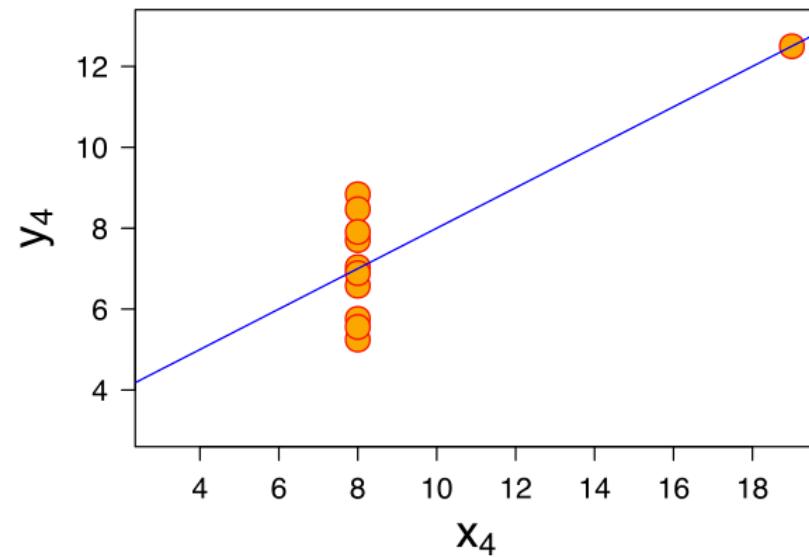
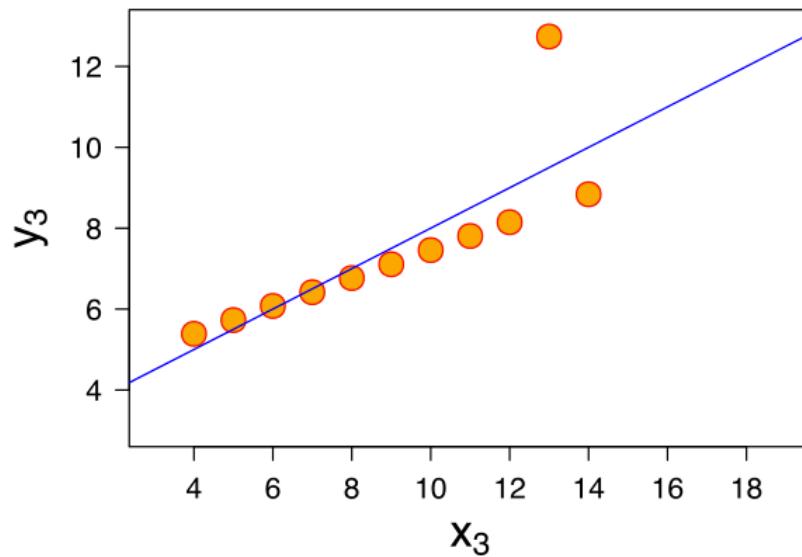
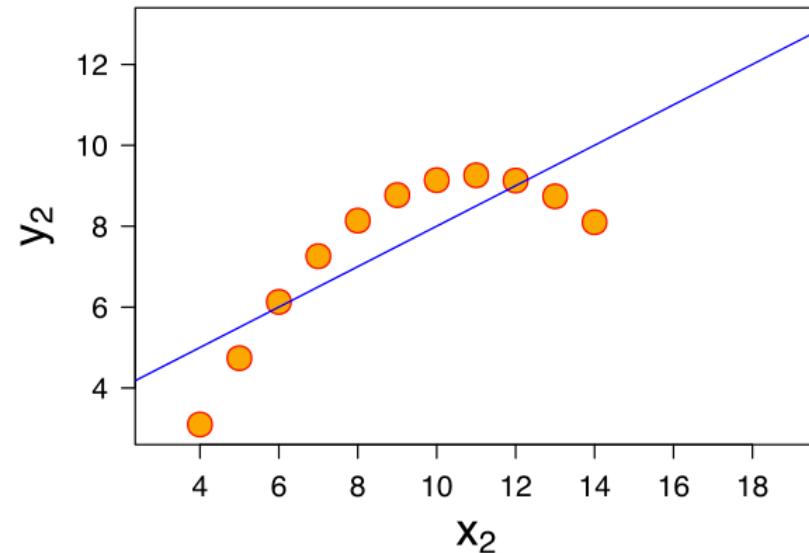
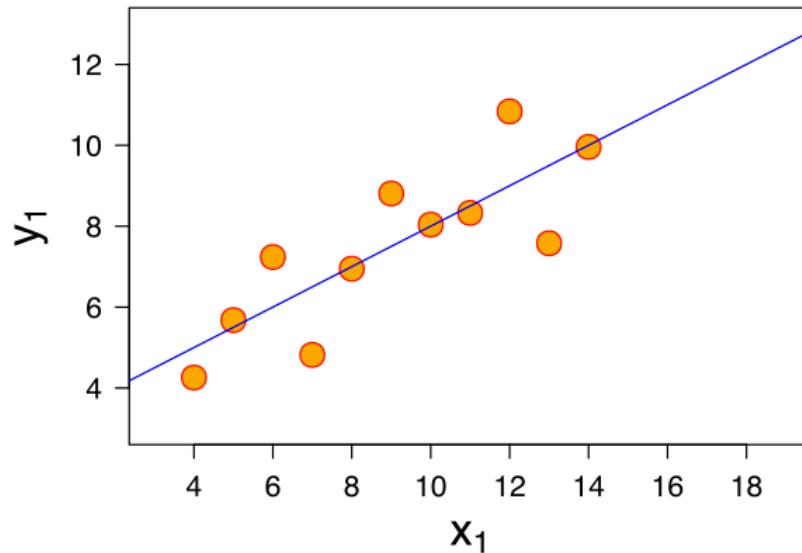


## **Today!**

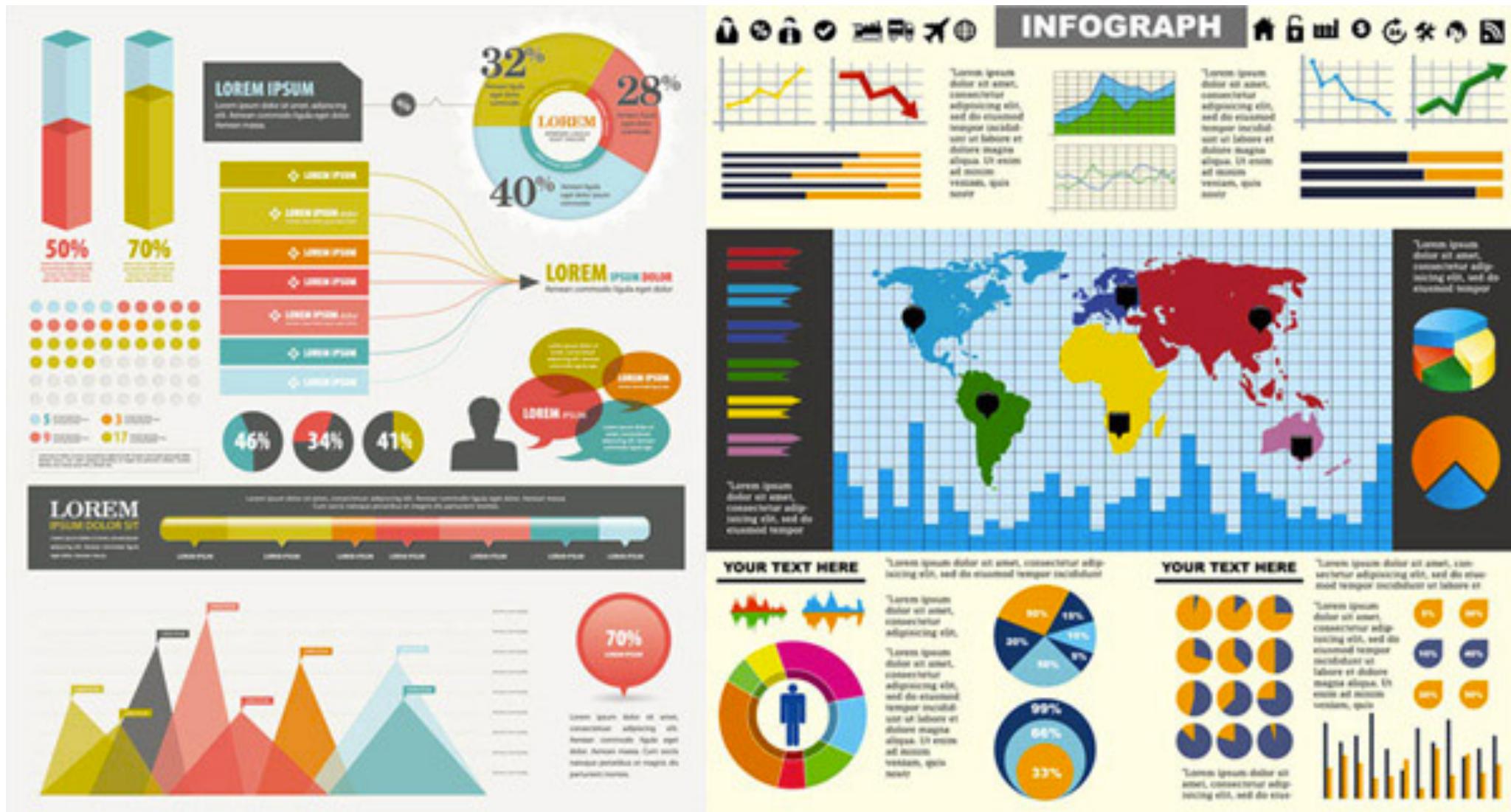
- What is Data Visualization – An overview & Introduction
- Bertin's semiotics
- Cognition and Perception – Highlights
- Gestalt Principles
- Use of metaphors
- Principles of Graphical Excellence and Best Practices
- Multimodal data expression

# Why Visualize Data?



Anscombe's quartet

# What is Data Visualization?



[http://images.all-free-download.com/images/graphicthumb/chart\\_elements\\_of\\_color\\_vector\\_graphic\\_530706.jpg](http://images.all-free-download.com/images/graphicthumb/chart_elements_of_color_vector_graphic_530706.jpg)

# Some Examples...

[http://www.ted.com/talks/david\\_mccandless the beauty of data visualization#t-576041](http://www.ted.com/talks/david_mccandless_the_beauty_of_data_visualization#t-576041)

<http://www.informationisbeautiful.net/>

<https://public.tableau.com/s/gallery>

<https://github.com/mbostock/d3/wiki/Gallery>

<http://labratvenge.com/nation-of-poverty/>

<http://demographics.coopercenter.org/DotMap/>

<http://www.davidmccandless.com/>

<http://www.iadb.org/en/topics/energy/energy-database/energy-database,19144.html>

<http://www.informationisbeautiful.net/visualizations/billion-dollar-o-gram-2013/>

[http://infobeautiful4.s3.amazonaws.com/2015/05/1276\\_left\\_right\\_usa.png](http://infobeautiful4.s3.amazonaws.com/2015/05/1276_left_right_usa.png)

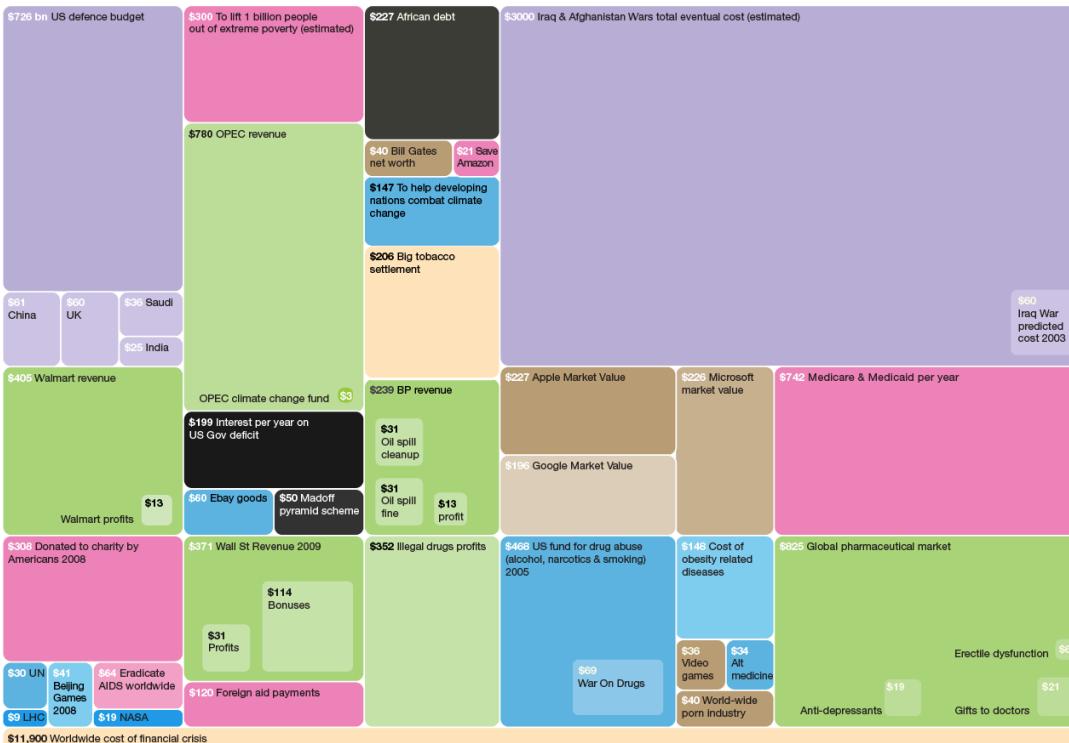
[Gapminder!](#)

<http://www.on-broadway.nyc/>

# The Billion Dollar-o-Gram

■ Giving   
 ■ Spending   
 ■ Fighting   
 ■ Accumulating   
 ■ Owing   
 ■ Losing   
 ■ Earning

\*Estimated



<http://www.informationisbeautiful.net/visualizations/billion-dollar-o-gram-2013/>

*1.1. Mäkijärvi proudly presents:*

# **The Magnificent BEARS**

*of the Glorious Nation of  
**FINLAND***

*Approximately before & after the year 2010*

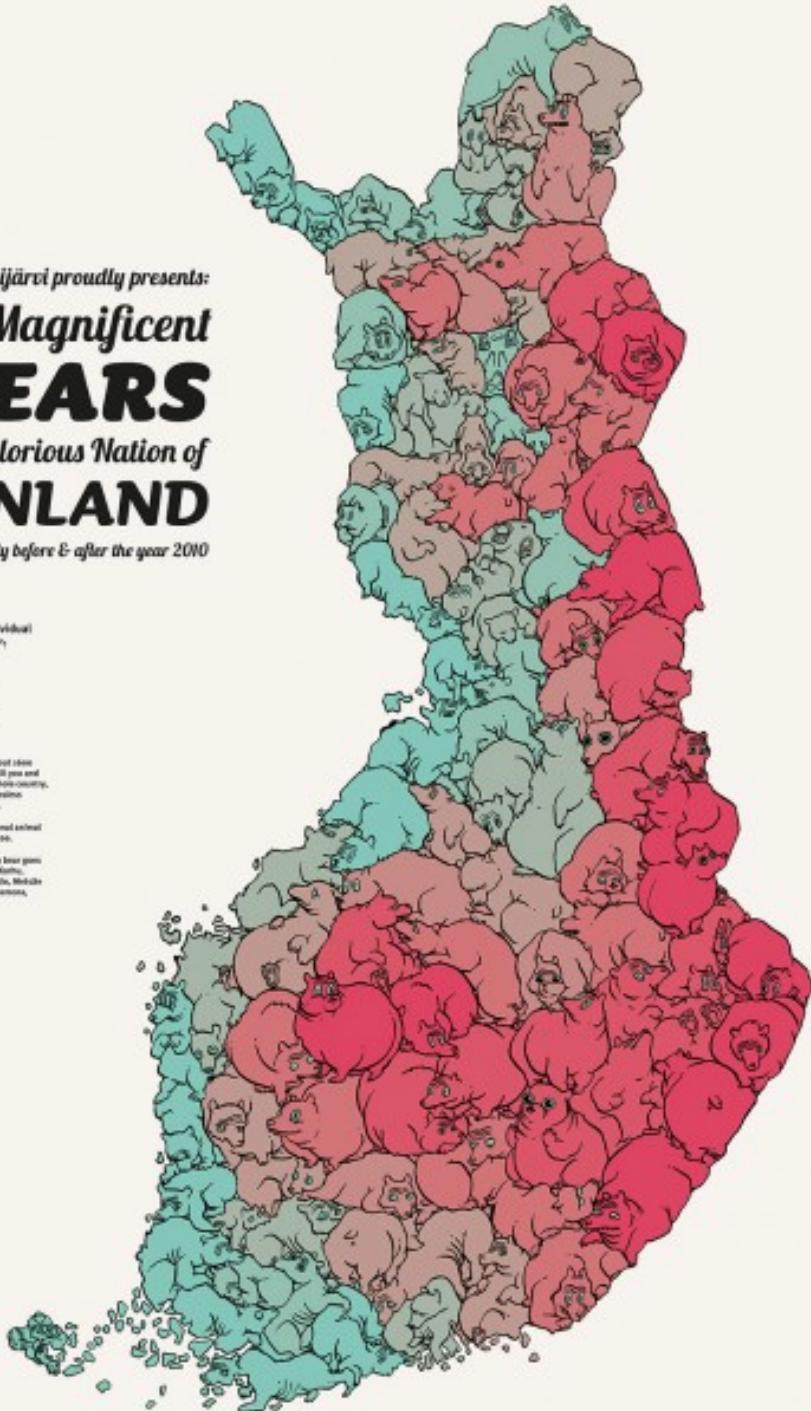
The amount of individual  
bears per 1000 km<sup>2</sup>:

- 0 - 2,0
- 2,1 - 4,0
- 4,1 - 6,0
- 6,1 - ∞

Which means there is about 2000  
grizzly bears ready to kill you and  
your loved ones in the whole country,  
except for the northernmost  
provinces of Lapland.

