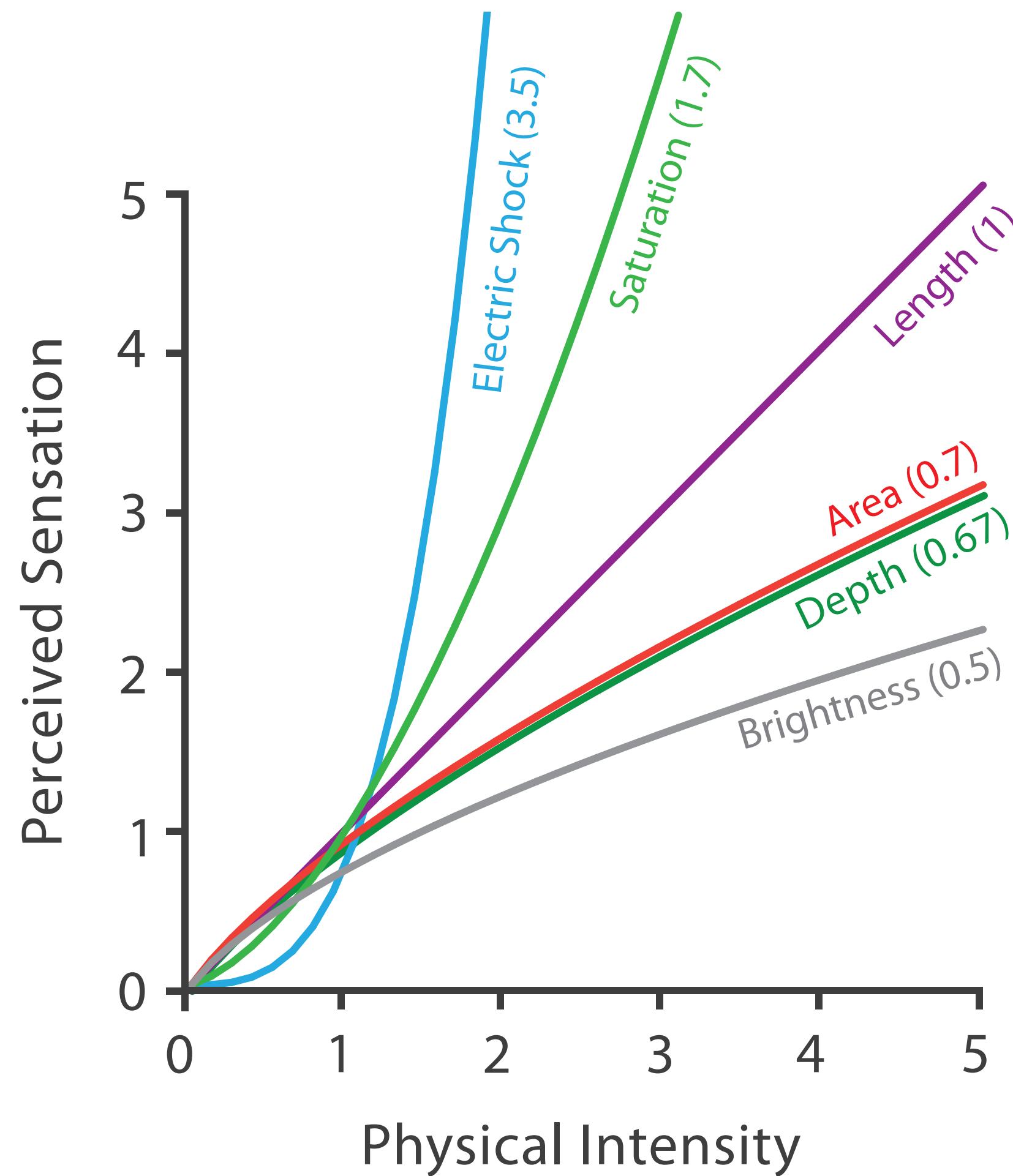
Does it work?  
Not really!

# More Channels



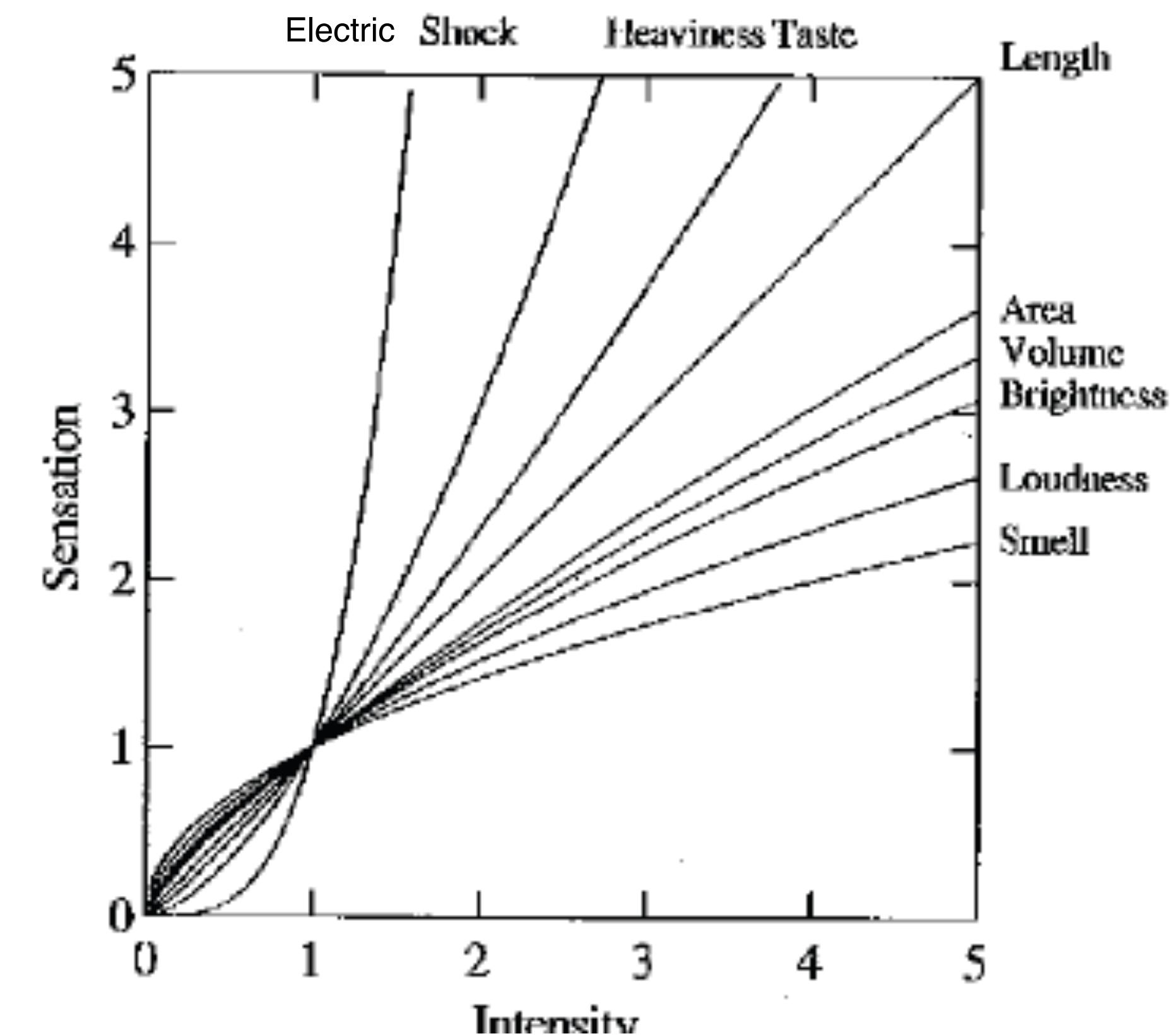
# Why are quantitative channels different?

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



$S$  = sensation  
 $I$  = intensity

# Steven's Power Law, 1961



# Design Critique