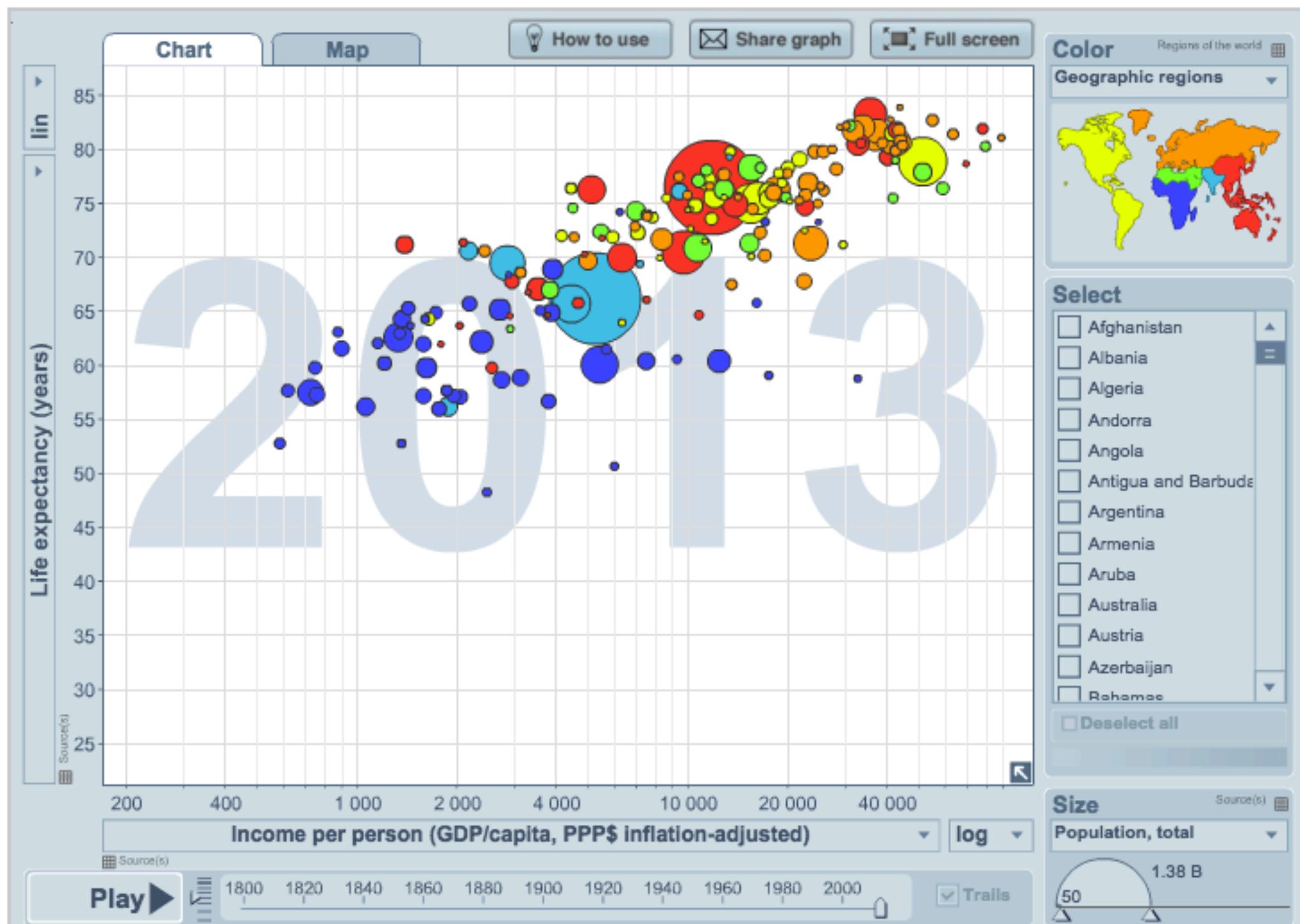
The fact bear is the national animal  
of Finland. And Russia's too.

In the Finnish language a bear goes  
by the following names: Karhu,  
Karhukarhu, Karhu, Karhu, Karhu,  
Karhu, Karhu, Karhu, Karhu,

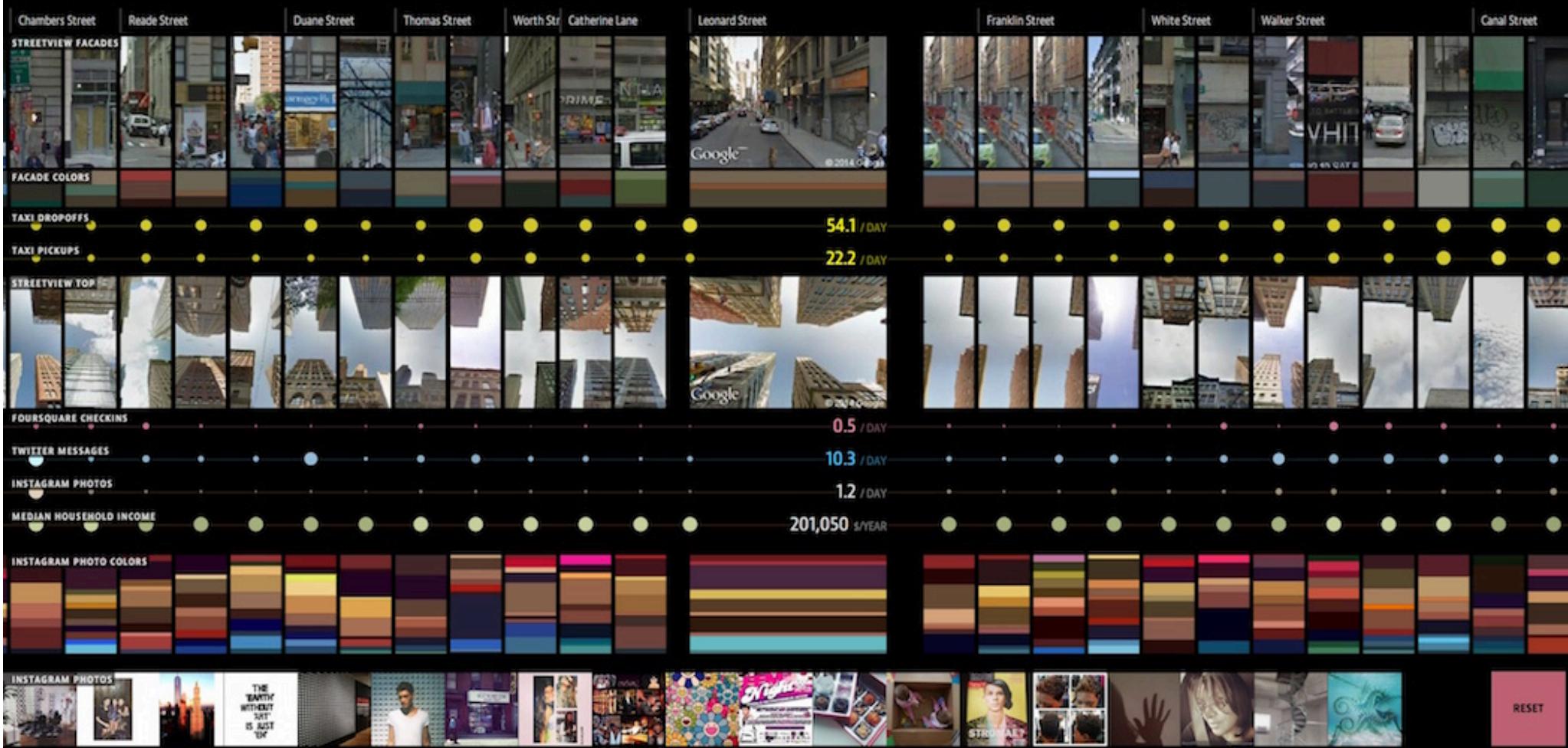


[http://grrr.fi/wp-  
content/uploads/2014/05/annukka-  
makijarvi/Karhukartta\\_makijarvi\\_w-  
455x650.jpg](http://grrr.fi/wp-content/uploads/2014/05/annukka-makijarvi/Karhukartta_makijarvi_w-455x650.jpg)

<http://gapminder.org>



# ON BROADWAY

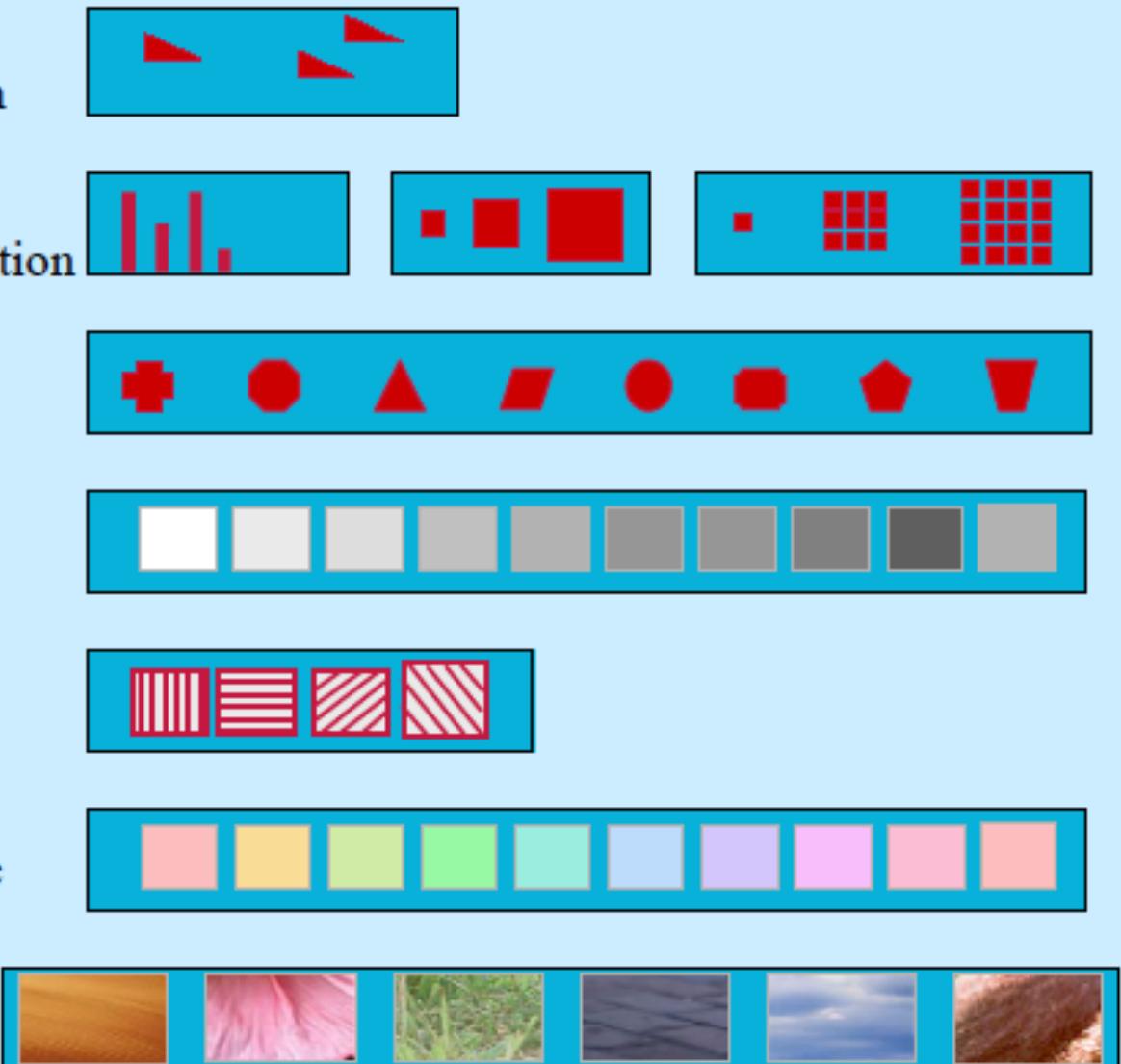


<http://www.on-broadway.nyc/>

# Jacques Bertin: Semiology of Graphics, 1967

## Visual Variables

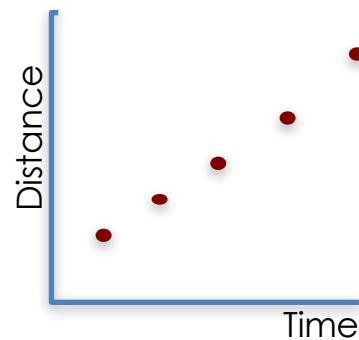
- **position**
  - changes in the x, y, (z) location
- **size**
  - change in length, area or repetition
- **shape**
  - infinite number of shapes
- **value**
  - changes from light to dark
- **orientation**
  - changes in alignment
- **colour**
  - changes in hue at a given value
- **texture**
  - variation in pattern
- **motion**



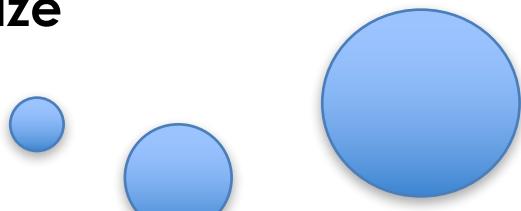
Graphic by: Sheelagh Carpendale

# Visual variables for quantitative data (used to represent quantities)

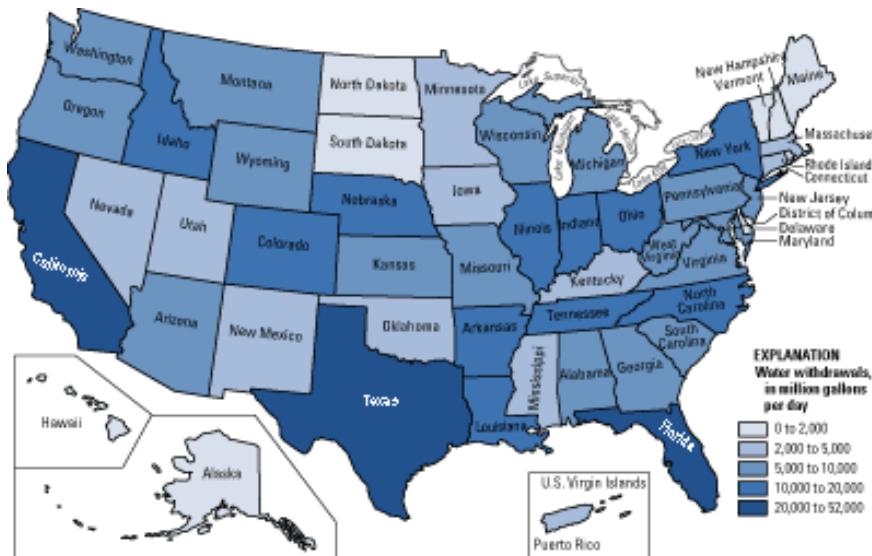
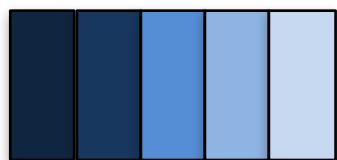
## Position



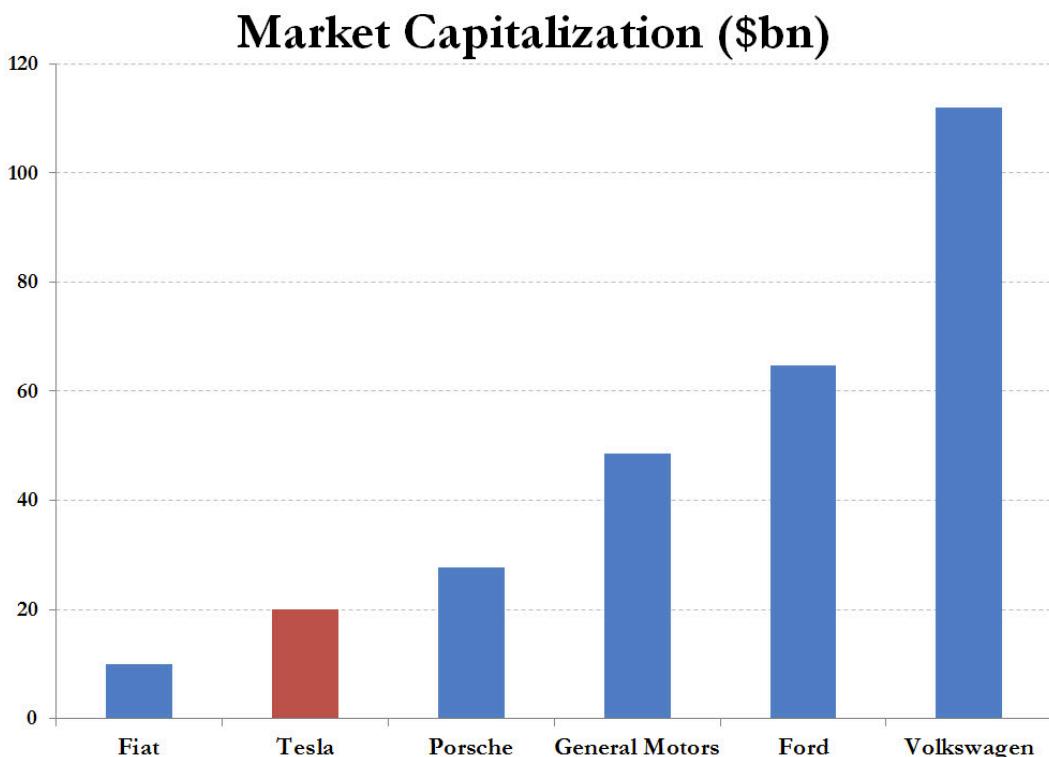
## Size



## Value



## A word on size: Area vs. Length



## A New Tech Giant

How Alibaba's proposed IPO valuation stacks up based on the midpoint of its \$60 to \$66 share price range.

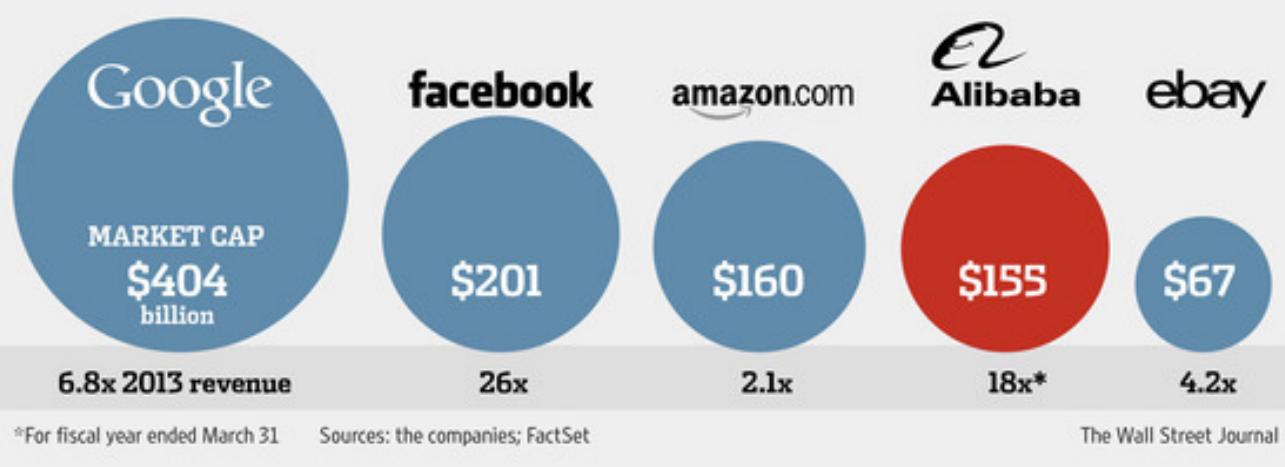
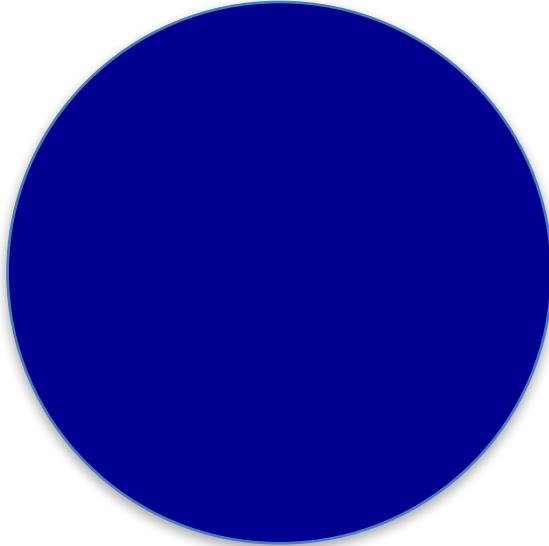
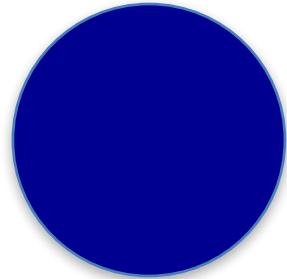
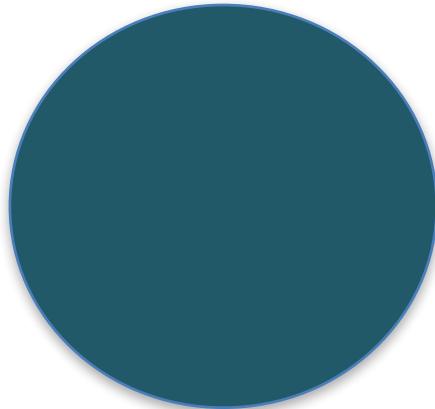
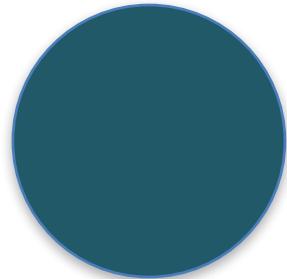


Image sources: [http://si.wsj.net/public/resources/images/BF-AI151\\_ALIBAB\\_G\\_20140905165108.jpg](http://si.wsj.net/public/resources/images/BF-AI151_ALIBAB_G_20140905165108.jpg)  
[http://www.zerohedge.com/sites/default/files/images/user5/imageroot/2013/08/20130826\\_TSLA.jpg](http://www.zerohedge.com/sites/default/files/images/user5/imageroot/2013/08/20130826_TSLA.jpg)

When making bubble visualizations:  
use area to represent quantities, not radius or diameter



The bigger circle has twice the diameter as the smaller circle, and four times the area



The bigger circle has twice the area as the smaller circle.

# Visual variables for qualitative data (used to represent a category)

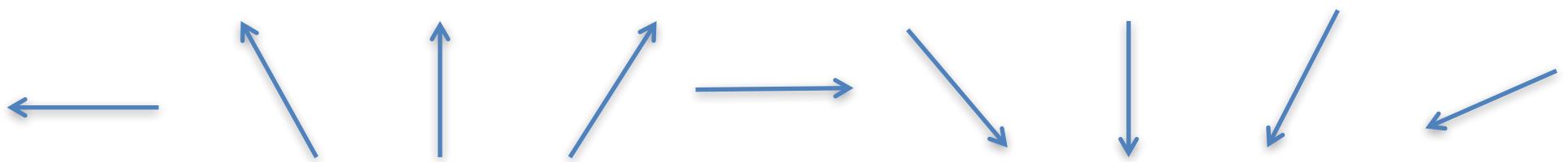
## Texture



## Colour



## Orientation



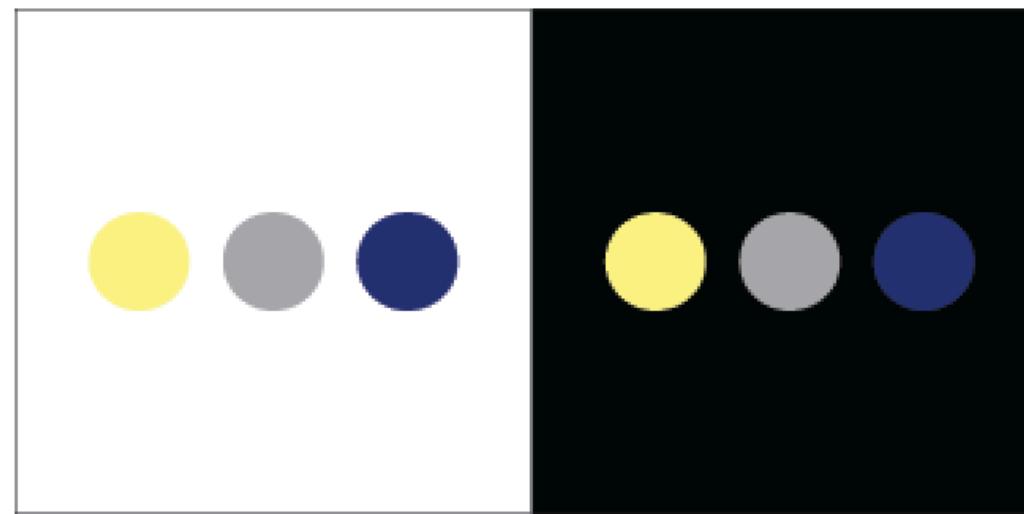
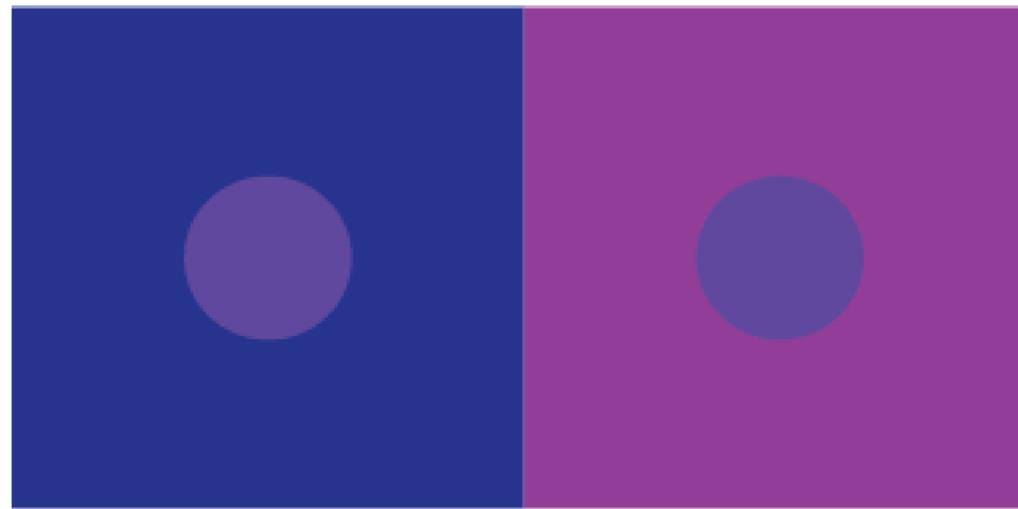
## Shape



## Movement

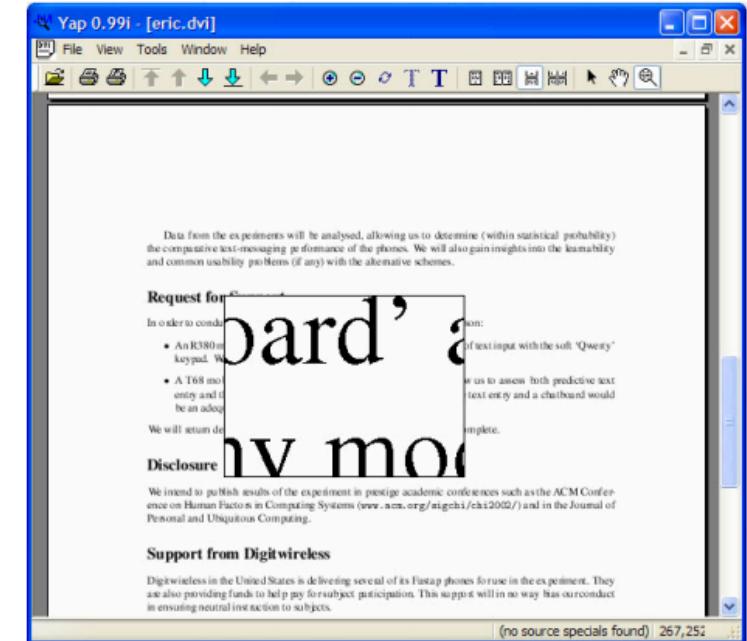
- Metaphorical <http://visual.ly/100-years-rock-and-roll-visualized>
- Transition between animations <http://fathom.info/kitchen>

## A word about Color



check out this useful resource for helping with color:  
<http://colorbrewer2.org/>

# Interactivity



Overview, pan, and zoom

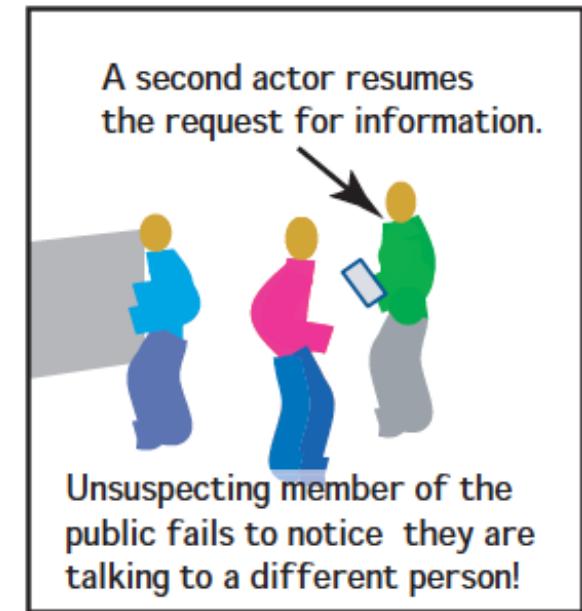
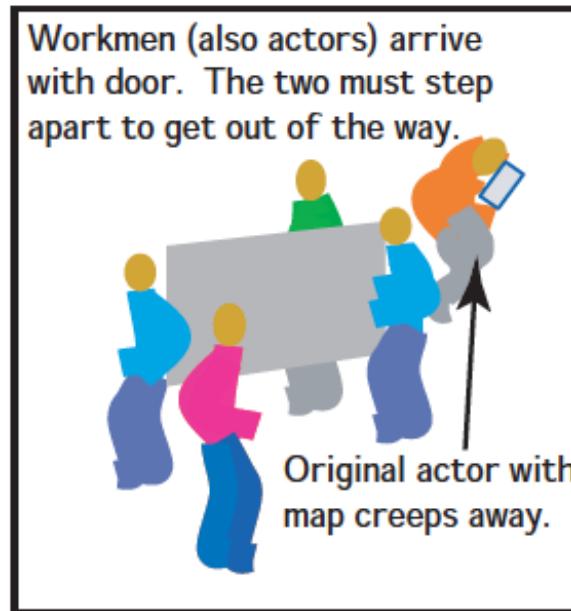
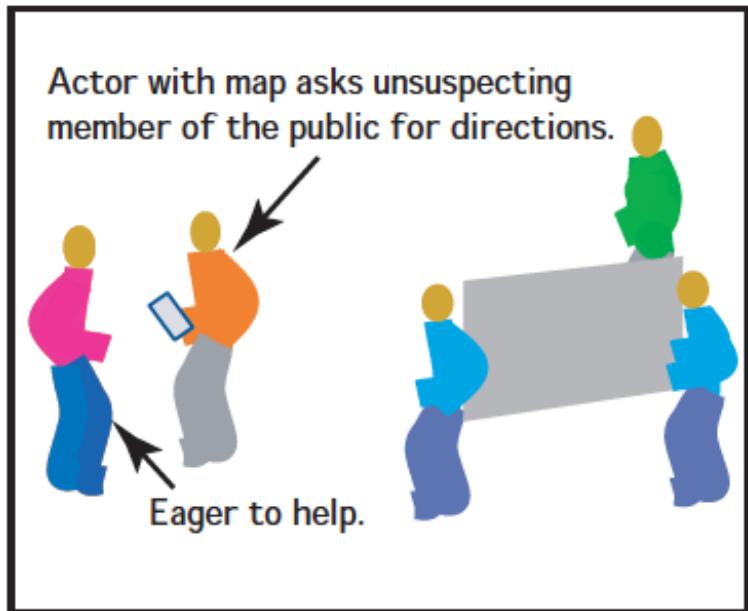
View details

Filter

The power of the unaided mind is highly overrated. Without external aids, memory, thought, and reasoning are all constrained. But human intelligence is highly flexible and adaptive, superb at inventing procedures and objects that overcome its own limits. The real powers come from devising external aids that enhance cognitive abilities. How have we increased memory, thought, and reasoning? By the invention of external aids: It is things that make us smart. Some assistance comes through cooperative social behavior; some arises through exploitation of the information present in the environment; and some comes through the development of tools of thought – cognitive artifacts – that complement abilities and strengthen mental powers.

- Don Norman (Things That Make Us Smart: Defending Human Attributes in the Age of the Machine)

# Perception and Cognition



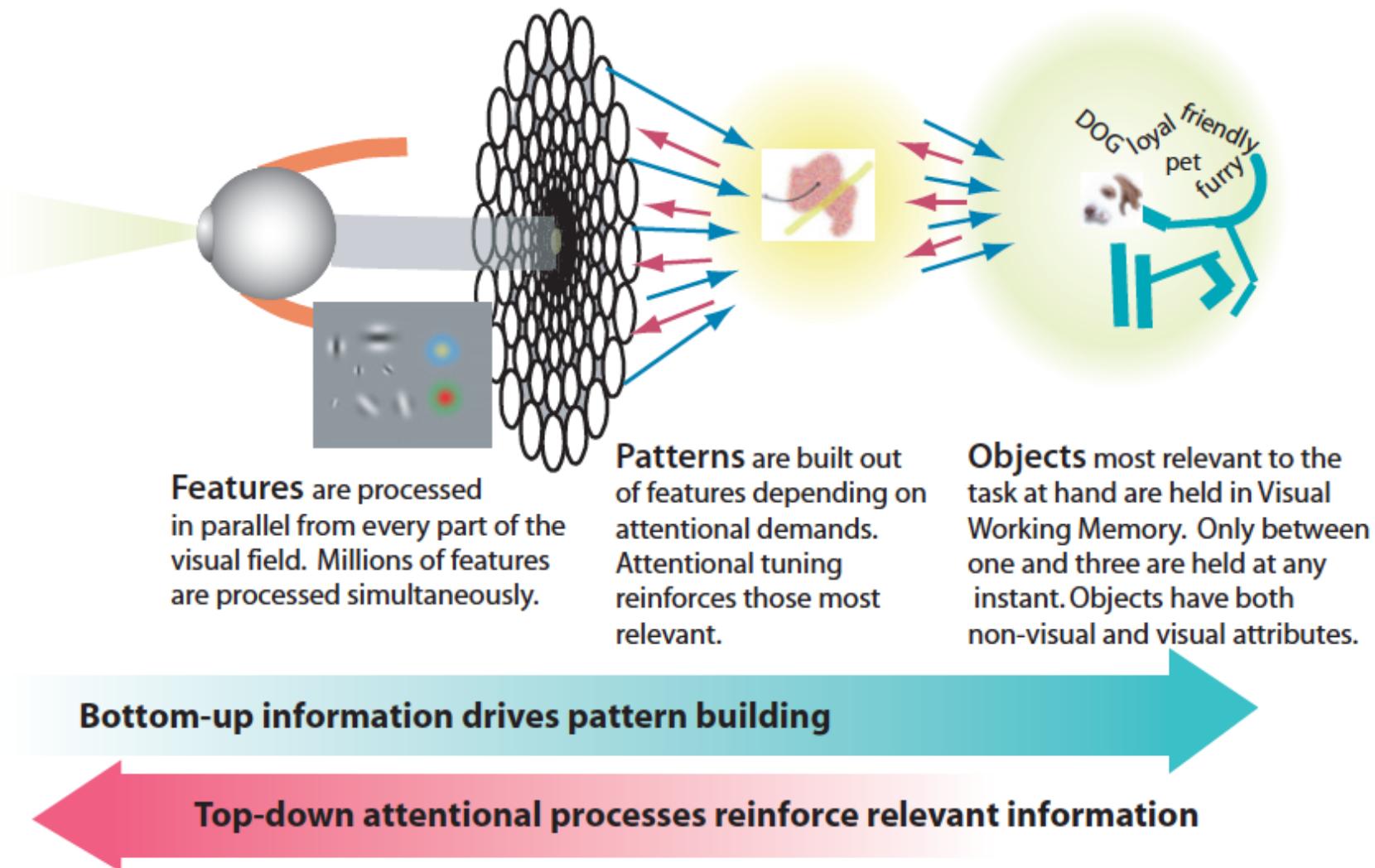
- Perception is fragmented
- Eyes are constantly scanning and constructing reality

<https://www.youtube.com/embed/FWSxSQsspiQ>

Image from: Ware, Colin. *Visual thinking: For design*. Morgan Kaufmann, 2010.

Original Study: Daniel J. Simons and Daniel T. Levin. 1998. "Failure to detect changes to people during a real world interaction." *Psychonomic Bulletin and Review*. 5: 644–669.

# Visual thinking is about finding patterns



Bottom-up processes gather information and build patterns.

Top-down processes determine where you look and what you pull out from the patterns

# Pre-Attentive Processing

- Bottom-up
- Fast, automatic
- Instinctive
- Efficient
- Multitasks

# Attentive Processing

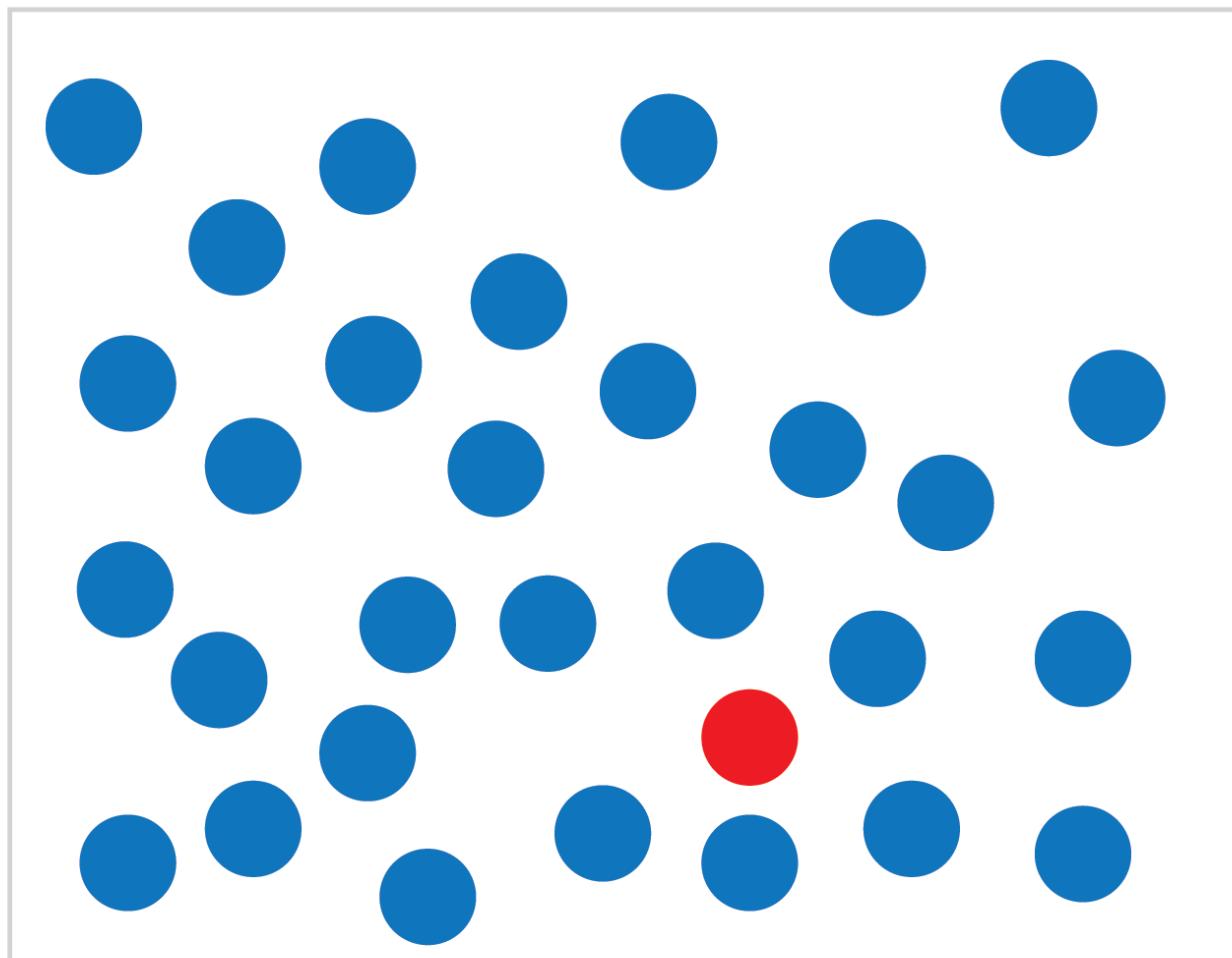
- Top-down
- Slow, deliberate
- focused

## Goal of information design:

- help humans process information as efficiently as possible.
- make as much use of pre-attentive processing as possible.

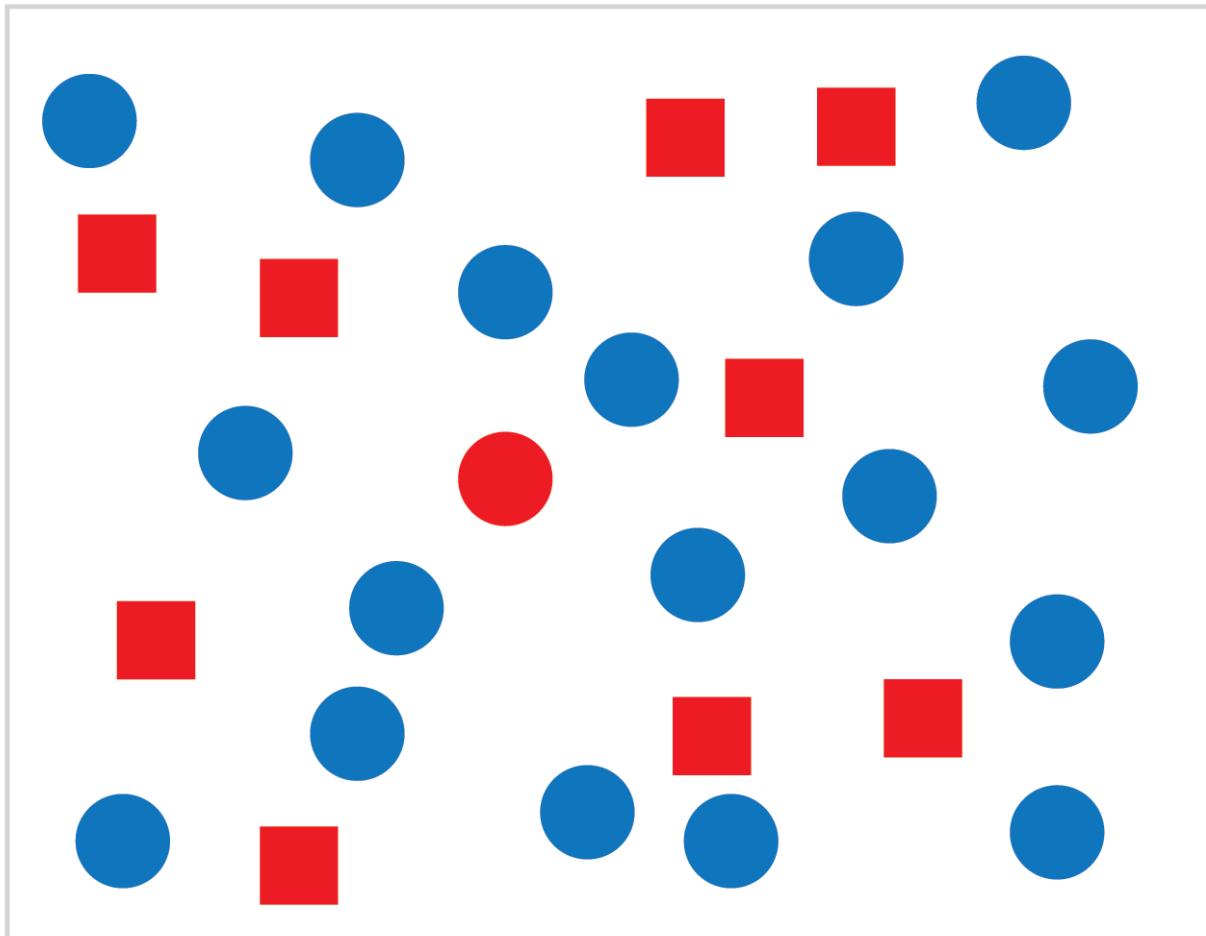
# Pre-Attentive Processing Example

Find the red circle:



# Attentive Processing Example

Find the red circle:



<https://www.youtube.com/watch?v=vJG698U2Mvo>

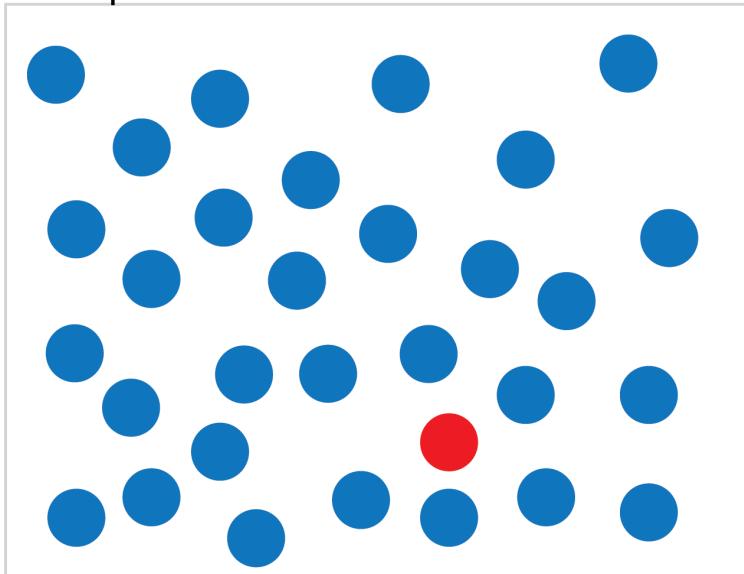
# Goal of information design:

- help humans process information as efficiently as possible.
- make as much use of pre-attentive processing as possible.

## **Pre-Attentive Processing**

- Bottom-up
- Fast, automatic
- Instinctive
- Efficient
- Multitasks

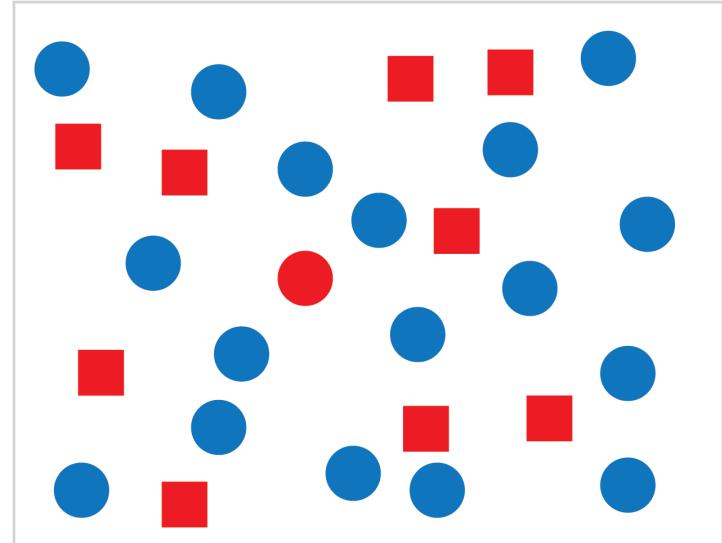
Example: Find the red circle



## **Attentive Processing**

- Top-down
- Slow, deliberate
- Focused
- Single-tasked

Example: Find the red circle



<https://www.youtube.com/watch?v=vJG698U2Mvo>

[https://photos.google.com/share/AF1QipPX0SCI7OzWilt9LnuQliattX4OUCj\\_8EP65\\_cTVnBmS1jnYgsGQAieQUC1VQWdgQ?key=aVBxWjhwSzg2RjJWLWRuVFBBZEN1d205bUdEMnhB](https://photos.google.com/share/AF1QipPX0SCI7OzWilt9LnuQliattX4OUCj_8EP65_cTVnBmS1jnYgsGQAieQUC1VQWdgQ?key=aVBxWjhwSzg2RjJWLWRuVFBBZEN1d205bUdEMnhB)

<http://qz.com/432678/the-dreams-of-googles-ai-are-equal-parts-amazing-and-disturbing/>



# Gestalt Principles

Visual information is understood holistically before it is examined separately.

Our brains use Gestalt principles create unity in a composition.

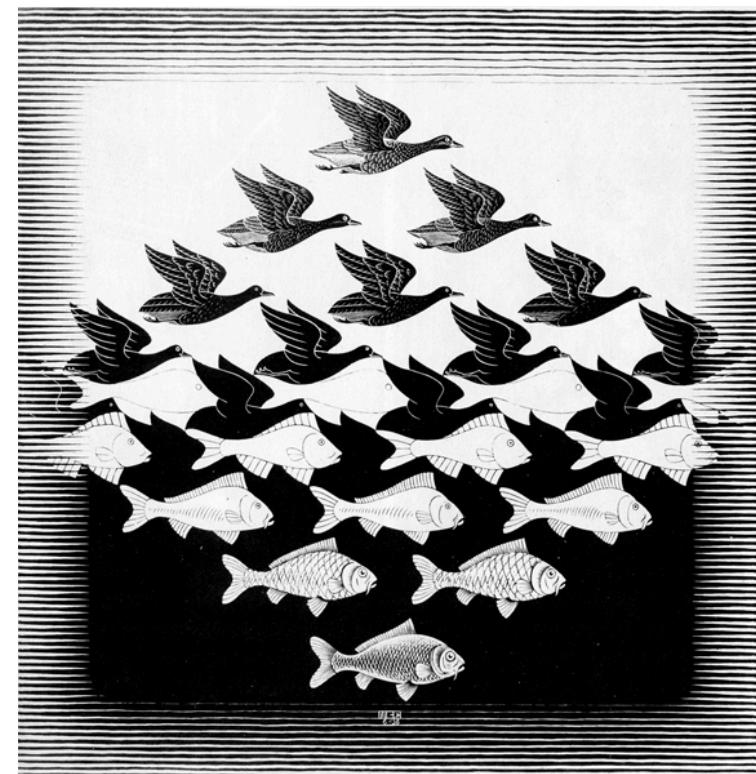
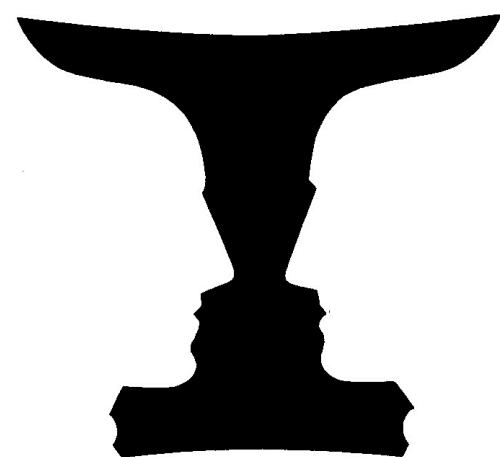
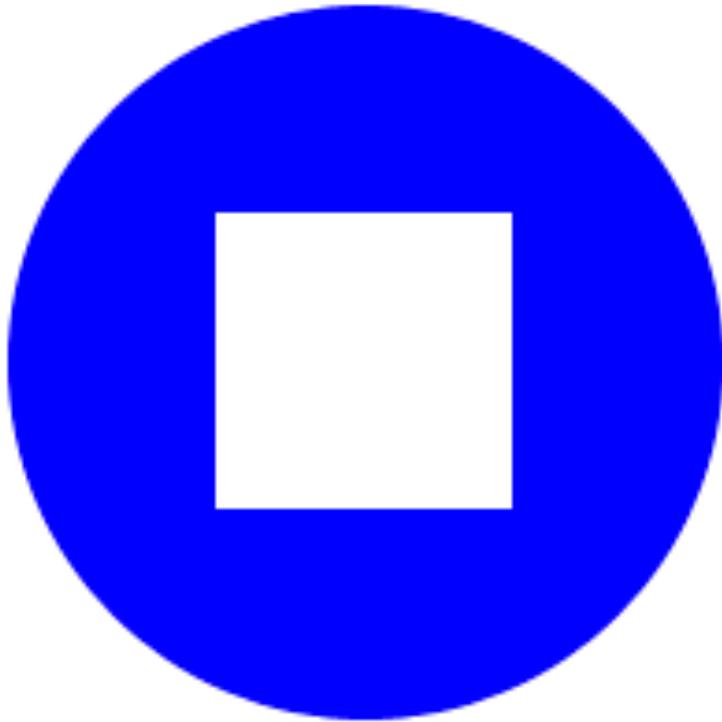
Designers reinforce unity by applying Gestalt principles.

An image composed of units that are unrelated in size style orientation and color appears chaotic and unresolved.

- Figure/Ground
- Proximity
- Similarity
- Symmetry
- Continuity
- Closure

## Figure/Ground

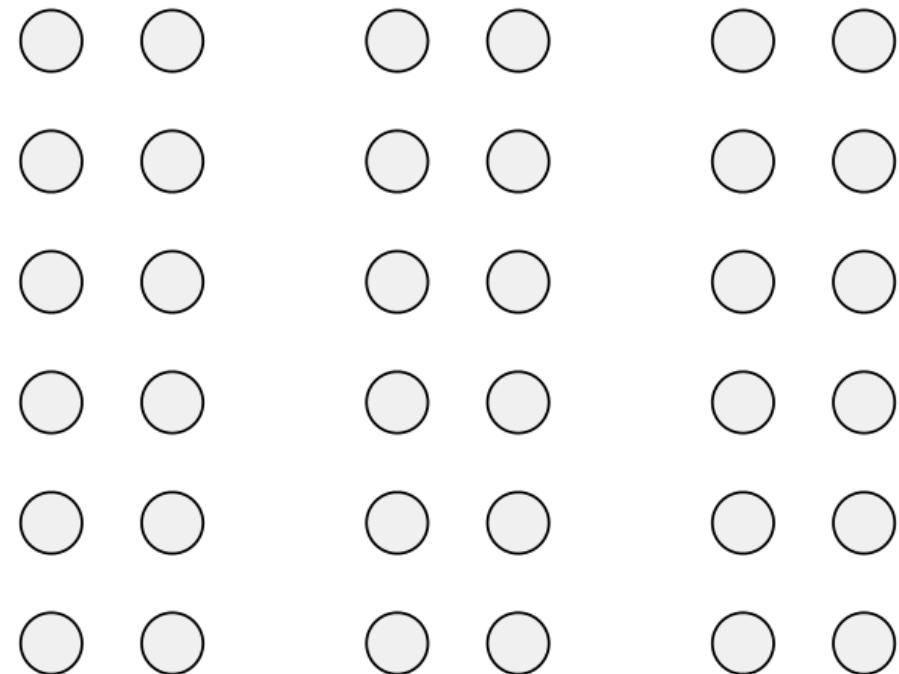
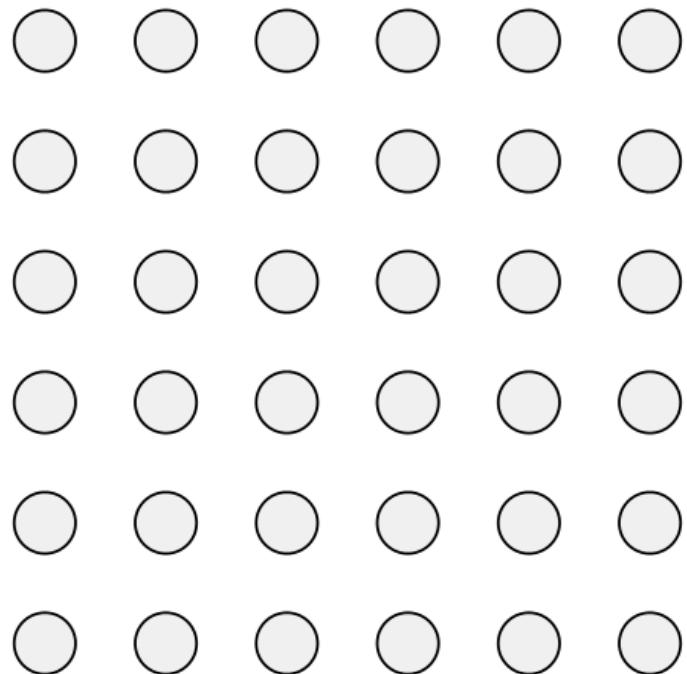
Our perceptual tendency to separate whole figures from their backgrounds



M. C. Escher Sky and Water I 1938

## Proximity (AKA Grouping)

Our perceptual tendency to perceive objects in close proximity as a single unit



## Similarity

Our perceptual tendency to conceptually group objects that are similar in shape, size, color, or texture.

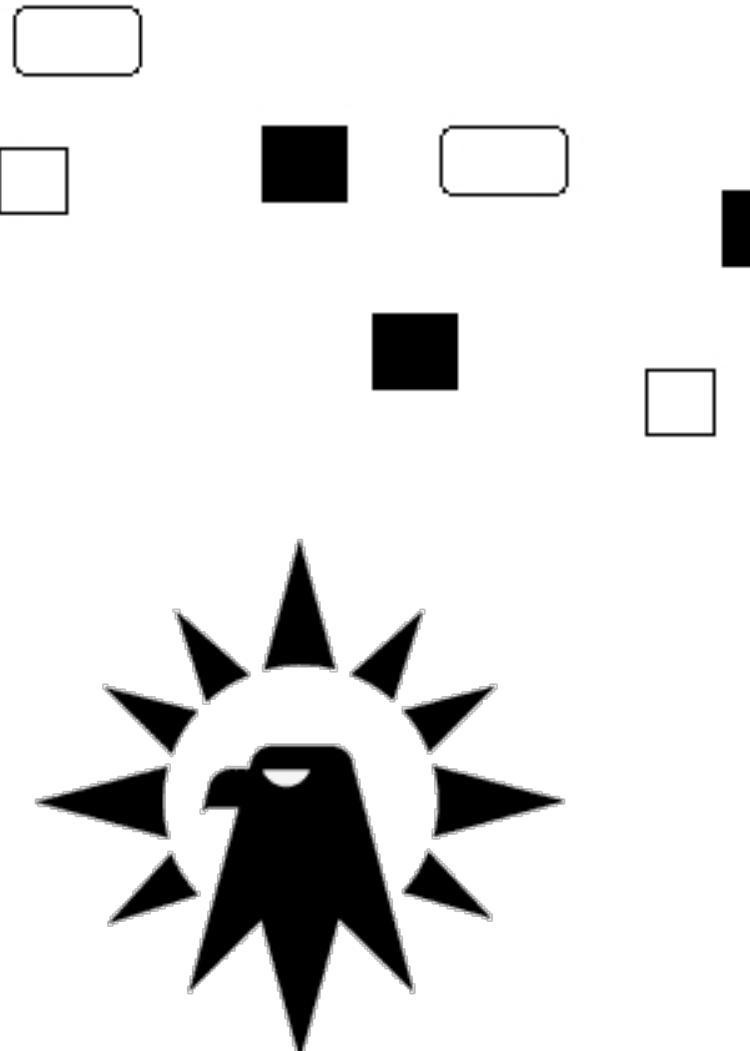


Image Source:

<http://graphicdesign.spokanefalls.edu/tutorials/process/gestaltprinciples/gestaltprinc.htm>

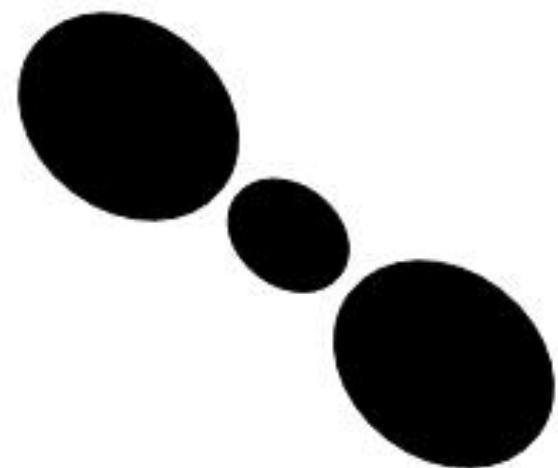
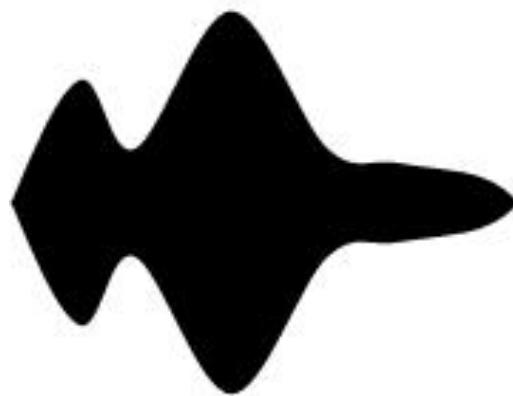
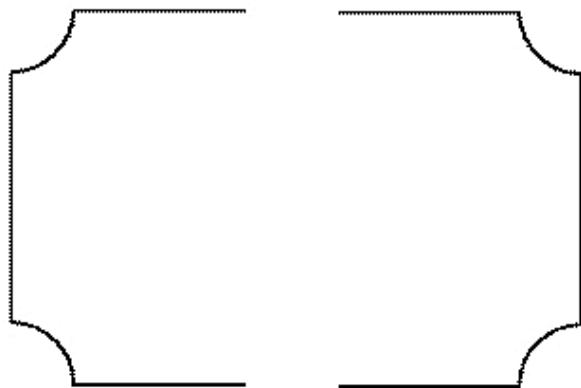


Image Source:

[http://facweb.cs.depaul.edu/sgrais/gestalt\\_principles.htm](http://facweb.cs.depaul.edu/sgrais/gestalt_principles.htm)

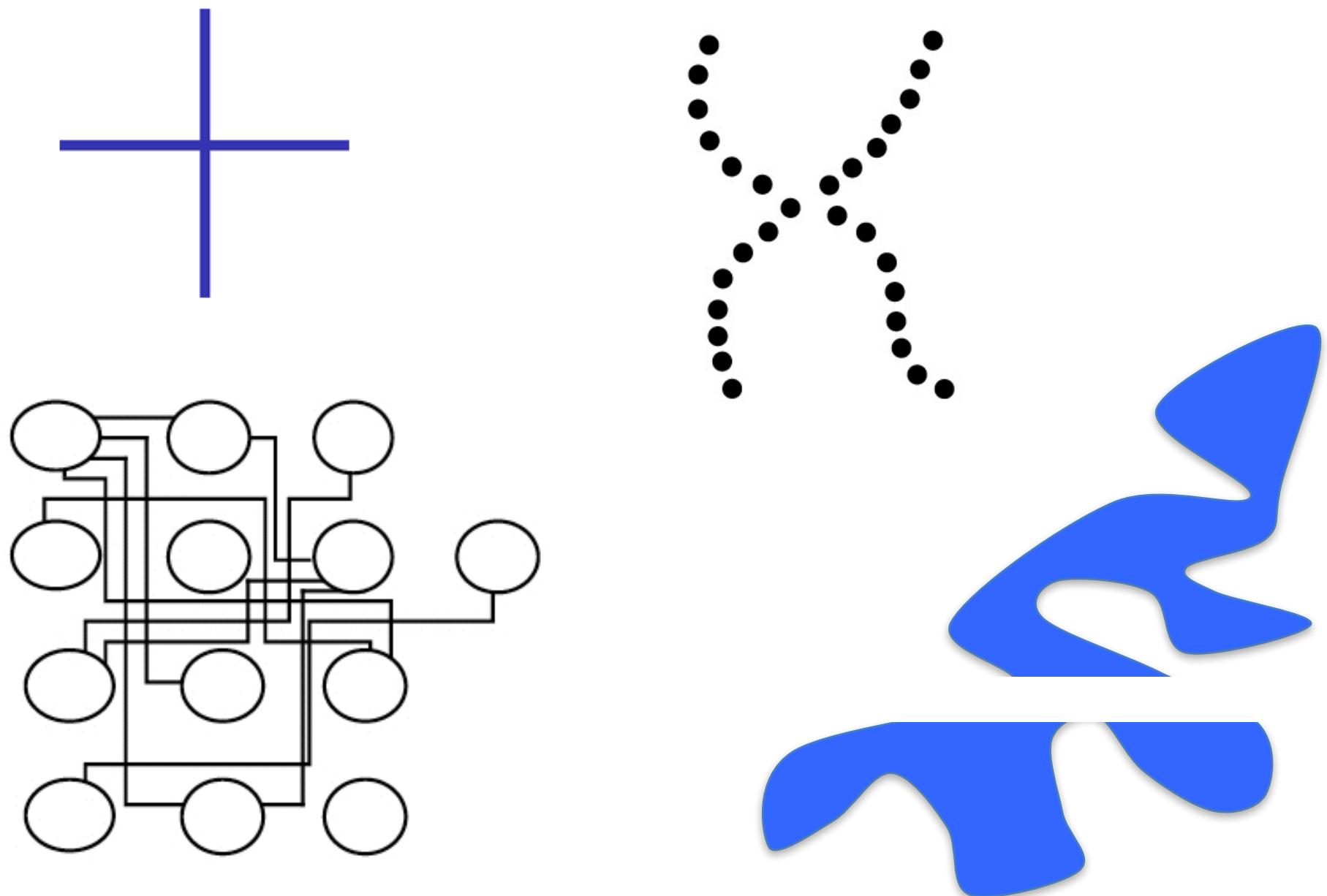
## Symmetry

Our perceptual tendency to seek symmetry and connect symmetrical elements to form a coherent shape.



## Continuity

Our perceptual tendency to see lines as continuous even when they are intersected; and to see two groupings of similar things as one interrupted group.



## Closure

Our perceptual tendency to fill in missing parts of an object so it appears whole.

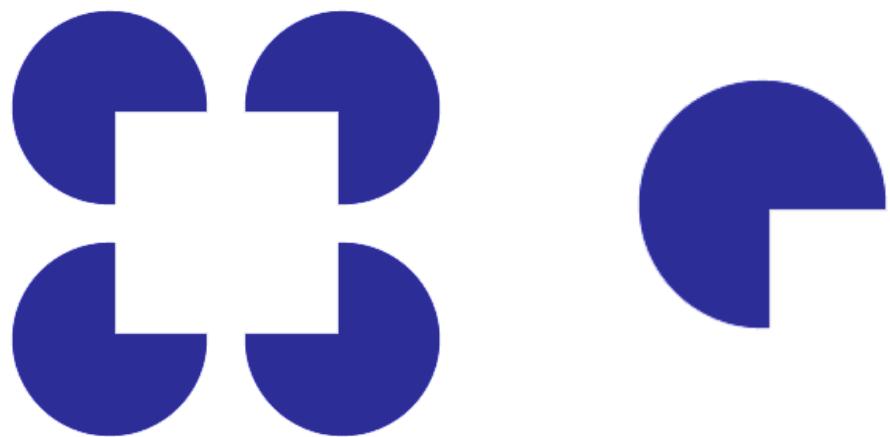
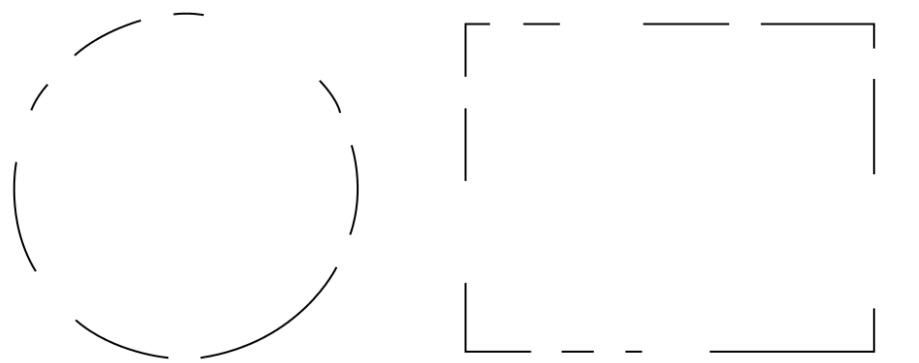


Image Source:  
[http://facweb.cs.depaul.edu/sgrais/gestalt\\_principles.htm](http://facweb.cs.depaul.edu/sgrais/gestalt_principles.htm)

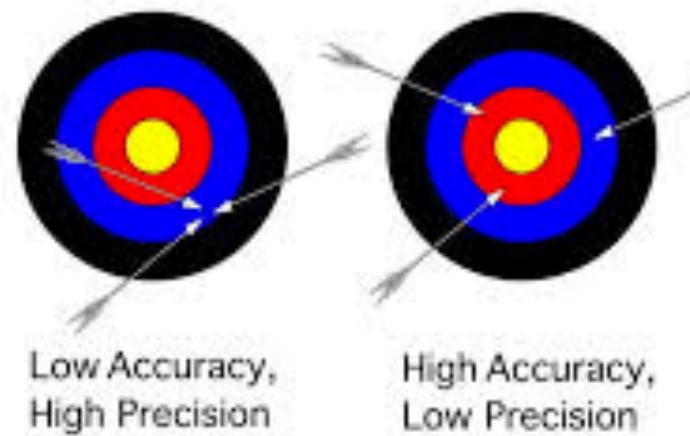


Panda image Source:  
<http://graphicdesign.spokanefalls.edu/tutorials/process/gestaltprinciples/gestaltprinc.htm>

# Visual Metaphors

- Fundamental spatial metaphors
  - Up, down
  - Fast, slow
  - Inside, outside
  - Warm, cold

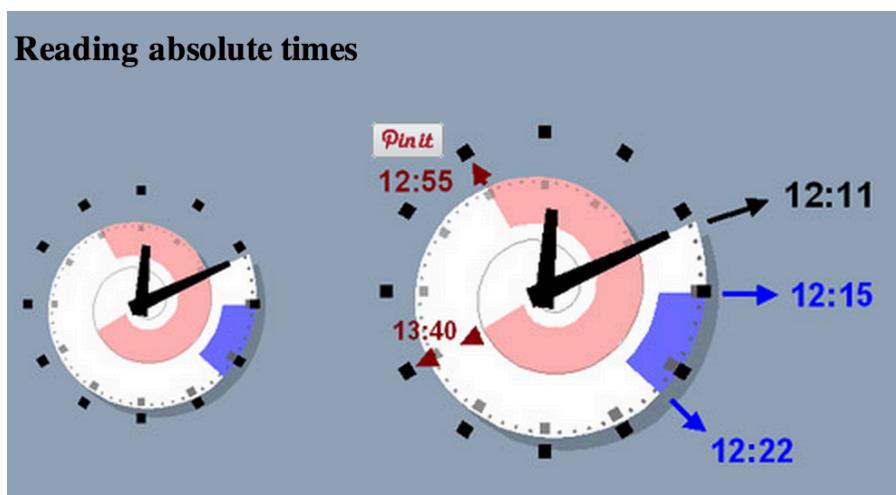
Complex metaphors are built on simpler metaphors



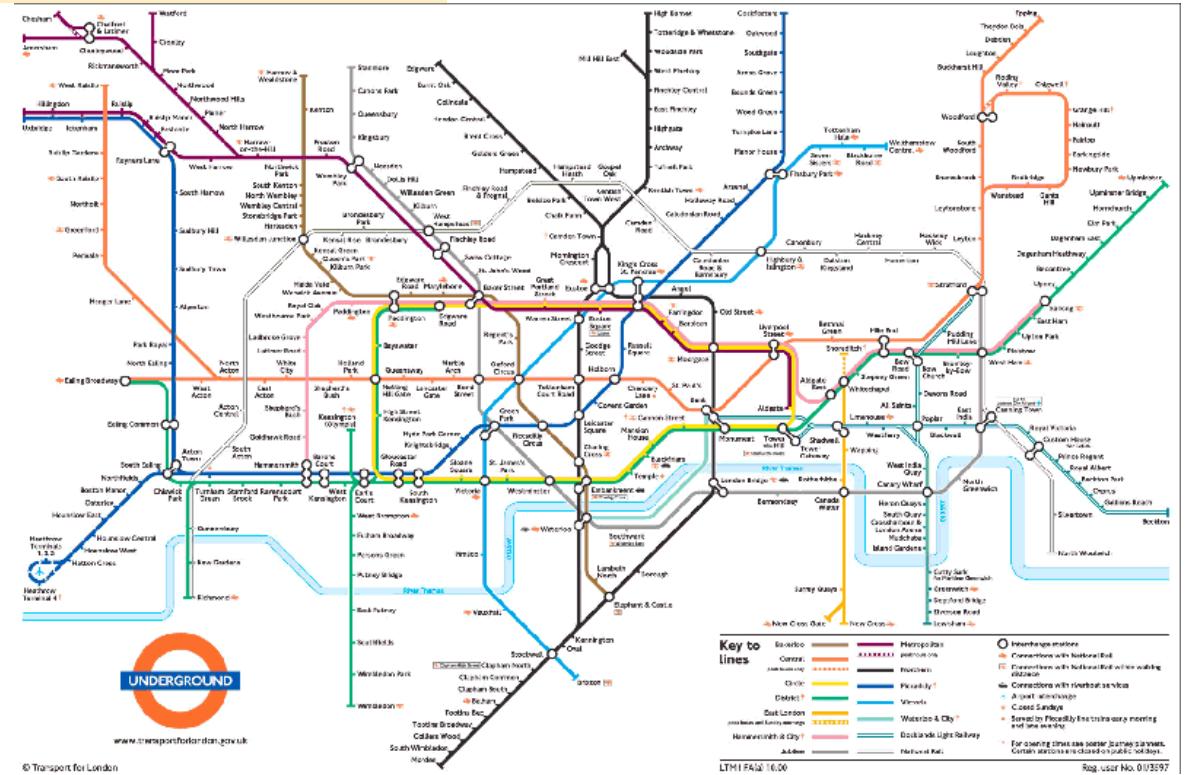
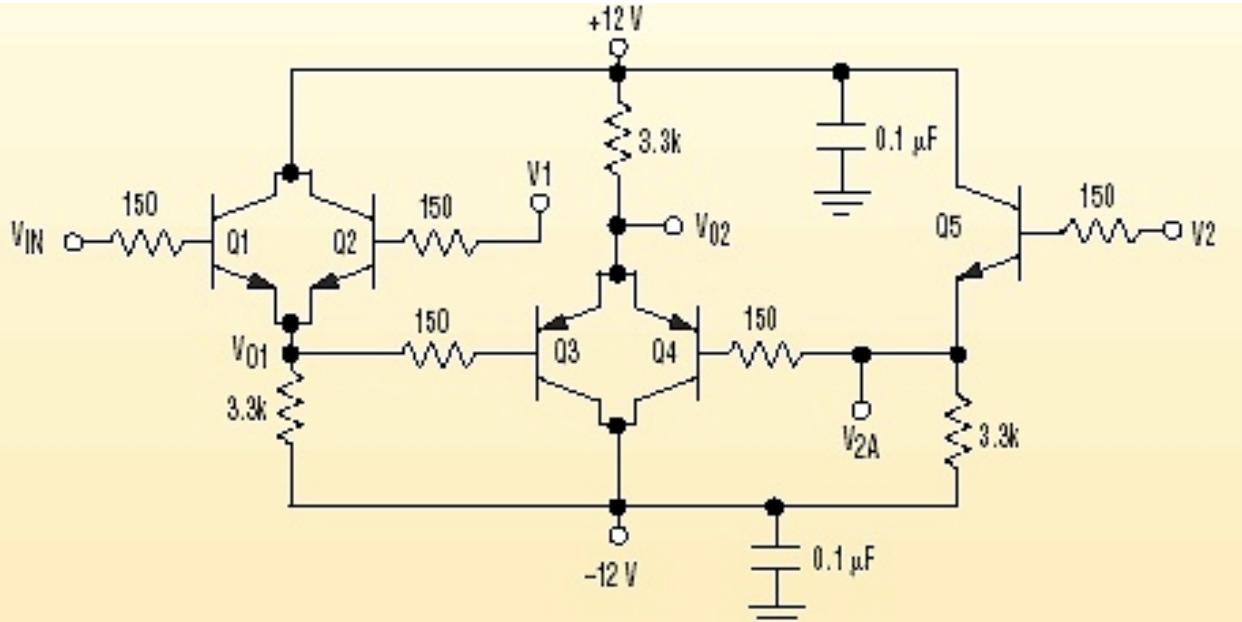
# Metaphors of time



## Reading absolute times



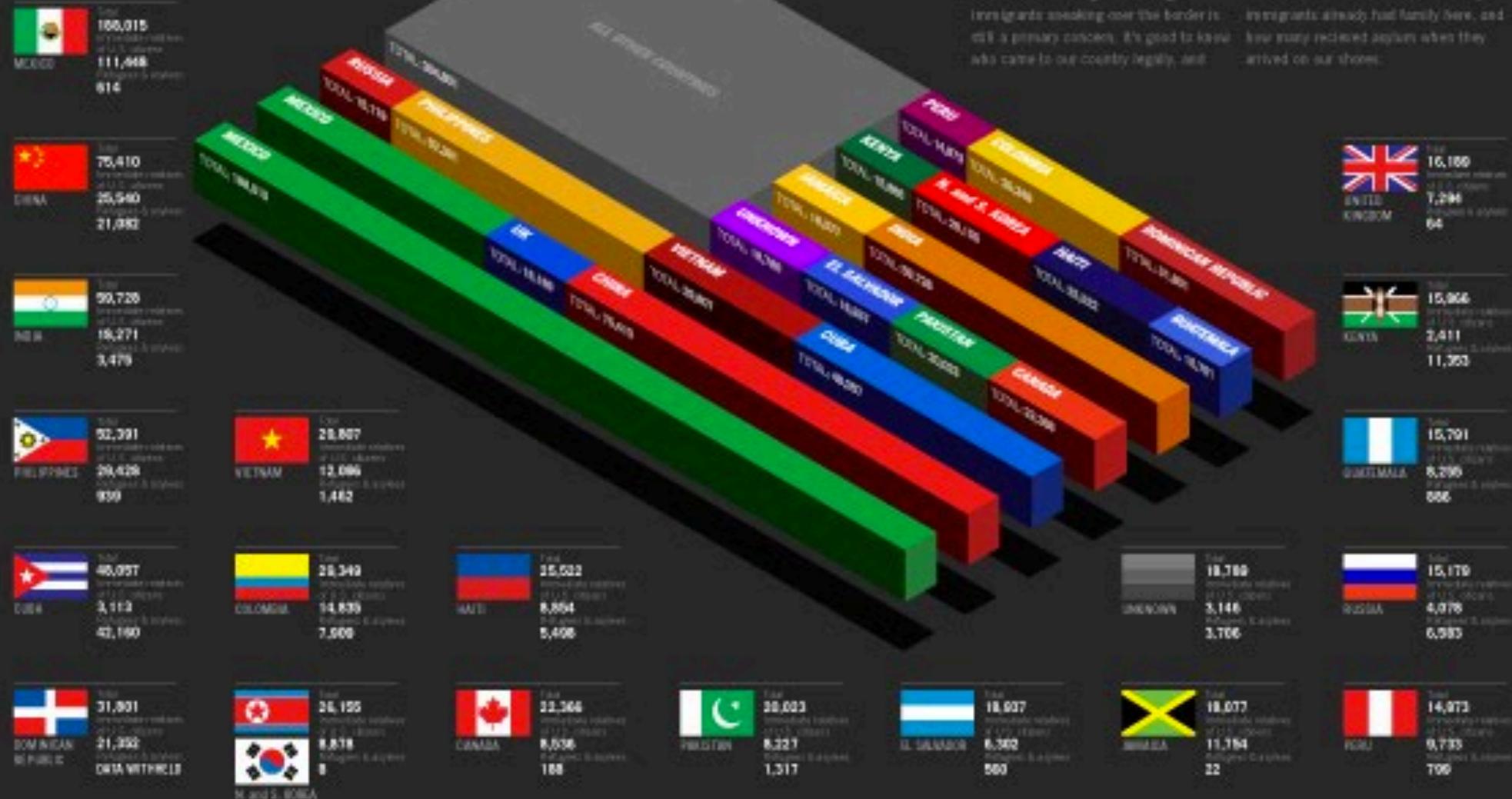
# Visual Conventions



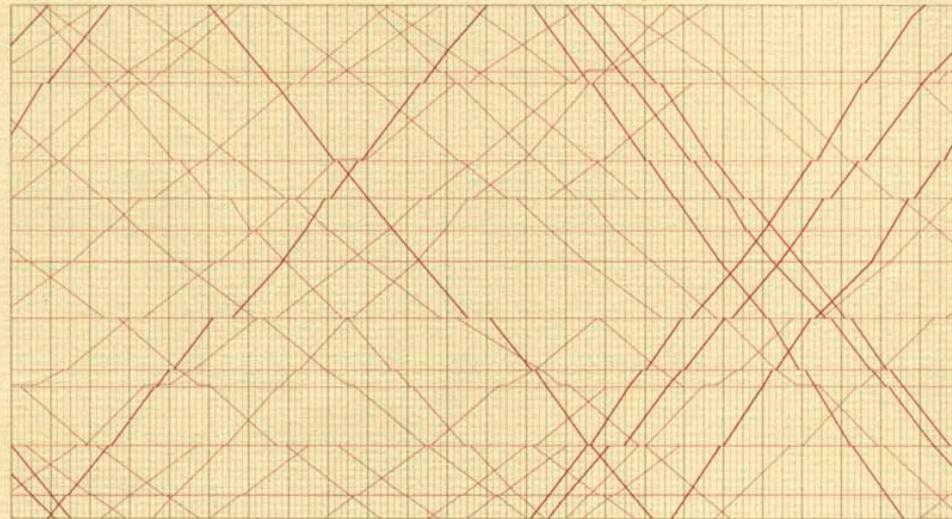
Most metaphors have a cultural context

## WHO IS COMING TO AMERICA?

Immigration may have taken a back seat, from where. This is a look at the 20 during the financial crisis, but the issue countries from which the most people will need to resolve while illegal. came to America in 2009, how many Immigrants crossing over the border is immigrants already had family here, and still a primary concern. It's good to know how many received asylum when they who came to our country legally, and arrived on our shores.



LAUNCH INFOGRAPHIC



The Visual Display  
of Quantitative Information

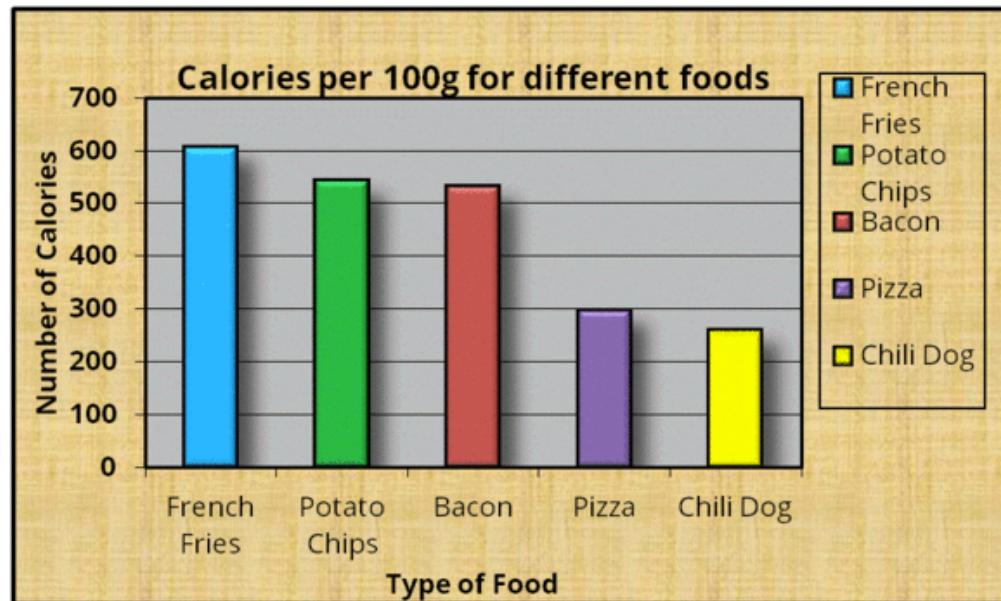
EDWARD R. TUFTE

# Principles of Graphical Excellence

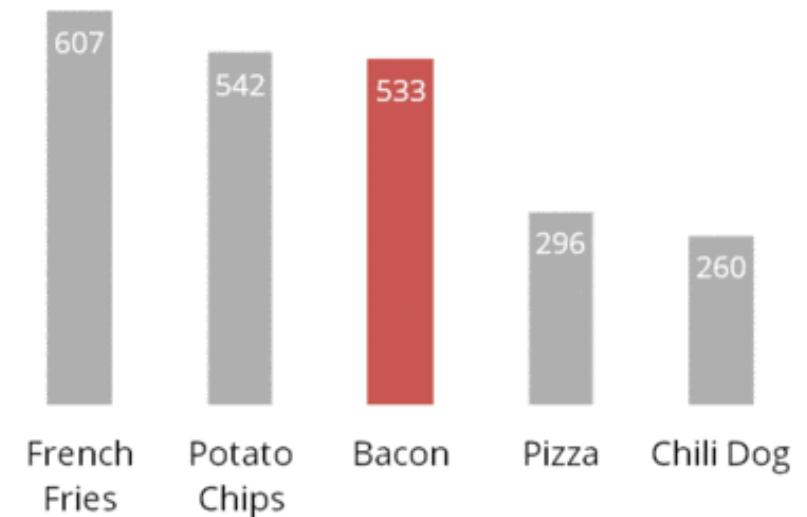
from E.R. Tufte

- Show the data
- Induce the viewer to think about the substance of the findings rather than the methodology, the graphical design, or other aspects
- Avoid distorting what the data have to say
- Present many numbers in a small space, i.e., efficiently
- Make large data sets coherent
- Encourage the eye to compare different pieces of data
- Reveal the data at several levels of detail, from a broad overview to the fine structure
- Serve a clear purpose: description, exploration, tabulation, decoration
- Be closely integrated with the statistical and verbal descriptions of the data set

# Show the data means high data to ink ratio.



Calories per 100g



Avoid distorting what the data have to say

## ***Maryland Budget Smaller Today Compared to 3 Years Ago***

General Fund Spending  
Net of Appropriation to Rainy Day Fund  
\$ in Billions



4

Don't Lie!

## OBAMACARE ENROLLMENT

6,000,000

AS OF  
MARCH 27

7,066,000

MARCH 31  
GOAL

SOURCE: HHS

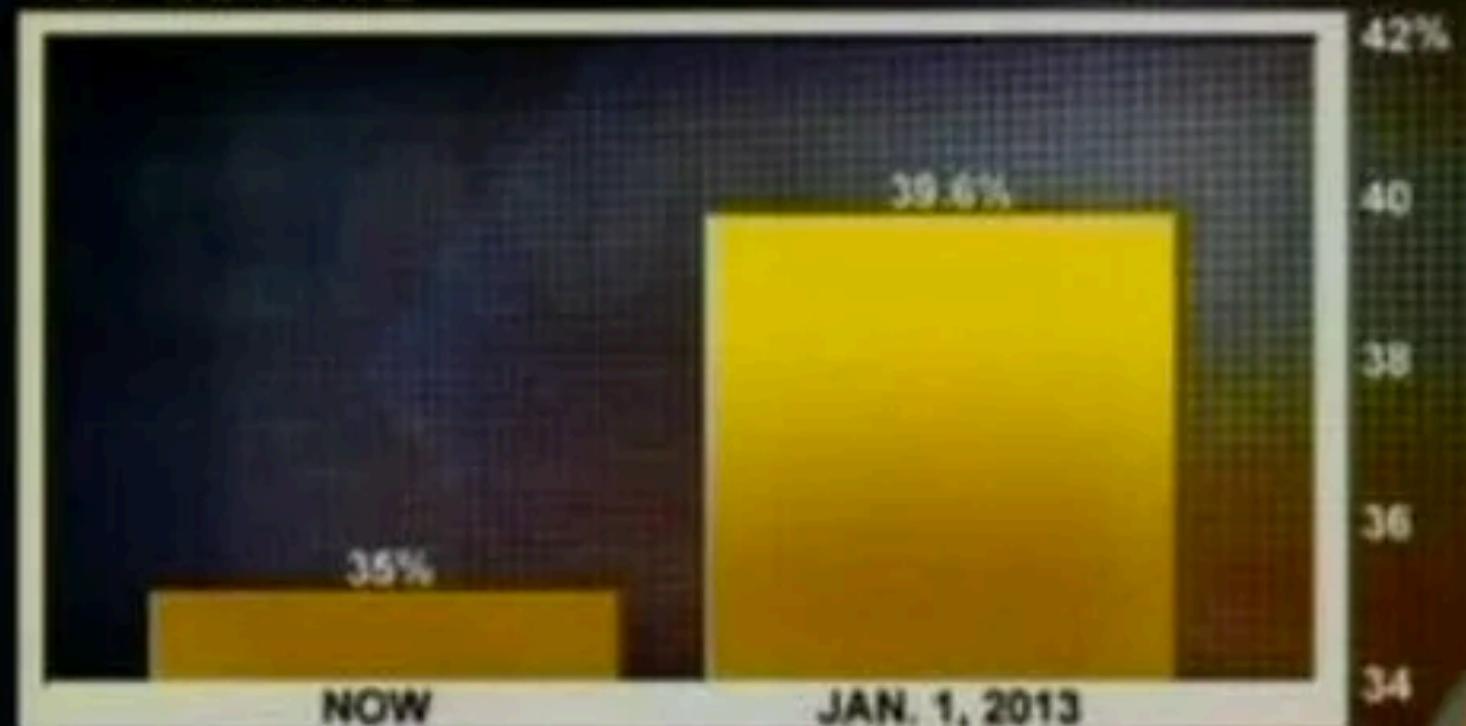
FOX  
NEWS  
channel

mediamatters.org

IE IN SECOND PLACE WITH \$26.5 MIL, WHILE "MUPP DOW FUT 16,325.00

# IF BUSH TAX CUTS EXPIRE

TOP TAX RATE



8:01 p ET

**FOX**  
BUSINESS

TOP STORIES

TECHNOLOGY

CONSUMER

WITH THE JUSTICE DEPARTMENT AND ACQUIRES FULL T

DOW 13008.68 ▲ 64.33

S&P 1379.32 ▲ 5.98

NASDAQ 2939.52 ▲ 6.32

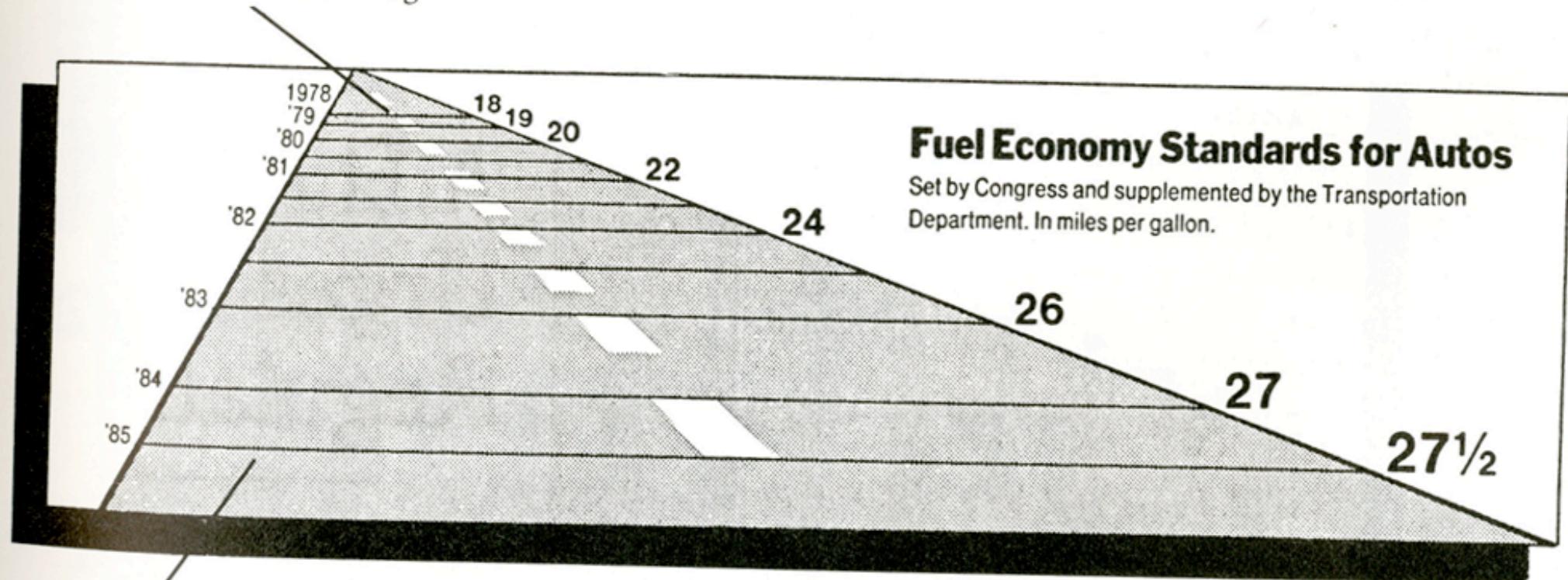
## Graphical Integrity:

The representation of numbers, as physically measured on the surface of the graphic itself, should be directly proportional to the quantities represented.

Lie Factor =

$$\frac{\text{Size of effect shown in graphic}}{\text{Size of effect in data}}$$

This line, representing 18 miles per gallon in 1978, is 0.6 inches long.

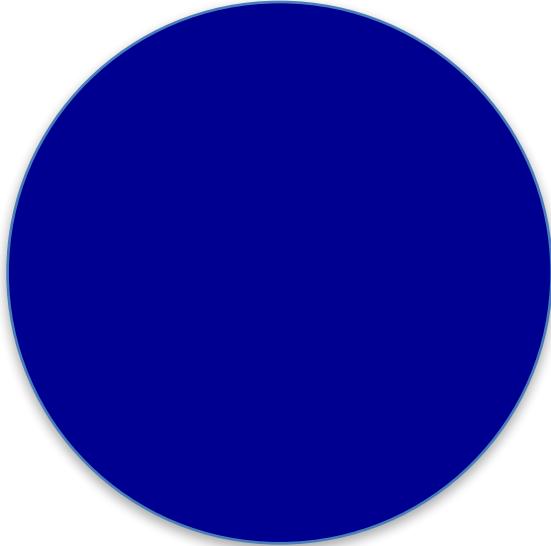
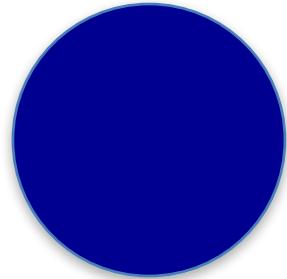


This line, representing 27.5 miles per gallon in 1985, is 5.3 inches long.

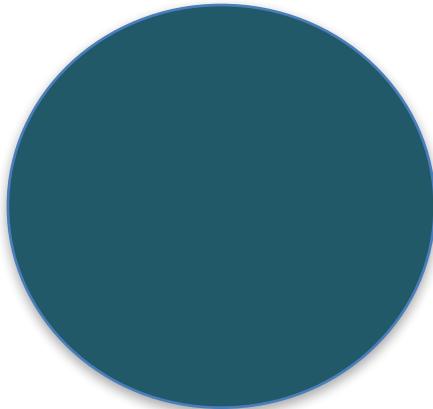
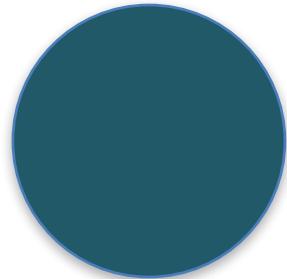
Lie Factor =

$$\text{Lie Factor} = \frac{\text{Effect in Graphic} = 5.3/06}{\text{Effect in data} = 27.5/18} = \frac{8.8}{1.5} = 5.9$$

When making bubble visualizations:  
use area to represent quantities, not radius or diameter



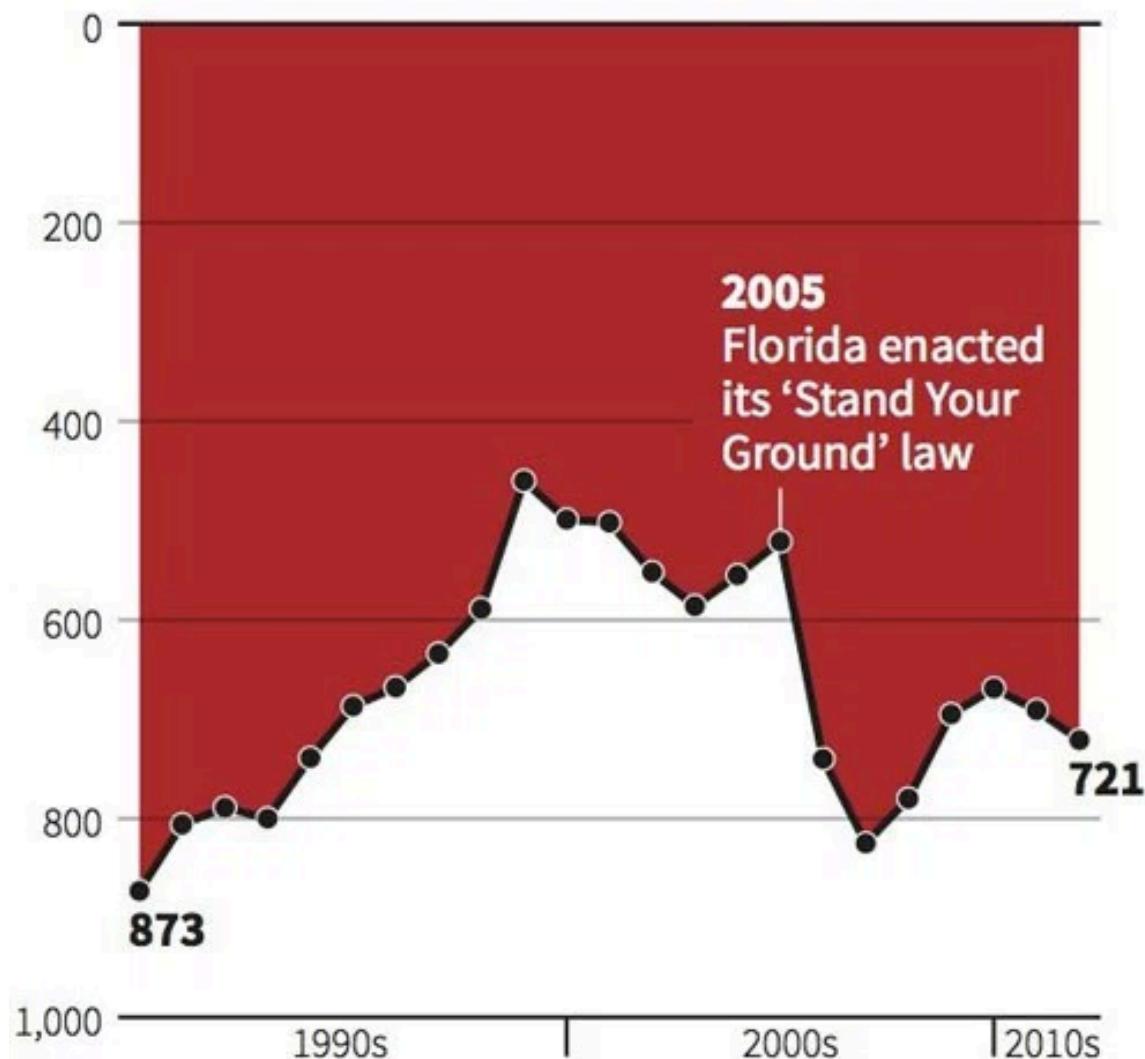
The bigger circle has twice the diameter as the smaller circle, and four times the area



The bigger circle has twice the area as the smaller circle.

# Gun deaths in Florida

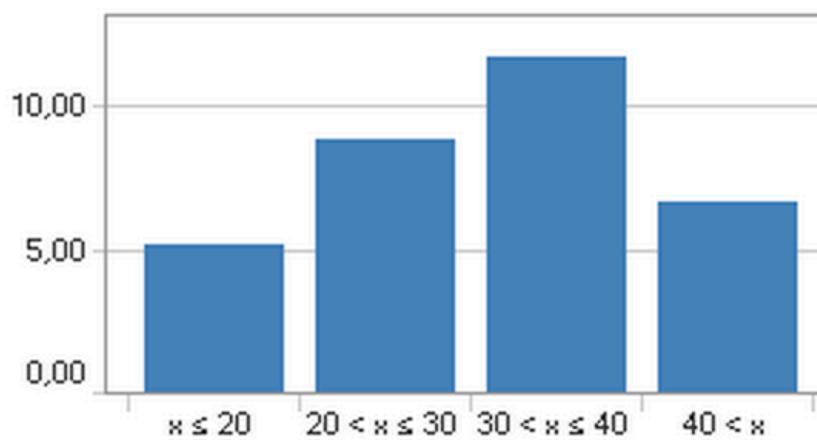
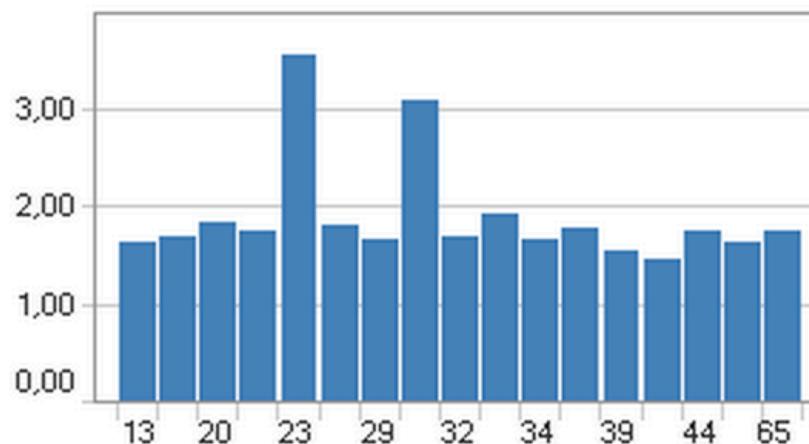
Number of murders committed using firearms



Source: Florida Department of Law Enforcement

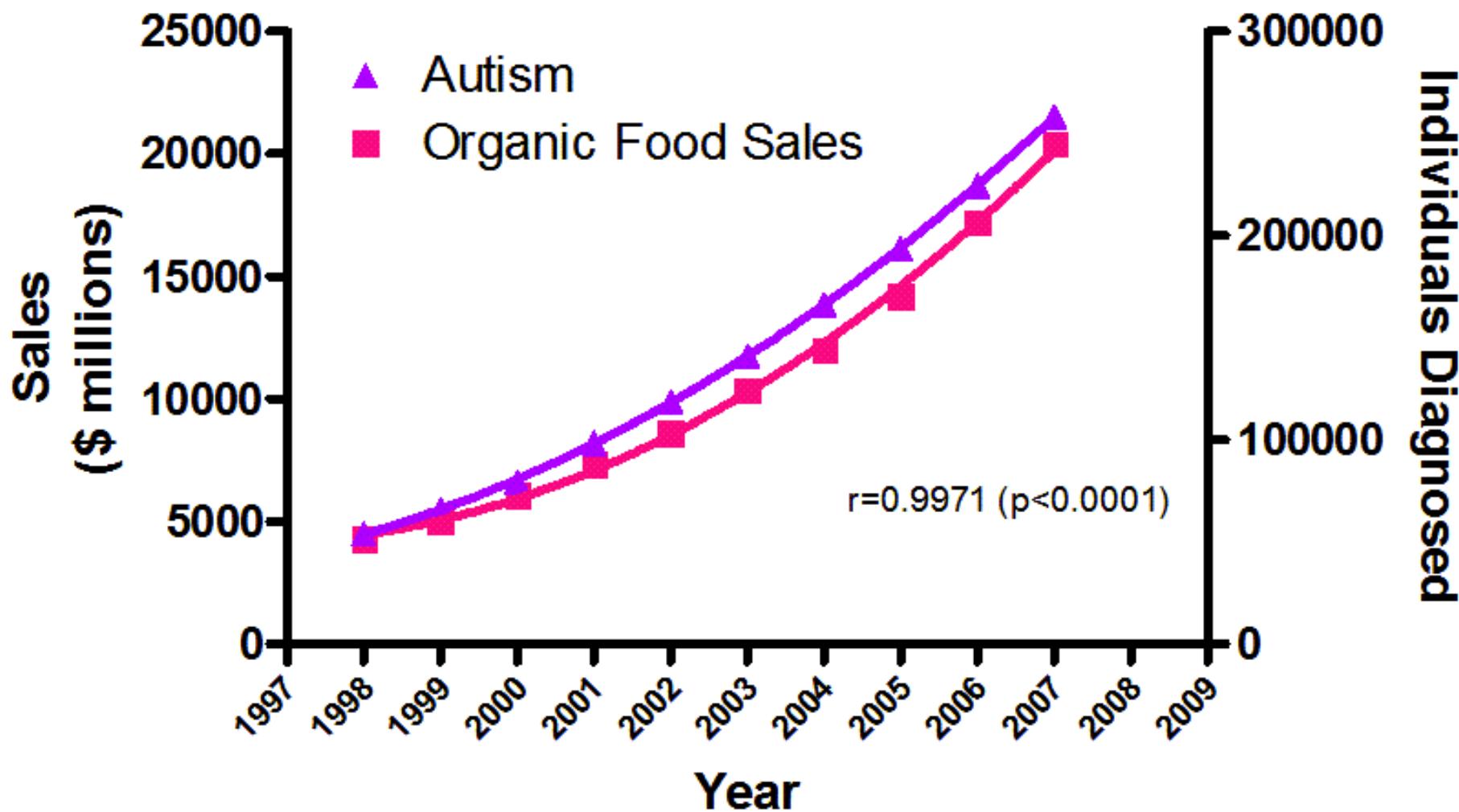
REUTERS

## Careful with averaging out data



Example: increasing the bin size here obscures relevant information

## The real cause of increasing autism prevalence?



Sources: Organic Trade Association, 2011 Organic Industry Survey; U.S. Department of Education, Office of Special Education Programs, Data Analysis System (DANS), OMB# 1820-0043: "Children with Disabilities Receiving Special Education Under Part B of the Individuals with Disabilities Education Act"

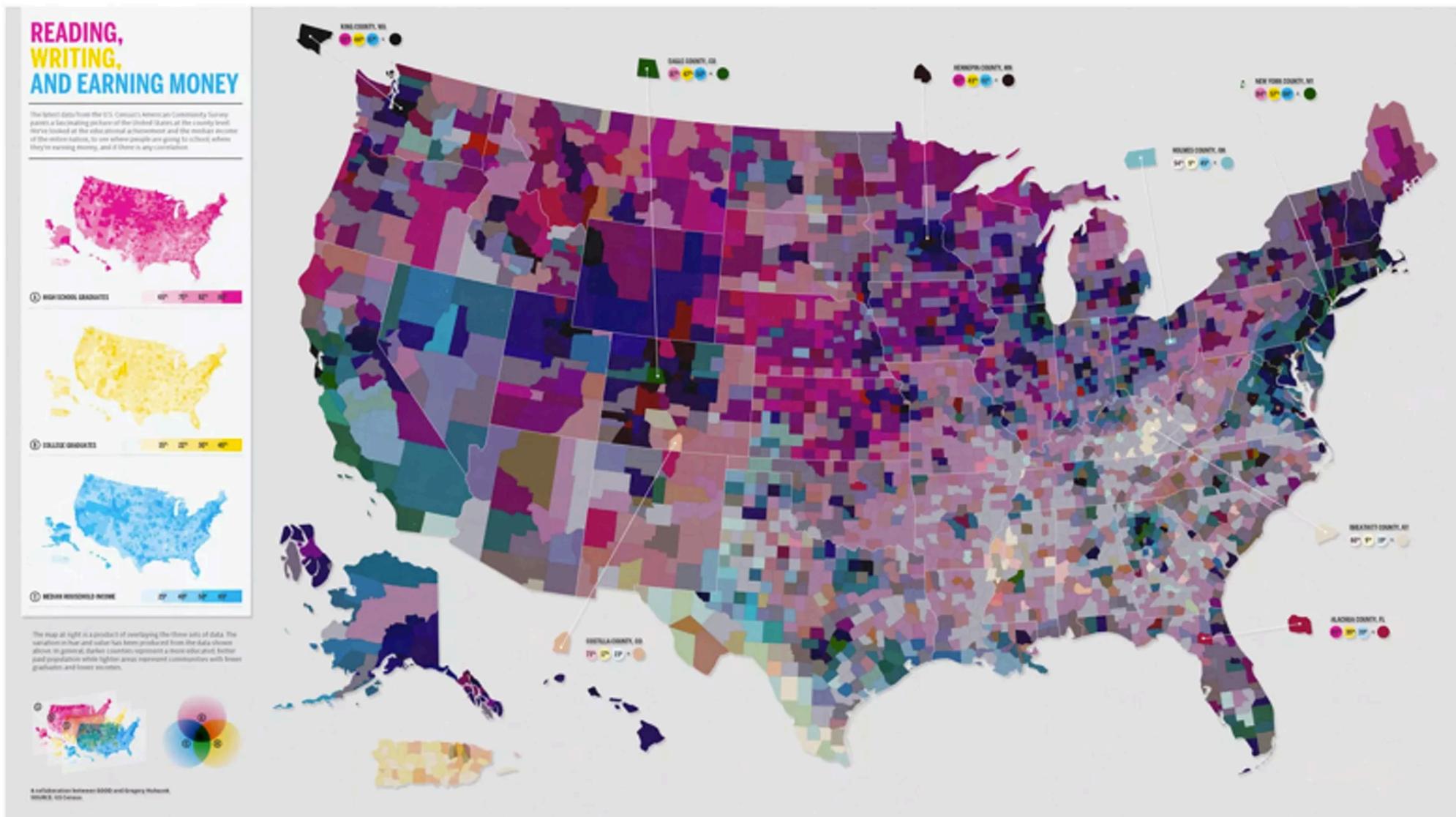
More good examples (along with corrections) of misleading graphics:

<http://qz.com/580859/the-most-misleading-charts-of-2015-fixed/>

See this research study on deceptive graphics:

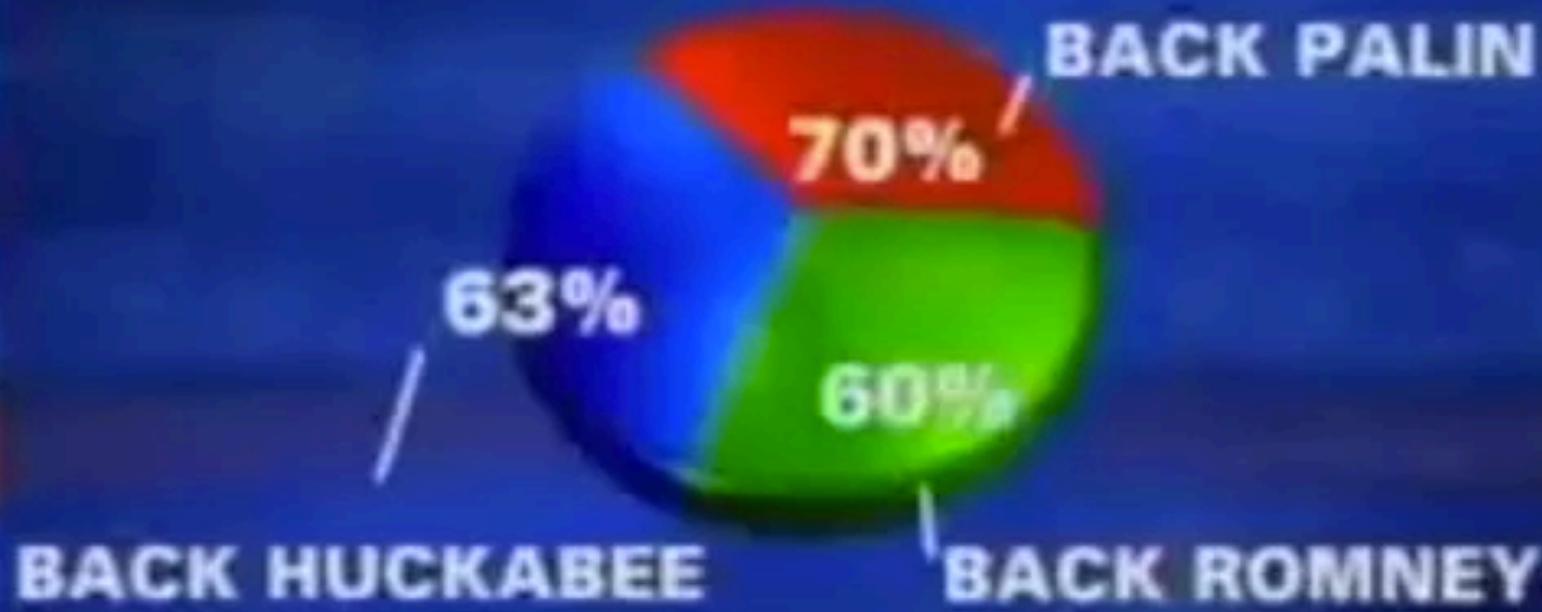
<http://fellinlovewithdata.com/research/deceptive-visualizations>

# Best Practices



# 2012 PRESIDENTIAL RUN

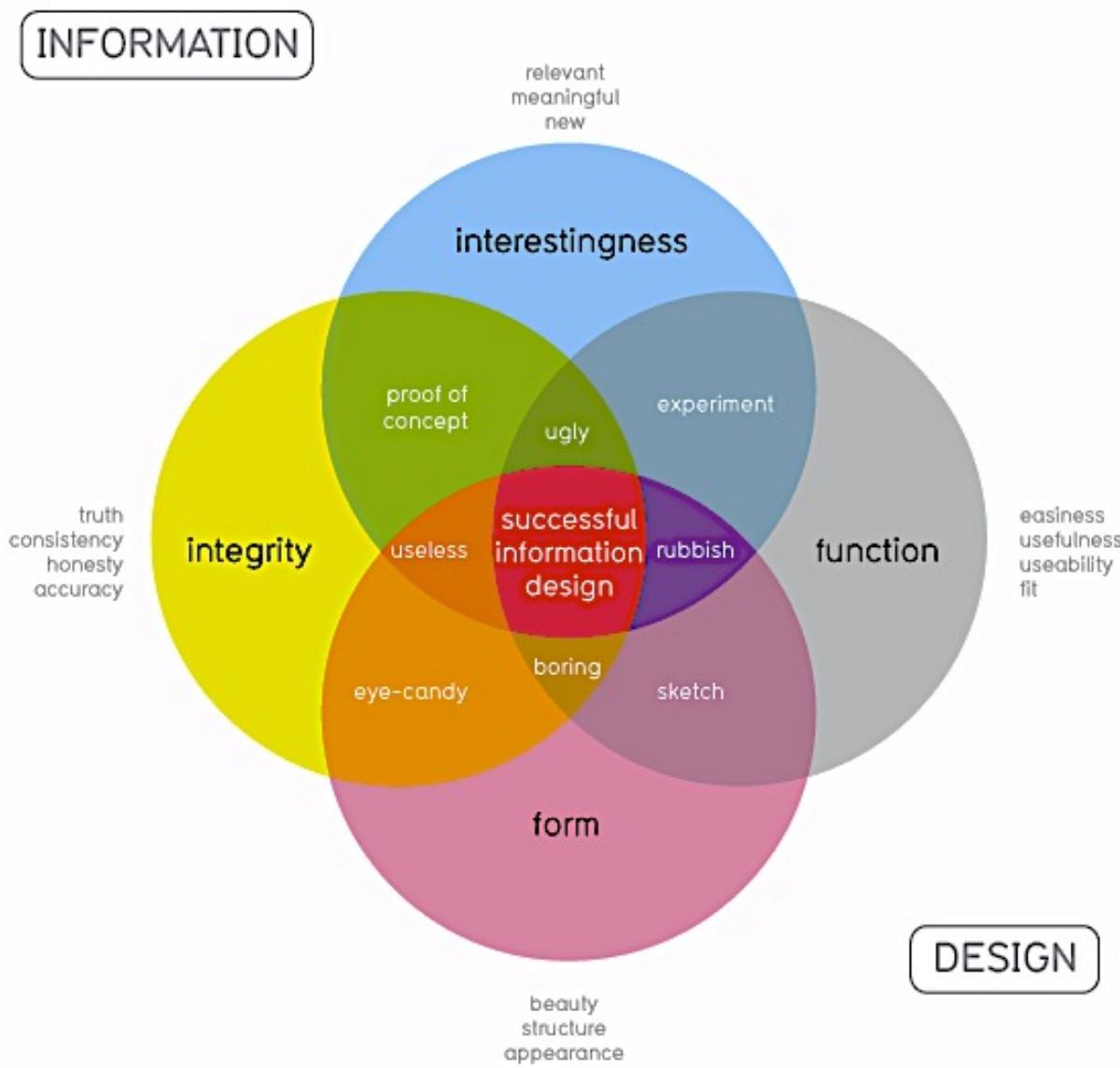
GOP CANDIDATES



**FOX**  
9:17 PM

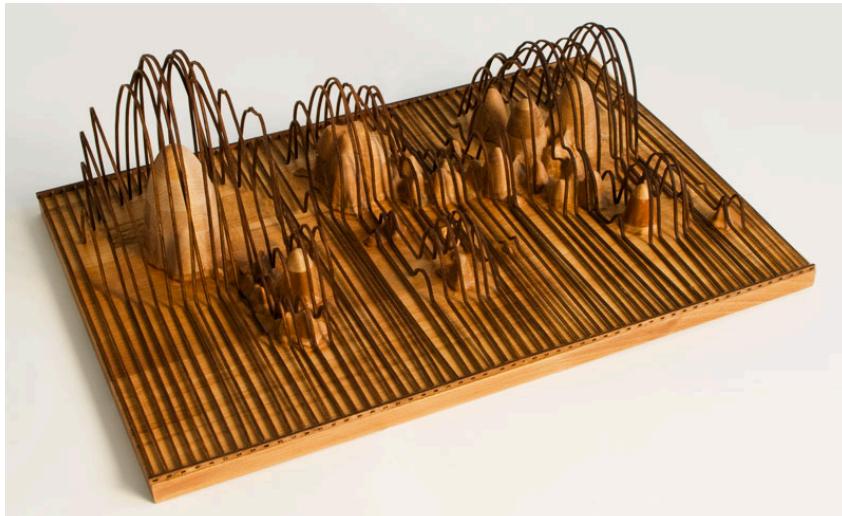
SOURCE: OPINIONS  
DYNAMIC

# What Makes Good Information Design?



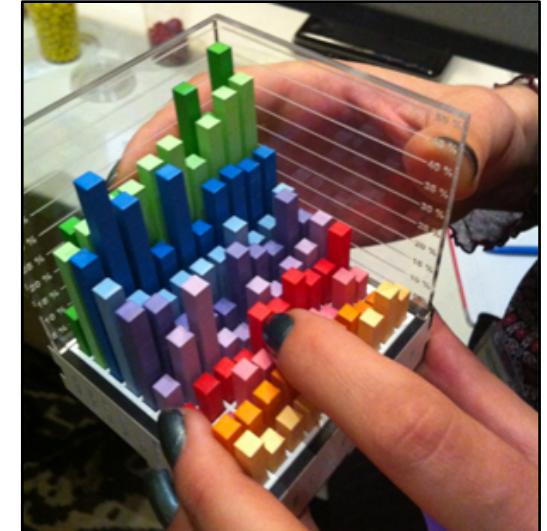
# Beyond Visualizations

<http://dataphys.org/list/tag/data-sculpture/>



Fundament, Andreas Nicolas Fischer. 2008.

<http://anf.nu/fundament/>



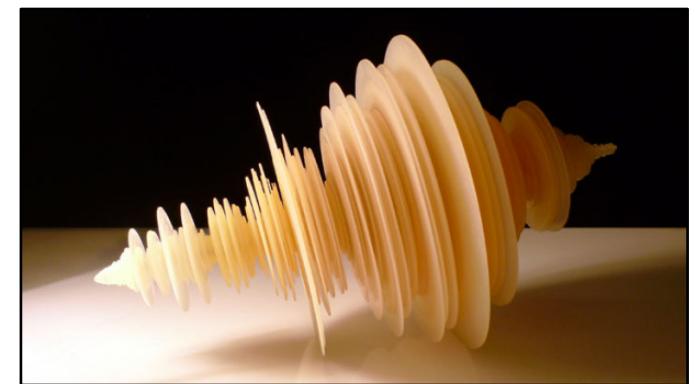
<http://dl.acm.org/citation.cfm?id=2481359>

Jansen, Yvonne, Pierre Dragicevic, and Jean-Daniel Fekete.

"Evaluating the efficiency of physical visualizations." Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. ACM, 2013.



Keyboard frequency sculpture. Michael Knuepfel  
[aviz.fr/Research/PassivePhysicalVisualizations](http://aviz.fr/Research/PassivePhysicalVisualizations)



Tokyo earthquake data sculpture. Luke Jerram  
[http://www.lukejerram.com/projects/t%C5%8Dhoku\\_earthquake](http://www.lukejerram.com/projects/t%C5%8Dhoku_earthquake)

**SINCE 1980 CALIFORNIA BUILT  
22 PRISONS 1 UNIVERSITY\***



**\*UNIVERSITY**

Manifest Justice Exhibition, Los Angeles, May 2015

<http://www.afropunk.com/profiles/blogs/feature-manifestjustice-art-exhibit-in-los-angeles>

# Data Sculptures

[http://www.newloren.com/data\\_art.html#0](http://www.newloren.com/data_art.html#0)

[http://www.nytimes.com/interactive/2015/10/11/us/politics/2016-presidential-election-super-pac-donors.html?\\_r=1](http://www.nytimes.com/interactive/2015/10/11/us/politics/2016-presidential-election-super-pac-donors.html?_r=1)

<http://www.stanscafe.co.uk/project-of-all-the-people.html>

<http://dataphys.org/list/?o=date-desc>

## Participatory Visualization

<https://www.youtube.com/watch?v=hD5f8GuNuGQ>

## **Class Activity:**

Find a visualization online.

Answer the following questions:

In one or two sentences, what story does it tell?

If it is interactive, show the interaction, and the data revealed.

Identify the data. What type of data is it?

Identify the visual variables used.

How many dimensions being visually mapped?

Identify the type of visualization, or methods used.

Referring to the Venn Diagram for information design, comment on this visualization's interestingness, integrity, form, and function. Where does it succeed and where does it fall short?